The role of pulses

The Value of Pulses in a Farming System

Pulses have a role in the modern farming system, far greater than the traditional "nitrogen fix' and 'disease break'. They are a cash crop in their own right, but also a valuable part of the whole farming system, especially for weed control within crop rotations.

Stubble retention is common for erosion protection and moisture retention, and pulses fit into such systems. Seeding machinery used in no-till or minimum tillage systems can now handle stubble retention, to allow pulse crops to be sown after a cereal. *(See Page 1 : 19)*

Diversity of crops in a rotation is important for continuous cropping systems:

- To handle herbicide resistant weeds or delay the onset by varying herbicide options and timings for weed control *(See Chapter 5)*
- Disease control of all crops in the rotation *(See Chapter 7)*
- Spreading the timing of farm operations
- Spreading risks across commodities
- Minimising the impact of increased fertilizer nitrogen and fuel costs

Crop topping or weed ('wick') wiping of weeds in the pulse crop prevents the seed set of escape weeds in the crop. Desiccation or windrowing may help too. *(See Chapter 5)*

These practices have turned pulses from the weak link in resistant ryegrass control to the strongest phase.

Pulses can be dry sown successfully, particularly in lower rainfall areas, in years with a late break to the season and with crops like beans and lupins that need to be sown early. Dry sowing ensures early sowing and timeliness of other crop operations. Issues with timely sowing in years with a late break to the season can now be handled with dry sowing of pulses. Results with dry sowing can be improved with new varieties, better sowing systems and the future use of granular inoculants to ensure nodulation. *(See Chapter 3)*

Pulses can be sown in wide rows if required, enabling non-selective weed control between the rows using hooded shields. Sowing the pulse crop between the standing rows of cereal stubble is beneficial, and is now possible with GPS guidance and auto-steer sowing systems. *(See Chapter 3)*

Pulse crops can be versatile if not used solely for grain harvest. 'Green' or 'brown' manure crops, hay cuts or grazing as standing crops are options.

Improved varieties of pulses are available, with higher yields, increased reliability and lower risks because of their improved disease resistance and reduced fungicide inputs. *(See Chapter 2)*. Specific variety management packages are now available to maximise the benefits from new improved pulse varieties.

The pulse effect - higher cereal yields.

Pulses and cereal crops are complementary in a cropping rotation.

Pulses fix their own nitrogen, leaving available nitrogen in the soil for the following cereal crop.

However, pulses also play a vital role in controlling major cereal root diseases, particularly cereal cyst nematode and take-all (haydie).

The combination of higher soil nitrogen and reduced root diseases is cumulative and can result in a dramatic increase in subsequent cereal yields. *(See Plate 1)*

Numerous trials have clearly demonstrated the yield increases possible when pulses are included in a cropping rotation.

(See Tables 1 : A, 1 : B and 1 : C).

TABLE 1 : A
COONALPYN ROTATION TRIAL
(Soil type sand over shallow clay)

Rotation	Wheat Yields (t/ha)
Continuous wheat + nitrogen†	3.0
Volunteer pasture – wheat	2.2
Sown pasture – wheat	2.2
* Pulse – wheat	3.7

* Pulses were field peas, lupins and beans
† Nitrogen was applied at 30kg/ha

TABLE 1 : B
MUNDULLA ROTATION TRIAL – WHEAT YIELDS IN THE TWO YEARS FOLLOWING THE GROWING OF A RANGE OF CROPS
(Soil type brown clay loam)

Initial Crop Type	Second Year Wheat Yields Rate of Nitrogen (kg/ha)			Third Year Wheat Yields Rate of Nitrogen (kg/ha)		
	0	25	50	0	25	50
* Pulse	4.75	4.95	4.99	2.71	3.23	3.48
Fallow	4.71	4.91	4.82	2.88	3.30	3.37
Pasture	3.69	4.22	4.27	2.85	3.21	3.28
Cereal	3.65	4.20	4.40	2.70	2.95	3.02

* Pulses were lupins (narrow leaf and albus), peas and beans.

Some of the most significant early trial results came from Tarlee, in the Mid-North of South Australia where intensive cropping rotations including pulses were continued for over 10 years until herbicide resistance became a problem. *(See Table 1 : C.)*

TABLE 1 : C
TARLEE ROTATION TRIAL
(Soil type red brown earth)

Rotation	Wheat Yields (t/ha) Five-year Average
Fallow – wheat	2.20
Continuous cereal + nitrogen†	1.82
* Pulse – wheat	2.45
Sown pasture – wheat	2.23
Volunteer pasture – wheat	1.99

* Pulses grown were field peas, lupins and faba beans.
† Nitrogen was applied at 40kg/ha

Much of the yield increase was directly associated with the control of cereal root diseases including cereal cyst nematode and take-all. The weed control measures used in the pulses successfully reduced grass populations which also act as host to many cereal root diseases. Herbicide resistance however developed, highlighting the fact that sustainability is more than improving soil fertility and disease control.

CONTROLLING CEREAL ROOT DISEASE

Cereal Cyst Nematode (CCN or eelworm)

Cereal cyst nematode was considered the most serious root disease in most cereal growing districts. Because it must have a cereal or grass host to develop, the disease's severity is significantly reduced following a grass free pulse crop. *(See Table 1 : D)*

TABLE 1 : D
EFFECT OF ROTATION ON CEREAL CYST NEMATODE DAMAGE TO ROOTS, NUMBERS OF WHITE CYSTS AND YIELD OF WHEAT
(Avon, S.A.)

Previous Rotation	Disease Rating* of Wheat Roots	No. of White** Cysts per plant	Grain Yield of Wheat (t/ha)
Wheat	2.6	25	0.7
Volunteer pasture	2.5	13	1.0
Oats (Avon)	0.4	2	1.3
Sown medic	0.6	1	1.9
Peas	0.7	4	2.2

* Disease rating increasing from 0 (no disease) to 5 (severe disease).

** White cysts contain the nematode eggs for future crop infection.

In Table 1 : D, peas grown before wheat produced a wheat yield increase of 1.5t/ha. The yield increase associated with disease control being 0.6t/ha (oats -wheat) and the increase from available nitrogen, 0.9 t/ha (peas - oats). The oats were resistant to CCN.

Pulses should be used as one of the key factors in an overall long-term management strategy to control or avoid CCN.

Other management tools include resistant cereals (such as Frame or Annuello wheat, SloopSA barley, Tahara and Tickit triticale, and the oat varieties Wintaroo, Wallaroo and Marloo) and canola.

Take-all (haydie)

Take-all like CCN must have a cereal or grass host to develop.

Pulses, being a non-host, can be used very effectively as a one-year disease break-crop in a cereal rotation.
(See Tables 1 : E and 1 : F.)

TABLE 1 : E
EFFECT OF THE PREVIOUS CROP ON THE INCIDENCE OF TAKE-ALL AND GRAIN YIELD OF WHEAT
(Avon, S.A.)

Previous Crop	% of Wheat Plants with Take-all	Grain Yield of Wheat (t/ha)
Wheat	67	1.7
Pasture*	58	1.4
Oats (Avon)	14	2.3
Medic**	10	2.8
Peas	8	3.0

* Pasture = Mixture of medics, ryegrass, barley grass and wild oats.

** Medic = Sown snail medic.

Table 1 : E shows that wheat following peas out yielded continuous wheat by 1.3t /ha. As oats are also resistant to take-all the increase attributed to disease control can be put at 0.6 t/ha and the increase from nitrogen at 0.7 t/ha.

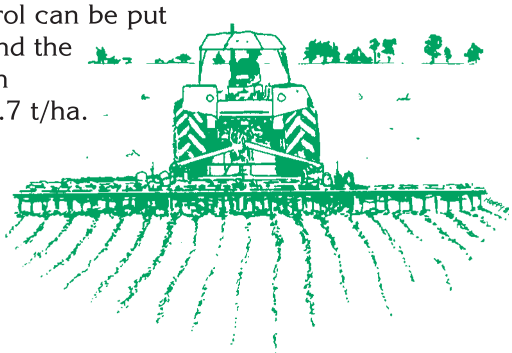


TABLE 1 : F

EFFECT OF THE PREVIOUS CROP ON AVAILABLE NITROGEN AT SOWING, INCIDENCE OF TAKE-ALL AND GRAIN YIELD OF WHEAT

(Kapunda, S.A.)

Previous Crop	* Available Nitrogen at Sowing (kg/ha)	% of Wheat Plants with Take-all	Grain Yields of Wheat (t/ha)
Wheat	52	54	3.3
Pasture	61	42	4.0
Lupins	53	15	4.8

* to 50cm.

Rhizoctonia

Rhizoctonia has a very wide host range and so, unlike CCN or take-all, trying to reduce the problem through crop rotation is not very effective. Modern sowing and tillage practices can be very effective though. There is also the nitrogen story to consider.

Including a pulse in a cereal rotation increases the amount of available nitrogen to the following crop and this can mask some of the effects of the disease and help the crop recover after an attack.

This nitrogen effect is often seen as reduced areas of poor growth patches in wheat following peas, a medic pasture or any other pulse.
(e.g. Table 1:G)

TABLE 1 : G

EFFECT OF THE PREVIOUS CROP ON AVAILABLE NITROGEN AT SOWING, RHIZOCTONIA AND GRAIN YIELD OF WHEAT

(Avon, S.A.)

Previous Crop	* Available Nitrogen at Sowing (kg/ha)	Area of Poor Growth Patches (%)	Grain Yields of Wheat (t/ha)
Wheat	50	35	1.2
Pasture	65	42	1.4
Medic	97	27	2.0
Peas	107	27	2.9

* to 50cm.

In Table 1:G the yield increase when wheat followed peas compared to continuous wheat was 1.7 t/ha. Laboratory tests indicated 0.3 t/ha increase was due to control of rhizoctonia, 0.5 t/ha to available nitrogen and 0.5 t/ha to take-all.

Root lesion nematode (Pratylenchus)

Either of the two species of root lesion nematode *(Pratylenchus neglectus or P. thorneii)* can reduce cereal crops yields. Growing a pulse crop that is resistant to root lesion nematode can increase cereal yields through reducing the nematode numbers. *(See Page 1 : 18 and Table 1 : O)*

Disease combinations

In a normal cropping rotation it is unusual for root diseases to occur independently.

This means the ability of a pulse crop to reduce the severity of most major cereal root diseases is considerable.

For take-all, one year of a grass-free break-crop is enough to gain maximum benefit.

With CCN maximum benefit is achieved through a rotation management program involving pulses in the rotation in combination with resistant cereal varieties, grass-free pastures and canola.

However, the crop rotation's effectiveness in controlling cereal root diseases is dependent on grass weed control in the non-cereal phases.

So the pulse crop's success as a break-crop hinges on the control of all grassy weeds and volunteer cereals. Grassy weeds and volunteer cereals that survive in the pulse phase can carry-over cereal root disease.

What Rotation is Best?

Determining the most suitable cereal-pulse-oilseed rotation requires careful planning.

There are no set rules and it is best to work out a separate rotation for each cropping paddock.

The prime aim should be to achieve sustainability and the highest possible overall profit. But to achieve this the rotation must be flexible enough to cope with key management strategies such as maintaining soil fertility and structure, controlling crop diseases, and controlling weeds and their seed set.

The same pulses should not be grown in succession and extreme care must be taken if growing the same crop in the same paddock without a spell of at least three years. Successive cropping with the same pulse is likely to result in a rapid build up of root and foliar diseases as well as weeds. *(See Plate 7 : 4.)* Where possible, alternate the type of pulse crop being grown in a continuous rotation with cereals. Some farmers have adopted a pulse-wheat-barley sequence for their basic rotation. However, where a pulse and other crops can be grown, an increasing number of farmers are adopting a continuous pulse-cereal-oilseed-cereal rotation, e.g. beans-wheat-canola-barley-peas. A hay cut is often also included for weed control, as preventing weed seed set is a major priority.

What Paddock is Best?

To minimize foliar diseases it is important to recognise that a distance of at least 400m is needed between the planned pulse crop and the stubble of that pulse (or others) from the previous year. *(See also Tables 7 : B and 7 : C.)*

Nitrogen Fixation

A pulse crop does not necessarily add large quantities of nitrogen to the soil.

Pulses are usually able to fix sufficient nitrogen from the air for their own needs, but a large amount is removed in the grain when crops are harvested.

Soil nitrogen levels following a pulse crop usually remain undepleted, and so it is the available nitrogen that is high. *(See Table 1 : I.)*

Where a pulse crop grows well but produces a poor yield, perhaps due to a harsh finish to the season, the net result may be an increase in total soil nitrogen levels.

Crops producing average or above average yields are likely to remove as much nitrogen as they produce and, in some cases, more.

As a general rule high soil nitrogen levels following a pulse crop are the result of a carryover effect of residual nitrogen rather than a net gain from the crop. *(See Table 1 : I.)*

In low-yielding cereal-pulse rotations the pulse may provide enough nitrogen for the following crop.

Researchers believe that in lupin growing areas of Western Australia nitrogen fixed by the plants is supplying enough for the crop's requirements as well as for the following low-yielding cereals which are producing an average yield of 1 t/ha.

Comparing information about the amount of nitrogen fixed by pulse crops with that fixed by pastures it appears that a grazed medic or sub-clover pasture with a high legume content will increase the total soil nitrogen level more than a pulse. *(See Table 1 : H.)*

Soil Fertility

The move by many farmers to adopt more intensive cropping rotations, including pulses, raises the question of the long-term effects such a practice will have on soil fertility.

The Tarlee rotation trial provided a valuable guide. After ten years of continuous cereal and pulse cropping soil fertility was maintained in terms of both total soil nitrogen and organic matter levels. *(See Table 1 : H.)*

To ensure that soil fertility is maintained in an intensive cropping rotation, reduced tillage and stubble retention should be practised, along with planned herbicide management.

TABLE 1 : H

TARLEE ROTATION TRIAL

Effect of Rotation on Total Soil nitrogen (%) and Organic Carbon (%) in the Surface Soil (0-10cm)

Rotation	Total Soil Nitrogen %		Organic Carbon %	
	At start	5 years later	At start	5 years later
Continuous Wheat	0.087	0.079	0.93	0.88
Wheat/Peas	0.090	0.088	0.99	0.95
Wheat/Lupins	0.089	0.102	0.95	0.92
Wheat/Beans	0.094	0.095	0.98	0.95
Wheat/Volunteer Pasture	0.087	0.088	0.95	1.01
Wheat/Sown Pasture	0.092	0.099	0.98	1.12
Wheat/Fallow	0.090	0.086	0.98	0.88

Availability of Nitrogen

One of the very tangible benefits of a pulse crop is the rapid breakdown of the nitrogen rich organic matter remaining after the crop has been grown.

Most of this organic nitrogen is readily available to the following crop and is one of the reason why cereal yields are often high following a pulse crop. *(See Table 1 : I.)*

TABLE 1 : I

SOIL NITRATE-N (kg/ha, 0-60cm DEPTH) AT SOWING OF WHEAT FOR DIFFERENT 2-YEAR ROTATIONS

Rotation	1	2	3	4	5	6	7	8	Average years 5-8
Wheat/Wheat	47	39	15	35	37	35	24	18	29
Wheat/Peas	95	44	56	45	46	39	36	54	44
Wheat/Lupins	67	50	87	49	88	60	106	60	79
Wheat/Beans	85	-	67	44	66	72	75	64	69
Wheat/Vol. Pasture	-	-	22	34	18	59	37	33	37
Wheat/Sown Pasture	44	43	60	43	38	67	71	66	61
Wheat/Fallow	-	65	63	40	33	45	34	37	37

Weeds

There is a range of effective herbicides available to control grasses in pulse crops. It is now possible to control wild oats and ryegrass as well as the harder to kill brome and barley grasses.
(See Weed Control Section 5.)

Controlling herbicide resistant weeds like ryegrass is however now a major issue and crop topping and wickwiping are common strategies in some pulses.

Some of the weeds are not effectively controlled in the following cereal crop. However by controlling them in the pulse phase of a rotation and preventing them from setting seed, it is possible to virtually eliminate them from the following cereal crop.

Pulses are poor weed competitors. Unless close attention is paid to effective control measures weeds are likely to build up, reducing yields and seriously affecting future crops.

Many of the broad leaf weeds are hard to kill and can cause serious problems.

These include, wild radish *(Raphanus raphanistrum)*, ball mustard *(Neslia paniculata)*, three horned bedstraw or cleavers *(Galium tricornutum)*, soursob *(Oxalis spp)*, bifora *(Bifora testiculata)*, wild vetch *(Vicia spp)*.

A good knowledge of likely weed problems is needed, as most broad leafed herbicides are applied before sowing or before crop emergence.

Soil Erosion

Pulses make slow early growth and consequently leave the soil more susceptible to the effect of wind and water erosion than cereals. Hence the benefits of stubble retention and limited tillage with pulses in the farming system.

Pulse stubbles require careful grazing management on light soils. This applies particularly to pea stubble residues which break easily from the roots and tend to collect in heaps leaving pea paddocks prone to wind erosion.

On heavier soils overgrazing can create dust problems, affecting clean fleece yields.

Poor emergence is more likely with pulses on hard setting soils. This can lead to a higher potential for soil erosion. Rolling after sowing a pulse crop can also leave some soils prone to erosion, and in these situations post emergent rolling is prefered where possible.

Grazing pulse stubbles

The advantages of feeding a pulse stubble to livestock are well recognised.

The main benefits come from grain left on the ground after harvest. *(See Section 10 on Using Pulses – See Plate 2.)* Sheep and cattle grazing trials point to a much faster growth rate and more profitable carcasses when the animals are fed on bean stubbles, compared with those from barley.

Trials involving young Merino ewes grazing a range of unharvested, standing pulse crops indicate lupins and beans produce excellent weight gains. Peas provide good weight gains until summer rains germinate the peas.

Cattle perform well on unharvested pulses until the pods shatter and the animals are unable to gather spilt grain from the ground. An exception is large seeded beans. Evidence suggests that pulses other than large beans are better fed to sheep than cattle.

Grazing the crops immediately after harvest is more likely to reduce management problems associated with toxic fungal diseases such as lupinosis. *(See Page 7 : 15. Disease Identification and Control.)*

With chemical applications to pulse crops, graziers and pulse growers need to be aware of the grazing and harvest withholding periods for each chemical applied, as well as the export slaughter intervals (ESI). Some products have an ESI that means the livestock cannot be slaughtered straight off the treated pulses stubble or crop. Other products have nil grazing of stubbles. Livestock owners now need to declare what chemicals have been applied to the pulse stubble their stock has been grazing prior to sale. This means careful attention to product choice and the intention to graze the pulse stubble.

Areas Suited to Pulses

More farmers are realizing the advantages of including a pulse in their cropping rotation. With improved varieties and new export markets being developed, it is likely this trend will continue for some time. But, it raises the question, which areas are best suited to the various pulse crops?

Pulses are not as adaptable as wheat or barley, with rainfall and soil type being the main limiting factors.

All pulses require a well drained soil if maximum yields are to be achieved. Crops growing on black friable soils will usually outyield those grown on the hard red-brown earths.

To grow beans, chickpeas and lentils on acid soils the aluminium saturation levels must be low to medium.

Inoculation is essential for most pulses where the pH is low. A low pH affects nodulation and subsequently plant growth.

Lupins are the exception, but as a general rule pulse crops experience more problems when grown on the more acid soils.

The rainfall figures in Table 1 : J relate to winter dominant rainfall areas only. The lower rainfall figures are suggested as the minimum required for the crop to produce economic yields in most years.

However, there are areas outside these limits which are regularly growing pulse crops. These usually enjoy cool conditions while the crops are flowering and the grain is filling.

Lupins can be grown successfully on higher pH soils providing the lime content is very low or nil. A simple soil test is to use a 10 percent hydrochloric acid solution. If the acid begins to bubble and foam when mixed with the soil the sample contains lime.

The spreading or delving of clay on non-wetting sands has improved the cropping potential of land previously limited by water repellence and lower fertility. Where previously only lupins and barley would grow, the potential is for some of the other pulses and wheat to be also grown on these clayed sands. *(See Table 1 : J)*.

Growers need to be aware of the changed nutrient status of the new top soil after claying, as nutrient deficiencies can develop, particularly if the clay is poorly incorporated. Pulse crops with shallow roots do mature quickly on clayed sands, particularly if a deep sand. The high lime content associated with some clay subsoils can prevent the growing of lupins in some cases.

TABLE 1 : J

AREAS SUITED TO PULSES

Crop	Soil Type: Clay	Soil Type: Loam	Soil Type: Sand	Light Sand	Clayed Sand (low lime)	Clayed Sand (free lime)	Waterlogging Tolerance	Optimum Soil pH (H_2O)	Lower Rainfall Limit (mm)
Beans									
- Faba	exc.	exc.	poor	very poor	medium	medium	good	6.5-9.0	400
- Broad	exc.	exc.	poor	very poor	poor	poor	good	6.5-9.0	450
Chickpeas									
- Desi	exc.	exc.	fair	poor	fair-good	fair-good	poor	6.0-9.0	350
- Kabuli	exc.	exc.	fair	poor	fair	fair	poor	6.0-9.0	425
Lentils	good	good	fair	poor	medium	medium	very poor	6.5-9.0	400
Lupins									
- N.L.	fair	exc.	fair	exc.	fair-exc.	very poor	poor	4.5-7.5	375
- albus	exc.	exc.	poor	very poor	fair	fair	very poor	4.5-7.5	400
- yellow	poor	medium	good	good	medium	poor	good	4.0-7.0	400
Peas	exc.	exc.	fair	poor	med	medium	fair	6.0-9.0	350
Vetch	exc.	exc.	fair	fair	exc.	exc.	poor	5.5-9.0	250

exc. = excellent N.L. = narrow leaf

CHICKPEAS

Soils:

Chickpeas prefer well drained loam to clay soils with a pH in the range of 6 to 9. They will not grow in light acid soils. Areas prone to waterlogging should be avoided. This advice also applies to stoney ground as the plants need to be harvested close to the ground.

Chickpeas are susceptible to hostile sub-soils, with boron toxicity, sodicity and salinity causing patchiness in affected paddocks.

Broad leafed weeds and resistant ryegrass can cause major problems and a careful management strategy must be worked out well in advance.

It may be possible to control the weeds in the year prior to cropping. However, it is best to avoid paddocks with specific weeds that cannot be controlled by herbicides. *(See Section 5)*
Foliar sprays of zinc and manganese may be needed in areas where these deficiencies are known to be a problem.

Rainfall:

Chickpeas are not well suited to the lower rainfall areas, although the plants will set seed under warmer conditions than all other pulses.

Cool wet conditions are more likely to stimulate foliar diseases and these can adversely affect seed set and yield.

Controlling ascochyta is a major issue in chickpeas. Variety choice, crop hygiene, fungicide choice and timing are all important in an overall chickpea management strategy for ascochyta.

Delayed sowing is not necessary now with ascochyta resistant varieties, and strategic foliar fungicide use is only required at podding. Susceptible varieties require delayed sowing and fungicides applied regularly through the growing season.

Desi varieties should only be grown in areas where the rainfall is greater than 350mm. Sowing is best carried out from early May to late June with early sowing recommended for the lower rainfall areas.

Kabuli varieties are later maturing and should only be grown in areas where the rainfall is over 450mm. Sowing is best from mid May to late June. *(See Page 3 : 9)*

FABA BEANS

Soils:

Beans are the most demanding of all pulses. Production will be best when crops are grown on either well structured loam or clay soils with a pH of 6.5 to 9.0.

Nodulation failures have occurred on soils with a pH lower than 6.0 especially if they are hard setting or prone to waterlogging.

Beans are prone to suffer from compaction and hard pans.

Restricted growth has also been observed on shallow calcareous loams, particularly those on an exposed limestone reef.

Faba beans are not suited to light sandy or infertile soils. *(See Plate 3)*

Crops prefer moderate levels of nitrogen, phosphorous and organic matter in the soil.

Although the plants have a reasonable tolerance to waterlogging, they can perform poorly because of increased infections from chocolate spot. Early sowing is essential in areas prone to waterlogging, and increased foliar disease control measures may also be necessary.

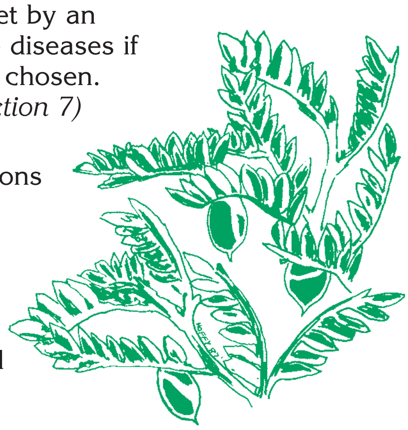
Rainfall:

Faba beans are best suited to areas receiving a rainfall above 400mm. These areas usually have a longer growing season and a more assured spring rainfall.

Beans can be grown as an opportunity crop in a drier environment, but need mild spring temperatures and an early break. They are less likely to be highly profitable because of the production costs and the higher risk of crop failure.

There are very significant yield advantages in sowing bean crops early as beans have the ability to begin flowering in late winter. However yield advantages may be offset by an increased risk from crop diseases if susceptible varieties are chosen.
(See Table 2 : D and Section 7)

Beans show reasonable tolerance to cold conditions and frost, but they are particularly sensitive to high temperatures and hot drying winds during flowering. If possible select paddocks that will provide protection from such conditions.



LENTILS

Soils:

Lentils prefer a well drained loam to clay soil with a pH between 6.5 and 9. They will not grow in areas where the soil is light and acid and they will not tolerate waterlogging, even short term waterlogging in spring.

Lentils are very susceptible to hostile subsoils with boron toxicity, sodicity and salinity. Poor patches in paddocks occur even with low levels of boron, sodicity or waterlogging.

Because the plants are short (35cm to 45cm) and have a tendency to lodge at maturity they should be sown on ground free from surface stones and other objects likely to cause harvesting difficulties.

Weed control is essential and it is important to work out a management strategy to control broadleaved weeds well in advance. This will require good weed control in the years prior to cropping with lentils.

Lentils should not be grown in a paddock containing broadleaved weeds that cannot be controlled by herbicides. *(See Section 5)*

Foliar sprays of zinc and manganese may be needed in areas where these are known to be deficient.

Rainfall:

Current lentil varieties can be grown in areas where the rainfall is 400mm or more. Sow late May to late June with the early sowing in the 400mm to 450mm districts.

Sow early to late June, with the early sowing recommended for the 450mm to 500mm rainfall areas.

In the higher rainfall areas with a long cool spring, seeding may need to be delayed until August or September to avoid foliar diseases during pod fill. *(See also Page 3 : 10 for sowing dates)*

LUPINS

Soils:

Lupins are very sensitive to calcareous soils, preferring neutral to acid conditions with a pH of 4.5 to 7.5. They grow well on sandy soils, deep sandy loams, gravelly soils overlaying clay subsoils and well structured red brown earths.

They will tolerate slightly alkaline soils (to pH 8.0) providing the free lime or calcium content of the soil is low. It is advisable to do a 'fizz' test across the paddock (to 20cm) to test for free lime presence. *(See Page 1 : 6)*. Confirm with a soil test or grow a few small test strips before planting a large lupin area.

Lupins can also be grown successfully on neutral soil with a subsurface of clay or rubble providing this layer is at least 40cm below the surface.

Where non-wetting sands are clayed or delved, lupins may not necessarily grow if the clay brought to the surface has too high a free lime content.

The current lupin varieties are mostly narrow leafed types *(L. angustifolius)*. They are not ideally suited to deep low-fertile sands, but can be grown successfully on these soils if adequate fertiliser is used.

Soil fertility levels can have a significant influence on sowing dates. Crops should be sown as early as possible but early sown crops on fertile soil can produce excessive growth. *(See Page 3 : 11)*

Well drained soil is needed for maximum yields, but lupins tolerate waterlogged conditions better than most cereals. Their tolerance is similar to most oats.

Some areas of sand over clay *(solodized solonetz)* soil that are regularly subjected to flooding are not suited for lupin production.

Lupins can be grown on the poorest sands and used in a pasture renovation rather than a cropping program. Yields from these areas are generally below 2 tonnes per ha. Production on the better sand over clay soils usually provide much higher yields i.e. 2.5 tonnes per ha and over.

Rainfall:

TABLE 1 : K

Rainfall (mm)	Flowering Type	Optimum Sowing	Example of variety
350-400	early	before third week in May	Mandelup
400-500	early mid	early May to mid June early to late May	Mandelup Jindalee
Above 450	early mid late	end May to late June mid May to mid June mid May to mid June	Wonga Jindalee -

(See also Page 3 : 11 for sowing dates)

Lupins are sensitive to high temperatures (greater than 30°C) and hot northerly winds during flowering. If possible select paddocks which offer the best protection from northerly winds.

Lupins also show reasonable tolerance to frost because their long flowering period usually allows the late flowers to compensate for lost podding.

PEAS

Soils:

Peas are the most adaptable and least demanding of all pulse crops.

They will grow successfully on a wide range of soil types from sands to clay loam, but best results can be expected from those with a heavier texture.

Crops can be grown successfully on sandy soil, but there is a considerable soil erosion risk, particularly after harvest as the remaining pea vine can break down very rapidly leaving the soil exposed.

Management techniques including stubble retention and not grazing before mid to late autumn are critical where erosion is likely.

The addition of nitrogen fertiliser can help with crop establishment where peas are grown e.g. on deep siliceous sands.

Peas have a poor tolerance to saline soils and those prone to surface sealing or waterlogging. *(See Plate 4)*

Crop tolerance to waterlogging is fair. This compares with lupins (poor) and beans (good). However, the fungal disease complex black spot is more severe on poorly drained soils.

Because of harvesting difficulties stony soils are generally unsuitable for pea production, although rolling when the crops are up to 10cm high may push the surface stones down to soil level. Stony areas may also indicate shallow soil over stone. Crops grown on these soils are likely to suffer stress in spring, producing poor yields

Rainfall:

Crops are best suited to areas where the rainfall is over 375mm. Worthwhile crops can be grown in the 350mm to 375mm areas where conditions during flowering and pod fill are cool and the crop is not likely to be exposed to stress. However, the risk of crop failure in the lower rainfall districts is much higher.

Peas are more sensitive than other pulses to frost during the flowering and pod filling stages of growth. Low lying, frost prone areas should be avoided. *(See Plates 5 and 6)*

Optimum sowing dates are earlier in lower rainfall areas than in higher rainfall areas. *(See Page 3 : 12)*

VETCHES

Soils:

Vetches, like peas, are adaptable to many soil types. They will grow in a wide range of soil types from light sandy soils to heavier clay soils.

On sandy soils the vetches will provide better soil protection than peas as there is more stubble holding the soil. On loam and clay soils all varieties produce well, but their best production will come from soils with moderate to high fertility.

Vetch crops can be grown across a wide range of soil pH. They are more tolerant of acid soils than most pulses. On acid soils, vetches have grown productively in pH 5.5 (H_20) when in the same situation faba beans have failed.

Vetches have poor tolerance to saline soils and those prone to surface sealing. The varieties, Morava, Languedoc and Blanchefleur will not survive prolonged waterlogged conditions and will die before peas or faba beans.

Because of harvesting difficulties, stony soils are generally unsuitable to vetch production. Roll or finely harrow soil at seeding to reduce problems at harvesting.

Rainfall:

Whilst the best yielding vetch crops will be grown in areas with rainfall greater than 350 mm, useful yields can be grown in areas with as little as 250 mm rainfall. Crops grown in these areas can fail in seasons with less than average rainfall.

Early sowing in above average rainfall years can lead to severe losses to chocolate spot. *(See Page 7 : 29).*

Optimum sowing dates are earlier in lower rainfall areas than in higher rainfall areas. *(See Page 3 : 12)*

Frosts during flowering and pod fill will reduce yield, although the podding period is prolonged and some will escape most normal frosts. Yield losses from frost are usually greater than for other pulses.

Yields

Constantly increasing production costs and increasing supplies of pulses will mean that future success with pulses will depend on greater productivity per hectare and per millimetre of rainfall.

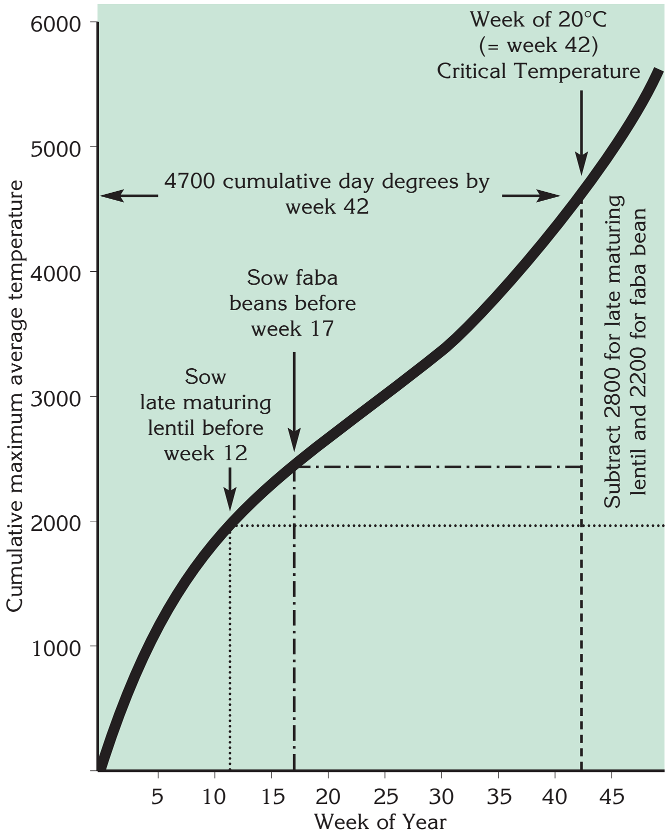
It will be necessary to find the best management practices for the crop in relation to tillage, time of sowing, weed control and fertilising.

There is a great deal of room for improvement in these areas. Under ideal conditions pulse crops should be able to produce 15kg/ha of grain for every millimetre of growing season rainfall above 130mm. By comparison wheat can produce 20kg/ha for every millimetre of rainfall above 110mm. *(See Figure 2.)*

Many factors influence the achievement of this maximum yield level.

FIGURE 1

EXAMPLE OF USING TEMPERATURES TO CALCULATE TIMES OF SOWING FOR DIFFERENT CROPS AT ONE LOCATION



Temperature

One of the most critical factors affecting pulse yield is temperature. Temperatures at flowering can be too high or too low for fertilisation and pod set.

Temperature lows at which pod set is affected range from -1.5°C to 15°C for the different crop species. Chickpeas require warmer temperatures at flowering than peas, beans, lentils, lupins and vetch. Most chickpeas require at least 15°C at flowering to set pods, but some of the newer varieties selected for ‘cold tolerance” (eg Sonali) can set pods at 10°C. If temperatures are less than -1.5°C, then plant tissue freezes.

High temperatures (greater than 30°C) can cause flower abortion and cause flowering to cease, even with adequate soil moisture.

For highest yields in peas, beans, lentils, lupins and vetch, flowering should be completed by the week in which the average maximum daily temperature reaches 20°C (by comparison the critical temperature for wheat and chickpeas is the week of 23°C).

The different pulse crops also need different amounts of time and cumulative temperature to go through various growth stages. Pulse crops will produce higher yields if they are sown early enough to allow them to finish flowering before the week of critical temperature (20°C or 23°C average daily maximum).

Table 1 : L shows the day-degrees (average of maximum temperatures) different crops need from sowing to flowering and harvest.

TABLE 1 : L

CUMULATIVE DAY DEGREES FROM SOWING TO VARIOUS GROWTH STAGES

	Beginning of Flowering	End of Flowering	Harvest
Faba Beans	1300	2200	3300
Peas	1600	2400	3300
Lupins	1600	2400	3600
Chickpeas, Lentils			
- early cultivars	1600	2400	3200
- late cultivars	2000	2800	3400
Wheat	1900	2200	3300

This means that it is possible to work out the ideal sowing time for pulse crops in any particular area from meteorological information showing the accumulation of maximum daily temperatures with time and the week the critical temperature occurs. *(See Figure 1)*. The sowing time for highest yield in each specific area can be worked out by defining when the week of 20°C occurs and counting back the day-degrees of cumulative temperature needed for the crop to develop from sowing to the end of flowering.

Sowing must be completed by the calculated date so that the crop can finish flowering before the week of high temperature occurs.

Time of sowing

The highest yields are achieved when the crop is able to complete flowering after the last frost but before the onset of the critical temperature.

In general, for pulses each day's delay in sowing after the optimum date reduces the day-degrees to the end of flowering by 5°C and therefore reduces the flowering time before the critical temperature.

Lupin yields can range from 3t/ha to 1.3t/ha with sowing dates from May 2 to June 4. Varying faba bean sowing dates from April 30 to July 2 have reduced yields from 3.5t/ha for early sowings to 1.2t/ha for late sowings.

While some early sowings can be affected by leaf diseases and produce lower yields than late sowings, early sowings are preferred for best yields, provided diseases are controlled.

Ratio of water use/evaporation

The average pulse crop is subjected to an evaporation stress of between 600mm and 650mm from sowing to harvest.

The best yields occur when water use by the crop is 0.7 times the evaporation level.

Other limits on yields

The main factors involved in producing high yield pulse crops are:

- weed control
- disease control
- adequate soil nutrition
- correct soil type
- sowing time.

Yields vary with location, depending on seasonal conditions and the factors listed above, but the following table can be used as a general guide for pulse yields.

TABLE 1 : M

PULSE YIELDS t/ha

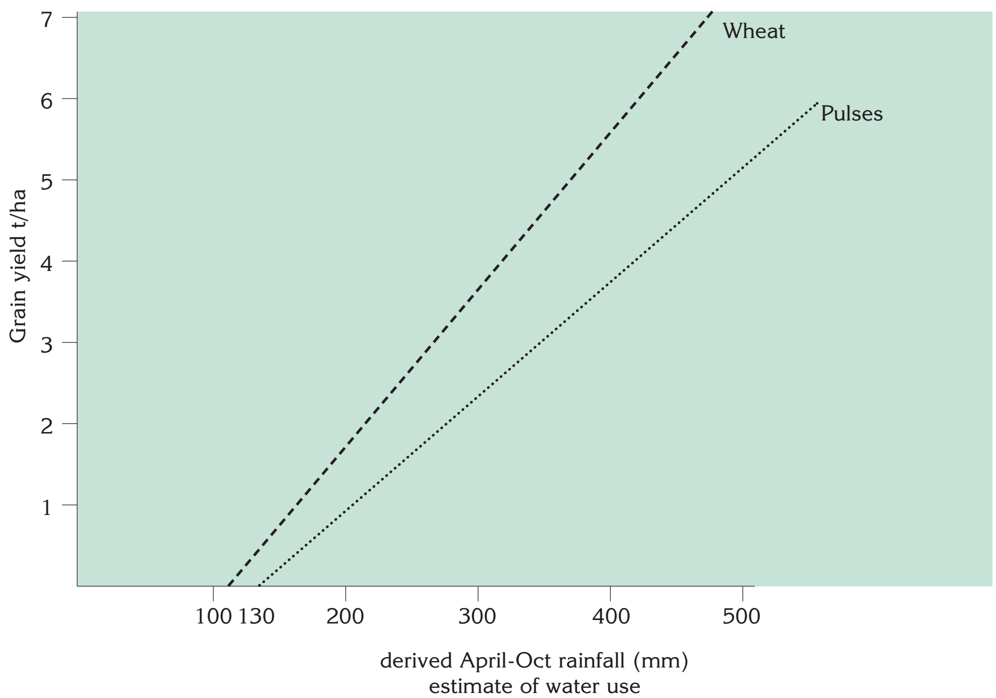
Rainfall 450mm to 600mm

	Peas	Lupins	Faba beans	Chickpeas	Lentils
Low	0.8-1.4	0.8-1.2	0.8-1.6	0.6-1.0	0.8-1.4
Average	1.4-2.0	1.2-1.8	1.6-2.4	1.0-1.6	1.4-2.0
High	2.0-3.7	1.8-3.0	2.4-5.0	1.6-2.4	2.0-3.7

Rainfall 350mm to 450mm

	Peas	Lupins	Faba beans	Chickpeas	Lentils
Low	nil-0.8	nil-0.8	nil-0.5	nil-0.4	nil-0.8
Average	0.8-1.6	0.5-1.5	0.5-1.2	0.4-0.8	0.6-1.2
High	1.6-2.5	1.2-2.5	1.2-2.0	0.8-1.5	1.2-2.0

FIGURE 2



Estimating Profitability

The role pulses will play in your farming program will, to a large extent, depend on their profit potential.

However, when considering the financial returns from pulses the cost of growing the crop must be taken into account as well as the return per tonne of grain. The impact on subsequent cereal yields and weed control options also needs to be considered

Many pulse crops require much higher chemical inputs than traditional cereal crops and these costs should be taken into account when calculating possible profits. The best way to estimate possible returns is to sit down an work out a "gross margin" for the crop. The gross margin is a measure of cash return from a enterprise prepared by subtracting direct cash costs from the gross income generated by grain sales.

Multiplying the estimated yield by price per tonne will give the gross income estimate. Cash costs include direct cash outlays but not overheads, such as depreciation on plant. By estimating gross margins for each pulse the relative cash profit for each crop can be calculated.

The advantages of each particular crop may be judged more accurately if rotations are worked out and gross margins of each particular rotation are calculated. It is important not to judge individual crop gross margins in isolation because each crop plays an important part in the overall rotation and their effects on yields and weed control options in following crops may have an impact on the farm's overall long-term profitability.
(See Page 1 : 1)

The following pages show gross margins calculated for a pea crop in a medium rainfall area. You may estimate gross margins for your own property by substituting your own yields and cost levels on the blank forms.

Page 1 : 13 is a gross margin sensitivity table with varying crop yields and prices received for a pea crop grown in a 450mm rainfall district.

Pulse crop profitability in crop rotations is indicated on page 1 : 17. Growers may like to calculate their own crop rotation gross margins from their paddock records.

One such example* of gross margins is:

	Gross Margin
Preferred rotation - hay, peas, wheat, wheat, hay	$311/ha
All wheat, no pulses wheat, wheat, wheat, wheat	$233/ha
Traditional Rotation wheat, pasture, wheat, pasture, wheat	$234/ha
Common Rotation wheat, lupins, wheat, canola, wheat	$226/ha

An economic study in WA[#] indicated that field peas need to be at 9 to 11% of cropped area to optimise farm returns. The result was not price sensitive, but yield increases needed to be over 20% to increase the proportion sown to peas.

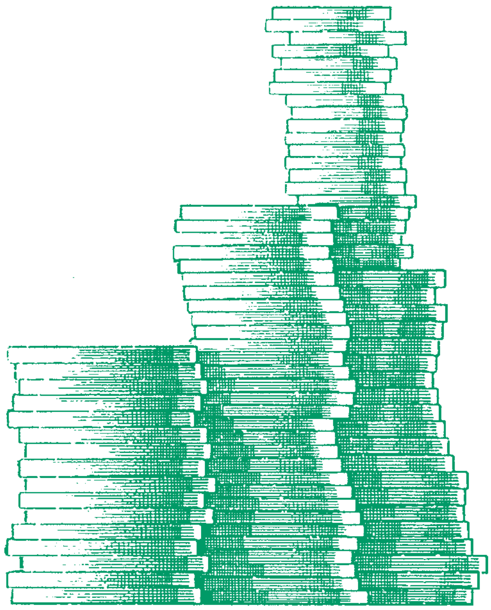
Relativity of commodity prices was however, significant.

In NSW**, if pea yields were 56% of the yield of wheat, pea prices needed to be 136% that of wheat (e.g. $204/t versus $150/t wheat) to be profitable in the rotation. At 65% of wheat yield, peas needed only to be 121% of the wheat price. If peas were 75% of wheat yield they needed to achieve only 107% of the price to equal the farm return.

** G. O'Brien in Field Pea Focus WA p 78*

 # R. Kingwell in Field Pea Focus WA p 74

*** J. Brennan in Field Pea Focus NSW p 26*



PEA CROP GROSS MARGIN 2004

Medium rainfall (450mm) area

INCOME		$/ha
Average yield	2.00t/ha @ $225.00/tonne (delivered)	450.00
	TOTAL INCOME	$450.00

EXPENSES		$/ha
Levies -	4.05	
Seed 100kg/ha @ $390.00/tonne	39.00	
Seed Treatment	100kg/ha @ $106.00/tonne	10.60
Fertilizer (0:20:0)	60kg/ha @ $409.00/tonne	24.54
Chemicals (see next page for details)		
Weed Control		59.00
Pest Control		10.80
Disease Control		4.50
Fuel	16.94	
Repairs Oil & Grease		31.92
Freight - Grain	2 tonnes @ $14.00/tonne	28.00
- Fertilizer	0.060 tonnes @ $14.00/tonne	0.84
Contract Work	Aerial Spray @ $10.00/hectare (1.25 times*)	12.50
Insurance	$16.00/$'000	6.68
Other		
	TOTAL EXPENSES	$249
	GROSS MARGIN per hectare	**$201**

Comments: Price of peas is highly influenced by world market conditions.

Contract reaping at an increased cost may be required. This reduces the gross margin considerably.

*1.25 spray means one full spray for budworm and one border spray for pea weevil.

Source: Rural Solutions SA Farm Gross Margin Guide

COSTS USED FOR GROSS MARGIN EXAMPLE ON PAGE 1 : 13

FUEL AND LABOUR

Operation	No.	Work Rate (ha/hr)	Fuel Cost (L/ha)	Fuel Cost ($/ha)	Repairs ($/ha)	Field Efficiency
Work Up	1	4.5	6.7	4.33	3.56	80%
Spray & Inc.	1	8.0	1.5	0.97	2.19	73%
Seed	1	4.00	5.5	3.57	3.75	81%
Spray	3	14.0	0.6	1.25	1.84	67%
Roll	1	6.0	2.5	1.62	1.28	89%
Harvest	1	2.5	8.0	5.19	19.30	70%
				$16.94	$31.92	

Total machinery hours	1.36 hours/hectare
Total labour hours	1.620 hours/hectare

Herbicide – pre-emergent				
	Glyphosate	1.00L/ha @	$5.00/litre	$5.00
	CT Trifluralin	1.00L/ha @	$7.50/litre	$7.50
– post-emergent				
	Paraquat	0.80L/ha @	$9.00/litre	$7.20
	Brodal Options	0.15L/ha @	$152.00/litre	$22.80
	Targa	0.30L/ha @	$55.00/litre	$16.50
Pesticide				
	Native budworm	0.024L/ha @	$200.00/litre	$4.80
	Pea weevil	0.024L/ha @	$200.00/litre	$4.80
	Pea weevil 25% Border	0.024L/ha @	$200.00/litre	$1.20
Fungicide				
	Triadimefon	0.050L/ha @	$9.00/litre	$4.50

Comments: Fuel cost is based on $0.64 a litre. Tractor (97K.W) maintenance cost $7.00 per hour.

GROSS MARGIN SENSITIVITY ($/HA)

Price ($/t)

		$200	$225	$250	$275	$300
	1.0	-36	-11	14	39	64
Yield	1.5	64	102	139	177	214
(t/ha)	2.0	164	214	264	314	364
	2.5	264	327	389	452	514

GRAIN LEGUME GROSS MARGIN: FILL IN YOUR OWN DETAILS

			Your Estimate
Area			
INCOME			$/ha
Average yield	.... t/ha @	.... /tonne	....
		TOTAL INCOME	
EXPENSES			$/ha
Seed	kg/ha @	/tonne	....
Seed Treatment	kg/ha @	/tonne	....
Fertilizer			
	kg/ha @	/tonne	....
	kg/ha @	/tonne	....
	kg/ha @	/tonne	....
Chemicals *(See next page)*			
Weed Control			....
Pest Control			....
Disease Control			....
Fuel			....
Repairs Oil & Grease			....
Freight			
Grain	tonnes @	/tonne	....
Fertilizer	tonnes @	/tonne	....
Contract Work	Aerial Spray @	/hectare	....
	@	/hectare	....
Insurance	/ha @	/$'000	....
Other			....
		TOTAL EXPENSES	
		GROSS MARGIN per hectare	

FUEL AND LABOUR

Operation	No.	Work Rate (ha/hr)	Fuel Cost ($/hr)	Fuel Cost ($/ha)	Repairs ($/ha)	Field Efficiency

Total machinery hours hours/hectare
Total labour hours hours/hectare

CHEMICALS

Herbicide — pre-emergent

l/ha @ /litre
l/ha @ /litre

— post-emergent

l/ha @ /litre
l/ha @ /litre

Pesticide

l/ha @ /litre
l/ha @ /litre

Other

l/ha @ /litre
l/ha @ /litre

GROSS MARGIN SENSITIVITY ($/HA)

		Price ($/t)			
		$	$	$	$ ....
	....	....	....	....	....
Yield	....	....	....	....	....
(t/ha)	....	....	....	....	....
	....	....	....	....	....
	....	....	....	....	....

Profitability of Pulses in the crop rotation

The profitability of pulses is often considered low, when annual gross margins of crops are compared. However the value of pulses is often greater when the gross margin of a cropping rotation is compared.

At Wagga, some long term rotation (14 years) experiments have been evaluated by E.L. Armstrong and others and show that on average a lupin- wheat rotation was

- 197% more profitable than wheat on wheat with no nitrogen added
- 108% more profitable than wheat on wheat with nitrogen added
- 20% more profitable than sub clover - wheat rotations.

Table 1 : N

Average gross margins ($/ha/year) for a range of two year rotations

Rotation	Wagga	Cowra	Eugowra
Wheat (0N) / wheat (0N)	-	265	22
Wheat (0N) / wheat (80N)	-	313	57
Barley (0N) / wheat (0N)	180	-	-
Lupin / wheat (0N)	401	323	127
Field peas / wheat (0N)	371	349	120
Faba beans / wheat (0N)	-	291	107
Canola / wheat (0N)	385	-	-
Linseed / wheat (0N)	324	-	-

FIGURE 3

Gross margin comparisons of long term rotations incorporating continuous wheat, lupins - wheat and sub clover - wheat. Data is centred as three year moving averages.

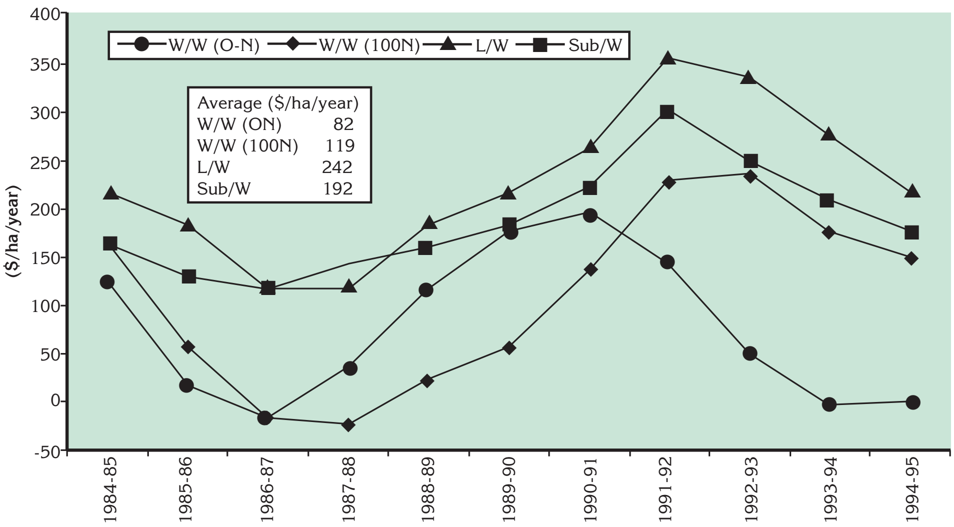
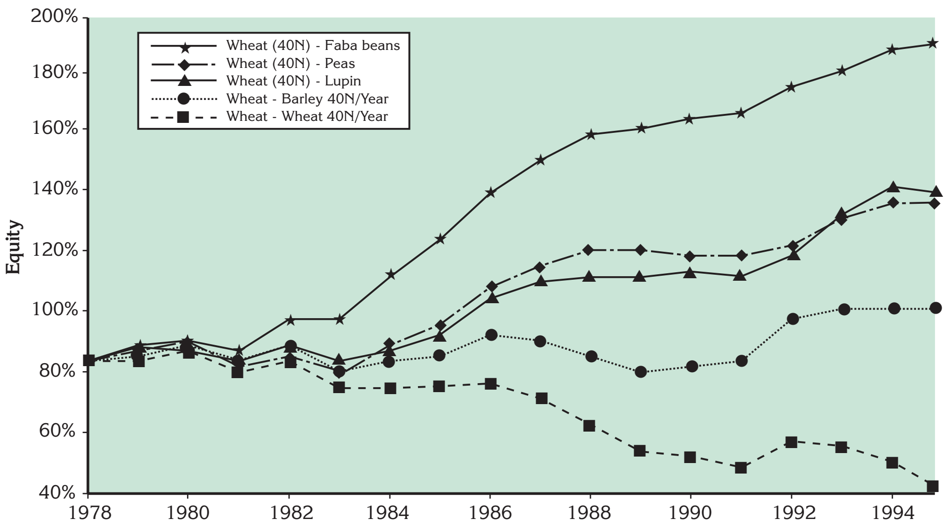


FIGURE 4

Changes in equity of different crop rotation at Tarlee, Mid-North SA



Pratylenchus in cropping rotations

Two species of root lesion nematode, *Pratylenchus neglectus* and *Pratylenchus thornei* occur in the cropping regions of southern Australia. Both species cause root damage and yield losses. Root lesion nematodes have a wide host range, including cereals and grassy weeds, pulses, pasture and forage legumes and oilseeds.

With the exception of chickpeas, pulses have good resistance to both species of Pratylenchus and so reduce nematode populations in cropping rotations.

Table 1 : O

Resistance and tolerance of pulses to Pratylenchus.

Resistance ratings are;	*Pratylenchus neglectus* Resistance	*Pratylenchus neglectus* Tolerance	*Pratylenchus thornei* Resistance	*Pratylenchus thornei* Tolerance
Field peas	R	-	R	T
Faba beans	R	-	MR	MI
Chickpeas	*	*	S	MI
Lentils	R	T	R	MT
Vetch - Blanchefleur	MR	T	S	I-MI
- Languedoc	MR	T	MS	I-MI
- Morava	MR	T	MS	I-MI

* Chickpea varieties have a range of resistances and tolerances to *Pratylenchus neglectus* (See Tables 2 : A, 2 : B).

Symptoms

Pratylenchus may impair root function, limiting water and nutrients to the plant. Affected plants may show general unthriftiness or symptoms of nitrogen deficiency. Symptoms are increased when plants are subjected to water and nutrient stress, or when combined with root damage caused by fungi.

Symptoms of infection on root systems include:

- disintegration of outer layers of root tissue.
- reduction in root hairs and/or nodules.
- a lack of / or stunting of side (lateral) roots.
- brown lesions and discoloration of roots.

Root symptoms are often difficult to diagnose in the field and are usually not seen until plants are older than 8 weeks. Root symptoms are generally more obvious in plants grown in sandier soils.

Yield losses

In trials in 1996, yield losses of Amethyst chickpeas due to *Pratylenchus neglectus* were 43%. The most tolerant varieties, with the least yield losses, were Dooen chickpeas, Icarus beans and Popany vetch.

For *Pratylenchus thornei*, the vetch varieties Blanchefleur and Languedoc appeared intolerant with losses of 27% and 30%.

Rotations

Resistant crops and varieties reduce nematode numbers reducing yield losses of less tolerant crops grown in the following year.

Table 1 : P

Resistance and tolerance of the main varieties and crop types sown.

	Pratylenchus neglectus Resistance	*Pratylenchus neglectus* Tolerance	*Pratylenchus thornei* Resistance	*Pratylenchus thornei* Tolerance
Wheat				
Frame	MS-S	MT-T	S	MI
H45	MS	MT-T	-	-
Janz	MS-S	MI	S	MI
Kukri	MR-MS	MT	MS	-
Pugsley	S	MT	MS	-
Wyalkatchem	MR	MT-T	MS	-
Yitpi	MR-MS	MT-T	MS	-
Tamaroi	MR-MS	MI	R	MT
Triticale				
Tahara	R-MR	MT	R	MT
Tickit	MR	MT	MT	R
Barley				
Barque	R-MR	T	MR	MT
Capstan	MR	T	-	-
Flagship	R	-	-	-
Gairdner	MR	T	MR-MS	-
Keel	MR	T	MR	-
Sloop SA	MS	MT	R	-
Oats				
Brusher	MR-MS	-	-	-
Euro	MR	T	R	-
Potoroo	MR	T	R	-
Wallaroo	MR	MI	-	-
Wintaroo	MR-MS	-	-	-
Canola	MS	MI	MR	-
Medics	MR	MI	R	-
Subclover	-	-	S	-

Resistance: R = Resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible, - = not known
Tolerance: T = tolerant, MT = moderately tolerant, MI = Moderately Intolerant, I = intolerant, - = No Information.

Reducing Soil Erosion with Pulses

Many of the pulses have weak stems or roots, and after harvest leave little or no stubble behind to protect the soil from wind or water erosion. Field peas, chickpeas and lentils are the crops which leave the soil at most risk of erosion.

Pulses fit well into a no-till (N.T.) program. They perform well, sown into stubble residue using N.T. techniques. Seeding emergence, vigour and productivity are enhanced.

No-till includes techniques such as direct drilling, stubble retention and reduced tillage.

Paddock Selection

- Choose the more fertile paddocks with medium to heavy textured soils. Paddocks with slopes greater than 4% should be contoured.
- Strip cropping may be used to protect the erosion prone crop with alternate strips of "protective" crop.

STUBBLE MANAGEMENT

Stubble Residues

- protect soil and young crops from wind damage, 2t/ha of cereal stubble reduces risk of wind and water erosion
- protect soil from rain impact and reduce water run-off and erosion, 3t/ha is needed on sloping land
- are a source of organic matter and help recycle plant nutrients
- improve soil structure, grain yields and farm viability
- increase earthworm activity.

HANDLING CEREAL STUBBLE

Begin stubble management at harvest by spreading both straw and chaff. Heavy stubbles need to be broken down into 10-15cm lengths.

Hints

- Straw and chaff spreaders, straw choppers and second cutter bars are useful attachments to headers.
- Rolling with a cross rib roller on hot day is effective in breaking up stubble.
- Slashing with a double blade slasher does an excellent job. CAUTION, "Care must be taken on hot days as stones can cause sparks and start fires".
- Cross harrowing can be useful but does not break up stubble as well.
- Grazing, after mechanical treatment will further spread and break up stubble. Feeding molasses and salt or scattering pulse seed (e.g. faba beans or lupins) can help stock to eat more cereal stubble. *(See Page 10:2)*

PADDOCK OPERATIONS

Reduce cultivation as much as possible prior to sowing to avoid damage to the soil structure. Keep as much of the stubble as possible on or near the soil surface. This maximises soil protection and reduces problems of nitrogen tie-up.

Tyned implements incorporate less stubble and are less aggressive to soil than discs. Cultivating and sowing implements with wide tyne spacings (min. 500-600mm) and high clearance are best. Straighter tynes block less than curved ones.

Prickle chains and rolling harrows work best in stubble.

If rolling field peas, wait until plants are 3 to 5 nodes high *(See Page 3 : 15)*. Do not spray with herbicide within 14 days either side of rolling.

HARVESTING: Harvest all pulse crops EARLY to reduce grain losses and minimise seed disease levels *(See Page 9.3)*. 'Plucker' fronts, where suitable *(See Section 9)*, leave more stubble and standing weeds. Spread or chop the straw from the harvester otherwise, pea straw in particular, can be blown across the paddock and collect on fencelines. Alternatively harvest in hot weather when stubble will smash up.

HANDLING AND GRAZING PULSE STUBBLE

Pulse stubbles are prone to erosion, particularly pea stubble. Pea residue will roll up and blow with the wind, leaving heaps of stubble and leaving the soil exposed. Grazing further increases the risk of erosion as stock feet loosen the soil surface. Graze carefully and avoid continual grazing, especially on sandy soils.

Pea stubble can be baled reducing the need for grazing and leaving the soil surface hard.

STUBBLE AND HERBICIDES

Cool, damp conditions can reduce weed kill with many tillage implements, especially with heavy stubbles. Knockdown herbicides may be a better alternative.

Experience has shown that activity of some pre-emergent herbicides is not adversly affected by up to 3 tonnes/ha of stubble (about 75% surface cover). However, check with chemical manufacturers.

PEST MANAGEMENT

Retention of stubbles can cause increased problems with pests such as red legged earthmite *(Page 6:1)* and snails *(Page 6:9)* – monitor closely.

Snails

Stubble Management such as rolling or cabling on hot days is an effective control measure for snails.

Burning is the cheapest and most effective form of snail control.

Baiting is an important management technique for snails during autumn and winter, and is most effective in autumn (March-May). For more detail see sections on white and conical snails. *(Pages 6 : 9 and 6 : 10)*.

Baiting with Mesurol (methiocarb) or metaldehyde

a) To prevent the spread of snails into the crop apply in a band 30cm wide along edge of crop at a rate of 3kg of Mesurol® /100m or 1.5kg of metaldehyde/100m.

b) To control snails throughout the crop bait across the crop at a rate of 5.5kg of Mesurol® /ha or 5kg of metaldehyde/ha.

Baiting 5kg of metaldehyde/ha is less effective for conical than for larger white snails.

The following table shows how snail control can be integrated into a cropping rotation.

Controlling Snails

Year 1	Year 2	Year 3
Wheat	**Barley**	**Peas**
Sow with minimum tillage or direct drill. Windrow wheat.	Burn wheat stubble. Sow with minimum tillage or direct drill. Bait fencelines, tracks, contour banks and creeks. Windrow barley.	Roll (or slash) barley stubble if not windrowed. Direct drill peas. Bait fencelines, tracks, contour banks and creeks.

REDUCED TILLAGE

Reduced tillage involves the use of a minimum of soil workings prior to sowing. Pulses can be readily established by direct drilling and minimum tillage.

DIRECT DRILLING

Direct drilling is sowing into unworked soil. Weeds are killed by herbicide prior to sowing. This method saves time enabling crops to be sown quickly.

Points to watch when seeding:

- Ensure all weeds are killed,
- Sow at the optimum time,
- Use narrow points, which cut deeper that the sowing depth
- Soil throw may be needed to incorporate some pre plant herbicides (such as trifluralin)
- Watch seeding depth – don't sow too deep. Depth will vary with different ground speeds.
- Press wheels can improve germination in some soils, especially water repellant soils. Light rolling can substitute for press wheels.
- Trace element deficiencies e.g. zinc, may need more frequent applications as the element is not distributed through the soil as much by cultivation.

MINIMUM TILLAGE

Minimum tillage involves one working only prior to sowing to control weeds.

Advantages

- Loosens compacted soils.
- Stimulates weed germination for better herbicide control.
- Reduces reliance on herbicide.
- Allows better incorporation of herbicides by burying some stubble and exposing more soil.

Sowing a pulse provides an ideal opportunity to begin stubble retention or try no-till for the first time.

For more detail refer to:

1. Conservation Farming – Stubble Retention by Tim Herrmann
   Bulletin 4/92 S.A. Dept. of Agriculture
2. Guidelines for Conservation Farming in Southern N.S.W. Dept. of Agriculture and Soil Conservation Service, N.S.W. Cons. Farm. 2 (1985).

SUSTAINABILITY INDEX

A Crop Rotation Sustainability Index has been developed, by Tim Herrmann, Primary Industries of South Australia, as a guide to the sustainability of farming systems.

HOW TO DETERMINE YOUR SUSTAINABILITY

Using the table on page 1:22 choose a paddock. List current or planned cropping/pasture rotation in the Sustainability Index Table, **(step 1)**. List one full cycle of arotation (including pastures), or cover 8 to 10 years if no set rotation.

Record all tillage operations for each year, including seeding, **(step 2)**. Record if crop and pasture residues were grazed and how they were managed, **(step 3)**.

Convert the rotation, tillage and residue management for each year into a point score using the point allocation chart. Enter point scores into the Sustainability Index Table, **(step 4a, b, c)**.

Add points for rotation, tillage and residue management over the total number of years, **(step 5a, b, c)**. Obtain an average score for each by dividing by the number of years, **(step 6a, b, c)**.

Mark these average scores on the left side of conversion table, **(step 7a, b, c)**. Convert scores to an index, **(step 8a, b, c)**. Transfer index numbers, **(step 9a, b, c)**.

Add the individual index numbers for rotation, tillage and residue management to establish the Total Sustainability Index, **(step 10)**.

Finally, check the sustainability category according to the index , **(step 11)**.

Use the point allocation chart to determine weaknesses (if any) in your farming system, and then , if needed, develop strategies to improve this, **(step 12)**.

POINT ALLOCATION CHART FOR MANAGEMENT PRACTICES (Step 4)

Rotation	• Clean vigorous legume pasture (>95% legume)	5
	• Legume dominant pasture (>75% legume)	4
	• Pulse or legume/grass pasture (about 50% legume)	3
	• Natural or weedy pasture (<25% legume)or cereal/legume mixed crop	2
	• Cereal or oilseed crop, long fallow started before August	1
Tillage	• Direct drill, narrow points	0.5
	• High speed harrow	0.5
	• Blade plough, rod weeder	0.5
	• Direct drill, full cultivation	1
	• Each additional cultivation	1
	• Offset discs	1.5
Residue retention	• Total retention: (over 90% retained) eg non grazed pasture, green manure	4
	• Most retained: (65-90% retained) eg lightly grazed pasture, or cereal	3
	• Part removed: (35-65% retained) eg grazed pasture or cereal stubble lightly grazed pulse	2
	• Most removed: (10-35% retained) eg baling, heavily grazed pasture, partial burn, grazed pulse	1
	• All removed: (less than 10% retained) eg complete burn	0

HOW SUSTAINABLE IS YOUR FARMING SYSTEM? (step 11)

Your Index	Sustainability
9 to 10	**HIGHLY SUSTAINABLE.** Long-term improvement in fertility and structure, with very low risk of degradation or erosion. Little or no additional nitrogen required. High earthworm activity.
7 to 8	**MODERATELY SUSTAINABLE (15-20 YEARS).** Soil fertility and structure, productivity and grain protein is being maintained or improved. Some nitrogen fertilizer may be required. Risk of erosion at critical times in the rotation. High earthworm activity.
5 to 6	**NOT SUSTAINABLE.** Decline in fertility and structure within 5-10 years. Loss of productivity and grain protein within a 10-15 years. Nitrogen fertilizer required on most cereal crops. Soil is vulnerable to degradation and erosion. Moderate earthworm activity.
3 to 4	**NOT SUSTAINABLE.** Decline in fertility and structure within five years. Productivity and grain protein will decline within 10 years. Nitrogen fertilizer required. Soil is very vulnerable to degradation and erosion. Low earthworm activity.
1 to 2	**NOT SUSTAINABLE.** Severe decline in fertility, structure and productivity within a few years. High levels of nitrogen fertilizer are required, and soil is very vulnerable to degradation and erosion. Minimal earthworm activity.

Note: *Local knowledge, experience and conditions must also be considered when interpreting this index. Use of high levels of nitrogen fertilizer to maintain production will increase the rate of acidification of certain soils.*

HOW TO IMPROVE YOUR 'SUSTAINABILITY' (step 12)

Rotation

- Grow vigorous, legume dominant pastures in the rotation.
- Grow pulses if rainfall and soil type permit.
- On average, aim for one legume year for each cereal or oilseed crop.

Tillage

- Reduce reliance on cultivation to kill weeds. Strategically use herbicides, grazing and careful management.
- On average, aim for one working per year, including sowing.

Residue

- Retains as much crop and pasture residue as practical. Graze with care and only burn when essential to control pests or weeds.
- On average, retain crop stubble equivalent to grain yield for each crop grown.

SUSTAINABILITY INDEX TABLE

Paddock name

MANAGE-MENT	YEAR										TOTAL	AVE	Ave. Score **Step 7**	Score to Index CONVERSION TABLE	Index No. **Step 8**	INDEX
	19	19	19	19	19	19	19	19	19	19						
ROTATION **Step 1**											**Step 5a**	**Step 6a**	**Step 7a**	0.0 to 1.0 = 0 1.1 to 1.4 = 1 1.5 to 1.8 = 2 1.9 to 2.4 = 3 2.5 to 3.0 = 4	**Step 8a**	
Step 4a Score																**Step 9a**
TILLAGE **Step 2**											**Step 5b**	**Step 6b**	**Step 7b**	0.0 to 1.2 = 3 1.3 to 2.2 = 2 2.3 to 4.0 = 1 4.1 to 5.0 = 0	**Step 8b**	
Step 4b Score																**Step 9b**
RESIDUE **Step 3**											**Step 5c**	**Step 6c**	**Step 7c**	0.0 to 1.0 = 0 1.1 to 1.5 = 1 1.6 to 2.0 = 2 2.1 to 3.0 = 3	**Step 8c**	
Step 4c Score																**Step 9c**
																Step 10
														SUSTAINABILITY INDEX		

Plate 1

The effects of including a well managed grain legume in the rotation are vividly shown in this infra-red photo (green, healthy crops show as red).
Soil type sandy loam; rainfall 350mm.
Top left: barley following a grassy natural pasture. Yield 1.7t/ha.
Bottom right: Triticale sown following beans. Yield 4.0t/hs.

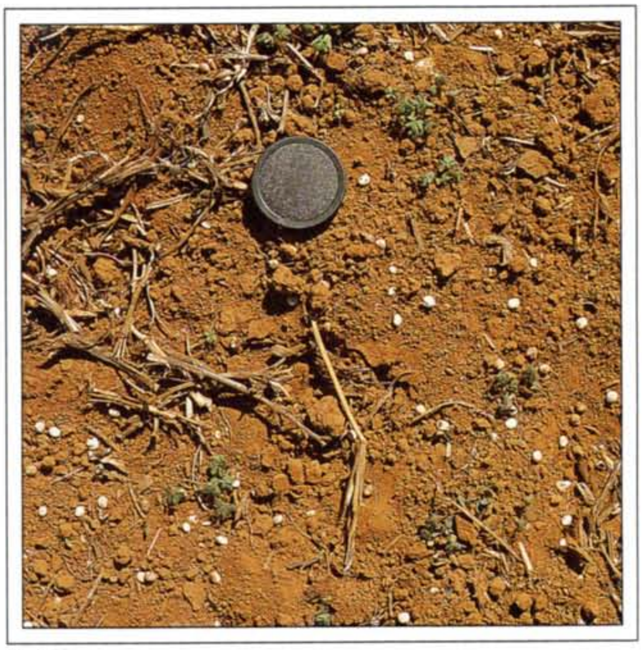


Plate 2

"After the Header."
Lupins on the ground are good stock feed. The amount shown here equals 130kg/ha.

Plate 3

Narrow leafed lupins will grow successfully on deep sands. Other grain legumes will not.
Centre . . . beans on deep sand.

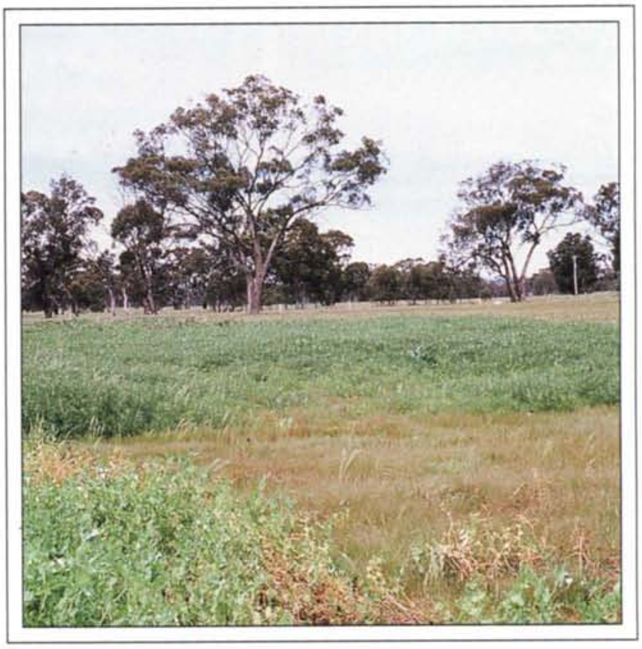


Plate 4

Waterlogging in peas. Although peas will tolerate waterlogged conditions better than other grain legumes they will still suffer under prolonged wet conditions.

Plate 5

Frost damage on peas. Note how only some of the seeds are affected. Unaffected pod on the right.

Plate 6

Frost damage on pea pods.
Note: pods are puffy and the outer layer of skin tends to lift off the pods.

Plate 7

Hail damage in peas. The pod is flattened and curved, with white spots on the outer skin.

Plate 8

Hail damage in beans. Note the holes in the leaves and broken stems.

Frost damage - Faba Beans

Plate 1:A
Normal and frosted bean seeds.

Plate 1:B
Frosted bean damage inside pod.

Plate 1:C
Normal and frosted bean seeds inside pod.

Plate 1:D
Frosted bean pods.

Frost damage - Peas

Plate 1:E
Frosted and split peas.

Plate 1:F
Frosted pea pod - note skin is lifting from the pod.

Plate 1:G
Frosted pea pods.