NORTHERN GRAIN PRODUCTION

– a farming systems approach

A review of research into the benefits of chickpeas to the farming system, supported by 13 case studies of leading farmers in the GRDC Northern Region.

SECOND EDITION
FEBRUARY 2006

GRDC Grains Research & Development Corporation

NSW DEPARTMENT OF PRIMARY INDUSTRIES

Queensland Government Department of Primary Industries and Fisheries

PULSE AUSTRALIA

“the low adoption rate of chickpeas is costing farmers at least $7.8 M each year despite the obvious benefits of including the crop in the farming system”

Apart from moisture, **crown rot** and **declining nitrogen levels** are the **two biggest limitations** to higher wheat yields in the Northern GRDC Region.

Leading growers, such as those in this publication, adopting farming systems based on ‘best management practices (BMP)’ allocate 15 - 20% of their winter cropping area to chickpeas and other winter broadleaf crops. The research indicates their wheat averages up to 1t/ha of extra yield plus an additional 1% grain protein. In addition there are savings in nitrogen and weed control inputs.

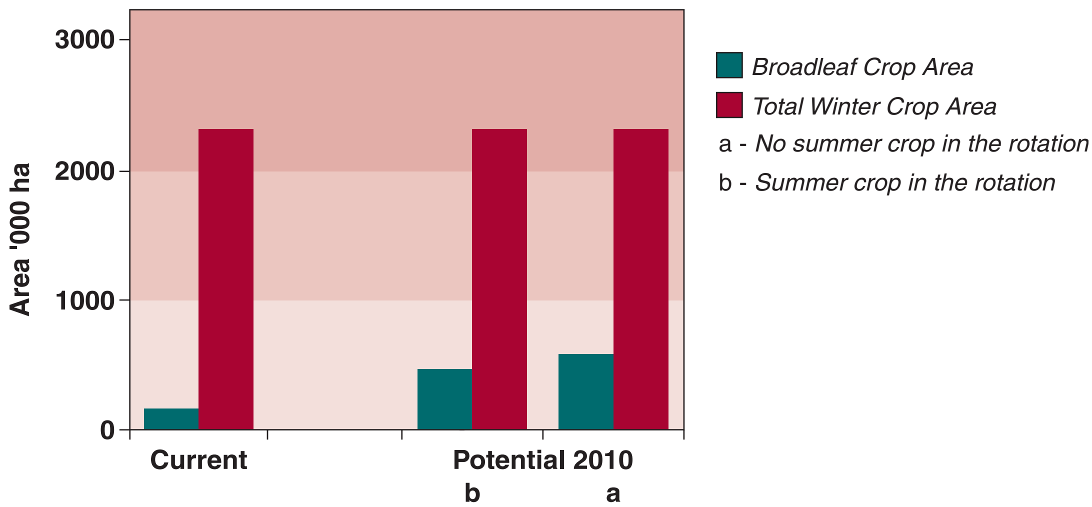
On the other hand many growers are sacrificing cereal yield and protein by not adopting the research findings included in this publication. **In 2005 some growers reported wheat yield losses of up to 75% from crown rot.**

Of the 2.3 M ha of winter crops currently sown in the region broadleaf crops (pulses and canola) account for only 7% or 160,000 ha. We acknowledge a lack of broadleaf rotation crops well adapted to the northern region has been a major limitation. Drought has also impacted on areas sown to not only broadleaf crops, but cereals as well.

However, with new varieties of pulses being released, our goal should be to have 20% or around 465,000 ha of the total winter crop area planted to broadleaf crops, if cereal areas remain similar to the 2.16 M ha currently sown.

“chickpeas and other broadleaf crops should ideally comprise a minimum of 25% of the cropping area in a solely winter cropping system and 20% where a summer crop is included in the rotation”

CURRENT AND POTENTIAL FOR ROTATION CROPS IN NORTHERN GRDC REGION



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INTRODUCTION

Much has been said about the rotational benefits of chickpeas in the farming systems of northern NSW and Queensland. This has been supported by:

- A substantial level of research, and
- Farmers adopting sustainable rotations where chickpeas play a vital role.

It was felt that this wealth of research and farmer experience needed to be more widely promoted and the idea of a publication such as this, that summarised the information in an easy-to-read publication was needed.

Our thanks to the Grains Research and Development Corporation (GRDC) and Mt Tyson Seeds for supporting the publication and distribution of this booklet.

Don McCaffery

Mike Lucy

John Slatter

BENEFITS OF CHICKPEAS TO THE FARMING SYSTEMS OF NORTHERN NSW AND SOUTHERN AND CENTRAL QUEENSLAND

Chickpeas are the preferred broadleaf rotation crop in the predominantly cereal farming systems of the northern region. The crop brings many benefits to the farming system and is currently the most adapted of all the rotation crops to the climate, soils and the no-till farming systems of the north.

Key benefits are:

- Expanded weed control options.
- A break for diseases such as crown rot in wheat.
- Improved nitrogen supply for cereal crops.
- Improvement in soil health.

Chickpeas also provide flexibility:

- A profitable crop in its own right.
- Ability to sow the crop in wide rows (up to 100 cm) using a no-till system which offsets small yield loss potential.
- Band spraying wide rows reduces the amount of pesticide in the environment.
- Ability to deep sow providing the opportunity to plant on time most years.

Depending on the scale of the farm operation, other winter rotation crops and summer crops could be integrated into a rotation that contains chickpeas.

A number of long-term rotation trials have been able to quantify the benefits of chickpeas to following cereal crops and to the overall farming system. These are summarised in this booklet.

There will always be variances between soil types, rainfall patterns and a range of other factors that all impact on the final yield outcome. In most situations, chickpeas increase soil nitrogen by around 35 kg nitrate-N/ha and yields of following wheat crops by up to 1 t/ha with an additional 1% of protein.

WEED MANAGEMENT IN CHICKPEA – OPPORTUNITIES, CHALLENGES AND BENEFITS

Andrew Somervaille, Jubilee Consulting, Ravensbourne Qld

Integrating chickpeas into crop rotations not only delivers benefits for disease breaks and boosts cereal crop yields, but also is an aid to maintaining of a **sustainable and effective weed management system**. Growing chickpeas provides opportunities to utilize a wider range of weed management practices than is available in a cereal dominated system. They also provide challenges since chickpeas do not provide the effective crop competition for emerging weeds that is given by winter cereals.

Crop rotation in general provides a good opportunity to integrate a range of weed control methods and avoid dependence on a limited range of herbicides with the possible consequences of shifts in weed spectrum and the development of resistance to certain herbicide groups. This is particularly true of chickpeas since the principal selective herbicides used for broadleaf control including Balance® (isoxaflutole'– Group F) and simazine (Group C) are not used for weed control in other major winter crops in the north eastern cropping belt. The only exception to this is triazine tolerant canola where simazine and atrazine may be used.

For some growers such as Adrian Lyons from Gulargambone, the effectiveness of the herbicide Balance® has made the placement of chickpeas in the rotation possible. As the product is not utilized in any other crop in the rotation, resistance to this product is much less likely compared to selective herbicides used extensively in wheat and other winter crops.

Row-cropped chickpeas provide the additional possibility of utilizing inter-row cultivation or inter-row spraying with glyphosate (only weed wiper application is registered in chickpea). This method of weed control is not feasible for most other winter crops not grown on wide rows and so provides a break from reliance on selective herbicides for control of winter weeds.

While the inadequacy of crop competition to weeds may be seen as a challenge in chickpeas with the greater reliance on selective herbicides, this in itself provides the greatest opportunity to growers in developing an effective and stable weed management system. In the first instance, it brings into sharp focus the need to manage weed seedbanks rather than the crisis 'just in time' management approach that can occur when attention is given to the immediate impact of uncontrolled weed competition.

Much lower levels of weed competition can be tolerated in chickpea compared to cereals so we are forced to make a much more long-term strategic approach in prior crops and fallow to ensure that reduced seedbank populations are available for infestation of the crop than would be tolerated in cereals. In addition weed control needs to be very effective in order to ensure unimpeded crop development at a time where weed development would normally overtake slow early crop growth.

The approach of **more effectively managing weed seedbanks** in the rotation and in chickpeas in particular, has resulted in growers such as Graham and Peter Schramm (North Star) realizing the benefit of more effective weed control with a reduction in chemical use. Others such as Adrian Lyons have noted a significantly reduced weed burden while Robert Perkins (Meandarra) has found that wild oats are no longer a major cost in the wheat enterprise.

The need to limit the interference of weed growth around harvest time by adopting effective selective weed control throughout the crop life and pre-harvest application of Roundup PowerMax® and metsulfuron is important. It is beneficial in reducing the seed bank of late germinating winter weeds including wild oats, climbing buckwheat (black bindweed) and sow thistle, as well as emerging summer weeds. This reduces seedbanks available for infesting future crops.

A further perceived challenge of chickpea production as far as weed control is concerned is in the need to control volunteer plants. The need to utilize herbicides in addition to glyphosate is again beneficial. The inclusion of 2,4-D, dicamba, Grazon DS®, Lontrel® and metsulfuron in tank mixes with glyphosate will reduce the likelihood of emerging populations of broadleaf weeds that are relatively poorly controlled by glyphosate.

Effective weed control with Balance® (far right)

ROLE OF CHICKPEAS IN THE MANAGEMENT OF CROWN ROT IN NORTHERN NSW

Steven Simpfendorfer, Andrew Verrell, Paul Nash and Kevin Moore NSW Department of Primary Industries, Tamworth

Introduction

Crown rot (CR) caused by the fungus *Fusarium pseudograminearum* (*Fp*) is a major constraint to winter cereal production in Australia. Although it is more common in the northern cropping belt, it can occur throughout all mainland cereal growing areas and is estimated to cost the Australian grains industry $56 million per annum.

The fungus is stubble-borne and survives as mycelium in cereal and grass weed residues. CR infection is characterised by a light honey-brown to dark brown discolouration of the base of infected tillers, while major yield loss from the production of whiteheads is related to moisture stress post-flowering.

The retention of standing winter cereal residues on the soil surface in reduced and zero-till cropping systems is a common practice in the northern cropping zone of eastern Australia. However, this has resulted in an increase in stubble-borne pathogens such as *Fp* with the increased incidence and severity of CR often offsetting the beneficial effects of residue retention.

Rotation to non-host winter pulse (chickpea, faba bean) and oilseeds (canola, mustard) or summer crops (sorghum, sunflower, mungbean, cotton) in the northern cropping zone, reduces CR inoculum levels by starving the fungus of a suitable host. The length of rotation needed to be effective in managing CR depends on the rate of decomposition of the infested residues.

Research Findings

The effectiveness of chickpeas as a disease break for crown rot has been examined in a number of studies throughout northern NSW.

Felton *et al.* 1998, compared wheat grown following chickpea or wheat in the previous season in 10 experiments conducted between 1987 to 1993. They found that grain yield was on average 0.85 t/ha (54%) higher following chickpeas, with the increase largely explained by the additional nitrogen input. However, the incidence of CR was also reduced by around 60% following chickpeas compared to growing wheat-on-wheat.

Further research looked at the break crop effect of chickpeas in rotation by supplementing trial plots with N fertiliser. Kirkegaard *et al.* 2004 compared chickpeas with *Brassicas* (mustard and canola), as break crop options for the management of CR at three trial sites between 1997-2002. Canola and mustard were generally more effective than chickpea in reducing CR disease severity. This appears related to more rapid decomposition of cereal residue under the denser Brassica canopies which reduce the survival of the CR fungus.

However, chickpeas were shown to still be a very effective break crop for the management of CR in northern NSW. At Cryon, the severity of CR was reduced by 53% with a corresponding 27% increase in yield when durum wheat was grown following chickpeas compared to durum after a winter cereal crop (wheat or barley).

In the two experiments conducted at Tamworth the severity of **CR following chickpeas was reduced by 37%** in a highly susceptible durum variety (Yallaroi), and by 21% in a partially resistant bread wheat variety (Sunco) compared to wheat-on-winter cereal treatments. Grain yields were increased on average by around 12% following chickpeas, compared to wheat-on-wheat, as a result of the reduction in CR severity (i.e. N effect removed).

In these experiments, the severity of CR infection following each rotation crop did not directly relate to the expression of whiteheads. Rotating to a non-host brassica or chickpea crop resulted in a significant reduction in the formation of whiteheads compared to a cereal-wheat rotation. However, the greater CR severity following chickpeas compared to canola or mustard was not directly reflected in the formation of whiteheads. This could potentially relate to the different water use patterns of these break crops. Chickpeas tend to use less water during the season than brassicas and generally do not root as deep in the soil. Thus the wheat crops growing after chickpeas may experience reduced moisture stress through this water saving which decreases the production of whiteheads in infected tillers.

This is a good reminder to growers of the need to think of CR in its distinct phases of **infection** and **yield loss** through the formation of whiteheads. The formation of whiteheads is related to moisture stress post-flowering, where the CR fungus is believed to block the 'plumbing' system of the plant preventing the movement of water from the soil into the heads. This results in the formation of a whitehead in infected tillers. Thus under a wet finish, tillers can still be infected with the CR fungus (i.e. still get inoculum build-up) but there is no moisture stress so the heads fill normally.

In a further replicated experiment at Tamworth the initial starting levels of CR inoculum and the season in which break crops are grown influence the effectiveness as disease breaks. Under low starting inoculum levels, **chickpeas reduced the incidence of CR by 56% and increased yield by 18%** compared to growing wheat-on-wheat. However, under high start-up inoculum levels with break crops grown in the drought of 2002 the incidence of CR following chickpeas was reduced by only 19% with a 6% increase in grain yield compared to growing wheat-on-wheat.

Microbial activity and the resulting decomposition of cereal residue would be expected to be lower in drier seasons and greater in wetter ones. Growing season conditions are likely to influence survival of *Fp* inoculum in cereal residues and the effectiveness of the various non-host legume and oilseed crops as breaks for CR.

In all of these experiments chickpeas were grown on row spacings of 30 or 38 cm. The row spacing at which a break crop is sown would be expected to influence canopy growth and ground cover throughout the season. Our research demonstrates that canopy growth and resulting ground cover influence the extent of microbial decomposition of cereal residues.

Many growers in northern NSW and southern Queensland establish chickpea crops on wider rows (50 cm to 100 cm) to gain disease pressure benefits and improved water use efficiency. It is likely that the breakdown of cereal residues that harbour the CR fungus would be reduced in chickpea crops grown on wider rows which may reduce their effectiveness as a disease break for CR.

Conclusions

Rotation to non-host break crops is critical to the integrated management of CR in the northern cropping zone.

Chickpeas play an important role as a viable break crop option for the management of CR. Averaged across trials and seasons chickpeas results indicate that a 40% reduction in CR levels compared to growing wheat-on-wheat which is translating into a yield benefit of approximately 16%.

Based on a long term average wheat yield of 2.5 t/ha for much of northern NSW the CR disease break provided by chickpeas is roughly 0.4 t/ha which equates to a gain of around $80/ha. This is a rough calculation of the direct benefit of chickpeas as a disease break for CR, growers need to also factor in the N benefits of growing chickpeas within the rotation.

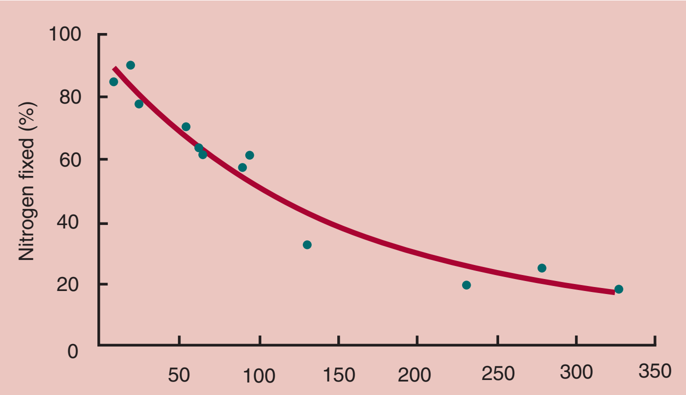
CHICKPEAS and their SOIL NITROGEN CONTRIBUTION

Chickpeas contribute a significant amount of nitrogen to the soil. However this contribution is dependent on both an effective nodulation of the crop and relatively low soil nitrogen levels at planting time.

While high levels of nitrate nitrogen have no significant effect on both the initial formation and number of nodules, it does markedly reduce both nodule size and activity.

Nodules basically remain inactive until the soil nitrate supply is exhausted (ineffective nodules remain white inside due to the absence of leghaemoglobin).

Soil Nitrate Nitrogen at chickpea establishment (kg/ha, 0-120cm)



(J A Doughton et al. 1993)

Effective nitrogen-fixing nodules on the other hand, are rusty red or pink colour inside.

Growing chickpeas on long fallows or in a situation with high residual nitrogen (e.g. after cotton) will substantially reduce nitrogen fixation.

Even growing chickpeas on summer fallows after wheat (6-month fallow) will delay the onset of nitrogen fixation due to the mineralisation of 30-50 kg N/ha in the fallow period.

This nitrate nitrogen, coupled with further in-crop mineralisation (15-20 kg/ha) provides a total soil supply of 45-70 kg N/ha, which is sufficient to grow a 1 t/ha chickpea crop.

Yields above this level are completely dependent on nitrogen fixation (and effective nodulation practices).

From the table below, an average chickpea crop of 1.5 t/ha requires 120 kg of nitrogen of which 50 kg is removed in the form of grain leaving a carryover of 70 kg of nitrogen. Generally this crop would follow a wheat crop and on average 40 kg of nitrogen would be available at the time of planting a chickpea crop in a soil of relatively low nitrogen status. The net contribution by the 1.5 t/ha chickpea could be 30 kg in this example and a 2.5 t/ha crop (not uncommon) could contribute 70 kg of nitrogen.

Source – Extracted from the "Accredited Chickpea Agronomist" Manual

Nitrogen amounts fixed in chickpea crops

	CHICKPEA GRAIN YIELD t/ha	NITROGEN FIXATION kg/ha
Double-cropped from sorghum	2.4	103
On long fallow (18 months)	2.4	27

(J A Doughton QDPI 1993)

Nitrogen balance

Total Plant Dry Matter (t/ha)	Total Shoot Dry Matter Yield (t/ha)	Grain Yield (t/ha) at 40% HI	Total Crop Nitrogen Requirement (2.3% N) (kg/ha)	Nitrogen Removal in Grain (kg/ha)
1.75	1.25	0.5	40	17
3.50	2.50	1.0	80	33
5.25	3.75	1.5	120	50
7.00	5.00	2.0	160	66
8.75	6.25	2.5	200	83
10.50	7.50	3.0	240	100

HI - Grain Harvest Index is the grain yield as a percent of total shoot dry matter production and averages approximately 40%.

OVERALL SUMMARY – NSW AND QLD

A number of long-term tillage and rotation experiments have examined the role of chickpeas in the farming system. The benefits of including chickpeas in rotations are summarised for NSW and Qld in the following two tables. Each individual experiment has also been described, the results presented and key conclusions drawn.

New South Wales

	No Nitrogen		Plus 100kg N/ha	
	Yield (t/ha)	% Protein	Yield (t/ha)	% Protein
Wheat (38, 24*)	2.0	10.9	2.3	12.7
Chickpea (44, 30)	1.9		1.9	
Wheat after wheat (34, 24)	2.1	11.2	2.7	13.2
Wheat after chickpea (40, 30)	2.8	12.2	2.9	13.8

Queensland

	No Nitrogen		Plus 100kg N/ha	
	Yield (t/ha)	% Protein	Yield (t/ha)	% Protein
Wheat (15, 15*)	2.2	10.3	2.8	13.8
Chickpea (15, 0)	1.5			
Wheat after wheat (15, 15)	2.2	10.3	2.8	13.8
Wheat after chickpea (15, 5)	2.8	11.7	3.1	13.8

**Number of crops in parentheses, for zero fertiliser N and plus fertiliser N.*
N.B. Data for Mulga View (QLD) was not included in the summary table.

Conclusions

- Results from the NSW and Qld trials were very similar. Wheat yields increased by an average of 0.7 t/ha in the NSW trials and by 0.6 t/ha in the Qld trials. Proteins were increased by an average of 1% (NSW) and 1.4% (Qld).
- The chickpea benefit was limited at most sites by water. Chickpeas have the potential to lift wheat yields in excess of 1.5 t/ha where water is not limiting.
- In the continuous wheat systems, fertiliser N had a larger effect on grain proteins (1.8% and 3.5% increases for NSW and Qld, respectively) than on yield (0.3 t/ha and 0.6 t/ha increases for NSW and Qld, respectively).
- Similarly, in the chickpea-wheat rotation systems, fertiliser N had a larger effect on grain proteins (1.6% and 2.1% increases for NSW and Qld, respectively) than on yield (0.1 t/ha and 0.3 t/ha increases for NSW and Qld, respectively).
- Arguably the major factor in the increased wheat yields was nitrate supply. In NSW, there was an additional 35 kg nitrate-N/ha in the 1.2 m profile after chickpea than in the continuous wheat.
- A secondary effect would have been the disease break.
- Chickpea yields were, on average, about 85% of the unfertilised wheat yield and about 70% of the N-fertilised wheat.

WARREN, NSW

"Good returns and a flexible sowing window"

Scott is acknowledged as an innovative farmer particularly in the areas of conservation farming, chemical rotation and innovative application methods and experience in growing a wide range of dryland and irrigated crops.

Scott was the runner up in a closely contested 2004 Pulse Australia Chickpea Farmer Awards.

Scott McCalman
"Jedburgh" Warren NSW

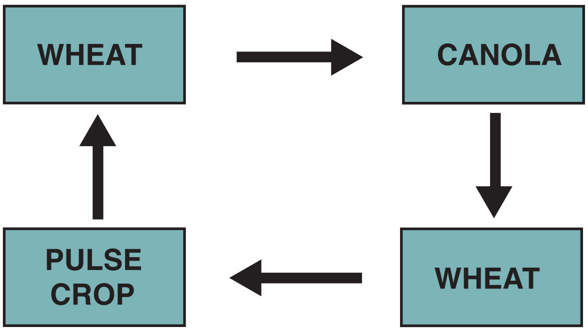
TYPE OF COUNTRY

The property is located 40 km north west of Warren.

The country is heavy grey and red self mulching clay soils. The native timber is rosewood, myall and belah.

THE ROTATION

The planned rotation is



The pulse crop is either chickpeas or albus lupin, the choice depending on soil types, sowing times and markets.

A degree of flexibility is required in any farming system as the entire winter crop area cannot be planted every year.

If circumstances allow, a double skip sorghum crop will be grown during summer, returning to the rotation the following winter.

KEY REASONS FOR ADOPTING THIS ROTATION

- All crops selected perform well in the local environment, particularly chickpeas which are better able to handle a hot spring.
- Chickpeas, whilst preferably sown earlier rather than later, are flexible and still perform.
- The rotation is agronomically good to manage and provides herbicide options.

PROVEN BENEFITS OF THE ROTATION

- The wheat crop following the break crop is always superior due to the disease break and some nitrogen contribution.
- The use of one metre rows for the chickpeas and albus lupins provide a wider range of chemical options, see *"Shielded Sprays Provide more Options".*

HAS GROWING CHICKPEAS MEANT ADDITIONAL OVERHEAD COSTS?

Machinery – Whilst no machinery has been purchased for chickpea production. The boomspray has been modified to better apply fungicides but this has also been of benefit to other on farm spray operations.

Management and Labour – Chickpeas have meant more detailed and time consuming management and operations compared to the other crops. These activities include different planter setups. However this has not resulted in any additional labour costs.

Shielded sprays provide more options.

Scott has been an innovator in the use of shielded spraying.

He has a dual boom and with his chickpeas in one metre rows this provides a wide range of spray application options.

For example a fungicide tank mixed with a Group A grass herbicide over the row and a broader spectrum herbicide between the rows.

FARMER CASE STUDY

GULARGAMBONE, NSW

"Chickpeas are easy to grow, they make money and help following crops"

Adrian Lyons

"Caraminyah" Gulargambone NSW

Adrian's success with chickpeas has convinced him of their value not only as an income stream but also as a valuable part of his farming system.

Wheat on its own is not sustainable and he has been willing to try new crops to improve not only returns but to provide a more sustainable farming system.

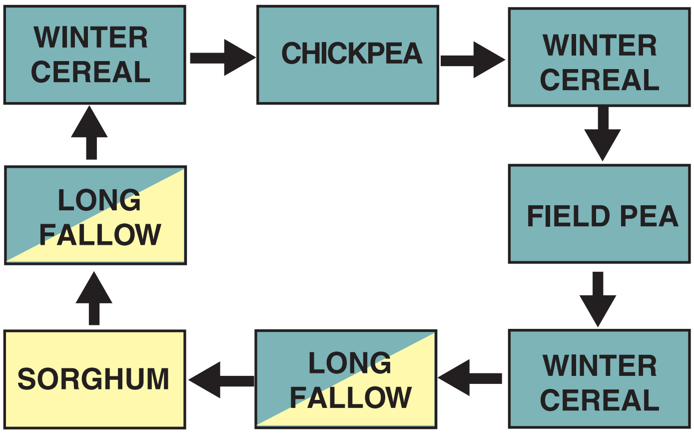
Adrian was the winner of the 2003 'Pulse Australia Champion Chickpea Farmer' award.

TYPE OF COUNTRY

The soil type is a heavy grey clay and the original timber primarily rosewood and myall.

AGRONOMIST – Scott Wallace, Coonamble Farming Cooperative.

ROTATION



Field peas are new to the system replacing canola which did not perform well over three years despite showing great potential.

This rotation has been followed since 1997.

REASONS FOR ADOPTING THIS ROTATION

- The need for a complete break between winter cereals, particularly wheat and disease outbreaks.
- Disappointing returns from wheat.
- To avoid having to control the three grasses in winter cereals.
- It spreads the exposure across a range of crops - not putting all the eggs in one basket.

PROVEN BENEFITS OF THE ROTATION

- A significantly reduced weed burden.
- Pulse returns have been greater than cereals, assisted by on farm storage.
- A healthy but not large nitrogen contribution.

HAS GROWING CHICKPEA MEANT ADDITIONAL OVERHEAD COSTS?

Machinery – A prickle chain ($7000) to level country after planting, plus a significant investment in additional storage and aeration to improve grain quality and marketing opportunities, particularly in the pulse crops.

Management and Labour – An extra man at both planting and harvest (compared to a straight wheat operation) to undertake the additional tasks.

CHICKPEA TIPS

- When growing chickpeas Adrian finds ascochyta management straightforward.
- Balance® makes it possible to achieve effective weed control.
- You can deep plant to better enable planting on time - it's an amazingly vigourous plant.
- Ensure the country is level after sowing otherwise harvest can be a nightmare, and headers hate stick picking.

Provide the complete management package and be a little patient early.

When growing pulse crops there will be new challenges which will not all be solved in the first year so we need to be patient.

Adrian does not believe in cutting costs or taking short cuts, particularly with his pulse crops. If you invest in the recommended management package for the situation they are more likely to work.

The easy option is not always the best option, stick with a rotation that fits.

FARMING SYSTEMS EXPERIMENT—CRYON (NSW)

Land system

This trial was located at Cryon, about 50 km east of Walgett on the eastern edge of the Cryon Plain.

The original vegetation was mostly open grassland of curly Mitchell grass, naturalised Coolah grass (*Panicum coloratum*) naturalised annual medics, scattered myall (*Acacia pendula)* and isolated coolibah (*Eucalyptus microthesa*) and whitewood (*Atalaya hemiglauca*).

Soil type

Cracking brown clay (Brown Vertosol) containing 46% clay, 31% silt and 23% sand in the surface layers (0-10 cm), with higher clay content (≥ 55%) below 20 cm.

The soil becomes increasingly sodic below 20 cm, and more saline below 60 cm with chlorides exceeding 300 mg/kg below 90 cm.

Annual rainfall

Mean annual rainfall is 500 mm.

Cropping history

The Cryon rotation experiment began in 1996 on country that had been cropped continuously since the 1970's. Wheat was the main crop grown over this period with no fertiliser inputs into the farming system prior to 1997.

Comments

This soil type is representative of the cultivated country used for wheat production in most of the Walgett Shire and the western and southern portions of the Coonamble Shire in north-west NSW.

Conclusions

- Chickpea in the rotation lifted wheat yield by an average of 0.8 t/ha and wheat proteins by 1.9% when no nitrogen was applied to the wheat.
- Chickpea yields were 53% of wheat yields.

Project Leaders

David Mitchell and John Friend, NSW DPI, Trangie

***Measurements taken in 1996 and 2004** (source: Graeme Schwenke and David Mitchell).*

Soil Depth (cm)	pH ($CaCl_2$)	Clay (%)	Silt (%)	Sand (%)	Organic carbon (%)	Total N (%)	EC_{se} (dS/m)*	ESP	Cl-mg/kg (2004)**
0-10	7.8	46	31	23	0.70	n.d.	2.20	2	27
10-30	8.0	55	27	18	0.43	n.d.	1.46	12	70
30-60	8.3	56	27	17	0.38	n.d.	2.18	17	66
60-90	8.4	56	28	16	0.31	n.d.	2.97	27	171
90-120	8.2	57	29	14	0.24	n.d.	8.87	31	318
120-150	7.9	59	29	12	0.21	n.d.	12.22	31	365

**Saturated Extract*

***Chloride was measured at the conclusion of the experiment by Bruce Haigh. Chlorides are the average for the whole site.*

n.d. = no data

Results (1996-2004) *Wheat and Chickpea Yields (t/ha). Wheat proteins (%) in parentheses.*

TREATMENT	1996	1997	1998	1999	2000	2001	2002	2003	2004
Continuous Wheat (No-Till)	2.7 (12.8)	1.4 (12.8)	3.5 (B)	2.1 (9.9)	1.5 (13.7)	1.8 (B)	(F)	1.1 (14.1)	2.0 (12.6)
Chickpea/Wh/Chickpea/Wh/ Chickpea/Wheat (No-Till)	1.4 (C)	1.6 (13.6)	1.5 (C)	3.6 (13.0)	0.8 (C)	2.3 (13.4)	(F)	0.4 (L)	1.9 (15.3)

(C) Chickpeas (B) Barley (F) Fallow – drought (L) Lentils

Grains Research & Development Corporation

NSW DEPARTMENT OF PRIMARY INDUSTRIES

FARMER CASE STUDY

BURREN JUNCTION, NSW

"Chickpeas have assisted me to maintain a sustainable and economic farming system"

Sandy Stump
"Eurambeen" Burren Junction NSW

The key philosophy behind Sandy's farming system is to maximise profitability in an extremely variable rainfall area.

To achieve this Sandy has adopted zero till using controlled traffic to maximise soil moisture. Crop rotation is fundamental and chickpeas are an integral part of the rotation.

TYPE OF COUNTRY

The home block is situated north west of Burren Junction with another farm on the Cryon Plain in the Walgett Shire.

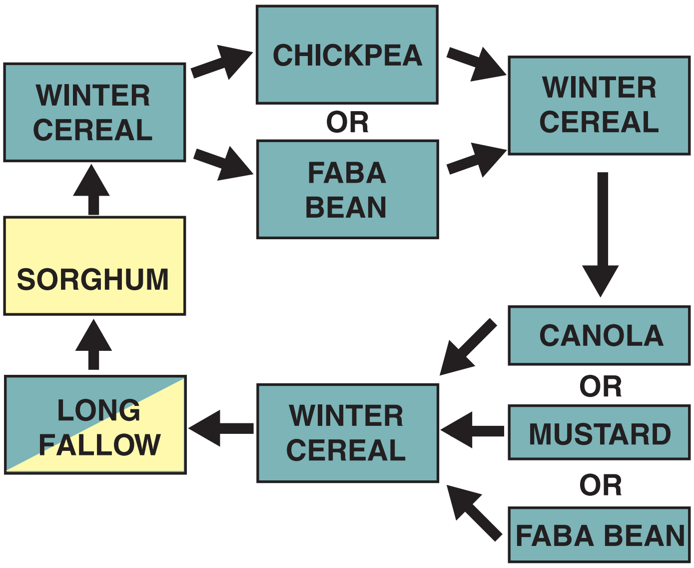
Soils are predominantly a grey self mulching clay. The original timber was Coolabah with Myall on the lighter soils. On the Cryon Plain there are subsoil constraints at depth, particularly on the lighter soils which can limit chickpea production, particularly in a dry spring.

AGRONOMIST - Sarah O'Brien, Walgett Sustainable Agriculture Group.

ROTATION

A number of rotations have been used over the years and there is naturally a degree of flexibility to allow for those seasons that do not permit a full planting.

The current rotation objective is-



Refer *"Rotations Necessary"*

Sandy has been able to maintain his philosophy of not planting wheat into its own stubble. This is primarily due to the performance of chickpeas and other newer broadleaf crops now being grown in the region.

REASONS FOR ADOPTING THIS ROTATION

- Diversity of income and marketing opportunities.
- Spreading labour and machinery resources over longer periods of time.
- Ability to generally get the right crop in the right sowing window in the right paddock.
- Crown rot is a major issue and therefore monoculture wheat is not an option.
- The system benefits a legume just as nature had a winter legume in medic.
- Ability to use a range of weed control options.

PROVEN BENEFITS OF THE ROTATION

- More profitable high yielding high protein wheat crops.
- Improvement in soil health and fertility.
- Risk and income diversification.

HAS GROWING CHICKPEA MEANT ADDITIONAL OVERHEAD COSTS?

The whole farming system has required a change from conventional tillage gear to specialised machinery. Growing chickpeas themselves has required a changeover from augers to tube elevators. Headers and operators also require improved management.

Rotations necessary.

In the 1980's the program was wheat – fallow – wheat. Then a move to zero till and the successful introduction of chickpeas to the region resulted in the first serious rotation which was-

Wheat – Chickpea – Wheat – Barley – Sorghum.

The advent of a wider range of winter broadleaf crops has resulted in the current rotation.

Wheat continues to provide the best gross margin but that is due to the benefits of including chickpeas and other legume or broadleaf crops in the system.

FARMER CASE STUDY

NARRABRI, NSW

"Chickpeas contribute to a rotation that is sustainable over time"

Ian has developed a rotation that reduces the impact of crown rot and Group A resistance in wild oats. His current rotation avoids consecutive crops of durum and includes one cultivation period in a largely zero till system.

In 2002 Ian was the Narrabri district winner and overall second place in the 'Pulse Australia Champion Chickpea Farmer' awards.

Ian Gourley
"Blue Hills" Narrabri NSW

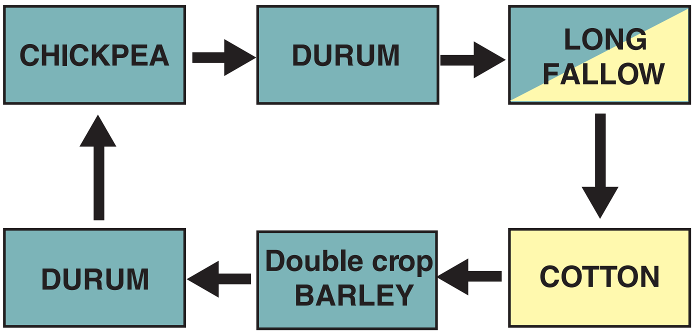
TYPE OF COUNTRY

The property is situated 25 km north west of Narrabri. The country was originally a treeless plain and the soils are a self mulching brown cracking clay loam.

There are no apparent subsoil constraints.

AGRONOMIST – Drew Penberthy.

ROTATION



The country is cultivated for pupae busting after the cotton and then double cropped to barley. Barley is grown to primarily provide a soil cover for the long fallow back to durum and is either sprayed out or taken through to harvest, depending on the season. Barley is sown in 66 cm rows so that when the following durum crop is planted it can be sown on 33 cm rows between the previous barley rows to reduce the impact of any crown rot.

This season, some of the nominated chickpea area has been sown to faba bean and the choice each year will depend on paddock suitability, distance from previous paddocks and market prospects.

REASONS FOR ADOPTING THIS ROTATION

- The need to avoid crown rot in durum crops.
- This rotation has proved the most viable and profitable.
- Greater weed control options.
- Reduced cultivation and improved soil health.

PROVEN BENEFITS OF THE ROTATION

- Not diminishing soil reserves or pushing crops too hard in the system.
- Cultivation after cotton is another method for additional weed control, reducing over reliance on herbicides.
- Each crop can perform to its potential as there is a sound reason for its position in the rotation.

HAS GROWING CHICKPEA MEANT ADDITIONAL OVERHEAD COSTS?

Machinery – No additional machinery or modifications specifically for chickpeas.

Management and Labour – Whilst there are more tasks in growing chickpeas this has not resulted in additional labour costs.

Lessons well learnt.

To grow quality durum you need to avoid crown rot which means you need a clean break between durum crops. Our challenge has been to provide ground cover after cotton without harbouring crown rot, thus the reason for our skip double crop barley.

Some years ago we planted a bread wheat after durum and whilst crown rot was evident it did not significantly impact on yield in this case. Whilst this was a one off situation it could not be recommended as a long term plan.

FARMING SYSTEMS EXPERIMENT—WARIALDA (NSW)

Land system

This trial was located at the Douglas McMaster Research Farm, 36 km north-west of Warialda on a soil type common to the terraces of major watercourses of the northern NSW wheatbelt.

The natural vegetation consisted of herbland and grassland, mainly plains grass (*Stipa aristiglumis*) on the valley floor.

Soil type

Black Earth (Black Vertosol) containing 58% clay, 12% silt and 30% sand in the surface layers (0-10 cm) and extending down to 30cm. The soil becomes heavier below 30 cm. Bulk density was 1.4.

The soil is slightly alkaline and has relatively consistent readings for pH and salinity throughout the profile to a depth of 150 cm.

Annual rainfall

Mean annual rainfall is 690 mm.

Cropping history

The Warialda tillage experiment commenced in 1981 on country that had been cropped for the previous 15-20 years. Only wheat, sorghum and soybean were grown between 1981 and 1986. In 1987 chickpeas, canola and barley were introduced into the existing tillage comparison, followed by wheat until 1992. A new set of rotation treatments, including chickpeas, faba beans and barley were imposed in 1993, with and without added nitrogen to the wheat plots. There was a forced long fallow in 1994 due to drought.

Comments

This soil type is representative of the cultivated black earth country used for wheat and summer crops on the undulating country around Warialda and Yallaroi, on the slopes of the Liverpool Range south of Gunnedah, and on the Darling Downs of south-east Queensland.

Soil Characterisation in 1996 *(source: Graeme Schwenke).*

Soil Depth (cm)	pH ($CaCl_2$)	Clay (%)	Silt (%)	Sand (%)	Organic carbon (%)	Total N (%)	EC_{se} (dS/m)*
0-10	7.5	58	12	30	1.25	0.108	0.94
10-20	7.7	58	12	30	1.01	0.076	0.96
20-30	7.8	58	12	30	0.96	0.069	1.01
30-60	7.8	62	12	26	0.93	0.063	1.27
60-90	8.0	62	11	27	0.91	0.056	1.62
90-120	7.6	64	11	26	0.74	0.041	1.07
120-150	7.7	64	14	22	0.48	0.028	1.12

**Saturated Extract*

Conclusions

- Chickpea in the rotation lifted wheat yield by an average of 0.6 t/ha and wheat proteins by 1.4% when no nitrogen was applied to the wheat.
- Adding nitrogen fertiliser increased wheat yields in the continuous wheat system (0.3 t/ha), but not in the chickpea-wheat rotations. Nitrogen fertiliser increased wheat proteins in all systems.
- The major benefit of the chickpea was to increase soil nitrate levels at sowing. Average levels to a depth of 1.2 m were 118 kg N/ha after wheat and 149 kg N/ha after chickpea, a difference of 31 kg N/ha.
- On the other hand, there was less soil water after chickpea, compared with wheat. Average levels to 1.2 m depth were 231 mm after wheat and 177 mm after chickpea.
- The size of any disease break effect at this site is not known as no data is available. The wheat yield and protein data suggests there may have been some break crop effect.
- No-till marginally improved soil water levels at sowing. When averaged over all rotations, soil water levels to a depth of 1.2 m were 238 mm for no-till, 220 mm for stubble burnt and 232 mm for stubble mulched.

- Chickpea yield benefited from the extra water (60 mm), averaging 2.7, 2.4 and 2.5 t/ha for the no-till, stubble burnt and stubble mulched treatments, respectively. Water Use Efficiency (WUE) of chickpea ranged from 3.8 to 10.0 kg/mm of water supply and averaged 5.9, 6.4 and 6.3 in the no-till, stubble mulched and stubble burnt systems respectively.
- Chickpea yields were 93% (+fertiliser N) and 109% (zero fertiliser N) of wheat yields.

Project team

Warwick Felton, Harry Marcellos and David Herridge, NSW DPI, Tamworth

Results (1993-1999) *Wheat, Barley and Chickpea Yields (t/ha). Wheat proteins (%) in parentheses.*

TREATMENT	1993	1995	1996	1997	1998	1999
NO-TILL						
Continuous Wheat	1.9 (9.4)	3.9 (10.6)	2.2 (8.2)	2.7 (9.7)	1.0 (11.9)	3.3 (12.2)
Continuous Wheat (+ N)	2.5 (10.8)	3.5 (12.4)	2.3 (9.9)	3.7 (11.2)	0.8 (14.8)	4.0 (15.4)
Chickpea/Wheat	2.3 (C)	4.8 (11.8)	2.3 (C)	3.6 (10.4)	2.5 (C)	4.4 (13.4)
Chickpea/Wheat (+ N)	2.4 (C)	5.1 (12.6)	2.0 (C)	3.7 (12.8)	2.6 (C)	4.0 (15.4)
Barley/Chickpea/Wheat	2.6 (B)	3.7 (C)	3.7 (9.3)	4.1 (B)	2.6 (C)	4.3 (12.7)
Barley/Chickpea/Wheat (+ N)	4.3 (B)	3.6 (C)	4.3 (10.7)	5.7 (B)	2.3 (C)	4.0 (15.1)
STUBBLE MULCHED						
Continuous Wheat	1.8 (9.3)	3.9 (11.6)	2.6 (8.8)	2.6 (9.3)	0.7 (11.9)	4.3 (12.4)
Continuous Wheat (+ N)	2.4 (11.5)	3.7 (13.2)	3.0 (11.7)	2.6 (12.0)	1.4 (13.8)	3.9 (15.7)
Chickpea/Wheat	2.0 (C)	3.7 (12.8)	2.1 (C)	3.2 (11.1)	2.2 (C)	4.4 (13.6)
Chickpea/Wheat (+ N)	2.0 (C)	3.9 (13.7)	1.7 (C)	3.2 (12.8)	2.5 (C)	3.7 (15.5)
Barley/Chickpea/Wheat	2.2 (B)	3.3 (C)	3.3 (8.6)	3.2 (B)	2.9 (C)	4.3 (13.0)
Barley/Chickpea/Wheat (+ N)	3.9 (B)	3.4 (C)	4.1 (10.6)	4.5 (B)	2.6 (C)	3.6 (15.6)
STUBBLE BURNT						
Continuous Wheat	2.0 (8.3)	4.0 (12.0)	2.6 (7.7)	3.1 (8.8)	0.7 (11.8)	4.0 (12.7)
Continuous Wheat (+ N)	2.9 (11.3)	4.1 (13.6)	3.8 (11.5)	3.3 (11.8)	1.5 (13.3)	3.6 (15.7)
Chickpea/Wheat	1.8 (C)	3.7 (13.2)	1.9 (C)	3.1 (10.6)	2.5 (C)	4.1 (13.7)
Chickpea/Wheat (+ N)	1.9 (C)	3.9 (13.9)	1.9 (C)	3.3 (13.0)	2.5 (C)	3.6 (16.3
Barley/Chickpea/Wheat	2.5 (B)	3.2 (C)	3.4 (8.4)	3.9 (B)	2.8 (C)	4.4 (13.6)
Barley/Chickpea/Wheat (+ N)	3.8 (B)	3.2 (C)	4.2 (10.6)	4.3 (B)	2.7(C)	3.7 (15.9)

(C) Chickpeas (B) Barley *1994 was fallowed due to drought*

Summary Yields and proteins averaged over the three fallow management treatments.

	No Nitrogen		Plus 100 kg N/ha	
	Yield (t/ha)	% Protein	Yield (t/ha)	% Protein
Wheat (12*)	2.3	10.1	2.7	12.3
Chickpea (15)	2.5		2.5	
Wheat after wheat (12)	3.3	10.3	3.5	12.8
Wheat after chickpea (15)	3.9	11.7	3.9	13.6

**Number of crops in parenthesis*

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NSW DEPARTMENT OF PRIMARY INDUSTRIES

FARMING SYSTEMS EXPERIMENT—CROPPA CREEK (NSW)

Land system

This trial was located 7 km south-west of Croppa Creek on a soil type characteristic of the Brigalow landscape of north-west NSW. The vegetation consisted of tall scrubland, mostly of brigalow *(Acacia harpophylla)* and belah *(Casuarina cristata).*

Soil type

Cracking grey clay (Grey Vertosol) containing 44% clay, 16% silt and 40% sand in the surface layers (0-10 cm) and extending down to 30cm. Bulk density was 1.4.

The soil becomes increasingly acid below 90 cm and is extremely acid below 120 cm. The profile also becomes increasingly saline below 60 cm, which could have implications for chickpeas. Soil pH and salinity are important subsoil characteristics of Brigalow soils.

Annual rainfall

Mean annual rainfall is 585 mm.

Cropping history

The Croppa Creek tillage experiment commenced in 1981 on country that had been cropped for the previous 15-20 years. Only wheat and sorghum were grown between 1981 and 1986. In 1987 chickpeas, canola and barley were introduced into the existing tillage comparison, followed by wheat until 1992. A new set of rotation treatments, including chickpeas, faba beans and barley were imposed in 1993, with and without added nitrogen to the wheat plots.

Comments

This soil type is representative of large tracts of cultivated brigalow country used for wheat production in northern NSW including the areas around, but not confined to, Gurley, Bellata, Croppa Creek, North Star, Pilliga and areas west of Narrabri.

Conclusions

- At this site chickpea in the rotation lifted wheat yield by an average of 0.3 t/ha and wheat proteins by 0.5% when no nitrogen was applied to the wheat.
- Adding nitrogen fertiliser increased wheat yields and wheat proteins across all tillage and rotation systems. The increases were greatest in the continuous wheat (0.4 t/ha and 1.3% protein) and marginal in the chickpea-wheat rotation (0.2 t/ha and 1.1% protein).
- The major benefit of chickpeas was to increase soil nitrate levels at sowing. Average levels to a depth of 1.2 m were 83 kg N/ha after wheat and 119 kg N/ha after chickpea, a difference of 36 kg N/ha.
- On the other hand, there was less soil water after chickpea, compared with wheat. Average levels to 1.2 m depth were 185 mm after wheat and 173 mm after chickpea.
- Crown rot was only marginally less in the wheat crop following chickpea (average of 35% incidence) than in the continuous wheat (48% incidence), suggesting that disease break was not a significant effect at this site.
- No-till improved soil water levels at sowing. When averaged over all rotations, soil water levels to a depth of 1.2 m were 201 mm for no-till, 175 mm for stubble burnt and 166 mm for stubble mulched.

Soil Characterisation in 1996 *(source: Graeme Schwenke).*

Soil Depth (cm)	pH ($CaCl_2$)	Clay (%)	Silt (%)	Sand (%)	Organic carbon (%)	Total N (%)	EC_{se} (dS/m)*	Cl-mg/kg (2001)**
0-10	7.0	44	16	40	1.19	0.127	1.02	27
10-20	7.5	44	16	40	0.94	0.107	1.40	n.d
20-30	7.6	44	16	40	0.81	0.095	1.63	37
30-60	7.7	50	15	36	0.66	0.080	2.04	114
60-90	7.3	52	15	33	0.43	0.049	3.87	270
90-120	4.9	53	19	28	0.29	0.037	6.42	515
120-150	3.9	50	20	30	0.19	0.029	5.95	752

**Saturated Extract*
***Chloride was measured at the conclusion of the experiment by Bruce Haigh. Chlorides are the average for the whole site.*

- Chickpea yield benefited from the extra water (30 mm), averaging 1.5, 1.3 and 1.2 t/ha for the no-till, stubble burnt and stubble mulched treatments, respectively. Water Use Efficiency (WUE) of chickpea ranged from 3.9 to 7.5 kg/mm of water supply and averaged 6.1, 5.4 and 5.8 in the no-till, stubble mulched and stubble burnt systems respectively.

- Chickpea yields were 72% (+fertiliser N) and 87% (zero fertiliser N) of wheat yields.

Project team

Warwick Felton, Harry Marcellos and David Herridge, NSW DPI, Tamworth

Results (1993-1998) Wheat, Barley and Chickpea Yields (t/ha). Wheat proteins (%) in parentheses.

TREATMENT	1993	1994	1995	1996	1997	1998
NO-TILL						
Continuous Wheat	1.9 (9.6)	1.0 (12.5)	1.3 (12.3)	1.4 (10.2)	1.4 (11.0)	1.2 (12.4)
Continuous Wheat (+ N)	2.4 (10.3)	0.9 (13.5)	1.5 (14.3)	2.0 (11.7)	1.9 (12.2)	1.9 (13.8)
Chickpea/Wheat	2.1 (C)	1.2 (14.0)	2.2 (C)	2.4 (9.9)	1.1 (C)	1.8 (12.8)
Chickpea/Wheat (+ N)	1.9 (C)	0.9 (14.2)	2.2 (C)	2.8 (11.3)	1.2 (C)	2.3 (13.7)
Barley/Chickpea/Wheat	2.8 (B)	0.8 (C)	1.5 (12.5)	3.3 (B)	1.3 (C)	1.8 (12.5)
Barley/Chickpea/Wheat (+ N)	4.1 (B)	0.6 (C)	1.6 (14.3)	4.9 (B)	1.3 (C)	2.5 (13.9)
STUBBLE MULCHED						
Continuous Wheat	1.9 (9.7)	0.9 (12.8)	1.5 (13.5)	1.9 (9.7)	1.6 (10.9)	1.4 (12.6)
Continuous Wheat (+ N)	2.6 (10.8)	0.9 (13.8)	1.6 (15.4)	2.7 (11.8)	2.3 (12.8)	2.3 13.7)
Chickpea/Wheat	1.7 (C)	0.7 (14.0)	1.9 (C)	2.9 (10.8)	1.2 (C)	1.9 (13.2)
Chickpea/Wheat (+ N)	1.7 (C)	0.3 (13.9)	1.9 (C)	3.4 (12.0)	1.2 (C)	2.4 (14.3)
Barley/Chickpea/Wheat	3.2 (B)	0.3 (C)	1.0 (14.6)	4.3 (B)	1.0 (C)	1.8 (12.9)
Barley/Chickpea/Wheat (+ N)	4.0 (B)	0.1 (C)	1.1 (16.2)	5.3 (B)	1.2 (C)	2.4 (14.2)
STUBBLE BURNT						
Continuous Wheat	2.4 (9.8)	0.8 (13.5)	1.4 (14.5)	2.0 (10.8)	1.9 (12.1)	1.5 (12.6)
Continuous Wheat (+ N)	2.8 (10.6)	0.7 (13.6)	1.4 (15.8)	2.8 (11.8)	2.5 (13.7)	2.6 (14.0)
Chickpea/Wheat	1.7 (C)	0.4 (14.1)	1.9 (C)	2.7 (10.3)	1.2 (C)	2.0 (13.0)
Chickpea/Wheat (+ N)	1.8 (C)	0.7 (14.1)	1.7 (C)	3.2 (11.7)	1.2 (C)	2.5 (13.9)
Barley/Chickpea/Wheat	3.3 (B)	0.4 (C)	0.9 (15.1)	4.3 (B)	1.1 (C)	1.8 (12.3)
Barley/Chickpea/Wheat (+ N)	3.8 (B)	0.3 (C)	0.8 (17.0	4.9 (B)	1.0 (C)	2.4 (14.0)

(C) Chickpeas (B) Barley

Summary

	No Nitrogen		Plus 100 kg N/ha	
	Yield (t/ha)	% Protein	Yield (t/ha)	% Protein
Wheat (12*)	1.5	11.9	1.8	13.1
Chickpea (15)	1.3		1.3	
Wheat after wheat (12)	1.4	12.3	1.8	13.6
Wheat after chickpea (15)	1.7	12.8	1.9	13.9

**Number of crops in parenthesis*

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NSW DEPARTMENT OF PRIMARY INDUSTRIES

GROSS MARGIN CASE STUDY—CROPPA CREEK (NSW)

Fiona Scott, NSW DPI, Tamworth

A gross margin comparison was done for the Croppa Creek trial that ran from 1993 to 1998. Crop prices used were; barley $140/tonne, chickpeas $340/tonne, fababeans $200/ tonne and wheat using a base price of $175/tonne for PH13 grade. Bonuses and discounts for wheat protein content were also applied. Crop growing and fallow costs, summarised in the table below, were calculated from trial operations. Nitrogen (N) fertiliser was applied as urea.

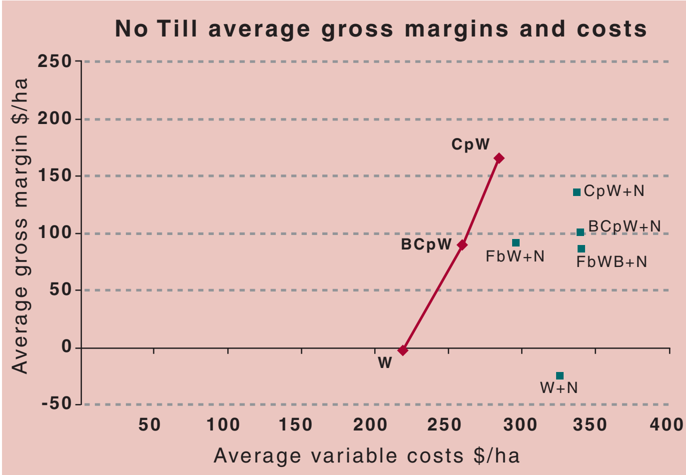
Results (1993-1998)

The three tables on page 21 show the total and average annual results for the 6 years of the trial. In each tillage treatment, the chickpeas-wheat rotation with no added nitrogen (N) fertiliser returned the highest gross margin.

In some cases, the variable costs of continuous wheat with added nitrogen were higher than a pulse-wheat rotation with no added N. However in gross margin terms, in almost all cases the pulse-wheat rotations with no added N outperformed continuous wheat, with or without added N.

Focus on no-till

The graph at right shows no-till gross margins graphed against variable costs. Generally pulse crops were more costly to grow than wheat without added fertiliser N. Continuous wheat (with or without added N fertiliser) was not an economic option under the no-till treatment. In terms of dollar return on costs, the best performing rotation was chickpeas-wheat. A reasonable lower cost option was the barley-chickpeas-wheat rotation.



Conclusions

- The chickpea – wheat rotation returned the highest gross margin for all three tillage treatments.
- Pulse-wheat rotations were generally no more (and sometimes less) expensive than adding 100 kg/ha of N as fertiliser to continuous wheat.
- In the majority of cases, the pulse-wheat rotations were more profitable than continuous wheat, with or without added N fertiliser.

Variable costs summary	no N	+100 kg/ha N	Harvest	Levies
Wheat	$144.71	$251.60	$35	1.015%
Barley	$139.63	$246.52	$37	1.015%
Chickpeas	$258.83	N/A	$47	1.015%
Fababeans	$268.13	N/A	$57	1.000%
Summer fallow, no-till (NT)	$43.88	Winter fallow NT		$26.10
Summer fallow, stubble mulch (SM)	$38.06	Winter fallow SM		$24.29
Summer fallow, stubble burned (SB)	$38.06	Winter fallow SB		$24.29

Results (1993-1998)

ROTATION	0N or +N fertiliser	Total Income $/ha	Total Costs $/ha	Total Gross Margin $/ha	Mean Annual Gross Margin $/ha
NO-TILL					
Continuous Wheat	0N	1,302	1,313	- 11	- 2
Continuous Wheat	+N	1,805	1,954	- 149	- 25
Chickpea/Wheat	0N	2,705	1,705	1,000	167
Chickpea/Wheat	+N	2,838	2,026	812	135
Barley/Chickpea/Wheat	0N	2,097	1,556	541	90
Barley/Chickpea/Wheat	+N	2,646	2,039	607	101
Fababean/Wheat	0N	2,321	1,775	546	91
Fababean/Wheat/Barley	+N	2,559	2,044	515	86
STUBBLE BURNT					
Continuous Wheat	0N	1,615	1,287	328	55
Continuous Wheat	+N	2,221	1,928	293	49
Chickpea/Wheat	0N	2,476	1,677	799	133
Chickpea/Wheat	+N	2,707	1,997	710	118
Barley/Chickpea/Wheat	0N	2,001	1,524	476	79
Barley/Chickpea/Wheat	+N	2,310	2,003	307	51
Fababean/Wheat	0N	1,585	1,705	- 120	- 20
Fababean/Wheat/Barley	+N	2,321	1,970	351	59
STUBBLE RETAINED					
Continuous Wheat	0N	1,442	1,285	157	26
Continuous Wheat	+N	2,097	1,926	171	28
Chickpea/Wheat	0N	2,514	1,679	835	139
Chickpea/Wheat	+N	2,718	2,000	719	120
Barley/Chickpea/Wheat	0N	2,005	1,524	481	80
Barley/Chickpea/Wheat	+N	2,362	1,964	399	66
Fababean/Wheat	0N	2,191	1,710	480	80
Fababean/Wheat/Barley	+N	2,246	1,971	275	46

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FARMER CASE STUDY

GURLEY, NSW

"Chickpeas provide a good income and a great break crop with cereals"

Peter Lee
"Worion" Gurley NSW

Peter has a flexible rotation mixing chickpeas, faba beans and sorghum with the traditional wheat and barley. The choice of crop is dependent on cereal disease, weed and soil type issues.

TYPE OF COUNTRY

The property is situated 8 km east of Gurley which is south of Moree.

There are two soil types, a heavy hard setting black clay (belah/wilga) and softer self mulching black clay (wilga).

See *"The Importance of Crop Choice"*.

AGRONOMIST - Garry Onus, Landmark.

ROTATION

Flexibility is the key but the most common sequences are two winter cereals followed by either a chickpea or faba bean crop or a sorghum crop.

Depending on conditions there may only be one cereal before and an alternative crop is preferred.

Chickpeas have been part of the farming system since 1998.

REASONS FOR ADOPTING THIS ROTATION

- The cost of nitrogen fertiliser dictates that a legume should be part of the farming system.

Effective nodulation (left row) is needed for nitrogen fixation.

- There is a range of crops that are well suited to the region and soil types.
- Improved weed control.
- A need to get away from growing cereals only.

PROVEN BENEFITS OF THE ROTATION

- Greatly improved wheat yields when wheat follows a chickpea or faba bean crop.
- Better weed control options, particularly the use of Group A grass herbicides for wild oats.

HAS GROWING CHICKPEA MEANT ADDITIONAL OVERHEAD COSTS?

Machinery – No specific machinery has been purchased to grow chickpeas.

Management and Labour–No additional labour costs.

The importance of a choice of crops

Having available two pulse crops with different attributes has made crop rotation for Peter far more effective.

On his better drained self mulching soils chickpeas provide both an ideal situation for the following wheat crop but also an attractive income.

On his heavier clays which can be prone to waterlogging faba beans are far better suited and whilst they do not generally provide the same returns as chickpea their benefits to the following wheat crop are greater.

FARMER CASE STUDY

NORTH STAR, NSW

"Chickpeas are the backbone of my farming system"

Ray Price

Ray Price has been following his rotation since 1987, and was the Pulse Australia Champion Chickpea farmer in 2004.

If chickpeas, or an equivalent winter broadleaf crop was not included as part of the cropping system, he believes that costs of production of all other crops would increase and some decline in yield would result.

Ray & Nikki Price
"Ashton" North Star NSW

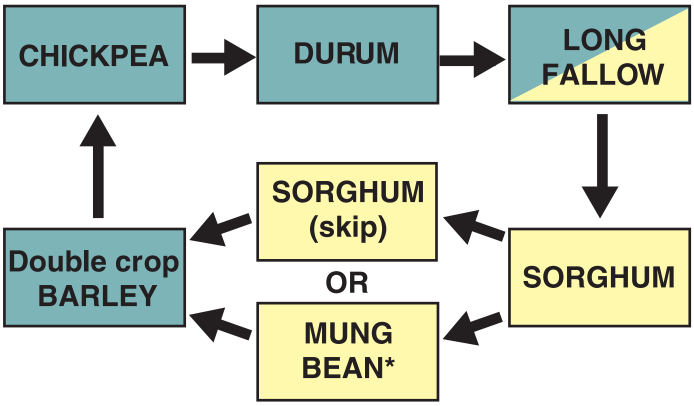
TYPE OF COUNTRY

The property 'Ashton' is situated south of North Star in the Yallaroi district of NSW.

Soils are predominantly a self mulching grey clay (brigalow/ belah). There are no obvious subsoil constraints that could affect crop performance.

AGRONOMIST - Andrew Stevenson, McGregor Agricultural Services..

THE ROTATION



* The choice of sorghum (skip) or mungbean is dependent on the level of soil moisture, markets, planting opportunities etc.

Ray has maintained this rotation at 100% for over 15 years except for one paddock of wheat following wheat which was necessary to make the area of each zone more uniform (see 'Learning Experience').

The very late break in 2005 forced a change in cropping, but Ray is confident that his proven rotation will be back on track in 2006.

KEY REASONS FOR ADOPTING THIS ROTATION

- All included crops are well suited to the region and soil types.
- Improved weed control, particularly the harder to control weeds such as fleabane and wild oats.
- It provides the ability to use a range of more cost effective grass herbicides.
- Each crop has the best opportunity to maximise yield.

PROVEN BENEFITS OF THE ROTATION

- Ensures a more consistent income as no one crop is consistently the best, with the possible exception of durum, which has the best position in the rotation.
- Lower production costs for each of the crops.
- Improved soil health.

HAS GROWING CHICKPEAS MEANT ADDITIONAL OVERHEAD COSTS?

Machinery – Whilst no machinery has been purchased for chickpea production, the boomspray has been modified for better application of fungicides. This has also benefited other on-farm spray operations.

Management and Labour – Chickpeas have meant more detailed and time consuming management and operations compared to the other crops. These activities include different planter setups. This has not however, resulted in any additional labour costs.

Learning by experience.

In late 1998, following the acquisition of additional land, it was necessary to plant one paddock back to wheat to balance up the areas to each crop.

It was a very wet spring and the wild oats got away. Since then it has been expensive to control the wild oats in that paddock, and even in 2004 spot spraying was still necessary.

Planting a winter cereal into winter cereal stubble in future would be a last resort decision.

FARMING SYSTEMS EXPERIMENT - NORTH STAR (GLENHOMA) (NSW)

Land system

This trial was located 5 km east of North Star on a soil type typical of the brigalow belt of north-west NSW.

The vegetation consisted of tall scrubland, mostly of brigalow *(Acacia harpophylla)* and belah (*Casuarina cristata*).

Soil type

Grey clay (Grey Vertosol) containing 44% clay, 11% silt and 45% sand in the surface layers (0-10 cm), with higher clay content (≥ 49%) below 30 cm. Bulk density was 1.4.

The soil becomes very acid below 90 cm and becomes extremely acid below about 120 cm. The soil also becomes increasingly saline below about 60 cm depth. Soil acidity and salinity are important subsoil characteristics of Brigalow soils.

Annual rainfall

Mean annual rainfall is 620 mm.

Cropping history

The North Star rotation x tillage experiment commenced in 1990 on land that had been continuously cropped with cereals for at least 15 years.

***Soil Characterisation in 1996** (source: Graeme Schwenke).*

Soil Depth (cm)	pH ($CaCl_2$)	Clay (%)	Silt (%)	Sand (%)	Organic carbon (%)	Total N (%)	EC_{se} (dS/m)*
0-10	7.1	44	11	45	1.13	0.116	0.82
10-20	7.6	44	11	45	0.83	0.093	1.36
20-30	7.7	44	11	45	0.63	0.078	1.56
30-50	7.8	49	10	42	0.49	0.050	2.46
60-90	7.3	50	10	40	0.34	0.038	7.22
90-120	5.0	52	9	39	0.31	0.034	7.67
120-150	3.9	50	10	40	0.25	0.033	6.87

**Saturated Extract*

Results (1990-1993) Wheat and Chickpea Yields (t/ha). Wheat proteins (%) in parentheses.

TREATMENT	1990	1991	1992	1993
NO-TILL				
Continuous Wheat	3.0 (10.2)	1.8 (10.6)	2.6 (13.9)	2.2 (8.3)
Chickpea/Wheat/Wheat/Chickpea	1.8 (C)	2.4 (12.9)	2.9 (14.7)	2.8 (C)
STUBBLE MULCHED				
Continuous Wheat	3.0 (9.9)	1.8 (10.7)	2.7 (13.2)	2.2 (8.6)
Chickpea/Wheat/Wheat/Chickpea	1.8 (C)	2.2 (13.7) (W)	2.7 (13.8) (W)	2.3 (C)

(C) Chickpeas (W) Wheat

Summary Yields and proteins averaged over the two fallow management treatments.

	No Nitrogen	
	Yield (t/ha)	% Protein
Wheat (4*)	2.6	9.3
Chickpea (4)	2.2	
Wheat after wheat (2)	1.8	10.7
Wheat after chickpea (2)	2.3	13.3

**Number of crops in parenthesis*

Comments

This soil type is representative of large tracts of cultivated brigalow country used for wheat production in northern NSW including the areas around, but not confined to, Gurley, Bellata, Croppa Creek, North Star, Pilliga and areas west of Narrabri.

Conclusions

- Chickpea in the rotation lifted wheat yield by an average of 0.5 t/ha and wheat proteins by 2.6% when no nitrogen was applied to the wheat.
- The major benefit of the chickpea was to increase soil nitrate levels at sowing. Average levels to a depth of 1.2 m were 50 kg N/ha after wheat and 100 kg N/ha after chickpea, a difference of 50 kg N/ha.
- On the other hand, there was marginally less soil water after chickpea, compared with wheat. Average levels to 1.2 m depth were 126 mm after wheat and 118 mm after chickpea.
- Crown rot was substantially less in the wheat crop following chickpea (average of 3% incidence) than in the continuous wheat (22% incidence), suggesting that disease break was a significant effect at this site.
- No-till improved soil water levels at sowing. When averaged over all rotations, soil water levels to a depth of 1.2 m were 95 mm for no-till and 80 mm for stubble mulched.
- Chickpea yield benefited from the extra water (20 mm), averaging 2.3 and 2.0 t/ha for the no-till and stubble mulched treatments, respectively.
- Chickpea yields were 85% of wheat yields.

Project team

Warwick Felton, Harry Marcellos and David Herridge, NSW DPI, Tamworth

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FARMING SYSTEMS EXPERIMENT—WINDRIDGE (NORTH STAR) (NSW)

Land system

This trial was located 3 km south-west of North Star on a soil type that is part of, but not characteristic of the brigalow landscape of north-west NSW.

The vegetation consisted of tall scrubland, mostly of brigalow *(Acacia harpophylla)* and belah (*Casuarina cristata*), but with isolated wilga (*Geijera parviflora*) and whitewood (*Atalaya hemiglauca*).

Soil type

Red Clay (Red Vertosol) containing 48% clay, 11% silt and 41% sand in the surface layers (0-10 cm), with higher clay content (≥ 55%) below 30 cm. Bulk density was 1.4.

The soil becomes very acid below 120 cm. The soil also becomes increasingly saline below about 90 cm depth. Soil pH and salinity are important subsoil characteristics of brigalow soils.

Annual rainfall

Mean annual rainfall is 620 mm.

Cropping history

The Windridge (North Star) rotation x tillage experiment commenced in 1989 on land that had been continuously cropped with cereals for at least 15 years.

Comments

This soil type is representative of about 4,000 ha of cultivated country used for wheat production in northern NSW, but would have applicability to much of the grey soil brigalow belt.

Soil Characterisation in 1996 *(source: Graeme Schwenke).*

Soil Depth (cm)	pH ($CaCl_2$)	Clay (%)	Silt (%)	Sand (%)	Organic carbon (%)	Total N (%)	EC_{se} (dS/m)*
0-10	7.1	48	11	41	1.19	0.127	0.70
10-20	7.4	48	11	41	0.88	0.094	0.96
20-30	7.4	48	11	41	0.69	0.080	1.07
30-60	7.7	55	9	36	0.59	0.059	1.43
60-90	7.7	55	9	36	0.44	0.042	2.60
90-120	7.3	55	9	36	0.30	0.035	4.83
120-150	4.6	55	9	36	0.27	0.031	5.29

**Saturated Extract*

Results (1990-1993) Wheat and Chickpea Yields (t/ha). Wheat proteins (%) in parentheses.

TREATMENT	1989	1990	1991	1992	1993
NO-TILL					
Continuous Wheat	1.4 (11.9)	1.5 (10.1)	2.4 (9.7)	1.2 (11.0)	1.4 (9.6)
Chickpea/Wh/Wh/Wh/Chickpea	2.8 (C)	2.8 (9.9)	2.5 (10.2)	1.2 (10.6)	1.7 (C)
TREATMENT	**1993**	**1994**	**1995**	**1996**	**1997**
STUBBLE MULCHED					
Continuous Wheat	1.7 (11.1)	1.8 (9.5)	2.5 (10.2)	1.5 (10.7)	1.7 (9.0)
Chickpea/Wh/Wh/Wh/Chickpea	2.9 (C)	3.9 (9.8)	2.3 (10.7)	1.7 (10.9	1.3 (C)

(C) Chickpeas

Conclusions

- Chickpea in the rotation lifted wheat yield by an average of 1.7 t/ha and wheat proteins by 0.1% when no nitrogen was applied to the wheat.
- The major benefit of the chickpea was to increase nitrate levels at sowing. Average levels to a depth of 1.2 m were 51 kg N/ha after wheat and 89 kg N/ha after chickpea, a difference of 38 kg N/ha.
- Similarly there was more soil water after chickpea, compared with wheat. Average levels to 1.2 m depth were 143 mm after wheat and 160 mm after chickpea.
- Crown rot was substantially less in the wheat crop following chickpea (average of 16% incidence) than in the continuous wheat (40% incidence), suggesting that disease break was a significant effect at this site.
- No-till improved soil water levels at sowing. When averaged over all rotations, soil water levels to a depth of 1.2 m were 121 mm for no-till and 108 mm for stubble mulched.
- Chickpea yield benefited from the extra water (18 mm), averaging 2.3 and 2.1 t/ha for the no-till and stubble mulched treatments, respectively.
- Chickpea yields were 138% of wheat yields.

Project team

Warwick Felton, Harry Marcellos and David Herridge, NSW DPI, Tamworth

Summary Yields and proteins averaged over the two fallow management treatments.

	No Nitrogen	
	Yield (t/ha)	% Protein
Wheat (4*)	1.6	10.4
Chickpea (4)	2.2	
Wheat after wheat (2)	1.7	9.8
Wheat after chickpea (2)	3.4	9.9

**Number of crops in parenthesis*

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ADDITIONAL NSW TRIALS

Additional data on the benefit of chickpea was collected in earlier years of the long-term tillage experiments or at other sites that were discontinued after 1988. This data can be found in *Australian Journal of Agricultural Research*, 1998, Volume 49, pp 401 – 407, and *Proceedings 7th Australian Agronomy Conference Adelaide 1993*, pp 276-278.

Results Wheat and Chickpea Yields (t/ha). Wheat proteins (%) in parentheses.

	YEAR 1		YEAR 2	
	Wheat	Chickpea	Wheat after wheat	Wheat after chickpea
Croppa Creek 1987-88	2.1	1.5	1.3 (12.1)	3.0 (11.2)
Gurley 1987-88	2.1	1.3	1.1 (12.5)	1.8 (12.4)
Warialda 1987-88	2.8	2.6	3.1 (12.0)	4.3 (12.5)
Winton 1987-88	-	-	1.3 (11.0)	2.4 (11.6)
Windridge 1992-93	2.3 (12.3)	1.2	2.7 (9.7)	3.8 (11.9)
Windridge 1993-94	1.4 (9.7)	1.7	0.3 (12.1)	0.2 (12.5)

Summary Yields and proteins

	No Nitrogen	
	Yield (t/ha)	% Protein
Wheat (5*)	2.1	11.0
Chickpea (5)	1.7	
Wheat after wheat (6)	1.6	11.6
Wheat after chickpea (6)	2.6	12.0

**Number of crops in parentheses*

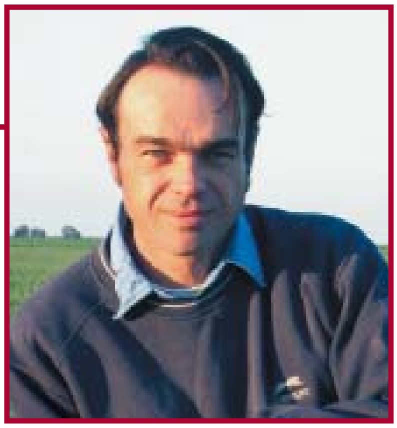
FARMING SYSTEMS EXPERIMENT—COONAMBLE (NSW)

This trial was located about 12 km east of Coonamble. There is no data presented for this site as data was insufficient to provide any worthwhile or useful comparisons. Only one chickpea crop was sown between 1998 and 2004 and the site suffered from drought in 2002, when chickpeas were to be sown.

FARMER CASE STUDY

NORTH STAR, NSW

"Chickpeas have been an important part of our farming system since the early 1980's"



Peter Schramm

Graham and Peter Schramm
"Kulai" North Star NSW

The first pulse crop grown on the property was narrow leaf lupins and the wheat that followed that lupin crop showed a significant yield response. This experience convinced Graham of the value of a pulse crop in the system and he was one of the early adopters when chickpeas became available.

Chickpeas have continued to be part of the system despite challenges in obtaining competitive gross margins in a country that has significant levels of subsoil constraints.

TYPE OF COUNTRY

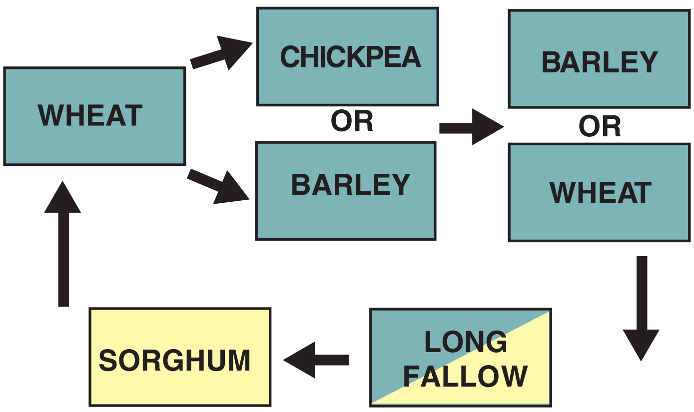
The property is situated east of North Star. Soils are predominantly a red clay loam and the original timber was brigalow-belah.

These red soils do not have the water holding capacity of the neighbouring darker clay soils.

Refer to *"The Challenge"*.

AGRONOMIST – Paul Castor, MCA Goondiwindi.

ROTATION



The choice of chickpea or barley in the second phase of the rotation will be dependent on gross margin prospects and soil types.

This rotations has been followed since 1997 and chickpeas grown every year since the early 1980's.

REASONS FOR ADOPTING THIS ROTATION

- Early experiences with both lupins and chickpeas clearly demonstrated the benefits offered to following cereal crops by a pulse crop.
- All crops are suited to the region.
- There is potential to significantly reduce herbicide costs.

PROVEN BENEFITS OF THE ROTATION

- Improved soil health.
- More effective weed control with a reduction in chemical use.
- A significant reduction in crown rot levels.

HAS GROWING CHICKPEA MEANT ADDITIONAL OVERHEAD COSTS?

Machinery – Some minor machinery modifications have been made to suit chickpea production.

Management and Labour – Whilst chickpeas require more intense management, this has not resulted in additional labour costs.

The challenge

On their red soils Graham and Peter have been a little frustrated with crops that look world beaters in August but do not yield as well as expected. This has resulted in some disappointing yields but the rotational benefits means chickpeas have been retained in the system.

Research by their agronomist looking at agronomic issues to improve average yields include planting times, row spacing and population etc.

The long history of chickpeas on the property has also meant that phytophthora has built up and is often reducing yields. New varieties in the coming years are expected to overcome most of these losses.

COOLIBAH LAND SYSTEMS—NINDIGULLY (QLD)

Land system

This rotation experiment was conducted on a heavy grey clay soil at Nindigully, 45 km south of St George.

The vegetation *at the trial site* is predominately coolibah *(Eucalyptus microtheca).*

Soil type

Cracking, heavy grey-clay (vertosol) with a clay content of 52% in the surface layers (0-10cm). Soil pH is 8.6 and bulk density 1.3 (0-10 cm).

PAW for wheat is 245 mm to a depth of 120 cm.

Organic carbon levels were 0.65% at the start of the trial in 1996.

Soil nitrogen mineralisation rates over the 6-month summer fallow only averaged 50 kg N/ha over the duration of the rotation trial. There was no significant difference between zero-till and cultivated fallows.

Over the 9 years, plant available water to a depth of 120 cm at sowing was 150 mm (range 60-215 mm) in the continuous wheat under zero tillage. Fallows maintained as zero-till accumulated an extra 20 mm of water than cultivated fallows.

Bicarbonate P levels are 9 mg/kg (0 -10 cm)

While soil EC's did increase significantly below 90 cm depth, this is mainly attributed to high calcium sulfate levels in the subsoil (gypsum). Neither subsoil EC's or ESP appeared to impact significantly on wheat or chickpea moisture extraction from depth.

Annual rainfall

Mean annual rainfall - 516 mm (1881-1996).

Rainfall during May-October (in-crop) averages 196 mm (38% of the annual rainfall).

Cropping history

The Nindigully rotation experiment was established in 1996 on country that had been under continuous cereal cropping since 1956 (40 years of cropping at the commencement of the trial). Wheat was the main cereal crop grown over this 40-year period.

Comments

This soil type is representative of the cultivated coolibah country used for wheat production in the border rivers region in southern Queensland and northern NSW.

Continuous cropping causes soil organic matter levels to decline and a gradual reduction in the amount of nitrogen available to the cereal crops.

Most grey clay soils are unable to mineralise sufficient nitrogen to meet crop requirements once they have been cropped for over 30 years.

- Nitrogen application rates varied from season to season and were adjusted according to both the supply of available water and nitrate nitrogen in the soil profile at planting (0-120 cm), The average rate of nitrogen applied was 90 kg N /ha (range 40 to 150 kg N / ha).
- Nitrogen rates used on the fertilised wheat crops following chickpeas averaged 70 kg N/ha (range 30-100 kg N/ha)
- Crops either failed or were not sown during the drought affected 2000, 2002 and 2003 seasons.
- The results presented above are for the zero tillage system.

Conclusions

- Chickpeas can lift wheat yields by 0.36 t/ha and protein by 1.2 % in situations where growers are not using nitrogen fertiliser on their wheat crops.

***Soil characterisation** (1996).*

Soil Depth (cm)	Bulk Density (Mg/m³)	pH (1:5 soil : water)	Clay (%)	Silt	Sand	Organic carbon (%)	Total N (%)	EC (mS/cm)	ESP	Sulfate -S (mg/kg)
0-10	1.30	8.6	52	14	34	0.65	0.07	101	3.8	15
10-20	1.42	9.0	53	15	32	-	-	109	6.2	6
20-30	1.42	9.0	53	15	32	-	-	109	6.2	6
30-60	1.47	9.2	55	14	31	-	-	183	11.7	25
60-90	1.53	8.8	54	15	31	-	-	587	15.5	679
90-120	1.60	8.1	54	16	30	-	-	1578	17.0	2067
120-150	1.65	-	-	-	-	-	-	-	-	-

- The full rotational benefits that chickpeas have on wheat yields were not fully realised in this trial because 40% of the wheat crops were preceded by drought induced long fallow. High rates of nitrogen were mineralised in these long fallows, which nullified most of the nitrogen benefits of chickpeas.
- Where wheat was only preceded by the planned 6 month summer fallow (1997-1999), chickpeas lifted wheat yields by 530 kg/ha and proteins by 2.7 %.
- The results indicate that the main contributor to increased wheat yield at this site is due to improved nitrogen supply.
- Crown rot did not appear to have a significant impact at this particular trial site location.
- Chickpeas yielded 1.89 t/ha over the duration of the trial (1997-2004), with an average water-use efficiency of 5.1 kg grain/mm water supply.
- Chickpea yields were generally 80% of wheat yields (without nitrogen fertiliser).
- This soil is not saline or acid at depth and would not have limited the chickpeas capacity to extract soil moisture from deep in the profile.
- At these relative yield levels, chickpeas were the most profitable winter crop option, as well as the most profitable farming system (rotation)
- There was no yield response in chickpeas to applied phosphorus or zinc at this site.

Project leader

Greg Thomas, Natural Resources & Mines (Qld), Toowoomba

Results (1997 - 2004)

Treatment	1997	1998	1999	2000	2001	2002	2003	2004	Average
Continuous wheat + 0 N	2.20 (7.7%)	1.12 (11.8%)	2.58 (8.0%)	—	2.78 (10.0%)	—	—	2.85 (14.1%)	2.31 (10.3%)
Continuous wheat + 90 kg N	2.93 (13.1%)	1.79 (13.8%)	4.02 (13.4%)	—	2.01 (14.8%)	—	—	3.36 (16.7)	2.82 (14.4%)
Wheat following chickpeas + 0 N	2.56 (10.6%)	1.57 (11.8%)	3.34 (9.5%)	—	3.03 (12.2%)	—	—	2.87 (13.2%)	2.67 (11.5%)
Wheat after chickpea + 70 kg N/ha	2.71 (12.0 %)	2.46 (13.4 %)	3.99 (13.6 %)	—	2.94 (14.3 %)	—	—	3.31 (15.7 %)	3.08 (13.8 %)
Chickpea	1.49	1.95	2.81	—	1.65	—	—	1.53	1.89

Summary of zero-tillage system (1997-2004)

	Yield	Protein (%)
Continuous wheat + 0 N	2.31	10.3
Continuous wheat + 90 N	2.82	14.4
Wheat after chickpeas + 0N	2.67	11.5
Wheat after chickpeas + 70 N	3.08	13.8
Chickpea yields	1.89	-

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Queensland Government Department of Primary Industries and Fisheries

MULGA LAND SYSTEMS—“MULGA VIEW”, (QLD)

Land system

This rotation experiment was conducted on a red earth soil type (Kandosol) at *“Mulga View”,* 30 km west of St George.

The vegetation *at the trial site* is predominately poplar box, which occurs in association with a mixture of mulga, silver-leaf ironbark, forest gum *and* cypress pine.

There is an understorey of wilga *(Geijera parviflora) and* false sandalwood.

This is undulating country with a slope of around 1%.

Soil type

The soil is a red earth, with a clay content of 12% in the surface layers (0-10cm). Soil pH is 7.0.

PAW for wheat is 105 mm to a depth of 120 cm.

Organic carbon levels were 0.58% at the start of the trial in 2001.

Bicarbonate P levels are 19 mg/kg (0 -10 cm).

This soil is not saline or sodic at depth.

Annual rainfall

Mean annual rainfall 516 mm (1881-1996).

Rainfall during May-October (in-crop) averages 196 mm (38% of the annual rainfall).

Cropping history

The “Mulga View” rotation experiment was established in 2001 on country that had been under continuous cereal cropping since 1980 (21 years of cropping at the commencement of the trial). Wheat was the main cereal crop grown over this 21 year period.

Comments

This soil type is representative of the cultivated red-earth mulga land systems used for wheat production in southern Queensland and north-western NSW.

- Drought has had a major impact on this trial since it was first commenced in 2001. Prolonged dry conditions have prevented the normal practice of only fallowing for 6 months over the summer period from one winter crop to the next.
- The dry conditions have resulted in most crops being preceded by long fallow periods of up to 18 months. This has nullified many of the rotational benefits normally associated with including chickpeas in the farming system
- Average yields for the three crops grown over the period 2001-2005 were:
  Wheat yields 1.5 t/ha (range 1.1— 2.0 t/ha)
  Chickpea yields 1.2 t/ha (range 0.6—1.7 t/ha)
- Interestingly, chickpea yields were 80% of wheat yields on these red-earth soil types. This was mainly in long fallow situations where higher than normal levels of nitrogen have been mineralised and which you would normally expect to heavily favour the cereal based system.
- This may be explained by the fact that these soils are not saline or sodic at depth, which would allow the tap-rooted chickpea plant to access soil water much deeper in the profile than in other soils which are saline at depth.

Project leader

Greg Thomas, Natural Resources & Mines (Qld), Toowoomba

GRDC Grains Research & Development Corporation

Queensland Government Department of Primary Industries and Fisheries

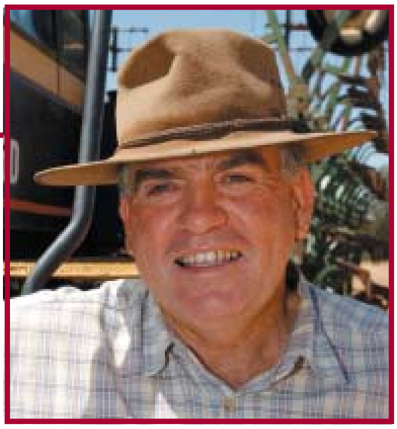
Soil characterisation (1990).

Soil Depth (cm)	Bulk Density (Mg/m^3)	pH (1:5 soil : water)	Clay (%)	Silt	Sand	Organic carbon (%)	Total N (%)	EC (mS/cm)	ESP	Sulphate -S (mg/kg)
0-10	?	7.0	12	6	82	0.58	0.03	0.03	0.2	3
10-20	?	7.4	15	5	80	0.30	0.02	0.02	0.2	2
20-30	?	7.4	15	5	80	0.30	0.02	0.02	0.2	2
30-60	?	7.5	19	3	78	-	-	0.04	0.2	4
60-90	?	8.0	22	3	75	-	-	0.07	0.2	6
90-120	?	8.3	23	4	73	-	-	0.09	0.3	2
120-150	?	8.5	24	3	73	-	-	0.11	1.2	2

FARMER CASE STUDY

TOOBEAH, QLD

"Since we started rotations in 2000 I have not had a bad chickpea experience"



Geoff Woods
Photo courtesy GRDC

Geoff and Mary Woods
"Coorangy" Toobeah QLD

Geoff was a traditional wheat farmer for 35 years, burning the stubble and cultivating. Stubble burning ceased but the stubble was still incorporated. In the 1990's he moved to zero till and with this change in farming practice he saw wheat diseases increase to an intolerable level.

This resulted in a move to a zone rotation system and the inclusion of chickpeas into the system.

Geoff has twice been the Goondiwindi area winner of the Pulse Australia Champion Chickpea Farmer.

TYPE OF COUNTRY

The property is situated north of Toobeah and some 100 km north west of Goondiwindi.

Soils are a brigalow-belah red-brown earth.

AGRONOMIST – Stuart Thorn, MCA Goodiwindi.

ROTATION

The current rotation which was adopted in 2004 is

GRAIN SORGHUM → LONG FALLOW → WHEAT → CHICKPEA → WHEAT → GRAIN SORGHUM

The reason for change is addressed in the section "Rotation Change".

It has been possible to follow the planned rotation each year since the rotation system was adopted in 2000, with the exception of the 2002 drought year.

REASONS FOR ADOPTING THIS ROTATION

- Any method of wheat stubble retention caused cereal diseases to increase to a level where a monoculture wheat system was not sustainable.
- The three crops used have a reliable track record on the property.
- The current rotation enables each crop to perform to its seasonal potential.

PROVEN BENEFITS OF THE ROTATION

- Improved soil health.
- The ability to use a range of weed control strategies resulting in more effective and economic weed control.

HAS GROWING CHICKPEA MEANT ADDITIONAL OVERHEAD COSTS?

Machinery – $400 spent to reconfigure a planter and $700 for new fingers for the header could hardly be considered prohibitive costs.

Management and Labour – Chickpeas certainly result in more management time and an increase in the number of operations, but this has not resulted in having to employ additional labour.

Rotation change.

As stated in the summary Geoff moved from a traditional wheat/sorghum production system to zero till, and then to a rotation involving sorghum and chickpeas.

His first rotation was

Grain Sorghum – Long Fallow – Wheat - Chickpea – Wheat – Wheat –

However, he found considerable downsides to growing consecutive wheat crops and moved to his current rotation. The problems Geoff experienced with consecutive wheat crops may be a carryover from the wheat monoculture days as there are still high levels of disease pathogens in the soil. This may change in time with the new rotation.

BELAH LAND SYSTEMS—BILLA BILLA (QLD)

Land system

This rotation experiment was conducted on a sodic red-brown earth at “Moruya”, Billa Billa, 40 km north of Goondiwindi.

The vegetation at the trial site is predominately belah (Casuarina cristata). There is some associated brigalow - *(Acacia harpophylla)* and poplar box *(Eucalyptus populnea)* and an understorey of wilga *(Geijera parviflora).*

The site had a slope of 1 %.

Soil type

The soil is a sodic red-brown earth, with a clay content of 35 % in the surface layers (0-10cm). Soil pH is 8.2.

The soil is sodic and hard setting in the surface layers, becoming increasingly sodic with depth. PAW for wheat is 180 mm to a depth of 120 cm. Organic carbon levels were 0.71% at the start of the trial in 1990.

Soil nitrogen mineralisation rates were still very high in this country that has only been cropped for 19 years. The available nitrate nitrogen in the soil (0-120 cm) at planting averaged 160 kg N/ha over the duration of the rotation trial. This is sufficient to support wheat yields of approx 4 t/ha without added nitrogen fertiliser.

Over the duration of the trial, plant available water to a depth of 120 cm at sowing was approximately 160 mm in the continuous wheat under zero tillage. Fallows maintained as zero-till accumulated an extra 20 mm of water than cultivated fallows.

Bicarbonate P levels are 7 mg/kg (0 -20 cm)

This soil was highly sodic and saline and would have limited the chickpeas capacity to extract plant available water from the subsoil.

Annual rainfall

Mean annual rainfall 620 mm.

Rainfall during May-October (in-crop) averages 236 mm (38% of the annual rainfall).

Cropping history

The Billa Billa rotation experiment was established in 1990 on country that had been under continuous cereal cropping since 1971 (19 years of cropping at the commencement of the trial). Wheat was the main cereal crop grown over this 19-year period.

Comments

This soil type is representative of the cultivated belah country used for wheat production in southern Queensland and northern NSW.

Soil characterisation (1990).

Soil Depth (cm)	Bulk Density (Mg/m³)	pH (1:5 soil : water)	Clay (%)	Silt	Sand	Organic carbon (%)	Total N (%)	EC (mS/cm)	ESP	Sulfate -S (mg/kg)
0-10		8.2	35	14	51	0.71	0.08	154	6.8	6
10-20		8.2	35	14	51	0.71	0.08	154	6.8	6
20-30		8.8	44	12	44	0.41	0.06	269	12.9	11
30-60		8.9	44	14	42	0.23	0.04	408	18.9	28
60-90		-	45	15	40	0.19	0.04	600	19.0	30
90-120		5.5	46	16	38	0.15	0.04	815	20.4	130
120-150		4.6	49	15	36	0.13	0.04	874	20.4	120

Results *(1992-1995)*

	1992	1993	1995
Continuous wheat + 0 N	2.10 (13.0 %)	1.61 (12.4 %)	2.61 (13.8 %)
Continuous wheat + 75 N	2.30 (13.7 %)	1.53 (14.2 %)	2.36 (14.6 %)
Wheat following chickpeas+ 0 N	2.69 (13.6 %)	2.33 (13.2 %)	2.84 (14.8 %)
Chickpea yields	0.93	1.50	1.52

- Soil nitrogen levels at planting were very high at this site (averaging 160 kg N /ha)
- Crops were not sown during the drought affected 2004 season.
- The results presented below are for the zero tillage system.

Conclusions

- This country had only been cropped for 19 years and consequently still had very high levels of soil nitrogen being mineralised during the fallow period.
- There was no significant yield response to applied nitrogen fertiliser.
- Chickpeas increased wheat yields by 0.51 t/ha and protein by 0.8 % in situations where no nitrogen fertiliser was applied to the wheat.
- The yield benefit derived from planting wheat after chickpeas at this site is largely due to a reduction in crown rot incidence.
- Chickpea yields averaged 1.32 t/ha over the duration of the trial (1992-1995).
- Chickpea yields were generally 63% of wheat yields grown without nitrogen fertiliser.
- This soil is sodic and saline at depth and would have limited the chickpeas capacity to extract soil moisture from deep in the profile.

Project leader

Greg Thomas, Natural Resources & Mines (Qld), Toowoomba

Summary of zero-tillage system (1992-1995)

	Yield	Protein (%)
Continuous wheat + 0 N	2.10	13.1
Continuous wheat + 75 N	2.06	14.2
Wheat after chickpeas + 0N	2.62	13.9
Chickpea yields	1.32	-

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FARMER CASE STUDY

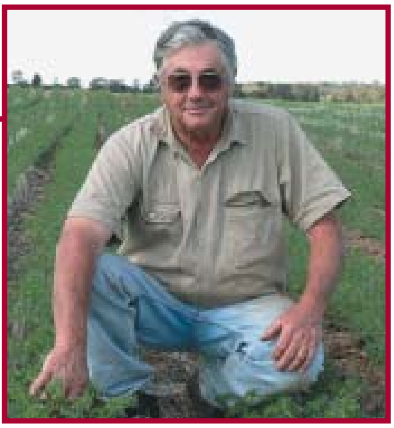
WALLUMBILLA, QLD

"Financially, chickpeas have provided good returns and they're ideal for wild oat control"

Tony farms 800 hectares, but is constrained from more extensive use of chickpeas due to isolation difficulties (ascochyta management).

He believes a set rotation is not always practical in his situation and paddocks are selected for chickpeas on the basis of their likely proximity to previous chickpea stubble and their 'ascochyta risk'.

The property has grown wheat for many years and chickpeas have been successfully included for the past 6 years.



Tony Bates
"Bengalla" Wallumbilla QLD

TYPE OF COUNTRY

The property is situated 60 km south east of Roma and comprises red, grey and black brigalow belah clay loams.

AGRONOMIST – Lindsay Ward.

ROTATION

As stated earlier there is no set rotation and chickpeas provide an occasional break from continuous wheat.

REASONS FOR ADOPTING THIS ROTATION

- To provide a break from consecutive wheat crops.
- Chickpea appeared to be a crop with proven potential.

PROVEN BENEFITS OF THE ROTATION

- Cost effective wild oat control, which has reduced weed control costs in subsequent wheat crops.
- Chickpea is a profitable crop in its own right.

HAS GROWING CHICKPEA MEANT ADDITIONAL OVERHEAD COSTS?

Machinery – Due to stones in the country, a flexi-coil roller was purchased to level the country after planting to facilitate harvest. Press wheels were purchased and due to the benefits experienced are now used for wheat and sorghum as well.

Management and Labour – No additional labour costs. However chickpeas do require additional jobs, for example almost a day to reconfigure the planter from wheat to chickpeas.

A wild oat control experience.

The benefits of the cost effective control of wild oats in chickpea and the subsequent savings in following wheat crops was confirmed by a recent experience. A paddock of chickpeas had a wild oat population in part and the rest appeared relatively free so only the infested area was sprayed.

A subsequent wheat crop required a more expensive wild oat control in the non sprayed area but not in the sprayed area.

FARMER CASE STUDY

MEANDARRA, QLD

"Financially chickpeas have held their own for six years and then you add the rotation benefits"

Robert Perkins
"Amaroo" Meandarra QLD

Some 15 years ago Robert and a neighbour were lamenting over common farming problems including problems with diseases and weeds in wheat and increasing erosion. Looking for answers they attended a CFI meeting in Dalby and were impressed with the confident presentation by agronomist Maurice Hayes, (Burr Cutter) on the benefits of zero till.

Robert returned home and commenced a minimum till regime which led to the incorporation of new crops and eventually he employed the services of agronomists, Michael Castor & Co to introduce a rotation.

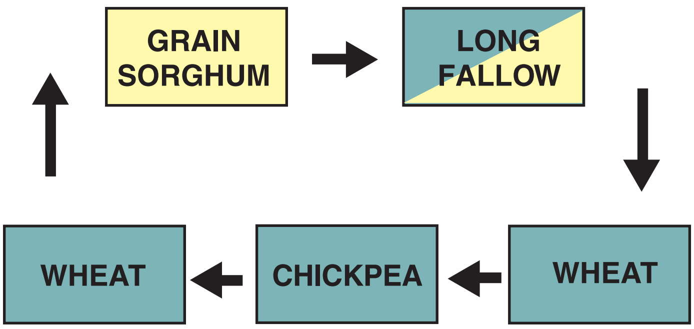
TYPE OF COUNTRY

The property is situated 55 km south of Meandarra. Soils are predominantly red/grey clay loam. The original timber comprised belah, wilga, some box and sandalwood and scattered brigalow.

AGRONOMIST – Stuart Thorn, MCA Goondiwindi

ROTATION

The current rotation which was adopted in 2004 is



The previous rotation included consecutive wheat crops and the second wheat was dropped to avoid issues of wheat on wheat.

The rotation is followed as closely as seasons allow, but wheat on wheat is totally avoided under any circumstances.

REASONS FOR ADOPTING THIS ROTATION

- To avoid consecutive wheat crops.

PROVEN BENEFITS OF THE ROTATION

- Wild oats no longer a major cost in our wheat enterprise.
- Disease break, there is little crown rot evident.
- The improved reliability of skip-row sorghum has considerably enhanced the system.

HAS GROWING CHICKPEA MEANT ADDITIONAL OVERHEAD COSTS?

Machinery – No

Management and Labour – No additional labour costs but growing chickpeas certainly results in more paddock spraying operations which can interfere with other work programs.

"There ain't no gain without pain."

CHICKPEA YIELDS

We have improved our chickpea agronomy and harvest efficiency and with new varieties such as Jimbour we have maintained good yields providing there is good starting moisture.

A good reason to avoid consecutive wheat crops.

A few years ago we had a fence dividing paddocks that had wheat and chickpeas in that year.

The next year one side of the fence was wheat following chickpea the other side wheat on wheat. The same variety of wheat was planted in both paddocks, at the same time.

The wheat after wheat paddock had a high level of crown rot and yielded three bags (0.6t/ha) less than the wheat after chickpea which had little crown rot. A further problem was the wheat on wheat had up to 10% screenings compared to only 3 to 4% for the wheat that followed the chickpeas.

A valuable lesson not forgotten.

BRIGALOW LAND SYSTEMS—WARRA, (QLD)

Land system

This rotation experiment was conducted on the *"brigalow floodplain"* at Warra, 80 km north-west of Dalby

The vegetation at the trial site was predominately brigalow *(Acacia harpophylla).* Belah *(Casuarina cristata) also occurs on lighter* "rises' throughout the district.

Soil type

Cracking, heavy grey-clay (vertosol) with a bulk density of 1.24 and a clay content of 56% in the surface layers (0-10cm). Soil pH is 8.6.

Moisture storage capacity (PAW) for these heavy brigalow clays is 235mm down to a depth of 120 cm.

Bicarbonate P levels at the commencement of the trial were 10 mg/kg (0-10 cm).

Organic carbon levels were 0.76% at the start of the trial in 1986.

Soil nitrogen mineralisation rates over the 6-month summer fallow only averaged 46 kg N/ha over the duration of the rotation trial. There was no significant difference between zero-till and cultivated fallows.

The soil becomes increasingly saline and acid below 90 cm depth. This is unlikely to have any effect on wheat yields and only minimal impact on soil water extraction and yield of the chickpeas.

Annual rainfall

Mean annual rainfall is 685mm (1890-1987).

Rainfall during May-October is 253mm on average (37% of the annual rainfall).

Cropping history

The Warra rotation experiment was established in 1986 on country that had been under continuous cereal cropping since 1935 (51 years of cropping). Wheat was the main cereal crop grown over this 51-year period.

Comments

This soil type is representative of 700,000 ha of cultivated brigalow country used for wheat production in north-eastern Australia.

Continuous cropping causes soil organic matter levels to decline and a gradual reduction in the amount of nitrogen available to the cereal crops.

Most Qld soils are unable to mineralise sufficient nitrogen to meet crop requirements once they have been cropped for over 30 years.

Over 500,000 ha of the arable cropping country in Qld has now been farmed for 50 years or longer, while over 1.3 million hectares has been cropped for over 30 years.

This main rotation trial was conducted on a reduced tillage system, where the fallows were maintained with a combination of tillage and herbicide sprays.

There was also a comparison of reduced tillage (cultivated fallow) and zero tillage systems for the various wheat based rotations.

Conclusions

- Chickpeas can lift wheat yields by 0.9 t/ha and protein by 1.5 % in situations where growers are not using nitrogen fertiliser on their wheat crops.
- The results indicate that the main contributor to increased wheat yield at this site is due to improved nitrogen supply.
- Chickpeas also provided benefits other than nitrogen supply. A further 0.3 t/ha in wheat yield has been derived from possible disease break effects (crown rot etc) and improved water supply to the wheat crop following chickpeas.
- Chickpeas left more soil water in the profile than wheat for the following crop. This averaged 23 mm per chickpea crop over the duration of the trial and was attributed to the presence of soil salinity at depth (below 90 cm). This could potentially increase yields of the following wheat crop by 0.2 to 0.3 t/ha.
- Crown rot did not appear to have a significant impact at this particular trial site location. This is difficult to explain.
- Chickpea yield averaged 1.3 t/ha over the duration of the trial (1988-95), with an average water-use efficiency of 5.9 kg grain/mm water supply. WUE varied markedly from year to year, ranging from 2.6 to 10.4 kg grain /mm.
- Chickpea yields were generally 60% of wheat yields.

Soil characterisation

Soil Depth (cm)	Bulk Density (g/cm³)	pH (1:5 soil : water)	Clay (%)	Silt	Sand	Organic carbon (%)	Total N (%)
0-10	1.24	8.6	56	17	27	0.74	0.072
10-20	1.27	8.9	57	16	27	0.63	0.056
20-30	1.28	9.0	57	15	28	0.59	0.046
30-60	1.36	9.0	59	16	25	0.51	0.036
60-90	1.42	7.7	63	17	20	0.42	0.026
90-120	1.43	5.3	65	16	19	0.37	0.020
120-150	1.45	4.9	66	15	19	0.33	0.021

Results (1988-1995).

Treatment	1988	1989	1990	1991	1992	1993	1994	1995	Average
Wheat + 0N	3.1 (8.3)	2.1 (8.0)	2.2 (8.3)	-	3.5 (10.8)	1.9 (9.6)	1.0 (8.6)	1.2 (11.8)	2.1 (9.3)
Wheat + 25N	4.4 (9.0)	2.6 (9.0)	2.8 (8.8)	-	3.7 (13.0)	2.0 (13.2)	1.4 (9.7)	1.1 (13.1)	2.6 (10.8)
Wheat + 75N	4.7 (12.9)	2.3 (14.5)	3.4 (11.8)	-	3.7 (13.5)	1.9 (15.1)	1.5 (13.2)	0.9 (13.9)	2.6 (13.6)
Wheat after chickpeas	4.6 (9.4)	2.9 (10.1)	3.6 (9.4)	-	4.2 (12.4)	2.2 (11.8)	1.6 (10.0)	1.8 (12.2)	3.0 (10.8)
Chickpea yields	2.4	1.2	1.2	-	1.9	0.9	1.1	0.4	1.3

	Cultivated fallow system	Zero-tillage system
Wheat + 0 N	2.1 (9.3 %)	2.2 (8.9 %)
Wheat + 25 N	2.6 (10.8 %)	2.7 (10.2 %)
Wheat + 75 N	2.6 (13.6 %)	2.9 (12.6 %)

Summary (1988-1995).

	Cultivated fallow		Zero tillage fallow	
	Yield	Protein	Yield	Protein
Continuous wheat+ 0 Nitrogen	2.1	9.3	2.2	8.9
Continuous wheat+ 30 kg Nitrogen	2.6	10.8	2.7	10.2
Continuous wheat+ 50 kg Nitrogen	2.7	12.0	-	-
Continuous wheat+ 75 kg Nitrogen	2.6	13.6	2.9	12.6
Wheat + O Nitrogen following chickpeas	3.0	10.8	-	-
Chickpea yields	1.3			

Project leader

Ram Dalal, Principal Scientist, Natural Resources and Mines, Indooroopilly, Brisbane Qld.

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FARMER CASE STUDY

JANDOWAE, QLD

"We never plant the same crop back to back, moisture is our main limitation for yield, not diseases or weeds"

Russell Bach
"Lauriedale" Jandowae QLD

In the 1970's Russell's father Bill was having trouble with nematodes and his wheat yields were suffering significantly.

He contacted Queensland DPI&F Research Agronomist, John Thompson who advised, "to overcome the problem you should be growing other crops as well as wheat". Bill tried a range of crops and they quickly moved to a rotation farming system.

TYPE OF COUNTRY

There are two properties. The Macalister property is situated 30 km north west of Dalby and comprises a treeless plain with a heavy self-mulching black earth.

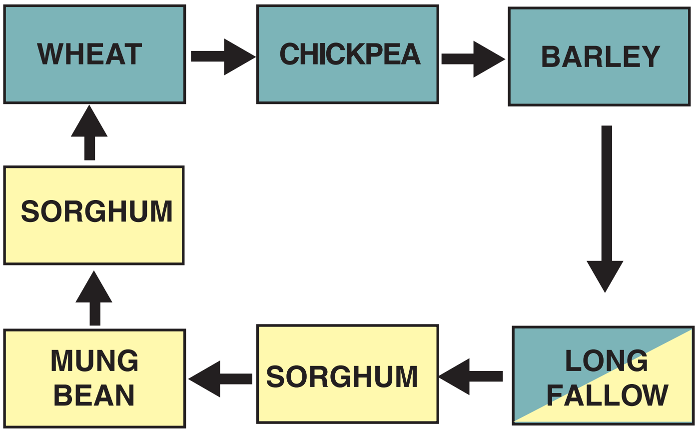
The Jandowae property 50 km north of Dalby comprises a mix of box/belah heavy clay and brigalow/belah clay loam soils.

There are no known constraints to chickpea production.

AGRONOMIST – Tony Lockrey, Total Ag.

ROTATION

For the past 10 years Russell has followed the following rotation, where the same crop is never planted back to back.



Harsh seasonal conditions such as in 2005, do not always allow the rotation to be followed. The 2005 season is an example of the flexibility combined with the rigidity of the system. The chickpeas could not be planted due to the late break, so the chickpea country will be planted to sorghum and the rotation will then continue as outlined above.

This means that the objectives of the rotation are not compromised and seasonal conditions are used to best advantage.

REASONS FOR ADOPTING THIS ROTATION

- For reasons outlined in the summary.
- All crops are well suited to the region. Sorghum forms the basis of the cropping system.

PROVEN BENEFITS OF THE ROTATION

- Each crop has the optimal opportunity to perform to its potential.
- Growing seed wheat is made easier with no wild oats.
- In dry winters chickpeas excel, eg in 2004 the chickpeas yielded 1.75 t/ha compared to wheat at 2 t/ha.

HAS GROWING CHICKPEA MEANT ADDITIONAL OVERHEAD COSTS?

Machinery – No new equipment or modifications have been required.

Management and Labour –No additional labour costs, but a little extra effort required.

This rotation spreads risks.

All crops contribute to both the system and to farm profitability. No one crop provides the best return each year so the crop mix provides a spread of marketing risk.

The mix of cereals and legumes also ensures that good stubble coverage is maintained.

Being all grain crops means there is no need for any specialized machinery.

FARMER CASE STUDY

GINDIE, QLD

"If we have subsoil moisture come Anzac Day we cannot afford not to plant chickpeas"

With father Ross and brother Scott, Andrew crops up to 4,000 hectares and has been growing chickpeas for many years. Andrew aims to plant 60% winter crops and 40% summer crop but recent seasons have seen many plans changed. Consistent with this region, there is no set rotation other than that chickpeas are an important crop in their farming system.

Andrew Bate
"Bendee" Gindie QLD

TYPE OF COUNTRY

The property is located 25 km south east of Emerald in central Queensland. There are two dominant soil types. A soft red clay loam which was originally a Bendee brigalow, yellow wood and bone wood scrub and a Downs black self mulching clay which originally was a semi open grass plain.

AGRONOMIST – Graham Spackman.

ROTATION

Typical of Central Queensland farmers, Andrew considers flexibility is the key in this region and does not have a set rotation. He does however, have a strategy and will plant chickpeas under the following situations

- Paddocks running low in nitrogen.
- Generally into wheat stubble, but can also be into a sorghum fallow.

REASONS FOR INCLUDING CHICKPEAS in the FARMING SYSTEM

- Chickpeas, in our experience can always be deep planted (See Chickpea experiences).
- Their soil nitrogen contribution.
- Chickpeas grow extremely well in CQ.
- A readily marketable crop.

PROVEN BENEFITS OF CHICKPEAS

- The ability to be able to plant almost every year, even without a planting rain.
- Weed control with simazine has been excellent. We wish weeds could be as easily controlled in other crops.
- There are marketing options available.
- Having a legume in the system.

HAS GROWING CHICKPEAS MEANT ANY ADDITIONAL OVERHEAD COSTS

Machinery – We have built a set of heavy rollers to level the country after deep planting. This is done to facilitate harvest.

Developed a special inoculum applicator for the airseeder which is currently being evaluated by the QDPI&F.

We utilise an existing feedlot mixer to apply P-Pickle-T to seed.

Management and Labour – More than required for other crops, but move staff to the task of the day.

Chickpea experiences.

Over the years chickpeas have proven to be a consistent crop for us, some examples include:-

In 2004 our last summer rain was in February, and after Anzac Day we were still able to deep plant chickpeas but not wheat. The chickpeas yielded 0.9 t/ha with no rain on crop except just before harvest

In 2001, we had both chickpeas and wheat in the same country and the chickpeas outyielded the wheat. The chickpeas yielded 1.65 t/ha and the wheat 1.54 t/ha

Provided we have some good soil moisture, similar to that you would require for sorghum, chickpeas will succeed.

Levelling after planting is essential.

FARMER CASE STUDY

DINGO, QLD

"Chickpeas are very profitable with yields ranging from 80% to over 100% of wheat"

Sandy Bauman

Sandy and Robert Bauman
"Karamarra" Dingo QLD

Sandy and Robert farm 3,000 hectares with the aim of 50% each to summer and winter crops.

The dry and variable seasons of the past decade have not allowed a set rotation to be followed as plantings are very moisture dependent. Chickpeas average one third of the winter crop area.

TYPE OF COUNTRY

Dingo is situated midway between Emerald and Rockhampton. The property is situated north east of Dingo on the Dawson River and the soils are a deep self mulching brigalow clay loam.

There are no obvious subsoil constraints and there are still no responses to N or P from either winter or summer cereals.

AGRONOMIST - John Kelleher.

ROTATION

The seasons have not allowed the following of any set rotation.

REASONS FOR INCLUDING CHICKPEAS in the FARMING SYSTEM

- Chickpeas are obviously well suited to the Central Queensland environment.
- The ability to deep plant chickpeas into summer retained soil moisture.
- With a chickpea yield range from 80% to over 100% of wheat, the crop can be very profitable.

PROVEN BENEFITS OF CHICKPEAS

- In a good season, chickpeas will outyield wheat.
- Chickpeas are effective in opening up the soil.
- Crops following chickpeas are always better.
- We still do not use fertiliser and chickpeas are one of the reasons for this.
- Choice of markets.

HAS GROWING CHICKPEA MEANT ADDITIONAL OVERHEAD COSTS?

Machinery – Whilst no machinery has been purchased for chickpea production, a boomspray has been modified to improve the application of insecticides. This has also been of benefit to other on-farm spray operations.

Management and Labour – Chickpeas have meant more detailed and time-consuming management and operations when compared to the other crops grown.

These activities include different planter setups. However this has not resulted in any additional labour costs.

Learning by experience.

In late 1998 it was necessary to plant one paddock back to wheat to balance up the areas to each crop following the acquisition of additional land.

It was a very wet spring and the wild oats got away. Since then it has been expensive to control the wild oats in that paddock and even in 2004, spot spraying was still necessary.

Planting a winter cereal into winter cereal stubble in the future would be a last resort decision

Ground Cover DIRECT

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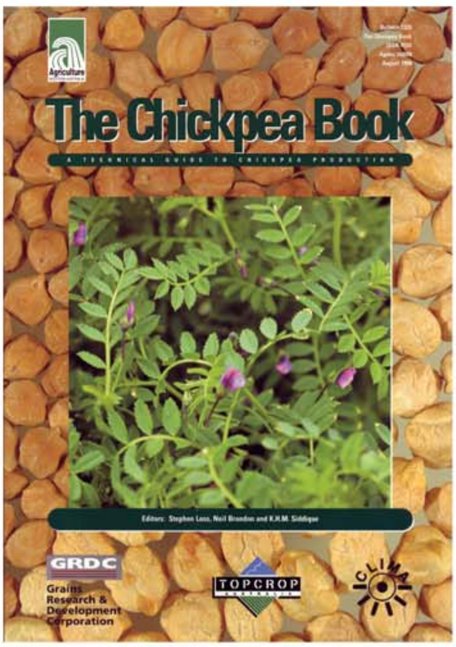

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