# Matching New Pulse Varieties to New Systems

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## INTRODUCTION

Pulses are now an integral part of sustainable cropping systems in south-eastern Australia, delivering significant rotational, economic and environmental benefits to growers. Frequent cereal cropping in many areas results in declining soil fertility, build up of grass weeds and increasing levels of soil borne diseases leading to low cereal yields. To increase the frequency of pulses in rotation it is important that we continue to improve the profitability, reliability and sustainability of pulses in modern farming systems through targeted research and development.

Modern farming systems offer many new opportunities and challenges for pulse breeding and agronomy. Conservation practices including no-till cultivation with press wheels, controlled traffic, wider row spacing's and stubble retention have been widely adopted by farmers in south-eastern Australia. However, current pulse varieties have been developed from breeding and agronomic research under traditional cultivation practices including, stubble burning or removal, narrow row spacings and harrows for soil levelling. It is suggested that these varieties will not have the complete package of traits best suited to modern systems.

Pulse breeding and agronomy programs are now identifying and incorporating new genes/traits into varieties that can have significant beneficial impacts on the farming system. In this paper we discuss the importance of pulses in modern farming systems and some key components of the modern no-till system that potentially impacts variety development. We also present some preliminary data and current research from the pulse agronomic research program in south-eastern Australia which is addressing these issues.

## PULSE BENEFITS TO THE CROPPING SYSTEM

The benefits of pulse cropping systems have been well documented in Australia over many years (Armstrong 1998, Angus 2002). Panagiotopoulos (2002) stated that pulse crops benefited following cereal and oilseed crops by an order of over $300 million in the 2001 cropping season, equivalent to almost 30% of the total value of the Australian pulse crop that year. The key benefits of pulses in sustainable farming systems can be summarised as follows:

**Economic -**
Pulses can provide significant returns to farmers and in many of the key production regions growers rotate the cereal phase around high value pulse crops. In these regions, an average 2.0 t/ha lentil crop can result in profits exceeding $1200/ha. A wheat crop would need to yield greater than 4.0 t/ha to equal these returns. In addition, many growers have found significant value in grazing pulse stubbles. Sheep and cattle show a higher growth rate when grazed on pulse stubble than when fed on crops such as barley stubble.

**Higher cereal yields (Table 1) through -**

A. ‘Disease break’ – pulses, when grown in rotation, are effective in controlling major cereal root diseases such as cereal cyst nematode and take-all. They can also provide improved control of root lesion nematode if a resistant species or variety is grown.

B. ‘Improved weed control’ – this particularly applies to the problem grass weeds (e.g. annual ryegrass, wild oats and brome). Grass specific herbicides (Group A) can be applied in-crop. In addition, wickwiping (lentils and potentially chickpeas) and crop-topping (desiccation) (peas, beans, lentils) can be used to kill grass weeds that are resistant to the Group A herbicides. In some cropping regions wheat is now seen as the weak link in resistant ryegrass control due to its relative low level of crop competitiveness and the absence of effective chemical controls.

C. 'Spread management windows' – pulses, due to their divergent growth and development, allow sowing, spraying and harvest windows to be widened, allowing for more efficient and timely use of farm machinery. For example pea can be sown later and chickpeas harvested later than cereal crops.

D. 'Improved nutrition' – as pulses fix their own nitrogen (N), no N inputs are required. In many cases the pulse will also contribute significant N to following cereal crop. Some studies have also shown this improved nutrition in the cereal can increase grain protein content by 0.5-1.8%.

**Table 1. Yield of wheat grown after pulse crops from a survey of published Australian experiments[1]**

| Previous crop | Yield as a % of wheat after wheat | No. of comparisons |
|---|---|---|
| Wheat | 100 | |
| Lupin | 146 | 75 |
| Fieldpea | 142 | 52 |
| Chickpea | 153 | 4 |

1. Angus, J. (2002). Opportunity cropping. GRDC Crop research Update, Birchip, 2002.

## MATCHING VARIETIES TO MODERN FARMING SYSTEMS

It is well known that genotypes perform differently in different environments. '*Genotype*' refers to the genes or traits that make up the variety's characteristics (e.g. tolerance to disease or abiotic constraints, flowering, growth habit etc). '*Environments*' refer to where the crop is grown and vary across regions but also within regions based on factors such as soil type or yearly variations in factors like rainfall, temperature and disease, rainfall or farmer management practices. To match varieties to modern farming systems, understanding the interaction between genotype and management (GxM) is essential. '*Management*' refers to all the components of the farming system that we can control that may alter the performance of a variety (e.g. herbicide/fungicide application, sowing time, plant density, row spacing, stubble management etc.). The way genotypes respond to different management practices can also vary across years.

In modern pulse agronomy research we investigate both the *impact of farming systems (M) on genetics (G) and the impact of genetics (G) on farming systems (M).*

*1. Impact of farming systems (M) on genetics (G)*

Breeding is a long term process and often old agronomy has been used to select varieties that will be grown in contrasting new systems. For example, no-till cultivation and stubble retention practices are being widely adopted in south-eastern Australia. Traditional varieties have come from breeding trials where stubble has been burnt and may not have the complete package of traits best suited to these systems. New farming systems offer challenges but more importantly new opportunities for breeding. Genes or traits that confer an advantage in new farming systems can be identified and incorporated into varieties that further enhance the profitability of the overall farming system.

*2. Impact of genetics (G) on farming systems (M)*

Genes (or traits) introduced by crop breeders can have significant impacts on the overall profitability and sustainability of the farming system. We need to understand and maximise these potential benefits by using the most appropriate agronomic management practices. Through Pulse Breeding Australia (PBA) several new novel agronomic traits are available or under development that will improve yield and adaptation. By exploring the impact of these new varieties in various farming systems breeders can be supplied with information on the value of new traits and how important they are among many breeding objectives. For example, several weed management traits are available, including herbicide tolerance (e.g. group B tolerant lentils), early maturing lentils, chickpeas or field peas for crop-topping and reduced height and evenness of canopy chickpeas for wickwiping.

## COMPONENTS OF THE MODERN NO-TILL FARMING SYSTEM THAT MAY IMPACT VARIETY DEVELOPMENT

Modern no-till farming systems have several key components that differ from conventional systems and may affect the type of variety that produces maximum yield and profitability. These include:

a. ‘Row spacing’ tends to be wider, often to aid with stubble management.
b. ‘Standing stubble’, particularly with interrow sowing; can also aid with lodging resistance.
c. ‘Sowing dates’ used are often earlier.
d. ‘Plant densities’ differ and are often reduced per unit area due to fewer rows but potentially greater number of plants per row.
e. ‘Herbicide usage’ and ‘weed management’ practices are altered to allow for ‘one pass’ cropping. In many cases herbicides are all applied pre-sowing.

Potential traits that may be valuable in no till systems are listed in Table 2 below.

Table 2. Aspects of the no till systems and potential traits that may provide yield improvements or improve management in no till systems. These traits are hypothetical and their benefit in the actual system is currently being investigated.

| System feature | Potential traits |
|---|---|
| Wide rows | Early vigour, lodging resistance, increased canopy width and biomass |
| Standing stubble | Increase height, early vigour |
| Sowing time earlier | Disease resistance, herbicide tolerance, flowering and maturity later |
| Herbicide usage and problem weed control | Early maturity chickpeas (crop-topping), reduced height chickpeas (wickwiping), improved herbicide tolerance including tolerance to group B chemicals (in crop use of imazadoline and sulfonurea residues). |

## 2007 RESEARCH TRIALS

In 2007, a preliminary trial was sown to investigate the adaptability of a range of lentil varieties to inter-row sowing in wider row spacings and conventional cropping systems. This trial is a comparison of two systems and not just row spacing as sowing methods and chemicals were not identical, i.e. in the wider row spacings plots were sown with narrow lucerne points, press wheels and herbicides were applied pre-sowing. The narrow row spacing’s plots were sown with narrow lucerne points, harrows and herbicides were applied post-sowing, pre-emergent.

### Methods

*Site details*
Site location: Dimboola, approximately 30 km north west of Horsham.
Soil Type: Black cracking clay and red rise.
Cropping History: 2007 – Lentils; 2006 – Barley; 2005 – Chickpeas; 2004 – Barley; 2003 – Fenugreek.
Tillage practise on farm: No-till, inter-row sowing, 30 cm row spacing.

*Varieties*
Varieties and lines were chosen to represent the range of growth habits, plant heights and flowering/maturity times available in the PBA lentil breeding program (Table 3). Growth habits vary

from prostrate to erect, tall to short, bushy to ‘stick like’, multi branching to few branches. Pod location in the canopy also varies.

*Treatments*

1. Inter-row, 30 cm row spacing, standing stubble (approximately 10-15cm high)
2. Inter-row, 30 cm row spacing, slashed stubble
3. 19 cm row spacing, slashed stubble

*Agronomic management details*

Plot size: 8 m x 1.5 m
Fertilizer: Grain legume super + 2% Zn (0:15:7) at 60 kg/ha.
Replicates: 4
Herbicides: Pre-sowing (2 weeks prior): glyphosate 450 @ 1500 mL/ha + carfentrazone-ethyl 240 @ 65 ml/ha. Pre sowing (on day of sowing): simazine 900 @ 1000 g/ha. Post emergent: diflufenican 500 @ 50 g/ha + flumetsulam 800 @ 20 g/ha + wetter.
Insecticides and Fungicides: Applied as required unless indicated in treatments.
Target plant density: 120 plants/$m^2$

**Results**

*Climate*

The season was characterised by an excellent early break in late April/early May (generally greater than 75 mm rainfall), followed by a relatively dry winter and spring. Maximum temperatures were generally slightly above average and minimum temperatures below average. Several maximum temperatures were recorded above 25°C in September and October, with the hottest day being 36.1°C on October 21. There were few significant frosts recorded during the flowering and podding periods of the lentils (September 25, October 2 and 8 at -0.2 °C). Rainfall was well below average for the growing season, but close to average annually, due to high summer rainfall (Table 4). Overall climatic conditions in 2007 were more similar to those experienced in northern cropping regions of Australia where crops are grown on stored moisture rather than in-crop rainfall.

Table 4. Monthly rainfall, growing season rainfall (GSR) and total rainfall (mm) at Dimboola in 2007 compared with long term averages

| Month | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | GSR (M-O) | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2007** | 64.4 | 23.2 | 8.8 | 89.8 | 65.4 | 5.4 | 33.4 | 6.2 | 10.6 | 6.2 | 41.6 | 23 | 127.2 | 378 |
| **Average (Horsham)** | 23.2 | 24.8 | 23 | 31.7 | 46.6 | 50 | 46.8 | 49 | 46.2 | 44 | 33.7 | 27 | 281.9 | 446.1 |

1. Underlined figures sourced from Bureau of Meterology (Horsham for Dimboola site)

*Plant growth and grain yield*

- Plant establishment – Most varieties established between 85 and 90 plants/$m^2$, Nipper was slightly higher at 100 plants/$m^2$ and CIPAL415 and Northfield significantly lower at 65 plants/$m^2$. There was no effect of system on emergence.
- Flowering – Row space had no impact on flowering date. Flowering dates of varieties were as follows: CIPAL411 (22 Sept), Boomer (23 Sept), CIPAL607 (24 Sept), Nugget and Aldinga (26 Sept), Nipper and CIPAL415 (28 Sept), and Northfield (30 Sept).
- Height – Generally crop height (top of canopy) and height of the lowest pod were greater in the 30 cm row spacing’s compared with 19.5 cm spacing’s (Table 5). In particular, height to lowest pod was increased by at least 20% in most varieties. The only variety to show no significant response to row spacing was CIPAL411. Boomer was the tallest variety followed by Nugget and CIPAL411. The increased height could have been because wider rows had a greater number of

plants per metre of crop row, thus increasing interplant competition for light and increasing height, or may have been due to the effects of stubble on growth. This will be tested in further experiments where row densities between systems are kept the same.

- Biomass – No major differences in biomass were noted between the row spacing treatments. CIPAL411 generally produced the most biomass, followed by Boomer and Nugget (data not shown). Northfield and Aldinga produced the least biomass.
- Grain Yield – Grain yields averaged approximately 25% higher in the plots sown at 30 cm row spacing's (standing) compared with 19.5 cm row spacing's (Table 6). Across the varieties, improvements in yield ranged between 15% (Northfield) and 50% (Aldinga). Harvestability was also much easier in the 30 cm row spacing's, as plants tended to be more erect and did not lodge.

Table 5. Total crop height (to top of canopy) and height of lowest pod at harvest for lentil varieties grown in 19.5 cm and 30 cm row spacing's at Dimboola in 2007

| **Stubble** | **Aldinga** | **Boomer** | **CIPAL411** | **CIPAL415** | **CIPAL607** | **Nipper** | **Northfield** | **Nugget** | ***Mean*** |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *Crop height (cm)* | | | | | |
| **Slashed 19.5 cm** | 17.5 | 20.3 | 21.3 | 15.5 | 18.0 | 18.3 | 16.8 | 20.0 | *18.4* |
| **Slashed 30 cm** | 18.5 | 22.5 | 21.8 | 16.8 | 19.0 | 19.3 | 17.3 | 21.5 | *19.6* |
| **Standing 30 cm** | 19.0 | 22.5 | 21.0 | 17.5 | 18.5 | 19.0 | 17.0 | 21.3 | *19.5* |
| ***Mean*** | *18.3* | *21.8* | *21.3* | *16.6* | *18.5* | *18.8* | *17.0* | *20.9* | |
| **lsd (P=0.05)(RSxVar)** - ns | **lsd (P=0.05) (RS)** – 0.8 | | **lsd(P=0.05) (Var)** – 1.1 | | | | | | |
| | | | | *Height to lowest pod (cm)* | | | | | |
| **Slashed 19.5 cm** | 6.3 | 9.0 | 10.0 | 4.8 | 7.0 | 8.8 | 6.3 | 8.5 | *7.6* |
| **Slashed 30 cm** | 8.8 | 11.3 | 10.8 | 6.8 | 9.3 | 9.8 | 7.8 | 10.5 | *9.3* |
| **Standing 30 cm** | 9.5 | 11.8 | 9.8 | 6.5 | 8.0 | 9.5 | 8.3 | 10.8 | *9.3* |
| ***Mean*** | *8.2* | *10.7* | *10.2* | *6.0* | *8.1* | *9.3* | *7.4* | *9.9* | |
| **lsd (P=0.05) (RSxVar)** – 1.4 | **lsd (P=0.05) (RS)** – 0.8 | | **lsd(P=0.05) (Var)** – 0.8 | | | | | | |

Table 6. Grain yield (t/ha) of lentil varieties grown in 19.5 cm and 30 cm row spacing's at Dimboola in 2007

| **Stubble** | **Aldinga** | **Boomer** | **CIPAL411** | **CIPAL415** | **CIPAL607** | **Nipper** | **Northfield** | **Nugget** | ***Mean*** |
|---|---|---|---|---|---|---|---|---|---|
| **Slashed 19.5 cm** | 0.47 | 0.65 | 0.74 | 0.46 | 0.46 | 0.48 | 0.29 | 0.57 | 0.51 |
| **Slashed 30 cm** | 0.71 | 0.77 | 0.67 | 0.56 | 0.63 | 0.60 | 0.38 | 0.65 | 0.62 |
| **Standing 30 cm** | 0.71 | 0.78 | 0.92 | 0.61 | 0.56 | 0.67 | 0.32 | 0.70 | 0.66 |
| ***Mean*** | 0.63 | 0.73 | 0.78 | 0.54 | 0.55 | 0.59 | 0.33 | 0.64 | |
| **lsd(P=0.05) (RSxVar)** – ns | **lsd(P=0.05) (RS)** – 0.1 | | **lsd (P=0.05) (Var)** – 0.1 | | | | | | |

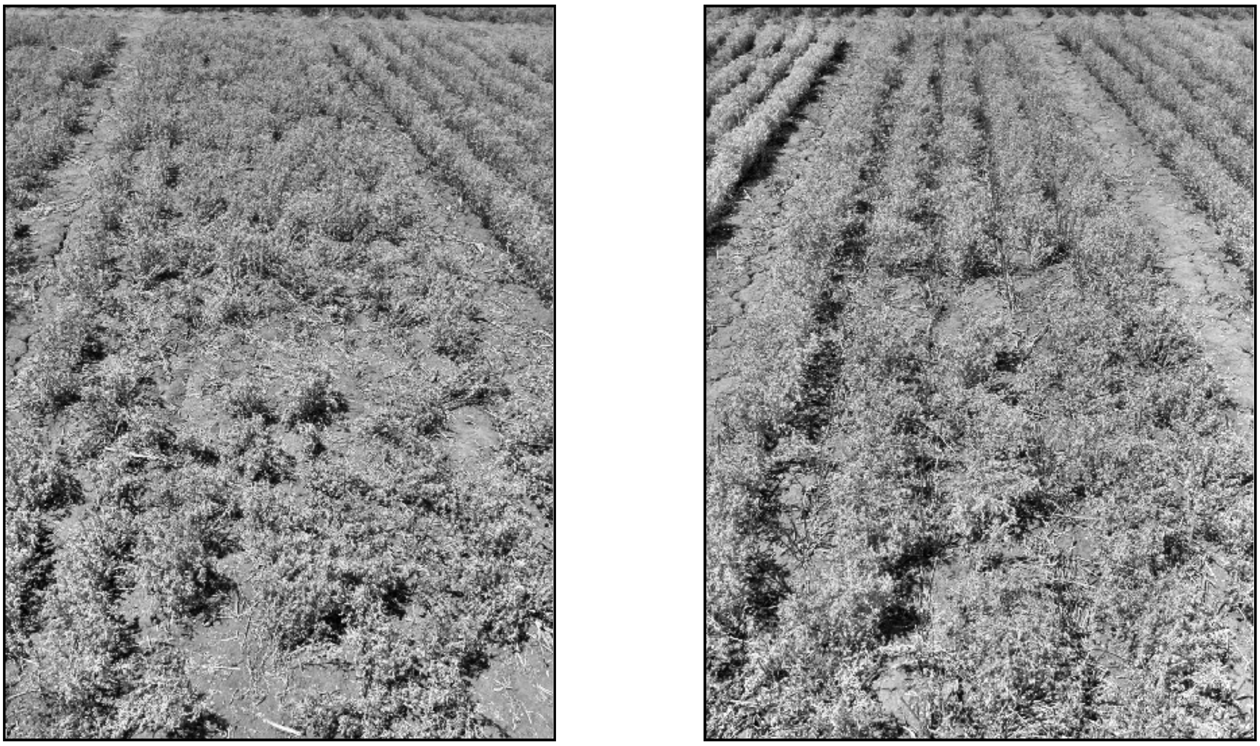

Figure 1. Improved harvestability in wider rows.
Aldinga in row space trial at Dimboola at harvest (bottom). Left – 30 cm row spacing, inter row into standing stubble; Right – 20 cm row spacing in slashed stubble.

## 2008 RESEARCH TRIALS

In 2008, trials have expanded to encompass a wider range crops, treatments, varieties and locations. Both lentils and chickpeas are being sown, with a wider range of varieties and breeding lines investigated. More specifically, selections were made in 2007 from breeding trials of lines with additional traits to the varieties sown in 2007 that may show response to wider, inter-row sowing into standing stubble. Two sites have been sown, one in the Wimmera (Horsham) and another in the southern Mallee (Curyo, 20 km NW of Birchip). Treatments that have been added are summarised below:

*Row Spacing*
1. Inter-row, 30 cm row spacing, standing stubble (approximately 15 cm height)
2. 19 cm row spacing, slashed stubble
3. Inter-row, 30 cm row spacing, slashed stubble (Horsham only)
4. Inter-row, 60 cm row spacing, standing stubble (approximately 15 cm height; Chickpeas only)

*Sowing dates*
Mid/late May and Late June

*Plant Density*
Four varieties have been sown at additional densities, 30% above and below the target plant density.

Full details of these trials will be available in presentation at conference (available on website).

## CONCLUSION

- Grain yields averaged approximately 25% higher in plots sown on 30 cm the row spacing system (standing stubble) compared with the 19.5 cm row spacing system. Varieties responded differently to changes in row spacing with yield improvements ranging from 15% (Northfield) - 50% (Aldinga). (Table 6)
- It was notable that in terms of grain yield the variety most susceptible to lodging, Aldinga, showed the greatest response to wider row sowing. The vigorous, taller new varieties such as Boomer appear to be well suited to wide rows and standing stubble, which provides a trellis to improve harvestability.
- Research is continuing and expanding to encompass a wider range of breeding lines and to the other pulses crops

## REFERENCES

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Armstrong (1998). 'Pulses increase profitability of winter crop rotations in southern NSW', Proceeding of the 9th Australian Agronomy Conference, Wagga, pp510-2).

Panagiotopoulos (2002). More to Pulses than Money.

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**Table 3. Disease and agronomic characteristics of lentil varieties and advanced breeding lines used in trials**

| | | Ascochyta Blight | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Name** | **Seed Type** | **Foliage (c)** | **Seed (d)** | **Botrytis Grey Mould (e)** | **Vigour #** | **Lodging Resistance#** | **Pod Drop #** | **Shattering #** | **Flowering Time #** | **Maturity** | **Comments** |
| **Aldinga** | Red | MR | MS | MS | Mod | S | MR | MR | Mid | Mid | tall |
| **Northfield** | Red | R | R | S | Poor/Mod | MS | MR | MS | Mid/Late | Mid | short |
| **Nugget** | Red | MR/R | MS/MR | MR* | Mod | MS/MR | MR | MS | Mid | Mid/Late | |
| **Nipper** | Red | R | R | R | Poor/Mod | MR | MR | MR | Mid/Late | Mid | short/erect |
| **Boomer** | Green | MR/R | MS | MR | Good | MS | S | MS | Mid | Late | tall/bulky |
| **CIPAL411** | Red | MR | MR | S | Mod | MR | MR | MR | Mid | Early/Mid | erect/high pods |
| **CIPAL415** | Red | MR | MR | MS | Mod | MS | MR | MR | Mid/Late | Mid | prostrate/many branches |
| **CIPAL501** | Red | MR | MR | MR | Mod | MS | MS | MR | Mid | Mid/Late | |
| **CIPAL607** | Red | R | R | R | Poor/Mod | MS | MR | MR | Mid/Late | Mid/Late | |
| **CIPAL611** | Red | R | R | MR | Mod | MR | MR | MR | Mid/Late | Mid | |
| **CIPAL801** | Red | R | R | | Mod | R | MR | MR | Mid | Mid | |
| **CIPAL802** | Red | R | R | | Mod | R | MR | MR | Mid | Mid | |
| **CIPAL803** | Red | R | R | | Mod | MR | MR | MR | Mid | Mid | |
| **99-088L*02H051** | Red | | | | | | | | | | |

R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible; # Ratings relative to Nugget