Chickpea concurrent session

Management impacts on N fixation of mungbeans and chickpeas

Nikki Seymour¹, RCN Rachaputi² and Richard Daniel³

¹ DAFF, Toowoomba, ² QAAFI, Kingaroy, and ³ Northern Grower Alliance

Key words

Nitrogen fixation, nodulation, rhizobia, row spacing, soil nitrate

GRDC code

DAQ00181, UQ

Take home messages

- Changes to agronomy can change N fixation in grain legumes
- In general, increasing row spacing may decrease amount of N fixed by legumes. N fixation in mungbean variety Satin 2/1 however appears to compensate in N fixation for wider rows.
- Varieties can differ significantly in amount of N fixation and is related to biomass.
- High soil nitrate levels can reduce legume nodulation and N fixation by rhizobia. The addition of N fertiliser does not give any yield advantage in chickpeas or mungbeans and may reduce the amount of N available for the following crop.

Background

Average amounts of N fixed annually by crop and pasture legumes are around 110 kg N/ha (ranging from close to zero to more than 400kg N/ha). The actual amount fixed depends on the species of legume grown, the site and the seasonal conditions as well as agronomic management of the crop or pasture. The legume crop uses this N for its own growth and may fix significantly more than needed, leaving a positive N balance in the soil for proceeding crops.

Chickpeas were the most widely grown legume crop in Australia in 2013 with about 85 per cent being grown in NSW and Queensland. Mungbeans in the years 2008 - 2010 were up to 70000 t average production after an average of just 40000 t in 2004 -2007, mainly through improved average yields. The vast majority are grown in the northern region of Australia.

The amount of N fixed by a legume increases as legume biomass increases but is reduced by high levels of soil nitrate. In general, legume reliance on N fixation is high when soil nitrate levels are below 50 kg N/ha in the top metre of soil. Above 200 kg N/ha, nitrogen fixation is generally close to zero. The fixed N is used for the growth of the legume itself (saving fertiliser application of the legume crop) as well as potentially leaving residual N for the following cereal or oilseed crop and providing a break from cereal stubble and soil-borne diseases.

Work by Doughton et al. (1993) clearly demonstrated the impact of increasing soil nitrate levels on N fixation of chickpeas (see Figure 1), with no yield advantage being gained by applying N. Moreover, chickpea provided a positive soil N balance when fixation rates were high and a negative balance at low fixation rates.
Researchers in GRDC project DAQ00181 (Optimising N fixation in grain legumes – northern region) will be working closely with the new Pulse Agronomy projects in Qld and NSW as well as some Grower Solutions projects to identify agronomic practices to optimise legume growth and N fixation without compromising crop yield.

**Row spacing, plant populations and variety**

Field trials with summer (mungbean) and winter pulses (chickpea) were grown in 2013 in Queensland to examine the effects of varying agronomic factors on the growth, yield and N fixation of the pulses.

**Mungbean**

Over the 2012/13 summer, two mungbean trials were conducted at Taabinga and Redvale, near Kingaroy, Qld. Both trials consisted of the factorial combination of the following treatments:

- 2 row spacings (30 and 90 cm) x 3 plant populations (20, 30 and 40 plants/m²) x 3 varieties (Crystal (C), Satin (S) and Jade-AU (J)). Each had 3 replicates. Yields were not significantly different for any of the treatments at either trial but N fixation analyses showed that variety interacted with row spacing for the %Ndaf (per cent N in the plant shoots that is derived from the atmosphere not from soil nitrate supplies). Both Crystal and Jade-AU had much reduced N fixation as row spacing changed from 30 to 90 cm but Satin II fixed a similar high proportion of N (48 and 49%) for both row spacings (Figure 2).
Chickpea

Two chickpea trials were conducted in the new GRDC Qld Pulse Agronomy project in the southern region (near Dalby and Goondiwindi). Each trial had the same design including 3 row spacings (0.25, 0.5 and 1.0 m) x 3 varieties

All 3 chickpea varieties at Dalby and Goondiwindi trials had significantly lower grain and total (grain + shoot) N uptake in kg/ha when grown at 1.0m row spacing. Also PBA HatTrick was significantly lower than Boundary and CICA0912 in N uptake at both sites. The impact of these management practices on N fixation and hence N uptake will be examined in detail following receipt of the $^{15}$N natural abundance data and will be discussed at the Update.

N fertiliser addition

Chickpea

Trials conducted by Northern Grower Alliance in Qld and northern NSW across 6 sites in 2012 and 2 sites in 2013, showed no significant yield response in any individual chickpea trial to the addition of nitrogen fertiliser or the addition of rhizobia. In 2012, residual soil N at planting ranged from <12 to 117 kg N/ha (3 sites had 30 kg N/ha or less). Yields ranged from 1.1 to 2.0 t/ha (only one site >1.6 t/ha). The average yield response to applied N across all 6 sites is shown below in Figure 3. In this same set of trials, there was also no response to the addition of rhizobia inoculum applied as granules with the seed into the planting furrow.

In 2013, yields ranged from 0.75 to 1.3 t/ha with no response to N applied at 10 and 50 kg N/ha.

The lack of response to rhizobia inoculum overall is possibly due to adequate numbers of effective rhizobia already in the soil, however no assessments of nodulation or N fixation and residual soil N were conducted due to the lack of yield response. The seasons were hard and yields were obviously limited primarily by soil water.
Figure 3. Yield response of chickpea (variety HatTrick!) to applied N (no significant differences). Values are averages for 6 trials planted across Qld and northern NSW in 2012 each with 4 replicates.

Mungbean

Work in Central Queensland in 2010 also indicated that nodulation was suppressed by applications of urea at rates of 10 or more kg N/ha or Triple Super at 5 or 10 kg P/ha (Figure 4). Also, no yield advantage was gained by the addition of fertiliser N (Figure 5). (Seymour et al. 2010). Pre-plant soil nitrate levels at this site started at about 80kg N/ha in the top 1m and were increased from there with applied fertilisers. There was also a history of mungbeans at this site contributing to the nodulation of the uninoculated treatments. Despite this, there was a significant yield response to inoculation.

Figure 4. Impact on nodulation of mungbean cv. Crystal/! from rhizobial inoculation and preplant fertiliser applications.
Figure 5. Response of mungbean cv. Crystal to inoculation and preplant fertiliser applications.

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References


Recommended reading

‘Inoculating legumes: A practical guide.’ Ground Cover Direct


Contact details

Nikki Seymour
Dept Agriculture, Fisheries and Forestry Queensland
Ph: 07 4639 8837
Fx: 07 4639 8800
Email: nikki.seymour@daff.qld.gov.au
The effect of plant density on yield in chickpea across central and northern NSW

Andrew Verrell¹, Rohan Brill² and Leigh Jenkins³

¹ Tamworth Agricultural Institute, NSW Department of Primary Industries, Tamworth NSW 2340, Australia. andrew.verrell@dpi.nsw.gov.au
² Wagga Wagga Agricultural Institute, NSW Department of Primary Industries, Wagga Wagga, NSW 2650, Australia. rohan.brill@dpi.nsw.gov.au
³ Trangie Agricultural Research Institute, NSW Department of Primary Industries, Trangie NSW 2823, Australia. leigh.jenkins@dpi.nsw.gov.au

Key words
grain yield, plant density, variety

GRDC code
DAN00171

Take home message
• When sowing within the optimum sowing window mid May – mid June;
  yield potential ≥ 1.5 t/ha sow at ≥ 30 plants/m²
  yield potential ≤ 1.5 t/ha sow at ≥ 20 plants/m²
• When sowing very late sow at high plant density
• To reduce losses due to virus, DO NOT sow below 20 plants/m²

Introduction
Research in Queensland by Beech and Leach (1989), recommended plant populations of 40 plants/m² and later work by Brinsmead et al. (1996) suggested an optimum sowing density of 20–40 plants/m².

Whish et al (2007) monitored 52 commercial chickpea crops over three seasons (2002-04) which showed the median plant density on farm fluctuated between 14 and 22 plants/m². Modelling by Whish et al (2007) suggested that increasing plant density independently of sowing date would improve yields 55% of the time for crops sown in early June and 60% of the time for crops sown in mid May.

Current agronomic advice suggests yields are relatively stable over plant densities of 20-30 plants/m², with an optimum target population of 25 plants/m² for northern regions (Cumming and Jenkins, 2011).

Methods
A series of variety x plant density factorial experiments were conducted across a number of central and northern NSW locations from 2011 to 2013.

Varieties examined were PBA HatTrick¹, PBA Boundary¹, Kyabra¹, CICA912 and GEN090 (small seeded kabuli) at plant densities of 5, 10, 15, 20, 30 and 45 plants/m². During 2011 and 2012 experimental sites were located at Coonamble and Tamworth. In 2013 the number of sites was expanded to eight with the commencement of DAN00171 to include; North Star, Moree, Edgeroi, Burren Junction (not harvested), Coonamble, Tamworth, Pine Ridge and Trangie.
Row spacing varied across sites; Trangie 33cm, Tamworth 40cm, North Star, Moree, Edgeroi, and Pine Ridge all at 50cm and Coonamble at 66cm.

Across all sites and years variety and plant density were significant as main effects but there were no significant interactions between variety and plant density. In this paper only yield responses to plant density will be reported.

**Effect of plant density on yield in contrasting environments – Coonamble and Tamworth**

Experiments were conducted at Coonamble and Tamworth from 2011-2013. The differences between these locations is best characterised in terms of crop season (May – November) rainfall and evapotranspiration.

In 2011, the wettest of the three crop seasons, Tamworth received 499mm compared to Coonamble with 381mm. Both 2012 and 2013 were drier years in both environments with Tamworth (262 and 268mm) receiving, on average, 130mm more in-crop rainfall in each year than Coonamble (132 and 139mm). Crop season evapotranspiration totals in Coonamble were 846, 918 and 1043mm, compared to Tamworth with 725, 818 and 872mm, for 2011, 2012 and 2013, respectively.

The response of yield to plant density at Coonamble and Tamworth are shown in Figures 1 and 2, respectively.

**Figure 1.** The effect of plant density on grain yield at Coonamble in 2011 (■), 2012 (♦) and 2013 (♦)

At Coonamble (see Fig. 1), in the two drier seasons, yield was ≤ 1.5 t/ha and was not significantly different at densities ranging from 15 to 45 plants/m². In the wetter year, 2011, grain yield reached over 3.5 t/ha ad there was a marginal but significant increase in yield between 15 (3.53 t/ha) and 45 plants/m² (3.89 t/ha).

At Tamworth, the wetter of the two locations, yields were more responsive across the range of plant densities over all years (see Fig. 2).
At Tamworth, the optimum plant density was 30 plants/m² with yields of 2.97, 2.18 and 2.15 t/ha in 2011, 2012 and 2013, respectively.

The linear response of yield to plant density, from 15 to 45 plants/m², was derived for each year at both locations. Coonamble had a flatter response across all years with slopes of 5.35, 0.18 and -7.35 kg/ha/plant/m², compared to Tamworth with, 23.51, 19.26, and 9.08 kg/ha/plant/m² for 2011, 2012 and 2013, respectively.

**Effect of plant density on yield across sites - 2013**

In 2013 the number of locations was expanded and sites have been grouped into northern (North Star, Moree, Edgeroi, Coonamble) and southern locations (Tamworth, Pine Ridge, Trangie). The May to November rainfall for the northern sites was; Coonamble = 139, Moree = 173, North Star = 205 and Edgeroi = 226mm, while for the southern sites it was; Trangie = 214, Tamworth = 266 and Pine Ridge = 306mm.

The plot of grain yield versus plant density for the northern sites is in Figure 3 while the same relationship for the southern sites is shown in Figure 4. For the northern sites the response of yield to plant density was flat from 15 to 45 plants/m² (see Fig. 3) with slopes of; Coonamble = -7.35, Edgeroi = -1.27, North Star = 1.6 and Moree = 3.93 kg/ha/plant/m². For the southern sites, the slope of yield to plant densities, from 15 to 45 plants/m² (see Fig. 4) were; Trangie = 5.31, Tamworth = 9.09 and Pine Ridge = 16.31 kg/ha/plant/m².
Figure 3. Effect of plant density (plants/m²) on grain yield (t/ha) for the 2013 northern sites; North Star ( ■ ), Edgeroi ( □ ), Moree ( • ) and Coonamble ( ○ ).

The southern sites, which on average received more in-crop rain, gave greater yield responses as plant density increased from 15 to 45 plants/m². Optimum yield was achieved around 30 plants/m². With the exception of North Star, the northern sites yielded less than 1.5 t/ha at optimum densities of about 20 plants/m². Even North Star had a flat yield response above 15 plants/m².
Conclusion

• When sowing within the optimum sowing window mid May – mid June;
  yield potential ≥ 1.5 t/ha sow at ≥ 30 plants/m²
  yield potential ≤ 1.5 t/ha sow at ≥ 20 plants/m²
• When sowing very late sow at high plant density
• To reduce losses due to virus, DO NOT sow below 20 plants/m²

Acknowledgements
Thanks to Michael Nowland and Paul Nash for their assistance in the trial program.

References

Contact details
Dr Andrew Verrell
NSW Department Primary Industries
Mb: 0429 422 150
Email: andrew.verrell@dpi.nsw.gov.au

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Effect of row spacing on yield in chickpea under high yield potential – past and present research

Andrew Verrell\(^1\) and Leigh Jenkins\(^2\)

\(^1\) Tamworth Agricultural Institute, NSW Department of Primary Industries, Tamworth NSW 2340, Australia. andrew.verrell@dpi.nsw.gov.au

\(^2\) Trangie Agricultural Research Institute, NSW Department of Primary Industries, Trangie NSW 2823, Australia. leigh.jenkins@dpi.nsw.gov.au

Key words
space, plant density, variety, sowing date

GRDC code
DAN00171

Take home message
- When sowing within the optimum sowing window mid May – mid June;
  - yield potential ≥ 2.0 t/ha sow on narrow rows (≤ 40cm)
  - yield potential ≤ 2.0 t/ha row spacing has less of an impact on yield
- When sowing very late, sow on narrow rows at high plant density
- When sowing very early, sow on wider rows to reduce early soil water extraction
- Current varieties (PBA HatTrick\(^1\)) have a lower rate of yield decline at wider row spacing

Introduction
Chickpeas are successfully grown using a wide range of row spacing’s, ranging from 20-100 cm with wider rows (50-100cm) becoming quite common. In northern New South Wales and Queensland, the current rule of thumb is that row spacing ranging from 25-75 cm results in no yield difference (Cumming and Jenkins, 2011).

These guidelines were based on the original research work of Felton et al (1996) conducted in the early 90’s. There was a need to look at the effect of row spacing under high yield potential situations utilising current varieties and newer agronomic practices.

Pioneering row spacing research
Research in the 1990’s demonstrated that no-till increased chickpea yields by 10%. Wider row spacing was seen as a means of increasing the commercial attractiveness of no-till chickpeas. Therefore, it was important to determine if this caused any decrease in productivity.

Research conducted by Felton et al (1996) explored the effects of row spacing 25, 50, 75 and 100cm and plant density, 20-80 kg/ha, on grain yield in chickpea (see Fig. 1). Across two sites and three seasons they concluded that in three low yielding experiments (1991-1992), there was no yield reduction due to row spacing. In 1993 (very wet year) the two sites showed an average linear yield decline of 4.4 ± 1.3 kg/ha/cm (Felton et al 1996). All of these experiments were conducted using cv Amethyst released 1987), the most popular variety at the time.

A point to note is that in all three years x two sites, yield never exceeded 2.5 t/ha even at the narrow row spacing under above average rainfall (see Fig 1.).
Contemporary row space x plant density research

An experiment was conducted in 2010 at TAI to examine the effects of row space x plant density on grain yield in chickpeas. PBA HatTrick was the variety used along with cv Amethyst as a comparator to the original work conducted by Felton et al (1996).

Four row spaces; 20, 40, 80 and 120cm were used with three plant densities 15, 30 and 45 plants/m² in a four replicate factorial. The experiment was sown into standing wheat residue. The 2010 cropping season experienced above average rainfall and both varieties were sprayed prior to every rainfall event with 2 L of chlorothalonil to remove the effect of Ascochyta blight on grain yield.

Amethyst is extremely susceptible to Ascochyta blight. The NuFarm 720 Unite label states: “DO NOT exceed 3.2 L of Unite 720 per ha of crop.” The regime of frequent use of chlorothalonil as used in this trial exceeded recommended use and was only used for experimental purposes.

The row space x plant density interactions on grain yield are shown in Fig. 2 and Fig. 3 for cultivars Amethyst and PBA HatTrick, respectively.

Under high potential yield, cv Amethyst showed a significant decline in yield across the three densities as row spacing increased (see Fig. 2). Highest yields were achieved under very narrow rows (20cm) with high plant density (3.1 t/ha). Yields fell below 2.5 t/ha once row space exceeded 40cm and density fell below 30 plants/m².

PBA HatTrick showed far more yield stability over wider row spaces and plant densities than cv Amethyst (see Fig. 3). Low plant density (15 plants/m²) showed significant yield loss across all row spaces. At 30 plants/m², yield was flat up to 40cm but was significantly lower at 80 and 120cm.
Figure 2. The effect of row space and plant density on grain yield of cultivar Amethyst.

Figure 3. The effect of row space and plant density on grain yield of cultivar PBA HatTrick.
Linear yield decline across row spacing was -9.42 and -6.93 kg/Ha/cm for cv Amethyst and PBA HatTrick\(^l\), respectively. These rates of decline in yield exceed the findings of Felton et al (1996) who reported an average decline of -4.4 ± 1.3 kg/ha/cm. In all row space x plant density combinations PBA HatTrick\(^l\) showed far less decline in yield compared to cv Amethyst suggesting a genetic advantage.

The response of these two cultivars to row spacing is best illustrated by comparing yield at a fixed plant density of 30 plants/m\(^2\) (Fig. 4).

![Figure 4](image)

**Figure 4.** Comparison of grain yield across row spacing for cv Amethyst (●) and PBA HatTrick\(^l\) (■) at a fixed plant density of 30 plants/m\(^2\).

Yield of cv Amethyst collapses as row space increases with a linear decline of -8.2 kg/ha/cm compared to PBA HatTrick\(^l\), -5.8 kg/ha/cm. Even though PBA HatTrick\(^l\) has a much flatter response, yield is still significantly lower at a row space of 80cm compared to 40cm.

**Effect of row space on yield over seasons**

Work by Horn et al. (1996) recommended early May to mid June as the optimum sowing times across northern NSW and southern Qld. In trials at Tamworth in 2003, June planted chickpea out yielded May sowing by 5% and July plantings by 20%, while a May planting was better than June by 11% and July by 42% in 2004 (Haig and McMullen 2012).

Yield comparisons of different cultivars, sown over different years at either 40 or 80cm row spaces and at a fixed plant density of 30 plants/m\(^2\) is shown in Table 1. Over four site years narrow row (40cm) chickpeas have consistently out yielded wide row (80cm) chickpeas. Within the optimum sowing window (early May to mid June), averaged across varieties, narrow row spacing has averaged 2.53 t/ha while the wide rows have averaged 2.17 t/ha.

In 2013 sowing was delayed due to late opening rains and main season sowing didn’t occur until the 22\(^\text{nd}\) June while a very late sowing was made on the 17\(^\text{th}\) July. A narrow row crop sown at the end of
the optimum sowing window yielded 2.20 t/ha while the very late sown crop yielded 1.45 and 1.08 t/ha for narrow and wide rows, respectively.

**Table 1.** Effect of sowing date and row spacing on the yield of different varieties over consecutive seasons. All sown at a fixed plant density of 30 plants/m².

<table>
<thead>
<tr>
<th>Year</th>
<th>Sow Date</th>
<th>Variety</th>
<th>Row-space</th>
<th>Yield</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>30th May</td>
<td>Flipper(†)</td>
<td>40cm</td>
<td>2.08</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>80cm</td>
<td>1.79</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jimbour</td>
<td>40cm</td>
<td>2.31</td>
<td>± 0.162</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>80cm</td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>29th May</td>
<td>Flipper(†)</td>
<td>40cm</td>
<td>2.70</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>80cm</td>
<td>2.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jimbour</td>
<td>40cm</td>
<td>2.83</td>
<td>± 0.190</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>80cm</td>
<td>2.23</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>1st June</td>
<td>Amethyst</td>
<td>40cm</td>
<td>2.58</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>80cm</td>
<td>2.14</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>PBA HatTrick(†)</td>
<td>40cm</td>
<td>2.98</td>
<td>± 0.093</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>80cm</td>
<td>2.74</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>22nd June</td>
<td>PBA HatTrick(†)</td>
<td>40cm</td>
<td>2.20</td>
<td>± 0.033</td>
</tr>
<tr>
<td></td>
<td>17th July</td>
<td>PBA HatTrick(†)</td>
<td>40cm</td>
<td>1.45</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>80cm</td>
<td>1.08</td>
<td>± 0.028</td>
</tr>
</tbody>
</table>

The significant yield advantage of narrow rows over wide rows for the very late sown (17th July) crop supports the findings of Whish and Cocks (2004) and Whish (2007), where narrow planted late crops produced higher yields.

**Conclusion**

- New varieties (PBA HatTrick(†)) have a lower rate of yield decline at wider row spacing compared to older varieties such as Amethyst
- When sowing within the optimum sowing window mid May – mid June;
  - yield potential ≥ 2.0 t/ha sow on narrow rows (≤ 40cm)
  - yield potential ≤ 2.0 t/ha row spacing has less of an impact on yield
- When sowing very late, sow on narrow rows at adequate plant density
- When sowing very early, sow on wider rows to reduce early soil water extraction

**Acknowledgements**

Thanks to Michael Nowland and Paul Nash for their assistance in the trial program.

**References**


Haig, B and McMullen, K.G. (2012). The Influence of planting date, sowing depth and soil type on chickpea production with no-tillage in northern New South Wales. 16th Australian Agronomy Conference

Contact details
Dr Andrew Verrell
NSW Department Primary Industries
Mb: 0429 422 150
Email: andrew.verrell@dpi.nsw.gov.au

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Row placement strategies in a break crop-wheat sequence

Andrew Verrell

Tamworth Agricultural Institute, NSW Department of Primary Industries, Tamworth NSW 2340, Australia. andrew.verrell@dpi.nsw.gov.au

Key words
row placement, wheat, mustard, chickpea

GRDC code
DAN00116 Integrated disease management in northern no-tillage systems using precision agriculture

Take home message
- Sow break crops between standing wheat rows, which need to be kept intact
- Sow the following wheat crop directly over the row of the previous years break crop and NOT between the old rows
- This system will only work for zero tillage systems where wheat stubble is kept intact

Introduction
Inter-row sowing has been shown to reduce the impact of crown rot and increase yield, by up to 9%, in a wheat-wheat sequence (Verrell et al 2009). Crop rotation reduces the incidence and severity of crown rot resulting in yield gains of 17-23% over continuous wheat (Verrell et al 2005). There was a need to examine whether row placement strategies coupled with a break crop – wheat rotation, would result in differences in grain yield over a five year crop sequence.

Experimental details
A five year crop sequence experiment consisting of three winter sequences;
1. wheat-wheat-wheat-wheat-wheat
2. wheat-chickpea-wheat-chickpea-wheat
3. wheat-mustard-wheat-mustard-wheat

was established in 2008 at the Tamworth Agricultural Institute (TAI). The TAI site consists of a brown vertosol with an average summer and winter rainfall of 400 mm and 280 mm, respectively, and soil plant available water holding capacity of 120mm to a depth of 1.0m. Durum wheat (cv. EGA Bellaroi) was sown in 2008 (40cm row spacing) and inoculated with a low level of the crown rot (CR) fungus, Fusarium pseudograminearum at a rate of 2.0 g/m row.

In 2009, wheat, mustard or chickpea was sown either on or between the 2008 wheat rows using GPS guided autosteer. In subsequent seasons crops were sown either on or between the previous year rows resulting in sixteen different row placement combinations by the time the 2012 wheat crop was sown. All crops were sown with Janke coulter-tyne-press wheel parallelograms along with 100 kg N/ha (mustard and wheat) and 10 kg P/ha (all crops).

Results
The results presented here will focus solely on the mustard-wheat and chickpea-wheat systems and the last three years of the sequence trial (2010-2011-2012). Four row placement options are
presented for both crop sequences and row placements are relative to the position of the 2010 wheat rows (Table 1).

<table>
<thead>
<tr>
<th>Row Sequence</th>
<th>Row Placement</th>
<th>Year 2011</th>
<th>Year 2012</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Between 2010 rows</td>
<td>Between 2010 rows</td>
<td>BB</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>On rows 2010 rows</td>
<td>Between 2010 rows</td>
<td>OB</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>On rows 2010 rows</td>
<td>On rows 2010 rows</td>
<td>OO</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Between 2010 rows</td>
<td>On rows 2010 rows</td>
<td>BO</td>
<td></td>
</tr>
</tbody>
</table>

The 2012 wheat yield, in the mustard-wheat sequence, was significantly higher for the BB row option (4.46 t/ha) compared to other placements (see Table 2). Both the OB and OO options had similar yields but lower compared to BB while the worst row placement option was BO (3.84 t/ha).

<table>
<thead>
<tr>
<th>Row Placement x Crop</th>
<th>2010 Wheat</th>
<th>2011 Mustard</th>
<th>2012 Wheat</th>
<th>2012 Wheat Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB</td>
<td>4.46a</td>
<td>87a</td>
<td>0.70a</td>
<td></td>
</tr>
<tr>
<td>OB</td>
<td>4.27b</td>
<td>88a</td>
<td>0.64a</td>
<td></td>
</tr>
<tr>
<td>OO</td>
<td>4.24b</td>
<td>86a</td>
<td>0.89ab</td>
<td></td>
</tr>
<tr>
<td>BO</td>
<td>3.84c</td>
<td>75b</td>
<td>1.53b</td>
<td></td>
</tr>
</tbody>
</table>

NB Values within a column with the same letter are not significantly different (P<0.05)

The BO row placement sequence had significantly lower grain nitrogen removal and the highest number of whiteheads compared to the other row placement options in the mustard-wheat sequence (see Table 2).

Similar data for the mustard-wheat sequence is presented for the chickpea-wheat sequence (Table 3). In this sequence there was no difference between the BB, OB and OO row placements for the 2012 wheat yield. However, the BO sequence had significantly lower yield (4.03 t/ha) for the 2012 wheat crop compared to other options. The BO sequence also had the lowest grain nitrogen removal rate and the highest number of whiteheads (see Table 3).
Whiteheads for the wheat-wheat sequence were 2.2, 0.8, 3.5 and 1.2 (heads/m²) for the BB, OB, OO and BO row placement options, respectively.

**Table 3.** Row placement by year with grain yield and grain N removal for the 2012 wheat crop in a wheat-chickpea-wheat sequence.

<table>
<thead>
<tr>
<th>Row Placement Sequence</th>
<th>Row Placement x Crop</th>
<th>2010 Wheat Yield (t/ha)</th>
<th>2011 Chickpea Yield (t/ha)</th>
<th>2012 Wheat Yield (t/ha)</th>
<th>2012 Wheat Crop Grain-N (kgN/ha)</th>
<th>Whiteheads (heads/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.92a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.92a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.83a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.63b</td>
</tr>
</tbody>
</table>

NB Values within a column with the same letter are not significantly different (P<0.05)

**Summary**

After five years, both break crop systems showed grain yield advantages in 2012, over continuous wheat, of 40% and 44%, for the mustard-wheat and chickpea-wheat systems, respectively. The chickpea-wheat system tended to have slightly higher wheat grain yields in 2012 for each of the four row placement strategies compared to the mustard-wheat sequence (see Table 2 and Table 3).

What this experiment has shown is that simply alternating row placement in consecutive years will not result in yield gains but a yield loss and increased CR (BO system). In the BO sequence the break crop was sown between standing cereal stubble which was kept intact. The following wheat crop was then sown between the previous years (break crop) rows but this put it directly over the old 2010 wheat row. The consequence of this sequence was that the wheat crop was sown into old infected wheat stubble hence the higher level of CR infection resulting in high whitehead counts. The benefit of the break crop in breaking any disease cycle was not realised. This is supported by the wheat-wheat whitehead data which showed higher incidence of CR for row placements where wheat was sown directly over the previous row (BB=2.5, OO=3.5) compared to between row sequences (OB=0.8, BO=1.2).

Even the traditional on row system (OO) had a better yield and CR outcome than the BO system because the break crop was sown directly over the old wheat stubble row excavating the residue out of the row (tyne with spear points) and providing a direct break to the CR fungus (see Table 2 and 3). This may not be the case however if a low disturbance disc system is used.
Based on these results the best option for row placement sequences in a break crop system is shown in Table 4.

**Table 4. Proposed row placement strategy to optimise crop yield in a wheat-break crop-wheat sequence.**

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>Chickpea</td>
<td>Wheat</td>
<td>Canola</td>
<td>Wheat</td>
</tr>
</tbody>
</table>

Following a wheat crop, the break crop (pulse or oilseed) should be sown between the standing stubble rows. In the next year, the wheat crop should be sown directly over the previous seasons break crop row. Then in the next year of the rotation the break crop should shift back and be sown between the standing wheat rows. Finally, in the fifth year, the wheat crop again should be sown directly over the previous years break crop row.

There are two simple rules that need to be followed;

- Sow break crops between standing wheat rows which need to be kept intact
- Sow the following wheat crop directly over the row of the previous years break crop

By following these two rules it ensures the following;

- Ensures four years occur between wheat crops being sown in the same row space (see Table 4)
- Substantially reduces the incidence of CR in wheat crops
- Improved germination of break crops, especially canola, not hindered by stubble
- Chickpeas will benefit from standing stubble reducing the impact of virus
- Standing wheat stubble gives better protection to break crop seedlings

**Acknowledgements**

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**References**


**Contact details**

Dr Andrew Verrell
NSW Department Primary Industries
Mb: 0429 422 150
Email: andrew.verrell@dpi.nsw.gov.au
**Viral diseases in chickpeas – impact and management**

*Murray Sharman¹, Kevin Moore², Joop van Leur², Mohammad Aftab³, Andrew Verrell⁴*

¹ DAFFQ Ecosciences Precinct Brisbane, ² NSW DPI Tamworth, ³ DEPI Vic Horsham

**Key words**

viruses, agronomy, surveys, diagnostics

**GRDC codes**

DAQ00186, DAN00179, DAN00140, DAN00143, DAN00171, DAN00176, DAV00134

**Take home message**

Minimise risk of virus by retaining standing stubble, planting on time and at optimal seeding rate for rapid canopy closure. Control weeds in and around crop and ensure adequate plant nutrition

**Viruses in chickpea crops**

Chickpea and other winter pulse crops are susceptible to many plant viruses. The effects on plants include stunting, reddening, chlorosis, distortion, shoot tip wilting, reduced yield and grain quality and for chickpeas, often premature death. Infections occurring early in the cropping cycle generally result in more severe disease outbreaks and yield losses. All are spread by flying insect vectors and almost all can be separated into two main groups, those that are transmitted by aphids persistently and those that are transmitted non-persistently. Persistently transmitted viruses (eg Beet western yellows virus - BWYV, Bean leaf roll virus - BLRV) include the luteoviruses and poleroviruses where the aphids can retain and transmit the viruses for many weeks but require up to 1-2hrs of feeding to transmit. Pea aphid, green peach aphid and cowpea aphid are considered to be important vectors of chickpea viruses. Non-persistently transmitted viruses (eg Alfalfa mosaic virus – AMV, Cucumber mosaic virus – CMV) are only carried by aphids for a few hours but can be transmitted in less than a minute of feeding. Some chickpea viruses are also transmitted by leaf hoppers. Virus disease outbreaks in chickpeas are sporadic and difficult to predict from season to season or between locations. Major outbreaks of virus diseases in chickpeas occurred in the early 1990s (when losses in many chickpea crops on the Liverpool Plains reached 100%) and most recently in 2012 in several regions of NSW.

**Impact of viruses in chickpea crops in northern region in 2013**

In 2013, virus infection was found in almost all chickpea crops inspected from southern QLD to Wellington in the south. The incidence of virus infection was generally lower than observed in 2012 with most crops inspected having <5% plants with symptoms but it was as high as 30-50% in several crops from the Breeze / Werris Creek area and Edgeroi. Overall, the most prevalent virus was BWYV and in some locations more than 90% of symptomatic plants were infected with BWYV (Table 1).

There are related virus species that also react with the BWYV assay as is discussed further below, so it is likely there was a mix of BWYV-like viruses present at many locations. Some of the main outcomes from the chickpea surveys in N-NSW were:

- Higher proportion of BWYV infections found at, and north of the Liverpool Plains. Higher proportion of AMV infections in the south (Table 1). Very low levels of BLRV and CMV.
- Up to 15% of non-symptomatic plants still had BWYV infection from the Liverpool plains.
- Accurate identification by PCR has shown the aphid transmitted luteovirus species to have a wide geographical range in a number of alternative weed hosts (Table 2).
• Soybean dwarf virus (SbDV) was the major virus affecting several crops in the Edgeroi region in Oct 2013 and was confused with BWYV in the antibody test (Table 1).

Using the virus species-specific PCR described below, 49 virus affected plants from 2013 were screened consisting of 38 SbDV, 5 PhBV, 3 BWYV, 2 BLRV and 1 mixed SbDV/BWYV. From the 45 samples that were not BWYV by PCR, 33 were false positives in the BWYV antibody assay. This demonstrates the BWYV antibody used (from DSMZ) was not useful for identifying BWYV and PCR indicated that SbDV was the dominant virus from the samples tested.

During this work, a new polerovirus referred to Phasey bean virus – PhBV (previously thought to be a strain of BWYV) has been identified from many hosts and locations in the northern region (Table 2). It is transmitted efficiently by cowpea aphid. Although the relative importance of PhBV in chickpea crops is still uncertain, it appears to have been responsible for approximately 30% of the infections thought to be BWYV in the 2012 virus outbreaks (Moore et al 2013).

**Table 1.** The percent infection of BWYV, AMV, BLRV and CMV from chickpeas displaying virus symptoms in northern NSW as determined by TBIA diagnostic. Virus identification based on antibody reaction. Sample locations shown roughly from north to south. Note that the BWYV infections may be a complex of related viruses. Samples from most locations were also tested for Turnip mosaic virus (TuMV) but no positives were detected.

<table>
<thead>
<tr>
<th>Location</th>
<th>Plants tested</th>
<th>% BWYV</th>
<th>% AMV</th>
<th>% BLRV</th>
<th>% CMV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boomi</td>
<td>6</td>
<td>100</td>
<td>0</td>
<td>n/t</td>
<td>n/t</td>
</tr>
<tr>
<td>North Star</td>
<td>12</td>
<td>67</td>
<td>17</td>
<td>n/t</td>
<td>n/t</td>
</tr>
<tr>
<td>Moree</td>
<td>19</td>
<td>79</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Edgeroi</td>
<td>32</td>
<td>62</td>
<td>0</td>
<td>n/t</td>
<td>n/t</td>
</tr>
<tr>
<td>Edgeroi</td>
<td>17</td>
<td>47</td>
<td>0</td>
<td>n/t</td>
<td>n/t</td>
</tr>
<tr>
<td>Tamworth</td>
<td>15</td>
<td>60</td>
<td>20</td>
<td>n/t</td>
<td>0</td>
</tr>
<tr>
<td>Tamworth</td>
<td>30</td>
<td>87</td>
<td>10</td>
<td>n/t</td>
<td>0</td>
</tr>
<tr>
<td>Breeza</td>
<td>18</td>
<td>89</td>
<td>0</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Breeza</td>
<td>25</td>
<td>88</td>
<td>8</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Breeza</td>
<td>26</td>
<td>77</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Breeza</td>
<td>19</td>
<td>53</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Liverpool Plains</td>
<td>20</td>
<td>90</td>
<td>10</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Liverpool Plains</td>
<td>21</td>
<td>90</td>
<td>10</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Werris Creek</td>
<td>15</td>
<td>73</td>
<td>13</td>
<td>n/t</td>
<td>0</td>
</tr>
<tr>
<td>Pine Ridge</td>
<td>15</td>
<td>93</td>
<td>7</td>
<td>n/t</td>
<td>0</td>
</tr>
<tr>
<td>Pine Ridge</td>
<td>15</td>
<td>80</td>
<td>13</td>
<td>n/t</td>
<td>0</td>
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<tr>
<td>Blackville</td>
<td>15</td>
<td>13</td>
<td>67</td>
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</tr>
<tr>
<td>Gilgandra</td>
<td>14</td>
<td>7</td>
<td>78</td>
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<td>n/t</td>
</tr>
<tr>
<td>Gilgandra</td>
<td>38</td>
<td>21</td>
<td>71</td>
<td>0</td>
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<tr>
<td>Gilgandra</td>
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<td>12</td>
<td>88</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
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<td>30</td>
<td>10</td>
<td>73</td>
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<td>n/t</td>
</tr>
<tr>
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<tr>
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<td>7</td>
<td>60</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wellington</td>
<td>20</td>
<td>5</td>
<td>55</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*A* not tested (n/t)

**Biology of significant viruses of pulses, particularly chickpeas**

Accurate identification of viruses is critical for long term resistance breeding to be successful and for meaningful studies of how viruses survive in weed hosts and move into crops. To this end, we have begun to develop improved accurate diagnostics for the luteoviruses to help overcome uncertainty of virus identifications that can result from cross reactions of viruses to some antibodies. We have
used a PCR for *Beet western yellows virus* (BWYV), *Bean leaf roll virus* (BLRV), Phasey bean virus (PhBV) and *Soybean dwarf virus* (SbDV) to investigate host range of the virus species from a range of locations (Table 2). While testing continues, Marshmallow weed is commonly found to be infected with BWYV from many locations and burr medic is a host for BLRV, PhBV and SbDV.

**Table 2.** The identification of virus species in different plant hosts from different locations in the northern region confirmed by species-specific PCRs. Testing of selected samples from 2012 and 2013 surveys.

<table>
<thead>
<tr>
<th>Virus (by PCR or sequencing)</th>
<th>Plant host</th>
<th>locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWYV</td>
<td>Chickpea</td>
<td>Wellington, Breeza, North Star, Boomi</td>
</tr>
<tr>
<td></td>
<td>Canola</td>
<td>Ardlethan, Burren Junction, Bellata</td>
</tr>
<tr>
<td></td>
<td>Marshmallow</td>
<td>Wagga Wagga, Coolamon, Griffith, Hillston, Leeton, Narrandera, Wellington, Tamworth, Narrabri, Wee Waa, North Star, Goondowindi, Grantham</td>
</tr>
<tr>
<td></td>
<td>Turnip weed</td>
<td>Gravesend, Wee Waa, Burren Junction</td>
</tr>
<tr>
<td></td>
<td>Sonchus sp.</td>
<td>Coolamon</td>
</tr>
<tr>
<td></td>
<td>Shepherds Purse</td>
<td>Kingsthorpe, Boomi</td>
</tr>
<tr>
<td>BLRV</td>
<td>Chickpea</td>
<td>Wellington, Edgeroi</td>
</tr>
<tr>
<td></td>
<td>Burr medic</td>
<td>Wellington</td>
</tr>
<tr>
<td></td>
<td>Faba bean</td>
<td>Edgeroi</td>
</tr>
<tr>
<td></td>
<td>Burr medic</td>
<td>Boomi, Burren Junction, Wee Waa</td>
</tr>
<tr>
<td></td>
<td>Lentil</td>
<td>Breeza</td>
</tr>
<tr>
<td></td>
<td>Vetch</td>
<td>Kingsthorpe</td>
</tr>
<tr>
<td>PhBV</td>
<td>Chickpea</td>
<td>Kingsthorpe, Boomi, North Star, Edgeroi, Burren Junction, Breeza, Horsham</td>
</tr>
<tr>
<td></td>
<td>Burr medic</td>
<td>Edgeroi</td>
</tr>
<tr>
<td></td>
<td>Burr medic</td>
<td>Boomi, Burren Junction, Wee Waa</td>
</tr>
<tr>
<td></td>
<td>Lentil</td>
<td>Breeza</td>
</tr>
<tr>
<td></td>
<td>Vetch</td>
<td>Kingsthorpe</td>
</tr>
<tr>
<td>SbDV</td>
<td>Chickpea</td>
<td>Wellington, Gilgandra, Breeza, Edgeroi, Bellata, North Star, Boomi, Clifton</td>
</tr>
<tr>
<td></td>
<td>Burr medic</td>
<td>Edgeroi</td>
</tr>
</tbody>
</table>

**Better agronomy – better chickpeas**

Field trials from 2012 and 2013 have shown that chickpea crops are at risk of increased damage from viruses when plant density is below about 20 pl / m² (Verrell 2013, Moore et al 2014). Significantly less plants are infected when plant densities are higher and it is recommended to aim for greater than 25 pl / m².

Trial crops deficient in N, K, P or all three have been shown to have significantly more virus affected plants than a crop with adequate nutrition (Verrell 2013).

Inter row planting into standing wheat stubble significantly reduced virus incidence in small trial plots of PBA HatTrick(1) when compared to the same amount of stubble slashed low to the ground (Moore et al 2014). The mechanism for this difference is unclear but these results are in agreement with many field observations by the authors in large crops during virus outbreaks.
While differences have been observed for the virus resistance of different varieties (Verrell 2013, Verrell 2014, Hawthorne 2008), further screening will be needed to strengthen confidence in these results under high disease pressure, from different regions, and to identify for which virus species resistance is effective. Under low virus pressure in field trials, some of the better performing varieties included Flipper, and PBA HatTrick although both these varieties have been observed with high rates of infection under high disease pressure. Variety Gully is very susceptible to Ascochyta but has moderate virus resistance so may be useful for breeding resistance into future varieties.

While a link could not be confirmed in the 2013 season between BWYV infections in canola and subsequent spread into nearby chickpea crops (van Leur et al 2014), the sometimes high incidence of BWYV in canola indicates it may still be prudent to avoid planting chickpea and other pulse crops next to canola.

Conclusions

Visit http://www.pulseaus.com.au/pdf/Virus%20Contol%20in%20Chickpea.pdf for detailed information on reducing losses from viruses in chickpeas. Currently, the best strategies to manage chickpea viruses are agronomic ones:

- Retain standing stubble which can deter migrant aphids from landing. Where possible, use precision agriculture to plant between stubble rows. This favours a uniform canopy which makes the crop less attractive to aphids.
- Plant on time and at the optimal seeding rate of greater than 25 pl / m² – these result in early canopy closure which reduces aphid attraction (Verrell 2013)
- Ensure adequate plant nutrition
- Control in-crop, fence-line and fallow weeds – this removes in-crop and nearby sources of vectors and virus.
- Avoid planting adjacent to lucerne stands – lucerne is a perennial host on which legume aphids and viruses, especially AMV and BLRV survive and increase (van Leur and Kumari 2011).
- Seed treatment with systemic insecticides such as imidacloprid may be effective for reducing early infections of the persistently transmitted luteoviruses such as BLRV in faba bean, but is not effective for non-persistently transmitted viruses or for late infections of either virus type. Unfortunately, local data supporting seed treatment is lacking.
- Given the high incidence of BWYV sometimes found in canola, consider growing chickpeas (and other pulse crops) away from canola.

Acknowledgements

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References


Contact details
Murray Sharman
DAFFQ
Ph: 07 3255 4339
Fx: 07 3846 2387
Email: murray.sharman@qld.gov.au
Reducing risk of virus disease in chickpea through management of plant density, row spacing and stubble – 2013 trials in northern NSW

Kevin Moore1, Andrew Verrell1 and Mohammed Aftab2

1Tamworth Agricultural Institute, NSW DPI, Tamworth NSW 2340, Australia.
2Grains Innovation Park, DEPI, Horsham VIC 3400, Australia.

Key words

virus, chickpea, plant density, row spacing, stubble management

GRDC code

DAN00143, DAN00171, DAN00176, DAV00134

Take home message

Reduce risk of viruses in 2014 chickpea crops by planting between rows of standing cereal stubble, sowing on time and targeting at least 25 plants/m2

This paper should be read in conjunction with Sharman et al (2014) Viral diseases in chickpeas – impact and management, also in these proceedings. Our paper provides further detail on the effect of agronomic practices on the incidence of chickpea viruses in 2013 at two locations in north western NSW.

Introduction

Controlling virus disease in chickpeas is difficult. Chickpea plants that become infected with a virus invariably die. All current commercial desi and kabuli varieties grown in the GRDC Northern Region are susceptible to the main viruses in that region. GRDC funded field trials at the Liverpool Plains Field Station, Breeza in 2000, 2001, 2002, and 2003 showed no benefit of seed applied insecticides or regular foliar applied insecticides or a combination of both against chickpea viruses. The best and at this stage only, control strategies to reduce risk of viruses in chickpeas are agronomic. These include; retaining cereal stubble, sowing on time, establishing a uniform closed canopy, providing adequate nutrition and controlling weeds (Schwinghamer et al 2009, Verrell 2013, Murray et al 2014).

Effect of chickpea genotype on incidence of virus at Pine Ridge and Tamworth

Incidence of symptomatic plants of four desi varieties (Kyabra, PBA Boundary1), PBA HatTrick1 and the advanced breeding line CICA0912) and one kabuli, Genesis™090 was assessed on 11 October 2013 in field trials at Pine Ridge and at Tamworth (TAI – Tamworth Ag Institute). Although the incidences of virus throughout the trial sites and, at Pine Ridge in the surrounding commercial chickpea crop, were relatively low (<10%), variety had a significant effect on incidence of virus at both sites (Figure 1). PBA HatTrick1 had the lowest incidence at both sites followed by Genesis090. The ranking of Kyabra, PBA Boundary1 and CICA0912 varied with site (Figure 1).

In a similar trial conducted in 2012, there was no effect of variety (the same ones as in this trial) on incidence of symptomatic plants. Accordingly, there is insufficient data to recommend using chickpea variety as a tool for reducing risk of virus.
Figure 1. Incidence (%) of chickpea plants with virus symptoms for four desis and one kabuli at Pine Ridge (top) and Tamworth (bottom) on 11 October 2013
Plant density and incidence of plants with virus symptoms

In September/October 2012, viruses were common in chickpea crops throughout north central and northern NSW – almost every crop inspected had some level of virus (Moore et al, 2013, van Leur et al, 2013). Observations during that period suggested a link between plant density and incidence of virus; in addition, growers and agronomists reported a higher incidence of virus in chickpea crops with thin stands. In a 2012 trial designed specifically to examine the effect of plant population on chickpea viruses, Verrell (2013) found the highest incidence of symptomatic plants occurred at the lowest plant density (5 plants/m²). Incidence declined in a curvilinear fashion as plant densities increased. However, there was no significant difference in the incidence of plants with virus symptoms for 20, 30 and 45 plant/m² densities.

Verrell’s 2012 trial was repeated in 2013 trials at two locations, one (Pine Ridge) in the virus prone region of the Liverpool Plains (van Leur et al 2003) and the other at the Tamworth Agricultural Institute (TAI), Tamworth. As occurred in the 2012 trial, incidence of symptomatic plants was greatest at the lowest sowing rate (5 plants/m²) at both 2013 sites and declined as plant densities increased. However, there was no significant difference in the proportion of plants with virus symptoms at 20, 30 and 45 plants/m² densities.

Row spacing and incidence of plants with virus symptoms

Row spacing had a significant effect on incidence of plants with virus symptoms in a 2013 trial at Tamworth. On 11 October 2013, there were more than twice as many symptomatic plants/m² in plots with 40cm rows compared to those with 80cm rows (Figure 4). Both row configurations were sown at 30 plants/m² so plant density per unit area cannot account for the difference. Rather, plant density within each row appears to be responsible (12 plants/m row @ 40cm and 24 pl/m row @ 80cm).
Stubble management and incidence of plants with virus symptoms

Planting into standing cereal stubble is known to help reduce risk of virus in lupin crops (Jones, 2001). Retaining standing winter or summer cereal is believed to be useful in reducing risk of virus in chickpea crops (Schwinghamer et al 2009) although van Leur et al (2013) found no relationship between stubble loading and incidence of virus in a quantitative survey of viruses in 2012 chickpea crops on the Liverpool Plains. However, we are not aware of any experimental data from trials designed specifically to examine the effect of stubble management on incidence of virus in chickpeas in the GRDC Northern region.

Two trials were conducted at Tamworth in 2013 to compare standing versus flat (slashed) wheat stubble on incidence of plants with virus symptoms. One trial was sown at 80cm row spacing; the other at 40cm spacing; both were sown with PBA HatTrick chickpea at 30 plants/m². The 80cm trial was assessed on 11 October and the 40cm trial was assessed on 9 October and again on 16 October. In both trials, incidence of plants with virus symptoms was lower where the chickpeas had been sown into standing stubble (Figures 4 & 5). Individual plots in these trials were small, 2m x 10m for the 80cm trial and 4m x 10m in the 40cm trial. This raises the question: “If the vectors have no choice i.e. the entire paddock has standing stubble (or not), is stubble management still a useful tool for reducing virus risk?” Based on our own and other’s observations in commercial crops, we believe the answer is Yes; but further research is needed.

Virus species in Pine Ridge and Tamworth trials

Chickpea plants with symptoms of virus infection were sampled for virus testing by Tissue Blot Immuno Assay (TBIA). At each sampling time, 15 symptomatic plants were collected and tested for Alfalfa mosaic virus (AMV), Cucumber mosaic virus (CMV) and Beet western yellows virus (BWYV). At Pine Ridge, 15 symptomatic plants were also tested from the surrounding crop of Almaz®
chickpeas. In addition 15 asymptomatic (healthy, turgid, vigorous, green plants) were also tested from each trial and the Almaz crop. By far the most common virus was BWYV, accounting for 65 – 94% (mean 83%) of symptomatic plants; 12% of symptomatic plants were positive for AMV; CMV was not detected in any symptomatic plants; only one (out of 105) plant was co-infected with BWYV and AMV. None of the 45 asymptomatic plants tested positive to any of the three viruses.

**Figure 4.** Effect of stubble management (flat vs standing) on incidence of chickpea plants with virus symptoms, Tamworth 2013.
Figure 5. Effect of stubble management (flat vs standing) on incidence of chickpea plants with virus symptoms assessed on two dates, Tamworth 2013.

Conclusions

- Sow at the optimal seeding rate - irrespective of sowing date
- Plant on time
- Retain standing cereal stubble and sow between the stubble rows

References


Acknowledgements

Thanks to Tom Bailey, ‘Gunnadilly, Pine Ridge for providing land and other resources for the Pine Ridge trial, and to Michael Nowland, Paul Nash and Gail Chiplin for technical support.

Contact details

Dr Kevin Moore & Dr Andrew Verrell
NSW Department Primary Industries, Tamworth
Kevin: 02 6763 1133; 0488 251 866; Andrew: 0429 422 150
Email: kevin.moore@dpi.nsw.gov.au, andrew.verrell@dpi.nsw.gov.au

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Phytophthora tolerance in chickpea varieties – paddock selection and management

Kevin Moore\(^1\), Mal Ryley\(^2\), Kristy Hobson\(^1\), Ted Knights\(^4\), Steve Harden\(^1\), Willy Martin\(^3\), Kris King\(^3\), Paul Nash\(^1\) and Gail Chiplin\(^1\)

\(^1\) NSW DPI, Tamworth, NSW; \(^2\) DAFF, Toowoomba, QLD; \(^3\) DAFF, Warwick, QLD

Key words
Phytophthora root rot, waterlogging, variety, risk management

GRDC codes
DAN00143, DAN00176, DAQ00154

Take home message

Minimise the risk of Phytophthora root rot, PRR in your 2014 chickpeas by:

- avoiding poorly drained paddocks
- avoiding paddocks with a history of lucerne, medics or chickpea PRR
- not growing PBA Boundary\(^1\) if you even suspect a PRR risk
- selecting the best variety suited to soil type, farming system and disease risk which, for PRR is Yorker\(^1\) > HatTrick\(^4\) > Jimbour > Kyabra\(^1\) > Boundary\(^1\)

Note: metalaxyl seed treatment is not recommended in any situation

The 2013 northern NSW/southern QLD chickpea season

The 2013 chickpea season in northern NSW/southern QLD followed a wet January to March, below average post-sow rain in Jun/Jul and then well below average rain for the rest of the growing season (Dalby’s July rain was just above average). Saturated soil in the early part of the chickpea season resulted in waterlogging and in certain paddocks Phytophthora root rot. Mild winter conditions favoured rapid vegetative growth resulting in valuable soil moisture being used to grow high biomass crops. From mid-late Aug to mid-Oct, average daily temperatures fluctuated above and below 15°C and this stress caused flower and pod abortion; 2-3 days of severe frosts around 20 Aug killed flowers and pods on what were by now moisture stressed plants. The much needed rain that started on 15 Sep, was too late and instead of encouraging crops to set new flowers and pods, had the opposite effect – most crops started shutting down by the end of Sep. Across the region, diseases were of little concern. Of 280 crops inspections, Ascochyta blight was found in only five and caused no yield loss. Viruses appeared in late Sep - end Oct, but unlike 2012 caused only minor losses across the region.

Phytophthora root rot

Phytophthora medicaginis, the cause of phytophthora root rot (PRR) of chickpea is endemic and widespread in southern QLD and northern NSW, where it carries over from season to season on infected chickpea volunteers, lucerne, native medics and as resistant structures (oospores) in the soil. The importance of alternative hosts in chickpea PRR was strikingly demonstrated at Moree in 2012. The paddock had never grown chickpeas and had only had three crops (all wheat) after at least 30 years of Coolatai grass and native medic. PRR was first diagnosed on 5 Jul 12 in a few groups of plants; but by mid-Aug, large areas had been killed and on 31 Aug, the entire crop was sprayed out. In contrast, no PRR was found in the adjoining paddock which had a long history of cropping (and thus opportunities to control medics).
The importance of varietal susceptibility became obvious on the Darling Downs during the 2013 season. The high yielding, Ascochyta resistant PBA Boundary was grown widely in the Dalby-Macalister-Warra-Jondaryan area. Unfortunately, saturated soil conditions in the early part of the season showed up PBA Boundary's susceptibility to Phytophthora, with lower parts of several paddocks killed.

PRR (and waterlogging) are favoured by wetter than normal seasons, or by periods of soil saturation in normal seasons as happened in the early part of 2013. Waterlogging can be confused with PRR, but differs in that (i) roots die from lack of oxygen whilst with PRR the Phytophthora organism consumes them; (ii) plants are most susceptible during flowering and early pod fill whereas PRR can affect plants of any age (iii) symptoms develop within 2 days of flooding compared to at least 7 days for PRR, (iv) roots are not rotted immediately after the waterlogging event and, (v) initially, plants are not easily pulled from the soil unlike those affected by PRR.

As there are no in-crop control measures for PRR or waterlogging, a critical management tool is avoidance of high risk paddocks (based on previous experience and paddock history). The other key tool for PRR is varietal selection. Current commercial varieties differ in their resistance to P. medicaginis, with Yorker and PBA HatTrick having the best resistance and are rated MR (Yorker slightly better than PBA HatTrick), Jimbour MS - MR, Flipper and Kyabra MS and PBA Boundary having the least resistance (S). PBA Boundary should not be grown in paddocks with a history of PRR, lucerne, medics or other hosts.

A 2012 PRR trial at Warwick showed that hybrid breeding lines, generated by crossing chickpea with a wild Cicer species, have higher levels of resistance to P. medicaginis than the most resistant variety, Yorker (Table 1). Although the yields of the hybrids in the absence PRR in this trial were slightly lower than those of PBA HatTrick and PBA Boundary, their improved Phytophthora resistance will compensate for that lower yield in wet years. The results also confirm that PBA Boundary suffers a higher yield loss from PRR than PBA HatTrick. The trial was inoculated with P. medicaginis, and some plots were soil-drenched with a fungicide to stop root infection; yield loss calculations for each variety/line were based on the difference in yield between the fungicide-treated plots and untreated plots.

**Table 1.** Yields of chickpea varieties and breeding lines in the absence of phytophthora root rot, and % yield losses from PRR in a 2012 trial at Warwick QLD (P Yield = 0.014; lsd Yield = 0.31; P %yield loss<0.001, lsd Yield loss = 24)

<table>
<thead>
<tr>
<th>Variety/lineA</th>
<th>Yield (t/ha) in absence of Phytophthora infection</th>
<th>% yield loss due to Phytophthora infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>D06318&gt;F3BREE2A8016</td>
<td>2.40</td>
<td>14</td>
</tr>
<tr>
<td>D06344&gt;F3BREE2A8027</td>
<td>2.47</td>
<td>22</td>
</tr>
<tr>
<td>D06321&gt;F3BREE2A8002</td>
<td>2.41</td>
<td>26</td>
</tr>
<tr>
<td>CICA0912</td>
<td>2.49</td>
<td>34</td>
</tr>
<tr>
<td>Yorker</td>
<td>2.52</td>
<td>35</td>
</tr>
<tr>
<td>CICA1007</td>
<td>2.87</td>
<td>60</td>
</tr>
<tr>
<td>PBA HatTrick</td>
<td>2.56</td>
<td>64</td>
</tr>
<tr>
<td>Jimbour</td>
<td>2.70</td>
<td>66</td>
</tr>
<tr>
<td>Kyabra</td>
<td>2.83</td>
<td>78</td>
</tr>
<tr>
<td>PBA Boundary</td>
<td>2.58</td>
<td>85</td>
</tr>
</tbody>
</table>

A D lines are hybrid crosses between chickpea (C. arietinum) and a wild Cicer species
In 2013, a scaled down version of this trial was again conducted at the Hermitage Research Station, Warwick. In this trial PRR was more severe than in the 2012 trial and differences among the varieties were not as great. It is thought the milder winter conditions of the 2013 chickpea season kept soil temperatures above average and this favoured the disease. Nevertheless, the improved resistance of hybrids over varieties was obvious and the ranking of the varieties remained similar to that of the 2012 trial. Indeed, since we started these PRR yield loss trials in 2007, the ranking of varieties has been consistent with the cumulative survival data showing: 

Yorker>HatTrick>Jimbour>Kyabra>Boundary

What the 2013 trial clearly demonstrated was that even the current best varieties eg Yorker, can sustain serious yield loss under high Phytophthora pressure. The trial also highlights the importance of assessing the PRR risk for a given paddock/season.

**Table 2** Yields of commercial chickpea varieties and breeding lines in the absence of phytophthora root rot, and % yield losses from PRR in a 2013 trial at Warwick QLD. (P Yield<0.001; lsd Yield = 0.25; P %yield loss<0.001, lsd Yield loss = 23)

<table>
<thead>
<tr>
<th>Variety/line A</th>
<th>Yield (t/ha) in absence of Phytophthora infection</th>
<th>% yield loss due to Phytophthora infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>D06318&gt;F3BREE2AB016</td>
<td>1.8</td>
<td>33</td>
</tr>
<tr>
<td>D06344&gt;F3BREE2AB027</td>
<td>1.9</td>
<td>37</td>
</tr>
<tr>
<td>CICA0912</td>
<td>1.9</td>
<td>63</td>
</tr>
<tr>
<td>Yorker</td>
<td>2.2</td>
<td>66</td>
</tr>
<tr>
<td>CICA1007</td>
<td>2.0</td>
<td>73</td>
</tr>
<tr>
<td>PBA HatTrick</td>
<td>1.8</td>
<td>79</td>
</tr>
<tr>
<td>PBA Boundary</td>
<td>1.8</td>
<td>82</td>
</tr>
</tbody>
</table>

A D lines are hybrid crosses between chickpea (C. arietinum) and a wild Cicer species


**Acknowledgements**

Thanks to growers and agronomists for help with crop inspections and submitting specimens, to Woods Grains, Goondiwindi for planting material for trials and to chemical companies who provided products for research purposes and trial management. Thanks to Steve Harden for trials designs and analyses and to Paul Nash, Gail Chiplin, Willy Martin and Kris King for technical support.

**Contact details**

Kevin Moore
NSW Department Primary Industries
Ph: 0488 251 866
Fx: 02 6763 1100
Email: kevin.moore@dpi.nsw.gov.au

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Chickpea varietal purity and implications for disease management – are we heading down the Sunvale trail?

Kevin Moore¹, Kristy Hobson¹, Ata-ur Rehman² and Jon Thelander³

¹Tamworth Agricultural Institute, NSW DPI, Tamworth NSW 2340, Australia
²EH Graham Centre for Agricultural Innovation, Charles Sturt University, Wagga Wagga, NSW 2650, Australia
³Seednet, Toowoomba, QLD 4350, Australia

Key words
chickpea, varietal purity, disease management, seed industry

GRDC code
DAN00143

Take home message

- Unusually aggressive levels of Ascochyta in chickpea crops raised questions about varietal purity
- DNA testing of 36 seed lots from commercial chickpea crops identified a high incidence of genetic contamination
- Growers can minimise the risk of planting the wrong variety or a mixture of varieties by acquiring planting seed from a reputable seed supplier

Background

Australian chickpea varieties differ in their reaction to Ascochyta blight, caused by the fungus Phoma rabiei (syn Ascochyta rabiei). Varieties released before 2005 e.g. Jimbour, are susceptible to Ascochyta and, in seasons conducive to disease, require intensive management with foliar fungicides. Most cultivars released in 2005 and later e.g PBA HatTrick¹, have improved Ascochyta resistance and require fewer fungicide sprays. Accurate identification of chickpea varieties is thus critical to Ascochyta management in commercial crops.

Since 2011, several chickpea crops in the GRDC northern region have shown inconsistencies in their reactions to Ascochyta blight. In all cases the variety was named as PBA HatTrick¹ and the seed was grower retained. PBA HatTrick¹, released in 2009, is rated Moderately Resistant (MR) to Ascochyta but the level of disease in these crops was more typical of varieties rated as Susceptible (S). Possible explanations for these unexpected higher levels of disease include (i) a change in the pathogenicity of P. rabiei ie breakdown of varietal resistance, and (ii) authenticity and/or purity of the variety ie mix up in seed source or contamination. Leo et al (2014), in a comprehensive study of the Australian population of P. rabiei, found the genetic diversity of isolates was low and there was little evidence for widespread changes in pathogenicity. Simpfendorfer et al (2013) showed varietal contamination caused the higher than expected levels of stripe rust in the MR bread wheat variety Sunvale. This posed the question: could contamination or a mix-up in source of planting seed account for the observed differences in Ascochyta levels in “HatTrick” crops grown from grower retained seed. It also raised the larger issue of maintaining genetic purity in Australian chickpea varieties after their release.

Purity of chickpea varieties ex 2011 harvest

Thirty six seed-lots from commercial chickpea crops grown in the GRDC northern region in the 2011 season were assessed for seed purity using four simple sequence repeats (SSR, also called
microsatellite) markers. These four were a subset of 15 SSR markers that were shown to differentiate 24 Australian commercially released chickpea varieties and breeding lines. These, and for the varieties, their year of release are listed in Table 1.

For each seed lot, DNA was extracted from eight seedlings and each seedling was assayed using the four SSR markers. Note: this work has not yet been peer reviewed.

The seed weight for each seed lot was determined by weighing three random subsamples, each of 100 seeds, per lot.

Table 1. Australian chickpea varieties and breeding lines used to identify SSR markers that could discriminate among individual varieties

<table>
<thead>
<tr>
<th>Variety/Genotype</th>
<th>Year of Release</th>
<th>Variety/Genotype</th>
<th>Year of Release</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jimbour</td>
<td>2001</td>
<td>PBA HatTrick</td>
<td>2009</td>
</tr>
<tr>
<td>Moti</td>
<td>2003</td>
<td>PBA Slasher</td>
<td>2009</td>
</tr>
<tr>
<td>Sonali</td>
<td>2004</td>
<td>Genesis™ 079</td>
<td>2009</td>
</tr>
<tr>
<td>Flipper(l)</td>
<td>2005</td>
<td>Genesis™ 114</td>
<td>2010</td>
</tr>
<tr>
<td>Kyabra(l)</td>
<td>2005</td>
<td>Genesis™ Kalkee</td>
<td>2011</td>
</tr>
<tr>
<td>Yorker(l)</td>
<td>2005</td>
<td>PBA Pistol</td>
<td>2011</td>
</tr>
<tr>
<td>Almaz</td>
<td>2005</td>
<td>PBA Boundary</td>
<td>2011</td>
</tr>
<tr>
<td>Genesis™ 090</td>
<td>2005</td>
<td>PBA Striker</td>
<td>2012</td>
</tr>
<tr>
<td>Genesis™ 425</td>
<td>2007</td>
<td>PBA Maiden</td>
<td>2013</td>
</tr>
<tr>
<td>CICA0709</td>
<td>not released</td>
<td>PBA Monarch</td>
<td>2013</td>
</tr>
<tr>
<td>CICA0912</td>
<td>not released</td>
<td>CICA1007</td>
<td>not released</td>
</tr>
<tr>
<td>CICA1016</td>
<td>not released</td>
<td>04067-81-2-1-1</td>
<td>not released</td>
</tr>
</tbody>
</table>

Results

In only 15 of the 36 seed lots, were all eight seedlings deemed to be the same; the remaining 21 lots showed varying degrees of contamination by known and unknown genotypes. Results for eight seed lots are in Table 2.
Table 2. Selected results from 36 chickpea seed lots ex 2011 harvest showing the variety declared at receipt, 100 seed weight and identity of each of 8 seedlings as determined by four SSR markers based on DNA profiles

<table>
<thead>
<tr>
<th>Declared</th>
<th>100 sdw g</th>
<th>DNA Identity (max 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jimbour</td>
<td>21.8</td>
<td>Jimbour (1), Kyabra(6), Undetermined (1)</td>
</tr>
<tr>
<td>Jimbour</td>
<td>20.0</td>
<td>HatTrick(8)</td>
</tr>
<tr>
<td>Kyabra(1)</td>
<td>21.8</td>
<td>Moti (7), Kyabra(1)</td>
</tr>
<tr>
<td>Kyabra(1)</td>
<td>20.9</td>
<td>HatTrick(4), Kyabra(1), Undetermined (3)</td>
</tr>
<tr>
<td>Kyabra(1)</td>
<td>18.3</td>
<td>Kyabra(1), Jimbour (2), Moti (4), Undetermined (1)</td>
</tr>
<tr>
<td>Howzat</td>
<td>17.2</td>
<td>Flipper(6), Undetermined (2)</td>
</tr>
<tr>
<td>HatTrick(1)</td>
<td>21.2</td>
<td>HatTrick(8)</td>
</tr>
<tr>
<td>Amethyst</td>
<td>18.2</td>
<td>Jimbour (7), Undetermined (1)</td>
</tr>
</tbody>
</table>

The DNA assays for the 36 seed lots suggest that unintentional contamination, or mix up in planting seed, is the most plausible explanation for any differences among the eight seedlings.

The seed weight data support the findings of the DNA assays. The 100 seed weights for Amethyst, Flipper(1), PBA HatTrick(1), Howzat, Jimbour, and Kyabra(1) in field trials conducted in Southern QLD from 2005 – 2008, were 14, 18, 20, 21, 20 and 24 grams respectively. Thus it is not surprising that the seed lot declared to be Amethyst in Table 2 was determined to be a variety with a 100 sdw greater than 14g. Similarly the lot declared to be Howzat had seeds that were too small to be Howzat (100 sdw 21g) but that were similar to those of Flipper(1) (100 sdw 18g).


How widespread is the purity problem?

We don’t know but the results of the 36 seed lots suggest it is a far bigger problem than the chickpea industry currently believes. It’s not difficult to see how this can happen. Assuming the multiplication rate for chickpea is 50 ie you plant one seed and get 50 back, a single seed of say Jimbour in a one hectare block of otherwise pure PBA HatTrick(1) yields 50 Jimbour seeds at the end of season one. Season two gives 2,500 Jimbour contaminants; season three 125,000 etc. And that is just one hectare. Whilst the problem first surfaced in 2011, it does appear to be getting worse. In 2013, on a property near Moree, three paddocks had been planted with seed from three different sources, all grower retained and all believed to be PBA HatTrick(1). When inspected on 8 & 9 August 2013, it was obvious that one of the paddocks was different from the other two and was clearly not PBA HatTrick(1) (possibly Howzat). A similar situation was observed, again in 2013, on another north western NSW property where the grower had sown one half of a paddock with grower retained seed and the other half with a different source of grower retained seed. The seed from the two sources was believed to be PBA HatTrick(1) but it was obvious when inspected that they were not the same variety and again one was not PBA HatTrick(1) (possibly Yorker(1)).
Does it really matter if a chickpea crop is a mixture of varieties?

Why is it important to know what you are growing and the level of contamination, if any? Accurate identification of chickpea variety is essential for:

- Implementing appropriate disease management strategies
- Minimising the risk to resistance genes in MR varieties from increased inoculum generated on contaminant plants or “mix up” crops, of susceptible varieties
- Maximising marketing opportunities by producing pure seed of one variety
- Supporting grower’s legal rights eg if seed you purchased is not what you paid for
- Assessing compliance with plant breeder’s rights legislation thus ensuring breeding programs receive the appropriate royalties
- Prolonging the commercial life of new varieties
- Providing confidence in the chickpea seed industry
- Providing technical support to research programs eg knowing the genotype of a plant from which an Ascochyta isolate is obtained is critical to the current GRDC project on the variability of the Australian population of the chickpea Ascochyta pathogen

Cost of Ascochyta management – an example of a consequence of varietal impurity

In a season that is conducive to chickpea Ascochyta, Tamworth research has shown that a crop of pure PBA HatTrick® will require two foliar fungicide sprays totalling $30/ha. A crop of an Ascochyta susceptible variety eg Jimbour would need six sprays costing $90/ha. This equates to a difference of $30,000 for a 500ha planting. If you are unsure of the variety’s identity or it is a mixture, the crop must be treated as a susceptible variety.

Where to from here?

As mentioned earlier, the molecular work has not been peer reviewed and, due to staff changes, is currently on hold. However, continuation of the variety identification work is being discussed with the University of Adelaide and that there is an opportunity to tap into existing genomic resources that have been funded by the Australian Federal Government through the Australia India Strategic Research Fund.

Conclusions

- DNA evidence has identified genetic contamination in commercial chickpea crops going back to at least 2011
- Crop inspections have revealed obvious differences among plantings believed by growers to be the one variety
- Minimise the risk of contamination of your 2014 planting seed by obtaining seed from a registered seed merchant
- When retaining your own seed, put in place a quality control system to avoid accidental contamination

Acknowledgements

Thanks to agronomists and growers for identifying paddocks and giving permission to inspect and sample crops. Thanks to Paul Nash and Gail Chiplin for technical support.

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Leo A, Ford R and Linde C (2014) Evolution and dispersal of a recently introduced pathogen of chickpea, *Ascochyta rabiei*, to Australia. Accepted by *Biological Invasions*

Contact details
Dr Kevin Moore
NSW Department Primary Industries, Tamworth
Ph: 02 6763 1133
Mb: 0488 251 866
Email: kevin.moore@dpi.nsw.gov.au

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Chickpea varieties – selecting horses for courses

Gordon Cumming, Pulse Australia

Key words
Chickpea, variety selection, adaptation, resistance, disease, ascochyta blight, phytophthora root rot, virus, nematodes.

GRDC code
PAL00019

Take home message
- Varietal selection should be made on; adaptation, yield potential, disease resistance and grain marketability.
- Disease free yield advantages can be quickly negated in situations of high diseased pressure.
- Growers need to determine their disease risk profile as they may be better served by selecting the variety with the greatest varietal resistance rather than the highest yield.
- Regardless of variety, best agronomic practices are needed to ensure maximum yields are achieved in any given environment and season.

Introduction
An increasing number of pulse variety options exist. Careful variety selection through knowing the agronomic, disease and marketing strengths and weakness of each variety is required to maximise pulse production and returns.

Best agronomic practise need to be employed regardless of variety to achieve maximum returns. These include, careful paddock selection, the planting of high quality seed and suitable crop protection practices including weed, disease and insect management, followed by careful harvest, handling and storage practices.

Consideration of market access and options, even prior to crop establishment can also have a significant impact on the crops value and profitability.

Choosing a variety
A component of risk assessment is to understand what different varietal ratings mean with respect to a given disease and its management.

The availability of varieties resistant to ascochyta blight now provides growers with low disease risk options for growing chickpea in northern Australia. Ascochyta blight of chickpeas has been a widespread and devastating disease in northern, southern and Western Australia and unless resistant varieties are used, can be a major limitation to overcome when growing this crop.

Some ascochyta blight resistant varieties available to growers may have other agronomic, disease or marketability limitations and will not suit all areas or situations (e.g. PBA Boundary®, which is susceptible to phytophthora root rot). When choosing varieties to grow, it is essential to consider their susceptibility to ascochyta blight and phytophthora root rot along with yield potential, price potential, marketing opportunities, flowering cold tolerance, maturity timing, lodging resistance and other agronomic features relevant to your growing region.
When comparing yields between varieties, growers need to be aware that under high ascochyta blight pressure, varieties with moderate resistance, or less, are more likely to suffer greater yield losses than the resistant lines, even with regular applications of foliar fungicides.

**Area of adaptation**

Chickpea varieties are bred for and selected in a range of different environments. Hence individual varieties have specific areas of adaptation for maximised yield and reliability. Specific adaptation of a variety depends on rainfall, geography, temperatures, disease pressure and soil types of where it is grown.

The national chickpea area has been categorised by Pulse Breeding Australia (PBA) into five regions based on rainfall and geographic location.

- Region 1 – Low rainfall tropical
- Region 2 – Medium rainfall, sub-tropical
- Region 3 – Low rainfall, sub-tropical
- Region 4 – Medium/high rainfall Mediterranean/temperate
- Region 5 – Low/medium rainfall Mediterranean/temperate

These regions cross state borders, and are target zones for national breeding and variety evaluation. Breeding trials and National Variety Trial (NVT) results help indicate specific adaptation even within a region.

There have been variety releases specific for central Queensland (PBA Pistol™ and Mot(™)) southern Queensland and northern New South Wales (PBA HatTrick™ and PBA Boundary™).

Area of adaption is specified for each variety so that potential users are aware of their best fit.

**Paddock selection criteria**

- Chickpea crops should be separated from previous year’s crop by at least 500 m and up to 1 km in areas where old stubble is prone to movement i.e. down slope and on flood plains. This helps to reduce the spread of ascochyta blight, a foliar/stubble borne disease.
- Avoid poorly drained paddocks and those with a history of water logging.
- Check herbicide use over the previous 12 months to 2 years to determine any potential residue problems prior to sowing.
- Check any soil tests and/or grower records, paying particular attention to the following soil characteristics and advise growers accordingly;
  - pH 5.2 – 8.0
  - Soil type – Loams to self-mulching clays
  - Sodicity, avoid ESP levels 3
  - Salinity/Chloride, avoid ECe levels above 1.5 ds/m
  - Potential water logging problems
  - Amount of stored soil moisture and received rainfall, noting their potential impact on herbicide residues.
• Have an understanding of the crop management and harvest problems created by unlevelled paddocks and/or paddock obstacles i.e. sticks and stones.
  o Avoid major variations in soil types
  o Avoid deep giligai or heavily contoured country.

Evaluation of yield potential

The most accurate prediction of a varieties performance is a stable yield in many locations over several years.

Yield results from Pulse Breeding Australia (PBA) and National Variety Trials (NVT) are available from the NVT website [www.nvtonline.com.au](http://www.nvtonline.com.au) as well from the specific Pulse Variety Management Package (VMP) brochure. Long term yields can be represented in several different ways but are typically displayed as either site specific, averaged over multiple years (Figure 1), or for each year averaged over multiple sites for a region (Table 1). All trial sites are disease free.

![Adjusted Average Yield](image)

**Figure 1.** NVT Long term yield report – chickpea – desi – SWQ – Billa Billa (2005 to 2012)
*Source: National Variety trials (NVT)*

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>R2</td>
<td>R3</td>
<td>R2</td>
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<tr>
<td>Flipper</td>
<td>95</td>
<td>86</td>
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<td>72</td>
<td>78</td>
<td>104</td>
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<td>Kyabra</td>
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<td>72</td>
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<td>PBA Boundary</td>
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<tr>
<td>PBA HatTrick</td>
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<tr>
<td>Yorker</td>
<td>88</td>
<td>98</td>
<td>100</td>
<td>96</td>
<td>98</td>
</tr>
<tr>
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<td>2.28</td>
<td>1.78</td>
<td>1.56</td>
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</table>

Region 2 (R2): Central/North-Western Slopes (NSW) and Darling Downs (Qld).
Region 3 (R3): Central/North-Western Palins (NSW) and Western Downs/Maranoa (Qld).
*Source: Pulse Breeding Australia (PBA) and National Variety trials (NVT)*
Disease management and varietal resistance

Ascochyta blight (*Phoma rabiei*), is a serious disease of chickpeas in Australia. It is now endemic in all growing regions including central Queensland.

Considerable advances have been made with recent varietal releases in terms of ascochyta blight resistance. However, there are several other diseases that need to be considered in terms of individual situation risks when selecting both varieties and paddocks. The most important of these is the soil borne disease phytophthora root rot (PRR).

Table 2; shows the relative yield responses of various varieties to both ascochyta blight and phytophthora root rot, in high disease pressure situations. The yield advantages of varieties like PBA Boundary and Kyabra can be quickly lost if they are exposed to diseases for which they are susceptible.

Growers need to determine their disease risk profile as they may be better served by selecting the variety with the greatest varietal resistance(s) to the expected disease pressures, even if the variety is lower yielding in disease free situations.

These decisions also need to be made in conjunction with an understanding of what management options are available.

**Table 2. Disease resistance rating and yield loss of desi chickpea in north-eastern Australia**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Ascochyta blight (AB)*</th>
<th>Phytophthora root rot (PRR)**</th>
<th>Yield (t/ha)</th>
<th>% Yield loss</th>
<th>Yield (t/ha)</th>
<th>% Yield loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipper</td>
<td>MR/MS</td>
<td>1.69</td>
<td>-</td>
<td>9</td>
<td>-</td>
<td>MS</td>
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<tr>
<td>Jimbour</td>
<td>S</td>
<td>0.44</td>
<td>0.00</td>
<td>77</td>
<td>100</td>
<td>MS/MR</td>
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<tr>
<td>Kyabra</td>
<td>S</td>
<td>-</td>
<td>0.00</td>
<td>0</td>
<td>100</td>
<td>MS</td>
</tr>
<tr>
<td>PBA Boundary</td>
<td>MR</td>
<td>1.84</td>
<td>2.32</td>
<td>4</td>
<td>4</td>
<td>S</td>
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<tr>
<td>PBA HatTrick</td>
<td>MR</td>
<td>1.71</td>
<td>1.71</td>
<td>8</td>
<td>34</td>
<td>MR</td>
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<tr>
<td>Yorker</td>
<td>MS</td>
<td>1.80</td>
<td>-</td>
<td>5</td>
<td>-</td>
<td>MR</td>
</tr>
</tbody>
</table>

* Ascochyta blight yield loss trial, Tamworth 2009 & 2010 – NSW-DPI
** Phytophthora root rot yield loss trial, Warwick 2012 – Qld DAFF and NSW-DPI
# Yield (t/ha) in absence of infection
## % Yield loss due to inoculation with phytophthora root rot

Source: NSW-DPI and Qld DAFF Plant pathology teams

Phytophthora root rot (PRR)

Is a soil and water-borne disease that can establish permanently in some paddocks. 2010 was particularly conducive to PRR because damage is greatest in seasons with above average rainfall. However, only a single saturating rain event is needed for infection, as was seen in 2012.

The most effective control strategy is to not plant chickpeas in high-risk paddocks, which are those with a history of waterlogging and PRR in previous chickpea crops, or a history of lucerne, annual medic or perennial legumes.

 Management options for phytophthora

Once a plant or crop is infected with phytophthora, there is nothing a grower can do.

There are no effective chemical sprays as there are for ascochyta blight. Thus, phytophthora root rot can only be managed by pre-sowing decisions and assessing risks for individual paddocks.
Development of the disease requires both the pathogen in the soil, and a period of soil saturation with water. Losses in a phytophthora-infested paddock may be minor if soil saturation does not occur.

The most effective control strategy is to not sow chickpeas in high-risk paddocks, which are those with a history of:
- Phytophthora noted in previous chickpea or lucerne crops.
- Lucerne or annual or perennial medics.
- Waterlogging or prone to flooding.

If you choose to sow chickpeas in high-risk paddocks, the following measures may reduce losses from phytophthora:
- Grow a chickpea variety with the highest level of resistance (see Table 2). Particularly in medium risk situations, where medic, chickpea or lucerne crops have been grown in the past 5 - 6 years.
- However, the level of protection offered by varietal resistance remains low.

**Nematodes**

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

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

However, chickpea will result in increased levels of *Pratylenchus* after the crop, although there does appear to be some varietal differences. The newer varieties PBA HatTrick and PBA Boundary have consistently showing lower Pratylenchus levels compared to Jimbour and Kyabra.

![Figure 2. Comparison of Pratylenchus population remaining as a % of Jimbour.](source)

*Source: Northern Grower Alliance (2010-2012)*
Viral diseases

There are over 14 viruses that cause significant losses in chickpea and currently all northern chickpea varieties are considered to be susceptible (S) to them.

The occurrence of virus in chickpea changes dramatically from season to season and location.

Control measures for viruses in chickpea are not adequate at the present time. Application of seed and foliar insecticides, aimed at preventing feeding by aphids, has failed to prevent infection by viruses in field experiments.

Best agronomic management can help to reduce damage by viruses and includes:

- retention of cereal stubble to deter aphids;
- sowing at recommended times to avoid autumn aphid flights;
- sowing at recommended seed densities to achieve early closure of the crop canopy (closed canopies deter aphids).

Future breeding directions

The current Pulse Breeding Australia (PBA) program continues to focus on regional adaptation, higher grain yields and greater levels of varietal resistance to the main two chickpea diseases of ascochyta blight and phytophthora root rot.

The next most likely release for southern Queensland and northern New South Wales is the coded line CICA0912 which is combining the yield potential of the current commercial lines as well as the best ascochyta blight and phytophthora root rot that is currently available into a single variety.

Additional valuable traits that the breeding program is working with include:

- resistance to botrytis grey mould (BGM)
- virus resistance
- improved resistance to root lesion nematodes (*Pratylenchus thornei* and *P. neglectus*)
- improved tolerance to soil salt levels
- improved reproductive cold tolerance has also been incorporated into the program.

Additional information


Contact details

Gordon Cumming
Pulse Australia Limited
Mb: 0408 923 474
Email: gordon@pulseaus.com.au

/ (/) Varieties displaying this symbol beside them are protected under the Plant Breeders Rights Act 1994