NORTHERN
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GRDC GROWNOTES™

GRDC™ GRAINS RESEARCH & DEVELOPMENT CORPORATION

CHICKPEA

SECTION 2

PRE-PLANTING

CHOOSING A VARIETY | AREA OF ADAPTATION | EVALUATION OF YIELD POTENTIAL | DISEASE MANAGEMENT AND VARIETAL RESISTANCE | FUTURE BREEDING DIRECTIONS | PLANTING SEED QUALITY | SEED TESTING

SECTION 2

Pre-planting

More information

http://www.grdc.com.au/Research-and-Development/National-Variety-Trials/Crop-Variety-Guides

http://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/chickpeas

http://www.dpi.nsw.gov.au/agriculture/broadacre/guides/winter-crop-variety-sowing-guide

Pulse Australia (2016), Chickpea production: northern region

QDAF (2015), Varieties of chickpeas

Pulse Australia (2015), Chickpea variety choices for 2015

K Hobson, A Verrell, A George, M Nowland, J Duncan (2014), PBA Chickpea program – Evaluation in 2013 p 36

2.1 Choosing a variety

Choosing a variety that has been bred for, and proven in, the northern grains region is the first step in successful chickpea production. Understanding varietal ratings with respect to diseases and their control is a key part of risk 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 all Australian grain regions, and unless resistant varieties are used, it can be a major limitation when growing this crop.

Some varieties with Ascochyta blight resistance that are 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 where Ascochyta blight pressure is high, 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. [1]

2.2 Area of adaptation

Chickpea varieties are bred for and selected in a range of environments. Hence, individual varieties have specific adaptations to help maximise yield and reliability under particular conditions. These conditions include rainfall, geography, temperatures, disease pressure and soil type.

The national chickpea area has been categorised by Pulse Breeding Australia (PBA) into five regions based on rainfall and geographic location (Figure 1):

- Region 1, low rainfall tropical
- Region 2, medium rainfall, subtropical
- Region 3, low rainfall, subtropical
- Region 4, medium–high rainfall Mediterranean–temperate
- Region 5, low–medium rainfall Mediterranean–temperate

1 G Cumming (2014) Chickpea varieties selecting horses for courses. GRDC Update Papers 5 March 2014, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Chickpea-varieties-selecting-horses-for-courses

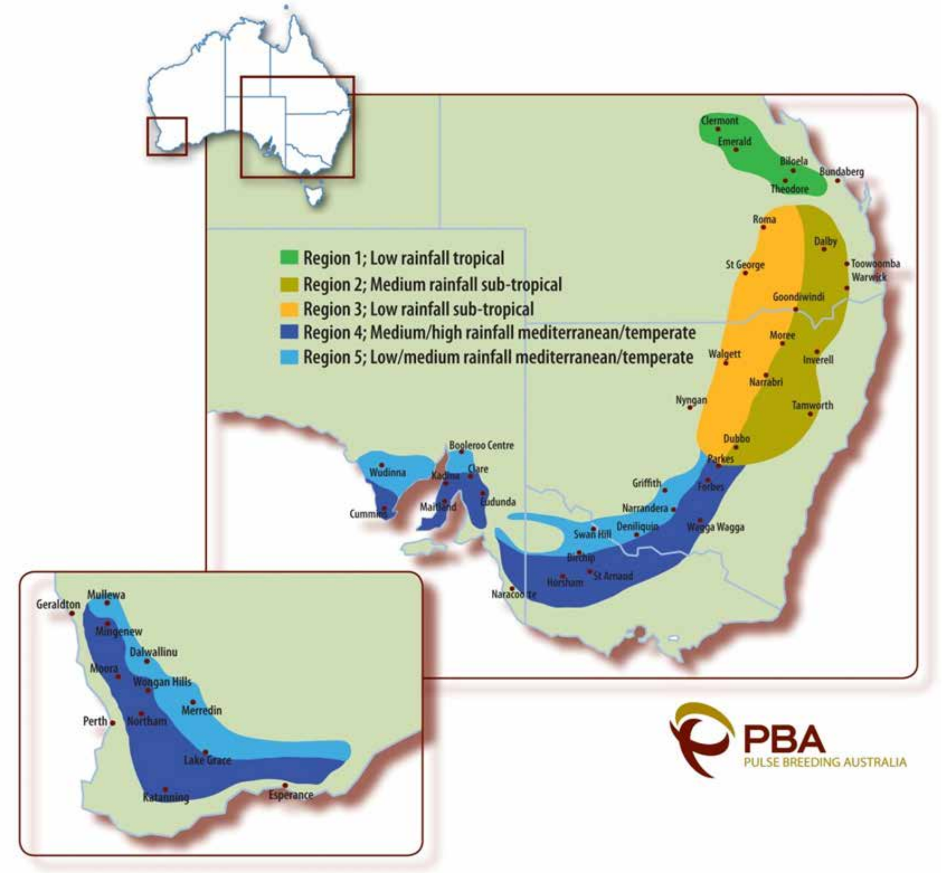

Figure 1: Five Australian chickpea-growing areas based on rainfall and geographic location.

These regions cross state borders and are target zones for national breeding programs 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 Seamerⓟ, PBA Pistolⓟ and Motiⓟ), southern Queensland and northern New South Wales (PBA HatTrickⓟ and PBA Boundaryⓟ).

The area of adaptation is specified for each variety so that potential users are aware of their best fit. [2]

More information

http://www.grdc.com.au/uploads/documents/PBA%20HatTrick%20-%20chickpea.pdf

http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Chickpea-varieties-selecting-horses-for-courses

[2] G Cumming (2014) Chickpea varieties selecting horses for courses. GRDC Update Papers 5 March 2014, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Chickpea-varieties-selecting-horses-for-courses

More information

http://www.nvtonline.com.au/variety-brochures/

http://www.grdc.com.au/Research-and-Development/Major-Initiatives/PBA/PBA-Varieties-and-Brochures

2.3 Evaluation of yield potential

The most accurate predictor of a variety's 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, as well as from the specific Pulse Variety Management Package (VMP) brochure at http://www.grdc.com.au/Research-and-Development/Major-Initiatives/PBA/PBA-Varieties-and-Brochures

Long-term yields can be represented in several different ways but are typically displayed either as site-specific, averaged over multiple years (Figure 2), or for each year averaged over multiple sites for a region (Table 1). All trial sites are disease-free. [3]

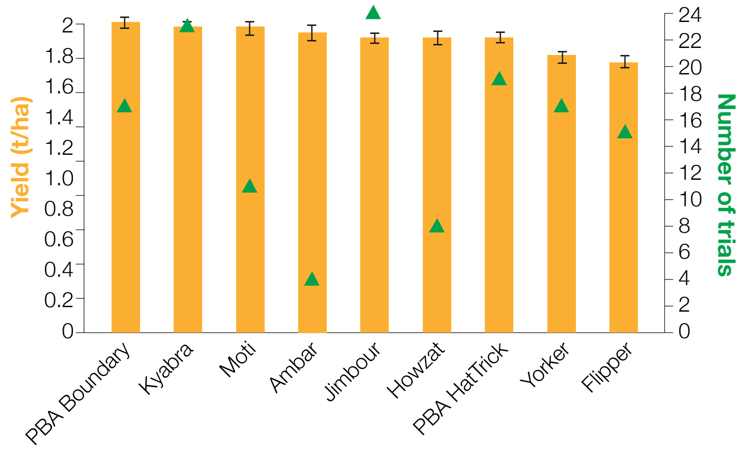

Figure 2: National Variety Trials long-term yield report: chickpea—Desi—SWQ—Billa Billa (2005–12). (Source: NVT)

Table 1: Long-term Desi chickpea yields in north-eastern Australia as a percentage of PBA HatTrick(|), 2006–10

Region 2, R2, Central/North-Western Slopes (NSW) and Darling Downs (Qld); Region 3, R3, Central/North-Western Plains (NSW) and Western Downs/Maranoa (Qld)

Variety	2010		2009		2008		2007		2006	
	R2	R3	R2	R3	R2	R3	R2	R3	R2	R3
Flipper(|)	95	86	97	92	96	90	97	86	96	89
Jimbour(|)	72	78	104	103	99	96	103	102	102	100
Kyabra(|)	78	72	106	105	99	96	105	104	106	–
PBA Boundary (|)	109	104	104	102	109	105	106	106	106	109
PBA HatTrick(|)	100	100	100	100	100	100	100	100	100	100
Yorker(|)	88	98	100	96	98	89	92	88	94	91
PBA HatTrick(|) (t/ha)	2.12	2.28	1.78	1.56	2.14	1.96	1.27	1.10	1.86	1.68

Source: Pulse Breeding Australia and National Variety Trials.

[3] G Cumming (2014) Chickpea varieties selecting horses for courses. GRDC Update Papers 5 March 2014, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Chickpea-varieties-selecting-horses-for-courses

More information

http://www.dpi.nsw.gov.au/agriculture/broadacre/guides/winter-crop-variety-sowing-guide

http://www.grdc.com.au/Research-and-Development/Major-Initiatives/PBA/PBA-Varieties-and-Brochures

https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2010/05/Chickpeas-In-2010-PBA-Hattrick-Performance-And-Management

L Lake, V Sadras (2016). The critical period for yield determination in chickpea

L Jenkins, A Verrell (2015). Chickpea and mungbean research to maximise yield in northern NSW

When choosing a variety many factors must be considered, including disease susceptibility, paddock suitability, seed availability, seed size and sowing rate (with reference to sowing machinery), seed cost, harvesting ease and marketing options. [4]

A Variety Management Package (VMP) is released with each new PBA variety. The brochures provide information about appropriate agronomic and disease management and disease ratings for each variety.

The information in the brochures is compiled from agronomic and disease management projects funded by the Grains Research and Development Corporation (GRDC) in conjunction with the PBA partner agencies, combined with yield data from variety trials conducted by both PBA and NVT. [5]

2.3.1 Yielding ability

Desi types

Ambar⫶. Resistant (R) to Ascochyta, similar to Genesis™ 509 and Genesis™ 090, superior to PBA HatTrick and PBA Boundary; susceptible (S) to Phytophthora root rot, so not recommended for northern NSW. Limited evaluation in southern NSW. Developed by DAFWA and UWA from germplasm bred by NSW DPI. Marketed by Heritage Seeds. An EPR of $4.40/tonne applies.

Flipper⫶. Moderately resistant–moderately susceptible (MR–MS) to Ascochyta, less resistant than PBA HatTrick and PBA Boundary; MS to Phytophthora, less resistant than PBA HatTrick; S to viruses. Tall, erect variety with very good lodging resistance and medium sized seed. Bred by NSW DPI; commercial partner is Seednet with seed available through Seednet agents. An EPR of $3.30/tonne applies.

Jimbour. Susceptible to Ascochyta. Suited to areas where Ascochyta is not considered a major threat and experience shows that the disease can be managed in susceptible varieties; MS–MR to Phytophthora. Bred by DAF Qld, commercialised by Mt Tyson seeds. No EPR applies.

Kyabra⫶. Susceptible to Ascochyta – suited to areas where Ascochyta is not considered a major threat and experience shows that the disease can be managed in susceptible varieties; MS to Phytophthora; S to Botrytis grey mould. Larger seed size and superior grain quality for the whole seed market compared with other current varieties. Bred by DAF Qld and NSW DPI; commercial partner is Heritage Seeds. A seed royalty applies to all seed sales of Kyabra; no EPR applies.

Neelam⫶. Resistant to Ascochyta, similar to Genesis™ 509 and Genesis™ 090, superior to PBA HatTrick and PBA Boundary; S to Phytophthora root rot, so not recommended for northern NSW. Limited evaluation in southern NSW. Developed by DAFWA and UWA from germplasm bred by DEDJTR Victoria. Marketed by Heritage Seeds. An EPR of $4.40/tonne applies.

PBA Boundary⫶. Moderately resistant to Ascochyta, superior to PBA HatTrick; S to Phytophthora, less resistant than PBA HatTrick and only suitable for paddocks with a low Phytophthora risk. Highest yielding variety across chickpea growing regions of northern NSW and southern QLD. Lower yielding than PBA Slasher in southern NSW, but a suitable option if a tall, erect plant type is required. Mid-season maturity, equivalent to PBA HatTrick. Medium sized desi seed suited to the human consumption market. Developed by Pulse Breeding Australia (PBA). Marketed by Seednet with seed available through Seednet agents. An EPR of $4.40/tonne applies.

4 P Matthews, Don McCaffery, L Jenkins (2014) Winter crop variety sowing guide 2014. NSW DPI, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/Winter-crop-variety-sowing-guide-2014.pdf

5 Pulse Breeding Australia. PBA Varieties and brochures. GRDC Major Initiatives, http://www.grdc.com.au/Research-and-Development/Major-Initiatives/PBA/PBA-Varieties-and-Brochures

Figure 3: PBA Boundary⚪ has better Ascochyta blight resistance than PBA HatTrick⚪ but is more susceptible to Phytophthora root rot. (Photo: Gordon Cumming, Pulse Breeding Australia)

PBA HatTrick⚪. Moderately resistant to Ascochyta, superior to Flipper; MR to Phytophthora, more resistant than Jimbour, but less than Yorker. High-yielding variety across chickpea growing regions of northern NSW and southern Qld, recommended and suited to areas north of Parkes. Tall, erect plant type with mid-season maturity, equivalent to Jimbour. Medium sized desi seed suited to the human consumption market. Developed by Pulse Breeding Australia (PBA). Marketed by Seednet with seed available through Seednet agents. An EPR of $4.40/tonne applies.

Figure 4: PBA HatTrick⚪ is moderately resistant–resistant to Ascochyta blight. (Photo: Gordon Cumming, Pulse Breeding Australia)

PBA Seamer⚪ is an improved desi chickpea for the northern region with the highest available Ascochyta blight resistance rating (rated R). It is broadly adapted from central NSW to central Queensland, with significantly higher grain yield than all current varieties in high disease years. PBA Seamer⚪ has a semi-erect plant type with superior lodging resistance to PBA HatTrickA and PBA Boundary⚪. PBA Seamer⚪ has improved seed quality with larger seed size than PBA HatTrick⚪ and higher dhal milling yield than all current varieties in southern QLD and northern NSW.

PBA Maiden⚪. Moderately resistant to Ascochyta, less than PBA Slasher; S to Phytophthora root rot, so not recommended for northern NSW. Semi-spreading plant type with mid-season maturity, similar to PBA Slasher. Large sized desi for southern environments with a yellow-tan seed coat suited to whole seed markets. Developed by Pulse Breeding Australia (PBA). Marketed by Seednet with seed available through Seednet agents. An EPR of $4.40/tonne applies.

PBA Slasher⫮. Resistant to Ascochyta, similar to Genesis™ 509 and Genesis™ 090, superior to PBA HatTrick and PBA Boundary; S to Phytophthora root rot, so not recommended for northern NSW. High-yielding variety across all southern and western Australian chickpea growing regions, recommended and suited to areas south of Parkes. Semi-spreading plant type with mid-season maturity, similar to Howzat. Medium sized desi with tan–brown seed coat suitable for the whole and split seed markets. Developed by Pulse Breeding Australia (PBA). Marketed by Seednet with seed available through Seednet agents. An EPR of $4.40/tonne applies.

PBA Striker⫮. Moderately resistant to Ascochyta, less than PBA Slasher; S to Phytophthora root rot, so not recommended for northern NSW. High-yielding variety in short season environments in southern and western Australian chickpea growing regions. Semi-spreading plant type with earlier flowering and maturity than PBA Slasher. Medium sized desi with tan–brown seed coat suitable for the whole and split seed markets. Developed by Pulse Breeding Australia (PBA). Marketed by Seednet with seed available through Seednet agents. An EPR of $4.40/tonne applies.

Yorker⫮. Moderately susceptible to Ascochyta, inferior to PBA HatTrick and PBA Boundary; MR to Phytophthora, better than PBA HatTrick. Suited to drier areas where Phytophthora rather than Ascochyta is the greater risk. Yorker is sensitive to Balance® herbicide (see Weed control in the next column). Bred by NSW DPI; commercial partner is Seednet with seed available through Seednet agents. An EPR of $3.30/tonne applies.

Kabuli types

Almaz⫮. Moderately susceptible to Ascochyta, inferior to Genesis™ 090 and Genesis™ 425; S to Phytophthora. Medium seed size, 8–9 mm. Introduced from ICARDA, Syria and selected by DAFWA. Commercial partner is COGGO Group. Contact Seednet in eastern Australia for seed orders. An EPR of $7.15/tonne applies.

Genesis™ 090. Resistant to Ascochyta, equal to Genesis™ 509; broadly adapted; VS to Phytophthora, suited only to areas with a low Phytophthora risk. Seed size is smaller than Almaz, predominantly 7–8 mm. Introduced from ICARDA, Syria and selected by DEDJTR Victoria. Marketed by Australian Agricultural CroP.Technologies. An EPR of $5.00/tonne applies.

Genesis™ 114. Moderately susceptible to Ascochyta, inferior to Genesis™ 090 and Genesis™ 425; S to Phytophthora. Medium seed size similar to Almaz, predominantly 8–9 mm. Introduced from ICARDA, Syria and selected by DEDJTR Victoria. Excellent harvestability with an erect plant habit and good lodging resistance. Marketed by Australian Agricultural CroP.Technologies. An EPR of $5.50/tonne applies.

Genesis™ 425. Resistant o Ascochyta, superior to Almaz, and equal to Genesis™ 090. The least susceptible kabuli variety to Phytophthora but a susceptible rating means it will sustain economic yield loss in high risk Phytophthora situations. Higher yielding than Almaz, but lower yielding than Genesis™ 090. Seed size is smaller than Almaz, but slightly larger than Genesis™ 090 (predominantly 8 mm). Genesis™ 425 has shown some sensitivity to Balance® in northern NSW trials and herbicide screening trials in South Australia. Introduced from ICARDA, Syria and selected by DEDJTR Victoria and NSW DPI. Marketed by Australian Agricultural CroP.Technologies. An EPR of $5.50/tonne applies.

Genesis™ Kalkee. Moderately susceptible to Ascochyta, inferior to Genesis™ 090 and Genesis™ 425; S to Phytophthora. Larger seed size than Almaz and Genesis™ 114, predominantly 9 mm. Introduced from ICARDA, Syria and selected by DEDJTR Victoria and NSW DPI. Yield is similar to Genesis™ 114 and Almaz in northern and southern NSW. Excellent harvestability with an erect plant habit and good lodging resistance. Marketed by Australian Agricultural CroP.Technologies. An EPR of $5.50/tonne applies.

PBA Monarch⫮. Moderately susceptible to Ascochyta, inferior to Genesis™ 090 and Genesis™ 425; S to Phytophthora. Early flowering and early maturing. Medium seed size, 8–9 mm, similar to Almaz. Highest yielding medium sized kabuli chickpea. Semispreading plant type, which can be prone to lodging. Developed by Pulse Breeding Australia (PBA). Marketed by Seednet with seed available through Seednet agents. An EPR of $7.15/tonne applies. [6]

Characteristics and disease ratings for these varieties are summarised in Tables 2 and 3.

Table 2: Chickpea variety characteristics

Variety	Plant height	Lodging resistance	100 seed weight (g)	Maturity	North: Yield as a % of PBA HatTrick 2011–2015		South: Yield as a % of PBA Slasher 2011–2015	
					East 1.94 t/ha	West 1.55 t/ha	East 1.56 t/ha	West 1.36 t/ha
Desi Types								
Ambar	MS	VG	16	E	n.d.	n.d.	93 (3)	95 (3)
Flipper	T	VG	18	M–L	n.d.	94 (5)	n.d	n.d
Howzat	M	M	21	M	n.d.	n.d.	95 (5)	95 (5)
Jimbour	T	VG	20	M	101 (13)	101 (35)	n.d.	n.d
Kyabra	T	VG	26	M	106 (10)	109 (28)	n.d.	n.d.
Neelam	MT	VG	17	M	n.d.	n.d.	99 (3)	99 (3)
PBA Boundary	T	G	19	M	102 (13)	103 (35)	94 (5)	95 (5)
PBA HatTrick	T	G	20	M	100 (13)	100 (35)	91 (5)	92 (5)
PBA Maiden	MS	M	24	M	n.d.	n.d.	97 (5)	99 (5)
PBA Slasher	MS	M	18	M	n.d.	n.d.	100 (5)	100 (5)
PBA Striker	MS	M	21	E	n.d	n.d	100 (5)	102 (5)
Yorker	M	G	21	M–L	n.d	95 (5)	n.d.	n.d
Variety	**Plant height**	**Lodging resistance**	**100 seed weight (g)**	**Maturity**	**Yield as a % of Almaz 2011–2015**		**Yield as a % of Genesis™ 090 2011–2015**	
					East 2.03 t/ha	West 1.52 t/ha	East 1.35 t/ha	West n.d.
Kabuli types								
Almaz	MT	G	41	L	100 (5)	100 (17)	93 (5)	n.d.
Genesis™ 090	M	G	30	M–L	104 (5)	109 (17)	100 (5)	n.d.
Genesis™ 114	T	VG	39	M–L	102 (5)	103 (11)	91 (5)	n.d.
Genesis™ 425	M	G	33	M–L	96 (5)	96 (14)	97 (5)	n.d.
Genesis™ Kalkee	T	VG	45	L	100 (5)	102 (17)	94 (5)	n.d.
PBA Monarch	M	F	42	E	101 (5)	101 (17)	97 (5)	n.d.

Yield results are a combined-across-sites analysis using NVT and PBA data from 2011–2015.
Number of trials in brackets ( ).
n.d. = No data. Plant height: T – tall; MT – medium tall; M – medium; MS – medium short.
Lodging resistance: VG – very good; G – good; M – moderate; F – fair; P – poor.
Maturity: E – early; M – medium; L – late.
(Source: Pulse Breeding Australia)

[6] A..Matthews, D McCaffery, L Jenkins (2016), Winter crop variety sowing guide 2016. http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2016.pdf

Table 3: Chickpea variety ratings for common chickpea diseases in Australia

Variety	Ascochyta blight	Phytophthora root rot[1]	Botrytis grey mould[2]	Virus[3]	Root-lesion nematode (*Pratylenchus thornei*)		Root-lesion nematode (*P. neglectus*)	
					Resistance[4]	Tolerance[4]	Resistance[4]	Tolerance[4]
Desi								
Ambar	R	S	S	–	–	–	–	–
Flipper	MR–MS	MS	S	S	MS	T	MS	–
Howzat	S	MS	MS	S	S	MT	S	MI
Jimbour	S	MS–MR	S	S	S	T	MS	T
Kyabra	S	MS	S	S	VS	–	R	–
Neelam	R	S	S	–	–	–	–	–
PBA Boundary	MR	S	S	S	–	–	–	–
PBA HatTrick	MR	MR	S	S	–	–	–	–
PBA Maiden	MR	S	S	S	–	–	–	–
PBA Slasher	R	S	S	S	–	–	–	–
PBA Striker	MR	S	S	S	–	–	–	–
Yorker	S	MR	S	S	MS	MT	MR	–
Kabuli								
Almaz	MS	VS	S	S	VS	T	MR	–
Genesis™ 090	R	VS	S	S	VS	T	MR	–
Genesis™ 114	MS	VS	S	S	–	–	–	–
Genesis™ 425	R	S	S	S	MS	MI	MR	–
Genesis™ Kalkee	MS	VS	S	S	–	–	–	–
PBA Monarch	MS	VS	S	S	–	–	–	–

R = Resistant, MR = Moderately resistant, MS = Moderately susceptible, S = Susceptible, VS = Very susceptible; T = Tolerant, MI = Moderately intolerant, I = Intolerant, – = No data.

[1] Ratings a compilation of NSW (Tamworth) and Qld (Warwick) data.

[2] The risk of Botrytis grey mould (BGM) damage can be affected by the management of Ascochyta blight (AB); fungicides used to control Ascochyta can also control Botrytis. Note that if BGM risk is high, then a fungicide with greater efficacy for BGM than for AB might also be needed. BGM screening is conducted in a controlled environment and rating is independent of plant architecture.

[3] Virus ratings could change with different virus species predominating in different areas.

[4] Resistance measures the plant's ability to resist disease. Tolerance measures the plant's ability to yield at a given disease level. Tolerant varieties, while potentially yielding well, are unlikely to reduce nematode numbers for following crops. Data supplied by John Thompson, DAF Qld, Toowoomba.

(Source: Pulse Breeding Australia)

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.

To achieve maximum returns, best agronomic practice needs to be employed according to the variety. These practices include careful paddock selection, planting of high quality seed, and suitable crop protection measures, 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 crop's value and profitability. [7]

[7] G Cumming (2014) Chickpea varieties selecting horses for courses. GRDC Update Papers 5 March 2014, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Chickpea-varieties-selecting-horses-for-courses

2.3.2 Desi chickpea variety regional yields

Comparative yield results for Desi chickpea varieties over 5 years are presented for central Queensland and north-eastern Australia (Table 4). Table 5 shows disease resistance ratings and yield loss over 4 years in north-eastern Australia.

Table 4: Comparative yield of desi chickpeas

Long-term yield of desi chickpea, % of PBA PistolA in central Queensland and % of PBA HatTrickA in northeastern Australia (2011–2015)						Yield of desi chickpea, % of PBA HatTrickA, in north-eastern Australia in 2010, a wet winter and spring conducive to AB and BGM					
Variety	Central QLD	South Western QLD	South Eastern QLD	North Western QLD	North Eastern QLD	Tamworth	North Star	Edgeroi	Moree	Bellata	Bullarah
PBA Pistol⦸ (t/ha)	2.51	-	-	-	-	-	-	-	-	-	-
PBA HatTrick⦸ (t/ha)	2.33	1.9	2.81	1.55	1.94	3.51	1.67	2.26	2.67	1.89	1.82
PBA Seamer⦸	99	104	101	102	101	108	119	137	112	142	118
PBA Boundary⦸	97	104	104	103	102	110	104	105	108	109	93
PBA HatTrick⦸	93	100	100	100	100	100	100	100	100	100	100
PBA Pistol⦸	100	-	-	-	-	-	-	-	-	-	-
Jimbour⦸	94	102	102	101	101	105	56	10	97	96	60
Kyabra⦸	101	107	107	109	106	110	46	6	97	111	60
Moti⦸	101	-	-	-	-	-	-	-	-	-	-

Source: Trial results from Pulse Breeding Australia (PBA) and National Variety Trials (NVT) programs. This report presents NVT "Production Value" MET data on a regional mean basis. This reduces the accuracy and reliability of the results. For detailed PV data, please use the NVT Yield App or Excel Reporting tools available on the NVT website.

Table 5: Disease resistance rating and yield loss of desi chickpea in north-eastern Australia

Variety	Ascochyta blight (AB)[1]					Phytophthora root rot (PRR)[2]				
	Resistance rating	Yield (t/ha)[3]		% Yield loss		Resistance rating	Yield (t/ha)[3]		% Yield loss	
		2014	2015	2014	2015		2014	2015	2014	2015
PBA Seamer⦸	R	2.13	1.57	2	15	MR	1.79	0.37	45	87
PBA Boundary⦸	MR	2.08	1.23	11	30	S	0.73	0.17	74	94
PBA HatTrick⦸	MR	1.76	0.42	23	76	MR	1.98	0.81	33	68
PBA Pistol⦸	S	Not tested				S	Not tested			
Kyabra⦸	S	0.00	0.00	0.00	0.00	MS	Not tested			
Moti⦸	S	Not tested				MS	Not tested			
Yorker⦸	MS	Not tested				2.69	0.57		33	79
PBA Seamer⦸ disease free		2.18	1.85				3.23	2.76		

Source: NSW DPI and DAF Pulse pathology and breeding teams

1 Ascochyta blight yield loss trial, Tamworth 2014 & 2015, NSW DPI

2 Phytophthora root rot yield loss trial, Warwick 2014 & 2015, NSW DPI & DAF

3 Yields are in the presence of high disease with no fungicide applications

More information

http://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/chickpeas/varieties

http://www.grdc.com.au/Resources/Factsheets/2013/05/Chickpea-disease-management

http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Chickpea-varietal-purity-and-implications-for-disease-management

2.3.3 Desi chickpea variety agronomic traits

Agronomic trait for Desi chickpea varieties are presented for central Queensland (Table 67) and north-eastern Australia (Table 7).

Table 6: Agronomic traits of Desi chickpea in central Queensland

R, Resistant; S, susceptible; M, moderately

Variety	Days to flowering	Plant height (cm)	Lowest pod height (cm)	Lodging Score	Disease resistance rating		
					Ascochyta blight		Phytophthora root rot
					Foliage/ stem	Pods	
Jimbourⓓ	65	71	37	4.3	S	S	MS/MR
Kyabraⓓ	65	73	37	3.4	S	S	MS
Motiⓓ	59	74	37	4.3	S	S	MS
PBA Pistolⓓ	58	81	39	2.8	S	S	MS

Source: Pulse Breeding Australia 2005–09.

Table 7: Agronomic traits of desi chickpea in north-eastern Australia

Variety	Flowering (score/days)#		Maturity (score)#		Plant height (cm)		Lowest pod height (cm)		Lodging resistance	Lodging score##	
	Region 2 & 3[1]	Region 1[2]	Region 2 & 3[1]	Region 1[2]	Region 2 & 3[1]	Region 1[2]	Region 2 & 31	Region 1[2]	Region 1[2] 2 & 3[1]	Region 2 & 3[1]	Region 1[2]
PBA Seamerⓓ	E-M (4.4)	E-M (67)	M (5.1)	E-M (4.1)	55.2	60.5	30.7	33.0	Good	1.7	2.8
PBA Boundaryⓓ	M-L (5.9)	M (69)	M (5.3)	M (5.3)	57.8	63.6	35.1	35.4	Mod	2.3	4.5
PBA HatTrickⓓ	M (5.0)	E-M (67)	M (5.1)	M (5.0)	56.2	60.7	32.8	33.3	Mod	2.4	4.9
Jimbourⓓ	M (4.9)	-	M (4.9)	-	55.3	-	32.6	-	Good	1.8	-
Kyabraⓓ	E-M (4.7)	E-M (68)	M (4.9)	E-M (4.5)	55.6	60.9	33.0	34.5	Good	1.7	3.2
PBA Pistolⓓ	-	E (65)	-	E (3.5)	-	66.7	-	35.0	-	-	2.8
Motiⓓ	-	E-M (68)	-	E-M (4.1)	-	60.2	-	34.4	-	-	2.8

 # Flower & Maturity score, 1 = very early, 9 = very late (E=early, M=mid, L=late)

##Lodging score, 1 = fully erect, 9 = flat on ground

1 Data collected from sites in southern QLD and northern NSW (2011–2015)

2 Data collected from sites in central QLD (2012–2015)

2.3.4 Desi chickpea grain quality

Grain quality (seed weight and dhal quality) for Desi chickpea varieties in northern NSW and southern and central Queensland are presented in Table 8. Availability of seed, EPRs and restrictions are in Table 9.

Table 8: Grain quality of Desi chickpea in north-eastern Australia and central Queensland

Variety	Seed weight (g/100)		Dhal yield (%)	
	Regions 2 and 3	Region 1	Regions 2 and 3	Region 1
Jimbour	19.8	22.0	64.2	66.7
Kyabra	25.3	25.3	64.9	63.9
Moti	–	22.2	–	63.8
PBA Boundary	19.5	–	64.7	–
PBA HatTrick	20.1	19.5	65.1	66.9
PBA Pistol	–	24.7	–	67.2
Yorker	21.2	–	62.9	–

Regions 2 and 3, northern NSW and southern Queensland; Region 1, central Queensland

Source: Pulse Breeding Australia.

Table 9: Desi chickpea variety seed availability

Variety	PBR	Licensee or agency	Commercial partner	Seed supplying agents	Telephone	End point royalty ($/t, incl GST), market restriction
Jimbour	PBR	DAFF Qld	Mount Tyson Seeds	Retail outlets	07 4693 7166	Seed royalty, none
Kyabra	PBR	DAFWA	Seedmark	Seedmark	1800 112 400	Seed royalty, none
Moti	PBR	DAFWA	Seednet	Seednet	1800 054 433	$2.75, none, central Qld only
PBA Boundary	PBR	PBA	Seednet	Seednet	1800 054 433	$4.40, none
PBA HatTrick	PBR	PBA	Seednet	Seednet	1800 054 433	$4.40, none
PBA Pistol	PBR	PBA	Seednet	Seednet	1800 054 433	$4.40, none, central Qld only
Yorker	PBR	NSW DPI	Seednet	Seednet	1800 054 433	$3.30, none

[A]Australian Agricultural Crop Technologies. [8]

2.4 Disease management and varietal resistance

2.4.1 Ascochyta blight

Ascochyta blight (caused by *Phoma rabiei*) is a serious disease of chickpeas in Australia (Figure 5). 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, several other diseases need to be considered for individual situation risks when selecting varieties and paddocks. The most important of these risks is the soil-borne disease Phytophthora root rot.

[8] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

Figure 5: Ascochyta blight. (Photo: Gordon Cumming, Pulse Breeding Australia)

Table 10 shows the relative yield responses of varieties to Ascochyta blight and Phytophthora root rot, in situations of high disease pressure. The yield advantages of varieties such as PBA Boundary⦶ and Kyabra⦶ can be quickly lost if they are exposed to diseases to which they are susceptible.

Growers need to determine the variety's 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 it is lower yielding in disease-free situations.

These decisions should be made in conjunction with an understanding of what management options are available. [9]

Table 10: Disease resistance rating and yield loss of Desi chickpea in north-eastern Australia

Variety	Ascochyta blight[A]					Phytophthora root rot[B]		
	Resistance rating	Yield (t/ha) 2009	Yield (t/ha) 2010	% Yield loss 2009	% Yield loss 2010	Resistance rating	Yield (t/ha)	% Yield loss[C]
Jimbour⦶	S	0.44	0.00	77	100	MS/MR	2.70	66
Kyabra⦶	S	–	0.00	0	100	MS	2.83	78
PBA Boundary⦶	MR	1.84	2.32	4	4	S	2.58	85
PBA HatTrick⦶	MR	1.71	1.71	8	34	MR	2.56	64
Yorker⦶	MS	1.80	–	5	–	MR	2.52	35

Yields are in absence of infection. R, resistant; S, susceptible; M, moderately

Source: NSW DPI and DAFF Qld Plant pathology teams

[A]Ascochyta blight yield loss trial, Tamworth 2009 and 2010, NSW-DPI.

[B]Phytophthora root rot yield loss trial, Warwick 2012, DAFF Qld and NSW DPI.

[C]% Yield loss due to inoculation with Phytophthora root rot.

9 G Cumming (2014) Chickpea varieties selecting horses for courses. GRDC Update Papers 5 March 2014, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Chickpea-varieties-selecting-horses-for-courses

2.4.2 Phytophthora root rot

Phytophthora root rot is a soil-borne disease that can establish permanently in some paddocks. The year 2010 was particularly conducive to Phytophthora root rot 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.

Management options for Phytophthora root rot

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 be managed only by pre-sowing decisions and assessing risks for individual paddocks.

Development of the disease requires the pathogen in the soil, and a period of soil saturation. Losses in a *Phytophthora*-infested paddock may be minor if soil saturation does not occur.

The most effective control strategy is to avoid sowing chickpeas in high-risk paddocks, which are those with a history of:

- Phytophthora root rot noted in previous chickpea or lucerne crops
- lucerne or annual or perennial medics
- waterlogging or flooding

If chickpea is to be sown in high-risk paddocks, then growing a variety with the highest level of resistance (Table 11) may reduce losses from Phytophthora root rot. This is particularly the case 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. [10]

More information

https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Rootlesion-nematode-management-the-cost-of-getting-it-wrong

https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2010/05/Chickpeas-In-2010-PBA-Hattrick-Performance-And-Management

2.4.3 Nematodes

Nematodes are minute, worm-like parasites that attack the root system of susceptible crops. They are usually <1 mm long. The most obvious symptom of nematode damage is patchy, uneven crop development. Approximately 70% of the wheat-based farming country in southern Queensland is infested to varying degrees with root-lesion nematodes. In paddocks with moderate nematode numbers, relatively susceptible varieties of chickpeas such as Amethyst or Sona can suffer a yield loss of up to 15–30%, whereas more tolerant varieties such as Jimbour might suffer a yield loss of 5–10% (Table 11). Soil test levels above 2000 nematodes/kg soil are likely to affect chickpea yields (based on 0–30 cm soil sampling).

Nematode numbers will also build up on the root system of chickpeas. The extent to which root-lesion nematodes numbers build up on the crop root system (resistance or susceptibility) may impact on subsequent crops in the rotation. Nematode build-up on chickpeas is similar to that on other susceptible hosts (barley, maize, and triticale), but much less (<50%) than on susceptible wheat varieties.

10 G Cumming (2014) Chickpea varieties selecting horses for courses. GRDC Update Papers 5 March 2014, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Chickpea-varieties-selecting-horses-for-courses

Table 11: Chickpea variety root-lesion nematode ratings 2008

Variety	*P. thornei*		*P. neglectus*	
	Resistance	Tolerance	Resistance	Tolerance
Desi types				
Amethyst	S	MT	MS	T
Flipper⊕	MS	T	MS	–
Howzat	S	MT	S	MI
Jimbour⊕	S	T	MS	T
Kyabra⊕	VS	–	R	–
Moti⊕	S	T	S	T
Yorker⊕	MS	MT	MR	–
Kabuli types				
Almaz⊕	VS	T	MR	–
Genesis™ 090	VS	T	MR	–
Genesis™ 425	MS	MI	MR	–
Kaniva	MS	MT	MR	I
Macarena	S	–	VS	–
Nafice⊕	VS	MR	R	–

R, resistant; S, susceptible; M, moderately; V, very; T, tolerant; I, intolerant. Resistance measures the plant's ability to resist disease; tolerance measures the plant's ability to yield given disease level; tolerant varieties, while potentially yielding well, are unlikely to reduce nematode numbers for following crops (data supplied by John Thompson, DAFF, Toowoomba)

More information

http://www.nga.org.au/results-and-publications/download/139/project-reports-diseases/multi-trial-summary-1/root-lesion-nematode-crop-variety-impact-on-populations-2011.pdf

Two species of root-lesion nematode, *Pratylenchus neglectus* and *P. 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.

Chickpeas are susceptible to both *Pratylenchus thornei* and *P. neglectus*. Mungbean, faba bean and soybean are susceptible to *P. thornei* but resistant to *P. neglectus*.

Chickpeas will result in increased levels of *Pratylenchus* after the crop, although some varietal differences are apparent. The newer varieties PBA HatTrick⊕ and PBA Boundary ⊕ have consistently shown lower *Pratylenchus* levels than Jimbour⊕ and Kyabra⊕ (Figure 6). [11]

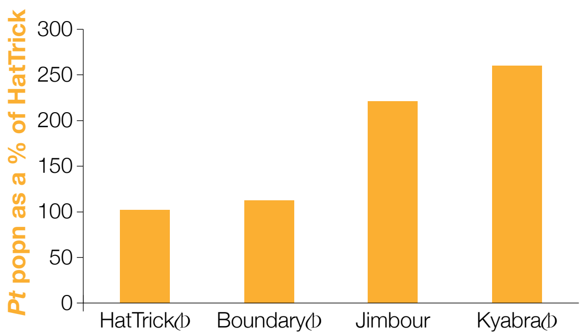

Figure 6: All varieties evaluated in 9 trials 2011-13 (DAFF, NSW DPI, NVT and NGA)

2.4.4 Viral diseases

At least 14 viruses cause significant losses in chickpea, and currently all northern chickpea varieties are considered susceptible to them.

[11] G Cumming (2014) Chickpea varieties selecting horses for courses. GRDC Update Papers 5 March 2014, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Chickpea-varieties-selecting-horses-for-courses

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

Control measures for viruses in chickpea are not adequate at present. 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) [12]
- effective weed control (particularly marshmallow)

More information

Pulse Australia (2015), Chickpea: High Quality Seed

GRDC (2013), Clean seed and care the recipe for chickpea success

2.5 Future breeding directions

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

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

- resistance to Botrytis grey mould
- virus resistance
- improved resistance to root-lesion nematodes (*Pratylenchus thornei* and *P. neglectus*)
- improved tolerance to soil salt levels
- improved reproductive cold tolerance [13]

2.6 Planting seed quality

High quality seed is essential to ensure the best start for your crop. Grower-retained seed may be of poor quality with reduced germination and vigour, as well as being infected with seed-borne pathogens:

- All seed should be tested for quality including germination and vigour.
- If grower-retained seed is of low quality, consider purchasing registered or certified seed from a commercial supplier and always ask for a copy of the germination report.
- Regardless of the source, treat seed with a thiram-based fungicide.
- Careful attention should be paid to the harvest, storage and handling of grower-retained seed intended for sowing.
- Calculate seeding rates in accordance with seed quality (germination, vigour and seed size).

Good establishment through correct plant density and good seedling vigour is important to maximise yields of pulse crops (Figure 7). A targeted density can only be achieved by having quality seed with good vigour and a known germination percentage to accurately

12 G Cumming (2014) Chickpea varieties selecting horses for courses. GRDC Update Papers 5 March 2014, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Chickpea-varieties-selecting-horses-for-courses

13 G Cumming (2014) Chickpea varieties selecting horses for courses. GRDC Update Papers 5 March 2014. http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Chickpea-varieties-selecting-horses-for-courses

More information

http://grdc.com.au/Media-Centre/Ground-Cover-Supplements/Ground-Cover-issue-94-SepOct-2011-Crop-Protection-Supplement/Chickpea-seed-research-to-improve-crop-establishment

http://agvantagecommodities.com.au/nsw-dpi-chickpea-seed-testing-service-available-at-tamworth/

http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/04/Chickpea-seed-tests-from-2010-harvest-explain-establishment-problems-in-2011-crops

http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/04/Chickpea-seed-treatment-improves-crop-establishment-and-increases-yields-2011-trials-using-seed-from-2010-crops

calculate seeding rates. A slight variation in seed size due to seasonal conditions or an incorrect germination percentage can make a huge difference in the calculated seeding rates required to achieve a satisfactory target plant density.

Many seed buyers are unaware that minimum germination requirement for certified pulse seed is 70%, which is far less than the 90% or greater often obtained in pulse seed. Many believe that this minimum should be raised to 80%, as not all growers or retailers request seed test results of certified pulse seed. Test results must be made available under the Seeds Act and Australian Seeds Federation guidelines, so ask for it.

Often, seed quality problems only emerge if the crop is not harvested under ideal moisture or seasonal finishing conditions. A sharp seasonal finish, a wet harvest or delayed harvest can have a big impact on seed quality.

Seed with low germination rates and poor seedling vigour can result in sparse establishment and a weak crop, which then becomes more vulnerable to viruses, fungal disease infection and insect attack, and is less competitive with weeds. Inevitably, this will result in significantly lower yields. The crop may also have variable maturity rates, making it difficult to manage.

Some pulses, such as field pea, may have low germination rates of 'normal seedlings' because they initially have a high percentage of dormant seed. The large size or fragile nature of pulse seed, particularly lupin, Kabuli chickpea and faba bean, makes them more vulnerable to mechanical damage during harvest and handling. This damage is not always visually apparent and can be reduced by operations such as slowing header drum speed and opening the concave, or by reducing auger speed and lowering the flight angle and fall of grain. A rotary header and a belt elevator are ideally suited to pulse grain and can reduce seed damage, which can result in abnormal seedlings that germinate but do not develop further.

Under ideal conditions, abnormal seedlings may emerge but lack vigour, making them vulnerable to other rigours of field establishment. Factors such as low temperature, disease, insects, seeding depth, and soil crusting and compaction are more likely to affect the establishment of weak seedlings. Those that do emerge are unlikely to survive for long, will produce little biomass and make little or no contribution to final yield. [14]

[14] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013, Pulse Australia Limited.

Figure 7: Good establishment through correct plant density and good seedling vigour is important to maximise yields of pulse crops.

2.6.1 Grower-retained planting seed

Grower-retained sowing seed should always be harvested from the best part of the crop where weeds and diseases are absent and the crop has matured evenly. Seed should be harvested first to avoid low-moisture grain, which is more susceptible to cracking. Seed moisture of 11–13% is ideal. Weeds, other grains, or disease contamination from other pulse crops should be avoided when selecting parts of the paddock for seed harvest.

Seed should be professionally graded to remove unviable seeds and weed seeds, and treated with a thiram-based seed treatment.

Seed-borne diseases can lower germination levels, and testing for presence in seed can be conducted by specialist laboratories for Ascochyta blight in chickpeas.

Seed with poor germination potential or high levels of seed-borne disease should not be sown. Cheaper costs of this seed will be offset by higher sowing rates needed to make up for the lower germination and there is potential to introduce further disease on to the property.

Do not use grain for seed of pulse crops harvested from a paddock that was desiccated with glyphosate. Germination, normal seedling count and vigour are affected by its use. Read the glyphosate label.

The only way to accurately know the seed's germination rate, vigour and disease level is to have it tested. [15]

More information

[L Jenkins, K Moore, G Cumming (2015). Chickpea: high quality seed]

[15] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

More information

http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Chickpea-varietal-purity-and-implications-for-disease-management

GRDC (2014). Grain Storage Fact Sheet: Storing Pulses

2.6.2 Safe storage of seed

Storing pulses successfully requires a balance between ideal harvest and storage conditions. Harvesting at 14% moisture content captures grain quality and reduces mechanical damage to the seed but requires careful management to avoid deterioration during storage.

Tips for storing pulses:

- Pulses stored at >12% moisture content require aeration cooling to maintain quality.
- Meticulous hygiene and aeration cooling are the first lines of defence against pest incursion.
- Fumigation is the only option available to control pests in stored pulses, and requires a gas-tight, sealable storage.
- Avoiding mechanical damage to pulse seeds will maintain market quality, seed viability and be less attractive to insect pests. [16]

See GRDC GrowNotes (Chickpeas) Section 13, Storage.

Retained seed needs to be stored safely to ensure its quality is maintained. Safest storing conditions for pulses are at 20°C and at 12.5% moisture content (Table 12).

Like other grain, chickpea seed quality deteriorates in storage. Most rapid deterioration occurs under conditions of high temperature and moisture. Crops grown from seed that has been stored under such conditions may have poor germination and emergence.

Reducing moisture and temperature increases longevity of the seed, although storage at very low moisture contents (<10%) may render chickpea more vulnerable to mechanical damage during subsequent handling as the seed pulls away from the seed-coat.

Table 12: Effect of moisture content and temperature on storage life of chickpea seed

Storage moisture	Storage temperature	Longevity of seed
12%	20°C	>200 days
	30°C	500–650 days
	40°C	110–130 days
15%	20°C	700–850 days
	30°C	180–210 days
	40°C	30–50 days

Note: Most sowing seed will need to be stored for a ≥180 days
Source: Ellis et al. (1982).

Storage at moisture levels >13% under Australian conditions is not recommended. Reducing temperature in storage facilities is the easiest method of increasing seed longevity. Not only will it increase the viable lifespan of the seed, it will also slow the rate at which insect pests multiply in the grain.

Reducing temperature in grain silos:

- Paint the outside of the silo with white paint. This reduces storage temperature by as much as 4–5°C and can double safe storage life of grains.
- Aerate silos with dry, ambient air. This option is more expensive, but in addition to reducing storage temperatures, is also effective in reducing moisture of seed harvested at high moisture content.
- Heat drying of chickpea sowing seed should be limited to temperatures ≤40°C. [17]

16 GRDC (2012) Storing pulses. GRDC Grain Storage Fact Sheet March 2012, www.grdc.com.au/GRDC-FS-GrainStorage-StoringPulses

17 Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

More information

http://storedgrain.com.au/wp-content/uploads/2013/06/chickpea_harvest_storage.pdf

For more information, see GRDC GrowNotes (Chickpeas) Section 13, Storage.

2.6.3 Handling bulk seed

The large size, awkward shape and fragile nature of many pulses mean that they need careful handling to prevent seed damage. The bigger the grain, the easier it is to damage. Seed grain, in particular, should be handled carefully to ensure good germination.

- Plan ahead so that handling can be kept to a minimum to reduce damage between harvest and seeding.
- Augers with screen flighting can damage pulses, especially larger seeded types such as broad beans. This problem can be partly overcome by slowing down the auger.
- Tubulators or belt elevators are excellent for handling pulses, as little or no damage occurs. Cup elevators are less expensive than tubulators and cause less damage than augers. They have the advantage of being able to work at a steeper angle than tubulators. However, cup elevators generally have lower capacities.
- Augering from the header should be treated with as much care as later during handling and storage because it has the same potential for grain damage.
- Combine loaders that throw or sling rather than carry the grain can cause severe damage to germination. [18]

More information

GRDC (2015) Chickpea seed testing

2.7 Seed testing

2.7.1 Germination testing

Germination tests can be conducted by a simple home test, or ideally by sending a representative sample to seed-testing laboratories for germination and vigour tests. For beans, chickpea, lupins, peas and vetch, the sample size required is 1 kg for each 25 t of seed. For lentils, take 1 kg for each 10 t of seed.

Sampling should be random and numerous subsamples should be taken to give best results. Sample either while seed is being moved out of the seed cleaner, storage or truck, or otherwise from numerous bags.

Do not sample from within a silo or a bagging chute, as it is difficult to obtain a representative sample and is dangerous. Mix subsamples thoroughly and then take a composite sample of 1 kg. Failure to sample correctly or test your seed could result in poor establishment in the field.

If an issue is suspected with kept grain, then it is better to get a sample tested early to avoid the cost of grading and time lost to procure suitable seed.

2.7.2 Vigour testing

In years of drought or a wet harvest, seed germination can be affected, but also more importantly, seedling vigour can be reduced. Poor seedling vigour can heavily affect establishment and early seedling growth. This can often occur under more difficult establishment conditions such as deep sowing, crusting, compaction, wet soils, or when seed treatments have been applied. Some laboratories also offer a seed vigour test when doing their germination testing. Otherwise it is wise to do your own test by sowing seeds into a soil tray that is kept cold (<20°C).

Vigour represents the rapid, uniform emergence and development of normal seedlings under a wide range of conditions. Several tests are used by seed laboratories to establish seed and seedling vigour.

18 Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

2.7.3 Accelerated ageing vigour test

Accelerated ageing estimates longevity of seed in storage. It is now also used as an indicator of seed vigour and has been successfully related to field emergence and stand establishment. This tests seed under conditions of high moisture and humidity. Seeds with high vigour withstand these stresses and deteriorate at a slower rate than those with poorer vigour. Results are reported as a percentage, and the closer the accelerated ageing number is to the germination result, the better the vigour. Results are expressed as a percentage normal germination after ageing (vigorous seedlings).

2.7.4 Conductivity vigour test

The conductivity test measures electrolyte leakage from plant tissues and is one of two ISTA-recommended vigour tests. Conductivity test results are used to rank vigour lots by vigour level.

It is important to have a germination test done too, because a conductivity test cannot always pick up all chemical and pathogen scenarios, which may be seed-borne.

2.7.5 Cool germination and cold tests

A cool or cold test is done to evaluate the emergence of a seed lot in cold wet soils, which can cause poor field performance. The cold test simulates adverse field conditions and measures the ability of seeds to emerge. It is the most widely used vigour test for many crops. It is also one of the oldest vigour tests.

This test is used to:

- evaluate fungicide efficacy
- evaluate physiological deterioration resulting from prolonged or adverse storage, freezing injury, immaturity, injury from drying or other causes
- measure the effect of mechanical damage on germination in cold, wet soil
- provide a basis for adjusting seeding rates

This test usually places the seed in cold temperatures (5–10°C) for a period, which is then followed by a period of growth. Then the seed is evaluated relative to normal seedlings according to a germination test. Some laboratories also categorise the seedlings further into vigour categories and report both of these numbers.

2.7.6 Tetrazolium test (TZ) as a vigour test

The tetrazolium test is used to test seed viability, but is also useful as a rapid estimation of vigour of viable seeds. It is done in the same way as a germination test, but viable seeds are evaluated more critically into categories of:

- High Vigour—staining is uniform and even, tissue is firm and bright.
- Medium Vigour—embryo is completely stained or embryonic axis stained in dicots. Extremities may be unstained. Some over stained or less firm areas exist.
- Low Vigour—large areas of non-essential structures unstained. Extreme tip of radicle unstained in dicots. Tissue is milky, flaccid and over stained.

Results have shown good relationships with field performance, and the test is useful for pulses.

2.7.7 Other

Another example of a vigour test used by some Australian laboratories is germination testing at 7°C for 12–20 days in the dark and under low moisture conditions. If seed vigour is acceptable, then this germination result should be within 10% of the regular germination test.

2.7.8 Weed contamination testing

Sowing seed free of weeds cuts the risk of introducing new weeds. It also reduces the pressure on herbicides, especially with increasing herbicide resistance. Tests for purity

More information

https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/04/Chickpea-seed-tests-from-2010-harvest-explain-establishment-problems-in-2011-crops

of a seed sample can be conducted if requested, including the amount of weed seed contamination.

2.7.9 Disease testing

Seed-borne diseases pose a serious threat to yields. Seed-borne diseases can strike early in the growth of the crop when seedlings are most vulnerable and result in severe plant losses and hence lower yields.

Testing seed before sowing will identify the presence of disease and allow steps to be taken to reduce the disease risk. If disease is detected, the seed may be treated with a fungicide before sowing or a clean seed source may be used.

For a disease test, 1 kg of seed is required, except for anthracnose where 2 kg is needed.

2.7.10 Major pathogens identified in seed tests

The NSW DPI plant pathology team offers a free seed-testing service as part of a GRDC-funded Integrated Disease Management project (Figure 8).

Seed samples will be tested for germination, vigour and pathology (i.e. Botrytis grey mould and Ascochyta blight infections) with the results forwarded to the supplier of the sample. Major pathogens identified in these tests are listed in Table 13.

If you wish to have samples tested, please forward a 1-kg sample of harvested chickpea seed to:
Dr Kevin Moore
C/- Gail Chiplin
Tamworth Agricultural Institute
4 Marsden Park Rd
Calala, NSW 2340

Dr Jenny Wood, NSW DPI Tamworth, is also testing seed as part of a GRDC-funded project to eliminate grain defects. The 1-kg sample can be analysed as part of this project and undergo testing by the pathology team as described above.

For more information, contact:
Dr Jenny Wood on jenny.wood@dpi.nsw.gov.au or phone 02 6763 1157.

Figure 8: Testing seed before sowing will identify the presence of disease and allow steps to be taken to reduce the disease risk. NSW DPI Tamworth offers this service. (Photo: Rachel Bowman, Seedbed Media)

Table 13: Major chickpea pathogens identified in seed tests

Check the test number against the laboratories that do seed tests

Test no.	Pathogen	Disease
1	*Ascochyta rabiei (Phoma rabiei)*	Ascochyta blight
2	*Botrytis cinerea*	Botrytis grey mould
3	*Cucumber mosaic virus* (CMV)	CMV

Refer to *GRDC GrowNotes (Chickpeas) Section 9, Disease management.*

Listed below are laboratories that will test for some or all of the diseases in Table 14.

SARDI Field Crops Pathology
GPO Box 379, Adelaide, SA 5001
Telephone (08) 8303 9384 Facsimile (08) 8303 9393
Tests: 1, 2
Web: http://www.sardi.sa.gov.au/crops/new_variety_agronomy/services/seed_testing_and_sampling

Asure Quality Australia
3-5 Lillee Cresent, PO Box 1335, Tullamarine, Vic. 3043
Telephone (03) 8318 9000 Facsimile (03) 8318 9001
Tests: 1–3
Web: www.asurequality.com

2.7.11 Seed purity

Accurate identification of chickpea varieties is critical to Ascochyta blight management in commercial crops.

Australian chickpea varieties differ in their reaction to Ascochyta blight. Varieties released before 2005 (e.g. Jimbour) are susceptible to Ascochyta blight and, in seasons conducive to disease, require intensive management with foliar fungicides. Most cultivars released in 2005 and later, such as PBA HatTrick⫚, have improved Ascochyta blight resistance and require fewer fungicide sprays.

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 HatTrick⫚ and the seed was grower-retained. PBA HatTrick⫚, released in 2009, is rated moderately resistant to Ascochyta blight but the level of disease in these crops was more typical of varieties rated as susceptible.

Possible explanations for these unexpected higher levels of disease include:

- a change in the pathogenicity of *Phoma rabiei* (i.e. breakdown of varietal resistance)
- authenticity and/or purity of the variety (i.e. mix up in seed source or contamination).

A comprehensive study of the Australian population of *Phoma rabiei* found low genetic diversity of isolates and little evidence for widespread changes in pathogenicity. Simpfendorfer *et al.* (2013) showed that varietal contamination caused the higher than expected levels of stripe rust in the moderately resistant 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 blight levels in PBA HatTrick⫚ crops grown from grower-retained seed? It also raised the larger issue of maintaining genetic purity in Australian chickpea varieties after their release.

Key points:

- 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 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.

Figure 9: As the issue of seed purity increases, growers should treat crops from suspect seed as a susceptible variety. (Photo: Rachel Bowman, Seedbed Media)

How widespread is the purity poblem?

It has not yet been established, but NSW DPI testing results from 36 seed lots suggest that the seed purity problem is far bigger than currently thought. Although the problem first surfaced in 2011, pathologists say it appears to be getting worse (Figure 9).

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⊕. When inspected on 8 and 9 August 2013, it was obvious that one of the paddocks was different from the other two and was clearly not PBA HatTrick⊕ (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⊕, but when inspected, it was obvious that they were not the same variety and again one was not PBA HatTrick⊕ (possibly Yorker⊕).

Does it matter if a chickpea crop is a mixture of varieties?

Why is it important to know which variety 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 moderately resistant 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 (e.g. 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 (e.g. knowing the genotype of a plant from which an isolate is obtained is critical to the current GRDC project on the variability of the Australian population of the chickpea Ascochyta blight pathogen)

More information

http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Chickpea-varietal-purity-and-implications-for-disease-management

Cost of Ascochyta blight management—an example of a consequence of varietal impurity

In a season that is conducive to chickpea Ascochyta, Tamworth-based NSW DPI research has shown that a crop of pure PBA HatTrick⸰ will require two foliar fungicide sprays totaling $30/ha. A crop of an Ascochyta blight susceptible variety (e.g. Jimbour) would need six sprays costing $90/ha. This equates to a difference of $30,000 for a 500-ha planting. If you are unsure of the variety's identity or it is a mixture, the crop must be treated as a susceptible variety. [19]

2.7.12 Performing your own germination and vigour test

A laboratory seed test for germination should be carried out before seeding to calculate seeding rates. However, a simple preliminary test on-farm can be done in soil after harvest or during storage. Results from a laboratory germination and vigour test should be used in seeding rate calculations.

For your own germination test, use a flat, shallow seeding tray about 5 cm deep. Place a sheet of newspaper on the base to cover drainage holes. Use clean sand, potting mix or a freely draining soil. Testing must be at a temperature of <20°C, so testing indoors may be required. Randomly count out 100 seeds per test, but do not discard any damaged seeds.

If the tray has been filled with soil, sow 10 rows of 10 seeds in a grid at the correct seeding depth. Do this by placing the seed on the levelled soil surface and gently pushing each in with a pencil marked to the required depth. Cover seed holes with a little more soil and water gently (Figure 10).

Alternatively, place a layer of moist soil in the tray and level it to the depth of sowing that will be required. Place the seeds as 10 rows of 10 seeds in a grid on the seedbed formed. Then uniformly fill the tray with soil to the required depth of seed coverage (i.e. seeding depth). Ensure that the soil surface is uniformly levelled, and water gently if required.

During the test, keep the soil moist, but not wet. Overwatering will result in fungal growth and possible rotting. After 7–14 days, the majority of viable seeds will have emerged. Count only normal, healthy seedlings. The number of normal and vigorous seedlings you count will be the germination percentage.

19 K Moore, K Hobson, A Rehman, J Thelander (2014) Chickpea varietal purity and implications for disease management. GRDC Update Papers 5 March 2014, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/03/Chickpea-varietal-purity-and-implications-for-disease-management

This germination test is in part a form of inbuilt vigour testing because it is done in soil. To further establish vigour under more adverse conditions, a second germination test done under colder or wetter conditions could be used as a comparison with the normal germination test, done at the same time.

Figure 10: Doing your own germination test. (Photo: E. Leonard, AgriKnowHow)

2.7.13 Safe rates of fertiliser sown with the seed

All pulses can be affected by fertiliser toxicity. Lupins are especially susceptible. Higher rates of phosphorus (P) fertiliser can be toxic to lupin establishment and nodulation if drilled in direct contact with the seed at sowing.

Practices involving drilling 10 kg/ha of P with the seed at 18-cm row spacing through 10-cm points rarely caused any problems. However, with the changes in sowing techniques to narrow sowing points, minimal soil disturbance, wider row spacing, and increased rates of fertiliser (all of which concentrate the fertiliser near the seed in the seeding furrow), the risk of toxicity is higher. Agronomists, however, can present anecdotal reports where toxicity has not been a problem, such as in northern NSW with rates of P at 50 kg/ha of DAP on 1-m rows with 4 cm of in-row disturbance.

The effects are also increased in highly acidic soils, sandy soils, and where moisture conditions at sowing are marginal. Drilling concentrated fertilisers to reduce the product rate per hectare does not reduce the risk.

The use of starter nitrogen (N) (e.g. DAP) banded with the seed when sowing pulse crops has the potential to reduce establishment and nodulation if higher rates are used. On sands, up to 10 kg/ha of N at 18-cm row spacing can be safely used. On clay soils, do not exceed 20 kg/ha of N at 18-cm row spacing.

Deep banding of fertiliser is often preferred for lupins, or else broadcasting and incorporating, drilling pre-seeding or splitting fertiliser applications so that lower rates or no P is in contact with the seed. [20]

More information

http://grdc.com.au/Resources/Factsheets/2011/05/Fertiliser-Toxicity

http://www.grdc.com.au/uploads/documents/4 Nutrition.pdf

[20] GRDC (2008) Grain Legume Handbook update 7 Feb 2008. Grain Legume Handbook Committee, supported by the Grains Research and Development Corporation (GRDC).