SOUTHERN

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GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

CHICKPEA

SECTION 2

PRE-PLANTING

VARIETAL PERFORMANCE AND RATINGS YIELD | PLANTING SEED QUALITY | REDUCING TEMPERATURE IN GRAIN SILOS | FUTURE BREEDING DIRECTIONS

Pre-planting

Key messages

- In variety choice, consider yield and adaptation to the area, disease resistance, grain quality, marketability, and proximity to receival point.
- Be aware of the specific management needs for the variety chosen through its Variety Management Package (VMP). [1]
- Kabuli chickpea provides a very profitable cropping option to southern Australian grain growers when produced under the right conditions and management.
- Test for seed quality in terms of germination and vigour prior to sowing. Only sow the highest quality seed.
- If using grower retained seed, ensure that it has been stored correctly; i.e. at the right moisture and temperature and for no longer than 12 months.

MORE INFORMATION

Checklist for Chickpea growers in the Southern region.

FAQ

2.1.1 Choosing a variety

Choosing a variety that has been bred for, and proven in, the southern grains region is the first step in successful chickpea production (Photo 1). Understanding varietal ratings with respect to diseases and their control is a key part of risk management.

Photo 1: *Chickpea trials test for varietal differences.*

Source: W.Hawthorne.

The availability of varieties resistant to Ascochyta blight now provides growers with low disease-risk options for growing chickpeas in southern 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.

Chickpea crops in southern Australia and isolated parts of northern Australia are being hit by a more virulent strain of the damaging ascochyta blight. Pulse pathologists in Victoria and South Australia have noted a marked decline in the

1 Pulse Australia. Southern Pulse Bulletin PA 2010 #05 – Chickpea checklist for southern growers. http://www.pulseaus.com.au/storage/app/media/crops/2010_SPB-Chickpea-checklist-south.pdf

resistance of several varieties of chickpeas, with varieties previously rated as moderately resistant performing like susceptible lines. [2]

Growers should check for revised AB resistance ratings and be prepared to monitor and act on disease control if AB disease levels are higher than expected during the season.

During 2015 at Curyo (southern Mallee), in early August a significant outbreak of ascochyta blight was observed in a kabuli chickpea trial. Symptom assessment indicated that this isolate of ascochyta was different from those observed previously in Victorian trials, having virulence on resistant lines such as Genesis090™ and PBA Slasher⁽ᵈ⁾. From the results in this trial, there appears to be some differences in resistance to this isolate with CICA1454 showing fewer symptoms and PBA Striker⁽ᵈ⁾ being significantly affected. [3]

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.

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.

Disease management is a major factor in chickpea cropping and with proactive management, foliar diseases can be managed to optimise potential yield.

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.

For details on disease ratings for chickpea varieties, see Section 9 - Diseases, Table 3.

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). The Southern Australia growing region includes:

- Region 4; medium/high rainfall mediterranean/temperate
- Region 5; Low/medium rainfall mediterranean/temperate

2 Heard G. (2016). Ascochyta pressure on chickpeas http://www.stockandland.com.au/story/4085979/ascochyta-pressure-on-chickpeas/

3 Brand J, Rodda M, Rosewarne G, Delahunty A, Kimber R, Davidson J, Hobson K. (2016). GRDC Update Papers: Your future pulse - pulse breeding and agronomy update https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/07/Your-future-pulse-pulse-breeding-and-agronomy-update

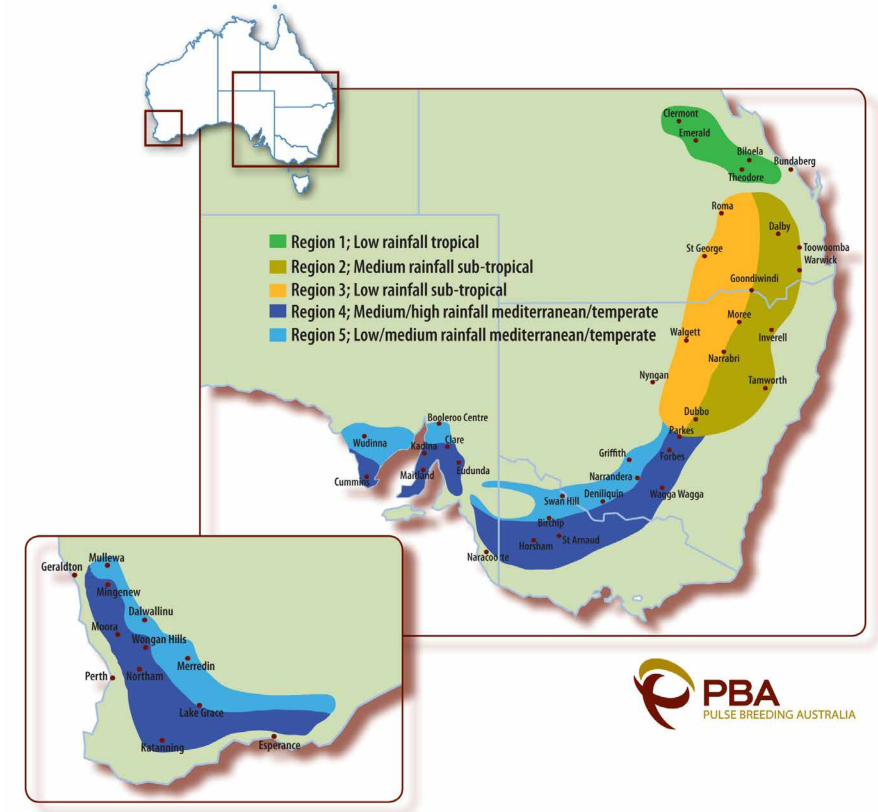


Figure 1: *Area of adaptation of chickpeas across Australian grain growing regions.*

Source: GRDC.

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. The area of adaptation is specified for each variety so that potential users are aware of their best fit. [4]

New opportunities for pulses in the Mallee

A key focus of the breeding programs has been improving yield (profit) stability across a range of soil types and environments. In the 'tough and dry seasons' in each of the pulse crops, through improved varieties and agronomy growers aim to achieve the economic breakeven level which generally ranges between about 0.3 and 0.8 t/ha, dependent on commodity price.

1. **Disease resistance**: Improving disease resistance for the Mallee is about minimising the potential for increased input costs associated with management. It also enables optimisation of other practices, such as earlier sowing to maximise yield potential.
2. **Improved vigour and biomass**: In the Mallee, early vigour and biomass development in cold winter conditions is important to ensure growers can maximise yield potential. It can also aid with weed management through improved competition. However, higher vigour and biomass can also create increased disease pressure, due to earlier canopy closure, hence the importance of disease resistance and potentially agronomic practices, such as wider row spacings.
3. **Changed flowering and maturity characteristics**: The primary aims here have been to minimise risks from frosts and major heat events occurring during the flowering and podding phase and then mature early enough to maximise yield and allow the potential of crop topping to prevent weed seed set. This has led

4 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

to the development of varieties that are generally classified as flowering in the early to mid-range with a similar maturity range. In Victorian Mallee environments, early vigour and biomass development has been essential to maximise any gain achieved through early flowering.

4. **Boron and salt tolerance**: This has been a long term aim of the breeding programs, to help alleviate soil variability that can occur throughout Mallee landscapes.
5. **Improved pod height and harvestability**: There has been significant improvements in both pod height and harvestability for all pulse crops and it continues to be an important goal in PBA breeding programs. On lighter Mallee soils it is also acknowledged that it is important to ensure there is sufficient stubble remaining in the paddock to prevent erosion events.

The value of agronomic management

While new traits are important, it is essential to remind ourselves of the value of optimum agronomic management of pulses. While stubble retention aids harvestability, yields can be more than doubled, in dry season in a retained stubble system versus a removed stubble situation.

Evaluation of yield potential

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.

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, as well as from the specific Pulse Variety Management Package (VMP) brochure. [5]

Long-term yields can be represented in several different ways but are typically displayed either as site-specific, averaged over multiple years, or for each year averaged over multiple sites for a region.

In association with Pulse Australia and its commercial seed partners, PBA launches its new varieties at targeted pulse field days during the spring field-day circuit. This gives growers and advisors the opportunity to view and assess the varieties in their growing regions prior to their availability.

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. [6]

MORE INFORMATION

http://www.pulseaus.com.au/growing-pulses/bmp/chickpea

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

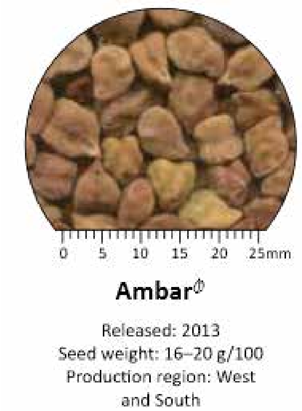
6 Pulse Breeding Australia. PBA Varieties and brochures. GRDC Major Initiatives, http://www.grdc.com.au/Research-and-Development/Major-Initiatives/PBA/PBA-Varieties-and-Brochures

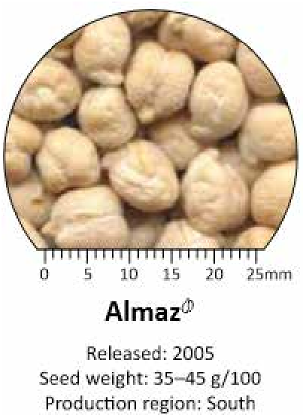
2.1 Varietal performance and ratings yield

Table 1: *Varieties and varietal traits for chickpeas in the southern growing region.*

Variety	Yield ability	Quality traits	Maturity	Other varietal traits
DESI				
PBA Striker$^{\phi}$ 	Produces high yields in the low to medium rainfall areas of southern Australia. Yields of PBA Striker$^{\phi}$ are substantially higher (7–13%) than PBA Slasher$^{\phi}$ and Genesis 836.	Suitable for both splitting and direct consumption use by traders in India and the Middle East. Medium-sized Desi seed with excellent milling quality, larger seed size than PBA Slasher$^{\phi}$ and Genesis 836.	Improved early vigour compared to PBA Slasher$^{\phi}$, with early flowering and early maturity. PBA Striker$^{\phi}$ flowers 5–7 days earlier than PBA Slasher$^{\phi}$ and is earlier maturing than PBA Slasher$^{\phi}$ and Genesis 836.	Susceptible to Ascochyta blight, it is a semi-spreading plant type similar to PBA Slasher$^{\phi}$. Plant height and lowest pod height is similar to PBA Slasher$^{\phi}$ but lower than Genesis 836.
PBA Slasher$^{\phi}$ 	Excellent adaptation to all areas of Southern Australia producing high yields.	Assessed as suitable for both splitting and direct consumption use by traders in India and the Middle East. Medium- sized Desi seed with good milling quality, with higher dehulling efficiency and dhal (splits) yield than Genesis 836.	Mid-flowering and mid-maturity. PBA Slasher$^{\phi}$ flowers 3–7 days earlier than Genesis 836 and is earlier maturing than Genesis 836.	Moderately susceptible to Ascochyta blight, high yield and good seed quality. Semi-spreading plant type. Plant height and lowest pod height is lower than Genesis 836. Susceptible (S) to Botrytis grey mould (BGM), similar to Genesis varieties.
Neelam$^{\phi}$ 	Highest yielding Resistant (R) Ascochyta blight rated Desi chickpea variety. Yields of Neelam$^{\phi}$ are 2–5% higher than PBA Slasher$^{\phi}$.	Desi type chickpea suitable for the whole and splitting human food markets. Seed size is 17 grams/100 grams (g), marginally larger than Genesis 836 similar to PBA Slasher$^{\phi}$. However its seed coat colour is lighter than PBA Slasher$^{\phi}$.	Mid-flowering and mid-maturity variety similar to Genesis 836.	Moderately susceptible Ascochyta blight rated. Medium/tall plant height, taller than PBA Slasher$^{\phi}$.

Variety	Yield ability	Quality traits	Maturity	Other varietal traits
Ambar$^{\phi}$	Well adapted to most of Southern Australia,. Ambar$^{\phi}$ yields are similar to PBA Slasher$^{\phi}$.	Desi type chickpea suitable for the whole and splitting human food markets. Seed size is similar to Genesis 836 at 16 g/100 g. However, its seed coat colour is lighter than PBA Slasher$^{\phi}$.	Earliest flowering and earliest maturing of all current Desi chickpea varieties making it particularly well-suited to shorter growing season (low rainfall) environments.	Rated as moderately susceptible to Ascochyta blight. Bushy growth habit with profuse branching it has a short/medium plant height slightly shorter than PBA Slasher$^{\phi}$.
PBA Maiden$^{\phi}$	It is broadly adapted to these regions and has shown similar yields to PBA Slasher$^{\phi}$.	Largest seed size of current southern Desi chickpea varieties (28% larger than PBA Slasher$^{\phi}$). Targeted for whole seed markets.	Moderate early vigour. Early to mid-flowering and maturity. Semi spreading plant type.	Susceptible to Ascochyta blight.
KABULI				
Genesis™ 079	Highest yields in short season environments than current varieties.	Budget for grain prices at lowest end of small Kabuli range due to 6–7 mm seed.	A small seeded Kabuli (predominantly 6–7 mm) with smaller seed than Genesis™090 (predominantly 6–7 mm). Early maturity and uniform short plant height offers improved potential for agronomic weed control options under some conditions.	Susceptible to foliar Ascochyta blight. A small seeded Kabuli (predominantly 6–7 mm) with smaller seed than Genesis™090 (predominantly 6–7 mm). Susceptible to phytophthora.



Variety	Yield ability	Quality traits	Maturity	Other varietal traits
Genesis ™ 090 	Broadly adapted with high yield potential. Grain prices will be lower than large Kabuli price but usually higher than a Desi price.	Genesis 090 has predominantly 7–8 mm seed, which is smaller than Almaz$^{\phi}$ (8–10 mm). Suits many farming systems including inter-row sowing into standing stubbles and wider (>30 cm) row spacings.	It is medium flowering and maturing, which makes it suitable for most growing areas.	Moderately susceptible to ascochyta blight. Small Kabuli chickpea in southern Australia. Not suitable for crop topping and its height makes it unsuitable for weed wiping.
Genesis ™ 114 	Yields are higher than Almaz$^{\phi}$ and Kaniva. Lower yielding and more susceptible to Ascochyta blight than Genesis 090.	Genesis 114 is a medium-sized Kabuli type chickpea (predominantly 8–9 mm). Is suited to regions with 400–700 mm annual rainfall. Medium to tall plant height with an erect plant type which is resistant to lodging. Produces cream coloured seed, larger than Genesis 090 but slightly smaller than Almaz$^{\phi}$ (predominantly 8–9 mm).	Flowering and maturity time are similar to Almaz$^{\phi}$ but later than Genesis 090.	Susceptible to Ascochyta blight.
Almaz$^{\phi}$ 	Yield greater than current large seeded Kabuli chickpea and previous standard varieties (Kaniva).	Greater seed size than Kaniva but smaller than Nafice. Attractive beige coat similar to Kaniva.	Almaz$^{\phi}$ starts flowering on average one day earlier than Kaniva with similar maturity.	Moderately susceptible to ascochyta blight. Moderately susceptible to PRR.

Variety	Yield ability	Quality traits	Maturity	Other varietal traits
Kalkee  0 5 10 15 20 25mm Genesis™ Kalkee Released: 2012 Seed weight: 40–50 g/100 Production region: North and South	Yields are equal to Genesis114 and Almaz$^{\phi}$ but seed size is larger. Improved grain weight (45 g/100 seeds) compared to Genesis 090 (33 g/100 seeds).	Is a large-sized Kabuli type chickpea (predominantly 9 mm) subject to rainfall at podset. Is suited to regions with 400–700 mm annual rainfall. Medium to tall plant height with an erect plant type which is resistant to lodging. Sets pods high in canopy (increased height to lowest pod than Genesis 090). Produces cream coloured, large seed, larger than Genesis 090 and Almaz$^{\phi}$.	Flowering and maturity time are slightly later than Almaz$^{\phi}$.	Moderately susceptible to ascochyta blight.
PBA Monarch$^{\phi}$  0 5 10 15 20 25mm PBA Monarch$^{\phi}$ Released: 2013 Seed weight: 35–45 g/100 Production region: South and North	Highest yielding medium-sized Kabuli chickpea in all Kabuli growing areas of Australia.	Predominantly 8–9 mm seed size (larger than Genesis 090 and similar to Almaz$^{\phi}$). Semi-spreading plant type.	Early flowering and maturity (earlier than Genesis 090 and Almaz$^{\phi}$).	Susceptible to Ascochyta blight (similar to Almaz$^{\phi}$ and Kalkee but more susceptible than Genesis 090). Susceptible (S) to Phytophthora root rot.

Sources: Pulse Australia

Table 2: *Chickpea variety agronomic guide*

Variety	Ave 100 seed wt (g)	Seed size group	Early growth	Flowering	Maturity	Height	Lodging resistance
DESI							
Ambar$^{\phi}$	16	small	poor-mod	early	early	short-mid	MS
Howzat$^{\phi}$	20	medium	poor-mod	mid	mid	mid	MS
Neelam$^{\phi}$	17	medium	mod	mid	mid	short-mid	MS
PBA Maiden$^{\phi}$	24	med-large	mod	mid	mid	short-mid	MS
PBA Slasher$^{\phi}$	18	medium	poor-mod	mid	mid	short-mid	MS
PBA Striker$^{\phi}$	22	medium	good	early	early	short-mid	MS
KABULI							
Almaz$^{\phi}$	38	medium	mod	mid-late	late	mid-tall	MR
Genesis 079	24	small	good	early	early	short	MR
Genesis 090	31	small	good	mid	mid-late	mid	MR
Genesis Kalkee	45	large	good	late	late	tall	R
PBA Monarch$^{\phi}$	40	medium	poor-mod	early	early	mid	MS

Source: Victorian Winter Sowing Guide 2016.

2.2 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 potentially being infected with seed-borne pathogens. No matter whether chickpea seed is acquired commercially or grower retained on-farm, it is important that it is of the highest possible quality. Poor quality seed can result in low plant establishment due to poor germination, vigour and/or seed-borne diseases such as Ascochyta blight and Botrytis grey mould (BGM).

- All seed should be tested for quality including germination (high germination—above 80%) and vigour (AA test). Use large, graded seed.
- Use seed at low risk of Ascochyta blight infection.
- If grower retained seed is of low quality, then consider purchasing registered or certified seed from a commercial supplier and always ask for a copy of the germination report.
- Regardless of the source, evenly 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).

High quality seed is vital (Photo 2). Check seed labels for germination percentage and purity and ask for the germination certificate. The results of a germination test must be supplied with all seed for sale. Take the additional precaution of having the seed tested for both Ascochyta and Botrytis grey mould. Harvesting on time minimises the development of disease on seed. [7]

Photo 2: *Poor quality seed (left) all sown on the same day. Note the lack of vigour.*

Source: Pulse Australia.

Effect of poor quality seed on yield

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.

Using severely weather damaged or mechanically damaged seed will result in:

- Poor establishment and poor crop performance.
- Reduced plant vigour (increased susceptibility to soil-borne pathogens during establishment and increased susceptibility to foliar pathogens).
- Patchy, uneven plant stands (increased susceptibility to weed competition, aphids and viruses).

7 Pulses Australia. Chickpea Production: Southern and Western region. http://www.pulseaus.com.au/growing-pulses/bmp/chickpea/southern-guide

- Uneven plant development complicating in-crop management (e.g. herbicide applications).
- Uneven and delayed crop maturity (e.g. making desiccation timing difficult and leading to a mixed grain sample).
- Lower yields from a combination of all of the above.

As a general guide, weather-damaged seed with lower than normal germination and vigour levels should only be sown under very good conditions (for rapid establishment) and at a higher seeding rate. Such seed is not recommended for deep sowing or moisture seeking. [8]

The large size or fragile nature of pulse seed, particularly albus, 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.

MORE INFORMATION

Chickpea: High Quality Seed

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. [9] Sow according to germination test for satisfactory populations.

Grower retained 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 quality may be adversely affected by several factors including:

- Early desiccation resulting in high levels of green immature seed and smaller seed size (affecting both germination and vigour).
- Cracking of the seed coat if the seed is exposed to several wetting and drying cycles. As the seed coat absorbs moisture it expands and then contracts as it dries. This weakens the coat increasing the risk of mechanical damage during harvesting and handling operations.
- Mechanical damage can result in reduced germination and vigour and increased susceptibility to fungal pathogens in the soil at sowing (exacerbated if establishment is delayed into cold wet soils).
- Delayed harvest due to wet weather can lead to increased (i) heliothis damage; (ii) mould infection; and (iii) risk of late Ascochyta seed infection.
- Harvesting at a moisture content >15% can lead to problems with moulds and fungal pathogens colonising on the seed coat during storage.
- Harvesting at a moisture content <10% can result in mechanical damage to the seed coat and/or seed splitting, which is compounded each time the seed is handled.
- Poor (temporary) storage in the rush to get harvest done in wet weather can reduce viability of the seed, resulting in poor germination and emergence.
- Using chickpea seed which was shot or sprouted when harvested is not recommended. Chickpea is a relatively large seed which requires considerable moisture for germination to begin. Unlike cereal grains with higher starch

8 L Jenkins, K Moore, G Cumming. Pulse Australia. Chickpea: High Quality seed. http://www.pulseaus.com.au/growing-pulses/bmp/chickpea/high-quality-seed

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

VIDEOS

1. GCTV16: Extension Files – Retained Pulse Seed.

content, once the chemical process has started, the seed will continue to germinate, use up its energy reserves and die due to lack of follow-up moisture whilst in storage.

- Seed-borne diseases such as Ascochyta blight and Botrytis grey mould, and/or in contamination with sclerotinia, all reduce the viability of the seed (germination and vigour). Crop establishment is reduced and any surviving infected seedlings act as an inoculum source to initiate disease infection within the new crop. [10]

NOTE: 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.

Grading

Chickpea seed for sowing should be professionally graded (preferably using a gravity grader) to provide a uniform seed lot and remove all small or split seeds, trash and weed seeds. A gravity grader is more efficient at removing lighter seeds, which are often disease infected. A higher proportion of small, shrivelled and light-weight grain can be expected in crops that have experienced high incidences of Ascochyta and or Botrytis grey mould.

Handling 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.

2.2.1 Testing for seed quality

The only way to accurately know the seed's germination rate, vigour, and disease level is to have it tested. Seed-borne diseases can lower germination levels, and testing for presence in seed can be conducted by specialist laboratories for a number of diseases such as 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.

2.2.2 Seed size

Seed size can affect the seedling vigour in grain legumes where large seeds produce more vigorous plants and may affect yield. [11]

10 L Jenkins, K Moore, G Cumming. Pulse Australia. Chickpea: High Quality seed. http://www.pulseaus.com.au/growing-pulses/bmp/chickpea/high-quality-seed

11 J Kamboozia, G McDonald, H Reimers. (1993). The effect of seed size, seed protein and genotype on seedling vigour in some grain legumes. 7th Aust. Agron. Conf.©, SARDI.

Seed size can be quickly calculated at home by counting out 200 seeds and weighing—multiply the weight (grams) by five to get a 1000-seed weight. Or divide 200,000 by the weight (grams) to get number of seeds per kilogram (depending on your preferred method of calculating seeding rates).

It is recommended that both the germination test and seed size test be done on several lots of seed (i.e. at least twice) to get a more accurate assessment of the sample.

2.2.3 Seed germination and vigour

Chickpeas often have poor seedling vigour which may reduce their competitiveness with weeds and pests. Low seedling vigour can also cause low WUE because of the long time to full canopy closure. Efforts that lead to improved seedling vigour among grain legumes may therefore be useful to improve yield and WUE. It has been suggested that there are inherent genetic differences in seedling vigour both between species and between varieties. [12]

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.

Grower retained seed should be tested for germination and vigour at least twice:

- Immediately post-harvest, to assess if the seed is worth retaining or better sold for grain or fed to livestock.
- Just before sowing, after grading and treatment with fungicide seed dressing, so seeding rates can be adjusted to compensate for any decline in quality during storage over summer.

Weather-damaged seed deteriorates quicker than usual in storage and a third test in mid-storage is advised. This will indicate if the seed is still suitable for sowing and if not, allows time to consider other options.

Pulse seed should have a minimum germination of 80% to be kept for sowing. Seeding rates for seed with only 50% germination should not be used.

Whilst increasing the seeding rate of poor quality seed may seem reasonable, it carries a high risk of seedling disease. If the poor quality is caused by seed-borne pathogens, the seed will be a source of infection for healthy seed and seedlings.

Simple germination tests are best done under cooler conditions. For beans, chickpea, lupins, peas and vetch, the sample size required is 1 kg for each 25 t of seed. There are two quick methods that both require 100 seeds for the test:

- Method 1: Place 100 seeds between at least four sheets of paper towel, roll up, fold the ends over and soak in fresh water for 30 minutes. Drain, put the 'seed doll' in a tray and place on the kitchen bench or workshop table. Ensure 'seed doll' does not dry out. After three, four, and five days unwrap 'doll', remove germinated seeds, taking a note of their vigour and re-wrap the 'doll'. After the fifth day, count the non-germinated and mouldy seeds.
- Method 2: Fill a flat shallow (5 cm deep) garden tray or non-rusty baking tray with clean sand, potting mix or freely draining soil. On the soil surface arrange your 100 sends in 10 rows and push the seeds into the soil with a pencil marked to a depth of 3 cm (Photo 3 - right). Cover with a little more sand/soil and water gently. Keep soil moist but not wet as overwatering will result in fungal growth and possible rotting.

A germination test does not always accurately predict emergence. For a valuable crop like chickpeas a laboratory test should be used. Growers can also conduct their own emergence test, as per method 2. If this is conducted in the intended paddock this will also help to identify potential herbicide residue problems.

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12 J Kamboozia, G McDonald, H Reimers. (1993). The effect of seed size, seed protein and genotype on seedling vigour in some grain legumes. 7th Aust. Agron. Conf.©, SARDI.

After 7–10 days the majority of viable seeds will have emerged (Photo 3 - left). Count only the normal and healthy seedlings. If left for another few days you will also be able to assess how many of the germinated seeds are actually deformed (e.g. missing cotyledons or mould/disease affected), which will also give some indication of vigour. [13]

Photo 3: *Doing your own germination test (left). Seedling growth after 12 days and after 5 days (right)*

Photo: E. Leonard, Kevin Moore. Source: Pulse Australia.

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. 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.

Testing seed vigour

Seed vigour is more accurately assessed by commercial laboratories as the assessment method is both temperature and time based. The seedling vigour test will also provide a better indication of the number of abnormal seeds present in addition to the germination percentage.

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. 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.

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.

13 L Jenkins, K Moore, G Cumming. Pulse Australia. Chickpea: High Quality seed. http://www.pulseaus.com.au/growing-pulses/bmp/chickpea/high-quality-seed

This test usually places the seed in cold temperatures (5–10°C, with variations between laboratories) 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.

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 of normal germination after ageing (vigorous seedlings).

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.

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.

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 of a seed sample can be conducted if requested, including the amount of weed seed contamination. Do not plant seed contaminated with weed seeds.

Disease testing

Seed-borne diseases such as ascochyta blight 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.

2.2.4 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 are susceptible to Ascochyta blight and, in seasons conducive to disease, require intensive management with foliar fungicides. Most cultivars released in 2005 and later have improved Ascochyta blight resistance and require fewer fungicide sprays. However, a new strain of ascocychta blight has left previously resistant varieties susceptible to the disease.

Contamination between seed varieties has been found to lead to higher than expected disease susceptibility in moderately resistant crops. Contamination or a mix-up in source of planting seed might account for the observed differences in Ascochyta blight levels in chickpea crops grown from grower-retained seed. This is part of the large issue of maintaining genetic purity in Australian chickpea varieties after their release.

Key findings from chickpea seed purity research:

- 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.

The extent of purity contamination is not yet determined; however, 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 (Photo 4).

For details on disease ratings for chickpea varieties, see Section 9 - Diseases, Table 3.

Photo 4: *As the issue of seed purity increases, growers should treat crops from suspect seed as a susceptible variety.*

Photo: Rachel Bowman, Seedbed Media

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 growers' legal rights (e.g. if seed you purchased is not what you paid for)

VIDEOS

2. Chickpea seed quality – Kevin Moore, 2013.

- assessing compliance with plant breeders' 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).

An example consequence of varietal impurity - Cost of Ascochyta blight management

In a season that is conducive to chickpea Ascochyta, Tamworth-based NSW DPI research has shown that a crop of pure PBA HatTrick⁽ᴰ⁾ will require two foliar fungicide sprays totalling $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. [14]

2.2.5 Seed storage

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. [15]

Most pulse seed should only be stored for 12 months, although longer storage periods are possible with high quality seed, provided both grain moisture and temperature within the silo can be controlled. Rapid deterioration of grain quality occurs under conditions of high temperature/moisture and with poor seed quality including weathered, cracked, and diseased seed.

Ideally, chickpea needs to be stored at 13% moisture content and at temperatures below 30°C. Storage at very low moisture contents (<10%) may make chickpeas (particularly Kabuli types) more susceptible to damage during subsequent handling, as the seed shrinks away from the seed coat.

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 temperature in storage facilities (to below 30°C) is the easiest method of increasing seed longevity. Temperatures can be reduced in grain silos by painting the outside of the silo white (temperatures reduced by 4–5°C), and/or aerating silos with dry, ambient air.

14 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

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

VIDEOS

3. Over the Fence: Insure seed viability with aerated storage.

MORE INFORMATION

Storing pulses

2.3 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. [16]

Insect pests in storage

Insects are generally not considered to be a major problem in stored chickpea seed. However, where a prior infestation exists in the storage structure (most commonly as a result of cereal grain residue) then the infestation can develop and spread in the chickpeas. Ensure all handling equipment and storages are cleaned of old cereal grain before they are used to handle chickpeas. Good hygiene, combined with aeration cooling, should prevent infestations developing. If insect pests are found in stored chickpeas, the only registered treatment is phosphine fumigation.

For more information, See Section 13: Storage.

2.3.1 Safe rates of fertiliser sown with the seed

All pulses can be affected by fertiliser toxicity. Higher rates of phosphorus (P) fertiliser can be toxic to 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.

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 an option, as well as broadcasting and incorporating drilling, pre-seeding, or splitting fertiliser applications so that lower rates or no P is in contact with the seed. [17]

2.4 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.

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

16 L Jenkins, K Moore, G Cumming. Pulse Australia. Chickpea: High Quality seed. http://www.pulseaus.com.au/growing-pulses/bmp/chickpea/high-quality-seed

17 GRDC (2008) Grain Legume Handbook update 7 Feb 2008. Grain Legume Handbook Committee, supported by the Grains Research and Development Corporation (GRDC), http://elibrary.grdc.com.au/project/glh00002

- improved reproductive cold tolerance. [18]

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