The chickpea book: a technical guide to chickpea production

Stephen Loss
Neil Brandon
K H M. Siddique

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The Chickpea Book
A TECHNICAL GUIDE TO CHICKPEA PRODUCTION

Editors: Stephen Loss, Neil Brandon and K.H.M. Siddique

Grains Research & Development Corporation

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and they are acknowledged at the respective
photograph.
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Preface

The area of chickpea production in Australia has expanded rapidly in recent years especially in south-western Australia. This has been partly brought about by the keen interest of farmers and a concerted research effort and industry development by Agriculture Western Australia, The Centre for Legumes in Mediterranean Agriculture (CLIMA) and other institutions, in partnership with the Grains Research and Development Corporation and other industry funding bodies. Private consultants, grain traders and other industry groups have also contributed to the expansion of the industry.

Much of the local knowledge generated by these research and development projects has been published in various experimental summaries, Technotes, Farmnotes, magazine articles, ‘On the Pulse’ newsletters, conference and workshop proceedings, and scientific papers. This book collates much of this research and development in the one document, together with experience and knowledge from the eastern states and overseas. It is a comprehensive publication, much more than simply how to grow the crop in Western Australia. It describes much of the scientific data behind our recommendations and highlights the role of chickpea production in maximising whole farm profits.

This book is targeted at researchers, agronomists, extension specialists, students and progressive farmers. However, other industry partners such as chemical and other retailers, and grain traders may also find it useful. The authors hope this book develops a well worn place on many book shelves.

Preface, Caution

Caution: Unregistered Product Uses

Any research with unregistered pesticides or unregistered products reported in this document does not constitute a recommendation for that particular use by Agriculture Western Australia. All pesticide applications must accord with the currently registered label for that particular pesticide, crop, pest and region.
Introduction

K.H.M. Siddique

Chickpea (Cicer arietinum L.) is known in various countries by different names, such as Bengal gram, gram, chana, Egyptian pea, pois chiche, hoos, grao-de-beco and garbanzo. In Germany they are called kichererbsen, which translates as 'giggle peas'.

The word cicer is a derivative of the Greek kiros referring to the well known Roman family Cicero. Arietinum is derived from the Latin aries meaning ram, referring to the shape of the kabuli chickpea seed which resembles a ram's head.

Chickpea was one of the first grain legumes to be domesticated by humans (vander Masen 1972). Based on seed protein electrophoresis, Ladizinsky and Adler (1976) consider C. reticulatum a wild progenitor of the cultivated chickpea and this species is found in areas of present-day south-eastern Turkey and the adjoining northern region of Syria. From this centre of origin, C. arietinum subsequently spread to India, Europe and other regions.

There are two types of chickpea. Desi types have small seeds with angular, sharp edges and the seed coat can vary from black to cream or yellow. Its shape is similar to a chicken's head with a characteristic 'beak', hence the name 'chickpea'. These are primarily grown in South Asia and Ethiopia.

The kabuli types have large rounded seeds shaped like a ram's head with cream, beige or white seed coats. Kabuli are predominantly grown in West Asia and North Africa, southern Europe and Mexico. Desi chickpea appears to have originated first while the kabuli types were developed by natural mutation and selection. Local food preferences would have helped in the spread and adaptation of these types in different regions. Almost 90 per cent of the world's chickpea crop is the desi type, grown mostly in the Indian sub-continent.

Figure 1. Areas of origin of chickpea and spread around the world (modified from vander Masen 1972).
Australia chickpea production is worth about A$80 million on farm. Australia is the fifth largest producer in the world. About 96 per cent of Australian chickpea production is the desi type and the remaining 15,000 tonnes is the large-seeded kabuli type.

A recent evaluation of soil types, likely rotations throughout the cropping regions and export market outlook of chickpea suggests that there is the potential to expand chickpea production in Western Australia up to 200,000 ha by the year 2005. Similar increases in the area of canola production have recently occurred in Western Australia.

Australian pulse (or grain legume) production has increased rapidly over the past three decades as farmers appreciate the financial returns from growing these crops and the role of pulses in sustainable cropping rotations. The area sown to pulses has increased from almost nothing in 1965 to 2 million ha in 1996, or about 10 per cent of the area cropped in Australia (Siddique and Sykes 1997).

Chickpea also has an important role in farming systems as an alternative for continuous cereal production or replacement of fallow. Being a legume, the crop fixes atmospheric nitrogen and reduces the need for nitrogen fertilisers. It also contributes to the sustainability of the production system by acting as a 'break crop' for diseases, pests and weeds.

Both the area and actual production of chickpea grew rapidly after the release of the desi variety Tyson in 1978, up until the 1990’s when drought restricted production in Queensland and northern New South Wales. Production in 1994 was very low due to dry conditions across most parts of Australia. Since then production has returned to about 250,000 tonnes p.a.

Chickpea has fitted well into the farming systems across a broad range of environments in Australia, extending from the tropical Ord River Irrigation Area, to subtropical southern Queensland and northern New South Wales, and to the Mediterranean-type environments of southern Australia.

The production of chickpea in 1997 was mostly confined to Victoria (80,000 ha), Western Australia (41,000 ha), New South Wales (30,000 ha), Queensland (20,000 ha) and South Australia (12,000 ha). Chickpea production in Western Australia is expanding rapidly, from less than 500 ha in 1991 to about 65,000 ha in 1998.

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Growth and Development

Heather Clarke and K.H.M. Siddique

Chickpea, being a legume, belongs to the botanical family of **Leguminosae**. It is a semi-erect annual with a deep tap root. The form and shape of the plant may vary according to variety, daylength, temperature, soil type and water availability at different locations.

Under optimum moisture and temperature conditions chickpea seeds imbibe water quickly and germinate within a few days. Unlike lupins (*Lupinus* spp.), chickpea seedlings have hypogeal emergence, that is, their cotyledons (embryonic leaves) remain underground inside the seed coat while providing energy to the rapidly growing roots and shoots.

Emergence occurs 7-30 days after sowing, depending on soil moisture and temperature conditions and depth of sowing. Growth of the shoot (plumule) produces an erect shoot and the first leaves are scales. The first true leaf has two or three pairs of leaflets plus a terminal one. Fully formed leaves with five to eight pairs of leaflets usually develop after the sixth node.
Leaves in chickpea are alternate along the branch. Each leaf is composed of 10-16 serrated leaflets which can fold slightly in dry conditions to minimise transpiration. Mutants with small leaves, tiny leaves and simple leaves are also reported. Despite having more leaves and branches than other legume crops such as faba bean, canopy development in chickpea is slow, especially during the cool winter months.

The entire surface of the plant shoot, except the flower, is densely covered with fine hairs known as trichomes. Many are glandular and secrete a highly acidic substance containing the malic, oxalic and citric acids. Secretions of acid increase with temperature throughout the day, and are reduced by dew overnight and wind shaking the acid droplets from the hairs.

The acids play a role in protecting the plant against pests such as red-legged earth mite, lucerne flea and aphids. These are also secreted through the root system and can solubilise soil bound phosphate and other nutrients (see Nutrition section). The acid also corrodes leather boots.

Chickpea root systems are usually deep and strong, and contribute to the chickpea's ability to withstand dry conditions. The plant has a tap root with few lateral roots. Root growth is most rapid before flowering but will continue until maturity under favourable conditions (Siddique and Sedgley 1987). In deep well-structured soils roots can penetrate more than three metres deep.

As well as their role in water and nutrient uptake, chickpea roots develop symbiotic nodules with the *Rhizobium* bacteria, capable of fixing atmospheric nitrogen. The plant provides carbohydrates and sugars for the bacteria in return for nitrogen fixed inside the nodules. These nodules are visible about one month after plant emergence, and eventually form slightly flattened, fan-like lobes. Practically all nodules are confined to the top 30 cm of soil and 90 per cent are within 15 cm of the surface. When cut open, nodules actively fixing nitrogen have a pink centre.

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In contrast, the white flowered kabuli types lack anthocyanin, have light green leaves and stems, and pale seeds. Increased pigmentation is evident following environmental stresses such as low temperature, salinity, waterlogging, drought and virus infection, especially in desi types.

Petals are generally purple in the desi type and white to cream in the kabuli type. There is a close relationship between the colour of the flower and other organs. Purple-flowered desi types generally contain high amounts of the red pigment anthocyanin, and their leaves, stems and seed coats are generally dark.

In contrast, the white flowered kabuli types lack anthocyanin, have light green leaves and stems, and pale seeds. Increased pigmentation is evident following environmental stresses such as low temperature, salinity, waterlogging, drought and virus infection, especially in desi types.

Figure 5. Chickpea at the 5 to 7 node stage of development.
Chickpea can tolerate high temperatures if there is adequate soil moisture and it is soon after the development of pods and seed filling, senescence of subtending leaves begins. If there is plenty of soil moisture, flowering and podding will continue on the upper nodes. However, as soil moisture is depleted, flowering ceases and eventually the whole plant matures. This is typical of grain legumes and annual plants in general.

Seeds are characteristically 'beaked', sometimes angular with a ridged or smooth seed coat. Seed colour varies between varieties from chalky white to burgundy and brown, to black, and is determined by the colour and thickness of the seed coat and the colour of the cotyledons inside. Seeds vary from one to three per pod.

Pollination takes place before the flower bud opens in chickpea, while the pollen and the receptive female organ are still enclosed within a fused petal, called the keel. Natural cross-pollination has been reported, however most studies indicate 100 per cent self pollination.

Chickpea plants generally produce many flowers. However, a large proportion (50-80 per cent) do not develop into pods, depending upon the variety, sowing date and other environmental conditions.

Under favourable conditions, the time taken from fertilisation of the ovule (egg) to the first appearance of a pod (pod set) is about six days. The seed then fills over the next three to four weeks. Once a pod has set, the jointed peduncle of the senescing petals reflexes, so that the developing pod hangs beneath its subtending leaf.

After pod set, the pod wall grows rapidly for the first 10 to 15 days while seed growth mainly occurs later. Any damage to the pod that punctures the pod wall during the first 20-30 days will result in seed abortion.

Chickpea pods vary greatly in size between varieties. Pod size is largely unaffected by the environment. In contrast, seed filling and subsequent seed size are highly dependent on weather conditions.

Days after pod set

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Soon after the development of pods and seed filling, senescence of subtending leaves begins. If there is plenty of soil moisture, flowering and podding will continue on the upper nodes. However, as soil moisture is depleted, flowering ceases and eventually the whole plant matures. This is typical of grain legumes and annual plants in general.

Chickpea can tolerate high temperatures if there is adequate soil moisture and it is...
Chickpea may be forced to mature early on soils with poor moisture holding capacity. As leaves begin to senesce, there is a rapid retranslocation of dry matter from leaves and stems into seeds (Leport et al. 1988, Davies et al. 1998).

Recent research has indicated that unlike other winter pulses under mild moisture stress, chickpea is capable of accumulating solutes (sugars, proteins and other compounds) in its cells, thereby maintaining stomatal conductance and low levels of photosynthesis. This process is known as osmoregulation (Morgan et al. 1991).

In south-western Australia, chickpea crops can reach maturity 140-200 days after sowing, depending on the sowing date, variety, and a range of environmental factors. Chickpea is ready to harvest when 90 per cent of the stems and pods lose their green colour and become light golden yellow. At this point the seeds are usually hard and rattle when the plant is shaken.

**CLIMATIC REQUIREMENTS FOR FLOWERING**

The timing of flowering is an important trait affecting the adaptation of crops to low rainfall Mediterranean-type environments (such as south-western Australia) and seed yields of many crops in these areas have been increased by early sowing and the development of early flowering varieties (Loss and Siddique 1994).

Temperature, daylength, and drought are the three major factors affecting flowering in chickpea. Temperature is generally more important than daylength. In general, flowering is delayed under low temperatures but more branching occurs.

Progress towards flowering is rapid during long-days, while under short-days, flowering is delayed but never prevented. However, some chickpea varieties are less sensitive to daylength than others. This has enabled breeders to identify improved varieties that flower early in our short-day winter growing season in southern Australia.

In short-days a period of cold or vernalisation may replace the daylength requirement in some late flowering genotypes (Angus and Moncur 1980, Summerfield and Roberts 1986).

Unlike many other cool season grain legumes, chickpea is particularly susceptible to cold conditions, especially at flowering, and any advantage derived from early flowering is often negated by increased flower and pod abortion (Siddique and Sedgley 1986). In many parts of southern Australia, mean daily temperatures fall below 15°C during winter and early spring, causing pollen sterility and the loss of reproductive structures.

At these low temperatures floral initiation (flower production) may commence, but in
In Western Australia, drought stress often accompanies high temperatures in spring, causing the abortion of flowers, immature pods and developing seeds. On the other hand, high levels of humidity and low light also prevent pod set, but these do not pose a major problem in Western Australia.

In Western Australia, temperatures above 35°C in spring may also reduce yield in chickpea, causing flower abortion and a reduction in the time available for seed filling. Chickpea, however, is considered more heat tolerant than many other cool season grain legumes.

In addition to the effects of cold described above, sub-zero temperatures in winter and spring can damage leaves and stems of the plant. Frosts can cause a bleaching of leaves, especially on the margins, and a characteristic ‘hockey-stick’ bend in the stem. However, chickpea has an excellent ability to recover from this superficial damage and is able to regenerate new branches in severe cases.

Late frosts also cause flower, pod and seed abortion. Pods at a later stage of development are generally more resistant to frost than flowers and small pods, but may suffer some mottled darkening of the seed coat.

In many chickpea crops it is not until temperatures rise in September or October that pod set and seed filling commences. When temperatures rise true flowers develop within a period of three or four days. Even after the production of true flowers, periods of low temperature may result in further flower and pod abortion at intermittent nodes on the stems.

Table 1. Time of year for average mean daily temperature (maximum + minimum/2) to reach 15°C at various locations in the Western Australian cropping regions (data from the Australian Bureau of Meteorology).

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<td>Morawa</td>
<td>4th week September</td>
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<td>Moora</td>
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<td>Central</td>
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<td>York</td>
<td>2nd week October</td>
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<td>Merredin</td>
<td>2nd week October</td>
</tr>
<tr>
<td>Southern</td>
<td></td>
</tr>
<tr>
<td>Katanning</td>
<td>4th week October</td>
</tr>
<tr>
<td>Mt. Barker</td>
<td>2nd week November</td>
</tr>
<tr>
<td>Esperance</td>
<td>2nd week October</td>
</tr>
</tbody>
</table>

In Western Australia, drought stress often accompanies high temperatures in spring, causing the abortion of flowers, immature pods and developing seeds. On the other hand, high levels of humidity and low light also prevent pod set, but these do not pose a major problem in Western Australia.

Frost will normally affect the earliest-formed pods low on the primary and secondary branches. In contrast, pod abortion induced by moisture stress is normally noted on the last-formed pods at the tips of the branches.

Temperatures above 35°C in spring may also reduce yield in chickpea, causing flower abortion and a reduction in the time available for seed filling. Chickpea, however, is considered more heat tolerant than many other cool season grain legumes.

In Western Australia, drought stress often accompanies high temperatures in spring, causing the abortion of flowers, immature pods and developing seeds. On the other hand, high levels of humidity and low light also prevent pod set, but these do not pose a major problem in Western Australia.

Frost can cause bends like a hockey-stick in chickpea stems. Photo S. Loss.
Tolerance to Low Temperature

Research overseas and within Australia has demonstrated a range of cold tolerance among chickpea varieties. In parts of the world where chickpea is grown as a spring crop because of the very cold winter, varieties have been developed that tolerate freezing conditions during vegetative growth. In this way, these varieties can be sown in autumn, survive over winter and are ready to flower and set pods when temperatures rise in summer.

However, chickpea varieties resistant to low temperatures during flowering have not yet been found. Some genotypes from India are less sensitive than those currently grown in Australia, and these are being utilised in chickpea breeding programs at Agriculture Western Australia and the University of Western Australia (UWA).

Controlled environment studies at UWA have identified two stages of sensitivity to low temperature in chickpea (Clarke et al. 1998). The first occurs during pollen development in the flower bud, resulting in infertile pollen even in open flowers. The second stage of sensitivity occurs at pollination when pollen sticks to the female style, and produces a tube that grows from the pollen down the style to the egg (ovule).

At low temperatures pollen tubes grow slowly, fertilisation is less likely and the flower often aborts. The rate of pollen tube growth at low temperature is closely related to the cold tolerance of the whole plant. This trait can therefore be used to select more tolerant varieties.

Figure 6. Proportion of pollen germination at various temperatures in cold sensitive (Amethyst) and tolerant (CTS60543) varieties.
The first variety developed from an Australian hybridisation program was the desi variety Amethyst, released in New South Wales in 1987. Amethyst was well suited to mechanised harvesting because of its tall stature and lodging resistance. These features helped extend chickpea cultivation into low rainfall areas of north-eastern Australia (Siddique et al. 1998).

Tyson proved to be widely adapted and at that time of its release its seed was acceptable to emerging export markets in the Indian sub-continent (Beech and Brinsmead 1980). It was subsequently grown in other regions of Australia where it remained the only desi variety available for nearly a decade.

Chickpea was first tested in Australia in the 1890s (Valder 1893), but it was not until 1972 that a diverse range of germplasm was introduced and tested at several locations throughout Australia. As a result, the Indian desi variety C235 (renamed ‘Tyson’) was released in Queensland in 1978.

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Subsequent breeding efforts in this region centred on disease control. Resistance to *Phytophthora* root rot became a major breeding objective after the disease emerged as an important production constraint in Queensland and New South Wales in the early 1980s. Field resistance to the disease was developed in desi varieties *Barwon* and *Norwin*, released in 1991 and 1992, respectively.

During the 1990s viruses replaced *Phytophthora* as the major disease problem in some parts of the north-eastern region. A desi selection from an Iranian landrace possessing field resistance to virus and improved seed quality, was released in 1997 under the name *Gully*.

New desi varieties have been released by local breeding and evaluation programs in the south-eastern and western regions of Australia. Hitherto, these programs relied on introduced germplasm and breeding lines as the source of improved local adaptation.

Significant yield increments were realised with the release of *Dooen* (1986), *Desavic* (1993) and *Lasseter* (1996) in Victoria and South Australia and with the early maturing Indian-derived varieties *Sona* and *Heera* released in Western Australia in 1997 (Siddique *et al.* 1998). *Sona* and *Heera* have superior seed size and colour to *Tyson* and appear to have slightly better cold tolerance than most other varieties.

Variety development in kabuli chickpea has relied mainly on introductions originating from overseas collections or breeding programs (Siddique *et al.* 1998).

The first Australian kabuli variety *Opal* was released in New South Wales in 1980 but was not widely grown due to its comparatively small seed (35 g per 100 seed) and late maturity. Significant expansion of the rainfed kabuli production area did not occur until the release of the early maturing, medium-seeded varieties *Garnet* and *Kaniva*.

The large-seeded variety *Bumper* (45 g per 100 seed) bred in New South Wales was subsequently released in 1997 for all rainfed production areas. Irrigated production of kabuli chickpea on the Ord River Irrigation Area commenced in 1983 with the release of the very large-seeded Mexican variety *Macarena* (55 g per 100 seed).

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The large-seeded early flowering varieties Heera and Sona have produced yields superior to Tyson in Western Australia and other states, especially in dry areas. Both are recommended for most parts of the cropping area in Western Australia, particularly in late sowing situations.

At this early stage after their release, it is difficult to determine whether Sona or Heera is best suited to any specific area. However, Heera flowers about one or two days later than Sona and appears to have greater potential for high yield in medium rainfall areas than Sona.

The medium maturing variety Dooen can be grown in areas where early sowing is an option or where soil type and climate ensure adequate soil moisture in spring.

Tyson, although it continues to produce reliable yields in many areas, has poor seed quality characteristics (small seed size and dark seed coat) and will probably be phased out in the coming years as markets become more discriminating. Likewise, Amethyst has relatively poor seed size and is particularly susceptible to cold. Tyson is also notably shorter than Sona and Heera making harvesting more difficult, especially in dry seasons.

To date the disease Phytophthora has not been a limitation to chickpea production in Western Australia. The varieties Barwon and Norwin are therefore not generally recommended, although reliable seed yields and good quality grain are produced in Western Australia.

Lasseter has not been evaluated widely in Western Australia. It is later flowering than Sona or Heera.

It remains to be seen whether virus diseases will be a major problem in Western Australia and the virus resistant variety Gully will be evaluated alongside other emerging lines in coming years.

Kabuli prices depend largely on the seed size produced with a premium for seeds greater than 9 mm diameter. Kaniva has produced large seeds and profitable yields in areas with more than 400 mm rainfall p.a. and deep fertile soils in Western Australia.

Garnet has smaller seed than Kaniva and hence, is not widely recommended. The recently released variety Bumper (45 g/100 seed) has a greater proportion of large seed than Kaniva and will be the preferred variety for most areas. Unfortunately, quarantine restrictions will limit the introduction of seed from the eastern states for several years.

The very large seeded variety Macarena (55 g/100 seed) remains the only recommended variety for irrigated production of kabuli chickpea in the Ord River Irrigation Area. Plant breeders are investigating better adapted genotypes for this region.

Table 2. Desi chickpea yields (t/ha) in Western Australia over the last six years.

<table>
<thead>
<tr>
<th>Variety</th>
<th>1992 (3 sites)</th>
<th>1993 (12 sites)</th>
<th>1994 (10 sites)</th>
<th>1995 (11 sites)</th>
<th>1996 (16 sites)</th>
<th>1997 (10 sites)</th>
<th>Mean</th>
<th>% Tyson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tyson</td>
<td>1.07</td>
<td>1.09</td>
<td>0.59</td>
<td>0.97</td>
<td>0.98</td>
<td>0.87</td>
<td>0.92</td>
<td>100</td>
</tr>
<tr>
<td>Amethyst</td>
<td>1.09</td>
<td>0.91</td>
<td>0.56</td>
<td>0.90</td>
<td>0.84</td>
<td>0.81</td>
<td>0.83</td>
<td>90</td>
</tr>
<tr>
<td>Barwon</td>
<td>0.70</td>
<td>0.97</td>
<td>0.64</td>
<td>0.94</td>
<td>1.00</td>
<td>0.77</td>
<td>0.87</td>
<td>95</td>
</tr>
<tr>
<td>Dooen</td>
<td>0.88</td>
<td>0.91</td>
<td>0.63</td>
<td>0.94</td>
<td>0.99</td>
<td>0.84</td>
<td>0.88</td>
<td>95</td>
</tr>
<tr>
<td>Desavic</td>
<td>0.88</td>
<td>1.08</td>
<td>0.56</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.86</td>
<td>92</td>
</tr>
<tr>
<td>Norwin</td>
<td>-</td>
<td>-</td>
<td>0.59</td>
<td>0.86</td>
<td>0.76</td>
<td>0.69</td>
<td>0.73</td>
<td>79</td>
</tr>
<tr>
<td>Sona</td>
<td>-</td>
<td>-</td>
<td>0.98&lt;sub&gt;a&lt;/sub&gt;</td>
<td>1.52&lt;sub&gt;b&lt;/sub&gt;</td>
<td>1.02</td>
<td>0.84&lt;sub&gt;c&lt;/sub&gt;</td>
<td>0.95</td>
<td>103</td>
</tr>
<tr>
<td>Heera</td>
<td>-</td>
<td>-</td>
<td>0.97&lt;sub&gt;a&lt;/sub&gt;</td>
<td>1.54&lt;sub&gt;b&lt;/sub&gt;</td>
<td>1.08</td>
<td>0.81&lt;sub&gt;c&lt;/sub&gt;</td>
<td>0.98</td>
<td>105</td>
</tr>
</tbody>
</table>

<sup>a</sup> = 2 sites only, mean Tyson yield at these sites = 0.75 t/ha, figure not included in overall mean
<sup>b</sup> = 7 sites only, mean Tyson yield at these sites = 1.30 t/ha, figure not included in overall mean
<sup>c</sup> = poor seed germination
Table 3. Kabuli chickpea yields (t/h) in Western Australia over the last six years.

<table>
<thead>
<tr>
<th>Variety</th>
<th>1992 (2 sites)</th>
<th>1993 (3 sites)</th>
<th>1994 (3 sites)</th>
<th>1995 (6 sites)</th>
<th>1996 (7 sites)</th>
<th>1997 (3 sites)</th>
<th>Mean</th>
<th>% Tyson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tyson*</td>
<td>1.01</td>
<td>2.10</td>
<td>0.82</td>
<td>1.93</td>
<td>1.57</td>
<td>1.27</td>
<td>1.54</td>
<td>100</td>
</tr>
<tr>
<td>Garnet</td>
<td>0.41</td>
<td>1.45</td>
<td>0.80</td>
<td>1.45</td>
<td>1.18</td>
<td>0.93</td>
<td>1.14</td>
<td>73</td>
</tr>
<tr>
<td>Kaniva</td>
<td>0.29</td>
<td>1.33</td>
<td>0.82</td>
<td>1.40</td>
<td>1.22</td>
<td>0.93</td>
<td>1.11</td>
<td>72</td>
</tr>
<tr>
<td>Mission</td>
<td>0.27</td>
<td>1.31</td>
<td>0.90</td>
<td>1.46</td>
<td>1.11</td>
<td>–</td>
<td>1.13</td>
<td>73</td>
</tr>
<tr>
<td>UC5</td>
<td>0.42</td>
<td>0.53</td>
<td>0.83</td>
<td>1.31</td>
<td>1.05</td>
<td>–</td>
<td>0.96</td>
<td>62</td>
</tr>
<tr>
<td>Bumper</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>101</td>
<td>1.41</td>
<td>0.95</td>
<td>1.41</td>
<td>92</td>
</tr>
</tbody>
</table>

* = Desi comparison
# = 3 sites
b = 6 sites

Suggested varieties for Western Australia

AMETHYST

**Origin** Bred and released in NSW in 1988.

**Seed type** Small seed (12-15 g/100 sd) with light brown colour

**Height** Medium to tall and erect

**Maturity** Medium – similar to Tyson

**Yield** On average, has yielded 90% of Tyson in WA

**Other traits** Very susceptible to low temperatures. Best suited to the northern regions.

BARWON

**Origin** Bred and released under PBR* from NSW and Queensland in 1992

**Seed type** Medium to large (16-20 g/100 sd), similar in colour to Amethyst

**Height** Medium to tall

**Maturity** Medium – similar to Tyson

**Yield** On average, has yielded 95% of Tyson in WA

**Other traits** Has Phytophthora resistance, best suited to medium rainfall regions or early sowing

* Plant Breeders Rights
### DOOEN

**Origin** Released in Victoria in 1988. Selected from material from the former USSR.

**Seed type** Medium (15-19 g/100 sd) with light brown colour

**Height** Medium

**Maturity** Medium to late – up to a week later than Tyson

**Yield** On average, has yielded 95% of Tyson in WA

**Other traits** Best suited to medium rainfall regions or early sowing. Prone to lodging under high fertility conditions.

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### GULLY

**Origin** Released in NSW in 1988. Selected from Iranian material.

**Seed type** Medium (15-19 g/100 sd) with light colour

**Height** Short to medium

**Maturity** Medium-late

**Yield** Has not been tested widely in WA but has yielded less than Tyson in Vic.

**Other traits** Resistant to virus diseases in NSW. At present, little seed is available in WA because of quarantine restrictions.

---

### LASSETER

**Origin** Released in Victoria in 1996. Selected from material from Iran.

**Seed type** Large (17-22 g/100 sd) with light brown attractive colour

**Height** Medium

**Maturity** Medium – similar to Tyson

**Yield** Has outyielded Dooen by 14-20% in Victoria. Has been tested in 3 trials in WA (66% Tyson), but is currently being tested more widely.

**Other traits** At present, little seed is available in WA due to quarantine restrictions.

---

### NORWIN

**Origin** Bred and released under PBR in Queensland in 1993

**Seed type** Medium to large (16-20 g/100 sd), similar in colour to Amethyst

**Height** Medium

**Maturity** Medium – similar to Tyson

**Yield** On average, has yielded 79% of Tyson in WA

**Other traits** Has Phytophthora resistance, best suited to medium rainfall regions or early sowing.
Two new varieties for Western Australia

HEERA – a Hindi/Urdu word meaning diamond

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed type</td>
<td>Large seed (17-22 g/100 sd) with light brown colour. A preferred variety by traders in the Indian subcontinent.</td>
</tr>
<tr>
<td>Height</td>
<td>Medium to tall</td>
</tr>
<tr>
<td>Maturity</td>
<td>Early – flowers and sets pods 7 to 13 days earlier than Tyson</td>
</tr>
<tr>
<td>Yield</td>
<td>Has yielded 10 to 41% more than Tyson at individual sites in WA</td>
</tr>
<tr>
<td>Other traits</td>
<td>Best choice for medium-low rainfall regions in WA. Processing and cooking characteristics are equivalent to or better than Tyson.</td>
</tr>
</tbody>
</table>

SONA – a Hindi/Urdu word meaning gold

<table>
<thead>
<tr>
<th>Origin</th>
<th>Released in WA in 1997. A selection from germplasm from the International Crops Research Institute for Semi-Arid Tropics, India, previously tested as ICCV88202.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed type</td>
<td>Large seed (17-22 g/100 sd) with attractive yellow colour. The most preferred variety by traders in the Indian subcontinent.</td>
</tr>
<tr>
<td>Height</td>
<td>Medium to tall</td>
</tr>
<tr>
<td>Maturity</td>
<td>Early – flowers and sets pods 9 to 15 days earlier than Tyson</td>
</tr>
<tr>
<td>Yield</td>
<td>Has yielded 10 to 41% more than Tyson at individual sites in WA</td>
</tr>
<tr>
<td>Other traits</td>
<td>Best choice for low rainfall regions in WA. Processing and cooking characteristics are equivalent to or better than Tyson. Has some resistance to Fusarium wilt.</td>
</tr>
</tbody>
</table>
**Kabuli Variety Descriptions**

**Suggested varieties**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Origin</th>
<th>Seed type</th>
<th>Height</th>
<th>Maturity</th>
<th>Yield</th>
<th>Other traits</th>
</tr>
</thead>
<tbody>
<tr>
<td>GARNET</td>
<td>Selected and released in NSW.</td>
<td>Medium seed (30-40 g/100 sd) with light colour</td>
<td>Medium to tall</td>
<td>Medium to late</td>
<td>On average, has yielded 73% of Tyson in WA</td>
<td>Produces a lower proportion of large seed than Kaniva</td>
</tr>
<tr>
<td>KANIVA</td>
<td>Selected and released in Victoria</td>
<td>Medium seed (35-45 g/100 sd) with light colour</td>
<td>Medium to tall</td>
<td>Medium to late</td>
<td>On average, has yielded 72% of Tyson in WA</td>
<td>Produces a larger proportion of large seed than Garnet</td>
</tr>
<tr>
<td>BUMPER</td>
<td>Bred and released under PBR in NSW in 1998</td>
<td>Large seed (40-50 g/100 sd) with light colour</td>
<td>Medium to tall</td>
<td>Medium to late</td>
<td>On average, has yielded 92% of Tyson in WA</td>
<td>Produces a larger proportion of large seed than Garnet or Kaniva. At present, little seed is available in WA because of quarantine restrictions.</td>
</tr>
</tbody>
</table>
Paddock Selection

Neil Brandon, Stephen Loss and Ian Pritchard

Good paddock selection is one of the first steps towards a successful chickpea crop. It has important implications for crop establishment, growth, weed and insect management, crop yield and profitability.

SOIL TYPE

Chickpea is successfully grown on a variety of soil types throughout the world (Saxena 1987). These range from coarse-textured sands (e.g. Thal desert in Pakistan) to fine-textured black soils (e.g. in northern New South Wales). They are commonly grown on calcareous soils.

The crop prefers neutral to alkaline soils. In south-western Australia, chickpea grows best on deep fine-textured soils (sandy loams, clay loams and well-drained clays) with a pH of 6.0-9.0 (measured in calcium chloride - CaCl₂). Chickpea can also be grown on soils with a marginal surface pH of 5.0-6.0 (CaCl₂) but yields will be reduced relative to more alkaline soils.

Measuring soil pH

Chemical and fertiliser companies offer soil pH measurement services. Good soil sampling is needed to ensure that the soil pH measured is representative of the paddock.

Take at least 10 samples randomly from the entire paddock from a depth of 0-10 cm, combine these in a bucket and mix thoroughly before pH is measured. Where the surface pH is marginal (6.0-6.0) it is worth measuring soil pH on samples collected from depths 10-20 and 20-30 cm.

Many farmers now own their own soil pH meters. These need to be calibrated if they are to be accurate. Mix the soil with a calcium chloride solution rather than water before measuring the pH as this gives a more consistent result. Soil pH measurements taken in water tend to be 0.5-1.0 pH units higher than those taken in calcium chloride.

Table 4. Soil pH suitability for chickpea.

<table>
<thead>
<tr>
<th>pH (CaCl₂)</th>
<th>pH in water (approximate)</th>
<th>Suitability for chickpea</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 5.0</td>
<td>less than 5.5 – 6.0</td>
<td>Unsuitable</td>
</tr>
<tr>
<td>5.0 – 6.0</td>
<td>5.5 – 6.5</td>
<td>Marginal, may be ok if subsoil is more alkaline</td>
</tr>
<tr>
<td>6.0 and above</td>
<td>6.5 – 7.0 and above</td>
<td>Suitable</td>
</tr>
</tbody>
</table>

Soils with a marginal surface soil pH or soil texture may still be suitable provided pH and texture increases with soil depth and rainfall are not major limitations.

Good soil water holding capacity is desirable as chickpea does not form pods until daily average temperature reaches approximately 15°C and in southern and eastern parts of the cropping region this does not occur until September or October (see Growth and Development section for more details). In these areas pod filling occurs during periods of low or unreliable rainfall.

This is particularly true for the large-seeded kabuli chickpea which has a long grain filling period. Hence, kabuli types are only recommended for deep fertile soil types in regions with greater than 400 mm annual rainfall. Inadequate rainfall or shallow soils

Chickpea does not tolerate waterlogging. Note the reddening (anthocyanin) in the stems and leaves. Photo K. Siddique.
Yields in duplex soils are generally less reliable than in the more uniform soils due to greater severity of drought in dry years and waterlogging in wet years.

Chickpea is sensitive to waterlogging and sodicity, probably similar to narrow-leaved lupin. Soils must have a good structure or a slope that allows drainage. Surface crusts of the soil can reduce plant establishment.

Chickpea is relatively sensitive to boron toxicity. It has a similar sensitivity to barley but is more sensitive than wheat, field pea or faba bean. Avoid soils where boron toxicity is known to be a problem (see Nutrition section for more details).

The best chickpea yields are produced on deep red or brown clay loam soils with good water holding capacity. For desi chickpea, sandy-surfaced soils can also be considered in the medium or low rainfall zones if a clay subsoil allows adequate drainage and roots access to moisture lower in the profile.

Yields in duplex soils are generally less reliable than in the more uniform soils due to greater severity of drought in dry years and waterlogging in wet years.

Options for the post emergence control of broad-leaved weeds in chickpea crops are currently limited. The crop has slow winter growth and is a poor competitor with weeds, especially during the seedling stages. Therefore, select paddocks with a low broad-leaved weed burden, especially wild radish (*Raphanus raphanistrum*), wild turnip (*Brassica tournefortii*) and double-ggee (*Emex australis*), and low levels of herbicide resistant grasses (see Weed Management section for further details).

Low weed burdens are most likely to occur after a cereal crop. Unless managed carefully, there is a high risk of broad-leaved weeds after pasture, canola or other pulse crops. There are few diseases common to chickpea and other pulse crops and while it is possible to grow two pulse crops in succession, this is not recommended because of the high risk of weed problems.

Field pea, narrow-leaved lupin and faba bean are difficult to control within chickpea crops and cannot be easily graded out of the harvested grain. Make sure these volunteers are controlled in the cereal phases of the crop.
Transporting seed large distances, dropping bags onto concrete floors and moving seed with screw-type augers are particularly

Chickpea seed is prone to physical damage and reduced germination percentage caused by handling the seed before sowing, especially with large-seeded varieties at low moisture contents.

Seed viability and germination percentage decreases marginally with time if seed is stored correctly. Storage at high temperature or high moisture content hastens the aging process of the grain (see Disease section for more details). Rainfall immediately before or during harvest can also reduce seed viability.

Chickpea seed is prone to physical damage and reduced germination percentage caused by handling the seed before sowing, especially with large-seeded varieties at low moisture contents.

Seed viability, purity and quality vary considerably depending upon location, season and many other factors, and testing for these parameters is recommended for all chickpea seed.

Seed and Seed Treatments

Neil Brandon, Stephen Loss and John Howieson

No matter whether chickpea seed is bought or produced on-farm, it is important to ensure it has good quality. Poor seed quality can result in low plant establishment and the unnecessary introduction of weeds and diseases.

In addition, chickpea seed needs to be inoculated with the appropriate nitrogen fixing bacteria before sowing to ensure the crop has adequate nitrogen and to provide large rotational benefits to following crops. In some cases, seed dressing fungicides may also be required.

Paddock check list:

- well drained, fine-textured soil with surface pH greater than 5.0 in CaCl₂,
- low broad-leaved weed burden,
- no sulfonylurea herbicide residues,
- no large rocks or stumps,
- at least a two year break between successive chickpea crops, and
- avoid soils where salinity or boron toxicity has been evident.

Good quality seed is an essential start to a successful crop. Photo S. Eyres

Seed viability and purity

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Seed viability and purity

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Good quality seed is an essential start to a successful crop. Photo S. Eyres

Seed viability and purity
Store the inoculum in the fridge but not against the cooling element where it might freeze. Don't leave the inoculum lying in the sun or the heat of a vehicle cabin.

Purchase fresh Group N inoculum every year and observe the use-by dates on the packet. The inoculum is a living bacterial culture growing in a peat base, so treat it like you would any other living organism.

The nitrogen-fixing bacteria (Rhizobium spp.) required to infect roots of chickpea are different to those of other grain or pasture legumes, and generally survive poorly on acid coarse-textured soils. It is therefore important that chickpea seed be inoculated each year prior to sowing. Regard the small cost of inoculum as cheap insurance against nodulation failure.

In regions that have experienced high aphid populations, also test seed for Cucumber Mosaic Virus. Reject seed with greater than 2 per cent infected seed if it is being grown in areas with a high aphid risk.

Most companies provide sampling kits with instructions on how to best sample grain to ensure a representative sample is obtained.

Ideally, test the seed immediately after harvest or early in the new year. Seed testing laboratories tend to be busy in autumn and test results may take six to eight weeks. Testing is available through commercial laboratories such as Academy of Grain Technology (AGT), Seed Grain Biotechnology (SGB) and Agriculture Western Australia by AGWEST Plant Laboratories.

AGWEST 08 9368 3721
SGB 08 9325 9119
Australian Grain Technology 08 9479 2480

For more information on seed testing:

SEED TREATMENTS

Seed can be treated for the fungal disease BGM but not for the viral disease CMV.

Spores of BGM are normally only present on the outside of mildly infected seed and good control is obtained with seed dressing fungicides. Thiram is the only seed fungicide currently registered for as a seed dressing for chickpea in Western Australia.

If chickpea seed is obtained from a field infected with BGM, always have the seed tested for disease infection. If the seed is being obtained from the northern cropping region and it is unknown whether the crop was infected, it should also be tested.

Kabuli chickpea may show a response to the application of thiram even in the absence of BGM. This is because they have a thin seed coat and a lower content of phenolic compounds which protect the seed against fungal attack. Therefore, it is generally recommended that kabuli seed be treated with thiram.

Improved establishment has also been observed in thiram treated desi chickpea, but as yet there has been no yield response to the application of thiram in the absence of BGM.

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In regions that have experienced high aphid populations, also test seed for Cucumber Mosaic Virus. Reject seed with greater than 2 per cent infected seed if it is being grown in areas with a high aphid risk.

Botrytis grey mould (BGM) is a fungal disease of chickpea that has been observed on crops in the northern cropping region of Western Australia. The disease occurs during warm wet conditions and is not expected to be a major problem in southern regions in most years. However, using infected seed can result in seedling death.

In regions that have experienced high aphid populations, also test seed for Cucumber Mosaic Virus. Reject seed with greater than 2 per cent infected seed if it is being grown in areas with a high aphid risk.

Narrow-leafed lupin and field pea contamination in desi chickpea seed need to be kept to a minimum, as these plants are difficult to control in the crop or remove in the harvested grain. The tolerance levels for these seeds is low and downgrading to stockfeed grade results in a large price penalty. Maximum receipt standards for these are 3 per 200g which is equivalent to 0.2 per cent.

Reject all seed with greater than 15 per cent infection with BGM. Treat seed with less than 15 per cent infection with thiram at the recommended rate.

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Improved establishment has also been observed in thiram treated desi chickpea, but as yet there has been no yield response to the application of thiram in the absence of BGM.
Inoculate only enough seed for sowing in the next 24 or 48 hours. Reinoculated any seed that has been inoculated but was then subsequently stored for any longer than two days.

Fungicidal seed dressings reduce the longevity of the nitrogen-fixing bacteria applied to the seed, but if contact is kept to a minimum, satisfactory nodulation can be obtained in most cases. Avoid sowing fungicide-treated seed in soils where the surface pH is 5.0-6.0 in CaCl₂ because the combination of fungicide and soil acidity is likely to lead to nodulation failure.

Inoculate fungicide-treated seed as close as possible to the time of sowing. If seed treated with fungicide is not planted within 12 hours, reinoculate before sowing.

The nitrogen-fixing bacteria are also sensitive to trace elements such as copper. Do not leave the inoculated seed in contact with trace element fertilizers for any longer than several hours.

In a few rare cases, inoculation is not essential. Paddocks that have grown three or four chickpea crops in the past eight to ten years and have a soil pH above 7.0 in CaCl₂ and clay content above 15 per cent, may have an adequate background of the nitrogen-fixing bacteria in the soil. These paddocks may be considered for dry sowing with fungicide-treated seed.

Improvement in the survival of the nitrogen-fixing bacteria in the soil is the

How to inoculate chickpea seed

Read the instructions on the packet carefully. Some inoculants have adhesives included, while others will require the addition of an adhesive when mixing up the slurry.

Mix the required amount of inoculum with cool tank water, not chlorinated water. Stir to make sure the inoculum is thoroughly dispersed. If the inoculum does not contain an adhesive, add fully dissolved 1.0 per cent methocel solution. Check the methocel instructions for further details. Extra adhesive is recommended if an airseeder is to be used for sowing.

Add the slurry to the correct weight of seed at the rate recommended on the inoculum packet, ensuring that seeds are evenly coated with the inoculum mixture. This can be achieved by adding the slurry to the grain as it is being augured into a storage bin or from a bin directly into the seeder.

Augers can be modified so that a pipe may be attached to the outside casing. The slurry can be gravity fed from a bucket with a hose fitting attached to the bottom. The rate of flow is controlled by either altering the height of the bucket relative to the auger, or by restricting the flow through the pipe using a clamp.

All seeds should have speckles of the black gum slurry.
Fortunately, chickpea also has a capacity to produce numerous flowers and set pods when temperatures become more favourable. If there is adequate soil moisture available or spring rainfall, the impact of flower and pod abortion can be minimal. Hence, there is much more flexibility in the optimum time of sowing for chickpea on soils with a good moisture holding capacity.

As discussed in the Growth and Development section, chickpea requires mean daily temperatures above 15°C for the fertilisation of flowers and pod set. Early sown chickpea crops tend to flower in late winter and can suffer from excessive flower and pod abortion, especially in the cool eastern and southern parts of the cropping regions of Western Australia.

Chickpea crops are poor competitors with weeds and the herbicide options for post-emergent broad-leaved weed control are limited. In many cases, waiting for a germination of weeds and killing them with a non-selective (knockdown) herbicide is essential.

These advantages, however, can be offset by poor weed management, increased fungal diseases and higher risks of frost damage near flowering, than when sowing is delayed.

In many crops in south-western Australia, sowing soon after the first autumn rains usually results in increased seed yield potential when compared to delayed sowing. With early sowing less water is lost through soil evaporation, biomass production is improved, flowering occurs early and the duration for grain growth is increased (Loss and Siddique 1984).

Different pulses require different inocula.

Photo S. Loss.

subject of ongoing research. Attempts are being made to identify an effective strain of bacteria that persists better under conditions in Western Australia, so that inoculation is not necessary every time chickpea is sown. Such a strain may also overcome the conflict between inoculation and fungicide application to the seed, especially on low pH soils.

Different pulses require different inocula.

Photo S. Loss.
Where conditions are favourable for rapid growth early in the season, planting desi chickpea too early may result in excessive vegetative growth leaving little stored soil moisture for grain filling in spring. It may also increase likelihood of Botrytis Grey mould in northern regions.

On the other hand, planting too late may cause yield loss as crops are more likely to suffer from moisture stress during grain filling, especially in low rainfall areas, and can be more difficult to harvest because of their short stature.

**Recommended sowing times in south-western Australia**:  

**Northern region** – spring rainfall is usually unreliable and the penalty for delayed sowing is quite large. Fortunately, winter temperatures are warmer than southern areas and flower and pod abortion are likely to be minimal. Sowing in **late April to mid May** typically produces maximum yield.

**Eastern region** – there is often a yield penalty with early sowings due to cool temperatures and frost causing excessive flower abortion, while spring rainfall is quite unreliable. The optimum sowing time in this region appears to be from **early to late May**.

**Medium to high rainfall central region** – rainfall is more reliable and temperatures tend to be higher than in eastern areas. This gives more flexibility for delayed sowing and pre-sowing weed control. The optimum sowing time in this region appears to be from **early May to early June**.

**Southern regions** – low temperatures are the main limitation to chickpea yields. Fortunately, spring rainfall tends to be more reliable than other areas. The optimum sowing time in this region appears to be from **mid May to early June**.

*Soils with good moisture holding capacity provide more scope for delayed sowing.*

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**Table 5. Sowing times for desi chickpea**  

- o = recommended time, • ideal time. Sow long season varieties such as Dooen or Barwon about one week earlier than indicated.

<table>
<thead>
<tr>
<th>Week</th>
<th>April</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2</td>
<td>3</td>
<td>4 4</td>
</tr>
<tr>
<td>Northern region</td>
<td></td>
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</tr>
<tr>
<td>Eastern region</td>
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<tr>
<td>Central region</td>
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<tr>
<td>(med/high rainfall)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern region</td>
<td></td>
<td></td>
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</tbody>
</table>

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**Figure 7. Typical grain yield responses to sowing time of desi chickpea grown in the northern (Mullewa), eastern (Merredin) and southern (Gnowangerup) regions (unpublished data K. Siddique).**
Sowing into dry soil before the first rains arrive is an establishment method that has been used successfully by experienced desi chickpea growers in the northern and eastern cropping regions.

The main advantage of dry sowing is that it allows part of the sowing program to be completed before the onset of autumn rain. However, as with dry sowing any crop, there is a risk of rain that germinates the seed with no follow-up rain, resulting in seedling death. This is commonly referred to as a ‘false break’. Dry sowing is therefore not recommended for first time or inexperienced growers.

Chickpea has relatively large seed that requires considerable soil moisture for germination. Hence, it is less likely to be affected by a ‘false break’ than small-seeded crops, especially if it is sown at 8-10 cm depth. When sowing into dry soil it is important that the soil is completely dry. Damp soil may cause partial germination and death of seedlings.

Dry sown crops tend to suffer from greater weed densities due to poor effectiveness of pre-emergent herbicides and no opportunities for the application of non-selective (knockdown) herbicides before sowing. Paddocks that are to be sown dry must have a low broad-leafed weed burden.

Establishment and inoculation may also be less successful with dry sowing due to the increased death of the seed and nitrogen-fixing bacteria in the hot dry soil. Doubling the rate of inoculum will increase the chances of bacterial survival, while increasing sowing rates will compensate for decreased seed viability.

Dry sowing also increases the risk of soil erosion, especially on coarse-textured surface soils. Fortunately, chickpea production is mostly limited to soils with a low risk of erosion. Ensure there is adequate stubble retention on soils prone to erosion.

Consider dry sowing 30 to 50 per cent of your chickpea sowing program after mid-May in northern and eastern regions. In other regions there is less need for early sowing, and it is safer to wait for rain before sowing.

Dry sowing is not generally an option with seed that has been treated with a fungicide. Prolonged contact between the fungicide and the inoculum in the dry soil will kill the nitrogen-fixing bacteria.

In some rare cases, inoculation is not essential. Paddocks that have grown three or four chickpea crops in the past eight to ten years and have a soil pH above 6.0 and clay content above 15 per cent, may have an adequate background of the nitrogen-fixing bacteria in the soil.

**Dry Sowing Checklist:**

- paddocks must have a low levels of broad-leafed or herbicide resistant weeds,
- there must be adequate stubble or soil cleddiness to prevent wind erosion,
- double the rate of inoculum and apply immediately before sowing,
- increase sowing rates by 10 per cent,
- sow at 8 to 10 cm depth to reduce the risk of a ‘false break’ and
- in general, do not attempt to dry sow seed that has been treated with a fungicide dressing.

Sowing rate influences the number of seedlings that establish, crop growth and yield, and ultimately the profitability of the crop. Establishment success also has implications for weed management and ease of harvesting the crop because of its effect on competitiveness and height of the crop. However, there is limited published information on the optimum sowing rate and plant density for chickpea in Australia.

The response of the growth and seed yield of desi chickpea Tyson to sowing rate (30-180 kg/ha) was examined in 16 field experiments conducted in 1994-1996 in Western Australia (Jettner et al. 1998). The optimum sowing rate was determined by fitting an asymptotic curve to the plant density and grain yield data, and calculating the point where the cost of extra seed equaled the return from additional seed yield, allowing a 10 per cent interest rate for the invested seed.

Estimated optimum plant densities tended to be greater (mean of 90 plants/m²) in the northern cropping region which
Conventional seeders may have trouble with the large recommended sowing rates of kabuli chickpea. Photo K. Siddique.

As chickpea is considered a risky crop compared to cereals, especially for new growers, many growers are reluctant to invest an $1.00 in extra seed for a return of $1.10 in additional yield. Optimum plant densities were also calculated using a return of $1.50 for every extra $1.00 invested (that is a 50 percent opportunity cost).

Under long season conditions in the south, chickpea shows a greater plasticity in terms of growth at a range of densities and has a relatively low optimum plant density (mean 52 plants/m²). A similar optimum plant density was estimated for the central region. These densities are substantially larger than the 30 plants/m² previously recommended.

Figure 8. The relationship between plant density and grain yield at three typical sites in 1995. Dotted lines indicate the estimated optimum plant density (adapted from Jettner et al. 1998).
Sowing

Calculating sowing rate:

\[
\text{weight of 100 seeds (g) x optimum density (plants/m}^2\rangle \times 10 = \text{sowing rate (kg/ha)}
\]

\[
\text{germination percentage}
\]

For example:

- Tyson, 13 g x 60 plants/m\(^2\) x 10 = 81 kg/ha 80%
- Heera or Sona, 19 g x 50 plants/m\(^2\) x 10 = 119 kg/ha 80%
- Kaniva, 26 g x 30 plants/m\(^2\) x 10 = 150 kg/ha 70%

These results indicate optimum plant densities about 15-20 per cent less than first estimated. However, in the long term, the data show that profit is sacrificed at these low densities.

Desi chickpea growers are advised to target a plant density of 50 plants/m\(^2\) for sites with a yield potential of 1.0 t/ha or less. This equates to a sowing rate of about 80-110 kg/ha depending upon germination and seed size. In regions with a yield potential above 1.0 t/ha (medium to high rainfall regions of the northern cropping region), higher plant densities will be beneficial.

As Sona or Heera have larger mean seed weights (17-20 g/100 seed) than Tyson (11-13 g/100 seed), seed rates may have to be increased accordingly with the new varieties.

Optimum sowing rates for kabuli chickpea are currently being calibrated in Western Australia. At present 30 plants/m\(^2\) is the recommended density. Kabuli are especially susceptible to mechanical damage and germination percentages are often low. This and large seed sizes result in sowing rates of 120-170 kg/ha. Many old style seeders may have trouble with these large sowing rates.

Unlike lupins, chickpea cotyledons remain below the ground with the seed and only the shoot is pushed above the soil surface as they emerge. This is known as hypogeal emergence. Hence, chickpea can be sown deep with little reduction in emergence and seed yield (Siddique and Loss 1998).

Sow chickpea at 5 to 8 cm. Sowing at this depth:

- reduces the risk of damage from pre-emergent herbicides,
- improves the chances of inoculum and seed survival due to the greater moisture and lower temperatures than close to the soil surface, and
- promotes lateral roots near the soil surface capable of exploiting light showers of rain.

The hypogeal emergence of chickpea also enables the plant to emerge through thick cereal stubble.

Figure 9. Response to sowing depth of Tyson chickpea at two sites over two years (redrawn from Siddique and Loss 1998).
Field experiments in southwestern Australia have shown no significant reduction in chickpea yield as a result of increasing row spacing from 180 to 360 mm. Very wide row spacings (up to 700 mm) are used in fertile conditions in other regions such as southern Queensland and the Ord River Irrigation Area. These wide row spacings allow mechanical inter-row cultivation. However, they are likely to result in excessive soil evaporation and low competition with weeds in southern Australia.

Airseeders can cause damage to the seed particularly with large-seeded varieties such as Heera and Sona or kabuli varieties. Keeping the air speed to a minimum will help reduce any damage.

Airseeders can damage chickpea seed if air speed is too high. Photo P. Maloney.

Covering the seed is important but limited experiments to date show no significant differences in emergence whether finger harrows, rotary harrows or press wheels are used. Press wheels leave a depression on top of the row that can harvest water into the row. This may increase waterlogging in shallow soils that are already wet. It may also increase the effective concentration of post-sowing pre-emergent herbicides and increase seedling mortality where significant rainfall occurs shortly after sowing, especially on coarse-textured soils.

For example, if soil moisture is marginal and declining at time of sowing, moisture loss following cultivation with triple disc machines may be less than deep narrow points due to lower soil disturbance with the narrow points.

Chickpea crops can be established successfully using either minimum tillage or single-pass conventional tillage techniques.

Yields of chickpea on coarse-textured sandy loams have sometimes been increased by tillage, either with narrow points working deep or wide points working at seed depth. However, no response to tillage has been found on fine-textured loams and clay loams. Minimising soil disturbance on these soils reduces soil moisture loss and may increase yields in some years.

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Large ridges left between rows can cause a problem for harvesting if the season is dry and plants do not grow very tall. Ideally the soil should be left flat by using rotary harrows. Rolling the paddock following sowing is another way of flattening the soil surface and burying small sticks and stones.

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Chickpea crops can be established either minimum tillage or single-pass conventional tillage techniques.

Yields of chickpea on coarse-textured sandy loams have sometimes been increased by tillage, either with narrow points working deep or wide points working at seed depth. However, no response to tillage has been found on fine-textured loams and clay loams. Minimising soil disturbance on these soils reduces soil moisture loss and may increase yields in some years.

For example, if soil moisture is marginal and declining at time of sowing, moisture loss following cultivation with triple disc machines may be less than deep narrow points due to lower soil disturbance with the narrow points.
The key to low harvesting losses is careful paddock selection and ground preparation. Harvest losses as high as 40 per cent have been recorded in chickpea crops in Western Australia due to inadequate ground preparation and harvesting the crop too quickly.

Rolling paddocks

The capacity of the seeder to handle large amounts of cereal stubble is generally improved by wide row spacings. However, long dense stubble can still cause blockages in tined seeders.

Try to leave the stubble short and spread evenly after the previous harvest. This will also ease the harvest of the chickpea crop as piles of stubble left from sowing blockages have to be avoided at harvest time.

Disc type seeders do not tend to block with stubble but if the stubble is pushed down into the seed zone it can dry the soil around the seed or allow toxins in the stubble to reduce emergence. Removing excess stubble by baling or burning windrows may improve establishment with disc seeders.

Some herbicides may be less active if applied to paddocks with excessive stubble. In these cases it may be better to remove some of the stubble. Leaving around 1.0 t/ha of stubble is generally adequate to reduce the soil erosion risk and soil moisture loss.

A main concern with wide rows is the placement of a large amount of fertiliser near the seed that may reduce crop emergence, especially if narrow points are used. In wide rows, fertiliser is better placed either below or to the side of the seed to avoid toxicity.

Under normal conditions, the maximum safe level of phosphorus placed with the seed on 360 mm row spacings with 180 mm points is about 8 kg/ha (or 88 kg/ha of single superphosphate). In any case, chickpea crops generally have modest fertilizer requirements and are unlikely to require such high rates of fertiliser (see Nutrition section for more details).

Chickpea can be sown into standing stubble with appropriate machinery. Photo K. Siddique.

Short stubble spread evenly after harvest enables trouble free sowing. Photo S. Loss.
As the weeds increase in size, higher rates will be needed, and the highest rates are recommended with zero-tillage practices. Any transplants that survive the knockdown herbicide and follow-up cultivation will be almost impossible to control later on within the crop.

Sufficient herbicide must be used to ensure that the weeds are completely killed. About 0.8-1.2 L/ha of glyphosate 450 or 1.1-1.6 L/ha of Spray.Seed 250® will be needed. The low rates indicated can be used on small weeds when seeders with full cut cultivation are to be used.

As the weeds increase in size, higher rates will be needed, and the highest rates are recommended with zero-tillage practices. Any transplants that survive the knockdown herbicide and follow-up cultivation will be almost impossible to control later on within the crop.
A single application of Spray.Seed® will not control large weeds with established root systems. If these are present, glyphosate is probably a better alternative. Any very large weeds that germinated from late summer rains will probably need an application of glyphosate followed by Spray.Seed® two weeks later. It is much easier to control such weeds in summer, just after they have germinated, than waiting until closer to sowing.

PRE-SOWING HERBICIDES

Bladex® has been the standard basal herbicide for chickpea crops for many years. At rates of 2-3 L/ha it controls a range of broad-leaved and grass weeds, but at a relatively high cost of $30-40/ha. Simazine has recently been registered for chickpea crops in Western Australia, and will provide equal or better weed control at a lower cost than Bladex®. Simazine at 2-3 L/ha costs $10-15/ha.

Simazine, however, has two drawbacks. On coarse-textured soil types, it may cause some damage to the emerging chickpea seedlings. As a general rule, if the soil is almost suitable for the production of narrow-leaved lupin, simazine use on chickpea is risky. On these soils, do not exceed 2 L/ha of simazine. Bladex® may also cause damage to chickpea on these soils, but tends to be less toxic than simazine.

Secondly, there is a high risk of herbicide carryover causing damage to next season’s cereal crop, especially on fine-textured alkaline soils in dry areas. To compound the problem, these soils often need high rates of triazine herbicides to achieve adequate weed control.

For example, 3 L/ha simazine is well tolerated by chickpea on red clay loams at Merredin. However, if the season is drier than usual, some 500-800 mL/ha of the simazine may persist into the next season. If this happens, seek specialist advice before sowing cereals next year.

Limited work with atrazine suggests it is more damaging to chickpea than simazine and is not recommended.

For control of ryegrass, especially where resistance to the fop herbicide group (Hoegrass®, Fusilade®, et al.) and the dim herbicide group (Sertin®, Select®, et al.) has developed, Stomp® and trifluralin can be used at 2 L/ha. These products will also give some suppression of wireweed and wild oats. If wild oats is a major concern, Avadex BW® at 2 L/ha will generally prove a better pre-sowing option.

POST-SOWING PRE-EMERGENCE HERBICIDES

Both metribuzin (Lexone®, Sencor®, etc.) and Spinnaker® are registered for use in chickpea crops before emergence. At 300 g/ha or 200 mL/ha respectively, they will give good control of most grasses, brassicas, capeweed, doublegee and wireweed. Their main use, however, is as an adjunct to a basal simazine treatment.

At half the above rates, crop safety is maintained and the weed control of the simazine is enhanced. In the case of Spinnaker®, a different herbicide chemistry is also introduced as a resistance control strategy.

POST-EMERGENCE HERBICIDES

All grass selective herbicides can be used in chickpea crops. The actual choice of product depends upon the specific grass weeds present and the potential for herbicide resistance.

For broad-leaved weeds, the options are limited. Tough at 1-2 L/ha will give control of capeweed and fumitory, while Broadstrike® provides suppression of brassica weeds and doublegee. Broadstrike® is best applied before the 3-5 leaf stage of the crop as it may retard chickpea growth.

The use of Brodal® or Eclipse® causes severe damage to chickpea crops.

More complete details are in the Cereal, Pulse and Oilseed Weed Spraying Chart, Agriculture Western Australia Bulletin 4347.
Table 6. Registered herbicides, their approximate cost/ha, and the weeds they control in chickpea crops in Western Australia. The grass elective herbicides are only roughly summarised.

<table>
<thead>
<tr>
<th>Product*</th>
<th>Rate/ha</th>
<th>Cost S/ha</th>
<th>Weeds controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simazine PPI</td>
<td>2 L</td>
<td>10</td>
<td>1-8, 10; 9 suppressed</td>
</tr>
<tr>
<td>Bladex® PPI</td>
<td>2 L</td>
<td>27</td>
<td>1, 2, 6-10; 3, 4 suppressed</td>
</tr>
<tr>
<td>Trifluralin PPI</td>
<td>2 L</td>
<td>12</td>
<td>2, 10; 9 suppressed</td>
</tr>
<tr>
<td>Avadex BW® PPI</td>
<td>2 L</td>
<td>24</td>
<td>1 suppressed</td>
</tr>
<tr>
<td>Stomp® PPI</td>
<td>2 L</td>
<td>21</td>
<td>2, 10</td>
</tr>
<tr>
<td>Metribuzin IPP</td>
<td>300g</td>
<td>26</td>
<td>1, 2, 6-10; 3 suppressed</td>
</tr>
<tr>
<td>Spinnaker® IPP</td>
<td>200 mL</td>
<td>20</td>
<td>1, 2, 4-8; 10</td>
</tr>
<tr>
<td>Simazine IBS +</td>
<td>2 L</td>
<td>23</td>
<td>1-10</td>
</tr>
<tr>
<td>Metribuzin IPP</td>
<td>150 g</td>
<td>20</td>
<td>1-10</td>
</tr>
<tr>
<td>Simazine IBS +</td>
<td>2 L</td>
<td>20</td>
<td>1-10</td>
</tr>
<tr>
<td>Spinnaker® IPP</td>
<td>100 mL</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Broadstrike® PO</td>
<td>25 g</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>Tough® PO</td>
<td>1-2L</td>
<td>33-65</td>
<td>7, 9</td>
</tr>
<tr>
<td>Correct® PO</td>
<td>200 mL</td>
<td>9</td>
<td>1, 4, 5</td>
</tr>
<tr>
<td>Fusilade® PO</td>
<td>450 mL</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Fusion® PO</td>
<td>250 mL</td>
<td>14</td>
<td>1, 4, 5</td>
</tr>
<tr>
<td>Select® PO</td>
<td>500 mL</td>
<td>27</td>
<td>2</td>
</tr>
<tr>
<td>Sertin® PO</td>
<td>1000 mL</td>
<td>19</td>
<td>1, 4, 5</td>
</tr>
<tr>
<td>Targa® PO</td>
<td>250 mL</td>
<td>14</td>
<td>1, 4, 5</td>
</tr>
<tr>
<td>Verdict® PO</td>
<td>200 mL</td>
<td>10</td>
<td>1, 4, 5</td>
</tr>
<tr>
<td></td>
<td>300 mL</td>
<td>15</td>
<td>2</td>
</tr>
</tbody>
</table>

*IBS = applied pre-plant, incorporated by sowing.  
IPP = applied immediately post planting.  
PO = applied post planting, usually at the 2-4 leaf stage.

Weeds controlled are:
1. brome grass or barley grass (Bromus sup., Hordeum leporinum);
2. ryegrass (Lolium spp.);
3. silvergrass (Vulpia myuros, V. bromoides);
4. wild oats (Avena barbata);
5. volunteer cereals;
6. wild radish, turnip, mustard (Raphanus raphanistrum, Brassica tournefortii, Sisymbrium arientale);
7. capeweed (Arctotheca calendula);
8. doublegea (Emex australis);
9. fumitory (Fumaria supp.);
10. wireweed (Polygonum aviculare).

Researchers and grower discuss grass control in chickpea.  
Photo S. Loss.
In contrast, many grain legumes require a supply of P from the soil throughout the growing season. The major nutrient deficiency in Western Australia for all grain legumes, including chickpea, has been phosphorus (P). Cereal plants typically take up almost all the P they require early during their growth when they are seedlings. This provides enough P for grain production later in the season.

PHOSPHORUS

• In Western Australia, there is often a carry-over of fertiliser from other crops in the rotation which is able to meet the plant’s requirements.

• Chickpea is adapted to alkaline soil types and in some cases has special mechanisms for extracting nutrients (e.g. phosphorus), and nutritional deficiencies are rarely observed in chickpea crops grown on neutral to alkaline fine-textured soils in Western Australia. This is because:

Nutritional deficiencies are rarely observed in chickpea crops grown on neutral to alkaline fine-textured soils in Western Australia. This is because:

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• In Western Australia, there is often a carry-over of fertiliser from other crops in the rotation which is able to meet the plant’s requirements.

To minimise the amount of sheep grazing damage to chickpea crops:

- Apply grass selective herbicides before you put the sheep into the paddock.
- Introduce the sheep into the paddock in late July or early August for 3 to 4 weeks. If they are introduced as soon as the chickpea plants have that acidic taste then damage should be minimal. By grazing weeds when they are small, they are less likely to recover and may also be pulled out of the ground by the sheep.
- Monitor closely what the sheep are eating.
- Spray out the fence lines around the paddock with SpraySeeds or glyphosate. This forces the sheep into the paddock to find food. Use older merino sheep.
- Use stocking rates less than 10 DSE/ha. If something goes wrong then the damage will be minimised at this low rate.
- Do not leave the sheep in the paddock once the crop has started flowering.
- Regularly taste the chickpea leaves to ensure they are acidic. If they loose their acidity, remove the sheep.

History of phosphorus fertiliser

When newly cleared, most soils in Western Australia were acutely phosphorus (P) deficient. However, the neutral to alkaline fine-textured soils frequently contained enough indigenous (native) P to grow reasonable cereal crops. Although these soils were naturally the most fertile, they were amongst the first soils cleared and have been producing crops and pastures for the past 80 to 130 years.

Up until the mid 1970s, it was profitable to apply liberal quantities of fertiliser P to these soils because single superphosphate was very cheap. Before 1974, single superphosphate cost $14 per tonne, $12 per tonne being a Commonwealth Government bounty.

So effectively, the farmer only paid $2 per tonne for the fertiliser. Consequently, most soils potentially suitable for growing chickpea in Western Australia are usually not P deficient, even at the present time.
whole growing season, even during grain filling. Fortunately, some grain legumes, including chickpea, have evolved ways of obtaining the insoluble forms of P present in the soil that are unavailable to cereals.

Research work conducted overseas has shown that chickpea secretes strong organic acids from its roots. These acids dissolve insoluble sources of P in the soil to provide water-soluble P for plant uptake.

Most of the soils in Western Australia suitable for growing chickpea have a history of P fertiliser application. Field experiments conducted with chickpea in Western Australia on these soils have shown either no or little grain yield responses to freshly-applied superphosphate, even when large responses were obtained for wheat. (Bolland et al. 1998).

Only one newly cleared field site suitable for growing chickpea could be found in Western Australia. Chickpea showed a large grain yield response to fertiliser P applications at this site. In any case, newly-cleared soils are a rarity these days.

It is therefore concluded that chickpea is very efficient at utilising fertiliser P applied in the current or previous years in Western Australia, confirming data obtained overseas. On soils with a good P fertiliser history, chickpea can be sown without any P fertiliser. In these cases P can be applied in the cereal and other phases of the rotation. On soils with marginal P status, it is recommended to apply about 10-20 kg P per ha.

Phosphorus in soils

Plant roots take up P from the soil as water-soluble phosphorus (P). Consequently, manufactured fertilisers containing 80 to 90 per cent water-soluble P are very effective for most crops in most situations. These fertilisers include superphosphate (single, double, triple) and ammonium phosphate fertilisers (MAP, DAP).

Once the soil becomes moist, the water-soluble P compounds in the fertilisers strongly attract water from the surrounding soil into the fertiliser granule. The water-soluble P dissolves rapidly in this water and moves out of the granule and into the soil where it can be taken up by plant roots.

The problem is that P is not chemically stable in the water-soluble form. It reacts rapidly to form insoluble P compounds, mostly with calcium, iron and aluminum in the soil solution, and on the surfaces of soil particles. The reactions continue even when the soil is dry, to form more stable compounds that are increasingly unavailable to plants.

Hence, even shortly after application, the freshly-applied fertiliser P is transformed into insoluble P in moist soils. As a result only 5 to 20 per cent of the applied fertiliser P is taken up by plants in the year of application. The remainder is ‘adsorbed’ or precipitated by the soil.

In the years after the application of the fertiliser, insoluble P in the soil and P returned to the soil as organic matter from the crop stubble and roots, supply small amounts water-soluble P for plant uptake. The fertiliser P is said to have a ‘residual value’.

After the application of fertiliser P for many years, the amount of insoluble P in soil eventually reaches a high enough level to supply an adequate quantity of water-soluble P to plants. In this situation, only enough fertiliser P needs to be applied to maintain the P status of the soil.

The fertiliser needs to replace the P removed from the system in grain or by soil erosion and leaching, and the P that has formed very stable inorganic and organic compounds in the soil that are no longer available to plants.

Figure 10. Chickpea is less responsive to applied phosphorus than faba bean (adapted from Bolland et al. 1998).
Deficiency symptoms include stunting and chlorosis (yellowing) of the youngest leaves, especially during cold winter weather. Often, marginal symptoms are observed in winter, but plants grow out of these when temperatures increase in spring.

An exception to this is iron deficiency which was reported on high pH soils in southern Queensland and northern New South Wales after the original release of the variety Tyson.

Secretion of organic acids by chickpea roots not only dissolve insoluble P in alkaline soils, but also insoluble copper, zinc, iron and manganese, thereby avoiding deficiency of all these nutrients. Hence, few deficiencies of these nutrients have been reported for alkaline soils anywhere in the world.

In some soils overseas, additions of potassium (K) up to 50 kg K/ha has increased chickpea yields and been profitable. However, K is unlikely to be a deficiency in Western Australia.

Potassium deficiency is likely to occur in grain legumes, including chickpea, when soil test values for K are less than 100 to 150 µg K/g soil (or ppm soil). The alkaline fine-textured soils suitable for growing chickpea typically have soil K contents much greater than this, in range of 400 to over 1,000 µg K/g soil.

All crop and pasture species grown on these soils, including chickpea, have shown no yield responses to applications of K fertiliser. Alkaline soils usually contain abundant sulphur, calcium and magnesium, so that deficiencies of these nutrients are rarely reported in chickpea.

As previously stated, chickpea grows well on alkaline soils. Most micronutrients (copper, zinc, iron and manganese) are less available to plants in alkaline soils than neutral to acid soils. This is because these nutrients form compounds that are less soluble in alkaline soils.

Indeed, most acid and alkaline soils in Western Australia typically contain low amounts of manganese, and so manganese deficiency is potentially a problem for all species of grain legumes. Fortunately, plants adapted to alkaline soils have evolved ways of avoiding deficiencies of nutrients that are less available in alkaline conditions.

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Deficiency symptoms include stunting and chlorosis (yellowing) of the youngest leaves, especially during cold winter weather. Often, marginal symptoms are observed in winter, but plants grow out of these when temperatures increase in spring.

In other grain legumes it has sometimes been shown that applications of a small amount of N fertiliser (10 to 15 kg N/ha) drilled with the seed at sowing ensures that plants are not N deficient during early growth. In addition, small amounts of N fertiliser tend to promote good root and shoot growth, especially if temperatures are low in winter.

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Fortunately, there is considerable genetic variation among chickpea genotypes for susceptibility to iron chlorosis and a more tolerant line was reselected from Tyson and released. Chickpea breeders are aware of the potential limitations caused by iron deficiency and few symptoms are seen in Australian varieties developed more recently.

In contrast to many other micronutrients, molybdenum becomes more available to plants in alkaline soils than in acidic soils. Consequently, growth limitation caused by molybdenum deficiency is rarely reported in crop or pasture species grown on alkaline soils.

Where the toxicity occurs, it is very patchy, and its severity varies depending upon the season. The plant takes up too much boron during pod set and filling, which can reduce yields.

Critical boron levels in plants have proved difficult to determine, because the distribution of boron within the plant is uneven, and it is readily leached from leaves by rain. Critical boron levels in cereal grain (wheat and barley) have been determined. Concentrations of 2 mg/kg (or 2 parts per million- ppm) in grain are likely to relate to high boron levels in the soil and grain yields are generally reduced when concentrations reach 3-5 mg/kg, especially in dry years.

Boron toxicity is thought to be a minor problem for chickpea in Western Australia. This is because most alkaline soils in Western Australia contain a low concentration of boron. However, some soils, mostly in the south-east near Salmon Gums, have high levels of soluble boron.

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tf

TABLE 7. A list of nutrient critical concentrations above which is considered adequate for chickpea growth (adapted from Reuter and Robinson 1997)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Plant sample</th>
<th>Critical concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus</td>
<td>Whole Shoot</td>
<td>0.24%</td>
</tr>
<tr>
<td>Potassium</td>
<td>Youngest mature leaf</td>
<td>2.0%</td>
</tr>
<tr>
<td>Sulphur</td>
<td>Whole Shoot</td>
<td>0.15%</td>
</tr>
<tr>
<td>Calcium</td>
<td>Youngest mature leaf</td>
<td>1.3%</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Youngest mature leaf</td>
<td>0.15%</td>
</tr>
<tr>
<td>Copper</td>
<td>Youngest mature leaf</td>
<td>4 mg/kg</td>
</tr>
<tr>
<td>Zinc</td>
<td>Youngest mature leaf</td>
<td>12 mg/kg</td>
</tr>
<tr>
<td>Manganese</td>
<td>Youngest mature leaf</td>
<td>60 mg/kg</td>
</tr>
<tr>
<td>Iron</td>
<td>Youngest mature leaf</td>
<td>11 mg/kg</td>
</tr>
<tr>
<td>Boron</td>
<td>Youngest mature leaf</td>
<td>22 mg/kg</td>
</tr>
</tbody>
</table>

Critical boron concentrations in seeds of chickpea have yet to be determined accurately. Removal of boron from toxic soils is impractical. The solution to this problem appears to be in the development of varieties that tolerate high levels of boron.

Recently a small research project has commenced in Western Australia with the aim of identifying chickpea varieties with high levels of boron tolerance.

The response of Australian chickpea varieties to high concentrations of boron are:

- **moderately tolerant**, Kaniva and Garnet;
- **moderately sensitive**, Opal, Semsen and Narayen;
- **sensitive**, Tyson, Barwon, Dooen, Amethyst and Macarena.
Seedlings from infected seed sown without a fungicide seed dressing, will often emerge and die within a few weeks. The grey spore mass typical of the disease may be visible on dead seedlings near the soil surface. The most obvious symptom of seed borne Botrytis is a reduction in plant establishment. In Victoria reductions in seedling establishment of up to 75 per cent have been observed. This disease is caused by the fungus Botrytis cinerea, which not only causes the stem disease known as Botrytis grey mould (BGM) but also a seed borne ‘damping-off’ disease of seedlings.

Rhizoctonia epicotyl rot, Sclerotinia white mould and Rhizoctonia root rot have also caused yield losses in some crops in Western Australia. Alalfa mosaic virus and root lesion nematodes have been observed in chickpea crops and are reported to cause significant yield losses in crops interstate and overseas.

Root rot diseases caused by Phytophthora, Fusarium, Pseudomonas and Phoma have occasionally caused serious damage to crops in eastern Australia. However, these diseases have not been observed in Western Australia and similar symptoms may be caused by prolonged periods of waterlogging and, in some instances, by triazine herbicides.

Chickpea growers in Western Australian are especially fortunate to be free from Ascochyta blight, the most damaging disease of chickpea in other major producing regions of the world.

Bill MacLeod, Simon McKirdy and Ian Riley

Disease Management

At present chickpea is generally disease free relative to other pulse crops in Western Australia.

The most significant diseases of chickpea in Western Australia are Botrytis Grey Mould and cucumber mosaic virus. At present, these are not common and can be easily managed with appropriate agronomic practices.

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The symptoms of the BGM phase of this disease become apparent in early spring when temperatures increase. Areas in the warm northern cropping region are more likely to become infected with BGM than in southern areas. Conditions suitable for the disease are unlikely to occur every year.

The disease is usually first apparent around flowering time, when the crop canopy is fully developed. BGM initially appears as dead plants scattered throughout the crop.

Close inspection of plants will reveal the presence of a fluffy grey (to brown) mould on the outside of dead branches, particularly under a closed canopy or lodged plants. Infection may spread from the initially infected plants to form patches of dead crop. BGM can infect pods and be carried into the next season through infected seed.

In addition to seed borne infection, BGM also persists on stubble and may survive for several years as sclerotia (fungal survival structures) in the soil. Spores produced on stubble can be blown several hundred metres to infect new crops.

To reduce the risk of Botrytis grey mould:

If you suspect your seed may have come from an infected crop or are unsure of the source, have it tested for BGM infection.

Discard seed with levels of infection greater than 15 per cent. Treat seed with lower levels of infection with thiram to minimise disease carry-over. See Seed Treatment section for more details.

Allow a three year break between successive crops (i.e. 1:4 rotation) in medium-high rainfall areas (>350 mm p.a.) in low rainfall areas, this may be reduced to a 1:3 rotation.

Avoid excessive vegetative growth in areas susceptible to BGM by using low sowing rates for early sowing, wide row spacing and in high rainfall areas sowing can be delayed until the end of May.

Several viruses, including the luteoviruses which are not found in Western Australia, are important diseases of chickpea in northern New South Wales. Cucumber mosaic virus (CMV) has been observed in several chickpea crops in Western Australia. It produces symptoms that differ somewhat between desi to kabuli types and may be confused with those produced by nutrient deficiencies, herbicide damage or waterlogging. In individual plants yield losses can be as high as 76 per cent when infected at early growth stages.
Rhizoctonia epicotyl lesions usually have red/brown margins. Note the production of a second shoot from some seeds.

Epicotyl rot may also be expressed as apparent delayed germination of some plants. The hypogeal germination of chickpea allows new shoots to be produced from the embryo when the This strain causes a black lesion on the epicotyl (below ground stem), frequently with a red/brown margin. Infection usually occurs in the first few weeks after sowing. Affected plants may wilt or be less thrifty than healthy plants and are usually scattered through the crop.

Epicotyl rot may also be expressed as apparent delayed germination of some plants. The hypogeal germination of chickpea allows new shoots to be produced from the embryo when the

RHIZOCTONIA EPICOTYL ROT

Alfalfa mosaic virus (AMV) has been identified in chickpea crops and seed stocks in Western Australia but its impact on yields is unknown. It also produces symptoms that may be confused with nutrient deficiency, herbicide damage or waterlogging.

The characteristic initial symptom is death of shoot tips followed by the leaves further down the shoot becoming chlorotic (yellow). In desi types, the affected leaves also develop red margins. Infected plants are stunted, shed their leaves and die prematurely.

The management of AMV is the same as that recommended for the management of CMV.

DISEASE MANAGEMENT

To reduce the risk of cucumber mosaic virus:

- Use seed that has been tested and shown to be free of the disease.
- Aphid activity in the crop and virus spread can be reduced by encouraging early canopy closure (sowing early with high sowing rates) and retaining stubble.

In both desi and kabuli types CMV causes chlorosis of shoot tips, reduction in leaf size and bunching of young leaves, proliferation of side shoots and may contribute to the stunted and bunchy appearance of infected plants. As the infection develops reddening of leaves occurs in desi types, whereas kabuli types tend to develop distinct chlorosis or yellowing.

CMV is seed-borne at low levels (up to 2 per cent). This is how it survives from one season to the next. Even though aphids will not colonise chickpea crops they will probe plants and spread the virus as they move through the crop. As with CMV in narrow-leaved lupins, the virus-infected seed produces infected seedlings from which the virus is spread by aphids.

The recommendations for the management of CMV in chickpea are the same as for lupins.

Alfalfa mosaic virus (AMV) has been identified in chickpea crops and seed stocks in Western Australia but its impact on yields is unknown. It also produces symptoms that may be confused with nutrient deficiency, herbicide damage or waterlogging.

Epicotyl rot of chickpea is caused by a strain of Rhizoctonia that also causes hypocotyl rot of lupins and pasture legumes.

This strain causes a black lesion on the epicotyl (below ground stem), frequently with a red/brown margin. Infection usually occurs in the first few weeks after sowing. Affected plants may wilt or be less thrifty than healthy plants and are usually scattered through the crop.

Epicotyl rot may also be expressed as apparent delayed germination of some plants. The hypogeal germination of chickpea allows new shoots to be produced from the embryo when the
Ascochyta blight has been detected in several chickpea crops in South Australia and Victoria. Therefore, there are quarantine restrictions on the importation of chickpea seed into this State, both from interstate and overseas. As long as the quarantine barriers are observed, Western Australia will remain free of this most damaging disease of chickpea.

**AscocHYTA BLIGHT**

The fluffy white Sclerotinia mould can usually be seen near the ground at the base of dying plants. Photo B. MacLeod.

Sclerotinia white mould causes scattered dead plants in the crop late in the season. Photo B. MacLeod.

The fungus Ascochyta rabiei which infects chickpea has not been detected in Western Australia but is a major disease of chickpea in most parts of the world. The fungus is different from the species of Ascochyta that infects faba bean, lentil and field pea.

Ascochyta blight has been detected in several chickpea crops in South Australia and Victoria. Therefore, there are quarantine restrictions on the importation of chickpea seed into this State, both from interstate and overseas. As long as the quarantine barriers are observed, Western Australia will remain free of this most damaging disease of chickpea.

**RHIZOCTONIA ROOT ROT**

This disease is also known as *Rhizoctonia* bare patch and produces similar symptoms in chickpeas to those seen in other crops, that is, distinct patches of stunted plants. Plants removed from the patches have severed tap roots and short lateral roots, similar to the symptoms seen in lupins.

The impact of this disease can be minimised by deep cultivation at or before sowing. Rotation does not reduce disease severity because the fungus has a wide host range.

**SCLEROTINIA WHITE MOULD**

This disease may occasionally cause plant death in crops after flowering. *Sclerotinia* white mould has a similar appearance in crops to BGM, that is, plants (singly or in small groups) turn yellow and die rapidly.

Lesions usually develop near the ground and have a white fluffy (cotton wool) appearance, rather than grey in the case of BGM. Lifting off the white fluff may reveal hard black 'grains' that are the sclerotes or survival structures of the fungus. The fungus survives on stubble or in the soil as sclerotes, and may persist for several years.

*Sclerotinia* infects other legume crops, canola and broad-leaved weeds such as capeweed. However, chickpea appears to be the most susceptible crop to this disease. The disease is favoured by warm humid conditions, similar to the conditions that favour BGM.

Rotation with cereals is the only practical management option for *Sclerotinia*. It is unlikely that this disease will regularly be of economic importance but the risk of damage may be increased if broad-leaved cropping rotations (including field pea, faba bean, canola or chickpea) are practiced.
Yield losses from O to 43 per cent have been recorded in South Australia but often damage can go unnoticed. Chickpea can contribute to increased nematode populations that are potentially damaging to following crops or pastures.

In Queensland, excellent resistance to root lesion nematodes has also been identified in wild chickpea species and this is being incorporated into commercial varieties (J. Thompson, personal communication).

Chickpea varieties vary in their tolerance to root lesion nematodes. Research in South Australia indicates that Kaniva is the most susceptible to infection with \( P. neglectus \), followed by Amethyst, then Tyson and Dooen. Once the plant is infected, however, Amethyst and Tyson are the most susceptible in terms of their response to infection, followed by Desavic, Kaniva and lastly, Dooen.

In Queensland, excellent resistance to root lesion nematodes has also been identified in wild chickpea species and this is being incorporated into commercial varieties (J. Thompson, personal communication).

Yield losses from 0 to 43 per cent have been recorded in South Australia but often damage can go unnoticed. Chickpea can contribute to increased nematode populations that are potentially damaging to following crops or pastures.
Caterpillars of the brown pasture looper are visible by day and have brown and yellow stripes down the length of the body. If no caterpillars are seen, scratching the soil at the base of recently damaged plants may reveal these pests. The plump, smooth cutworm caterpillars grow to 40 mm. Insecticide sprays may be warranted in patches of serious damage or if two or more large caterpillars are present per square metre.

Cutworms are sporadic pests which may survive in the soil through the crop establishment practices. They can cut off whole shoots at the base of the stem or chew leaves and stems. If shoots are cut off at ground level, chickpea plants can recover by producing branches from nodes under the soil surface in many situations.

Check chickpea crops for insect damage as they are emerging, so that early action can be taken if plants are being chewed and crop density is being seriously reduced. The most likely pests at this stage are the brown pasture looper or cutworm, which may be hidden under trash or the soil by day.

If no caterpillars are seen, scratching the soil at the base of recently damaged plants may reveal these pests. The plump, smooth cutworm caterpillars grow to 40 mm. Insecticide sprays may be warranted in patches of serious damage or if two or more large caterpillars are present per square metre.

Caterpillars of the brown pasture looper are visible by day and have brown and yellow stripes down the length of the body.

Rotation with resistant crops such as faba bean, field pea or lupins, varietal selection and weed control are the main options for nematode management. Given that the impact of these parasites in chickpea is not well defined, the best advice is to monitor populations (submit soil samples for assessment) and avoid planting intolerant varieties if populations are potentially damaging.

The most susceptible varieties appear to incur yield loss in soils with more than one P. neglectus per g, while all varieties are affected by levels greater than 30 P. neglectus per g soil.

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Other insects are rarely a problem because chickpea plants excrete organic acids from hairs on their leaves, stems and pods which are unpalatable to most crop pests. Aphids (Aphis spp.), red-legged earth mite (Halotydeus destructor) and lucerne flea (Sminthurus viridis) may be found in crops but they are unlikely to cause any damage and their numbers will usually diminish rather than increase in the season.

Unlike other field crops in Western Australia, chickpea has only one major pest. Caterpillars of the native budworm (Helicoverpa spp.) enter pods and chew seeds, causing yield loss and a downgrading of harvested seed. Several cutworm species (Agrotis spp.), the brown pasture looper (Ciampra arietaria) and several beetle pests may occasionally attack the crop especially at the seedling stage, but their impact in Western Australia has been minimal.

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Caterpillars of the brown pasture looper are visible by day and have brown and yellow stripes down the length of the body.
Native budworm moths are usually 20 mm long and 30 mm across the wings. Photo D. Hardie.

If damage from any of these pests is extensive, re-sowing patches of crop at high rates may be warranted. In-crop sprays are ineffective and there are no seed dressing insecticides registered for this crop.

This pest is unlikely to cut off whole plants but can defoliate plants when in large numbers.

Sprays may be warranted, especially along the crop edge, if caterpillars are migrating into the crop from adjacent pasture paddocks.

Beetle pests in or on the soil may occasionally thin the plant stand in chickpea crops. Cockchafer (Scarabaeidae spp.) have occasionally led to plant losses in areas of the State where they are active in other crops. False or true wireworms may also cause some damage where their populations have multiplied on dead plant material due to reduced tillage and stubble retention practices.

Native budworm is the most serious pest of chickpea in Western Australia. Effective native budworm management will require:

- an awareness of adult moth numbers in the region (e.g. via Pest Fax),
- regular measurement of the number of larvae in the crop (e.g. using a sweep net), and
- correct timing of pesticides to minimise damage to crop yield and quality.

Native budworm moths are usually 20 mm long and 30 mm across the wings. Photo D. Hardie.
Native budworm moths migrate from breeding grounds in the northern pastoral and desert areas after winter rainfall. Large numbers of moths usually fly into cropping areas during late winter and spring, with infestations commencing in the northern and eastern cropping areas.

Moths are attracted to traps containing a chemical sex-attractant (pheromone). This is specific to the species so only the native budworm is caught.

Growers can rest easy when no moths have been trapped in their region, but need to begin to monitor crops when moths are detected. The need for sprays cannot be determined by the moths traps, as there is not an established relationship between the numbers of moth trapped and the resulting caterpillar population in nearby crops.

Take note of news of native budworm moth flights and inspect crops for the presence of caterpillars when crops are flowering and podding. PestFax is a service available every week during the cropping season, which contains news of pests from over the State, together with warnings and recommendations on pests, particularly the native budworm.

**Accessing PestFax**

PestFax is a fax back service to farmers, agribusiness and consultants on insect pests in a variety of crops. Regular fax updates keep growers aware of the pests that may be threatening their crops.

The service aims to pass on first hand reports from Agriculture Western Australia field workers, industry agronomists and farmers. It contains regular updates on budworm flights and moth numbers caught in traps in regional locations.

Fax 1902 990 506
or
Poll 1902 990 660

**Grub Numbers and Yield Loss**

The development of native budworm from egg to mature caterpillar may take two months during winter. Caterpillars present in the crop at an early stage will feed mainly on leaves and flowers. These may reach the pupal stage before the pods begin to develop.

Chickpea plants produce numerous flowers and the loss of a few of these due to budworm is unlikely to cause a significant yield loss, especially if these flowers abort because of low temperatures. Hence, spraying is generally not recommended before pods begin to form.

However, as the season progresses and temperatures increase, the time for development of the caterpillars may be halved. It is likely that many of these later developing caterpillars will be present during the critical phase when pods are filling.

Caterpillars will enter pods and eat whole seeds or parts of seeds. Tiny caterpillars two to three mm long can enter small pods and be protected from sprays. The most damaging situation is where caterpillars...
Sweep net sampling is the most practical method of assessing caterpillar numbers in crops.

If two or more caterpillars are found in ten sweeps, then spray the crop with a suitable insecticide immediately. Critical levels in high value kabuli crops are about half those indicated above, that is, one caterpillar per ten sweeps.

If a desi chickpea crop is beginning to form pods and the average number of caterpillars found is less than two per ten sweeps, it is suggested that sprays be withheld unless there is news of increasing moth and caterpillar numbers. Continue to monitor the crop every two or three days to detect any new hatchings of caterpillars.

If two or more caterpillars are found in ten sweeps, then spray the crop with a suitable insecticide immediately. Critical levels in high value kabuli crops are about half those indicated above, that is, one caterpillar per ten sweeps.

20 - 40 mm long are present when pods are forming. If the pod wall is punctured the growing seed will abort, even if the seed is not damaged by the caterpillar.

Native budworm caterpillars cause serious yield losses in chickpea.

Determining budworm numbers

The easiest and quickest way to determine the number of caterpillars in a crop is to "sweep" the crop with an insect net. It is impossible to accurately determine numbers by simply looking in the crop.

A standard sized net (380 mm in diameter) can be purchased from most chemical suppliers. Follow these steps:

- Take ten sweeps of the net through the crop canopy while walking slowly through the paddock. A standard sweep of the net needs to be about two metres in length.

- Empty the contents into a tray or bucket and count the caterpillars of various sizes. It is important to look very carefully for small caterpillars as these have the most potential to cause damage.

- Repeat this process at least a dozen places throughout the paddock to obtain an average caterpillar density.

Sweep net sampling is the most practical method of assessing caterpillar numbers in crops.

Native budworm caterpillars cause serious yield losses in chickpea.

Photo K. Siddique.

Photo P. Michael.
One spray for the control of native budworm is usually sufficient if it is applied correctly and all the caterpillars present at the time are killed. It will usually take too long for a new population of caterpillars to redevelop into a damaging stage.

Some of the chemicals, particularly the synthetic pyrethroid group (such as deltamethrin, esfenvalerate and lambda-cyhalothrin) continue to kill caterpillars for several weeks after application. This can be confirmed with subsequent sweep netting.

In any case, sprays should not be applied too close to harvest. Some products should not be applied within 28 days of harvest.

### Table 9. Decision making for budworm management in chickpea crops

<table>
<thead>
<tr>
<th>Sweep results</th>
<th>Decision</th>
<th>Further action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before first pod</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than 2 grubs per 10 sweeps</td>
<td>No spray</td>
<td>Wait for first pod to sweep again</td>
</tr>
<tr>
<td>At first pod</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 2 grubs per 10 sweeps</td>
<td>No spray</td>
<td>Sweep every 2 – 3 days</td>
</tr>
<tr>
<td>2 or more grubs per 10 sweeps*</td>
<td>Spray</td>
<td>Check to see if spray effective</td>
</tr>
</tbody>
</table>

* for kabuli chickpea read 1 per 10 sweeps

### Table 10. Insecticide recommendations for chickpea crops.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Brand name</th>
<th>Rate (L/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native budworm</td>
<td>Deltamethrin (Decis Forte (ulv))</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Deltamethrin (Decis Forte (ec))</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Endosulfan 350 ec</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>Thiodan</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>Endosulfan 350 ec</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>Thiodan</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>Esfenvalerate Hallmark 10ulv</td>
<td>0.6–1.6</td>
</tr>
<tr>
<td></td>
<td>Esfenvalerate Hallmark 50 ec</td>
<td>0.13–0.5</td>
</tr>
<tr>
<td></td>
<td>lambda-cyhalothrin Karate</td>
<td>0.12–0.18</td>
</tr>
<tr>
<td>Methomyl</td>
<td>Lannate L</td>
<td>1.5–2.0</td>
</tr>
<tr>
<td>Methomyl</td>
<td>Nudrin insecticide</td>
<td>0.5–2.0</td>
</tr>
<tr>
<td>Methomyl</td>
<td>Nudrin 225</td>
<td>0.5–2.0</td>
</tr>
<tr>
<td>Methomyl</td>
<td>Lannate toss-n-go</td>
<td>0.9–1.2kg/ha</td>
</tr>
<tr>
<td>Thiodicarb</td>
<td>Larvin 375</td>
<td>0.5–0.75</td>
</tr>
<tr>
<td>Thiodicarb</td>
<td>Showdown 375</td>
<td>0.5–0.75</td>
</tr>
<tr>
<td>Thiodicarb</td>
<td>Larvin 375</td>
<td>0.5–0.75</td>
</tr>
<tr>
<td>Cutworms</td>
<td>Endosulfan 350 ec</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>Thiodan</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>Endosulfan 350 ec</td>
<td>2.1</td>
</tr>
</tbody>
</table>

### TIME OF SPRAYING

Unlike caterpillars in desi chickpea crops which usually eat the whole seed, caterpillars in kabuli crops tend to eat part of the large kabuli seed and many of the chewed seed end up in the harvest sample. Also, the minimum receival standards for kabuli chickpea has a lower percentage of defective seeds than for the desi types.

Native budworm can reduce the quality of chickpea grain, especially in kabuli types. Photo S. Eyres.
Yield and Yield Potential

K.H.M. Siddique, Stephen Loss and David Tennant

Seed yields as large as 6.5 t/ha have been recorded in winter sown kabuli chickpea in northern Syria (Singh 1987). However, the world average yield of chickpea is relatively low (about 700 kg/ha). Many biotic and abiotic stresses faced by chickpea contribute to the large gap between potential and actual yields. Low yields are also partly a reflection of the low input agricultural systems in which the crop is mostly grown and its inherent low potential yield.

In Australia, yields of 3.0 t/ha have been achieved in northern New South Wales and Victoria, however, average yields are about 1.0 t/ha. In south-western Australia, yields of 2.0 t/ha have been produced in commercial crops, while yields of 4.0 t/ha have been achieved in the Ord River Irrigation Area.

Seed yield can be expressed as a proportion of the total biomass produced or harvest index.

\[
\text{Seed yield} = \text{total biomass} \times \text{harvest index}
\]

Seed yield itself can be partitioned into the number of pods per unit area (or the product of plant density and the number of pods per plant), the number of seeds per pod and mean seed weight. Of these yield components, the number of seeds per pod and mean seed weight are relatively stable while seed yield is most highly correlated to the number of pods in chickpea (Siddique and Sedgley 1985) and many other legumes.

Increases in the yield of cereal varieties over the past half-century has been associated with rising values in harvest index with little increase in biomass, although no plant breeder has purposely sought this increase (Donald and Hamblin 1976). In Australia, the improvement in harvest index of cereals is largely associated with early flowering and a greater duration of reproductive growth (Loss and Siddique 1994). Biomass and harvest indices in chickpea are often lower than cereals and other pulse crops in Mediterranean type environments (Thomson et al. 1997).

Water use efficiency

As rainfall is usually the most limiting resource to most crops in south-western Australia, total biomass or grain production can be expressed as a function of the efficiency with which the crop uses soil water and/or rainfall.
Recently in Western Australia, the water use of faba bean, chickpea, lentil and field pea were measured with neutron soil moisture meters over several years at Mullewa, Merredin and Esperance to compare their adaptation to these environments. At other experiment sites, water use was estimated by adding rainfall received between April 1 and the end of the growing season to an estimate of stored soil water at April 1, made using a simple water balance model.

The measured and estimated water use values were plotted against respective grain yields and envelope lines fitted to include the highest yielding crops. The slopes of these lines describe potential water use efficiencies for grain production, and were of the order of 16 kg/ha/mm for each of the pulse crops. Similar methods have been used to estimate water use efficiencies of cereal crops (French and Schultz 1984).

The intercepts of these lines with the water use axes varied, indicating different average water loss through soil evaporation from under each crop which is largely dependent upon crop vigour and canopy cover. Intercepts were 125 mm for chickpea, compared to 115 mm for lentil and 100 mm for faba bean and field pea.

These intercepts relate to crop water use estimates over growing seasons commencing April 1 and ending September 30, October 31 or November 30. Water loss through soil evaporation will be lower with a May 1 start to the growing season and for crop water estimates over the period sowing to the end of the growing season. April 1 is used here for national consistency in the procedure to estimate potential yields and to allow for increasing acceptance of early planting technology.

Extension specialists have argued that potential yields are rarely achieved at the farm paddock level, and that an ‘achievable’ target yield of 75 per cent of potential yield is a more realistic benchmark. To calculate target yields for growers, it is best to convert potential water use efficiencies to target water use efficiencies (multiply by 0.75).

To calculate yield potential:

\[
\text{yield potential (kg/ha)} = (\text{estimated water use (mm)} - 125 \text{ mm}) \times 16 \text{ kg/ha/mm}
\]

For example, for a crop grown with an April – October rainfall of 225 mm the yield potential is:

\[
(225 - 125) \times 16 = 1600
\]

\[
1600 \times 0.75 = 1200 \text{ kg/ha}
\]

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Table 11. Yield components of good, average and poor crops of Tyson chickpea.

<table>
<thead>
<tr>
<th>Plants/m²</th>
<th>Pods/plant</th>
<th>Seed/pod</th>
<th>Mean seed wt.</th>
<th>Yield t/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good crop</td>
<td>45</td>
<td>25</td>
<td>1.2</td>
<td>0.13</td>
</tr>
<tr>
<td>Average crop</td>
<td>40</td>
<td>20</td>
<td>1.1</td>
<td>0.12</td>
</tr>
<tr>
<td>Poor crop</td>
<td>30</td>
<td>15</td>
<td>1.0</td>
<td>0.11</td>
</tr>
</tbody>
</table>

The number of seeds per pod and the mean seed weight vary slightly compared to the other yield components. Hence, potential yield is largely determined by plant density and the number of pods per plant. These characteristics are common in most pulse crops.
Harvesting chickpea crops is not as easy as cereals and care is needed to produce a quality product with minimal harvest losses.

Chickpea can be a relatively short crop, especially when grown under dry conditions. Fortunately, most pods set towards the top of the crop canopy, unlike field pea, faba bean and lentil. Nonetheless, harvesting losses of up to 50 per cent have been measured in Western Australia.

Successful harvesting will depend upon good paddock selection and crop establishment techniques. Even the most efficient harvester will have difficulty harvesting a thin chickpea crop on an uneven or rocky paddock.

While you may be in a rush to finish your harvesting program, it is worth considering the time and money invested in the crop and the fact that you are producing a human consumption product. At this stage you do not want to be complacent and compromise the quality and yield of your product.

Take care if rain has occurred before harvest as the wetting and drying cycle makes the seed particularly brittle.
Be careful when harvesting in hot dry conditions as chickpea dust and trash is highly inflammable. Keeping the harvester clean and well maintained will reduce the risk of fire.

When harvesting chickpea crops for seed, remember that the harvest sample will require secondary cleaning, and slow gentle harvesting will produce the best quality seed.

Chickpea is capable of withstanding high temperatures in early summer and is usually one of the last crops to mature. Plants are ready to harvest as soon as the stems and pods are light brown and the seed feels hard and rattles within the pod. At this point the seed moisture content is about 15 per cent.

Although chickpea pods do not shatter, delaying harvest beyond this point is not advisable as adverse weather can cause crop lodging and pod shedding. Depending upon the crop variety, rainfall at maturity may also darken the seed. If harvest is delayed the moisture content of the grain usually becomes low. Chickpea grain with less than 13 per cent moisture is highly susceptible to cracking.

Crop desiccation may be an option if there are a lot of late maturing weeds present in the paddock. Chickpea can still fill its seed very late in its life cycle, so take care not to apply desiccants before the stems and pods have turned brown, otherwise, yields will be reduced.

Harvester settings are going to vary but the suggested settings in Table 12 are a good starting point. Harvest a small area with these settings and check the sample for purity and cracking. Adjust settings if necessary.

Chickpea crops can be direct headed with most open and closed front machines.

Crop lifters may be useful if the crop has lodged. Harvesting with double density knife guards with plastic extensions may be an advantage as they reduce plant vibration and front losses.

Rotary harvesters tend to be more gentle on the seed due to the greater drum clearance. Air or pick-up reels are generally better than batt reels for reduced harvester front losses.

Floating or flexible cutterbars may be an advantage. If a closed front harvester is used the fingers will need to be spaced 19 mm or more apart.

Removing alternate wires and the blank-off plates from the concave will help reduce cracking. Fit screens under the platform auger and/or the broad elevator, as this helps remove dirt before it enters the harvester. Screens can also be fitted to the grain and seconds auger to remove dirt from the sample. Regularly check that the screens have not clogged.

Harvester settings are going to vary but the suggested settings in Table 12 are a good starting point. Harvest a small area with these settings and check the sample for purity and cracking. Adjust settings if necessary.
A slow ground speed is essential. This will help avoid excessive losses from the harvester front or dirt entering the harvester. A maximum speed of 8 kilometres per hour is suggested.

If the crop has lodged, harvest directly into or at right angles to the direction that the crop has fallen. This can reduce losses by up to 30 per cent.

Table 12. Suggested harvester settings:

<table>
<thead>
<tr>
<th>Reel speed</th>
<th>Same as the ground speed (slow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table auger clearance</td>
<td>High</td>
</tr>
<tr>
<td>Drum speed*</td>
<td>400 – 600 rpm</td>
</tr>
<tr>
<td>Concave clearance</td>
<td>10 – 30 mm depending upon desi or kabuli types</td>
</tr>
<tr>
<td>Fan speed</td>
<td>High</td>
</tr>
<tr>
<td>Top sieve</td>
<td>20 – 25 mm</td>
</tr>
<tr>
<td>Bottom sieve</td>
<td>12 – 16 mm</td>
</tr>
</tbody>
</table>

* Keep speed to a minimum without significantly reducing the harvesting capacity.

Inappropriate harvest settings result in a poor sample of harvested chickpea. Photo D. Wilkinson.

Serious harvest losses can reduce the profitability of chickpea crops dramatically. Generally, harvest losses range from 5 to 30 per cent but what is an acceptable loss varies with the operator. Some are not concerned with losses of 10 per cent while others are unhappy with any level of harvest loss.

If a contractor is being used, reach an agreement on acceptable losses before the crop is harvested and check losses at the start of the harvest.

Grain can be lost at a number of places during harvest and each loss needs to be assessed so that corrective action can be taken. Grain can be lost before harvest (due to pod shedding – A), at the harvester front (due to the front type or set up – B), and in the threshing system of the machine (due to drum, concave and sieve settings – C). See Figure 12.

All these losses may be reduced by resetting the machine or changing the harvesting technique. When adjusting a harvester to reduce losses, make only one adjustment at a time, checking the losses after each change.

To determine harvest losses:

- Harvest a typical area without stopping the machine, then stop and allow the machine to clear itself of material.
- Back the harvester about 10m and shut down the machine.
- Sample grain losses in each of the following three areas: pre-harvest (that is in the standing crop in front of the harvester – A), front (in the cut crop in front of the harvester – B), and machine (in the cut crop behind the harvester including trash – C). See Figure 12.
- Sampling is best done using a quadrat with an area of 0.1 square metre (approximately equivalent to a 30 cm by 30 cm quadrat). Count the number of seeds lying within each of 10 quadrats in each of the three locations. Average the 10 samples in each area.
- For each seed in the quadrat the yield loss will be equivalent to about 13 kg/ha for Tyson, 19 kg/ha for Sona or Heera and 40 kg/ha for Kaniva.

See Agriculture Western Australia Farmnote 104/96 for more details.
Chickpea seed is easily damaged, reducing both marketable value and germination percentage. Split seed is the most obvious type of damage but invisible damage to the seed coat can also affect germination.

Transporting seed large distances, dropping bags onto concrete floors and moving seed with screw-type augers are particularly damaging. Small diameter augers with close fitting flights cause more damage than large augers with greater clearance between the flights and the auger tubing.

**To minimise physical damage:**
- Plan farm operations to keep handling to a minimum.
- Use grain belt conveyors or brush flight augers rather than screw augers.
- Run augers slowly and full, and
- Where possible, avoid handling seeds that have a low moisture content or are brittle for other reasons.

Reducing moisture and temperature increases longevity of the seed. However, limited commercial experience with chickpea in Western Australia suggests that storage at very low moisture contents may make chickpea, particularly kabuli chickpea, more vulnerable to damage during handling as the seed shrinks away from the seed coat.

**Table 13. Effect of moisture content and temperature on storage time of chickpea seed (Ellis et al. 1981).**

<table>
<thead>
<tr>
<th>Storage moisture (%)</th>
<th>Storage temperature (°C)</th>
<th>Longevity of seed (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>20</td>
<td>&gt;2000</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>500 – 650</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>110 – 130</td>
</tr>
<tr>
<td>15</td>
<td>20</td>
<td>700 – 850</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>180 – 210</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>30 – 50</td>
</tr>
</tbody>
</table>

Storage at less than 13 per cent moisture is, therefore, 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, but it will slow down the rate that insect pests multiply in the grain.

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

Attention to storage conditions is particularly important when seed is being stored for more than one season. Research conducted in the United Kingdom has shown the importance of both seed moisture and temperature in the storage of chickpea seed.

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 seed storage time of grains.
- Aerate silos with 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.
End Use and Quality

K.H.M. Siddique, Stephen Loss and Nicole Kerr

Like other human consumption crops, the marketing of chickpea relies on matching product of consistent quality and supply with a demand generated by consumers. Therefore, good marketing requires an understanding of the end-use of the product.

Demand for pulses in many importing countries such as India, Pakistan and Bangladesh is increasing due to population growth and static local production (Siddique 1993). In the past these markets have been highly price sensitive and paid less attention to quality. However, grain quality is becoming increasingly important in most markets.

Chickpea is used predominantly for human consumption in key markets often linked traditionally or culturally to a vegetarian diet. Uses of chickpea in the human diet are highly diverse and major preparations have been reviewed previously (Pushpamma and Geervani 1987, Jambunathan and Singh, 1990).

Desi chickpea is mostly consumed in the Indian subcontinent in the form of whole seed, dhal (decorticated split cotyledons) or as flour (besan). The flour can be used in sweets, confectionery and bread.

In the Mediterranean Region, kabuli chickpea is traditionally consumed as whole seed in various dishes or as a ground paste (hommos-biteheneh) or fried patty (falafel). Kabuli types are frequently graded on their size and are priced into global markets as three different sized products – 7-8mm; 8-9mm and 9mm and above.

Traditional processing practices such as soaking, sprouting, fermenting, boiling, roasting, parching and frying are also used, while canning of kabuli chickpea and dehydration of immature green chickpea are becoming more popular.

Diets in the western world are becoming more diverse and the nutritional value of
chickpea is becoming widely recognised. Hence, chickpea consumption in these countries is increasing. However, they still comprise a small proportion of the global market.

Pulse recipes including chickpea are available. The Centre for Legumes in Mediterranean Agriculture has produced an excellent book of pulse recipes from around the world (Longnecker 1998).

### COMPOSITION

Several reviews of the chemical composition and nutritional quality of chickpea have been published (Williams and Singh 1987, Petterson et al. 1997). There is little difference between the chemical composition of desi and kabuli seed.

Chickpea seed is a good source of carbohydrate and protein. In Australia protein concentration is usually about 21 per cent but can range from 17-26 per cent. Chickpea is generally deficient in the sulphur-containing amino acids, methionine and cysteine.

In India, desi chickpea seed are puffed as a snack food, similar to pop-corn.

Photo K. Siddique.
Table 14. Desi chickpea composition from Petterson et al. (1998)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Mean (g/kg)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>201</td>
<td>170 - 243</td>
</tr>
<tr>
<td>Ash</td>
<td>26.0</td>
<td>22.9 - 31.5</td>
</tr>
<tr>
<td>Fat</td>
<td>38.6</td>
<td>28.5 - 48.0</td>
</tr>
<tr>
<td>Fibre</td>
<td>98.0</td>
<td>70.7 - 130.1</td>
</tr>
<tr>
<td>Calcium</td>
<td>1.8</td>
<td>1.2 - 2.3</td>
</tr>
<tr>
<td>Magnesium</td>
<td>1.4</td>
<td>1.2 - 1.6</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>3.6</td>
<td>2.3 - 6.6</td>
</tr>
<tr>
<td>Potassium</td>
<td>8.2</td>
<td>3.1 - 10.2</td>
</tr>
<tr>
<td>Sodium</td>
<td>0.1</td>
<td>0.1 - 0.3</td>
</tr>
<tr>
<td>Sulphur</td>
<td>1.8</td>
<td>1.6 - 2.2</td>
</tr>
<tr>
<td>Copper</td>
<td>6.6</td>
<td>3.1 - 11.6</td>
</tr>
<tr>
<td>Iron</td>
<td>50.3</td>
<td>34.7 - 120.0</td>
</tr>
<tr>
<td>Manganese</td>
<td>34.1</td>
<td>17.8 - 49.0</td>
</tr>
<tr>
<td>Mo&quot;bdenum</td>
<td>0.9</td>
<td>0.3 - 1.3</td>
</tr>
<tr>
<td>Zinc</td>
<td>31.0</td>
<td>22.0 - 42.1</td>
</tr>
<tr>
<td>Cobalt</td>
<td>180</td>
<td>110 - 350</td>
</tr>
<tr>
<td>Selenium</td>
<td>29</td>
<td>5 - 100</td>
</tr>
</tbody>
</table>

Total carbohydrate content varies from 52-71 per cent. Starch, the principal carbohydrate, is 20-30 per cent amylose and the remainder amylopectin. Chickpea seed contains 4-10 per cent fat and 4-9 per cent soluble sugars. The seed coat contributes about 70 per cent of the total seed calcium.

Chickpea is relatively free from anti-nutritional factors, has high protein digestibility and contains more phosphorus and calcium than most other pulses. It contains no cholesterol and has been reported to lower cholesterol levels in humans when included in the diet.

Although primarily used for human consumption, chickpea may be a useful protein and energy source for ruminant and monogastric animals, especially the dehulling residues, and the stubble after harvest has good forage value.
In the past the Australian chickpea industry paid little attention to quality parameters. However, in more recent times, traders, farmers, agronomists and plant breeders have emphasised seed size, seed coat colour, cooking time and splitting recovery to satisfy market requirements. At present, markets do not measure composition.

Chickpea is exported for human consumption, often with little or no cleaning or processing. Consequently, chickpea producers are expected to deliver a high quality product. The price penalties for not meeting human consumption standards are large.

While price premiums for high quality are not always available in international markets, there are signs that this may be starting to change. Nonetheless, quality will always capture market share even if price premiums are not obtained.

Appearance of the grain is particularly important when marketing chickpea as they are traded on a visual basis. At present, chickpea is largely traded in an unprocessed form, especially the kabuli types. Hence, it is difficult to disguise poor visual quality by splitting or milling.

Important quality characteristics that affect visual quality are:

- **Seed size** – both size and uniformity are important. Most markets prefer large and uniform seeds. Chickpea are often processed and to do this efficiently seed size must be uniform. Large-seeded desi chickpea are preferred as they produce less waste when dehulled and split, and can also be sold whole. Seed size is particularly important for kabuli chickpea, with substantial premiums for large seeds (greater than 9mm).

  - **Seed colour** – light-coloured chickpea seeds are preferred by most markets. White to cream kabuli seeds are preferred. Although seed colour is not as important for desi than kabuli markets, light brown desi seed is favoured. This is largely determined by the variety grown, however, seeds can also become discoloured by disease, environmental staining or prolonged storage. As expected, human consumption markets have low tolerance levels for discoloured seed.

  - **Split, chipped or broken seed** – chickpea are eaten or processed whole so the level of damaged grain must be kept to a minimum as this reduces cleaning losses for end users. Kabuli chickpea are especially brittle and prone to splitting or chipping.

  - **Admixture and foreign seeds** – the levels of admixture and foreign seeds present in a sample are important as they influence the amount of product that can be used for processing. Narrow-leafed lupin and field pea contamination in desi chickpea is particularly important, as these are difficult to remove and can result in downgrading to stockfeed grade. Faba bean can be a similar problem in kabuli crops. Admixture is not only important for human consumption markets but also for stockfeed markets as it influences the amount of product available for use by stockfeeders.

  - **Insect damage** – native budworm damage is particularly important for the quality of large seeded pulses such as kabuli chickpea. Budworm damage affects yield more than quality for the small-seeded desi types. Although not the case in Australia, many countries associate holes in the seed with live storage insects.

Other quality parameters are also important to consumers and processors. Pulses generally take a long time to prepare and in large cities where women often have full-time employment and the cost of cooking fuels is large, a rapid cooking time is highly desirable.

Splitting and milling recoveries are also important for chickpea processors. These traits vary according to variety and environment.

**Table 15. Human consumption receipt standards (No. 1 Grade) in Western Australia.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content</td>
<td>13%</td>
</tr>
<tr>
<td>Foreign material</td>
<td>3% of which 0.5% unmillable material</td>
</tr>
<tr>
<td>Detective grain</td>
<td>6%, 3% for kabuli plus 1% poor colour grain</td>
</tr>
<tr>
<td>Foreign seeds per 200 g</td>
<td>15 field pea</td>
</tr>
<tr>
<td></td>
<td>3 lupin and vetches</td>
</tr>
<tr>
<td></td>
<td>5 faba bean, doublegee, or any other</td>
</tr>
</tbody>
</table>
Quality through Management

Good crop management is essential to produce a high quality chickpea product. Practices for high quality often result in high yields so both are possible. Below is a summary of management practices that will improve quality. More details can be obtained from the relevant sections of this book.

**Seed size**
- choose large-seeded varieties such as Sona, Heera, Dooren or Lasseter (desi) and Kaniva or Bumper (kabuli)
- avoid late sowing in short season areas
- avoid shallow and marginal soils, avoid areas with less than 400 mm rainfall for kabuli types

**Seed colour**
- avoid varieties with dark-coloured seed such as Tyson
- control fungal diseases such as *Botrytis* Grey Mould
- avoid delayed harvest as rain at harvest can cause staining and discolouration

**Admixture and foreign seeds**
- use clean certified seed
- select paddocks with low weed burdens
- ensure good pre-sowing weed management
- ensure the harvester settings are appropriate
- do not feed lupins to sheep on paddocks that are to be sown to chickpea

**Contamination**
- ensure good management
- ensure the harvester settings are appropriate
- select paddocks with low weed burdens

**Insect damage**
- monitor crops for budworm caterpillars after flowering commences
- spray an appropriate insecticide if more than two grubs are found per 10 sweeps for desi, one grub per 10 sweeps for kabuli

**Cleaning and grading**
- some cleaning or grading of the harvested grain before export is usually required to produce a high quality product
- this can be done on-farm, though local farmer cooperatives or by traders.

Light coloured desi chickpea are preferred (ICCV88202 – Sona left, Tyson right). Photo S. Eyres.

Budworm can reduce yield and quality considerably. Photo S. Eyres.

Large amounts of broken seed make this sample unacceptable for human consumption. Photo S. Eyres.

Contamination with weeds, lupins and field pea is a major problem with desi chickpea. Photo S. Eyres.

Split, chipped or broken seed
- avoid delayed harvest, as cracking is minimised if the grain is about 15 per cent moisture
- ensure the harvester settings are appropriate
- take care when auguring or transporting the grain
- remember that large-seeded varieties are more prone to physical damage

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Chickpea production in Australia has expanded rapidly over the past 15 years, especially in south-western Australia. Photo S. Loss.

Indian trade and commerce appear chaotic, but large tonnages of pulses are used every day. India is the major market for Australia's desi chickpea. Photo K. Siddique.

Production and Trade

K.H.M. Siddique, David McKenzie and Bill O'Neill

Chickpea is the second most important pulse crop in the world, and is grown in about 33 countries in South Asia, West Asia, North Africa, East Africa, southern Europe, North and South America, and Australia. It accounts for 15 per cent of the world pulse area (10.2 million hectares) and 12 per cent of the production (8.7 million tonnes) (FAO 1996). Production statistics are subject to large yearly fluctuations due to changes in plantings and yields.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>133</td>
<td>69</td>
<td>309</td>
<td>266</td>
<td>209</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>67</td>
<td>62</td>
<td>62</td>
<td>60</td>
<td>63</td>
</tr>
<tr>
<td>India</td>
<td>4,417</td>
<td>4,981</td>
<td>6,208</td>
<td>6,000</td>
<td>5,402</td>
</tr>
<tr>
<td>Iran</td>
<td>286</td>
<td>299</td>
<td>365</td>
<td>360</td>
<td>328</td>
</tr>
<tr>
<td>Pakistan</td>
<td>347</td>
<td>411</td>
<td>559</td>
<td>559</td>
<td>469</td>
</tr>
<tr>
<td>Turkey</td>
<td>740</td>
<td>650</td>
<td>730</td>
<td>730</td>
<td>713</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>121</td>
<td>122</td>
<td>126</td>
<td>126</td>
<td>124</td>
</tr>
<tr>
<td>Mexico</td>
<td>163</td>
<td>80</td>
<td>116</td>
<td>152</td>
<td>128</td>
</tr>
<tr>
<td>Myanmar</td>
<td>82</td>
<td>60</td>
<td>77</td>
<td>77</td>
<td>74</td>
</tr>
<tr>
<td>Spain</td>
<td>28</td>
<td>55</td>
<td>27</td>
<td>99</td>
<td>52</td>
</tr>
<tr>
<td>Total World</td>
<td>6,767</td>
<td>7,108</td>
<td>8,885</td>
<td>8,748</td>
<td>7,877</td>
</tr>
</tbody>
</table>

Indian trade and commerce appear chaotic, but large tonnages of pulses are used every day. India is the major market for Australia’s desi chickpea. Photo K. Siddique.
Most of the world’s chickpea is consumed close to where they are grown and less than 10 per cent enters international trade. India, producing around 4.5-6.2 million tonnes of chickpea per annum, is the largest producer, consumer and importer of chickpea in the global market. This accounts for 60 per cent of global chickpea production.

Australia is a relatively new producer of chickpea with very little production before 1984. It is currently the fifth largest chickpea producing country in the world.

Kabuli chickpea accounts for much of world exports, with Turkey the major supplier, followed by Mexico and Syria. The major importers of kabuli chickpea are Europe, USA, countries in the Middle East and former states of the USSR.

Australia is the main producer of desi types and a substantial contributor of global exports. Iran, Tanzania and Myanmar are of lesser importance and satisfy windows of demand in the world market when global stocks are low. The Indian sub-continent and expatriates in other parts of the world are the main consumers of desi chickpea. Import requirements by the main importing countries, India, Bangladesh and Pakistan, are inherently volatile.

In most countries where chickpea is consumed, production regularly falls short of demand. This gap is increasing as populations grow and there is little change in the area under the production or crop yields.

In recent years the production of desi chickpea in the Indian sub-continent has failed to match population growth and imports have been necessary (Siddique 1993). The main reason for this is competition from high yielding cereal crops and high value horticultural crops, and government subsidised cereal and oilseed production.

Australian marketers capture only a small proportion of the kabuli markets in Europe, the Middle East and North Africa, which have recently been well supplied by Turkey and Syria who have a competitive freight advantage.

The most important factor contributing to the expansion of desi chickpea production in Australia was the opening up of export markets to the Indian sub-continent in the mid 1980s. The sub-continent is now Australia’s largest market for desi chickpea.

Australia dominates exports of desi chickpea, with some sporadic competition from Myanmar and Iran. Canada is emerging as a potential competitor for Australian desi chickpea. However, our close proximity to the Indian sub-continent will provide a freight advantage.

As Australian consumption accounts for only one per cent of our production with little scope for dramatic increases, the growth of the Australian chickpea industry will continue to rely on export markets. Domestic demand for chickpea is largely limited to supplying the ethnic wholesale markets with premium quality 10mm Ord River kabuli and food processing markets for hommos and dahl manufacture. This accounts for about 2,000-10,000 tonnes per annum.

Chickpea currently represents about 18 per cent of Australia’s pulse exports. In periods of price downturns, such as 1992 and 1996 when the market prices dropped and Australian stocks grew rapidly, chickpea became a competitive protein substitute in Australian stockfeed rations.

There are a number of pulse exporters in Australia that are supplied by several large domestic traders who purchase grain from growers and accumulate tradable stocks for bulk shipments. Australian chickpea is sold either in bulk shipments or containers.

Recent changes in chickpea production can be summarised as follows:

- planting areas in northern New South Wales, the Darling Downs and central Queensland have increased over the past two years due to a break in droughts and more favourable seasonal conditions. An advantage for growers in these areas is their geographical location to Brisbane-based exporters, container packing and splitting industries.

<table>
<thead>
<tr>
<th></th>
<th>1993</th>
<th>1994</th>
<th>1995</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imports</td>
<td>632</td>
<td>438</td>
<td>331</td>
<td>463</td>
</tr>
<tr>
<td>Exports</td>
<td>540</td>
<td>450</td>
<td>333</td>
<td>468</td>
</tr>
<tr>
<td>Production</td>
<td>7,087.0</td>
<td>8,865.8</td>
<td>8,908.1</td>
<td>7,672.5</td>
</tr>
</tbody>
</table>

Table 17. Global chickpea trade (kt).
- Victorian planting areas in the Wimmera region have stabilised after rapid expansion in the early 1990s with Victorian production now supplying 60 per cent of the national production of chickpea. The Wimmera region is well serviced by eight container packers which service the Melbourne delivered container terminal and by a growing number of processors.

- South Australian plantings have remained small but stable in the favoured mid-north region as they are serviced by bulk exporters, container packers and processors at Two Wells.

- Western Australian plantings are undergoing rapid expansion and this has contributed to the recent continued growth in national production.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>2.9</td>
<td>30.7</td>
<td>236.3</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>3.8</td>
<td>77.2</td>
<td>59.8</td>
</tr>
<tr>
<td>Pakistan</td>
<td>1.1</td>
<td>41.2</td>
<td>1.0</td>
</tr>
<tr>
<td>United Arab Emirate</td>
<td>6.2</td>
<td>12.9</td>
<td>12.2</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>5.9</td>
<td>5.0</td>
<td>77.7</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>8.5</td>
<td>6.8</td>
<td>8.2</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>0.03</td>
<td>2.7</td>
<td>2.5</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>0.8</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Mauritius</td>
<td>0.6</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>United States</td>
<td>0.5</td>
<td>1.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Taiwan</td>
<td>0.5</td>
<td>1.6</td>
<td>1.8</td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.5</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Italy</td>
<td>1.4</td>
<td>0.9</td>
<td>0.6</td>
</tr>
<tr>
<td>Total</td>
<td>36.4</td>
<td>71.3</td>
<td>341.5</td>
</tr>
</tbody>
</table>

Australian desi chickpea exports are largely targeted at the Indian sub-continent bulk food market and we hold a 15 per cent share of the Indian imports. The Indian share of Australia’s chickpea exports is volatile, varying from 43 per cent in 1995-96 to 70 per cent in 1996-97. Most Australian bulk shipments are discharged at the Mumbai (Bombay) port where they are bagged manually on the vessel before local distribution.

India is the largest destination for Australian chickpea exports followed by Bangladesh while Sri Lanka, the United Arab Emirate States consistently import small volumes. Exports to Pakistan, once a significant destination, have recently declined.

Australia has selling opportunities in the southern hemisphere summer from November to March as product from other exporters has usually already been sold into the world market.

Chickpea crops in the Indian subcontinent are harvested in March and April with the majority of production reaching the market in May or June. This supply dampens the volume of trade and international prices during that period.

• The ability to sell at times of high demand - e.g. in recent years, shipments of new crop from Western Australia and Queensland in November have been able to target the Islamic Ramadan festival in the December to January period.

The long term average price for desi chickpea has been about $340/t on farm in Australia. Prices for chickpea are inherently volatile ($220-500/t), mostly fluctuating in the range of $290-350/t. For example, the difference between prices in 1996-97 and 1997-98 was about $50/t. Prices can vary within each season (standard deviation from the mean of $54-58/t).

Prices for desi chickpea vary depending on:

• The size of the pulse production in the Indian subcontinent - e.g. the 1997 March to May price increase was driven by a smaller than normal crop in India.

• The production and price of alternative pulses from other exporting countries - e.g. cheap Canadian yellow field peas.

• The size of the Australian crop, especially in Victoria.

• The size of Australian stocks - e.g. large stocks during much of 1996 depressed prices, and was partly responsible for the long term price trough at the 1996-97 harvest.

• The ability to sell at times of high demand - e.g. in recent years, shipments of new crop from Western Australia and Queensland in November have been able to target the Islamic Ramadan festival in the December to January period.

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Australia has selling opportunities in the southern hemisphere summer from November to March as product from other exporters has usually already been sold into the world market.

The United Kingdom is the most important importer with several small volume importers serviced by the container trade. Mauritius, the United States, Taiwan and Sri Lanka are also significant container export destinations.

As Turkey, Syria and Mexico dominate the global export trade in kabuli chickpea, achieving premium prices in Australia is dependent on targeting specific periods of lull in global trade. Inconsistent demand is the cause of inherently volatile prices for kabuli. There is however, the opportunity for long term storage to capture premium prices.

**WHAT AFFECTS AUSTRALIAN PRICES**

**PRODUCTION AND TRADE**

**CONTAINER MARKETS**

There are three discrete container markets for chickpea:

**Desi**

This market provides a diversity of competitive pricing signals from container depot packers, adding liquidity to the market in between bulk shipments. It also provides the opportunity for segregation and marketing of a brand to target quality conscious markets and the opportunity for significant off-season price premiums, especially when there is little product available for exporters to accumulate bulk shipments.

The United Kingdom is the most important importer with several small volume importers serviced by the container trade. Mauritius, the United States, Taiwan and Sri Lanka are also significant container export destinations.

**Kabuli**

Kabuli chickpea are graded as 7-8, 8-9 and above 9mm by container packers and different grades may be targeted to specific markets. Growers are paid premiums according to the proportion of the various sizes.

As Turkey, Syria and Mexico dominate the global export trade in kabuli chickpea, achieving premium prices in Australia is dependent on targeting specific periods of lull in global trade. Inconsistent demand is the cause of inherently volatile prices for kabuli. There is however, the opportunity for long term storage to capture premium prices.

**Split desi**

Small scale value adding by processors who target high value food markets of the United Kingdom, Singapore, Mauritius, Sri Lanka and Germany usually achieve significant premiums in the split desi chickpea market. This provides the opportunity for segregation and marketing of brand lines to quality conscious export markets.

Container trade can be used to target high quality markets.

Photo P. Maloney.

**Photo P. Maloney.**

**Photo P. Maloney.**

**Photo P. Maloney.**

**Photo P. Maloney.**

**Photo P. Maloney.**
Warehousing provides growers with flexibility to minimise double handling and on-farm storage, and can be used to defer sales away from depressed harvest pressure prices.

Warehousing is a form of post-harvest spot sale where the sale transaction involves the warrant transfer with the inherent benefits of credit risk management. There is no immediate storage cost to grower as this is usually picked up by the trader.

Chickpea can be sold in the spot or cash market, either at harvest directly off the harvester (cash price at receival site or delivered packing depot) or post-harvest (sold from farm storage or the bulk handling system). This is a simple system allowing grain to be converted to cash easily with a quick response to short term market trends by holding or selling immediately. It does not provide long term pricing ability and the product must be available for sale.

Production risks need to be managed in balance with market risks with forward contracts. Important considerations are matching the proportion of crop sold to the type of season and contract ‘wash out’ or ‘roll over’ provisions.

These type of contracts tend to capture prices above the long term $340/t average. Generally, the forward price tracks old crop prices at a $20-30/t discount. In situations of low old crop supplies inducing high prices, there is usually opportunities to capture high priced forward contracts.

Spot pricing

These contracts are for a fixed grade, fixed tonnage at a fixed price for delivery to a specified location at a specified time.

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Forward contracts

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Marketing tools

Chickpea growers have a small array of marketing tools at their disposal, providing them with a degree of flexibility and opportunity to separate the marketing functions of pricing and title transfer. There are a number of marketing consultants who can help growers formulate a marketing strategy for chickpea. It is recommended that growers inexperienced with marketing use these services.

Tools for marketing chickpea include forward contracts, spot pricing and warehousing.

Formulating a marketing strategy

The following are the main criteria for formulating an annual marketing strategy:

- Know the cost of production, including break-even price and yields.
- Measure risks using a price and yield sensitivity analysis (see Gross Margin section).
- Know the target market and its needs.
- Choose the best variety choice to achieve the market needs.
- Assess and monitor domestic and global market supply and demand trends, especially conditions in the Indian sub-continent market, Australian carry over stocks and the anticipated size of crop in the eastern states.
- Monitor cash prices and know what is a realistic price expectation.
- Recognise main price trends, sorting out the difference between long term and short term fluctuations.
- Recognise the effect of seasonality and harvest pressure on prices.
- Spread sales over an extended time frame.
- Assess the cost of storing grain on farm, compared with warehousing as an alternative.
- Have product available to sell during periods of short supply.
- Use ‘scale up’ or ‘price down’ techniques depending on market direction.
**Gross Margins and Rotational Benefits**

*Bob French, Steven Schilizzi, Ross Kingwell and Daniel Fels*

Producing crops is essentially about making a profit in a long-term sustainable fashion. Chickpea can produce large profits while providing benefits to other farm enterprises.

**GROSS MARGIN**

One of the attractions of producing chickpea crops is their low cost of production and high prices relative to other crops. The following gross margin example is based on growing desi chickpea where average yield is estimated at 1.0 t/ha (on fertile red loams at Mingenew for example) and the chickpea price is assumed to be $320/t. Costs exclude machinery depreciation and interest.

This yield is realistic given good paddock selection and appropriate crop management. The costs associated with the example are only $145/ha, producing a gross margin of $175/ha. Based on these assumptions, the 'break even' yield for desi chickpea is only 0.44 t/ha.

A sensitivity analysis for various crop yields and prices scenarios is also included.

In addition to the gross margin of the crop itself, chickpea crops provide substantial rotational benefits to subsequent cereal or oilseed crops, and hence, increase the overall gross margin of the cropping rotation.

For the last two decades, farmers in Western Australia have realised the benefits of narrow-leaved lupin (*Lupinus angustifolius* L.) in developing sustainable cropping rotations on deep coarse-textured soils with a neutral to acidic pH. For many growers, the rotational benefits of lupin are valued more than their ability to produce profitable yields.

Anecdotal evidence suggests that similar rotational benefits are available on many fine-textured neutral to alkaline soils with chickpea. The rotational benefits of chickpea is an area of ongoing research in

**INCOME**

1.0 t/ha @ $320t  
(Net Delivered Port) $320.00

**COSTS**

<table>
<thead>
<tr>
<th>Item</th>
<th>Net Delivered Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed</td>
<td>130 kg/ha</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>50 kg DAP</td>
</tr>
<tr>
<td>Inoculant</td>
<td></td>
</tr>
<tr>
<td>Herbicides</td>
<td></td>
</tr>
<tr>
<td>Glyphosate</td>
<td>400 mL/ha</td>
</tr>
<tr>
<td>Simazine</td>
<td>1.5 L/ha</td>
</tr>
<tr>
<td>Diuron</td>
<td>1.0 L/ha</td>
</tr>
<tr>
<td>Verdict</td>
<td>300 ml/ha</td>
</tr>
<tr>
<td>Broadstrike</td>
<td>25 g/ha</td>
</tr>
<tr>
<td>Insecticides</td>
<td></td>
</tr>
<tr>
<td>Hallmark ULV 600ml/ha</td>
<td></td>
</tr>
<tr>
<td>Repairs and Maintenance</td>
<td></td>
</tr>
<tr>
<td>Fuel and Oil</td>
<td></td>
</tr>
<tr>
<td>Insurance 1%</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL COSTS</strong></td>
<td></td>
</tr>
</tbody>
</table>

**GROSS MARGIN**

$174.80

**Table 19. A gross margin analysis for a typical chickpea crop.**

**Table 20. Gross margins for various desi chickpea yield and price scenarios.**

<table>
<thead>
<tr>
<th>Yield (t/ha)</th>
<th>Price ($/t net on farm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>220</td>
</tr>
<tr>
<td>0.6</td>
<td>-10</td>
</tr>
<tr>
<td>0.8</td>
<td>34</td>
</tr>
<tr>
<td>1.0</td>
<td>78</td>
</tr>
<tr>
<td>1.2</td>
<td>122</td>
</tr>
<tr>
<td>1.4</td>
<td>166</td>
</tr>
</tbody>
</table>
Some researchers dispute this interpretation, claiming that the elevated nitrate levels are due to N exudation from the crop roots, implying that standard methods underestimate the amount of N fixed by these crops. There is evidence in

Legume crops do not derive all of their N from fixation as some N is taken up from the soil. The N fixation process is ‘metabolically expensive’, requiring energy that could otherwise be used for growth. So legumes tend to use soil N in preference to fixed N, especially if there is a large amount of soil N available.

The proportion of crop N derived from fixation depends on:

- availability of soil N – nitrate in the soil suppresses nodulation and N fixation and legume crops use more soil N where soil N levels are high (Jessop and Mahoney 1985).
- crop N demand – crops growing vigorously require more N than poor crops, and hence, will derive a greater proportion of their N from fixation.
- legume species – faba bean and lupin appear to fix more N than field pea and chickpea.

The amount of N that is left for following crops also depends on the partitioning of N within the legume crop. One of the aims of growers and agronomists is to improve seed yields. However, as chickpea seed has a high N content (about 4 per cent), increasing yields involves the removal of large amounts of N in the harvested grain.

In some cases, usually where soil N contents are high, more N is removed in the seed than the crop actually fixes from the atmosphere, resulting in a depletion of soil N (Unkovich et al. 1997, Schwenke and Herridge 1998).

Legume crops may also enhance N supply to subsequent crops through ‘N sparing’ (Herridge et al. 1995). Nitrate levels in the root zone of legume crops are usually higher than in the root zone of non-legume crops. It has been proposed that legumes place less demand on soil N than other crops, due to their ability to fix atmospheric N, allowing it to accumulate as it is released from soil organic matter.

Some researchers dispute this interpretation, claiming that the elevated nitrate levels are due to N exudation from the crop roots, implying that standard methods underestimate the amount of N fixed by these crops. There is evidence in
Chickpea in cropping rotations helps produce large wheat yields and protein contents. 
Photo S. Eyres.

In one trial at Goomalling in 1997, a chickpea crop yielding 0.96 t/ha produced a positive N balance of 22 kg/ha. This was equivalent to the N removed in a 1.5 t/ha wheat crop.

There have been few N balance measurements on chickpea in Western Australia.

At Pingaring in 1993, wheat yields after chickpea were about the same as after field pea, but not as great as after faba bean or lentil. More than 50 kg N/ha had to be applied before the wheat yields grown after wheat were matched by wheat grown after pulses in the absence of N fertiliser.

In one trial at Goomalling in 1997, a chickpea crop yielding 0.96 t/ha produced a positive N balance of 22 kg/ha. This was equivalent to the N removed in a 1.5 t/ha wheat crop.

Table 21. Summary of measurements of the nitrogen balance of narrow-leafed lupin, field pea and chickpea crops in southern Australia (adapted from Unkovich et al. 1997)
The amounts of N left behind after a chickpea crop are usually small, so it will frequently be necessary to use some N fertiliser in cereals following chickpea. This will occur after chickpea crops that had poor growth (especially if yields were moderate), in intensive continuous cropping rotations where soil organic N may already be depleted, and in years when cereals have a high yield potential.

In Western Australia we can expect cereal yields and grain protein to be better after chickpea than after a non-legume crop. In many but not all cases, this will be due to improved soil N supply. On average, chickpea may not fix or leave behind as much N as narrow-leafed lupin or faba bean, but on soils or in environments where it grows better than these crops, this may not be the case. Chickpea crops that grow well but produce low grain yields are likely to have the largest N benefit.

At Bencubbin in 1993, and again in 1995, chickpea contributed about 35 kg/ha, judging by the wheat response to fertiliser N. However, no amount of fertiliser N given to wheat after wheat could raise its grain protein to that of wheat after chickpea. This indicates that non-N benefits were also involved in increasing protein levels.

The amounts of N left behind after a chickpea crop are usually small so it will frequently be necessary to use some N fertiliser in cereals following chickpea. This will occur after chickpea crops that had poor growth (especially if yields were moderate), in intensive continuous cropping rotations where soil organic N may already be depleted, and in years when cereals have a high yield potential.

**Getting maximum benefit from your rotation**

- Inoculate your seed carefully: Poorly nodulated plants will not fix as much N as well nodulated plants.

- Grow chickpea after a cereal or oilseed crop. High N levels in the soil such as after a good medic pasture will inhibit nodulation and reduce the N benefit from chickpea crops.

- Good crop management. Well grown crops will fix large amounts of N. Paddock selection, time of seeding, sowing rate, weed and pest management and nutrition all contribute to good plant growth.
enterprises and activities, given the possible variation in yields and prices seasons and soil types were described by the model. The model incorporated two levels of attitudes to risk. It also took into account the rotational benefits of chickpea, such as N fixation and disease break benefits to following cereals, and the improved protein content of wheat which fetched higher prices.

On average over the eleven types of seasons, the model predicted average chickpea yields of 728 kg/ha across the three soil types (S5: well-drained loam; S6: poorly drained loamy-clay, non-responsive to gypsum; and S7: well drained loamy-clay, gypsum responsive). Across the soil types, the minimum yields were 317 kg/ha, once every 28 years, and maximum yields were 1.38 t/ha, once every 6.5 years.

The average expected farm-gate price for chickpea, calculated from the available data set (seven years) was $328 per tonne. The five price states, each with a probability of occurrence of 20 per cent, were $245, $260, $315, $360 and $460 per tonne.

The main finding was that chickpea crops are a robust addition to farm profits in the low rainfall parts of the cropping area of Western Australia. Chickpea is often selected as part of optimal farm plans under a range of scenarios as described below.

On the standard farm
On 'standard farms' with 40 per cent of their arable area as the fine-textured soils (S4, S6, S7), chickpea were selected as part
of optimal farm plans and boosted farm profit by about 7 per cent for low risk averse farm management. More precisely, the certainty equivalent of the variable profit stream was increased by 7 per cent.

For a very risk averse farmer, chickpea boosted farm profits by more than 8 per cent.

**On heavy land farms**

On “heavy land” farms with 75 per cent of arable land as fine-textured soils the increase in farm profit because of the incorporation of chickpea was greater (up to 23 per cent). Such farms are not overly common in the study region.

The preference for chickpea by a risk averse farmer was not because chickpea had a stable yield. Rather, chickpea price had a low correlation with wheat prices, and hence, tended to smooth out the revenue variability within a farming system largely dependent on wheat.

Chickpea contributed to farm profitability in so far as it is grown in rotation with wheat. Besides its cash value due to high relative prices, chickpea also boosted wheat yields and the protein content of wheat. This reduced the costs of nitrogen fertiliser and herbicides applied to following wheat crops. These benefits are independent of the market value of chickpea.

However, the model predicted that chickpea was profitably grown only on two of the three fine-textured soil categories. One of soil categories was prone to waterlogging which chickpea does not tolerate well. The model suggested that even with a 30 per cent drop in its expected price, chickpea remained profitable to grow in most seasons on roughly the same proportion of land.

**COMPARISON TO OTHER PULSES**

Chickpea has to compete with other pulse crops such as faba bean, field pea and lentil for a place in cropping rotations. It was not certain how choice of pulse crop influences the profitability of cropping.

An analysis of the profitability of chickpea, faba bean and field pea crops in rotation with a number of cereal varieties was undertaken using an economic model based on the Model of an Integrated Dryland Agricultural System (MIDAS). The model describes representative heavy soil types in the Merredin region (S5, S6 and S7) and takes into account the rotational benefits of grain legumes, such as N fixation and disease break effects on yield and protein of subsequent cereal crops.

The results indicate that pulse crops contribute to the most profitable rotations in the eastern wheatbelt on fine-textured soils. For example, a chickpea/wheat/faba bean/wheat rotation produced $114/ha/yr on the loam soil type (S5), whereas rotations with pasture produced $87/ha/yr or less.

<table>
<thead>
<tr>
<th>Degree of risk aversion</th>
<th>Standard farm</th>
<th>“Heavy land” farm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>+ 7.2%</td>
<td>+ 15.7%</td>
</tr>
<tr>
<td>High</td>
<td>+ 8.4%</td>
<td>+ 22.8%</td>
</tr>
</tbody>
</table>

The percentage change in profit refers to the percentage change in certainty equivalents of profit streams given risk aversion, and given current economic data.
In general, the rotational benefits of the various pulse crops did not differ greatly, and the profitability of the pulse crop largely accounted for differences in the profitability of the rotation. Hence, chickpea produced more profit in rotation with wheat than other grain legumes because its own profitability was higher. On soil type S6, however, faba bean had an advantage because of its tolerance to transient waterlogging and was included in the most profitable rotations.

It is worth noting that the chickpea/wheat/faba bean/wheat rotation was more profitable than the chickpea/wheat/wheat or chickpea/wheat rotation (data not presented) because the break between the pulse species was greater. There are few diseases common to chickpea, faba bean and field pea, and the chickpea/wheat/faba bean/wheat rotation allowed a three year break between these crops and a one year break between wheat crops.

The model suggested that even if the chickpea price was reduced by $40 while other grain legume prices remained unchanged, chickpea was more profitable to grow on the well drained soil types.

### Table 23.
Assumptions for chickpea, faba and field pea prices and yields in the economic model.

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Chickpea</th>
<th>Faba bean</th>
<th>Field pea</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$320/t</td>
<td>$240/t</td>
<td>$250/t</td>
</tr>
<tr>
<td>S5: loam, well-drained</td>
<td>720 kg/ha</td>
<td>900 kg/ha</td>
<td>900 kg/ha</td>
</tr>
<tr>
<td>S6: loamy-clay, non-responsive to gypsum, poorly drained</td>
<td>640 kg/ha</td>
<td>850 kg/ha</td>
<td>800 kg/ha</td>
</tr>
<tr>
<td>S7: loamy-clay, gypsum responsive, well drained</td>
<td>800 kg/ha</td>
<td>1000 kg/ha</td>
<td>1000 kg/ha</td>
</tr>
</tbody>
</table>

### Table 24.
Profitability of various rotations on the loam soil type (S5) at Merredin.

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Profit ($/ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>chickpea</td>
<td>wheat</td>
<td>faba bean</td>
<td>wheat</td>
<td>114</td>
</tr>
<tr>
<td>chickpea</td>
<td>wheat</td>
<td>wheat</td>
<td></td>
<td>109</td>
</tr>
<tr>
<td>faba bean</td>
<td>wheat</td>
<td>wheat</td>
<td></td>
<td>95</td>
</tr>
<tr>
<td>manipulated</td>
<td>pasture</td>
<td>wheat</td>
<td></td>
<td>87</td>
</tr>
<tr>
<td>volunteer</td>
<td>pasture</td>
<td>wheat</td>
<td></td>
<td>73</td>
</tr>
</tbody>
</table>
Summary – The Production Package

Chickpea can be grown in rotation with cereals and other crops on fine textured, neutral to alkaline soils unsuitable for narrow-leaved lupins. Current varieties, when well managed, can yield 0.8-1.5 t/ha in most years in the low, medium and high rainfall zones, especially in the warm northern wheatbelt. The first of the chickpea varieties selected in Western Australia are now available commercially. These flower earlier, are slightly taller and higher yielding than current variety Tyson. More importantly, they have larger and lighter coloured seed, and require a shorter time to cook. These traits are expected to give them a marketing advantage in the Indian subcontinent and other markets.

Good Preparation

Select paddocks which have:
- well-drained sandy loams to clay loams with a pH 5.0-9.0 (CaCl₂),
- a soil structure or slope that allows good drainage,
- few rocks and roots and can be left relatively flat after sowing,
- no sulfonylurea herbicide residues such as Glean® and Logran®,
- a low frost risk, and
- a low broad-leaved weed burden.

To minimise the risk of diseases, do not grow chickpea more often than one year in three in the same paddock.

Varieties

There are two types of chickpea:
- desi – (small seeded <26 g/100 seeds)
- kabuli – (large seeded >26 g/100 seeds).

Desi varieties include:
Sona, Heera (early flowering)
Tyson, Amethyst (early-medium flowering)
Dooen and Barwon (medium flowering).

Kabuli varieties include: Kaniva, Garnet and Bumper.

Desi varieties are more suited to the low to medium rainfall areas. Kabuli chickpea varieties are generally more suitable for the long season areas (400 – 600 mm p.a.).

High Quality Seed

Where possible, use certified seed where details of germination per cent, seed size and presence of weeds and seed borne diseases are provided. Kabuli seed is especially prone to physical damage making germination testing essential.

A Good Start

North: mid April – end May. Ideally, use medium flowering varieties with April and early May sowings.

South and Central: mid May – mid June. Sowing in June should be matched with an early flowering variety.

To produce maximum yields, chickpea (especially kabuli) needs warm conditions in spring along with adequate water either from rainfall or stored soil moisture. While early sown crops may produce flowers in late winter, pods will only develop when average temperatures are above 15°C. Sona and Heera have slightly better cold tolerance than other varieties. Frost causes flower and pod abortion.

Sowing Rate

On average, the optimum plant density for desi chickpea is 50 plants/m² and for kabuli chickpea 30 plants/m². Higher densities (a 15% increase) are economic in situations of high yield potential (>1.0 t/ha). Actual sowing rates will depend upon seed size and germination per cent:

80-100 kg/ha for Tyson, Amethyst and Dooen
120-140 kg/ha for Sona, Heera and other large seeded varieties
120-170 kg/ha for kabuli varieties
**SEEDING DEPTH**

The recommended planting depth is 5-8 cm. For dry sowings, increase depth to 8-10 cm and sowing rate by 10%.

**INOCULUM**

Chickpea seed should be inoculated with group N inoculum every year. With pickled seed, sow seed within 6-10 hrs of inoculation.

**FERTILISER**

Chickpea is able to extract phosphate from soil more efficiently than many crops. A maintenance application of 50-100 kg/ha of superphosphate is recommended. It is useful to apply nitrogen at 10-15 kg N/ha in soils with marginal pH (<5.0) and clay content.

**Protect Your Crop**

**WEED MANAGEMENT**

Chickpea is slow growing in winter and competes poorly with weeds emerging with the crop. Late germinating weeds, such as wild oats, wild radish and mustard, which escape herbicides applied at sowing, make harvesting very difficult.

As post-emergent herbicide options are limited, most weed management strategies in chickpea crops depend upon substantially reducing the viable weed seed population in the soil before the crop emerges.

Chickpea should be planted in paddocks with few broad-leaved weeds, such as doublegeye, wild mustard and wild radish. Choose paddocks such as cereal stubbles and control weeds before sowing.

Registered chemicals for in-crop use include:

- **pre-emergent**
  - Trifluralin 1.0-2.0 l/ha
  - Simazine 2.0 L/ha

- **post emergent**
  - Broadstrike® 25 g/ha
  - Tough® 2 L/ha
  - Various grass selectives

Following emergence monitor crop for pasture looper and cutworm.

Chickpea seedlings are normally tolerant of red-legged earth mite and lucerne flea due to the production of acid from their leaves and stems. The plant is very susceptible to native budworm damage from flowering through to pod fill.

After the appearance of the first pod, spray if there are two or more grubs per 10 sweeps in desi crops and one or more in kabuli.

**DISEASES**

Botrytis grey mould (BGM) caused serious yield losses in several crops in the northern wheatbelt in 1997. This disease requires warm moist conditions in spring. The effect of BGM can be reduced by planting clean seed. A seed test for BGM is available and seed with a low level of infection can be treated with a fungicide.

Root rot diseases associated with Phytophthora, Pythium, Phytophthora and Fusarium fungi can be minimized by avoiding poorly drained soils. Infection by Rhizoctonia can be reduced by avoiding paddocks previously used for medic pasture. These diseases are rarely of economic significance in WA.

Have seed tested for Cucumber Mosaic Virus in aphid prone areas.

The crop is ready to harvest when the stems and pods are light brown and the seed is hard and rattles within the pod. Seed moisture needs to be about 15 per cent. Pods will be shed if harvest is delayed.

Minimise physical damage to seeds during harvest, especially on large-seeded varieties. Suggested harvester settings are:

- **reel speed** same as ground speed
- **spiral clearance** high
- **fan speed** high
- **drum speed** 400-700 rpm
- **concave clearance** 10-25 mm
- **top sieve** 20-25 mm
- **bottom sieve** 12-16 mm
Marketing

Chickpea is freely traded for human consumption and can also be used as a stockfeed. Desi types are predominantly exported to the Indian sub-continent (India, Bangladesh and Pakistan). Kabuli chickpea is traditionally sold into the Middle East and Mediterranean markets and Europe.

Prices are somewhat volatile but averaged about $320/t for desi types over the past decade.

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References


Further reading


