21-2-2001

Crop Updates 2001 - Pulses

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ISSN 1445-0592

CROP UPDATES
Technical Information for Agribusiness

PULSE RESEARCH AND INDUSTRY DEVELOPMENT IN WESTERN AUSTRALIA 2001

Presented at Burswood Convention Centre, Perth, Western Australia, 21-23 February 2001

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2000 PULSE INDUSTRY HIGHLIGHTS

The growing season in WA during 2000 was challenging for pulse growers, industry and researchers alike. Many areas received substantial unseasonal summer rainfall (January/February) that caused flooding in some places (e.g. Esperance). Most of the cropping regions in WA then experienced a late start to the season (mid-late June), lower than average winter rainfall, and extremely dry and hot spring conditions. In addition, locust plagues loomed as a threat over wide areas for much of the season. Fortunately minimal damage by locust on pulse crops occurred. Yields of most pulse crops were below average, but quality was generally good. Commercial yields ranged between 0.2-1.0 t/ha for desi chickpea, 0.2-1.8 t/ha for field pea, 0.1-1.0 t/ha for faba bean, 0.3-1.2 t/ha for lentil and 0.3-1.2 t/ha for vetch.

Prices for pulses during 2000 were excellent with historical highs for desi chickpea and red lentil (> $600) and over $300 for good quality faba bean. A premium price ($20-30/tonne) was paid for good quality Sona and Heera over the standard variety Tyson and Fiesta received a premium (~ $20) over Fiord. Field pea price increased up to $210/tonne towards the end of November. The price outlook all pulses is likely to remain strong during 2001.

The area of pulse production declined by almost 55,000 ha in WA during 2000 compared to the 1999 season. The area was approximately 40,000 ha for chickpea, 63,000 ha for field pea, 9,000 ha for faba bean, about 3,000 ha of lentil, and about 10,000 ha of vetch. A decrease in the area sown to chickpea and faba bean was offset by an increase in the area sown to field pea. Concerns over ascochyta blight and the late start to the season were the major reason for a drop in the area sown to chickpea. The late start to the season was the main cause for the reduction in faba bean area. The increase in the area of field pea in 2000 was largely due to the wider availability of new varieties, better production packages, greater farmer confidence in field pea production, and better suitability of field pea to delayed sowing given the dry and late start to the season.

The fungal disease incidence was generally low in the majority of pulse crops. Ascochyta blight in chickpea was observed throughout WA, but the yield and quality losses due to the disease were minimal where farmers followed the recommended agronomic packages. The ascochyta blight management system was developed for chickpeas and implemented in 2000. This package was developed as a collaborative effort between AGWEST, pulse growers and other industry personnel, and was communicated widely throughout the industry. The value of early fungicide sprays (commencing four weeks after emergence) in managing the disease was clearly demonstrated. Consequently, ascochyta blight had a lower impact on the 2000 crop than predicted from earlier experience in the Eastern States. Despite the widespread presence of ascochyta in crops, chickpeas remained the most profitable crops for many growers during 2000.

A potential new kabuli chickpea variety was released to growers during the year. The line, 'G846-3-9' (sister line of Bumper) has high yields, excellent seed colour and large seed size, but is susceptible to ascochyta blight (similar to Kaniva). Ownership of the seed was transferred to two pulse grower groups (PASE and GSPGA). The groups are now in the process of multiplying and certifying the seed. This line is expected to meet the interest of kabuli producers in WA until a new variety with improved ascochyta blight resistance is available.

Evaluation of introduced chickpea germplasm continued in 2001. Several kabuli chickpea lines from Turkey/International Centre for Agricultural Research in the Dry Areas (ICARDA) have demonstrated superior ascochyta resistance and agronomic adaptation in Australia. Single plant selections were carried out at Bindoon on superior lines during 2000 and these will be multiplied and fast tracked at Carnarvon during 2001. Four to six promising kabuli chickpea lines introduced from Spain and Mexico have been identified for the high value kabuli chickpea industry in the Ord River Irrigation Area (ORIA). The introduced lines have extra large seed and superior yield compared to Macarena, the standard variety. Basic seed production and further evaluation of these lines will continue in 2001 in the ORIA.

Herbicide management trials in collaboration with Aventis showed that the new herbicide 'Balance' was very effective in controlling broadleaf weeds (wild radish, mustard, etc.) in chickpea crops. This herbicide offers greater flexibility in weed management of chickpeas. Row spacing studies showed that chickpea grown in rows spaced at 570 mm produced greater yields than when grown in rows spaced at 180 mm. Wide row spacing will now be investigated as a possible method for improving disease management in chickpea.

Germplasm screening nurseries for faba beans were established at Dongara, Merredin, Katanning and Esperance. These sites will be maintained for several years and will be used to screen faba bean germplasm under consistent disease pressure. The nurseries are key components of the strategy to develop chocolate spot and ascochyta resistant faba bean varieties for WA.

Field pea quality research showed that the most important factor affecting seed quality was variety. Among the agronomic factors examined, very high sowing rates (above recommended rates) significantly reduced mean seed size. Sowing rate did not affect the variability of seed sizes within the sample, nor did it affect seed colour or hard seededness.

Marrowfat pea was identified as a high value crop and was shown to be a potentially a lucrative cropping option for spring planting in high rainfall regions of the south-west. The WA company, Premium Grain Handlers (PGH), was able to obtain the license (from Cebeco Zaden of the Netherlands) to supply the marrowfat pea variety 'Primo'. About 200 kg of this variety was supplied to PGH and is currently being multiplied.

In collaboration with CSIRO Livestock Industries (Perth) the nutritional value of *Lathyrus cicera* (cv. Chalus) compared to narrow leafed lupin grain for sheep was undertaken. The feeding experiments showed that Chalus has a higher nutritional value than lupin in terms of voluntary feed intake, live weight gain, carcass weights, wool growth and feed efficiency. There were no differences in meat quality between sheep fed lupins or Chalus (e.g. redness, pH, taste or tenderness). Compared to lupin grain, Chalus grain appears to be of high nutritional value for sheep, with no adverse effects on sheep health.

Agronomic and disease management packages for pulse varieties continued to be developed in all regions through an extensive field program in 2000. Research continued on variety and germplasm evaluation, row spacing in chickpea, seed quality testing, and herbicides for broad-leaf weed control in pulse crops. Large scale demonstration trials of pulse varieties, crop management (raised beds, row spacing) and disease management strategies were conducted on farms. Other more basic research on drought resistance and cold tolerance of chickpea was conducted in collaboration with CSIRO and the Centre for Legumes in Mediterranean Agriculture (CLIMA). Work on the epidemiology of major fungal diseases of pulses also commenced during the 2000 season.

Major pulse field days were organised in conjunction with each of the pulse grower associations. These were all well attended with about 50-100 growers present at each meeting. Pulse field walks were held at trial sites on farmers paddocks throughout the grain belt, which allowed first hand observation of current work on pulse management and new varieties. Numerous press releases, television and radio interviews, newspaper and magazine articles by the project team helped promote pulses in WA. About 12 contributions to corporate publications (e.g. AgMemo, Primary Focus) and technical bulletins were published and four issues of 'On the Pulse' newsletter were produced during the year. Major extension publications for 2000 included 'Managing Ascochyta Blight in Chickpeas' and 'Common Vetch Production Technology'. A total of 16 scientific papers, two book chapters and 12 conference papers on pulses were published during 2000.

For the first time, a pulse grower group (PASE) in WA successfully organised direct export of Dundale field pea from the Esperance port to Calcutta, India. In addition, a record of over 30,000 tonnes of desi chickpeas was taken as a bulk shipment from the Geraldton port in July 2000. Finally, the first pulse splitting plant was established by PGH at Fremantle in October 2000, an important move towards value adding that signifies confidence in the expanding pulse industry in WA.

CONTRIBUTORS

Pulse research and industry development at Agriculture Western Australia (AGWEST) is spread across several projects within the Pulse and Oilseeds Program. The research and extension staff of the Pulse Productivity and Industry Development Project (UAP) made major contributions to the 2000 activities reported in this book. Since every staff member contributed to the project, these names are generally not mentioned at each article in this book. In addition to these, staff from other projects within the Pulse and Oilseeds Program and outside institutions also contributed and their names are mentioned at each article. In many cases, the data presented in this book are only preliminary results because of time constraints. Some experiments were only harvested a week before the articles were written. Data is analysed in more detail throughout the year and those interested are encouraged to contact the authors for further information.

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CAUTION: UNREGISTERED PESTICIDE USES

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

BACKGROUND

Grain legumes (pulses) are rapidly becoming a vital part of Australian agriculture as farmers appreciate the benefits these crops provide in the development of sustainable production systems. Growers in WA have benefited for many years from growing narrow-leafed lupin (*Lupinus angustifolius*) on deep coarse-textured soils with a neutral to acidic pH. However, narrow-leafed lupin is poorly adapted to the calcareous red-brown earths, duplex soils and shallow red earths which occupy a substantial area throughout southern Australia. Growers looking to intensify their cropping require one or more pulses for these soils.

The term 'alternative grain legumes' coined in the mid 1980s refers to grain legumes suited to fine-textured alkaline soils where the narrow-leafed lupin is poorly adapted. Cool-season grain legumes can be separated into those with immediate potential for inclusion into WA farming systems and those with medium-term potential (Fig. 1).

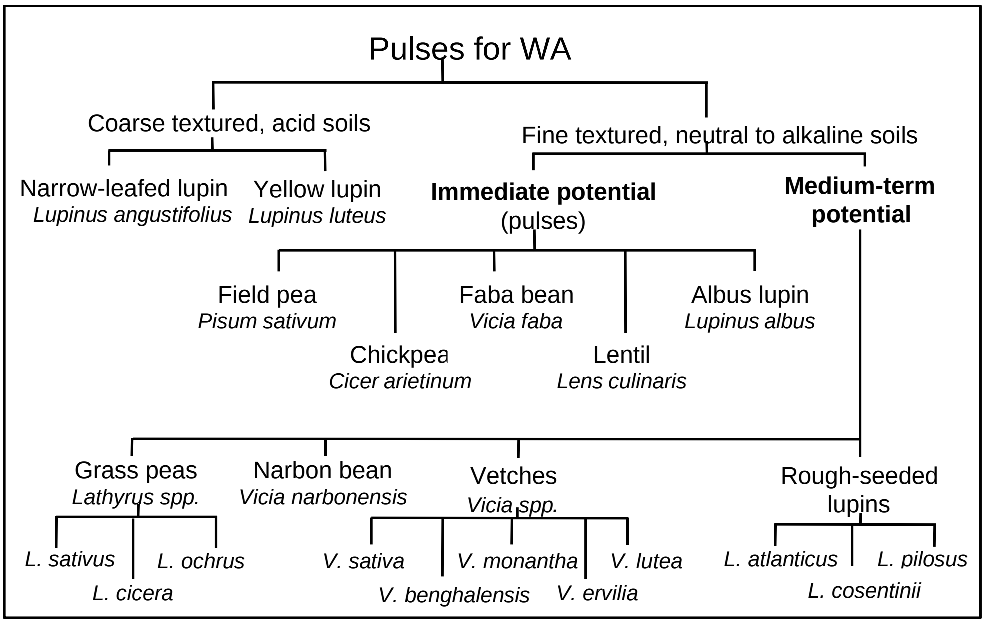

Figure 1. The range of cool-season pulse options for southern Australia.

Pulses with immediate potential

Pulses with immediate potential are all fully domesticated crops. They are grown in many parts of the world - chickpea (desi and kabuli), lentil (red and green), faba bean, albus lupin and field pea. These are mostly used for human consumption and hence, are called pulses.

A preliminary investigation of pulse production, consumption and trade in the Indian sub-continent identified an excellent market for desi chickpea, field pea and lentil in India, Pakistan, Bangladesh and the Middle East (Siddique 1993, Van Rees, Siddique and McClelland 1995). Although these countries are the largest producers of pulses in the world, they are also the largest consumers and static production coupled with increasing population is creating an enormous demand. Based on the present rate of population growth and improvements in the economy, the additional demand for pulses will be about 3-6 million tonnes per annum by the year 2005. Thus, the medium-term outlook for pulse markets looks promising. However, we need to keep a close eye on pulse production and export from our competitors (e.g. Canada and Turkey) in the world market.

In the case of faba bean and albus lupin, the human consumption markets are mainly in the Middle East and in the Mediterranean region, and are relatively small. However, faba bean is also well established as a stockfeed. Although albus lupin is higher in protein than the narrow-leafed lupin, there is some concern in feeding them to monogastrics, especially pigs, and this is being clarified so they will be widely accepted for stockfeed purposes. Providing anthracnose can be managed effectively in albus lupins (resistant varieties), growers can exploit these

markets. In the long-term, faba bean and albus lupin will attract prices above narrow-leafed lupins as stockfeed, with a $20-30/t premium for human consumption. Over the past three years, however, a reduction in the faba bean production in China resulted in high human consumption prices, about $50-100/t more than stockfeed prices. Field peas have good human consumption markets overseas and attract a $20-50/t premium over narrow-leafed lupin grain. The recent bovine spongiform encephalopathy (BSE, mad cow disease) scare in Europe has also resulted in a large interest in plant production for animal feed industries in Europe and elsewhere.

Pulses with medium potential

The second group of pulses has medium-term potential for WA and include species such as grass pea (*Lathyrus* species) narbon bean, vetches and rough-seeded lupins (Fig. 1). These semi-domesticated species are grown for stockfeed (both forage and grain) and human consumption in many under-developed parts of the world, however they contain various anti-nutritional factors and will require further breeding or processing before they are widely accepted as food legumes.

Research and industry development of the pulse crops with immediate potential is being undertaken largely through AGWEST, while CLIMA at The University of WA is concentrating on the species with medium potential in addition to some basic research on the pulse crops. Good progress has been made with the *Lathyrus* species and a line of *Lathyrus cicera* (ATC80490 - Chalus) was released for commercial production in 1998. Low neurotoxin lines of *Lathyrus sativus* and narbon bean are also under going seed multiplication for possible release. A more detailed description of the species with medium term potential can be obtained from their individual sections in this book, previous reports and scientific publications (see section on Publications by Pulse Productivity Project Staff). Vetches have also gained popularity, especially in the southern regions, where they have been used as green manure, hay fodder and grain crops. A vetch production technology manual was published recently to promote the crop in the farming systems of WA.

Future

Agronomic research and genetic improvement of the pulse crops within AGWEST and other research organisations has intensified over the last eight years and we are now seeing an increase in the area of production of these crops. A similar increase in narrow-leafed lupin production occurred in WA in the early 1970s which was followed by a decrease after many farmers produced poor crops because of lack of agronomic experience and inferior varieties. A consolidated effort to develop and extend agronomic packages for growers in the late 1970s and early 1980s resulted in a massive increase in the production of narrow-leafed lupin from about 50,000 ha in 1980 to more than 0.8 million ha in 1987.

Research and industry development staff are working diligently to produce similar increases in pulse production in WA. Production packages for these crops have been developed and are being fine-tuned in various regions. In addition, new locally adapted varieties of chickpea, field pea and lentil have been developed which will provide greater yield and quality than the many varieties imported from the Eastern States. New varieties of faba bean and albus lupin can also be expected in the near future. Aspects of disease, weed and pest management are also being investigated and more fundamental research into genetic, molecular marker, crop adaptation and nitrogen fixation have also commenced.

Our evaluation of soil types and likely rotations throughout the WA grain belt demonstrated the potential for about 0.5 million ha of pulse production within the next decade. This includes more than 170,000 ha of chickpeas, 100,000 ha of faba beans, 85,000 ha of field peas, 30,000 ha of albus lupin, 5,000 ha each of kabuli chickpea, and 20,000 ha of lentil and vetch. This is an ambitious target, however the current production of about 180,000 ha (1999) is more than the area of narrow-leafed lupin production in 1980. We are optimistic about the future of the pulse industry in WA and believe the target is achievable.

In the past, WA pulses were considered to have inferior quality when compared to Eastern States products. This was largely a consequence of ill-adapted varieties with poor quality (e.g. Tyson, Fiord, etc.) and limited knowledge of production and quality improvement packages. The recent development of new varieties, together with production, disease and weed management, and market information has raised the profile of WA pulses in the international markets. However, further improvement in varieties and production packages on a farm-scale basis, along with industry promotion will accelerate the export of WA pulses into overseas markets. The formation of four pulse grower groups and the WA Pulse Council are indicative of the strong commitment by the growers and industry.

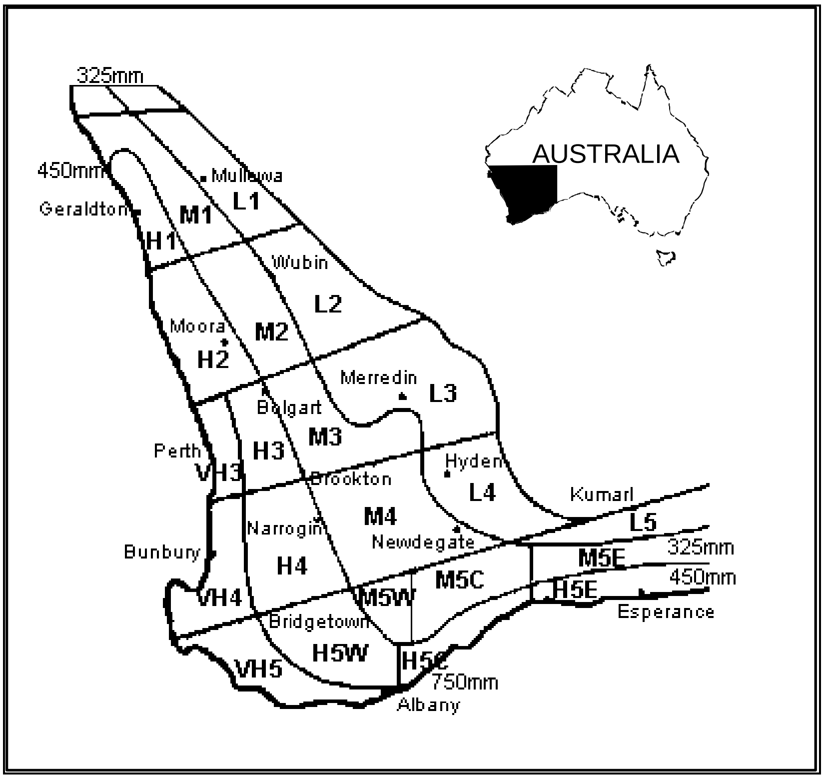

Figure 2. Cropping areas of south-western Australia, showing rainfall isohyets. L = low rainfall, M = medium, H = high and VH = very high.

SUMMARY OF PREVIOUS RESULTS

Seasons 1991-92

AGWEST decided to undertake a new examination of the potential of new pulses as alternatives to narrow-leafed lupin in 1991. Field trials were conducted in 1991 and 1992 at 13 sites to compare the growth and adaptation of six winter pulses to fine-textured alkaline soils (Siddique *et al.* 1993). In the relative dry year of 1991, Dundale field pea produced the greatest mean seed yields (1.3 t/ha) followed by Fiord faba bean (1.2 t/ha) and Yorrel narrow-leafed lupin (0.8 t/ha). Chickpea (Tyson), lentil (Cobber) and albus lupin (Kiev Mutant) all produced mean seed yields of about 0.6 t/ha across all sites.

Rainfall was well above average in 1992 and mean seed yields increased relative to 1991 in all species except field pea, which was affected by waterlogging and increased fungal disease. Fiord faba bean produced an average seed yield of 2.9 t/ha followed by Yorrel narrow-leafed lupin (1.2 t/ha), Tyson chickpea (1.1 t/ha) and Dundale field pea (1.1 t/ha). Cobber lentil produced on average 0.8 t/ha. In other trials, an early flowering chickpea line (T1587) and two cold tolerant lines from India (CTS) outyielded Tyson. Lines of *Lathyrus*, narbon bean and vetches were also evaluated with the best lines producing biomass and seed yields equivalent to field pea.

Season 1993

Overall, rainfall was about average in 1993. Nine faba bean time of sowing trials were established and further selection and variety testing was conducted for all species. Faba beans again produced impressive yields, more than 4.0 t/ha with sowings in early May at several sites. Seed yields declined at an average rate of 250 kg per week delay in sowing. The variety Ascot showed excellent resistance to ascochyta blight at Speddingup and produced slightly more seed yield than Fiord with a very low level of seed infection suitable for human consumption.

On average across 12 sites in 1993, the chickpea line T1587 yielded 8% more than Tyson and the Indian CTS lines performed as well as Tyson, especially at Muresk where yields were up to 2.9 t/ha. Kabuli chickpeas (Garnet and Kaniva) produced up to 2.0 t/ha at Dongara. The red lentil varieties released in Victoria (Digger and Cobber) produced up to 1.4 t/ha at Muresk and Merredin, while Matilda was clearly the best green lentil (up to 1.2 t/ha). Seventeen lines each of three *Lathyrus* species from ICARDA were also tested at three sites. All lines were later flowering than field pea, especially *L. ochrus*, but some lines of *L. cicera* and *L. ochrus* produced biomass and seed yields similar to field pea. Several lines of narbon bean produced similar seed yields to faba bean at Mullewa but were significantly less than faba bean at Merredin and Muresk.

Season 1994

In one of the driest seasons in decades for many parts of the wheatbelt the pulses produced respectable seed yields in field trials and farmer paddocks. For example, Merredin received 165 mm of rainfall (decile 1) and faba bean produced yields up to 1.2 t/ha, chickpea up to 0.9 t/ha and lentil 0.8 t/ha. Field pea again showed its good adaptation in dry years, producing up to 1.8 t/ha at Merredin. Albus lupin also produced up to 2.0 t/ha in the northern wheatbelt.

Several early flowering (ICCV88202 and ICC14880) and CTS lines introduced from India continued to out perform standard Australian varieties by up to 35%. These lines are earlier flowering, taller and have better seed size and colour than Tyson. Agronomic trials demonstrated the benefits of a ‘starter dose of N’, (10-15 kg/ha) and deep sowing (5-7 cm) with chickpea and faba bean. Faba bean, chickpea, lentil and albus lupin yields generally declined with delayed sowing.

In a joint effort between AGWEST and The Lentil Company, Horsham, 14 commercial growers produced lentils over 250 ha for the first time in WA. No major problems were encountered and seed yields ranged from 0.4-1.8 t/ha. In collaboration with CLIMA, screening of lentil

germplasm from ICARDA, Pakistan and Bangladesh revealed several early flowering lines with better adaptation and seed yield (30%) than current Australian varieties.

Season 1995

In contrast to the 1994 season, rainfall was above average for many parts of the wheatbelt in 1995 and the pulses produced impressive seed yields in field trials and in commercial farmer paddocks. For example, faba bean produced yields more than 4.0 t/ha in several trials, chickpea up to 2.5 t/ha and lentil 2.0 t/ha. Albus lupin also produced up to 2.2 t/ha in the northern wheatbelt. Of the species with medium term potential, vetch, *Lathyrus cicera, L. sativus* and narbon bean showed good adaptation and produced the highest yields.

Several early flowering and cold tolerant desi chickpea lines introduced from India continued to out perform standard Australian varieties by up to 35%, particularly under dry conditions. These lines are earlier flowering, taller and have better seed size and colour than Tyson, and two lines, ICCV88202 and ICC14880, were multiplied over summer at Manjimup and during winter at Kununurra ready for release in 1997.

The red lentil industry in WA expanded to 500 ha in 1995. The crops grew very well and had high yield potential but strong winds and rain in late September, just as many of the crops were mature, caused lodging and pod shedding. Harvesting losses were high and seed yields ranged from 0.2-1.5 t/ha.

In collaboration with CLIMA, screening of lentil germplasm from ICARDA, Pakistan and Bangladesh revealed several early flowering lines with better adaptation and seed yield than current Australian varieties. These will be evaluated further, however promising lines (ILL590 and ILL7200) were multiplied over summer in New Zealand for possible release in 1998.

Season 1996

Despite the late break to the season in many parts of the cropping areas in WA, good spring rains in most districts resulted in above average pulse yields in farmers' fields. In the field trial program, faba bean produced up to 5.0 t/ha at Kojonup, while desi chickpea and lentil produced up to 2.5 t/ha at Merredin. The late break to the season favoured field pea growth and yield, producing up to 2.7 t/ha at Nyabing. New pulse species (narbon bean, *Lathyrus* species and vetches) also continued to show considerable promise as pulses for WA cropping areas. In collaboration with CLIMA several local selections were multiplied for commercial release.

Early flowering and cold tolerant selections of desi chickpea (ICCV88202 and ICC14880) demonstrated their superior performance over standard varieties, especially at dry sites. On average over all sites, the lines yielded 3-7% more than the standard variety Tyson. Seed of the new lines was again multiplied under irrigation at Kununurra and about 50 t of each line was ready for commercial release in early 1997. Considering these lines were first identified in 1994 when only 4 kg of seed was available, their release after three years is a major achievement for the chickpea industry.

Seed of the early flowering red lentil lines (ILL7200 and ILL590) were again multiplied over the 1995/96 summer at Lincoln New Zealand. These lines produced yields in excess of the standard variety Digger at many locations. Pulse management packages were tested at a number of regions. Potential water use efficiencies for the pulse crops were found to be similar to those for cereals. Suitable choice of pulse species and variety, together with appropriate management packages will ensure water use efficiencies are maximised in commercial crops.

Season 1997

The season provided mixed results for pulse growers in WA. Apart from the eastern wheatbelt, which experienced a dry winter and spring, moist warm conditions in late September enabled a rapid infection of chocolate spot in most faba bean crops. Fortunately, a dry October halted the spread of the disease and the impact on yield and quality was generally small. Botrytis grey mould had a devastating affect on some kabuli chickpea crops at Dongara and low levels were also observed in a few desi chickpea crops.

At the beginning of 1997 pulse prices were quite low, especially chickpea. However, by harvest time prices had increased considerably, particularly desi chickpea and lentil, due to increased demand from the Indian sub-continent, decreased pulse production in Turkey and a dry season in eastern Australia. After a quality management guide was developed and an extension campaign were conducted in the middle of the year, the quality of pulses produced in WA improved considerably when compared to previous years, in particular faba bean. Large quantities of desi chickpea, field pea and faba bean were exported to various human consumption markets. The quality of lentil seed produced was excellent and the exporters paid a premium to growers in WA as part of early shipment contract.

New desi chickpea varieties (Sona and Heera) and field pea varieties (Magnet and King) were commercially released. Growers multiplying seed of Sona and Heera were pleased with their improved seedling vigour, early flowering, plant height, seed size and yield potential compared to existing varieties. Similarly, Magnet and King are significant improvements over current field pea varieties for medium and high rainfall regions.

Early flowering red lentil lines (ILL7200 and ILL590) produced yields in excess of the standard variety Digger at many locations in WA and the Eastern States. Seed of these lines were multiplied and will be released through CLIMA. Vetches and narbon bean continued to show considerable promise as pulses particularly for the high pH soils in low to medium rainfall areas. *Lathyrus cicera* also performed well at number of sites and the line ATC80490 will be commercially released in 1998 in collaboration with CLIMA. Pulse management packages, including agronomy, disease, weed and pest management, were fine-tuned in a number of regions.

In addition to the existing Mid West Pulse Growers Association, a Central Districts Pulse Growers Group (based at Merredin) and Pulse Association South East (based at Scaddan) were formed in 1997. These groups provide a focus for the marketing, production, research and extension of pulses in each region and will have input into Pulse Australia.

Season 1998

The 1998 season in Western Australia (WA) will be remembered as one where pulse yields and quality was good, while prices were good to excellent. For the second year in succession, warm temperatures and moist conditions combined to produce serious infections of chocolate spot in August and September throughout most of the cropping areas. September frosts caused some damage to chickpea and field pea crops in southern areas, while faba bean and lentil appeared relatively unaffected. Serious infections of *Botrytis* grey mould were reported in some chickpea crops, mostly in the northern region.

Good demand from the Indian subcontinent and the outbreak of ascochyta blight of chickpea, which severely reduced production in eastern Australia, helped bolster chickpea prices to near record highs in 1998. A container of the superior quality chickpeas Sona and Heera were sent to Dubai for commercial splitting and test marketing. The quality of lentils produced in WA was excellent and an exporter paid a premium to growers as part of the early shipment contract with overseas buyers. Faba bean and field pea prices remained stable.

New varieties of chickpea (Sona and Heera) and field pea (King and Magnet) continue to show superior yield and quality over standard varieties. The first red lentil varieties Cumra and Cassab developed for short season environments of WA were commercially released in 1998 in collaboration with CLIMA. The performance of these varieties throughout southern Australia has been outstanding, particularly Cassab. A *Lathyrus cicera* variety (Chalus) with low neurotoxin content and superior seed yield was also released in collaboration with CLIMA. The new faba bean variety Fiesta showed considerable promise for WA conditions with a useful level of chocolate spot resistance, producing similar yields to Fiord but with improved seed quality.

Major pulse field days were organised in conjunction with each of the pulse grower associations: the Midwest Pulse Growers Association at Mingenew, the Central Districts Pulse Growers Association centred at Merredin, and the Pulse Association of the South East at Esperance. Pulse field walks were also held at trial sites, demonstration sites and farmers pulse paddocks

which allowed first hand observation of current work on pulse management and new varieties. A major achievement was the publication of 'The Chickpea Book - A Technical Guide to Chickpea Production'. The Pulse Western Australia Council, involving the presidents of the growers associations and research and industry representatives, was formed to discuss State pulse issues and provide overall industry coordination.

Season 1999

The 1999 season in Western Australia (WA) saw further expansion in the pulse cropping area with excellent quality grain and good prices. The good yields were the result of substantial stored soil moisture from summer rainfall, cool conditions together with good finishing rains during spring in most parts of the WA grain belt. Most areas received above average rainfall during 1999 with some transient waterlogging experienced in the early part of the season. Moderate frost in the Great Southern and Lakes districts, and hail in the North Midlands caused some damage to pulse crops.

The first outbreak of ascochyta blight in commercial chickpea crops was reported during the second part of the year in the northern and central cropping region. Botrytis grey mould was also reported in chickpea crops in the northern agricultural region. A record chickpea crop was harvested again in 1999 and a substantial quantity (about 40,000 t) was exported by early February 2000. The quality of chickpea was generally excellent, but some concerns were raised about the high proportion of discoloured, speckled and black seed in crops of the new varieties in the northern agricultural region.

Chocolate spot disease was a minor constraint for faba beans in WA in 1999. Consistent rains in August and September allowed delayed sown crops to escape most fungal disease problems and produce good yields. Better than expected yields, higher prices, a very low incidence of chocolate spot disease, and availability of a new variety (Fiesta) with improved seed quality and disease resistance combined with improved management, had many growers expressing a renewed interest in faba bean towards the end of 1999. A premium of $20-40/t was paid for human consumption quality Fiesta faba bean over standard varieties in South Australia (SA).

Demand for the seed of new desi chickpea (Sona and Heera), field pea (King, Magnet, Helena and Cooke), red lentil (Cassab and Cumra), and grass pea (Chalus) varieties remained strong. A premium of about $25-$40 per tonne was paid by WA grain traders for good quality Sona and Heera over the standard variety Tyson. Exports of high quality chickpea, field pea, faba bean, lentil and vetch continued from WA.

A limited area (about 500 ha) of very large seeded, high value kabuli chickpea (Macarena) was grown under irrigation in the dry winter conditions in the Ord River irrigation Area (ORIA). Commercial yields of high value kabuli chickpea (Macarena variety) exceeded 2.5 t/ha fetching a premium price of $1500/t. Promising lines from Spain and Mexico with greater seed size and yield than Macarena have been identified in the ORIA. Seed production of the lines has commenced in the ORIA.

For further details of previous year's results refer to the previous summaries of experimental results (Loss *et al.* 1994, 1995, Siddique and Loss 1996, Loss and Siddique 1997, Loss and Siddique 1998, Loss *et al.* 1999, and Regan *et al.* 2000).

2000 REGIONAL ROUNDUP

Northern Agricultural Region

M. Harries, AGWEST, Geraldton and **W. O'Neill**, AGWEST, Three Springs

The 2000 season was marked by heavy rain in February and March that allowed some growers to sow faba bean and chickpea crops in April. Most growers refrained from sowing early, because of concern about the potential for high disease levels in early sown crops. Unfortunately, suitable rains for sowing did not occur again until mid-June in most areas. Consequently, farmers reduced the area they had planned to sow to pulses. The season also had a sharp finish resulting in a shorter than normal growing season and consequently, reduced yields for all crops. Early sowing in 2000 appeared to be the key to obtaining high seed yields. Crops sown early were able to produce deeper roots that accessed soil moisture from the summer rain stored in the soil profile.

Strong grower interest was shown for faba bean by many growers in the region at the start of the season due to excellent yields and little disease incidence in faba bean crops in 1999. In addition, the price outlook for the 2000 season was high (~ $300/t) and the new variety Fiesta, which has better seed quality and higher disease resistance, was more widely available. Despite this interest, the late state to the season meant that the area sown to faba bean was lower in 2000 than in 1999 with many growers leaving their faba bean seed in the bin. Similarly, the chickpea area also decreased significantly in 2000, because of the late start and concerns over ascochyta blight, particularly in areas with a history of the disease (e.g. Mingenew). Many farmers planted field peas as an alternative pulse crop to faba bean or chickpea.

Chickpea yields ranged from 1.2 t/ha for early sown crops to 0.2 t/ha for very late plantings. Ascochyta reduced yields in a number of locations, particularly where the recommended management practices were not followed. Faba bean crops that were planted early produced about 1.2 t/ha, but yields were very low in later sown crops. There were no reports of significant disease problems in faba bean crops in the region. Field peas were less affected by the dry season and yields were in the range of 0.8 to 1.1 t/ha. The area of field pea production is expected to increase further in the northern agricultural region with the increased adoption of new varieties. Lentil also performed relatively well, with yields of about 0.8 t/ha.

The Mid West Pulse Growers Association (MWPGA), in collaboration with the Mingenew-Irwin group, held an annual field day exhibiting pulse trials in August. More than 100 growers attended. Marketing issues continued to be addressed by the MWPGA in 2000. At this stage, the MWPGA are continuing to trade through established traders due to the volatility in the market. In July, a record of over 30,000 tonnes of desi chickpeas was taken as a bulk shipment from the Geraldton port.

Central Agricultural Region

R. French, AGWEST, Merredin

The 2000 season was a difficult for pulse growers in the Central region. After excellent summer rain, which raised hopes of a good season, there were poor rains in May and a decisive break didn't come until mid-June. This meant that most pulse crops were sown well after the ideal time, some even as late as early July. The growing season rainfall was also well below average with almost a total absence of spring rainfall. Despite the season, lentil yields were good with crops producing between 0.6 to 1.0 t/ha. Field pea yields ranged from 0.2 to 1.3 t/ha and chickpea yields ranged from 0.2 to 0.8 t/ha. Because of the late start to the season the total area of pulses in the central region contracted in 2000, particularly for faba bean, however the area of field pea increased.

Despite late sowing and a dry growing season, ascochyta blight of chickpea was widespread in the region. Growers who undertook the ascochyta blight management package were able to successfully grow chickpeas. Early in the season some growers were concerned about the

extra costs of chickpea production associated with ascochyta blight management. However, chickpea prices reached a record high by the end of season and chickpea crops were still profitable with yields of 0.4 t/ha.

The Central Districts Pulse Grower Association (CDPGA) visited pulse trials in the region and held their Annual General Meeting concurrently with the project's Spring Coordination Meeting in Merredin at the end of August 2000. Several topics for research and demonstration work were identified by the CDPGA during the meeting.

Great Southern and Lakes

N. Brandon, N. Runciman and **S. White**, AGWEST, Great Southern

All regions in the Great Southern received lower than average annual rainfall in 2000. Some regions like Gnowangerup, Lake Grace, and Ongerup received the lowest or close to lowest April to October rainfall on record. Many crops would have failed, however above average summer rainfall allowed some moisture to be stored at depth in the soil profile.

Farmers were generally impressed with the performance of field pea. Seed yields of commercial crops and trials ranged between 0.5 and 1.0 t/ha. However, some field pea crops on lighter soil types in low rainfall regions performed very poorly. Chickpea, which has a strong taproot and is better able to access water stored deeper in the soil, also performed well during the season. The impact of ascochyta blight during 2000 was minimal under the dry conditions. Seed yields of faba bean were disappointing mainly due to the delayed sowing (late June). Faba bean also appeared to be unable to cope with the dry finish. Faba bean sown early at Hyden produced 0.6 t/ha and late sown crops in more favourable rainfall regions produced similar or slightly greater seed yields on better soil types. Clearly, the break to the season in late June was too late for faba bean on all but the very best soil types given the dry finish.

Major trial and demonstration sites in the Great Southern in 2000 were located at Gnowangerup and Ongerup in the medium rainfall zone and Lake Grace and Hyden in the low rainfall zone. Some of the trials at Gnowangerup were conducted in collaboration with SBS-IAMA, which provided a strategic link to the farming community and excellent exposure of trials at field days. The site at Lake Grace became a focus for the newly formed GSPGA. Smaller trials at Kendenup, Tambellup and Woodanilling targeted growers in the higher rainfall zones.

The 2000 season was not conducive to the development of fungal diseases, given the low winter rainfall and dry finish. Hence, older early maturing field pea varieties, such as Dundale, and faba bean varieties, such as Fiord and Barkool, performed relatively well in field trials.

The GSPGA, formed in March 2000, currently has 20 members and is likely expand quickly the coming years. The first major achievement of the group was the provision of a receival point for milling grade dun peas at Pingrup following negotiations with Cooperative Bulk Handling (CBH). Two field days organised by the group at Lake Grace were well attended.

Esperance Mallee

M. Seymour, AGWEST, Esperance

In a repeat of 1999, the year 2000 started with very high summer rainfall. Salmon Gums, a region that normally receives an average rainfall of 330 mm for the year, received 280 mm in the first three months of the year. Once again, this caused extensive flooding in the Esperance region and damage to paddocks, river systems and roads. It also led a widespread germination of plants, requiring paddocks to be sprayed for control of weeds and volunteer crops. The rain and subsequent stored moisture led to high farmer expectations for early sown crops. Unlike most of WA, the Esperance region received rain in April, which allowed to early sowing opportunities. The month of May saw very disappointing rainfall of only 4 mm at Salmon Gums. Growers who had delayed sowing to match maturity, or had not sprayed summer weeds and so had low soil moisture in the seedbed, did not get another opportunity to sow until late-May or

early-June. Subsequently, there was patchy emergence of crops in the Mallee. Rainfall for the remainder of the year was also below average and September had a record low rainfall throughout the State. Crop growth was reduced and grain filling occurred under water limited conditions. Screenings were high in cereals, and seed yields reduced by 25-50% in the Mallee. However, the dry winter conditions were beneficial by reducing disease pressure and waterlogging in July and August, given such heavy summer rainfall.

The pulse industry continued to expand in the Esperance region. The area sown to field pea increased to 11,000 ha, with many areas sown by first-time growers. Yields have been in the range 0.8-1.8 t/ha and generally, positive reports have been received about the performance of field pea crops and their ability to withstand the extended dry period. Screenings of field pea were lower in 2000 due to the change to a 4.76 mm sieve, which prevented this becoming a serious issue for growers delivering to the Esperance port.

The Pulse Growers Association of the South East continued to expand with 82 growers now becoming financial members. The group held very successful field days (5) with about 60 growers attending each event. New growers attending the field days obtained advice on agronomy from AGWEST staff, private company agronomists and other farmers. The occasional newsletter 'Setting the PASE', continued to provide timely advice to all Mallee farmers in the Esperance region. During the field day in October, the AGWEST bulletin 'Common Vetch Production Technology' was launched. This booklet provides a one stop guide to growing vetch in WA and has been well received by industry and farmers from WA and interstate.

Table 1. Monthly rainfall at experimental sites in 2000

Trial site	J	F	M	A	M	J	J	A	S	O	N	D	Total	M-O
Bindoon[A]	22	0	28	32	48	135	192	131	23	13	11	0	635	542
Borden	77	2	32	10	8	37	57	43	16	4	5	1	292	165
Cascades	92	85	98	35	13	24	34	55	8	8	6	11	469	142
Corrigin	207	0	20	31	5	37	60	39	10	0	5	7	422	151
Esperance DRS	89	68	138	51	38	27	41	58	15	18	18	14	575	197
Gnowangerup	98	1	16	8	9	35	67	45	21	2	21	2	325	179
Hyden	208	23	50	33	14	26	49	39	14	0	6	3	466	142
Jerramungup	147	32	8	12	11	44	34	0	12	16	4	2	321	116
Kalannie	105	0	108	15	2	15	39	28	20	1	0	n/a	333	105
Katanning	87	0	12	22	7	59	87	67	30	5	9	9	394	255
Kendenup	54	16	57	21	31	55	90	76	43	6	25	1	475	301
Lake Grace	168	9	7	7	3	37	50	30	5	5	3	1	325	130
Manjimup	51	25	30	63	62	115	221	150	76	37	35	16	881	661
Merredin	93	2	51	14	7	18	51	38	14	1	4	3	296	129
Mingenew	21	0	68	11	8	45	118	57	33	3	2	14	380	264
Mukinbudin	102	0	94	6	5	13	32	17	16	0	2	0	287	83
Mullewa	36	2	127	8	4	28	39	35[b]	21	2	0	4	270	94
Ongerup	115	8	32	16	5	40	55	40	15	5	23	2	356	160
Salmon Gums	109	61	136	26	5	9	23	24	7	2	4	9	415	71
Scaddan	109	50	151	42	20	24	36	39	9	20	6	11	518	148
Tammin	129	0	18	17	13	32	63	45	18	0	2	9	346	171

Where rainfall data was not available (n/a) at the experimental site or data was missing, the following sites were used: [a]Gin Gin.

PULSE PRODUCTION AGRONOMY AND GENETIC IMPROVEMENT

Faba bean

Germplasm evaluation

In recent years chocolate spot disease has had a major negative impact on the faba bean industry in WA. The area sown to faba beans in 1999 (~ 15,000 ha) was less than half that sown when the area was at it's peak in 1997 (~ 40,000). The main reason for the decline in the faba bean area is the severe chocolate spot outbreaks in 1997 and 1998 which reduced yields and dented growers confidence in the crop. The identification of faba bean varieties resistant to chocolate spot has been a major focus for faba bean development in WA since the 1997 epidemics. The inability to develop consistent levels of infection in trials however, has been an impediment to this work. Disease screening nurseries were therefore developed in 2000 with the aim of evaluating faba bean germplasm under consistently high chocolate spot, ascochyta, or rust pressure.

Nurseries were established at Dongara, Merredin, Katanning and Esperance on growers' properties or AGWEST research stations. Nurseries were set up to ensure a close rotation (1:1 cereal:faba bean) could be followed. In 2001, wheat will be grown on the plots where faba bean was grown in 2000 and new faba bean plots will be established adjacent to these plots. The tight rotation and the close proximity of each year's plots to the previous year's plots should encourage chocolate spot to develop in the nurseries. In addition, faba bean stubble infected with *Botrytis fabae*, the fungus that causes chocolate spot, was spread over all sites in 2000.

Because of the late opening rains in most areas, the nurseries could not be established until early June at Dongara and Merredin. Irrigation, however, allowed the plots to be established in early May at Katanning and good early rains along the south coast allowed the nursery to be sown in late April at Esperance. Unfortunately, chocolate spot disease did not develop to any significant degree in any of the nurseries despite spreading the diseased stubble. Nevertheless, moderate to severe ascochyta blight occurred on the faba beans grown at Katanning and moderate rust pressure occurred in the nursery at Esperance. Slight chocolate spot disease, which did not affect yields, occurred late in the season at Dongara and no disease of any consequence occurred in the nursery Merredin. It is expected that, given favourable circumstances, a higher level of chocolate spot should gradually build up in these nurseries over time.

Fiord performed consistently well at all sites, producing the highest or equal highest yield all sites except Merredin (Table 2 to 5). Fiesta produced a similar yield to Fiord at Merredin, but produced only 60% to 80% of the yield of Fiord at the other sites. Barkool produced high yields at Katanning and Merredin, but produced 80% of the yield of Fiord at Dongara and Esperance. Few accessions or crosses tested produced consistent results. The crossbreds 286*970/3/4 and 286*970/2/8 produced relatively high yields at Merredin and Dongara and had a low ascochyta ratings (similar to Ascot) at Katanning. These crossbreds produced similarly high yields and low ascochyta ratings at Gnowangerup in 1999, and have potential for short season environments in WA. These crosses produced flowers and pod at similar times or earlier than Fiord and performed best at Merredin which had the shortest growing season in 2000. These lines combine the early maturity (Acc286) and ascochyta resistance (Acc970) of their parents. Further crosses with these lines to incorporate chocolate spot resistance are being developed by the National Faba Bean Improvement Program (NFBIP). Acc482 also produced a high yield, and flowered and podded at similar times as Fiord at Merredin. At the other sites this accession produced less than 80% of the yield of Fiord but in 1999 it produced the same yield as Fiord. This accession has some chocolate spot resistance but relatively poor ascochyta or rust resistance and will be evaluated further in 2001. Some Icarus x Ascot crosses (Ic*As7/5, Ic*As7/3 and Ic*As31/5) produced relatively good yields at the southern sites but performed poorly at Dongara.

Accessions (Acc1405/1 to Acc1421/1) obtained from ICARDA after being selected for early flowering entered the evaluation trials for the first time in 2000. These accessions produced low yields relative to Fiord. The highest yielding line from this group was Acc1419/1, which produced about 1.7 t/ha at Dongara (73% of the yield of Fiord). The highest yielding line relative to Fiord was Acc1407/1, which produced 81% of the yield of Fiord at Katanning. Most of these lines produced flowers and pods at similar times to Fiord and had similar ascochyta and rust scores. None of the lines was exceptional in terms of disease resistance or earliness. More lines selected for these traits from ICARDA will be evaluated in 2001.

Despite yielding higher than other lines, Fiord, clearly showed greater susceptibity to rust (Esperance) or ascochyta blight (Katanning). At Esperance, Fiord was rated very susceptible and showed rust pustules commonly on leaves and stems that covered more than 80% of the leaf area. No line was rated more susceptible to rust than Fiord, although several plants were rated as moderately resistant to rust (Acc1253/1 and Ic*As7/3) and were relatively high yielding (> 1.5 t/ha). At Katanning, Fiord showed moderately severe ascochyta disease symptoms during vegetative growth while few symptoms were noted on Ascot, an ascochyta resistant variety. Nevertheless, Ascot produced slightly lower yields (~ 50 kg.ha) than Fiord.

The chocolate spot at Dongara was only slight and did not affect the yield of plants. In contrast, the severity of ascochyta was negatively correlated with yield ($r^2 = -0.41$) at Katanning. Time to flowering or podding was not related to yields at Katanning, probably because the trial was sown early and irrigated at the start of the season. At Merredin days to start of podding showed the strongest correlation ($r^2 = -0.39$) to grain yield. Rust did not effect the yield of plants at Esperance despite the apparent severity of the disease. The disease was most severe during the latter part of the season and affected the leaves of the plants when most of the yield had already been formed. Plant density showed the strongest correlation to seed yield at Esperance ($r^2 = 0.52$).

Table 2. Plant density (plants/m^2), days to flowering or podding, ascochyta score and seed yield (kg/ha) of selected faba bean lines at Katanning (00GS01). Sown 1 May

Line	Plant density	50% flowering	50% podding	Ascochyta score[a]	Seed yield	Seed yield (% Fiord)
Ascot	44	95	113	2.7	1253	95
Barkool	48	84	107	6.3	1358	103
Fiesta	32	94	122	5.0	813	61
Fiord	42	84	109	6.0	1323	100
Icarus	22	117	130	6.7	560	42
Manafest	31	96	118	6.3	1198	91
Ic*As22/6/DAW52	39	102	120	5.0	1341	101
Ic*As7/5	28	102	121	5.0	1299	98
Ic*As7/3	29	101	121	4.3	1283	97
Ic*As31/5	43	95	112	4.3	1290	97
Ic*As30/5	34	103	117	4.7	1241	94
Acc415/1	28	98	116	3.3	1248	94
Acc1266/3	27	108	117	4.5	1183	89
Acc610	28	84	113	4.0	1170	88
Acc1038	28	85	113	4.0	1150	87
Acc278/1	24	94	117	4.0	1157	87
Ic*As30/4	40	101	120	5.3	1135	86
Acc1275/2	36	104	117	5.0	1084	82
Acc1407/1	29	101	133	6.7	1076	81
Acc482	31	91	119	5.3	1076	81
Acc278/2	27	95	117	4.3	1051	79
286*970/4/5	21	91	124	3.0	1038	78
Ic*As12/4	34	100	120	5.0	1001	76
286*970/2/8	21	77	112	3.0	990	75
Ic*As12/6	31	103	124	4.0	934	71
Acc1020	31	86	110	5.3	939	71
286*970/3/4	26	80	106	3.0	907	69
Ic*As35/3	32	103	121	4.3	856	65
Acc983	24	91	119	6.3	865	65
Acc1408/1	30	82	113	5.5	797	60
Acc1415/1	24	89	118	6.7	787	59
286*970/14/2	18	90	125	3.0	774	58
Rebaya	34	86	110	6.0	736	56
Acc1022	41	89	118	6.0	745	56
Ic*As12/2	29	106	120	3.0	705	53
Acc1418/1	26	79	114	6.3	566	43
Acc1266/1	30	106	124	6.3	546	41
Acc1241/1	24	123	122	5.5	534	40
Acc1411/1	28	75	115	8.0	329	25
LSD 5%	8.3	8.2	8.1	1.32	324.1	na
CV%	17	5	4	16	22	na

[a] Ascochyta score: 1 = slight to 9 = severe.

Table 3. **Plant density (plants/m²), days to 50% flowering or podding, lodging score, chocolate spot score and seed yield of selected faba bean lines at Dongara (00GE03). Sown 2 June**

Line	Plant density	Lodging score[a]	Chocolate spot score[b]	Seed yield (kg/ha)	Seed yield (% Fiord)
Aquadulce	16	3.2	1.0	1083	45
Ascot	42	1.0	1.7	1666	69
Barkool	47	1.0	2.3	1956	81
Fiesta	27	1.0	1.0	1980	82
Fiord	41	1.2	1.7	2406	100
Icarus	25	1.0	1.0	1190	49
Manafest	25	1.0	1.0	1333	55
Acc610	27	1.0	2.0	2214	92
286*970/3/4	21	1.0	1.3	1988	83
Acc1038	23	1.2	1.0	1961	82
286*970/2/8	22	1.0	1.0	1950	81
Acc575	28	1.3	1.0	1920	80
Acc524	30	1.2	2.3	1911	79
Acc278	26	1.0	2.7	1853	77
Icarus/DAW51	29	1.0	1.0	1848	77
Acc278/2	20	1.0	1.0	1846	77
Acc1020	28	1.8	2.0	1818	76
Acc823	34	1.5	1.7	1815	75
Acc115/3	27	1.0	1.3	1788	74
Ic*As12/2	28	1.2	1.0	1780	74
Acc982	26	1.0	1.0	1768	73
Ic*As7/3	26	1.2	1.0	1765	73
Acc1419/1	25	1.0	1.3	1756	73
Acc278/1	17	1.2	1.3	1710	71
Acc482	28	1.0	2.0	1706	71
Ic*As31/5	39	1.0	2.0	1643	68
286*970/4/5	14	2.0	1.3	1606	67
Rebaya	31	1.0	2.0	1576	66
Ic*As12/6	25	1.0	1.3	1575	65
Ic*As54/3	27	1.0	1.3	1545	64
286*970/14/2	17	1.5	1.0	1498	62
Ic*As30/4	38	1.0	1.0	1488	62
Ic*As12/4	28	1.0	1.8	1481	62
Ic*As30/5	36	1.0	1.7	1421	59
Acc1287/5	26	1.0	1.5	1417	59
Acc1418/1	28	1.0	1.0	1383	57
Ic*As22/6/DAW52	35	1.0	1.3	1146	48
Acc1247/3	28	5.3	1.3	913	38
Acc1231/2/DAW9	25	1.0	1.5	400	17
LSD 5%	7.1	0.56	0.89	365.1	na
CV%	16	26	43	14	na

[a] Chocolate spot score: 1 = slight to 9 = severe.
[b] Lodging score: 1 = erect to 5 = flat.

Table 4. Plant density (plants/m²) days to start of flowering or podding and seed yield (kg/ha) of selected faba bean lines at Merredin (00ME01). Sown 6 June

Line	Plant density	Days to start of flowering	Days to start of podding	Seed yield	Seed yield (% Fiord)
Ascot	31	86	100	262	59
Barkool	28	85	98	502	114
Fiesta	24	85	99	434	98
Fiord	33	84	98	441	100
Manafest	14	85	98	232	53
Acc482	26	86	99	470	107
286*970/2/8	19	83	98	456	103
286*970/3/4	14	83	98	428	97
Acc1020	18	84	98	388	88
Ic*As7/5	19	96	99	383	87
Ic*As7/3	15	86	100	366	83
Acc278/2	19	86	100	339	77
Acc1418/1	16	83	98	337	76
Acc415/1	14	96	102	329	75
Ic*As12/4	21	86	100	325	74
Acc1420/1	21	83	98	321	73
Acc779	13	84	98	315	71
Acc278/1	19	90	102	310	70
Ic*As12/6	22	87	101	286	65
Acc1411/1	17	84	98	284	64
Acc1410/1	19	83	98	274	62
Acc1038	23	86	99	272	62
Ic*As31/5	45	77	100	272	62
Rebaya	20	84	98	269	61
Ic*As35/3	29	96	106	268	61
Acc1408/1	22	84	98	267	61
Acc1419/1	16	84	99	263	60
Ic*As30/5	29	95	106	258	58
Acc823	21	84	98	247	56
286*970/3/5	10	90	101	233	53
Acc1417/1	19	83	98	221	50
Acc1409/1	15	86	99	217	49
Ic*As54/3	20	96	106	217	49
Ic*As30/4	32	100	108	193	44
Ic*As22/6/DAW52	32	100	108	193	44
Ic*As12/2	18	91	102	177	40
Acc1407/1	23	91	103	147	33
286*970/14/2	10	94	104	129	29
Acc1421/1	23	96	106	94	21
Acc1413	16	86	99	87	20
LSD 5%	7.6	7.8	4.1	150.2	na
CV%	22.6	5.4	2.5	33.1	na

Table 5. Plant density (plants/m²) days to 50% of flowering or podding, rust score and seed yield (kg/ha) of selected faba bean lines at Esperance (00ES01) sown 20 April

Line	Plant density	50% flowering[a]	Rust score[b]	Seed yield	Seed yield (% Fiord)
Aquadulce	19	100	6.7	858	44
Ascot	46	97	7.7	1126	57
Barkool	47	84	8.0	1561	79
Fiesta	35	85	7.0	1472	75
Fiord	43	72	7.7	1967	100
Icarus	26	120	5.3	1301	66
Manafest	24	92	6.3	1512	77
Acc524	40	78	7.3	1785	91
Acc1253/1	34	118	5.5	1665	85
Ic*As7/5	28	84	7.0	1589	81
Acc1038	30	94	6.7	1589	81
Ic*As7/3	30	97	6.3	1581	80
Acc1020	32	70	7.0	1569	80
1270/4	34	97	6.0	1537	78
Rebaya	35	60	7.7	1524	77
Ic*As35/3	42	101	6.3	1492	76
Acc278	20	92	7.0	1472	75
Ic*As31/5	42	85	7.3	1455	74
Ic*As22/6/DAW52	40	101	6.0	1407	71
286*970/3/4	25	69	7.7	1394	71
Ic*As54/3	31	106	6.3	1390	71
Ic*As30/5	34	92	6.7	1337	68
Acc575	36	83	7.3	1305	66
Acc482	35	84	7.0	1297	66
Acc415/1	25	93	6.7	1285	65
Ic*As12/2	31	100	6.0	1268	64
Acc610	32	86	7.0	1260	64
Ic*As30/4	36	94	7.0	1236	63
Acc115/3	28	64	7.0	1211	62
Acc278/1	21	93	6.7	1199	61
Ic*As12/4	32	85	7.0	1126	57
Ic*As12/6	32	100	7.0	1073	55
Acc1419/1	23	64	7.7	1073	55
Acc1418/1	26	77	7.0	1065	54
Ic*As12/8	30	87	7.0	1041	53
286*970/14/2	15	92	7.0	1004	51
286*970/4/5	20	85	7.7	785	40
LSD 5%	7.8	-	0.85	350.7	na
CV%	15.7	-	7.6	16.4	na

[a] Days to flowering was determined on one rep only.
[b] Rust score: 1 = slight, 9 = severe.

Variety evaluation

Two new varieties of faba bean have been released in WA over the past two years. Manafest was released in 1996, but has only recently become available in WA while Fiesta was released in 1998; both varieties were released by NFBIP. Fiesta has moderate resistance to chocolate spot and ascochyta and has medium sized seed (~ 60-65 g/100 seeds), but is slightly later flowering than Fiord. Manafest has good resistance to chocolate spot and is tolerant to iron and manganese deficiency, has larger seed than Fiesta (~ 90 g/100 seeds), and is late flowering. The suitability of these varieties to the Western Australian growing environment has not been thoroughly assessed. In South Australia, Fiesta has generally produced similar or higher yields than Fiord, however in trials conducted in WA, Fiesta has produced about five to seven per cent less grain than Fiord or Barkool, the highest yielding and most widely suited varieties in WA. Manafest has not yet been tested in variety trials in WA, but has produced relatively low yields in the germplasm screening nurseries in 1999.

Faba bean varieties were evaluated over eight locations in 2000 (Tables 6 and 7). Trials at Lake Grace and Gnowangerup were part of a larger trial investigating the effects of fungicide spray on seed yield of faba bean varieties. Fungicides did not affect yields in these trials because disease levels were very low. Data has been averaged across fungicide treatments when presented here. Manafest was not tested at Lake Grace or Gnowangerup because insufficient seed was available.

Table 6. Plant establishment (plants/m²) in faba bean variety trials

Variety	Tammin 00AD01 20 June	Salmon Gums 00ES20 5 May	Dongara 00GE04 1 June	Mingenew 00GE05 17 June	Merredin 00ME02 7 June	Scaddan 00ES04 22 May	Gnowang-erup 00GS03 21 June	Lake Grace 00NE05 15 June	Mean
Ascot	58	58	66	46	46	54	61	67	55
Fiord	48	48	54	43	40	53	49	56	48
Manafest	31	27	30	33	27	27	na	na	29
Fiesta	40	46	45	43	28	32	37	43	39
Barkool	54	59	63	46	40	62	58	59	54
LSD 5%	9.1	7.9	10.1	18.1	6.4	6.0	4.1	4.5	na
CV	12	10	13	27	12	10	8	8	na

Table 7. Seed yields (kg/ha) in faba bean variety trials

Variety	Tammin	Salmon Gums	Dongara	Mingenew	Merredin	Scaddan	Gnowan-gerup	Lake Grace	Mean	Mean % Fiord
Ascot	168	330	1626	1173	278	1024	381	475	815	65
Fiord	388	503	2486	1447	458	1657	510	790	1251	100
Manafest	126	371	1372	861	219	1004	na	na	659	57
Fiesta	223	507	1647	1012	361	1085	327	654	910	73
Barkool	330	521	2268	1428	468	1340	608	719	1162	93
LSD 5%	97.6	117.1	273.1	50.4	88.7	140.1	135.1	131.6	na	na
CV	26	17	9	28	16	10	29	19	na	na

Plants established well in all trials (Table 6). Plots were sown at a constant sowing rate (200 kg/ha) so that differences in plant establishment between varieties were caused by difference in seed size. Manafest the variety with the largest seed was established at the lowest plant density, while Ascot, which has slightly smaller seeds than Fiord, was established at the highest density. In general, all plots were established within an optimal range so that yields were not constrained by low plant density.

Seed yields produced in the trials ranged from less than 200 kg/ha to more than 2000 kg/ha (Table 7). This large variation can be explained by the unusually late and variable start to the season, coupled with a dry September in some parts of the grainbelt. Diseases did not significantly affect the growth of plants at any site.

Fiord and Barkool consistently produced higher yields than other varieties. Averaged over all sites, Fiord produced 7% more grain than Barkool, which in turn, produced 20% more grain than the next highest yielding variety, Fiesta. With the exception of Salmon Gums where Fiesta produced the same yield as Fiord, Fiesta produced only 60% (Tammin) to 80% (Merredin) of the yield of Fiord which was considerably lower than in previous years. Ascot similarly produced lower yields than in previous years relative to Fiord. Manafest also performed poorly relative to Fiord, producing between 30% (Tammin) to 70% of the yield of Fiord.

The superior performance of Fiord occurred at the driest, lowest yielding site (Tammin) as well as the wettest, highest yielding site (Dongara). The gap between Fiord and the other varieties as indicated by highest relative yield of Fiord against each other variety, was greatest at the dry site, Tammin. Fiord was also the highest yielding variety in trials conducted in 1999, a relatively, wet, long and high yielding year, but in 1999, the gap between Fiord and other varieties was lower. These results show that, in the absence of disease, Fiord is the most widely adapted variety in WA being suited to both wet and dry environments. Most other varieties are better suited to medium to high rainfall environments and only approach the yield of Fiord in these situations.

Fiord and Barkool (a selection from Fiord) are susceptible to all major faba bean diseases (ascochyta, chocolate spot and rust) occurring in WA, whereas the Fiesta, Manafest and Ascot contain some resistance to either one or all of these disease. Significant disease pressure did not occur in the variety trials conducted in 1999 or 2000. Under conditions of moderate to severe disease pressure it is likely that Fiord and Barkool will produce relatively lower yields compared to the other varieties.

Sowing rate and time of sowing

Research conducted in WA with Fiord faba bean show that 45 plants/m^2 is the economic optimum planting density for this small seeded variety. New larger seeded varieties (Fiesta) are now available in WA and are gaining popularity. These varieties have different growth habits and phenology compared with Fiord. In addition, chocolate spot has become an important constraint to faba bean production and various agronomic strategies (e.g. delayed sowing) are now used to manage this disease. All of these factors will affect the relationship between plant density and yield. It is therefore appropriate to re-examine the optimum sowing rate for faba bean under these new conditions.

This study is a continuation of work that has been conducted for the past three years over several locations in WA. Fiord, Ascot and Fiesta, which differ in seed size and level of disease resistance, were grown at two sowing times at five locations: Dongara, Merredin, Katanning, Scaddan and Salmon Gums in WA. Chocolate spot infected stubble was spread over the trials in order to encourage the development of disease. Results are not presented for Dongara or Salmon Gums The late start to the season also forced the first time of sowing treatment at Merredin to be sown dry which led to lower and uneven plant establishment.

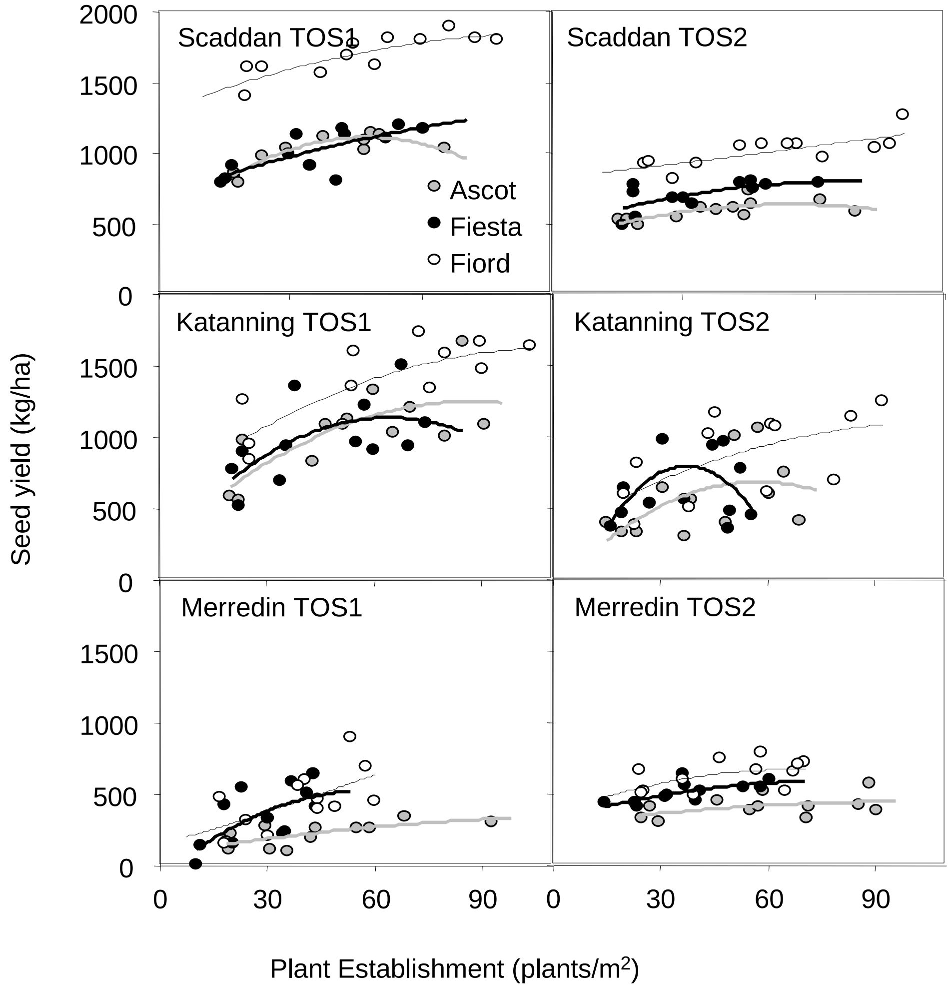

Figure 3. Seed yield response of three faba bean varieties to increasing sowing rate at Scaddan, Katanning and Merredin.

Fiord produced the highest yield at both sowing times at all sites and at most seeding rates (Fig. 3). The relationship between plant density and yield, however, changed with variety and sowing time. These differences were similar between sites. At most sites and sowing times Ascot was less responsive to sowing rate than Fiord. This was shown by the generally flat response curve for Ascot where yields increased by less than 50% from the lowest to the highest planting density. In contrast, the response curve for Fiord was steep with yields continuing to increase up to the highest plant densities. The response of Fiesta to plant density was to be intermediate between Fiord and Ascot

Delayed sowing tended to decrease yields (except at Merredin where the first time of sowing was planted dry) and reduce the response to sowing rate. Response curves were flatter for all varieties at the second time of sowing and there was a greater tendency for yields to begin to decline at high plant densities (particularly for Ascot and Fiesta).

The number of pods per plant decreased substantially with increased plant density and delayed sowing (Tables 8, 9 and 10). The number of seeds per pod and the mean seed weight, however, was generally unaffected by increased plant density, but decreased with later sowing time. Mean seed weights for all varieties at both sowing times, however, were substantially lower than expected. These effects were generally similar at all locations although some variation occurred.

Seed staining was substantially worse at the second time of sowing compared to the first and, in general Fiord showed a greater level of staining than Ascot and Fiesta. The seed staining was unlikely to be caused by fungal infection because disease levels in all trials were low during the season and the dry finish to the season was not conducive to fungal growth. The high levels of seed staining are thought to be a physiological response of the plant to drought stress and are

likely to contribute to high levels of hard seededness. This will be confirmed in subsequent tests to be conducted on the seed harvested from these trials.

Current recommendations for sowing rate for Fiord (45 plants/m^2) and Fiesta (30-35 plants/m^2) are consistent with these results when plants are sown early within the planting window. However, the results indicate that these recommended plant densities are likely to be too high in delayed sowing situations or low potential seasons such as occurred in 2000. Additionally, the greater proportion of small and stained seeds where sowing is delayed may lower value of the harvested product which would further reduced the economic optimum seeding rate. More extensive analysis of these results will be conducted in order to determine the economic optimum sowing rates for each variety under these conditions.

Table 8. Effect of sowing rate and time of sowing on the plant density (plants/m^2), seed characteristics and seed yield of Fiord, Fiesta and Ascot sown at Merredin (00ME19)

Variety	Sowing rate (kg/ha)	TOS 1 (2 May)				TOS 2 (26 June)			
		100	200	300	400	100	200	300	400
Ascot	Pods/plant	8.4	3.6	3.2	3.6	9.0	4.2	2.9	2.3
	Seeds/pod	2.1	2.2	1.8	1.8	1.7	1.6	1.6	1.4
	Seed weight (g/seed)	0.34	0.33	0.31	0.33	0.30	0.29	0.28	0.27
	% Stained	4	4	6	1	17	13	10	15
Fiesta	Pods/plant	5.9	5.8	3.8	4.5	10.7	6.0	3.6	3.4
	Seeds/pod	2.1	2.1	2.2	2.3	2.2	2.0	1.8	1.5
	Seed weight (g/seed)	0.43	0.44	0.42	0.48	0.43	0.43	0.36	0.54
	% Stained	2	5	4	3	5	6	7	7
Fiord	Pods/plant	14.9	7.4	6.7	3.8	12.9	7.4	5.2	3.4
	Seeds/pod	2.2	2.2	2.1	4.2	2.7	2.0	2.2	1.9
	Seed weight (g/seed)	0.34	0.33	0.34	0.25	0.28	0.30	0.28	0.28
	% Stained	10	10	9	11	19	15	17	15
		LSD 5%				CV%			
	Pods/plant	1.79				31			
	Seeds/pod	0.33				10			
	Seed weight (g/seed)	0.096				17			
	% Stained	9.2				23			

Table 9. **Effect of sowing rate and time of sowing on the plant density (plants/m²), seed characteristics and seed yield of Fiord, Fiesta and Ascot sown at Katanning (00GS02)**

Variety	Sowing rate (kg/ha)	TOS 1 (8 May)				TOS 2 (20 June)			
		100	**200**	**300**	**400**	**100**	**200**	**300**	**400**
Ascot	Pods/plant	16.4	12.5	10.4	9.6	10.4	6.0	4.4	4.1
	Seeds/pod	1.9	1.9	1.9	2.0	1.9	1.8	2.0	1.7
	Seed weight (g/seed)	0.40	0.39	0.37	0.36	0.31	0.28	0.30	0.31
	% Stained	5	5	6	7	8	6	8	9
Fiesta	Pods/plant	11.2	7.3	6.8	4.9	5.4	4.8	3.4	2.9
	Seeds/pod	2.3	2.4	2.3	2.3	2.2	2.0	1.8	2.0
	Seed weight (g/seed)	0.54	0.54	0.48	0.48	0.41	0.42	0.41	0.36
	% Stained	5	8	5	6	12	6	6	7
Fiord	Pods/plant	16.3	12.1	13.3	8.2	9.9	7.4	5.6	4.0
	Seeds/pod	2.0	1.9	2.0	2.0	1.9	2.1	1.9	1.9
	Seed weight (g/seed)	0.38	0.37	0.36	0.35	0.30	0.30	0.30	0.28
	% Stained	22	25	23	30	18	16	19	17
		LSD 5%				CV%			
	Pods/plant	2.95				22			
	Seeds/pod	0.59				22			
	Seed weight (g/seed)	0.053				9			
	% Stained	8.6				12			

Table 10. **Effect of sowing rate and time of sowing on the plant density (plants/m²), seed characteristics and yield of Fiord, Fiesta and Ascot sown at Scaddan (00ES02)**

Variety	Sowing rate (kg/ha)	TOS 1 (9 May)				TOS 2 (2 June)			
		100	**200**	**300**	**400**	**100**	**200**	**300**	**400**
Ascot	Pods/plant	8.3	4.9	4.6	3.8	10.8	5.8	5.3	5.5
	Seeds/pod	2.2	1.9	2.1	2.2	1.6	1.6	1.6	1.5
	Seed weight (g/seed)	0.43	0.44	0.43	0.42	0.37	0.37	0.38	0.37
	% Stained	2	2	3	3	5	4	3	5
Fiesta	Pods/plant	5.4	3.6	3.2	3.4	5.5	2.9	2.7	2.7
	Seeds/pod	2.7	2.5	2.4	2.2	2.4	2.2	2.1	2.1
	Seed weight (g/seed)	0.58	0.57	0.53	0.53	0.49	0.49	0.46	0.46
	% Stained	2	3	3	3	2	3	5	2
Fiord	Pods/plant	13.6	7.5	6.3	4.0	10.7	4.7	3.9	3.3
	Seeds/pod	2.2	2.2	1.7	2.1	1.9	2.2	2.4	1.9
	Seed weight (g/seed)	0.44	0.44	0.42	0.40	0.37	0.39	0.38	0.38
	% Stained	10	10	14	21	10	8	12	12
		LSD 5%				CV%			
	Pods/plant	2.99				33			
	Seeds/pod	0.57				17			
	Seed weight (g/seed)	0.025				3.5			
	% Stained	5.3				24			

Variation in root morphology

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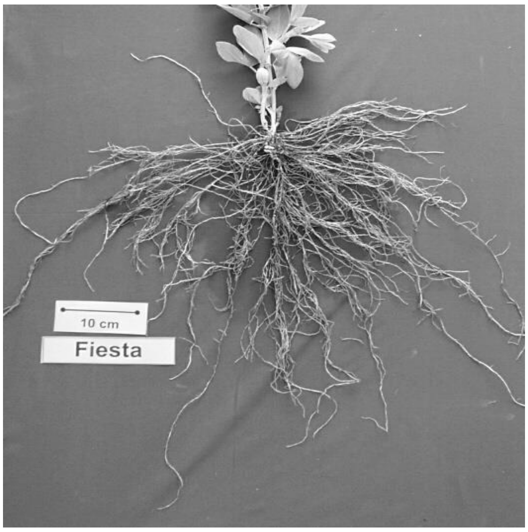
Faba beans are usually shallow rooting and have a reputation as drought sensitive plants. They are also not well adapted to acid, sandy soils. Restricted root penetration and subsequent limited access to stored soil moisture may be one of the reasons for the poor adaptation to sandy soils. It has been suggested that a modest enlargement in the root zone of faba beans will substantially increase their adaptation to low rainfall environments. It may also extend their adaptation the sandier soils, which have lower water storage capacities.

Various factors affect the ability of roots to extract soil water. These include, root morphology (size of taproot, number of lateral roots, frequency of lateral roots, root length, etc.), water uptake rate and root growth rate. Of these factors least is known about the root morphology and the genetic variation in root morphology with genotype.

An important current focus of the faba bean development work in WA is the selection of genotypes with greater adaptation and disease resistance in WA soils and environments. All of this work, however, is based on shoot morphology, phenology and yield. Variation in root morphology is not measured. It is impractical to measure root morphology in a conventional breeding and selection program that aim to screen large numbers of lines. Nevertheless, it is important to understand the range in root morphologies that may occur. This experiment examined the root morphology of 24 faba bean lines that have been collected from a diverse range of environments throughout the world. The morphology of roots of these lines was compared with that of varieties currently grown in WA.

Faba bean originating from climatic zones ranging from temperate (England), Mediterranean (Portugal) and tropical (Ecuador) environments as well as from hot, dry environments (Egypt) and relatively cold, wet environments (Norway) were used in this experiment (Table 11). The experiment was conducted in the glasshouse at South Perth. Plants were grown in large reinforced plastic bags that had a 50 cm diameter and 60 cm depth. Pots were filled with a red-brown sandy loam collected from the Medina research station. The soil was sieved and steam sterilised before being placed into bags. Three seeds of each of three lines were sown per pot, hence, each pot contained nine plants. Plants were inoculated with *Rhizobium leguminosarum* and watered daily with a nutrient solution containing all nutrients except nitrogen. Plants were harvested after eight weeks; most plants had begun flowering by this stage. At harvest, roots were washed free of soil using tap water.



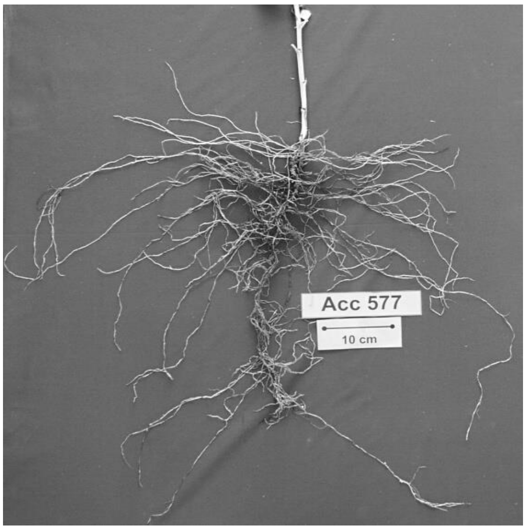


Figure 4. Appearance of the roots of faba bean lines, Fiesta (left) and Acc577 (right). The taproot appears to have been broken in Acc577.

There was no clear correlation between root characteristics and country of origin. There was a large range in root characteristics measured between lines, however, random variation in the data was also high. In addition, root breakage (particularly the taproot) occurred with some plants (Fig. 4). These factors must be considered when interpreting these results.

Table 11. Line number, country of origin and seed size of germplasm

Line	Country of origin	Seed size
Acc369	England	S
Acc376	England	S
Acc524	Swaziland	S
Acc553	Sweden	M
Acc577	Egypt	S
Acc611	Lebanon	L
Acc614	Belgium	M
Acc724	Norway	M
Acc779	Jordan	M
Acc792	Afghanistan	S
Acc846	Yemen	S
Acc937	USSR	M
Acc1018	Ethiopia	S
Acc1056	Turkey	M
Acc1060	Morocco	S
Acc1061	Crete	M
Acc1071	Sudan	S
Acc1123/1	China	M
Acc1143/1	Portugal	L
Acc1175	Pakistan	M
Acc1190	France	S
Acc1193	Bangladesh	VS
Acc1206	China	M
Acc1213/1	China	M
Acc1221	Ecuador	M
Acc1305/5	Turkey	M
Fiord	Greece	S
Fiesta	Spain	S
Aquadulce	Spain	M

L = large, M = medium, S = small, VS = very small.

Taproot length varied almost threefold between lines (Table 12). Much of this range, however was due to the exceptionally long taproot of Acc1018. Fiord, Fiesta and Aquadulce were generally in the group of lines with longer taproots. Taproot length was not well correlated with any other character. The length of the longest lateral root was generally similar or longer than the taproot for all lines except Acc1018, which indicate that few lines had a dominant taproot, however as mentioned, taproots of some plants had been broken during the root washing process.

Total root length also varied widely between lines but much of this variation was related to root and/or shoot weight. Correlation coefficients between total root length and shoot or root dry matter was 0.78 and 0.93 respectively. Despite this strong correlation there were wide differences amongst lines in the their relative proportions of shoot or root. For example the root weight/shoot weight ratio of Acc1123 was twice that of Acc553 despite both lines producing

similar root weights indicating a stronger investment by Acc1123 into roots than shoots compared to Acc553. Similar trends occurred in the root length/shoot weight ratio. The most consistent character amongst lines was the root length/root weight ratio, which indicated that most lines had roots of similar thickness. This, again, indicates that no line had a root system that was strongly dominated by a large thick taproot.

Table 12. Characteristics of the roots and shoots of several faba bean lines

Line no.	Taproot length (cm)	Longest lateral (cm)	Total root length	Shoot weight (g)	Root weight (g)	Root wt/ shoot wt	Root length/ shoot wt	Root length/ root wt
Fiesta	50.00	60.00	65.87	4.26	2.05	0.55	18.68	33.89
Aquadulce	49.83	62.67	81.65	4.50	2.95	0.78	23.17	28.78
Fiord	48.17	46.00	37.46	1.52	0.89	0.63	24.13	38.76
Acc1018	92.00	55.17	65.61	2.13	1.34	0.72	34.96	48.74
Acc1221	56.40	72.50	85.36	4.74	3.00	0.68	19.99	29.11
Acc1060	56.25	60.50	61.03	3.75	2.21	0.59	16.71	28.80
Acc553	50.50	62.00	71.63	5.52	2.15	0.46	16.59	35.19
Acc1190	48.83	55.33	51.33	2.28	1.36	0.59	22.55	38.82
Acc1071	48.33	37.00	24.41	2.14	0.68	0.33	12.50	37.00
Acc1305	48.17	75.33	78.94	3.75	2.40	0.68	22.64	33.54
Acc1061	46.40	56.17	58.01	2.73	1.75	0.71	23.51	33.79
Acc1175	45.75	78.00	80.14	3.35	2.19	0.70	24.76	37.68
Acc614	45.00	63.33	66.92	4.29	2.58	0.67	19.82	28.57
Acc724	44.20	56.83	68.78	4.31	2.26	0.56	17.90	31.23
Acc1123	43.83	50.00	56.94	2.35	2.07	0.93	24.58	27.03
Acc937	43.80	62.00	95.91	6.07	3.08	0.55	16.94	31.53
Acc611	42.67	63.17	76.34	3.50	2.43	0.72	22.05	31.56
Acc1143	42.67	64.83	82.24	8.54	3.16	0.38	11.41	29.68
Acc524	41.50	42.00	31.41	0.96	0.74	0.82	35.97	43.72
Acc792	41.40	60.33	67.49	2.58	2.10	0.85	27.40	32.34
Acc577	40.25	56.83	38.06	2.10	1.19	0.58	18.29	31.72
Acc1193	38.33	26.00	11.36	0.82	0.31	0.41	15.36	37.16
Acc369	37.50	48.83	33.22	1.24	0.99	0.86	28.70	33.66
Acc846	36.40	54.50	63.10	4.09	1.52	0.41	17.61	46.22
LSD 5%	14.008	16.5	31.1	3.449	1.131	0.267	11.611	11.211
CV	14	14	25	49	29	20	26	16

These results indicate the faba bean germplasm from a wide range of environments are unlikely to vary strongly in the dominance of their taproot. Most faba bean germplasm is likely to have a fairly weakly dominant taproot. However, wide variation amongst germplasm is likely to occur in the length of roots; both in terms of total length and the length of roots relative to shoots. It remains to be tested as to whether the type of variation observed in this experiment has implications for the ability of plants to adapted to different soils and rainfall environments. Further studies will be conducted under conditions where taproot expansion is not restricted.

Desi chickpea

Breeding highlights

The WA chickpea breeding project is a node of the Australian Coordinated Chickpea Improvement Program (ACCIP). It started in 1992 to develop germplasm for short season environments. The focus is on desi types, due to their wider adaptation in this region, but a limited kabuli program is also included. The course of the program has changed twice due to the ascochyta blight (*Ascochyta rabiei*) epidemic. In 1996 the presence of ascochyta blight was confirmed in the Eastern States and consequently, the WA program became isolated due to the quarantine ban on import of segregating material from the core Program (Tamworth, NSW). In 1999, ascochyta blight was found in WA and this had a profound effect on the future direction of the WA program. Current industry funding is also ending on 30 June 2001. Changes are anticipated that will lead to the following priorities:

- Screening for ascochyta blight resistance of all currently developed germplasm.
- Critical risk assessment of all near-release varieties for ascochyta blight.
- A crossing strategy that develops ascochyta blight resistant germplasm.
- Vigorous introduction effort to obtain wide sources of ascochyta blight resistance.
- Developing germplasm for cooler southern areas to widen the adaptation of chickpea.

In 2000, the chickpea breeding program initiated screening for ascochyta blight resistance, but continued with agronomic evaluation of the germplasm developed so far. Over 6,500 field plots were sown at Dalwallinu, Wilgoyne and Merredin. The disease nursery was developed at Medina. The Wilgoyne site became infected with ascochyta blight and was not harvested. The epidemic, unfortunately, was not uniform to allow for the assessment of ascochyta blight resistance at Wilgoyne. Uniform infection developed at Medina where ascochyta blight reaction was rated at pre-flowering and podding stages. None of the lines currently in AGWEST's Cultivar Variety Testing (CVT) stage three and four trials showed any resistance. Resistance was found in the lines that were assembled as a disease nursery by the core Program of the ACCIP (Table 13). Most resistant lines were of kabuli type, but the desi lines ICC13729, ICC14903 and ICC12004 also showed good resistance. Unfortunately, the seed quality of these lines is poor. Less resistant desi lines Paidar-91, ICCV96828 and ICCV96834 were more resistant than our current varieties and they have acceptable seed quality.

The advanced breeding trials for agronomic evaluation of the elite fixed lines were carried out at Dalwallinu, Wilgoyne and Merredin. In this dry season a great number of breeding lines outyielded the current chickpea varieties. The 20 highest yielding lines are presented in Table 14. Most lines originate from cold tolerance crosses of Dr Heather Clarke. The two best yielding lines, 94C001-7-21 and 94C001-7-7, also have the most outstanding seed colour. All lines will be screened against ascochyta blight in 2001 before their future is determined.

In 2000, the lines 8825-20H, WACPE 2012 and WACPE 2013 were being considered for release. Line 8825-20H has now been discarded due to its susceptibility to ascochyta blight. The latter two lines will be assessed in several replicated disease trials to determine their ascochyta blight reaction in comparison to Sona. This will allow a decision on the future of these lines.

Table 13. Seed yield (% Tyson), ascochyta score (0-4 rating, 4 most susceptible), mean seed weight (g/100 seeds) and seed colour (1-9 scale, 1 most desirable) for desi chickpea lines with potential ascochyta blight resistance

Variety/line	Seed yield (Merredin)	Ascochyta Score at Medina		Mean seed weight	Seed colour
		Pre-flowering	Podding		
Heera	107	3.5	4	19.40	4
Sona	110	3.75	4	17.49	3
Tyson	100	3	3.75	12.89	5
Kaniva	97	4	4	41.54	K[a]
ICC13729	96	1	1.75	12.84	9
ICC14903	87	1.5	1.75	12.64	9
Flip 94-62C	104	1.5	1.75	30.98	K
S95360	82	1.5	1.5	30.07	K
S95425	92	1.5	2.25	30.14	K
ICC12004	101	1.75	2	12.95	8
Flip 94-73C	86	1.75	1.75	35.07	K
Flip 94-32C	80	2	2	32.81	K
Flip 94-90C	107	2	1.75	30.25	K
S 95099	101	2	2.5	29.41	K
S 95313	72	2	2	32.38	K
S95443	102	2	2	21.98	K
ICC3996	104	2.25	2.25	12.33	8
ICC4475	76	2.25	2.5	11.25	9
Flip 94-102C	97	2.25	2.25	25.45	K
Flip 94-37C	87	2.25	1.75	31.71	K
Flip 94-508C	99	2.25	1.5	16.58	4
Flip 94-65C	95	2.25	2.25	29.17	K
Flip 94-93C	78	2.25	2	25.83	K
Flip 94-96C	69	2.25	2.25	25.5	K
S 95287	65	2.25	1.75	35.76	K
S95344	66	2.25	2.75	36.28	K
S95362	98	2.25	2.25	25.25	K
S95392	89	2.25	2.5	33.94	K
Flip 94-45C	82	2.5	2.25	30.24	K
Paidar-91	96	2.5	2.75	17.85	5
ICCV96828	96	2.5	2.75	23.45	5
ICCV96834	92	2.5	2.75	23.88	5
ICCV96836	97	2.5	3	16.11	4
Sona-4028	87	3	3.25	20.61	2
8511-19	100	3	3.5	20.36	3
9105-33N	95	3	3.75	18.55	1
90102-5Q	93	3.25	3.5	20.13	2
Tyson yield (kg/ha)	*1350*				

[a] Kabuli type.

Table 14. Seed yield (as % Tyson), mean seed weight (g/100 seeds) and seed colour score (1-9 scale, 1 most desirable) of 20 promising lines from advanced breeding trials lines (stage 22)

Name	Pedigree	Seed yield		Mean seed weight	Seed colour
		Dalwallinu	Merredin		
Amethyst	Control	148	119	14.32	5
Heera	Control	128	115	17.95	4
Sona	Control	95	118	17.23	3
Tyson	Control	100	100	11.25	5
Barwon	Control	67	93	17.70	3
94C001-7-21	CTS60543/FLIP84-15C	216	150	23.87	1
94C001-7-7	CTS60543/FLIP84-15C	222	142	25.77	1
91-35-16-2	90-140/90-153	190	158	23.17	4
94C002-29-25	CTS60543/AMETHYST	202	139	28.44	5
94C001-14-3	CTS60543/FLIP84-15C	207	138	20.13	1
WAD 032-8	ICCV 90008	202	138	23.40	4
HEERA-NF10	Re-selection from Heera	173	144	22.96	5
94C003-1-5	CTS60543/T1587	189	138	17.40	5
94C001-14-4	CTS60543/FLIP84-15C	210	134	23.78	1
94C001-7-19	CTS60543/FLIP84-15C	188	136	23.24	1
94C001-28-10	CTS60543/FLIP84-15C	193	134	26.35	4
WAD 223	ICCV 92904	178	137	26.51	6
HEERA-WF4	Re-selection from Heera	151	148	19.70	6
89-59-9W-8	Amethyst/T1587	185	134	15.40	6
WAD 214	ICCV 92064	160	137	17.65	6
WAD 233	ICCV 93004	170	132	22.51	6
94C001-1-8	CTS60543/FLIP84-15C	173	131	22.88	5
94C002-32-13	CTS60543/AMETHYST	141	138	15.17	6
94C002-29-18	CTS60543/AMETHYST	168	127	22.99	5
94C002-29-12	CTS60543/AMETHYST	158	128	19.62	6
Tyson's yield	*kg/ha*	*266*	*526*		

Variety evaluation

Crop variety testing stage three trials were conducted at five sites in 2000 (Table 15). Most of these lines originated from Dr Heather Clarke's crosses involving cold tolerant parents. As one of the parents was a kabuli line, the seed size is generally large and a few exhibit very desirable seed-coat colour. The dry conditions of the 2000 season greatly favoured the WA selected lines. Results show that 19 of the 24 lines outyielded Sona and 12 lines yielded 20% more than Sona. The high yielding line WACPE 2095 is particularly notable, because testing at SARDI in 1999 indicated that it has more resistance to ascochyta blight than Sona. All lines will be tested in ascochyta nurseries in 2001.

Table 15. Chickpea seed yields (kg/ha) from Crop Variety Testing stage 3 trials

Variety/line	Mingenew 00GE47 17 June	Watheroo 00BA28 30 May	Gnowangerup 00GS30 22 June	Mullewa 00MW20 16 June	Merredin 00ME66 16 June	Mean	Mean % Tyson
Tyson	989	456	167	677	278	513	100
Heera	1069	488	149	566	389	532	104
Sona	1012	445	148	667	510	556	108
WACPE2074	735	275	218	664	495	477	93
WACPE2075	1520	1118	305	696	682	864	168
WACPE2076	1174	398	393	756	626	669	130
WACPE2077	917	327	183	684	475	517	101
WACPE2078	1204	788	207	789	556	709	138
WACPE2079	1165	807	188	693	449	660	129
WACPE2080	1002	695	144	773	348	592	115
WACPE2081	1361	848	299	705	576	758	148
WACPE2082	995	375	186	616	662	567	110
WACPE2083	1198	-	194	711	515	655	128
WACPE2084	1188	516	274	742	545	653	127
WACPE2085	1213	769	239	690	525	687	134
WACPE2086	1218	598	378	779	515	698	136
WACPE2087	1364	534	391	752	576	723	141
WACPE2088	1353	903	202	826	475	752	147
WACPE2089	1091	442	258	790	434	603	118
WACPE2090	849	200	155	793	348	469	91
WACPE2091	1150	646	225	753	621	679	132
WACPE2092	762	565	282	694	495	560	109
WACPE2093	943	579	177	636	278	523	102
WACPE2094	833	272	106	796	308	463	90
WACPE2095	1071	866	390	835	566	746	145
WACPE2096	1150	620	232	674	515	638	124
WACPE2097	1159	645	207	619	475	621	121
Mean	1099	587	233	718	490		
LSD 5%	133	246	134	179	201		
CV%	6	21	29	12	20		

Desi chickpea varieties and advanced breeding lines in stage four CVT trials were tested at 11 sites during the 2000 season (Table 16). A late seasonal break together with below average rainfall and short growing conditions at most of the sites resulted in generally low and variable (> 20% CV) seed yields. The yield levels achieved in the CVT trials are comparable to that of farmer's chickpea crops in respective regions. Ascochyta blight was observed at a number of sites early in the season and all sites received two to four regular applications of Dithane at recommended rates. The disease was managed at most sites with the fungicide and other management packages (e.g. clean seed source, crop rotation, safe distance, etc.). The greatest mean seed yield was recorded at Mullewa (758 kg/ha) followed by Kalannie (710 kg/ha). Among the standard varieties, Sona and Heera produced on average 9 and 13% greater seed yield than Tyson, respectively. Four advanced breeding lines produced between 18 to 33% more seed yield than Tyson. However, ascochyta blight resistance testing of these lines in disease nurseries in South Australia and Medina showed that they have less resistance to the disease than Sona. The kabuli chickpea variety Kaniva produced about 20% less seed yield than Tyson with smaller seed size (< 7 mm diameter) at a number of drier sites.

Table 16. Chickpea seed yields (kg/ha) from Crop Variety Testing stage 4 trials

Variety/line	Mingenew 00GE48 17 June	Coorow 00GE66 15 May	Watheroo 00BA29 30 May	Lake Grace 00NE38 15June	Gnowangerup 00GS31 22 June	Mullewa 00MW21 16 June	Morawa 00GE54 12 June	Kalannie 00WH26 21 June	Merredin 00ME67 16 June	Tammin 00AD44 20 June	Mt Madden 00NE15 27 June	Mean	Mean % Tyson
Dooen	793	88	287	207	190	566	481	486	370	276	276	365	82
Heera	847	265	747	295	253	777	585	610	539	350	250	502	113
Kaniva[a]	646	76	578	221	288				340			358	81
Sona	786	360	455	311	268	709	569	603	471	391	385	483	109
Tyson	909	247	527	299	244	714	591	575	343	233	210	445	100
ICCV-88201	794	226	556	312	242	732	562	594	535	346	339	476	107
WACPE2003	1008	434	963	253	240	951	600	667	613	473	235	585	132
WACPE2013	753	317	194	299	206	727	544	581	374	352	321	424	95
WACPE2073	678	60	388	164	238				481			335	75
WACPE2012	804	438	844	278	423	848	723	667	586	405	484	591	133
WACPE2031	927	352	755	267	275	880	719	682	562	354	335	555	125
WACPE2044	699	315	399	341	344	758	577	710	552	436	624	523	118
Mean	804	265	558	271	276	766	595	617	490	362	346		
LSD 5%	110	113	296	86	91	105	131	60	176	102	267		
CV%	8	26	32	19	19	8	13	6	22	17	44		

[a] Kabuli variety.

Seed discolouration

C. Veitch, AGWEST, South Perth

In 1999 a premium was paid for Sona and Heera varieties due to their superior size and lighter seed colour compared to Tyson. However, a higher than expected proportion of discoloured seeds observed in some Sona and Heera deliveries resulted in downgrading to the Tyson segregation. Due to the implications to marketing of these varieties, seed discolouration of chickpea was examined in the glasshouse at South Perth and in the field at Merredin to determine if seed colour and staining carried over to the next generation of seed. The study examined three varieties (Sona, Heera and Tyson) and five specific seed conditions (black, speckled, spotted, tiger and 'normal'). Less discoloured seed of Tyson was available so the full range of discoloured seed types was not examined in Tyson.

Fewer black seeds were produced in the glasshouse than in the field, but plants grown in the glasshouse produced a significant proportion (30%) of dark tan coloured seeds. These were produced by plants grown from normal, black, spotted and speckled seeds. Although these seeds were darker than expected they were considered to be in the normal range and have been included with the normal coloured seed in the data presented here. The occurrence of these darker coloured seeds in the glasshouse, but not the field, indicates that there is an environmental component, as well as a genetic component in chickpea seed colour.

All plants grown in the glasshouse produced mainly normal seed, regardless of the colour of the seed sown, except for plants grown from speckled Heera seed which produced mainly speckled seed (Table 17). The largest proportion of normal seed was produced by plants grown from normal Sona seed. Black seed was only produced by plants grown from black seed.

Table 17. Proportion (%) of different seed types produced from desi chickpea varieties with varying seed colour when grown in the glasshouse at South Perth

Treatment		% Seed produced				
		Black	Normal	Speckled	Spotted	Tiger
Heera	Normal	0	66	32	0	2
	Black	21	79	0	0	0
	Speckled	0	33	62	2	2
	Spotted	0	80	0	6	15
	Tiger	0	64	1	15	20
Sona	Normal	0	96	0	0	4
	Black	21	59	20	0	0
	Speckled	0	69	31	0	1
	Spotted	0	67	0	3	30
	Tiger	0	66	20	0	14
Tyson	Normal	0	100	0	0	0
	Speckled	0	100	0	0	0

Plants grown in the field tended to produce a greater proportion of normal coloured seed than plants grown in the glasshouse, except for plants grown form black or speckled coloured seed (Table 18). Plants grown from normal seed produced 100 and 67% normal seed for Heera and Sona, respectively. Sona also produced 33% speckled seed from normal sown seed. Sona plants grown from black seed produced a high proportion of black seeds with only 2% normal seeds and 14% speckled. Heera, on the other hand, produced 45% normal and only 63% black seeds from black sown seeds with the remainder being speckled. Both varieties produced 100% normal seeds from seeds sown with tiger stripe markings. Speckled Tyson seed produced mainly normal seed with only 1% speckled.

These results indicate that crops grown from a seed lot that contains discoloured seed would tend to produce higher proportions of normal coloured seed than occurred in the original seed lot. The proportion of spotted and tiger striped seeds would tend to diminish more quickly than the proportions of black and speckled seeds. Environment, however is likely to affect seed colour and more information of these effects is needed.

Table 18. Proportion (%) of different seed types produced from desi chickpea varieties with varying seed colour at Merredin

Treatment		% Seed produced				
		Black	Normal	Speckled	Spotted	Tiger
Heera	Normal	0	100	0	0	0
	Black	63	45	9	0	0
	Speckled	4	29	67	0	0
	Spotted	0	99	0	1	0
	Tiger	0	100	0	0	0
Sona	Normal	0	67	33	0	1
	Black	84	2	14	0	0
	Speckled	0	50	50	0	0
	Spotted	0	97	0	3	0
	Tiger	0	100	0	0	0
Tyson	Speckled	0	99	1	0	0

Performance under drought stress

J. Berger, **N.C. Turner**, CLIMA and CSIRO Plant Industry and
K.H.M. Siddique, AGWEST, South Perth and CLIMA

As part of a larger study into genotype by environment interaction in chickpea (ACIAR project CS1/1996/007), a diverse group of 73 genotypes, dominated by putatively drought-resistant genotypes from India, but also including Australian lines, was grown at Merredin in 2000. Due to the extremely dry season experienced during 2000 (112 mm from sowing to harvest), seed yields were very low, with a mean of 660 kg/ha compared to 2060 kg/ha in the previous year. Nevertheless, a very wide productivity range was recorded (40-1310 kg/ha) (Table 19).

While genotypes such as PANT G 114, Garnet, and ICCV95906 were consistently unproductive in both years, overall there was a very poor correlation between seed yields recorded across the two seasons ($r^2 = 0.08$). Note that the stressful conditions experienced in 2000 increased the variability in the trial (CV = 38%). Consequently, although 20 genotypes appeared to be more productive than the check variety Sona, only one, BG 362, had a significantly greater seed yield.

Under the dry conditions experienced in 2000, seed yield was strongly linked to the a number of plant attributes recorded. Principal components analysis revealed that seed yield was positively associated with biomass, harvest index, the length of the flowering phase, and productivity per plant, and negatively associated with the date of flowering and podding, and the amount of time taken to complete pod development. The length of the vegetative phase, and time taken to mature were also negatively associated with seed yield, but not as strongly as the characters listed above ($r = -0.33$ to -0.38, $P < 0.005$). Interestingly, plant density and early vigour were unrelated to productivity in 2000 ($r = 0.01$-0.05).

Figure 5 shows the genotypes arranged along the X-axis (PC1) in order of seed yield: from the low yielding group on the left to the high yielding group on the right. This is a reflection of the strong positive correlation between seed yield and PC1 ($r = 0.86$). Given that PC1 was dominated by phenological variables, it is not surprising to find significant differences in phenology between the three productivity groups. Table 20 shows strong linear trends: as

productivity increases, genotypes tended to flower, set pod, and mature earlier, fill pods more rapidly, increase the lengths of the post-anthesis phases, and decrease the vegetative growth phase.

Table 19. **Seed yield (kg/ha) estimated using duplicated 0.5 m^2 quadrats per plot for 73 chickpea genotypes evaluated at Merredin in 1999. The well-replicated check genotype (Sona; *n* = 12) and accessions that were significantly more or less productive than the check, are shown in bold font to simplify comparisons using the min-max LSD (Sona). LSD (min rep) is provided for comparisons between any two genotypes excluding the check variety Sona**

Variety	Yield (kg/ha)	CV%	Variety	Yield (kg/ha)	CV%
PANT G 114	**40**	21	Tyson	660	30
Dooen	**140**	89	C -235	680	21
Garnet	**260**	71	Heera	680	32
H - 75-35	**310**	64	BG 372	680	32
BG 212	**320**	24	PDG 84-16	690	36
ICC 10459	**350**	49	DeSaVic	690	56
Norwin	**390**	23	ICC 7684	700	55
IPC 92-1	**400**	40	WACPE2001	710	24
ICCV95906	**400**	80	C 214NT	710	22
ICC 8334	**420**	32	BG 361	730	24
Barwon	**420**	92	ICC 5742	730	34
Kaniva	**430**	46	ICC 10004	740	50
IPC 94-132	**450**	66	BG 364	750	85
ICCV88201	**460**	39	ICC 4958	750	24
ICC 8414	**470**	25	IPC 92-2	770	37
BG 276	**470**	10	ICC 10441	780	28
Amethyst	**500**	101	**Sona**	**790**	**30**
C 214	510	17	IPC 92-39	800	11
ICC 10415	510	58	K850	800	20
ICC 5824	520	44	CTS60543	820	8
JG 62	530	58	BG 369	830	26
UNE946-512	550	28	ICC 10426	830	11
T -3	550	73	ICC 10406	860	25
ICC 8412	550	22	ICCC 33	860	21
BG 391	570	60	ICC 5823	880	14
WACPE2007	580	62	BG 396	890	37
ANNIGERI 1	580	42	BG 1006	910	42
G 130	590	62	ICC 12952	910	21
WACPE2006	610	25	ICC 7692	910	31
BG 365	620	52	ICCV10	970	32
BG 256	630	59	ICC 5829	970	21
ATC4073	630	61	Lasseter	980	17
HIMA	630	35	ICC 5810	980	24
T1587	630	46	ICCV93929	990	14
ICCC 37	630	30	ICCV95905	1000	14
Bumper	640	17	DZ-10-11	1060	22
H 208	650	25	**BG 362**	**1310**	14
LSD (min rep)	350		LSD (min rep)	350	
LSD (Sona)	290		LSD (Sona)	290	
Mean	660	38	**Mean**	660	38

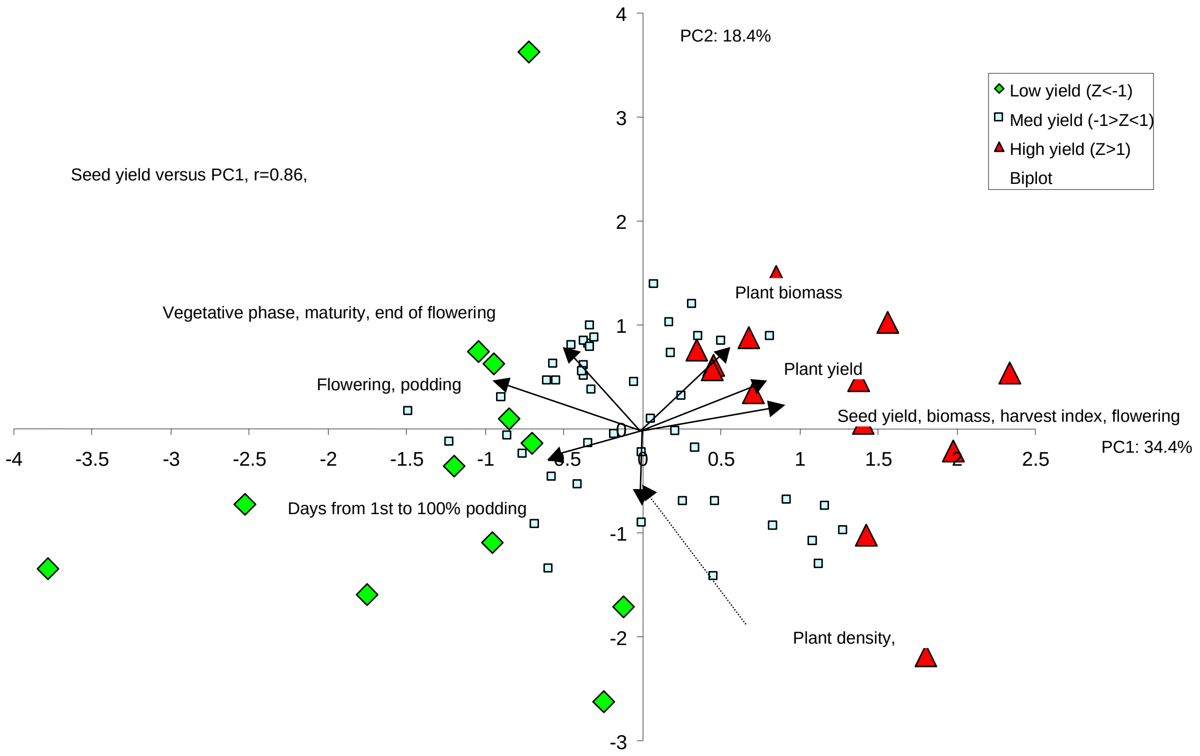


Figure 5. **Principal components analysis of plant attributes recorded at Merredin in 2000. Factor loadings for principal components 1 and 2 are presented as biplot vectors. Genotypes are separated into low, medium and high yielding groups on the basis of Z scores.**

Table 20. **Phenology of poorly (z < -1), intermediate (-1 < x < 1), and highly (z > 1) productive chickpea genotypes in Merredin 2000**

Productivity group	Emerg. 50	Flow 50%	Pod 50%	Maturity	Flowering phase	Pod filling phase	Pod development	Veg. phase
High (n = 13) Std Deviation	32.8 4.7	93.5 3.8	103.6 2.6	137.0 3.2	20.4 4.4	33.4 2.5	7.0 3.2	60.8 6.2
Medium (n = 51) Std deviation	33.5 4.4	96.8 3.7	105.7 2.7	138.2 2.4	17.3 3.2	32.5 2.9	7.8 5.1	63.3 5.9
Low (n = 12) Std deviation	34.9 4.5	100.2 5.2	108.8 3.4	139.7 4.7	15.4 5.4	31.0 2.6	13.7 10.6	65.3 6.6
P linear trend	0.091	0.000	0.000	0.002	0.000	0.003	0.000	0.009

Resistance to chilling at flowering and to budworm

H. Clarke, CLIMA

Sensitivity to chilling at flowering is a contributing factor to variable yield in chickpea, and Heliothine moths are now a major pest in the Australian farming system. In the cool dry regions of southern Australia, chilling resistant early podding varieties have a clear advantage over late varieties, because they avoid drought and budworm damage later in the season.

Pollen selection among recombinant progeny of crosses between the ICRISAT bred cold tolerant CTS60543 and the sensitive variety Amethyst has resulted in breeding lines that set pods at temperatures 2°C lower than parental varieties. In trials at Merredin in 2000, these lines set pods two to three weeks earlier than Tyson for a consecutive year. Further crosses between locally bred WACPE lines and cold tolerant or pod borer resistant lines from ICRISAT

were conducted at CLIMA. F2 seed was passed to the AGWEST chickpea breeding program in May 2000.

The limited range of budworm resistance observed in local chickpea varieties has restricted further improvement for this trait. Accessions with reputed resistance to *Helicoverpa armigera* in Nepal were introduced through quarantine by CLIMA. Resistance to *H. punctigera* will be checked under controlled conditions when the seed has been multiplied.

Molecular markers were further developed during the year. The markers are based on Amplified Fragment Length Polymorphisms (AFLPs), which is a Polymerase Chain Reaction (PCR) method. Five potential markers linked to chilling resistance were identified. The most closely linked band was successfully cloned and sequenced. A specific primer has been made from the sequence. Its suitability as a probe for routine screening for chilling resistance is now being tested.

Effect of row spacing, sowing rate and orientation on growth and seed yield

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Planting chickpeas in rows spaced wider than the standard 190 mm may have potential to reduce fungal disease incidence. Trials in 1999 indicated that in the absence of disease, there is little yield penalty in sowing chickpeas in wider rows. Botrytis Grey Mould (BGM) develops when canopy closure occurs in the middle of spring. Delaying canopy closure with wide rows may similarly delay BGM development to a period when conditions are less favourable for infection. In addition, crops sown in a north-south orientation allow better light penetration to dry out the lower leaves, which may further reduce disease development. The wide row spacing allowing better ventilation and drying of the crop canopy, combined with better light penetration of a north-south orientation may provide good management of this disease in chickpeas. An added advantage of wide rows is the possibility of reducing fungicide costs by just spraying over the rows and not the inter-row.

An experiment was conducted at Mukinbudin (00ME06) to determine the influence of row spacing and planting orientation on BGM disease development in chickpeas. Plots were established at four row spacings: 190, 380, 570 and 760 mm with two sowing orientations: north-south or east-west. There were very few weeds in the experiment with only a few wild mustard plants emerging mainly in the soil thrown out next to the rows.

The emergence was good but decreased with increasing row spacing (Table 21). This is a common occurrence which may be associated with increasing inter-plant competition or increasing fertiliser toxicity with increasing row spacing (76 kg/ha of DAP was banded 3 cm below the seed). There was no effect of orientation on plant density.

Since no BGM was observed, most likely due to the dry season (103 mm rainfall May-October), it was decided to investigate the effect of a fungicide application on ascochyta blight, so half of each plot was sprayed with 1 L/ha Bravo on 1 August. The trial was very variable (CV = 44%) and seed yields were very low due to the dry season. Also, budworm damage was high (30-40%).

The only significant effect was the relatively low yields of the 190 mm row spacing (Table 21). These plots emerged the best, but looked poor (i.e. shorter than the rest) from around August onwards. It is possible that the fertiliser was effectively more concentrated in wider rows and if the soil had a high Phosphorus Retention Index (PRI) then less phosphorus would be available in the 190 mm rows, particularly given the dry season. Alternatively, chickpea plants in 190 mm rows may have used up the stored soil water (196 mm rainfall from January to March 2000) faster than the wider rows.

Table 21. **Plant density (plants/m²) and seed yield (kg/ha) with various row spacing, orientation and fungicide treatments at Mukinbudin (00ME06)**

Row spacing (mm)	Plant density		Seed yield			
			Minus Bravo		Plus Bravo	
	E-W	N-S	E-W	N-S	E-W	N-S
190	43	45	215	60	168	182
380	41	42	382	232	189	295
570	37	38	442	343	387	312
760	29	32	311	284	378	289
LSD 5%	Orientation	ns	ns			
	Spacing	5.1	115			
	Ori. x Spac.	ns	ns			
	Bravo	-	ns			
CV (%)		12.8	43.8			

Table 22. **Plant density (plants/m²) and seed yield (kg/ha) with row spacing and seed rate at Mullewa (00GE07)**

Treatment	Row spacing (cm)	Sowing rate (kg/ha)	Establishment (plants/m² on 4 August)	Seed yield (kg/ha)
1	19	150	36.7	643
2	38	150	33.9	673
3	57	150	29.3	586
4	76	150	31.1	648
5	38	75	18.7	653
6	57	50	13.1	551
7	76	37.5	10.6	596
8	19	50	12.9	581
9	38	50	14.8	620
LSD 5%			5.05	50.2
CV %			15.5	5.6

There appeared no overall effect of orientation or fungicide (Bravo) on seed yield. Ascochyta was only detectable at low levels when the second fungicide spray (2 L/ha Bravo) was applied (23 August). However, when the experiment was inspected in mid-September, ascochyta was clearly evident and at higher levels in the unsprayed areas compared to the sprayed areas. The dry conditions for the remainder of the season precluded the disease affecting final yields.

A similar experiment was also conducted at Mullewa (00GE07) to determine the effect of row spacing and seed rate on BGM disease development. The trial was sown on 26 May and the establishment was reasonably good considering the dry season (142 mm rainfall May-Oct). Some plants germinated before substantial rains were received in mid June. There tended to be fewer plants as the row spacing increased, which is consistent with other studies. Although BGM disease did not develop, the trial was sprayed three times with Bravo to reduce the incidence of ascochyta blight. From limited observations, there appeared to be no apparent effect of row spacing on ascochyta incidence.

At the 150 kg/ha seed rate, increasing the row spacing to 760 cm had little effect on yield (Table 22). This is encouraging for possible inter-row weed control and over-the-row fungicide sprays in wide row crops. At constant plant spacing within each row (treatments 1, 5, 6 and 7), there appeared a slight drop in yield with increasing row spacing. Thus, in the absence of

disease and in a dry season, there appears to be no need to reduce the seed rate in wide rows to maintain yields. Analysis of just the 50 and 150 kg/ha seed rates on 19, 38 and 57 cm row spacings showed there was no interaction of seed rate with row spacing.

Due to the dry conditions and low incidence of BGM during the season, the impact of row spacing and orientation on BGM development could not be evaluated. These experiments will be repeated in 2001 at a site with high BGM pressure.

Kabuli chickpea

In recent years kabuli chickpea prices have returned to high levels (up to $1,000/t). Prices will probably remain high in 2001, because ascochyta blight is likely to cause the production of kabuli chickpea in Australia to contract.

Kabuli prices are largely determined by seed size and colour, especially when supply exceeds market demand. Seeds greater than 8 mm diameter are generally sold at a premium over smaller seeds, while prices for seeds that are less than 7 mm may be lower than those for desi chickpea. Hence, in addition to yield, the size distribution of seed produced is an important quality parameter for profitable kabuli production.

While varietal differences influence seed size, large seeds are more likely to be produced in areas with 400-600 mm annual rainfall, deep fertile soils and mild spring conditions favourable to seed filling. Economical yields of kabuli chickpea with large seed size are unlikely to be achieved on a regular basis in lower rainfall areas. Excellent soil types for kabuli production have been identified around Dongara, Mingenew, the Avon Valley and parts of Esperance and Katanning.

Variety and germplasm evaluation

Kabuli chickpea varieties were evaluated at three sites in 2000 (Table 23). The trial at Tammin was not sown until 20 June due to a late break of the season and only received 158 mm of rain between June and October. Hence the trial was quite variable and seed yields were compromised. When averaged across all sites there was little difference between Kabuli varieties with seed yields ranging from 96-99% of Kaniva. As observed in previous years, the small desi chickpea (variety Sona) produced greater seed yield than kabuli varieties. However, at one site (Mingenew) where grain size was measured, the new line G846-3-9 produced substantially larger seeds than the other varieties (Table 24). G846-3-9 produced 16% more seed with a diameter greater than 9 mm compared to Kaniva, and 3% more than Bumper. G846-3-9 also has excellent seed colour, however it is susceptible to ascochyta blight (similar to Kaniva). G846-3-9 was released to growers during the year (PASE and GSPGA). The line is currently in the process of being bulked up and the seed certified. G846-3-9 is expected to meet the interest of kabuli producers in WA (with fungicide management strategies implemented) until a new variety with improved ascochyta blight resistance is available.

Table 23. Seed yields (kg/ha) from kabuli chickpea variety trials

Variety	Tammin 00AD03 20 June	Mingenew 00GE12 17 June	Tambellup 00GS07 29 June	Mean kg/ha	Mean % Kaniva
Bumper	214	650	332	399	99
G846-3-9	225	709	270	401	99
Garnet	176	689	292	386	96
Kaniva	181	790	242	404	100
Sona	263	943	458	555	137
LSD 5%	63	94	60	-	-
CV%	19	8	12	-	-

Table 24. Mean seed weight and proportion (%) of various seed sizes of kabuli chickpea at Mingenew (00GE12)

Variety	MSW (g/100 seeds)	Seed size distribution (%)			
		7-8 mm	8-9 mm	9-10 mm	> 10 mm
Bumper	0.38	14	32	42	9
G846-3-9	0.44	6	26	50	17
Garnet	0.28	58	21	7	1
Kaniva	0.38	11	38	38	10
Sona	0.18	-	-	-	-
LSD 5%	0.03	11.4	8	7.5	4.5
CV%	6	32	17	14	30

Premium quality kabuli chickpea development in the ORIA

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The kabuli chickpea industry in the Ord River Irrigation Area (ORIA) is based on a large seeded chickpea variety ‘Macarena’ and is valued at around $1.0 million p.a. There is potential to increase kabuli production in the area to over $6 million with existing and new export markets. During recent years average yields with the variety Macarena have varied between 2.0 to 3.1 t/ha while yields on individual farms have ranged from 1.0 to 4.0 t/ha within a single season. Factors contributing to this variation are being examined with the aim to improve management packages that increase and stabilise yields, and improve quality (seed size).

Over the past three years, the area of kabuli chickpea sown in the ORIA has ranged from 500 to 750 ha. In 1998, seed yields were disappointing, ranging from 0.56-2.3 t/ha. This was due to a combination of higher than average temperatures (approx. 2^{o}C), and high insect (*Heliocoverpa*) and disease (root and wilt complex) pressure. Surveys of growers crops during 1998 and 1999 indicated that variation in chickpea yields was due to shallow sowing depth, sub-optimal timing of irrigations and low soil phosphorus status. In 1999, seed yields ranged from 1.76–3.3 t/ha. The improved yields and less yield variability when compared to 1998 was associated with more favourable growing conditions and greater attention to sowing depth, irrigation scheduling and fertiliser application by growers. The 2000 season was another year with disappointing and variable seed yields. This was largely due to a late start to the season, increased root rot complex, high temperatures and late rains close to harvest. It was clear that sowing rate and rotation were important factors affecting seed yields during 1999 and 2000. Sowing rates ranged from 90 to 140 kg/ha, and greater yields were achieved at higher sowing rates. Seed yields also appeared to be reduced where chickpea had been grown in successive years. It is likely that root rot complex (Pythium, Fusarium and Phytophthora) causing root and seedling disease persist in the soil infecting subsequent crops. A ‘best bet’ management package is currently being developed for kabuli chickpea production in the ORIA.

Varietal improvement for the ORIA may be possible through the strategic introduction, evaluation and selection of large-seeded kabuli chickpea germplasm from countries where chickpea is grown in similar conditions (e.g. Spain and Mexico). Germplasm evaluation has included 55 large seeded Spanish/Mexican chickpea lines introduced from ICARDA along with 20 lines from ‘off-type’ plants selected in the field in Kununurra by the Ord River Cooperative in 1998. Seed from these lines was grown in single row plots at Kununurra in 1998 (28 lines) and 1999 (27 lines plus 20 off-type) along with Macarena as a control. Emergence, vigour, days to flowering and podding, plant height at maturity, seed yield, seed colour and seed size were measured.

Seven lines were selected from the 1998 trial with appropriate maturity as well as greater seed size and yield when compared to Macarena. A yield evaluation trial in 1999 indicated that six lines had improved yield and seed size, along with good colour, compared with Macarena. The six lines selected in 1999 were evaluated in large scale field plots, and bulked up in progeny rows (for pedigree seed production) in 2000. On average across years, the selected lines generally had similar flowering times to Macarena and greater mean seed weight (Table 25). Mean seed yield of the selected lines were 19 to 51% greater than Macarena. However, IG9351 showed greater disease (root rot wilt complex) susceptibility than the other lines. GCN133-2 and Fern Leaf produced the largest proportion of seeds greater than 10 mm diameter (Table 26). Given that premium prices are offered for larger seeds, this is a desirable characteristic for improved returns for growers.

Table 25. Mean time in days after sowing to 50% flowering, 100 seed weight (g) and seed yield of kabuli chickpea lines at Kununurra

Line	50% flower[a]	100 swt[a]	100 swt % Macarena	Seed yield[b]	Seed yield % Macarena
Macarena	40	51.9	100	1298	100
GCN133-2	41	58.2	112	1700	131
IG9216	39	54.1	104	1542	119
IG9337	39	51.7	100	1857	143
IG9351	38	53.9	104	1695	131
IG96220	38	59.0	114	1962	151
Fern Leaf	42	56.4	109	1654	127

[a] Mean of 1998,1999 and 2000.
[b] Mean of 1999 and 2000.

Table 26. Seed size distribution of kabuli chickpea lines at the Frank Wise Institute, Kununurra, 2000

Line	Proportion (%) of seed				
	> 11 mm	10-11 mm	9-10 mm	8-9 mm	< 8 mm
Macarena	8.1	34.7	42.6	8.8	5.8
GCN133-2	7.8	40.0	39.6	7.2	5.3
IG9216	7.0	20.9	50.0	16.8	5.4
IG9337	8.4	27.2	51.1	8.2	5.2
IG9351	6.4	30.7	48.5	9.0	5.4
IG96220	7.2	25.0	53.0	9.5	5.4
Fern Leaf	8.9	40.6	38.2	7.0	5.3
CV%	14	12	7	21	6
LSD 5%	ns	5.34	4.86	3.00	ns

In addition to agronomic evaluation, preliminary seed quality tests (seed colour and cooking) were conducted by AGWEST's Grain Quality Laboratory on the 2000 harvest samples. Seed colour is represented in three dimensions; lightness (L*, black/white), chroma (a*, green/red) and hue (b*blue/yellow). In general, markets prefer light coloured kabuli chickpea seeds. There was no difference in the hue between the seven lines, however Fern Leaf was the lightest and least red sample (Table 27).

Cooking quality is measured by seed deformation after cooking, the number of unhydrated seeds and the hydration capacity of individual seeds. In this trial, the force for 75% deformation of the seed was less for Macarena, IG9351 and GCN133-2, suggesting quicker cooking time for these lines. There were no unhydrated seeds after soaking for 16 hours for any line, and

relatively small differences in hydration capacity. It is likely that there is little difference in cooking quality between the selected lines and Macarena, although these quality tests are the result of one trial in one year and will need to be tested more extensively in 2001. Market testing will be undertaken in collaboration with the Ord River Cooperative on the most promising lines during the coming years. Seed yield and quality evaluation, and seed bulk-up of these lines will be continued in 2001.

Table 27. Quality parameters of kabuli chickpea lines at the Frank Wise Institute, Kununurra

Line	Seed colour[a]			Deformation[b] (Newtons)	Unhydrated seeds (%)	Hydration capacity[c] (%)
	L*	a*	b*			
Macarena	67.2	5.6	15.5	111	0	102
GCN133-2	65.8	5.6	15.4	122	0	102
IG9216	64.6	6.4	16.7	148	0	106
IG9337	64.1	6.3	16.7	142	0	102
IG9351	66.9	5.8	15.9	119	0	103
IG96220	64.1	6.2	12.6	147	0	102
Fern Leaf	67.7	5.1	15.3	125	0	104
CV%	1	3	20	6	-	1
LSD 5%	1.21	0.25	ns	11	-	1.9

[a] L* (lightness), a* and b* (chroma and hue).
[b] Force in Newtons required for 75% deformation of seeds after cooking.
[c] Mean percentage increase in weight of seeds due to water uptake over 16 hours.

From the 47 lines evaluated in small row plots in 1999, ten lines exhibited good seed colour, produced greater yields and had similar or earlier flowering when compared to Macarena. These ten lines were evaluated in larger field plots in Kununurra during 2000 and three lines produced greater seed yield and larger seeds than Macarena. Yield and quality evaluation will be continued for these three lines in 2001 in Kununurra and pedigree seed production will commence through the selection of single plants.

International screening for ascochyta blight resistance

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Ascochyta blight caused by *Ascochyta rabiei* is the most damaging disease of chickpea in most parts of the world. Prior to 1996 this disease was exotic to Australia. However, ascochyta caused widespread yield losses in eastern Australia in 1998 and 1999, and was identified in chickpea crops in the north-western areas of the cropping region of WA in 1999. In a collaborative project between CLIMA, the National Chickpea Breeding Program, Tamworth NSW, ICARDA, Syria, and the Agean Agricultural Research Institute (AARI - Menemen Turkey), breeding lines and commercial varieties from Turkey and Australia have been screened for resistance to ascochyta blight, potential adaptation to Australian conditions and seed quality in Turkey. A total of more than 2000 breeding lines from the ICARDA and AARI breeding programs with superior ascochyta resistance (score < 5.0) and agronomic traits have been evaluated in Turkey and 341 superior lines introduced to Australia between 1998 and 2000.

A set of breeding lines (1125) from breeding programs at the ICARDA and AARI, in addition to the commercial varieties grown in Turkey and Australia (Garnet, Kaniva and Bumper) were evaluated in trials at Menemen and Kemalpasa, Turkey in 1997/1998. Two hundred and two lines were selected in Turkey, and released from quarantine facilities at the South Australian Research and Development Institute (SARDI) in March 1999. A second set of breeding lines (287) from the ICARDA and AARI breeding programs were planted at Menemen, during January 1999. Ninety lines were selected in June 1999 in Turkey, sent to Australia, and

released from quarantine at SARDI in April 2000. The final set of breeding lines (175) from the ICARDA and AARI breeding programs were planted in December 1999 and January 2000 at two sites at Menemen, in Turkey. Forty nine breeding lines were selected in June 2000 and are currently being grown in quarantine at SARDI.

A number of promising lines introduced to Australia have been evaluated in the field in WA, and distributed and evaluated in eastern Australia by collaborators in the Australian Coordinated Chickpea Improvement Program (ACCIP). Wide scale ascochyta screening and agronomic evaluation will ensure the identification of the most promising lines for progress towards direct commercial release and for use in crossing programs in the Australian chickpea breeding programs.

During the project, a desi chickpea evaluation nursery was also established in Turkey (1998/99) to screen for ascochyta resistant lines from the International Crops Research Institute for the Semi-arid Tropics (ICRISAT). Sixteen desi chickpea lines with superior ascochyta resistance were selected and grown in quarantine in Perth. These desi lines were multiplied over summer 1999/2000 at Manjimup and also used as parental genotypes in the WA chickpea breeding program. The lines have been evaluated in the field in WA and the Eastern States in 2000. Preliminary data on seed quality (size and colour) indicates that the lines are not suitable for direct release as commercial varieties. However, some of the lines will be useful as parental genotypes for breeding in ACCIP

Evaluation of ascochyta resistant germplasm in Australia

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Agronomic evaluation

As part of the international screening for ascochyta blight resistance in chickpea (see section on International screening for ascochyta blight resistance), lines introduced to Australia from ICARDA and Turkey have been evaluated for their agronomic traits at Bindoon in WA. To date, an initial set of 202 superior lines were evaluated during 1999 and a second set of 90 lines during 2000. Due to the limited quantity of seed, the trials have consisted of small row plots. In addition to the ascochyta resistant lines (score < 5.0 in Turkey) selected in Turkey, the standard kabuli varieties (Garnet, Kaniva, Bumper, G846-3-9) and desi varieties (Sona and Heera) were included in the trials.

In 1999, the trial was sown on 10 June. Plant growth and development of the first set of introduced kabuli lines (202) was good at Bindoon with no ascochyta observed at the site (Regan *et al.* 2000). Several lines flowered earlier or at the same time as the standard varieties and showed greater early vigour, plant height, seed yield, mean seed weight and harvest indices than the standard variety Kaniva (Table 28).

A similar trial was sown on 21 June 2000 to evaluate the second set of lines (90 lines). Once again, plant growth and development were good and ascochyta was not detected at the site. However, rainfall was poor during spring and the trial was hand watered twice during this period. Time from sowing to flowering for Kaniva and Garnet was 95 days, and ranged from 91 to 120 days for other lines (Table 29). Many lines had similar or slightly later flowering when compared to the Australian commercial varieties. At this stage, harvest data (mean seed weight and seed yield) is unavailable.

Ascochyta disease screening

Ascochyta disease screening of the introduced lines was carried out in Australia during 1999 and 2000. Evaluation of ascochyta resistance of the first set of 202 lines was carried out in eastern Australia during 1999 and 2000 and at Mingenew in WA in 2000. At Mingenew, the disease pressure was very high, because the previous crop was chickpea, which had been affected by ascochyta. Because of the drought, intense disease pressure, and weed infestation only 32 lines survived at the site (Table 28). The disease resistance observed in these lines

correlated well with the ascochyta scores recorded in eastern Australia, although scores from the glasshouse and field sites in SA were higher in 1999 compared to other sites. Based on large seed size (mean seed weight), seed yield and ascochyta scores (Turkey and Australia), single plant selections have been carried out on about 20 promising lines. The seed from these plants will be grown in progeny rows at Carnarvon in 2001. An additional 10-20 lines were selected based on ascochyta resistance (ascochyta scores Turkey and Australia) alone and will be utilised in the AGWEST crossing program as part of the ACCIP.

Table 28. Time in days after sowing to 50% flowering, mean seed weight (MSW, g) and MSW and seed yield as % Kaniva at Bindoon 1999, and ascochyta disease scores (AS: 0 = no disease to 9 = dead) in eastern Australia during 1999 and 2000 of ascochyta resistant kabuli chickpea lines (subset from first set of 202 lines)

Pedigree	Bindoon 1999				Eastern Australia 1999				Eastern Australia 2000		
	Sown 10 June				NSW	VIC	SA	SA	VIC	NSW	SA
	FLW	MSW	MSW as %Kaniva	SY as % Kaniva	Field AS	Field AS	GH[a] AS	Field AS	Field AS	Field AS	Field AS
Flip97-537	116	0.417	102	132	3	1	4	5	3		4
Flip97-501	119	0.404	99	101	3	5	4	4	4	3	
Flip97-521	129	0.395	97	86	3	4	4	4	3	4	
Flip97-527	121	0.388	95	77	3	5	4	3	4		4
Flip97-679	124	0.387	95	78	3	4	3	6			
Flip97-603	115	0.376	92	117	3	4	5	4	3	4	4
Flip97-504	115	0.366	90	145	4		6		4		4
Flip97-678	123	0.364	89	83	5	5	6	7			
Flip97-651	117	0.358	88	107	3	3	4	5	3	6	4
Flip97-579	123	0.355	87	101	3	3	4	4	4	4	
Flip97-611	114	0.355	87	93	4	5	6	5	4	4	4
Flip97-567	114	0.351	86	84	3	3		6	3	5	
Flip97-690	133	0.353	86	80	3	4	4	3			
Flip97-614	124	0.352	86	85	3	4	4	5	4	5	
Flip97-652	125	0.352	86	125	4	4	4	4	3	5	4
Flip97-654	124	0.352	86	74	3	3	5	5	3	3	
Flip97-515	117	0.348	85	103	3	2	4	3	3	5	4
Flip97-578	125	0.344	84	107	3	4	3	4	4	4	4
Flip97-583	122	0.344	84	108	3	4	2	4	3		
Flip97-555	134	0.34	83	92	3	4	6	4	4		
Flip97-577	134	0.34	83	130	4	4	6	3	4	4	4
Flip97-588	122	0.338	83	60	3	4	4	4	3		4
Flip97-624	113	0.335	82	116	3	5	6	4	3	5	4
Flip97-559	134	0.332	81	98	3	4	5	4	4	4	
Flip97-568	117	0.331	81	89	3	2	6	5	3	4	
Flip97-642	123	0.332	81	94	3	3	3	3	4	4	3
Flip97-571	126	0.328	80	93	3	3	3	4	3		4
Flip97-522	124	0.322	79	99	3	4	5	3	4	4	4
Flip97-573	124	0.313	77	92	3	3	5	4	4	4	3
Flip97-528	118	0.312	76	72	2	2	2	4	3		
Flip97-535	118	0.304	74	100	3	4	2	3	3		4
Flip97-689	127	0.295	72	60	2	3	3	3			

[a] Glasshouse.

Ascochyta disease screening was also carried out during 2000 on the second set of lines from Turkey (90 lines) in eastern Australia. A number of lines showed good resistance to ascochyta along with similar flowering and podding to Australian varieties (Table 29). The ascochyta scores from New South Wales were assessed during the early growth stage. More recent scoring at flowering and podding show excellent ascochyta resistance (T. Knights, pers. communication). The disease scores form the glasshouse trial in SA were higher than field scores. All 90 lines will be evaluated in WA and in eastern Australia for agronomic adaptation and ascochyta resistance in 2001.

A final set of 49 lines introduced from the ICARDA and AARI breeding programs (1999/2000 selections) will be evaluated for agronomic performance at Bindoon and ascochyta resistance in the Eastern States during the 2001 season.

Table 29. Ascochyta blight scores (AS: 0 = no disease to 9 = dead), mean seed weight (MSW, g), and time from sowing to 50% flowering (FLW) and podding (POD) for some promising kabuli chickpea lines in Turkey and Australia (subset from second set of 90 lines)

Pedigree/ variety	Turkey 1999				Australia 2000				
	Sown 26 Jan.		Sown 15 Mar.		NSW Field	SA GH[a]	SA Field	WA (Bindoon)	
	AS	MSW	AS	MSW	AS	AS	AS	FLW	POD
Bumper								91	111
Kaniva								95	114
Garnet								95	114
Sona								96	114
FLIP98-570	2	0.326	2	0.380	4	5		91	114
FLIP98-575	2	0.366	2	0.346				97	114
FLIP98-514	5	0.450	2	0.360	5	6	4	99	117
FLIP98-773	2	0.396		0.320	3	6		100	114
FLIP98-518	4	0.420	2	0.383	3	6	4	102	114
FLIP98-520	4	0.415	2	0.396	5	6	5	102	117
FLIP98-545	2	0.400	2	0.295				102	123
FLIP98-615	2	0.326	0	-	4	6		102	119
FLIP98-671	3	0.416	2	0.340	3	4	3	108	123
FLIP98-756	2	0.336	2	0.240	3	4		107	123
FLIP98-655	2	0.373	2	0.326	3	4		112	123
FLIP98-649	2	0.323	2	0.296	3	4		105	123
FLIP98-613	3	0.336	0	-	3	4		108	123
FLIP98-659	2	0.375	2	0.316	3	4	4	109	123
FLIP98-644	2	0.380	2	0.310	3	5	6	115	126
FLIP98-562	2	-	3	0.313	3	5	4	109	126
FLIP98-505	3	0.420	2	0.376	3	6		104	117
FLIP98-591	2	0.370	2	0.320	3	6		109	126
FLIP98-655	2	0.373	2	0.326	3	4		120	126

[a] Glasshouse.

Field Pea

Breeding highlights

The WA field pea breeding program started in 1988. It is part of the Australian Coordinated Pea Improvement Program (ACPIP) The main focus of the WA program is on short season environments with limited work on field peas for high rainfall regions. Over 180 crosses were made in 2000. The crossing was aimed at improving seed yield and adaptation, and enhancing quality. Another small set of crosses was made with the aim of improved standing ability. Crossing for black spot resistance included inter-crossing amongst the WA-bred F6 lines, which showed combination of black spot resistance and desired agronomic characteristics.

The breeding for black spot resistance continued to show promising results. The resistance seen in the lines derived from single plant selections in 1998 exceeded that of the parents in some cases. It was particularly encouraging that some of these lines were earlier flowering with better adaptation. A Grains Research and Development Corporation (GRDC) funded project (CLIMA) to screen field pea lines for black spot from the collection held at the Vavilov Institute, St Petersburg, Russia and offshore in Ethiopia continued in 2000. So far, more than 250 lines have been introduced to Australia. The lines imported in 1998 and 1999 were tested for resistance in the 2000 season at Medina. About one dozen lines show some resistance and the best three or four will be used as parents in the 2001 crossing program.

The field trials, involving over 10,500 plots, were conducted at Wilgoyne and Merredin (low rainfall), Dalwallinu (medium rainfall), and Katanning and Mt Barker (high rainfall). A disease nursery was located at Medina. South Australian germplasm was evaluated at Esperance. The opening rains were late and hence all sowing was delayed. This was followed by very low rainfall in spring resulting in a very short season. Surprisingly, at most sites field pea produced reasonable seed yields despite the adverse conditions.

Sixteen lines in advanced breeding trials (stage 22 trials) have been selected for promotion to the CVT trials in 2000 (Table 30). The stage 22 trials were sown at five sites. The results from the Mt Barker trial were discarded due to uneven waterlogging at the site. The high rainfall site at Katanning was the lowest yielding, while the low rainfall marginal site (Wilgoyne) the highest yielding. This highlights the local variations in this very dry year that may have been caused by stored soil moisture and other factors. All selected lines are WA-bred except for 92-244P5*8-4, which comes from the Victorian Program. This line is of particular interest because of its blue seed colour. Only four selected lines are dun types, but three of these (93P758-F4B-9, 93P758-F4B-10 and 93P851-F4B-12) are large seeded and therefore of interest from a market perspective. Of the white round seeded lines, 93P747-F4B-8, 93P772-F4B-5 and 93P772-F4B-1, show a combination of good seed yield and an acceptable seed size. Helena, appeared to be highest yielding entry out-yielding all lines at Wilgoyne (highest yielding site) and Katanning (lowest yielding site).

The new varieties Cooke and Helena (released in 1999) will enter the commercial market in the coming season. Both varieties, particularly Helena, have continued to perform strongly. A new field pea line, WAPEA 2074, is being considered for commercial release in 2001 for the high and some medium rainfall areas. So far, it appears to match Helena in seed yield and Parafield's quality in the target areas. Of the round white seeded lines, WAPEA 2080 and WAPEA 2081 have produced promising seed yield and quality. They will be critically assessed for possible release in 2002.

Table 30. Lines selected from the 2000/2001 Stage 22 trials for the 2001/2002 Crop Variety Testing. Magnet is the only semi-leafless line in this table

Name	Pedigree	Yield as a % of Dundale				Flower colour[a]	MSW[b]	Seed[c]
		Dalwallinu	Katanning	Merredin	Wilgoyne			
Cooke	Control	123	181	134	130	W	15.32	W
Helena	Control	138	204	151	142	P	15.80	D
King	Control	86	127	104	114	P	17.79	D
Magnet	Control	71	122	115	107	P	16.00	D
Dundale	Control	100	100	100	100	P	-	D
93P747-F4B-8	BONZER/JI096	147	180	132	133	W	17.41	W
93P869-F4B-5	WIRREGA/WA985	128	185	138	133	W	15.76	W
93P772-F4B-5	WA403/ORB	144	170	131	129	W	17.40	W
93P883-F4B-25	WA763/LAURA	134	170	130	131	W	15.90	W
93P773-F4B-14	WA403/WIRREGA	128	178	135	126	W	17.32	W/G
92-244P5*8-4	Ex Victoria	135	169	134	120	W	24.60	B
93P772-F4B-2	WA403/ORB	145	156	133	116	W	16.53	W
93P758-F4B-9	WA963/BONZER	127	154	120	123	P	22.50	D
93P772-F4B-1	WA403/ORB	129	149	122	122	W	17.70	W
93P833-F4B-17	88P048-6/88P133-4	104	165	135	123	W	16.37	W/G
93P758-F4B-10	WA963/BONZER	121	161	133	114	P	22.30	D
93P772-F4B-9	WA403/ORB	127	145	126	116	W	16.24	W
93P871-F4B-3	AUS WIN/WA992	98	170	138	120	W	15.85	W/G
93P851-F4B-12	WA985/BALLET	120	145	114	124	P	20.10	D
93P860-F4B-10	JI096/WIRREGA	127	143	121	116	W	20.79	W/G
93P789-F4B-7	88P397-7/88P133-4	100	158	132	118	P	17.49	D
Dundale	*Yield (kg/ha)*	*1013*	*413*	*946*	*1681*			

[a] W = white, P = purple.
[b] Mean seed weight: g/100 seeds).
[c] Seed description: W = white, Gy = grey, Gn = green, B = blue and D = dun.

Variety evaluation

During the 2000 season, variety testing of advanced field pea breeding lines and varieties were conducted at six sites throughout the grain belt of WA. Despite dry conditions, the average yields in stage three trials were reasonable, except at Merredin (Table 31). Helena was the highest yielding named variety and surprisingly, King also yielded very well. Amongst the crossbreds the dun type lines WAPEA 2122 and WAPEA 2123, round white seeded line WAPEA 2113, and speckled dun seeded line WAPEA 2106 outyielded Helena.

In the stage four series of trials Helena continued its outstanding yield performance (Table 32). Its superior yield in this very dry and short season environment is indicative of its wide adaptation in WA. All other named varieties yielded less than Dundale. Seed yields of the new releases from the Eastern States, including Parafield, were particularly low. The line WAPEA 2074 produced an average of eight per cent greater seed yield than Parafield, which will strengthen the case for releasing this line as a replacement. WAPEA 2127, an early flowering dun type line with good quality attributes, performed well, but failed to show any advantage of early flowering in this short season year. Seed yield of the early flowering round white seeded line WAPEA 2081 also remained modest in comparison to Dundale.

Table 31. Seed yields (kg/ha) from the crop Variety Testing stage 3 trials

Variety/line	Cranbrook 00MT14 29 June	Mt Barker 00MT16 6 June	Lake Grace 00NE36 16 June	Scaddan 00ES68 28 May	Morawa 00GE52 12 June	Merredin 00ME64 16 June	Mean	Mean % Dundale
Dundale	921	1753	1363	1694	1155	732	1270	100
Cooke	848	1367	1193	1555	1083	515	1094	86
Helena	1111	1910	1434	1586	1481	571	1349	106
King	687	2145	1327	2076	1289	389	1319	104
Laura	921	1671	1227	1496	1295	551	1193	94
WAPEA2101	950	1723	1200	1595	919	581	1161	91
WAPEA2102	848	1541	1390	1453	843	525	1100	87
WAPEA2103	81	1340	1288	1444	1089	551	1088	86
WAPEA2104	819	1755	1327	1363	1022	692	1163	92
WAPEA2105	687	1639	1293	1417	1157	725	1153	91
WAPEA2106	1038	1813	1566	1938	1603	697	1442	114
WAPEA2107	1053	1798	1439	1468	1169	843	1295	102
WAPEA2108	863	1449	1287	1791	1137	636	1194	94
WAPEA2109	936	1827	1399	1630	938	616	1224	96
WAPEA2110	833	1948	1245	1747	1294	894	1327	104
WAPEA2111	980	1167	1403	1607	1149	803	1185	93
WAPEA2112	892	1495	1300	1801	1295	813	1266	100
WAPEA2113	863	2251	1358	1751	1314	793	1388	109
WAPEA2114	863	1859	1381	1661	1292	611	1278	101
WAPEA2115	702			1216	1185	753	964	76
WAPEA2116	994	1579	1318	1481	1355	624	1225	96
WAPEA2117	833	1555	1328	1233	1189	712	1142	90
WAPEA2118	716	1937	1262	1453	1291	667	1221	96
WAPEA2119	790	1632	1089	1183	1091	348	1022	80
WAPEA2120	848	1964	1220	1356	997	338	1120	88
WAPEA2121	746	2209	1208	1515	898	444	1170	92
WAPEA2122	863	1778	1482	1837	1402	758	1353	107
WAPEA2123	965	2329	1516	1694	1220	677	1400	110
WAPEA2124	863	1782	1275	1520	1205	581	1204	95
WAPEA2125			1424			884	1154	91
Mean	871	1758	1329	1571	1185	644		
LSD 5%	108	546	162	248	176	234		
CV%	6	16	6	8	7	18		

Table 32. Seed yields (kg/ha) from the Crop Variety Testing stage 4 trials

Variety/line	Cranbrook 00MT15 29 June	Tenderton 00MT17 30 June	Mingenew 00GE44 16 June	Pithara 00WH27 23 June	Doodlakine 00ME45 15 June	Lake Grace 00NE37 20 May	Salmon Gums 00ES55 28 May	Scaddan 00ES69 28 May	Morawa 00GE53 12 June	Kalannie 00WH25 21 June	Merredin 00ME65 16 June	Mean	Mean % Dundale
Dundale	977	1615	1140	874	549	1285	907	1797	1277	1013	1098	1139	100
Cooke	1050	1553	1182	736	461	1206	880	1674	1058	1023	791	1056	93
Excell	450	720	1098	517	218	811	352	1406	553	769	700	690	61
Helena	1235	1759	1307	874	560	1484	873	1677	1482	1290	1051	1236	109
King	943	977	1581	792	403	1284	563	1758	1268	999	886	1041	91
Laura	996	1224	1002	794	391	1331	673	1553	1169	1091	1141	1033	91
Magnet	911	1193	1732	857	398	1296	608	2061	1196	1213	1054	1138	100
Mukta	697	1070	1169	675	303	1093	476	1555	876	1042	811	888	78
Parafield	858	1173	1168	781	387	1218	513	1530	1122	1049	1027	984	86
Paravic	798	1224	1203	697	365	1142	498	1808	1089	991	968	980	86
Santi	782	1296	1316	728	409	1144	597	1741	1064	1021	1148	1022	90
Snowpeak	688	875	1747	859	423	1012	768	2039	1038	1021	970	1040	91
Soupa	461	833	970	530	195	996	272	1889	637	810	680	752	66
WAPEA2021	1000	1564	1528	907	511	1401	801	1726	1508	1038	1138	1193	105
WAPEA2023	1036	1698	1303	817	449	1383	878	1392	1354	1099	1094	1137	100
WAPEA2028	990	1451	1346	835	485	1298	676	1571	1401	1022	943	1092	96
WAPEA2039	823	1451	1480	763	379	1201	741	1667	1107	1048	1064	1066	94
WAPEA2074	947	1533	1311	792	421	1352	627	1709	1109	1161	998	1087	95
WAPEA2089	833	1337	886	612	313	1164	444	1517	701	1005	680	863	76
WAPEA2127	1076	1626	1225	852	443	1318	1028	1670	1345	1079	1104	1161	102
PSI7	786	1204	1493	815	380	993	516	1691	808	976	852	956	84
WAPEA2076	714	1060	1274	756	337	1033	561	1610	922	980	1125	943	83
WAPEA2080	751	1296	1142	759	420	1309	878	1632	1170	1164	976	1045	92
WAPEA2081	995	1111	1558	987	539	1246	849	1449	1540	1030	1121	1130	99
WAPEA2083	854	1327	899	644	338	1272	474	1161	951	928	912	887	78
Mean	866	1287	1282	770	403	1211	658	1651	1110	1034	973		
LSD 5%	142	184	184	102	110	110	102	340	152	90	254		
CV%	10	9	9	8	17	6	9	13	8	5	16		

Agronomic and varietal effects on seed quality

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AGWEST's Grain Quality Laboratory tested the quality of seed from three field pea sowing rate trials (Salmon Gums, Scaddan, and Mt Barker) and one field pea time of sowing trial (Scaddan) conducted in 1999. The seed was evaluated for: seed size distribution, 100-seed weight, whole seed colour, hydration capacity and unhydrated (hard) seed percentage. Yield details of these trials can be found in Regan *et al.* (2000).

All varieties in these experiments, apart from Dundale and Laura, have been released since 1997. Parafield consistently had the largest seed weight and seed size (Table 33 34 and 35). Of the recently released varieties, Cooke had the smallest seed size followed by Helena. Both King and Magnet were comparable in size to Dundale. The seed size distribution of Parafield was more variable than any other variety, which may reduce milling yield (data not presented). Helena, King and Magnet generally had more uniform seed size than Dundale. In all of these experiments, all varieties met the Pulse WA seed size standards for No. 1 Milling Grade peas (97% of seed sample larger than 4.76 mm).

Increasing the sowing rate reduced seed size, but at sowing rates normally used by farmers the shift in mean seed size rarely exceeded 0.1 mm (data not presented) or 1 g/100 seeds. Seed size was larger with late sowing at Scaddan, but the standard deviation of the distribution was greater (Table 33 and 35). Further work will be necessary before firm conclusions about the effect of sowing time on seed size can be drawn.

Table 33. 100–seed weight (g) of six field pea varieties sown at different times at Scaddan in 1999

Variety	Sown on 3 June	Sown on 17 June
Parafield	22.0	23.8
Helena	15.7	17.4
King	19.4	19.7
Magnet	18.6	20.0
Cooke	16.5	16.6
Laura	14.9	15.7
SED	0.42	

Table 34. 100–seed weight (g) of different field pea varieties in sowing rate trials in WA in 1999

Variety	Sowing rate (kg/ha)	Salmon Gums	Scaddan	Mt Barker
Dundale	50	19.8	20.0	21.4
	100	19.3	18.5	21.4
	160	19.2	17.8	21.0
	220	18.3	17.7	19.7
Parafield	50	22.4	22.2	22.1
	100	21.4	20.7	21.7
	160	21.8	19.8	21.5
	220	18.8	19.7	20.1
Helena	50	15.6	16.1	16.4
	100	13.9	14.6	17.1
	160	15.4	14.7	16.7
	220	14.6	14.7	16.9
King	50	n/a	19.0	19.1
	100	n/a	18.8	17.9
	160	n/a	18.0	18.0
	220	n/a	17.2	18.3
Magnet	50	n/a	19.0	18.9
	100	n/a	18.5	18.1
	160	n/a	17.8	17.5
	220	n/a	16.7	17.9
Cooke	50	15.4	n/a	n/a
	100	14.5	n/a	n/a
	160	14.4	n/a	n/a
	220	15.1	n/a	n/a
SED		1.04	0.43	0.48

Table 35. Parameters describing seed size distributions of six field pea varieties sown at different times at Scaddan in 1999

Variety	Mean size (mm)		Standard deviation (mm)		% Sample > 4.76 mm	
	3 June	17 June	3 June	17 June	3 June	17 June
Parafield	7.19	7.40	0.48	0.52	100	100
Helena	6.36	6.42	0.36	0.38	100	100
King	6.72	6.77	0.37	0.39	100	100
Magnet	6.65	6.82	0.36	0.38	100	100
Cooke	6.27	6.29	0.38	0.40	99.9	99.9
Laura	6.03	6.14	0.35	0.36	99.9	99.9
GLM results:	Variety effect on mean size significant at $P < 0.001$. Sowing date effect on mean size significant at $P < 0.001$. Variety × sowing date interaction on mean size significant at $P < 0.001$. Variety effect on standard deviation significant at $P < 0.001$. Sowing time effect on standard deviation significant at $P < 0.01$.					

A large hydration capacity leads to better cooking quality and quicker sprouting, so is ultimately desirable to the end-user. However, it cannot be assessed visually by buyers like seed size or colour, so it will not have a large immediate impact in the market place. However, if we consistently produce field pea grain with a high hydration capacity it will benefit the reputation of WA field peas overseas. Helena clearly had the greatest hydration capacity and Parafield the lowest (Table 36 and 37). King was comparable to Parafield, with Dundale and Magnet intermediate. The white peas, Cooke and Laura, had large hydration capacities, but not as great as Helena. Increasing the sowing rate led to increased hydration capacity, but late sowing reduced it.

Table 36. Hydration capacity (g H_2O/g seed) of six field pea varieties sown at different times at Scaddan in 1999

Variety	Sown on 3 June	Sown on 17 June
Parafield	81.9	78.1
Helena	115.5	109.4
King	89.5	85.2
Magnet	97.2	90.3
Cooke	103.4	99.5
Laura	107.7	105.2
SED	1.82	

Unhydrated seeds are also undesirable. When processed they cause losses during sprouting and may reduce cooking quality. In crop rotations, they can remain dormant in the soil in the year they are planted but then emerge in subsequent crops, sometimes several years later. The levels of unhydrated seed across all sites and experiments ranged from 0-23%. Parafield had the largest amount of unhydrated seeds, followed by King. Helena and Cooke both had lower levels than Dundale. Laura also had very low levels of unhydrated seed. Neither sowing rate nor time of sowing had any effect on the level of unhydrated seed.

Whole seed colour is the most obvious aspect of seed quality, but also the most difficult to interpret in terms of market acceptance. Field peas are usually dehulled before use, so there is little relationship between the colour of the seed coat at harvest and the appearance of the finished product (the cotyledons) to consumer. Nevertheless, whole seed colour is still important for marketing. The variety King, for instance, is not accepted into milling grade peas, because of its brown colour despite its good, uniform seed size. Mixture of varieties with different seed colours appears visually non-uniform and unattractive despite uniformity in terms of size, cooking and milling qualities. Colour preference is therefore likely to remain subjective.

Seed colour is a three-dimensional character, where the dimensions are L* (lightness) ranging from 0 (black) to 100 (white); a* (chroma) where low values indicate greenness and high values redness; and b* (hue) where low values indicate blueness and high values yellowness. There were large differences between varieties in whole seed colour (Table 38). Dundale and Parafield were the most similar, while Helena tended to be greener (negative a*) and King redder (high a*). The white varieties Cooke and Laura were lighter (high L*) and yellower (high b*) than dun seeded varieties.

Seed rate had a significant effect on whole seed colour in the experiments at Scaddan and Mt Barker, but it was very small compared to the effect of variety (Table 38). Increasing seed rate reduced b* slightly, making seeds bluer. Site also affected the colour of seeds: Helena was less green, and Dundale more yellow, at Mt Barker compared to at Salmon Gums or Scaddan. Time of sowing had no effect on whole seed colour..

Table 37. Hydration capacity (g H_2O/g seed) of different field pea varieties in sowing rate trials in WA in 1999

Variety	Sowing rate (kg/ha)	Salmon Gums	Scaddan	Mt Barker
Dundale	50	101.3	101.1	96.1
	100	101.7	105.1	97.2
	160	100.2	106.4	99.6
	220	100.1	107.8	100.7
Parafield	50	87.5	85	94.1
	100	94.6	90.7	95.7
	160	93.8	96.0	96.4
	220	100.2	88.8	101.4
Helena	50	114.3	113.5	108.6
	100	120.3	120.0	107.8
	160	113.3	120.2	110.6
	220	118.8	121.3	113.5
King	50	n/a	91.2	86.7
	100	n/a	90.7	91.5
	160	n/a	92.5	90.1
	220	n/a	95.7	92.0
Magnet	50	n/a	97.6	99.8
	100	n/a	99.2	102.2
	160	n/a	98.3	102.8
	220	n/a	103.7	102.8
Cooke	50	103.8	n/a	n/a
	100	107.7	n/a	n/a
	160	107.0	n/a	n/a
	220	108.4	n/a	n/a
SED		3.52	2.16	2.72

Varietal effects on field pea seed quality were much greater than the environmental and agronomic effects studied here. It is possible to reduce seed size by increasing sowing rate, although there seems to be little risk of this occurring at the seed rates commonly used by WA growers. Even at 220 kg seed/ha used in these experiments, all seed satisfied the size requirements for No. 1. Milling Grade field peas. The small seeded WA varieties Helena and Cooke consistently achieved No. 1. Milling Grade, and potential growers should feel confident in selecting these varieties to achieve this grade. Whether the larger mean seed size of Parafield will attract a premium over Helena is yet to be seen, but some consideration will have to be made for Parafield's greater seed size variability. Increasing sowing rate also raised hydration capacity, but since it is not currently tested in the marketplace, this finding has little immediate value.

Table 38. Whole seed colour of different field pea varieties in seed rate trials in WA in 1999 (L* - lightness, a* - chroma (green - red), b* - hue (blue - yellow))

Variety	L*				a*				b*			
	Seed rate											
	50	100	160	220	50	100	160	220	50	100	160	220
	Salmon Gums											
Dundale	54.5	55.3	54.5	55.1	0.8	1.3	1.5	1.4	14.0	14.2	13.9	14.1
Parafield	54.8	54.8	54.8	54.7	4.1	4.6	4.4	4.1	14.7	14.6	14.2	14.4
Helena	53.9	54.0	52.8	53.9	-2.6	-2.9	-2.1	-2.2	13.8	13.9	13.1	13.4
Cooke	62.1	62.6	63.1	62.3	6.3	6.5	6.6	6.4	16.6	16.9	17.0	16.8
SED	0.48				0.37				0.38			
	Manova: Variety effect significant at $P < 0.001$											
	Scaddan											
Dundale	54.2	54.9	54.6	54.4	2.1	2.0	2.4	2.5	14.7	14.3	14.1	13.9
Parafield	54.8	55.0	53.9	54.2	4.8	4.8	4.2	4.9	14.9	14.6	14.2	14.2
Helena	54.5	54.2	54.4	54.5	-3.1	-3.1	-2.7	-2.4	14.5	14.2	13.9	13.7
King	50.2	50.4	49.7	49.8	9.0	9.4	9.2	9.2	12.2	12.4	11.8	11.7
Magnet	51.3	51.0	50.2	50.1	4.9	5.8	5.8	6.8	11.7	11.5	11.7	11.4
SED	0.51				0.37				0.26			
	Manova: Variety effect significant at $P < 0.001$ Seed rate effect significant at $P < 0.001$											
	Mt Barker											
Dundale	53.9	53.7	54.0	52.8	3.2	3.8	2.7	3.9	13.8	13.8	13.3	13.2
Parafield	54.5	54.6	54.5	53.9	4.6	3.7	4.4	3.9	13.8	14.1	14.1	13.1
Helena	53.3	52.9	52.8	52.7	-1.1	-1.3	-0.7	-0.6	12.8	13.3	12.5	12.2
King	51.5	51.0	50.8	50.5	8.5	8.3	9.1	8.2	12.4	12.2	12.5	12.3
Magnet	51.5	51.5	50.9	50.4	4.5	4.7	5.7	4.9	11.5	11.3	11.4	11.4
SED	0.59				0.40				0.32			
	Manova: Variety effect significant at $P < 0.001$ Seed rate effect significant at $P < 0.01$ Variety × seed rate interaction significant at $P < 0.05$											

Seed yield and quality in the Great Southern

N. Brandon, R. Beermier, AGWEST, Katanning, **N. Brown** and **S. White** AGWEST, Jerramungup

Ten field pea varieties were sown at two sites in the Great Southern to compare yield and seed quality characteristics of recently released varieties from South Australia (Parafield, Mukta), Victoria (Snowpeak, Excel) and WA (Helena and Cooke) with older varieties such as Dundale and Laura. Seasonal rainfall at Ongerup (May to October rainfall of only 117 mm) was the driest on record and at Gnowangerup (May to October rainfall 163 mm) was the second driest on record. All varieties were sown at 120 kg/ha. Both sites were sown on 21 June. Measurements included phenology (date of flowering and podding), progress of pod development, seed yield and seed quality. Pod development data is yet to be analysed, but initial results on phenology, seed yield and quality are presented here.

Plant density was similar or greater than recommended levels (50 plants/m^2) (Table 39). The only exception was Snowpeak which had lower establishment due to poor quality seed (also observed in CVT trials this year) and Laura which had higher than the recommended plant density. Dundale, and Snowpeak (90 days), were the earliest flowering varieties, while to King (99 days) was the latest.

Table 39. Plant density (plants/m^2) and phenology (days after sowing) of field pea varieties/lines at Gnowangerup

Variety (type)[a]	Plant density	50% flowering	End of flowering	50% podding	Maturity
Cooke (W)	67	96	120	101	139
Dundale (D)	45	90	110	98	139
Excel (B)	57	93	119	98	135
Helena (D)	73	94	110	100	132
King (D)	61	99	117	105	141
Laura (W)	95	93	120	100	140
Mukta (W)	66	96	120	101	141
Parafield (D)	56	96	110	101	141
Snowpeak (W)	32	90	120	98	139
WAPEA2074 (D)	57	97	110	101	141
LSD 5%	6	0.7	0.3	0.3	9.3 (NS)

[a] (W = white pea, D = Dun pea B = Blue pea).

Dundale outyielded other varieties at both sites (Table 40). Mean seed weights were greater at Gnowangerup, but ranking was consistent between sites. Cooke Helena and Laura produced smaller seeds than Dundale, Parafield and WAPEA2074 at both sites.

Split or cracked seed was removed from 100 g samples, and seed remaining (%) after being shaken on 7 mm and 4.76 mm round sieves was measured. Varieties with more than 20% seed larger than 7 mm (as measured by a round screen) at both sites were Dundale, Parafield and WAPEA 2074 (Table 40). Helena, despite it’s small 100 seed weight did not fail current seed size standards at either site with less than 1.5% grain falling through a standard 4.76 round screen (the current standard is 3%). Laura failed at both sites (> 5%) and Cooke failed at Ongerup (> 6%).

These results confirm the adaptability of field pea to regions and years with low rainfall. Seed yields obtained in these trials (0.4-1.0 t/ha) are consistent with those achieved commercially in the Great Southern region this year. Also, given the dry year, and the extreme conditions at Ongerup, it was encouraging to see that all varieties were able to pass the current seed size standards without the need for further grading, with the exception of Laura and Cooke. The

similarity in seed size of Dundale and Parafield contrasts with results from other sites (see section on new field pea and faba bean varieties in the Great Southern) and years (see section on Agronomic and varietal effects on seed quality), and may be due to the severe seasonal conditions experienced at these sites.

Table 40. Seed yield (kg/ha), mean seed weight (MSW, g/100 seeds) and seed size (% seed > 7 mm) of field pea varieties/lines at Ongerup and Gnowangerup

Variety/line	Gnowangerup			Ongerup		
	Seed yield	MSW	Seed size	Seed yield	MSW	Seed size
Cooke (W)	1194	14.9	6.2	376	10.8	1.6
Dundale (D)	1232	19.1	42.2	618	16.9	21.7
Excel (B)	875	18.4	8.7	273	16.1	8.1
Helena (D)	1172	14.4	13.1	550	12.5	7.0
King (D)	1186	17.5	19.2	230	15.0	5.2
Laura (W)	1036	14.2	0.2	405	11.1	1.0
Mukta (W)	976	15.6	4.1	328	13.3	0.5
Parafield (D)	1085	19.4	48.5	497	17.1	26.2
Snowpeak (W)	1153	19.6	12.4	409	17.3	5.4
WAPEA2074 (D)	1104	20.2	46.5	514	17.9	36.2
LSD P < 0.05	132	1.6	14.1	88	1.0	4.8

Herbicide tolerance of new varieties and lines

Esperance region

M. Seymour, AGWEST, Esperance

The WA breeding program has a number of new dun field pea lines close to commercial release. Two trials were conducted in the Esperance region at Scaddan (00ES23, topsoil pH 8 in water) and Beaumont (00ES24, topsoil pH 7.5 in water) to evaluate the safety of commonly used herbicides on field pea varieties grown on alkaline mallee soils.

The lines tested were Dundale, Parafield, Helena, WAPEA2074 and WAPEA2127. The treatments consisted of six herbicides applied either immediately before sowing (IBS) or post sowing pre emergent (PSPE) (Table 41). At the 3-5 node stage plots were split to include a plus or minus treatment with a Brodal/Lexone® mix treatment.

At both sites there were very few weeds present. The main weed was wild mustard, which was only present in the interplot spaces. There was no visual damage caused by herbicide application in any plot in either trial.

At Scaddan, Dundale produced the least seed yield, and there was no difference in seed yield between Parafield, Helena and WAPEA2127. No herbicide treatment had any significant effect on seed yield, so only the variety data is shown (Table 42). The new line WAPEA2074 and Parafield produced good quality seed (Table 43). Helena produced smaller seeds and more screenings using a 7 mm screen, but achieved the current delivery standard for No.1 milling grade peas of 97% above a 4.76 mm round sieve.

Table 41. Herbicide treatments evaluated at Scaddan and Beaumont

IBS or PSPE treatments	Rate (mL/ha)	Timing
Unsprayed	Nil	
Bladex®	2000	IBS
Diuron	2000	IBS
Lexone®	300	PSPE
Spinnaker®	150	PSPE
Spinnaker®/Diuron	150/1000	PSPE

Table 42. Seed yield of field pea varieties at Scaddan (00ES23) sown 2 June

Variety	Seed yield (kg/ha)
Dundale	1323
Helena	1516
Parafield	1575
WAPEA2127	1525
WAPEA2074	1468
LSD 5%	77
CV%	3

Table 43. Mean seed weight (MSW, g/100 seeds) and screenings for field pea varieties at Scaddan (00ES23)

Variety	Screenings (%)			MSW
	> 7 mm	4.76 to 7 mm	> 4.76 mm	
Dundale	18	81	99	16.5
Helena	6	94	99	14.5
Parafield	59	41	100	20.8
WAPEA2074	56	44	100	20.2
WAPEA2127	40	60	100	17.1
LSD 5%	6	6	0	2.2
CV%	6	3	0.1	3

At Beaumont the herbicide treatments had no effect on seed yield ($P > 0.05$), however the application of Brodal/Lexone® increased yield despite low weed levels (Table 44). Seed yields were low due to a combination of late sowing in a dry year and budworm damage. Observations close to harvest indicated Parafield was more affected by budworm than other lines. The early maturing line WAPEA2127 produced the greatest seed yield at this site and has shown good potential at other low rainfall regions of the mallee in 2000.

The results of these trials indicate that the new Dun field pea lines react in a similar manner to Dundale for the herbicides evaluated.

Table 44. Seed yield (kg/ha) of field pea varieties treated with post emergent herbicides at Beaumont (00ES24) sown 29 June

Variety	Seed yield		Mean seed yield
	Nil	Post emergent[a]	
Dundale	429	490	460
Helena	534	593	564
Parafield	440	536	488
WAPEA2127	590	643	616
WAPEA2074	407	447	427
Mean	480	542	
LSD 5%	Variety	33	
	Post emergent	61	
CV%	22		

[a] Brodal 60 mL/ha + Lexone 60 mL/ha (applied at the 5 node stage on 10 August).

Mullewa

H. Dhammu and **T. Piper**, AGWEST, Northam, **D. Nicholson**, AGWEST, Geraldton and **M. D'Antuono**, AGWEST, South Perth

Trials during 1999 showed some sensitivity of new field pea varieties to registered herbicides. This trial was intended to further evaluate these sensitivities. The site was a red sandy loam soil at Mullewa, well suited to field peas. The herbicide mixes tested were aimed at achieving the best chemical weed management practice (Table 45). Seven varieties were sown on 30 June 2000 in 20 m wide strips parallel to each other. Herbicides were applied across these strips in three randomised blocks. Half of the trial strip (10 m) of each variety was sprayed with Brodal 100 mL + Lexone 100 g/ha when the field peas were at 3-5 nodes. No post-emergent treatment was scheduled for the other half of the strip, but after a high density of brassica weeds appeared, it was sprayed with Brodal 100 mL/ha when field peas were at the 4-6 node stage.

In summary, the results indicate that:

- With no pre-emergent treatment, field pea yielded slightly more when treated with Brodal + Lexone compared to Brodal alone, except for Helena. This is probably a reflection of its greater efficacy on radish.
- Bladex, Diuron, Spinnaker, and their combinations were generally safe. Diuron reduced the yield of Parafield significantly (2 L/ha), but at 1.5 L/ha plus Bladex, there was no effect. These results are consistent with previous years.
- Lexone caused significant yield reductions in all except Cooke and Parafield, both alone and in mixtures. This is consistent with previous results, except that King was then more tolerant than Cooke.
- Brodal/Lexone applied post-emergent caused no crop damage, provided that Bladex and/or Diuron had not been used pre-emergent, except for WAPEA2074. This result is in contrast to previous results where Brodal/Lexone has been a very safe option.
- Spinnaker as immediately post planting (IPP) followed by post-emergence application of Brodal + Lexone reduced the yield of King, Magnet, Helena and Parafield. Spinnaker + Diuron applied IPP followed by Brodal + Lexone also reduced the yield of Parafield and WAPEA 2127 significantly.
- Cooke, Magnet and WAPEA2127 tolerated all the herbicides applied IPP well, while King tolerated everything except Lexone, and Parafield tolerated all, except Diuron. This contrasts somewhat with previous results, where King has been generally more tolerant than Cooke or Magnet.

- Spinnaker/Diuron remains the best overall recommendation, both for safety and efficacy.
- The use of Brodal/Lexone for post-emergent radish control must be considered carefully, given the crop damage observed in this trial when used following pre emergent herbicides. This result may be due to the very short growing season, which did not allow the crop to fully recover from any crop damage caused by this mixture.

Herbicide tolerance of Cooke on marginal soil

H.S. Dhammu and **T.J. Piper**, AGWEST, Northam, **D.F. Nicholson**, AGWEST, Geraldton and **M.F. D'Antuono**, AGWEST, South Perth

As the price of lupins drops, farmers are attempting to push other pulses such as field pea and chickpea into soil types that would be considered marginal for their growth - more suited to lupins. Research over the past few years has developed some robust herbicide recommendations for use in these crops, but they have not been tested on lighter soil types where the herbicides may become more active and/or the crops may be less tolerant.

A trial was conducted at Mullewa on a sandy soil (88.5% sand, 4.2% Silt and 7.3% clay), low in nitrogen and organic carbon with pH 4.97 and EC 2.67. Due to the late break to the season, weeds were not controlled by knockdown herbicides effectively and thus weed free conditions were not achieved. Major weeds present were wild radish and doublegee. Field peas (cv Cooke) were sown on 30 June in a 20 m wide strip. A range of herbicide treatments were applied across the trial strip involving three replications. Half of the trial strip (10 m) was sprayed with Brodal 100 mL + Lexone 100 g/ha when field peas were at 3-5 node and wild radish at 4-6 leaf stage. Another half of the strip was sprayed with Brodal 100 mL/ha when field peas were at 4-6 node and wild radish at 6-8 leaf stage.

Brodal + Lexone controlled the weeds effectively, whereas the application of Brodal alone failed to control weeds (Table 46). Weeds caused significant yield reduction (45.3%) compared to the most effective herbicide, Bladex. Seed yield reduction (42.1%) was also significant in plots treated with Brodal alone compared with the Brodal + Lexone tretament. Lexone alone and in mixture with Spinnaker and Diuron applied as IPP caused significant yield reduction compared to Bladex. The yields were further reduced significantly when these treatments were followed by Brodal + Lexone as post -emergent treatments. Bladex alone and Bladex applied immediately before sowing (IBS) + Diuron applied IPP followed by post-emergent application of Brodal + Lexone caused significant yield reduction as compared to Bladex alone and/or Brodal + Lexone treated controls. The reduction in yield is also evident from less biomass production by field peas under these treatments. Interestingly, Lexone was tolerated well by the variety Cooke in another trial on a red sandy loam soil at Mullewa (a more suitable soil type for field pea).

The results of this study indicate that Bladex, Spinnaker and Spinnaker + Diuron can safely be used in Cooke field peas on sandy soils. The recommended herbicide Lexone alone and in mixture with Spinnaker and Diuron reduced the yields. Use of Brodal + Lexone as post-emergence treatment needs further investigation under a weed free situation.

Table 45. Herbicide effects on yields of field pea varieties (% of untreated in all varieties except % of Bladex in WAPEA 2074) at Mullewa (00MW32)

Trt[a]	Herbicide treatment	King[b]	King[c]	Magnet[b]	Magnet[c]	Cooke[b]	Cooke[c]	Helena[b]	Helena[c]	2074[b]	2074[c]	2127[b]	2127[c]	Parafield[b]	Parafield[c]
1	Untreated (kg/ha)	100	100	100	100	100	100	100	100	85	116	100	100	100	100
		472	512	803	855	626	647	748	629	491	744	878	895	741	802
2	Bladex 2.0 L[d]	111	99	102	92	116	98	93	98	580[e]	641[e]	104	111	110	111
3	Diuron 2.0 L	93	91	87	90	112	100	99	87	102	115	103	102	**87**	90
4	Lexone 300 g	**58**[f]	**34**	83	**52**	100	**83**	**71**	**60**	76	**72**	87	**50**	98	**55**
5	Spinnaker 200 mL	85	**51**	84	**77**	97	96	96	**80**	79	97	97	87	101	**82**
6	Lexone/Diuron 200 g/1.5 L	101	**80**	92	**57**	91	**88**	112	**67**	94	91	93	**78**	109	**84**
7	Spinnaker/Diuron 150 mL/1.5 L	113	88	95	89	96	95	101	91	81	107	112	**85**	110	**86**
8	Spinnaker/Lexone 150 mL/200 g	80	**39**	84	**57**	101	**85**	**86**	**78**	**67**	96	107	87	107	**88**
9	Spinnaker/Lexone/Diuron 100 mL/ 150 g/1.0 L	**64**	**61**	108	**75**	102	94	109	**81**	104	96	95	**66**	124	91
10	Diuron 2.0 L + 1.5 L[d]	94	101	109	85	112	98	108	90	94	128	91	108	112	113
LSD 5%	Untreated v/s Herbicides (%)	21	19	20	18	12	11	13	15	20	13	15	14	11	11
	Herbicides v/s Herbicides (%)	26	25	24	23	15	14	16	19	25	16	19	18	14	13
	Herbicides across [a] & [b] (%)	25	25	23	23	14	14	17	17	20	20	18	18	14	14
	Untreated across [a] & [b] kg/ha)	65	65	109	109	49	49	65	65	64	64	81	81	55	55

[a] Treatment 2 was incorporated by sowing, Treatments 3-10 were applied immediately post-plant.
[b] Brodal @ 100 mL/ha was applied along half of the each variety at 4-6 nodes.
[c] Brodal 100 mL + Lexone 100 g/ha was applied along half of the each variety at 3-5 nodes.
[d] Basal Bladex @ 2.0 L/ha.
[e] Yield kg/ha of WAPEA 2074.
[f] Figures in bold are significantly different from untreated in all varieties except from Bladex 2.0 L/ha in WAPEA 2074.

Table 46. Effect of herbicides on dry matter (% reduction) and seed yield (kg/ha) of Cooke field peas at Mullewa (00MW33)

Trt[a]	Herbicides/ha	Biomass reduction (%)[b]		Seed yield	
		Cooke[c]	Cooke[d]	Cooke[c]	Cooke[d]
1	Bladex 2.0 L[e]	0	0	671 (100)[f]	433 (64.5)
2	Diuron 2.0 L	0	0	583 (86.9)	580 (86.5)
3	Lexone 300 g	37	64	364 (54.3)	198 (29.6)
4	Lexone/Diuron 200 g/1.5 L	38	67	372 (55.5)	174 (25.9)
5	Spinnaker 200 mL	0	0	642 (95.7)	606 (90.4)
6	Spinnaker/Diuron 150 mL/1.5 L	0	2	658 (98.0)	534 (79.6)
7	Spinnaker/Lexone 150 mL/200 g	8	22	510 (76.0)	438 (65.2)
8	Spinnaker/Lexone/Diuron 100 mL/ 150 g/1.0 L	8	17	516 (76.9)	381 (56.8)
9	Diuron 2.0 L + 1.5 L[e]	2	4	586 (87.4)	534 (79.5)
10	Untreated	0	0	367 (54.6)	633 (94.4)
	LSD (0.05)	Untreated v/s Herbicides		76	87
		Herbicides v/s Herbicides		94	112
		Herbicides across [c] & [d]		103	103
		Untreated across [c] & [d]		51	51

[a] Treatment 1 was incorporated by sowing, Treatments 2-8 were applied immediately post-plant.
[b] Visual biomass reduction scored on 30 August.
[c] Brodal @ 100 mL/ha was applied along half of the trial strip at 4-6 nodes.
[d] Brodal 100 mL + Lexone 100 g/ha was applied along half of the trial strip at 3-5 nodes.
[e] Treatment has basal Bladex @ 2.0 L/ha.
[f] Values in the parentheses are % yield of Bladex.

Post emergent weed control using Raptor®

Raptor® (700 g/kg Imazamox), produced by Cyanamid, may find a role for post emergent control of wild radish, turnip and mustard in field peas. It will be an alternative to Brodal® and Brodal®/Lexone® mixes. A small scale experiment (two replicates) was conducted on a farmers bulk crop at Scaddan to test its efficacy and safety on Dundale field peas.

Herbicide treatments were applied on 27 June when the field peas were at the six node stage (Table 47). Brodal®/Lexone® and Raptor® reduced weed levels significantly (weed rating $P < 0.05$), but there was no effect of herbicide on seed yield. Due to the trial variability there was no significant difference in the other traits measured, however there was a trend for better weed control of turnip using Raptor® and Brodal® (Table 48).

Table 47. Seed yield (kg/ha), weed rating (1 = good, 5 = bad), and yield components of Dundale field pea treated with post emergent herbicides at Scaddan (00ES106)

Treatment	Rate (mL/ha)	Seed yield (kg/ha)	Weed rating	Dry matter (g/m²)	Pod no. (/m²)	Seed wt (g/m²)
Nil	0	794	5.0	247	247	64
Brodal®	150	722	2.5	273	281	73
Brodal®/Lexone®	60/60	860	2.0	301	301	75
Raptor®	45	895	1.5	390	377	102
LSD 5%		ns	2.9	ns	ns	ns
CV%		23	13	7	7	27

Table 48. Number of stems or tillers per m² of weeds measured at crop maturity (10 Oct.) in a Dundale field pea crop treated with post emergent herbicides at Scaddan (00ES106)

Treatment	Rate (mL/ha)	Type of weed			
		Turnip	Radish	Grass	Other
Nil	0	14	0	1	10
Brodal®	150	3	0	10	7
Brodal®/Lexone®	60/60	14	0	6	3
Raptor®	45	1	0	1	5
LSD 5%		ns	ns	ns	ns
CV%		96	0	52	18

Lentil

Approximately 3,000 ha of lentil were sown in WA during the 2000 season. Cassab and Digger were the main varieties grown, with a small area of Northfield. The short and dry season in 2000 was not conducive to the development of fungal diseases and hence, the incidence of ascochyta blight and botrytis grey mould in lentil trials and commercial crops was low or absent. Average seed yields of commercial crops in WA in 2000 ranged from 0.4-1.0 t/ha. In the eastern region of the grain belt, several growers reported that Cassab out-yielded Digger by up to 15% on their farms. With greater confidence in the production packages, varieties and continued promising price outlook, it is likely that the lentil area in WA will increase substantially in 2001.

In 2000, lentil trials in WA included evaluation of varieties (Merredin, Mukinbudin, Mingenew, Speddingup, Lake Grace and Tammin), CIPAL advanced breeding lines (Merredin), elite lines from ICARDA and an ACIAR project (PN9436), and a nursery of F3/F4 lines derived from an ACIAR project (PN9436).

Variety evaluation

Australian varieties and a promising advanced lentil line (ILL7220) were evaluated for adaptation and yield at six sites across a wide range of environments in WA. In general, an optimum plant density of 150 plants/m^2 is recommended for lentil in WA. The sowing rate required to achieve this density will vary depending on seed size (lentil type and variety) and germination percentage. In the past, research has shown that plant establishment of lentil in WA has often been poor (Siddique *et al.* 1998), and hence, greater sowing rates have been promoted. In general, a sowing rate of 90-110 kg/ha for red lentil is recommended. In these variety trials, sowing rate was calculated for each variety based on mean seed weight and a germination percentage of 70% (actual tests indicated > 90% germination). Despite this, most sites achieved plant densities around 120-130 plants/m^2 (Table 49). Only one site (Lake Grace) exceeded 150 plants/m^2 for all varieties.

Table 49. Plant establishment of lentil varieties and breeding line in WA

Variety	Seed type	Lake Grace 00NE01 16 June	Merredin 00ME08 17 June	Mingenew 00GE78 17 June	Mukinbudin 00ME11 13 June	Speddingup 00ES06 26 June
Aldinga	Red	160	123	118	133	103
Ansak	Red	167	118	134	129	112
Cassab	Red	172	124	129	127	125
Cobber	Red	170	111	131	127	119
Cumra	Red	160	115	126	126	113
Digger	Red	179	114	123	118	121
Matilda	Green	164	118	138	124	132
Northfield	Red	180	136	127	124	111
Nugget	Red	176	140	137	136	131
ILL7220	Red	-	145	120	134	-
Mean		170	124	128	128	119
LSD 5%		6	14	10	9	9
CV%		15	ns	18	16	15

Mean seed yields across trials ranged from 187 kg/ha at Mukinbudin (the driest site) to 1092 kg/ha at Mingenew (the wettest site) (Table 50). In general, seed yields were poor at most sites due to the dry conditions experienced during the season. At Mingenew, the growing season rainfall (May to October) was 264 mm. However, much lower growing season rainfall was recorded at Merredin (129 mm), Mukinbudin (83 mm), Lake Grace (130 mm), Speddingup (148 mm) and Tammin (171 mm).

At Lake Grace, Mukinbudin and Tammin, trial variability was large and no significant differences were observed in seed yield between varieties. At other sites, Cassab, Cumra and Digger continued to be strong yield performers in WA during 2000. At Merredin, Cumra produced the greatest seed yield, while at Speddingup, Cassab and Northfield produced the greatest seed yield and Cumra the least. At Mingenew, Cassab, Digger, Cumra and ILL7220 produced the greatest seed yields. The newly released variety Nugget produced 1040 kg/ha at Mingenew and 336 kg/ha at Merredin. Northfield and Ansak have relatively late maturity for WA conditions and produced the least seed yield at Mingenew, however Northfield performed well at Speddingup.

Table 50. Seed yields (kg/ha) from lentil variety trials

Variety	Lake Grace 00NE01 16 June	Merredin 00ME08 17 June	Mingenew 00GE78 17 June	Mukinbudin 00ME11 13 June	Speddingup 00ES06 26 June	Tammin 00AD01 20 June
Aldinga	494	283	999	198	746	231
Ansak	513	252	809	161	607	-
Cassab	590	376	1273	168	843	189
Cobber	432	397	1135	238	723	168
Cumra	465	538	1231	201	434	207
Digger	493	397	1325	176	763	201
Matilda	492	334	1057	186	638	172
Northfield	407	328	829	184	832	208
Nugget	507	336	1040	190	701	209
ILL7220	-[a]	296	1269	166	-	-
Mean	493	354	1092	187	699	198
LSD 5%	ns	91	161	ns	198	ns
CV%	19	18	10	20	26	23

[a] ILL7220 was not sown at Lake Grace, Mukinbudin or Tammin.

Despite the dry season, mean seed weight was relatively high in 2000 (Table 51). In general, Aldinga and Matilda produced the heaviest seeds, and Northfield the lightest. However, Cumra, Cassab and Ansak produced seed of similar size to Matilda at Merredin. The line ILL7220 produced a similar seed weight to Northfield.

Table 51. Mean seed weight (g/100 seeds) of lentil varieties and lines in WA

Variety	Lake Grace 00NE01 16 June	Merredin 00ME08 17 June	Mingenew 00GE78 17 June	Speddingup 00ES06 26 June
Aldinga	5.31	4.21	4.42	5.31
Ansak	4.39	3.65	3.69	4.30
Cassab	4.37	3.69	3.66	4.07
Cobber	4.23	3.46	3.72	3.92
Cumra	4.18	3.64	3.71	3.91
Digger	4.48	3.47	3.51	3.88
Matilda	4.71	3.64	4.39	4.79
Northfield	3.12	2.66	2.83	3.10
Nugget	4.12	3.30	3.50	3.80
ILL7220	-	2.89	2.94	-
Mean	4.32	3.46	3.64	4.12
LSD 5%	0.24	0.14	0.12	0.21
CV%	4	3	2	4

Evaluation of advanced breeding lines from the CIPAL

Potentially high yielding, ascochyta resistant lentil lines identified in preliminary trials at Horsham, Victoria and other primary sites were evaluated at Merredin for their adaptation and yield performance in WA. The trial consisted of small plots (four row by 7m long) and variable replications (one to three) of each line. Trial replicates were restricted by availability of seed. Seed yield was analysed using REML statistical methods.

Table 52. Seed type (red or green), time in days after sowing (DAS) to 50% flower and maturity, mean seed weight (MSW, g/100 seeds), seed yield (kg/ha) and seed yield as a %Digger of lentil varieties and breeding lines at Merredin (00ME10)

Line	Seed type	50% flower	Maturity	MSW	Seed yield	SY as % Digger
Aldinga	Red	95	143	3.4	264	65
Cassab	Red	87	135	3.2	427	105
Cumra	Red	87	137	3.6	652	160
Digger	Red	94	143	3.2	408	100
Matilda	Green	92	140	3.6	260	64
Northfield	Red	95	143	2.3	345	85
Nugget	Red	94	143	2.8	325	80
1989.164*3	Red	94	143	3.3	375	92
94-003L*97H15	Red	91	139	3.3	470	115
94-004L*97H10	Red	92	139	4.5	392	96
94-004L*97J6-98G001	Red	95	143	3.9	465	114
94-004L*97J6-98G002	Red	87	135	-	433	106
94-009L*97H8	Red	95	143	4.3	285	70
97-028L*98H004	Red	87	135	3.4	401	98
97-028L*98H006	Red	94	143	3.3	472	116
97-028L*98H010	Red	95	143	2.9	468	115
97-028L*98H014	Red	87	135	3.2	518	127
97-028L*98H015	Red	87	143	3.7	609	149
97-028L*98H016	Red	87	135	3.8	524	128
I93S212L*97H2	Red	90	139	3.1	426	104
I94S136L*97H9	Red	95	139	2.8	281	69
I94S140L*97H5	Red	91	143	3.1	277	68
I94S160L*97H10	Red	87	135	3.4	419	103
I94S160L*97H8	Red	90	139	3.1	468	115
ILL7558	Red	87	135	4.1	387	95
ILL8076	Red	95	143	3.8	301	74
ILL8107	Green	87	135	4.5	595	146
ILL8109	Green	87	135	4.7	796	195
ILL8178	Red	95	143	2.6	275	67
ILL8186	Red	95	143	3.7	648	159
ILL8194	Red	94	143	3.0	482	118
ILL8197	Red	95	143	3.0	256	63
ILL8198	Red	87	135	2.7	519	127
ILL8199	Red	87	135	3.0	532	130

Given the late break to the season and low seasonal rainfall, lentil lines/varieties with early flowering and maturity performed the best in this trial. Mean seed yield of the trial was 434 kg/ha. Cumra produced the greatest seed yield (652 kg/ha) of the commercial varieties (Table 52). A number of lines produced seed yields substantially greater than Digger. Two early flowering green lentils (ILL8107 and ILL8109) produced seed yields that were 46 and 95% greater than Digger, respectively. In addition, their mean seed weights were almost 30% greater than Matilda. Unfortunately, disease screening in Victoria during 2000 has indicated that these lines are both susceptible to ascochyta blight.

The results from this trial and similar trials across Australia will be used to evaluate the potential of these lentil breeding lines. Preliminary results from the CIPAL screening program in 2000 have identified of early maturing red lentil lines with improved ascochyta and lodging resistance. Promising lines will be selected for further screening and yield evaluation in 2001.

Elite germplasm from ICARDA and ACIAR project

K. Regan, AGWEST, South Perth, **J. Clements** and **K.H.M.** Siddique, CLIMA and AGWEST, South Perth and **C. Francis** CLIMA

Lentil germplasm with early maturity and other desirable characteristics were selected at ICARDA for testing under WA conditions. These lines (15) were were evaluated for yield and other agronomic characteristics in 2000. In addition to these, five lines selected for good adaptation and yield in WA in another project (ACIAR Project No. PN9436) were evaluated in this trial.

Many of the lentil lines had similar phenology to Digger and Cassab (Table 53). Plant establishment was low and variable in this trial, and there were no significant differences in seed yield between lentil lines. Once again, unfavourable seasonal conditions were largely responsible for the uneven establishment and poor yields. The mean seed yield in this trial was 304 kg/ha. These lines will be evaluated again in 2001.

Single row evaluation of F3/F4 breeding lines

K. Regan, AGWEST, South Perth and **J. Clements** CLIMA and AGWEST, South Perth

Lentil germplasm with early maturity and other desirable characteristics originating from crosses developed in WA during an ACIAR project (PN9436) were evaluated. These lines (F4) were grown in small plots at Merredin in 2000. A number of lines showed good early vigour, tall plant habit and early maturity. Due to the poor growing conditions, single plant selections were not made in 2000. Instead, all plants were harvested. The seed from each plot will be re-sown in small plots during 2001 at Merredin for agronomic evaluation and single plant selections.

Table 53. Plant density (plants/m²), time in days after sowing to 50% flower, 1st pod and maturity, and seed yield (kg/ha) of lentil lines at Merredin

Line	Plants/m²	50% flower	1st pod	Maturity	Seed yield
Cassab	104	94	100	140	259
Cumra	82	90	97	138	314
Digger	119	92	98	139	391
Northfield	103	97	102	143	335
ILL358	114	94	102	142	350
ILL6260	107	93	99	139	242
ILL6783	91	96	102	142	308
ILL6821	103	88	94	137	236
ILL7168	76	92	99	139	225
ILL7512	80	95	100	141	211
ILL7537	90	91	98	139	283
ILL7979	78	94	100	140	270
ILL7980	92	90	97	138	316
ILL7983	95	96	101	142	206
ILL8008	116	90	96	138	473
ILL8091	113	91	98	138	302
ILL8095	99	91	98	138	369
ILL8112	89	93	99	140	342
ILL8114	79	92	99	139	196
JCMMF-18.1	91	90	97	138	228
JCMMF-4-13	117	88	96	138	199
95M3-21	119	90	96	138	448
95M3-24	114	93	99	139	400
95M3-7	104	90	97	138	388
LSD 5%	29.9	4	3.2	2.4	ns
CV%	21	3	2	1	45

Vetch

Germplasm evaluation

In collaboration with the National Vetch Improvement Program based at SARDI, a number of introduced common vetch lines were compared with standard varieties at four sites in 2000.

Due to a seed source error, the most widely grown variety (Languedoc) was not sown in this series of trials. Seed yields were extremely low and variable (high CV%) at Salmon Gums (< 200 kg/ha) due to drought (Table 54). Merredin and Gnowangerup showed a strong relationship between early flowering and yield. In general, the dry spring conditions were unfavourable for the late flowering lines such as Morava. Scaddan had better spring conditions and yields of 1t/ha or more were achieved for most lines.

At Gnowangerup the line SA33115 performed well, producing 1.4 t/ha compared to 1 t/ha for Morava. However, results from SA indicate SA33115 is more susceptible to rust than Morava. At Scaddan there was a low level of rust and BGM prior to and during flowering and pod set (see section on time of sowing). The plots were split just prior to 50% flowering of the early lines to examine the effect of fungicide application on half of each plot. There was no consistent response to fungicide application across all lines (data not shown), probably due to the dry spring conditions. Therefore, there is no local information on the rust tolerance of SA33115 at this stage. Given the poor rating found in SA, the value of SA33115 must be treated with some reservation, despite its good yield potential.

Time of sowing x fungicide

M. Seymour, AGWEST, Esperance

In recent years the late flowering rust resistant variety Morava has been released to growers. It is a very different variety to the early flowering rust susceptible variety Languedoc, the main stay of the WA vetch industry. In 2000 we conducted an experiment at Scaddan to test the response of vetch varieties to time of sowing in the presence of rust and BGM. The site was selected on a farm that has a history of growing vetch and where rust was observed in 1999.

In early August, rust and BGM were present at low levels (< 5%). The level of rust infection increased to about 25% of the lower leaves affected, however, BGM was the dominant fungus present affecting up to 50% of the foliage. Botrytis grey mould appeared to cause infection of the vetch late in the season (September). Dithane was applied at 2 kg/ha of on 22 August and 1.5 kg/ha on 11 September. The first application coincided with flowering of Languedoc in the first time of sowing, but prior to flowering in Morava and later sowing dates of Languedoc.

Sowing in the first week of May resulted in poorer seed yields compared to later sowings for both varieties due to increased BGM infection in September (Table 55). There was a response to applying fungicide at most times of sowing, whilst maximum yield was achieved by delaying sowing until 22 May.

The late flowering variety Morava appeared to be more affected by BGM than the early flowering variety Languedoc, which was not expected. Although Morava grew well, producing comparable dry matter to Languedoc, the timing of the BGM infection combined with the poor spring conditions contributed to Morava’s poor pod and seed set.

In previous years we have noted that Morava can be a ‘shy seeder’ and tends to be not as efficient as Languedoc at converting dry matter into yield (HI). The observations from 2000 show that, in some instances, Morava is more susceptible to BGM, which is cause for concern

Table 54. Flowering time in days after sowing at Scaddan and seed yield (kg/ha) in vetch variety trials

Variety	Scaddan 50% flower 00ES5 22 May	Scaddan 00ES5 22 May	Salmon Gums 00ES8 1 June	Gnowangerup 00GS12 21 June	Merredin 00ME13 15 June	Mean seed yield[a]	Seed yield as % Morava
Blanchefleur	113	1096	97	1114	784	998	110
Cummins	105	1311	92	1189	913	1138	125
Early Albino Lang.	100	1091	135	1069	1016	1059	116
Filler	121	1055	75	1090	644	930	102
Morava	113	1078	59	971	680	910	100
SA3300	100	1083	130	1329	887	1100	121
SA33115	113	882	158	1405	933	1074	118
SA33133A	113	1114		379	460	651	72
SA33150	100	778		298	273	450	49
SA33158					364	364	40
SA33165	100	1026	120	1285	987	1099	121
SA33224	113	1034		983	758	925	102
SA33224A	113	1122		1099	851	1024	113
SA33232	113	1169		1093	724	995	109
SA33248A	113	834	160	491	504	610	67
SA33258	100	1086	156	1221	944	1084	119
SA33555	121	878	102	482		680	75
SA33585	113	989	159	497	482	656	72
SA33587	121	922		553	582	686	75
SA33600	100	1151	196	1108	898	1052	116
SA33777	121	386	4	161	222	257	28
SA33857			126				
SX8253	113	1209	132	639	916	921	101
LSD 5%		256	ns	181	163		
CV%		4	47	4	4		

[a] Mean excluding 00ES08.

Table 55. Seed yield (kg/ha) response of two common vetch varieties to time of sowing and fungicide application at Scaddan in 2000

Variety	Sowing date	Sprayed	Unsprayed	Mean
Languedoc	9 May	787	564	675
	22 May	1233	1020	1126
	2 June	1137	862	999
	27 June	587	460	523
	Mean	936	726	831
Morava	9 May	338	216	277
	22 May	849	485	667
	2 June	743	481	612
	27 June	545	326	435
	Mean	619	377	498
Mean		777	552	664
CV%		17		
LSD	Fungicide	121		
	Fungicide TOS	ns		
	Fungicide. TOS variety	ns		

Tolerance to post emergent application of Sniper®

M. Seymour, AGWEST, Esperance

A new product, Sniper® (Picolinafen), is being released as an alternative herbicide to Brodal for post emergent control of wild radish, turnip and mustard. Currently, it is difficult to manage these weeds in vetch.

Sniper® was applied at three rates to a commercial crop of Languedoc at Scaddan on 27 July at the mid to late vegetative stage. At the two higher rates, reduced crop growth and leaf bleaching (similar to that commonly seen following Brodal® application) were visible. The crop appeared to recover from the setback and all treatments produced good dry matter and seed yield given the dry spring. The response to Sniper® application was not consistent for seed yield, pod number or total dry matter production due to trial variability and inadequate replication (Table 56). However, there was a trend for greater dry matter production, pod number and seed yield in the control (unsprayed) treatment. This trial will be repeated during 2001.

Table 56. Dry matter production at maturity (g/m^2), pod number ($pods/m^2$) and seed yield (kg/ha), of Languedoc following herbicide (Sniper®) application at Scaddan (00ES107)

Rate of Sniper® (mL/ha)	Dry matter	Pod number	Seed yield
0	647	1130	1895
33	357	691	1085
42	409	858	1070
55	445	916	1530
Mean	464	898	1395
LSD 5%	ns	ns	ns
CV%	9	1	10

Herbicide tolerance

A number of herbicide treatments were tested at Ongerup in 2000 (Table 57). The trial was designed as a herbicide tolerance experiment using rates and products that growers are likely to try. The variety used was Languedoc. Seasonal conditions were very harsh with very little spring rainfall. Hence, spring growth was limited, resulting in low seed yields.

Key observations:

- MCPA 250 treatments caused significant crop damage and reduction in seed yield.
- Sniper damaged plants and reduced seed yield.
- Simazine post emergent caused no apparent crop damage and did not reduce seed yields.
- Spinnaker PSPE showed a trend ($P < 0.1$) towards reducing seed yield. This is an interesting observation given the widespread use of Spinnaker by vetch growers.
- A number of Post E. treatments damaged leaves and resulted in stunted plants (Broadstrike, Spinnaker. Brodal, Brodal/Lexone), but crops recovered with no effect on seed yield. Observations from elsewhere indicate Broadstrike can damage vetch, as observed in this trial, and lead to reduced yields. Post emergent applications of Spinnaker may have implications for plant back period for following crops.
- Simazine, Brodal and Brodal/Lexone appear to be useful herbicides in vetch and are worth pursuing further.

Table 57. Response of vetch to herbicides applied either post sowing pre-emergent (PSPE) or post emergent (PostE., 4-6 leaf stage) at Ongerup (00MT43)

Chemical (rate/ha)	Time of application	Seed yield (kg/ha)	Seed yield (% control)	Damage[a]	Stunting[b]
Untreated		248	100	0.3	0.3
Spinnaker (75 mL)	PSPE	192	77	0.8	1.0
Spinnaker (150 mL)	PSPE	200	81	2.5	1.5
Diuron (2 L)	PSPE	253	102	0.5	0.8
Simazine (0.5 L)	PostE.	377	152	0.0	0.3
Simazine (1 L)	PostE.	284	114	0.0	0.0
Sniper (50 g)	PostE.	180	73	3.5	1.8
Lexone (60 mL)	PostE.	237	96	0.5	0.0
Brodal (60 mL)	PostE.	236	95	2.4	0.8
Brodal (60 mL)/Lexone (60 mL)	PostE.	249	100	3.3	2.0
MCPA 250 (1/ha)	PostE.	116	47	2.0	2.8
MCPA 250 (500 mL)/Brodal (60 mL)	PostE.	89	36	3.3	3.0
Spinnaker (100 mL)	PostE.	237	95	1.5	0.8
Broadstrike (15 g) + oil uptake	PostE.	231	93	3.0	1.5
LSD 5%		92		1.0	1.0
CV%		20		6	31

[a] Damage (0 = No damage to 5 = dead) taken on 1/9/00.
[b] Visual ratings of stunting (0 = no stunting to 3 = very stunted).

Narbon bean

Germplasm evaluation

M. Seymour, AGWEST, Esperance

Evaluation of 63 lines of narbon bean was conducted at Salmon Gums. The trial was sown on 18 May in dry conditions, but despite this crop establishment was excellent. The dry spring conditions reduced the seed yield of Tanami and most other lines (< 700 kg/ha). Two lines (SA26554 and N9701*003) produced greater seed yield than Tanami (Table 58). The line N9701*003 showed vigorous growth, good canopy height and produced large seeds. The seed of N9701*003 will be tested for GEC content to determine its suitability as a stockfeed.

Table 58. Early vigour, time in days after sowing to 50% flower, mean seed weight (MSW, g/100 seeds) and seed yield (kg/ha of narbon bean germplasm evaluated at Salmon Gums (00ES9)

Variety	Early vigour[a]	50% Flower	MSW	Seed yield	Seed yield (% Tanami)
Tanami	3	110	14.9	648	100
SA26554	4	105	23.5	926	143
N9701*003	4	105	21.3	1014	157
N9662*008	3	110	24.8	714	110
N9662*005	5	105	23.9	686	105
N9662*003	3	105	25.3	709	109
N9662*002	4	105	22.8	657	101
N9662	4	105	24.7	767	118
N9660*002	4	116	24.0	564	87
N9656*001	4	116	24.5	481	74
N9655*001	4	105	22.0	739	114
N9650*009	4	105	23.3	530	82
N9650*007	4	116	23.7	554	85
N9650*006	2	125	25.7	401	62
N9650*003	2	125	25.5	355	55
N9650*001	3	116	22.7	451	70
N9650	2	125	24.6	539	83
N9648*004	4	125	23.9	558	86
N9648*001	4	116	24.3	501	77
N9647*004	2	125	25.1	319	49
N9647*003	3	116	23.8	467	72
N9644*001	3	116	24.3	532	82
N9642*001	3	116	23.6	545	84
N9636*006	3	116	23.6	419	65
N9636	2	116	24.6	420	65
N9634*001	3	116	24.5	432	67
N9628	4	105	14.1	697	108
N9626	5	105	22.4	770	119
N9622	5	116	24.5	506	78
N9619	4	116	21.9	501	77
N9616	4	116	23.3	487	75
N9608	3	116	24.7	406	63
N9604	4	105	21.2	690	106
N95,0084N4*5	5	105	23.0	746	115

Table 58 continued …

Variety	Early vigour[a]	50% Flower	MSW	Seed yield	Seed yield (% Tanami)
N95,0084N4*4	4	105	23.9	740	113
N95,0082N4*1	3	116	23.5	512	79
N95,0077N4*4	2	105	15.6	678	105
N9404*001	5	105	28.2	543	84
N9027*003	4	105	16.8	586	90
N9025*005	3	105	12.2	468	72
N89/53	5	105	26.8	591	91
N89/13	3	116	21.7	432	67
N60176*001	5	105	21.5	630	97
ATC62374	3	116	27.4	584	90
ATC62369	3	116	20.3	645	100
ATC62363	5	105	21.2	842	130
ATC60669	2	125	15.7	297	46
ATC60668	3	105	12.4	373	57
ATC60188	2	116	14.9	393	61
60395*001	2	116	13.4	355	54
60185*002	3	105	15.2	675	104
60156*003	3	116	16.3	340	52
60114(49)	5	105	17.4	732	113
60195	4	105	23.3	622	96
60142	3	116	21.7	668	103
60124	2	116	21.5	630	97
60123	4	105	21.1	855	132
60122	3	105	20.4	678	105
60114	3	105	21.8	583	90
60107	3	116	12.0	449	69
60105	3	105	20.4	454	70
60099	3	116	12.0	648	100
Mean	3	112	21	576	89
LSD 5%			1.3	211	33
CV%			4	23	

[a] Early vigour: 0 = poor to 5 = excellent.

Herbicide tolerance

M. Seymour, AGWEST, Esperance

The tolerance of narbon beans to a range of pre sowing, post sowing pre emergent, and post emergent herbicides was examined in 1998 at Salmon Gums. In 2000 we repeated this experiment at Scaddan using the variety Tanami and with the inclusion of a Brodal®/Lexone® post emergent treatment. The soil type at the trial site was sandy loamy clay with pH 6.0. The presowing and post sowing pre emergent treatments were applied on 3 June in addition to 1 L/ha of Treflan to the whole site. Post emergent treatments were applied on 26 July when plants were at the six node stage.

Post emergent application of Broadstrike® and the mix of Brodal® and Lexone® reduced the seed yield of Tanami (Table 59). Dry matter was similarly affected for these treatments and the Brodal® treatment. Harvest index was greater with the application of Brodal®/Lexone® PostEm. (Table 60). Based on the results from this and the earlier trials at Salmon Gums in 1998, narbon bean growers should use Simazine, Diuron or Spinnaker® around the time of sowing for effective weed management and also to minimise damage to Tanami. The best options for post emergent weed control include Spinnaker® and Brodal®.

Table 59. Response of Tanami narbon beans to herbicides at Scaddan

Timing	Herbicide	Rate (mL/ha)	Dry matter at maturity (g/m²)	Seed yield (kg/ha)	Seed yield % unsprayed
	Unsprayed	Nil	351	1511	100
IBS[a]	Simazine	1500	341	1466	97
IBS	Bladex®	2500	308	1470	97
IBS	Diuron	1000	326	1482	98
PSPE[b]	Spinnaker®	120	330	1474	97
PostEm[c].	Broadstrike®	15g	257	1243	82
PostEm.	Brodal®	150	252	1423	94
PostEm.	Spinnaker®	120	369	1475	98
PostEm.	Brodal®/Lexone®	60/60	189	1264	84
LSD 5%			79	120	8
CV%			18	6	

[a] Immediately before sowing, [b] post sowing pre emergent, [c] post emergent.

Table 60. Harvest index (HI) and mean seed weight (MSW, g/100 seeds) of narbon bean variety Tanami treated with various herbicides at Scaddan

Timing	Herbicide	Rate (mL/ha)	HI (%)	MSW
	Unsprayed	Nil	44	16.0
IBS	Simazine	1500	44	16.4
IBS	Bladex®	2500	51	16.7
IBS	Diuron	1000	46	16.1
PSPE	Spinnaker®	120	48	16.8
PostEm.	Broadstrike®	15 g	49	15.5
PostEm.	Brodal	150	57	16.8
PostEm.	Spinnaker®	120	40	16.1
PostEm.	Brodal®/Lexone®	60/60	70	16.8
LSD 5%			14	0.5
CV%			19	2

Post emergent use of knockdown herbicides

M. Seymour, AGWEST, Esperance

In Victoria, a number of trials have shown that low rates of Roundup® CT have good potential for management of weeds in narbon bean crops, with minimal damage to the crop. In 2000, we evaluated the use of Roundup® for this purpose at Scaddan. The trial also included another herbicide, Sprayseed 200®, given its widespread use in removing weeds from sub-clover pastures.

The trial was sown on 3 June using the line SA26554. Weed control at sowing included 1 L/ha of Roundup® mixed with 1 L/ha of Treflan applied IBS, followed by 100 mL/ha of Spinnaker® PSPE. The Roundup® and Sprayseed® treatments were applied on the 4 August when the narbon beans were at the 6-8 node growth stage, two to three weeks before flowering.

All treatments except 500 mL/ha of Sprayseed® reduced dry matter from 3000 kg/ha to less than 2300 kg/ha (Table 61). Seed yield was reduced by all treatments. The Roundup® treatments, whilst initially appearing less severe, reduced seed yield more than the Sprayseed® treatments based on per mL of applied product. Following treatment with the low rates of Roundup® and all rates of Sprayseed® the crop was able to recover and produce seed yields of 1000 kg/ha or more. Therefore, these herbicides appear to have some potential for post emergent control (salvage option)of weeds in narbon beans.

Table 61. Response of narbon bean to post emergent application of knockdown herbicides at Scaddan (00ES26)

Product	Rate (mL/ha)	Growth rating[a] (21 August)	Dry matter (27 September) (kg/ha)	Seed yield (kg/ha)	MSW (g/100 seeds)
Nil	0	4.0	2970	1843	26.8
Roundup® CT 450	300	3.8	2350	1636	26.5
Roundup® CT 450	600	2.6	1790	1242	26.5
Roundup® CT 450	900	2.2	1260	970	26.7
Sprayseed® 200	500	3.6	2590	1617	26.7
Sprayseed® 200	1000	2.6	2340	1495	26.3
Sprayseed® 200	1500	2.4	1780	1412	26.0
LSD 5%		1.0	610	163	ns
CV%		7	9	6	9

[a] Growth rating: 0 = dead, 5 = excellent.

Albus lupin

Time of sowing

N. Brandon and **R. Beermier**, AGWEST, Katanning

The effect of time of sowing on albus lupin was evaluated at a high rainfall site at Mt Barker in 1999. Seed yields were greatest when sown between the end of May and early July (1.4-2.1 t/ha). Albus lupins have a long seed filling period and the good yields achieved at the later sowing times in the Mt Barker trial were probably due to the long growing season at this southern site. In medium rainfall regions greatest seed yields can be expected from earlier sowings. To evaluate this, a trial was established at a medium rainfall site at Katanning in 2000. The experiment included two albus lupin varieties (Esta and Kiev) sown at four times.

Due to the late break to the season, the first sowing time was later than intended (12 June) (Table 62). The second time of sowing was sown immediately after the first effective rain (20 June). The first and second time of sowing suffered from weed competition due to inadequate opportunities for pre emergent weed control. Seed yield was greatest at the third time of sowing (29 June), with the shorter season variety Kiev achieving almost 0.5 t/ha. There was no interaction between variety and time of sowing.

Table 62. Effect of time of sowing on seed yield (kg/ha) of Esta and Kiev albus lupins at Katanning (00ES04)

Sowing date	Esta	Kiev	Mean
12 June	170	205	188
20 June	274	321	293
29 June	414	480	447
12 July	182	216	199
Mean	260	303	
LSD 5%	Time of sowing	126	
	Variety	33	

Lathyrus development

C. Hanbury and **K.H.M. Siddique**, CLIMA and AGWEST, South Perth

Both *Lathyrus cicera* and *L. sativus* have potential as multi-purpose crops in low to medium rainfall dryland farming systems. They are tolerant to a wide range of herbicides, tolerate some waterlogging, have no serious disease, have high seed protein levels (25-30%) and are highly palatable to a range of animals. The neurotoxin 3-(-N-oxalyl)-L-2,3-diamino propionic acid (ODAP) in *Lathyrus* spp. has constrained commercial release of varieties to those with low seed concentrations (< 0.10%) of ODAP. In 1998 CLIMA released one *L. cicera* variety 'Chalus' which has ODAP concentration of 0.09%. Advanced breeding lines of *L. sativus* are now at the F_8 plant stage and release of a variety low in ODAP is anticipated.

Field evaluation

In 2000, *L. cicera* cv Chalus was grown on about 20 farms in WA, SA and Victoria, with an average of 10 ha each. On farm yields ranged from poor to 2 t/ha. Poor seasonal conditions in WA and Victoria resulted in heavy losses from low harvestability (short crops) and heavy grazing due to pasture failures.

Animal feeding trials

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In order to establish markets for *L. cicera* grain feeding recommendations must be established experimentally since little useful data is published internationally. All trials to date mentioned here use *L. cicera* cv Chalus, since it has low levels of ODAP.

Sheep

The nutritional value of *L. cicera* was compared to narrow leafed lupin (*Lupinus angustifolius*) grain for sheep. *Lathyrus cicera* and lupins were fed *ad libitum* to immature Merino wethers over a 10 week period. They were fed at two rates, 35% and 70% of the diet, the remainder being hay. There were 20 sheep per diet group, fed individually. The major findings from this study are summarised below:

- *Lathyrus cicera* contained less protein (28% vs 36%), fat (0.7 vs 4.1%) and fibre (25% vs 36% neutral detergent fibre (NDF)) but more starch (42% vs 1%) and antinutritional compounds (ODAP, tannins, trypsin inhibitor) than lupin. Essential amino acid composition was similar for the two grains, as were *in sacco* degradabilities of dry matter (84 vs 81%) and protein (92 vs 94%).
- The feeding experiment showed that *L. cicera* had a higher nutritional value than lupin in terms of voluntary feed intake, liveweight gain ($P < 0.01$), carcass weights ($P < 0.05$) and feed efficiency ($P = 0.05$). Wool growth reflected metabolisable energy (ME) intake, and there was no independent effect of grain type ($P > 0.05$).
- Results from the balance study showed that ME concentration was the same for both grains (14 MJ/kg dry matter), as was protein quality.
- There were no visible or biochemical signs of ill health (inappetence, lethargy, shaking or instability) in any sheep fed *L. cicera*. Several sheep fed the 70% lupin diet had mild diarrhoea, and two were eventually removed from the experiment due to anorexia.
- There were no differences in meat quality between sheep fed lupins or *L. cicera* (e.g. redness, pH, taste or tenderness).
- In conclusion, compared with lupin grain, low ODAP *L. cicera* grain appears to be of high nutritional value for sheep, with no evidence of adverse effects on sheep health.
- The likelihood of toxicity signs appearing after a longer exposure cannot be discounted, but it is considered unlikely given that ODAP appears not to be a cumulative poison, and animals can recover from the toxic effects of other *Lathyrus* species when the source is removed.

- Before farmers begin to plant large areas of *L. cicera*, information is needed on rates of ruminal degradation of ODAP and on tissue residue levels of ODAP in livestock fed Lathyrus hay and grain.

Pigs

An inclusion rate trial with pig weaners (5-15 kg body weight) was conducted in 2000. This was to further evaluate pig performance following pleasing results with larger grower pigs (20-110 kg body weight). Forty-five pigs were allocated to five treatment groups and each group was offered a diet in which soybean meal was replaced by *L. cicera* meal at 0, 5, 10, 15 or 20%. The diets were fed for three weeks, from one week after weaning (Table 63).

Table 63. Growth and feed intake measures of pig weaners fed differing rates of *Lathyrus cicera* cv Chalus

Measurements	Chalus inclusion rate					P
	0%	5%	10%	15%	20%	
Final live weight (kg). Day 21	13.26	13.77	13.51	13.36	12.56	0.475
Average daily gain (g). Days 1-21	354	382	368	360	321	0.155
Voluntary feed intake (g/day). Days 1-21	567	614	601	586	619	0.621
Feed conversion rate (feed consumed/live weight increase) Days 1-21	1.61	1.62	1.67	1.66	1.95	0.056

There were no significant differences between treatments for final live weight (kg), average daily gain, and voluntary feed intake of feed conversion rate. However, although not significant, it appears that pigs fed 20% of *L. cicera* had reduced growth performance. The increased voluntary feed intake for pigs in this treatment group may be the result of food wastage rather than increased intake *per se*. It is also likely that weaners' digestive systems are not mature enough for high rates of plant protein. Chalus can be used as an alternative source of energy and protein in diets for weaner pigs, however inclusion levels greater than 15% are not recommended as they can result in reduced growth performance.

Further information on pig amino acid availabilities and digestibility data will be available early in 2001. To this end experiments with cannulated pigs were completed at the end of 2000 and nutritional analysis is underway.

Poultry

In order to complete a range of animal feeding studies funding was obtained from RIRDC for a large laying poultry study in collaboration with the Pig and Poultry Production Institute, SARDI. This study involves feeding a range of rates of *L. cicera* cv Chalus to 900 laying hens for a period of eight weeks. Rates of egg production and quality parameters will be measured throughout. Preliminary experiments are complete and indicate normal egg laying rates. The final large experiment will commence in March 2001 and be completed by June 2001.

Future

Over the period 1999-2001 animal feeding trials conducted have pleasingly shown that Chalus is as good or better than industry accepted pulses such as soybean and narrow leafed lupin. These trials have been performed on weaner and grower pigs, mature sheep and preliminary experiments with laying and meat poultry in collaborations with AGWEST, CSIRO and SARDI. By early in 2001 this range of experiments will be essentially complete with the laying poultry experiments finalised, although further trials with dairy cattle may proceed. It is intended to use this data to promote the use of Chalus (and future varieties) in both the manufactured feed industry and for on-farm feed use. Trial shipments will be made in 2001 to overseas animal feed compounders.

Species comparison

Time of sowing

Time of sowing trials with a range of pulse species were conducted at four sites across the grain belt with the aim of comparing time of sowing responses of the various species. Data from two sites are presented here (Table 64). Merredin and Mullewa experienced low seasonal rainfall and a hot, dry spring, which limited seed yield potential. Despite this, some species produced seed yields between 1100 and 1500 kg/ha at Mullewa. Faba bean and vetch produced the greatest seed yield at Merredin and Mullewa in early and late sowing treatments, except at Mullewa for the second and third time of sowing, where desi chickpea also performed well. Sowing time had little effect on seed yield at Merredin, although faba bean appeared to perform better at the second time of sowing. At Mullewa, sowing time had little effect on the seed yield of kabuli chickpea, however all other species produced greater seed yields at the first sowing time. The generally greater seed yields produced at Mullewa from the first sowing time was due to the utilisation of stored moisture from rainfall in March (127 mm) and the plants being able to develop, flower and pod, prior to the onset of drought at the end of the season. Additionally, the dry conditions reduced the incidence of fungal diseases. Therefore, there was minimal yield penalty due to disease from early sowing.

Table 64. Seed yields (kg/ha) of pulse species at different sowing times

Species		Merredin 00ME16			Mullewa 00MW04	
	2 May	15 June	29 June	28 April	24 May	26 June
Desi chickpea (Heera)	501	533	476	1109	792	749
Faba bean (Fiord)	688	790	573	1532	825	606
Field pea (Dundale)	568	564	501	1251	542	433
Kabuli chickpea (Kaniva)	278	295	305	401	385	290
L. cicera (Chalus)	552	674	501	604	553	267
Lentil (Digger)	232	143	166	599	354	359
Vetch (Languedoc)	855	808	756	1369	680	668
LSD 5%		202			241	
CV%		18			19	

Seed moisture of pulse species at harvest

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Eastern States experience has shown that the timing and techniques of harvesting pulses can have a large effect on seed quality and up to 30% greater seed yields. Seed with greater moisture (approximately 13.5%) is less likely to be shed and damaged by impact in the harvesting operation. Harvesting earlier also reduces the risk of inclement weather problems. Seed with high moisture may have to be aerated or dried for storage, but this cost may be less than the cost of quality and yield loss.

This study investigated the effect of seed moisture at harvest on the seed yields of two varieties of lentil, faba bean and field pea. The experiment was sown at Merredin in a randomised block design with five replications (one rep used to adjust the harvester settings). Seed moistures (hand sampled on 11 October) were 51, 46 and 55% for the lentil, faba bean and field peas, respectively. It was planned to harvest at four times with moisture contents of 20, 16, 12 and 8%. However, seed moistures were lower than these levels at each harvest due to the rapid drying rate of the crops from warm dry weather (Table 65).

Table 65. Seed moisture (%) of lentil, faba bean and field pea varieties at different harvest dates

Harvest date	Lentil		Faba bean		Field pea	
	Digger	Cassab	Fiord	Fiesta	Dundale	Parafield
24 Oct.	13.8	13.9	10.3	-	10.1	-
27 Oct.	10.2	14.1	10.7	-	7.9	8.6
30 Oct.	9.2	9.2	9.3	11.9	8.3	9.0
1 Nov.	-	-	-	10.4	-	7.9
3 Nov.	-	-	-	9.0	-	-
17 Nov.	6.7	6.6	7.2	7.7	5.3	6.5

The lentil varieties Digger and Cassab produced similar seed yields at each harvest, and there was no difference in seed yield across the first three harvest times (Table 66). The last harvest date on 17 November (24 days after the first harvest) was 14% lower yielding, probably due to increased harvest losses.

There was no effect of seed moisture on the seed yield of faba beans, but there was an interaction with variety (Table 66). Fiord harvested on 24 October was lower yielding than when harvested later. Given the harvested seed moisture was only 10.3% on 24 October, it is possible that some green pods were thrown out the back of the harvester, since hand samples on 23 October indicated a higher level of moisture and immature seeds. Fiord produced greater seed than Fiesta due its earlier maturity and better adaptation in this region.

Field pea seed yields were similar across the first three harvests (Table 66). At the final harvest (least moisture), seed yields were lower due to some sections of plots being removed by wind. Excluding the final harvest, Dundale produced greater seed yields than Parafield.

In general, harvesting these pulses above 10% moisture produced the greatest seed yields. However, uneven maturity may create a threshing problem for harvesting at a moisture of around 13.5%. This study will be repeated in 2001 and include evaluation of crop desiccation as a method to even crop maturity and obtain greater seed moisture levels.

Table 66. Seed yield (kg/ha not adjusted for seed moisture) of lentil, faba bean and field pea varieties at Merredin

Harvest date	Lentil		Faba bean		Field pea	
	Digger	Cassab	Fiord	Fiesta	Dundale	Parafield
24 Oct.	668	594	600	-	972	-
27 Oct.	594	629	703	-	924	832
30 Oct.	616	632	715	526	969	793
1 Nov.	-	-	-	490	-	819
3 Nov.	-	-	-	405	-	-
17 Nov.	551	520	720	416	689	410
LSD 5%	Variety	ns		51		59
	Date	65		ns		83
	Var. x Date	ns		101		ns
CV %		10		12		10

Rotational benefits of pulses on grey clay soils

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A farmer scale trial was initiated at Mindarabin in 1999 to evaluate yield and rotational benefits of commercially available pulses on an alkaline shallow loamy duplex soil (grey clay). Six replicate plots of nine pulse species and wheat (cv Brookton) were sown in plots 5 m wide and 60 m long using a combine seeder. Pulse plots were divided into two and either green manured at the early podding stage or harvested for seed at maturity. Due to the favourable year in 1999, dry matter production and seed yields of pulses were high (generally ranging from 1.5-3.3 t/ha). However, some species lodged making harvest of the more prostrate species such as grasspea (Chalus), lentils (Digger) and field pea (King) difficult, and harvest losses ranged from 400-1100 kg/ha. Harvest losses in the other species were less than 250 kg/ha. Desi chickpea (Sona and Dooen) appeared to nodulate poorly perhaps due to an antagonistic effect of a seed fungicide dressing applied for ascochyta control prior to inoculation and seeding.

In the 2000 growing season, wheat (cv Nyabing) was grown across all plots. Unlike the 1999 season that resulted in excellent pulse growth, the yield of wheat was poor due to the low and generally uneven distribution of rainfall (total May-October rainfall 162 mm). Good summer rainfall occurred in January (67 mm) but the season did not break until mid-June. Mild waterlogging was observed during mid-season while the plants were still small and the season finished earlier than normal following low rainfall and warm conditions in September and October (15 mm total). Plots were harvested using a small plot harvester, following quadrat samples taken from the centre of green manured and non green manured treatments. Seed yield and protein content of these treatments was compared to nitrogen (N) application rates made to green manured and harvested sections of either wheat (3 N rates in 10 m) or Sona chickpea (3 N rates in 10 m).

Differences in soil N and N uptake between green manured and harvested treatments did not translate into yield differences for wheat in 2000. This was probably due to adverse seasonal conditions (i.e. low total rainfall) limiting yield of wheat in the higher N input treatments. There was however, a small but significant increase in protein (average increase of 0.4%). Increased mid season waterlogging was also observed in the green manured treatment (5.5 m plot length affected compared to less than one metre in the harvested plots). It is not clear whether this was due to greater infiltration of summer rainfall following cultivation, or to the more uneven surface left after ploughing with a disc plough (i.e. greater accumulation of water in the hollows left after disc ploughing and harrowing). Infiltration measurements taken prior to sowing of wheat are yet to be analysed. However increased variability within plots in the green manured treatment made interpretation of N rate subplots difficult and N rate data are only presented for the harvested treatment.

In the harvested treatment, seed yield and protein content were greater in wheat following pulses (Table 67). Despite the small effects on wheat yield, the N uptake, seed yield and grain protein all suggest that N input by the pulses was equivalent to at least 75 kg N/ha in wheat after wheat or 25 kg N/ha in Sona chickpea after wheat. Theoretical N input from the various pulse treatments based on N concentrations in stubble and grain remaining after harvest left on the ground (assuming 60% N in plant was fixed by pulses) ranged from 16 kg N/ha to 31 kg N/ha for pulse species with minimal harvest losses and 40-55 kg/ha in pulses which had significant harvest losses (lentil and grasspea).

Although there was no significant interaction of green manuring and pulse species on seed yield ($P = 0.15$), there was a significant interaction between green manuring and pulse species on protein in wheat ($P < 0.001$). Here, green manuring of wheat and chickpea appeared to have a greater effect in increasing grain protein than for other pulses.

Table 67. Calculated N contribution, measured soil mineral N, and seed yield and grain protein content of wheat grown in 2000 following green manured (GM) or harvested pulse species in 1999

1999 pulse crop	GM	N rate[a] (kg/ha)	Calculated N contribution[b] (kg/ha)	Soil mineral N[c] (mg/kg)	N uptake[d] (kg/ha)	Wheat yield (kg/ha)	Grain protein (%)
Fiesta faba bean	Yes	0	59	40	104	982	11.8
Parafield field pea	Yes	0	70	43	97	1138	11.8
Sona chickpea	Yes	0	22	30	66	1089	11.7
Brookton wheat	Yes	0	-	20	56	869	11.6
Fiesta faba bean	No	0	26	19	85	1078	11.8
Parafield field pea	No	0	31	21	92	1078	11.8
Sona chickpea	No	0	16	19	41	791	11.3
Sona chickpea	No	25	16	19	66	948	11.8
Sona chickpea	No	75	16	19	69	995	12.1
Brookton wheat	No	0	-	21	32	683	10.1
Brookton wheat	No	25	-	21	44	692	11.4
Brookton wheat	No	75	-	21	63	893	11.9
LSD GM			-	-	-	ns	0.25
LSD Pulses[e]			-	-	-	254	0.26
LSD N rates			-	-	-	240	0.54

[a] N was applied to wheat crop in 2000 at early tillering stage.
[b] Calculated from N% and yield components of vegetative (green manured treatment) or vegetative + non harvested grain (harvested treatment) and assuming 60% of N was fixed by the plant (pulses).
[c] Soil mineral N measured as nitrate N in 0-10 cm soil sampled on 22 June (reps combined).
[d] N uptake calculated using Tissue N concentration measured at anthesis multiplied by dry matter at anthesis (replicates combined).
[e] LSD ($P < 0.05$) for comparing pulses within green manured and non green manured treatments.

It appears that N supplied by harvested pulses was generally sufficient to meet the needs of the following wheat crop. A positive response to green manuring was only observed where there was a problem with nodulation (chickpea) or where there was no N fixed (wheat) (protein not seed yield). However, these results need to be interpreted with care since the 1999 season was better than average, resulting in very good pulse growth (N supply high), while the 2000 season was poorer than average, resulting in low wheat yields (N demand low).

Further work needs to be carried out to extrapolate the results of this trial to more average seasons. However, the results show that unless there are other good reasons for green manuring (e.g. presence of herbicide resistant weeds, poor growth of pulse, or a need to drastically improve soil structure), there may not be any economic value for green manuring a good pulse crop. These data along with that of trials in other locations and soil types will be used by the renovation cropping project to define the conditions and factors needed before green manuring is an economic option. The significance of the increased waterlogging observed in this trial is probably soil specific and exacerbated by unusual seasonal conditions, but also warrants consideration when considering green manuring in these shallow duplex soils.

Pulse species response to phosphorus and zinc

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It has taken a huge number of trials and many years to develop the current fertiliser recommendation systems for cereals, lupins and pastures. This work has been mainly conducted on sandy acid soils. Similar recommendation systems are in demand for new crops such as pulses on fine-textured alkaline soils. The GRDC funded a joint three year project between The University of WA, AGWEST and CSBP futurefarm to examine phosphorus (P) and zinc (Zn) nutrition of chickpea (CP), faba bean (FB) and field pea (FP). The project compares the P responsiveness of pulses to wheat and determines critical P and Zn levels in plant tissue to optimise future fertiliser management in pulse crops.

Trials comparing the P response of field pea, faba bean and chickpea to wheat were conducted at three sites in 1999. Two of these sites were followed up in 2000 to compare the residual value of the P applied in 1999 with freshly applied P in 2000.

Sowing was delayed at Mingenew until after the first effective rain (> 10 mm) in mid June. Plant establishment and early growth were good despite below average winter rainfall. Dry spring conditions limited plant growth and seed filling, especially in faba bean which was too short to harvest by machine. Seed yields responded significantly to applied P in all species, especially to freshly applied P. For example, wheat after faba bean at 40 kg/ha P applied in 1999 and 2000 produced 1.14 t/ha and 1.45 t/ha, respectively (Figs 6 and 7). Field peas showed no difference in yields between P applied in 1999 or 2000 (0.8 t/ha at 40 kg P/ha). Wheat utilised previously applied P better and produced greater yields after chickpea and faba bean than after field pea.

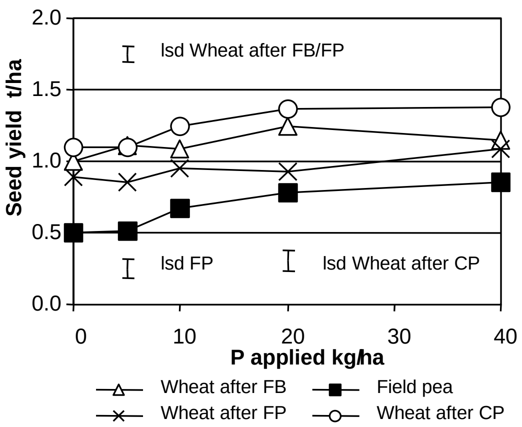

Figure 6. Seed yield in 2000, P applied in 1999.

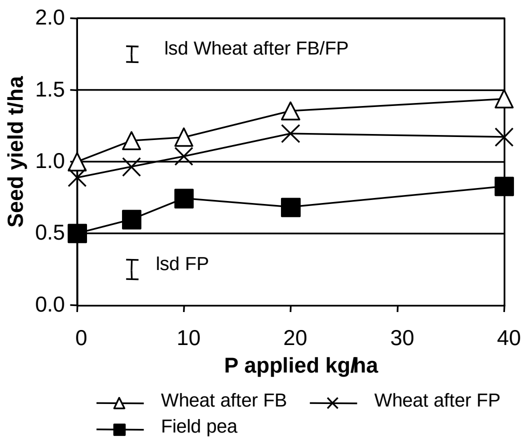

Figure 7. Seed yield in 2000, P applied in 2000.

The Coorow site was sown into dry soil in May resulting in variable seed placement and the site did not receive any effective rain for about 4 weeks after sowing. Even then, the rain was relatively light for several weeks. Consequently, plant establishment was very patchy, staggered and plant development variable. The trial was eventually abandoned after below average winter rainfall and a very dry spring.

Similar P trials were commenced in 2000 at Mukinbudin and Calingiri. Unfortunately, the Mukinbudin trial was not sown until mid June and, following very dry winter and spring conditions, it was abandoned due to poor growth. Although, the Calingiri trial was also sown in mid June, rainfall was more favourable. In field pea and wheat, yields ranged from 0.5 t/ha in the nil up to 1.3 t/ha at 20 kg P/ha (Fig. 8). Faba bean appeared to be more severely affected by the late sowing and dry spring, producing 0.2 t/ha in the nil up to 0.8 t/ha at 40 kg P/ha. This trial will be continued in 2001 to compare the residual value of P in the various crops.

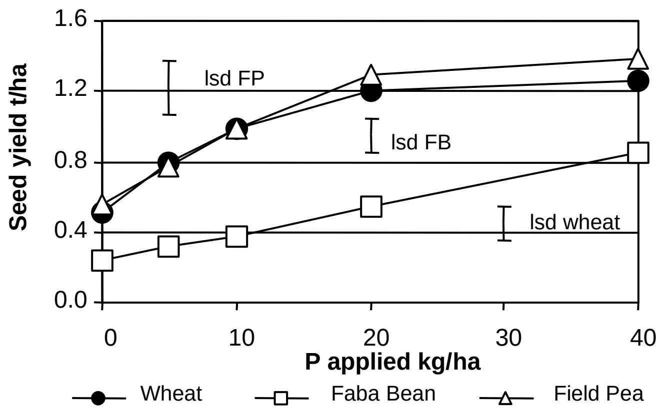

Figure 8. **Seed yield at Calingiri.**

In another aspect of the project, two trials examining Zn responses in chickpea, faba bean and field pea were established. At Mingenew, field pea seed yield increased with Zn applied as ZnO from 1.1 t/ha at nil Zn to about 1.4 t/ha at 2 kg Zn/ha (Fig. 9). Faba bean and chickpea yields were about 0.9 t/ha and were unresponsive to Zn application.

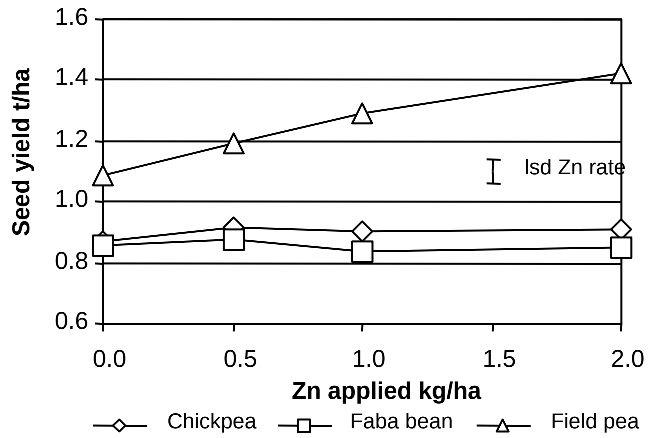

Figure 9. Seed yield at Mingenew

The trial at Calingiri was sown in early May into subsoil moisture and plants grew well, but the trial was overrun with late germinating radish and could not be machine harvested. Consequently, quadrat cuts were taken at maturity to estimate biomass and yield. Seed yield data from these quadrats were not available at the time of writing this report. Faba bean final biomass increased from 2.2 to 3.0 t/ha with increasing Zn application (Fig. 10). Field pea responses to Zn were consistent throughout the season and they finished the season well with biomass increasing from 2.6 to 3.2 t/ha. Chickpeas showed a slight downward trend in biomass with increasing Zn.

In the final year of this project, the data generated will be used to derive fertiliser recommendation models for pulse crops.

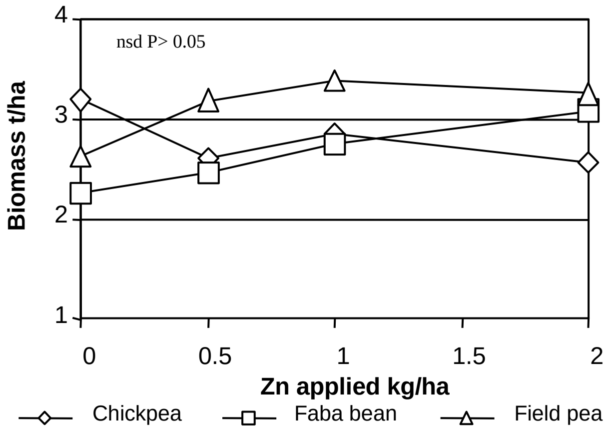

Figure 10. Final biomass at Calingiri.

The effect of soil applied lime and lime pelleting on pulses

M. Seymour, AGWEST, Esperance

Historically lupins are grown on sandy soils in the northern mallee. However, lupin prices have been low recently and growers may consider pulses such as chickpea and faba bean as alternatives. In this region the soil has a slightly acidic topsoil with pH increasing with depth. In recent years, faba bean has been grown in paddocks with a sandy topsoil, but nodulation is frequently delayed. It may be possible to grow pulses such as chickpea and faba bean in this soil with the application of lime or inoculation with improved rhizobia. Therefore, a large scale trial was undertaken to assess the potential of chickpea and faba bean on these soil types.

The soil type was Circle Valley sand with a grey topsoil of pH 4.8 ($CaCl_2$), the texture improved at 20 cm to a sandy clay loam and a sandy clay (pH 6-7) at 40 cm. Two t/ha of lime was topdressed onto the soil and scarified in 15 days before sowing. This increased the pH of the topsoil from 4.8 to 5.7 ($CaCl_2$). The trial was topdressed with 10 kg/ha of Nitrogen immediately prior to sowing. The trial was sown on 19 May in drying conditions with ascochyta blight free seed of Sona (120 kg/ha) and Barkool (200 kg/ha).

The treatments were plus and minus lime with four seed treatments (nil, commercial rhizobia, commercial rhizobia plus lime pelleting, or new rhizobia) and either with or without N. Two species (faba bean and chickpea) were sown. A split-split plot design was used with replicates (four) as main plots, lime as sub plots and nitrogen subplots within lime plots. Species and seed treatments were randomised within the lime treatment blocks.

The lime treatments reduced seed yield, despite having no effect on dry matter or nodulation (Fig. 11). Inoculation improved dry matter and seed yield of faba bean and chickpea. Lime pelleting of seed also increased dry matter, seed yield and nodulation scores for both species. It was of more benefit for chickpea, particularly since the new rhizobia (WSM 1667) did not outperform the commercial Group N rhizobia. The potential new faba bean rhizobia WSM1455 improved nodulation and dry matter production, but there was no response on seed yield. It appears that the early response of lime pelleting and new rhizobia on nodulation and dry matter was not translated into seed yield due to the extremely dry spring conditions experienced at the site. This trial will be repeated during 2001 to study the response of liming and new rhizobia on faba bean and chickpea growth and seed yield.

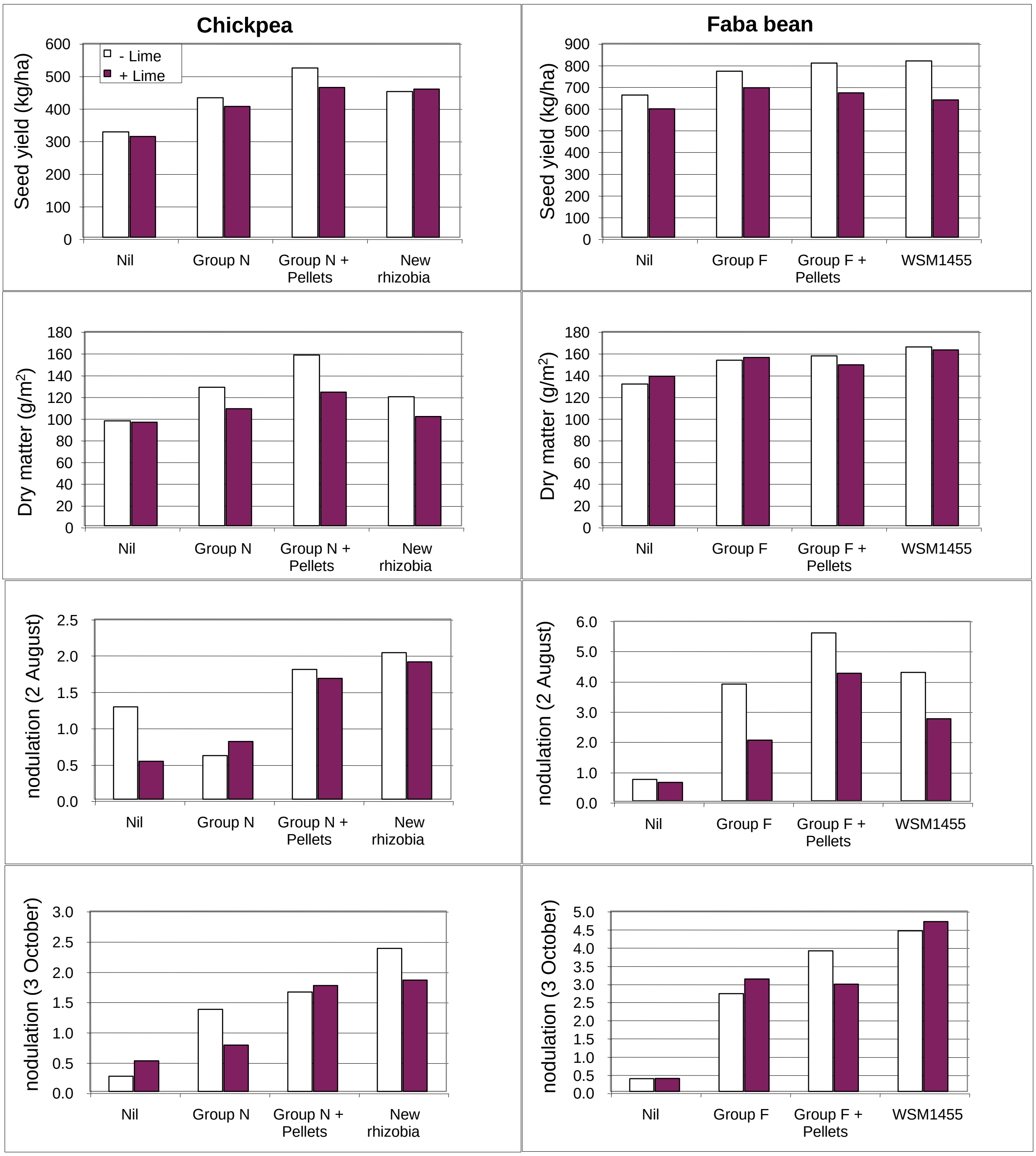

Figure 11. Effect of lime on seed yield, dry matter at maturity and nodulation of chickpea and faba bean on a sandy soil in the Mallee (00ES27). Nodulation was measured (score: 0-10 scale) on 2 August and 3 October.

Antitranspirants

Antitranspirant sprays applied at the podding stage have been found to improve seed yields of pulses under dry conditions in India and Syria. Antitranspirants leave a thin coat on leaves, stems and pods which reflects sunlight and reduces canopy temperatures and transpiration. The use of antitranspirants under WA conditions has been evaluated over the past few years. Kaolin, Envy®and Iriodin® were evaluated during 1997 and 1998, with Iriodin® providing the most promising results. Iriodin® is a reflective pigment that remains on the leaves, stems and pods of plants after spraying. It is a horticultural product and costs approximately $25 per kg.

Iriodin® was originally tested at Merredin in 1998. It was applied at a rate of 10 kilograms per hectare and gave an encouraging 22% increase in chickpea yields. Hence, testing was undertaken at Mullewa in 1999 at a range of lower rates, 1.0, 2.5, 5.0, and 10.0 kg/ha, to see if this product would be effective at economical rates. Results from Mullewa in 1999 indicated a 10% yield increase in desi chickpea when sprayed at the 10 kg/ha rate.

A similar study was conducted in 2000 to evaluate the effect of Iriodin® on chickpea at Merredin and Mullewa. Iriodin® was applied to the foliage of chickpea plots during the mid-podding stage at a rate of 15 kg/ha at Mullewa and 30 kg/ha at Merredin. Seed yields were poor at Merredin and Mullewa due to low rainfall in 2000, although good rainfall during March at Mullewa provided some stored soil moisture at this site. The effect of antitranspirants on seed yield is likely to be more evident in seasons with harsh spring conditions. Despite observing these conditions in 2000, the treatments had no effect on seed yield of desi chickpea at Merredin, or kabuli and desi chickpea at Mullewa (Table 68).

For kabuli chickpea, reduced drought stress at podding through the application of an antitranspirant may increase the proportion of large seeds produced. Because seed size is a very important aspect in the profitability of kabuli chickpea, this treatment could increase the value of the crop and allow kabuli chickpeas to be grown reliably in marginal rainfall areas. However, the application of Iriodin® had no effect on seed size distribution at Mullewa in 2000 (Table 69).

It is unlikely that the commercial use of antitranspirants (Iriodin®) for broad-scale use on chickpea crops will be of economic value in WA in the near future. Evaluation of Iriodin® in chickpea plots over the past few years has shown only limited seed yield advantage and no effect on seed size distribution (kabuli).

Table 68. Seed yield (kg/ha) of chickpea treated with Iriodin® at Merredin (00ME20) and Mullewa (00MW05)

Iriodan rate (kg/ha)	Merredin	Mullewa	
	Desi	Desi	Kabuli
0	268	629	490
15	-	610	499
30	289	-	-
LSD 5%	ns	ns	
CV%	18	6	

Table 69. Proportion (%) of various seed sizes of kabuli chickpea treated with Iriodin® at Mullewa (00MW05)

Iriodin rate (kg/ha)	Seed size distribution (%)			
	7-8 mm	8-9 mm	9-10 mm	> 10 mm
0	6.5	31.2	44.2	16.9
15	7.3	32.2	44.7	14.7
LSD 5%	ns	ns	Ns	ns
CV%	8	6	4	9

Mapping soils for pulses in the Great Southern

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Pulse crops, such as chickpea, lentil, field pea and faba bean, are generally not suited to shallow acidic soils which tend to dominate much of the landscape in agricultural regions of WA. In the Great Southern region, many soils are shallow with limited water holding capacity and are prone to waterlogging. This makes selection of pulse species for this region perhaps one of the most difficult in the State. Recent soil survey work in the Great Southern has aimed at mapping soil and landforms in the Katanning region at a high level of detail (1:150,000 scale) and include some information on soil properties of the major soils identified in the survey. It was therefore of interest to see if some of this information could be used to highlight particular regions with greater suitability to pulse crops.

The initial method employed aimed at developing capability tables for field pea, faba bean and lentil crops in terms of adaptation to soil pH, waterlogging, soil conductivity, etc. These attributes were then used to produce maps of most suitable soil types from the Katanning soil survey database. Although similar methods have been used successfully to identify soils suitable for the growing durum wheat, the method did not appear to be successful for pulse crops perhaps for the following reasons: (i) As yet, not all the soil attributes were available for each soil mapping unit in the mapping area. Proxy attributes were sometimes used (e.g. in some cases total water holding capacity had to be used as an estimate of clay content). (ii) In some cases there was insufficient information on adaptability of pulse crops to some attributes that were measured (e.g. to soil water storage, soil rooting depth). (iii) In some cases the greater sensitivity of pulse crops to soil characteristics such as salinity and pH meant that while it could identify soils that were unsuitable for pulse crops it was insufficiently sensitive to discriminate between pulse crops. For all these reasons, the maps initially produced did not reflect some areas known to be suited to field pea, faba bean and lentil production.

A second broader approach was therefore tried, which evaluated suitability of a region for pulse crops in general based simply on soil type (as indicated by soil group), soil pH and susceptibility to waterlogging. The maps used were less detailed and the focus was changed from the Katanning region to the whole of the Great Southern region (excluding the southern coast). Soil types that were considered suitable for pulse crops in the medium and low rainfall regions were alkaline shallow duplex, calcareous loamy earths and clays. In the higher rainfall regions, deep loamy duplex soils, loamy earths and loamy gravels were also considered suitable. Using these methods, a total of just under one million hectares in the Great Southern was identified as being suitable for pulse crops, which represented approximately 20% of arable soils in the surveyed region. However, the percentage of suitable soils ranged from less than 10% in some of the western shires to over 30% in some of the more Eastern shires. Shires with approximately 20% or more suitable soils were Dumbleyung, Gnowangerup, Katanning, Kent and Lake Grace.

The distribution of soil types within shires was mapped based on the proportion of soil types considered suitable for pulse crops (i.e. > 50%, 30-50%, 10-30% and < 10%), and was consistent with the performance of pulse crops grown commercially and in trial work. For example, the Borden region adjacent to the Stirling ranges had the highest proportion of suitable soils (> 50%). Areas in the Kent shire, north and south of Pingrup as far north as Lake Grace were also highly suitable (> 50%). However, care needs to be taken to avoid wet or waterlogged soils affecting approximately 10-30% of these soils (areas of potential waterlogging are highlighted on the map). The Dumbleyung shire also contained regions with highly suitable soil types (> 50%), but these were scattered in smaller areas almost throughout the shire. Many regions were elevated and not subjected to waterlogging, while an almost equal amount were closer to salt lakes and valley floors and were susceptible to waterlogging with greater than 30% identified as being wet and subject to salinity. The largest areas of moderately suitable soil types (30-50%) were found in the shire of Kent. The Lake Grace shire, while having its best heavy soils adjacent to the lakes, had vast areas with 10-30% suitable soil types, representing the heavier more alkaline duplex soils. These findings are consistent with our current understanding of suitable areas for pulse crops and represent regions where much of the trial work and adoption of pulse crops have occurred.

Although the western shires tended to have lower proportion of suitable soils, regions in the Wagin, Darkan and Cranbrook areas had regions with 10-30% suitable soils if deep loamy duplex, loamy earths and loamy gravels were included. Although these soils have lower water holding capacity, they have been shown to grow good pulse crops in the higher rainfall regions provided soil pH is suitable. This is also consistent with trial results, and commercial production of pulse crops is possible on these soil types. In some cases, these areas may be more profitable than eastern regions where rainfall can be a greater limitation. However, results of this survey work suggest that these soils are a minority and it is expected that the greatest expansion in pulse crops in the near future will be in the central and eastern shires.

This soil mapping work will help identify areas in high and low rainfall regions in the Great Southern to concentrate further pulse research and industry development. Our current aim is to work closely with the Great Southern Pulse Growers Association, which predominantly includes growers in the eastern regions. However, work will also continue with growers in the high rainfall southern and western regions on high value pulse crops. Further mapping work is currently being continued for some shires north of the Great Southern region.

DEMONSTRATION OF PULSES IN THE FARMING SYSTEM

New field pea and faba bean varieties in the Great Southern

The new field pea varieties Parafield and Helena, and the new faba bean variety Fiesta were grown in large scale field plots at Hyden, Lake Grace and Borden in the Great Southern. At Hyden, the break of the season occurred in early May. At Lake Grace and Borden, effective rains were not received until June. Two times of sowing were undertaken at Hyden and Lake Grace.

Plant establishment was good at all sites with the exception of Fiesta at all three sites, and Ascot at Hyden (data not presented). At all sites, faba beans were sown at a rate of 150 kg/ha, which is at the lower end of the current recommended rate for the large seeded variety Fiesta (150-220 kg/ha). However, even at this low seeding rate, numerous blockages of the seeding tube outlet occurred at Hyden, while at Borden the maximum sowing rate that could be achieved for Ascot and Fiesta was about 130 kg/ha. No problems were encountered at Lake Grace where the plots were established using an experimental cone seeder.

The very dry finish to the season appeared to severely limit the seed yield of faba bean, particularly in June sowings. The greatest faba bean seed yields were achieved at Hyden from the earliest sowing (13 May) (Table 70). As expected, field pea seed yields at Hyden increased with delayed seeding. This appeared to be due to a reduction in foliar disease (black spot, downy mildew and septoria). Experience over a number of years by the farmer has indicated that greatest seed yields and minimal disease is achieved with late May sowings in this region. At Lake Grace, where field pea has not been grown before, the greatest seed yields were achieved from dry-sowing immediately before the break. Dry seeding at this site appeared successful due to: (i) a low weed burden; (ii) low disease pressure (field pea had not been grown at the site before); and (iii) inoculation was successful with numerous nodules forming on the young plants despite being a new site for field peas. Dry sowing was not as successful at Borden, because plants failed to nodulate or nodulated poorly, despite seed being inoculated prior to sowing. Weeds were also a greater problem at this site and were difficult to manage.

Despite difficulties in achieving the desired sowing rate, Fiesta produced similar or greater seed yields than Ascot. Seed size of Fiesta ranged from 40-50 g/100 seeds compared to 30-40 g for Ascot across all sites (data not presented). There appeared to be a slight yield advantage of the new field pea varieties Parafield and Helena over Dundale, although this was not consistent across all sites. CVT trials at Lake Grace showed similar trends, but this was not observed in trials at Gnowangerup and Ongerup where Dundale slightly outyielded the newer varieties. Parafield produced larger seed (17-22 g/100 seeds) than either Dundale or Helena (both ranging from 13-17 g/100 seeds depending on location and time of sowing).

Table 70. Seed yield (kg/ha) of field pea and faba bean varieties at three sites in the Great Southern

Site	Time of sowing	Faba bean		Field pea		
		Fiesta	Ascot	Parafield	Helena	Dundale
Hyden	13 May	980	870	-	-	-
	25 May	824	700	700	640	570
	13 June			760	800	580
Lake Grace	7 June	310	170	960	920	800
	30 June	310	180	800	780	600
Borden	12 June	455	572	770	610	780

Given the dry season, field pea and faba bean seed yields did not exceed 1 t/ha. However, at Hyden field pea and faba bean produced similar seed yields from the mid-May sowing, and suggests that there may be a role for faba bean in these drier regions. Dry seeding was also successful at one site for field pea and faba bean. This may be a useful strategy, but is risky and is likely to compromise weed control and nodulation. In 2001, a similar demonstration will be conducted to evaluate the potential for faba bean in drier regions of the Great Southern.

Harvesting methods for field pea in the Great Southern

N. Brandon, R. Beermier, M. Seymour and the Great Southern Pulse Grower Association (GSPGA)

At a meeting of the newly formed GSPGA in November 2000, it was suggested that a major constraint to the adoption of field pea by new growers in the Great Southern region was the perception that field pea is one of the more difficult crops to harvest. This was despite the fact that experienced growers considered that management packages are available to allow harvest with minimal difficulty. Others in the group were keen to try relatively untried methods such as swathing directly in front of the harvester. Therefore, it was decided that experienced growers in the group would video tape their 2000 harvest. The videotape will be an educational tool for new and potential growers, and will allow GSPGA members to view other growers' harvesting methods.

Despite a very dry year, and generally much sparser than normal field pea crops, the experience appears to have been extremely worthwhile, with many growers finding a wide range of successful methods and with most being recorded on video. Whilst these have not been compiled onto a single videotape yet, some short notes are provided below on the range of methods used and some of the advantages and disadvantages.

Method	Comments
Sund raking pickup	The Sund raking pickup was designed in Europe some 40 years ago for picking up thin crops, particularly vine and specialty crops. A number of farmers in the Great Southern region now own a Sund raking pickup. It is probably the most thorough in terms of picking up thin and prostrate crops (can even pick up very flat crops like grass pea). The concentration and skill needed by driver is probably less than for some other methods like lifters but the method is also slower than lifters.
Lifters	Lifters generally work best when the crop is harvested early across the lay of the crop, and in thicker crops. Harvesting, particularly by experienced growers can be quicker than with other methods and there is minimal financial outlay. Driver concentration and skill is required to ensure that the front is kept at the right height. In many crops, particularly thin crops, it may require harvesting across the lay of the crop.
Phillips pea pickup	Whilst not actually tried in the Great Southern region this year, it has been designed and manufactured at Merredin specifically for field pea. It appears to be a wider canola pickup with various modifications.
Swathing	Swathing has been used with varying success for the last few years. About 700 ha were swathed in the Nyabing area this year with good results using a self propelled swather and with the harvester following immediately behind. The main advantage is speed and minimal experience required by the harvester driver. Lifters on swather ensure that most rocks and other hard objects are not brought into the swath. If anything does come through, the driver can be warned by two way radio by the swathing contractor. This may be an option for new growers who currently only own a canola pickup.
Hay rake	This hay rake was used successfully this year by one grower to form windrows in a thin field pea crop that was then harvested like a swathed crop. It relies on getting the moisture content of the plant right (i.e. dry enough for plant to snap off at ground level but not too dry as to allow pod shatter). Clearly some skill and experience is needed and the paddock needs to be relatively free of sticks and stones.

DISEASE AND PEST MANAGEMENT

Ascochyta blight of chickpea

Ascochyta blight of chickpeas, caused by *Ascochyta rabiei,* was first detected in commercial crops in WA in 1999. Crop surveys and seed tests on crops grown in 1999 indicated that the disease was confined to the northern half of the agricultural area. Reports in 2000 of infected crops in southern areas, as far as Esperance, show that the disease is now endemic throughout the agricultural area. All farmers intending to sow chickpeas in 2001 should make their plans based on the assumption that all chickpea crops were infected in 2000. Starting with this assumption, growers will be in the best position to minimise the impact of the ascochyta on their chickpea crops in 2001.

The late break and generally low rainfall during the 2000 growing season greatly reduced the potential yields of chickpeas. However, these conditions also reduced the extent of development of ascochyta within chickpea crops. This was fortunate for some growers who had not followed all components of the chickpea management package recommended for 2000. A number of crops developed high levels of infection early in the season because they were sown too close to the stubble of 1999 chickpea crops, were established with seed that had not been tested, or where seed had not been dressed with fungicide. Some of these crops were ploughed in or abandoned. Others were managed with foliar applications of fungicide, but at a higher cost and for a lower yield than would have been achieved without the early disease setback.

Trials were conducted in 2000 to examine the value of fungicides as seed dressings and foliar applications. Experiments with similar objectives were also conducted in eastern Australia in 2000. The findings of all of these experiments have been used to update the previous recommendations (where necessary) which were based on experience and experimental data gained during the 1998 and 1999 growing seasons in eastern Australia.

Seed dressing and sowing depth

The value of fungicide seed dressings were assessed in an experiment at Beverley on a site which was isolated from any paddock in which chickpeas were grown in 1999, to ensure that all of the ascochyta infection observed was introduced on the treated seed. The trial was inspected three and four weeks after sowing and no ascochyta infection was obvious. Additionally, fungicide seed dressing did not increase plant emergence compared to untreated seed sown at the same depth (Table 71).

Seven weeks after sowing the seed-borne infection had spread to create patches of infected plants up to one metre in diameter. The extent of these patches was assessed within each treatment. P-pickle-T® was the most effective registered product in reducing the transmission of seed borne infections to infected seedlings. Rovral®, which does not have a permit for this use, also reduced disease score in this experiment and will be tested further. In this experiment, Thiraflo® did not reduce the level of infection measured at seven weeks after sowing compared to the control treatment (no seed dressing). Seed dressing trials in Victoria and New South Wales also supported the previous recommendation that P-pickle-T® is the preferred seed dressing for management of ascochyta of chickpeas.

Seeding depth is also shown to be an important factor in limiting the transmission of seed borne infection to the emerged seedlings in this experiment. The small increase in the actual seeding depth from 3 cm to 5 cm almost halved the level of disease transmission, a similar reduction to that achieved by P-pickle-T® for seeds sown at 3 cm. Previous research overseas also demonstrated that increasing seeding depth reduced ascochyta transmission. Previous extensive research in chickpea has shown that increasing seeding depth up to 8 cm had no negative effect on crop establishment and seed yield.

These results show that it is possible to make considerable reductions in the ascochyta disease pressure in a chickpea crop by applying a fungicide seed dressing (P-pickle-T®) and avoiding

shallow sowing (sow at 5 to 8cm). These are two cheap and easily achieved options when establishing 2001 chickpea crops.

Table 71. The effect of seeding depth and fungicide seed dressing on the transmission of ascochyta blight in chickpea

Fungicide	Actual seeding depth (cm)	Plant emergence (No/m^2)	Disease score[a]
Nil (4 cm target depth)	3.0	73	2.9
Nil (8 cm target depth)	4.5	67	1.4
Nil (12 cm target depth)	5.0	70	1.7
P-Pickle T®	3.0	83	1.0
Thiraflo®	3.0	80	2.6
Rovral®	3.0	83	1.5
LSD 5%	0.6	11	1.1

[a] Disease was scored seven weeks after sowing (0 = no disease to 7 = severe).

Foliar fungicide sprays

The foliar fungicide spray program recommended for the 2000 growing season, was developed based on the results of experiments conducted in South Australia and Victoria in 1999. However, in both of those experiments very severe epidemics of ascochyta developed and the value of some of the fungicide applications were compromised by poor timing of applications of the protectant fungicides. These two fungicide trials were designed to test the efficacy of mancozeb and Bravo® at both a recommended rate and at half that rate. Additionally, the trials assessed the value of fungicide sprays applied at various times through the growing season.

The experiments were sown on 13 June at Morawa and 16 June at Mingenew, both of which are late relative to the recommended sowing windows for these locations. The late sowing together with the dry finish to the growing season limited the final level of disease, and also the yields achieved. However, consistent and clear differences developed between fungicides and times of application at the two sites.

Both sites were sown with clean seed from the same source, treated with P-Pickle-T® and were inoculated with two infected seedlings per plot. However, differences between the trials were apparent in the initial level of disease when assessed six weeks after sowing. At Morawa, the only infection apparent was that originating from the two infected seedlings, whereas at Mingenew there were many infection foci distributed throughout all plots. The additional infection points at Mingenew must have originated from infected trash from 1999 crops, although none was nearby to the trial site.

The first fungicide sprays were applied about four weeks after emergence (25 July), and subsequent sprays were applied at roughly three weekly intervals (14 August, 4 September and 26 September) (Fig. 12). The actual timing of sprays was adjusted to be just prior to a forecast rain event. Significant spread opportunities occurred following the first two fungicide sprays, however, only one spread opportunity occurred shortly after the third spray. The remainder of the interval between the third and fourth sprays was dry. The forecast rain event which triggered the fourth fungicide application was very minor (3 mm at Mingenew; 1 mm at Morawa) and would have caused little or no spread of infection. Consequently, there was no real difference in the level of disease control applied to the plots, which received three sprays, and those which received four.

Bravo® is clearly a more effective product for the control of ascochyta than mancozeb (Table 72). The level of disease control achieved, at both sites, by two applications of 1 L/ha Bravo® is at least as good as that achieved with three or four sprays of 2 kg/ha mancozeb. At the Mingenew site, this comparison is also valid for the dry matter and grain yield. However, at Morawa the lower initial disease level and spread has resulted in considerably lower final disease levels, and consequently lower impacts of disease on yield. The cheapest treatment, 1 kg/ha of mancozeb, did not increase the yield at Mingenew, but did significantly increase the yield at Morawa, achieving about two thirds of the increase provided by the best treatment.

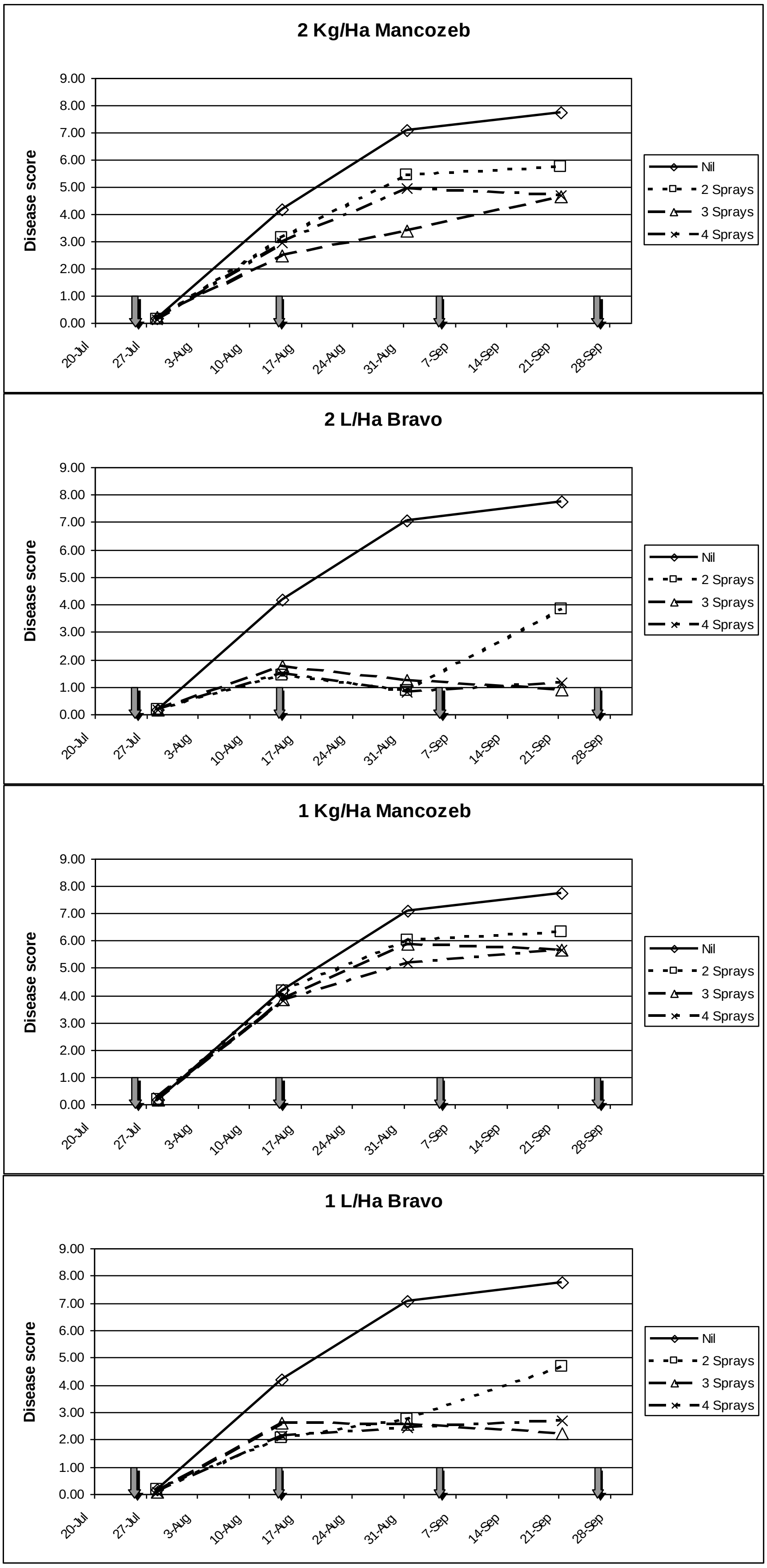


Figure 12. Disease progress curves in plots treated with two rates of both Bravo® and mancozeb at Mingenew 2000. Fungicide sprays were applies at times indicated with arrows (⇓). The Nil treatment (solid line with diamond symbol: ◊), is the same in all four graphs.

The product and rate comparisons provided by these trials are valid for most situations, however, extending other comparisons to different locations and years must be undertaken with caution.

These trials show that the greatest impact on disease was achieved by the first two applications of a fungicide treatment. Also, applying the fourth spray gave no additional benefit over the three spray treatment. It is generally true that the greatest impact on this disease will be achieved with fungicide sprays applied early in the season through delaying and slowing the period of rapid development of the disease. However, as stated above, in 2000 disease development stopped shortly after the third spray. In a season where disease infection opportunities continue past the fourth spray, the residual value of the first two sprays will be considerably eroded. Consequently, in an average year the trial at Morawa would have produced results similar to those from the Mingenew trial in 2000.

An additional benefit of an adequate fungicide spray program was seen at the Mingenew site in 2000. The plots which had poor or no disease control developed significant weed burdens by the time they were harvested, and had late and uneven ripening of the crop. In contrast, the plots in which ascochyta was controlled, weeds did not become a problem (good canopy coverage by chickpea crop) and the crop ripened evenly. Lower weed numbers most likely resulted from greater canopy coverage by the more vigorous chickpea crop. Consequently, where disease is not controlled additional costs may be incurred to control weeds in following crops.

Table 72. Final disease severity and grain yield for fungicide spray trials at Mingenew and Morawa in response to the first two, first three or all four applications of the products and rates being tested

Product (rate #)	Sprays applied	Mingenew			Morawa	
		Final disease score*	Dry matter (4 Oct.)	Seed yield (kg/ha)	Final disease score*	Seed yield (kg/ha)
Nil	0	7.8	52	80	4.3	197
Mancozeb (1 kg ai/ha)	1 & 2	6.3	127	260	3.3	508
	1, 2, & 3	5.7	134	302	2.3	540
	1, 2, 3 & 4	5.7	146	364	2.6	559
Mancozeb (2 kg ai/ha)	1 & 2	5.8	268	357	2.8	555
	1, 2, & 3	4.9	256	474	1.8	632
	1, 2, 3 & 4	4.7	209	410	2.0	604
Bravo® (1 L/ha)	1 & 2	4.7	248	421	1.1	632
	1, 2, & 3	2.3	471	629	0.8	633
	1, 2, 3 & 4	2.7	455	575	0.6	693
Bravo® (2 L/ha)	1 & 2	3.8	355	456	1.0	635
	1, 2, & 3	0.9	714	866	0.6	648
	1, 2, 3 & 4	1.2	751	834	0.7	662
LSD 5%		0.7	150	88	0.3	93

The rate of mancozeb if kg/ha of active ingredient, the Bravo® rate is L/ha of the 720 g/L formulation.
* Disease scored on 0-10 scale, last assessment 21 September.

The ascochyta management package for 2001

There are two major influences on the final level of ascochyta, and yield loss, in a chickpea crop in the absence of a fungicide management program. The first is the number of infected seedlings in the crop in the first two weeks after emergence (whether these are from seed-borne or stubble-borne sources). The second is the number of cycles of multiplication, which occur in the crop, this is roughly equivalent to the number of rain events, which occur between

emergence and harvest. These two factors will also determine the cost and success of the fungicide management program.

The regional zones given below for seed quality have been based on the average number of rain-days for the June-September period. The zones are based on the CVT areas familiar to most farmers. The lowest number of rain-days occurs in the L1 CVT area and the highest number in the H5W. It should be noted that annual rainfall is not always directly related to the number of rain days.

Paddock selection
Only grow chickpeas in paddocks with suitable soils as the yield from marginal soils may not be adequate to recover the costs of establishing a chickpea crop and managing ascochyta with a fungicide spray program. Keep a three year break between chickpea crops in a paddock (i.e. 1:4 rotation) to minimise the carry-over of stubble-borne infection. For the year 2001 chickpea crops, paddock separation from 2000 and 1999 stubbles is far more important than rotation. The level of ascochyta blight present in 1997 and 1998 chickpea crops was low and almost all infection potential will have broken down prior to sowing the 2001 crop.

Paddock separation
Only sow chickpeas into paddocks that are at least 500 m from 2000 stubble. This distance should be increased where the selected paddock in relation to the 2000 stubble, is down-wind for the prevailing wind or strong summer/autumn winds.

Seed source
Ascochyta blight is a seed borne disease so select seed with the lowest risk of disease. Low risk seed is not guaranteed 100% free from ascochyta.

Seed testing
Test all seed for ascochyta (AGWEST Plant Laboratories will be using a DNA test available through SARDI - this is the only test with adequate sensitivity at present). The results from tests conducted for the 2000/01 season will be reported in three categories; Undetected (< 0.01%), Low infection (0.01-0.25%), High infection (> 0.25%).

Seed quality and infection risk for chickpea growing zones in the 2001 growing season
ZONE 1 (L1 and L2): Ascochyta has been seen in many crops in this zone so a significant risk exists of crops becoming infected from the previous year's stubble. The average number of rain days is lowest in this zone, therefore the multiplication from seed borne infection will be least. Seed with up to 0.25% infection can be used, but clean seed is preferred.

Zone 2 (M1, M2, M3 and L3): Ascochyta has been seen in many crops in this zone so a high risk exists of crops becoming infected from the previous year's stubble. Multiplication from seed borne infection alone is sufficient in this area to result in crops being wiped-out if disease spread is not restricted by a foliar fungicide program. Seed in which ascochyta is undetectable (i.e. < 0.1%) is preferred. Seed with up to 0.25% infection can be used if sowing is delayed to the end of the recommended sowing window.

Zone 3 (L4, L5, M4 and M5E): Ascochyta has been seen in chickpea crops in the eastern half of this zone, however the majority of the zone remains free of ascochyta. Multiplication from seed borne infection alone is sufficient in this zone, in an average year, to result in crops being wiped-out if disease spread is not restricted by a foliar fungicide program. Only seed in which ascochyta is undetectable (i.e. < 0.1%) should be sown.

Zone 4 (M5W, M5C, H1, H2, H3, H4 and H5): Ascochyta has been severe in crops in the northern half of this zone, it has also been detected in some crops in the southern half of this zone. An initial low level of infection from stubble or seed-borne infection is sufficient in this area to result in crops being wiped-out. To control ascochyta in desi varieties in this zone will require a strict foliar fungicide program which may amount to six to eight applications in an average year. Kabuli varieties should be considered, because the potential returns are greater in suitable soil types. Only seed with in which ascochyta is undetectable (i.e. < 0.1%) should be sown.

Crop hygiene

Undertake a program of stubble reduction (i.e. burning, cultivation, grazing) to minimise the carry-over of stubble borne infection. Ensure stubble from the 2000 crop is not moved to the year 2001 chickpea paddock by vehicles or moving stock.

Variety selection

Select varieties which have the lowest level of susceptibility to ascochyta blight if new seed is being purchased (Table 73). However, it is not recommended that growers change their varieties based solely on the relative susceptibility of the chickpea variety to ascochyta blight, because a fungicide spray program is essential to achieve satisfactory yield regardless of the variety grown.

Table 73. Chickpea variety susceptibility to ascochyta blight

Disease rating	Desi	Kabuli
Extremely susceptible	Lasseter, Gully, Norwin, Desavic, Semsen	
Highly susceptible	Heera, Tyson, Barwon	Garnet, Kaniva, Bumper
Moderately susceptible	Sona, Dooen, Amethyst,	
Resistant	None	None

Seed dressings

Seed should be treated with P-Pickel T®. This product has proven better than thiram alone.

Time of sowing

Delaying the time of sowing of chickpea crops will minimise the multiplication of ascochyta blight and may reduce the number of fungicide applications required. Varieties should be sown during the recommended sowing window for each region (Table 74).

Table 74. Time of sowing recommendations for chickpea

Region	CVT areas	Desi sowing window	Kabuli sowing window
North			
Low rainfall	L1	15 May-30 May	Not recommended
Medium rainfall	M1	1 June-15 June	25 May-10 June
High rainfall	H1	Not recommended	1 June-15 June
Central			
Low rainfall	L3	15 May-10 June	Not recommended
Medium rainfall	M3	20 May-15 June	25 May-15 June
High rainfall	H3	Not recommended	1 June-20 June
South			
Low rainfall	L4	20 May-15 June	Not recommended
Medium rainfall	M4	5 June-20 June	
Medium rainfall 2	M4,M5	Not recommended	5 June-20 June
South E.			
Medium rainfall	M5E	25 May-15 June	Not recommended

Note: Desi chickpeas are not recommended for the high rainfall zone.

Fungicide applications

Coverage is important so high water volumes are recommended (100 L/ha for ground equipment, and 30 L/ha for aircraft), maintain high pressure to ensure atomisation of spray. A brochure produced by Pulse Australia, ‘Strategies for the control of foliar diseases in chickpeas (2001)’, provides more information on fungicide application and nozzle selection.

Spray 1*.* 4 weeks after emergence. 1.5 L/ha* Bravo® (720 g/L chlorothalonil).

Spray 2. 3 weeks after first spray. 1.5 L/ha* Bravo® (720 g/L chlorothalonil).

Zone 1 (L1, L2) Monitor crop for ascochyta blight. Use the guidelines given under Spray five to determine the required fungicide application strategy.

Spray 3 (Zone 2, 3 and 4)*.* Three weeks after second spray. 1.5 L/ha Bravo® (720 g/L chlorothalonil).

Zone 2 and 3 (L3-5, M1-4, M5E) Monitor Crop for ascochyta blight. Use the guidelines given under Spray five to determine the required fungicide application strategy.

Spray 4 (Zone 4)- Three weeks after third spray 2.0 L/ha Bravo® (720 g/L chlorothalonil)

Monitor Crop for ascochyta Blight. Use the guidelines below to decide the required strategy.

Spray 5, etc. Spray at three weekly intervals if required until the crop reaches maturity. The product and rate of fungicide to be applied will be determined by the disease level in the crop and the intensity and frequency of rain likely to occur during the next two to three weeks:

- If ascochyta is conspicuous in a crop (i.e. Patches are evident or an infected plant can be found every one or two paces when inspecting the crop) and two substantial fronts are likely during the next two weeks, then 2 L/ha of Bravo® is recommended.
- At the other extreme, where ascochyta is only present at very low levels (no patches evident and only one infected plant is found in 10 or more paces when inspecting a crop) and low in the canopy. No spray would be required if the forecast were for a brief front. Two kg/ha mancozeb may be appropriate where a single substantial front is forecast to be followed by an extensive dry period.

Fungicides should only be applied just prior to a rainfall event. Therefore, if rain is forecast for 20 days after the last fungicide application, spray on day 18 or 19 to avoid the strong pre-frontal winds that accompany rain-bearing patterns in WA. If no rain is forecast at the end of the three week period, delay the next fungicide application until just prior to the next forecast event.

* In zone 1 (L1 and L2), Bravo® may be applied at 1.0 L/ha for the first two applications if the disease pressure for the crop is low and exceptional rain events are not forecast.

Machinery hygiene
It is important to clean down ground spraying rigs before moving between chickpea paddocks to minimise the risk of spreading ascochyta.

Initiation of ascochyta diseases from infected stubble

J. Galloway and **W. MacLeod**, AGWEST, Northam

Black spot of field pea and ascochyta blight of chickpea and faba bean can survive from one season to the next on infected seed and stubble. On infected stubble sexual and/or asexual fruiting bodies develop. The asexual fruiting bodies are known as pycnidia and produce spores referred to as conidia. These conidia are spread for short distances during rain events by rain splash. The sexual fruiting bodies are known as pseudothecia and produce windborne ascospores. Ascospores are released during and after rain events and can be carried relatively long distances with the wind.

The contribution of infected stubble to the initiation of ascochyta diseases in chickpea, faba bean and field pea under WA conditions was determined in an experiment conducted at the CSIRO's Yalanbee research station at Bakers Hill. From the end of April 2000 to mid-September 2000, sets of potted chickpea, faba bean and field pea were placed at various distances from stubble infected during the 1999 season. Each set of potted plants was exposed to the stubble for one week and then was replaced with a fresh set of potted plants. The plants that had been exposed to the stubble were returned to the glasshouse and the amount of infection that occurred during the weeks exposure was measured.

Black spot of field pea

Black spot of field pea, caused by *Mycospharella pinodes* (the sexual stage of *A. pinodes*), was initiated by ascospores released from pseudothecia on the infected pea stubble from the start of the experiment in April 2000 to the conclusion of the experiment in September 2000. Initially disease severity was rainfall dependent with rainfall amounts as low as 0.2 mm being sufficient for the spread and subsequent infection by this pathogen. By the end of May, once the pea stubble had received a total of 35 mm of rainfall, disease severity was no longer related to rainfall amount. The same level of disease severity developed in weeks that received a total of 1.0 mm of rainfall compared with weeks receiving a total of 65.8 mm of rain. This loss of dependency on rainfall amount coincided with the peak infection period of June through to late-July. From August onwards disease severity declined but was still sufficient to be considered as a potential contributing factor to the development of black spot epidemics (Fig. 13).

From the data it is apparent that early sown pea crops could be badly affected by black spot due to repeated exposure to ascospores released from the previous seasons infected stubble. Later sowing will reduce the number of infection opportunities, however the crop will still be exposed to the peak infection period. *Mycosphaerella pinodes* is spread by windborne ascospores, therefore separating the current season's crop from the previous season's stubble is the most effective means of reducing disease initiation. During this experiment disease occurred in field peas at a distance of 400 metres from the infected stubble source. This suggests that a separation of a minimum of 500 metres or more between the previous season's stubble and the current season's field pea crop should be observed.

Ascochyta blight of chickpea

Ascochyta blight of chickpeas was initiated by rain splash dispersed conidia that formed in pycnidia on the infected chickpea stubble. These pycnidia produced a large number of mature conidia that were released during rain events from the start of the experiment in late April until mid-July. From mid-July onwards little or no infection occurred from the stubble. Rain events of 0.2 mm were insufficient to spread *Ascochyta rabiei*, however in weeks that received 1.0 mm of rain this was sufficient to cause spread of this pathogen and initiate ascochyta blight infection in a highly susceptible variety of chickpea (Fig. 14).

The results of this experiment show that early sown chickpea crops could potentially be exposed to multiple infection opportunities and supports the current recommendations for delayed sowing of chickpeas as a means of minimising exposure of the crop to repeated spore release events.

Ascochyta blight of faba bean

In this experiment, despite being exposed to the infected stubble from late April 2000, no ascochyta blight developed in the faba beans until late-June 2000. The peak infection period only lasted two weeks and then the level of disease initiation from the stubble decreased to low levels until the end of the experiment in September 2000 (Fig. 15). Disease was initiated from the stubble by a combination of rain-splash dispersed conidia and windborne ascospores.

Pycnidia containing mature *Ascochyta fabae* conidia were present on the faba bean stubble from the beginning of April but did not initiate ascochyta blight in the faba beans until late-June, which coincided with significant conidia release. The spore content of the pycnidia was depleted over the following two weeks after which time the majority of the pycnidia found on the stubble were empty. Pseudothecia of *Didymella fabae,* the sexual stage of *A. fabae,* developed on the naturally infected faba bean stubble. These pseudothecia matured from April to July reaching an advanced state of maturity in late-July. This suggests that exposure to cold temperatures is required for their development. High numbers of ascospores were release from the stubble from the end of June to mid-July and this coincided with the onset and peak infection period of ascochyta blight in the faba bean plants. In September, 2000 at the end of this experiment, all of the pseudothecia recovered from the stubble still contained mature ascospores. This work will continue during the next growing season to determine if these structures remain viable over the summer and are able to initiate disease from the stubble for a second season.

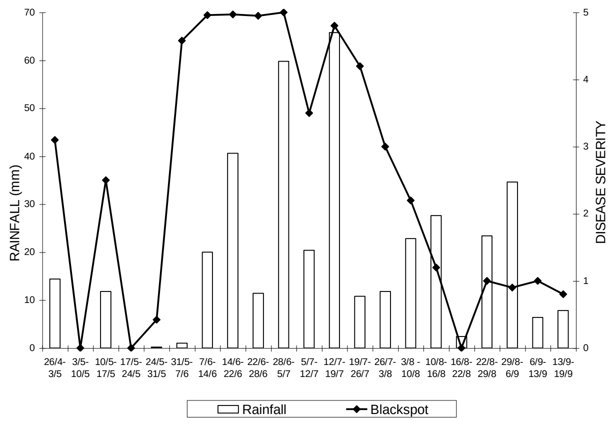


Figure 13. Black spot (*Mycospharella pinodes*) disease initiation from infected stubble on field pea at Bakers Hill in 2000.

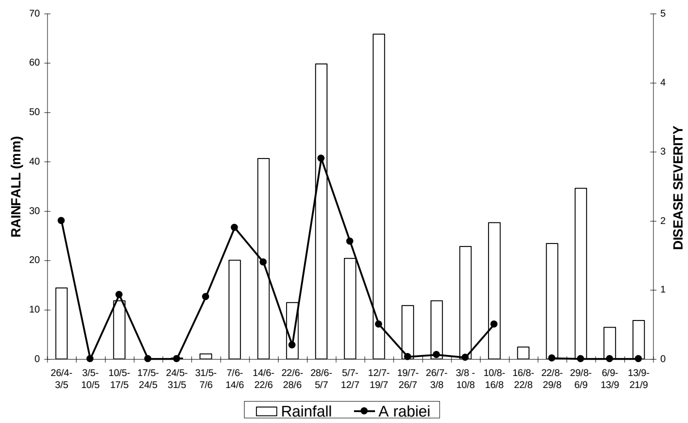


Figure 14. Ascochyta blight (*Ascochyta rabiei*) disease initiation from infected stubble on chickpea at Bakers Hill in 2000.

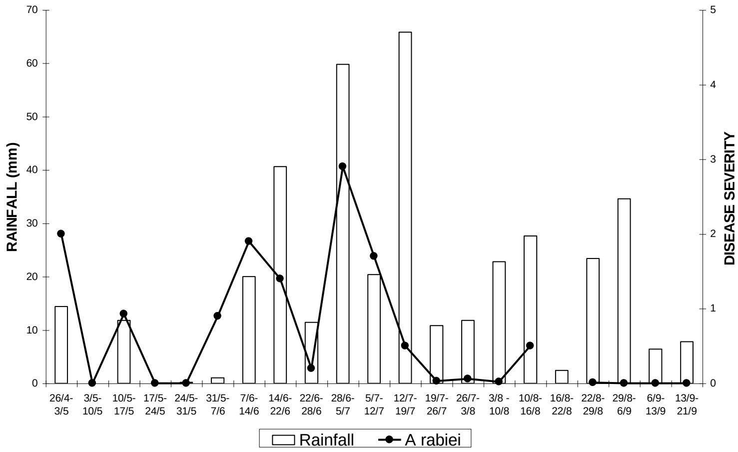


Figure 15. Ascochyta blight (*Ascochyta fabae*) disease initiation from infected stubble on faba bean at Bakers Hill in 2000.

Pulse disease diagnostics

D. Wright and **N. Burges**, AGWEST, South Perth

In July 1998, a broadacre diagnostic service for the grain growers of WA commenced as a section of AGWEST Plant Laboratories. This service was set up in response to the increasing demand for disease diagnostic services due to the dramatic expansion in cropping activity in recent years and a greater awareness of disease through the increased use of private agronomists by growers and the TOPCROP initiative.

The diagnostic service is a valuable tool for sustaining productive crop industries in WA. Growers are able to respond appropriately to significant disease constraints, and the service prevents the over reaction to minor or perceived disease threats.

Each year, the service has received an increasing number of samples and a positive response from clients. Even with the introduction of a fee-for-service in July 1999, demand remained high with 876 samples being received during the growing season. During 2000, a lower number of samples (550) were received, due to the late start in the season and the dry conditions that followed. Of these, 17% were pulse and oilseed crops. The break down by host; was: canola 24%, chickpea 24%, lupin 41%, field pea 5%, faba bean 6%.

The most common disease diagnosed by host for pulses was ascochyta blight of chickpea. Ascochyta blight was detected for the first time in the Narrogin and Esperance districts this year in chickpea crops. At present 11 seed samples have been submitted for ascochyta testing. Over 60% of the samples had a high infection present and all the samples submitted are from the North Central agricultural zone. As it was a dry season very little BGM was detected on the seed samples submitted.

Viruses in pulses

Virus infection causes seed discolouration and poor seed quality

R. Jones and **L. Latham**, AGWEST, South Perth and CLIMA

Visual appearance is a key feature when pulses are sold for human consumption. Discolouration of edible pulse seeds leads to downgrading of bulk consignments resulting in their sale for stockfeed at substantially lower prices. This is particularly so where this discolouration is easily seen as with faba beans, white field peas and kabuli chickpea.

In the past, seed discolouration of pulses in Australia has been attributed to environmental staining, insect damage and fungal diseases. However, a virus disease, recently shown to be common in pulses in WA, pea seed-borne mosaic virus (PSbMV), impairs field pea seed quality. Overseas, PSbMV reduces seed size and induces shrivelling and splitting. In addition, it causes obvious symptoms of necrotic rings and line patterns on the seed coat surface, sometimes called 'tennis balls'. PSbMV is spread in pulse crops by aphids and through sowing infected seed.

In a survey of crops and seed stocks of pulses in WA in 1999/2000, PSbMV was found in 42% of the field pea crops sampled and 63% of commercial seed stocks of field pea. It was also found in commercial seed stocks of faba bean and chickpea (growing crops of these edible pulses were not surveyed), and was often present in breeders' plots of field pea, faba bean and lentil.

In commercial and trial seed, poor seed quality caused by PSbMV infection was evident not only in seed of field pea but also in seed of faba bean, chickpea, *Lathyrus* and vetch. Seed coats showed obvious necrotic (dark brown) line patterns, rings or concentric rings. The rings and line patterns varied in intensity and size. Sometimes they were 'mirror imaged' on both halves of the same seed. In addition to the necrotic rings, smaller size and shrivelling of seeds due to PSbMV was always present in faba bean but less evident with the other pulses (Fig. 16).

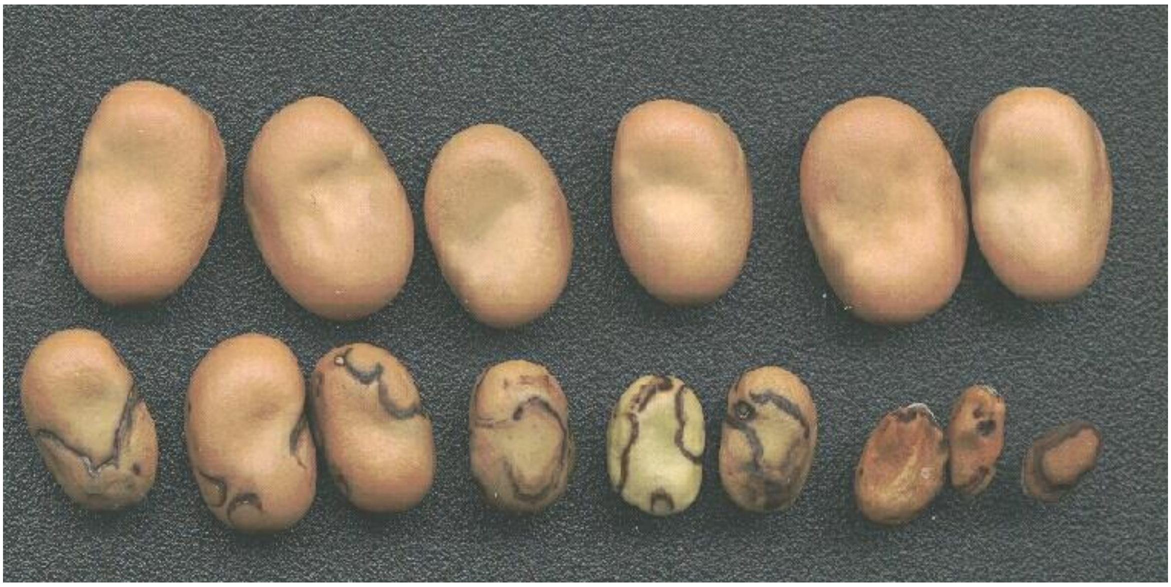


Figure 16. Seed appearance of normal faba bean (top) and infected with PSbMV (bottom).

In seed from partially PSbMV-infected plots, the necrotic symptoms were very frequently evident on seed coats of faba bean (> 80% of seeds from infected plants), and frequent on seed coats of dwarf *Lathyrus* species (*Lathyrus cicera*, *L. sativus* and *L. ochrus)* (> 50%). They were less obvious on seed coats of dun type field pea and chickpea (< 5%), in part due to seed coat colour. Symptoms were difficult to observe on seed coats of common, purple and bitter vetch due to their dark colours, but faint concentric necrotic rings were sometimes observed with each of them. We did not examine seed of narbon bean or lentil from PSbMV infected plots, but similar seed quality defects due to PSbMV infection are reported for these species overseas.

In the past, PSbMV was mistakenly considered to be a minor disease of pulses in Australia because of its generally mild foliar symptoms and the lack of information on its occurrence in pulse crops. Following the recent survey findings of widespread infection with PSbMV in pulses and the realisation that it has severe effects on quality of harvested seed, a reappraisal of its economic significance to pulse production in WA has occurred.

Our results from tests for PSbMV on seeds of different pulses with necrotic rings on their seed coats found that they were rarely associated with PSbMV seed transmission through seed to seedlings with any of the range of species tested. They are therefore caused by infection spreading from the PSbMV-infected mother plant on which the seed develops to the seed coat rather than infection coming directly from the embryo. Similarly, Broad Bean Stain Virus (BBSV) infection *via* the mother plant is known to cause necrotic ring and line pattern symptoms on seed coats of faba bean.

A project has been formulated with the aim of overcoming the PSbMV problem. If funded (GRDC), the project will develop and extend a targeted 'clean up' program that will address the current PSbMV contamination of commercial field pea and other pulse seed stocks, and contamination with PSbMV in pulse breeder's seed stocks. Surveys will pinpoint where seed-borne infection is present and where the 'clean up' program should be targeted. The 'clean up' program will provide a clean 'pipeline' for new varieties emerging from breeding and selection programs as well as improving the health status of commercial seed stocks.

In collaboration with the State Agricultural Biotechnology centre, the project will also develop cost effective, practical, quantitative dry seed tests for detection of PSbMV in commercial seed samples of field pea, chickpea, and faba bean. The 'TAQMAN' technology provides a quantitative result (% seeds infected) from single tests on bulk 1000 seed samples, thus avoiding the current need for labour intensive multiple testing of sub samples of the seed. Experience with similar 'TAQMAN' based seed tests developed for detecting CMV in commercial lupin seed suggests that they will be widely adopted by seed testing laboratories for use on growers' samples.

Insect pests

Aphid ecology in pulses

O. Edwards, J. Ridsdill-Smith and **R. Horbury**, CSIRO Entomology

Surveys of legume aphids in WA in 1998 and 1999 showed that populations build on alternative host plants, including broad-leafed weeds and pastures, before colonising paddocks of pulses. Though aphid invasion is usually sufficient to introduce virus infection, aphid feeding damage will only occur if the pulse host is suitable enough to promote rapid aphid growth and reproduction. Previous work determined the suitability of the most commonly grown pulses in WA to the three major legume pest aphids in WA: the green peach aphid (*Myzus persicae*), the cowpea aphid (*Aphis craccivora*), and the bluegreen aphid (*Acyrthosiphon kondoi*). All three of these aphid species can cause feeding damage on lupins. Two pulses were identified as being at high risk of aphid feeding damage: faba bean by cowpea aphid, and lentil by both cowpea aphid and bluegreen aphid. These crops can support the other aphid species as well, as can field pea, but populations are not likely to achieve damaging levels. Only chickpea is completely unsuitable for feeding by any of the three aphid species.

For each crop where an aphid risk was identified, aphid performance was tested on some commonly-used varieties. No differences in cowpea aphid or bluegreen aphid performance were observed among the lentil varieties tested, nor was there a difference in cowpea performance among the faba bean varieties (Fig. 17). These results indicate that the use of aphid-resistant varieties is not currently a management option for growers of faba bean and lentils in WA.

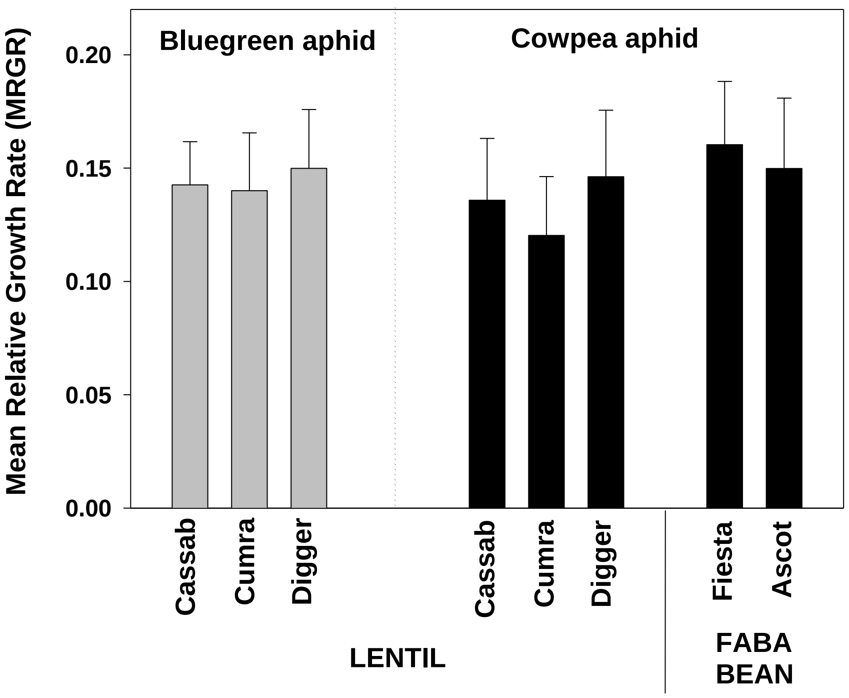


Figure 17. Mean relative growth rate of potential pest aphids on popular varieties of susceptible pulse crops.

Research is continuing on the dynamics of legume aphid populations in the WA wheatbelt. Surveys have shown that green peach aphids and bluegreen aphids are usually more widely distributed throughout pulse paddocks than are cowpea aphids. There are probably two reasons for this. First, the preferred alternative hosts upon which green peach aphid (broad-leafed weeds) and bluegreen aphid (clovers) populations build up are more common in WA than the preferred alternative hosts of cowpea aphid (medics). In addition, bluegreen aphid and green peach aphid are more active at the lower temperatures commonly experienced during the winter months (Fig. 18). As a result, they probably colonise paddocks earlier and in higher numbers, resulting in a wider distribution before the onset of the higher spring temperatures.

Research has been initiated to analyse the movement patterns of these aphids under field conditions. When more is known about the invasion pattern of pulse paddocks by each of these species, management strategies will be devised that aim to minimise the number of colonising aphids.

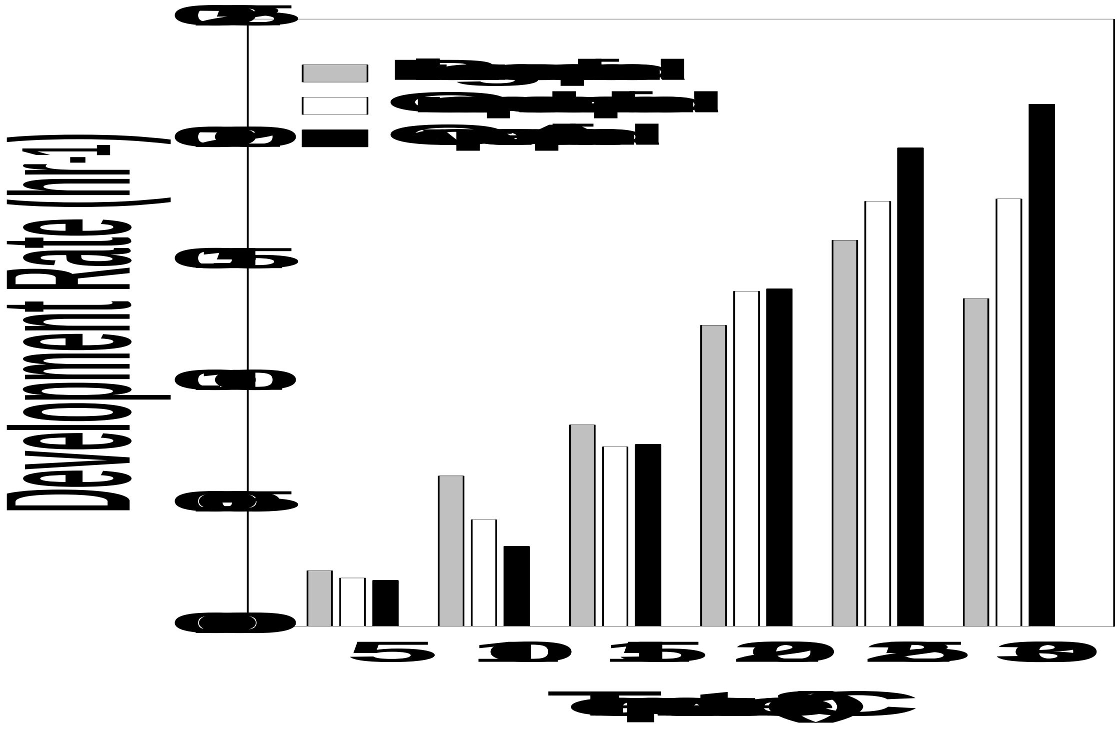


Figure 18. Differences in development rate between three legume aphid species at various temperatures.

Evaluation of transgenic field pea against pea weevils (*Bruchus pisorum*)

Ms M.J. de Sousa Majer, Curtin University of Technology; **N.C. Turner**, CSIRO Plant Industry and **D. Hardie**, AGWEST South Perth

Seeds of the common bean (*Phaseolus vulgaris*) are resistant to many species of seed beetles, mainly because of the presence of an α-amylase inhibitor (α-AI-1). This gene has been transferred by CSIRO researchers to field pea (*Pisum sativum*) and this provides a high level of protection against pea weevil (*Bruchus pisorum*), a pest of developing pea seeds. GRC has funded a PhD project which aims to evaluate the efficacy of transgenic peas against the pea weevil and to generate important data to develop strategies for growing field pea that will minimise, or reduce, the development of resistance in weevil populations.

Stress experiment

As part of environmental and pest management requirements, a transgenic field pea line was evaluated under glasshouse conditions to quantify the level of α-AI-1 when the field pea was subjected to heat and water stress during pod filling. The experiments were carried out in growth cabinets under control (27/22°C day/night temperatures, and 1.3 kPa vapour pressure deficit (VPD)) and heat stress (32/27°C day/night temperatures, and 1.3 kPa VPD) conditions. The water stress experiment was conducted in a PC2 glasshouse where the field peas were grown at 29°C maximum temperature during the day, 11°C minimum during the night and 68% RH. The water supply to selected pots was stopped to create the stress condition, and plastic beads were placed on the soil to reduce evaporation during subsequent maturation. Individual pods were tagged under heat and water stresses for nine and 12 days, respectively. Seeds were collected from pods harvested at maturity, 46-63 days after the start of heat or water stress period. Previous studies have shown that heat- and water stressed plants produced 27%

and 79% fewer seeds, respectively, than controls. Although heat stress had no effect on seed size, water stressed plants produced smaller seeds. Seeds were harvested at maturity, and the content of α-AI-1 was measured in both treatments using Western blot analysis. The level of expression of α-AI-1 was not influenced by water stress. However, the level of expression of α-AI-1 in peas subjected to heat stress was reduced by an average of 33% when compared to unstressed plants (Table 75). The implications of these results are being assessed and further analysis is in progress.

Table 75. Effect of stresses on seed yield, size, % of protein and αA1 level

	Seed yield (g/plant)	Seed size (mg/seed)	% Protein (% DM)	% αA1
Control	39.0 g (100%)	186.0 (100%)	20.0	(100%)
Heat stress	28.4 g (73%)	184.3 (100%)	19.6	(67%)
Control	42.0 g (100%)	200.2 (100%)	27.8	(100%)
Water stress	9.0 g (21%)	104.5 (50%)	36.3	(100%)

Comparison of the two α-amylase inhibitor α-AI-2 and α-AI-1

Investigations into the effects of a second type of α-amylase inhibitor (α-AI-2), on the life cycle of the pea weevil are currently being conducted in a growth cabinet. This study will also compare responses of pea weevil to the α-AI-2 and α-AI-1 inhibitors.

Field evaluations

A field trial, carried out on grower's properties in WA, consisted of three treatments, plots (5 x 5 m), contained 100% transgenic peas, 90% transgenic peas (10% refuge) and 80% transgenic peas (20% refuge), respectively. In the 90 and 80% treatments, the non-transgenic peas were sown in strips between the transgenic peas within the plot, rather than mixed with the transgenic peas. Each treatment had four replicate plots. Four plots with 0% transgenic plants were sown as a control. This resulted in a total of sixteen plots. The distance between the plots was at least 400 m. Fifty pea weevils were released in each plot at flowering. Weevils were marked with fluorescent dye and re-sampled four days later with a sweep net in order to estimate the incipient population of weevils in the plots. Mark-recapture population estimates revealed that initial levels varied from 100-600 weevils per plot. Overall, the weevils did not show any preference for conventional field pea over transgenic lines. This indicates that the weevils cannot detect the presence of the α-amylase inhibitor. All plants have been hand harvested from the non-transgenic and transgenic strips within each plot, so that infestation levels can be quantified The estimated final weevil population size has been calculated. The results from the first field trial indicate that transgenic peas might be a viable way to control the pea weevil, thus enabling a reduction in the use of field insecticide and storage fumigants.

Searching for markers for resistance to pea weevil

O. Byrne, CLIMA and Plant Sciences, UWA, **N. Galwey**, Plant Sciences, UWA, **D. Hardie**, AGWEST, South Perth and **P. Smith**, Botany, UWA

The wild field pea species *Pisum fulvum* is a source of resistance to pea weevil, and resistant recombinant progeny can be obtained from crosses between *P. fulvum* and the cultivated field pea (*Pisum sativum*). This indicates that *P. fulvum* will be a valuable source of resistance in the genetic improvement of cultivated field pea. However, the identification of resistant plants is laborious, and a molecular-genetic marker for resistance would be of great value in field pea breeding programs. Here we report on the identification of molecular-genetic polymorphisms that are candidates for use as such a marker.

A *P. fulvum* × *P. sativum* cross was made, and 250 F_2 plants were evaluated for resistance to pea weevil by determining the percentage of seeds without exit holes. Thirty F_2-derived families

were produced from plants at the two extremes of the resistance distribution. Pea weevil resistance was again determined in a total of 57 F_3 plants belonging to these families. DNA was extracted from each F_3 plant, and amplified fragment length polymorphisms (AFLPs) were sought using 64 primer pairs. Fifteen pairs were identified that gave rise to 385 AFLP bands polymorphic among these plants.

For each polymorphic band, a restricted maximum likelihood (REML) analysis was performed with presence/absence of band as a fixed effect and variance among families as a random effect. The statistic t = effect of band/SE_{effect} was taken as a measure of the ability of each band to identify resistant plants, and the variance among families was taken as a measure of the genetic variation *not* accounted for by the band in question. For every possible pair of bands, the similarity of their distribution over families was calculated using the Euclidean distance criterion, and a principal coordinate analysis (PCO) was performed on this similarity matrix. The position of each band in the first two PCO dimensions was studied in relation to its t value.

The results of REML analysis are illustrated for one of the AFLP bands that showed strongest association with susceptibility to pea weevil (Band PE56375) in Table 76. They show that the association between this band and susceptibility is highly significant (the Wald statistic is much greater than one and the difference between the predicted means is much greater than its standard error). However, there is also a substantial amount of genetic variation that is *not* associated with this band (the variance among families is also much greater than its standard error).

Table 76. REML analysis of the association between AFLP band PE56375 and pea weevil resistance (% plants with exit holes)

Wald test		
Band	Wald statistic	DF
PE56375	22.6	1

Predicted means

Band absent	**Band present**	**SE_{diff}**	***t***
53.40	12.17	8.664	–4.759

Variance components

Model term	**Variance component**	**$SE_{component}$**
Variance among families	529.1	171.7
Variance among plants within family	138.2	40.5

The corresponding analyses for all AFLP bands demonstrate a curved relationship between t and the remaining variance among families as expected, with values of t close to zero being associated with the largest variances (Fig. 19). Bands with t values above three are candidates for use as markers for resistance, and those with t values below minus three are candidates for use as markers for susceptibility.

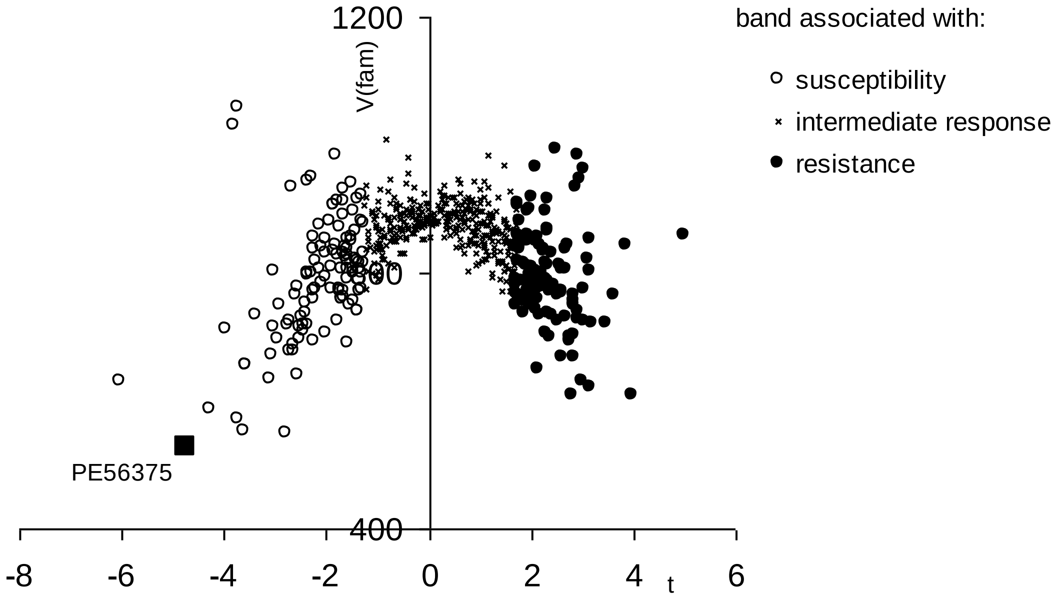


Figure 19. Strength of the association of each AFLP band with pea weevil resistance (each data point represents a band. *t* = effect of band/SE_{effect}. V(fam) = variance among families after allowing for effect of band).

The principal coordinate analysis indicates that 43% of the variation in the distribution of the AFLP bands among families is accounted for by the first two dimensions (Table 77), and the position of each band on these dimensions shows that resistance to pea weevil is strongly associated with the second dimension (Principal Coordinate 2, Fig. 20).

Table 77. Principal coordinate analysis of AFLP band data

Dimension no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
% Variation	27.59	15.78	5.27	4.53	4.43	3.96	3.65	3.26	3.19	2.71	2.46	2.3	2.12	1.95	1.77

There are many bands strongly associated with resistance to pea weevil (*t* up to 4.976), and many associated with susceptibility (*t* down to -6.034). Each of these is a candidate for marker-assisted selection. However, in all cases the remaining variance among families was more than three times its standard error, indicating that no single band accounted for all the genetic variation. Thus in order to obtain the most resistant progeny possible, selection would have to be based on more than one molecular marker, or on preliminary selection on the basis of a molecular marker followed by phenotypic evaluation of the selected lines. REML analysis identified PE56375 as one of the AFLP bands most strongly associated with susceptibility, and in PCO analysis the second dimension identified is strongly associated with resistance and susceptibility. However, PE56375 is rather atypical in that it does not have a very low score on this dimension. It may be preferable to use as markers for resistance or susceptibility those bands that have an extreme score on Principal Coordinate 2 in addition *to* an extreme *t* value in the REML analysis. It is planned to clone the AFLP bands chosen as potential molecular markers for pea weevil resistance, in order to develop a rapid assay based on the polymerase chain reaction (PCR).

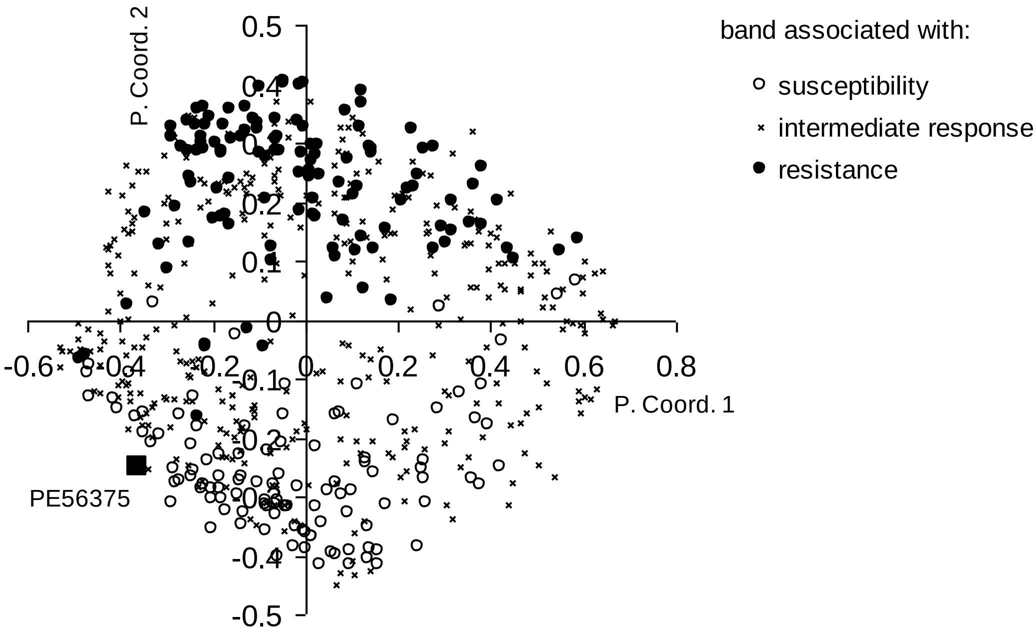


Figure 20. Relationship between pea weevil resistance and the first two principal coordinates (each data point represents a band).

Improved stored grain fumigation on-farm with the Phoscard®

R. Emery and **E. Kostas**, AGWEST, South Perth

Export grain is one of the mainstays of Australian agriculture with over 80% of grain produced by Australian growers destined for export. For Australia to remain competitive with other countries we must continue to ensure that our grain including pulses remain completely free of insects. Unfortunately the warm storage conditions in Australia are conducive to the establishment and development of grain insects while other countries like Canada are just too cold for the rapid development of insect populations in stored grain.

Australia is satisfying markets for residue-free pulses with the use of fumigants, particularly phosphine. In WA sealed storage is used on over 60% of farms and a similar percentage of Cooperative Bulk Handling Ltd (CBH) storage is sealed. Since 1990 all grain has been exported from WA without the use of contact insecticides at any stage during storage. Unfortunately, this reliance on phosphine at all stages of storage places a lot of pressure on a single fumigant, particularly with respect to resistance development. Worse still, there are few alternatives and use of the 'fall back' fumigant, methyl bromide is soon to be heavily restricted or terminated completely.

Researchers around the world have shown the ineffective use of phosphine in poorly sealed storage can lead to resistance and eventually control failures. In the early 1980s, highly resistant strains of lesser grain borer were found in Bangladesh where phosphine has been misused extensively for many years. In Australia, strains have been found in Queensland and New South Wales, which appear to have similar levels of resistance to the much-maligned Bangladesh borers. Early research in WA has shown that grain insect resistance rarely develops in bulk storage, because the cost and return of fumigating large amounts of grain is so high that bulk handlers make sure the job is done correctly the first time, every time. In the past, resistance has developed on-farm where grain protectants and fumigants are not always used in accordance with the label. There is a danger that these strains could find their way from the farm into the central handling system or worse still, an export market. Bulk handlers routinely monitor the gas concentrations in storage under fumigation throughout the fumigation period; this is the key factor that is missing from farm fumigations. Gas detection/monitoring equipment is often seen by farmers as being too expensive, too difficult to maintain and calibrate and too sensitive to the rigours of day to day farmer use.

As an alternative to monitoring, the current recommendation is that farmers pressure test their storage to assess the gas-tightness of the structure prior to fumigation. If the storage is sufficiently well sealed we know that an effective fumigation will take place provided the storage is kept sealed for seven to ten days for stored grain insects and 21 days for the pea weevil. Unfortunately, from a farmer perspective, this pressure testing bears little relationship to the actual fumigation, which usually appears successful because all the adults are dead. This ignores the fact that the eggs and pupae are likely to survive the fumigation and will turn into adults and reinfest the grain within days. The complexity of the phosphine product label further compounds the problem.

With support from the AGWEST Pulse and Oilseeds program and GRDC, we decided to develop an extension tool in the form of a farm fumigation card that outlines key points for conducting a safe and effective fumigation. The card would also have an indicator strip that would give farmers a 'no frills' assessment of the standard of their fumigation.

The fact that phosphine gas corrodes copper is well known. We therefore began experimenting with various forms of copper until we found one that gave an obvious response after exposure to lethal concentrations of phosphine for at least seven days. Copper used in electronic circuit boards gave the best results and could be readily applied as a strip to a plastic card. We tested the cards in over 20 sealed and unsealed farm storages. The copper strip consistently indicated successful fumigation. The Phoscard® is styled on a credit card (Fig. 21). The front side bears five key fumigation principles, while the back side has a copper strip which is protected from tarnishing by a layer of transparent adhesive tape which must be removed before use. There is a hole to attach string for retrieval and instructions for use.

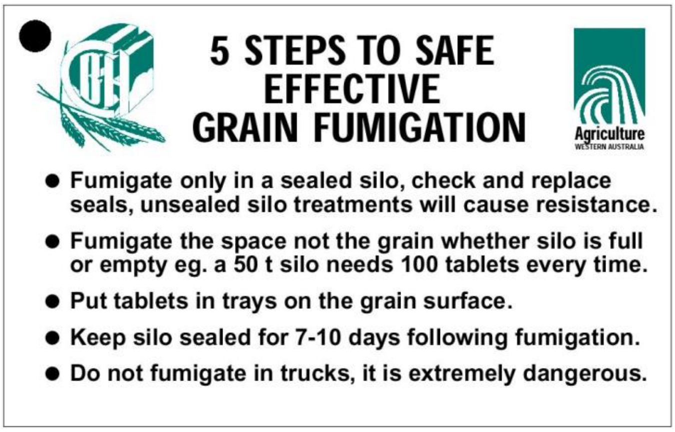
Farmers can place a Phoscard® in a storage prior to fumigation. If the copper strip is exposed to sufficient phosphine for at least seven days, the shiny copper strip will turn almost completely black. There is a colour chart printed alongside the copper strip to allow easy comparison. If the strip has not turned black at the end of the fumigation, something has gone wrong: usually a leaky storage or insufficient number of aluminium phosphide tablets being placed in the storage.

The Phoscard® is an extension tool for farmers, it will not replace phosphine monitoring equipment and is not intended to be used by fumigators or bulk handlers. However, we are hopeful that farmers experiencing fumigation failures indicated by the Phoscard®, will contact their State department of agriculture or primary industries for advice on how to improve their fumigation. The cards will introduce farmers to the value of fumigation monitoring and may even encourage them to purchase one of the digital phosphine meters to more accurately monitor their fumigation. The cards store indefinitely as long as the protective tape remains in place but they can only be used once. Production costs are about $1 each for a run of 10,000. In recognition of the importance to the entire grain industry of safe effective phosphine fumigation, CBH (WA) have funded production of the first 10,000 Phoscards® and will be distributing them among their clients. Collaborative arrangements with companies and agencies in other States will also be considered.

Sample Phoscards® are available from:

Rob Emery Senior Entomologist Agriculture Western Australia 3 Baron-Hay Court, South Perth Western Australia 6151	Rob Lake Manager Grain Protection Co-operative Bulk Handling (WA) 22 Delhi St, West Perth Western Australia 6005
Ph: 08 9368 3247 Fax: 08 9368 3223 remery@agric.wa.gov.au	Ph: 08 9237 9600 Fax: 08 9322 3942 rob.lake@cbh.com.au

Front:



Rear:

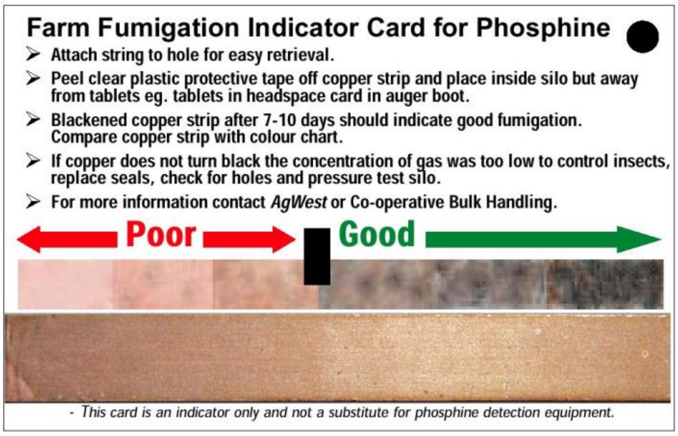


Figure 21. Front and rear side of the phosphine detector card with adhesive tape printed with ‘PEEL OFF’ removed from copper strip.

ACKNOWLEDGMENTS

We are grateful for the continuing financial support of our work by AGWEST, GRDC, GRC, ACIAR and CLIMA.

Our large experimental program would not have been possible without the technical excellence and enthusiasm of AGWEST staff at the Geraldton, Avondale, Merredin, Katanning, Mt Barker, Manjimup, Lake Grace, Jerramungup, Kununurra and Esperance Research Station Business Units. We particularly thank M. Baker, C. Veitch, T. Pope, M. Blythe, R. Beermier, A. Harrod, L. Evans and L. Young who provided full-time technical assistance in the trial program.

We thank the many farmers who provided trial sites and the Bindoon Catholic College for their collaboration and use of land. We gratefully acknowledge the cooperation and assistance provided for the trial and demonstration program by the four pulse grower groups in WA (Mid West Pulse Growers Association, Central Districts Pulse Growers Group, Pulse Association of the South East, and Great Southern Pulse Association).

We also thank cooperating scientists from the national pulse breeding programs based in the Eastern States for supplying germplasm to test in WA. We continued collaboration with CMAR, CSIRO, Perth, during the 2000 season. International organisations including ICARDA Syria, ICRISAT India, AARI Turkey, ACAR, India, IARI India, BARI Bangladesh and Nepal and Ethiopia, also supplied germplasm for evaluation.

We acknowledge the excellent cooperation and support shown by a large number of private agricultural consultants and pulse industry groups in the State.

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VARIETIES PRODUCED AND COMMERCIALLY RELEASED

Desi chickpea

Siddique, K.H.M. and Khan, T.N. (1997) variety ‘Sona’
Khan, T.N. and Siddique, K.H.M. (1997) variety ‘Heera’

Field pea

Khan, T.N. (1997) variety ‘Magnet’
Khan, T.N. (1997) variety ‘King’
Khan, T.N. and French, R.J. (1999) variety ‘Helena’
Khan, T.N. and French, R.J. (1999) variety ‘Cooke’

Red Lentil

Siddique, K.H.M. (1998) variety ‘Cumra’
Siddique, K.H.M. (1998) variety ‘Cassab’

Lathyrus species

Hanbury, C.D. and Siddique, K.H.M. (1998) *Lathyrus cicera* (dwarf chickling) variety ‘Chalus’