Development and adoption of new kabuli chickpea varieties in Australia

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Abstract

Production of chickpea in Australia has rapidly declined over the past decade due to the devastating fungal disease ascochyta blight (AB), caused by *Ascochyta rabiei* (Pass.) Lab. The future of the Australian chickpea industry relies on the development of varieties with high levels of resistance to AB along with integrated crop management packages. An international collaboration was initiated in 1998 to fast track improved, AB resistant, breeding lines with improved seed yield and quality (seed size and colour) for commercial release in Australia. We screened a large number of chickpea lines from major overseas chickpea breeding programs off-shore prior to import to Australia. Selection of lines and seed production carried out concurrently with development of agronomic and disease management practices in Australia ensured the availability of the first improved AB resistant kabuli chickpea varieties together with crop production packages in 2005. Early results from growers have shown the value of the new varieties during 2005. It is expected that the new chickpea varieties together with their production packages will be rapidly adopted by growers in Australia.

Key Words

Chickpea, ascochyta blight, kabuli, screening, breeding, international collaboration

Introduction

Ascochyta blight (AB), caused by *Ascochyta rabiei*, is the most damaging disease of chickpea in many parts of the world, and has caused widespread yield losses in Australia (Knights and Siddique 2002) and a significant decline in the area of production. To rejuvenate the industry, new varieties with high levels of AB resistance and integrated management packages are necessary. In this study we developed an international collaboration to fast track the release of new improved kabuli chickpea varieties with AB resistance for Australia. The study commenced in 1998 at a time when AB was not well established in Australia and relied on off-shore screening in Turkey to identify improved germplasm from the world's major kabuli chickpea improvement programs. The major objectives were to select AB resistant chickpea breeding lines with high quality likely to be well adapted to Australian conditions, introduce promising lines to Australia, develop crop management packages, and fast track new varieties with AB resistance, improved seed yield and quality for commercial production.

Methods

Screening for AB resistance

Off-shore screening for AB was undertaken at the Aegean Agricultural Research Institute (AARI) field site in Menemen, Izmir (Turkey) during 1998 and 2001. The disease nurseries involved more than 2000 breeding lines from the International Centre for Agricultural Research in the Dry Areas (ICARDA), Syria and AARI, Turkey, and standard varieties from Syria, Turkey and Australia. The breeding lines and varieties were screened for reaction to AB and agronomic characteristics (e.g. phenology, plant morphology, seed size and colour). Disease was scored on a 0-9 scale, where 0 = no disease and 9 = dead; and rated as highly resistant (HR= 1-2), resistant (R= 3), moderately resistant (MR= 4), MR-moderately susceptible (MR-MS= 5), MS (6), MS-susceptible (MR-S= 7), S (=8) and very susceptible (VS=9). More than 300 superior lines with an AB score less than five were selected and introduced to Australia during 1998 to 2000. In Australia, breeding lines were initially screened for AB in 1999 in South

Australia (SA), Victoria (Vic), and New South Wales (NSW). Disease screening continued at interstate locations in 2000 and 2001, and expanded to Medina Western Australia (WA) during 2002 to 2005, and Dongara (WA) in 2003 after the disease had spread through the Western Region.

Yield and agronomy

Fifty seeds of selected breeding lines were initially grown in quarantine (glasshouse) then evaluated in small field plots in WA (Bindoon). Evaluation in field trials followed during 2002 to 2005 at 18 sites across southern Australia (WA, Vic, SA and NSW). Seed yield and seed quality (seed weight, seed colour and seed size distribution) were measured in field trials. Field trials included the susceptible standard variety Kaniva in 2002 – 2004, but this variety was omitted from trials in 2005 due to difficulties in managing AB. Fungicide was applied twice (one at four weeks after emergence and second at podding) at each site in WA, except in 2002 where no fungicide was applied. No fungicide was applied in NSW, SA or Vic in 2003 and 2004, but multiple applications were made at one site in NSW in 2003 and 2004.

Disease management

Fungicide management options were evaluated for three of the most promising breeding lines (FLIP97-530-CLIMAS, FLIP97-503-CLIMAS and FLIP97-537D-CLIMAS) in replicated field trials in WA during 2004 and 2005. All plots were inoculated with AB by introducing infected stubble at a rate to simulate approximately 0.1% of emerged seedlings being infected. Yield was compared for breeding lines treated with various fungicide spray regimes of one strategic fungicide spray up to four regular fungicide sprays, or left unsprayed (Table 1).

Table 1. Fungicide treatments (Bravo, 720 g ai/L) and application dates used in disease management trials 2004/05

Year	**2004**		**2005**	
Spray No (timing)	**Dongara (27 May)[1]**	**Beverley (30 May)**	**Dongara (25 May)**	**Northam (9 May)**
1 (4 weeks PE[2])	**5 July, 1.5 L/ha**	**9 July, 1.5 L/ha**	**29 Jun - 1.5 L/ha**	**20 June - 1.5 L/ha**
2 (7 weeks PE)	**26 July, 1.5 L/ha**	**30 July, 1.5 L/ha**	**18 July - 1.0 L/ha**	**5 July - 1.5 L/ha**
3 (Flowering)	**30 Aug. 1.5 L/ha**	**20 Aug., 1.5 L/ha**	**9 Aug. - 1.5 L/ha**	**5 Sept. - 1.5 L/ha**
4 (Podding)	8 Oct., 1.5 L/ha	13 Oct., 1.5 L/ha	**13 Sept. - 1.5 L/ha**	**5 Oct. - 1.5 L/ha**

[1] Sowing date [2] PE- post-emergent

Seed production

Seed production of the most promising breeding lines commenced by selecting single plants from plots at Bindoon in 1999 and continued under irrigation or rainfed conditions in WA (Carnarvon, Geraldton and Kununurra) and in Eastern Australia (Vic) until 2005.

Results

Screening for AB resistance

Disease ratings of kabuli chickpea breeding lines to AB in Turkey were R-MR (<5) for many lines. The standard Australian varieties (Kaniva & Bumper) were VS (9) to AB and there were no surviving plants at flowering. Similar results have been reproduced in Australian disease nurseries and indicate that AB resistance is reproducible under local growing conditions (Fig. 1.).

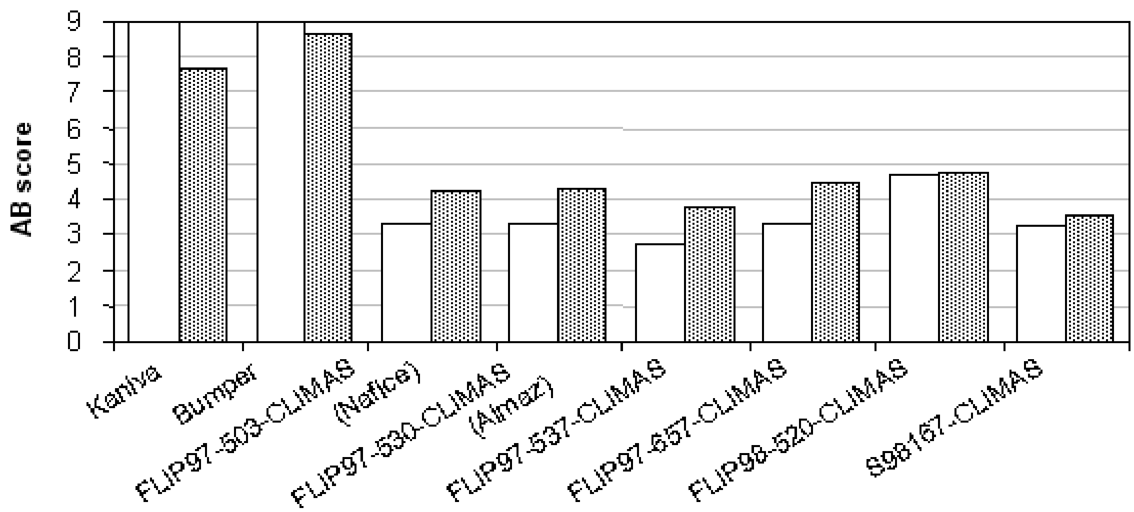

Figure 1. Disease reaction of some kabuli chickpea breeding lines and standard varieties (Kaniva and Bumper) to ascochyta blight infection (where 0 = no disease to 9 = dead) measured in Turkey (☐) and Australia (▒)

Yield and seed quality

On average across sites and seasons, many breeding lines produced greater yield and mean seed weight than Kaniva (Table 2 and 3). A number of breeding lines also produced a larger proportion of seeds greater than 9 mm in diameter (Table 3). Of the breeding lines, AlmazA (FLIP97-530-CLIMAS) and NaficeA (FLIP97-503-CLIMAS) exhibited the most desirable combination of seed yield, seed quality (seed size, seed colour and seed size distribution), phenology, plant height and AB resistance.

Table 2. Mean seed yield (expressed as % of seasonal mean) for some kabuli chickpea breeding lines and Kaniva in southern Australia, 2002-2005 (Number of trials indicated in parentheses)

Variety/breeding line	2002 (1)	2003 (8)	2004 (6)	2005 (3)	Mean
AlmazA (FLIP97-530-CLIMAS)	112	131	113	115	118
NaficeA (FLIP97-503-CLIMAS)	109	105	96	95	101
FLIP97-537D-CLIMAS	100	108	83	-	97
FLIP97-657-CLIMAS	103	115	112	116	112
FLIP97-695-CLIMAS	109	101	117	98	106

FLIP98-520-CLIMAS	-	102	102	92	99
S98167-CLIMAS	-	119	103	110	111
Kaniva	110	93	89	-	97
Seasonal mean[1] (t/ha)	1.08	0.93	1.07	1.17	1.06

[1] Mean seed yield of all genotypes across all sites within each year of testing.

Table 3. Ascochyta blight (AB) rating, mean seed weight and seed size distribution for some kabuli chickpea breeding lines and Kaniva

Variety/breeding line	AB	Mean seed weight[1]		Proportion of seed (%)[1]			
	Rating	% Kaniva	mg/seed	> 9 mm	8-9 mm	7-8 mm	< 7 mm
AlmazA (FLIP97-530-CLIMAS)	MR	117	39	39	45	14	2
NaficeA (FLIP97-503-CLIMAS)	MR	120	40	53	35	10	2
FLIP97-537D-CLIMAS	MR	116	39	36	43	16	5
FLIP97-657-CLIMAS	MR	113	38	41	44	12	3
FLIP97-695-CLIMAS	MR	112	38	27	56	32	11
FLIP98-520-CLIMAS	MR/MS	115	39	60	34	5	1
S98167-CLIMAS	MR	116	39	46	42	11	2
Kaniva	VS	100	34	24	46	23	7

[1] Mean seed weight: mean of trials during 2002-2005. Seed size distribution: mean of trials during 2002-2005 in WA.

Seed production

Seed production was undertaken in conjunction with yield, disease and quality evaluation in an effort to minimise the time to release a new variety from this project. Initially, single plants were taken from a large number of promising breeding lines, but seed bulk-up was reduced each year to those lines with the greatest potential as varieties. In 2005 two breeding lines, FLIP97-530-CLIMAS (AlmazA) and FLIP97503-CLIMAS (NaficeA), were selected for release. Commercial seed was made available to growers in 2006.

Disease management

The most promising breeding lines exhibit moderate resistance to AB but can suffer a yield penalty from modest numbers of AB sources in a conducive environment (eg Dongara 2005) unless strategic fungicide applications are implemented (Table 4). For moderately resistant kabuli chickpea, two fungicide applications are desirable in WA. The first spray at four weeks after emergence is required to prevent the development of AB from seed or airborne spores. A second spray should then be applied after flowering to protect seed yield and quality if AB is evident in the crop. Further sprays will be required if the crop is sown in a high risk situation.

Table 4. Yield (t/ha) of kabuli chickpea varieties in response to six fungicide (Bravo; 720 g/L chlorothalonil) application regimes for experiments conducted in the northern and central high rainfall zones of WA in 2004 and 2005

Treatment	**Northern high rainfall**		**Central high rainfall**	
	Dongara 2004	**Dongara 2005**	**Beverley 2004**	**Northam 2005**
Variety				
NaficeA (FLIP97-503-CLIMAS)	2.56	2.54	-	0.60
AlmazA (FLIP97-530-CLIMAS)	2.57	2.64	0.71	0.74
FLIP97-537D-CLIMAS	-	-	1.06	-
lsd 5%	ns (0.05)	ns (0.38)	0.68	ns (0.34)
Fungicide programs				
Potential yield (all sprays)	2.63	2.69	0.95	0.62
2 sprays (1 & 2)	2.52	2.55	0.88	0.63
2 sprays (1 & 3)	2.57	2.58	0.96	0.67
2 sprays (1 & 4)	2.57	2.63	0.82	0.69
1 Spray (Spray 1 only)	-	2.60	-	0.74
0 Sprays (Nil)	-	2.49	-	0.65

lsd 5%	ns (0.23)	0.12	ns (0.27)	ns (0.16)

Adoption

Seed production on a commercial scale was undertaken in WA, Vic and Queensland in 2004 and 2005. Chickpea growers involved with the production of the new varieties have had positive experiences and produced yields up to 2 t/ha with excellent seed quality (Table 5). The new varieties AlmazA and NaficeA are rapidly being adopted by chickpea growers with all available seed purchased for the 2006 season. An improved chickpea production package is also available to growers (Regan *et al.* 2006).

Table 5. Details of commercial bulk-up crops of AlmazA in 2005

Location	Soil type	Rainfall (annual)	Yield (t/ha)	Seed quality
Dongara WA	Neutral (pH 7.0) self mulching clay	< 400 mm	2.0	67% > 8 mm
Wimmera Vic	Alkaline (pH 8.2) grey clay	< 400 mm	2.1	50% > 9 mm 40%> 8 mm

Conclusions

The international collaboration with ICARDA and AARI enabled us to respond quickly to the increasing AB pressure in Australia by screening a large number of chickpea lines prior to import. Selection of lines and seed production carried out concurrently with development of agronomic and disease management practices allowed the release in 2005, of the first improved AB resistant kabuli chickpea varieties with large, high quality seed. Release of these varieties to growers was achieved in less than eight years after introduction into Australia and will give a major boost to the Australian chickpea industry.

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