Disease resistant mungbean varieties will increase the productivity and reliability of rainfed and irrigated sub-tropical farming systems

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Abstract
Mungbeans are the main broadleaf rotation for rainfed farming systems in Eastern Australia and a valuable export crop worth $100M each year. Since 2003 the DAF and GRDC co-investment 'National Mungbean Improvement Program' (NMIP) has focused on improving the yield potential and grain quality of established varieties while incorporating architectural traits and disease resistance from key germplasm donors. Eight years of foliar disease testing, agronomic and grain yield evaluation from the Central Highlands to the Liverpool Plains identified Opal-AU which was released in 2020 with improved protection from the seed-borne bacterial disease halo blight and from the fungal disease powdery mildew. Opal-AU and the varieties that follow will increase the productivity, reliability and wider expansion of mungbean.

Keywords
Mungbean, tropical pulses, broadleaf, disease, halo blight, tan spot, powdery mildew, fusarium, GRDC

Introduction
With a value of $1,000 per tonne, mungbean is one of the most valuable crops for Australia's sub-tropical and tropical farming systems. From its origins as an opportunity crop introduced from the United States in the 1960s, the Australian industry has since been transformed from 'mongrel beans' to 'money beans' through coordinated public sector investment in breeding, agronomy, entomology and pathology. Locally adapted varieties and best management practice have given graingrowers the tools and skills to produce this almost-horticultural crop both profitably and repeatedly. Besides a lucrative bottom line, mungbean is also highly valued for its systems benefits. As a short duration crop of 65 to 100 days it is water efficient and depending on location can be sown through a wide window that encompasses spring, summer and even autumn. Mungbean is nitrogen neutral and provides disease and weed control breaks for winter and summer cereals.

Though mungbeans are a significantly more attractive proposition than they were prior to the early 2000's, the crop still has untapped potential in terms of productivity and reliability. Grain yield (industry average 1.25 t/ha) is heavily influenced by a short crop duration as well as by biotic and abiotic factors. A survey of mungbean crops across the 2017/18 season documented yields from 0.4 to 2.6 tonnes per hectare (Collins & Bell 2019) and highlighted that almost half of the crops which had yield gaps of > 500 kg/ha were associated with the presence of *Pratylenchus thornei* nematode populations, or very high temperatures at flowering, or low soil N levels.

Australian industry growth and confidence in mungbeans as well as our global reputation for premium grain quality is built on Crystal and Jade-AU. These varieties accounted for over 90% of production in the ten years up to 2020. However, they have such narrow pedigrees that the industry could be considered a monoculture and at heightened risk from disease. Both are 'moderately susceptible' to the seedborne bacterial diseases halo blight and tan spot as well as to the fungal disease powdery mildew. Reports of Fusarium wilt, caused by *Fusarium oxysporum* and *F. solani* have become more prevalent in recent years with many Darling Downs crops severely affected in the autumn of 2020 and 2021. Both Crystal and Jade-AU have tested as 'very susceptible' to Fusarium.

Since 2003 NMIP has widened the genetic base of mungbean, introducing resistance to foliar disease along with new plant architectures and phenologies while maintaining large green shiny seed for Australia's key export markets. New pedigrees and traits such as those in Opal-AU will fortify the current industry and support further growth for the crop in northern production environments, in irrigated cotton and sugar systems and in supplying niche plant protein markets.

Methods

Breeding trials (47 field experiments, in 27 environments corresponding to year x site x management combinations) were conducted between 2013 and 2020 on DAF's Hermitage Research Facility (Warwick, Qld 4370), the Emerald Agricultural College (Qld 4720) and on farmer-collaborator properties in the Callide-Dawson, Western Downs, northern NSW and Liverpool Plains districts. Trials were sown on row spacings of 50 cm and 100 cm in central Queensland and 76 cm at all other sites. Disease nurseries were conducted at DAF's Research Facilities at Hermitage and at Redlands (Qld 4163) and at 'Tosari' (Qld 4352). Halo blight (*Pseudomonas savastanoi* pv. *phaseolicola*, 6 experiments in 4 environments) and tan spot (*Curtobacterium flaccumfaciens* pv. *flaccumfaciens*, 5 experiments in 3 environments) bacterial disease screening were artificially inoculated while those for powdery mildew (*Podosphaera xanthii* and *Erysiphe vignae* sp., 11 experiments in 5 environments) relied on natural infection. All trials were water injected with rhizobium strain CB1015 and had granular starter fertiliser applied at sowing.

Results

Regional yield evaluation over eight years identified Opal-AU as having outstanding performance in Queensland's Eastern Downs and in New South Wales (Douglas 2021). Its superior package of grain yield as well as protection from the foliar diseases is presented in Table 1 and Figure 1 respectively. Opal-AU is more resistant to halo blight and powdery mildew but more susceptible to tan spot than Crystal and Jade-AU. Opal-AU performed less well in the hotter, drier environments of the Western Downs and Central Queensland. The yield performance of Opal-AU was better in 2013-16 than in the most recent four years of testing when the climate was extremely dry and there were very limited summer planting opportunities in New South Wales, though Table 1 shows data for the entire eight years of regional yield testing.

Variety	Eastern Downs and NSW (10)	Callide-Dawson (4)	Western Downs (7)	Central Highlands (6)
Jade-AU (t/ha)	1.278	1.198	1.673	1.322
Opal-AU	112%	101%	93%	88%
Crystal	93%	96%	91%	92%
Satin II	94%	91%	89%	93%
Celera II-AU*	89%	52%	57%	43%

Table 1 Long term yield performance of mungbean varieties in north-eastern Australia
Source: National Mungbean Improvement Program trials conducted 2013-2020. Jade-AU is expressed in tonnes per hectare and other varieties as a percentage of Jade-AU. Columns represent key production environments, figures in brackets are the number of environments completed in each region. * Breeding trials contain predominantly lines with medium maturity and are managed for a Crystal and Jade-AU type. Consequently the grain yields recovered from early maturing variety Celera II-AU are compromised in Western Downs and Central Queensland trials

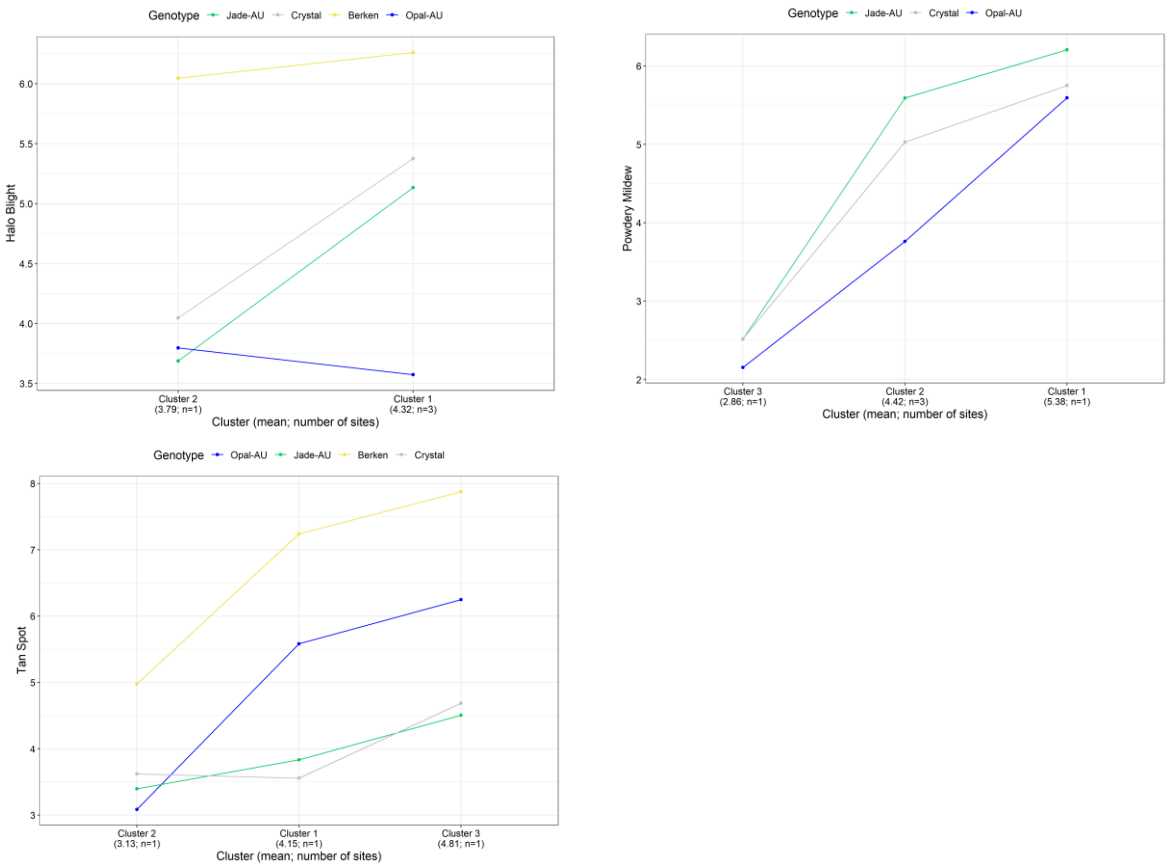

Figure 1. Reactions of key mungbean varieties to foliar disease. Clockwise from top left are results of field disease screening for halo blight, powdery mildew and tan spot. Vertical axis is disease score (1-9 where 1 = no symptoms and 9 = dead plants). Multi-environment trial analysis groups individual disease environments into clusters based on rankings of genotype performance.

Conclusion

Broadly adapted varieties Crystal and Jade-AU have been the mainstay of the Australian industry for the last decade or more and have played a major part in quadrupling mungbean production. These varieties have been under increasing pressure from seedborne bacterial diseases and are known to be very susceptible to the emergent disease Fusarium wilt. There is no likelihood of in-crop control for such diseases and genetic resistance will be the cornerstone of integrated disease management. Opal-AU will provide renewed confidence for mungbean growers in more southern regions where halo blight and powdery mildew are the main foliar diseases while alternate pedigrees with resistance to tan spot and adaptation to hotter drier environments are in advanced stages of regional testing. Future expansion and resilience of the mungbean relies upon new varieties like Opal-AU that have improved overall fitness through specific packages of regional adaptation, improvements in physiology and protection from biotic and abiotic stresses.

References

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