FINAL REPORT

GRDC
Grains Research & Development Corporation

Reducing the impact of pulse diseases in the northern region (incorporating DAQ00073)

DAQ00108

Project Details

- **Project Code:** DAQ00108
- **Project Title:** Reducing the impact of pulse diseases in the northern region (incorporating DAQ00073)
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Summary

Diseases remain a significant impediment to the achievement of maximum yield potential of pulses (chickpea, peanut and mungbean) and sunflowers in the GRDC northern region. This project worked closely with public and private breeding programs to identify sources of resistance to the major diseases of pulses and sunflower that dominate in the region. Through varied surveillance activities, a watching brief on pulse and sunflower diseases was maintained and a timely and appropriate response was made to several significant disease outbreaks. Information on the biology and management of diseases was extended to clients in a wide variety of ways.

Conclusions

1. Integrated Disease Management (IDM) is the desirable approach for diseases of pulses and sunflowers in the northern region. Significant advances have been made in identifying mungbean germplasm with high levels of resistance to the pathogens that cause tan spot, powdery mildew and halo blight. For the latter, lines with putative immunity to the pathogen were identified. It is anticipated that within the next five years, new mungbean varieties with high levels of resistance to all three pathogens and desirable agronomic and seed quality traits will be available to Australian growers. For chickpeas, new varieties e.g. HatTrick[⌽], with high levels of resistance to the ascochyta blight and *Phytophthora* root rot pathogens are starting to be released to northern region producers. The recently-released peanut variety, Sutherland⌽, with very good resistance to several foliar pathogens, has set the benchmark for future varieties. However, for all three crops, an integrated disease management approach is desirable, as partial resistance is strongly affected by weather conditions. Fewer, but timely fungicide sprays are an important component of IDM for ascochyta blight of chickpea, foliar diseases of peanuts and powdery mildew of mungbeans. Variety-specific spray management strategies have been developed for the first two diseases by Industry and Investment New South Wales (I&I NSW) and Queensland Department of Employment, Economic Development and Innovation (DEEDI) respectively. An additional project (DA00154) aims to develop similar strategies for mungbean varieties. Where the use of genes which confer immunity to significant pathogens are currently used (e.g. rust of sunflower) or have the potential to be used (e.g. halo blight of mungbean), the existence of pathotypes which may defeat such genes threatens their long-term effectiveness. The sunflower rust work conducted over many years by DEEDI has shown there is considerable pathotypic variation in the Australian rust population. It has also demonstrated that ongoing monitoring of pathotypes for both sunflower rust pathogen and also the mungbean halo blight pathogen is essential.

2. An effective and timely response to significant outbreaks of exotic and endemic diseases of pulses and oilseeds in the northern region is reliant on (i) surveillance intelligence provided through surveys and information obtained from industry networks and samples for diagnosis, (ii) maintenance of close links with industry organisations e.g. Pulse Australia and biosecurity organisations, and (iii) well-trained and informed personnel. The first reported outbreak of ascochyta blight in central Queensland in 2008 provides an example of the interrelatedness of these three factors. The previous year, in collaboration with Pulse Australia, this project had provided many local agronomists with information on recognition of ascochyta blight at a certified chickpea agronomist course at Emerald, and a pre-season chickpea Update attended by over 70 people. Within a day of the confirmation of ascochyta blight in a specimen forwarded by a private agronomist, the project team worked closely with DEEDI and Pulse Australia personnel to inform the chickpea industry in central Queensland (CQ) of the outbreak, its potential consequences and options for current and future management. Meetings, brochures, press releases, personal discussions and radio interviews were used to extend the information. The effectiveness of the response relied on the interaction of all three factors mentioned above; the absence of any of these factors could have jeopardised the final outcome.

Recommendations

1. The emphasis on development of Integrated Disease Management (IDM) packages for pulses, sunflowers and other field crops needs to be maintained and broadened. The management of diseases of field crops should rely on a suite of management tools that synergize into a functional and robust IDM package which effectively minimises the impact of a particular disease on a crop. Management of ascochyta blight of chickpea in the northern region is an example of an integrated approach, where agronomic practices (rotations, proximity to previous chickpea paddocks, use of fungicide treated seed, etc), on- and off-farm biosecurity (cleaning of headers, machinery), and resistance is combined with variety-specific fungicide spray regimes. The project team is also developing such IDM packages for foliar diseases of peanuts and powdery mildew of mungbean. Despite this focus on IDM for individual pathogen-host combinations, there is a need to understand the impact of IDM packages on a whole farming system scale, in particular, on the interrelatedness between all of the plant pathogens in that system. For example, in a particular paddock or farming system, what effect does an IDM package for ascochyta blight of chickpea have on a plant pathogen of wheat (e.g. the crown rot pathogen)? There is scope for crop protection research and development (R&D) to be integrated into multidisciplinary teams including growers and advisers that focus on all aspects of the abiotic and biotic interactions in particular farming systems.

2. A national database which records the spatial and temporal distribution and dynamics of diseases of all field crops is desirable. Records of the incidence, severity and distribution of endemic plant pathogens are fragmented, not only between State departments of agriculture, but also within States. Such information is vital not only for quarantine requirements, but also for planning and prioritising current and future research, development

and extension (R,D&E) activities. Although there is a unified database of herbarium records of plant pathogenic and other fungi (Australian Plant Disease Database) in Australia, a national database of crop disease records would provide a different function. Information in that database (provided by plant health professionals) could be accessed by any interested party.

3. Support for the maintenance of plant pathology capacity needs to continue. In an environment where the emphasis on teaching of agriculture-related disciplines is declining in Universities and the activities of State Government departments of agriculture are under review, the capacity of plant pathologists and other specialists to not only conduct relevant R,D&E, but also to respond effectively to disease outbreaks, is under threat. There is an opportunity for research organisations such as GRDC to work with State departments of agriculture and tertiary institutions to provide opportunities for training of targeted undergraduate students across work environments, similar to the Grains Research Scholarships for postgraduate studies.

Outcomes

Economic

Economic benefits have accrued from the R,D&E pulse pathology activities resulting from this project to all sectors of the agricultural industry throughout the northern region through (i) improved reliability of production and quality of pulses and sunflowers by minimising the impact of diseases, and (ii) greater farm and agribusiness viability resulting from the use of integrated disease management packages with major focus on resistance, and the use of targeted fungicide applications. For example, this project clearly demonstrated that fewer sprays (0-4, depending on the season), are needed to effectively manage foliar diseases on the resistant peanut variety Sutherland, compared to other varieties (6-8 sprays). The Peanut Company of Australia has estimated that the deployment of varieties such as Sutherland results in a saving of $500/ha mainly due to reduced number of fungicide sprays. Although this variety comprises less than 3% of the total peanut production area (approx. 12,000 ha) in Australia, it is anticipated that in the near future, all peanut varieties will have equivalent resistance to foliar diseases. This will result in considerable economic benefit to Australian agriculture.

Environmental

The project's focus on identifying sources of resistance to major diseases of mungbean, peanut and chickpea, and promoting reduced and targeted fungicide usage in these pulses has resulted in (i) improved environmental health from a reduction in fungicide use, (ii) sustainability of farming systems through better management of rotations and other agronomic practices, (iii) safeguarding native flora through surveillance for exotic pathogens. An example of the environmental benefits which this project has contributed to is that growers of the peanut cv. Sutherland[Φ] have reduced their fungicide usage by 3-4 sprays equating to 1,500-2,000 litres less fungicide applied, particularly along the environmentally-sensitive southern and central Queensland coastal farming systems. In the future, as more of the total Australian peanut area is devoted to foliar disease resistant varieties, the quantity of fungicides entering the environment will reduce considerably.

Social

Through a focus on reducing the impacts of pulse diseases in the northern region, this project has facilitated (i) support of rural communities and businesses through improved and more sustainable production of pulses and other crops, (ii) more robust farm enterprises, leading to reduced stress on the agricultural community, and (iii) a better trained and more knowledgeable workforce. Participation in certified mungbean and chickpea agronomists courses in 2007 and 2009 resulted in the 191 participants (approx. 175 public and private agronomists) improving their knowledge of the biology and management of major diseases of these pulses. In turn, an estimated 2,000 clients of these agronomists will benefit from the training activities.

Achievement/Benefit

BACKGROUND

Pulses and sunflowers remain a very important component of the varied farming systems in the GRDC northern region, and are conservatively estimated to be worth $170 million per annum at the farm gate and $500 million per annum after value-adding. In addition, pulses provide an important disease break in cereal and sugarcane farming systems by reducing soilborne disease levels and improving soil health through their impact on nitrogen levels. A variety of diseases impact on the production of pulses (mungbean, peanut and chickpea) and sunflowers in the northern region. During this project the focus was on (i) developing and delivering management strategies to combat the pathogens responsible for these diseases, and (ii) maintaining a watching brief on, and responding to, outbreaks of endemic diseases.

ACHIEVEMENTS

1. Identification of resistant germplasm

During this and previous projects the research team worked closely with the National Mungbean, Peanut and Chickpea Improvement Program people to identify sources of resistance to the important pathogens.

Mungbean. Reliable glasshouse and/or field screening techniques were developed for the halo blight (the bacterium *Pseudomonas savastanoi* pv. *phaseolicola*: *P.s.p.*), tan spot (the bacterium *Curtobacterium flaccumfaciens* pv. *flaccumfaciens*; *C.f.f.*), powdery mildew (the fungus *Podosphaera fusca*) and charcoal rot (the fungus *Macrophomina phaseolina*) pathogens, which has enabled the identification of resistant germplasm and the development of commercial varieties with improved resistance. Information from 13 field trials and complimentary glasshouse trials resulted in the identification of small- and large-seeded lines with immunity or high levels of resistance to halo blight, and with high levels of resistance to the halo blight and powdery mildew pathogens. The two recently-released varieties Crystal⌽ and Satin II⌽ have levels of resistance to *P.s.p.*, *C.f.f.* and *P. fusca* equal to, or better than other commercial varieties. It is anticipated that future varieties will have high resistance to all three pathogens.

The existence of different pathotypes of *P.s.p*. in Australia could pose a serious threat to the putative immunity identified in some mungbean lines. Nine *P.s.p.* pathotypes have been identified on *Phaseolus* species overseas. The project imported the differential set of *Phaseolus* lines into Australia through quarantine, developed a rapid screening test, and fortunately to date, identified only one pathotype (Pathotype 7) in the Australian population.

Peanut. The peanut cv. Sutherland⌽ is the first Australian variety with very high levels of resistance to the rust (the fungus *Puccinia arachidis*) and late leaf spot (the fungus *Mycosphaerella berkeleyi*) pathogens. Glasshouse experiments with *P. arachidis* have demonstrated that the resistance mechanisms include a longer (latent) period between inoculation and pustule appearance, and the development of small pustules, which together result in a slower rate of disease development compared to susceptible varieties. Project staff assessed breeding lines for resistance to the rust, late leaf spot, and CBR (the fungus *Cylindrocladium parasiticum*) pathogens in 14 field and/or glasshouse trials at Bundaberg, Kingaroy and Kairi (NQ) over the three years of the project. The advanced breeding lines D147-p8-6f and D193-p3-6 (ultra-early maturity) have improved yield over Sutherland combined with good foliar disease resistance. They are being considered for release in the next few years.

Chickpea. *Phytophthora medicaginis* (the cause of phytophthora root rot) is a widespread pathogen of lucerne, medics and chickpea in the northern region, and although the relative resistances of chickpea varieties and advanced breeding lines are known, the yield losses associated with the disease have not been quantified. Trials were conducted at Hermitage Research Station to assess the yield losses of Yorker⌽ (MR), Jimbour⌽ (MR-MS) and the advanced breeding line CICA512 (soon to be released as HatTrick) in the presence of *P. medicaginis*. The trials were inoculated with a mixture of isolates; some plots were drenched with metalaxyl[#] to inhibit infection and invasion of seedlings and plants by the pathogen and others not treated. HatTrick⌽ can be considered to have moderate resistance to *P. medicaginis*, with yield losses intermediate between those of Yorker and Jimbour. This information provides a precise measure of phytophthora resistance for Variety Management Packages (VMP) of new chickpea varieties in the northern region.

2. Fungicide strategies for peanut varieties.

All current commercial peanut varieties, apart from the newly-released cv. Sutherland are highly susceptible to rust and late leaf spot, necessitating up to eight fungicide sprays per season for effective management. Trials were conducted over three seasons at Bundaberg (southern coastal Queensland) and Kairi (Atherton Tableland) to develop a variety-specific disease fungicide management strategy. Various combinations of fungicide rates x timing were compared for their influence on disease development, and on yield. Major findings were (i) rust and late leaf spot developed at a much slower rate on cv. Sutherland than on susceptible varieties, (ii) only 0-4 sprays were needed to manage foliar diseases on Sutherland compared to susceptible varieties e.g. Menzies⌽, depending on the seasonal weather conditions, (iii) the first fungicide spray on Sutherland must be applied at the first sign of the disease on a susceptible variety, and (iv) additional sprays need to be applied at 14- or 21-day intervals. Industry experience with Sutherland has paralleled our results, with growers finding that in, general, only three or four sprays are needed to effectively manage foliar diseases. VMP for Sutherland is being prepared that will incorporate information on resistance, agronomic practices and fungicide application strategies, for delivery to the industry.

Refer to 'Report Disclaimer' page 1

Colleagues at Katherine, Northern Territory, conducted trials over three years to compare the efficacy of two fungicides [tebuconazole# (Folicur®#), and azoxystrobin + cyproconazole# (Amistar® Xtra#)] to manage late leaf spot on the susceptible cv. Holt$^{\Phi}$ at 21-day intervals or at times predicted by the Virginia Advisory Model. This model uses accumulated hours of 'time value of infection' (TDVi) (based on RH $\geq$ 95% and temperature 16-32°C) to calculate the total number of hours conducive to infection; fungicide application is only necessary when the threshold of 48TDVi is reached. In all trials, for the same fungicide, the 21-day interval had a lower leaf spot rating and a higher yield than the corresponding treatment which used the model to predict the spray time. Folicur was superior to Amistar®Xtra in both parameters.

3. Biology of halo blight and CaCV.

Nothing is known of the biology of the halo blight pathogen on mungbean, but our studies have revealed that the bacterium (i) survives for only 4-5 months on infected residues, (ii) is not systemic in infected plants, unlike some overseas reports of systemic movement in the vascular tissue of *Phaseolus vulgaris* (green bean) plants, and (iii) internal seed infection results from infection of developing green pods by waterborne bacterial cells, while external seed infection can result from pod infection, as above, or contamination from infected plant residues during harvesting. Consequently, rotations are likely to be effective in eliminating the carryover of infected residue from one season to the next. The inspection of crops intended for planting seed for signs of halo blight (and tan spot) infection has aided in the reduction of seed transmission.

Weeds, particularly *Ageratum* spp., have been found to be important and widespread alternative hosts of Capsicum chlorosis virus (CaCV) in the Bundaberg region, where they are transmitted by the common insects *Thrips palmii* and *Frankliniella schultzi*. Management of weeds in and near peanut paddocks, and/or avoiding paddocks with *Ageratum* species is the only practical method of reducing the impact of CaCV in peanut crops in coastal farming systems.

4. Sunflower rust.

Rust, caused by the fungus *Puccinia helianthi*, is regarded as the most important disease of sunflower in Australia. It has the potential to be a major constraint to production under favourable conditions. In response to the deployment of single resistance genes in commercial hybrids, a complex structure of pathotypes evolved in the Australian rust population. The final report of DAQ0073 "Implementing technologies and strategies to maintain resistance to sunflower rust" provides detailed information on the identification of new sources of resistance, the development of lines with durable and pyramided resistance genes aided by the use of gene markers, and the linkage relationships for many rust resistance genes. Monitoring the pathotypes of *P. helianthi* is the cornerstone of management of sunflower rust, and remains an important, ongoing activity. The focus of surveys and collections has been on volunteer and wild sunflower populations throughout Australia that are reservoirs and generators of a diversity of pathotypes. Over the past 30 years, more than 3,500 isolates of *P. helianthi* have been collected, purified, pathotyped and stored, with more than 115 pathotypes identified. Since July1 2008, when this activity was incorporated into project DAQ00108, two new pathotypes were identified from the approximately 140 isolates collected throughout Australia.

5. Remote sensing.

Remote sensing studies using satellite (Quickbird) and plane borne multispectral imagery on rust, late leaf spot and fusarium root rot of peanut, and ascochyta blight of chickpea have been conducted. The results indicate that infrared imagery is capable of differentiating between varying levels of peanut rust, and detecting the location and distribution of plants infected by both foliar and root pathogens. The detection of less than 1m diameter patches of ascochyta blight#infected plants in a central Queensland paddock indicates the sensitivity of the satellite imagery, and its ability to identify the very early stages of infection. Remote sensing has the potential to be an extremely valuable aid in surveillance, and in quantifying the incidence and distribution of plant pathogens over time and space.

6. Surveillance and response.

Through surveys, grower/adviser networks and specimens submitted for diagnosis, project staff monitored the incidence, severity and distribution of endemic diseases, and maintained a vigilance for exotic pulse and oilseed diseases. No exotic diseases of these major crop types were detected in the GRDC northern region during the project, and major endemic diseases varied in their significant from year to year and region to region. There was a timely and appropriate response to three significant outbreaks of pulse and oilseed diseases. In 2008, ascochyta blight was detected in chickpea crops for the first time in central Queensland. The project team worked closely with Pulse Australia, local agronomists, growers and DEEDI staff to determine its distribution, and to provide up-to-date information on the situation and management of the disease through press releases, brochures and meetings. Significant outbreaks of powdery mildew developed on sunflowers across the region in 2008, prompting an extension campaign through brochures, presentations at grower field days and meetings and GRDC Update (Dalby 2008). The team also responded to outbreaks of *Phoma/Phomopsis* stem canker of sunflowers in northern NSW and southern Queensland by facilitating identification of the pathogens, and providing information to biosecurity organisations, agronomists and growers in both states.

7. Extension.

Project staff conducted a wide range of extension activities to deliver timely information on project results, which were incorporated into information on the biology and management of pulse and sunflower diseases in the northern region. They worked closely with I&I NSW, Pulse Australia, the Australian Mungbean Association, the Australian Oilseeds Federation and Peanut Company of Australia to deliver consistent, reliable, and targeted information to clients. We also revised and delivered the disease modules of certified agronomists courses for chickpeas (seven courses) and mungbeans (three courses), updating the skills of approx. 190 attendees. During the course of the project one scientific paper, three conference papers, 13 miscellaneous publications (e.g. in *Groundcover*, *Northern Pulse Bulletin*), and five press releases were produced. This resulted in 17 popular press articles. Information was also presented at 44 grower meetings and field days and two conferences, with three interviews given.

Other Research

1. There is an opportunity for the development of multidisciplinary farming systems teams, in which all aspects of the farming system are addressed. Current R&D activities in plant pathology tend to focus on the development of IDM packages for particular pathogen-host combinations, with little regard for the impact of these IDM packages on other pathogens in the system. Also, plant pathologists have traditionally not worked in whole-of-farming systems projects, which tend to be focussed on agronomic activities.
2. This project has demonstrated that remote sensing technology can play an important role in the detection of both foliar and soilborne diseases, and in studying the distribution and dynamics of exotic and endemic plant diseases. The relevance of remote sensing technology to biosecurity activities is clear, but there is also capacity for remote sensing to be used in other R&D activities e.g. disease severity assessments in field trials. Currently, the relatively high cost of satellite imagery may be inhibitive to such a use, but an increasing interest in the use of remote-controlled small planes could provide an opportunity to foster these activities.

Intellectual Property Summary

Breeding lines of peanut and mungbean have been identified as having resistance to major plant pathogens. Commercialisation of this IP will be captured when the relevant breeding programs release new varieties.

Collaboration Details

The sunflower rust group has an established relationship with Dr Tom Gulya, sunflower plant pathologist with the United States Department of Agriculture at Fargo, North Dakota, with whom they exchange information and data on pathotypes of the sunflower rust pathogen (*Puccinia helianthi*) in the United States and Australia. Details on the protocols for classifying rust isolates into pathotypes have also been exchanged. During the recent outbreaks of powdery mildew and stem canker in the northern region, a two-way interchange of relevant information on the biology and management of the diseases was conducted.

Additional Information

Publications

Keller, L.A., Ryley, M.J., Trevorrow, P.E., Tatnell, J.R., and Nastasi, C. (2009). Reduced fungicide use in the new peanut cultivar Sutherland, highly resistant to the leaf spot and rust pathogens. Australasian Plant Pathology; in preparation.

Fuhlbohm, M.J., Tatnell J.R., and Ryley, M.J. (2007). *Neocosmospora vasinfecta* is pathogenic on peanut in Queensland Australasian Plant Disease Notes 2: 3-4.

Further information is provided in the attachment.

- Attachment DAQ00108: Reducing the impact of pulse diseases in the northern region