Summary
Major outcomes of this project have been the release of three high oleic varieties (Walter\textsuperscript{1}, Ashton\textsuperscript{1}, Sutherland\textsuperscript{1}) with improved yield, drought and aflatoxin tolerance, and foliar disease resistance. Two other lines (D136-97-5 and D147-p3-115) show considerable promise for release next year. The web-based decision support package (AfloMan) has integrated aflatoxin risk factors into concrete recommendations. A peanut drying model was developed and has shown there are large potential cost savings from use of more efficient drying strategies. Management of cadmium (Cd) contamination in peanuts may not be as simple as originally thought, with observed spatial variability indicating management will need to become more site-specific.

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Conclusions

Variety improvement:

a. The project was highly successful in releasing three elite varieties filling four target niches: Walter$^{(0)}$ (D116-p35-2) - the first ultra-early high oleic variety released in the world; Ashton$^{(0)}$ (D57-1-p2-10) - a full-season Virginia variety adapted to dryland conditions with a more erect bush than Middleton$^{(0)}$; Sutherland$^{(0)}$ (D147-p3-6) - a variety that has exceptional resistance to leaf spots and rust, is high oleic, has good yield potential and is adapted to North Queensland (N QLD) and coastal production systems.

b. Variety x management packages have been developed for these new varieties, including guidelines on optimal time of sowing and plant population required to maximise yield and quality.

c. There are two potential new releases in the pipeline: D136-p7-5 - a red seeded, high oleic, ultra-early type for niche marketing into Japan; and D147-p3-115 - a sister line of Sutherland with exceptional foliar disease resistance (FDR), higher yield and better cylindrocladium black rot (CBR) resistance.

d. Screening trials for genetic tolerance to low Cd uptake showed that while there was significant genetic variation in Cd uptake among varieties, there was also large genotype x environment interaction present, especially among the commercially grown varieties, suggesting that a varietal solution to minimise Cd uptake is not yet present.

Aflatoxin minimisation:

a. The AfloMan program has been well accepted since its creation. AfloMan training workshops were held for Burnett growers during the project. Regular aflatoxin updates were published weekly during the January-April period in the South Burnett Times newspaper over the past three years.

b. While the AfloMan program clearly assisted growers in reducing aflatoxin risk in 2002, the impact of the aflatoxin minimisation program over the severe droughts of 2004-2007 seems not to be as great. In these severe drought years, it showed that virtually no management or variety options were available to growers to reliably reduce on-farm aflatoxin levels.

c. Long-term modelling analyses have shown a worrying trend for dryland peanut growers, where there has been an increasing frequency of high aflatoxin risk years since the late 1970s, thus providing evidence for climate change in this region. For example, while there were only 19% of years with significant aflatoxin risk from 1890-1975, over 60% of years from 1975-2007 showed risk to the disease.

d. Detailed field and growth chamber studies were conducted to study the effect of temperature and water stress on the developmental cycle of the etiella moth. A prediction model was developed using the field and controlled environment data, which will be very useful to predict expected population peaks and warn growers that damage is likely.

e. A grain drying model developed by researchers from the University of New South Wales (UNSW) was adapted for peanuts, and has shown there are potential large dollar savings from use of more efficient drying strategies, including reduced airflows and product mixing.

Cadmium minimisation:

a. Field trials evaluating Cd minimisation practices (zinc foliar application, and application of lime and gypsum) have shown
inconsistent responses with large site-specific effects for Cd contamination observed. There was significant spatial variability for soil and kernel Cd within a paddock, with the proportion of exchangeable Cd increasing exponentially when the soil pH was less than six. Pot trials showed that Cd is absorbed by roots and remobilised to pods from leaves, suggesting that management practices should focus on reducing the exchangeable Cd in the root zone (liming) or restricting the root surface area for Cd.

Recommendations

Variety Improvement:

a. The three new elite varieties will fill different niches across Australia. Walter$^{D116-p35-2}$ will be suitable for dryland production to avoid drought and aflatoxin in severe drought prone years; Ashton$^{D57-1-p2-10}$ is a higher yielding replacement for the normal oleic Streeton, and shows better drought tolerance; and Sutherland$^{D147-p3-6}$ is a highly foliar disease resistant full season type which will have good potential in coastal and northern QLD production systems.

b. A number of variety x management packages have been developed for these new varieties, and will be communicated to growers and industry via information packages and field days in 2007 and 2008.

c. Screening for genetic tolerance to low Cd uptake indicates there is a very large genotype x environment interaction present, suggesting that a varietal solution to minimising Cd uptake is not yet present. Although there is some germplasm with low Cd accumulation, this breeding objective is probably of lower priority compared to other traits currently being targeted in the breeding program.

Aflatoxin minimisation:

a. The AfloMan aflatoxin minimisation program can assist growers in reducing aflatoxin risk in medium drought years, while in more severe drought years (e.g. in 2004-07) the impact of the aflatoxin minimisation program will not be as great.

b. The etiella moth ecology and modelling work has provided a sound basis for predicting potential peaks in etiella infestations. The challenge ahead is to develop and test economically viable control programs using attractant spray technologies. This is being conducted within the new GRDC pulse Integrated Pest Management (IPM) project.

c. The new peanut drying model developed by UNSW researchers and the associated scenario runs for new dryer designs and operation, need to be validated over larger commercial volumes of peanuts before recommending any changes to drying practices at the commercial level.

Cadmium minimisation:

a. The research done in this project has revealed management of Cd contamination in peanuts may not be as simple as originally thought. The observation of significant spatial variability in soil and kernel Cd will mean that future management practices will need to be more site-specific. More basic research and development (R&D) is required to understand the underlying mechanisms of Cd uptake and the causes of spatial variability. These studies are proposed to be conducted in the new Peanut Agronomy project.

Outcomes

Expected outcome: “The release of adapted and marketable varieties will give growers more varietal options to minimise drought and aflatoxin risk, better disease resistance, and better prices for high oleic, contaminant-free large kernels. The extension of ’integrated’ aflatoxin and Cd reduction strategies will lead to the production of high quality, safe and more profitable dryland and irrigated farming systems”.

Economic outcomes:

Release of three elite varieties will have a major impact on the profitability of the industry. The ultra-early variety Walter$^{D}$ will have major benefits in dryland production systems by allowing crops to escape drought and aflatoxin risk. In areas with limited irrigation, it will provide growers with new rotational options in cane and other cropping systems. Sutherland$^{D}$ has exceptional resistance to leaf spots and rust, so is expected to be widely adopted by growers in high input systems. This variety will lead to cost savings of $400-$500/ha.

The aflatoxin minimisation component has had a major impact on the profitability of the industry. Results show that during the moderate to high aflatoxin risk years (e.g. 2001-2002), peanut loads delivered from growers who adopted the program had 30% less aflatoxin positive loads, compared to the overall (dryland) industry average. Estimated direct economic benefits
were of the order of $0.5–$1.2 million p.a. In extreme drought years, as occurred in the Burnett over the past three years, the impact of the program has not been as great. In these drought years, it seems there are virtually no management or variety options available to growers to reliably reduce on-farm aflatoxin levels. A grain drying model was adapted for peanuts, and has shown there are potential large cost savings from use of more efficient drying strategies.

Environmental Outcomes:

The use of ‘Sutherland’ will significantly reduce the use of fungicides for foliar disease control in coastal and northern QLD farming systems. A reduction of more than 50% is expected once the variety becomes more widely adopted, thus benefiting the environment. The adoption of Walter in irrigation areas with limited water availability will lead to significant improvements in water use efficiency.

Social Outcomes:

All sections of the community, including growers, processors and consumers in Australia, should benefit from the research outcomes of this project. The research, development and evaluation (RD&E) program has ensured that peanut growers in dryland production regions of QLD will remain viable by adopting the new varieties, and aflatoxin and Cd minimisation technologies. Processors will benefit from the project by a lower intake of aflatoxin and Cd positive product. Lower processing costs should also be reflected in higher prices for grower stock. The general community as peanut consumers also benefit by having safer peanut products. Lower aflatoxin and Cd levels in Australian peanuts will mean the industry can promote the ‘clean and green’ label for expanding export markets.

Achievements/Benefits

Output 1: Release of adapted and marketable varieties

The breeding component of this project aimed to evaluate and release peanut varieties specifically suited to the dryland production areas located in the Burnett and northern QLD regions. A range of high oleic varieties with varying maturities (105–150 days) and kernel sizes will provide dryland growers with options to minimise drought and aflatoxin risk. With the peanut industry aiming to expand production in coastal regions of QLD under full irrigation, along with traditional production in the Atherton Tableland region of northern QLD, there is also an urgent need to access, develop, evaluate and release suitable peanut varieties for these emerging regions. Key traits for new varieties in these production areas include high oleic, leaf spot and leaf rust resistant, high blanching and market acceptable peanuts.

Key expected outputs from this project component included:

Release of 4-5 high oleic varieties for the dryland and coastal industry including:-

- 1-2 ultra-early varieties maturing in 15 weeks (105-110 days)
- One early maturing (130 days) high oleic replacement for VB-97
- One full season (150 days) high oleic large seeded variety
- One full season type with high foliar disease resistance.

Variety releases

The project was highly successful in releasing three elite varieties filling four target niches:

Walter\(^{(l)}\) (D116-p35-2): the first ultra-early high oleic variety released in the world. The short growing season allows more planting options and hence risk-spreading, particularly in years of severe drought and limited irrigation.

Ashton\(^{(l)}\) (D57-1-p2-10): is a full-season Virginia variety adapted to dryland conditions with a more erect bush than Middleton\(^{(l)}\). It can outperform VB 97 in both yield and shelling percentage when harvested early (around 130 days). Ashton therefore meets two targets and improves grower flexibility.

Sutherland\(^{(l)}\) (D147-p3-6): has exceptional resistance to leaf spots and rust, is high oleic and has a good yield potential. It is adapted to northern QLD and coastal production systems.

Variety x management packages:
A number of experiments were conducted during the 2006–07 season to determine optimal agronomic packages for two of the new releases (Walter and Sutherland).

Sutherland: We are confident to recommend a planting time anywhere from late September to early December, as for other full season varieties. Other observations with Sutherland have indicated that this variety needs to be left in the ground until full maturity (e.g. 85-90% black shells) as earlier harvest (e.g. at 70% black) has clearly led to lower yields and significantly lower grade out. Preliminary trials also showed that a population of around 100,000 plants/ha will be required to optimise kernel yields for this variety.

Walter: Our trials showed Walter is highly responsive to plant population, and that this response is highly dependent on soil water availability. For instance, under severe drought conditions, there was no response to plant population or row spacing above 100,000 plants/ha, while under higher water availability (and hence yield potential) an increasing yield response to a population of 150,000–175,000 plants/ha was evident at the Kingaroy and Bundaberg sites. The exciting result from the Bundaberg trials was the very high pod yield potentials achieved from Walter under high input conditions. Results show that pod yields in excess of 5.5t/ha are achievable in around 110 days, a truly remarkable result, and showing the potential for the ultra-early types in irrigated production systems.

Potential releases in the pipeline

There are two potential lines developed in the project that may have the potential to progress to release in the new breeding project.

D136 p7-5: This is an ultra-early line with high oleic small red-seeded kernels. The industry has identified a substantial worldwide market for small red-seeded peanut kernels. A draft release proposal for this line has been prepared.

D147-p3-155: This line is a sister line to Sutherland (D147-p3-6) and has performed extremely well in the 2006–07 trials in northern QLD and southern QLD. Results from 2006–07 trials demonstrated it has better overall yield potential than Sutherland (8–28% higher in three of the yield trials), while maintaining as good FDR as Sutherland. It also possesses significantly better CBR tolerance.

Genetic variation for cadmium tolerance

A sub-set of commercial varieties as well as a number of germplasm lines were evaluated in separate Cd genetic tolerance trials in 2004–05 and 2005–06 at high Cd sites in the Bundaberg region. Results from these trials showed that while there was significant genetic variation in Cd uptake among varieties, there was also large genotype x environment interaction present, especially among the commercially grown varieties. This result strongly suggests that a varietal solution to minimise Cd uptake is not available at present. There was however a couple of germplasm lines (B57-p5-1 and RMP 91) which did show consistently low Cd levels across environments. It may be possible to cross these lines with commercially adapted lines and conduct future screening and selection.

Output 2: Development of web-based information packages, and management practices to reduce on-farm aflatoxin contamination, including development of optimal post-harvest drying practices and etiella control packages

Aflatoxins are a group of toxins produced in peanut kernels by the fungus *Aspergillus flavus* under certain conditions of high temperature and lowered moisture availability. Aflatoxin contamination in peanut kernels continues to be a major food safety issue and costs the Australian peanut industry (shellers and growers) between $5 million–$10 million p.a. via analytical costs and associated sorting losses. This project component had three issues: 1.) continue and extend the in-season aflatoxin monitoring service to a wider cross section of peanut growers by using novel web-based communication systems (AfloMan); 2.) better understand and control etiella (an insect); and 3.) develop optimal post harvest drying techniques to minimise aflatoxin contamination prior to storage and delivery to the buying point.

1.) AfloMan: This system uses a novel distributed computing approach to produce password-protected graphical output in near real time, utilising crop management details, local rainfall, and ambient and soil temperatures entered by a user. The AfloMan website has had 3,700 hits since its implementation indicating a good level of acceptance, and has functioned well since its creation. AfloMan training workshops were held for North Burnett and South Burnett growers in conjunction with internet training courses run by the Peanut Company of Australia (PCA) during February 2005.

A regular AfloMan article was published weekly during the January–April period in the South Burnett Times newspaper over
the three years of this project to provide aflatoxin risk updates in the model farms for the three main production regions in
the Burnett district.

Project Impact:
The seasonal conditions in the inland Burnett region during the three years (2004–07) of this project were characterised by
the worst three years of severe drought on the 100+ year climate record. These conditions resulted in very low yields and
many crop failures, and associated aflatoxin contamination was severe in many cases. Sheller aflatoxin intake statistics
(percentage of positive aflatoxin loads delivered to PCA) over the past 30 years were used to assess the impact of the AfloMan
program.

Key points are summarised below:
While the AfloMan program clearly assisted growers in reducing aflatoxin risk in 2002 (e.g. model farm loads were 35%
persistent versus 65% for all loads tested positive in this high risk year), in 2004–07 where the droughts were far more severe,
the impact of the aflatoxin minimisation program was not as great.

These severe seasons (where aflatoxin risk, as determined by AfloMan, is more than 75%) have demonstrated that there
seems to be virtually no management or variety options available to growers to reliably reduce aflatoxin levels.
The data, however suggest, that aflatoxin minimisation practices will be effective in seasons with less severe drought
scenarios (i.e. where aflatoxin risk, as determined by AfloMan, is less than 75%).

In order to put the past three seasons into perspective in terms of the frequency of severe droughts and likely associated
aflatoxin risk, the Agricultural Production Systems sIMulator (APSIM) Peanut/Aflatoxin model was run for the period 1890-
2007 for the Kingaroy region, with results clearly showing the following trends:
The past three years were the worst consecutive years for aflatoxin risk over the past 110+ year climate record.
The worrying trend for dryland peanut growers is that there has been an increasing frequency of high aflatoxin risk years
since the late 1970s, which indicates potential evidence for climate change in this region. For example, while there were only
19% of years with aflatoxin risk of more than 10% from 1890-1975, it was over 60% of years in the period 1975-2007.
This recent trend has been associated with lower in-season rainfall and increasing ambient temperatures, suggesting strong
evidence for climate change in the Burnett region. These modelling scenarios also present a worrying outlook for dryland
peanut producers in the Burnett region, where aflatoxin risk will likely be the ‘norm’ rather than the exception in future years.

2.) Etiella: Detailed ecological studies were conducted to better understand the population dynamics of the etiella moth.
Growth chamber studies were conducted to study the effect of temperature on the development cycle of etiella. A prediction
model was developed using the field and controlled environment data, which will be very useful to predict expected
population peaks and warn growers that damage is likely. This work is planned to continue in conjunction with Hugh Brier’s
new GRDC Pulse IPM project, where he is investigating the use of attractant sprays applied at regular intervals in the crop.

3.) Drying research and development:
As the peanut industry focussed on the quality of the product by offering price incentives for superior quality, there has been
increasing awareness of the importance of post-harvest drying methods, both in the windrow and via artificial drying. Both
under or over-drying in silos can significantly affect seed quality (especially splits, blanchability, flavour (off-flavours) and seed
germinability in the case of seed programs). Earlier work on peanut drying in Australia concentrated on applying
psychometric relationships to setting up of heat and fan operation times. However, there has been little work on relating the
drying with product quality and the efficiency of the drying system as a whole. The grain drying model developed by UNSW
researchers was adapted for peanuts and validation experiments completed to enable an operational model by the third year
of the project. A desktop analysis was conducted to assess the potential dollar savings in commercial driers by optimising
drying strategies. This analysis showed there is potential for saving nearly 40–50% of energy costs by following novel
strategies for drying. For example, variable fan speed and product mixing can be varied in the peanut drying model to
simulate new drying scenarios, rather than conducting large scale and expensive experiments. These strategies need to be
validated over larger volumes of peanuts before recommending for commercial application.
Output 3: Minimise cadmium accumulation by agronomic management strategies

Cadmium contamination is an important food safety issue for peanuts grown on sandy, light textured soils with a history of phosphatic fertiliser use. Penalty payments for grower stocks with kernel Cd levels exceeding 0.149 mg/kg were introduced recently by PCA, which reflect the economic cost and seriousness of this food safety issue. While agronomic packages involving zinc and lime management have been developed and tested experimentally under controlled conditions in a previous GRDC-PCA-Queensland Department of Primary Industries (QDPI) project (Bell et al, 2002), there has been little on-farm validation of their impact.

Field trials evaluating Cd minimisation practices (zinc foliar application, application of lime and gypsum) showed inconsistent responses with large site-specific effects for Cd contamination observed. There was significant spatial variability for soil and kernel Cd within a paddock, with the proportion of exchangeable Cd increasing exponentially when soil pH was less than six. Pot trials showed that Cd is absorbed by roots and remobilised to pods from leaves suggesting that management practices should focus on reducing the exchangeable Cd in root zone (by liming) or restricting the root surface area for Cd uptake.

The research done in this project revealed management of Cd contamination in peanuts may not be as simple as originally thought. The observation of significant spatial variability in soil and kernel Cd meant that future management practices will need to be site-specific. More basic R&D is required to understand the underlying mechanisms of Cd uptake and the causes of spatial variability. These studies are proposed to be conducted in the new Peanut Agronomy project.

Other research

A number of other R&D opportunities arose from project DAQ00070. A summary of these opportunities are listed below:

1. Exploring opportunities for incorporating functional food traits into new varieties for the niche marketing of peanuts into high value ‘health food’ markets.
2. Understanding the genetic basis of foliar disease resistance in the new variety Sutherland and its relatives.
3. Post harvest drying technology, including non-destructive pod moisture content measurement and modelling of drying in commercial drying facilities.
4. Applications of aerial remote sensing technology for the identification of high aflatoxin risk peanuts.
5. Better understanding of Cd uptake mechanisms and spatial variability.

Intellectual property summary

APSIM Peanut is the intellectual property (IP) of the Agricultural Production Systems Research Unit (APSRU). The AfloMan peanut aflatoxin decision support package has unrestricted access to both APSIM and Whopper Cropper software.

A system of licensing users (growers, consultants, agribusinesses) has been investigated with APSRU management, in order to maintain a register for updating new versions of the program. It is unlikely however that a fee for service arrangement will be implemented for the program given the ongoing drought and continued uncertainty of dryland peanut production.

Varieties Walter, Ashton and Sutherland have all been granted provisional Plant Breeders Rights (PBR) and have had their descriptions accepted by IP Australia (i.e. they are on track for full grant of PBR). All three varieties will be marketed by PCA and a seed royalty will be collected.

Additional information

Publications (during the Period 1 July 2004 to 30 June 2007).

Refereed Publications


Chauhan, Y., Wright, G.C., Nageswara Rao Rachaputi, Krosch, S., Robertson, M, Hargreaves, J., Broome, A. (2007). Using APSIM-
Soil Temp to simulate soil temperature in the podding zone of peanut. Australian J. Experimental Agric. 47 (6), 992-999.


Refereed Publications (In Preparation)


Conference and Other Non-Refereed Publications


