SRDC Research Project Final Report

New soybean varieties for fallow cropping of sugarcane fields

Project Reference Number: CPI009

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A statement of confidentiality: The contents of this report are not confidential, however the soybean varieties Stuart and Fraser have been protected by Plant Breeders Rights.

Australian Government
Sugar Research and Development Corporation

Executive Summary:
Cropping of soybean has been shown by the yield decline joint venture to increase the yield of the following sugar crop by 15 to 30 percent. Part of the benefit occurs via provision of nitrogen to the following cane crop and part due to improvement in soil health. Soybean is unique among the tropical grain legumes in its ability to fix large amounts of nitrogen and maintaining reasonable fixation even in the presence of moderate levels of soil nitrogen. It also appears that the amount of nitrogen left behind for the following cane crop by a soybean green-manure crop is well in excess of requirements. Soybean may therefore be grown, grain harvested and sold for cash, whilst maintaining the rotational benefit to the following cane crop.

The release of new soybean varieties by this project and its predecessor and work conducted by other researchers to help overcome yield decline in sugarcane cropping has seen a dramatic change in farming practice toward inclusion of soybean into the system. Availability of soybean grain harvested from crops grown on the coast has found a steady market. More recently several processing plants are planned for the tropics and at least one of these plants is contracting purchase of grain from the 2008 crop at good prices.

This project sought to build on the recent release of variety Stuart by providing complimentary varieties suited to oilseed or human consumption use to coastal growers with a range of attractive traits, but focussing on high grain yield and biomass, strong lodging resistance, nematode and phytophthora resistance. In this way it was planned to provide a better and more profitable soybean rotation to benefit canegrowers.

Varietal evaluation trials were conducted at sites in the Burdekin, and on the Atherton Tablelands at early, mid season and late summer planting dates and in the south at Bundaberg and Nambour also at late summer planting dates and in the Burdekin during the dry season. In addition farmer participation in varietal evaluation was encouraged via strip trials. Ultimately nine strip trials were conducted in the second year of the project leading to the release of the new cultivar Fraser in October 2007, in time for the 2007/08 planting season. Fraser is adapted to the southern cane coast. A range of other lines were also selected that showed enhanced performance over the whole sugarcoast and may ultimately be released to industry.

Soybean is unique among grains in having a very high content of protein of a type which is highly digestible and finds ready acceptance in stock feed milling. The oil is the preferred feedstock for producing quality biodiesel. Grain of light hilum varieties is also readily accepted into higher-value human consumption markets. Due to this very wide range of uses, soybean grain of a wide range of quality is relatively highly valued. Higher quality grain is well accepted into the human consumption markets, grain of a lower quality is accepted for flour making and other qualities are used for full-fat meal or crushing. In effect, the crushing price is based on import parity pricing relative to the Chicago board of trade [currently AU$560/t as at 31 Oct 08], and various other markets are priced relative to it. In 2008 human consumption attracted a premium of between $150 and $500 a tonne. This contrasts with grains of other legumes, which tend to have a high human consumption value but much lower stockfeed or processing values due to much lower protein content and negligible oil content.

The new soybean variety ‘Fraser’ was named after the Fraser coast region of southern Qld in because it is the first variety specifically released for the area and in recognition of the efforts of growers in that region to see soybean cropping increase. Fraser is adapted to coastal production from the NSW border to the Fraser coast region. It has a clear hilum and is suitable for most human consumption uses.

Background:
Approximately, 500 000 hectares of N Qld is suited to soybean, about 70 percent of which currently grows sugarcane of which 15-20 percent is potentially available for soybean cropping in any year without displacing cane. Recent trends indicate that about 25 000 Ha will come into soybean grain production by 2010 and a similar area for soybean cover crop. At a conservative price of $500 /t for crushing and a conservative yield of 3 t/Ha or 75 000 t/yr, the value of soybean grain in tropical regions is $40 M/yr. The benefits of soybean in a cane rotation range from increase of 15 to 30 percent. This projects to a value of ~ $50 M annually.

The projected annual value of soybean in tropical production systems in 2010 is $90 M. Additional benefit through the provision of locally produced and competitively priced protein meal to intensive livestock industries (chicken, pig, aquaculture), or through the development of local biofuel industries have not been included but are substantial.

Under the auspice of previous ACIAR projects in Vietnam and Thailand and under the GRDC national soybean improvement program, experimental varieties were developed which possessed a range of attractive traits. Evaluation of this material was underway in Vietnam, also underway in the preceding SRDC project and in the partner GRDC project. This SRDC project aimed to select new varieties from this material

Objectives:
Improve profitability, sustainability and diversification of the sugar industry though the selection and release of grain-type soybean cultivars with higher yield and better adaptation to Queensland.

This project sought to build on the current varietal release and previous investment by 1. providing a small seeded (for high germ-high vigour seed), long duration, high biomass nematode, rust and phytophthora root rot resistant and light hilum replacement for the existing green manure/rotation soybean variety Leichhardt. This will broaden rotation options and enable access to higher value human consumption markets for grain. This variety would possess the extreme robustness and exceptional biomass production of Leichhardt and be an improvement for disease and nematode resistance. 2. provide a well-adapted high tofu-quality variety for those growers who seek to access the high-end export markets for beans to north Asia. High tofu quality requires a special purpose variety and high standards of agronomy and insect control and it is for this reason that a special variety is needed. 3. a light hilum variety with high yield and much improved lodging resistance to overcome some of the limitations with current varieties in the Bundaberg region. This was planned to be achieved through selection and release of experimental varieties already in the pipeline which were thought to possess potential for high grain yield and much enhanced tolerance to rust and weathering, but which required evaluation and selection prior to release.

Methodology:
Varietal evaluation leading to selection of a variety for release was conducted via two methods in this project. The first method was the traditional white-peg varietal

evaluation trial, conducted each year for three years on the Atherton Tablelands, the Burdekin and at Nambour or Bundaberg using an array of planting dates in the wet season to identify relative yield and adaptation of experimental varieties. Adaptation of the experimental varieties to cropping in the dry season was also evaluated in the Burdekin. Resistance to nematodes was evaluated under extreme field conditions in Mackay and under laboratory conditions.

The project also remained partnered with the national soybean improvement program but responsible for tropical and coastal evaluation of new varieties. Three key niches appeared to require new varieties. One was for a light hilum, long duration replacement for Leichhardt possessing strong nematode resistance, one for a type to permit production of grain with quality suited to high-value export markets for tofu in north Asia and the third type was for a light hilum variety with high yield and much improved lodging resistance to overcome some of the limitations with current varieties in the Bundaberg region.

Agencies with capacity for production and supply of high quality planting seed to the coast were considered for a license to commercialize the new variety and the Northern Australian Soybean Industry Association (NASIA) was invited to tender for the licence of the new variety. This was because NASIA is made up of many members with skills in production and distribution of high quality planting seed and thus has a broader skill base than any one individual merchant. In addition the umbrella of the Association improves communication, policing of quality and ethical standards.

Commercialization has therefore proceeded via development of close linkage to members of the Northern Australian Soybean Industry Association (NASIA). In the second year of the project, several members were involved in pre-commercial evaluation of the new variety. Impact of the projects will be measured through volume of Stuart and Fraser planting seed sold and the amount of grain harvested. From this it will be possible to estimate area planted and make an economic assessment of the direct contribution of Stuart. Annual reports of seed sales will be made to SRDC.

Results and discussion:

North Queensland trials.

In the north Qld trials, the dominant source of variation in analysis of variance for the wet season trials was genotype. That is trial lines ranked relatively similarly for the wet season evaluations irrespective of location of the site in either the Burdekin or on the Atherton Tablelands or year or planting date. For this reason trial results have been averaged over the 12 trials conducted in 2005 to 2007 and presented in Figure 1 for biomass and in Figure 2 for grain yield. Local varieties Leichhardt and Stuart performed uniformly well in these trials. One trial line showed promise by producing slightly higher biomass and grain yield than Leichhardt and Stuart. However it was judged unsuitable for release due to excessive susceptibility to purple seed stain. The S Qld-adapted variety selected in the project Fraser was found to be too daylength-sensitive to permit cropping in the north. In contrast, the near daylength-insensitive tofu-quality variety Bunya was shown to be reasonably adapted to grain cropping in the region. It is a special purpose type and requires good agronomy, good insect pest management and skilled harvesting to ensure grain yield and quality suited to higher value markets.

Figure 1. Total dry matter of soybean trial lines averaged over twelve evaluations conducted over the summer wet seasons of 2005 to 2007. Planting dates were early December and mid January at Ayr and Walkamin in each year.

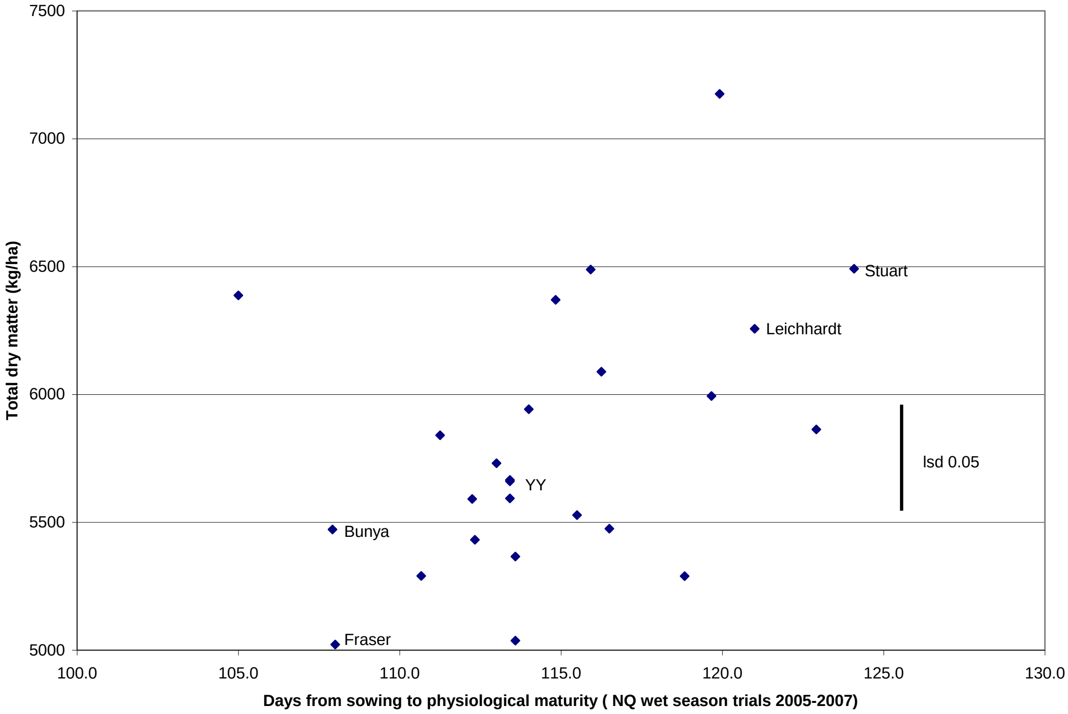
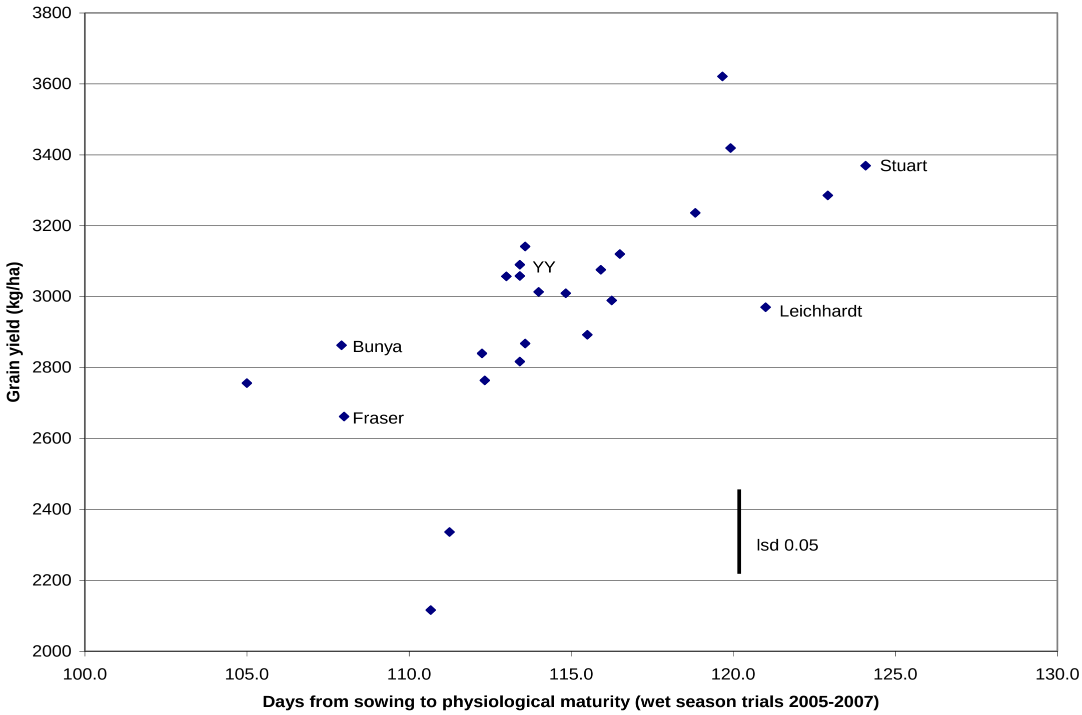
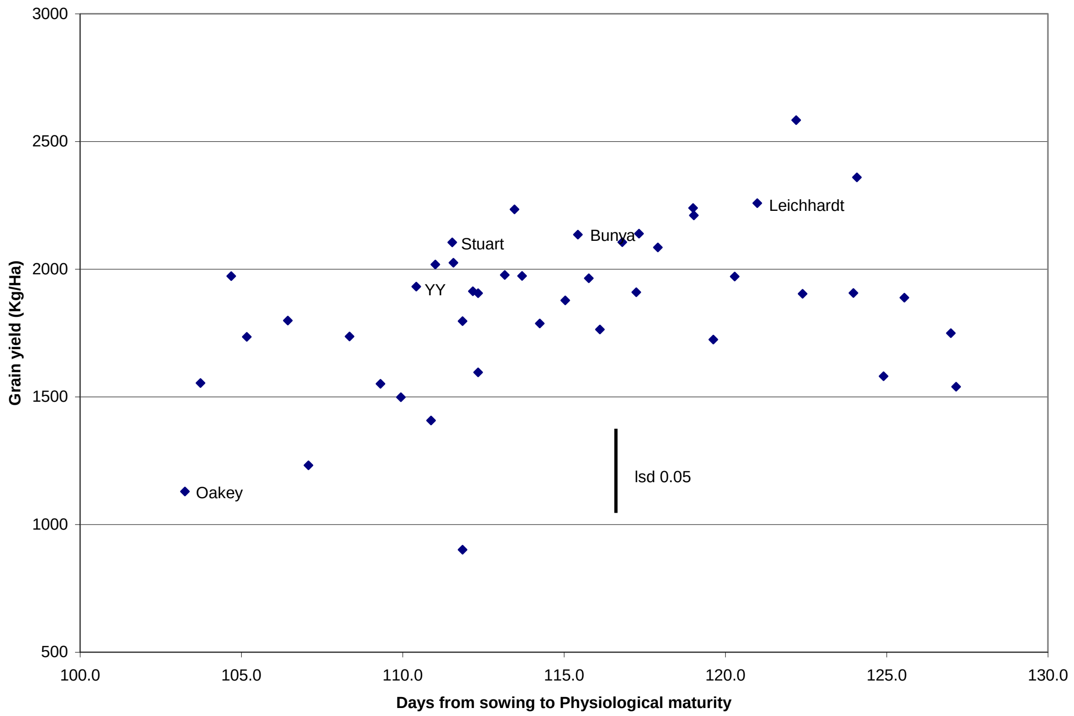


Figure 2. Grain yield of soybean trial lines averaged over twelve evaluations conducted over the summer wet seasons of 2005 to 2007. Planting dates were early December and mid January at Ayr and Walkamin in each year.



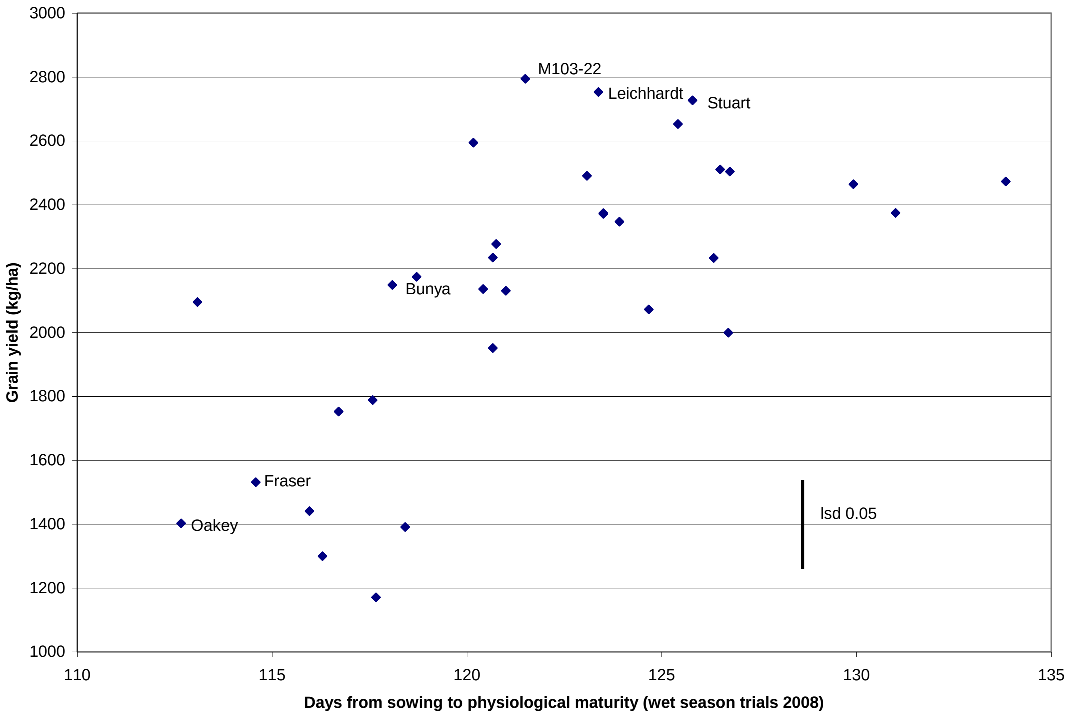
Trial varieties performed quite differently in the dry season due to the much larger differential effect of daylengh sensitivity. Traditional daylength sensitive types are quite unadapted in the tropical dry season because they flower precociously when exposed to the warm temperature short-day conditions of the tropical dry season. In contrast, the lower daylength sensitivity of Leichhardt, Stuart and Bunya enable cropping to be successful in the dry season. Dry season cropping is potentially important as it allows a strategy whereby crops are grown in the dry season for seed production. This permits seed to be harvested in October or November in dry and somewhat coolish conditions. Excellent quality, high germination and high vigour seed can then be produced for planting of the main wet season crop. The main purpose of the dry season trials is therefore to test if the trial line has reasonable daylength insensitivity and appropriate crop duration and good yield potential. Varieties Stuart, Bunya and Leichhardt all have good dry season adaptation along with the great majority of trial lines. Because of the large genotype re-ranking between wet season and dry season trials, trial results for the dry season are presented separately (Figure 3).

Figure 3. Grain yield of soybean trial lines averaged over three evaluations conducted over the winter dry seasons of 2005 to 2007 at Ayr. Planting was in June each year.



In the final year of the project, a suite of new varieties were introduced to the north Qld trials from the partner GRDC project. A subset of trial lines from the earlier varietal evaluations were also evaluated. The new lines were selected on the basis of apparent near daylength insensitivity and they came from crosses of adapted parents with a focus on clear hilum, strong lodging resistance and new sources of nematode resistance. In particular one line M103-22 appeared to combine near daylength insensitivity with high yield and very strong lodging resistance with seed size about the same as Leichhardt. M103-22 also has very strong resistance to purple seed stain, a clear hilum and is likely to have good acceptance into most human consumption, crushing and stockfeed markets. It is hoped that one of these new lines will be advanced over the next few years and provide a successor variety to Leichhardt (Figure 4). As in earlier trials, Leichhardt and Stuart has consistent good performance.

Figure 4. Grain yield of soybean trial lines averaged over four evaluations conducted in the summer wet season of 2008. Planting dates were early December and mid January at Walkamin and early December and April at Ayr.

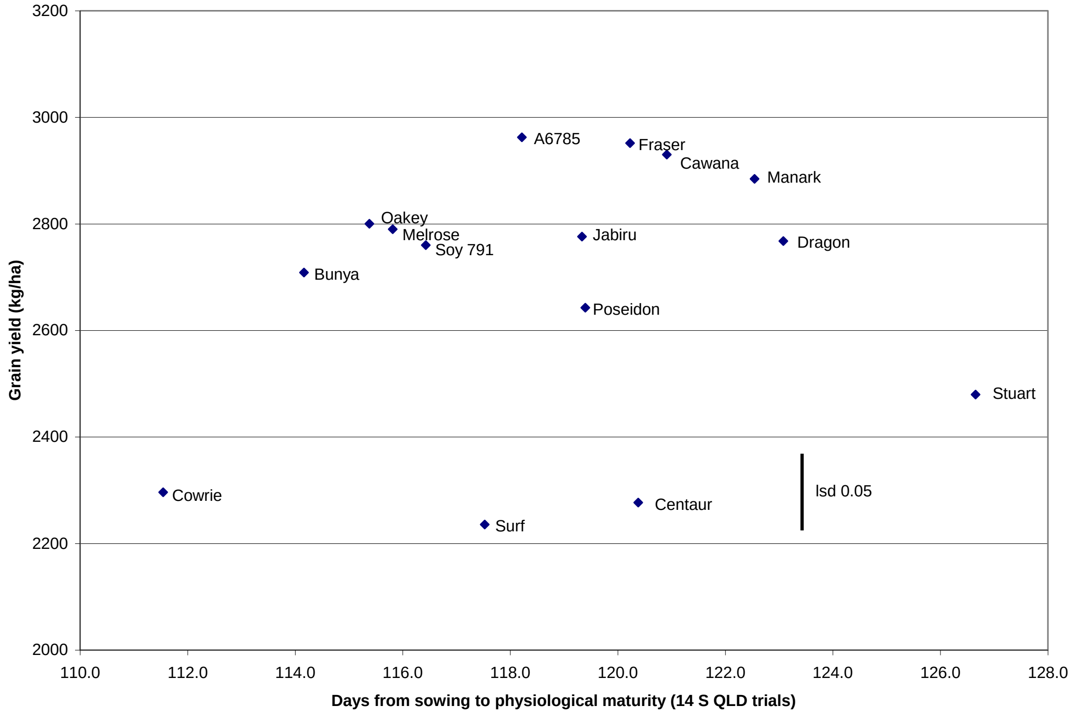


Southern Queensland trials.

Generally, varieties with adaptation to southern Qld are poorly adapted to northern Qld. This is because most traditional type varieties are sensitive to daylength in time to flower and mature. In the tropics they flower and mature too quickly to achieve adequate biomass for acceptable grain yield. For this reason, the southern Qld trials are considered separately from the north Qld trials, although there are some links via broadly adapted varieties such as Bunya and Stuart. A comparison of varieties is presented in Figure 5 for performance in southern Qld. This is the data set used to support the release of the new variety Fraser.

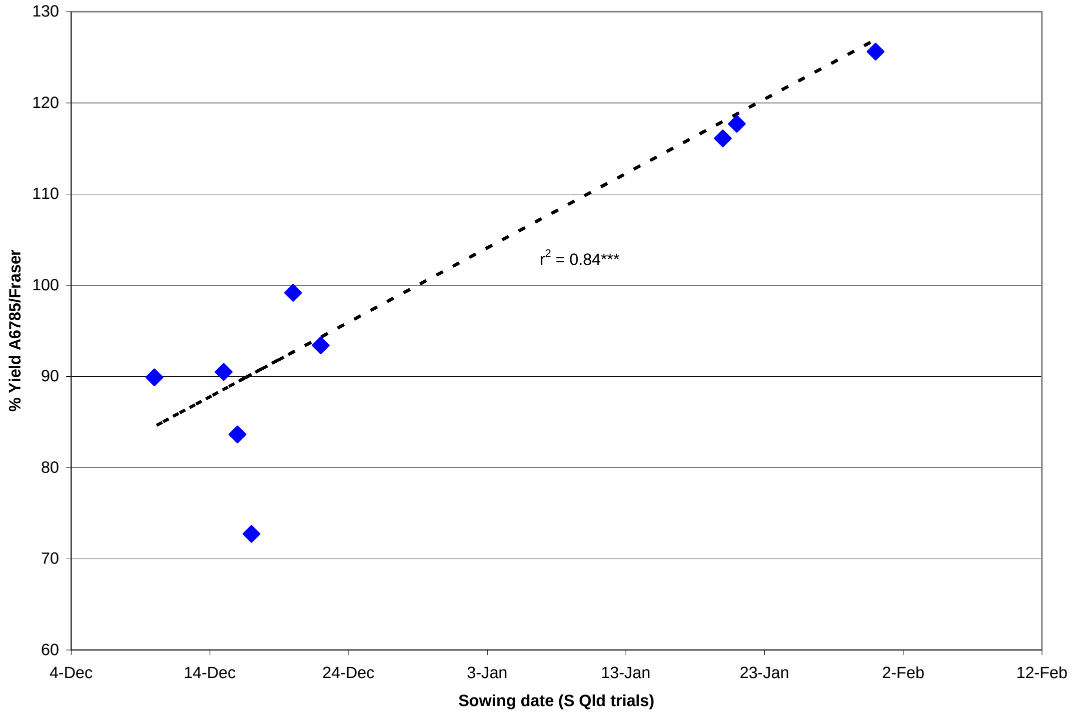
With the larger dataset and mostly well-adapted varieties in Figure 5, the effect of maturity on grain yield can clearly be seen. Varieties Bunya, Oakey, Melrose and Soy 791 are a little too quick maturing to maximise grain yield under average agronomy, and Dragon and Stuart are a little too late. As a rule of thumb, with traditional photosensitive varieties it is best to plant early varieties early in the cropping window and progressively change to use of later varieties later in cropping window. A similar change can also be made with plant population, in that plant population can be increased at later planting dates to compensate for smaller plant size. With the more recent near-photoinsensitive varieties, the same variety can be planted over a wider cropping window and over a wider north-south range. For example, the variety Bunya can be grown from the Atherton tablelands (with high plant population) through to the Macquarie valley in central NSW (at normal plant population) and achieve good results. This range of environments would hitherto require five photosensitive varieties.

Figure 5. Grain yield of soybean trial lines averaged over 14 evaluations conducted in 2005-2007 in southern Qld in partnership with the GRDC soybean breeding project.



Fraser was released especially for the Fraser coast region of southern Qld where it should replace the older variety A6785. Growers in this region prefer to plant soybean from late November through to the end of December. Over this range of planting dates, Fraser shows about 15% yield superiority over A6785.

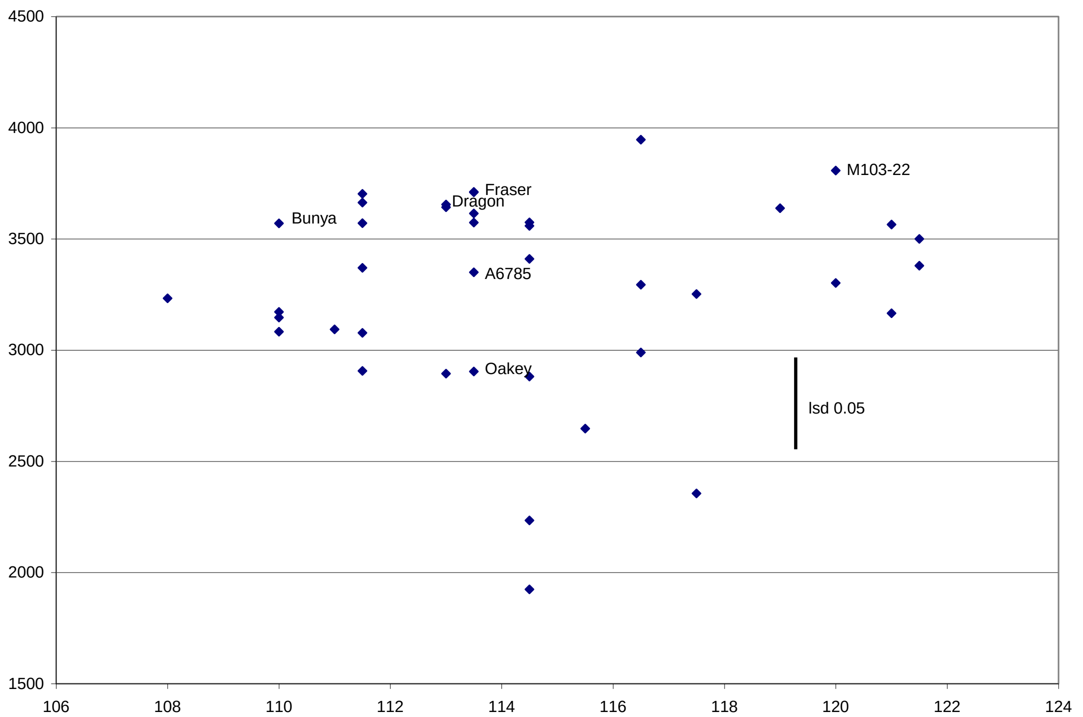
Figure 6. A comparison of grain yield of soybean varieties A6785 and Fraser, showing Fraser's higher grain yield at early planting dates and A6785's at later planting date.



Fraser also has slightly higher protein content, much whiter colour, much fewer purple seed stain, much stronger lodging and seed shattering resistance than A6785. At later planting dates in this region, growers should choose a slightly later maturing variety in order to maximise grain yield.

As with the north Qld trials, a suite of new lines were introduced to evaluation at Bundaberg in the final year of the project in 2008. About one third of the entries were in common with the N Qld trials. Again varieties Fraser, A6785, Dragon and Bunya performed well, but several higher performing lines were identified. One of these M103-22 also topped the variety trials for grain yield in N Qld. If this line or one with similar broad adaptation is ultimately released to commercial production, it will permit much increased efficiency of seed production and a wider choice of varieties and end use markets for northern soybean growers.

Figure 7. Grain yield of soybean trial lines averaged over two evaluations conducted in the Bundaberg region in 2008 in partnership with the GRDC soybean breeding project.



Outputs:

1. New soybean variety Fraser has been licensed to NASIA (a subsidiary of Soy Australia) for commercialisation. Fully commercial quantities of seed will be available for planting in November 2008.

2. A broader range of grain merchants have become involved in tropical soybean production with the licence for soybean varieties Stuart and Fraser passing to the NASIA. In time this will lead to increased purchasing and utilisation of grain in the north.

3. Variety Bunya with potential to produce grain of high quality suited to high-value markets for tofu was found to be well adapted to north Qld. However, growers should

be aware that it requires a high standard of management to achieve grain of quality suitable for the market.

4. Several other lines have been selected which appear to offer hope for a clear hilum successor variety for Leichhardt with improved grain yield, nematode and lodging resistance.

5. Future varietal evaluation in the north will be conducted via strip trials in farmers' fields conducted by Soy Australia members.

Intellectual Property:
Release of new soybean cultivar Fraser has been conducted in consultation with SRDC. It has been protected via Plant Breeders Rights (details in Appendix 1). Consideration was made of agencies with a capacity to commercialise the new variety and capacity to deliver strategic benefit to the broader soybean and sugar industries. The Northern Australian Soybean Association (a subsidiary of Soy Australia) was invited to and was ultimately accepted as successful tender for a licence to commercialise both Stuart and Fraser.

Environmental and Social Impacts:
Inclusion of soybean into the cropping system will improve sustainability of the sugarcane cropping system via the following routes:

1. Inclusion of soybean into the cropping system arrests yield decline of sugarcane monocrop principally through provision of a break to the build up of disease and to a lesser extent through provision of slow release nitrogen to the following cane crop. Slower release of biologically-fixed nitrogen will reduce the need for bag-fertilizer and reduce nitrogen in runoff.

2. Enhanced cash flow from harvest and sale of soybean grain will make inclusion of soybean into the cane rotation more attractive and hence encourage greater uptake.

3. Synergistic effect. Improved cash flow via harvest of grain will encourage growers to achieve better agronomy in the soybean crop, particularly in the areas of weed-grass and cane control and in establishment of good plant populations. This will in turn result in an improved break to continuous cane cropping and greater benefits to following cane crops.

4. Provision of locally produced and much more competitively priced protein meal to intensive livestock industries (chicken, pig, aquaculture) will result in more intensification of livestock production systems in the north.

5. Provision of a locally produced oilseed crop can help to support local production of biofuels.

Expected Outcomes:
The total expected outcome through inclusion of soybean into the Sugarcane cropping system is described here. In order to assure ongoing industry development and

diversification, a continuous flow of varieties with complimentary attributes, agronomic types and improved disease resistances are necessary. The release of Stuart in NQld and Fraser in SQld are an important step towards providing this suite of varieties to industry. Where grain is the preferred target in North Qld coastal, it is anticipated that growers will prefer to use Stuart rather than the older cultivar Leichhardt. Further south, the variety Fraser produces grain of superior quality than existing varieties. It can be argued that the net benefit to growers in cane regions of use of soybean in their cropping system is in the vicinity if $90 million by 2010. About half of this benefit will come from use of varieties Stuart and Fraser developed by SRDC funding.

Future Research Needs:

There is opportunity for a large expansion of soybean grain production in Qld coastal and sub-coastal areas, stimulated by pressures to diversify and the demonstrated success of soybean cover crops on fallow sugar cane land. The constraint of distance from Australian oil and protein markets is declining as local crushing and biodiesel users of soybean become used to consistent supply and ramp up consumption. The area also has proximity to high value human food and feed markets in SE Asia which provides unique export opportunities. A trickle of new varieties will come via strip trial evaluation of existing lines by Soy Australia members, however conduct of formal of breeding trials anywhere north of Bundaberg ended in June 2008 with the end of this project.

Breeding Priorities

1. High yielding varieties. Growers are currently well served by varieties Leichhardt and Stuart in the north. If seeking to supply specialty markets, growers may choose to use Bunya. A possible addition to the list of available varieties will be M103-22.

2. A vision for soybean cropping in the north. Assuming that soybean cropping will continue its rapid expansion in the north, it is likely that pressure will build to take advantage of newer technologies such as herbicide tolerance and higher value food and feed traits. Import of USA varieties and their utilisation in northern Australia is precluded by their lack of adaptation to the daylength and temperature conditions found in the tropics.

The public gene for sulfonylurea herbicide tolerance is already in the GRDC breeding program as are genes for altered protein nutritional profile, aphid resistance, reduced allergenicity, reduced raffinose and stachyose and absence of beany flavour. If the industry wants, these could be delivered to growers in North Qld in the form of cultivars with inbuilt herbicide tolerance or with grain suited to much higher value food, feed or oil values.

A wide range of biotechnology derived traits are becoming progressively available in soybean. If industry and markets for Australian soybean accept these, they could be delivered in locally adapted varieties or in introduced varieties converted to tropical adaptation.

Recommendations:

1. If growers wish to see ongoing breeding and formal varietal evaluation of grain soybean in north Qld, they may like to lobby the Grains Research and Development Corporation to see this happen. GRDC is the recipient of levies on soybean grain sold and therefore the research and development corporation with responsibility.

Appendix 1.

Plant Breeders Rights application

<u>Details of Application</u>

Application Number	2007/305
Variety Name	'Fraser'
Genus Species	*Glycine max*
Common Name	Soybean
Synonym	Nil
Accepted Date	27 Nov 2007
Applicant	Commonwealth Scientific and Industrial Research Organisation, Canberra, ACT and Grains Research and Development Corporation, Barton, ACT
Agent	N/A
Qualified Person	Andrew James

<u>Details of Comparative Trial</u>

Location	Gatton, QLD.
Descriptor	Soya Bean (*Glycine max*) TG/80/6.
Period	Feb to Jun 2008.
Conditions	Trial was conducted in the fields of the CSIRO Cooper Laboratory within the grounds of the University of Queensland at Gatton, QLD. The field site was fully cultivated, fertilised with 100 kg/ha each of Sulphate of Potash and Superphosphate. Preplant application of Treflan was used to control weeds. Soil was formed into 1.5m beds. Plots were one meter in length and spaced at one meter intervals along the bed.
Trial Design	Each plot consisted of one metre row with approximately 30 plants. Plots were arranged in a randomised complete block design with four replicates.
Measurements	Days to flowering and maturity, leaf length and width on the terminal leaflet on the 8th fully expanded leaf on five plants, at maturity; total main stem node number on five plants, length of the main stem on five plants.
RHS Chart - edition	N/A

<u>Origin and Breeding</u>

Controlled pollination: the cross between 'Manark' and 'PKN' was made in the glasshouse of the Hermitage Research Station, Warwick, QLD, under the supervision of Dr John Rose of the QLD Department of Primary Industries. The seed parent 'Manark' is characterised by buff hilum colour and the pollen parent 'PKN" is characterised by grey hilum colour. Selection criteria: high yield, yellow hilum, lodging resistance, multiple disease resistance. Propagation: seed. Breeder: Andrew James, CSIRO Plant Industry, St Lucia, QLD.

Choice of Comparators Characteristics used for grouping varieties to identify the most similar Variety of Common Knowledge

Organ/Plant Part	Context	State of Expression in Group of Varieties
Hypocotyl	anthocyanin colouration	absent
Plant	growth type	determinate
Plant	growth habit	erect/semi erect
Plant	colour of hairs on the main stem	grey
Plant	height	medium/tall
Flower	colour	white
Pod	intensity of brown colour	light
Seed	shape	spherical flattened
Seed	ground colour of testa	yellow
Seed	hilum colour	yellow
Plant	time of beginning of flowering	late/medium to late
Plant	time of maturity	late/ medium to late

Most Similar Varieties of Common Knowledge identified (VCK)

Name	Comments
'Warrigal'	similar in most attributes except leaf shape.
'Ivory'	similar in most attributes except leaf shape.
'Bunya'	similar in most traits except leaf shape and seed size.
'Oakey'	similar for most traits except seed size.

Varieties of Common Knowledge identified and subsequently excluded

Variety	Distinguishing Characteristics		State of Expression in Candidate Variety	State of Expression in Comparator Variety
'Manark'	Seed	hilum colour	yellow	light brown
'Manark'	Leaf	shape of lateral leaflet	lanceolate	pointed ovate
'Cawana'	seed	hilum colour	yellow	grey
'Cawana'	Leaf	shape of lateral leaflet	lanceolate	pointed ovate
'Centaur'	Seed	hilum colour	yellow	light brown
'Centaur'	Leaf	shape of lateral leaflet	lanceolate	pointed ovate
'Davis'	Seed	hilum colour	yellow	light brown
'Davis'	Leaf	shape of lateral leaflet	lanceolate	pointed ovate
'Dragon'	Seed	hilum colour	yellow	light brown
'Dragon'	Leaf	shape of lateral leaflet	lanceolate	pointed ovate
'Soy 791'	Seed	hilum colour	yellow	light brown
'Soy 791'	Leaf	shape of lateral leaflet	lanceolate	pointed ovate
'A6785'	Seed	hilum colour	yellow	light brown
'A6785'	Leaf	shape of lateral leaflet	lanceolate	pointed ovate
'Stuart'	Plant	colour of hairs of main stem	grey	tawney
'Stuart'	Plant	growth type	determinate	indeterminate
'Cowrie'	Leaf	shape of lateral leaflet	lanceolate	pointed ovate
'Cowrie'	Plant	time of beginning of flowering	late	early to medium
'Cowrie'	Plant	time of maturity	late	early to medium
'Djakal'	Seed	hilum colour	yellow	light brown
'Djakal'	Plant	time of beginning of flowering	late	early

‘Snowy’	Plant	growth type	determinate	indeterminate
‘Snowy’	Plant	time of beginning of flowering	late	early

<u>Variety Description and Distinctness</u> - Characteristics which distinguish the candidate from one or more of the comparators are marked with a tick.

Organ/Plant Part: Context	**‘Fraser’**	**‘Bunya’**	**‘Ivory’**	**‘Oakey’**	**‘Warrigal’**
☐ *Hypocotyl: anthocyanin colouration	absent	absent	absent	absent	absent
☐ *Plant: growth type	determinate	determinate	determinate	determinate	determinate
☐ Plant: growth habit	erect	erect	erect	erect to semi-erect	erect
☐ *Plant: colour of hairs of main stem	grey	grey	grey	grey	grey
☐ *Plant: height	medium to tall	medium to tall	medium to tall	tall	tall
☐ Leaf: blistering	medium	medium	medium	medium	medium
☑ *Leaf: shape of lateral leaflet	lanceolate	rounded ovate	pointed ovate	lanceolate	pointed ovate
☑ Leaf: size of lateral leaflet	medium to large	large to very large	medium	small to medium	medium
☑ Leaf: intensity of green colour	medium	light	medium	medium	medium
☐ *Flower: colour	white	white	white	white	white
☐ Pod: intensity of brown colour	light	light	light	light	light
☐ Seed: size	medium	large to very large	medium	very small	medium
☐ Seed: shape	spherical flattened	spherical flattened	spherical flattened	spherical flattened	spherical flattened
☐ *Seed: ground colour of testa	yellow	yellow	yellow	yellow	yellow
☐ *Seed: hilum colour	yellow	yellow	yellow	yellow	yellow
☐ Seed: colour of hilum funicle	same as testa	same as testa	same as testa	same as testa	same as testa
☐ *Plant: time of beginning of flowering	late	late	medium to late	late	late
☐ *Plant: time of maturity	late	late	medium to late	late	late

Statistical Table

Organ/Plant Part: Context	'Fraser'	'Bunya'	'Ivory'	'Oakey'	'Warrigal'
Plant: time of beginning of flowering (days)					
Mean	50.00	60.00	48.25	61.50	54.75
Std. Deviation	0.00	0.01	0.50	0.58	0.50
LSD/sig	0.50	P≤0.01	P≤0.01	P≤0.01	P≤0.01
Note: days from sowing until 50% of plants within a replicate possess an open flower					
Plant: time of maturity (days)					
Mean	115.00	150.50	116.50	133.00	122.75
Std. Deviation	0.80	1.91	2.38	1.41	0.96
LSD/sig	0.80	P≤0.01	ns	P≤0.01	P≤0.01
Note: days from sowing until 95% of pods on plants within a replicate have changed from green to yellow or brown					
Plant: number of main stem nodes (count)					
Mean	11.05	13.30	11.50	15.45	52.40
Std. Deviation	0.30	0.62	0.26	3.78	0.35
LSD/sig	0.58	P≤0.01	ns	P≤0.01	P≤0.01
Note: number of main stem nodes at maturity, average of five plants within a replicate					
Plant: main stem length (cm)					
Mean	59.20	65.90	48.30	60.10	63.40
Std. Deviation	3.78	3.36	2.01	7.82	2.69
LSD/sig	6.65	ns	P≤0.01	ns	ns
Note: length of main stem at maturity, average of five plants within a replicate					
Leaf: 8th main stem leaf, terminal leaflet length (cm)					
Mean	152.65	137.10	120.95	117.10	125.30
Std. Deviation	3.70	4.87	3.37	1.32	1.95
LSD/sig	5.96	P≤0.01	P≤0.01	P≤0.01	P≤0.01
Note: length of terminal leaflet at 8th node					
Leaf: 8th main stem leaf, terminal leaflet width (cm)					
Mean	51.80	88.25	83.00	42.30	86.50
Std. Deviation	1.86	9.64	3.45	0.93	2.16
LSD/sig	6.80	P≤0.01	P≤0.01	P≤0.01	P≤0.01
Note: width of terminal leaflet at 8th node					
Leaf: leaflet width/length ratio of 8th main stem leaf terminal leaflet					
Mean	0.33	0.63	0.69	0.36	0.69
Std. Deviation	0.01	0.06	0.03	0.01	0.01
LSD/sig	0.46	P≤0.01	P≤0.01	ns	P≤0.01
Note: measure width and length of terminal leaflet at 8th node and calculate ratio					

Prior Applications and Sales

Nil.

Description: **Andrew James,** CSIRO Plant Industry, St. Lucia QLD.