SRDC Research Project Final Report

Adapting soybean for profitable rotations in sugarcane farming systems

Project Reference Number: CSP -9A

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A statement of confidentiality: The contents of this report are not confidential, however the soybean variety Stuart has 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. One impediment to the increase of soybean in sugarcane production systems is that the financial benefit of inclusion of a fallow crop like soybean into a sugarcane production system is delayed until sugar crops harvested in the following years. However, by inclusion of a grain soybean option, growers are more likely to manage the crop better and can gain the financial return from harvest of grain in addition to benefits to the following cane crop delivered by improved soil health.

This project sought to complete varietal evaluation of experimental varieties with improved potential for harvest of grain through to the point of commercialisation to industry. 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 eleven strip trials were conducted in the second year of the project and five in the third. In addition large scale seed increase of the new variety was conducted at Nambour and at Walkamin and a second round of seed increase sown in June 2005 in northern Australia.

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. Grain of light hilum varieties is also readily accepted into higher-value human consumption markets. During the last year of this project, members of the Northern Australian Soybean Industry Association (NASIA) were involved in commercial evaluation and release of the new variety named Stuart. In particular North Queensland Tropical Seeds and Bettacrop conducted pre-release evaluation and also participated in the next round of evaluations along with Mt Tyson seeds Queensland Cotton, Beangrowers Australia and Philp Brodie Grains. The new variety has been licenced to NASIA for commercial production.

The new soybean variety ‘Stuart’ was named after Mt Stuart south of Townsville, following the theme of local mountains. Stuart is adapted to coastal production from Nambour to Mossman. It has a very light grey hilum and is suitable for some human consumption uses. It has high levels of nematode and rust resistance, maturity a week or more earlier than Leichhardt and is adapted to both wet and dry season planting in north Qld and has generally higher grain yields. Stuart is taller than Leichhardt and adapted to row widths from 50 to 130 cm. It has a more erect and open canopy than Leichhardt, making control of insects by insecticide application slightly easier. Lodging may however occur with plant populations over 35 plants per square metre or in early-season sowing. Good quality grain possessing light hilum and apparent suitability for food grade uses was produced from strip trials in several farmers fields. Relative to existing varieties Leichhardt and YY, Stuart offers higher grain yield and higher value grain through access to food grade uses rather than feed or oilseed crushing. Release of a new soybean variety and an ongoing varietal improvement program will help to underpin sustainability in tropical cropping systems and provide a basis for new industry development.

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 $300 /t for crushing and a conservative yield of 2.5 t/Ha or 62 500 t/yr, the value of soybean grain in tropical regions is $19 M/yr. The benefits of soybean in a cane rotation range from increase of 15 to 30 percent. This projects to a value of ~ $45 M annually. The projected annual value of soybean in tropical production systems in 2010 is $60-65 M. Additional benefit through the provision of locally produced and competitively priced protein meal to intensive livestock industries (chicken, pig, aquaculture), have not been included but are substantial. It is likely that this region will initially produce beans for crushing and stockfeed markets and for less quality sensitive human consumption markets such as flour or export to Asia. First exports of 100 tonnes of soybean grain from the Burdekin to Indonesia foe human consumption have occurred from the 2005 crop.

The previous soybean-sugarcane system used the cultivar Leichhardt as a green manure crop. However, Leichhardt is a very long-maturity cultivar which is highly susceptible to soybean rust and nematodes and is only moderately tolerant of weathering of grain prior to harvest. Soybean rust has emerged as a serious disease during wetter seasons in the Tablelands and in the wet tropics during the winter season. Weathering of grain occurs when the crop nears maturity in the field but is exposed to rainfall prior to harvest. This can result in germination of seed in the pod and eventually lead to total loss of harvested grain before harvest. Use of a single variety over the entire region also increases risks of weathering and loss of a harvestable grain crop as all crops will tend to mature at the same time. In addition reliance on a single variety is inherently risky due to the emergence of new diseases.

Under the auspice of previous ACIAR projects in Vietnam and Thailand, experimental varieties were developed which possessed shorter duration, greatly improved tolerance to rust and better tolerance to pre-harvest weathering. Evaluation of this material was underway in Vietnam and to a limited extent in Australia. This SRDC project aimed to complete selection of new varieties from this material

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

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 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 and tolerance to soybean rust was evaluated in parental material prior to the commencement of this project. Resistance in experimental varieties was evaluated under field

inoculation conditions in 2002, 03 04 and again in 2005. Resistance to nematodes was evaluated under extreme field conditions in Mackay.

The second method of varietal evaluation occurred via farmer participatory evaluation of advanced lines in a push me-pull you methodology which combined provision of agronomic advice with strip evaluation of new varieties. This was conducted so that, for example growers in the Burdekin were provided with seed of near release varieties, assisted to establish good plant populations, helped to check for insect pests during critical periods and assisted with appropriate timing of harvest to maximize quality. In this way a key group of growers acquired additional agronomic skills to better manage the critical aspects of soybean agronomy and the project was able to receive valuable feedback on acceptability of several near release varieties. The process is however more complicated to manage and the information more difficult to interpret than a straight varietal evaluation trial data, however it provides the additional benefits of two way learning and advice. The researchers have learnt from the process and would try for a more formal structure to grower-feedback in future participatory evaluation.

A summary of varietal evaluation results is in Appendix 1.

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 final year of the project, two members were involved in pre-commercial evaluation of the new variety. One member, North Queensland Tropical Seeds, based on the Atherton Tablelands conducted seed increase and pre-commercial evaluation at Walkamin and the other Bettacrop, based at Emerald, conducted pre-release evaluation at Nambour. In the second phase of seed increase these NASIA members were joined by Mt Tyson seeds-Queensland Cotton and Beangrowers Australia in commercial scale dry season seed increase.

Impact of the project will be measured through volume of Stuart planting seed sold. 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.

Outputs:

1. New soybean variety Stuart has been licensed to NASIA for commercialisation. Fully commercial quantities of seed will be available for planting in November 2005.

2. New methodologies for grower and research agency participation in push me-pull you transfer of agronomic advice and varietal evaluation information have been implemented. It is anticipated that a more formal implementation of this process will occur in the new SRDC project and in the broader GRDC soybean breeding project.

3. A broader range of grain merchants have become involved in tropical soybean production with the licence for soybean variety Stuart passing to the Northern Soybean Industry Association. In time this will lead to increased purchasing and utilisation of grain in the north coast region.

Intellectual Property:
Release of new soybean cultivar Stuart has been conducted in consultation with SRDC. It has been protected via Plant Breeders Rights (details in Appendix 2). 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 was invited to and was ultimately accepted as successful tender for a licence to commercialise Stuart.

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 lessor 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.

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 is 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 Stuart has longer cropping duration, and so becomes more dual purpose grain and green manure. For this reason, in southern Qld coastal, Stuart will tend to be used for green manure or in late season sowing for grain.

North Qld coastal (Mackay –north). Around 500 000 Ha of N Qld is suited to soybean, about 70 percent of which grows sugarcane of which 15-20 percent is potentially available for soybean cropping in any year without displacing cane. Recent trends indicate about 25 000 Ha in soybean grain production by 2010 and a similar area for soybean cover crop. At a conservative price of $300 /t for crushing and a conservative yield of 2.5 t/Ha or 62 500 t/yr, the value of soybean grain in tropical regions is $19 M/yr. The benefits of soybean in a cane rotation range from increase of 15 percent to 30 percent depending if grain if harvested or green manure. This projects to a value of ~ $15 M annually to the sugar crop where harvested for grain and ~ $30 M annually for cover crop. The projected annual value of soybean in tropical production systems in 2010 is $60-65 M. Additional benefit through the provision of locally produced and competitively priced protein meal to intensive livestock industries (chicken, pig, aquaculture), have not been included but are substantial. It is likely that this region will initially produce beans for crushing and stockfeed markets and for less quality sensitive human consumption markets such as flour or export to Asia. First exports of 100 t soybean grain from the Burdekin to human consumption markets in Indonesia have occurred from the 2005 crop. It is anticipated that around half of the projected annual benefit of soybean to tropical farming systems will be directly attributable to release of Stuart, this amounts to about $30 M annually by 2010.

Southern Qld coastal (Maryborough –Nambour). Similarly to North Qld coastal, soy is a recent addition to the cropping system. About 150 000 ha in this region is potentially suited to soybean. Growers have greater capacity both for managing soybean crops though to harvest and for inclusion of other crops into their cropping system. Uptake of soybean into this region is therefore likely to increase faster than further north, but peak earlier. It is therefore estimated that around 15 000 Ha in soybean grain production is likely by 2010, giving a production of 37 500 t at a value of soybean grain (assuming half crushing at $300 and half culinary at $500) from this region of $15 M/yr. It is anticipated that around 30 percent of this production will come as a result of the release of Stuart, this amounts to about $4.5 M annually by 2010.

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. While distance from Australian oil and protein markets is a constraint, proximity to high value human food and feed markets in SE Asia provides unique export opportunities. Market development will be a major challenge for the northern coastal sugar areas. Given the region's proximity to SE Asia, the export of high value food and feed grains is a realistic option. Likewise, there is opportunity for high value grains (i.e. with specific amino acid/nutritional profiles and free of adverse growth factors) for the rapidly developing NQ aquaculture industry and for aquaculture in SE Asia. For both food and feed grain, Australia's status as a GMO-free supplier is a major advantage.

Breeding Priorities

1. High yielding, high value varieties. Locally adapted high-value varieties are needed that are suitable for export into Asia for the human food and for the aquaculture feed markets (locally as well as Asia). Considerable progress has been made in developing germplasm with the requisite quality attributes for whole-bean export into specialty Asian food market (e.g. tofu, edamame, natto, etc). Because soybean is sensitive to photo-thermal conditions, southern varieties cannot be simply transferred into the topics, and breeding R&D is required to build tropical adaptation into these lines. This work needs to be complemented by R&D to extend the range of high value attributes to include processing qualities, such as enzyme active flour and specific amino acid profiles.

2. Weathering tolerant varieties. Weathering is likely to emerge as a problem with wet season crops in some of the more humid coastal areas, and while opportunity exists for adjusting sowing dates to minimise risk, a reasonable level of varietal resistance is critical for new markets to be developed for high value product in SE Asia. It will be possible to build on the past breeding successes that produced varieties resistant to weathering under humid conditions in northern NSW. However, a breeding response is required to develop local adaptation to day lengths and temperatures in the tropics. Soybean varieties that are adapted to northern coastal NSW will not be adapted in northern coastal Qld.

3. Varieties suited to different rotation niches. It is unrealistic to expect that any one variety would be adapted across the range of potential coastal/sub-coastal environments (spanning latitudes 10-27 ^{o}S) where soybean might be grown, especially given its photo-thermal sensitivity. In addition, while the main opportunity for near future will be as a summer (wet season) crop in fallow sugar areas, locally-adapted varieties are needed for nearby areas (e.g. Atherton Tableland, lower Cape) where irrigated dry season crops can be grown, and for the additional rotational niches where soybean might be grown in the sugar system. For example, there is increasing interest in growing soybean as a companion crop in ratooning sugarcane for both rotational benefits and additional cash flow. Short duration high value soybean is likely to be needed to best suit a companion cropping system.

These research needs are being implemented in part in the new SRDC funded soybean project. Adequate implementation of #1 and #2 above will however require some input from the GRDC through the national soybean improvement project with is being negotiated October-December 2005.

Recommendations:

1. That soybean cropping continue to expand in normal sugarcane cropping systems and ongoing development of new varieties and improved agronomic methods be encouraged.
2. That Stuart be used in north Qld instead of Leichhardt where grain soybean is required.
3. Stuart be used in southern Qld as either green manure or grain soybean, but only be sown late (mid January or later) as a grain crop.
4. Some more work be done on the push me-pull you approach to varietal evaluation given the declining funds that agencies are willing to commit to traditional white-peg evaluation and the need to combine technology transfer with new varietal release.

Appendix 1.

Data presented here is the average of trials conducted in the Burdekin Irrigation area, the Atherton Tablelands and in south-east Qld over the period 2000-2004.

	Physiological Maturity (harvest maturity is another 7-12 days)	Seed Size (g/100 seed)	Grain protein content (%DM)	Grain Yield (t/ha)	Wet season grain yield (t/ha)	Dry season grain yield (t/ha)
Stuart	116	20.1	42.9	3.37	3.27	3.64
Leichhardt	121	16.3	41.7	2.86	3.00	2.50
YY	112	20.6	42.7	2.84	2.81	2.91
lsd (0.05)	2	1.3	0.9	0.35		
G x E	**	n.s.	*	**		

Stuart is the first variety for coastal and tropical Qld with a light hilum which should make its grain suitable for some human consumption markets. Growers have sought a tropically-adapted light hilum cultivar so that they may gain access to premiums for such grain. Stuart is broadly adapted to planting in both the wet and the dry season in the tropics and to planting from around Nambour through to North Qld. Adaptation to dry-season planting is important as it can help to overcome the problem of poor seed quality common in the tropics. Dry season crops mature seed at a time when conditions are highly conducive to production of high quality seed, and seed only need be stored for a short time before planting.

Stuart appears to possess a gene of major effect for resistance to soybean rust (*Phakopsora pachyrhizi*) in a somewhat tolerant genetic background. Stuart has also been selected for resitance to bacterial pustule (*Xanthomonas campestris pv. phaseoli*), bacterial blight (*Pseudomonas syringae pv. glycinae*), downy mildew (Peronospora manshurica) and purple seed stain (Cercospora kikuchii). No symptoms of virus have bee notes in crops of Stuart or on its seed.

Stuart matures a few days later than YY but a few days to more than 10 days earlier than eichhardt. This is because Stuart has greater stability of maturity time over differing daylengths than Leichhardt. Stuart has higher grain yield than both YY and Leichhardt. Dry matter or green manure yields of Stuart approach that of Leichhardt, and are superior to that of YY.

Stuart is generally taller than both YY and Leichhardt and is reasonably adapted to row spacing from 0.5 to 1.2m. Plant populations around 30 plants per m2 are preferred.

Stuart has a light grey hilum compared with brown hila of Leichhardt and YY. In some environments, the hilum colour is effectively colourless whilst on others it appears light grey.

To date insufficient samples have been made into tofu to draw a conclusion, however from samples tested to date Stuart appears somewhat similar in tofu making potential as other light hilum varieties from Qld. Stuart also appears to make soymilk and flour of quality similar to other light hilum varieties from Qld.

Stuart was bred and initially selected by CSIRO with funding support from ACIAR and SRDC.

Appendix 2.

Plant Breeders Rights application

Details of Application

Application Number	2005/056
Variety Name	'Stuart'
Genus Species	*Glycine max*
Common Name	Soybean
Synonym	Nil
Accepted Date	18 Apr 2005
Applicant	Commonwealth Scientific and Industrial Research Organisation
Agent	Nil
Qualified Person	Andrew James

Details of Comparative Trial

Location	CSIRO Cooper research station, Gatton 4343
Descriptor	
Period	31 Jan 2005 to 30 May 2005
Conditions	Trial sown on 31 Jan 05 into 1.5 metre beds formed from a well-prepared seed bed. Trial watered every 14 days and maintained substantially free of insect pests except whitefly which caused some damage.
Trial Design	A randomised complete block design with three replicates. Each plot consisted of a one metre row containing 25 plants.
Measurements	Plants scored for hypocotyl colour, hypocotyl anthocyanin pigmentation, stem termination, plant growth habit, plant pubescence colour, plant height, leaf blistering, shape of lateral leaflet, size of lateral leaflet, leaf intensity of green colour, flower colour, pod intensity of brown colour, seed size, seed shape, seed coat colour, seed hilum colour, seed colour of hilum funicle. Days to flowering and physiological maturity were taken on a plot basis. At maturity average main stem length and average number of main stem nodes were recorded on a five plant sub-sample from each plot.

Origin and Breeding

Controlled pollination: seed parent 'CM60-10KR-71' x pollen parent 'WAM 392. The F_1 hybrid was made in the glasshouse of CSIRO, St Lucia Brisbane in Apr 1999. The F_1 seed was harvested in May 1999 and a single seed sown in Jun 1999. The plant was verified as an F_1 by very light grey hilum colour in seed harvested from the F_1 plant compared with dark brown hilum of the maternal parent and yellow hilum of the pollen parent. Seed was harvested from the F_1 plant in Oct and immediately sown. Upon maturity, F_2 seed was sown in the field at Walkamin. Single plants possessing apparent immunity to soybean rust (*Phakopsora pachyrhizi*) and late maturity were advanced to the F_3 and F_4 generation. The F_4 generation was again grown in Walkamin in 2001 and single plant selections made for light hilum, apparent immunity to soybean rust (*Phakopsora pachyrhizi*) and upright plant architecture. Varietal evaluation for grain yield and agronomic traits was then conducted in Jun sowing at Ayr in 2001 through to 2004 and in Dec and Jan sowing dates in Ayr and Walkamin in 2001 though to 2004. Grain from all trials was evaluated using a near infra red analyser for protein and oil content. In the summer of 2002/03, selections were made for resistance to bacterial pustule bacterial pustule (*Xanthomonas campestris* pv. *phaseoli*), bacterial blight (*Pseudomonas syringae* pv. *glycinae*) and downy mildew (*Peronospora manshurica*). Grain from the 2003 harvests was also evaluated for tofu quality traits. Seed with a brown hilum rather than grey occurs as an off type at a frequency of less than one in one thousand seed. Selection criteria: light hilum, late maturity, soybean rust immunity, high grain and dry matter yield. Breeder: Andrew James, CSIRO, St. Lucia, QLD.

Choice of Comparators

Characteristics used for grouping varieties to identify the most similar Variety of Common Knowledge		State of Expression in Group of Varieties
Organ/Plant Part	**Context**	
Plant maturity	time of maturity	late to very late
Pubescence	colour	tawny
Flower	colour	violet
Hypocotyl	anthocyanin colouration	present
Plant height	height	tall
Leaf	shape of lateral leaflet	pointed ovate
Leaf	size of lateral leaflet	medium
Seed	ground colour of testa	yellow
Plant flowering	time of beginning of flowering	late to vary late

Most Similar Varieties of Common Knowledge identified (VCK)

Name	Comments
'Leichhardt'	
'CM60-10KR-71'	'CM60-10KR-71' is thought to be a mutant differing by enhanced rust tolerance and flower colour from its parent variety CM60 from Thailand. CM60-10KR-71 is a parent of Stuart.
'WAM 392'	'WAM 392' is a selection from the cross Warrigal x Manta. 'WAM 392' is a parent of 'Stuart'.

<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	'Stuart'	'CM60-10KR-71'	'Leichhardt'	'WAM 392'
☐ *Hypocotyl: anthocyanin colouration	present	absent	present	present
☐ Hypocotyl: intensity of anthocyanin colouration	strong		strong	strong
☐ *Plant: growth type	indeterminate	indeterminate	determinate	determinate
☐ Plant: growth habit	erect to semi-erect	semi-erect	semi-erect	erect
☐ *Plant: colour of hairs of main stem	tawny	tawny	tawny	grey
☐ *Plant: height	tall to very tall	tall to very tall	medium to tall	medium
☐ Leaf: blistering	medium	medium	medium	medium
☐ *Leaf: shape of lateral leaflet	pointed ovate	pointed ovate	pointed ovate	rounded ovate
☐ Leaf: size of lateral leaflet	medium	medium	medium	medium to large
☐ Leaf: intensity of green colour	medium	medium	medium	medium
☐ *Flower: colour	violet	white	violet	violet
☐ Pod: intensity of brown colour	medium	dark	medium	very light
☐ Seed: size	medium to large	small to medium	small to medium	medium to large
☐ Seed: shape	spherical flattened	spherical flattened	spherical flattened	spherical flattened
☐ *Seed: ground colour of testa	yellow	yellow	yellow	yellow
☐ *Seed: hilum colour	grey	dark brown	dark brown	yellow
☐ Seed: colour of hilum funicle	same as testa	same as testa	same as testa	same as testa
☐ *Plant: time of beginning of flowering	late to very late	late to very late	late to very late	medium to late
☐ *Plant: time of maturity	late to very late	late to very late	late to very late	medium to late

Statistical Table				
	'Stuart'	**'CM60-10KR-71'**	**'Leichhardt'**	**'WAM 392'**
Flowering: time of 50% flowering (days)				
Mean	44.00	46.33	52.67	33.67
Std. Deviation	1.00	0.58	0.58	0.58
LSD/sig	1.13	P≤0.01	P≤0.01	P≤0.01
Maturity: time of physiological maturity (days)				
Mean	107.33	118.00	118.67	98.00
Std. Deviation	2.08	0.00	0.58	1.00
LSD/sig	3.18	P≤0.01	P≤0.01	P≤0.01
Nodes: number of nodes on the main stem (count)				
Mean	18.73	17.93	17.13	9.33
Std. Deviation	0.81	0.12	0.23	0.31
LSD/sig	0.74	P≤0.01	P≤0.01	P≤0.01
Height: length of the main stem (cm)				
Mean	64.26	69.07	61.27	32.33
Std. Deviation	0.70	1.85	2.32	2.04
LSD/sig	3.54	P≤0.01	ns	P≤0.01

Prior Applications and Sales

Nil.

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