Taro Industry Development in Australia
— The first steps —

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Taro Industry Development in Australia:

*The first steps*

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Foreword

Taro (*Colocasia esculenta*) production is not new to Australia but it has only become significant over the last few years. It has an estimated value of $4 million and is predominantly located in the wet tropics of north Queensland.

This project addressed several issues that were considered to be hampering development of the industry. It assesses the current state of the industry and explores the agronomy of taro, including cropping strategies, pest and disease issues and the accessibility of existing technical information. It also addresses the lack of an R&D strategic plan.

The Australian taro industry was surveyed to identify R&D needs, other information needs and to provide a snapshot of crop production practices. An R&D Strategic Plan meeting was held to consult with Stakeholders. Integrated pest management and market development studies were identified as the most pressing needs of the industry.

In response, a taro industry information resource centre was assembled which functions as a hard copy loan library. It is administered by Taro Growers Australia, and subsequent collaboration with the Queensland University of Technology in the ACIAR *Taro Pest* project has resulted in the production of colour field guides on taro pests and diseases, plus a diagnostic software package for Australian growers.

This project was funded by RIRDC core funds which are provided by the Australian Government through the Asian Foods Program and the Queensland Government.

This report, an addition to RIRDC’s diverse range of over 1800 research publications, forms part of RIRDC’s Asian Foods R&D program, which aims to foster the development of a viable Asian Foods industry in Australia.

Most of RIRDC’s publications are available for viewing, downloading or purchasing online at [www.rirdc.gov.au](http://www.rirdc.gov.au). Purchases can also be made by phoning 1300 634 313.

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Managing Director  
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Acknowledgments

The authors would like to thank all taro growers who contributed to this project and, in particular, Philippe Petinaud, Sam Phillips, Rod Hourston, John Doyle, Ken Lake, Peter Salleras, Khuong Nguyen and Sok Lee.

Abbreviations

ACIAR  Australian Centre for International Agricultural Research
AQIS  Australian Quarantine and Inspection Service
BA  Biosecurity Australia
DPI&F  Department of Primary Industries and Fisheries (Queensland)
QUT  Queensland University of Technology
RIRDC  Rural Industries Research and Development Corporation
TGA  Taro Growers Australia
Contents

Foreword ................................................................................................................................. iii
Acknowledgments ....................................................................................................................... iv
Abbreviations .............................................................................................................................. iv
Contents ......................................................................................................................................... v
List of Figures ............................................................................................................................... vi
List of Tables ................................................................................................................................... vii
Executive Summary ....................................................................................................................... viii
What the report is about .............................................................................................................. viii
Who is the report targeted at? ...................................................................................................... viii
Background .................................................................................................................................... viii
Aims/objectives ............................................................................................................................ viii
Methods used .............................................................................................................................. viii
Results/key findings ..................................................................................................................... ix
Implications for relevant stakeholders ...................................................................................... x
Recommendations ...................................................................................................................... xi

1. Introduction ................................................................................................................................ 1
1.1 Background to project ............................................................................................................... 1
1.2 Industry situation and market opportunities .......................................................................... 1
1.3 Objectives of the project ........................................................................................................... 5

2. Method ......................................................................................................................................... 6
2.1 Survey of current industry practices/problems ........................................................................ 6
2.2 Development of information resource .................................................................................... 6
2.3 Taro information workshops ................................................................................................ 6
2.4 Field monitoring sites ............................................................................................................. 6
2.5 R&D strategic plan .................................................................................................................. 7

3. Results and discussion .............................................................................................................. 8
3.1 Survey of current industry practices/problems ........................................................................ 8
3.2 Development of information resource .................................................................................... 8
3.3 Taro information workshops ................................................................................................ 11
3.4 Field monitoring sites ............................................................................................................. 16
3.5 Research and development strategic plan ............................................................................. 27

4. Implications and recommendations .......................................................................................... 30
Implications ................................................................................................................................. 30
Recommendations ...................................................................................................................... 30

5. Publications .............................................................................................................................. 32

6. Appendices ................................................................................................................................ 33
Appendix A: International taro symposium poster ................................................................. 33
Appendix B: Taro crop nutrition management – a review of the literature ................................ 37
Appendix C: Newspaper project announcement ........................................................................ 47
Appendix D: AuSHS conference poster ..................................................................................... 48
Appendix E: Australian taro industry benchmark survey ....................................................... 49
Appendix F: R&D strategic planning workshop ......................................................................... 50
List of Figures

Figure 1: Cleaned Bun Long taro corms on wheel ready for packing .......................................................... 2
Figure 2: Taro Niue is a Pacific type taro favoured by Polynesians ............................................................. 3
Figure 3: Taro leaf blight is a serious exotic disease threat to taro production ............................................... 3
Figure 4: Attendees to the Third International Taro Symposium .................................................................. 4
Figure 5: TGA field day examining the application of bagasse for weed control in taro using a manure spreader ....................................................................................................................... 7
Figure 6: The Taro Industry Information Resource .............................................................................. ........ 8
Figure 7: Identifier on each item in the resource ......................................................................................... 10
Figure 8: Shot hole is similar in appearance to taro leaf blight ................................................................... 10
Figure 9: One manifestation of corm rot with young lesions at edge of corm – *Fusarium solani* ..................... 11
Figure 10: Corm rots can quickly destroy the corm ...................................................................................... 11
Figure 11: Cluster caterpillar skeletonising leaves ........................................................................................ 13
Figure 12: Cluster caterpillar attacking leaves as they emerge .................................................................... 13
Figure 13: Corm borer damage symptoms – entry points for disease development ..................................... 14
Figure 14: Corm borer damage symptoms – entry points for disease development ..................................... 14
Figure 15: Coccotrypes cypri adults feeding in taro (red bar is 3 mm) .......................................................... 14
Figure 16: Coccotrypes cypri adult and larvae ............................................................................................. 14
Figure 17: TaroPest was made available to all Australian Taro Growers ..................................................... 15
Figure 18: Amy Carmichael presenting TaroPest at growers workshop in north Queensland ..................... 15
Figure 19: Tony Clarke discussing the background to TaroPest at growers workshop .................................. 15
Figure 20: Northern Territory trial site at planting ....................................................................................... 17
Figure 21: Response of marketable yield to applied fertiliser ...................................................................... 18
Figure 22: Relationship between petiole nitrate levels of taro and SPAD readings ....................................... 20
Figure 23: Cultures used in inoculations ..................................................................................................... 21
Figure 24: Wilt symptoms caused by corm rot in glasshouse trial .................................................................. 21
Figure 25: Corm rots can cause wilt during crop growth ............................................................................ 23
Figure 26: Severe corm rot that occurred well before harvest ....................................................................... 23
Figure 27: Sometimes taro grower Steve Scopoletti is dwarfed by the ‘Giant’ Bun Long selection ............... 24
Figure 28: ‘Standard’ Bun Long often does not grow taller than the crop shown ........................................ 24
Figure 29: Taro growers inspecting specialty potatoes as they enter the packing shed on Serra Farms .......... 25
Figure 30: Sam Phillips fighting taro imports ............................................................................................... 26
Figure 31: Taro corms damaged by taro beetle in PNG ............................................................................... 27
Figure 32: Japanese taro imported from China showing live growing points ............................................... 27
Figure 33: Key to taro nutrient disorders (from Miyasaka et al. 2002) .......................................................... 38
Figure 34: Time course of leaf N, P and K levels in Northern Territory fertiliser trial .................................. 43
Figure 35: Innisfail Advocate 2 September 2004 .......................................................................................... 47
Figure 36: Poster displayed at AuSHS Coolum conference ........................................................................... 48
List of Tables

Table 1: Titles in the Taro Industry Information Resource

Table 2: Taro disease samples received by DPI&F and organisms recovered

Table 3: Pests recorded on 2 taro growers properties (Tully/Innisfail) June 2005 – June 2006

Table 4: Effect of fertiliser rates on marketable yields of taro

Table 5: Within leaf variability in SPAD readings

Table 6: Pathogenicity of *R. solani* and *F. solani* and the use of mancozeb and benomyl to control crm rot of taro

Table 7: Effect of *Erwinia chrysanthemi* and *Pythium* sp. on the development of crm rot and root rot of taro grown in a glasshouse

Table 8: Taro Production / Consumption Statistics

Table 9: Number of migrants from selected Asian/Pacific countries resident in Australia, 30 June 1976, 30 June 1991, 30 June 2001

Table 10: Number of migrants from selected countries resident in USA, 2000

Table 11: Potato Production / processing

Table 12: Range in chemical composition of taro corms (after Bradbury and Holloway 1988 & modified by Blamey 1996), and the ranges in nutrient removal by a crop of 8 t/ha (av. yield in Pacific) and of 65 t/ha (estimated yield potential)

Table 13: Preplant fertiliser applications based on soil analysis

Table 14: Taro leaf blade nutrient concentrations associated with deficiency, sufficiency and toxicity

Table 15: Post-planting fertiliser application recommendations for flooded (paddy) taro based on leaf analysis
Executive Summary

What the report is about

This report presents the results of a taro industry development project which included: a survey of current industry practices/problems; development of an industry information resource; information workshops; and an R&D Strategic Plan.

Who is the report targeted at?

This project was developed at the request of Taro Growers Australia (TGA) and was conducted principally for the benefit of Australian taro growers and those considering entering the industry. The report will also serve as a valuable reference for relevant research, development and extension staff. The report includes recommendations for future R&D, which should be considered by growers, industry representative bodies, researchers and fund provider/investors alike in developing or assessing projects.

Background

Taro (Colocasia esculenta) is not a new crop to Australia but it is only in the last few years that a significant industry has emerged, situated mainly along the wet tropical coast of north Queensland. At a RIRDC New Plant Products Review Workshop held in February 2003, taro was nominated as a crop with considerable potential and deserving of increased research and development investment.

Several factors were considered to be hampering industry development not least of them being (inter alia): limited knowledge of what was actually happening in the industry including cropping strategies; pest and disease issues; poor access to existing information about the crop; and lack of an R&D strategic plan. Taro Growers Australia requested a project be funded to secure further information to support the development of the industry. The request was the impetus for this project.

Aims/objectives

This project sought to assist in the sustainable development of the Australian taro industry by increasing the availability of information. It was considered that enhanced access to relevant information would lead to adoption of improved production practices including sustainable pest control strategies and plant nutrition management.

Methods used

This project was conducted in close consultation with industry representatives and included the following:

- Survey/benchmarking of current industry practices/problems to provide a snapshot of the industry
- Provision of an information resource for the taro industry
- Taro information workshops
- Field monitoring sites
- Development of an Australian Taro Industry R&D Strategic Plan.
Results/key findings

Industry survey
A mail survey questionnaire was sent out to taro growers in 2005 seeking information on producer background, industry needs, sources of information, production costs and general farm practices. Eighty-six per cent of producers had been involved in the industry for less than six years. During the course of the project it also became quite evident that there is a significant turnover of growers producing taro.

Taro plantings were small in area with 96% of producers growing crops of two hectares or less.

R&D needs were mostly split between market development/market pricing and control of pests and diseases/registration of chemicals for the industry. Growers also demonstrated a preference to for either electronic or paper-based information, although no single method is likely to be sufficient.

Average industry yields were about 15 t/ha, with main markets existing in Sydney and Melbourne. A break-even point for production was about $2/kg.

Information resource
A taro industry information resource was put together, comprising booklets and DVDs, on taro growing and related matters, drawing from information from around the world. The resource contains about 50 items and is operated as a mobile loan library administered by Taro Growers Australia. Unfortunately to date, the library has had limited use, which could be partly attributed to infrequent Taro Growers Australia meetings and declining attendance at meetings.

Information workshops
In the lead up to the pest and disease workshop, taro disease samples were identified and pests were monitored on two properties. Whilst this was taking place, a new pest was found called scolytine weevil (Coccothrips cypeni). It is possibly associated with corm rot.

Guest speakers at the workshop from QUT spoke about the diagnostic software package TaroPest and demonstrated its use to growers. Feedback highlighted the necessity for a hardcopy, weather-proof guide to enable in-field identifications. A photograph-rich field guide was produced by QUT in response to this need. Copies of this guide were provided free to Australian taro growers via Taro Growers Australia. The field guide includes a self running CD-rom version of the TaroPest website (taropest.sci.qut.edu.au)

A crop nutrition workshop was proposed and as background to the workshop relevant literature was reviewed. This literature generated the content for the workshop, which was attended by 15 growers.

Monitoring blocks
A taro fertiliser requirement trial in the Northern Territory demonstrated that 60% of the normal fertiliser rate was sufficient to attain 95% of maximum yield. A subsequent fertigation demonstration block on the trial property using the 60% rate helped convince the grower that reducing fertiliser rates is viable. This should greatly reduce potential losses of nutrients such as N and P to the environment.

Corm rot and root rot are serious diseases of taro and an important constraint to production on the wet tropical coast of north Queensland. Rhizoctonia solani and Fusarium solani isolated from corm rot samples were proven to be pathogenic on taro corms forming rots. Benomyl was shown to have potential as a pre-plant treatment control measure. Pythium sp. were shown to cause severe root rot but along with Erwinia chrysanthemi did not cause corm rot in the glasshouse study. Circumstantial evidence from the industry survey indicated that those with falls greater than three years had no problem with rots, whilst those with less than one year fallow all had rots and, for those in-between,
some had rots and some didn’t. This indicates that being able to fallow for long periods is probably advantageous in the management of taro corm rots.

Fresh taro (Japanese taro and Bun Long) began to be imported to Australia from mainland China during the course of the project and was sold for about $2/kg wholesale making it very difficult for Australian growers to remain profitable. Importation of taro from China raised a number of issues which were brought to the attention of AQIS and Biosecurity Australia.

Small Australian horticulture industries, like taro are most susceptible to incurring competition from overseas imports due to rapid completion of the assessment of import risks which do not fully take into account the quarantine risks involved.

Existing AQIS import requirements need to be enforced and fresh corms imported from countries with major exotic pest and diseases pose a risk and should be treated accordingly.

R&D strategic plan
The stakeholder meeting reinforced earlier findings from the industry survey with priorities being:

- implementation of IPM and registration of chemicals
- market development with emphasis on promotion of health aspects to capture new consumers
- continuation of the monitoring of taro importation activity.

Implications for relevant stakeholders
The industry survey has benchmarked current industry practices providing a snapshot of the industry for planning and future reference.

Collaboration with QUT in the ACIAR TaroPest project has made it possible for taro growers to now have a practical colour field guide to most of their pest and disease problems as well as an authoritative database of information on these pests and diseases.

A taro fertiliser requirement trial in the Northern Territory demonstrated that 60% of the normal fertiliser rate was sufficient to attain 95% of maximum yield. This showed that there is a significant opportunity to reduce fertiliser use in the industry without resulting yield loss and greatly reducing potential losses of nutrients such as N and P to the environment.

A literature review prepared on nutrition of the crop provides the basis for an approach to improve overall management for improved efficiency of fertiliser use and reduced impact on the environment.

Putting an end to the importation of taro from China means that the major disease risk to the industry that importation posed has been halted. This has already translated to improved profits for growers. Merchants no longer have the leverage of cheap imported product to lower the market prices received by growers.

Throughout the project there has been strong emphasis on relationships. Relationships are vital to grower support and involvement, to maximise project impacts and the flow of information to the industry. Especially important was the collaboration with QUT on TaroPest outputs. Building bridges with outside organisations added value to projects.
Recommendations

The R&D Strategic Plan developed with industry has recommended that their priorities lie with the implementation of IPM and registration of chemicals for the industry. Also market development should be a priority including drawing attention to the health benefits of taro and also the continuation of Taro Growers Australia’s efforts to ensure that imported taro does not pose a pest and disease risk to their industry. Projects on these subjects need to be supported to both maintain the industry and move it forward.

Most taro is consumed by the Asian and Pacific Islander ethnic markets. Market development to broaden the consumer/market base domestically could involve investigating new taro varieties, particularly those with texture preferred by the western palate. Suitable varieties have been identified in Hawaii and Vanuatu which should be imported for evaluation.

Taro Growers Australia has developed a website with links to various publications. The impact of the taro industry information resource could be increased by obtaining permission to scan the publications from the resource not currently available on the internet and post them on the Taro Growers Australia site.
1. Introduction

1.1 Background to project

Taro (*Colocasia esculenta*) is not a new crop to Australia but it is only in the last few years that a significant industry has emerged, based mainly on the wet tropical coast of north Queensland. In 2001 Taro Growers Australia was formed. Associated with this development has been the completion of three RIRDC funded projects. One looked at increased industry mechanisation; another was the development of small corm taro for export; and a third investigated commercialisation of taro chip (crisp) production.

On 12-13 February, 2003, at the RIRDC New Plant Products Review Workshop, taro was nominated as a crop with considerable potential and deserving of increased research and development investment.

Several factors were considered to be hampering industry development. These included (*inter alia*): limited knowledge of what is actually happening in the industry including cropping strategies; pest and disease issues; poor access to existing information about the crop; and lack of an R&D strategic plan. Taro Growers Australia requested another project be funded on taro industry development covering these issues, thus creating the basis for this project.

1.2 Industry situation and market opportunities

Industry statistics are very limited but Australian production was estimated at commencement of the project at 1 000-1 500 tonne with a wholesale value of about $6 million to the 150 or so growers\(^1\). The main variety grown is Bun Long which is also known as Chinese taro. This variety is mostly consumed by the ethnic Asian community in Australia. Smaller quantities are also produced of Pacific varieties including Taro Niue and the small corm taro, Ishikawa Wase.

The industry is mostly based in north Queensland with smaller plantings in southern Queensland, the Northern Territory and New South Wales. There are also imports of taro to Australia which are about two to three times that of domestic production. Most of the imports come from Fiji with the main variety imported being Taro Niue. Processed taro in the form of frozen corm pieces are also imported from a number of Asian countries including Thailand and Vietnam. The main market in Australia for the Pacific taro is the significant Pacific Islander community that traditionally consume relatively large quantities per person. There were approximately 100 000 people of Pacific Island birth, including Papua New Guinea, resident in Australia at the June 2001 census.

Participants at the RIRDC New Plant Products Review Workshop in 2003 were of the opinion that the taro industry had considerable potential being ranked as the third most important exotic crop of the future behind rambutan and mangosteen. A visit to the southern markets in April/May 2003 by Brett Wedding et al. indicated that merchants could sell a great deal more taro if growers could deliver consistent supply (volume) and consistent quality (grade standards). Thus, coordination of supply of product to the marketplace would appear to be crucial to achieve significant increases in sales. In particular, the Australian industry must ensure that they do not oversupply the market from March to July when imports from the Pacific Islands are greatest. However, the industry must first improve their agronomic capability to produce a quality product. Taro Growers Australia began addressing this issue

\(^1\) Growers come and go regularly in the industry but the 150 anecdotally reported to be involved appears to be a considerable over-estimate. The authors estimate that 30 to 40 would be a closer approximation of growers involved in the taro industry in Australia.
at their September 2003 association meeting which led to a subcommittee putting together grading and packaging standards. This was circulated to the industry for adoption and implementation.

Merchants indicated that fresh Pacific taro from north Queensland was of a superior quality to imported taro from Fiji. Thus, if Pacific taro could be produced at a competitive price then a market two to three times greater than for Bun Long would open up to producers. To be competitive with these imports Australian producers will need to improve their efficiencies of production so that the market price they need to receive to make worthwhile profits can be reduced. It was hoped this project would contribute via flow-on increases in productivity and/or reduced costs of production.

Figure 1: Cleaned Bun Long taro corms on wheel ready for packing

Increased mechanization in the industry will also be crucial in making the industry more competitive and facilitate the development of larger farming operations. Reducing labour costs are vital to success in competing with products from countries with cheaper labour costs. It was expected that the RIRDC project ‘Taro production mechanization and industry development’ which was completed in 2006 would develop mechanical harvesting and processing equipment to improve efficiencies of production but at its completion the prototypes were still far from ready for commercial growers.

Currently, most growers have relatively small areas of taro and are not capitalized enough to make big mechanization steps. Information from southern wholesale markets suggests that when the price falls below $2.50/kg ($2 to the grower) taro sales are high. Thus, consumer demand can be greatly increased if more efficient production can be implemented.

Another RIRDC project: ‘Commercial taro chip development using agrichain partnerships,’ examined the opportunity for adding value to the product to increase overall market sales whilst being able to utilize second grade and oversupplied product. The processing of taro in this way was further supported by a grant of $100 000 from the New Industries Development Program (NIDP) to establish a taro chip factory at Babinda, north Queensland. This factory is expected to commence production in 2008. Projected sales of taro chips, at one stage, were 1.75 tonne in the first year building to 25 tonne after four years. Twenty-five tonnes of chips would require 87.5 tonne of fresh taro corms (x3.5) each
year which represents <10% of the current production of the variety Bun Long, which is the preferred
variety because of its low acridity. These projections are extremely conservative because of the
relatively high price that needs to be received for the product but it is interesting to note that in the
consumer acceptance panel 3% of panellists said they would buy taro chips “at any price”.

Figure 2: Taro Niue is a Pacific type taro
favoured by Polynesians

Figure 3: Taro leaf blight is a serious exotic
disease threat to taro production

Market performance over the next two years will provide a better idea of just how significant a market
can be built. Since the beginning of this development there has been a shift in expected outputs away
from taro and more to cassava and potatoes which can be purchased from growers for considerably
less per kilogram.

There may also be good prospects for expanding market sales by the development of ready-to-cook
frozen taro products. This includes both chips (fries) ready for frying and corm sections ready for
boiling. It will need to be a high quality product with particular attention given to the supply chain to
ensure that the market is not eroded by cheap imports from Asia and the Pacific. Taro fries are
particularly interesting because they will be more readily accepted by Western palates and sales should
be significant when one considers that 40% of all English potatoes reach the frozen fries market.

As indicated, most of the consumption of taro in Australia is by Asian and Pacific Islander
communities which represent less than 7% of the population. This means that per capita consumption
is only 0.2 kg/person/year compared with about 60 kg for potato (Solanum tuberosum). Absolute and
proportional consumption should increase with time due to continued immigration and the desire for
greater choice by the general consumers. As agronomic capabilities improve increases in production
can be expected. This creates a need to increase demand for taro by via promotion/marketing.

Promotion/marketing could exploit some of the following features of taro:

1. A new exotic food for most of the population
2. Chips (crisps and fries) are better for you than potato chips because taro absorbs a great deal
   less oil during the frying process
3. Taro has a low glycemic index (GI factor) i.e. it provides slow sustained release of energy to the body. Thus it is a desirable food in the treatment and prevention of the blood sugar disorders diabetes and hypoglycemia which are rampant in the western world.

Other factors that could greatly alter the status quo in the market relate to imports and exports. If taro leaf blight (*Phytophthora colocasiae*) became established in Fiji then production of the susceptible variety Taro Niue would be largely destroyed, so that there would be little of this preferred variety available for export to Australia. This would make an easy road for import substitution in Australia and possibly export to New Zealand.

![Figure 4: Attendees to the Third International Taro Symposium](image)

Left to right, Jeff Daniells (Queensland DPI&F), Peter Salleras (long term taro grower), and Philippe Petiniaud (inaugural President Taro Growers Australia) in a crop of Bun Long taro in North Queensland

The third RIRDC project completed: ‘Development of taro, yam, yam bean and sweet potato exports to Japan and USA,’ targeted development of small corm taro (Japanese taro) particularly for the export market. This taro is quite distinct from the large corm taro types such as Bun Long and Taro Niue. To date, development of an export market has been disappointing but if negotiations in Japan progress well, a significant market for fresh product might eventually open.

In the lead up to the commencement of the project reported here Mr. Daniells attended the Third International Taro Symposium in Nadi, Fiji 21-23 May 2003. This was valuable in that it provided a forum to meet people involved in the taro industry internationally. Mr. Daniells compiled a trip report and together with two NQ growers who also attended, contributed an article for *Good Fruit and Vegetables* (Oct 2003 pp 43-45) detailing symposium highlights and implications for the industry. At about the same time Mr. Daniells was asked to contribute a chapter on large corm taro for RIRDC’s *The new crop industries handbook*, which he again co-authored with the two prominent NQ growers.
1.3 Objectives of the project

The project objectives were to assist in the development of the Australian Taro Industry by:

- Survey/benchmarking of current industry practices/problems to provide a snapshot of the industry
- Provision of an information resource for the taro industry
- Unlocking taro information workshops
- Field monitoring sites testing workshop recommendations
- Development of an Australian Taro Industry R&D Strategic Plan.
2. Method

The project was developed at the request of Taro Growers Australia (TGA). The project leader attended TGA meetings/field walks, and through this involvement provided technical support when required and kept growers informed of project progress and industry developments. An industry steering committee, which was drawn predominantly from the TGA executive, provided input into the various components of the project to meet industry needs. Additionally, Messrs Daniells and Vawdrey, handled numerous taro industry enquiries during the course of the project. Providing assistance to growers in a timely manner and building relationships were vital in achieving credibility with the industry and ensuring industry participation in the various aspects of the project.

2.1 Survey of current industry practices/problems

The taro industry was surveyed by mail to establish current industry practices in key areas as well as perceived problems/opportunities and information needs. Particular attention was given in the survey of industry practices to ensure that an environmental benchmark was established so that industry progress could be monitored over time. The results were analysed and reported back to industry.

Pest and disease specimens were collected during the project to gain an understanding of the pests and diseases that are causing problems in the industry.

2.2 Development of information resource

Prior to the commencement of the project, some taro information was already available to growers via DPI&F information centres, various websites and the TGA newsletter. During the project we substantially upgraded the range of relevant information available by purchasing publications and assembling them in to a small mobile library for use by TGA members.

2.3 Taro information workshops

Workshops covering the following subjects which had already been identified by the taro industry included:

- Pest identification and management
- Disease identification and management
- Weed management
- Plant nutrition requirements
- Quarantine issues/exotic threats.

In consultation with the industry in 2006, it was agreed to reduce the number of workshops by combining pest and disease identification and management including exotic threats, and discarding weed management which had received some coverage at a TGA field day in January 2005. Prior to each workshop a review of the literature was to be made on each subject. The content of each workshop was planned in consultation with TGA.

2.4 Field monitoring sites

Field monitoring sites were to be established to test some of the formulated recommendations from the workshops. Content and direction was determined through the workshops. The activities can be described as follows:
• DBIRD (now DPIFM) staff in the Northern Territory established a fertiliser rates trial and a fertigation block.
• DPI&F plant pathology staff examined through glasshouse trials the pathogenicity of a number of fungi and bacteria recovered from plants suffering from corm rot.
• Bun Long selection with potentially larger corm size was compared with standard Bun Long on a grower’s property.
• Growers’ meeting to examine greater uptake of mechanisation by the taro industry.
• Field trip to Atherton Tablelands to seek further information on harvesting and washing/cleaning machinery with visits to potato, sweet potato and yam bean growers.

2.5 R&D strategic plan

A workshop of taro industry stakeholders was conducted at South Johnstone Research Station to formulate a taro industry R&D strategic plan.

Figure 5: TGA field day examining the application of bagasse for weed control in taro using a manure spreader
3. Results and discussion

3.1 Survey of current industry practices/problems

The survey findings have been published separately in the Queensland DPI&F Monograph Series (PR08-3392) *Australian taro industry: benchmark survey*. It is reproduced as Appendix 1 in this report.

3.2 Development of information resource

During the development of this project Taro Growers Australia considered that improved access to information on taro growing would assist in industry development. There was quite a bit of information that had been produced on taro growing around the world but for most growers this was not easily accessed. In response, we obtained copies of this information and put it together in the one location as a Taro Industry Information Resource (shown in Figure 6). The concept was based on the information file system which operated in the Queensland DPI&F office in Innisfail during the late 1980s/early 1990’s. The resource consists of about 50 items including books, booklets and DVDs. These are itemised in Table 1.

Figure 6: The Taro Industry Information Resource
<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>“Taro cultivation in Asia and the Pacific” I. Onwueme (1999)</td>
</tr>
<tr>
<td>4</td>
<td>“Taro diseases - a guide to field identification” J. Ooka CTAHR</td>
</tr>
<tr>
<td>5</td>
<td>“Nutrient deficiencies and excesses in taro” S. Miyasaka CTAHR</td>
</tr>
<tr>
<td>6</td>
<td>“Taro varieties in Hawaii” CTAHR</td>
</tr>
<tr>
<td>7</td>
<td>“Pacific islands farm manual” N. Glover &amp; L. Ferentinos ADAP</td>
</tr>
<tr>
<td>8</td>
<td>“Quality standards and marketing of selected South Pacific root crops” M Brown</td>
</tr>
<tr>
<td>9</td>
<td>“Diseases and pests of taro” G.V.H. Jackson SPC</td>
</tr>
<tr>
<td>11</td>
<td>“Taro - Mauka to Makai” 1997 CTAHR</td>
</tr>
<tr>
<td>12</td>
<td>“Taro Tissue Culture Manual” 1979 SPC</td>
</tr>
<tr>
<td>14</td>
<td>“Tropical root crops: potato, cassava, sweet potato, taro” (1996) Luis A. Manrique (Manrique International Agrotech)</td>
</tr>
<tr>
<td>15</td>
<td>“Mineral nutrient disorders of root crops in the South Pacific” ACIAR Proc.No 65</td>
</tr>
<tr>
<td>16</td>
<td>“Select markets for taro, sweet potato and yam” No 03/052</td>
</tr>
<tr>
<td>17</td>
<td>“Commercial taro chip development using agri-chain partnerships” No 05/144</td>
</tr>
<tr>
<td>18</td>
<td>“Improved marketing of NQ fresh taro” Wedding/O’Keefe</td>
</tr>
<tr>
<td>19</td>
<td>“Plant nutrient management in Hawaii’s soils” CTAHR ISBN 1-929235-08-8</td>
</tr>
<tr>
<td>20</td>
<td>“This Hawaii product went to market” Hollyer et al CTAHR</td>
</tr>
<tr>
<td>21</td>
<td>“Easy profit estimator” CTAHR poster</td>
</tr>
<tr>
<td>22</td>
<td>“Options for change - New ideas for Australian farmers” No 03/030</td>
</tr>
<tr>
<td>23</td>
<td>“Trees for shelter: a guide to using windbreaks on Australian farms” No 02/059</td>
</tr>
<tr>
<td>24</td>
<td>“Successful Land Leasing in Australia” No 03/080</td>
</tr>
<tr>
<td>25</td>
<td>“Thirty Australian Champions” No 00/141</td>
</tr>
<tr>
<td>26</td>
<td>“Adding Value: the critical factors for farmers” No 04/047</td>
</tr>
<tr>
<td>27</td>
<td>“Adoption of Environmental Management Systems in Agriculture Part 1: Case studies from Australia &amp; New Zealand farms” No 03/121</td>
</tr>
<tr>
<td>27B</td>
<td>“Adoption of Environmental Management Systems in Agriculture: An Analysis of 40 Case Studies” No 05/032</td>
</tr>
<tr>
<td>28</td>
<td>“The rural and regional guide to e-commerce” No 03/052</td>
</tr>
<tr>
<td>29</td>
<td>“Good enough never is - lessons from inspirational businesses in rural Australia”</td>
</tr>
<tr>
<td>29B</td>
<td>“Regional Foods: Australia’s Health and Wealth” No 05/045</td>
</tr>
<tr>
<td>30</td>
<td>“Northern Territory tropical fruits industry - market opportunities” No 04/105</td>
</tr>
<tr>
<td>31</td>
<td>“Beyond Agriculture: Changing patterns of farm household income”</td>
</tr>
<tr>
<td>32</td>
<td>“Landcare in the Philippines - stories of people and places”</td>
</tr>
<tr>
<td>33</td>
<td>“The new crop industries handbook” No 04/125</td>
</tr>
<tr>
<td>34</td>
<td>“The recovery of the taro industry in Samoa 2002” DVD</td>
</tr>
<tr>
<td>35A,B&amp;C</td>
<td>“Moloka’i taro conference” 3 Volumes (1990) 3 DVD’s</td>
</tr>
<tr>
<td>36</td>
<td>“Phytophthora colocasiae ... resistant taro cultivars from Palau” (1998) DVD</td>
</tr>
<tr>
<td>Code</td>
<td>Title</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>37</td>
<td>&quot;Sustainable taro culture for the Pacific-Gather the leaves, nourish the roots&quot; DVD</td>
</tr>
<tr>
<td>38</td>
<td>&quot;Organic weed control - weed control concepts&quot; (1993) DVD</td>
</tr>
<tr>
<td>39A,B&amp;C</td>
<td>&quot;Taking taro into the 1990’s&quot; 3 Volumes (1989) 3 DVD's</td>
</tr>
<tr>
<td>40</td>
<td>&quot;Agribusiness Marketing - learning from others&quot; CD</td>
</tr>
<tr>
<td>41</td>
<td>&quot;Agribusiness Supply Chains - learning from others&quot; CD</td>
</tr>
<tr>
<td>42</td>
<td>&quot;Taro Recipes&quot; R1 - R11 Display Folder</td>
</tr>
<tr>
<td>43</td>
<td>&quot;Good Fruit and Vegetables articles by David Hanlon&quot; 2003 - present</td>
</tr>
<tr>
<td>44</td>
<td>&quot;Miscellaneous&quot; - Newsletters/Project articles etc</td>
</tr>
<tr>
<td>45</td>
<td>&quot;Made in Australia&quot; series</td>
</tr>
<tr>
<td>46</td>
<td>&quot;Safe Produce&quot; CTAHR poster</td>
</tr>
<tr>
<td>47</td>
<td>&quot;Tropical Tastes&quot; DPI&amp;F</td>
</tr>
</tbody>
</table>

Figure 7: Identifier on each item in the resource

Figure 8: Shot hole is similar in appearance to taro leaf blight

The information resource includes a photo album which provides documentation of TGA field days. Fourteen of the items are RIRDC publications and as such are currently available from the web. Most of the other publications are not available in electronic format.

The resource is meant to work as a library with each item catalogued and labelled. Originally it was intended that the resources would be housed in the reference section of a public library but available for loan by TGA members. However, the taro growers were concerned that information on taro growing would be too readily available encouraging too many new growers in what is a relatively small market. They voted that the library remain in the hands of TGA and one member took on the task of librarian. The launch of the resource took place at TGA’s November 2005 AGM. Eventually the assigned TGA librarian was no longer available and TGA voted that the resource be held by DPI&F and brought along to TGA meetings for loan purposes.
The resource is very much underutilised. Since its launch only 11 items have been loaned according to the loan book at 3 March 2008. This is partly due to a limited number of TGA meetings attended, at times, by only a handful of growers and the resource has not been made available at all meetings. The resource has been advertised in TGA’s newsletter Tarotopics but further publicity may be helpful. [http://home.iprimus.com.au/sphil/taro/Index.htm](http://home.iprimus.com.au/sphil/taro/Index.htm)

### 3.3 Taro information workshops

#### 3.3.1 Pest and disease identification and management

In the lead up to the workshop requests were made of the industry to supply pest and disease samples from taro for identification by DPI&F staff. Numerous disease samples were received but only three insect pest samples were received. The disease samples were identified and are listed in Table 2. A range of fungi and bacteria were isolated. Four of the corm rot organisms received were later examined for pathogenicity and are reported in section 3.4.2.

![Figure 9: One manifestation of corm rot with young lesions at edge of corm – *Fusarium solani*](image1)

![Figure 10: Corm rots can quickly destroy the corm](image2)
Table 2: Taro disease samples received by DPI&F and organisms recovered

<table>
<thead>
<tr>
<th>DISEASE</th>
<th>LOCALITY</th>
<th>CONTRIBUTOR</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corm Rot</td>
<td>Babinda</td>
<td>Philippe Petiniaud</td>
<td>Erwinia sp.</td>
</tr>
<tr>
<td>Leaf Spot</td>
<td>Garradunga</td>
<td>Philippe Petiniaud</td>
<td>Isos: Phoma sp.</td>
</tr>
<tr>
<td>Leaf &amp; Petiole Spot</td>
<td>Murray Upper</td>
<td>Graham McLeod</td>
<td>Isos: Phoma sp., Colletotrichum sp., Penicillium sp., Colletotrichum gleosporoides</td>
</tr>
<tr>
<td>Leaf Spot</td>
<td>Babinda</td>
<td>Philippe Petiniaud</td>
<td>Isos: Colletotrichum gleosporoides., Phoma sp.,</td>
</tr>
<tr>
<td>Corm Rot</td>
<td>Yarrabin Rd</td>
<td>Denis Garvey</td>
<td>Erwinia sp, Sclerotium rolfsi</td>
</tr>
<tr>
<td>Basal Corm Rot</td>
<td>Yarrabin Rd</td>
<td>Denis Garvey</td>
<td>Erwinia sp, Sclerotium rolfsi</td>
</tr>
<tr>
<td>Corm Rot</td>
<td>Babinda</td>
<td>Philippe Petiniaud</td>
<td>Isos: a) 'Soft Bottom' – bacteria only b) Basal Corm Rot – bacteria only c) Basal Internal Corm Rot – bacteria only, heavy with nematodes</td>
</tr>
<tr>
<td>Leaf Necrosis</td>
<td>Mission Beach</td>
<td>Tim Sutton</td>
<td>Suspect drought damage, some aphids, Leptosphaerulina sp.</td>
</tr>
<tr>
<td>Corm Rot</td>
<td>Babinda</td>
<td>Philippe Petiniaud</td>
<td>Isos: Fusarium solani, Rhizopus sp., bacteria</td>
</tr>
<tr>
<td>Internal Corm Rot</td>
<td>Babinda</td>
<td>Philippe Petiniaud</td>
<td>Dry rot at centre of corm. Isos: Rhizopus sp., bacteria</td>
</tr>
<tr>
<td>Leaf Spot</td>
<td>Babinda</td>
<td>Uscifono - Sauvao</td>
<td>Isos: Phoma sp. (100%)</td>
</tr>
<tr>
<td>Internal Corm Rot</td>
<td>Deeral</td>
<td>Ken Lake</td>
<td>Isos: Phoma colocasiae observed</td>
</tr>
<tr>
<td>Leaf Spot</td>
<td>El Arish</td>
<td>Bruno Jung</td>
<td>Root developing internally following Root Rot – Pythium sp., Fusarium sp</td>
</tr>
<tr>
<td>Leaf Spot</td>
<td>East Feluga</td>
<td>Peter Salleras</td>
<td>Phoma colocasiae</td>
</tr>
<tr>
<td>Corm Rot</td>
<td>Murray Upper</td>
<td>Scotchie McLeod</td>
<td>3rd crop of Taro on same ground. Erwinia sp. assoc’d</td>
</tr>
<tr>
<td>Leaf Spot</td>
<td>Giru</td>
<td>Per P. Chay</td>
<td>Alternaria alternata</td>
</tr>
<tr>
<td>Dry Corm Rot</td>
<td>Bilyana</td>
<td>Brian Machan</td>
<td>Isos: Young lesions at edge of corm. Fusarium solani</td>
</tr>
<tr>
<td>Early Corm Rot</td>
<td>Bilyana</td>
<td>Brian Machan</td>
<td>Isos: Young lesions, internal possible entry via roots. Menispora sp, Cercosporidium henningsii assoc’d</td>
</tr>
<tr>
<td>Heart Rot</td>
<td>Granadilla Rd</td>
<td>Ken Lake</td>
<td>Isos: Bacteria only</td>
</tr>
<tr>
<td>Tuber Rot</td>
<td>El Arish</td>
<td>Ken Lake</td>
<td>Root at base of tuber. Fusarium solani isolated, bacteria, Rhizoctonia solani, Penicillium sp.</td>
</tr>
<tr>
<td>Shot Hole (Leaf Spot)</td>
<td>Murray Upper</td>
<td>John Doyle</td>
<td>Phoma sp.</td>
</tr>
</tbody>
</table>
Insect pest monitoring was commenced at two grower sites from Innisfail to Tully every 2-4 weeks from June 2005 to June 2006. 30 plants per farm were checked, examining leaves and corms for pest presence and damage symptoms. All pests were identified and recorded on sampling sheets. The list of pests found feeding on taro is shown in Table 3. Cluster caterpillar was the most common, consistent and problematic pest found during these observations. A new pest of taro was found called scolytine weevil (*Coccotrypes cyperi*) possibly associated with corm rot (Figures 13 – 16).

Table 3: Pests recorded on 2 taro growers properties (Tully/Innisfail) June 2005 – June 2006

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
<th>Plant part affected</th>
<th>Recorded Australian taro?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dermolepida albohirtum, Lepidiota caudate, Lepidiota consobrina and Lepidiota grisea</td>
<td>Cane grubs x 4</td>
<td>corm</td>
<td>Yes</td>
</tr>
<tr>
<td>Spodoptera litura (most consistent)</td>
<td>Cluster caterpillar</td>
<td>leaves, stem</td>
<td>Yes</td>
</tr>
<tr>
<td>Teleogryllus oceanicus and Teleogryllus commodus</td>
<td>Field crickets x 2</td>
<td>corm</td>
<td>Yes</td>
</tr>
<tr>
<td>Gryllotalpa sp</td>
<td>Mole cricket</td>
<td>corm</td>
<td>Yes</td>
</tr>
<tr>
<td>Nomadacris gutulosa, Gastrimargus musicus, Locusta migratoria and Valanga irregularis</td>
<td>Grass hoppers, locusts x 4</td>
<td>leaves</td>
<td>Yes</td>
</tr>
<tr>
<td><em>Coccotrypes cyperi</em> <em>new</em></td>
<td>Scolytine weevil</td>
<td>corm</td>
<td>No</td>
</tr>
</tbody>
</table>

* Note current pest status is unknown for each listed pest in Australia – surveys are only based on 1-2 taro farms in the Innisfail to Tully region surveyed 1-2 times each month over 1 growing season from June 2005 to June 2006. Local pest list is not extensive and more surveys are required for region specific pest complexes and seasonality fluctuations.
In 2004 the ACIAR project CP/2004/001 ‘TaroPest: A computer based information and diagnostics package for taro pests of the South Pacific’ commenced, led by QUT’s Anthony Clarke and supported by Amy Carmichael. In November 2005 DPI&F hosted a visit by Amy Carmichael to north Queensland to visit taro growers and hold discussions on potential linkages with ACIAR project PHT/2001/023 ‘Horticulture industry development for market remote communities’ (Mr Daniells was a team member in the project) and with this RIRDC taro project. It was our intention through this collaboration to ensure that the TaroPest information package was not only useful for the countries involved in the ACIAR project but also of benefit to the Australian industry. Both projects participated in formal beta-testing and training workshops which fine tuned the package so that it was user-friendly and accurate.

Feedback provided to QUT particularly by DPI&F and TGA highlighted the necessity for a hardcopy weather-proof guide, to enable in-field identifications. A photograph-rich field guide was produced by QUT in response to this need. Through the collaborative efforts copies of this guide were provided free to Australian taro growers via TGA. The field guide includes a self running CD-rom version of the TaroPest website (taropest.sci.qut.edu.au/).

On the 10 November 2006, the taro pest and disease workshop was held at South Johnstone Research Station which was attended by 15 growers. Tony Clarke and Amy Carmichael from QUT were guest speakers, providing information about the development of TaroPest, its contents and a demonstration of how to use it. Other speakers included Lynton Vawdrey, David Astridge and Jeff Daniells who applied the information to a local context. Industry feedback to the workshop was extremely positive.
Figure 17: TaroPest was made available to all Australian Taro Growers

Figure 18: Amy Carmichael presenting TaroPest at growers workshop in north Queensland

Figure 19: Tony Clarke discussing the background to TaroPest at growers workshop
3.3.2 Taro crop nutrition workshop

The Taro Crop Nutrition Workshop was held on 20 April 2007 again at South Johnstone Research Station and was attended by 15 growers. Jeff Daniells spoke on what ‘the literature’ had to say and the results of the Northern Territory fertiliser trial, Mike Hughes presented relevant industry survey results and guest speaker John Armour, a soil scientist with NRM at Mareeba, pulled all the information together and highlighted environmental issues that are impacting on the industry. Again the feedback from participants was very positive. Mr. Daniells prepared a review of the literature on crop nutrition of taro in preparation for the grower workshop. This is represented at Appendix B.

3.4 Field monitoring sites

3.4.1 Northern Territory fertiliser trials

One fertiliser rate trial and one fertigation block were established by Mark Traynor (DBIRD/DPIFM) on the property of Mr. Sok Lee at Darwin River.²

Fertiliser rates trial

The objectives of the trial were to:

- Establish a fertiliser response trend for Bun Long taro under local dry season conditions
- Record the effect of a range of fertiliser inputs on marketable corm yield
- Provide the basis for a sound fertiliser recommendation for current and potential taro growers.

References for fertiliser rates for Bun Long taro varied widely depending on location and management. Local taro growers were producing good crops with the recommended fertiliser inputs but these rates were speculative and possibly excessive to requirements for optimum marketable yield. This recommendation was tested along with experimental rates to more accurately quantify the nutrient requirement for taro in the Top End dry season environment.

Materials and methods

Planting material was with setts which consist of the upper 1-3 cm tip sections of sucker corms with 30-40 cm of leaf stalk attached. Trial design involved eight fertiliser rates randomised over two blocks of four beds.

Plants were 0.6 m apart, 24 plants per bed, one row per treatment rate, buffer plants each end of beds, one buffer row each side of four bed block, and buffer rows subject to the same rate as the adjacent treatment row. Site pH was adjusted to 6.5 using agricultural lime and standard basal fertiliser applied to the beds.

The trial was planted on 19 May 2004 and irrigation spray jets were installed between plants so applied fertiliser was adequately watered into the soil. Soil moisture was monitored with tensiometers. Pest and disease control was performed by the grower as required. Harvest of plots commenced at 210 days after planting (DAP) and was determined by plant maturity indicators observed by the grower.

² The DPIFM Chemistry laboratory was used for leaf nutrient analyses and the DPIFM Biometrician service was provided by Mark Hearnden.
Fertiliser treatments were monitored using leaf nutrient analyses. Samples collected were the second youngest open leaf blade from three designated tagged plants within each treatment. The same plants were sampled each month, 10 days after the monthly fertiliser application. The petioles were removed as close as possible to the blade. Leaves were then washed, oven dried, milled and analysed.

There was a standard basal fertiliser application of 140 kg N: 230 kg P: 120 kg K. The following fertiliser treatments were the side dressing applications over six months. These were divided into six equal applications applied monthly for six months after planting.

The rates are in kg/ha and applied using muriate of potash, urea and superphosphate:

1. 20% (100 N, 40 P, 240 K)
2. 40% (200 N, 80 P, 480 K)
3. 60% (300 N, 120 P, 720 K)
4. 80% (400 N, 160 P, 960 K)
5. 100% (500 N, 200 P, 1200 K) farmer’s rate
6. 120% (600 N, 240 P, 1440 K)
7. 160% (800 N, 320 P, 1920 K)
8. 200% (1000 N, 400 P, 2400 K).

Data collected were monthly leaf nutrient analyses for each treatment and corm number and individual weight per plant. Corms were graded to the following standard provided by the Taro Growers Australia:

- Large 1.25 kg – 3 kg
- Medium 0.75 kg – 1.25 kg
- Small 0.35 kg – 0.75 kg.

**Figure 20: Northern Territory trial site at planting**

**Results**

Due to the limited planted area available for the trial the design was restricted to only eight data points and used as a pilot study to determine where the response to fertiliser reaches a peak. Figure 21 shows
the predicted market yield response. The equations produced indicate the value of fertiliser where yield is at a maximum for each market grade. There was a poor relationship within the small grade with no significant maximum. The medium and large grades showed loose relationships with maximum yield produced at 104% and 109% fertiliser inputs.

![Graph](image)

**Figure 21: Response of marketable yield to applied fertiliser**

Table 4 shows the marketable yield for the fertiliser rates applied in the trial and shows that the yield response of taro to increasing amounts of fertiliser was not dramatic. The treatment with 60% of the farmer’s rate was sufficient to attain 95% of maximum marketable yield. These data indicate that fertiliser is not a strong determinate of marketable yield in Bun Long taro.

Figure 34 (see Appendix B) shows the NPK leaf levels for the treatments that produced at least 95% of maximum marketable yield. These levels could be used as a guide to the adequate leaf nutrient concentrations throughout growth. Excessive amounts of fertiliser, particularly nitrogen, promotes excessive above ground growth and reduces dry matter allocated to the corms and a reduced yield. Although not presented in this report, the high fertiliser treatments in the trial maintained high leaf N levels throughout all growth phases including the period of maximum dry matter production and corm enlargement (100 to 130 DAP). This resulted in more dry matter allocation to plant tops at the expense of corm growth.
Table 4: Effect of fertiliser rates on marketable yields of taro

<table>
<thead>
<tr>
<th>N:P:K kg/ha</th>
<th>treatment</th>
<th>marketable means</th>
<th>% of maximum marketable yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>small</td>
<td>medium</td>
<td>large</td>
</tr>
<tr>
<td>100:40:240</td>
<td>20</td>
<td>5.16</td>
<td>9.79</td>
</tr>
<tr>
<td>200:80:480</td>
<td>40</td>
<td>4.96</td>
<td>10.26</td>
</tr>
<tr>
<td>300:120:720</td>
<td>60</td>
<td>4.81</td>
<td>10.60</td>
</tr>
<tr>
<td>400:160:960</td>
<td>80</td>
<td>4.70</td>
<td>10.82</td>
</tr>
<tr>
<td>500:200:1200</td>
<td>100</td>
<td>4.63</td>
<td>10.91</td>
</tr>
<tr>
<td>600:240:1440</td>
<td>120</td>
<td>4.61</td>
<td>10.87</td>
</tr>
<tr>
<td>800:320:1920</td>
<td>160</td>
<td>4.69</td>
<td>10.41</td>
</tr>
<tr>
<td>1000:400:2400</td>
<td>200</td>
<td>4.94</td>
<td>9.45</td>
</tr>
</tbody>
</table>

**Discussion**

This trial showed that the ‘farmer’s rate’ is excessive and that a 40% reduction in fertiliser inputs would result in only a 3-4% reduction in marketable yield. Although the limitations of this trial required that the fertiliser be applied in the solid form, the injection of fertilisers through the irrigation would be the method used by growers.

**Fertigation block**

The fertiliser rate trial on taro conducted in 2004 resulted in a recommended fertiliser injection rate that was applied to a commercial planting in 2005. The nutrition of this planting was monitored by weekly petiole sap analyses throughout growth. The SPAD-502 meter was used in conjunction with the sap testing to determine any correlation with sap nitrate levels. The soil plant diagnostic (SPAD) chlorophyll meter provides a quick and non-destructive method for estimating the level of N in leaves.

**Method**

The youngest fully expanded leaf was collected from five random plants each week. Six SPAD readings were recorded equally spaced around the margin of each leaf. The petioles were then removed from the leaves and the combined sample submitted to the DPIFM chemistry lab for sap analysis. This method was repeated weekly over fifteen weeks.

**Results**

Figure 22 shows the fairly poor relationship between the average SPAD readings and the petiole nitrate levels for those leaves.
Table 5 shows the typical range of SPAD readings recorded from a taro leaf. The variation in readings from a single leaf is evident and indicates that chlorophyll levels may fluctuate within individual leaves especially with large leafed crops like taro. The average of a large number of readings would be required for a more accurate indication of chlorophyll level.

**Table 5: Within leaf variability in SPAD readings**

<table>
<thead>
<tr>
<th>leaf 1</th>
<th>leaf 2</th>
<th>leaf 3</th>
<th>leaf 4</th>
<th>leaf 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>52.7</td>
<td>51.9</td>
<td>60.6</td>
<td>62.1</td>
<td>58.9</td>
</tr>
<tr>
<td>45.4</td>
<td>51.0</td>
<td>56.6</td>
<td>55.2</td>
<td>57.7</td>
</tr>
<tr>
<td>50.0</td>
<td>54.2</td>
<td>50.1</td>
<td>49.4</td>
<td>53.2</td>
</tr>
<tr>
<td>55.1</td>
<td>53.4</td>
<td>56.2</td>
<td>49.4</td>
<td>55.3</td>
</tr>
<tr>
<td>56.1</td>
<td>55.7</td>
<td>62.1</td>
<td>63.0</td>
<td>53.5</td>
</tr>
<tr>
<td>58.6</td>
<td>55.2</td>
<td>47.3</td>
<td>63.0</td>
<td>50.7</td>
</tr>
</tbody>
</table>

**Conclusion**

The fairly poor correlation between petiole nitrate and SPAD readings in this trial shows that measuring chlorophyll content using the SPAD meter would not provide an accurate indication of plant nitrogen levels in taro.

### 3.4.2 Pathogenicity of Rhizoctonia solani and Fusarium solani associated with corm rot of taro and use of fungicides to control this disease

**Introduction**

Corm rot is a serious disease of taro and major constraint to the expansion of the industry in the wet tropics region of north Queensland. Corms affected by this disease are rendered unmarketable. Symptoms include small rotted areas at the edge of the corm and significant dry rots at the base of the corm. In a recent survey of taro growers in the region, a number of fungi and bacteria were recovered from corms with symptoms of rot however the fungi *Rhizoctonia solani* and *Fusarium solani* were most consistently isolated. Both *R. solani* and *F. solani* are known to cause tuber rots of potato (*Solanum tuberosum*). Recent research examined the pathogenicity of these fungi and evaluated the efficacy of fungicides applied to setts just prior to planting as a means of controlling corm rot.
**Materials and methods**

Planting material used in the glasshouse experiments was obtained from taro corms cv. Bun Long which had been grown for 4 months in pasteurised potting mix. Both the original corms and the setts used in the pot experiment were thoroughly washed, trimmed and stripped of any fibrous material before planting into 15 cm diameter plastic pots. Plants in the experiment were assessed 4 months after planting for rot, number of corms and fresh weight of corms and roots.

The pathogenicity of *R. solani* and *F. solani* was tested by planting single setts of taro into pasteurised potting mix amended with macerated mixed grain (2% w/w) colonised with either fungi. In the other treatments, an appropriate amount of talc was added to benomyl as Benlate (500 g a.i./kg) and mancozeb as Dithane M45 (800 g a.i./kg) to provide a concentration of 200 g a.i./kg for each fungicide. Treatments consisting of benomyl at 200 g a.i./kg and mancozeb at 200 g a.i./kg were dusted on freshly trimmed taro setts just prior to planting into pasteurised potting mix amended with macerated mixed grain (1% w/w) colonised with both fungi. Uninoculated plants were included in the experiment.

**Results**

There was no significant difference (*P* > 0.05) in the number of corms formed in any of the treatments. No rots developed in corms grown in uninfested soils. The results in Table 6 show that 51% of corms grown in *R. solani* infested soil and 57% of corms grown in *F. solani* infested soil had rots. Setts treated with mancozeb and planted in infested soil developed rot in 56% of corms while setts treated with benomyl developed rot in only 11% of corms. The fresh weight of corms and roots was significantly less (*P* < 0.05) in *R. solani* infested soil than in all other treatments except *F. solani* infested soil.

**Discussion**

Both *R. solani* and *F. solani* proved to be pathogenic on taro corms causing rots and a reduction in the fresh weight of corms and roots. The fungicide mancozeb applied as a pre-plant dust on setts had no effect on reducing the number of rotted corms but benomyl applied similarly significantly reduced the incidence of corm rot. Benomyl has potential as a pre-plant treatment for the control of corm rot of taro.

![Figure 23: Cultures used in inoculations](image)

![Figure 24: Wilt symptoms caused by corm rot in glasshouse trial](image)
Table 6: Pathogenicity of *R. solani* and *F. solani* and the use of mancozeb and benomyl to control corm rot of taro (means in the same column followed by the same letter are not significantly different \((P > 0.05)\)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>No. of corms</th>
<th>No. of rotted corms</th>
<th>Fresh wt. of corms and roots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uninoculated control</td>
<td>8.0</td>
<td>0.0 a</td>
<td>443.3 a</td>
</tr>
<tr>
<td><em>Rhizoctonia solani</em> infested soil</td>
<td>8.2</td>
<td>4.2 bc</td>
<td>373.5 b</td>
</tr>
<tr>
<td><em>Fusarium solani</em> infested soil</td>
<td>9.0</td>
<td>5.2 c</td>
<td>411.8 ab</td>
</tr>
<tr>
<td>Mancozeb treated setts</td>
<td>7.2</td>
<td>4.0 bc</td>
<td>445.5 ab</td>
</tr>
<tr>
<td>Benomyl treated setts</td>
<td>7.5</td>
<td>0.8 a</td>
<td>460.0 a</td>
</tr>
</tbody>
</table>

3.4.3 Pathogenicity of *Pythium* sp. and *Erwinia chrysanthemi* associated with corm rot and root rot of taro in north Queensland

**Introduction**

Corm rot and root rot are serious diseases of taro and major constraint to the expansion of the industry in the wet tropics region of north Queensland. Symptoms include a significant rotting of primary roots and a wet breakdown ‘wet bottom’ at the base of corms. Rot affected corms are rendered unmarketable and plants with root rot are often stunted with poorly developed corms. In a recent survey of taro growers in the region, a number of fungi and bacteria were recovered from corms and roots with symptoms of rot. Previous research showed the fungi *Rhizoctonia solani* and *Fusarium solani* can cause dry rots of taro corms. Recent research examined the pathogenicity of the bacterium *Erwinia chrysanthemi* which was recovered from corms with symptoms of a bacterial soft rot and the fungus *Pythium* sp. which was recovered from severely rotted roots.

**Materials and methods**

Planting material used in the glasshouse experiments was obtained from taro corms *cv.* Bun Long which had been grown for four months in pasteurised potting mix. Both the original corms and the setts used in the pot experiment were thoroughly washed, trimmed and stripped of any fibrous material before planting into 15 cm diameter plastic pots. Plants were hand watered as required for the first two months then a regime of water stress was imposed where plants were only watered when they showed signs of wilt. This watering regime was used to help induce disease development. Plants in the experiment were assessed four months after transplanting for number of corms, number of rotted corms, root rot severity and fresh weight of roots.

The pathogenicity of *E. chrysanthemi* was tested by drenching corms planted (one corm per pot) into pasteurised potting mix with a bacterial suspension (concentration of \(1 \times 10^8\) spores per mL). The pathogenicity of *Pythium* sp. was tested by planting a single corm into pasteurised potting mix amended with macerated mixed grain (2% w/w) colonised with *Pythium* sp.

**Results**

There was no significant difference \((P>0.05)\) in either the number of corms formed or the number of rotted corms between treatments (Table 7). No rots developed in corms grown in uninfested soils. The results in Table 7 show that severe root rot of taro developed in *Pythium* amended soil and this caused a significant reduction \((P<0.05)\) in fresh root weight.
Table 7: Effect of *Erwinia chrysanthemi* and *Pythium* sp. on the development of corm rot and root rot of taro grown in a glasshouse (means in the same column followed by the same letter are not significantly different ($P > 0.05$))

<table>
<thead>
<tr>
<th>Treatments</th>
<th>No. of corms</th>
<th>No. of rotted corms</th>
<th>Root rot severity (1-4)</th>
<th>Fresh wt. of roots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uninoculated control</td>
<td>3 a</td>
<td>0.0 a</td>
<td>1.00 b</td>
<td>129.31 b</td>
</tr>
<tr>
<td>Erwinia infested soil</td>
<td>3 a</td>
<td>0.0 a</td>
<td>1.17 b</td>
<td>124.34 b</td>
</tr>
<tr>
<td>Pythium infested soil</td>
<td>3 a</td>
<td>0.0 a</td>
<td>3.0 a</td>
<td>95.38 a</td>
</tr>
</tbody>
</table>

**Discussion**

*E. chrysanthemi* and its close relative *E. carotovora* have been recorded causing bacterial soft rot of taro in the South Pacific Islands (Jackson and Gollifer 1975). These bacteria are known to be widespread in soil and enter the host material via wounds inducing a soft slimy rot. In dryland taro, *Pythium* sp. are recorded as causing root rot but occasionally rots do occur in corm pieces (Jackson 1980). In severe cases plants remain stunted with slightly rolled yellow leaves. In our pot experiment, *E. chrysanthemi* and *Pythium* sp. had no effect on the number of corms produced or the development of corm rot. This result is likely to have been influenced by a lack of wounding or injury to the corms to pre-dispose infection and the use of well-drained potting mix in the experiment. However, *Pythium* sp. did cause severe root rot and a subsequent reduction in fresh weight of roots indicating its importance as a pre-harvest pathogen. Overseas, the recommendations for *Pythium* control involve the use of disease-free planting material, the removal of diseased plant material at harvest, crop rotation, ploughing and drying of taro fields prior to planting (Parris 1941), and the application of lime prior to planting (Carpenter 1919).

**3.4.4 Superior Bun Long selection demonstration**

Planting material for new plantings is usually obtained from old plantings following harvest with no particular selection of better performing plants and so forth. Growers may be inadvertently proliferating those plants that produce the most suckers (for planting material) rather than those that yield best.

![Figure 25: Corm rots can cause wilt during crop growth](image1)

![Figure 26: Severe corm rot that occurred well before harvest](image2)
It was agreed at the October 2005 TGA meeting to establish field monitoring sites to investigate the potential of making improved taro selections. More specifically this commenced on two properties to compare the relative growth of two Bun Long selections. One selection appeared to be a much larger plant with an associated larger corm. If selections with larger corms can be identified there is the potential to greatly improve efficiencies of production which is crucial to taro industry growth.

Unfortunately cyclone Larry hit on 20 March 2006, which greatly disrupted the comparisons being made by the growers. However, in the opinion of one grower the larger accession appeared to perform no differently than the standard Bun Long on his property and did not grow to extraordinary size under his crop management regime. The large growth attributed to the original selection may be due to a combination of very favourable climatic, soil and cultural strategies which may be worthy of future investigation.

3.4.5 Taro mechanisation discussion group meeting

Enhanced levels of mechanisation in the taro industry are another important key to improving efficiencies of production. A taro mechanisation discussion group meeting was held at South Johnstone on 24 January 2005 attended by nine TGA members plus Craig Lemin and Jeff Daniells from DPI&F. The current state of mechanisation in the industry was discussed and further needs identified. Craig Lemin’s taro washing machine and taro harvester prototypes were inspected following the meeting. The group considered that the greatest mechanisation needed in the industry was for a good quality cleaning/washing machine. The meeting proved to be a useful gathering to contemplate further industry advances in mechanisation and resulted in further follow-up visits by several growers to investigate commercial manufacture of a grower’s cleaning/washing machine.

3.4.5 Atherton Tablelands machinery field trip

A field trip was organized to the Atherton Tablelands on 8 September 2006 which was attended by five growers. We visited NorthQual, one of the largest potato packing sheds on the tablelands, which processes product from > 800 ha. We viewed the processing shed operations and a double row potato
harvester. This was followed by a visit to Serra Farms whose operations include specialty potatoes and yam bean which was then followed by visits to two sweet potato properties (Jim Sabin and ‘Horse’ Nicolosi). The growers came away from the day with some very useful ideas to pursue on their own properties.

3.4.6 Taro quarantine issues

In 2005 Mr Daniells was asked by TGA to draft a letter on their behalf to send to AQIS and Biosecurity Australia (BA) to express the industry’s concerns regarding fresh taro imports from China and alleged breaches of import standards from Fiji. The Tarotopics newsletter (Volumes 7-14) has covered this issue in quite some detail. TGA has gained the attention of the Australian Government when addressing this issue, in particular, highlighting the key issues that they see confronting the taro industry, specifically:

- The importation of fresh taro into Australia predates the IRA process. Thus, there has been no formal process of review of quarantine risks with stakeholder input.
- According to BA, where importation already occurs any review of standards is referred to as a ‘pest risk assessment’. The process does not appear to involve stakeholders. At the beginning of this process TGA did not know that import standards were apparently being reviewed.
- Neither AQIS nor BA has been able to provide TGA with a background document justifying the import standard requirements which appear on the AQIS website.
- BA has indicated that they will respond to "substantial scientific evidence" concerning their internal review of taro imports.
- Fresh taro was imported to Australia from China for almost three years despite taro leaf blight (Phytophthora colocasiae) being widespread in that country. Small quantities of corms were also imported from Samoa following the taro leaf blight epiphytotic.

![Figure 29: Taro growers inspecting specialty potatoes as they enter the packing shed on Serra Farms](image)
• Some TGA representatives visited the southern markets in May 2003 and saw taro corms from Fiji that still had soil on them in contravention of the AQIS importation standards.

• On the same visit many imported corms had not been properly ‘topped’ and still possessed the apical growing point as well as prominent side ‘eyes’ on the corm, both of which would allow easy propagation. This is also in breach of import standards. There appears to be a lack of capacity to adequately police the standards.

• Serious quarantinable virus diseases of taro are present in Fiji, China, and elsewhere, which can be readily spread if any plants are propagated from imported corms. The import standard does not adequately address the risks associated with such propagation because it is almost impossible to remove all the eyes from corms from which plants can be propagated.

• The onus appears to be on the Australian industry to detect quarantine infringements.

• AQIS and BA were not prepared to immediately suspend imports while the taro industry waited for the outcome of the internal review process.

• There have been very strict AQIS controls in recent years on the entry of taro for propagation purposes with virus indexed tissue culture plants required for entry to Australia. The taro industry has been trying to import new varieties from overseas to diversify their markets but this has been difficult due to the prevalence of virus diseases overseas.

• The major taro pest, taro beetle (Papuana spp.) present in Fiji can be spread via fresh taro corms. However, this is not mentioned in the import standards. Alternative hosts notably include Musa spp (banana), Solanum tuberosum (potato), Saccharum officinarum (sugar cane), Ipomea batatas (sweet potato) as well as Dioscorea alata, Brassica spp., Crinum spp., Areca catechu, Cocos nucifera, Elaeas guineensis, Dioscorea rotundata, Coffea arabica, Camellia sinensis, Theobroma cacao, Xanthosoma saggitifolia, Alocasia spp., Cyrtosperma spp., Angiopteris spp. This omission could mean that a minor crop could severely impact on several other much more important industries.

Figure 30: Sam Phillips fighting taro imports
3.5 Research and development strategic plan

In the lead up to the R&D strategic planning workshop Mike Hughes and Jeff Daniells interviewed four growers (three face-to-face, one over phone) about their perceptions of industry issues and R&D needs. This was undertaken to provide an update to the 2005 industry mail-out survey and to uncover any matters which had not been covered in the mail-out survey.

A synthesis of what our learnings were from these interviews follows:

- Small growers indicated that R&D needs were more on agronomic issues rather than marketing. They have found their own niche but have difficulty with reliably supplying these niche markets.
- Larger growers have a lot of product to sell in a small, easily oversupplied market so marketing is their main concern. Perhaps too, the larger growers are generally more skilled than smaller growers in taro growing, which may be associated with more capital backing to better manage their crops (mechanisation, nutrition etc).
- The emphasis of any further R&D should be on activities/research to develop the market further. Build demand and suppliers will innovate to meet the opportunity through mechanisation and other changes.
- A market study by Wedding et al (2003) was made on improved marketing but it does not clearly identify the various opportunities and requirements for expanding/developing the taro market in a systematic manner.
- Market Questions include:
  1. What is needed to crack the non-ethnic market:
     o introduce/evaluate new varieties?
     o publicity/awareness of taro preparation/recipes?
     o value adding for convenience?
2. How to increase sales volumes to ethnic market:
   • bulk bins from paddock to retail outlet for reduced handling costs/more competitive pricing?
   • Pest/disease management - studies to reduce dependence on chemicals desirable (biocontrol approaches) plus chemical registration in the meantime so growers are more able to comply with regulations.
   • The feedback from smaller growers that their R&D needs are agronomic may suggest the need for a type of taro production manual (agrilink style?) to provide assistance without the need for actual research but support for the marketing needs of the larger growers will likely have much more industry impact.

The R&D Strategic Planning Workshop was held at South Johnstone Research Station on 1 February 2008 with eight attendees (see Appendix F for a list of attendees).

The day commenced with presentations by Mark Traynor on the ‘NT taro scene’, Mike Hughes on ‘R&D needs from 2005 survey’ and Jeff Daniells on ‘R&D needs from 2008 interviews’. This was followed by a listing of the R&D needs by the attending growers using the nominal group technique followed by prioritisation of those needs.

The issues which follow were raised by the growers include the following:
   • Marketing:
     o Palatable varieties required for non-ethnic market
     o Better quality product required in marketplace
     o Quality control required to meet TGA grade standards
     o Greater cultural awareness of Asian & Middle Eastern consumers required
     o Greater focus on promoting taro as health food as new market opportunity
     o Need for market expansion.
   • Agronomy:
     o Registration of chemicals for taro
     o Reduce reliance on chemicals for cluster caterpillar control
     o Effective control required for cane grub
     o Control of ‘sudden death’ and ‘wet bottom’
     o Weeds in ratoons.
   • Quarantine:
     o Continued awareness of import issues.
   • Agents:
     o Feedback from agents on quality requirements.
   • Communication:
     o Agronomy index for selected growing areas – regionally specific information
     o Communication with agribusiness.
These issues were then prioritised. The growers who attended received votes to allocate towards the listed R&D opportunities identified in the morning. Each grower received a four point vote, a three point vote, a two point vote and a one point vote.

The outcome of the voting was

- 13 points ‘Agronomy’ – specifically chemical registration and development of IPM
- 12 points ‘Marketing’ - emphasis to be on promoting health aspects of taro to consumers
- 11 points ‘Quarantine’ – continue the active fight against imports
- 3 points ‘Agents’
- 1 point ‘Communication’.

Judy Noller discussed the need for the taro industry to identify one or two ‘industry champions’ who could make presentations to health seminars/conventions, chef & food schools, food shows and other relevant events. The ‘industry champions’ should also focus attention on developing markets in the ‘elite fruit and vegetable stores’ in areas such as the north shore of Sydney. Customers of these stores are believed to be not price sensitive but driven by the ‘food experience’. They are therefore perceived as being more willing to adapt to new foods, especially those with health benefits.
4. Implications and recommendations

Implications

- The survey provides a snapshot of an industry and its views. Documenting the significance of an industry in this way is vital to securing government support and assistance. The survey results also provided significant direction to the industry for its R&D planning.

- The industry survey feedback on preferred learning methods by taro growers reiterated the review findings of Black (2000 – ‘Extension theory and practice: a review’ AJEA 40:492-502) that “the main conclusion is that no single model or strategy (in extension) is likely to be sufficient by itself”.

- The information resource to date has been under utilised. However, the feedback from one taro grower who read the RIRDC publication “Thirty Australian Champions” which is included in the taro industry information resource, was gratifying. He saw that he was not alone in what he was going through as a grower and was very encouraged after reading the grower testimonies.

- The information workshops on nutrition and pests and diseases of taro have helped consolidate the information available to the industry and to put it into context. The nutrition review sets forth an approach to improve the overall management of nutrition of the crop. Collaboration with QUT in the ACIAR TaroPest project has made it possible for growers to now have an excellent colour field guide to most of their pest and disease problems as well as an authoritative database of information on these pests and diseases, which should help improve their overall management and bottom line.

- TaroPest is a great start for helping growers to manage pests and diseases. However, most pest complexes are very region specific. Each region, sometimes even down to a farm level will have its own unique pest complex so we need to know more about what pests are economically important in specific areas to get the most effective integrated pest management strategies in place.

- A taro fertiliser requirement trial in the Northern Territory demonstrated that 60% of the normal fertiliser rate was sufficient to attain 95% of maximum yield. Along with a subsequent fertigation demonstration block on the growers property using the 60% rate which attained good yields this has helped convince the grower that reducing fertiliser rates is viable. This should greatly reducing potential losses of nutrients such as N and P to the environment.

- DPI&F has provided assistance to TGA in bringing to a halt the importation of taro from China which posed a major disease risk to the industry. This has already translated to improved profits for growers. Merchants no longer have the leverage of cheap imported product to lower the market prices received by growers.

- Throughout the project we have built a strong relationship with TGA by attending grower meetings and working in closely with TGA in the conduct of the project. Relationships are vital to grower support and involvement in projects and are a major key to the flow of information to the industry. The importance of relationship has been a revelation to the project leader during the life of this project. Additionally, building bridges with outside organizations adds much value to projects.

Recommendations

- The R&D Strategic Plan developed with the industry has recommended that their priorities lie with the implementation of IPM and registration of chemicals for the industry as well as
market development. This includes drawing attention to the health benefits of taro and also of the continuation of TGA’s efforts to ensure that imported taro does not pose a pest and disease risk to their industry. Projects on these subjects need to be supported to maintain the industry and move it forward.

- Some taro growers also have a need to investigate new taro varieties which may have more appeal to the non-ethnic market (>90% of Australian population not currently eating taro). They wish to broaden the consumer/market base domestically and perhaps increase export potential. Contact with taro specialists in Vanuatu and Hawaii have recommended a shortlist of 14 varieties more suited to the western palate. Developing a new variety is a big undertaking and the way to go about it successfully is not well understood so the importation of such varieties would need to form part of a larger project which includes a strategy to develop markets and production protocols.

- TGA has developed a website with links to various publications. This could be developed further by gaining permission to scan the remaining publications from the taro industry information resource and making them available on the internet.
5. Publications

As mentioned in section 1.2 prior to the commencement of this project Mr. Daniells was able to get funding support from ACIAR to attend the Third International Taro Symposium in Nadi, Fiji 21-23 May 2003. A comprehensive trip report was written:


Together with two NQ growers that attended contributed a 3-page article for Good Fruit and Vegetables detailing symposium highlights and implications for the industry:


The content of the poster I presented in Nadi is included as Appendix A and deals with world taro statistics, ethnic market statistics and opportunities to capture new markets.

At about the same time as the symposium, Mr. Daniells was asked to contribute a chapter on large corm taro for RIRDC’s ‘The new crop industries handbook’ which he again co-authored with the two prominent NQ growers. It has been a useful handout for new and prospective growers:


An information article about the newly commenced project appeared in the October 2004 edition of Good Fruit and Vegetables:


Similar information appeared in local newspapers to bring the project to the attention of growers old and new.

The more distant growers of taro from Ingham to Nambour were visited soon after project commencement en route to the AuSHS Coolum Conference ‘Harnessing the potential of horticulture in the Asian Pacific Region’ where I presented a poster paper:


This helped in a small way to raise the profile of the crop. A copy of the poster is included as Appendix D.

The Australian taro industry was surveyed at the commencement of the project and the results have been published in the DPI&F Monograph series:


This is reproduced as Appendix E in this report.
6. Appendices

Appendix A: International taro symposium poster

Taro – Beyond the Umu, Jeff Daniells

The World scene

Oceania is very much ‘small fry’ when one considers world taro production figures shown in Table 8. Per capita consumption is amongst the highest in the world but relatively small populations means that absolute production is small despite some exports. Nevertheless taro production is extremely important for Oceania in terms of food security and export earnings generated.

Targeting/developing ethnic markets

In Australia and New Zealand the main market for taro is the ethnic Asian and Pacific Islander market that are familiar with the product. The number of people in Australia born in overseas countries where taro is an important food source is shown in Table 9. The ethnic population has increased over seven times in the 25 year period. Taro production/consumption has also greatly increased over this period.

Table 10 shows similar data for the USA. In 2001 39 000 t of taro were imported into the USA so their ethnic market is probably reasonably well catered for but is the same true for the UK, France and Germany? FAO does not report any imports into these countries. If transport/handling systems for fresh taro isn’t suitable for distant markets then frozen taro ‘chunks’ would be a good alternative. In 1997 54 000 t of frozen taro was imported into Japan. Taro stores well with such preparation and quarantine is less of an issue.

Taro as a fast food

Currently sales of taro fries and crisps are minor. Both however can be excellent products and as the marketplace continues to increase its diversity of products the opportunity is there. To get an appreciation of the size of the market consider potatoes (Solanum tuberosum). Table 11 shows potato production of some key countries. Assuming that 50% of the production is processed (this is the situation in Australia, 40% for fries and 10% for crisps) and that taro fries and crisps captured only 1% of the market then the required production for just the countries listed would exceed Fiji’s current total taro production by 6 times!

Pie in the sky?

An important component of being able to enter such markets and be competitive will involve minimizing/reducing costs of production. Taro cultivation is very labour intensive so mechanization is a key to reducing production costs. Developments are currently underway in Queensland to further mechanize production (Plates 1 & 2). Processing procedures and facilities for fries/crisps need to be put in place – a very significant investment in infrastructure is needed. Also pulling it all together to put new products in the marketplace and achieve adoption by consumers is no small task – the taro industry in the Australia/Pacific region needs a relationship with a marketing organization that oversees all aspects of the supply chain including managing supply and promotions.

It’s a big world out there, ‘Beyond the Umu’, one that is largely undeveloped in terms of taro consumption and room enough for all of us here to work together to make the most of the opportunity.
<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>Population (x1000)</th>
<th>Taro Production (t)</th>
<th>Taro Production (% of world)</th>
<th>Taro Consumption (kg/person/year)</th>
<th>Taro Exports (t)</th>
<th>Taro Imports (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>Nigeria</td>
<td>116,929</td>
<td>3,910,000</td>
<td>43</td>
<td>.6</td>
<td>33</td>
<td>.4</td>
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<tr>
<td></td>
<td>Ghana</td>
<td>19,734</td>
<td>1,687,506</td>
<td>18</td>
<td>.8</td>
<td>85</td>
<td>.5</td>
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<tr>
<td></td>
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<td>16,349</td>
<td>369,000</td>
<td>4</td>
<td>.1</td>
<td>22</td>
<td>.6</td>
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<td>.2</td>
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<td>46</td>
<td>.8</td>
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<td>44,625</td>
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<td>.5</td>
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<td>.7</td>
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<td>3,080</td>
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<tr>
<td></td>
<td>Sierra Leone</td>
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<td>2,340</td>
<td>0</td>
<td>.03</td>
<td>0</td>
<td>.5</td>
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<td></td>
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<td>120</td>
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<td></td>
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<td>1,292,382</td>
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<td>Thailand</td>
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<td>.9</td>
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</tbody>
</table>

Table 8: Taro Production / Consumption Statistics 2001 (Source FAO)
<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>Population (x1000)</th>
<th>Taro Production (t)</th>
<th>Taro Production (% of world)</th>
<th>Taro Consumption (kg/person/year)</th>
<th>Taro Exports (t)</th>
<th>Taro Imports (t)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Cyprus</td>
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<td>Lebanon</td>
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<td>Turkey</td>
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<td>500</td>
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<tr>
<td></td>
<td>Maldives</td>
<td>300</td>
<td>348</td>
<td>0</td>
<td>.004</td>
<td>1</td>
<td>.2</td>
</tr>
<tr>
<td></td>
<td>Macao</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>56</td>
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</tr>
<tr>
<td></td>
<td>Total</td>
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<td></td>
<td></td>
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<td>21 .4</td>
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<tr>
<td>Americas</td>
<td>Dominica</td>
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<td>11,200</td>
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<td>.6</td>
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<tr>
<td></td>
<td>French Guiana</td>
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<td></td>
<td>Trinidad and Tobago</td>
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<td>.3</td>
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<tr>
<td></td>
<td>United States of America</td>
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<tr>
<td></td>
<td>Saint Lucia</td>
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<td>300</td>
<td>0</td>
<td>.003</td>
<td>2</td>
<td>.0</td>
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<tr>
<td></td>
<td>Barbados</td>
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<td>180</td>
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<td>1</td>
<td>.2</td>
</tr>
<tr>
<td></td>
<td>Antigua and Barbuda</td>
<td>65</td>
<td>30</td>
<td>0</td>
<td>.0003</td>
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<td>Total</td>
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<td></td>
<td></td>
<td></td>
<td>22,405</td>
<td>0 .2</td>
</tr>
<tr>
<td>Oceania</td>
<td>Papua New Guinea</td>
<td>4,920</td>
<td>172,000</td>
<td>1</td>
<td>.9</td>
<td>35</td>
<td>.0</td>
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<td></td>
<td>Fiji Islands</td>
<td>823</td>
<td>37,880</td>
<td>0</td>
<td>.4</td>
<td>38</td>
<td>.1</td>
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<td></td>
<td>Solomon Islands</td>
<td>463</td>
<td>34,000</td>
<td>0</td>
<td>.4</td>
<td>73</td>
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<td></td>
<td>Samoa</td>
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<td>0</td>
<td>.2</td>
<td>93</td>
<td>.5</td>
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<tr>
<td></td>
<td>Tonga</td>
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<td>3,700</td>
<td>0</td>
<td>.04</td>
<td>36</td>
<td>.5</td>
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<td>0</td>
<td>.04</td>
<td>1505</td>
<td>.0?</td>
</tr>
<tr>
<td></td>
<td>New Caledonia</td>
<td>220</td>
<td>2,300</td>
<td>0</td>
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<td>10</td>
<td>.5</td>
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<tr>
<td></td>
<td>Australia</td>
<td>19,338</td>
<td>1,750</td>
<td>0</td>
<td>.02</td>
<td>0</td>
<td>.2</td>
</tr>
<tr>
<td></td>
<td>Wallis and Futuna Is</td>
<td>15</td>
<td>1,600</td>
<td>0</td>
<td>.02</td>
<td>106</td>
<td>.7</td>
</tr>
<tr>
<td></td>
<td>Kiribati</td>
<td>84</td>
<td>1,600</td>
<td>0</td>
<td>.02</td>
<td>19</td>
<td>.1</td>
</tr>
<tr>
<td></td>
<td>American Samoa</td>
<td>70</td>
<td>1,500</td>
<td>0</td>
<td>.02</td>
<td>64</td>
<td>.3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>272,780</td>
<td>3 .0</td>
</tr>
<tr>
<td></td>
<td>GRAND TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6,134,138</td>
<td>8,974,383</td>
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</table>
Table 9: Number of migrants from selected Asian/Pacific countries resident in Australia, 30 June 1976, 30 June 1991, 30 June 2001 (Source ABS)

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<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Philippines</td>
<td>5,800</td>
<td>74,328</td>
<td>103,942</td>
</tr>
<tr>
<td>Hong Kong &amp; Macau</td>
<td>8,900</td>
<td>73,207</td>
<td>67,122</td>
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<tr>
<td>China</td>
<td>20,100</td>
<td>68,514</td>
<td>142,780</td>
</tr>
<tr>
<td>Thailand</td>
<td>n.d.</td>
<td>12,313</td>
<td>23,600</td>
</tr>
<tr>
<td>Fiji</td>
<td>5,900</td>
<td>29,630</td>
<td>44,261</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>15,400</td>
<td>24,303</td>
<td>23,616</td>
</tr>
<tr>
<td>other Pacific Islands</td>
<td>4,700</td>
<td>22,124</td>
<td>30,744</td>
</tr>
<tr>
<td>TOTAL</td>
<td>60,800</td>
<td>304,419</td>
<td>436,065</td>
</tr>
</tbody>
</table>

Table 10: Number of migrants from selected countries resident in USA, 2000 (Source US Census Bureau)

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<thead>
<tr>
<th>Country / Region</th>
<th>Number of Residents</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1,518,652</td>
</tr>
<tr>
<td>Japan</td>
<td>347,539</td>
</tr>
<tr>
<td>Philippines</td>
<td>1,369,070</td>
</tr>
<tr>
<td>Thailand</td>
<td>169,801</td>
</tr>
<tr>
<td>Ghana</td>
<td>65,572</td>
</tr>
<tr>
<td>Nigeria</td>
<td>134,940</td>
</tr>
<tr>
<td>Melanesia</td>
<td>32,305</td>
</tr>
<tr>
<td>Polynesia</td>
<td>35,194</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3,673,073</td>
</tr>
</tbody>
</table>

Table 11: Potato Production / processing 2001 (Source FAO)

<table>
<thead>
<tr>
<th>Country</th>
<th>Potato Production (t)</th>
<th>Processing (t)(^3)</th>
<th>1% of Processed Product (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>19,862,270</td>
<td>9,931,135</td>
<td>99,311</td>
</tr>
<tr>
<td>Germany</td>
<td>11,503,000</td>
<td>5,751,500</td>
<td>57,515</td>
</tr>
<tr>
<td>UK</td>
<td>6,528,000</td>
<td>3,264,000</td>
<td>32,640</td>
</tr>
<tr>
<td>France</td>
<td>6,259,000</td>
<td>3,129,500</td>
<td>31,295</td>
</tr>
<tr>
<td>Australia</td>
<td>1,250,000</td>
<td>625,000</td>
<td>6,250</td>
</tr>
<tr>
<td>TOTAL</td>
<td>45,402,270</td>
<td>22,701,135</td>
<td>227,011</td>
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<tr>
<td>WORLD</td>
<td>309,306,566</td>
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<td></td>
</tr>
</tbody>
</table>

\(^3\) Assumption that 50% of production processed for French fries and crisps
Appendix B: Taro crop nutrition management – a review of the literature

Introduction

Total world production of taro (*Colocasia* sp.) was estimated in 2001 (FAO) at about 9 million tonnes. About 400 million people include taro in their diet and in much of the Pacific, West Africa and the Caribbean it is a staple food crop. Taro is actually ranked as the 14th most important food crop (Daniells 2005). Despite the importance of taro there is relatively little information available on the diagnosis and correction of nutrient disorders it suffers from and its overall nutrition management (Blamey 1996). This can be attributed to the subsistence nature of much of the cropping and only about 1% of production enters world trade. The most significant information is available from Hawaii where it is both an important crop and has received government and university study. This includes a booklet on nutrient deficiencies and excesses by Miyasaka et al. (2002), a section in ‘Taro – Mauka to Makai’ (CTAHR 1997) and a ‘review’ by Manrique (1996). In the 1990s, the University of Queensland completed useful work in the Pacific reported in Craswell et al. (1996).

Nutrient requirements and effects

High yielding taro crops extract relatively large amounts of nutrients from the soil (see Table 12). These nutrients need to be replaced to maintain soil fertility and to permit the repeated production of high yields. This can be achieved by the application of various forms of organic and inorganic fertilisers. Factors other than just crop removal must also be accounted for in fertiliser practices when considering the amount of fertiliser to apply. The following points need to be considered (i) existing levels of nutrient in the soil, for nitrogen this might be as much as 7 t/ha of total nitrogen to a depth of 50 cm (Daniells and Armour 2003). (ii) losses of nutrients from the soil from leaching (N & K), erosion (N, P & K), volatilisation (N) and denitrification (N). These can be particularly severe in some environments including the wet tropical coast with values under bananas listed as 240 kg N/ha/yr for leaching and 5-70 kg N in gaseous losses (Daniells and Armour 2003).

Table 12: Range in chemical composition of taro corms (after Bradbury and Holloway 1988 & modified by Blamey 1996), and the ranges in nutrient removal by a crop of 8 t/ha (av. yield in Pacific) and of 65 t/ha (estimated yield potential). Nutrient concentrations on a dry matter basis were calculated using 70% moisture in the corms

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Concentration (dry matter basis)</th>
<th>Nutrient Removal (kg/ha) corn yield 8 t/ha</th>
<th>Nutrient Removal (kg/ha) corn yield 65 t/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>0.60-1.43%</td>
<td>14-34</td>
<td>117-280</td>
</tr>
<tr>
<td>P</td>
<td>0.17-0.47%</td>
<td>4-11</td>
<td>39-91</td>
</tr>
<tr>
<td>K</td>
<td>1.08-1.77%</td>
<td>25-42</td>
<td>210-345</td>
</tr>
<tr>
<td>Ca</td>
<td>0.04-0.13%</td>
<td>1-3</td>
<td>9-25</td>
</tr>
<tr>
<td>Mg</td>
<td>0.07-0.38%</td>
<td>2-9</td>
<td>13-75</td>
</tr>
<tr>
<td>S</td>
<td>0.03%</td>
<td>0.7</td>
<td>5.5</td>
</tr>
<tr>
<td>Fe</td>
<td>16-57 mg/kg</td>
<td>0.04-0.1</td>
<td>0.3-1.1</td>
</tr>
<tr>
<td>Mn</td>
<td>11-16 mg/kg</td>
<td>0.03</td>
<td>0.2-0.3</td>
</tr>
<tr>
<td>Cu</td>
<td>7-9 mg/kg</td>
<td>0.02</td>
<td>0.1-0.2</td>
</tr>
<tr>
<td>Zn</td>
<td>40-120 mg/kg</td>
<td>0.1-0.3</td>
<td>0.8-2.3</td>
</tr>
<tr>
<td>B</td>
<td>3.0 mg/kg</td>
<td>0.007</td>
<td>0.06</td>
</tr>
</tbody>
</table>

The overall requirement of nutrients can be determined from analysis of the whole plant and estimated plant growth. The grower must know the ability of the soil to meet these requirements and whether supplementary fertilisers are needed. The best way to approach this is the analysis of plant and soil, with the aim of estimating the amount of fertiliser required to optimize yields.
Deficiency symptoms can be useful in diagnosing nutrient imbalance and they are summarized in a key of Miyasaka et al. (2002) – Figure 33. However, by the time symptoms appear, yield may already have been depressed severely (Reuter et al. 1981). Furthermore diagnosis of nutrient deficiencies from symptoms should be confirmed by response of the crop to nutrients. Thus the technique has most application in subsistence and semi-commercial situations where less investment in inputs is warranted and only provides some troubleshooting assistance for commercial taro production – more sophisticated soil and leaf analysis is needed for optimizing production.

**Figure 33: Key to taro nutrient disorders (from Miyasaka et al. 2002)**

Miyasaka et al. (2002), O’Sullivan et al. (1996a) and O’Sullivan et al. (1996b) cover in detail the role of each of the essential elements as they pertain to taro as well as including colour photographs of deficiency symptoms and some toxicity symptoms.

**Integrated Plant Nutrition (IPN)**

Managing the nutrition of a taro crop is much more than just applying fertiliser from a bag. The objective of IPN is to increase the efficiency and productivity of the cropping system. This means better use of all sources of plant nutrients while at the same time protecting the environment. IPN provides the framework to demonstrate profitable and responsible farming practices. IPN consists of fertiliser management, irrigation management, soil fertility/soil health management and soil surface management all of which require a monitoring component.

Soil fertility and its maintenance are thus pivotal to taro nutrition management. One definition of soil fertility is “the quality of a soil that enables it to provide essential chemical elements in quantities and proportions for the growth of specified plants” (Brady and Weil 1999). The development and health of the taro root system, which accounts for most nutrient uptake, will be greatly influenced by the physical, chemical and biological properties of the soil. Thus the more fertile the soil the better will be the results. No amount of soil health investment on poor class soils is likely to be as profitable as choosing better class soils in the first place. Unfortunately not much is documented on the dynamics of the soil properties as it pertains to crop nutrition requirements of taro. The soil in which taro grows is a

<table>
<thead>
<tr>
<th>Plant part</th>
<th>Visual symptoms</th>
<th>Nutrient disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stunting</td>
<td>Uniform</td>
<td>Manganese toxicity</td>
</tr>
<tr>
<td>Deformation</td>
<td>Between veins</td>
<td>Manganese deficiency</td>
</tr>
<tr>
<td>Yellowing</td>
<td>Uniform</td>
<td>Nitrogen deficiency</td>
</tr>
<tr>
<td>Browning, death of tissues</td>
<td>Between veins</td>
<td>Magnesium deficiency</td>
</tr>
<tr>
<td>Deformation</td>
<td>Between veins</td>
<td>Magnesium deficiency</td>
</tr>
<tr>
<td>Yellowing</td>
<td>Uniform</td>
<td>Manganese toxicity</td>
</tr>
<tr>
<td>Browning, death of tissues</td>
<td>Between veins</td>
<td>Magnesium deficiency</td>
</tr>
<tr>
<td>Deformation</td>
<td>Between veins</td>
<td>Magnesium deficiency</td>
</tr>
<tr>
<td>Bacterial rot</td>
<td>Leaf margins</td>
<td>Phosphorus deficiency</td>
</tr>
</tbody>
</table>

---

38
very complex living system and there is much still be known about managing it optimally. What follows are some comments about preferred soils based mainly on observations of the crop.

Taro grows on a wide range of soils but does best in soils where soil moisture does not become limiting. Thus best results are usually obtained on deep, well drained, friable loams, particularly alluvial loams, with a high water table (Kay 1987). Taro can tolerate highly acidic soils but growth is reduced (Follett 1976). The optimum soil pH is 5.5-7.0 (Masalkar and Keskar 1998). Hydroponic experiments indicated that a salinity of ≥ 4.9 mM NaCl would retard growth of cultivar Bun Long (Hill et al. 1998).

**Fertiliser application rates**

Fertiliser application rates for taro vary widely both in Australia (Hughes et al. 2008) and overseas (those cited by Blamey 1996). Often where taro is grown as a subsistence crop no fertiliser at all is applied. Blamey (1996) prepared the following – “Recommended fertiliser rates for taro have varied 60-140 kg N/ha, 25-125 kg P/ha and 80-340 kg K/ha (de Geus 1967). More recent results have indicated similar rates to be appropriate, viz. 40-80 kg N, 10 kg P and 40-80 kg K per hectare for high corm yield, with split applications of N and K (Mohankumar and Sadanandan 1989; Mohankumar et al. 1990). In Hawaii, higher rates of fertiliser of 515 kg N/ha and 670 kg K/ha (Silva et al. 1990) and 250 kg P/ha (Sato et al. 1990) have been recommended. There is much less information on the application of macronutrients, other than N, P and K, or micronutrients. More research is clearly needed on the fertiliser rates needed to overcome the limitations and optimise the economic return.”

Plucknett and de la Pena (1971) recommended that all of the P requirement for the crop should be applied before planting and incorporated in the soil. They recommended 200-250 kg/ha at that time. Certainly incorporation of all the P requirements at planting is sound in minimising erosive losses and impact on the environment.

High fertiliser rates (500N: 200P: 1200K) were also practised in the commercial taro plantings in the Northern Territory at the commencement of this RIRDC taro project. However, studies by Mark Traynor during the course of this project indicate that the rates previously applied were excessive and that 97% of the maximum yields obtained at the above rate could still be obtained with the 60% rate (300N: 120P: 720K). The same is probably true for the high rates recommended in Hawaii. Manrique (1996) makes much comment about over fertilising of taro but the quality of the work on which the comments are based is not entirely convincing and much more thorough study is warranted.

In Hawaii most farmers apply fertilisers during the first 4 or 6 months; some split the fertilisers equally or nearly equally into 2 or 3 applications (Plucknett and de la Pena 1971). This remains the recommendation (de la Pena 1997). Frequent applications of small amounts of N and K will be the approach that will lead to greatest efficiency of fertiliser use and reduce losses to the environment (Daniells and Armour 2003).

It is generally recommended (Plucknett and de la Pena 1971) that N fertilisation only occurs in the first 4-6 months as this is the period of major vegetative growth. Pot studies by Jacobs and Clarke (1993) indicated that N applied early in plant development may be beneficial to growth (and productivity) by increasing leaf area and biomass production at a time when low light interception is a major limitation to growth (Wilson 1984). Conversely some consider that K fertiliser application should be scaled up during the major period of corm filling. However, there are no taro trial results that verify this approach. Also there still remains a great need for determining the dry matter accumulation pattern during the course of a taro crop and the relative partitioning to different plant components. This will be very useful in better tailoring fertiliser applications to plant growth.

**Soil and leaf analysis**

Rates of plant growth and yield of taro will differ between localities, properties and paddocks, any of which will influence the amount of nutrient required. In many cases, this variability influences farmers.
to apply more fertiliser than is required in some blocks, while in others, insufficient is applied. To overcome this problem, the best approach is to monitor nutrient levels in the soil and plant in each paddock as a guide to modifying the fertiliser program so that they are appropriate for each situation.

Silva et al. (1998) have developed some interim recommendations based on soil analyses for flooded (paddy) taro in Hawaii (Table 13). Silva also recommended the following fertiliser applications during the first three months: one month 28 kg/ha N as urea and 47 kg K; two months ditto; three months 56 kg N and 47 kg K. No other such recommendations based on soil analysis appear to exist.

Critical leaf tissue concentrations, as well as the adequate/sufficiency range (Table 14) have been presented by both O’Sullivan et al. (1996 a&b) and Miyasaka et al. (2002). O’Sullivan’s results were based on solution culture studies so they should be treated with caution whilst those presented by Miyasaka were mostly based on field surveys of healthy (high yielding) field crops. The leaf tissue analyses for N, P & K in the Northern Territory trial suggest that the Hawaiian critical/optimum levels may be more applicable to field conditions in Australia than the tentative levels established by O’Sullivan et al. (1996).

Silva et al. (1998) recommends leaf tissue analysis samples should be taken at three months and six months after planting so that fertiliser applications can be adjusted as necessary during the crop. Silva has also made some post planting fertiliser recommendations based on leaf tissue analysis (Table 15).

The recommended indicator (index) tissue that the leaf analyses are based on is the lamina of leaf two (second youngest leaf). The influence of sampling plants of different ages would not appear to be known.

Daniells and Armour (2003) have described how to use soil and leaf analyses for banana. They point out the intrinsic value of regular soil and leaf sampling and the use of the adjustment technique to customize fertiliser management for farm blocks. They point out that nutrient analyses is a decision aid that takes much of the guesswork out of fertiliser management whilst being able to demonstrate care for the environment by objectively justifying fertiliser inputs.
**Table 13: Preplant fertiliser applications based on soil analysis (from Silva et al. 1998)**

<table>
<thead>
<tr>
<th>Soil pH and calcium</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH &gt; 5.8, Ca &gt; 10 m.e./100g..................................do not apply CaCO₃</td>
</tr>
<tr>
<td>pH &lt; 5.8 but &gt; 5.5 Ca &lt; 10 m.e./100g .......................1 tonne CaCO₃</td>
</tr>
<tr>
<td>pH &lt; 5.5 Ca &lt; 10 m.e./100g ....................................2 tonnes CaCO₃</td>
</tr>
<tr>
<td>pH &gt; 5.8 Ca &lt; 10 m.e./100g ....................................1 tonne gypsum</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 75 mg/kg..........................................................do not apply P</td>
</tr>
<tr>
<td>&lt; 75 mg/kg but &gt; 30 mg/kg ........................................50 kg P</td>
</tr>
<tr>
<td>&lt; 30 mg/kg ..........................................................200 lb P₂O₅</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil potassium</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 0.5 m.e./100g........................................................do not apply K</td>
</tr>
<tr>
<td>&lt; 0.5 m.e./100g ........................................................186 kg K</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil magnesium</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 3.3 m.e./100g........................................................do not apply MgSO₄</td>
</tr>
<tr>
<td>&lt; 3.3 m.e./100g but &gt; 1.65 m.e./100g........................112 kg MgSO₄</td>
</tr>
<tr>
<td>&lt; 1.65 m.e./100g ........................................................224 kg MgSO₄</td>
</tr>
</tbody>
</table>

**Ground cover management**

Ground covers are essential for protecting the soil surface from the loss of soil and fertilisers by erosion. Mulch (coconut leaves etc) are often used in taro cropping systems in the Pacific and elsewhere. Bagasse surface broadcast at planting is used by some taro growers in north Queensland. They can provide excellent weed control, which would otherwise be a major issue for the crop, and also help maintain soil moisture whilst contributing to the nutrient requirements of the crop as they breakdown. However, Miyasaka et al. (2001) found that silage and/or woodchip mulch increased yields but in one year it also increased the incidence of corm rots – mostly ‘opportunistic’ organisms rather than standard pathogens such as Pythium.

Miyasaka et al. (2002) has also indicated that it had been found that excessive nitrogen can promote taro leaf blight when conditions are conducive to disease development. However, in SPC Advisory Leaflet No. 20 it is stated that “the use of fertilisers to promote vigorous plant growth is an important additional factor in the control program. In Hawaii, for instance, phosphorus is considered to be intimately related to resistance to root and corm rot. It is likely that plant resistance is increased in well-nourished plants. Healthy plants are more able to withstand and outgrow damage caused by Pythium attack”. There are many opinions on taro nutrition but not a lot of hard data to support them.
Table 14: Taro leaf blade nutrient concentrations associated with deficiency, sufficiency and toxicity

<table>
<thead>
<tr>
<th>Mineral element</th>
<th>Measured in</th>
<th>Deficiency range</th>
<th>Sufficiency range</th>
<th>Toxicity range</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>%</td>
<td>&lt; 4.0&lt;sup&gt;p&lt;/sup&gt;</td>
<td>4.0-4.5&lt;sup&gt;p&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>%</td>
<td>0.3-0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>%</td>
<td>3.2-5.5&lt;sup&gt;p&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>%</td>
<td>&lt; 0.7&lt;sup&gt;q&lt;/sup&gt;</td>
<td>0.7-1.5</td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>%</td>
<td>&lt; 0.2&lt;sup&gt;r&lt;/sup&gt;</td>
<td>0.2-0.5</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>%</td>
<td>&lt; 0.2&lt;sup&gt;s&lt;/sup&gt;</td>
<td>0.2-0.3</td>
<td></td>
</tr>
<tr>
<td>Cl</td>
<td>%</td>
<td></td>
<td>&gt; 2.0&lt;sup&gt;t&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>ppm</td>
<td>&lt; 100&lt;sup&gt;u&lt;/sup&gt;</td>
<td>100-200&lt;sup&gt;p&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>ppm</td>
<td>20-50&lt;sup&gt;p&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td>ppm</td>
<td>50-300&lt;sup&gt;v,w&lt;/sup&gt;</td>
<td>&gt; 2000&lt;sup&gt;mx&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>ppm</td>
<td>20-40&lt;sup&gt;y&lt;/sup&gt;</td>
<td>&gt;400&lt;sup&gt;y&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>ppm</td>
<td>10-20&lt;sup&gt;z&lt;/sup&gt;</td>
<td>unrelated&lt;sup&gt;i&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

<sup>m</sup>Actual deficient, sufficient and toxic concentrations of elements in leaf blades may vary depending on taro variety, environmental conditions and quantities of other nutrients present. <sup>n</sup>Sufficiency ranges are based on concentrations of elements in leaf blades of healthy taro plants grown under upland or wetland conditions (Uchida 2000). <sup>o</sup>Osorio et al. (2002). <sup>p</sup>Silva, J.A. (personal communications). <sup>q</sup>Miyasaka (1979). <sup>r</sup>Austin et al. (1994) found that 0.14 % Mg was associated with 95% of the maximum growth. <sup>s</sup>Kelly and Jansen (unpublished) showed that 0.18% S was associated with 95% maximum growth. <sup>t</sup>Hill et al. (1988). <sup>u</sup>Ares et al. (1996) found that a range of 55-70 ppm Fe was associated with 95% of maximum growth. <sup>v</sup>R.T. Hamasaki (personal communications). <sup>w</sup>Taro is tolerant to high levels of Mn and foliar concentrations between 1400-2000 ppm have been observed without detrimental effects. <sup>x</sup>Miyasaka and Webster (1994). <sup>y</sup>O’Sullivan et al. (1996). <sup>z</sup>Hill et al. (2000) found levels ranging from 14-18 ppm Cu in taro plants supplied with sufficient Cu. Foliar Cu concentrations cannot be used to predict toxicity, because they did not increase in leaf blades under toxic Cu levels.
Figure 34: Time course of leaf N, P and K levels in Northern Territory fertiliser trial
Beyond the Lo‘i (Hawaiian taro garden)

Much agriculture is ‘production-focussed’ rather than on ‘long-term profitability’. Increasing fertiliser rates might increase yields but what effect are they having on other issues? It is a widely held belief in Samoa that addition of fertiliser is detrimental to the taste of taro. Work by Berwick et al. (1972) in Fiji showed that N, particularly at the heavier rate (1200 kg/ha) tended adversely to affect both taste and texture, particularly when applied only 11 weeks before harvest. The 400 kg N treatment also had reduced palatability.

Table 15: Post-planting fertiliser application recommendations for flooded (paddy) taro based on leaf analysis (from Silva et al. 1998)

<table>
<thead>
<tr>
<th>Leaf nitrogen</th>
<th>Leaf potassium</th>
<th>Leaf calcium</th>
<th>Leaf magnesium</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 4.2% do not apply N</td>
<td>&gt; 0.8% do not apply K</td>
<td>&gt; 0.8% do not apply gypsum</td>
<td>&gt; 0.3% do not apply MgSO4</td>
</tr>
<tr>
<td>&lt; 4.2% but &gt; 3.8% 22 kg N/ac at 4 mo, 34 kg at 5 mo, 45 kg at 6 mo</td>
<td>&lt; 0.8% but &gt; 0.6% 112 kg gypsum at 4, 5 and 6 mo</td>
<td>&lt; 0.3% but &gt; 0.25% 112 kg MgSO4</td>
<td></td>
</tr>
<tr>
<td>&lt; 3.8% but &gt; 3.4% 45 kg N at 4 mo, 56 kg at 5 mo, 67 kg at 6 mo.</td>
<td>&lt; 0.5% but &gt; 0.4% 168 kg gypsum at 4, 5 and 6 mo</td>
<td>&lt; 0.20% 168 kg MgSO4</td>
<td></td>
</tr>
<tr>
<td>≤ 3.4% 67 kg N at 4 mo, 67 kg at 5 mo, 67 kg at 6 mo.</td>
<td>≤ 0.4% 224 kg gypsum at 4, 5 and 6 mo</td>
<td>≤ 0.20% 168 kg MgSO4</td>
<td></td>
</tr>
</tbody>
</table>

References


Appendix C: Newspaper project announcement

DPI backs taro

The Department of Primary Industries and Fisheries wants to involve Australian’s taro growers in undertaking the potential of DPI’s growing million-dollar industry.

Department principal horticulturalist Jeff Danielli, who is based at South Johnstone, said the time had come to develop the foundations to build up the taro industry’s potential for Queensland and Australia.

Mr Danielli said Australian annual taro production was about 4000 tonnes with an estimated wholesale value of $1.5 million to about 100 growers, most of them in Queensland.

Taro is a root crop that produces edible corms. The young leaves may also be used as a vegetable. Taro is grown in coastal areas, but predominantly in Queensland’s wet tropics.

“Taro is already grown in the area, with potential for more growers to take up the opportunities to the project benefits to this emerging new project to further build this emerging industry,” he said.

All commercial taro growers are needed to contact Mr Danielli.

“I would like to start work on this immediately to ensure all commercial taro growers can take advantage of the benefits that can be obtained from the project.

The two-year project, entitled “Taro industry development: the first step”, will be conducted by the department in conjunction with the Northern Territory Department of Industry, Trade and Investment, with funding from the Rural Industries Research and Development Corporation.

The five major components to the project are:

- An industry survey.
- A compilation of taro information resources.
- A taro information workshops to update growers, industry, weeds, crop nutrition, and pest management.
- Establishment of field monitoring sites to test and compare recommendations from the workshops.
- Development of a taro industry research and development strategic plan.

Figure 35: Innisfail Advocate 2 September 2004
Appendix D: AuSHS conference poster

Figure 36: Poster displayed at AuSHS Coolum conference
Appendix E: Australian taro industry benchmark survey

Australian taro industry: benchmark survey

M.J. Hughes
J.W. Daniells
L.L. Vawdrey
D.A. Astridge
M. Traynor
Appendix F: R&D strategic planning workshop

The R&D Strategic Planning Workshop was held at South Johnstone Research Station on 1 February 2008 with eight attendees:

Rod Hourston – TGA President
John Doyle – TGA Treasurer
Sam Phillips – TGA Secretary
Ken Lake – NQ taro grower
Mark Traynor – NT DPIFM Researcher
Judy Noller – DPI&F Marketing (trade and business) Officer
Mike Hughes - DPI&F Extension Agronomist
Jeff Daniells – DPI&F Horticulturist

Apologies – Peter Salleras, Dieter Kirchner, Leo Burgoyne and John Oakeshott.
Taro production is not new to Australia but it has only become significant over the last few years. It has an estimated value of $4 million and is predominantly located in the wet tropics of north Queensland.

This project addressed several issues that were considered to be hampering development of the industry. It assesses the current state of the industry and explores the agronomy of taro, including cropping strategies, pest and disease issues and the accessibility of existing technical information. It also addresses the lack of an R&D strategic plan.

The Australian taro industry was surveyed to identify R&D needs, other information needs and to provide a snapshot of crop production practices.

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