Pineapple News

Issue No. 11 Newsletter of the Pineapple Working Group, International Society for Horticultural Science May, 2004

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Pineapple Working Group (PWG)

Dear Colleagues:

You will notice a new layout for Pineapple News in this issue. Now that the primary format for the newsletter is an Adobe Acrobat PDF file, readability on the computer screen becomes important. I hope the single-column format and increased font size will accomplish that. Two-column text is more compact and easier to read as text, but I find the extra navigation required to read a full-page articles on screen a bit irritating.

One of the most enjoyable benefits of working with pineapple is the people it brings me into contact with. Among the many contacts made over the past year, three stand out in my mind. Sometime last spring or summer I received an email from Francesca Beauman who wrote from London, England seeking help in collecting information on the history of pineapple. Francesca had written a masters thesis on the social-cultural aspects of pineapple while at the University of Cambridge and was interested in expanding the scope of her work to a readable history of the crop. She planned to travel to Hawaii in the fall to search out information not available in England and asked she could meet with me. I was pleased to have the opportunity to assist with her project, at least in part because history has become a more interesting subject as I have gotten older and lived a little bit of it. Meeting Francesca, who also writes comedy for a BBC children's show, was delightful and if her book is as interesting and charming as she is, it will be highly recommended reading. Francesca's visit resulted in renewed contact with Geo Coppens d'Eeckenbrugge, who co-authored the chapter on Morphology, Anatomy, and Taxonomy for the new pineapple book and got all of us straightened out on the taxonomy and appropriate horticultural terminology for pineapple. Francesca wanted to know what was known about the origin of pineapple and Geo immediately came to mind. Geo shared with me what he wrote to Francesca and I hope some day he will complete and share his fascinating story with readers of the newsletter. Another "pineapple person" I have been in contact with over the last year is Jack Larson, a former Del Monte employee and State of Hawaii legislator. Jack, who is now 80 years young, or perhaps 81 this year, moved to the U.S. mainland some years ago but still has family in Hawaii and returns here at least annually. While he is here, much of his time is spent at the University of Hawaii library where he has been researching material for a history of pineapple in Hawaii. He has told me he intends to complete the book while here in June 2004. I look forward to announcing the publication of the both of these books on the history of pineapple in a future issue of the newsletter.

Changes in the Pineapple Industry

In the 10th issue of the newsletter, I wrote about some of the changes that have taken place in the pineapple industry, and particularly the fresh fruit industry. I noted that an important change was the growing importance of hybrid pineapple varieties and particularly the MD-2 or Del Monte Gold hybrid. Ownership of and access to planting material of the MD-2 hybrid was a contested issue for a few years, the result of legal disputes among Dole Food Company, Fresh Del Monte Produce, and Maui Pineapple Company. The disputes were all settled in the last year or so and the hybrids in question, specifically the Pineapple Research Institute of Hawaii (PRI) hybrids 73-50 (also known in Hawaii as CO-2) and 73-114, known in the commercial market as Del Monte Gold and also at least for a time as MD-2, are now in the public domain and the area planted to this hybrid is being expanded rapidly in Hawaii and elsewhere. More about the disputed issues can be found the October 7, 2003 issue of the Wall Street Journal.

The two hybrids are siblings from a cross between the PRI hybrids 58-1184 and 59-443 (Chan *et al.*, 2003). While few characteristics about the hybrids have been published, it is known that they are much more susceptible to natural flowering than is 'Smooth Cayenne', with 73-114 being more susceptible than 73-50 (Chan *et al.*, 2003). The result of this higher susceptibility is that research to control natural flowering has become a much higher priority, at least in Hawaii, than it was when 'Smooth Cayenne' was the main fresh fruit variety. Chan *et al.* (2003) also state that the hybrids are more susceptible to root and heart rots caused by *Phytophthora* spp. than is 'Smooth Cayenne'. My personal observations, supported by anecdotal comments, indicates a higher incidence of seediness in Del Monte Gold than is seen with 'Smooth Cayenne'. Despite some defects, both hybrids apparently are superior to 'Smooth Cayenne' as fresh fruit varieties. They have higher total soluble solids and vitamin C contents and lower titratable acidity when grown in subtropical climates and especially during the winter months. However, the lower titratable acidity might result in an overly sweet or bland-tasting fruit when grown in warmer climates or when fruit mature during warm summer months. Both hybrids are being planted at lower elevations in Hawaii to help reduce the incidence of natural flowering. It will be interesting to see how fruit quality is affected by the warmer summer temperatures at these elevations. Both hybrids yield as well as or better than 'Smooth Cayenne' under intensive management and storage life under refrigeration is reported to be better as the fruits are less prone to develop endogenous brown spot.

Of great significance is the impact of 73-114 (Del Monte Gold) on the pineapple fresh fruit market and the growing importance of both hybrids to pineapple growers in Hawaii. According the above mentioned Wall Street Journal article, Fresh Del Monte Produce made hundreds of millions of dollars on Del Monte Gold since 1996. The company's sales of fresh pineapple increased from less than $200 million in 1996, the year the variety was launched nationwide in the U.S., to $440 million in 2002, the last year that pineapple sales were broken out by the company. Both sales of fresh pineapple and the per capita consumption of pineapple in the U.S. have increased dramatically since Fresh Del Monte Produce began selling the Del Monte Gold hybrid. This success has not gone unnoticed in Central and South America and the Wall Street Journal article indicated that shipments of hybrid fruits from Central and South America (see News From Ecuador below), are expected to put pricing pressure on the fruit. The ready acceptance of 73-114 also is assumed to be the reason that Hawaii growers are rapidly converting fields from 'Smooth Cayenne' to the hybrids (Hawaii plantations switching to hybrid varieties, Lyn Danninger, Honolulu Star Bulletin, October 8, 2003). The good news for growers is that consumption of fresh pineapple is up greatly and growing. The events of the past several years indicate that quality is important to the consumer, even when it commands a premium price.

Plans for the 5th Symposium Move Forward

As was noted in the last issue of Pineapple News, the dates of the Fifth International Pineapple Symposium are April 11-15, 2005 and the symposium will be held in the Civic Center at Port Alfred, South Africa. A web site to facilitate communications and provide information about the 5th Symposium has been established and can be found at http://www.pinesymp05.org/. According to the information at the web site, the second announcement and call for papers will be available in June 2004. No printed copy of the second announcement will be provided by regular mail, but all pre-registered delegates will be informed, updated and contacted by E-mail. A pre-registration form is available at the web site.

The deadline for the submission of abstracts will be October 2004 and the submission form will only be available on-line. Some information on the program is presently available at the above web site and the second announcement will include detailed information on the scientific program, submission of abstracts, preparation of papers and posters, registration, accommodation, social events and tours.

The cost of early registration for the symposium is $500 for ISHS members and $600 for nonmembers. Early registration is before December 31, 2004. Regular registration is $550 for ISHS members and $650 for nonmembers. Be sure to check the symposium web site for updates on the available information.

Suranant Subhadrabandhu, In Memorium

It is with much regret that I inform readers of the passing of Dr. Suranant Subhadrabandhu on the 16th of July, 2003. Those readers who had the pleasure of getting to know Suranant as I did while attending the Third International Pineapple Symposium held in Pattaya, Thailand in November of 1998, will remember that he contributed much to the organization and management of the symposium. Suranant is listed in the program of that symposium as Editor, but my recollections are that he seemed to be ever-present and was involved in almost every aspect of the symposium. He was a gracious host, tour leader, and organizer but he was especially the consummate editor. The meeting was a large one with many research contributions, but through Suranant's efforts, the proceedings of the Third Symposium appeared in print in near-record time for a proceedings of the Pineapple Working Group.

A memorial to Suranant written by I.J. Warrington, Professor of Horticulture Science, Massey University and ISHS Vice President, appeared in the ISHS publication Chronica Horticulturae, 43, No. 3, p. 29, 2003. Dr. Warrington filled almost two columns writing about Suranant's accomplishments without mentioning his role in the Third Pineapple Symposium. That such an an important contribution should go unmentioned is an indication of the many wide and varied contributions Suranant made to horticulture in Thailand as well as in the tropics in general. The following material about Suranant was extracted from Dr. Warrington's eulogy to Suranant.

Suranant received a BS in Horticulture from Lincoln Univ., New Zealand, 1967, followed by an M.S. in Plant Physiology. He went on to Michigan State Univ. where he earned a Ph.D. while supported on a Rockefeller Fellowship. At the end of his training, Suranant returned to Kasetsart University in Bangkok, Thailand where he dedicated himself to teaching and research. Surananat was Vice President of that University for two terms, chaired the Fruit Research and Development Committee of the Royal Project Foundation, and was decorated by the King of Thailand for his services to his country and to horticulture. He held the Knight Grand Cordon (Special Class) of the Most Exalted Order of the White Elephant, the Thai equivalent of a Knighthood.

Suranant was a strong supporter of ISHS where he served as the representative on Council for Thailand for many years and was fairly recently elected as Vice Chair of the ISHS Section for Tropical and Subtropical Fruits, a position he held until his death. Suranant will be awarded an Honorary Doctorate posthumously at special convocation ceremony at 125th anniversary celebrations of Lincoln University in October, 2003 in recognition of his contributions to horticultural science.

ISHS Membership and Benefits

The ISHS is one of the foremost organizations promoting cooperation and communication among researchers, growers and consumers in the horticultural industries. The aim of the ISHS is to promote and encourage research and to facilitate the cooperation of scientific activities and knowledge transfer on a global scale by means of its publications, events and scientific structure. The ISHS provides the structure under which our Pineapple Working Group functions and provides for the publication of meeting proceedings in a volume with high visibility. An important benefit of membership is to support an organization with the goal of improving horticulture across the globe. Detailed information about ISHS and the benefits of membership can be found at http://www.ishs.org . All titles and abstracts of all issues of Acta Horticulturae are available there and members have access to up to 10 Acta articles at no additional cost. For more information go to the ISHS web site or contact the society by writing to: ISHS Secretariat, P.O. Box 500, 3001 Leuven, Belgium (E-Mail: info@ishs.org.

Contributions to Pineapple News

Please plan now to contribute to the next issue of **Pineapple News**. When submitting articles for publication in the newsletter, please follow the guidelines below.

1. All contributions should be written in English. Assistance with editing will be provided.

2. Preferred contributions are timely news about research on issues related to culture, processing, storage, and marketing of pineapple, new, interesting, or unique problems encountered by growers, and status reports on the pineapple industry within a country or region. If uncertain about the suitability of material for the newsletter, contact the editor.
3. If possible, please send contributions by E-mail as attached files in MS Word or rich text format or on floppy disks. Printed copy should be clean and sharp so it can be scanned to speed conversion to a wordprocessor format.
4. **Tables in papers must be submitted with columns separated by tabs. Authors will be asked to revise tables not in the requested format.**
5. Submit photographs that can be scanned or provide digital files in jpg format with a resolution of 300 dpi so they can be printed with acceptable resolution in grey scale with a laser printer.
6. Mail contributions and inquiries to: **D.P. Bartholomew, Dept. of NREM, Univ. of Hawaii, 1910 East-West Rd., Honolulu, HI 96822 U.S.A.** (Phone (808) 956-7568; Fax (808) 956-6539; E-mail: duaneb@hawaii.edu.
7. ***Pineapple News*** is available on the Web at: http://tpss.hawaii.edu/pineapple/pineappl.htm.
8. **Address corrections:** Please send mailing and E-mail address corrections to D.P. Bartholomew at the above address.◆

News From Australia

2003 Pineapple Field Day

The Annual Pineapple Industry Field Day was held on 18 July, 2003 at Wamuran Sports Club, Wamuran. Most details of the program are provided below and, in most cases, abbreviated versions of the presentation made available to Pineapple News follow the program. The editor regrets any errors introduced when shortening or abstracting articles.

Field Day Program, Morning
- Registration
- Welcome, Alan Smerdon, Queensland Fruit & Vegetable Growers (QFVG) Pineapple Sub Committee, Chairman for the day
- Opening address: Improved performance for the customer and greater profitability for the grower Bernie Kelly, General Manager Supply Chain & Northgate Operations, Golden Circle Ltd.
- Manipulating the soil biology to suppress nematode pests. Graham Stirling, Biological Crop Protection Pty Ltd.
- New sunburn protection: Surround WP. Nick Phillips, Marketing Manager, Engelhard Corp, USA
- Overview of the pineapple study group project. Simon Newett, DPI
- Snippets on nematodes, Phytophthora and Symphyla. Graham & Marcelle Stirling, Biological Crop Protection Pty Ltd.
- Technical benefits of applying compost to pineapple soils. Adam Willson, Director of Organic Compost Pty Ltd
- Update on QFVG current and future situation. Jan Davis, Chief Executive Officer QFVG
- The pineapple industry in the Philippines. Val Tanguilig, Golden Circle Ltd.
- Introduction of an Australian government Envirofund project –
- Pineapple Grower's Best Practice Project - Sustainable Farming. The Honourable Mal Brough, Federal Member for Longman and Minister for Employment Services
- Horticultural forum industry issues raised by growers prior to the field day are discussed with a panel consisting of speakers from the morning sessions and other industry people (30 mins)
- Announcements, introduction of trade representatives and introduction of inventions. Alan Smerdon, QFVG Pineapple Sub Committee.
- **Field Day Program, Afternoon**
- Inspection of entries and judging of the Favco Pineapple Inventors Competition
- Other competitions
- Inspection of trade displays
- Discussions with other growers and presenters.
- Announcement of competition winners and presentation of prizes

Field Day Papers and Abstracts

Manipulating the Soil Biology to Suppress Nematode Pests

Graham Stirling, Biological Crop Protection, Brisbane, Australia

Introduction

Soil is not just an inert medium for growing plants. A healthy soil contains a vast array of living organisms that perform three important functions:
- Bind soil particles together, producing an aggregated structure that determines important physical characteristics (e.g. water infiltration, water holding capacity, aeration)
- Reduce nutrient losses due to leaching and regulate the level of nutrients that are in a mineral form and are therefore available to plants

- Suppress pests and pathogens through predation, competition and antibiotic production

The biological component of soil (sometimes referred to as the soil foodweb) is made up of a diverse array of organisms that are often sub-divided into four main groups on the basis of their size:

- *Microorganisms* (bacteria, fungi, actinomycetes and algae)
- *Microfauna* (nematodes and protozoa)
- *Mesofauna* (mites, collembola, other microarthropods and enchytraied worms)
- *Macrofauna* (earthworms, spiders, slaters, centipedes, millipedes, insects and molluscs)

Organic matter is the driving force behind the soil foodweb. When root and leaf material from plants is returned to soil, it is initially broken down by microorganisms. Organisms at the next trophic level (e.g. nematodes and protozoa) then consume these microorganisms and in turn provide food for a third trophic level (e.g. mites, predatory nematodes, predatory fungi). The mesofauna and macrofauna accelerate the decomposition process by fragmenting and redistributing large pieces of organic matter.

The soil foodweb in cropped and natural (undisturbed) soils

In soils used for cropping, the foodweb is relatively simple. Bacteria are the predominant group of microorganisms because they are favoured by the nitrogen inputs that are used to fertilise crops and the cultivation process increases the availability of readily-decomposable organic materials that are their main food source. Lack of complexity occurs because large organisms (e.g. the predatory and omnivorous nematodes) are destroyed by cultivation and they do not return because they have relatively long life cycles and cannot reproduce before the next tillage event occurs. The foodwebs of natural soils are quite different. They contain many more species and they are dominated by fungi. The increased complexity occurs because the soil fauna is not destroyed by cultivation, while fungi predominate because they survive well in the litter layer on the soil surface and are able to degrade recalcitrant compounds such as cellulose and lignin, which are important components of plant residues.

Suppression of root-knot nematode in a natural soil

Suppression is a term used to describe the process in which beneficial soil organisms keep pest species under control in some soils. The following experiment demonstrates that these natural suppressive forces operate in some Australian soils. Soil was collected from under a grass pasture at Bundaberg that had been mowed periodically for many years. Half the soil was fumigated with methyl iodide and then both natural and fumigated soils were potted, planted to tomatoes and inoculated with root-knot nematode. Gall ratings (on a 0-10 scale) and counts of nematodes in roots after 5 weeks (Table 1) showed that the natural soil contained organisms that suppressed the nematode. When these organisms were removed by fumigation, the number of nematodes in roots and the level of galling increased.

Table 1. Suppression of root-knot nematode by organisms present in a natural soil.

Treatment	Gall rating	Number of nematodes in roots
Fumigated soil	6.4 a	577 a
Natural soil	2.2 b	15 b

Numbers in the each column followed by different letters are significantly different (P=0.05).

The organisms causing the suppression in this soil were not determined. However, there were large numbers of fungal-feeding nematodes in the soil, indicating that the decomposition pathway was dominated by fungi. The presence of omnivorous and predatory nematodes also indicated that the foodweb had some structure and complexity, with many organisms present and many interactions between those organisms.

Suppression of root-knot and lesion nematodes by adding organic matter

An experiment done recently within the Sugar Yield Decline Joint Venture (Stirling 2003) showed that a sugarcane-growing soil from Bundaberg became suppressive to root-knot nematode after materials with a high C/N ratio (e.g. sugarcane trash, grass hay, sawdust) were added. Nitrogenous amendments (e.g. poultry manure, feedlot manure, mill mud) did not induce suppressiveness. In the 2002/03 season, numbers of lesion nematodes in roots were reduced by 95% when sugarcane was grown in soil amended five months previously with sugarcane trash (Table 2). Data collected in both experiments showed that the suppressive soils were fungal-dominant, had high numbers of free-living nematodes, many fungal-feeding and omnivorous nematodes, and low to moderate levels of NO_3-N.

Table 2. Effect of sugarcane trash (Trash) without and with added nitrogen on lesion nematode (*Pratylenchus zeae*) and free-living nematodes 6 months after planting sugarcane and 11 months after the organic matter was incorporated into soil.

Amendment	No. Lesion nematodes		Free-living nematodes
	Per g root	Per 200 mL soil	Per 200 mL soil
Nil	3482 a	1785a	854 b
Trash	146 b	196b	2376 a
Trash + N	218b	537b	1563b

Numbers in the each column followed by the same letter are not significantly different (P=0.05)

Biological suppression of plant-parasitic nematodes

The above observations in both natural and organically-amended soils suggest that plant-parasitic nematodes tend to be kept under control in soils where there are many free-living nematodes, particularly omnivorous and predatory species, and the soil foodweb is dominated by fungi. The latter point is perhaps not surprising, as free-living nematodes are a food source for natural enemies of nematodes and most of the parasites and predators of nematodes are fungi (Figure 1).

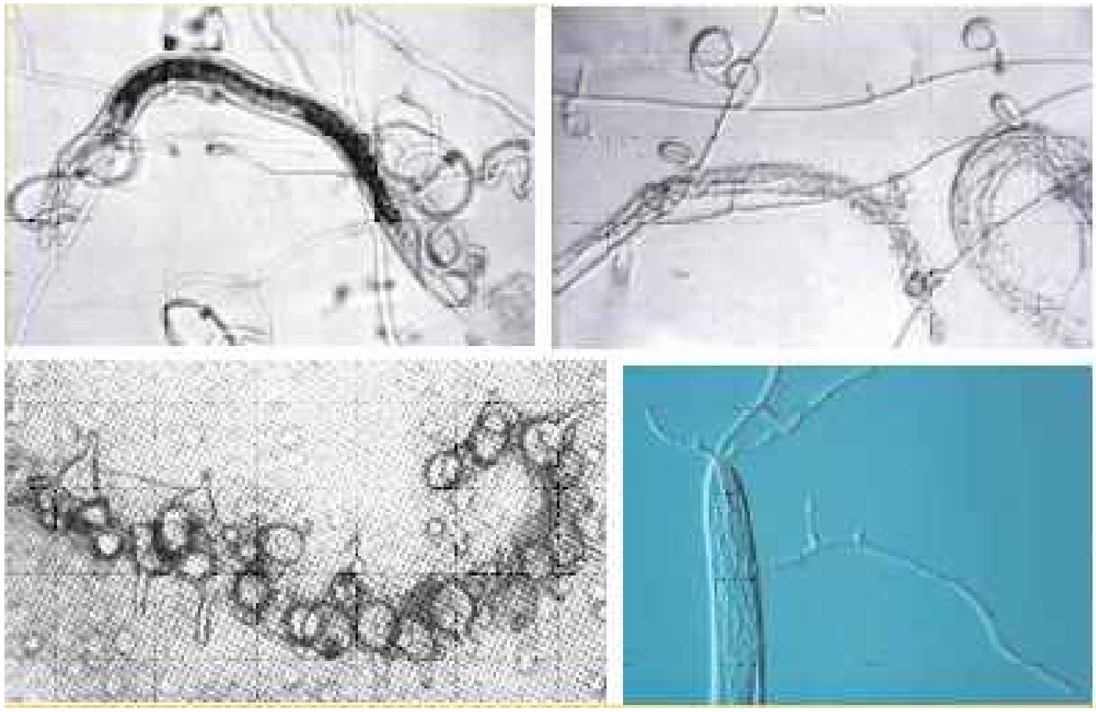

Figure 1. Fungal parasites and predators of nematodes.

As indicated previously, bacteria rather than fungi predominate in cultivated soils. It is therefore possible that the reason plant-parasitic nematodes have become pests in many cropping systems is that we have lost the fungi that normally keep them under control. Thus soil management practices that favour fungi may reduce the impact of plant-parasitic nematodes.

An experiment with organic amendments in a pineapple-growing soil

In August 2001, an experiment was established in a sandy soil on Mr. Peter Pierantozzi's farm near Beerwah, where a pineapple crop had been ploughed out following plant crop harvest. There was approximately 25 tonnes dry weight of pineapple trash on the surface of soil and this material was incorporated on its own or with 50 t/ha of either sugarcane trash, lucerne hay, poultry manure or a commercial compost. Organic amendments were initially incorporated into the soil with a rotary hoe on 24 August 2001 and plots were then cultivated every 2-3 months to enhance breakdown of organic matter. Five months after amendments were incorporated, soil samples were collected and the number of free-living nematodes in various trophic groups was counted.

The results (Table 3) showed that bacteria were the predominant component of the microbial community in this soil, as there were relatively few fungal-feeding nematodes in any treatment. Sugarcane trash increased populations of fungi, but there were still many more bacterial-feeding nematodes than fungal-feeding nematodes after the organic materials had decomposed for 20 weeks. The large predatory and omnivorous nematodes had also not returned.

Table 3. Number of free-living nematodes in organically-amended pineapple soil after decomposition for 20 weeks.

Treatment†	No. nematodes/200 mL soil		% Fungal-feeding nematodes
	Fungal-feeding	Bacterial-feeding	
PT	166	1412	11
PT + ST	676	2454	22
PT + LH	363	1820	16
PT + PM	312	3019	9
PT + C	129	1737	7

†Abbreviations are: PT, pineapple trash at 25 t ha^{-1}; ST, sugarcane trash at 50 t ha^{-1}; LH, legume hay at 50 t ha^{-1}; PM, Poultry manure at 50 t ha^{-1}; and compost at 50 t ha^{-1}.

One of the reasons the decomposition pathway was dominated by bacteria in the above experiment is that pineapple trash contains considerable amounts of nitrogen. In the above case, the trash had a nitrogen content of 0.75%, which meant that all treatments received 190 kg of nitrogen/ha when the pineapple trash was incorporated. The nitrogen input would have been as high as 300 kg/ha if a ratoon crop (which can leave behind as much as 40t dry matter/ha) was incorporated. This amount of N, together with the regular cultivation that was done to break down the trash, caused the soil biology to remain bacteria- dominant. Continual cultivation also destroyed many of the large organisms such as the omnivorous and predatory nematodes. This result suggests that the most likely way of enhancing the fungal component of pineapple soils and keeping some of the other predators is to minimize cultivation.

Minimum tillage x organic matter experiment

The aim of this experiment was to enhance fungal and nematode biological control agents using minimum tillage, crop rotation and organic amendments, and to determine whether this resulted in some control of root-knot nematode in the following pineapple crop. The experiment was established on Mr. David Treloar's farm at Bundaberg and consisted of six treatments, each replicated five times.

In July 2002, a ratoon crop was slashed and the above-ground material (about 40 t ha^{-1} dry matter) was left lying on the soil surface. Treatments 1-5 (see Table 4) were established in September 2002 by incorporating the pineapple trash into soil and immediately preparing standard pineapple beds. In some plots, sugarcane trash was added at 10 t ha^{-1} dry matter and incorporated with the pineapple trash. Pangola grass was then planted on most of the plots, but some plots were left unplanted. The grass grew well over summer, soon covering the bed surface and the inter-rows, but was sprayed out with glyphosate in March 2003. Two months later, pineapples were planted by hand into grass-covered and bare plots, and into plots prepared as per normal commercial practice (treatment 6). In August 2003, a surface mulch of sugarcane trash will be applied to treatments 2 and 4.

Table 4. Soil amendment, crop rotation and tillage treatments used in an experiment on the property of D. Treloar, Bundaberg.

Treatment†	9/02-4/03	Planting (5/03)	8/03
1	Pangola grass	-	-
2	Pangola grass	-	SC mulch‡
3	Pangola grass	-	-
4	Pangola grass	-	SC mulch
5	-	-	-
6	Rotary hoe	Beds formed	-

†All treatments were established in September, 2002. Treatments 1 and 2 were pineapple trash + sugarcane trash incorporated and beds formed, treatments 3-5 were pineapple trash incorporated and beds formed, and treatment 6 was pineapple trash rotary hoed (normal commercial practice) followed by occasional rotary hoeing between 9/02 and 4/03.
‡SC represents sugarcane mulch.

At the time the pineapples were planted (May 2003), there were only four treatments in the experiment because the mulch of sugarcane trash had not been applied to treatments 2 and 4. Soil samples were collected from the former treatments at this time and microbial activity (FDA method) and culturable fungi were measured, free-living nematodes were counted and the suppressiveness of soils to root-knot nematodes was assessed in a laboratory assay. The results (Table 5) clearly showed that the current soil management practices used in the pineapple industry have a detrimental impact on the soil biology. Microbial activity was very low in plots managed according to normal industry practice, while the low number of free-living nematodes also indicates the poor biological status of this soil.

Table 5. Effect of soil management practice in the nine months prior to planting pineapples on the biology of soil and its suppressiveness to root-knot nematode.

Treatment	Microbial activity (FDA, $\mu g\ g^{-1}\ min^{-1}$)	Fungal propagules log cfu g^{-1}	Free-living nematodes per 200 mL soil	Root-knot nematodes (supression assay)
1	1.01a	5.64a	8590a	331b
3	0.77ab	5.68a	5820b	350b
5	0.69b	5.41b	3760c	371b
6	0.37c	5.43ab	960d	994a

Treatments are: 1, Cane trash + Pangola grass (undisturbed); 3, Pangola grass (undisturbed), 5; No amendment or Pangola grass (undisturbed); 6, No amendment or Pangola grass (cultivated as per industry practice).

Cultivation appears to be the main reason for this detrimental effect, as treatment 5 (which was similar to treatment 6 except that beds were prepared 9 months previously) had a much higher microbial activity, more omnivorous nematodes and many more free-living nematodes. The use of Pangola grass to protect the surface of beds over summer, and the addition of sugarcane trash at bed formation further improved the biological status of the soil at the time of planting. However, despite these improvements, only 23-39% of the free-living nematodes were fungal-feeding species, indicating that bacteria were the dominant component of the soil foodweb at this time.

Discussion

Research in other soils and cropping systems has demonstrated that plant-parasitic nematodes tend to be kept under control in complex soil foodwebs that are dominated by fungi. However, it is difficult to achieve such a foodweb in pineapple soils because nitrogen inputs are high and soil is cultivated regularly during the intercycle period. One possible way of enhancing the predatory nematodes and fungi that are a component of complex foodwebs is to prepare beds early, grow grass on beds over summer to protect the soil from erosion, and amend soil with organic materials that have a high C/N ratio. Initial results from an experiment at Bundaberg have shown that these strategies improve the biological status of pineapple soils, although bacteria still remain the dominant component of the soil foodweb. Nevertheless, laboratory assays showed that pineapple soils that were not regularly disturbed were more suppressive to root-knot nematode than soils managed according to normal industry practice. Studies over the next 12 months will determine whether there are benefits (in terms of nematode control) in the newly-planted pineapple crop.

Acknowledgements

This work was funded by Horticulture Australia Ltd., with contributions from the pineapple industry through Golden Circle Ltd. and Queensland Vegetable Growers. Marcelle Stirling and Liz Wilson helped with nematode counts, enzyme analyses and suppression assays, and their contribution is gratefully acknowledged.

References

Stirling, G.R., Wilson, E.J., Stirling, A.M., Pankhurst, C.E., Moody, P.W. and M.J. Bell (2003). Organic amendments enhance biological suppression of plant-parasitic nematodes in sugarcane soils. Proceedings of the Australian Society of Sugar Cane Technologists, volume 25.

Surround WP Crop Protectant for the Reduction of Sunburn Damage in Pineapple

Nick Phillips, Engelhard Corporation & David J. Bell, AgNova Technologies Pty Ltd.

Background

Surround WP is a new crop product for the protection of crops from the damaging effects of sunburn and heat stress. Surround WP was developed jointly by Engelhard Corporation and scientists from the U.S. Department of Agriculture. Surround contains a specially sized and shaped kaolin, which is a naturally occurring, soft, inert white mineral.

Surround WP has been successfully used in Australia for the past two seasons, for the management of sunburn in apples and plums and is being developed for use on a number of other crops including pineapples, tomato, mango, avocado, citrus, capsicums, melons and grapes. Surround has been used extensively in the United States in the past four years, for sunburn reduction on apples, tomatoes, grapes, and walnuts. In 2002, Surround WP was used on an estimated 20% of the Washington State apple crop.

Surround is formulated as a wettable powder that suspends readily in water and is easily applied through most conventional spraying equipment. Once dry, Surround forms a white "particle film" that reflects infrared and ultraviolet light, reducing the incidence of sunburn on plants, fruits and vegetables. Under high temperatures, Surround treated plants are cooler than those that are untreated, reducing heat stress.

The particles of Surround are very small, averaging <1 micron and the film formed after application is friable with microscopic gaps that allow gases and water vapour to pass in and out of the stomata. The Surround particle film also allows Photosynthetically Active Radiation (PAR) to pass through it and into the leaf, allowing the plant to photosynthesise normally.

Studies have shown that under hot conditions, when untreated plants partially shut down photosynthesis by closing their stomata, plants treated with Surround continue to photosynthesise at high levels because their stomata remain open. This can lead to higher levels of carbon fixation that in turn may result in benefits such as generally increased plant vigour, soluble solids (Brix), fruit number, size and colour.

Reducing Sunburn Damage in Pineapple

Trials conducted in Queensland during the summer of 2002/3 have shown that Surround WP can significantly reduce sunburn damage to pineapple when applied before severe conditions occur and the particle film coverage is maintained throughout the hot period. The data show that initial applications of Surround WP at 50, 75 and 100 kg/ha followed by four subsequent applications at 25, 37.5 and 50 kg/ha respectively, at intervals from 7 to 22 days, significantly reduced the numbers of fruit exhibiting sunburn and moderate bleaching at harvest. Fifty percent of the untreated fruit harvested showed signs of sunburn or sun bleaching. The standard grower practice reduced percentage sunburn to 30%. Whilst there was no statistical difference between any of the Surround WP rates and the grower standard, there was a distinct trend that shows that Surround WP at 50 + 25, 75 + 37.5, 100 + 50 kg ha^{-1} provided better management of sunburn and sun bleaching than the grower standard.

The degree of whiteness of the Surround film on the fruit varied with application rate, but generally exceeded that provided by 5 sequential applications of the grower standard (a mixture of talc, bentonite and linseed oil that was difficult to mix and apply). Coverage data recorded following significant rainfall events suggests that the Surround WP particle film will resist erosion by rainfall at least as well if not better than the grower standard

Data* were provided on the effects of the treatments on fruit weight, length and girth. Surround WP significantly increased individual pineapple fruit weights at the highest rate of 100 + 50 kg ha^{-1} when compared to the grower standard. No significant differences in fruit weight at the lower use rates was found, although a trend is seen toward higher fruit weights in plots treated with Surround WP compared to the untreated control and a numerical increase of up to 20% compared to plots treated with the grower standard. Fruit length and girth were not significantly affected by Surround WP. Surround WP reduces canopy temperature and therefore can also significantly reduce heat and water stress.

Surround is made from kaolin. Engelhard mines and purifies its kaolin to remove other minerals. The result is a naturally occurring white mineral that is used in consumer products such as toothpaste, cosmetics, and baby powder.

Surround is listed for use in organic agriculture in the United States by the Organic Materials Review Institute (OMRI) and the Washington State Department of Agriculture (WSDA). It is also listed for use in organic agriculture in New Zealand, by Bio-Gro.

Surround is a registered trademark of Engelhard Corporation and is manufactured by Engelhard Corporation, 101 Wood Avenue, P.O. Box 770, Iselin New Jersey 08830-0770, USA. Surround WP is distributed in Australia by AgNova Technologies Pty Ltd through IHD outlets. For further information contact your supplier or David Bell on 0417-501503 or at david.j.bell@telstra.com or the AgNova Technologies web site at www.agnovatech.com.au. A full copy of Surround pineapple sunburn trials can be obtained on request from the authors.

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***Ed Note**: The text was edited and tables were deleted for brevity. I regret any errors associated with the editing.

Snippets on Nematodes and Phytophthora

Graham Stirling and Marcelle Stirling, Biological Crop Protection, Brisbane

Quantification of root-knot nematodes using DNA technology

Nematodes are relatively easy to extract from soil, but it is becoming increasingly difficult to find people with the skills to identify and count them. Identification must be done under a microscope and basic training in nematology is required to differentiate plant-parasitic species from the many other nematodes that occur in soil.

Because all organisms contain unique DNA sequences in their genomes, it is now possible to use DNA technologies to detect and quantify any organism. The process involves designing sets of primers that hybridise with a unique sequence of DNA in the target organism, amplifying the sequence using a process known as the polymerase chain reaction (PCR), and measuring the amount of organism-specific DNA that is obtained. DNA techniques are now routinely used for identification in areas such as medicine and forensic science, while Australia leads the world in using DNA technology for quantifying soil-borne pathogens directly from soil samples. Research groups in CSIRO and the South Australian Research and Development Institute have developed a DNA test for the six main nematode and fungal pathogens of cereal crops in southern Australia, and this test has been available commercially for five years (Ophel-Keller, 1999). We have worked with these research groups to extend the use of this DNA technology to horticulture, and have recently demonstrated that it is effective for detecting and quantifying two important pathogens of tomato: root-knot nematode (*Meloidogyne* spp.) and *Fusarium oxysporum* f. sp. *lycopersici*, the fungus that causes Fusarium wilt (Stirling *et al.* 2003).

The above research clearly showed that the DNA test was as effective as standard methods for detecting root-knot nematode in soils used for tomato production. However, humic substances and other organic compounds are sometimes detrimental to DNA and because they are common in pineapple soils, we needed to check that they did not have an adverse effect on the test. We therefore collected 40 soil samples from typical pineapple fields in Queensland and processed them using both the DNA test and standard methods. Because we wanted to ensure that the DNA test could detect the very low root-knot nematode population densities that are sometimes damaging to pineapple, we targeted sites that were likely to have had relatively low counts. Thus 13 of the samples had a count of zero when processed using the standard method, and 12 samples had counts between 1 and 20 root-knot nematodes/400 mL soil.

The results (Figure 1) clearly showed that there was an excellent relationship (R2 = 0.84) between the root-knot nematode counts obtained with the DNA test and the standard method. However, there were some anomalies at very low nematode densities that were probably related to sampling problems. This demonstrates that regardless of the quantification method used, more than one soil sample should be processed in situations where it is important to detect low numbers of nematodes.

Although the results with the DNA test are promising, there is no guarantee that the test will be commercialized for use in horticulture in the near future. A high throughput of samples is required for a commercial service to be economically viable, and commercialisation will only proceed when assays for other important pathogens of horticultural crops are developed. Eventually, however, DNA methods will become the standard way of detecting and quantifying organisms in soil, as many organisms can be quantified in one sample without markedly increasing the cost. In the case of the pineapple industry, for example, the levels of *Phytophthora*, *Pythium*, root-knot nematode and Symphyla could all be measured in a single soil sample.

The potential of furfural as a nematicide for the pineapple industry

Because of concerns about the effect of pesticides on human health and the environment, the number of nematicides available for use against nematode pests has declined over the last 25 years. During a search for safer materials that do not have major environmental impacts, Rodriguez-Kabana et al. (1993) reported that furfural had considerable nematicidal activity in soil. Later, Sipes (1995) claimed that furfural applied at 1867 L ha^{-1} was as effective against reniform nematode on pineapples as 1,-3 D at 337 L ha^{-1}, although this claim is not substantiated by the data presented.

Furfural is a natural product found in many plants. It is manufactured in commercial quantities through heat-treatment of agricultural residues such as corn cobs, sugarcane bagasse or oat, rice or cotton seed hulls. In Australia, one of the sugar mills in Queensland has recently shown interest in manufacturing furfural and developing it as a nematicide.

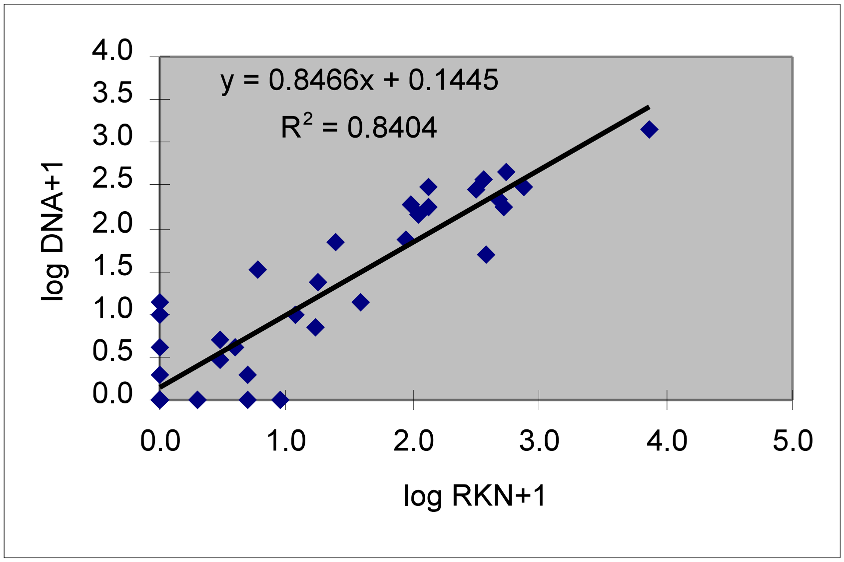


Figure 1. Relationship between root-knot nematode counts (expressed as [log number of second-stage juveniles/400 mL soil +1]) obtained using DNA and the standard extraction tray method.

The potential of furfural as a nematicide for the pineapple industry was evaluated in an experiment set up in May 2003 on the property of Mr David Treloar, Bundaberg. Furfural was applied to pineapple beds at 0, 200, 400 and 800 L ha^{-1} (equivalent to 0, 106, 212 or 424 L furfural/ha of pineapples), with the four treatments being applied to six replicate plots each 12.5 m long. The chemical was mixed with the equivalent of 4500 L ha^{-1} of water and applied to the soil surface with a watering can. The chemical was immediately incorporated with a rotary hoe and then beds were formed, with the whole operation from application to bed formation taking no longer than 3 minutes. The soil temperature at a depth of 15 cm was 19˚C at the time of application, but increased to 26˚C later in the day.

Within 30-60 minutes of bed formation, 20 mL of sand containing 20 egg masses of root-knot nematode was mixed with 200 mL of soil from each plot and the mixture was then placed in a styrofoam drinking cup punctured with 50 holes 3 mm in diameter. Cups were buried 12-21 cm below the soil surface in the plots from which the soil was obtained. One week after application, soil was collected from each plot, cups were retrieved from the field and nematodes were extracted from both cups and soil using standard methods. Pineapples were planted 10 days after the furfural was applied.

The results showed that furfural had limited nematicidal activity under the test conditions (Table 1). At an application rate of 800 L ha^{-1}, there was some evidence of activity against root-knot nematode, but because the effect was not consistent between replicates, the number of nematodes was not reduced significantly. A possible reason for the inconsistent response is that furfural has a density of 1.55 g mL^{-1} and therefore settles out in water. It was therefore difficult to keep the water/furfural suspension agitated with the application equipment used, and so the application rate may have varied somewhat within each plot, despite the fact that the soil was cultivated with a rotary hoe. The lack of an effect of furfural against beneficial free-living nematodes could be seen as a useful trait, but because these nematodes usually respond to nematicides in much the same way as plant parasites, it may also indicate poor nematicidal activity under the test conditions.

Table 1. Effect of furfural on inoculum of root-knot nematode and numbers of free-living nematodes in soil one week after the chemical was applied to a pineapple-growing soil.

Furfural (L/treated ha)	Number of nematodes/200 mL soil*	
	Root-knot nematode	Free-living nematodes
0	406	954
200	229	766
281	400	744
800	50	705

*Numbers are equivalent means from log transformed data. Numbers in each column are not significantly different (P=0.05).

Although the potential of furfural cannot be fully evaluated until the pineapple crop is at least 12 months old, these results suggest that higher application rates and/or different application methods may be needed to achieve satisfactory nematode control in pineapple.

Control of root-knot nematode and Phytophthora using plant defence-promoters

A considerable amount of work has been done in the last 10-15 years on a group of chemicals that act against pathogens by stimulating the natural defence mechanisms of plants. One of the most widely researched compounds is acibenzolar, which is produced by Novartis as Bion and by Syngenta under the trade name Boost. This product and various related compounds have been shown to induce resistance in plants to a wide range of root pathogens, including fungi and nematodes (Cohen 2002; Owen *et al*. 2002; Chinnasri *et al*. 2003). In this paper, we report on its effects against Phytophthora and root-knot nematode on pineapple. In the case of Phytophthora, we were interested in whether acibenzolar was effective on its own or whether it could be used to improve the level of control currently obtainable with phosphonate, as this strategy was found to be useful on other plants (Ali *et al*. 2000).

Effect of acibenzolar/ and or phosphonate on Phytophthora. Fosject-200 at a rate equivalent to 12L ha^{-1}, acibenzolar at 50 mg L^{-1} as Boost, or the two chemicals combined, were sprayed onto pineapple plants growing in pots. One week later, the plants were challenged with P. cinnamomi by transplanting them into potting mix containing autoclaved wheat inoculated with the fungus. Two rates of *P. cinnamomi* were used: 0.1 and 1.0 g inoculum/L of potting mix. Plants sprayed with water and plants not challenged with *P. cinnamomi* were included as controls. One week after inoculation, the soil was subjected to periods of soil saturation followed by drying to provide conditions that favoured infection by the fungus. Plants were harvested after two months and rated for % healthy roots.

The results (Table 2) showed that in a situation where root rotting was not severe, both Boost and phosphonate reduced the amount of root rotting compared to the unsprayed control. Boost on its own was as effective as phosphonate.

Table 2. The effect of phosphonate, acibenzolar (Boost) or a combination of the two chemicals on root rot of pineapple caused by *P. cinnamomi*.

Inoculum	% primary roots rotted			
(g L^{-1})	Unsprayed	Phosphonate	Boost	Boost + phosphonate
0.1	10b*	0.8a	0.7a	0.6a
1.0	19.9b	1.6a	2.1a	0.3a

* Numbers followed by the same letter are not significantly different (P=0.05).

Effect of acibenzolar on root-knot nematode. Two-month-old pineapple plants in pots were sprayed to run-off with acibenzolar (as Bion). Two rates of acibenzolar (25 mg/L or 50 mg/L) and three spray regimes were used so that nine plants per treatment received one, two or three sprays at each application rate. Unsprayed plants were also included in the experiment. One week after the last spray, the soil was inoculated with 40,000 root-knot nematode eggs per pot. After two months, roots were checked for terminal galls and the number of galled roots and the total number of roots was recorded. Root dry weights were also determined.

The results (Table 3) show that acibenzolar reduced root galling by about 30% and that a single spray was as effective as two or three sprays. However, root dry weight was reduced substantially by spraying with acibenzolar. Given this unexpected result, further pot and field experiments are currently underway to confirm our initial results and further evaluate the effects of acibenzolar on root growth in pineapple.

Table 3. The effect one, two or three sprays of acibenzolar on galling and root dry weight of plants inoculated with root-knot nematodes.

acibenzolar	% roots with terminal galls			
`(mg $L^{-1}$)`	No sprays	One spray	Two sprays	Three sprays
0	33.1b*			
25		10.1a	19.1	16.4a
50		11.5a	10.8a	8.0a
	Root dry weight (g)			
0	4.44a			
25		2.98c	1.54c	1.53c
50		2.27bc	1.38c	1.45c

*For each of the parameters measured, numbers followed by the same letter are not significantly different (P=0.05).

Root rot control in pineapple: a field experiment

The main purpose of this experiment was to evaluate the efficacy of acibenzolar (see above) in reducing root rot of pineapple in the field. It was established on the Henzell farm at Elimbah, at a site where typical root rot symptoms had been observed in the previous pineapple crop. There were three pre-plant treatments and three post-plant treatments in a factorial design with five replicates (Table 4).

Pineapples were planted on 14 December 2001, with the specific details of each treatment as follows:

- Metham sodium: The fumigant was applied at 850 L/ha on 3 December 2001 using commercial application machinery.
- Compost: Envirorganics Premium Compost was applied on 13 December 2001 at 50 t/ha and incorporated into soil with a rotary hoe.
- Metalaxyl: Ridomil 480 EC Gold was applied at 0.5 L/ha on 13 December 2001 and incorporated into soil with a rotary hoe. A second application at the same rate was drenched onto the soil six weeks later.
- Phosphonate: An EC formulation (400 g/L) was sprayed at 6L/ha on 9 April 2002, 29 August 2002, 16 January 2003 and 16 April 2003.

- Acibenzolar: Boost was sprayed at 125 mL/ha at the same time that phosphonate was applied.

Four plants were dug from each plot after 6 months, root health was assessed and root biomass was measured. Soil samples were also collected, microbial activity was determined, nematodes were counted and soil was bioassayed for Phytophthora and Pythium. In April 2003 (i.e. 16 months after planting), above-ground biomass was rated on a scale of 3, 2 and 1, where 3 = good, 2 = medium and 1= poor growth. The plant crop is due to be harvested in October 2003.

Analyses of the data showed that there were significant effects of pre-plant treatments on plant growth, but no effect of either metalaxyl or acibenzolar. At 16 months, plants treated with metham sodium were larger than untreated plants. Root biomass at 6 months was reduced by compost, but at 16 months compost-treated plants were intermediate in size (Table 5).

Measurements of pathogens and beneficial organisms and observations of root rotting failed to explain these responses. Treatments had little impact on the beneficial soil biology, except that metham sodium reduced microbial activity at 6 months. There were no signs of root rotting when the roots of the crop were inspected at 6 months, and the weather in the following 12 months was unusually dry and not conducive to root rot problems. Also, Phytophthora, the main cause of root rot in Queensland, was never detected at the site. Root-knot nematode, another important root pathogen, was also absent.

Table 4. Treatments applied in a field trial at Elimbah.

Pre-plant treatment	Post-plant treatment
Metham sodium	Nil
Metham sodium	Metalaxyl + phosphonate
Metham sodium	Metalaxyl + phosphonate + acibenzolar
Compost	Nil
Comoost	Metalaxyl + phosphonate
Compost	Metalaxyl + phosphonate + acibenzolar
Nil	Nil
Nil	Metalaxyl + phosphonate
Nil	Metalaxyl + phosphonate + acibenzolar

Table 5. Effect of pre-plant treatments on root biomass and plant growth in a field trial at Elimbah.

Treatment	Average root dry wt./plant at 6 months (g)	Growth rating at 16 months
Metham sodium	4.08a*	2.53a
Compost	2.58b	2.27b
Nil	3.86a	1.68c

*Numbers in the same column followed by the same letter are not significantly different (P=0.05)

In conclusion, results to date indicate that there has been a clear response to metham sodium that is not due to the control of either nematodes or Phytophthora. Work is underway to identify the pathogen/s involved. Pythium is one possibility, as it is commonly isolated from soil and roots at this site and is a known pathogen of pineapple (Klemmer and Nakano, 1964).

Acknowledgements

We thank Dr. Kathy Ophel-Keller and Dr. Alan McKay for the DNA analyses, Neale Williams, Proserpine Sugar Mill for arranging supplies of furfural, Jenny Hargreaves and Liz Wilson for technical help and Doug Christensen and Tim Wolens for assistance with some of the field trials. Funding was provided by Horticulture Australia, with contributions from Golden Circle Ltd. and Queensland Fruit and Vegetable Growers.

References

Ali, Z., Smith, I. and D.I. Guest (2000). Combinations of potassium phosphonate and Bion (acibenzolar–S-methyl) reduce root infection and dieback of *Pinus integrifolia* and *Isopogon cuneatus* caused by *Phytophthora cinnamomi*. Australasian Plant Pathology 29, 59-63.

Chinnasri, B., Sipes, B.S. and D.P. Schmitt (2003). Effects of acibenzolar-S-methyl application to *Rotylenchulus reniformis* and *Meloidogyne javanica*. Journal of Nematology 35, 110-114.

Cohen, Y.R. (2002). β-aminobutyric acid-induced resistance against plant pathogens. Plant Disease 86, 448-457.

Klemmer, H.W. and R.Y. Nakano (1964). Distribution and pathogenicity of *Phytophthora* and *Pythium* in pineapple soils of Hawaii. Plant Disease Reporter 48, 848-852

Ophel-Keller, K, McKay, A., Driver, F and J. Curran (1999). The cereal root disease testing service. In Proceedings, First Australasian Soil-borne Diseases Symposium (ed. R. Magarey). Bureau of Sugar Experiment Stations, QLD, Australia, pp. 63-64.

Owen, K. J., Green, C. D. and B.J. Deverall (2002). A benzothiadiazole applied to foliage reduces development and egg deposition by *Meloidogyne* spp. in glasshouse-grown grapevine roots. Australasian Plant Pathology Society, 31, 47-53

Rodriguez-Kabana, R., Kloepper, J.W, Weaver, C.F and D.G. Robertson (1993). Control of plant parasitic nematodes with furfural- a naturally occurring fumigant. Nematropica 23, 63-73.

Sipes, B.S. (1995). Pre-plant and post-plant nematicides for nematode control in pineapple. Acta Horticulturae 425, 457-464.

Stirling G.R. et. al. (2003). Monitoring and diagnostic aids for predicting and managing soil-borne diseases in fresh tomatoes. Final report of VX99029, Horticulture Australia Ltd., Sydney.

Pineapple Growers' Best Practice Project – Sustainable Farming

An Australian Government Envirofund – Pumicestone Catchment Coordination Association initiative

Anita Petzler, Project Officer, PRCCA and Doug Christensen, Golden Circle Limited

Sensitive Fit Between Farming, Urbanization and Natural Heritage Values

Half of all pineapple production is located within the sensitive Pumicestone Passage water catchment. This area focuses on the Wamuran-Elimbah and Beerwah-Glasshouse townships from 60km to 100km north of Brisbane. This region is experiencing rapid increases in population density and is faced with the challenge of protecting natural heritage values whilst balancing economic and social growth.

The Pumicestone Passage is internationally recognised for its ecological values under the RAMSAR convention, which identifies wetlands of international importance. However the Passage faces major runoff effects from land based activities, leading to significant levels of sedimentation in creek beds, increased water turbidity and nutrient enrichment of the waterways.

Horticulture is identified as one of the causes of runoff in the catchment. Pineapples are one of the largest horticulture crops in the area with approximately 2700 hectares under cultivation. Furthermore, pineapple farming employs one of the most exposed soil growing systems of any crop cultivation and demands a high fertiliser input regime for the first year of crop growth.

Agriculture Codes of Practice

Since 1996 there have been upgraded social and environmental standards via the state Farm Codes of Practice and local government Sediment and Stormwater Management Strategies. In addition, coastal management strategies have also been developed, aimed at protecting sensitive reefs and sea grass beds.

Pro-active Response Through Growers' Best Practice

The Pineapple Growers' Best Practice Education Project seeks to establish best practice techniques in land management on pineapple farms by addressing practical in-field applications for soil conservation. Growers are invited to have direct input during the development of useable ideas for soil conservation in crops. Information will be presented in a user-friendly handbook and field plots will be established on four farms in the locality, demonstrating various best practice techniques. The handbook can be distributed through a field day in which the demonstration sites will also be visited.

Partnerships in a Sustainable Future

The project is funded for year 2003, under the Australian Government Envirofund scheme and is a collaborative effort between the Pumicestone Region Catchment Coordination Association, Golden Circle Limited and local Farmers, with the guidance of scientists from the Queensland Department of Natural Resources and Mines. The project has excited interest from political representatives, government bodies and community groups.

Pineapple Mealybug Wilt Disease in Australia

Cherie Gambley, Department of Primary Industries, Indooroopilly

General

Previous research into the cause of mealybug wilt disease in Australia found that there were at least three viruses, one badnavirus and two closterovirids, which infect pineapple. The current research project by our group began 4 years ago. Initially we aimed to clarify how many viruses were present in pineapples. For example, another vegetatively propagated crop, grapevine, when affected by leafroll disease, can be infected with at least eight different closteroviruses. Thus it was thought there were likely to be more viruses present in pineapple. Once additional viruses were identified, diagnostic assays would be developed for their detection. This would allow us to make comparisons between which virus or viruses are present in healthy pineapples and which are present in mealybug wilt-affected pineapples. A field trial to evaluate the role insect feeding in the development of wilt disease has been established. Another aim of the research is to use tissue culture in an attempt to produce closterovirid-free pineapples.

Viruses infecting pineapple

We have found at least five badnaviruses and four closterovirids in Australian pineapple. Two of the closterovirids detected in Australian pineapples are Pineapple mealybug wilt associated virus 1 and Pineapple mealybug wilt associated virus 2 (PMWaV-2), both recently reported to also occur in Hawaiian pineapples. The remaining two closterovirids were previously unknown. Pineapple bacilliform virus (PBV) is known to infect Australian pineapples. The remaining four badnaviruses were previously unknown and four of the five badnaviruses have been detected in Australian pineapples. Mealybugs are a known vector of closterovirids and badnaviruses. The pineapple mealybug (Dysmicoccus brevipes) is a known vector of three of the closterovirids and one of the newly detected badnaviruses, but is likely to transmit all.

Disease Surveys

Mealybug wilt disease was monitored in two SE Qld pineapple crops. A selection of healthy and disease-affected F180 and GC1 pineapples were sampled and indexed for the four closterovirids. There was no clear association between the presence of any one virus or any particular virus combination and disease symptoms. Importantly, there was no clear association between PMWaV-2 and the disease, in contrast to overseas reports. The disease symptoms were more prominent in the F180 as compared to the GC1 crop and all plants recovered from disease to produce fruit. Indexing the plants for badnaviruses will also be done.

Field Trial

A field trial was planted early this year at Redlands Research Station, DPI. The aim of the trial is to investigate the role mealybug feeding has on the development of wilt disease in the presence or absence of closterovirids. Virus infected pineapples with and without mealybug infestation will be compared to determine whether closterovirid infection and mealybug feeding together are necessary for the development of the disease. Closterovirid-free plants with and without mealybugs will also be compared to see if insect feeding alone causes any symptoms. Mixed plots containing plants with and without virus will also be monitored for virus spread in the presence and absence of mealybugs. This trial will be initially monitoring closterovirids only.

Virus Free Pineapples

Experiments aimed at producing closterovirid free pineapples began late last year. A harsh bleach treatment of pineapple buds was used during initiation into tissue culture. It is believed the harsh bleach treatment kills most cells within the bud, leaving only a few alive to regenerate the plant. This increases the chance of producing a virus free plant as not all cells are infected. Plants have been transferred to soil and are awaiting virus indexing.

Summary

There are many viruses infecting pineapple and initial results have not identified a clear cause of mealybug wilt disease in Australia. Field trial data and disease surveys will help to determine which virus or viruses contribute to disease symptoms. As most commercial cultivars are totally infected with one or more viruses, the production of virus-free pineapples will remove many constraints to current research into mealybug wilt disease as well as providing great benefit to the industry.

Staff: The current research has been a combined effort between myself and the following DPI staff, Visnja Steele, Dr Andrew Geering and Dr John Thomas. All tissue culture experiments were done in collaboration with staff at the Maroochy Research Station and in particular with Mrs Sharon Hamill.

Gm Pineapples: What Are the Specific Licence Conditions Set by the Office of the Gene Technology Regulator?

Mike Smith, Lien Ko and Ralf Dietzgen, QDPI, AFFS – Biotechnology

The text of the article was not included here for the sake of brevity and because it was assumed to be site-specific. Some information on the topic can be found at http://www.ogtr.gov.au.

White Grubs and Other Incidental Pests of Pineapple

Doug Christensen, Golden Circle Limited

Whitegrubs (Christmas Beetles) – South Queensland Districts

Southern white grub problems are due to species associated with grass pastures and lawns. Species are unconfirmed, but the common Christmas beetles can be implicated as pests, these include a medium sized bronze coloured beetle and small brown beetle or black beetle. These are not cane grubs and feed on organic matter, but can be damaging root feeders in the advanced larval stages. The affected pineapple soils are sandy, but compacting fine sands and silty soils are rarely affected.

In summer and autumn of 2001 a serious root-feeding white grub problem emerged in crops in the Beerwah-Glasshouse and Wamuran-Elimbah districts. The grub problem has been present again in 2002, but to a much lesser degree. This is part of the cycle of insect population behaviour, but is also due to growers re-adopting soil fumigation and routine bed-soil incorporation of chemical before planting. Note that if egg laying occurs several weeks after soil fumigation, then fumigation will not have controlled the white grub pest.

Life Cycle: The affected pineapple crops are those planted between December and March, when main beetle flights and egg laying occurs. Damage is apparent from plant yellowing and wilting. This is visible from April-June, during and after the main larvae feeding period. From May-June to September the grubs are deep in the soil 35cm to 60cm and are in a resting stage. In spring larvae are back close to the surface, for a short pupal stage and then adult emergence.

Control: Chemical application should be timed to when the pest is close to the soil surface and when the soil is moist and conditioned to the absorption of the sprays. Chemical contact is nearly impossible deep in soil, but deep ploughing and chiselling can be effective during fallow. Delivery of chemical is effective by pre-plant soil incorporation using rotary cultivation.

These insects have an epidemic behaviour, with a cycle of favourable weather allowing concentrated egg laying and high survival rates of the root feeding larvae stages. Populations of pest can crash due to extended soaking rain or drying of the complete soil profile. Natural enemies such as parasitic nematodes and fungi are also important natural controls of the soil living larvae. Prior to 2000-2001 the only previous damage in young plants close to planting in Glasshouse was in 1985.

However in most average years there may be late damage to ratoon crops. This can be due to low levels of grubs each year over-lapping generations and building up to problem levels over two years. Beetle swarm behaviour concentrates egg laying in certain pockets of crop, often in a regular pattern due to terrain, tree-lines and soil type.

The grower is often unaware of whitegrub as a ratoon pest until plough-out reveals them. Chemical controls have dissipated from the soil at this stage and further chemical application by penetrating the foliage cover and soil crust is difficult in ratoons.

Cane grub (types of White Grub)

Known sugar cane pest species can be found in pineapple fields adjacent to sugarcane crops and in soil rotated with sugarcane. There are around 19 different species of true cane grub in Queensland, many are localised to certain regions and soil types and a few are wide ranging. Both clay loams and sandy soil types can therefore be affected. In clay loams white grubs often co-exist with the Symphylid root pest. In designated pineapple areas, species such as Greyback *Dermolepida albohirtum* can occur in Yeppoon, Lepidiota frenchi, L. noxia in Bundaberg - Hervey Bay. In April 2002, L. negatoria was positively identified causing a total ratoon pineapple failure at Woombye. While true cane grubs do infest grey sandy soils, persistent problems for pineapple crops are noted in the red loam soils of Yeppoon, Hervey Bay and Woombye.

Identification of true cane grub species is important because one or two species may be tolerant to chlorpyrifos. Identification is done by close examination of rasta hair patterns on larvae, but 100% identification sometimes requires incubation to adult beetle stage. Lately DNA marker identification of species has commenced.

Acknowledgements: We acknowledge the assistance of the BSES for identification, Cropcare-Nufarm and Maurice Schiavon of Agrisearch for recent work in identification and field proving trials, and Bayer Cropscience (Robert Vitelli) for information on a new chemical of interest for canegrub.

Black beetles (African Black Beetle *Heteronychus arator* and native Black Beetle *Metanastes vulgivagus*)

Black Beetle is associated with grass pasture and sugar cane areas. In the past it has been noted after long grass fallow in the Beerwah area, but it is most notable and persistent in the Hervey Bay-Pialba districts. Black Beetle, adult stage, swarm at times into pineapple fields and can cause serious damage to young plants by chewing base leaves off the stem and by boring into the stem. The beetles can be hard to find at times because they burrow just under the soil at the base of the plant. But the signs of leaf-stem boring with plant gum present are characteristic.

The early larvae stage (grubs) feed shallow in soil organic matter, but older grubs are capable of serious root feeding injury. The grubs are 25-30mm long with different colour, appearance and lack the characteristic hair patterns of cane grub.

Life Cycle: Black Beetle has a one-year lifecycle with the beetles emerging from mid-summer to autumn. But as the beetles have a resting stage over winter, worst activity and damage can be in the spring. The egg laying period is from September to February and the eggs hatch in 2-3 weeks. There are three grub growth stages each of three months, then a short pupae stage before adult emergence.

Control: There is no specific registration for Black Beetle, but high volume chlorpyrifos 500EC targeted at the base of plants as programmed for mealy bug and ant control in Spring and Autumn will be effective on beetle species.

Bud moths and Wireworms

Unidentified moth larvae have been observed feeding on and destroying the hearts of pineapple crowns. Small outbreaks occurred on summer crop tops in January 2003. A more persistent problem observed in Glasshouse and Wamuran is damage to the root buds of planting material crowns. This is attributed to Bud Moths, possibly Opogona glycyphaga larvae that can live in the base leaves and chew entry holes in the root buds. Damage can occur before harvest, but the pest may harbour and continue to feed soon after crowns have been planted. Damage to root buds can be extensive and significant.

Soil living wireworms Heteroderes spp. are not a noted pest of pineapple, but have been observed in pineapple fields. Wireworms are a pest at establishment stages for many crops and damage to pineapple root buds on planted crowns consistent with the eye damage in sugarcane plantings has been observed.

Termites (white ants)

Termites are active in many pineapple soils and colonise old woody plant butts. Recently growers have attributed white ants to very minor damage of plant roots, but this has not been qualified as fact.

Mealy bug

Poor plants often have high infestation of Mealy Bug on the roots and this is observed during crop inspections for root health.

Controls: When pineapples are planted without any preventative chemicals, then trivial or secondary pests may in combination assume more importance to uneven and poor plant starts. While against the principles of IPM, grower experience dictates that blanket use of fumigation or organophosphate pesticide at planting is a most successful practise.

While chlorpyrifos in particular is registered as effective soil application for Mealybug and Ants we are aware that chlorpyrifos is not appropriate, nor effective against some species and therefore cooperative research continues into more precise chemical use and integrated crop protection measures.

Pest and Life Cycle References

Australian Sugarcane Pests (J.R.Agnew 1993) BSES.

A Method for Screening Pineapple Genotypes for Resistance to Phytophthora Cinnamomi

Garth Sanewski, Queensland Horticulture Institute, Maroochy Research Station, Nambour, Queensland.

Introduction

The main form of plant resistance to *Phytophthora* appears to follow the hypersensitive response (HR). The hypersensitive response is where plant cell death occurs before the pathogen can infect the adjacent cells (Kamoun, 2001).

The early work of the Pineapple Research Institute of Hawaii is the most comprehensive regarding screening of pineapple genotypes for resistance to *P. cinnamomi*. Several approaches were used, including field screening and tooth pick inoculation of plants suspended in cups of water (Anderson and Collins, 1949; Smith, 1966). The hydroponic approach appeared the most promising (Johannessen and Kerns, 1964).

From the work of PRI researchers, the genotypes *Ananas comosus* var. *ananassoides* and *A. comosus* var. *lucidus* were considered to possess moderately good levels of resistance but *A. comosus* var. *bracteatus* and *Ananas macrodontes* possessed high levels of resistance (Anderson and Collins, 1949; Collins, 1960; Johannessen, 1964; Anderson, 1966).

The hydroponic approach seemed to be the most suitable for screening small numbers of pineapple genotypes and observing the infection pattern. This describes a screening method developed at Maroochy Research Station for *Phytophthora cinnamomi* screening and infection studies using pineapple genotypes. 'Smooth Cayenne', C10 was used as a susceptible, *A. comosus* var. *bracteatus* was used as a putative resistant and PRI 73-50 was used as a genotype of unknown resistance. Crowns of these three genotypes were established in hydroponic culture in styrofoam boxes in a controlled-temperature facility and grown for about 3 months before inoculation.

Method

Some isolates of *P. cinnamomi* do not produce sporangia in culture. For these reasons several isolates were initially used until sporulation was confirmed.

P. cinnamomi cultures were established on P10VPH agar and grown in the dark at 26°C for 4 d then transferred onto 10% CaV8 agar and held in UV at 26°C for a further 3-4 d. These cultures were then used to inoculate gauze squares (1 cm^2) on 10% CaV8 agar.

The colonised squares were gently lifted off after 4 d and placed into sterilised 250 mL Erlenmyer flasks containing 100 mL of 5% cleared CaV8 juice. The flasks were held at 24-26°C on an orbital shaker under fluorescent lights for 1 d. After that time the squares were covered with a thick mat of young, vigorous hyphae. The colonised gauze squares were removed and rinsed three times at 15 min intervals in a sterilised mineral solution (Chen and Zentmyer, 1970). The squares were transferred to flasks containing the mineral solution and placed on the shaker under fluorescent lights at 24°C for a further 2 d. Numerous sporangia were evident after 2 d.

The colonised gauze squares were placed in the refrigerator (5-10°C) for 20 mins before being added to the hydroponic baths. The baths contained aerated distilled water (22-24°C) in which the pineapples to be tested were suspended. Nutrients were added to suit plant growth after infection was confirmed.

Discussion

Infection occurred as a small brown mark about 1 mm behind the root tip. All 3 cultivars displayed symptoms of infection after three d. After 17 d the entire root systems of 'Smooth Cayenne' and 73-50 had turned brown and collapsed. However, the root system of *A. comosus* var. *bracteatus* no longer showed any signs of infection. While the primary root tips of *A. comosus* var. *bracteatus* had ceased growth, the secondary roots, not far along the root, had developed considerably. *A. comosus* var. *bracteatus* had a healthy, white, clean root system. Infection was prevented from spreading throughout the root system and new root growth was initiated. The behaviour of the root system of *A. comosus* var. *bracteatus* appears consistent with the HR model.

References

Anderson, E. J. and Collins, J. L. (1949). Progress in breeding for resistance to heart rot-root rot. Special Report 16. Pineapple Research Institute.

Anderson, E. J. (1966). I - The organisms and diseases. In: Review of the root rot and heart rot problem in pineapple. PRI Research Report No. 118.

Chen, D, and Zentmyer, G. A. (1970). Production of sporangia by *Phytophthora cinnamomi* in axenic culture. Mycologia. 62, 397402.

Collins, J. L (1960). The Pineapple. Interscience publishers Inc. New York. 294 pages.

Johannessen, G. A.. and Kerns, K. R. (1964). Screening and classifying new varieties for resistance to *P. cinnamomi* and *P. parasitica*. PRI Research Report No. 11.

Johannessen, G. A. (1964). Preliminary screening and classifying new varieties for resistance to *Phytophthora cinnamomi* and *P. parasitica*. PRI News 12 (2), 32-34.

Kamoun, S. (2001). Non-host resistance to *Phytophthora*: novel prospects for a classical problem. Current Opinion in Plant Biology. 4, 295-300
Smith, J. B. (1966). Plantation variety tests 1965. PRI News 13, 255-262.
Smith, J. B. (1966). II - Breeding for resistance. In: Review of the root rot and heart rot problem in pineapple. PRI Research Report No 118.

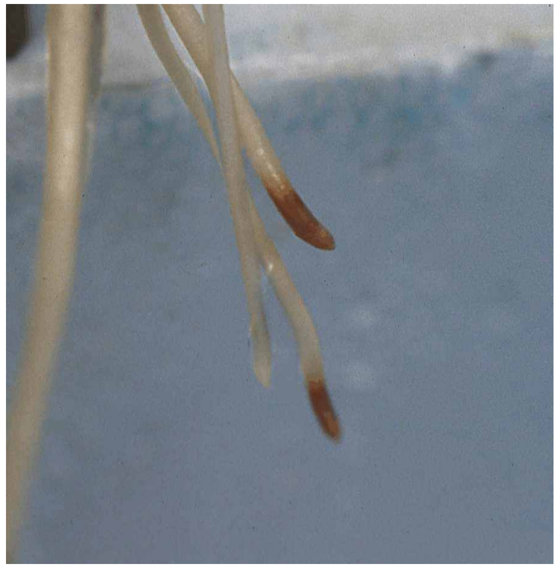


Figure 1. Cayenne roots showing infection with *P. cinnamomi* 4 days after inoculation.

News from Brazil

Inhibiting Natural Flowering on Pineapple

Getulio Augusto Pinto da Cunha and Domingo Haroldo Reinhardt, Embrapa Cassava and Fruit Crops, P. O. Box 007, 44.380-000, Cruz das Almas/BA-Brasil. E-mail: getulio@cnpmf.embrapa.br

Natural flowering in pineapple, mainly when precocious, makes pineapple management difficult in all producing areas around the world and it is becoming very frequent. It is important to control or minimize this problem because fruits of assorted sizes are produced and harvest dates can not be scheduled. Precocious pineapple flowering can be avoided or delayed, if (1) the vegetative growth of the plant is reduced so that it will not be able to flower at the time when the weather conditions become favorable for natural flowering; (2) the vegetative growth rate of the plant is increased due to the use of such production factors as nitrogen fertilization and irrigation; and (3) the biosynthesis and action of ethylene in the plant are inhibited or blocked, with the use of some chemical substances.

The growth regulators used in the work carried out at Embrapa Cassava and Fruit Crops were selected for their general inhibiting effects on vegetative growth of plants, and also because they have previously been shown to provide some control of natural flowering. The objective of the this study was to determine the role of these vegetative growth inhibitors applied in different seasons of the year, on the inhibition, reduction or delay of natural flowering of 'Perola' pineapple.

Methodology

The experiment was carried out at the experimental field of Embrapa Cassava and Tropical Fruit Crops, in Cruz das Almas/BA (12° 40" 30' S; 30° 06" 23' W; 225 m altitude), during the years of 1997-1999. The planting material used were slips (250-350 g), of 'Perola', the most widely planted cultivar in Brazil. The growth regulator solutions were sprayed on the whole plant (50 mL) with a manual sprayer. Repeated treatments were applied early in the morning at fortnightly intervals beginning either on April 17 (period A) when the plants were eight months old or May 19, 1998 (period B) when the plants were nine months old . The treatments spanned the period from April to July, the most critical time for natural flowering in the region. The number of growth regulator applications made in each of the two periods and the amount (a.i.) applied was: 2-(3-chlorophenoxy) propionic acid (ACP), 2 x 45, 3 x 30 and 4 x 30 mg L^{-1}; paclobutrazol (PBZ), 2 x 120, 3 x 80 and 4 x 80 mg L^{-1}; tebuconazole (TBZ), 3 x 20 and 3 x 40 mg L^{-1}; propaconazole (PPZ), 3 x 40 mg L^{-1}; and control (water, 4 x 50 mL $plant^{-1}$). The data on flowering percentage was based on the number of plants with inflorescences counted weekly for a period of five months beginning 40 days after the first application of the treatments.

Discussion

Season 1 (April/May): The comparison among treatments showed that at 156 days after the first application of the products, ACP and PBZ significantly inhibited pineapple flowering relative to the control (Table 1A). That effect may be the result of inhibition of vegetative growth of the plant, as the products also caused a significant reduction in the 'D' leaf length. While the 'D' leaf of the control plants was 81.3 cm long, the 'D' leaf lengths of the plants treated with ACP3, PBZ1 and PBZ3 were 69.9, 68.7 and 70.3 cm, respectively.

In another study with the same objective, plants treated with 3 applications of either 50 or 100 mg L^{-1} of 2-(3-chlorophenoxy) propionic acid showed some internal and external modifications on the leaves, including:

1. Leaf morphology - The young 'E' and 'F' leaves had small constrictions on the central portion of their limbs, while similar constrictions were observed near the bases of 'C' and 'D' leaves. At about 5-10 cm from the constrictions, callus-like structures from which adventitious roots originated were observed (Figure 1). The leaves of the central rosette were shorter, wider, and twisted in a manner similar to the "crook-neck" symptom caused by Zn deficiency (Figures 2 and 3).
2. Leaf anatomy - Leaf sections observed under the optical microscope (40X), showed that the adventitious roots originated from meristems found in the vascular bundles (xylem and phloem), and the anatomical structure of the leaves at the points of constriction were not modified. The roots in transverse section were typical in structure. Assimilative parenchyma was observed in the cortex of those adventitious roots, suggesting that this tissue carried on photosynthesis. The location of the adventitious roots was assumed to correspond with the point of accumulation of the applied product on the leaves. Despite the above anomalies, there were no dead plants and all recovered and by the end of the experiment had produced normal fruits.

Table 1. Effect of growth regulators on the control of natural flowering (%) of 'Pérola' pineapple, in seasons of application 1 and 2. Cruz das Almas, BA, 1997-99.

Treatment*	A (April/May)			B (May/June)		
	Evaluation (days after 1st application of treatments)‡					
	108	156	199	80	128	179
Control	0	80.5 a†	87.0 a	0	48.9 abc	69.5 a
ACP 1 (2 x 45 mg L^{-1})	0	9.1 c	39.0 bc	0	10.5 cde	17.0 dc
ACP 2 (3 x 30 mg L^{-1})	0	7.1 c	34.0 bc	0	7.1 ed	10.1 d
ACP 3 (4 x 30 mg L^{-1})	0	5.6 c	16.5 c	0	4.2 e	19.1 bcd
PBZ 1 (2 x 120 mg L^{-1})	0	21.5 c	42.0 abc	0	45.0 abcd	58.0 abc
PBZ 2 (3 x 80 mg L^{-1})	0	32.1 bc	45.5 abc	0	25.1 bcde	60.5 ab
PBZ 3 (4 x 80 mg L^{-1})	0	28.0 bc	46.5 abc	0	22.0 bcde	67.0 a
TBZ 1 (3 x 20 mg L^{-1})	0	59.5 ab	65.0 ab	0	48.1 abc	76.0 a
TBZ 2 (3 x 40 mg L^{-1})	0	68.5 a	74.4 ab	0	66.5 a	66.0 a
PPZ (3 x 40 mg L^{-1})	0	67.0 a	76.5 ab	0	54.0 ab	68.5 a
Growth regulator means	0	41.4	55.2	0	37.5	54.2
ACP	0	7.3	29.8	0	7.9	15.4
PBZ	0	27.2	44.7	0	30.7	61.8
TBZ	0	36.0	69.8	0	57.3	71.0
CV (%)	-	40.4	41.3	-	56.3	39.5
LSD (Tukey, 5 %)	-	32.6	46.3	-	39.7	43.0

*ACP, 2-(3-chlorofenoxy) propionic acid, PBZ (paclobutrazol), TBZ (tebuconazole); PPZ (propaconazole).
‡ Differences in numbers of days among evaluations, between seasons 1 and 2, are due to the dates data were collected, which were the same for both seasons (Aug/05, Sept/23 and Nov/04/98).
†Values followed by the same letters, in the same column, are not significantly different (Tukey, 5%).

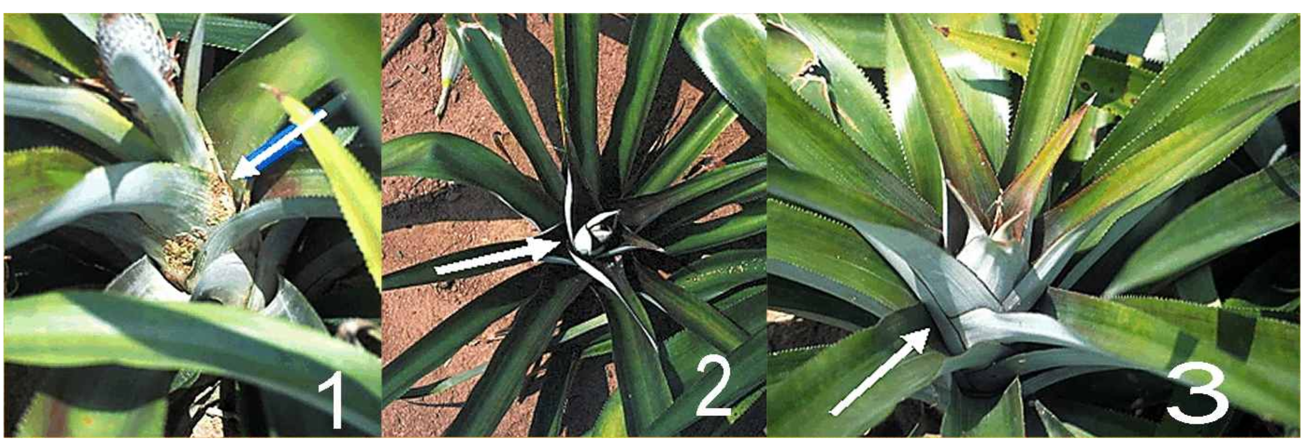


Figure 1, 2, and 3. Effects of 2-(3-clorofenoxi) propionic acid on 'Pérola' pineapple;.1, adventitious roots on leaves; 2, twisting of the leaf rosette; and 3, shortened and widened leaves.

While some inhibition of flowering was observed with tebuconazole (TBZ1 and TBZ2) and propaconazole (PPZ) (Table 1A), the reduction was not significantly less than the control. ACP significantly reduced natural flowering relative to the control but there were no differences among concentrations and numbers of applications of ACP (Table 1A). The best result with PBZ was obtained with 2 x 120 mg L^{-1} (PBZ 1), though that treatment was not significantly better than treatments PBZ 2 and PBZ 3.

The results at 199 days were similar to those at 156 days, but an increase in percentage natural flowering was observed for the ACP and PBZ treatments and only the ACP treatments had significantly less natural flowering than the control (Table IA). The average effect of the different products showed that all reducing flowering (Table 1A), but the greatest reduction was obtained with ACP.

Season 2 (May/June): As was observed in the season 1, the ACP was the product which decreased more efficiently the natural flowering of the pineapple (4.2% and 10.5%, with 128 days, and 10.1% and 19.1%, at the final evaluation), being still the only one to differ significantly from the control (Table 1B). It was also able to maintain its efficiency for a longer period, even under favorable weather conditions for flowering. So, during the period of evaluation, the ACP showed only a small decrease in its efficiency, when compared to season 1.

The PBZ was less efficient than ACP, with its flowering rates varying from 22.0 % to 45.0% and from 58.0% to 67.0%, relative to the observations with 128 and 179 days, respectively (Table 1B). According to those results, it did not differ from the other treatments, including the control. At that time, with 179 days, the inhibition caused by the PBZ presented a decrease of 31.1% in relation to the one with 128 days, very higher than the one observed in season 1.

During season 2, the only product to affect the vegetative growth of the plant was the PBZ, which presented the least "D" leaf length (74.0 cm) and dry weight (8.1 g), against 82.6 cm and 10.1 g of the control.

Season 1 vs. Season 2: In the first evaluation (Aug 05, 1998), 108 days in season 1 and 80 days in season 2, none of the plants produced flowers (Table 1A/B), which means that until 40 days before the above cited date, the floral initiation at the apical meristem had not taken place, despite the decrease in the temperature and irradiance in June.

Based on a combined analysis of the results obtained in both seasons, all the treatments presented the same pattern of performance, confirming that ACPand PBZ were the most efficient flowering inhibitors (Table 2). The month of application did not enhance, in a significant manner, the effectiveness of the growth regulators.

As previously noted, natural flowering in pineapple is very inconvenient, because the fruit production is scattered, increasing harvesting costs. Since the commercial cultivation of pineapple depends on the artificial induction of flowering, harvesting should be planned for seasons when fruit supply is lower and prices are better. Thus, inhibiting natural flowering or delaying harvesting, even for a short period of time, becomes of great importance, due to the increase in fruit prices, and also in the growers' income. A main objective of this research was to identify growth regulators that could control natural flowering since natural flowering control by the traditional cultural practices (planting material, fertilization, irrigation) have not proved to be consistently efficient.

Table 2. Combined analysis of the effects of growth regulators on the percentage natural flowering of pineapple, cv. 'Pérola' in two seasons of application (2nd and 3rd evaluations averages). Cruz das Almas, BA, 1997/99.

Treatments	Percentage flowering		
	2nd evaluation	3rd evaluation	Overall mean
Control	64.7 a†	78.3 a	(71.5)
ACP* 1 (2 x 45 mg L^{-1})	9.8 cd	28.0 bcd	
ACP 2 (3 x 30 mg/L^{-1})	7.1 d	32.1 cd	
ACP 3 (4 x 30 mg/L^{-1})	4.9 d	17.8 d	
PBZ 1 (2 x 120 mg/L^{-1})	33.3 bc	50.0 abc	
PBZ 2 (3 x 80 mg/L^{-1})	28.6 cd	53.0 ab	
PBZ 3 (4 x 80 mg/L^{-1})	25.0 cd	56.8 ab	
TBZ 1 (3 x 20 mg/L^{-1})	53.8 ab	70.5 a	
TBZ 2 (3 x 40 mg/L^{-1})	67.5 a	70.3 a	
PPZ (3 x 40 mg/L^{-1})	60.5 a	72.5 a	(66.5)
DMS (Tukey 5%)	24.9	30.6	
C.V. (%)	48.0	40.4	

*ACP, 2-(3-chlorofenoxy) propionic acid, PBZ (paclobutrazol), TBZ (tebuconazole); PPZ (propaconazole).
†Values followed by the same letters, in the same column, are not significantly different (Tukey, 5%).

Rind Color and Fruit Quality of 'Pérola' Pineapples under Ethephon Treatment

Domingo Haroldo Reinhardt, Valdique Martins Medina and Ranulfo Correa Caldas, Embrapa Cassava & Fruits, Caixa Postal 7, 44.380-000, Cruz das Almas, Bahia, email dharoldo@cnpmf.embrapa.br

'Pérola' pineapple sales have been affected by the greenish rind color of ripe fruits offered to consumers. The increasing consumer demand for an improved fruit appearance has influenced sellers and growers to apply the growth regulator ethephon to 'Pérola' pineapple fruits without a scientifically-based knowledge about its impacts. Ethephon can have negative impacts on fruits and also on planting material by forcing slips to flower when still attached to their mother plants or during the first months after planting in the field. In order to define appropriate fruit management practices, Embrapa Cassava & Fruits has been carrying out studies to evaluate the effects of application methods and concentrations of ethephon on rind and pulp characteristics of 'Pérola' pineapples during their post-harvest storage under natural conditions (temperature of 26˚C, air humidity above 60%), similar to those faced by most Brazilian pineapple growers and traders.

Green-ripe fruits were harvested and treated in a commercial orchard in Itaberaba, Bahia, and then transported, stored and evaluated at the Plant Physiology and Post-Harvest Laboratory of Embrapa Cassava & Fruits, Cruz das Almas, Bahia. A completely randomized experimental design with a 4 x 3 + 1 factorial scheme and five or more replications was used. The treatments consisted of concentrations in mg L^{-1} of ethephon (2-chloroethilphosphonic acid - 24% a.i.) in water (0, 500, 1000, 2000 and 4000), and three forms of application: small jet spraying on one side of the fruit (four days pre - harvest); broad spraying over the fruits harvested and placed into a basket (just as practiced by many growers); and immersion of the fruit into solutions for 10 seconds, without reaching the crown. At 4, 5, 7 and 11days after harvest evaluations were done on rind color and firmness, as well as on firmness, color, translucence, total soluble solids (TSS), total titrable acidity (TTA) and TSS/TTA ratio of the pulp.

Ethephon treatment accelerated fruit rind yellowing at all concentrations and application methods studied. The higher the ethephon concentration used the faster rind yellowing occurred, but the risk of discoloration of the lower crown leaves also increased, which may affect fruit acceptance by consumers. Dip of fruits into the ethephon solution produced a more rapid and even rind yellowing than that observed for the other methods of application.

Ethephon treatments did not significantly affect rind firmness or the pulp quality aspects evaluated. Dip of the fruits right after harvest was the best ethephon application method because it slightly increased rind firmness, TSS and TSS/TTA ratio and slightly decreased TTA. In spite of being classified as non climacteric, there were significant reductions in rind and pulp firmness and some other minor, but important changes in internal attributes (acidity increase and TSS/TTA decrease) in 'Pérola' pineapple fruits during the post-harvest storage period.

In summary, results allowed the recommendation that 'Pérola' pineapple fruits be treated at harvest by immersion into ethephon solutions of 500 to 2,000 mg L^{-1}, thereby getting a yellow color on about 40% to 50% of their rind area within three to four days, which usually is the time period required for their transport by trucks from the main production zones to the large cities in Southeast and South Brazil.

Selfing in Pineapple Breeding

José Renato Santos Cabral, Domingo Haroldo Reinhardt, Embrapa Cassava & Fruits, Caixa Postal 7, 44.380-000, Cruz das Almas, Bahia, email jrenato@cnpmf.embrapa.br

Programs of pineapple genetic improvement, which have relied on direct hybridization among existing cultivars, have been of low efficiency in the generation of new cultivars. One of the major reasons for that is the heterozygosis of parent plants commonly used in the crossings. The high level of segregation in the progenies from those crossings and the large number of characters used in the selection process reduces the chances of obtaining hybrids with favorable combinations of characters. The breeder must produce a very large number of offspring in order to have a chance of success in the selection phase (Coppens d´Eeckenbrugge & Duval, 1995; Chan *et al*, 2003).

Selfing has been little used in pineapple breeding programs, even though this strategy may result in significant advances in the genetic improvement of this fruit crop. One generation of selfing producing plants with 50% of homozygous genes, may open the chance for the elimination of unfavorable not dominant alleles and the identification of favorable alleles, but the effects of pineapple selfing are still little known. The self-incompatibility existent in pineapple plants is not a complete one. A certain level of selfing can be obtained by protecting the inflorescence before anthesis. The seeds harvested will generate plants that express the effects of selfing (Leal & Coppens d´Eeckenbugge, 1996).

In the Experimental Area of Embrapa Cassava & Fruits, Cruz das Almas, Bahia, inflorescences of plants from the cultivars Primavera, Perolera and Roxo de Teffé were protected before anthesis in order to force the occurrence of self-pollination. The largest number of seeds were obtained from the cultivar Primavera (15.7 per inflorescence), with lesser numbers being obtained from the other cultivars. For germination seeds were embedded in a Murashige & Skoog medium supplemented with 30 g L^{-1} of saccharose and jelled with 2 g L^{-1} of Phytagel (Sigma Chem. Co, USA) in Petri dishes, and placed into a growth chamber at 27 ±1ºC with a photoperiod of 16 hours and light intensity of 1500 lux.

The germination percentages observed were Roxo de Teffé, 44%, Primavera, 6.9% and Perolera, 6.5%. In the selfing progeny of 'Primavera' all plants had green leaves without spines ("piping"), similar to the parent plants. In the 'Perolera' progeny all plants had green leaves, but there was segregation for spines on leaf margins with two plants having spines and three plants having smooth leaf margins. These results indicate that 'Primavera' is homozygous for the dominant gene controlling the "piping" character, whereas 'Perolera' is heterozygous. In the 'Roxo de Teffé' progeny the leaf margins were covered with spines, as it is typical for the cultivar, but there was segregation for leaf color.

Seeds produced by selfing of the cultivars had low germination percentages, and plants produced from the seeds had low growth rates and vigor, needing eight to ten months under greenhouse and ten to twelve months under nursery conditions. Plants from selfings that survived the nursery phase and reached an adequate size (20 to 30 cm), were transferred to the field, where their growth was observed in comparison to slips of their parent plants presenting the same initial size. Plants from 'Primavera' and 'Perolera' selfings were shorter and had smaller 'D' leaves than their parent plants at 120 days after planting in the field (Table 1).

Faster field growth during several growth phases has been observed in plants from progenies obtained by crossings of 'Primavera' and 'Perolera' with 'Smooth Cayenne' than in plants of those varieties obtained by selfing. These results indicate that plants from selfing, under field conditions, have lower growth rate and vigor than their parent plants, due to inbreeding depression. These plants will be evaluated for resistance to fusariosis and for other characters of interest for genetic improvement. The plants with the largest number of positive characters will be used in future crossings in order to determine their general and specific capabilities for combination of parent plants used in crossings.

In a progeny of 24 plants obtained by crossing the genotype Primavera (selfing - 02), with 'Smooth Cayenne', all plants had spineless leaves ("piping") and survived after their artificial inoculation with Fusarium subglutinans, showing resistance to fusariosis. This genotype obtained by 'Primavera' selfing has been selected as a preferred parent plant, as it has the gene that controls the character for smooth "piping" type leaves and the homozygous gene for fusariosis resistance.

These preliminary results have suggested that selfing may contribute to advances in the pineapple genetic improvement program carried out at Embrapa Cassava & Fruits, opening perspectives to get more homogenous plant populations with higher selection indices as compared to those that have been obtained until now.

Table 1. Comparison of growth of plants from two pineapple cultivars, originated or not by selfing, at 120 days after field planting. Embrapa Cassava & Fruits, Cruz das Almas, BA, Brazil, 2002.

Genotype	Plant height(cm)	'D' leaf (cm)	
		length	width
Primavera (auto-fecundation)	64.0	58.0	3.3
Primavera	74.0	70.0	4.2
Perolera (auto-fecundation)	64.0	55.0	4.7
Perolera	72.0	65.0	4.9

Literature Cited

Coppens d'Eeckenbruge, G.; Duval, M.F. Bases genéticas para definir una estrategia de mejoramiento de la piña. Revista de la Facultad de Agronomia, Maracay, v. 21, p. 95-118, 1995.

Leal, F.; Coppens d'Eeckenbruge, G. Pineapple. In: Janick, J.; Moore, J.N. (eds.) Fruit breeding. Vol.1. Tree and tropical fruits. New York, John Wiley & Sons, 1996, p. 565-606.

Chan, Y.K., Coppens d'Eeckenbruge, G.; Sanewski, G.M. Breeding and variety improvement. In: Bartholomew, D.P.; Paull, R.E.; Rohrbach, K.G. (eds.) The pineapple: botany, production and uses. New York, CAB International, 2003, p. 33-55.

In Vitro Conservation of Pineapple Germplasm at Embrapa Cassava & Fruits

Fernanda Vidigal Duarte Souza (tissue culture), José Renato Santos Cabral (breeding), Embrapa Cassava & Fruits, Caixa Postal 7, 44.380-000, Cruz das Almas, Bahia, email fernanda@cnpmf.embrapa.br

Juscilene Vitória de Almeida (undergraduate student, Agronomy College of the Federal University of Bahia, Cruz das Almas, BA)

Brazil is one of the main centers of origin of the pineapple plant and presents the largest genetic variability of bromeliaceae. However, the use of a small number of varieties, together with the intensive agricultural exploitation and the accelerated deforestation, has been causing a genetic erosion of the *Ananas comosus* (L.) Merr. species.

Embrapa Cassava & Fruits has a ex-situ collection of 744 accessions of the genus Ananas and some other bromeliaceae, certainly containing a great part of its intra and interspecific genetic variability. Some of those accessions have been characterized by morphologic descriptors. Sources of fusariosis resistance, spineless leaves, short peduncle and other characteristics useful for genetic improvement of pineapple have been detected. However, accessions have been lost due to lack of adaptation to the environmental conditions at the local Active Germplasm Bank and, in other cases, due to the increasing incidence of pests after successive cultivation at the same site. Among the pests the most important one has been the PMWaV (pineapple mealybug wilt associated virus), emphasizing the relevance of application of alternative techniques of germplasm conservation.

A *in vitro* pineapple germplasm bank is being established at Embrapa Cassava & Fruits aiming at the protection of that patrimony very important for species conservation and the genetic improvement program being carried out at that research center. The first genotypes chosen for this purpose were those showing a high risk of loss, due to high susceptibility to pests and low adaptation to local environmental conditions. Due to the high incidence of PMWaV in the Active Germplasm Bank, the indexation of genotypes before their introduction to the in vitro germplasm bank is essential. The cleaning of genotypes of viruses by thermotherapy and cultivation of axillary buds has to be done to reduce risks of introducing infected materials. The in vitro bank should also function as a supplier of healthy planting material.

The strategy of conservation used has been to establish the conditions for minimum growth of plants kept under laboratory conditions in order to reduce successive subcultivations that may induce somaclonal variations and increase costs.

Among the most important factors to influence in vitro plant growth are growth regulators. Paclobutrazol (PBZ), a growth inhibitor, has been studied for more than 15 years as an alternative to conventional growth regulators (Sterreftt, 1985; Valle e Almeida, 1991; Daquinta, 1994; Berova *et al.*, 2002). That substance interferes with the synthesis of gibberelic acid inhibiting the growth of several plant species (Carvajal *et al.*, 1998; Sterreftt, 1985). However, almost no literature is known on its utilization for pineapple in vitro conservation.

In an experiment carried out at the Biotechnology Laboratory of Embrapa Cassava & Fruits, it was observed that PBZ caused a drastic reduction in plant growth in MS medium, inducing, however, a morphology in rosette form, very different from the normal one (Figure 1). The final evaluations of this work will be done at the end of two years of cultivation, when possible somaclonal variations will be assessed and the regenerative capacity of the plants subjected to the different treatments can be evaluated. The main goal is to get cultivation intervals of 36 to 48 months.

Forty healthy accessions have already been introduced into the *in vitro* germplasm bank and the objectives are to get the germplasm bank to be complete, and free of viruses, within about two years. At present ten plants per genotype are being introduced under incubation conditions, where temperature, photoperiod and light intensity are reduced, and plants are grown in culture media with low saline concentration and without any growth regulator.

Figure 1: Morphologic aspects of plants during *in vitro* conservation. a) eight months old pineapple plant being grown in MS medium with half of saline concentration; b) eight months old pineapple plant being grown in MS medium with half of saline concentration, supplemented with 1mg.L^{-1} of PBZ. (Embrapa Cassava & Fruits, Cruz das Almas, Bahia, Brazil).

Literature cited

Berova, M., Zlatev, Z., StoevA, N. Effect of Paclobutrazol on wheat seedlings under low temperature stress. Bul. J. Plant Physiol. v.28, n.(1-2), p.75-84, 2002.
Carvajal E., Alvarado, A.; Sterling, F.; Rodrigues, J. Uso de Paclobutrazol en clones de Palma aceitera durante la etapa de vivero. ASD oil Palm papers. n. 18. P. 29-33. 1998. Acessado em internet em 18/09/2003. http://www.asd-er.com/PSD-Pub/Bol C4E sp.htm
Daquinta, M.; Martines, T.; Castillo, R.; Benega, R. y Rodrigues, J. Estimulacion del ahijamiento en vitroplants de piña con paclobutrazol. Centro Agrícola, a.21, n. 2, mayo-agosto, 1994.
Sterreftt, J.P. Paclobutrazol: a promising growth inhibitor for injection into woody plants. J. American Society for Horticultural Science, Alexandria, 110, 4-8, 1985
Valle, R.R.; Almeida, A. Growth reduction effects of Paclobutrazol applied at different cacao seedling stages. Pesquisa Agropecuária Brasileira. Brasília. n.26. v.(11/12). P. 1991-1917, nov/dez. 1991.

The Brazilian Pineapple Industry: in Search of New Markets

Clóvis Oliveira de Almeida, Domingo Haroldo Reinhardt, Embrapa Cassava & Fruits, Caixa Postal 7, 44.380-000, Cruz das Almas, Bahia, email calmeida@cnpmf.embrapa.br

Brazil is the world's third largest producer of fruits, but the country still has a long way to go to become one of the leaders in the production and export to the world market of fresh and processed fruits. In 2002, only six fruit species (orange, cashew, banana, mango, grape and pineapple) occupied about 88% of the area of fruits harvested in Brazil (IBGE, 2003). Pineapple ranked as sixth with an area of around 60,000 ha, about 2.5% of the total. The production, in volume and value, mostly reflected the area distribution among the fruits: orange, banana, cashew, papaya and pineapple represented about 85.2% of volume and orange, banana, grape, pineapple and papaya about 70.7% of the production value. Pineapple ranked fifth in volume and value. However, taking into account the value/area ratio, a measure of relative efficiency, pineapple was third behind grape and papaya. Brazilian pineapple production is spread over all 27 States as well as the Federal District. The States of Minas Gerais (Southeast region), Paraíba (Northeast) and Pará (North) were responsible for 56% of the area harvested and 62% of the production volume in 2001 (IBGE, 2003).

International Market: A big challenge, a great chance

The international market of fresh fruits is a business valued at about US$25 billions a year, which exceeds the value of traditional crops such as soybeans (US$11.8 billions), wheat (US$16.6 billions) and beef (US$12.6 billions) (FAO, 2003). In spite of being a large market there is still a lot of room to grow. It is estimated that less than 10% of fruits produced in the world are sold on foreign markets, being mostly consumed within the country. Brazil has a rather small share of this world market, which is estimated to be less than 2%.

The international market for pineapple is relatively small when compared to the banana market, which is valued at about US$6billions and represented 24% of the total international fresh fruit market in 2001 (FAO, 2003). The total world imports of pineapple products were close to US$1.7 billions, distributed as follows: fresh – US$720.3 millions, canned – US$613 millions, simple juice – US$245.4 millions, and concentrated juice – US$83.5 millions. The potential market to be conquered by pineapple is rather large, as some numbers from the year 2001 suggest:

- Just 8.15% of pineapple world production was sold on the international market, whereas 91.85% was marketed inland;
- 31 countries did not know about this fresh fruit or did not have access to it;
- the imported volume of fresh pineapple has grown at an annual rate of 6.28% from 1990 to 2001, in spite of still being a little known fruit.

These figures show that pineapple is still considered an exotic fruit on the international market, even in some importing countries, where just a small part of the population knows about the fruit. This indicates that a more aggressive program of marketing is needed.

Total world production of pineapple in 2002 was 14.076 million tons, with the following shares held by the main producers: Thailand (14%), Philippines (12%), Brazil (10%), India (8%) and Costa Rica (7%). In spite of ranking third in production, Brazil only ranked 14th in exports of pineapple, contributing only 1.17% of the total exported volume worldwide. Costa Rica has been the largest exporter since 1995. Before that the Philippines and Ivory Coast were the largest exporters.

In 2002, the United States was the world's largest importer of pineapple (28% of the total), followed by France (14%), Japan (10%) and Belgium (9%). The main pineapple importers desire fruits with the following characteristics: yellow pulp, yellow rind, cylindrical shape, small crown, flavor close to that of the 'Pérola' variety, with the total soluble solids between 13% and 14%, although there is some variation in standards among the importing countries. The 'Smooth Cayenne' pineapple, even though it has relatively high acidity, presents most of those characteristics and is the most sold on the international market. Brazil produces mostly the 'Pérola' pineapple, which has a sweeter flavor and is compatible with the present foreign market requirements, but is visually less appealing, especially the green-mature rind, white pulp, conical shape and spiny crown.

Nowadays the market is looking for varieties that are similar to 'Pérola' in flavor and to 'Smooth Cayenne' in physical aspects. That is the major reason the 'MD2' (Gold) pineapple conquered consumer preferences in Europe. However, any plan to export 'Pérola' pineapple should not be discarded, but it certainly requires investments for its commercial promotion. Some recent experiences with 'Pérola' exports to European countries by producers from the States of Pará, Tocantins and Paraíba have underlined this (Souza and Souza, 2000).

In 2002, Brazil exported pineapple worth US$6.2 millions, of which US$3.2 millions was juice, US$1.7 million was fresh fruit and US$ 1.3 million was canned products. Most of the juice was exported from Pará State (77.2%), where there are three pineapple processing industries belonging to the same company. Fresh fruits are mostly exported from Minas Gerais (47.5%) and São Paulo (16.4%) States, where there is a good share of 'Smooth Cayenne' pineapple in production.

Pineapple juice is the main Brazilian pineapple product exported and its main destination is The Netherlands (66.3)%, probably due to the importance of the port of Rotterdam as the main entrance of agricultural products to Europe. Other important destinations are Puerto Rico (12.5%) and Italy (11.8%). Argentina has been the main importer of fresh pineapples from Brazil (85.7% of total, in 2002). Although the main volume of the Brazilian pineapple exports continues to be concentrated within a few countries, there has been diversification of the importing countries. In 2002, 16 countries received Brazilian pineapples, doubling the number of countries importing pineapples in 2001. This suggests that "windows" are being opened for the commercialization of Brazilian pineapples outside the country, what certainly is just the beginning of a long way to be gone, in the direction of a world market share in accordance to its condition as one of the largest pineapple producers.

Increasing requirements, prices ...

The requirements of the international fruit market are growing and, in some cases, the average prices are showing declining tendencies. Under those conditions, the immediate consequences are reduction of profit and increase of difficulties to access the markets. Hence, to be a large producer is not enough for warranting access to the international market. More important than being the largest is for the country to meet competitively the requirements of the main importing markets. And this is also true for the international pineapple market: Costa Rica, the largest exporter is just the fifth largest producer.

Just as happens for other fruits, the international pineapple market is becoming more and more exigent, but the recurrent pattern of average prices is characterized by strong oscillations from one period to the other, without any defined tendency of growth or decline. However, the average prices (FOB) of Brazilian fresh pineapple exports have shown a clear tendency of decline during the period 1990 to 2001, as shown by the following figure. This result may mostly reflect the condition of the market in Argentine, by far the largest importer of Brazilian pineapples, emphasizing the importance of opening of new markets.

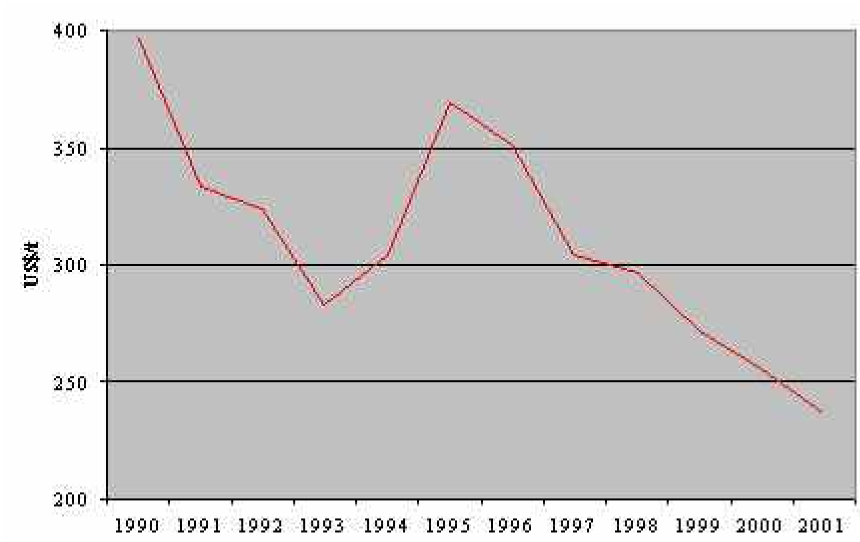
References

BRASIL. Ministério do Desenvolvimento, Indústria e Comércio. Available at: <http://aliceweb.desenvolvimento.gov.br/default.asp>. Accessed on July 15, 2003.

IBGE (Brazilian Institute for Geography and Statistics). Produção Agrícola Municipal (Municipal Agricultural Production). Available at :<http://www.sidra.ibge.gov.br>. Accessed on July 20, 2003.

Souza, L. F. da S.; Souza, J. da S. É possível exportar abacaxi 'pérola'? (Is it possible to export 'Pérola' pineapples?) Available at: <http://www.agrosite.com.br>. Accessed on July 27, 2000.

Average prices, FOB, of Brazilian fresh pineapple exports, 1990 to 2001



'Pérola' Pineapples as Influenced by Maturation Stages, Thermal Treatment, Refrigeration and Modified Atmosphere

Rosilene Ferreira Souto, José Fernando Durigan, Gustavo Colombini, João Luiz Palma Menegucci, DFA-GO, Caixa Postal 7, 44.380-000, Goiânia, GO, Brazil, email rosilenef@agricultura.gov.br

Introduction

In Brazil, the third largest world producer of pineapples, the most cultivated variety is 'Perola'. Its fruit is very well accepted on the fresh produce markets, because of its juicy and well flavored pulp. Its quality, however, depends strongly on its maturation stage at harvest. Usually, fruits must be harvested at the green-ripe or slightly colored stages.

Brazilian exports of 'Pérola' pineapples are still small, but there is a large potential to be developed. However, in addition to efficient marketing strategies, it is very important to develop post-harvest technologies that may enable the conservation of the fruits' best qualities until reaching the foreign consumers. Low temperatures have been used for transportation and storage of export pineapples. Internal browning or chilling lesions and other problems have shown that this treatment is not enough to extend storage life and to avoid undesirable changes in fruit quality. The aim of this work was to determine the effects of thermal treatments and different storage temperatures and packings on the post-harvest conservation of 'Perola' pineapples.

Methods

For all studies, 'Perola' pineapples were harvested at the green-ripe and colored maturation stages from commercial fields in Frutal, Minas Gerais State, one of the most important pineapple production areas in Brazil. Fruits were selected, washed with neutral detergent and treated with Prochloraz at 450 mg a.i. L^{-1} for 20 minutes at 10 ºC. In the first study, fruits were subjected to a pre-storage heat treatment of 40ºC for 24 h. Fruits were then stored for 17 days at 8, 14 and 25ºC, followed by 12 day at room temperature (25 ºC, 75-80% RH). In a second study, the effects of packing materials and wax treatments on storage life and quality were evaluated. The treatments were the control without packing; low density polyethylene (LDP) film, 0.05 mm thick, partial vacuum; low density polyvinyl carbon film (PEDB) with partial vacuum; polyvinyl chloride (PVC) film, 0.017 mm thick; immersion into "Sta Fresh" wax (FMC); and immersion into 1:1 "Spartan" wax (Spartan of Brazil) water solution. Fruits were kept at 8^{o}C and 95% RH for 17 days, then at room temperature for 12 days. The effects of storage treatments on fruit quality were evaluated at 0, 5, 9, 13, 17, 21, 25 and 29 days. In the last work, fruits were treated or not with heat (40^{o}C for 24 hours) and then submitted to the same packing treatments mentioned above. These fruits were refrigerated at 8^{o}C and 90% RH for 16 days and then transferred to environmental conditions for six days. Evaluations were done at days 6, 11, 16, 19 and 22.

In all studies, fruit quality evaluations were based on the following variables: loss of fresh mass, rind color; rind, central core and pulp firmness; pulp yield, appearance and color; presence of rots; contents of total soluble solids (TSS), titratable acidity (TA), ascorbic acid, soluble and reducing sugars, and insoluble residues; pH; TSS/TA ratio; internal browning and respiration rates. The pulp color was assessed with a Minolta Chroma Meter, following the methodology of the Commission Internacionale de L'Eclaraige (CIE). Rind color measurements were done following the methodology of Wolf et al., 1997 (J. American Society for Horticultural Science, 122:.698-702).

Main Results

Color and firmness of the central fruit core and TSS, soluble and reducing sugars contents were not influenced by any of the treatments. Fruit rind color changed from green to yellow and overall fruit pigmentation increased during the storage period. In general, firmness of the rind, core and pulp decreased with time, but fruit stored at 8 ºC were firmer than those stored at 14 ºC and 25 ºC. In general, pulp TSS and TA increased and the soluble sugars contents decreased along the storage period. At harvest, colored fruits had higher pulp yield, TSS, soluble and reducing sugars contents and TSS/TA ratio than green-ripe fruits. The latter had higher TA and ascorbic acid contents and weight losses. The pH was similar for both fruit maturation stages studied.

The thermal treatment did not affect rind and pulp firmness and rind luminosity, but reduced pulp TA and ascorbic acid contents and increased TSS/TA ratio and pH. Storage temperature did not influence the pulp pH, TSS/TA ratio or the contents of reducing sugars, ascorbic acid and insoluble residues, but increased rind and pulp firmness. At environmental temperatures the fruit rind became yellower and less firm along the storage period.

Concerning the packing treatments, the largest fruit losses occurred in the control, followed by the wax treatments and the LPD packing with holes (5 mm diameter) in 3% of total surface area. Fruits in the PVC treatment had low weight losses, but the lowest ones were observed for the LPD treatments with and without vacuum. The packing treatments did not influence the contents of reducing sugars, insoluble residues and ascorbic acid or the TSS/TA ratio, pulp firmness or rind color and firmness.

Internal browning did not occur in fruits stored at room temperatures. However, it occurred earlier and more intensely at the lower storage temperatures in fruits harvested at the green-ripe stage and submitted to thermal pre-storage treatment. In green-ripe fruits the first symptoms appeared after a 21-days storage period, four days after transfer from 8 ºC to environmental conditions. In colored fruits this happened four days later. Fruits stored at 14 ºC also had some internal browning, but later and less intensely than observed for those stored at 8 ºC.

Conclusions

The modified atmosphere treatments (packing and wax) did not affect the main 'Perola' fruit quality characteristics, but the use of PEBD and PVC delayed the occurrence of internal browning after transferring fruits from the cold chamber to room temperature conditions. The treatments did not avoid the internal browning. The thermal treatments shortened storage life and resulted in larger losses of fresh matter than those observed for untreated fruits. The treatments did not affect pulp color evolution, which increased with storage time.

XVIII Brazilian Congress on Fruitculture

Domingo Haroldo Reinhardt, Embrapa Cassava & Fruits, Caixa Postal 7, 44.380-000, Cruz das Almas, Bahia, email dharoldo@cnpmf.embrapa.br

Promoted and organized by the Brazilian Society of Fruitculture - SBF (Sociedade Brasileira de Fruticultura), the Agricultural Research Corporation of Santa Catarina (EPAGRI) and the Santa Catarina State Government, the XVIII Brazilian Congress on Fruitculture (Congresso Brasileiro de Fruticultura - CBF) will take place in the city of Florianópolis, capital of Santa Catarina, located in South Brazil, from November 22 to 26, 2004. The city, as well as the State of Santa Catarina, have been major touristic attractions due to its great beaches, good food and interesting cultural aspects, strongly influenced by its predominantly German and Italian colonization.

The SBF, founded on October 19, 1970, has presently more than a thousand members and publishes the most important scientific journal on fruit crops in Brazil, the Brazilian Fruitculture Journal (Revista Brasileira de Fruticultura - RBF), which is now in its 25th volume, with three numbers per year containing a total of about 170 papers written in Portuguese, English and Spanish, among them those on pineapple.

The CBFs have been the most important technical and scientific events on fruit crops in Brazil for the past 30 years, usually gathering more than thousand participants from all over the country and abroad. Pineapple agribusiness has been one of the most addressed issues at those conferences.

The XVIII CBF has as central theme "Technology, competitiveness and sustainability" and as thematic nuclei the following: Fruitculture and transgeny, fruits for the globalized market, fruits and health, family fruitculture, fruitculture and rural tourism, fruitculture and environment, quality from the orchard to the table. Papers (expanded abstracts) should be submitted until July 31, 2004. More information on the event may be obtained at the site www.xviiicbf.com.br. For information on the Brazilian Society of Fruitculture send e-mail to sbfruti@ufpel.tche.br and access the site www.ufpel.tche.br/sbfruti. For contacts with the Brazilian Journal on Fruitculture send E-mail to to rbf@fcav.unesp.br.◆

News From Ecuador

Pineapple Marketing and The Export Potential for Ecuadorian Fresh Pineapple to the United States Market

Ricardo Contreras, (Hubert Humphrey Fellow in Agricultural Economics, University of California at Davis), 1735 Coronado Ave No.32, Long Beach, CA 90804

Introduction

When agricultural producers want to expand their businesses to foreign markets, they need to begin by analyzing the export potential to the target market. The export potential is the producer's capacity to take advantage of the market opportunities. Initial research about the export potential should include information related to both external and internal factors. Market research is one of the most important variables to be considered when looking into external factors. A thorough study of external factors includes the following five indicators: import demand, consumption per capita, production, origin of imports and market access and market characteristics. In the case of pineapple, market research of external factors for the United States as a target market reveals that there are good prospects for Latin American producers.

World Production

According to the FAO statistics (Table 1) the total production of pineapple in the world in 2002 was 14.8 million MT, an increase of 2% over 2001 and virtually unchanged in 2003. Six countries produce 54% or 8.47 million MT of that pineapple. In 2003, Thailand was the main producer of pineapple in the world followed by Philippines, Brazil, China, India, and Costa Rica (Table 1).

Table 1. Major world producers of pineapple as reported by the FAO in 2002 in metric tons and the relative percentages.

Country	Tonnage†	Percentage
Brazil	1,404	9.54
China	1,316	8.94
Colombia	0.353	2.40
Costa Rica	1.060	7.20
Cote d'Ivoire	0.250	1.70
India	1.100	7.47
Indonesia	0.463	3.14
Kenya	0.600	4.07
Mexico	0.721	4.90
Nigeria	0.888	5.98
Philippines	1.652	11.22
South Africa	0.161	1.09
Thailand	1.700	11.55
United States (Hawaii)	0.296	1.97
Vietnam	0.348	2.37
Venezuela	0.296	2.38
All other	2.074	14.08

† Million metric tons. FAO, 2003 (http://www.fao.org).

World Imports

Only 8.8% or 1,311,286 MT of the world's pineapple production participated in the international fresh market trade in 2002. The United States was by far the largest single-country importer of pineapple with France, Japan and Belgium also being important importers (Table 2).

The United States Market

Imports of fresh fruit

Statistics compiled by the Economic Research Service, USDA show a steady increase in the importation of pineapple to the US market since 1998 (Table 3). The reason for the sharp increase in imports between 1998 and 2002 is assumed to be due at least in part to improved varieties such as the sweet low-acid hybrid MD-2 or Del Monte Gold, which first began shipping in volume from Costa Rica in 1996. This rapid growth in imports of fresh pineapples continued into 2003. For the period from January to October, imports increased almost 20% between 2002 and 2003. Based on the increase in imports of fresh pineapple since 1998, it is projected that fresh imports into the United States will continue to increase, at least for the next few years.

Consumption

The total consumption of fresh pineapple in the United States increased from 512 million pounds to 902 million pounds in 2001. Population growth could explain some of the increase in consumption because the population of the United State increased from approximately 248 million in 1990, 281 million in 2000, and 288 million in 2002, so there were more consumers in the marketplace. Per capita consumption corrects for simultaneous changes in population growth and growth in consumption of a commodity. In the case of fresh pineapple, consumption per capita was 2.0 pounds in 1990 but increased to 3.2 pounds by 2001. It is clear that the increase in pineapple consumption reflects a change in dietary preferences among U.S. consumers rather than just an increase due to population growth, perhaps as a result of the greater availability of improved varieties of fresh pineapple. This change in per capita consumption appears to provide good sales opportunities for Latin American pineapple producers.

Table 2. Importation of fresh pineapple in the world in 2002 as reported by the FAO.

Country	Tons	Percentage
United States	405,715	31
France	156,426	12
Japan	122,871	9
Belgium	198,539	8
Italy	78,677	6
Germany	78,677	6
Canada	52,451	4
Spain	52,451	4
UK	39,338	3
Korea	26,226	2
Others	183,580	14

Table 3. Growth in pineapple imports in the United States.†

Year	Value	Value (January to October)
1997	$77,269,000	
1998	$74,354,000	
1999	$113,571,300	
2000	$121,128,600	
2001	$143,722,300	
2002	$181,392,000	$149,000,000
2003		$178,000,000

†US Trade Information System, Foreign Agricultural Service. US Department of Agriculture (22 December 2003).

Suppliers of Pineapple

Hawaii

The most important suppliers of pineapple to the US mainland market are the U.S., from Hawaii, a relatively small player in the canned product market, and a number of Latin American countries. Pineapple production in Hawaii decreased significantly between 1988 and 2002 but has been relatively stable since 1996 (Table 4). The U.S. production situation is likely to change fairly quickly over the next few years due to low profits from processed pineapple. Maui Pineapple Company, the only processor remaining in Hawaii, has announced plans to shift emphasis from processed to fresh fruit because of the low profitability of canned pineapple. In 2002 out of a total production of 320,000 MT, just 117,000 MT were marketed fresh. With U.S. consumption growing and Hawaii supply relatively stable, there is likely to be a growing gap in the supply of pineapple on the US market. This gap easily could be filled by Latin American producers.

Table 4. Pineapple farms, acreage, production, disposition, price, and value in Hawaii, 1998-2002.

Year	Farms	Hectares	Production‡	Disposition†		Farm Price‡		Value*
				Processed	Fresh Market	Processed	Fresh market	
1996	15	8057	345	220	125	113	500	87,360
1996	15	8097	347	232	115	117	598	95,914
1997	15	8057	324	221	103	127	618	91,721
1998	15	8502	332	221	111	131	575	92,776
1999	15	8502	352	230	122	126	570	98,520
2000	15	8380	354	232	122	130	585	101,530
2001	15	8138	323	213	110	129	626	96,337
2002	15	7733	320	203	117	136	624	101,616

†1,000 MT
‡Dollars MT^{-1}
*Thousands of dollars

The Latin American countries that participate actively in the U.S. fresh pineapple market include Costa Rica, Ecuador, Mexico and Honduras (Table 5). In fact, the total shipments of pineapple from these four countries represented 99% of the total pineapple imported into the USA in 2002. Costa Rica was the main supplier of pineapple to the United States with the other countries supplying just over 10% of the U.S. market in 2002. Statistics also show that the rate of growth in exports was greater for those countries that supplied a smaller fraction of the market. In the case of Ecuador, exports grew by 160% between 2001 and 2002 while exports from Costa Rica grew by 27.96% in the same period. In summary, the Latin American exporters have the conditions to keep this trend and also to take the leadership in supplying pineapple to the United States.

Table 5. Major suppliers of fresh pineapple to the United States in 2002*.

Country	Metric tons	Value
Costa Rica	162.0	89.4
Ecuador	6.7	3.7
Mexico	5.9	3.3
Hondouras	5.6	3.1

*Suppliers of Pineapple in the United States Market - 2002. US Trade Information System, Foreign Agricultural Service. US Department of Agriculture (22 December 2003).

Ecuadorian Exports

Ecuador is increasing its participation in the pineapple marketplace and, according to Ecuadorian statistics, exportation of pineapples increased sharply in the recent years. Ecuador exported pineapple valued at $2.6 million in 1997, $4.7 million in 2001, and surprisingly, reached $12.7 million in 2002 and almost doubled in 2003 to $21.24 million. The large increase in 2002 was in part because the multinational Dole Food Company incremented its production areas in Ecuador, but also because other producers who believed in the export potential of this fruit expanded their production. Ecuador exports fruit in all months of the year, with the greatest volume of fruit being exported in the latter half of the year (Figure 1). Growth in exports continued into the first four months of 2003. Exports for the period from January to April 2002 were valued at $2.9 million while for the same period in 2003, exports increased sharply, particularly in the month of January (Figure 1).

According to pineapple export statistics (Ecuadorian Exports - 2002, 2003. Central Bank of Ecuador, Statistical Service, 22 December 2003), the main market for Ecuadorian exporters of pineapple is the U.S.A. and that country represented 57% of the total fresh pineapple exports with a value of $7.3 million in 2002. In 2003, exports to the U.S.A. represented 53% of the total pineapple exports while exports to other countries were Germany, 29.5%, Belgium, 4.4%, Italy, 3.3%, Spain, 3.3%, Holland, 2.9%, and Chile, 2.4%.

Product Characteristics

In the United States market, different varieties of pineapple are found but the two varieties that dominate the market are 'Champaka', a clone of 'Smooth Cayenne', which has been the traditional fresh fruit variety for many years, and Del Monte Gold, also known as Pineapple Research Institute of Hawaii (PRI) hybrid 73-114. 'Champaka' and other 'Smooth Cayenne' clones are well known for their conical shape, pleasant fragrance, relatively large size, and during winter production, there relatively high acidity. The production of hybrid pineapples has increased rapidly since the introduction of the Del Monte Gold hybrid in 1996. The fruit of this hybrid is generally sweeter than 'Smooth Cayenne', has lower acidity, especially in the winter months, has up to four times the amount of vitamin C and keeps longer under refrigeration. According to an article in the Wall Street Journal (Frank, 2003) per capita consumption of fresh pineapple is growing more rapidly than any other fruit except papaya. Katy McLaughlin (McLaughlin, 2003) stated that "Fresh Del Monte Produce Inc. has been dominating the pineapple market for 10 years with Del Monte Gold based on the fact that it is sweeter, brighter and less acidic than other pineapple varieties." The extent of Fresh Del Monte Produce's dominance of the U.S. fresh market for pineapples likely is known only to insiders, but the company's sales of fresh pineapples increased dramatically from less than $200 million in 1996 when Del Monte Gold was first introduced to $440 million in 2002, the last year that separate sales figures for fresh pineapples were reported to stockholders.

Supplies of hybrid pineapples such as 73-114, as well as other new hybrid varieties are likely to continue to replace 'Smooth Cayenne' clones in the marketplace. In a report to stockholders (Fresh Del Monte, 2003), Fresh Del Monte Produce announced the development of a new pineapple variety named Del Monte Honey Gold, also known as MA2 (patent pending), which will be

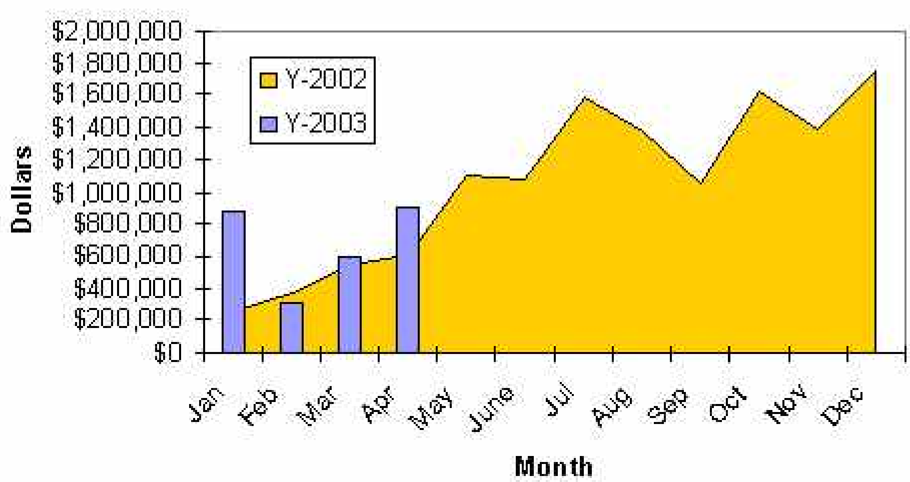


Figure 1. Ecuadorian exports of pineapple by month.

ready for sale in 2006. Maui Pineapple Company recently announced plans to focus more on the fresh pineapple market (Kubota, 2004) and their primary fresh fruit hybrid is known as Hawaiian Gold based on the PRI hybrid 73-50, a sibling of 73-114.

Market Segmentation

To segment the market, we have to consider the import districts. The objective is illustrate where consumers of pineapple are located within the United States. Imports to the United States were mostly to ports in Philadelphia and Tampa, Florida and represented 88% of the total pineapple imports. However, the concentration of imports to those two cities is primarily due to production in Hawaii. Hawaii's proximity to the western United States and the high volume of air traffic between Hawaii and the mainland U.S. provides Hawaii growers with relatively easy access to that market. That presumably explains the small fraction of imported fruit that reaches the Los Angeles market. It is concluded that production of Hawaii fulfills most of the demand of the United States west coast of the market.

Market Access

Finally, Commercial policies of the US government encourage imports from Latin American countries, facilitating market access. One important policy is the Andean Trade Promotion and Drug Eradication Act signed by the President of the United States of America on October 31, 2002. This act provides certain preferential tariff treatment, duty free, for products imported from Ecuador, Colombia, Bolivia, and Peru. Under this act, any importer of pineapple can bring in ten containers valued at $30,000 from Ecuador without having to pay any tariff in customs for the shipment. Another important negotiation related to improving market access is the creation of the Free Trade Agreement of the Americas, which had the objective of eliminating customs tariffs and trade barriers on the American continent. The plan of the U.S. government was to reduce tariffs in consumer, chemical, construction, mining and industrial goods but also to reduce tariffs for about 56% of agricultural imports, including pineapple. The external policies of the US government support trade with Latin American countries giving them new export opportunities.

Conclusion

The aforementioned external indicators about the United States market enhance the export potential of pineapple to that market. Although, the pineapple industry is dominated by multinational companies, there are other variables such as good growth rates of the import demand, incrementing per capita consumption, favorable commercial policies as well as reduction in the Hawaii production. The Latin American producers should consider the future potential, and they have to plan how to fulfill the import needs of pineapple in the United States Market. But it also is important to measure the demand trend, and so avoid oversupply in the marketplace.

References

Fresh Del Monte, 2003. http://www.corporate-ir.net/ireye/ir_site.zhtml?ticker=FDP&script=410&layout=0&item_id=458607. Accessed on March 20, 2004.

Frank, Robert. 2003. Going for 'The Gold' Turns Pineapple World Upside Down. Rush Is On to Grow Versions Of Fresh Del Monte's Fruit. Wall Street Journal, Oct. 7, 2003.

Kubota, Frank. 2004. Cannery braces for bad times. Honolulu Star Bulletin, March 30, 2004.

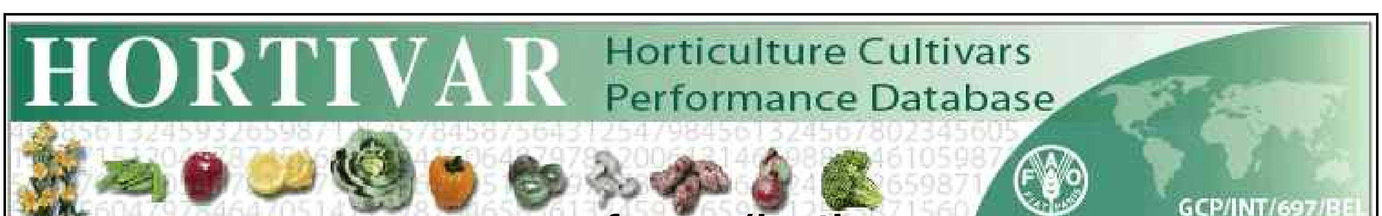
McLaughlin, Katy. 2003. Cranky Consumer: Cranky's Pineapple Acid Test, Wall Street Journal, Oct. 28, 2003.

Trade Information System. US Department of Agriculture. Foreign Agricultural Service. 29 Aug. 2003; http://www.fas.usda.gov/ustrade/.

Economic Research Service. US Department of Agriculture. Food Consumption. 25 Aug. 2003; http://www.ers.usda.gov/Data/foodconsumption/.

NASS. US Department of Agriculture. Pineapple Output Lower. 11 March 2003; http://www.nass.usda.gov/hi/fruit/pine.htm/.◆

News from Food and Agricultural Organization, United Nations



www.fao.org/hortivar
Hortivar@fao.org

HORTIVAR is a horticultural crop cultivars performance database, developed by the Food and Agriculture Organization of the United Nations (FAO) as part of the World Agriculture Information Centre (WAICENT).

HORTIVAR is a tool for safeguarding and easily retrieval of information on the agronomic performance of horticultural cultivars in relation to agro-ecological conditions, cultivation practices, the occurrence of pests and diseases and timing of the production. It is suitable for recording data obtained by producers and by public, private sector, seed companies and horticultural research centres around the world that conduct field trials to assess the performance of horticultural crop cultivars in different agro-climatic and agro-economic environments.

HORTIVAR serves as:
- A tool for easy and quick retrieval of information related to horticulture cultivars all over the world
- A standard methodology for data recording of current and future cultivar trials
- A template for educational purposes in colleges and universities
- A lively interface between scientists and growers
- A source for quick retrieval of available seeds of required cultivars for emergency operations

HORTIVAR covers six categories of horticultural crops: fruits, vegetables, roots and tubers, ornamentals, mushrooms, herbs & condiments.

HORTIVAR has two primary functions which are interdependent: Data retrieval and data entry. Data are retrieved by searching according to various parameters such as crop, species; cultivar, country, geographical references, resistance to pest and diseases, ecozone, and production system. For data entry, interested partners have to register and obtain their personalised username and password from the HORTIVAR Desk Office at FAO Headquarters by sending an e-mail to hortivar@fao.org. Access and use of HORTIVAR database in free of charge.

The structure of the HORTIVAR database has the following essentially elements:
1. **General Information** (site and geo-references, seed supplier and contact address)
2. **Cultivar** (standard cultivar descriptor and the actual characteristics observed under local field conditions)
3. **Basic Cropping and Yield** data (target plant product, production system, data recording environment, transplanting or direct seeding system, planting density, total fresh yield, crop cycle)
4. **Source** (origin of data, publication reference if any, data originator and his/her e-mail contact, country and species gatekeepers and his/her e-mail contact)
5. **Additional data** (*inter alia* climate information, target product destination and use, nursery practices, field operations and practices including substrate, irrigation, fertilization, plant protection, harvesting practices)
6. **Photograph**

Given the lack of cultivar listings and the modest amount of information on pineapple, we would like to invite the pineapple community to use the database and participate in data entry.◆

News From France

Characterization and Diversity of Pineapple Varieties Using Microsatellite Markers

Jérôme Blanc[1], Jean-Louis Noyer[2], Jean-Pierre Horry[3], Marie-France Duval[1]

[1]Cirad-flhor – Bvd de la Lironde – TA50/PS4 – 34398 Montpellier Cedex 5 – France
[2]Cirad-amis – UMR 1096 PIA - Av. Agropolis – TA40/03 – 34398 Montpellier Cedex 5 – France
[3]Cirad-flhor - Pôle de recherche agronomique de la Martinique - BP 214 - 97285 Le Lamentin Cedex 2 – Martinique – FWI

Microsatellites or simple sequence repeat loci (SSR) are a valuable tool for genetic analysis. Features such as the ability to score co-dominant loci, high allelic variability, frequency and dispersion in eukaryotic genomes make them useful molecular markers at various levels: analysis of mating systems and population structure, diversity studies, genetic mapping, and cultivar identification. Based on sequences information, the microsatellite technique is easily shared between laboratories and thus suitable for cooperative work.

A microsatellite-enriched genomic library was constructed from the DNA of a single pineapple specimen at Cirad in Montpellier using a procedure developed in this laboratory (Billotte et al., 1999). The enriched pineapple genomic library contained 325 positive inserts whose lengths varied between 118 and 1044 base pairs (bp). All of these inserts were sequenced and revealed 182 tandem repeat motifs of which 119 were potential microsatellite markers. A first set of 53 locus-specific primer pairs was designed using the Primer 3 program (Rozen and Skaletzky, 1997). Polymerase chain reaction (PCR) amplification was completed for 41 primer pairs. Polymorphism tests were conduced on a sub-sample including cultivars used in the Cirad breeding programs. Twenty-nine out of the 41 loci amplified displayed polymorphism (Figure 1).

Twenty of these microsatellites markers were selected for use in analyzing a sample of 60 *Ananas comosus* accessions from the Cirad pineapple germplasm collection maintained in Martinique (FWI) including representatives of the botanical varieties (Coppens et al., 2003, i.e. : two *A. comosus* var *bracteatus*, one *A. comosus* var *parguazensis*, two *A.comosus* var *erectifolius* and two *A. comosus* var *ananassoides*), known varieties (such as ‘Smooth Cayenne’, ‘Pérola’, ‘Perolera’, ‘Queen’, ‘Red Spanish’) and hybrids, with the objectives of i) characterizing the new hybrids bred by Cirad and ii) improving our knowledge of pineapple diversity. All hybrids tested, including siblings from the same cross, were characterized by a unique allelic combination and their parentage was assessed identifying shared alleles with the putative parents.

Polymorphism evidenced within the 40 non-hybrid accessions of the sample was high with 234 alleles revealed. Dissimilarities between accessions were calculated using the Sokal and Michener index and these dissimilarities evidenced a high genetic diversity level between botanical varieties. Dissimilarity analysis using the Neighbor Joining method (Saitou and Ney, 1987) divided *A. comosus* var *comosus* accessions in two major clusters, in accordance with their geographic origin (Figure 2). Heterozygosity was calculated for each of these clusters and ranged higher within accessions collected in the East-Guiana than in those collected in West-Amazonia, which supports the hypothesis of a primary domestication center in the East of the Guianese shield (Duval et al, 2003). This difference in heterozygosity level stands also with the parents used in the Cirad breeding program: heterozygosity rate ranges 0.89 for the ‘Smooth Cayenne’ parent originating from French Guyana- Brazilian Amapa and 0.64 for the ‘Perolera’ Colombian parent.

This first insight in the development and utilization of pineapple SSR markers provided suitable tools in characterization and study of pineapple diversity.

References

Billotte, N., Lagoda, P. J. L., Risterucci, A.-M., and Baurens, F.-C., 1999, Microsatellite-enriched libraries: applied methodology for the development of SSR markers in tropical crops., Fruits 54(4):277-288.

Duval, M. F., G. S. C. Buso, F. R. Ferreira, J.-L. Noyer, G. Coppens d'Eeckenbrugge, P. Hamon and M.E Ferreira., 2003 Relationships in Ananas and other related genera using chloroplast DNA restriction site variation. Genome 46: 990-1004.

Coppens d'Eeckenbrugge, G., and F. Leal, 2003 Morphology, Anatomy and Taxonomy, pp. 13-31 in *The pineapple: Botany, Production and Uses*, edited by D. P. Bartholomew, R. Paull and K. G. Rohrbach. CAB International, Honolulu.

Rosen, S., and H. Skaletzky, 1997 PRIMER3, available at : http://www.genome.wi.mit.edu/genome_software/other/primer3.html.

Saitou, N., and M. Nei, 1987 The Neighbor-Joining method: a new method for reconstructing phylogenetic trees. Mol. Biol. Evol.: 406-425.◆

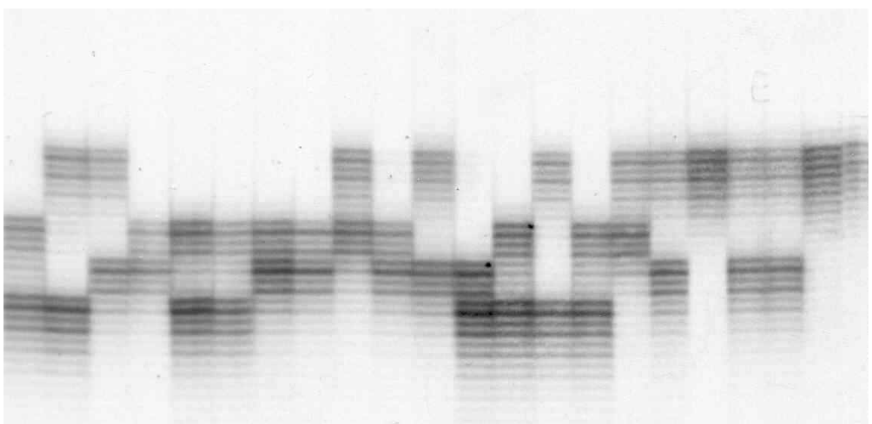


Figure 1 : Autoradiography of a denaturing UREA-Page gel shows allelic variation at Ananas SSR locus MAcCIR01.

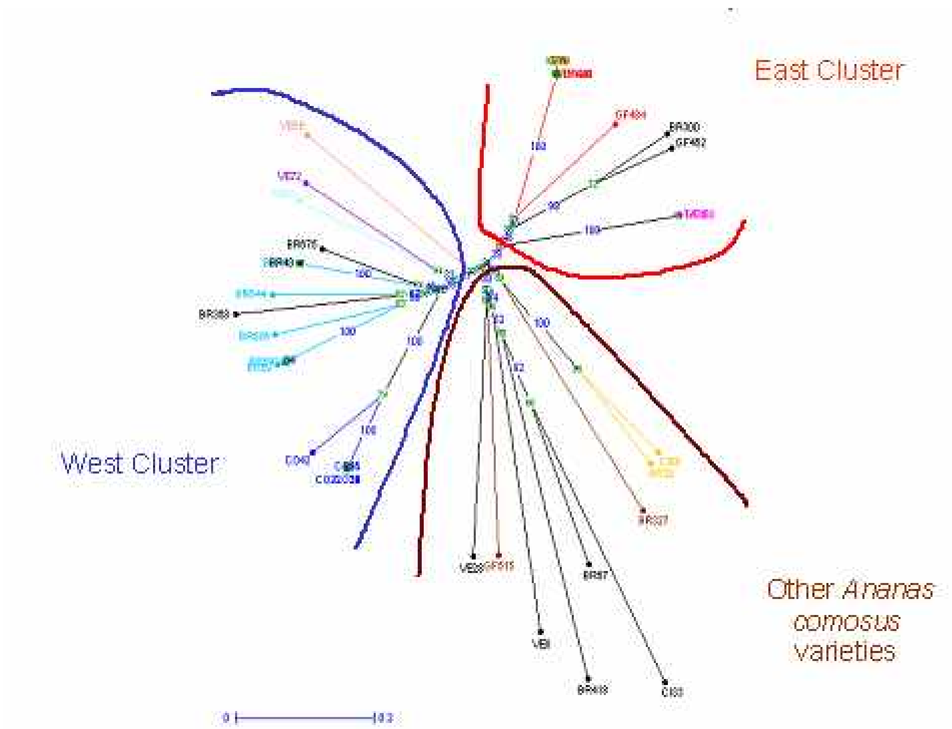


Figure 2 : Neighbor-joining representation of the Sokal and Michener dissimilarities observed at 20 microsatellites (SSR) loci.

News From Peru

Prevention of Pineapple Black Rot by Chemical Treatment

Villachica Vivanco, Jorge Hugo[1], Agricola Italia & Bretaña S. A. C. and Cadenas Giraldo, Carlos Alberto, Entomology and Phytopathology Academic Dept. at the National Agrarian University La Molina.

Abstract
Thielaviopsis paradoxa (Of Seynes) Hohrel, causing Black Rot of Pineapple (*Ananas comosus* L. Merr), was isolated and identified. Diverse contact and systemic fungicides were evaluated to determine their effectiveness in the prevention of the disease (Figure 1). Thirteen fungicides at two concentrations were evaluated *in vitro* for efficacy . Of these, captan, benomyl, chlorothalonil, thiophanatometil, triadimefon, prochloraz, triflumizol, bromuconazol and difenoconazol were selected for the post-harvest chemical treatment test, because they resulted in 100% inhibition of the growth of the mycelium and those that statistically, according to Duncan Test had turned out to be similar to these. For the test, the recently cut peduncle of the harvested fruits were inoculated followed by immersion of the fruits in diverse solutions of the fungicides. There were four treatments for each fungicide: two concentrations for each one and inoculation immediately after or three hours later. The fungicides that in the two used doses prevented infection of *T. paradoxa* in the fruits at the two times of immersion were: benomyl, triadimefon, prochloraz, triflumizol, bromuconazol, difenoconazol.

Figure 1. Photos are 1, three-day old *T. paradoxa* colony, and 2, pineapple fruit infested by *T. paradoxa*, three days after inoculation.

[1]Thesis to opt the Agricultural Engineer title of Hugo

Villachica, carried out in the laboratory of the area of Entomology and Phytopathology Dept. at the National Agrarian University La Molina, and in the Agricola Italia & Bretaña Farm S. A. C in San Ramón.

News From Sri Lanka

Protocol for Post-Harvest Management of Mauritius Pineapple

Wilson-Wijeratnam, R.S. Industrial Technology Institute, 363, Bauddhaloka Mawatha, Colombo 7, Sri Lanka; E-mail: shanthi@iti.lk

We have formulated protocol for the post harvest management of our Queen type Mauritius variety pineapple intended for sea shipment, and are in the process of conducting a commercial trial. We are working with a private company and will be testing the treatment we have developed for the control of Internal Browning (otherwise referred to as Endogenous Brown Spot) and also a wax formulation that we have developed which has worked very well with our laboratory trials.

News From Taiwan

Delaying natural flowering in pineapple

Lin, Chin-ho, Life Science Department, National Chung Hsing University
Kuan, Chin-san, Chia-Yi Agricultural Experiment Station
Hsu, Yu-Mei, Kaohsiung District Agricultural Improvement Station

In commercial production of pineapple, natural induction can be a serious problem for growers because it results in unwanted precocious flowering in a field. Further, natural flower induction in subtropical latitudes mainly occurs in the cooler winter months, beginning in November in Taiwan (latitudes 22˚-26˚N) when temperatures are cooler and winter day lengths are shorter. The duration of the period of natural induction in a field (or production area) of pineapple is determined by a variety of factors including cultivar sensitivity, plant size, and the prevailing temperature. Sensitive cultivars, sharp drops in temperature, and unseasonably cool temperatures appear to be the factors most important in natural induction. Depending on the interaction of these factors, natural induction can produce narrow or very broad flowering induction and ripening peaks. Precocious flowering causes serious scheduling problems and reduction of income for growers, in particular of fresh market growers. Control of natural induction is more critical where cultivars of high sensitivity are grown at subtropical latitudes.

Aviglycine ([S]-trans-2-Amino-4-(2aminoethoxy)-3-butenoic acid hydrochloride), an inhibitor of ethylene biosynthesis, was applied as a foliar spray to evaluate its potential to prevent natural flowering in one-year-old pineapple cv. Tainon 17 (a cross between 'Smooth Cayenne' and Rough).

Treatments were started on November 10 during the 2003/2004 production season and bolting rate evaluation ended on April 26, 2004. Treatments consisted of multiple applications (2, 3, 4, 5) of aviglycine made at 10, 15 or 20 day intervals and all treatments significantly inhibited natural flowering. Five consecutive applications of 75ppm aviglycine made at 10-day intervals reduced flowering from 82.5% in the control to 0% when evaluated on March 2nd, 113 days after the initial application. There was 85.5% flowering in the control (CK in Figure 1), and only 6.6% (A in Fig.1) for the same treatment when evaluated on March 30, 139 days after the

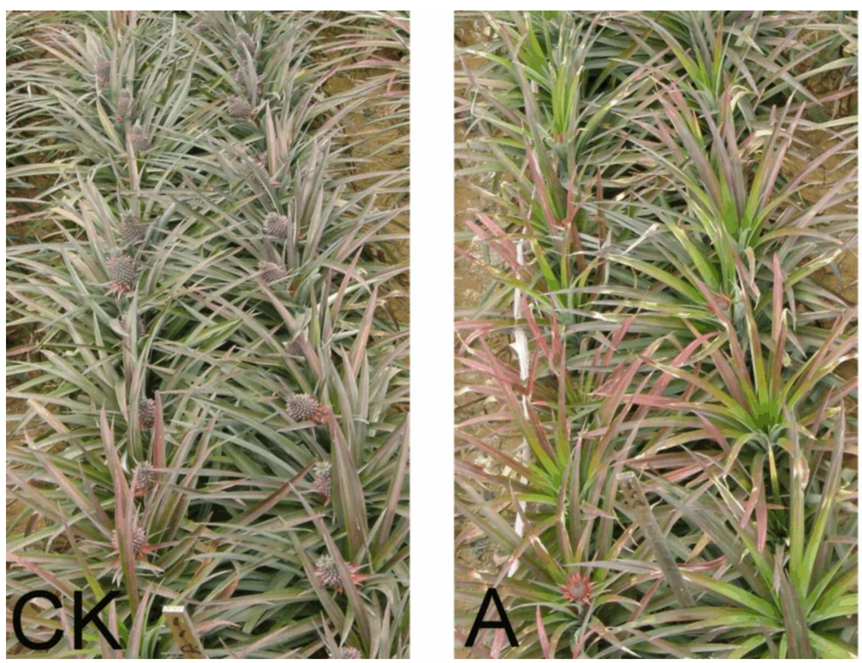


Figure 1. Photos of one-year-old Tainon 17 pineapple comparing the untreated control (CK, 85.5% bolting rate) with plants treated with five applications of 75ppm aviglycine at 10-day intervals (A, 6.6% bolting rate). Photos taken on March 30, 2004, 139 days post initial treatment of November 10, 2003

initial treatment. An effective inhibition of more the 4 months serves well for delaying natural flowering in commercial production.◆

News From the United States (Hawaii)

The Pineapple Industry in the U.S. and Asia from the Perspective of an Old Farmer

L. Douglas McCleur, Senior Management, Maui Pineapple Co. (Retired), Haliimaile, Hawaii

Canned Pineapple

Consumption of pineapple in cans is declining throughout the United States and Western Europe while at the same time there is some increase in consumption in China and Eastern Europe.

Hawaii

In Hawaii there are three pineapple companies remaining, Dole, Del Monte, and Maui Pineapple Company, Ltd. Maui Pineapple Company is the only producer of canned pineapple in the United States. In Hawaii, the canned fruit quality is the best in the world. This has resulted from a good climate for canned pineapple and years of research and experience in its production. The cost of production, however, is the highest in the world. Hawaii has expensive labor, expensive transportation, high government costs, high energy costs, and an expensive infrastructure. What has been done over the years in Hawaii is to spend money on research that will increase yields per hectare and thus reduce the cost per unit. This has been successful and has resulted in the highest yields in the world and has allowed Hawaii to remain competitive for many years. Additionally, drip irrigation was developed to supply efficient irrigation water to the crops. This has allowed Hawaii to be a reliable and consistent producer of high quality canned pineapple. In addition, work has been done in marketing to: 1) the government; 2) shift to fresh when fresh product is short; and 3) meet the high end market where 100% Hawaiian in the name is of value and where quality products from Hawaii are worth the additional cost.

Asia

In Asia there are basically two types of producers. Number one is the brands and number two are the independents. The brands, which are primarily Dole and Del Monte, have a history of extensive research and good knowledge of the crop. They do have a higher overhead cost but have been able to reliably supply the market and be able to support strong marketing organizations to sell the fruit that is often grown on their own plantations. The independents normally buy their fruit from small farmers. This is frequently an unreliable supply of low cost fruit of variable quality. Thus, the variable supply results in an over-supply or under-supply situation on a regular basis and with small farmers, that normally are unable to irrigate, weather is a major problem and contributes to the over and under supply situation.

What has been done?

Independents and brands are continuing to buy fruit from local farmers but are trying to form grower groups to educate them in the problem of fluctuating supply by providing technical assistance and purchase contracts. The major producers in Thailand and Indonesia are trying to develop water systems to provide irrigation during drought and improve the reliability of supply.

What I see that needs to be done.

In Hawaii we need to market the Hawaii name and continue to promote government sales. Number two, Hawaii needs to look at labor cost reductions in various ways such as mechanization, and further yield increases to reduce the man hours per case. This will probably mean major changes in the way fields are planted to allow for this mechanization. Some areas may not be suitable due to difficult terrain. In Asia, reliability needs to improve and quality on a year-around basis needs to be provided. And three, some order needs to put into the pricing to prevent antidumping regulations and frequent gluts of supply. The third thing that needs to be done is to continue work on an alternative to the tin can that has a long shelf life. While work has been done in this area the shelf life is still inadequate to meet the needs of long-term storage. Number four, continued market development needs to be undertaken to sell canned product to the huge market in China and Eastern Europe

Fresh pineapple

Throughout the world fresh fruit consumption is increasing and fresh pineapple consumption is increasing also, primarily due to new fresh-cut items that are more convenient for the consumer and two new whole fresh fruit varieties. Currently there are four fresh fruit varieties. Number one, MD-2, 73-114, Del Monte Gold. This is all the same variety and has greatly changed the business as it has great flavor and good shelf life as well as exceptionally good shape. The problem with this variety is its susceptibility to natural flowering. Number two, Smooth Cayenne. Smooth Cayenne is an old standard. Its reliable, easy to control in flowering, a strong plant, but the fruit tends to be high in acidity during cold short day length periods. Number three, Hawaiian Gold, 73-50, or CO2. This variety has a great flavor, is sweet, but also is subject to natural flowering. This is a big fruited variety that some think has a better flavor profile than MD-2. It does, however, have lower acidity than MD-2 and tends to be more diseased. Number four, miscellaneous varieties. Red Spanish, Sugarloaf, White Pine, and numerous other varieties are sold in small quantities throughout the world.

Major markets

The major markets for pineapple production are primarily local as the local population is close to the source and understands how to consume it. Number two, the United States. The United States continues to grow in fresh fruit consumption and fruit from both Central America and Hawaii are major players in this market. Number three, Western Europe. Western Europe consumes large quantities of fruit from Africa and Central America.

What needs to be done

The new varieties that have the greatest market acceptance have natural flowering problems. These crops need to controlled in order to supply the supermarkets and consumers with product on a year-around basis. Number two, new varieties need to be developed that are insect, nematode, and naturally flowering resistant. Number three, over supply will be a problem in the fresh fruit business if production cannot be controlled. As independent farmers get more planting material I foresee this as being a problem. Number four, the shelf life of pineapple is relatively short compared to other crops such as apples, pears, and grapes. Further solutions must be found particularly since flowering is not yet under control.

Over the last 40 years I have watched our industry go through its growing pains, change considerably, and still flourish. I believe the future is bright but all involved throughout the industry have to be adaptable and change. With change our future is strong. Without it, only the strong will survive.

Ed. Note: I hope Doug McCleur's article will encourage others to write about their personal interest in or experience with pineapple. I greatly appreciate Doug's willingness to "stick his neck out" and provide this commentary on pineapple.

Current Nematode Control Research in Hawaii

Brent Sipes, Dept. of Plant and Environmental Protection Sciences, University of Hawaii, Honolulu, 96822; E-mail: sipes@hawaii.edu

Induction of natural plant defense is a hot topic in plant pathology. We have tested two products that induce systemic acquired resistance in plants–Actigard (Bion in some markets) and Messenger–in the greenhouse. Preplant, 1-, and 3-month postplant applications of Actigard at 2.4 and 4.8 mM reduced reniform and rootknot nematode egg production by 50% at the end of one year. At concentrations greater than 4.8 mM, Acibenzolar stunted pineapples. Messenger applications did not increase pineapple growth nor reduce nematode populations in our tests.

We are also investigating reduced-risk pesticides for nematode control. Dragonfire and Dragonfire CPP are two products that have recently been tested in the greenhouse. Dragonfire, a powder that is incorporated into the soil at planting, did not increase pineapple growth in soil infested with reniform nematodes. Final nematode population numbers were not different between the Dragonfire and the untreated control treatments. A single at-planting application of Dragonfire CPP at 46.7 L ha^{-1} (5 gal ac^{-1}) increased pineapple growth as compared to the untreated control. Nematode populations were higher in the Dragonfire CPP treatment suggesting that initial nematode populations were reduced but subsequently a pineapple food source allowed the surviving nematodes to reproduce well. Multiple postplant applications of Dragonfire CPP, the oil of a special sesame cultivar, will be tested.

A third aspect of our nematode control research involves the evaluation of more traditional nematicides. Idomethane, a potential methyl bromide replacement, was applied at 128.8 kg ha^{-1} (115 lb ac^{-1}) with commercial equipment and compared to the standard 1,3-Dichlorpropene (1,3-D) fumigation. Initial nematode control was similar between the idomethane and 1,3-D treatments. Pineapple growth 6 months after planting was slightly stunted in the idomethane treated plots. Postplant applications of 1,3-D are being tested. Postplant applications of 1,3-D reduce reniform nematode population densities but timing of application appears crucial. The 1,3-D is phytotoxic at levels as low as 500 ppm. The phytotoxicity and nematode control effects of the 1,3-D must be balanced. In seasons or areas with especially high nematode pressure, the nematode control achieved by postplant application of 1,3-D may out weigh the phytotoxicity of the application and give yield increases.

Effect of Calcium Sources and Basaltic Dust on Pineapple Nutrition and Production

J.A. Silva, R. Hamasaki,, R. Ogoshi, R. Paull, D. P. Bartholomew, N.V. Hue, S. Fukuda, G. Uehara, and.G. Tsuji. Dept. of Tropical Plant and Soil Science, Univ. of Hawaii, Honolulu, HI 96822, U.S.A.

Introduction:

Pineapples are well adapted to acid soils and tolerate relatively high levels of soluble aluminum and manganese. In soils containing large amounts of soluble iron and manganese, pineapple plants can absorb relatively large amounts of both elements but apparently are unable to effectively utilize absorbed iron, resulting in severe iron deficiency. In such soils in Hawaii, iron deficiency of pineapple plants is corrected by regular sprays of iron, usually as iron sulphate, a costly practice. Soils with low pH's also tend to have low levels of soil calcium and liming such soils increases soil pH, soil calcium supply, and reduces soluble levels of manganese and aluminum. One problem associated with liming of acid soils, at least if soil pH is raised above about 5.5, is increased incidence of heart and root rots caused by *Phtophthora* (Frossard, 1976).

Liming raises soil pH and reduces manganese solubility (Hopkins *et al.*, 1944). Increasing the calcium supply with gypsum could also reduce manganese solubility while leaving soil pH unchanged. If moderate amounts of lime or lime plus gypsum could reduce manganese solubility without raising soil pH above about 5.0, it was hypothesized that there would be no need for foliar iron sprays. High calcium would also reduce manganese uptake (Hue and Mai, 2002). Further, fertilization with calcium increases fruit calcium levels and reduces the incidence of internal browning associated with refrigerated storage (Herath et al., 2000a; Herath et al., 2000b; Herath et al., 2001; Selvarajah et al., 1998). High fruit translucency can be a problem in fresh fruit production in some months of the year. High translucency results in increased bruising injury and fruit leakage, which promotes fruit storage diseases. No studies on the effects of calcium or other plant nutrients on fruit translucency of pineapple were found.

We report here the results of a study of the effects of calcium, gypsum, and basaltic dust, a by-product of the rock quarrying industry, on iron nutrition, plant and fruit calcium, and fruit translucency.

The treatments for the split-plot experiment consisted of:

Main-plot treatment: plus and minus iron sulfate spray

Sub-plot treatments:

1. Ground coral ($CaCO_3$)	3 tons/acre	(2400 lb Ca/acre)
2. Gypsum ($CaSO_4$)	4 tons/acre	(1840 lb Ca/acre)
3. Basaltic Dust (BD)	22.3 tons/acre	(3,000 lb total and 193 lb extractable Ca/acre)
4. Lime + Gypsum	1.5 + 2.0 ton/acre	(2100 lb Ca/acre)
5. Gypsum	8 tons/acre	(3680 lb Ca/acre)
6. Check (plantation practice only)		

The quantities of ground coral and basaltic dust were selected to raise soil pH to 5.0 while the gypsum and gypsum plus lime treatments were selected to provide additional amounts and forms of calcium. All treatments were replicated three times. Plots were 5.12 by 8.84 m in size. All plots received manure, fumigation to help control nematodes, and pre-plant fertilizer. The calcium and BD treatments were applied before planting and incorporated into the soil in each plot. Iron sulfate sprays were applied approximately monthly beginning at about 2 months after planting. Foliar fertilizers were applied following standard plantation practices except the minus-iron plots did not receive that micronutrient.

The experiment was forced approximately 12 months after planting. Data were collected from four rows in two beds by 7.62 m. Approximately 100 fruit were harvested from each plot. The collected data included soil samples from each plot three months after planting, tissue analysis of ‘D’ leaves at six months after planting and at forcing, estimated plant weights at the time of forcing, and data on fruit size distribution, total fruit weight per plot, and fruit characteristics. Fruit size distribution was based on boxed fresh fruit classes 8, 10, 12, 14, 16, and rejects (culls). Fruits were harvested beginning on June 3, 2003 and weekly thereafter until all fruit were harvested (July 1, 2003) at shell color 2 (yellowing visible at the base of the fruit) or higher, classified by size, weighed, and subsampled for fruit characteristics, which included total soluble solids (TSS), titratable acidity (TA), tissue calcium, and fruit translucency. Subsample size at each harvest for fruit characteristics was six fruit per plot at the same stage of maturity with representation where possible from the four larger size classes. The results were analyzed by analysis of variance using Statistix software (Analytical Software, Tallahassee FL; http://www.statistix.com/home.html) and means were classified by Least Significant Difference (LSD) test.

Results and Discussion

Manganese-induced iron deficiency was not corrected by any of the amendments and plant growth and fruit yield were poor where iron was not applied. Foliar iron nutrition is essential if growers are to obtain acceptable yields on Hawaii's high-manganese soils. Because of the poor growth of the minus-iron treatments, all further comments relate only to the results for the plus iron treatments.

There were no statistically significant differences in number of fruit and weight of fruit for any of the treatments in any of the fruit classes except for class 8 where the number and weight of fruit in the 8 tons of Gypsum/acre treatment were significantly greater than those in the other treatments. There also was no significant difference between treatments in the total weight of fruit produced. Fruit TSS decreased significantly from that of Check treatment only with the Basaltic Dust and the Lime-Gypsum treatments. There was no significant difference in TA levels between treatments. Application of calcium in the soil amendments resulted in higher concentrations of calcium in the basal white leaf tissue and in the fruit than in the Check. The Basaltic Dust, Gypsum 4 tons/acre, Gypsum 8 tons/acre and the Lime treatments had significantly lower fruit translucency than the check (range 3.03 to 3.49 vs. 4.21 for the Check on a 0 to 5 scale), which did not receive added calcium. There was a trend for fruit translucency to decrease significantly as fruit calcium concentration increased with a negative correlation coefficient of 0.92. These results suggest that calcium from soil amendments increases calcium concentrations in the plant and can help reduce fruit translucency.

Soil Calcium in the 0-15 cm layer was increased significantly over the calcium level in the check by all soil amendments except basaltic dust. Soil pH was increased significantly over the pH of the check by only the lime and lime-gypsum treatments which had the lowest levels of soil manganese. The iron concentration of the 0-15cm layer was relatively unaffected by the soil amendments.

The D leaf Fe/Mn ratio is considered to be important in the utilization of iron in the plant. The Fe/Mn ratios of the soil amendment treatments were similar to that of the Check and all were well below the level of 0.4 where iron deficiency would be expected to occur (Marchal, 1971). However, no iron deficiency occurred when iron sprays were applied. Where pH or soil calcium levels, or both, are very low, the results of this study indicate fruit translucency will be reduced if calcium supplies are increased.

References

Frossard, P. 1976. Study of Phytophthora heart rot of pineapple. Ph, calcium and fungicide treatments in the field. Fruits 31:617-621.
Herath, H.M.I., D.C. Bandara, and D.M.G.A. Banda. 2000a. Effect of calcium and potassium fertilizer applied at the time of planting on the control of internal browning under cold storage of Mauritius pineapple. Tropical Agricultural Research 12:352-359.
Herath, H.M.I., D.C. Bandara, and D.M.G.A. Banda. 2000b. Effect of pre-harvest calcium application level for the post- harvest keeping quality in Mauritius pineapple. Tropical Agricultural Research 12:408-411.
Herath, H.M.I., D.C. Bandara, and D.M.G.A. Banda. 2001. Effect of basal application of different sources of calcium on the control of Internal Browning of Mauritius pineapple under cold storage. Tropical Agricultural Research 13:231-238.
Hopkins, E.F., V. Pagan, and F.J.R. Silva 1944. Iron and manganese in relation to plant growth and its importance in Puerto Rico. Journal of Agriculture, University of Puerto Rico 28, 43-101.
Hue, N.V. and Y. Mai. 2002. Manganese toxicity in watermelon as affected by lime and compost amended to a Hawaiian soil. Hort Sci. 37:656-661.
Marchal, J. 1971. Les oligo-elements dans l'ananas (Cu, Fe, Mn, Zn) (Minor nutrient elements in the pineapple (Cu, Fe, Mn, Zn)). Fruits 26:263-277.
Selvarajah, S., H.M.W. Herath, D.C. Bandara, and D.M.G.A. Banda. 1998. Effect of pre-harvest calcium treatment on post-harvest quality of pineapple. Tropical Agricultural Research 10:214-224.◆

Reviews of Books and Book Chapters

Rohrbach K.G. and D.P. Schmitt. 2003. **Diseases of Pineapple**. In Ploetz R.C.(Ed.) Diseases of Tropical Fruit Crops. CABI Publishing, Wallingford, 544 pages.

This chapter on Diseases of Pineapple is one of 19 chapters in the book. The chapter is a concise introduction and summary of the diseases that can occur on pineapple. The chapter covers fruit, leaf, and root diseases. Each disease is introduced and discussed as symptoms, causal agent, epidemiology, and management. While not a field guide for disease identification, the 11 color plates and four black and white photographs help to illustrate the diseases of pineapple. The reference list is extensive and current. While the pineapple chapter alone probably does not warrant purchasing the book, the book is a definite must have for any one working with more than one tropical fruit.

Bartholomew, D.P., R.E. Paull and K.G. Rohrbach. 2003. **The Pineapple: Botany, Production and Uses**. CABI Publishing, Wallingford, 301 pages.

This book fills a gaping void in the pineapple industry and research communities. The standard reference on pineapple cultivation by C. Py, J.J. Lacoeuilhe and C. Teisson published in 1983 in French and in 1987 in English is out of print and dated. In the preface of this new book, the editors state that they have taken the opportunity to capture the expertise, knowledge, and wisdom of scientists and industry leaders who oversaw the international expansion of pineapple as these individuals are now retiring. In this the editors have succeeded, as well as introducing younger authors whose expertise should be available for years to come.

The book is divided into 11 chapters and has 42 color plates. Black and white photographs, diagrams, graphs and tables are found throughout the chapters. The index is well done making quick navigation to desired topics easy. While technical, the information is easy to read and understand. The chapters on Morphology and Breeding were especially interesting to me. The chapters on commercial production practices were also particularly good. The chapter on Pests, Diseases and Weeds took a different approach in that it followed the pests and problems associated with the different stages of the crop cycle. While innovative, this approached led to redundancy as some pests appear more than once during the cropping cycle. The chapter on Biotechnology, as with all leading-edge technology, was probably outdated at the time of publication and now seems even more dated. With the increasing importance of fresh pineapple in the market, it is disappointing that greater attention was not given to this aspect. Fresh fruit is placed with postharvest physiology rather than being elevated to a chapter of its own. I would have found a chapter on marketing to be enlightening and an appropriate addition to the book.

Overall, The Pineapple: Botany, Production and Uses is well done and a valuable addition to any library-commercial or research-dealing with pineapple. The book is a worthy successor to Collin's 1960 The Pineapple and Py et al's 1983 The Pineapple: Cultivation and Uses.

The above reviews were provided by Brent Sipes, Plant and Environmental Protection Sciences, Univ. of Hawaii, Honolulu, HI 96822..◆

Notices

Commercial Services

Maintain CF 125 continues to be available for use in pineapple plant propagation. A renewal letter for registration of the product was received in 2003. For further information, contact Bhushan Mandava, Repar Corporation, P.O. Box 4321, Silver Spring, MD 20914 Tel: 202-223-1424 Fax: 202-223-0141; E-Mail: mandava@compuserve.com

Directory of Professionals

This listing is maintained as a convenience for those seeking assistance from professionals with experience in pineapple production and processing. If you have such expertise and are able to provide consulting services, please send you rname, address, E-mail address, and areas of expertise to D.P. Bartholomew (duaneb@hawaii.edu).

Ian Greig. Phone: 813-908-7698; Fax: 813-963-6229; E-mail: iangreig@ij.net; web:http://www.ag-consult.com. Management and technical services for all phases of pineapple production. Pineapple industry and market analysis.

Jerry D. Vriesenga; 194 Dole Road; Wahiawa, HI 96786; E-mail: hsvries@msn.com . Production and management of pineapple.

Web Sites of Possible Interest

http://www.uga.edu/fruit/pinapple.htm
http://www.botgard.ucla.edu/html/botanytextbooks/economicbotany/Ananas/index.html
http://www.extento.hawaii.edu/kbase/crop/Type/d_neobre.htm
http://www.accessexcellence.org/RC/Ethnobotany/page4.html
http://rics.ucdavis.edu/postharvest2/Produce/ProduceFacts/Fruit/pineapple.shtml
http://www.crfg.org/pubs/ff/pineapple.html
http://www.hort.purdue.edu/newcrop/morton/pineapple.html
http://www.ncbi.nlm.nih.gov/ICTVdb/ICTVdB/62up0040.htm
http://www.extento.hawaii.edu/kbase/crop/Type/d_brevip.htm
http://www.ncbi.nlm.nih.gov/ICTVdb/ICTVdB/1701t202.htm
http://www.ncbi.nlm.nih.gov/ICTVdb/ICTVdB/11050003.htm
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References

This list includes papers published or located since the last issue of the newsletter was printed. Reprints of many of the publications listed below can be obtained from the authors, are obtainable from most research libraries, or from Library External Services, Hamilton Library Room 112, University of Hawaii, 2550 The Mall, Honolulu, HI 96822 U.S.A.; contact the library for current charges.

Abraham, M., C.T. Abraham, and M. George. 2002. Competition of Mikania with common crops of Kerala. Indian Journal of Weed Science 34:96-99.

Adediran, J.A., N.d. Baets, P.N.S. Mnkeni, L. Kiekens, N.Y.O. Muyima, and A. Thys. 2003. Organic waste materials for soil fertility improvement in the border region of the Eastern Cape, South Africa. Biological Agriculture & Horticulture 20:283-300.

Ahmed, S., A. Nose, and K. Wasano. 2002. In vivo properties of phosphoenolpyruvate carboxylase in crassulacean acid metabolism plants - is pineapple CAM not regulated by PEPC phosphorylation? Environment Control in Biology 40:343-354.

Ahmed, S., A. Nose, and K. Wasano. 2003. Pyrophosphate : D-fructose-6-phosphate 1-phosphotransferase (PFP) Activities in Response to Fructose-2,6-P2 in Illuminated and Darkened Pineapple Leaves. Environ. Control in Biol 41:25-36.

Ahmed, O.H., M.H.A. Husni, A.R. Anuar, and M.M. Hanafi. 2003. Production of humic acid from pineapple leaf residue. Journal of Sustainable Agriculture 22:113- 124.

Ahmed, O.H., M.H.A. Husni, A.R. Anuar, and M.M. Hanafi. 2003. Economic viability of pineapple residues recycling. Journal of Sustainable Agriculture 21:129- 137.

Ahmed, O.H., A.M.H. Husni, R.A. Anuar, and M.M. Hanafi. 2003. Alternative means of recycling pineapple leaf residues. Fruits (Paris) 58:53-60.

Almeida, O.A.d. 2001. Irrigacao na cultura do abacaxi: aspectos tecnicos e economicos (Irrigation of pineapple crops. Technical and economic aspects) No.41.

Arene, C.J., and A.O. Okafor. 2001. Exchange rate liberalization as a policy instrument for stimulating non-traditional agricultural exports in Nigeria. Economic Affairs (Calcutta) 46:236-248.

Avallone, S., J.P. Guiraud, J.M. Brillouet, and C. Teisson. 2003. Enzymatic browning and biochemical alterations in black spots of pineapple *Ananas comosus* (L.) Merr. Current Microbiology 47:113-118.

Barbosa, N.M.L., G.A.P.d. Cunha, D.H. Reinhardt, P.G. Barros, and A.R.L.d. Santos. 2003. ;Indução de alterações morfológicas e anatômicas em folhas de abacaxizeiro 'Pérola' pelo ácido 2-(3-clorofenoxi) propiônico (Induction of morphological and anatomical alterations in leaves of 'Pérola' pineapple by 2-(3-chlorophenoxi) propionic acid). Revista Brasileira de Fruticultura, Jaboticabal, SP 25:386-389.

Bonnas, D.S., A.B. Chitarra, M.E.T. Prado, and D. Teixeira Junior. 2003. Qualidade do abacaxi cv Smooth cayenne minimamente processado (Quality of minimally processed pineapple cv. Smooth Cayenne). Revista Brasileira de Fruticultura 25:206- 209.

Botelho, L., A.d. Conceicao, and V.D.d. Carvalho. 2002. Caracterizacao de fibras alimentares da casca e cilindro central do abacaxi 'smooth cayenne' (Characterization of dietary fibers of the skin and central cylinder of the pineapple 'smooth cayenne'). Ciencia e Agrotecnologia 26:362-367.

Budu, A.S., and D.C. Joyce. 2003. Effect of 1-methylcyclopropene on the quality of minimally processed pineapple fruit. Australian Journal of Experimental Agriculture 43:177-184.

Cabral, J.R.S., A.d.S. Souza, A.P.d. Matos, and R.C. Caldas. 2003. Efeito da autofecundacao em cultivares de abacaxi (Effects of self pollination in pineapple cultivars). Revista Brasileira de Fruticultura 25:184- 185.
Chenchaiah, K.C., A.K. Sit, and C.R. Biswas. 2002. Evaluation of some annual and perennial intercrops in areca garden under sub-Himalayan Terai region of West Bengal. Journal of Plantation Crops 30:41-43.
Cherian, T.T., and Mani Varghese. 2002. *Thielaviopsis paradoxa* (de Seynes) V. Hohnel infection and early ripening of fruits. Journal of Mycopathological Research 40:49-50.
Chirino, L., M., and M. Ramirez, A. O. 1999. Adaptabilidad de la pina cv. Espanola Roja al procesamiento industrial (Suitability of frozen 'Red Spanish' pineapple to industrial processing). Revista de la Facultad de Agronomia 25:95-103.
Coelho, E.F., V.F.d. Sousa, A.d.O. Aguiar Netto, and A.S.d. Oliveira. 2000. Manejo de irrigacao em fruteiras tropicais (Irrigation management in tropical fruit crops) 40. Embrapa Mandioca e Fruticultura, Cruz das Almas, BA, Brazil.
Cunha, G.A.P.d., J.T.A. Costa, and D.H. Reinhardt. 2002. Alterações na massa foliar, produção de mudas, rendimento e colheita do abacaxizeiro 'Pérola' causadas por reguladores de crescimento (Alterations of foliar mass, slips production, yield and harvest period of 'Pérola' pineapple caused by growth regulators). Magistra, Cruz das Almas, BA 14:97-105.
Cunha, G.A.P.d., J.T.A. Costa, and D.H. Reinhardt. 2003. Natural flowering in pineapple: inhibition by growth regulators. Fruits (Paris) 58:27-37.
Datta, M., and K.R. Dhiman. 2001. Effect of some multipurpose trees on soil properties and crop productivity in Tripura area. Journal of the Indian Society of Soil Science 49:511-515.
Deliza, R., A. Rosenthal, and A.L.S. Silva. 2003. Consumer attitude towards information on non conventional technology. Trends in Food Science & Technology 14:43-49.
Deng, S. 2002. Cultural techniques for high quality and high yielding pineapple. South China Fruits 31:28-29.
Devi, T.P., and L.R. Singh. 2001. The relative bromelain contents in different parts of pineapple plant cv. Queen. Indian Journal of Hill Farming 14:128-129.
Duarte, A.G., I.S.d. Lima, D.M.d.A.F. Navarro, and A.E.G. Sant'ana. 2003. Captura de Rhynchophorus palmarum L. (Coleoptera: curculionidae) em armadilhas iscadas com o feromonio de agregacao e compostos volateis de frutos do abacaxi (Capture ofRhynchophorus palmarum L. (Coleoptera: Curculionidae) in traps baited with aggregation pheromone and volatile compounds from pineapple). Revista Brasileira de Fruticultura 25:81- 84.
Feuser, S., K. Meler, M. Daquinta, M.P. Guerra, and R.O. Nodari. 2003. Genotypic fidelity of micropropagated pineapple (*Ananas comosus*) plantlets assessed by isozyme and RAPD markers. Plant Cell 72:221-227.
Firoozabady, E., and N. Gutterson. 2003. Cost-effective in vitro propagation methods for pineapple. Plant Cell Reports 21:844-850.
Hanafi, M.M., and A. Halimah. 2002. Growth, yield, and quality of pineapple, cv. Josapine, on sandy tin tailings. Communications in Soil Science and Plant Analysis 33:2949-2964.
Hatano, K., Y. Sawano, and M. Tanokura. 2002. Structure-function relationship of bromelain isoinhibitors from pineapple stem. Biological Chemistry 383:1151-1156.
Ishihara, M., T. Tamashiro, T. Taira, S. Tawata, N. Kobamoto, M. Nozaki, and N. Araki. 2003. An antihemolysin from pineapple stem. Nippon Shokuhin Kagaku Kogaku Kaishi = Journal of the Japanese Society for Food Science and Technology 50:141-144.
Kakaty, B.M., B.K. Chakrabarty, and A.C. Thakur. 2002. Multistoreyed cropping in bearing and pre-bearing arecanut plantations in Assam. Journal of Plantation Crops 30:33-38.
Kawamitsu, Y., K. Kosaka, S. Abe, A. Nose, and J.N. Buah. 2002. Regulation of photosynthesis during the light period in CAM plants - evaluation by a gas-phase O2 electrode and a compensating infrared CO2 analysis system. Environment Control in Biology 40:355-364.
Khamsouk, B., and E. Roose. 2003. Ruissellement et erosion d'un sol volcanique tropical cultive en systemes intensifs en Martinique (Runoff and erosion of a tropical volcanic soil (nitisol) cultivated in intensive crop systems in Martinique). Cahiers Agricultures 12:145-151.
Kim, E., I. Choe, and S. Hwang. 2003. Effects of singular manner or mixed type treatment of proteases isolated from pear, pineapple and kiwifruit on actomyosin degradation. Korean Journal for Food Science of Animal Resources 23:193-199.
Kondo, A., A. Nose, H. Yuasa, and O. Ueno. 2000. Species variation in the intracellular localization of pyruvate, Pi dikinase in leaves of crassulacean-acid-metabolism plants: an immunogold electron-microscope study. Planta 210:611-621.
Lallo, F.H., I.N.d. Prado, W.G.d. Nascimento, L.M. Zeoula, F.B. Moreira, and F.Y. Wada. 2003. Niveis de substituicao da silagem de milho pela silagem de residuos industriais de abacaxi sobre a degradabilidade ruminal em bovinos de corte (Substitution levels of corn silage by pineapple by-products on ruminal degradability in beef cattle). Revista Brasileira de Zootecnia 32:719- 726.
Mello, M.R.F.d., R.L.R. Mariano, M. Menezes, T.R. Camara, and S.M.P. Assis. 2002. Selecao de bacterias e metodos de bacterizacao para promocao de crescimento em mudas de abacaxizeiro micropropagadas (Screening of bacteria and bacterization methods for growth-promotion of micropropagated pineapple plantlets). Summa Phytopathologica 28:222-228.
Mercier, H., B.M. Souza, J.E. Kraus, R.M. Hamasaki, and B. Sotta. 2003. Endogenous auxin and cytokinin contents associated with shoot formation in leaves of pineapple cultured in vitro. Brazilian Journal of Plant Physiology 15:107-112.
Morales, M., M.S. Hernandez, M. Cabezas, J. Barrera, and O. Martinez. 2001. Caracterizacion de la maduracion del fruto de pina nativa (*Ananas comosus* L. Merrill) cv. India (Characterization of the ripening of pineapple (*Ananas comosus* L. Merrill) cv. India fruit). Agronomia Colombiana 18:63-69.
Oliveira, L.F.d. 2001. The advantages in the use of bromelain in alimentation and health. Alimentos e Nutricao 12:215-226.
Pandey, C.B., Kanak Lata, A. Venkatesh, and R.P. Medhi. 2002. Homegarden: its structure and economic viability in South Andaman. Indian Journal of Agroforestry 4:17-23.
Pena, J.E., J.L. Sharp, and M. Wysoki. 2002. Tropical fruit pests and pollinators: biology, economic importance, natural enemies and control CABI Publishing, Wallingford, UK.
Perez, A., L. Napoles, J.C. Lorenzo, and M. Hernandez. 2003. Protease excretion during pineapple micropropagation in temporary immersion bioreactors. In Vitro Cellular & Developmental Biology - Plant 39:311-315.
Piedade, J., and S.G. Canniatti-Brazaca. 2003. Comparacao entre o efeito do residuo do abacaxizeiro (caules e folhas) e da pectina citrica de alta metoxilacao no nivel de colesterol sanguineo em ratos (Comparison with the effect of pineapple residue (stems and leaves) and the high metoxyl citric pectin on rats blood cholesterol level). Ciencia e Tecnologia de Alimentos 23:149- 156.
Piza, I.M.T., G.P.P. Lima, O.G. Brasil, and P.L.B.T. Piza. 2002. Atividade da enzima bromelina emplantas de abacaxi (*Ananas comosus* L. Merril), sob condicoes de salinidade "in vitro" (Bromelain enzyme activity on pineapple plants (*Ananas comosus* L. Merril) under saline conditions "in vitro"). Revista Brasileira de Plantas Medicinais 5:68-74.
Poonam, B., and A. Nanjappa. 2002. Development of a rapid method for micropropagation of a new pineapple Ananas comosus (L.) Murr.

clone, 'Yeppoon Gold'. Acta Horticulturae 575:125-131.
Prado, M.E.T., A.B. Chitarra, D.S. Bonnas, A.C.M. Pinheiro, and L.M. Mattos. 2003. Armazenamento de abacaxi 'Smooth cayenne' minimamente processado sob refrigeracao e atmosfera modificada (Storage of fresh-cut pineapple Smooth Cayenne with refrigeration and modified atmosphere). Revista Brasileira de Fruticultura 25:67- 70.
Prado, I.N.d., F.H. Lallo, L.M. Zeoula, S.F. Caldas Neto, W.G.d. Nascimento, and J.d.A. Marques. 2003. Niveis de substituicao da silagem de milho pela silagem de residuo industrial de abacaxi sobre o desempenho de bovinos confinados (Bulls performance in feedlot with levels of substituting corn silage by pineapple by-products silage). Revista Brasileira de Zootecnia 32:737- 744.
Praxedes, S.C., A.F.d. Silva Junior, F.L.B. Figueiredo, M.d.L. Figueiredo, F.A.A. Camara, and O.F.d. Oliveira. 2001. FT:Estiolamento in vitro do abacaxizeiro perola em presenca de ANA e AIA (Perola pineapple etiolation in presence of ANA and AIA). Caatinga 14:13-15.
Rajasekharan, P., and S. Veeraputhran. 2002. Adoption of intercropping in rubber smallholdings in Kerala, India: a tobit analysis. Agroforestry Systems 56:1-11.
Reinhardt, D.H., and G.A.P.d. Cunha. 2003. O uso de fitoreguladores e a floração do abacaxizeiro 'Pérola' (The use of growth regulators and the flowering of the 'Pérola' pineapple plant). Magistra, Cruz das Almas, BA 15:63-65.
Reinhardt, D.H., A.P.M. Souza, R.C. Caldas, J.d.P. Alcântara, and A.d.A. Alves. 2003. Management of slips and its effects on growth and production of 'Pérola' pineapple plants. Revista Brasileira de Fruticultura, Jaboticabal, SP 25:248-252.
Rodriguez, Y., M. Mosqueda, B. Companioni, M. Arzola, O. Borras, M.C. Perez, J.C. Lorenzo, and R. Santos. 2002. Bioassay for in vitro differentiation of pineapple cultivar resistance levels to heart rot disease. In Vitro Cellular & Developmental Biology - Plant 38:613-616.
Santana, L.L.d.A., D.H. Reinhardt, G.A.P.d. Cunha, and R.C. Caldas. 2001. Altas densidades de plantio na cultura do abacaxi cv. Smooth Cayenne, sob condicoes de sequeiro (High planting density for the Smooth Cayenne pineapple crop, grown under rainfed conditions). Revista Brasileira de Fruticultura 23:353- 358.
Sarma, U.J., and D. Chowdhury. 2002. Synergestic effect of high density multiple cropping on soil productivity and yield of base crop (coconut). Indian Coconut Journal 33:18-22.
Selvarajah, S., A.D. Bauchot, and P.J. John. 2001. Internal browning in cold-stored pineapples is suppressed by a postharvest application of 1-methylcyclopropene. Postharvest Biology and Technology 23:167-170.
Shaheen, A., A. Nose, and K. Wasano. 2003. Pyrophosphate: D-fructose-6-phosphate 1-phosphotransferase (PFP) activities in response to fructose-2,6-P2 in illuminated and darkened pineapple leaves. Environment Control in Biology 41:25-36.
Silva, G.C., G.A. Maia, M.d.S.M.d. Souza Filho, R.W.d. Figueiredo, H.A.C. Filgueiras, and A.C.R.d. Souza. 2003. Efeito de diferentes concentracoes de cloreto de calcio na qualidade do abacaxi "Perola" minimamente processado (Effect of different concentrations of calcium chloride on the quality of minimally processed pineapple 'Perola'). Revista Brasileira de Fruticultura 25:216- 219.
Singh, S.P., B.L. Manjunath, H.H. Khan, and Bhanu Shalini. 2002. Coconut based high density cropping system in Goa. Indian Coconut Journal 33:9-12.
Souza, B.M., J.E. Kraus, L. Endres, and H. Mercier. 2003. Relationships between endogenous hormonal levels and axillary bud development of Ananas comosus nodal segments. Plant Physiology and Biochemistry 41:733- 739.
Stirling, G.R., and A.M. Stirling. 2003. The potential of Brassica green manure crops for controlling root-knot nematode (Meloidogyne javanica) on horticultural crops in a subtropical environment. Australian Journal of Experimental Agriculture 43:623-630.
Stuppy, W.H., J.A. Maisano, M.W. Colbert, P.J. Rudall, and T.B. Rowe. 2003. Three-dimensional analysis of plant structure using high-resolution X-ray computed tomography. Trends in Plant Science 8:2-6.
Suneerat, S., R. Marchant, J.B. Power, and M.R. Davey. 2003. Plant regeneration by somatic embryogenesis and organogenesis in commercial pineapple (Ananas comosus L.). In Vitro Cellular & Developmental Biology - Plant 39:450-454.
Surya, Y.P. 2003. Great Giant Pineapple Company. Fruit Processing 13:250-252.
Tai, D., and S. Fu. 2003. Bromelain catalyzed synthesis of peptides in organic solvent. Journal of the Chinese Chemical Society 50:179-183.
Villegas, V.N. 2002. Breeding new fruit varieties in the Philippines. Acta Horticulturae 575:273-277.
Walker, A.F., R. Bundy, S.M. Hicks, and R.W. Middleton. 2002. Bromelain reduces mild acute knee pain and improves well-being in a dose-dependent fashion in an open study of otherwise healthy adults. Phytomedicine 9:681-686.
Wang, K.H., B.S. Sipes, and D.P. Schmitt. 2003. Intercropping cover crops with pineapple for the management of Rotylenchulus reniformis. Journal of Nematology 35:39-47.
Wang, K.H., B.S. Sipes, and D.P. Schmitt. 2003. Enhancement of Rotylenchulus reniformis suppressiveness by Crotalaria juncea amendment in pineapple soils. Agriculture 94:197-203.
Weber, O.B., D. Correia, M.R.S.d. Silveira, L.A. Crisostomo, E.M.d. Oliveira, and E.G. Sa. 2003. Efeito da bacteria diazotrofica em mudas micropropagadas de abacaxizeiros Cayenne Champac em diferentes substratos (Effect of diazotrophic bacteria on pineapple Cayenne Champac plantlets with different substrates). Pesquisa Agropecuaria Brasileira 38:689- 696.
Zhou, Y., J.M. Dahler, S.J.R. Underhill, and R.B.H. Wills. 2003. Enzymes associated with blackheart development in pineapple fruit. Food Chemistry 80:565-572.◆

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