Pineapple News

Issue No. 12 Newsletter of the Pineapple Working Group, International Society for Horticultural Science July, 2005

Table of Contents

Pineapple Working Group (PWG)

Dear Colleagues:

Contributions to the newsletter were very slow in coming this year so I am quite late in getting it sent out. I hope the slow start is due to the fact that those who would commonly contribute were involved in preparations for the 5th International Pineapple Symposium that was held in April (10 to 15) of this year at Port Alfred, South Africa. The 5th symposium is now history and it was a very interesting and enjoyable experience. The venue, Port Alfred, South Africa, is a beautiful sea coast town with many kilometers of white-sand beaches. A disadvantage of the venue for some was that participants were scattered among several small hotels and B&B facilities so opportunities for socializing after hours were somewhat limited. Some missed the night life, karaoke bars, etc. available in a larger city but most found the small city environment charming. Brent Sipes provides a synopsis of the symposium below and the abstracts of papers can be found at the end of the newsletter.

Zululand Pre-Symposium Tour

Reporting on a pineapple tour associated with an international pineapple symposium is a first for Pineapple News. However, meeting innovative pineapple farmers growing 'Queen' pineapple in an exotic setting among big game parks in Zululand was such a unique experience that it seems a worthy subject for the newsletter. Also, most literature focuses on 'Smooth Cayenne' and, more recently, new hybrids while the cultural practices and problems confronted by growers of 'Queen' and other pineapple cultivars are less well researched or at least less well reported. While cultural practices for different pineapple cultivars likely are more similar than different, the Zululand tour introduced participants to some new practices and certainly a lot of innovation. And how many growers outside of South Africa find controlling losses to monkeys an important practice?

There were five of us on the Zululand pre-symposium tour, which was held in the Hluhluwe (approximate phonetic pronunciation Schu-schlu-we) area of Zululand, from April 6 through 8, 2005. A small town of the same name is located in the heart of this Zululand pineapple growing area. Elmarie Rabie, who supervises research at a small pineapple research station outside of Hluhluwe, deserves special recognition for organizing the tour. Elmarie had to deal with many issues at nearly the last minute because registration for the tour was unexpectedly low. Our hosts for the duration of the tour were Joshua and Corne Van Straaten who manage Ezulwini Game Lodge a few km from Hluhluwe. The Van Straatens also have begun to grow some pineapple to diversify their very seasonal lodging business. The only other crops being grown in the area on a commercial scale were sugarcane and *Eucalyptus* sp. stands that are harvested primarily for pulp. According to one farmer, pineapples are about the only commercial crop suited to the area. Because of recent rains, all growers fields visited on the tour were on sandy soils but clay soils are also found in the area. Practices differ on the two soil types. Only a plant crop is harvested on sandy soils while at least one ratoon crop is harvested from fields with clay soils, presumably because of greater water storage in the clays.

Casper Badenhorst's Badenhorst Boerdery

This farm plants 140 ha per year and approximately 40% of the crop is exported, mostly to Europe. The fruit is air shipped at a cost of Rand (R) 14 kg^{-1} (in April 2005 the exchange rate was about R6.1 to the dollar) or almost $2.00 per kg. Travel time to Europe by ship is 21 days. Much of the rest of the fruit is trucked to Johannisburg, a trip of over 1,000 km, on farm-owned trucks. Exports were down in 2005 because the Rand has recovered relative to the Euro resulting in a less favorable exchange rate than prevailed as recently as 2002.

'Queen' pineapples on this farm are grown on fine sandy soils. Planting is done from August through May (early Fall though late Summer) and plants are forced with ethephon 8 to 12 months after planting. Fruit is ripe five to six months after forcing. Sucker development usually begins at the time of flower induction so suckers typically are well developed at the time of harvest. June and July are the coldest months and growth is slow during this time with only about one new leaf produced per month.

The typical crop intercycle is three-years, primarily to "rest" the land between crops to reduce nematode pressure. Land preparation is fairly conventional for a small pineapple farm and consists of plowing, harrowing, and bed shaping that includes mulching with plastic. Ethylene dibromide fumigant is applied under the plastic for nematode control, mainly *Pratylenchus sp.* 'Queen', at least the one grown in the area, produces no slips but suckers prolifically and suckers provide the planting material for the next crop. Suckers are harvested by uprooting the plants by hand from this friable sandy soil. One worker uproots the plants and lays them in a windrow while other workers remove suckers from the windrowed plants and grade them by size. Sucker sizes are 1, the largest at 0.5 to 0.6 m in length, through 4, where length ranges from 0.2 to 0.3 m. Each sucker size is planted in a different area to improve uniformity.

Planting is accomplished by plunging the suckers through the plastic mulch into the soft, sandy soil. The plastic mulch is not imprinted with a guide for the planter so spacing is done by eye. Suckers have a pointed tip so planters can force suckers through the plastic and to a suitable depth without first opening a hole. On the Badenhorst farm, a planter will plant 12 beds by 27 m, about 5000 suckers, in one day and be paid R27.5. The planter can earn an additional R25 by planting an additional 6 beds. Start and stop times are determined by the worker and some workers are finished soon after lunch. A supervisor checks spacing and planting depth to assure that the desired plant population is maintained suckers are at a suitable depth.

Plant population densities are the highest this writer has encountered in pineapple, typically ranging from 100,000 to 120,000 plants ha^{-1}. On the Badenhorst farm, plants are spaced 22 cm apart on 4-row beds with rows spaced 20 cm apart. Bed center to center distance ranges from 1.5 to 1.7 m. Yields were reported to be 64 to 73 T ha^{-1}, producing 8,000 8 kg boxes. The packing plant was a marvel of innovation for a single-family farm. A fruit sorter developed on-farm included digital image collection and processing of each fruit so the fruit could be sorted by physical size as well as by color.

As with most farmers in the region, multiple sources of income diversified the income streams. In addition to pineapple, the Badenhorst farm does custom timber drying and runs a goat sales shed. Pineapples are trucked to markets to the north and goats are hauled back for sale in the local market.

Hluhluwe Research Station

The station was established in 1987 to serve pineapple farmers in the area and presently is staffed by Elmarie Rabie and research assistant Heila Tustin. Salaries are paid by the government, about 60% of the operating budget, while the remainder is paid by the growers. In an overview of the Zululand pineapple industry, Elmarie said that approximately 1,500 ha of 'Queen' pineapple are being grown in the area and about 650 ha are harvested annually. A total of 29,084 T of fruit passed through the local and export markets. The total tonnage is actually 35,000 when direct-marketed fruit and fruit supplied for fresh cut outlets, the latter mainly for export, are included. Most fruit are from the mother-plant crop.

Typical details of cultivation practices are as follows. Land preparation, including 2 to 6 T $ha^{-1}$of lime, begins at three months prior to planting. Just prior to planting, preplant fertilizer (in kg ha^{-1}, 25 P, up to 250 K as KCl, as well as small amounts of nitrogen and zinc) plus ethylenedibromide for nematode control are applied during ridging, and the ridges are then covered with plastic. Up to 250 kg ha^{-1} of KCl is applied prior to planting and if more K is required during the vegetative growth phase, sprays of potassium sulfate or potassium nitrate are used. Most farmers plant four rows to the bed and plan to place at least 100,000 plants ha^{-1}; losses after planting result in an average of 90,000 plants ha^{-1} at forcing. After planting, weed control with Hyvar-X/Visor followed by Ametryn plus Atrazine at one month post planting (mpp). At 2 mpp, N as ammonium sulphate is applied. Farmers also spray N as urea and copper and iron are added as needed. The total N applied ranges from 300 to not more than 400 kg ha^{-1}. Excessive amounts of N have been found to reduce fruit shelf life. Additional pesticides for nematode control (aldicarb/phenamiphos) are applied at 3 and again at 6 mpp. Post-planting fertilization includes additional potassium, magnesium and nitrogen as required. Flower induction is with ethephon at 6 to 8 mpp and planting and forcing are done on a regular schedule because most growers plan to ship fruit to market every month of the year. After inflorescence emergence, pesticides are applied to control blackspot. At dead petal Swelpine (3-chlorophenoxypropionic acid) is applied to increase fruit size with gains of up to 30% being realized. Degreening is done with ethephon at one week before harvest to reduce harvest passes. It was noted that sometimes ethephon application to degreen fruit forced suckers. One of the tour participants noted that the problem was reduced by adjusting the pH of the ethephon solution to 2.0 with phosphoric acid.

Given the small number of staff and the fact that Elmarie commutes from Durban, about 1,000 km away, the research station maintains an ambitious research program. To keep this report brief, suffice it to say that most of the problems being investigated are common to many areas where pineapples are grown. Among those fairly unique to Zululand and South Africa are winter blotching, which produces small lesions on the fruit surface, and monkeys and warthogs. Despite the large areas devoted to game preserves in this region, lions, cape buffalo, elephants, and other large mammals were not mentioned as threats to the crop or to workers.

Kleynfaan Boerdery

The pineapple operations at the Kleynfaan farm were in most respects similar to those described above. A practice not mentioned previously was the use of Swelpine (3-chlorophenoxypropionic acid) to control natural flowering. The treatment consisted of three applications spaced at 2-week intervals of 1.6 L ha^{-1} in 2,000 L of water. Although control was not complete, adjacent treated and untreated fields clearly showed the benefit of the practice. To this writer's knowledge, 3-CPA is not approved for flowering control on pineapple outside of South Africa. Scarecrows were an integral part of the farming operation supplanted during the day by a worker, all with the objective of reducing crop losses to monkeys.

Zululand Pines

Len Heard runs this operation with other family members. Len plants 24 ha per year and exports 25% to Europe with the rest of the fruit going to the local market. Len's farm was unique among those we visited in using Telone® for nematode control. Len also has written his own software package to manage farm operations, which includes tracking all fertilizer and pesticide applications, managing farm labor and scheduling field operations. This tracking system assures that Len's farm conforms to European Union requirements for food safety and traceability. I was impressed with the sophistication built into this software package and it also drew the attention of the plantation manager of Del Monte in the Philippines who manages a 12,000 ha pineapple plantation. Len indicated he was working with a South African software company to bring his information technology software to market. He also has his own website at http://www.zululandpineapples.co.za and readers can see some aspects of the capability of the software at the "Process" link.

Besboks Corrugating Factory and WeGro Farming

Hennie Bisschoff met us at his corrugated box factory and led a tour of the facility. Readers likely are wondering what box making has to do with a pineapple farm tour. Hennie is another enterprising South African farmer who felt compelled to explore the possibility of making his own boxes when the local supplier raised prices to what seemed to be unjustifiably high levels. Rough spots along the road to developing the new venture included a lawsuit against his former supplier who tried to force him out of business by selling boxes below cost. Hennie has invested over $3 million in a successful corrugated box business and does custom manufacturing of boxes for many fruit, produce, and meat packing operations in Zululand. All operations are carried out at the factory from making the cardboard from paper stock to printing, cutting and forming. Hennie is also one of the larger growers of 'Queen' pineapples in Zululand, planting 210 ha per year. Ninety percent of WeGro's production is sold in the South

African market and only 10% is exported. Because of recent rains, the tour group could not go into the fields but we did see the packing shed where a Bisschoff-developed fruit grader was in operation.

Gwanzi Farms

The last tour stop was at Du Toit Vissers farm where 100 ha of pineapples are planted each year. Fifty five percent of the fruit is marketed locally while 45% is shipped to the United Kingdom as fresh cut fruit salad.

The small size of the tour group no doubt was a disappointment to the organizers because once logistics are worked out for a few, little effort is required to host a much larger group. However, for those of us doing the touring, the small size of the group provided an unequaled opportunity for each of us to have our own conversations with the growers. Tour group members also were open to sharing knowledge with these innovative and successful Zululand pineapple growers. The tour ended with a half-day trip to Hluhluwe Game Preserve in the forenoon where the group had a chance to see a large variety of South African wildlife. In the afternoon we had a sumptuous and traditional South African lunch followed by a visit to a Zululand cultural park. The Zululand pre-conference tour was a wonderful introduction to South African pineapple production practices, scenery, and culture. Thanks to all those who made this visit so special.

Fifth International Pineapple Symposium

Brent Sipes, Dept. of Plant and Environmental Protection Sciences, Univ. of Hawaii, Honolulu, HI 96822, U.S.A. E-mail: sipes@hawaii.edu

Our fifth symposium was a resounding success. The venue, Port Alfred, South Africa, was situated in the heart of the Eastern Cape pineapple growing region. Most pineapple growing regions of the world were represented at the meeting—South Africa, Australia, Benin, Brazil, Costa Rica, Côte d'Ivoire, Ecuador, Indonesia, Israel, Malaysia, Martinique, Mexico, the Philippines, Portugal, Swaziland, Sri Lanka, Thailand, Taiwan, and the United States. Researchers from France and an importer from Germany were also present. The symposium was organized into tours, technical sessions, and social activities.

Participants toured farms growing Smooth Cayenne for canning and the Bathurst Pineapple Research Facility. Some attendees also took advantage of the pre-conference tour of the Queen pineapple growing region in Zululand.

The technical sessions highlighted challenges that face the pineapple producers around the world. Some problems are local in nature whereas others are international in scope. Internal browning was one example of a problem faced by more growers as low acid cultivars replace the traditional Smooth Cayenne cultivar. The keynote speakers delivered messages that were informative and stimulating. The pineapple community received a daring call to adopt minimal tillage practices from one speaker. Other speakers explored pest control, genetics, breeding, and molecular biology. The quantity of research in pineapple was impressive given the scarcity of funding available. The questions and discussions following each presentation were lively, sometimes challenging, and often times unanswerable. Several workshops were held which explored pest control and organic pineapple production. The poster session echoed the oral presentations in the breadth of information presented. We know lots about pineapple but there is certainly more to be learned!

Our South African hosts treated participants to two major social gatherings. These dinners served more than food—they allowed interactions and networking among attendees. At the opening dinner, we were honored to have the Eastern Cape Premier Nosimo Balindela attend and speak. Her message highlighted the success of the Peddie Pineapple Project, a cooperative program among Summerpride and Collandale pineapple canneries and small-scale previously disadvantaged farmers.

New Books on Pineapple

Hawai`i's Pineapple Century. A History of the Crowned Fruit in the Hawaiian Islands
Jan K. Ten Bruggencate. Mutual Publishing, Honolulu, 2004, xii + 187 pp. Illustrated. Appendix. Index. $13.95.
See review below.

The Pineapple: King of Fruits
Fran Beauman. Chatto & Windus, London. November 3, 2005. 512 pages.
Synopsis (from http://www.amazon.co.uk/exec/obidos/ASIN/0701176997/ref%3Dnosim/schildnet0a/202-9422161-1035010)
This enchanting, juicy history takes us from the pineapple's origins in the Amazon rain forests to its first tasting by Columbus in Guadeloupe and its starring role on the royal dinner tables of Europe. In the eighteenth-century this spectacular fruit reigned supreme: despite the fact that, at first, to cultivate just one cost the same as a new coach, every great house soon boasted its own steaming pits filled with hundreds upon hundreds of pineapple plants. As the Prada handbag of its day, a real-life, homegrown pineapple was a powerful status symbol, so much so that at first, it was extremely unusual actually to eat the fruit. The image appeared on gateposts, on teapots, furniture and wallpaper. A new phase opened when growers in the Caribbean began supplying pineapples in the 1840s and later the first canning factory was built in Hawaii. As the story rolls on, through the heyday of pineapple chunks and cocktails, right up to the fashions of today, it touches on pineapples and sex, pineapples and empire, pineapples in art. Why is the pineapple so special? In one surprising sense it is indeed ideal. Made up of hundreds of separate fruitlets, its spirals embody the gradations of the Golden Mean - it is mathematically perfect. But it is more than that - for years a focus of traveller's tales, it is a treasure of sight and scent and taste. Packed with fascinating illustrations, this delicious book sees Fran Beauman explore the life and lore of the king of fruits: scholarly, witty and fun, it is a true hamper of delights.

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).

Proceedings of The 4th Symposium Now Available

The proceedings of the 4th International Pineapple Symposium was published as Acta Horticulturae Volume 666 in January of 2005. The proceedings can be purchased at the ISHS web site (www.ishs.org) for € 79 (79 euros) in print or as a CD. The papers published in the proceedings are included in the reference list at the end of the newsletter.

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.◆

News From Australia

2004 Pineapple Field Day

The Annual Pineapple Industry Field Day was held on 30 July, 2004 at French's Farm, Pumicestone Rd, Bruce Highway, Elimbah/Toorbul. The details of the program that are not restricted and are believed to be of interest to pineapple growers and researchers are provided below. The editor regrets any errors introduced when shortening or abstracting articles.

Field Day Program, Morning

- Registration and tea/coffee
- Welcome and explanation of the role of the QFVG Pineapple Special Interest Group. Gavin Scurr, Chairman QFVG Pineapple Special Interest Group, and Chairman for the day.
- Official opening and launch of "**Pineapple Grower's Handbook for the Management of Erosion and Sedimentation.**" The Honourable Mal Brough, Federal Member for Longman and Minister for Revenue and Assistant Treasurer
- Introduction of Mr Steve Morrow. Michael Cruice, Chairman Golden Circle Ltd
- Golden Circle - The Road to Recovery. Steve Morrow, new Chief Executive, Golden Circle Ltd
- Tailoring a nutrition program for smooth cayenne and hybrids. Val Tanguilig, Golden Circle Ltd.
- Integrated pest management of symphylids - final results. Tim Wolens, Golden Circle Ltd
- Nitrate management. Val Tanguilig, Golden Circle Ltd.
- Overview of pineapple research in progress. Val Tanguilig, Golden Circle Ltd.
- Progress with the study group/best practice project. Simon Newett, Queensland DPI & F
- Environmental Protection Agency / Golden Circle Ltd project to reduce the impact of pineapple farming on the environment. Nicole Colledge, Golden Circle Ltd
- Industrial relations - obligations of employers. Lyn Mear, QFVG (Queensland Fruit and Vegetable Growers)
- Overview of mechanisation projects and introduction to afternoon demonstrations. Tim Wolens, Golden Circle Ltd .

- Announcements, introduction of trade representatives

Field Day Program, Afternoon

- FARM WALK COMMENCES: incorporates machinery demonstrations (mulcher and detopper harvester), Telone rig, bed layout and planting densities etc (see below for details)
  - First location
    - Mulcher - Adam Desira, CVM
    - South African canning varieties - Val Tanguilig
    - Summer plant crop, inspect bed layout and plant densities to achieve fruit size for QBPS - Tim Wolens & Tony French
  - Second location
    - Telone rig & inspection of plants from Metham vs. Telone treatments, the use of soil temperature and moisture sensors to judge appropriate soil conditions for fumigation - Tim Wolens & Tony French
    - Spring plant crop, inspect bed layout and plant densities to achieve fruit size for QBPS - Tim Wolens & Tony French
  - Return to first location
    - De-topper harvester, labour saving results - Tony and Alan French

Field Day Papers and Abstracts

Pineapple Study Group/Best Practice Project Progress

Simon Newett, Department of Primary Industries and Fisheries, Nambour

Introduction

The project began with the formation of five study groups, (Wamuran, Glasshouse, Wide Bay, Yeppoon and North Queensland) in late 2002 / early 2003 and the initial meeting took the form of a facilitated workshop to find out the particular growing issues of each group. These groups have continued to meet and seven new members have joined. Typically the meeting takes place on a farm, it includes a prepared workshop or a discussion on a particular topic, this is followed by a farm walk and then a beer. Three hours are allocated to each meeting and farm walk although meetings with distant groups run for longer since they are less frequent. Detailed minutes are prepared from each meeting and distributed to members. The minutes are a useful reference in the preparation of the Best Practice Growing Manual. Existing farm management practices have been documented.

Meetings

Since the project began, the North Queensland group (7 active members) has met 3 times and has had prepared workshops on drainage (Bob Stewart, drainage consultant), pest & disease control (Tim Wolens, GC Ltd) and a presentation on the CAM photosynthetic pathway used by pineapples (Prof Joe Holtum, James Cook University).

The Yeppoon group (11 members) has met 4 times and has had prepared workshops on pest & disease control (Tim Wolens, GC Ltd), and nutrition (Doug Christensen, formerly GC Ltd). Discussions have also been held on yields and existing nutrition practices, a lychee orchard was visited as part of one meeting for a different farming perspective.

The Wide Bay group (8 members) has met 6 times and has had discussions on topics including growing practices particularly drainage and fallow, growing costs (using PINEMAN), alternative approaches to managing the soil and controlling nematodes (Graham Stirling, Biological Crop Protection), soil conservation (Anita Petzler, PRCCA), controlled traffic beds, and agronomic aspects of the new Quality Based Payment Scheme (QBPS).

The Wamuran group (9 members) has met 11 times and has held discussions on topics including planting densities (a three row bed trial has been established by Brennan Henzel), planting, pest & disease control, nutrition, pineapple water relations and irrigation (Matt Dagan, QFVG Water for Profit), induction, harvesting, crop removal, the fresh fruit breeding program and the biotech ethylene free and blackheart free pineapple projects (Garth Sanewski, DPI & F) soil conservation (Anita Petzler, PRCCA), a visit to GC Ltd cannery which included an introduction to the EPA funded Sustainable Pineapple Growing Project (Nicole Colledge, GC Ltd & Sarah Heenan, EPA) and a look at waste management (Marcus Cordingley, GC Ltd), discussion of a holistic approach to a fertiliser/nutrition program (Val Tanguilig, GC Ltd) and planting densities to help address the new QBPS.

The Glasshouse group (10 members) has met 10 times and has covered similar topics to the Wamuran group, a few of these meetings have been held jointly with the Wamuran group. An additional item was a presentation on the use of remote sensing technology with paddock data for more precise farm management (Mark Pawsey, SciAg).

Yield discussions

Of the 100 or so pages of minutes written so far I believe the notes from the discussions about yields (which have so far been held with the Wamuran, Glasshouse and Yeppoon groups) contain some particularly interesting observations about growing practices which are worth summarising here.

Yeppoon group

- Critical factors contributing positively to yield:
  - Use of irrigation for contract fruit, in dry times & for better suckering in ratoon crop.

    - Planting on time.
- Factors reducing yield:
    - Lack of fumigation especially on ratoon crops - minimal roots
    - Forcing too early in order to target better prices, or forcing too late with the result of natural flowering and costly picking.
- Management plans to address negative factors:
    - Fumigate if in any doubt
    - Selective irrigation with limited water supply
    - Force out of season if necessary in order to harvest fresh fruit every month

Glasshouse group

- Critical factors contributing positively to yield:
    - Rely on own planting material
    - Use bigger tops
    - Have a man on the bin sorting tops as they are picked up
    - Sorting and grading tops for uniformity
    - Using fresh planting material
    - Getting the crop off to a good start
    - Have a man follow the planter to fix up poorly planted tops
    - Good land preparation with a smooth seedbed
    - Planting on time
    - Don't harvest fruit late March or early April - instead use this time to get the planting done on time
    - Uniformity
    - Using mainly F180
    - Good drainage
    - Laser levelling fields with low spots
    - Use as high a bed as possible (about 25cm at the start)
    - Ensure that Lindane® and Ridomil® are hoed in preplant
    - Use Ridomil® more frequently
    - Use a full Nemacur® program
    - Correct timing for chemical applications - eg. Nemacur® immediately after rain
    - For gassing (forcing) ensure it is done under the best conditions possible and pay attention to detail
- Factors reducing yield:
    - Spots in the fields with poor drainage
    - Soil pH got too high(6 to 6.5) (as a result of a combination of chook (chicken) manure and dolomite applications) which led to root rot problems
    - Symphylids on red soil
    - Red mites and their ability to multiply quickly
    - High levels of nematodes
    - For fresh fruit growers the difficulty in getting good quality planting material
    - Too reliant on "farm run" varieties
- Management plans to address negative factors:
    - Improve drainage
    - Install more AgPipe
    - Remove build up of silt that accumulates at the ends of walkways
    - Use higher beds
    - Identify and fix spots with poor drainage
    - Do more land levelling
    - More efficient use of chemical control measures for root rot
    - Use higher spray volumes with Ridomil® treatments
    - Ridomil® at pre-plant is hoed in (rather than just sprayed on)
    - More Ridomil® and phosphorous acid applications against root rot
    - White grub - try and time applications so chlorpyrifos applications are rained in
    - Reduce chook (chicken) manure rates (so as not to raise pH too high)
    - Telone® helps control symphylids
    - Try using irrigation at critical times
    - Go back and check on the effectiveness of red mite treatments after application
    - Use Maintain® for generating planting material
    - Review fertiliser program

Wamuran group

- Critical factors contributing positively to yield:
    - Grading all tops

    - Careful selection of planting material
    - Being more self reliant for planting material
    - Preference for tops heavier than 200 grams
    - Select tops with a broad base rather than long skinny tops
    - Good seedbed, no clods
    - Plant on time
    - Not pushing plant growth with excessive fertiliser
    - Use less nitrogen late in the crop so that plants are not growing too vigorously at gassing
    - Irrigation
    - Gas (force) under the right conditions
    - Do more rounds of Ridomil®
    - Try and manage the entire growing period without any growth checks (in order to avoid yield reductions and keep timing)
- Factors reducing yield:
    - Poor drainage
    - Soil erosion
    - Sites of old fire heaps
    - Poor spots in fields bringing average yield down
    - Inappropriate planting times
    - Poor planting material
    - Root rot/nematodes/white grub
    - Effect of drought has greater effect on marginal country - need to be able to hold over
    - Clone 10 tops tended to fall over in marginal country
    - QC tops produced excessive juice grade in 2003 ratoon crop
    - Less than perfect gassing (forcing) and gassing too early
- Management plans to address negative factors:
    - Improve drainage both on surface and underground
    - Improve bed height
    - Better and more consistent bed height and tilth
    - Use more laser levelling
    - Re-orient rows in order to get appropriate % slope down rows
    - Improve row direction to reduce erosion and silt build up in rows
    - Put in extra cross drain to reduce erosion, prevent silt build up and thus improve drainage
    - Improve drainage by using shorter rows
    - Try to only plant F180 tops/slips
    - Plant on schedule and don't push growth
    - Experiment with irrigation after plant crop to improve sucker growth and vigour
    - Pay greater attention to gassing under optimum conditions
    - Use Nemacur® in ratoons
    - Use Chlorpyrifos after rain to combat white grubs

A common trend in all areas over the past few years is to higher planting densities

Future activities
Study group meetings will continue but more time will now be devoted to developing the Best Practice Growing Manual. The focus of this publication will be for a user-friendly guide that will assist growers efficiently produce fruit that attracts the best prices in Golden Circle Ltd's new Quality Based Payment Scheme and the fresh fruit market. The project has another 15 months to run.

Acknowledgements
The project could not exist without the involvement and openess of the study group members. The project has been supported throughout by Golden Circle Ltd horticulturists Tim Wolens and Val Tanguilig and formerly by Doug Christensen, their support has been crucial to the project. The project is funded by Queensland DPI & F, Golden Circle Ltd and QFVG. I thank all these people and organisations.

An Update on the Etiology of Pineapple Mealybug Wilt Disease in Australia

Cherie Gambley, DPI&F

General
I am reporting on our current progress in research into mealybug wilt disease. This includes the number of different viruses found to be infecting pineapple, results from our disease survey correlating viruses with disease, attempts to produce closterovirid-free plants and efforts to reproduce mealybug wilt disease in a field trial. Overseas research indicated that one virus,

Pineapple mealybug wilt virus - 2 (PMWaV-2) was important in the development of mealybug wilt disease. An important aim of the project was to determine if this virus was the cause of the disease in Australia. A second important aim of the project was to determine if Pineapple bacilliform virus (PBV) has an integrated form of its genome within the pineapple DNA. A similar phenomenon occurs with a badnavirus that infects banana. Evidence supporting the likelihood of PBV integrants was obtained using DNA based diagnostic assays. All pineapples test positive to this virus using these assays, which is unlikely if PBV only existed as an infectious virus.

Viruses

Our research has revealed that there are at least five badnaviruses and four closterovirids in Australian pineapple. These include Pineapple mealybug wilt associated virus 1 (PMWaV-1) and PMWaV-2, both reported to also occur in Hawaiian pineapples and two previously unknown closterovirids. PBV has been detected in pineapples worldwide and the remaining four badnaviruses were previously unknown. Of the five badnaviruses three have been detected in Australian pineapples. Diagnostic assays for all four closterovirids have been developed. 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. Transmission experiments for all four viruses have been done with Australian isolates and mealybugs.

Disease Surveys

Previous disease surveys (2002) indicated that PMWaV-2 was not causing mealybug wilt disease in Australia, as this virus was found in less than ten plants from a total of 80 tested. Thus, further investigation into the cause of mealybug wilt disease in Australia was required.

A second round of disease surveys were conducted in 2003. Table 1 summarises the different virus combinations detected in both rounds of surveys. Mealybug wilt disease was monitored in a C30 and a F180 crop located in SE Qld. The survey followed the protocol used for the first round where plants were monitored from a F180 and GC1 crop. This involved sampling both healthy and disease-affected plants and indexing for all four closterovirids. Previously, there was no clear association between the presence of any one virus or any particular virus combination and disease symptoms. In the latest surveys there appears to be a possible association between the presence of PMWaV-1 in combination with PMWaV-4 and diseased F180 plants but not for C30 plants. In addition the presence of PMWaV-2 seems to be associated with diseased C30 plants. Importantly, the apparent association of PMWaV-2 with disease symptoms at least in one crop, means that in some mealybug wilt disease outbreaks in Australia the hypothesis reported by overseas researches appears valid. However, in three of the four crops surveyed this relationship was not observed, indicating there is either multiple causes for the disease or the true disease agent(s) has not been identified. Indexing the plants for PBV and Pineapple bacilliform virus 2 (PBV2) will also be done once assays become available. This will provide a more complete view of the interaction of pineapple viruses and mealybug wilt disease.

Table 1: The incidence of PMWaV-1, -2, -3 and -4 in symptomless (S) or mealybug wilt disease affected (D) pineapple plants surveyed from four commercial crops grown in south-east QLD.

Virus Status	GC1		F180 Site 1		C30		F180 Site 2	
	S	D	S	D	S	D	S	D
NVD[a]	16	1	0	0	0	0	10	1
W1[b] only	1	1	17	1	0	0	4	2
W2 only	1	0	0	0	0	0	1	0
W3 only	0	1	0	0	0	0	1	0
W4 only	0	1	0	1	0	0	1	3
W1+W2	0	0	0	3	0	0	1	0
W1+W3	0	1	1	0	0	0	0	0
W1+W4	1	6	2	11	34	3	1	11
W2+W3	0	0	0	0	0	0	1	0
W3+W4	0	0	0	2	0	0	0	0
W1,2,4	0	1	0	1	0	18	0	3
W1,3,4	1	4	0	4	5	4	0	0
ALL 4	0	0	0	1	1	15	0	0
Total sampled	20	16	20	24	40	40	20	20

[a]No virus detected is abbreviated to NVD

[b]Virus names are shortened to W1 (PMWaV-1), W2 (PMWaV-2), W3 (PMWaV-3) and W4 (PMWaV-4).

Field Trial

A second approach to investigating the cause of mealybug wilt disease was to evaluate likely candidates in a field trial. The main aim of the field trial is to determine if virus infection alone or virus infection plus mealybug feeding is required for disease development. Research in Hawaii has indicated that PMWaV-2 and mealybug feeding is necessary and either agent alone will not induce disease.

The field trial that was planted early 2003 at Redlands Research Station; DPI&F is continually being monitored for mealybug wilt disease and the presence of closterovirids. The trial includes plants of a closterovirid-free seedling line and plants derived from a MWD-affected plant, both lines propagated through tissue culture. Selected plots were each infested with several hundred immature mealybugs that were raised on butternut pumpkin, a non-host of the viruses. Duplicate plots are maintained insect free by regular application of insecticide. A comparison will be made between disease development in virus-infected pineapples with and without mealybug infestation. This will assist in determining if closterovirid infection alone or in combination with mealybug feeding initiates development of the disease. Conversely, 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. To date there has been no symptoms observed in any plants.

Virus Free Pineapples

The production of closterovirid-free pineapples may be important for the control of mealybug wilt disease and freeing plants of virus may increase yield per se. The affect of virus infection (with or without disease symptoms) on the productivity of pineapples has not been examined due to a lack of suitable virus-free material. Hawaiian researches have reported success in producing closterovirid-free pineapples using tissue culture methods and these methods formed the basis of our attempts to eliminate virus from Australian pineapples.

Experiments aimed at producing closterovirid free pineapples began late 2002. 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. Virus indexing for these plants relies on an assay with high sensitivity to prevent false negative results. It is quite likely that low virus levels in these tissue culture plants are below the detection limits of the existing assays and thus plants appear to be uninfected. A new assay is currently under development to decrease the detection limit to an appropriate sensitivity level that gives confidence in results.

Badnavirus Integration

Recent experiments have indicated that PBV has at least part of its DNA genome integrated into the DNA of pineapple. A similar situation occurs with badnaviruses that infect banana. Occasionally the integrated pieces of virus from the banana DNA can be activated to produce a complete form that is infective, can induces disease symptoms and be transmitted by mealybugs. It is unknown how much of the PBV genome is integrated into the pineapple chromosomes and unless the complete form is present it is unlikely that the virus would become reactivated. Further investigations to determine the amount of virus genome integrated in pineapple are underway.

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 should provide a higher yielding source of planting material and will remove many constraints to current research into mealybug wilt disease.

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.

Genetic Engineering of Pineapple for Blackheart Resistance and Control of Natural Flowering

Mike Smith, Lien Ko, Karen Kretschmann, Paul Campbell and Tim Holton, Department of Primary Industries and Fisheries, Queensland

Summary

The goal of DPI&F's pineapple GE research program is to develop a 'Smooth Cayenne' pineapple cultivar with demonstrated resistance to blackheart and/or control of natural flowering. It is also necessary to develop a business and intellectual property strategy to allow the Australian pineapple industry freedom to operate on national and international markets. A comprehensive audit of the Intellectual Property ownership relevant to the project has been completed.

The gene responsible for blackheart is called PPO2 and the gene responsible for natural flowering is referred to as the ACC2 gene. Transgenic plants have been produced and will need to be assessed, not only for blackheart resistance and control of natural flowering, but for their agronomic performance and fruit quality.

Pineapple transformation

To generate transgenic pineapples we have established and optimised a plant regeneration system based on the production of highly regenerable cells from leaf bases of tissue cultured plantlets. This system is proving highly efficient, approximately 90% of leaf explants produce callus within three months of initial culture and at least 90% of such callus pieces have proven regenerable upon transfer to a shoot regeneration medium, multiple shoots can be readily obtained within four weeks. Over 2530 regenerated plants have been grown in the field and most appear quite normal.

All transgenic plants were produced from a selection of F180 provided by Col Scott.

Small-plant bioassays for blackheart

Pineapple plants take 18 months to bear fruit in southeast Queensland, hence an assay using leaves could be used to determine the effectiveness of genetic transformation at an early stage of the plant's development. Published reports have indicated that browning in leaves is induced in a similar way to that of blackheart in the fruit.

Two experiments were conducted to develop a suitable assay for determining specific pineapple transformants that were likely to exhibit minimal expression of blackheart in fruit. Leaves were collected in July 2001 and again in November 2001 from field grown plants at Redlands Research Station.

A successful assay was developed using the youngest fully-extended leaf from an individual pineapple plant. Such leaves are easily 'plucked' from the plant and offer a degree of uniformity between plants. Leaves were wounded at the base and immersed for 5 min in a 70% ethanol solution to induce browning such that the degree of the browning-response could be easily measured.

The width of the brown band was used as a measure of the extent of wounding and therefore PPO expression. The wider the band the more PPO activity and therefore the more susceptible the clone is to injury expression. Of course, the converse is the narrower the band, the more PPO activity is suppressed and the more resistant the clone is to injury expression.

The transgenics generated by either biolistics or Agrobacterium are both capable of preventing leaf browning with lines PPO-A3 and PPO-B4 being consistently most effective following damage to the leaf bases. Interestingly, transgenic line PPO-B3 was not effective in preventing browning while GUS-B4 suppressed the extent of browning. Also of interest is that browning was more extensive in leaves collected in winter, suggesting that field-induced chilling predisposed the leaves to injury expression. This is similar to the situation with blackheart in the fruit. PPO expression in these tissues is currently undergoing analysis to confirm visual findings.

Plant bioassay for natural flowering

Flowering studies have also been completed which indicate that screening of transgenic lines using fluctuating cool/warm temperatures is possible in a temperature controlled glasshouse. The results for plants held at a constant 20°C agree well with data collected in a previous project, however not all of the plants were induced to flower. Four temperature regimes were examined (20°/15°C, 20°/20°C, 25°/15°C, 25°/20°C). The treatment that achieved 100% natural flowering the earliest was obtained from mature Smooth Cayenne plants grown in 15 L polybags during autumn to early winter and exposed to the 25°/20°C temperature regime for 60 days.

The background research has now been completed to control natural flowering in pineapples. The aim is to produce a sufficiently large enough population of engineered plants so that an elite selection of 'Smooth Cayenne' is produced for the pineapple industry.

Planting and field evaluation

Over 2530 plants have been produced and established in the field from 50 transgenic lines. A further 2000 plants are ready for glasshouse establishment from 55 transgenic lines. Field trials are managed as per commercial practice.

The plants in trial 1 established and grew well. They were of a sufficient size for flower induction in February 2002 and fruit was harvested during October 2002. Unfortunately fruit failed to develop blackheart symptoms following storage at 10°C for 3 weeks followed by 23°C for 1 week, the standard induction treatment. Even control plants showed no blackheart development and therefore the trial produced inconclusive results. We did observe a number of fruit mutations including changes to fruit shape (round, conical, fan-shaped), reduced fruit size, multiple crowns and spininess. However the majority of fruit was of normal appearance and size.

Table 1. Status of Pineapple Field Trials under Licence DIR/028/2002

Trial	Planted	Flowered	Harvested	Current Status
1	RRS[1], 21/2/01	Induced Feb 2002	October 2002	Plants herbicide treated and rotary hoed; site fallow
2	MRS[2], 26/3/01	Natural flowering	Not harvested	Plants remain at trial site
3	RRS, 5/2/02	Induced Feb 2003 (partial induction)	Oct-Nov 2003; Feb-March 2004	Plants remain at trial site
4	MRS, 20/10/03	n/a	n/a	Winter harvest planned for 2005
5	MRS, 6/4/04	n/a	n/a	CE trials planned

[1]Redlands Research Station; [2]Maroochy Research Station

Flower induction was only partially successful in trial 3 and the fruit was harvested over an extended period, with peak

harvests between October-November 2003 and February-March 2004. Again fruit failed to develop blackheart after a standard induction treatment. Plants and fruit were mostly of normal appearance but leaf spininess and fruit abnormalities were seen in some lines (eg. one line was totally spiny and another produced small, spherical fruit).

Plans are to destroy the current planting at Redlands and conduct future trials at Maroochy Research Station where we believe conditions may be more suitable for blackheart induction. The trial work at Redlands Research Station will be suspended subject to availability of funds.

Interesting observations from the trial work

- All of the ACC lines had delayed flowering after being 'forced'
- One of the ACC lines had a high proportion of fruit that failed to colour
- 10 PPO lines showed little to no browning in the leaf bioassay
- One of the PPO lines was highly susceptible to a "disease" in the glasshouse
- Off-types, while high 30-40%, were not significantly different between tissue cultured (controls) and GE pineapples

Commercialisation of DPI&F Pineapple Varieties

G. Sanewski, Department of Primary Industries and Fisheries
D. Christensen, Favco Queensland Ltd

The pineapple fresh market breeding program is now entering the commercialisation phase. After an extensive selection process, a commercialisation partner, FAVCO Qld Ltd was chosen. DPI&F will now work with FAVCO Qld Ltd to bring our varieties to market. This will involve commercial-scale multiplication, formal taste tests, storage trials, blackheart trials, and quality assessments. FAVCO Qld Ltd and DPI&F will continue to work with established co-operators in SE Qld, Central Qld and Nth Qld to ensure varieties suited to all regions are selected.

FAVCO Qld Ltd has a full commercialisation licence for all DPI&F varieties for all Australian markets. This includes responsibility for managing multiplication, production, marketing and some further research. The initial objective is to establish a presence in the market place within the next 3 years.

Key attributes of selected varieties should include,

- Consumer specific attributes
  - high sugars,
  - low to moderate acid,
  - aromatic flavour,
  - optimum size,
  - absence from internal blemish,
  - absence from skin blemish.
- Grower specific attributes
  - minimal translucency to increase % of marketable fruit and allow harvesting at optimum maturity,
  - minimal skin blemish to avoid bagging,
  - increased fruit firmness for ease of handling and extended shelf-life,
  - adequate plant vigour to ensure acceptable fruit size
  - low susceptibility to natural flower initiation.

Four varieties are currently undergoing tissue culture and a further 3 will be multiplied conventionally for larger scale testing. There are still however many varieties held. These will be screened over the next 2-3 years and either discarded or multiplied further.

In addition to whole fresh fruit, the screening of varieties maintains an interest in possible new types that are suitable for canning and minimal processing.

FAVCO Qld Ltd is currently working with a small number of growers including established co-operators but as new varieties are proven and plant numbers grow, the new material can become more widely available.

Commercialisation of DPI&F Ornamental Pineapple Varieties

G. Sanewski, Department of Primary Industries and Fisheries
N. Macleod, Pinata Marketing

A small scale exploratory breeding program for ornamental types of pineapple conducted in the mid to late 1990's produced several varieties with promise. Some appeared to have potential for the cut-flower market and some for the landscape market. A tender for expressions of interest was published in November, 2002. A joint application from Pinata Marketing and Australian Nurserymen's Fruit Improvement Company (ANFIC) was selected and a testing agreement was signed in May, 2003.

Twelve varieties were licensed to Pinata/ANFIC for testing. Several of these are currently being multiplied by tissue culture

for preliminary agronomic and market studies. The most promising cut-flower varieties at this stage are Anna Rose, Anna Pink, Anna Flame and 34-76. The most promising landscape types are Anna Red and Anna Belle. Most are hybrids involving *Ananas bracteatus* and *Ananas erectifolius*.

The objective over the next 12 months is to produce enough of each of the more promising varieties to evaluate market response and to elucidate any likely production problems. It is expected that the export market will be the most promising.

Sorting on Internal Quality Attributes

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Technologies

In the good old days, fruit was sorted by hand, by colour, shape, blemish and weight. Then came grading machines, starting with simple diverging belts and progressing through mechanical weight graders. Some decades ago, vision based electronic graders were implemented, using weight cells and colour video cameras to assess fruit weight, shape and colour. With increasing sophistication in image analysis came the ability to detect blemishes on fruit also. This technology is implemented at belt speeds of up to 1 m/s (or up to 10 items of fruit per second). A well designed system will have good fruit transfer facilities (e.g. between belt and table) to minimize fruit bruising.

Today a number of non-invasive technologies are being added to these systems. These capabilities represent spin-offs from advances in the defence, telecommunications and medical sectors - e.g. think of the range of non-invasive detections used when you present at a hospital, before the surgeon sinks the knife in. Among these are techniques for assessing density differences within fruit (e.g. seed size, Xray imaging), firmness (acoustic and accelerometers), chemical composition (nuclear magnetic resonance and near infra-red spectroscopy). As in most fields, there is a world wide consolidation of fruit grading equipment manufacturers occurring, at least at the technologically advanced end of the market. The world market is dominated by the European manufacturers, MAF-Roda, Aweta and Greefa.

A NIRS Primer

If evaluating 'NIR' equipment for your packhouse, the following should be borne in mind:

NIR refers to near infrared, that is those invisible wavelengths just beyond red in a rainbow ('spectrum'). S refers to spectroscopy, that is measuring light at discrete wavelengths. So a NIRS instrument will measure at a range of wavelengths in the NIR. As it happens a CCD camera is also sensitive into the NIR. For normal video recording a filter is used to stop these wavelengths getting to the CCD, but in fruit sorting it can be useful to let these through. This can improve blemish detection in this image. This is not spectroscopy however.

Near infrared spectroscopy is being used commercially for the sorting of sugar and dry matter content in a range of commodities, particularly thin skinned items such as apple, stonefruit and kiwifruit. The technology is not well suited to the measurement of acidity in fruit, but it may pick up extreme high or low samples.

It can be used in three configurations : reflectance, partial transmission, or full transmission. Reflectance is where the detector views an illuminated part of the fruit. Some light passes into the fruit and bounces back to the detector, but most light 'seen' by the detector has just bounced off the surface of the fruit (and carries no information about internal constituents). This method is sensitive to changes in surface condition. Full transmission is where the light illuminates one side of the fruit and the detector the opposite. This method can slow the packline down, requiring a longer time per fruit to get a reasonable signal, and can be sensitive to dense items inside the fruit). Partial transmittance involves having the light source and the detector at less that 180° to each other.

The performance of a NIRS unit is assessed in terms of its ability to predict a new group of fruit, relative to the actual values. Information should be presented in terms of R^2 (where 1 is perfect and 0 worst), SEP (standard error of prediction, this is a measure of the error of the technique, e.g. an SEP of 0.5 °Brix would be acceptable, while 2.0 Brix would not). The trick is to see the equipment work on a new group of fruit (e.g. harvest from a different field), as you can get relationships that work for a given set of fruit but not with new groups (e.g. a relationship between shell colour and Brix).

NIRS based fruit grading units first became available in Japan, where there are now several hundred packhouses so equipped. In the Western World, commercial NIRS units are available from CVS-MAF Roda, Compac, Aweta and Fantec. The CVS technology is home grown, developed in Australia with Horticulture Australia and The Harvest Company support, and currently in use here, and in Europe and the USA.

There is a certain 'magic' in NIR sorting - to be able to tell the sugar content of up to 10 pieces of fruit per second, just by shining a light on them and measuring light coming back! It's an amazing capability, a synthesis of improvements in optics and electronics (think fibre optics and telecommunications) and the speed of computers, and I am always impressed to see systems in operation in a packinghouse.

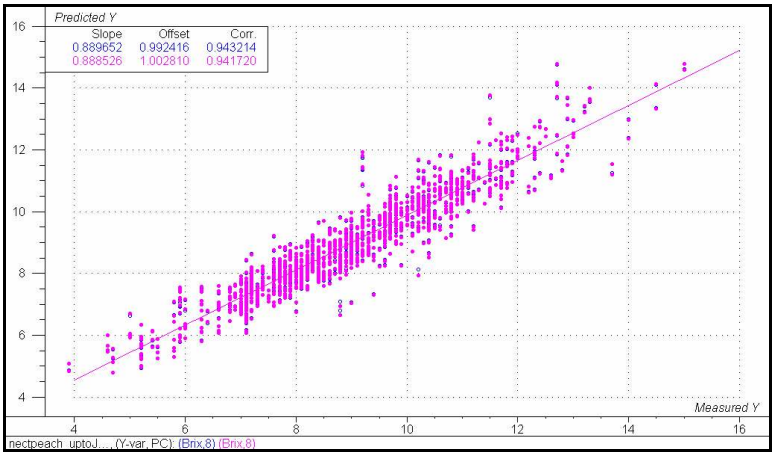

Figure 1. Calibration performance for peaches and nectarines (mixed varieties) from a Ballandean packhouse (NIR predicted values on y axis, refractometer measured values on x axis). Note that picking crews make mistakes! – delivering immature fruit with as low as 4 %SSC!

Pineapple

Pineapple can be electronically assessed on shell colour, weight, size and shape. Despite its fearsome skin, it is relatively easily bruised and sorting machinery must have gentle transfer action.

Pineapple does not have a simple skin, and the 'skin' is composed of bract tissue, air cavities in locules, stamens, etc. As such any NIRS technique trying to assess internal quality on intact fruit is working uphill. It can be used to sort on TSS, but there is a reasonable amount of 'maintenance' required. There is no commercial application of NIRS sorting of intact pineapple for Brix. Of course, it would work very well with skin removed (eg. fresh cuts).

Pineapple suffers other internal defects such as black-heart and translucency. Lyn Smith (DPI) considered the used of flotation tanks to separate maturity grades of fruit on specific gravity but concluded this method was unreliable, with specific gravity affected by sugar content and internal cavities. Optical (eg. NIRS) and acoustic techniques offer promise for the detection of these defects.

News from Brazil

Brazilian Pineapple: Law Regulates Fruit Classification

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Brazil is the third world producer of tropical fruits, commodities with great potential to generate income and jobs. In some cases income from these commodities reaches about US$8,900 and utilizes up to six workers per hectare. Without considering increased exports, the value of fresh fruits reached, US$267 million in 2003, which corresponded to a growth in value of 39% over 2002 (Informative IBRAF n. 5, 32, 2004). Agribusiness in general is responsible for a third of IGP, 42% of the exports and 37% of the jobs, having generated, in 2003, a commercial superávit of US$25.8 billion. Among the advantages in Brazil are large available land area, a long agricultural tradition, favorable climates, fertile soil, water availability, rich biodiversity and qualified hand labour, and a moderate climate that permits the harvest up to two annual grain crops.

Brazil is also the third world producer of pineapple, whose agribusiness grew strongly in the last years, presenting an estimated production value of half billion dollars (about 1.78 billion "Real") per year, being considered the volume of about 1.7 million tons, produced in about 62.000 hectares of cultivated area. That activity generates more than 100.000 jobs, most of them linked to the small agricultural production, the most lacking of support, however the more prioritised in the current Brazilian government's plans. Almost all the Brazilian production of pineapple (about 98%) it is consumed internally and as fresh fruit. That is because, in spite of the great world demand, Brazil is just the 14th exporter of that fruit.

With base in the aspects above and still considering the consumer's demands, mainly in regard to his alimentary safety, the Brazilian Government sanctioned the Law n. 9.972/00, May, 25, 2000, instituting the compulsory nature of the classification for the agricultural products, their by-products and residues of economical value in the whole national territory, whose official patterns will be determined by the Ministry of Agriculture, Livestock and Food Supply (MAPA). The referred classification is

also subject to the normative organisation, technical supervision, fiscalization and control of MAPA.

Therefore, one can not find strange that this activity is one of the strategic priorities of MAPA, established in the Horticultural Development Program, an essential part of the government structural programs and also of the Plurianual Plan (PAP). The general objective of that program is to consolidate the quality patterns and competitiveness of the Brazilian horticulture, have seen the requirements of the international trade. It is expected that this objective will be reached with the advances in the working and management capacities of farmers and other actors of the productive chain of fruits, and with the increase in the internal and external markets. For that, it will be necessary the implementation of actions of technological training with focus on the incorporation of methods, techniques and processes based on integrated production systems that involve economical viability, environmental sustainability, alimentary safety and social justice.

The Law 9.972/00 defines classification as the action of determining the intrinsic and extrinsic qualities of the vegetable product, based on officials patterns, physical or described ones. The classification and its fiscalization will be executed by the States and Federal District, directly or through their specialised organs or companies; agricultural co-operatives and specialised companies in the activity; and commodities markets, universities and research institutes, properly authorised / accredited by MAPA. The referred Law was regulated by the Decree 3.664/00.

Thus, considering: 1 - what is determined in the law and decree referred above, as well as the need and importance of disciplining the trade of fruits produced in Brazil and imported ones, concerning to their quality control and, via of consequence, to the consumer's protection; and 2 - that the Technical Regulations are instruments of facilitation and transparency of the commercialisation of fruits, the General Office of Rural Support and Co-operativism (SARC), of MAPA, approved the Technical Regulations of Identity and Quality for the classification of some fruits, among them the Pineapple - Normative Instruction SARC 001/02, that in its Annex I specifically refers to the pineapple for consumption in natura. In that annex the following items are detailed:

1. Objective: to define identity and quality characteristics for classification of the pineapple for consumption in natura;
2. Application extent: to comply with the request of the Law 9.972/00, Art. 1o., clauses I, II and III;
3. Definition of the product: pineapple is the fructescence of the species Pineapple comosus comosus (Cöppens & Leal);
4. Concepts:
4.1.Physiologically developed: fructescence in condition of being picked, with characteristic maturation degree of the variety;
4.2. Exempt of noxious substances to health (within the foreseen maximum limits);
4.3. Clean: free from dust etc.;
4.4. Characteristics of the fructescence:
- Weight: of the fruit (kg);
- Coloration: of the peel;

4.5. Defects: alterations caused by several agents, that compromise the quality of the product:
4.5.1. Serious defects: they compromise the appearance, conservation and quality, restricting and making unfeasible the use and/or commercialisation of the fructescence:
- Lesion: any damage that exposes the pulp;
- Rottenness: damage that implicates in decomposition, disintegration or fermentation;
- Without crown: absence of the crown;
- Fasciation: deformation of the fructescence (in fan form);
- Sunburned: discoloration / necrosis of an area of the peel caused by the sun;
- Immature: fructescence that don't reach the minimum of 12o (twelve degrees) Brix (SST);
- Passed: fructescence without firmness (advanced maturation or senescence);
- Crushed or bruised: softening of mechanical cause;
- Exuded or sweated out: gum deposit or resins in the peel (fungal or bacterial causes);
- Soft: peel without firmness (several causes);
- Chocolate: pulp of brown colour (physiological causes);
- Damage by cold: brown pulp (causes: frost or cold storage);

4.5.2. Light or superficial defects: alterations that just harm the appearance of the pineapple, depreciating its commercial value, and that are related just to the crown of the fructescence;
- Multiple crowns: fructescence with more than one crown, without losing the form;
- Damaged crown: crown with partial damage;
- Bent or curved crown: with pronounced deviation in relation to the fructescence axle;
- Deformed: any deviation in the form of the fructescence, no characteristic of the cultivar;

4.5.3. Out of category: product that does not comply with the quality specifications (Table of Tolerance, item 5.4);
4.5.4. Lot: amount of products with the same specifications;
4.5.5. Packing: wrapper destined to guarantee the conservation and to facilitate the transport of the product;
4.5.6. Wrapped product: product inside a package to be offered to the consumer;
4.5.7. Pollutants or noxious substances to the health: contamination with values within the maximum limits foreseen in the legislation;
5. Classification - the pineapple must be classified in Groups, Subgroups, Classes or Calibres and Categories:
5.1. Groups: based on the colour of the pulp of the fructescence:
- Group I: fructescences of yellow pulp;
- Group II: fructescences of white pulp;

5.2. Subgroups: in agreement with the colour of the peel, applicable just for the pineapples of white pulp:
- Green or Greenish: fructescence with peel completely green, but with the maturation process initiating, presenting, at least, 12° Brix;
- Painted: fructescence with up to 25% of the peel yellows;
- Coloured: fructescence with 25% to 50% of the peel yellows;
- Yellow: fructescence with more than 50% of the peel yellow;

5.2.1. A mixture of up to 20% of the fructescences is admitted, since they belong to the immediately superior or inferior subgroups. Out of those limits the lot should be reprocessed or considered mixed;

5.3. Class or Calibre: based on the weight of the fructescence (kg) - Table below:

Class or Calibre	Weight of fructescence - kg
1	Larger than 0,900 up to 1,200
2	Larger than 1,200 up to 1,500
3	Larger than 1,500 up to 1,800
4	Larger than 1,800 up to 2,100
5	Larger than 2,100 up to 2,400
6	Larger than 2,400

Tolerance: a mixture of up to 10% is admitted, since they belong to the immediately superior or inferior classes. Out of those limits the lot should be reprocessed or considered mixed;

5.4. Categories: in agreement with the quality of the fructescence (Table below), which contains the maximum limits of defects allowed by category - the serious defect alone determines the category:

Categories	Extra	I	II	III
Serious Defects				
Lesion	0	1	5	10
Rottenness	0	1	2	3
Absence of crown	0	1	5	10
Fasciation	0	1	5	10
Sunburn	0	3	10	20
Immature	0	1	5	10
Passed	1	1	5	10
Crushed or bruised	0	0	2	5
Exuded or sweated out	0	0	2	5
Soft	0	1	5	10
Chocolate	0	1	5	10
Injury by cold	1	1	5	10
Total of Serious Defects	1	3	10	20
Total of Light Defects	0	10	35	100

5.5. Out of Category: Lot which presents percentages of defects exceeding the maximum limits of tolerance specified for the Category III, as previously fixed, except for the total of light defects, established in the same Table;

It would not be allowed the commercialisation of the pineapple classified as Out of Category, for serious defects; in that case, the lot should be reprocessed;

In the case of lots Out of Category for light defects, the following criteria should be observed:
- The identity, quality and other informations about the product should comply with the specific classification / labelling, established in the item 5;
- They can be sold as such, since complying with the demands referred in the previous item;
- They can be reprocessed, unfolded or recomposed, for framing effect in some Category;

5.6. Disqualified - Lot that present one or more of the characteristics below, being prohibited its commercialisation for human consumption:
- Bad conservation state;
- Mould aspect or fermentation;
- Residues of pesticides, other pollutants and noxious substances to human health, above the foreseen limits;
- Strange odour, inappropriate to the product;

The MAPA can request the analysis, in accredited laboratories, of the product suspected of contamination, with the expenses paid by the holder of the product. The person responsible for the classification should communicate to MAPA the occurrence of any disqualified product, for the due providences, being the duty of the referred ministry the decision about the destiny of the product;

6. Package: To the internal market, in the wholesale, the pineapple can be sold in bulk or preferably in boxes; in the latter, the packing must be of material that does not cause any alteration in the fruits nor transmit odour, and should be clean and drought allowing its arrangement in pallets;

6.1. It is obligatory that all the packages are of the same material and have identical packaging capacity;

6.2. The quality specifications of the fruit should be contained on the labels, in a visible place and in consonance with the Certificate of Classification, and should not present any graphic representation which may confuse the consumer.

7. As in wholesale as in retail, wrapped or in bulk, the product should be properly identified, based on the items of its classification (lot, origin, harvest time, group, subgroup, class, category etc.);
8. The classification is based on processes that involve specific samplings for the cases of products to be sold wrapped and in bulk;
9. The Certificate of Classification is the appropriated document to prove the accomplishment of the classification, corresponding to one lot of the product, and it will be emitted by MAPA or any accredited juridical person;
10. Storage and means of transportation: they should offer full safety and indispensable technical conditions to the perfect conservation of the product.

Those norms, that should already be being in force, if they come to be really adopted and respected, certainly they will contribute in a decisive way to reaffirm and expand the pineapple agribusiness as a really viable socio-economic activity in the Country.◆

News from Costa Rica

A Characterization of Monte Lirio Pineapples from Costa Rica

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Monte Lirio pineapples (Figure 1) have important characteristics for industrial purposes, due mainly to its white flesh and juice and an appreciated balance between acidity and sweetness. Under a public-private alliance of industry, small-scale farmers and government agencies, Monte Lirio pineapples were studied from July 2003 to April 2004 as a way to support farmers in the Puriscal area (San José Province of Costa Rica) as fresh fruit suppliers for the fresh-drink industry.

These studies described fruit characteristics that served as a guide for both farmers and processors for field and postharvest fruit quality and management. The main target was to identify a maturity index fulfilling profit needs for farmers and the appropriate pulp quality, not only for industrial purposes but for the fresh fruit market.

Under normal conditions, fruit suitable for this activity were those of color grade 2-3 (based on a 0 to 5 scale with 0 being green but fully developed fruit and 5 full yellow fuit peel). Averages were 1.88 kg per fruit, an equatorial diameter of 14.5 cm and a crown length/fruit length ratio of 1.2. Total Soluble Solid (TSS) content was 12.39 % and the maturity index (TSS/acidity ratio) reached 26.43. Pulp translucency averaged 1.93 (scale from 0 -opaque- to 5 -fully translucent-) and tended as normal, reaching maximum values as grade advanced, from 0.55 (grade 0) to 4.25 (grade 4). Ascorbic acid was 273.97 mg kg^{-1}. Ethanol contents were lower on grades 2-3 (104.58 mg kg^{-1}); grades 0.1 and 4 reached 257.46 mg kg^{-1} ethanol, but all data were significantly lower than the limit permitted by industry. Pulp represented 65.48 % of the total fruit weight, although the inclusion of fruit core increased efficiency to 74.69%.

Some adjustments in production techniques are necessary to develop a sustainable and more efficient production system. Low-scale plant-forcing is still inefficient due to application methods; fertilization is under review based on some of our findings and some critical levels are to be determined. On the other hand, plant density is very low due to topographical conditions, although increases to 35000 plants ha^{-1} are being tested.◆

Figure 1. Monteliro pineapple from Costa Rica.

News from Cuba

A Role for Brassinosteroids During Acclimatization of Pineapple Plantlets

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Summary

Demands for quality plants have been rapidly increasing worldwide. Micropropagation is a plant tissue culture technique used for obtaining a large number of genetically identical plantlets. Commercial micropropagation of pineapple plants has many advantages over conventional methods of vegetative propagation, in part due to its efficient and rapid increase of selected varieties. Temporary immersion bioreactors (TIB) are an efficient tool for mass propagation because they increase multiplication rate and plant quality. Little knowledge is available on environmental stress suffered by pineapple plantlets during the transit from TIB to ex vitro acclimatization. Fresh mass did not show significant differences among the treatments with 35% and 75% relative humidity (RH) respectively, despite the fact that appearance of the plantlets grown under 75% RH was better than those grown under 35% RH; but net photosynthesis (Pn) showed a dependence on RH. Pn was very low, indicating a low respiration rate when the RH was higher. Free proline contents of pineapple plantlets grown under 75% RH indicated that they suffered environmental stress. Addition of the brassinosteroid analogue MH5 reduced free proline levels and presumably the level of stress.

Introduction

Pineapple micropropagation involves sequential culturing in liquid medium for meristem and axillary shoot-bud multiplication by means of conventional micropropagation (Firoozabady et al., 1995; Daquinta and Benega, 1997), which is a limiting factor in obtaining sufficient pineapple plants needed annually to start up new plantations. In general, the commercial use of micropropagation is currently reduced because of high production costs as a result of high labour cost, low multiplication rate, and poor survival rates during acclimatization. However, these limitations are improved using automated temporary immersion bioreactors (TIB) (Escalona et al., 1999, 2003; Firoozabady and Gutterson, 2003).

Many experiments have been conducted to improve the anatomy and physiology of tissue-cultured plants during in vitro stages, the objective being to enhance the survival of plantlets transferred to the ex vitro acclimatization stage. Among the treatments evaluated were relative humidity (RH) levels, light intensities and CO_2 concentrations (Laforge et al., 1991; Nguyen and Kozai, 1998). Other components of culture system, in most cases the sugar content in the media, have also been evaluated (Niu et al., 1998; Louche- Tessandier et al., 1999; Le et al., 2001). Similar studies need to be made during the plantlet acclimatization phase because little is still known on this topic.

During ex vitro acclimatization, plantlets are exposed to diurnal and seasonal changes in their physical environment, which include extreme and stressful climatic variations. During the transit from in vitro to ex vitro conditions these stresses are relevant. The brassinosteroids, a new important class of phytohormones that regulate plant morphogenesis, influence such important physiological processes as cell elongation and tolerance process (Wilen et al., 1995; Sasse, 1997; Clouse and Sasse, 1998; Dhaubhadel et al., 1999; Catterou et al., 2001; Mazorra et al., 2002). This study is mainly concerned with the response to changes of environmental conditions and the effect of the addition of brassinosteroids during acclimatization of pineapple plantlets cultured in TIB.

Materials and Methods

Pineapple plants (*Ananas comosus* L. Merr) cv Smooth Cayenne, were obtained from established liquid cultures grown on a shooting medium, which consisted of MS salts (Murashige and Skoog, 1962) supplemented with 9.31 µM BA and 1.61 µM NAA, as recommended by Daquinta and Benega (1997). The cultures were grown under cool white fluorescent lamps providing a photosynthetic photon flux (PPF) of 80 mmol m^{-2} s^{-1}, with a 16-h photoperiod at 25 °C.

Plants were propagated in temporary immersion bioreactors (TIB), which consisted of two containers, one for growing plants and a reservoir for liquid medium. The protocol to propagate pineapple plantlets in TIBs involves three phases: proliferation, pre-elongation and final growth of the buds (Escalona et al. 1999).

When in vitro culturing was finished, the plantlets were transferred to a greenhouse for acclimatization following the technology of Yanes et al. (2000 a, b) during the first 21 days. Plantlets were divided in two groups of 40 units per group and the groups were grown under 35% and 75% RH. In a second trial at 75% RH, plantlets were divided in two groups of 40 units each and one group was treated with 0.1 mg L^{-1} MH5, a brassinosteroid analogue (C27O6H42, molar mass = 462.606) at 18th day.

At the end of first experiment, all plantlets were harvested and counted and non-destructive measurements were taken on fresh mass. The photosynthetic capacities of ten whole plantlets for each treatment were measured. Net photosynthesis rate (Pn) was calculated from the net assimilation rate of CO_2 by the whole leaf area of each plant placed in chamber designed for conifers using the IRGA LI-6400 Portable Photosynthesis System. The conifer unit is a half cylinder, 80 mm long by 50 mm diameter, which is suitable for the stems of conifers having needle clusters up to about 25 mm diameter. The base of the chamber contains a heat exchanger and stirring fan. Pn of pineapple plantlets became saturated at a PPF of 600 mmol m^{-2} s^{-1}. Free proline contents were measured according to the method of Bates et al. (1973) in both groups of plantlets on the 21st day at the end of the second trial. All statistical analyses were done using SPSS version 9.0. Differences due to the treatments were analyzed using ANOVA, followed by Duncan´s test at $P \leq 0.05$.

Results and Discussion

There was no significant effect of relative humidity on plant or foliage fresh mass (Table 1). However, there was a dependence of Pn on RH. RH did not significantly influence plant water balance despite the better appearance of plantlets grown under 75% RH. However, Pn values indicate a lower respiration rate when the RH was higher.

Pineapple is a CAM plant, which allows the temporal separation of CO_2-fixation and CO_2-reduction. During the dark period, phosphoenolpyruvate carboxylase catalyses the fixation of CO_2 and malate is formed. During the light period, CO_2 is released from malate descarboxylation and reassimilated via the photosynthetic carbon reduction cycle. However, Gonzalez-Olmedo et al. (2005) indicated that shoots grown in a TIB were not genuinely CAM because their behavior resembled that of a C3 plant.

Nevertheless, CAM plants can take up CO_2 in the latter part of the light period when stomata are open (Winter, 1985). Cote et al. (1989) reported that at least 50% of the total CO_2 fixed during the last hour of the light period by *A. comosus* plantlets during acclimatization was stored into malate. Under those conditions, they also identified a limited C3-photosynthetic phase using exclusively atmospheric CO_2 during the light period.

Table 1. Effect of relative humidity on plant and leaf fresh mass and net photosynthesis (Pn) of pineapple plantlets during a 21-day ex vitro acclimatization

Relative humidity, %	Plant fresh mass, g	Leaf fresh mass, g	Pn (μmol CO_2 s^{-1} g^{-1})
35	1.71	1.42	-0.035
75	2.04	1.71	-0.303
Significance	NS	NS	*
SE_x	1.47	1.23	0.001

*Significant at the 0.05 level of probability.

Analyzing the effects of different culture methods and photosynthetic photon fluxes (PPF), Escalona et al. (2003) reported that shoot growth did not totally depend on the photosynthesis process, since in vitro pineapple plantlets appeared to use more nutrients in the culture medium than those from photosynthesis. For this reason it is very important to increase photo-mixotrophic metabolism nearer to photo-autotrophism by maintaining high PPF and CO_2 and low sucrose (Gonzalez-Olmedo et al., 2005). Similar in vitro pre-treatments are important for ex vitro acclimatization and growth (Kadlecek et al., 2001). Growth was highest in tobacco plantlets originally grown with 3% sucrose and high PPF, and lowest in plants originally grown without sucrose under high irradiance. Thus, photo-mixotropic in vitro culture using TIB is most suitable for later ex vitro development of the plants.

Under the conditions of this study, the data for photosynthetic capacity indicate the plantlets use more nutrients from the medium than from photo-assimilates for the elaboration of new tissues. On other hand the data indicate that the plantlets suffered environmental stress. This is indicated by the elevated level of free proline of pineapple plantlets grown under 75% RH (Table 2).

Table 2. Effects of brassinosteroid analogue on proline contents of pineapple plantlets during ex vitro acclimatization (21d).

MH5, mg L^{-1}	Proline content, μg mL^{-1}
0	0.343
0.1	0.147
Significance	*
Sex	0.021

*Significant at the 0.05 level of probability.

The acclimatization period and stress suffered by the plants can be reduced if treatments affecting carbohydrate status as well as leaf morphology and juvenility are applied in vitro (Laforge et al., 1991). Apparently these were the metabolic influences of the best management induced by TIB. Therefore, it was also possible to elevate the efficiency of the process and to reduce the production costs. Reduction of losses due to low quality plantlets, saving electric energy for substitution of autoclaving, decrease of material manipulation for higher uniformity of plantlets, rapid growth rate and less time needed to reach commercial size overcome the costs of new elements introduced for propagation of pineapple in TIB. In this study, we demonstrated that it is possible to reduce free proline content and thus the stress that affects plant quality by including the brassinosteroid analogue MH5 in the medium. Early studies of brassinosteroid activity in plants depended on exogenous application followed by recording the observable response. For instance they have been shown to moderate abiotic and biotic stresses, including salt and drought stress, temperature extremes and pathogen attack (Clouse and Sasse, 1998; Mazorra et al., 2002).

In summary, TIB did not seem to improve Pn of pineapple shoots before transplanting, nor plantlets either during three first weeks after the transit, as the results demonstrated. The respiratory rate of plantlets was higher, as well as the free proline contents indicating signals of stress, those were reduced by inclusion of the brassinosteroid analogue MH5, which also improved the quality of pineapple plantlets propagated in TIB during the acclimatization phase.

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Physical Properties of Pineapple Stumps in Relation to Cutting

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Summary

Experimental investigations were conducted on pineapple stumps to define their physical properties in relation to impact cutting. The results show that the knife edge angle and the knife thickness, together with the cutting inclination (angle between the knife edge and the stump axis), have a significant influence on the energy demand of the process

Introduction

In the cutting process a cutting element (knife) penetrates the material, surpassing its resistance and shearing it in parts. During the cutting various deformations occur to the material, depending on the shape of the knife and the kinematics of the process, therefore it is not possible to speak in general terms of cutting resistance if not relating to given cutting edge and cutting kinematics (Sitkei, 1986).

In our case cutting is a process that causes the mechanical breakage of stumps and leaves, and so the structure and the resistance to breaking and to bending of this material are of great interest (Srivastavaat et al., 1993). The size and the resistance to bending of the stumps increases with the development of the plants (Persson, 1987).

Prasad and Gupta (1975) have studied several variables involved in maize stalk cutting using an impact cutting apparatus based on a pendulum. The results showed that the angle of the cutting edge of the knife, its inclination with respect to the direction of movement and the inclination of the plane of the knife with respect to the stalk axis should be respectively 23˚, 32˚ and 55˚ while the knife speed must be around 2.65 m s^{-1}. The energy and the maximum force needed for cutting were directly proportional to the area of the cross section and inversely proportional to the moisture content of the stalks.

Focusing on pineapple it appears that the mechanical properties of the plants with respect to cutting have not been sufficiently considered in the scientific literature. Cykler (1951) found, using a Charpy type pendulum, that the energy needed for separating the crowns from pineapple fruits of 'Smooth Cayenne' was 12.8 lbf•ft (17.35 J). Roy and Salokhe (1999) reported that average values of length and diameter of pineapple stumps are 388 mm and 37 mm respectively while shearing resistance was 807 kN m^{-2} (0.807 MPa).

Perez de Corcho et al. (2005) carried out some experimental trials to determine the influence of the geometric parameters of

the knife and of its speed on the energy needed for impact cutting of stumps of 'Smooth Cayenne'. Knives with rectangular trapezoid section and three angles (20°, 25° and 30°) of the cutting edge were tested, at three different speeds (13.54 to 14.32 m s^{-1}) and with two different inclinations with respect to the stump axis (90° and 60°). The knife with the 20° edge required less energy and less specific energy than the others and so did cutting with a 60° inclination, probably because of tangential tensions that enhance the cutting action.

However the cutting characteristics of pineapple stumps have not been sufficiently studied. The aim of the work described here is to further investigate the physical properties of the stumps related to the impact cutting process in order to define the geometric parameters of the knives to diminish the energy consumption during the process of demolition of pineapple plants in the fields after the end of their productive cycle.

Materials and Methods

The specific energy for cutting pineapple stumps of 'Smooth Cayenne' was determined with the use of a pendulum apparatus following Feller's methodology (Feller 1959). The cutting was done with knives sharpened on one side (trapezoid section) and two sides (pentagonal section), the latter with smooth and serrated edges.

The stumps were mature (after harvesting stage) and with a moisture content of 64.9%. The samples were taken with the diagonal method and the trials occurred within 2-3 hours from collection; 30 repetitions were carried out. The surface of the sheared section of each stump was measured and the ratio between the cortex and the nucleus surfaces was determined (VISJOM, 1972). The measurement scheme is shown in Figure 1.

Results and Discussion

Significant differences were found calculating the section surfaces and the ratio K ($p < 5\%$) in the various combinations of the experimental variables, being bigger in both cases when the cutting occurred with an inclination of 60° compared with most other cases. The ratio K was significantly bigger for the stumps with higher section surface (F1 + F2). Significant differences also appeared in the specific energy necessary for cutting. Higher values were measured when using the serrated knife with trapezoid section and edge angle of 28°.

When testing the 4 mm thick knives with two side smooth cutting edge the smaller values of specific energy were obtained when cutting with an inclination of 90° with respect to the stump axis. Changing this inclination to 60° caused a significant increment of the energy need, differently from what happens with the knifes with one side cutting edge (Pérez de Corcho et al., 2005)

In the trials done using knives with smooth edge sharpened on only one side the results were significantly different in terms of specific energy. For the knives of 5 mm of thickness the energy needed for cutting grew when augmenting the angle of the edge from 20° to 28° while in the case of knifes with angle of 20° the specific energy increased when varying the thickness from 5 to 10 mm. Increasing the angle of the edge and the thickness of the knifes produces a significant increment of the values of specific energy, due to a major distortion of the fibers in the section. The scheme and the results of the trials are detailed in Table 1.

$$F_1 = \frac{\pi \cdot d_1^2}{4}$$

$$F_2 = \frac{\pi \cdot (d_2 - d_1)^2}{4}$$

$$K = \frac{F_1}{F_2}$$

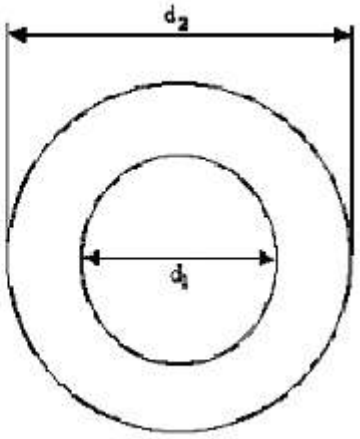

Figure 1. Measurement scheme for the sheared surfaces in the section of a pineapple stump; F1 = surface of the nucleus, F2 = surface of the cortex (when the cutting was done with the inclination of 60° with respect to the stump axis, the surfaces F1 and F2 were considered elliptical).

Table 1. Scheme and results of the impact cutting trials.

Knife characteristics				Cutting parameters		Cutting section surface (mm^2)			K ratio			Specific energy ($mJ\ mm^{-2}$)		
s	**e**	**t**	**a**	**i**	**v**	Avg.	stat. error	c.v., (%)	Avg.	stat. error	c.v. (%)	Avg.	stat. error	c.v. (%)
A	2	4	28	90	15.60	2680.51ab	88.59	18.10	2.10 a	0.04	11.55	27.07ex	1.23	24.90
A	1	4	28	90	15.61	2606.78ab	112.31	23.60	2.15a	0.06	15.42	10.78ax	0.43	22.02
A	1	4	28	70	15.61	2880.72bx	149.07	28.34	2.02 a	0.12	33.59	15.55bx	1.08	38.02
A	1	4	28	60	15.61	3459.47cx	166.43	26.35	2.55 b	0.08	16.84	21.27cd	0.85	21.99
B	1	5	28	90	15.33	2637.29ab	72.51	15.06	2.16 a	0.04	10.05	29.96ex	2.26	41.33
B	1	5	20	90	15.40	2438.94ax	77.50	17.40	2.05 a	0.04	11.67	19.37cx	0.91	25.62
B	1	10	20	90	14.93	2646.76ab	84.28	17.44	2.17 a	0.04	11.11	22.61dx	1.12	27.23

s = section (A = pentagonal, B = trapezoid); **e** = edge (1 = smooth, 2 = serrated); **t** = thickness (mm); **a** = edge angle (°); **i** = inclination (°); **v** = velocity ($m\ s^{-1}$); Avg. = average; c.v. = coefficient of variation, %.
Numbers followed by different letters indicate significant differences, $P < 0.05$.

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News from Egypt

The Effect of Planting Dates , Size of Plant Materials and Water Stress on Vegetative Growth, Yield and Fruit Quality of Pineapple

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Abstract

A study was carried out to determine the effect of four different planting dates (April, June, August and October), three sizes of planting materials (suckers length range, 25, 40, 55 cm. and weight 100, 200, 300 g) respectively and four different water stress treatments (nonsalinized control, Ecw 4.5dS. m^{-1}, Ecw 9 dS. m^{-1} and drought which received tap water every 15 days) on the vegetative growth, yield, and fruit quality of pineapple (*Ananas comosus* L. Merr.) Cv. Smooth Cayenne grown in the greenhouse. The experimental area was located at Pellpeace Horticultural Research Station, Agriculture Research Center, El Sharkia Governorate , Egypt, from April 2002 to Oct., 2004. Plant height and leaf dimensions (length, dry weight and area) were recorded every six months, while total yield, fruit characteristics (fresh weight, diameter, TSS, soluble sugar, Acidity) and ion uptake concentrated in leaves were analyzed at harvest. Results of the experiment showed that mean leaf dry weight per plant was greatest for the June planting and decreased in all plantings with decreasing the size of planting materials. The fruit weight was unaffected by planting dates. The mean fruit weight harvested from the lightest weight of planting materials was 1.30 kg whereas those harvested from the heaviest treatment weighed 1.56 kg, an increase of about 20%. Fruit quality was not affected by the size of planting materials. Neither salinity irrigation with 4.5dS. m^{-1} nor drought treatments had any effect on the fruit quality, except for the highest level of salinity at 9 dS. m^{-1}.◆

News from Italy

New Possibilities for Field Clearing in Pineapple Cultivation

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Elimination of pineapple plants after last harvest can be done with various machinery, (mowers, mulchers, shredders, tillers ...) but the results are often not satisfactory in terms of work quality, efficiency, timeliness and costs, due mainly to the fact that none of these machines was specifically designed for this purpose. The authors analysis of the performances of horizontal axle flail mowers has convinced us to consider the possibility of using vertical-axle multilayer mowers to improve this process.

Presently the action of a pair of vertical-axle rotors, each one bearing 12 layers of 3 knives each, is being evaluated. The rotors were built in the DIAF workshop with the support of an Italian manufacturer of agricultural equipment, particularly specializing in shredders and rotary tillers. This manufacturer has expressed interest in transforming this prototype into a commercial machine. The two rotors with their knives cover a cross sectional area 1 m wide by 0.65 m high and rotate at a velocity between 1,000 and 1,500 r.p.m. The knives are of the kind used in harvesters and small choppers for straw and plant residues.

The prototype was tested in the workshop with various plant materials including plants of *Agave americana L.*, whose leaves are shaped like those of pineapple, have a high fiber content, but are longer and thick and succulent. They also do not grow around a well developed central stump.

The parameters that have been considered are rotor velocity, the direction of rotation, the inclination of the rotors, the distance between them, the kind and number of knives, whether they are free or fixed on the rotors, and the distance between the layers. System performance was evaluated mainly in terms of particle size and the directions in which they were projected.

At this stage the results are very encouraging in terms of the quality of the chopping and the low energy consumption. After the first trials some improvements are being made on the prototype and soon a second set of trials will be done in the workshop using pineapple plants. After any further modifications that might be needed, the prototype will be tested "on field" in pineapple plantations.

For this last stage of testing the authors would like to involve some pineapple farm willing to contribute to the development of this machine by offering some logistical assistance as well as providing plants ready to be shredded.

The aim of the whole work is to gain enough information to construct a machine driven by a tractor of 70-90 kW, based on two or three pairs of rotors capable of chopping two or three lanes of pineapple plants at a speed of at least 3 m s^{-1}.

Figure 1 (top) Prototype being tested on an Agave plant.
Figure 2. Residue size after chopping.

News from Pakistan

Pineapple Propagation: Pakistan's New Venture

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Introduction

Pineapples (Ananas comosos (L.) Merr.) are considered to be an exotic dessert fruit in Pakistan mainly due to its high sugar content and attractive flavor; additionally it contains vitamins A and C. Presently pineapples are being imported into the country as fresh fruits, canned chunks or slices. Pineapples are propagated by vegetatively from suckers and slips. Crowns are also being used

with varying degrees of success. In Pakistan, there is a great need to multiply and expand plantings of this valuable crop. Pineapples can be grown by intercropping with coconuts or bananas, thus making the production highly feasible for local farmers. For commercial cultivation, good quality planting material in large quantity is required. Tissue culture is a feasible option for propagating pineapples here in Pakistan and an efficient and economical micropropagation protocol for the large scale propagation of pineapples was developed in our laboratory.

Materials and Methods

The medium used in this study consisted of full and half strength MS basal salts, (Murashige & Skoog, 1962). Sucrose was added as the sole carbon source at 3% (w/v) and the pH of the medium was adjusted to give a final value range of 5.6-5.8. The media was then sterilized by autoclaving at 15 psi and 121ºC for 20 minutes. The medium was cooled and allowed to set before being used.

Pineapple crowns of young 'Smooth Cayenne' fruits obtained from the nursery of the HEJ Research Institute of Chemistry, University of Karachi were taken as the source of explants. The crown leaves were gently peeled off to expose the axillary buds. The crown stem was thoroughly washed under running tap water for 30-40 minutes. The axillary buds were gently removed from the crown and placed in a 250 ml sterile jar containing sterile distilled water with 2-3 drops of Tween 20. The buds (explants) were washed at slow speed on a gyratory shaker for 15 minutes, dipped in 70% ethanol for 5 seconds, and further washed in 20% NaOCl containing 3 drops of Tween 20 on the gyratory shaker for 30 minutes. This was followed by three consecutive rinsings in sterile distilled water for five minutes each to remove traces of NaOCl. An alternative explant sterilization procedure was to soak them in 0.1% Mercuric chloride for 3-4 minutes followed by rinsing the explants thoroughly in sterile distilled water for 5 minutes to remove traces of mercuric chloride. All sterilization work was done under laminar flow cabinets in sterile environment. The axillary buds were used as explants for shoot initiation under in vitro conditions. For the multiplication experiments, the explants were subjected to different concentration and combination of benzylaminopurine (BAP) and naphthaleneacetic acid (NAA) (Table 1) on full and half-strength MS with 20 replications. Each explant represents a single replication. Cultures were maintained in a growth room at 24 ± 2 ºC under cool white florescent lights in a 16h photoperiod. Average number of shoots per explant and increase in shoot length (mm) were recorded at 7-day intervals for 6 weeks. When newly initiated adventitious shoots reached a length of >70mm they were cut off and transferred to root initiating media. Callus formed, if any, was cut off from the shoot using a sterile scalpel before transfer. The number and length of new shoots and roots per plant were recorded. Rooting was induced by adding 0.25, 0.50, 1.00, or 1.50 mg L^{-1} of indolebutyric acid (IBA) or NAA to half-strength MS medium with 20 replications per growth regulator and concentration. Cultures were incubated as described above. Total number of roots were counted and increase in root length (mm) for each replication was measured at 7-day intervals for 6 weeks and the average was calculated. When a considerable network of adventitious roots had been established the plants were transferred to the green house for acclimatization.

Plantlets with roots ranging from 20-40mm in length were removed from culture, gently washed in luke-warm distilled water to remove any residual gel or medium from the roots, and planted in 250 mm plastic pots in one of the mediums described below and transferred to the green house. Plantlets were potted in: (i) sand, (ii) wood charcoal (charcoal), (iii) cow dung (dung), (iv) sand + dung (50:50), (v) sand + charcoal (50:50), (vi) dung + charcoal (50:50), or (vii) equal parts dung, charcoal and sand. The sand employed was previously washed in 1 M HCl to adjust the pH to 5.5 from an original soil pH of 8.5. The humidity in the green house was approximately 80%. Data were recorded on number of shoots per initiated bus and length of shoots) to determine which type of medium was optimum for acclimatisation. Over 4 weeks, plants were gradually shifted from full shade into semi-shade to harden them.

All experiments were of completely randomized design and repeated at least twice. Each treatment consisted of 80 explants (four explants per 250 ml jar). Shoot and root numbers were subjected to square root transformation prior to statistical analysis. The number and length of both roots and shoots were also presented as mean values with a standard error. Data was analyzed employing SPSS version 4.0 (Scientific Enterprises, USA).

Results and Discussion

The number of adventitious shoots per explant and shoot size increased greatly during the approximately 20-day culture period (Figure 1). The increase in shoot number and shoot length was approximately the same in both full and half-strength MS media. The number of shoots per explant increased as the concentration of BAP increased up to about 0.5 mg L^{-1}, while levels beyond that reduced shoot number (Table 1, Figure 2).

When NAA was used with BAP, an increase in shoot length was observed at BAP levels of 0.5 and 1.0 mg L^{-1}. Multiple shoots appeared as tiny crowns (1-2mm) amongst longer shoots. These tiny crowns, when transferred to fresh medium continued to produce secondary crowns. Therefore, a cyclic production of shoots was possible, leading to continuous cultures and the production of large numbers of shoots. Shoots produced in full-strength MS showed relatively better results. When the shoots were transferred into rooting media, thick networks of roots were establish within three weeks.

Figures. 1. Two weeks after cultures were subjected to subculture. 2. Shoot elongation 4 weeks after plants were cultured in MS media containing 5 mg L^{-1} benzylaminopurine. 3. Profuse rooting after culturing in media containing 1 mg L^{-1} indolebutyric acid. 4. Plants thriving in the greenhouse.

Table 1: Effect of benzylaminopurine (BAP) alone or in combination with naphthaleneacetic acid (NAA) on shoot proliferation after six weeks on full and half strength MS medium.

Media	BAP (mg L^{-1})	NAA (mg L^{-1})	No. of shoots per bud explant MS	1/2MS	Length of shoots (mm) MS	1/2MS
M1	0	0	1.85 ± 0.58	1.65 ± 1.04	77 ± 27.99	74 ± 16.98
M2	0.25	0	2.85 ± 0.60	1.85 ± 1.50	78 ± 25.69	70 ± 11.47
M3	0.50	0	2.95 ± 0.22	2.50 ± 1.14	80 ±52.31	81 ± 23.40
M4	1.00	0	2.25 ± 0.86	2.15 ± 0.59	88 ± 37.40	86 ± 24.71
M5	1.50	0	1.95 ± 0.22	1.75 ± 0.86	84 ± 23.86	80 ± 25.23
M6	0	0.001	1.45 ± 1.13	1.05.± 0.21	80 ± 64.69	76 ± 14.91
M7	0.25	0.001	2.89 ± 0.59	2.65.± 1.04	84 ± 16.05	77 ± 10.09
M8	0.50	0.001	3.85 ± 0.58	3.15.± 0.59	95 ± 29.36	82 ± 58.49
M9	1.00	0.001	2.40 ± 1.10	2.20.± 0.73	90 ± 67.92	81 ± 17.19
M10	1.50.	0.001	2.15 ± 1.50	1.80.± 0.73	85 ± 39.01	76 ± 10.50

Means are for 20 explants ± SE for each treatment.

Similarly in the rooting experiments, where several concentrations of IBA and NAA were employed, the greatest average number of roots obtained was 5.00 in a media containing 1.0 mg L^{-1} of IBA (Table 2, Figure 3). The optimum concentration of NAA was also 1.0 mg L^{-1} but the rooting percentage and the average root length was reduced relative rooting performance in the presence of IBA. These results are in contrast to the finding by Devi et al (1997) of good rooting on MS medium supplemented with 9.84 µM IBA (1.99 mg L^{-1}). Mathew & Rengan (1981) reported that the media has to be supplemented with activated charcoal for the induction of rooting. In contrast to their findings, our study indicates that all the plantlets could be rooted without addition of activated charcoal in the medium and could be successfully established in soil. The difference may be due to differences in cultivars genetic material.

Table 2. Effect of indolebutyric acid (IBA) and napthtaleneacetic acid (NAA) on adventitious root formation in vitro in *Ananas comosos* microcuttings cultured for 6 weeks at 25 °C under a 16 h photoperiod.

Auxin	Conc. (mg L^{-1})	Rooting (%)	Roots per shoot	Avg root length (cm)	Days of emergence
IBA	0.25	85	1.20 ± 0.73	1.43 ± 0.2	15-20
	0.5	88	2.45 ± 2.5	1.03 ± 0.3	10-15
	1.0	100	5.00 ± 1.78	3.43 ± 0.26	8-12
	1.5	90	4.0 ± 1.80	2.02 ± 0.40	7-10
NAA	0.25	95	1.20 ± 0.58	1.0 ± 0.20	10-15
	0.5	100	1.51 ± 2.05	1.3 ± 0.17	10-15
	1.0	86	3.55 ± 2.51	2.3 ± 0.10	8-15
	1.5	80	2.15 ± 0.58	1.7 ± 0.13	7-12

Means are for 20 explants ± SE for each treatment.

Survival of plantlets with sterile roots in the greenhouse was almost 100% and plants exposed to the open environment grew rapidly. The pH of the media played a major role in plant physiology. When plants were grown in basic soil types, severe chlorosis was observed; in such media the pH was adjusted to pH 5.5. Addition of organic fertilizers strongly attracted insects, which feed on the fragile leaves, so fertilizers were excluded from the soil medium. When charcoal was added in combination with sand, plant growth was stunted. In a series of experiments, it was found that an ideal soil type was one containing sand, charcoal and dung in equal proportions with a fine sprinkle of garden sand soil on the surface of the pot in order to avoid exposure to fertilizer. Thus, an efficient and a viable protocol was established for the mass propagation of pineapples. All 10,000 plants subjected to acclimatization are surviving in the green house (Figure 4) and are ready to be planted in open field conditions.

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News From Taiwan

2004 Pineapple Symposium Held at Chia-yi University

Communicated by: Chin-Ho Lin, Life Science Department, National Chung Hsing University, Taichung, Taiwan

A symposium on"Research and Development of Pineapple in Taiwan" was held on 10 December, 2004 at National Chiayi University. Participants included pineapple researchers, breeders, extension, trades, educators, and growers, who gathered to share their experiences, and new findings on this important crop as well as to seek to advance the position of the industry in the international community.

Symposium program I : forum topics

Registration & opening address by Dr. Min Jen Lee, Vice Chancellor of National Chiayi University.
Present status of pineapple production, marketing and its development in Taiwan.
Investigation of factors that impact pineapple variety genetic marker.
Relationship between pineapple fruit quality and enzyme activities of sugar metabolism.
Application of acoustic impulse response on the quality grading of pineapple fruits.
Feasibility assessment of year round pineapple fruit production in Taiwan.
Impact of heat treatment on the fruit quality of Tainon 13 pineapple.
A survey of pineapple fruit injury during harvest and shipping.
Panel discussion.

Symposium program II : field trip

A field tour was arranged to visit the on going trial at experimental plot of Chiayi agriculture experiment station.

A proceedings of the symposium in Chinese edited by Dr. Tan-Cha Lee, Department of Horticulture Science, National Chiayi University, was published.

Abstracts of Papers Presented at the Symposium

Studies on Plant Characteristic and Genetic Correlation of Pineapple, (Ananas comosus (L.) Merr.)[1]

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Abstract

The genetic similarities among currently available pineapple (*Ananas comosus* (L.) Merr.) clones and cultivars in Taiwan were investigated using RAPD Analysis. The possibility of identifying a reliable marker for the selection of hybridized seedlings was also investigated. The results of RAPD Analysis indicated that bands of DNA obtained from the clones and cultivars were almost identical. In a separate experiment, RAPD Analysis was applied to test 11 cultvars with the same primer. The results showed that separate bands could be classified into several clusters. This proves that RAPD can be adopted to identify different cultivars of pineapple. RAPD analysis on the 2,000 bp position of OP P10 primer revealed that cv. TN20 had lost a distinct band. The finding was taken to mean that loss of the band resulted in the gene expression of piping leaf characteristic of this cultivar.

[1]This paper is a part of the first author's PhD thesis.

Relationship Between Pineapple Fruit Quality and Sugar Metabolizing Enzyme Activity

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Abstract

Pineapple (*Ananas comosus* L. Merr.) fruit flesh accumulated soluble sugars (mainly sucrose) rapidly, in parallel with an increase in cell-wall invertase activity, during the late stage of fruit development. The data collected from the analysis of mature fruit of the main cultivars grown in Taiwan showed that there were significant correlations between sucrose synthase activity and some fruit characteristics, including fresh weight, total soluble sugars, sucrose content, total soluble solids (TSS) and titratable acids (TA). The results suggested that the sucrose synthase activity in mature fruit flesh might be one of the important factors in regulating pineapple fruit quality. Where fruit of various cultivars were grown in the same field, there was a significantly negative correlation between fruit size and flesh TSS and TA among cultivars. However, the same correlation was not found when the fruit of various cultivars were harvested from different fields from different areas, suggesting that environmental factors had significantly greater impact on pineapple fruit size, flesh TSS and TA than did genetic factors.

Grading Pineapple Quality by Impulse Excitation Response

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Abstract

Traditional farmers in Taiwan always use a finger or a soft plastic rod to tap pineapple. The sound response provides an estimate of quality without damaging the fruits. Generally the sound response divides pineapple fruits into three categories, solid-pulp-sound, drum-sound, and disease-sound pineapple. Traditional farmers with many years of experience can successfully judge the quality of pineapple by this method. The purpose of this study was to develop an automatic method to judge pineapple internal quality and effectively to apply this method in the development of an automatic grading system of pineapple quality. In following the traditional striking method, the first issue is to design the appropriate striking mechanism. Then the impulse excitation method was used by an accelerometer to acquire the acoustic signal when the pineapple was struck. The signal was analyzed with "Matlab" formula and the signal process methods, included the Logarithmic Decrement value of time domain, the main peak frequency of frequency domain after "FFT", the analysis of signal with wavelet transfer method for the disease-sound pineapple. The pineapple density and the modulus of elasticity was obtained in this study to try to find the index of detecting pineapple quality. Finally the "Matlab/GUI" was used to design a monitor-control panel which is able to tell the pineapple quality automatically. From the experimental result, the main peak frequency of solid-pulp-sound and disease-sound pineapples are over 315 Hz, and the drum-sound pineapple is below 315 Hz. The wavelet transforming energy's index is below 3.8 for solid-pulp-sound and drum-sound pineapple, and the disease-sound pineapple is over 3.8. Finally, the main peak frequency of 315 Hz was used as a standard criterion to distinguish between the solid-pulp-sound pineapple and drum-sound pineapple while a wavelet transforming energy index over 3.8 was used as a standard criterion to judge disease-sound pineapple. Using those criteria, additional experiments have shown that the error in judging diseased pineapple by a farmer is 11.8% but only 4.4% by the method described here. It is concluded that the impulse excitation method identifies diseased pineapple fruits better than the traditional farmer.

Studies on Reducing Acidity of Winter Pineapple Fruit[1]

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Summary

The effects of heat treatments after harvest and bagging treatment before harvest on fruit quality were investigated in pineapple (*Ananas comosus* (L.) Merr.) cultivars TN 13 and TN 17. The heat treatment temperatures were 23 ±2°C, 33 ±2°C, 38 ±2°C and 43±2°C. The results indicated that the fruits in higher temperature treatments had a higher respiration rate, more ethylene production, more weight loss, and a higher total soluble solids/titratable acidity (TSS/TA) ratio. After 72-hours of treatment at 23°C, the weight loss from fruits of 'TN 13' was 2.3% while the loss from 'TN 17' fruits was 1.7 %; losses at 43°C were, respectively, 8.0 and 7.5%. Heat treatment also decreased chlorophyll, TA, and citric and malic acid contents of pineapple fruits. However they had no significant effect on the fruit flesh color, TSS or fruit glucose and sorbitol contents. When pineapple fruit were bagged before harvest to increase fruit surface temperature, the treatment increased fruit TSS about 0.9 °Brix and also decreased TA about 0.05%. The results showed of heat treatment after harvest or bagging before harvest could decrease TA and improve fruit flavor in the winter season.

[1]This paper is a part is MS thesis of the first author.

The Investigation of the Injury to the Pineapple Fruits During Picking and the Process of Centralizing Fruits[1]

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Abstract

When pineapple fruits fell from 70cm above the floor, 36.5% of fruits had visible injury. Fruits that fell from 35cm above the floor had no immediate visible signs of injury. However, after 4 days of simulated shelf storage, the flesh was injured and deterioration was visible. When we centralized the fruits by hand harvesting into containers on the backs of workers, fruits had no visible signs of injury. There was 30% visible injury of fruits moved by truck to the central collection area, 19.6% when moved by wheelbarrow (put the fruits in horizontal vertical type) and 11.9% when moved by tracked vehicle. Hand harvesting into containers on the backs of workers, relative to other methods, reduced fruit injury to an obvious degree. The degree of injury between the fruits from different planters was different, too. For example, 13.8% fruits in Chai-yi experimental area were injured during collection on the farms. But visible signs of fruit injury were different between Chai-yi and the Tainan and Pingtung experimental areas. The percentage of injured fruits sent from the experimental areas to the centralizing market were Chai-yi, 12.5%, from Tainan, 1.7% and from Pingtung, 0.4%. When we packed and shipped the fruits to the Sanchong market, the percentage of injured fruits from the three experimental areas referred to above were, respectively, 58.3%, 1.7% and 2.8%. The results showed that the greater the height of a drop to a flat surface, the more serious the fruit injury. When fruits were hand harvested and collected by workers, fruit injury was reduced relative to other methods of fruit collection. When the fruits from different planters were handled by different people and were stored and carried in the same process, the percentage of injured fruits was different.

1.The study was supported by the Agriculture and Food Agency council of Agriculture , Executive Yuan , ROC, (92AS-1.1.2-FD-Z1¤Î93AS-1.1.2-FD-Z1). This paper is a part is MS thesis of the first author.◆

News From the United States (Hawaii)

Pineapple Fruit Organic Acid Accumulation and Metabolism During Growth and Development

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Low acid pineapple cultivars are more desired for the fresh fruit market than the high acid cultivars, however, our understanding of difference in organic acid accumulation and metabolism between these pineapple lines is limited. The accumulation of citrate and malate and the enzymes involved in their metabolism during fruit growth and development were investigated in '3621' and

'Monte Cristo', high and low acid cultivars, respectively. Fruits were sampled from the eleven week before to the one week after commercial harvest. Developmental changes in fruit citrate were the key organic acid whose changes correlated with fruit juice titratable acidity. During early growth, the low acid cultivar accumulated significantly more citrate than the high acid cultivar. Two weeks before commercial harvest, the citrate content in the low acid cultivar declined while the content in the high acid cultivar remained high. Fruit malate in the low acid cultivar was slightly higher than in the high acid cultivar and the changes were similar pattern in both cultivars. The in vitro citrate synthase (EC 4.1.3.7) and aconitase (EC 4.2.1.3) had similar patterns of activity in both cultivars during fruit growth though they differed in activity level. Phosphoenolpyruvate carboxylase (EC 4.1.1.31), NAD-malate dehydrogenase (EC 1.1.1.37) and NADP-malic enzyme (EC 1.1.1.40) were slightly different in both cultivars during development. The data suggest that the activities of the citrate synthase and aconitase appear to play a role in organic acid accumulation during the late stage of pineapple fruit development.

Perspectives on a Pesky Pest of Pineapple; The Biology and Management of Opogona sacchari Bojer (Tineidae)

By Adam E. Vorsino and Mark G. Wright. Department of Plant and Environmental Protection Sciences, University of Hawaii at Manoa

Pineapple remains Hawaii's largest agricultural resource, with a market value in 2004 worth $79.9 million. The banana bud moth (*Opogona sacchari*) is infesting both the planting material and fruit of pineapple in Hawaii, resulting in yield reduction and posing phytosanitary risks. Estimates of damage to pineapple crops by *O. sacchari* are ~15%, but may reach extreme levels of almost 60% in some cases. Current control depends on the use of diazinon as a pre and post-planting treatment. However, diazinon is being removed from the market owing to FQPA requirements. This research focuses on management techniques essential for the economic and environmentally sound control of these new pineapple pests. The biology of the pest on pineapple is summarized and management techniques are proposed resulting from statistically significant ($P < 0.05$) edge effect patterns within fields, varietal preference and planting material preference field experiments. Natural enemy populations were also assessed for predators, parasitoids and entomopathogenic nematodes, fungi and bacteria. Of 300 larvae raised in the laboratory no possible biological control agents were found. Under field conditions only spiders were found to be associated with *O. sacchari* presence, and appear to have limited impact on their abundance.

Hawaii Pineapples - 2004 Production Takes a Sharp Drop

D.P. Bartholomew based on data from Hawaii Pineapples. Annual Summary. Hawaii Agricultural Statistics, Hawaii Dept. of Agriculture and U.S. Dept. of Agriculture, 1428 S. King St., Honolulu, HI 96814

Hawaii Agricultural Statistics (http://www.nass.usda.gov/hi/stats/t_of_c.htm) statistical information on pineapple for 2004 shows both acreage and production dropped sharply from 2003, continuing a downward trend that began in 2001 (Table 1). Prior to 2001, area in production and total fruit tonnage had been relatively steady for a decade or so. The decline in area planted to pineapples was due a shift from 'Smooth Cayenne', which has all but disappeared from the island of Oahu, to low-acid hybrids. The low-acid hybrids have commanded a premium price in the market due to their greater consumer acceptance, primarily because they have lower acidity and higher total soluble solids content relative to 'Smooth Cayenne'. The difference in acidity is particularly evident during Hawaii's winter months and according to data collected by the US Department of Agriculture, the low-acid hybrids have a 1.0 to 2.0% greater total soluble solids content than does 'Smooth Cayenne'. Some 'Smooth Cayenne' is still being grown on Maui to supply the cannery of Maui Pineapple Company but even that company has announced plans to place greater emphasis on fresh fruit production. On all plantations, the low-acid hybrids are being planted at lower elevations where air temperatures are slightly warmer. That should help to reduce the incidence of natural induction of flowering during the winter months.

The number of farms growing pineapple actually increased from 15 in 2001 to 25 in 2002. No information is available about these additional farms. However, with three major plantations, Del Monte Fresh Produce Hawaii, Dole Fresh Fruit, and Maui Pineapple Company, comprising the majority of pineapple production in the state, the number likely includes small family farms or families who have multiple sources of income, some of which would come from the production of pineapple for the local fresh fruit markets.

Table 1. Pineapple farms, acreage, production, disposition and value.

Year	Farms	Acreage in crop	Production	Disposition		Farm Price		Value
				Processed	Fresh	Processed	Fresh	
			----------1,000 tons----------			--Dollars per ton--		
2000	15	20,700	354	232	122	130	585	101,530,000
2001	15	20,100	323	213	110	129	626	96,337,000
2002	25	19,100	320	203	117	136	624	100,616,000
2003	25	16,000	300	170	130	135	604	101,470,000
2004	25	13,000	215	116	99	148	634	79,934,000

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Abstracts of the 5th International Pineapple Symposium

Delaying Natural Flowering in Pineapple

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Natural induction of flowering of pineapple (NI) is an important problem for growers, especially where cultivars of high sensitivity are grown at subtropical latitudes, e.g. Taiwan (22°-26°N lat.). Aviglycine, an inhibitor of ethylene biosynthesis, was applied as a foliar spray to evaluate its potential to prevent NI in one-year-old pineapple. In the 2001/2002 season, 100 ppm of aviglycine applied on Nov. 9 and Dec. 1 had no effect on NI of 'Tainon 18' while 500 ppm aviglycine reduced it from 95.0% in the control to 51.3% on Feb. 25, 2002. In the 2002/2003 season, 500 ppm of aviglycine was applied on Nov. 10 and Dec. 1 and 20, 2002. On Mar. 28, 2003, there was 95.8% NI in the control, 64.6% at 250 and 375 ppm aviglycine, and 50% at 500 ppm For the 2003/2004 season, 'Tainon 17' was treated at 10, 15, or 20 day intervals with 500 ppm aviglycine between Nov. 10 and Dec. 25, 2003. On March 30, 2004, there was 82.5% NI in the control, 6.6% for the 10-day application interval (five applications), 18.3% for the 15-day interval (four applications), and 19.1% for the 20-day interval (three applications). Aviglycine provided good control of NI of pineapple for nearly three months after the last treatment was applied.

Inhibition of the Flowering Pineapple MD-2 cv Using Fruitone CPA at Different Rates and Application Dates

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In order to inhibit the natural flowering of the pineapple cultivar MD 2, different doses and times for application of Fruitone CPA (2-3 clorofenoxipropinic acid) were evaluated. The experiment was carried out in Veracruz, Mexico, in a AWo weather, at 18° 58' North Latitude and 50 meters over the sea level. The experimental design was random blocks (split plot) with four replicates. The big plot was counted as the "starting date for the application": October 30, November 6, November 13, November 20, November 27, and November 4. In the small plots, the treatments were: control, two, three, four, five and six applications which were poured over every week at a concentration of 20 mg L^{-1} of active ingredient. Each plant received 50 mL of the solution. Planting density was 60,000 plants ha^{-1}. Highly significant effect on floral inhibition was only observed on October 30 and November 6. The best results in October were reached with four, five, and six applications with percentages of floral inhibition of 94%, 86%, and 91% respectively. On November 6, the best treatments were three, four, five, and six applications with 92%, 96%, 96%, and 92% of floral inhibition respectively. It is concluded that the best results for inhibit the natural flowering of the cultivar MD 2, were reached around the end of October and early November, using four applications. It is not recommendable to initiate the applications after November 13.

Conventional and Organic Fertilization in 'Perola' Pineapple-1. Growth Response in a Degraded Soil of the Brazilian Coastal Table Lands

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A large demand for organic pineapples in Brazil contrasts with an insignificant offering. The development of organic cultivation systems is a major challenge, especially for a crop with high nutrient requirements. This work presents the effects of inorganic and organic fertilization on the vegetative performance of 'Perola' pineapple plants grown in a degraded yellow latosol typical for the ecosystem of the Brazilian Coastal Table Lands. Two identical experiments were carried out on soils treated, respectively, with limestone and the soil improver MB4 (Mibasa, Alagoas, Brazil). Four fertilization treatments were compared using a randomized block design with six replications. The treatments were: control, inorganic (urea, simple superphosphate, potassium chloride), organic (ricinus seed cake and cow urine) and natural (Bokashi cake and "efficient microorganism - EM4" in water). Plant growth was evaluated based on 'D' leaf weights and dimensions and emergence of new leaves. The soil's population of microorganisms,

respiration, carbon contents in the microbial biomass and the enzymatic activity were also determined. Plant growth in the inorganic treatment was superior to the control, whereas the organic and natural treatments resulted in intermediate growth. Limestone soil treatment was superior to MB4 amendment. The organic fertilization favored the soil microbial population. Project sponsored by the Northeast Brazil Bank (BNB/ETENE/FUNDECI)

Determination of Anthocyanin Biosynthesis in the CIRAD Pineapple Hybrid Flhoran 41

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FLHORAN 41 is a red pineapple hybrid from CIRAD. Shell anthocyanins appear to be synthesized relatively early during the green stage and clearly, before ripening. Green fruits develop a depp reddish colour after 3 to 5 weeks in cold storage at 13°C. Anthocyanins are synthesized in larger quantity in fruits from higher altitude (350 m) than those from sea level. With multilocal experimentation we determined that a minimum sum of temperature of 300 hours under 25°C between forcing an dharvest is required to get most of the fruits showing the nice deep red colour.

Aspects of Calcium Nutrition to Limit Plant Physiological Disorders

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Problems with Calcium (Ca) nutrition are often first noticed as disorders within rapidly developing, low transpiring plant organs. More severe Ca deficiencies will be noticed in other plant organs and growth parameters as well. In order to prevent these disorders, such as blossom end rot (BER) in tomatoes, peppers and melons, tip burn in lettuce, bitter pit in apples, internal browning (IB) in pineapples, twins in pineapples, internal brown fleck in potatoes and many other Ca related disorders, it is important to understand the functions as well as all the conditions that may affect the uptake and translocation of Ca within the plant. Since Ca is needed to strengthen cell walls and to maintain membrane integrity, Ca deficiencies lead to the collapse of cells, resulting in tissue enzymatic browning, caused by polyphenol oxidase and peroxidase enzymes, as well as tissue susceptibility to secondary infections, such as Phytophthora spp, Erwinia spp and Botrytis spp. Leaky membranes may also lead to chlorophyll losses or water soaked areas. Since Ca ions are passively taken up by the roots with water and transported in the xylem with the transpiration stream, any factor affecting the uptake of water, such as climatic conditions, root functioning, salinity and so on, will affect the uptake of Ca. Several conditions may enhance the development of Ca related disorders and may be grouped as: 1) Insufficient Ca uptake by the plant due to inadequate root zone moisture, low available soil Ca and cation imbalances in the soil or fertigation solution, poor root growth and saline root zones; 2) Inadequate Ca distribution to low transpiring, rapidly developing plant organs due to poor xylem development, high transpiration rates in leaf canopies and low night time root pressures; 3) Intraplant factors such as strong carbohydrate sinks, high growth rates and auxin and enzyme activities; and 4) Varietal differences. Some practical aspects of Ca nutrition, with special reference to pineapple, are also discussed.

Benchmarks for Organic Pineapple Production in Latin America

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The rapid growth of organic markets, as well as the higher prices paid, have attracted the attention of many Latin American companies, who have adopted organic standards to explore new niches. This situation has led the Sustainable Markets Intelligence Center (CIMS) to contact all Latin American companies known to grow organic pineapple or in transition to meet organic standards and analyse the current supply situation and trends. With a 90% response, CIMS estimates that approximately 150 certified organic pineapple producers, mostly in Honduras and Costa Rica, have planted 700 ha and harvested 45,600 tons of fresh fruit during 2004. Crop yields averaged of 65 tons/ha with a range of 20 to 82. Around 15% of the production is sold for fresh consumption and 85% is processed, mostly as concentrate or dehydrated. The United States appears as the main market receiving 55% of the fruit exported. In the medium term, a major increase in Latin American supply is expected. This will come from the companies in transition process, which includes 140 producers, 235 hectares and an annual production of 10,300 tons. Costa Rica will become an important leader of the organic industry.

Soil Conservation in Pineapple Plantations

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Soil erosion due to rainfall on newly established pineapple plantations was a major problem in the Eastern Cape, South Africa,

during the 1980's when the industry was expanding into new areas. Erosion on these farms was washing away valuable topsoil and silting up dams, rivers and estuaries. The existing Soil Conservation Act was inadequate to deal with this problem. Officers of the Technical Support Services, together with soil classification experts were instructed to draw up guidelines for the cultivation of agricultural land, and these were to be used to assist with the implementation of the act. Initially, soil surveys were conducted on all existing lands, and those proposed for cultivation. Various methods were developed (a) to determine soil loss for different soil types and slopes, and (b) to measure rainwater runoff from the lands. These included silt traps between planting ridges and collection drums at ridge ends; soil loss was determined from the silt collected. For these studies, a rainfall simulator was developed, by means of which water was applied to standardised field plots at controlled intensities. Based on the results of these studies, guidelines for the prevention of excessive soil loss were formulated and made available to all farmers. By applying these guidelines the Soil Conservation Act was successfully enforced resulting in the reduction of soil erosion on all cultivated land.

Lime, Gypsum, and Basaltic Dust Effects on the Calcium Nutrition and Fruit Quality of Pineapple

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Pineapples grown in acid soils containing high levels of manganese (Mn) can exhibit iron deficiency because Mn interferes with iron bio-functioning. This situation is corrected in Hawaii with regular iron sprays. Soil Mn concentration can be reduced by liming, but a soil pH above about 5.5 can increase the incidence of heart and root rots caused by Phytophthora sp. This study was conducted in Hawaii on an acid soil high in Mn to evaluate the effects of calcium source (lime, gypsum, and basaltic dust, a quarry by-product), on soil pH, plant iron utilization, and plant calcium nutrition of a low-acid hybrid pineapple. The effects of calcium source and amount on fruit translucency, acidity and sugars were also examined. Without iron sprays, no calcium source prevented severe iron deficiency in this acid soil. When pineapple was sprayed with iron, all calcium sources increased calcium levels in the soil and in D-leaf and fruit tissues. Basal-white leaf calcium in the treatments ranged from 0.19 to 0.55% and all levels were at or above those considered adequate; green tissue levels ranged from 0.11 to 0.20%. There were no significant effects of treatments on plant growth, fruit weight, fruit size distribution or most indices of fruit quality. Further analysis showed that the fruit translucency index (TI) decreased as the amount of calcium applied was increased and 64% of the decrease in TI was accounted for by applied calcium. There was also a significant negative correlation between TI and extractable soil calcium, basal white and green D-leaf calcium, and fruit calcium. Lime can raise soil pH to levels that can increase the incidence of root and heart rot while gypsum and basaltic dust will supply calcium without increasing soil pH. Basaltic dust could provide calcium as well as other nutrients in organic farming.

Some Thoughts on Conservation Agriculture and its utilisation by Pineapple Producers

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Conservation Agriculture incorporates all crop production systems which involve minimal soil disturbance, permanent soil cover and multi cropping. Over 70 million hectares of a wide variety of crops on many different soil types and in most climatic conditions are planted internationally using such systems. Benefits which accrue include reduced soil and water loss and more efficient soil water and nutrient usage; reduced weed, insect and disease infestations and consequently agro chemical requirement; reduced cost of production both per hectare and per tonne and as a
result increased profits. Although at first many pineapple producers might believe Conservation Agriculture Systems not to be suited to pineapple production, the first commercial pineapple producers in South Africa and many other parts of the world used very similar systems before the introduction of herbicides. 21st Century producers could, therefore, benefit greatly if they reconsidered their production techniques in the light of Conservation Agriculture principles.

In Vitro Micropropagation and Growth of Ananas comosus Merr. Terminal Buds and Transplant to Topsoil

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Although several pineapple micropropagation protocols have already been published, significant improvements could be achieved if the stages of in vitro culture were better defined. Our work concerned several experiments aiming at the mass production of high quality plantlets and hardening at transfer to soil. Tissue culture experiments were therefore conducted to develop rapid multiplication procedures for *Ananas comosus* L. (merr). Terminal buds from suckers were treated with 0.025 % (w/v) mercuric chloride for 2 minutes and placed in different media. Explants were transferred to MS medium supplemented with IAA (2 mg/L) and BAP (0, 1, 2, 3, 4, 5, 6, 7 mg/L) and kept for 2 4 months under 16 h photoperiod (1.500 Lux) and 28 ± 2°C. Results showed

that higher multiplication rates for *Ananas comosus* were obtained with BAP concentrations of 5 mg/L at 3 months. The in vitro proliferated shoots produced roots with maximum frequency (90%) on MS medium without growth regulators at 6 weeks intervals. All rooted plantlets of *Ananas* were transferred to ex vitro acclimatization and then were successfully established in plastic pots containing garden soil, perlite and compost (2:1:2) with 100% success. Using the protocol described in this work, it is possible to obtain 1 million rooted , plantlets after 12 months from a single bud, with a 45 day subculture interval and a 20 day acclimatization period in greenhouse.

The Pineapple EST Sequencing and Microarray Project

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Pineapple is a tropical fruit crop of significant commercial value. Yet surprisingly little molecular information exists. A nucleotide database search of GenBank yielded only 54 sequence entries for *Ananas comosus* (as of February 2004). As a first step toward understanding the molecular basis of pineapple fruit development and plant-nematode interactions, we have initiated a sequencing project to survey a range of expressed sequences from green unripe fruit, yellow ripened fruit, nematode infected roots, and uninfected root tissue. In total, we have obtained 5681 EST sequences with an average edited read length of 769 bp. All sequenced clones have been annotated and assigned functional classifications. We have compiled a comprehensive database to house the sequence information. The database can be accessed over the internet, and can be searched using text words or Blast searched by sequence homology. Additionally, we have constructed microarrays containing 10000 EST clones from the fruit and root EST libraries. These microarrays are being used to investigate the changes in gene expression that occur during pineapple fruit ripening and the formation of galls during root knot nematode infection. Here we will present the results of the EST sequence analysis, and microarray experiments used to identify key gene expression changes involved in the progression of fruit ripening.

Control of Flowering in Pineapple (Ananas comosus) by Genetic Engineering

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Smooth Cayenne accounts for approximately 70% of the world production of pineapple. Conventional breeding strategies are unsuitable for developing new processing types since Smooth Cayenne is highly heterozygous and exhibits considerable transgressive recombination. Genetic engineering is ideally suited to improve Smooth Cayenne as it allows specific changes to be made to target genes without rearranging the entire genome. Natural flower induction is a major industry problem, usually occurring when shortening days and low temperatures give raise to increased ethylene production in the leaf tissue and plant stem apex which in turn stimulates flowering. Natural flowering fruit matures 4 to 6 weeks ahead of the normal summer harvest resulting in the need for extra harvest passes. Ethylene is produced through the sequential action of ACC synthase and ACC oxidase. Our team has cloned an ACC synthase gene from pineapple, expressed in meristems and activated under the environmental conditions that induce flowering in nature (ACACS1). Genetic constructs have been produced containing ACACS1 in sense orientation to induce silencing of the gene in the plant by co-suppression mechanisms. Transgenic plants have been produced and field trials conducted in Queensland for four years in order to study the characteristics of the transgenic lines. Promoter constructs driving the expression of the GUS gene have also been tested in the field trial. We have identified a number of transgenic lines with promising behavior that seem to have natural flowering inhibited.

Transgene Stability, Expression and Herbicide Tolerance of Genetically Manipulated Pineapple (Ananas comosus) Under Field Conditions

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Pineapple plants transformed with the *bar* gene for bialaphos resistance, were evaluated for gene stability, expression and tolerance to glufosinate ammonium herbicide (Basta^{TM} X) under field conditions. Genetically modified plants of the cultivar 'Phuket', generated by biolistics, were micropropagated, rooted, transferred to the glasshouse and later established in an experimental field plot. Seven months after transfer to the field, plants were tolerant to 1,600 cc/rai of Basta^{TM} X (twice the recommended dose) when sprayed with this herbicide. Such transgenic pineapples retained their photosynthetic pigments and

continued to grow normally following herbicide application. In contrast, non-transformed plants became necrotic and died 21 days after being sprayed with Basta™ X at the recommended dose of 800 cc/rai. *Bar* gene stability and expression in clonally-derived plants were assessed by PCR, Southern analysis and RT-PCR at 120, 210, 240, 270 and 380 days following transfer to the field. At all these times, the *bar* gene was stable and expressed in transgenic plants.

Agrobacterium Mediated Transformation of Pineapple Leaf Bases and Analysis of Transgenic Plants

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Recently, the plant expression vector pMSI168 which contains MSI-99, a substitution analogue of magainin (an antimicrobial peptide), was successfully used to transform tobacco plants which were found to exhibit enhanced resistance against *Sclerotinia sclerotiorum*, *Alternaria alternata* and *Botrytis cinerea*. Banana plants transformed with this vector showed resistance to *Fusarium oxysporum* f.sp. *cubense* and *Mycosphaerella musicola*. Leaf bases of in vitro shoots of pineapple (*Ananas comosus* cv 'Queen') were transformed with Agrobacterium strain EHA 105 harboring the pMSI168 and co-cultivated on growth regulator free MS medium. Post co-cultivation, the leaf bases were transferred to shoot multiplication MS medium containing NAA, IBA and Kinetin and supplemented with Kanamycin 50 mg/L and Cefotaxime 400 mg/L. Six percent of leaf bases produced callus and only 2% produced direct multiple shoots. Shoots were multiplied on medium of the same composition and rooted on liquid White's medium supplemented with NAA and IBA and containing Kanamycin 100 mg/L and Cefotaxime 400 mg/L. Transgenic plants were established first in cups and later in pots in the green house. Total DNA was isolated from 12 hardened plants as well as untransformed plants using a modified CTAB method. PCR analysis was carried out using the upstream primer specific to the secretory signal sequence (P168) and the 3' end primer (P *nos*). The transformed status of the transgenic plants was determined by Southern hybridization of PCR products and reverse transcription (RT)-PCR.

Characterization and Control of Pineapple Mealybug Wilt Associated Closteroviruses

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Pineapple mealybug wilt (PMW) is a devastating disease of pineapple worldwide. *Pineapple mealybug wilt associated virus 2* (PMWaV-2) infection and mealybug exposure are involved in the etiology of PMW whereas PMWaV-1 is not a necessary component in PMW but correlates with reduced yields. Degenerate primers derived from conserved sequence regions of the HSAP-70 homolog gene of various closteroviruses were used in RT-PCR assays to identify additional closteroviruses in pineapple. Our results show that PMWaV-3 shares 64%, 73%, and 79% amino acid identity with PMWaV-1 in the RNA dependent RNA polymerase, small hydrophobic protein, and HSP-70 homolog ORFs, respectively. Shared amino acid identity between PMWaV-3 and PMWaV-2 in the same ORFs is 30%, 13%, and 44%. Preliminary data have shown that PMWaV-3 is more closely related to PMWaV-1, whereas PMWaV-4 is more closely related to PMWaV-2. The coat protein gene of PMWaV-2 was constructed as an inverted repeat in the pCAMBIA 1300 vector and used to produce transgenic pineapple plants using particle bombardment and *Agrobacterium*-mediated transformation approaches. Several lines of putatively transgenic pineapple plants resistant to PMWaV-2 infection have been produced. These plants have remained resistant to PMWaV-2 infection after multiple challenges with viruliferous mealybugs and have not developed any MWP symptoms after several months.

Evaluation of Acclimatization Conditions of Phytophthora nicotiana var. parasitic Resistance and Finale Herbicide in Transgenic Pineapple (Ananas comosus (L.) Merr) Plants

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Pineapple: (*Ananas comosus* (L.) Merr) is a crop of great commercial importance in the family Bromeliaceous. Its annual yields are seriously affected by incidence of diseases, in which the most important ones are the fusariosis which provoke the fungus *Fusarium subglutinans* and the Heart Rot that cause by the fungus *Phytophthora nicotiana* var. *parasite*. The obtaining of resistant varieties will be the solution to these problems, but the traditional breeding method consumes a lot of time, is for them that the techniques of genetic engineer contribute a grate measure to resolve this problem. They obtained genetically modified vitroplants of pineapples apart from genetic transformation protocol proposed by Espinosa et al.(2001). Three months of adaptation the Transgenetic plants in solar house realize an experiment against the pathogen (*Phytophthora nicotiana* var. *parasite*). From the 40 lines of transgenetic plants that considered independent of transformation, in six, it observed more than

66% of survival against the pathogen. In plants that were used for positive control, (plants didn't transform), had 100% mortality, contrary to what had happened with the control resistant, plants of *Bromelie penguin*, where didn't observed any plants of mortality. When evaluate the resistance of the transgenetic lines of pineapple against the herbicide Glufosinate of ammonium, at a concentration of 2%v/v, six lines of transgenetic plants showed major resistance, where 70% of the leaves of the plant had little damage, inverse to what had happened to plants that didn't transform, that didn't survived at the concentration of the herbicide that had applied.

A Novel Wax Formulation for Extending Storage Life and Controlling Black Rot Disease of Pineapples

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A cost effective wax formulation, which could be manufactured in Sri Lanka was developed and tested on ‘Mauritius' (Queen type) and ‘Kew' (Cayenne type) fruits. Untreated fruits from both varieties were used as controls. 'Kew' pineapples harvested at the 10 % yellow stage of maturity, and treated with the ITI formulation showed no symptoms of internal browning when stored for 14 days at 10°C and 48 hours at 28° C ± 2°C, nor did those treated with the FMC pineapple wax 7055, while a 30% loss of fruit was observed in the untreated controls of this variety when held under similar storage conditions. The chill sensitive 'Mauritius' variety showed 65% loss when harvested and treated as above. An 80% loss occurred in the untreated controls. The ITI wax was combined with a 3% acetic acid (AA) treatment to control *Thielaviopsis paradoxa* (De Seyn.) Hohn, the causal agent of black rot disease of pineapple. With in vitro studies on the response of the pathogen to AA, complete inhibition of spore germination at 2% AA (v/v) and radial mycelial growth at 3% AA (v/v) was observed. No disease on 'Mauritius' pineapples occurred when fruits were subjected to a three minute dip in 4% AA (v/v) combined with either the ITI formulation or the FMC wax treatment. Untreated inoculated controls, and fruits treated with only the respective wax formulations, or acid concentrations (2,3, and 4%) showed symptoms of disease.

Transport of Pineapple ‘Queen’ in a Cargofresh Controlled Atmosphere Sea Freight Container From South Africa to Europe

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Until recently, pineapples of the cultivar ‘Queen’ were only shipped by airfreight from South Africa to overseas markets. Together with the exporter "Agrilink (Pty) Ltd." the Controlled Atmosphere (CA) equipment manufacturer "Cargofresh Technologies GmbH" conducted a first trial with 20 pallets in a 40' h/c Cargofresh CA reefer container by sea freight. The produce was harvested mid November 2004 with 50-80% colour and transported to Cape Town. Stuffing date of the CA container was November 18th and after 19 days in transit it was unloaded in Rotterdam, NL. After unloading the shelf life of the pineapples was observed under ambient conditions. Various quality parameters like temperature, TSS and colour were controlled after harvest, at unloading and during shelf life observation and documented by photos. The pineapples arrived in good condition in Rotterdam though there were minor problems with packaging, superficial mould and increased colourisation during transport. The produce showed good shelf life according to degree of colour. This first trial proved that sea freight shipment of cultivar "Queens" is possible and is the basis for further trial shipments in 2005.

Genetic Mapping of DNA Markers in Pineapple

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Two genetic maps of DNA markers (RAPD, AFLP and ISSR) of *Ananas comosus* var. *bracteatus* and *A. comosus* var. *comosus* have been previously published by our team. These maps were constructed at the Laboratory of Genetics and Plant Breeding of FERN, University of Algarve, using an F1 mapping population derived from a cross performed in Martinique between the two botanical varieties. However, the use of a F1 population, the small size of this population and the use of molecular markers with dominant inheritance allowed only markers that were heterozygous in the parents to be included into those maps and prevented the construction of an integrated high density map. A new genetic map, intended to cover all the pineapple genome, is currently under construction using a mapping population of 144 F2 plants. This new map will integrate the already published maps and will include markers that have remained unlinked, markers polymorphic but homozygous in parental genotypes and newly identified molecular markers. At the present time, the new map consists of 7 linkage groups (> 40cM) that integrate markers from both parents, 21 groups (> 40cM) with markers from one parent, and 11 other smaller (< 25cM) linkage groups, covering approximately 62.0% of the pineapple genome.

Hybridization and Selection in Pineapple Improvement: The Experience in Malaysia

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Pineapple cultivars are heterozygous and hybridization between them often leads to development of fertile seed that presents a wide spectrum of genotypes. This segregating F_1 population provides an excellent source of gene recombinants for selection and cloning of new, superior individuals. Important considerations in hybridization include the choice of parents, direction of cross, time of crossing and suitable hybrid population size. Early progeny evaluation including seed handling, germination, nursery management and rapid vegetative propagation using leaf buds and 'quartering' is necessary to develop preliminary elite clones. These elite clones are then put in 'genotype x environment' trials to establish their performance and stability. In Malaysia, it takes about 12 years from the time of the first cross to the release of a commercial clone. The Malaysian Agricultural Research and Development Institute (MARDI) successfully developed a commercial hybrid 'Josapine' using this methodology and more promising hybrids particularly those with the 'piping leaf' character and ornamental pineapples are in the pipeline. This paper also discusses the prospects of hybridization in improving 'not often considered characters' such as earliness in bearing. Several new exciting hybrids in the MARDI programme have shown potential to be harvested within a year making the pineapple a truly annual crop.

Evaluation of Pineapple Genotypes for Resistance to Fusarium subglutinans

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Fusarium subglutinans, the causal agent of the pineapple fusariosis, is the most serious problem of that crop in Brazil, where the disease was first reported in 1964. Yield losses due to fusariosis disease vary according to time of harvest and growing season as well. Since genetic resistance is considered an important component of disease management, several experiments were carried out at Embrapa Cassava & Fruits, under screenhouse conditions, in a completely randomized design with five replicates, in order to evaluate the reaction of pineapple genotypes to inoculation, by the wounding and dipping technique, with *F. subglutinans*. A total of 260 genotypes, all of them from the Pineapple Active Germplasm Bank, were evaluated for resistance to the pathogen. Reference genotypes used were the cultivars Perola and Smooth Cayenne, susceptible, and Perolera and Primavera, resistant. Evaluations performed three months after inoculation showed that 122 genotypes, or 47%,showed no symptoms of the disease, while the remaining 138 genotypes, corresponding to 53%, behaved as susceptible to *F. subglutinans*. All inoculated plants of cultivars Perola and Smooth Cayenne, reference genotypes for susceptibility, showed fusariosis symptoms at evaluation. These data indicate that resistance to fusariosis is of fairly common occurrence among pineapple genotypes.

Pineapple Genebanks: An Underused Richness

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Throughout the twentieth century, substantial collections of germplasm were created. In the nineties, large collections of germplasm have been made in the centres of diversity under the aegis of IPGRI. Characterization and evaluation have been carried out in several field genebanks. However the utilization of genetic resources in both breeding programs and production is still limited. The difficulty of accessing the plant material as well as associated information may be one cause. Another reason is the lack of crucial information on pest and disease behaviour. Networking could improve germplasm information and use.

Relaunching Pineapple Breeding At CIRAD

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Cirad pineapple breeding program achieved the creation of 'Smooth Cayenne' x 'Manzana' hybrids in the nineties. Presently, some of these hybrid varieties are under development in the French West Indies and in West Africa. Pineapple breeding was relaunched at Cirad in 2004, building up one of the world's largest genebanks. The objective is to produce new hybrids for the local and export markets. Two approaches were developed. In the first option, we engaged in direct hybridisation to improve the storage behaviour of existing hybrids. Secondly, selfing was introduced to reduce heterozygosity and the size of progenies to be evaluated: this will also result in heredity studies. The two approaches and preliminary results are presented.

Preliminary Report on Systemic Acquired Resistance in Pineapple Plants

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The fusariosis, caused by *Fusarium subglutinans*, is the most serious pineapple disease in Brazil where it was reported in 1964 on fruits of cultivar Smooth Cayenne. By 1992 that disease was detected in Bolivia. Systemic acquired resistance (SAR) is a well-reported phenomenon that shows possibilities for the integrated management of plant diseases. Thus we evaluated the effect of benzo[1,2,3]thiadizole-7-carbothioic acid-S-methyl ester (ASM), as a SAR inducer on pineapple plants, aiming at developing an alternative control measure for the fusariosis disease. Pineapple slips, grown in plastic bags under greenhouse conditions, were sprayed with ASM (50, 100, 150, 200 and 250 ppm). Inoculation with *F. subglutinans*, by wounding and dipping technique, was performed at 2, 4, 6 or 8 weeks after treatment. Results showed that spraying ASM reduced disease severity when inoculation was performed at 2 or 4 weeks after treatment. Similarly, ASM at 150 ppm reduced fusariosis severity in pineapple fruits when plants were sprayed at 2 or 4 weeks before inflorescence inoculation at mid-flower stage, the later treatment showing the best results. Although preliminary, those results show the potential of SAR on the control of the pineapple fusariosis.

Surround WP Crop Protectant-For the Reduction of Sunburn Damage and Heat Stress in Pineapple

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Surround® WP crop protectant, jointly developed by Engelhard Corporation and the U.S. Department of Agriculture, is a new product for the protection of crops from the damaging effects of sunburn and heat stress. Surround contains specially sized and shaped particles of kaolin, a naturally occurring, soft, inert white mineral. Pineapple plants and fruits are susceptible to damage from high temperatures and solar radiation that can result in significant financial losses. Symptoms include external sunburn or bleaching and internal sunburn or "boiling". Pineapples with external sunburn show a bleached, yellow white skin that turns pale grey/brown with damage the tissue underneath. Damaged areas are susceptible to disease infection. Sunburn is common during hot > 32°C, periods of the year. Internal sunburn, thought to be the result of high air temperatures, cannot be detected without cutting open the fruit and renders the fruit unfit for commercial use. Highly translucent fruit appear to be most susceptible to internal sunburn. Replicated trials in Australia, Costa Rica and South Africa showed that sequential applications of Surround significantly reduced the incidence of external and internal sunburn. In addition, in the hot dry conditions of Costa Rica, applications of Surround prevented leaf damage, resulting
in a significant yield increase (P>0.05.).

Winter Blotching: A Study on the Occurrence and Possible Cause

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Since 1997 Queen pineapples from South Africa, that were destined for the export market, were rejected due to the occurrence of winter blotching. Winter blotching occurs as a circle of reddish brown corked tissue around the floral cavity of the fruitlet. It may appear on only a few fruitlets but in severe cases almost all fruitlets are affected. The fruit has a "dirty" appearance and is unacceptable to the buyer. No effect on the internal quality of the fruit has been found. A study was conducted to find a possible cause. The occurrence of winter blotching of the fruit, seasonal variation, the effect of chemicals such as fruit enlarger and fertilizer as well as the effect of plant and fruit size on the occurrence of winter blotching were determined. No specific cause of winter blotching could be found, but wind direction and fertilizer application appear to play a role.

Prevention and Control of the Big Headed Ant, Pheidole megacephala (F.), (Hymenoptera: Formicidae) in Pineapple Cultivation Using Bait Stations With Amdro

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Control of the big headed ant, *Pheidole megacephala*, in pineapple plantations is essential for the prevention of economically significant infestations of pineapple mealybugs which have a close symbiotic relationship with this ant species. At a demonstration site for growers, bait stations with Amdro were placed around the perimeter of a newly planted pineapple field for a period of one

year. This treatment prevented big headed ants from migrating into the field and establishing colonies. At a nearby untreated control site, a newly planted field became infested on several occasions and required treatment with ant baits and a single application of Diazinon for mealybug control.

Control of Balck Spot Disease/Fruitlet Core Rot in Queen Pineapple With Integrated Mealybug, Pineapple Fruit Mite and Fungus Control Programmes

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The economic consequences of Black Spot disease/Fruitlet Core Rot in the Hluhluwe district of KwaZulu Natal are far more serious than any other post harvest disease in Queen pineapples. In a 5 x 2 x 2 factorial trial at Hluhluwe, twenty different insecticide - miticide - fungicide treatment combinations were applied to pineapple field plots in an attempt to control the biota known to be associated with this disease, i.e. the fungi, *Penicillium funiculosum* and F*usarium subglutinans*; the pink pineapple mealybug, *Dysmicoccus brevipes*; the pineapple fruit mite, *Steneotarsonemus ananas*. A fungicide programme comprising of five benomyl 50% WP and mancozeb 80% WP sprays, applied as a tank mixture from one week before to eleven weeks after flower induction gave a highly significant 75.8% reduction ($P < 0.001$) of total number of Black Spots per fruit with fourteen days storage at ambient temperature. Incidence of Black Spots in fruits was also, on average, significantly reduced ($P = 0.032$) by the application of endosulfan 35% EC for fruit mite control; two to five pre- and post-flower induction sprays, at four week intervals from five weeks before, to eleven weeks after flower induction gave reductions of: 22.6%, 24.1%, 41.9% and 45.2%, respectively. Mealybug control programmes gave a nonsignificant 7.5% reduction in Black Spot incidence. There were no significant first or second order interactions between the different control programmes. The treatments applied are unregistered and the results obtained are unconfirmed research data.

Further Investigation of the Effects of Thioflo on Black Spot of Pineapples

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We have previously reported on the unexplained increase in Black Spot which was observed where Thioflo (Endosulfan) was applied for mite control on Queen pineapples in Hluhluwe. The previous trials were not all replicated, two being observational trials, but sufficient concern was raised for growers to cease using Endosulfan. The current series of trials was initiated to establish, on a rigorous basis, whether the Endosulfan effect was true. The trial was designed as a randomised block with eight treatments and four replicates, laid out on each of three farms, the statistical design being the same, but the physical layout adjusting to circumstances. A five spray Thioflo (Endosulfan) program effectively controlled mites but was consistently and significantly in the worst group as regards Black Spot control at all sites. This contradicts previous results obtained with varying Endosulfan sprays from the Eastern Cape and elsewhere, including Hluhluwe, but supports other results obtained previously at Hluhluwe. No explanation can be offered why this insecticide should increase disease.

Evidence for the Induction of SAR by Acibenzolar in Cultivated Pineapple

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Acibenzolar induces Systemic Acquired Resistance (SAR) in plants. The application of 100 mg acibenzolar-s-methyl/L water to *Ananas comosus* reduced reproduction of *Rotylenchulus reniformis* and *Meloidogyne javanica* in half. To test whether SAR was being induced by the acibenzolar treatment, the level of the PR 1 gene transcript was measured as a molecular marker of the SAR pathway. One month old *A. comosus* were sprayed with 0 or 100 mg acibenzolar-s-methyl/L. Two days later, plants were removed from pots and the roots gently washed free of soil. The roots were cut from the base of the crown, placed on ice, and RNA immediately extracted. First strand cDNA was synthesized from total RNA by RT PCR using oligo-dT primers, followed by a regular PCR using primers designed to two conserved regions of the rice basic *PR 1* gene. A PCR product of 266 bp was only detected in the RNA sample from plants treated with acibenzolar-s-methyl. The nucleotide sequence of the PCR fragment had high identity (79 to 94%) with the *PR 1* genes from other monocots and the deduced amino acid sequence was 58% to 73% similar to other *PR 1* proteins. We concluded that Acibenzolar induced SAR in *A. comosus* and propose that SAR provided some resistance to nematode infection.

Nematode Control for the Early 21st Century

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The era of nematode control with effective but toxic products like methyl bromide, EDB, DBCP, ethoprop, and fenamiphos has nearly come to an end in the USA and other parts of the world. A search for environmentally friendly and effective alternatives for nematode control in pineapple has been underway. In greenhouse tests, Messenger® (the harpin protein) was not effective in controlling nematode damage to pineapple. Maxicrop® (the seaweed *Ascophyllum nodosum*), Myti-gro® (the rhizhobacterium *Bacillus* sp.), and Agri-50® (potassium phosphate) also did not reduce nematode damage to pineapple in greenhouse experiments. Preplant applications of methyl iodide reduced nematode populations densities to numbers similar to treatments of 1,3 D in two field tests. However, plant crop yields were not as high in the methyl iodide treated plots as in the 1,3 D treated plots. DiTera® (heat killed *Myrorhecium verrucaria*) reduced nematode damage to pineapple plants, increased early root growth, and resulted in acceptable yields. Actigard®, an inducer of systemic acquired resistance, reduced nematode populations on pineapple by nearly 50% in greenhouse trials. Dragonfire CPP®, a sesame oil product, increased pineapple growth in nematode infested soil. Many environmentally friendly products have not proven to be effective in controlling nematode damage to pineapple. However, a few environmentally friendly products are promising in greenhouse tests and preliminary field trials. Nematode control in pineapple is in transition and will continue to change as effective, safe and economical controls are evaluated in the field.

MARTAnanas 2004: Software to Help Farmers and Researchers in Management of Pineapple Plots From Land Preparation to Harvest

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MARTAnanas is a database software (Microsoft access) that facilitates pineapple plot management. It allows forecasting of all field activities with complete traceability. The Harvest Forecasting module, which is based on the Aloha Pineapple model, provides good prediction of date of harvest and expected tonnages. An Inputs module allows accurate forecasting of input requirements. Different versions are being tested for individual fresh pineapple producers, processed pineapple producers (cooperative) and a special version for researchers for experiment management and recording of data.

Mechanized Application of Calcium Carbide, Ethylene Gas and Ethephon for Pineapple Forced Flowering

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In Mexico, most pineapple flowering induction is done with calcium carbide, but ethylene gas plus activated carbon are beginning to be used. In addition, other options such as the application of the acetylene generated by calcium carbide are being explored. This study evaluated some mechanically applied flowering inducers, in order to achieve a more efficient forced flowering and evaluate the perspectives of using acetylene. The experiment was carried out in the state of Veracruz, located at 18° 58' North Latitude and 50 m above sea level. Smooth Cayenne plants over 2.5 kg were used. The experiment design was randomized blocks with four replicates. The treatments were: a) acetylene gas obtained from 12 kg of calcium carbide per 100 L of water; b) ethylene gas; c) ethephon and; d) control. The application was done on June 18 and 20, at midnight. High pressure sprinklers with ethylene mixer or acetylene generator were used, as required by the treatments. Ethylene gas at 2 kg ha^{-1} was the best treatment with 82% efficiency of flowering induction compared to 57% obtained with acetylene. However, these results are considered preliminary since this is the first trial, and further adjustments on calcium carbide doses, gas pressure, application speed and/or other details, could improve acetylene gas performance.

Effect of Microbial Complex IC-10 on Slip Production of a Mexican 'Smooth Cayenne' Clone in a First-Harvest Plantation

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An experiment was carried out to determine the effect of Microbial Complex IC-10 (IC-10) as a growth bio-stimulant to increase slip production of a Mexican 'Smooth Cayenne' clone in a first harvest plantation. A randomized complete block design with five

replications was used. The treatments were 30, 60 and 90 L ha^{-1} of IC-10 applied as a foliar spray. Data were collected on slips per plant and average fruit weight. Significant differences were obtained in relation to the control for all treatments. Fruit weight was greatest for the 30 L ha^{-1} treatment reaching 0.851 kg with an estimated yield increase of 19,5 t ha^{-1} relative to the control. The 90 L ha^{-1} treatment resulted in the greatest slip production with 44,154 more slips ha^{-1} relative to the control. Regarding to the increase in planting material relative to the control, with a sowing density of 33 000 plants ha^{-1}, the 30 L ha^{-1} treatment produced enough slips to plant an additional 0.70 ha, the 60 L ha^{-1} treatment produced slips to plant an additional 0.98 ha and slips from the 90 L ha^{-1} would plant an additional 1.34 ha

Nutritional Deficiency in Pineapple, cv. Imperial, in the Vegetative Growth Phase and Leaf Nutrient Concentration

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The pineapple nutritional supply in the vegetative phase is very important to fruit yield and quality. The objective of this work was to evaluate the effects of deficiencies of macronutrients and boron on growth, deficiency symptoms, and 'D' leaf nutrient concentration in Pineapple, cv. Imperial, five and seven months after planting. Growth evaluation consisted of fresh and dry weights and length, width and area of 'D' leaves, which also were used for nutrient analysis. Plants were grown in sand irrigated with nutrient solution in a green house. Growth parameters were not affected by the deficiencies at five months after planting but leaf number was decreased at seven months after planting where N was deficient. All nutrients under deficiency had their own leaf concentration reduced, the reduction being greater at the seven month determination. Only N deficiency caused clearly visible symptoms during the seven month evaluation. N, Ca, and Mg deficiencies increased leaf K concentration. P deficiency reduced leaf N concentration, while N deficiency increased leaf P concentration. Leaf boron was lower where boron was deficient. Leaf boron had no effect on the concentration of other nutrients.

Antifungal Activity of Lemongrass Essential Oil Combined with High Hydrostatic Pressure Against Fusarium subglutinanas F. Sp Ananas

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The Fusarium fruit rot, caused by *Fusarium subglutinans* f.sp. ananas, is one of the most important pineapple (*Ananas comosus* (L.) Merrill) diseases and its presence in the fruit is an important problem affecting pulp and juice quality. Fungicides are recommended for its control, however, in the long run, resistant pathogen populations to the conventional fungicides may arise. High hydrostatic pressure (HHP) treatment is an alternative technique for food preservation. Inactivation of the spores of *F. subglutinans*. f.sp. ananas in saline solution by the use of HHP and lemongrass (*Cymbopogon citratus*) essential oil was studied. Spores from two different isolates, E 203 (wild type) and E 261 (resistant to the commercial fungicide benomyl) were used. The two strains behaved similarly for all tested conditions. Spore germination of both strains was efficiently inhibited after a treatment of 400 MPa of pressure for 4 min. When they were treated with 0.45 mg ml^{-1} of lemongrass oil, the pressure needed to achieve the same spore inhibition was 250 MPa. Analysis of the spores by scanning electron microscopy showed that they were crushed and destroyed. This work suggests the use of HHP and plant essential oil as an alternative control for fruit diseases. Financial support: CNPq and FUNDECI/BNB.

Economic Impact of Technology for Inhibiting winter Natural Floration of Pineapple in Mexico

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In Mexico, about 20% of the 15,000 ha of pineapple cropped every year, are damaged by undesirable winter premature floration. Such phenomena account for losses of around 100,000 t, as a result of a 35% reduction of the potential yield. When plants bloom before reaching their optimal development, the fruits have a weight lower than the optimal. In addition, some 120,000 t of plants under natural floration are cropped during a very short season (June and July), resulting in excessive offering and a drastic fall on product price. However, after the regular cropping season, demand exceeds supply and prices rise again. Therefore, the aim of this study was to evaluate the economic impact of a technology to effectively cope with this problem, considering the development costs and the economic benefits resulting from the inclusion of such technology for pineapple production in Mexico. During six years, INIFAP performed research and generated technology on the inhibition of winter natural flowering, combining fall

application of 2-3 chlorophenoxy-propionic acid, and agronomic management of the plantations. Research development estimated cost was US$ 275,735 included salaries, establishment and operation costs. This technology allows taking advantage of market opportunities, and increasing significantly the rentability. Average yield was over 35 t ha^{-1}, and average cost was US$ 4826 ha^{-1}. By the year 2002, at least 1,500 ha were using this technology, generating US$15,840,517 annually. In 1998, at the time of releasing the technology, the expectation was that the adoption process would be completed some eight years later, with a probability of success of 90%. However, statistics show that the use of the technology had surpassed the expectations. Furthermore, the required investment for adopting the technology is extensively overbalanced by its rentability.

Minimum Growth Conditions for the in Vitro Conservation of Pineapple Germplasm

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Embrapa Cassava&Fruits has the largest collection of pineapple germplasm in the world. However, this collection is kept in the field, being subjected to losses caused by biotic and abiotic factors. In order to minimise this problem and to assure a replicate of the field collection, an in vitro collection is being established, based on the culture of axillary buds for the production of plants to be kept under conditions of minimum growth. Until now, 120 accessions have been replicated under in vitro conditions. The aim is that, by the end of year 2005, at least 50% of all accessions available will have been replicated. Currently, the plants are being conserved in a basic MS/2 medium without growth regulators and at temperatures of 21°± 2°C and a phatoperiod of 12 hours, which is delaying growth. In addition, other trials are being carried out seeking to extend the period of conservation, by taking into account the variation of the behaviour of different varieties in micropropagation works. Growth regulators, like paclobutrazol and abscisic acid, combined with different concentrations of MS salts, have been tested. Preliminary results have shown delaying effects of those regulators on the in vitro growth of pineapple genotypes.

Total Antioxidant Capacity, Malonyldialdehyde Content, Peroxidase and Polyphenol Oxidas Activities in Queen and Smooth Cayenne Pineapples During Low Temperature Storage

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Pineapple (*Ananas comosus* (L.) Merr.) is susceptible to chilling injury. Symptom development depends on cultivars, growing conditions as well as maturity stages. After storage at 10°C for two weeks, Queen pineapples clearly developed higher internal browning symptom in the flesh near the core than Smooth Cayenne pineapples. During this storage period, total antioxidant capacity in Queen was higher. Malonyldialdehyde (MDA) and hydrogen peroxide (H_20_2) levels were higher in Queen. The activities of polyphenol oxidase (PPO) and peroxidase (POD) were also higher in Queen. The results indicated that low temperature caused lipid peroxidation in pineapple tissues due to the high H_20_2 content. The higher antioxidant capacity and higher POD activity, however, did not help preventing oxidative damage in Queen. Higher activities of PPO in Queen might be involved in the higher symptom development rather than the cause of chilling injury. Further study on others antioxidant enzymes could better explain the difference in chilling susceptibility between these two pineapples cultivars.

Determination of 'Perola' Pineapple Jam Formulation Using the Mixture Design Method

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Pineapple post harvest losses can be reduced by processing the fruits into jam. In this work were tested ten 'Perola' pineapple jam formulations, using a centered simplex design with the following variables: pulp (varying from 50 to 70%), sucrose (from 30 to 50%), glucose (from 0 to 20%). The selection of the formulation was based on the averages of general acceptance (9 point hedonic scale) by a team of 30 judges. The mathematical model obtained was the following: Y = 1.47 A - 5.95 B - 48.06 C + 34.66 AB + 152.00 AC +169.59 BC - 427.50 ABC, in which: Y = acceptance average (30 judges); A, B and C are, respectively, the pulp, sucrose and glucose contents. The acceptance was higher for formulations with lower amounts of sucrose tested and higher amounts of glucose studied. The best acceptance was obtained for the formulation with the following proportions: 60% of pulp; 30% of sucrose and 10% of glucose.

An Economic Analysis of Post-Harvest Operations and Marketing Efficiency of Pineapple

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The North Eastern Region of India with wide diversity in topography, rainfall, soil type and climatic conditions has immense potential for growing a wide range of fruits. This study was conducted on pineapple with 200 sample farmers and 80 market middlemen. Post harvest loss was found to be 9.25 percent of the total production. It was more at the middlemen level than at the farmers' level. The highest loss occurred during assembling and in the market for farmers and middlemen level, respectively. Pineapple is stored in open floor, gunny bags and in *khasa* with thatch. Average cost of storage was found to be Rs. 13.54 per 100 fruits. Grading of pineapple is mainly done on the basis of size and the average cost of grading was found to be Rs. 1.51 and Rs. 1.95 per 100 fruits for growers and middlemen, respectively. The major mode of transportation was bicycle and truck, respectively for growers and middlemen. The cost of transportation was lowest (Rs. 0:68/km/100nos) in truck. The most efficient marketing channel was Producer - Wholesaler (via Commission Agent) - Retailer - Consumer with an efficiency of 3.60. The most effective channel was Producer - Wholesaler - Retailer - Consumer, through which about 60% of the commodity were transacted.

Identification and Selection of Ornamental Pineapple Plants

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At present, there is a great demand for exotic tropical ornamental plants due to the beauty, exuberance and durability of their flowers. In the Bromeliaceae, special interest is shown in the ornamental pineapples. Brazil presents the largest genetic variability in the genus Ananas, with a great potential for breeding new varieties. The Pineapple Germplasm Bank of Embrapa Cassava & Fruits presently has 743 accessions belonging to the genus Ananas and other bromeliad genera and is the largest pineapple germplasm bank in the world. Some of their accessions are potential sources of materials with ornamental value due to their beauty, rusticity and originality. In a preliminary trial with the objectives of characterizing and identifying accessions with ornamental value, morphological characteristics, after floral induction, have been used. The main aspects considered were colours and shapes of flowers and leaves and the absence of spines. Different accessions of *A. comosus* var. *bracteatus* ('Tricolor'), *A. comosus* var. *erectifolius* and *A. comosus* var. *ananassoides* were crossed. The progenies were evaluated and some hybrids with interesting characteristics have been retained.

Identifying and Mapping the Area of Occurrence of five species of Ananas in Brazil

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Brazil is one of the main centers of genetic diversity of *Ananas*. For more than two decades, Embrapa has been collecting, exchanging and conserving *Ananas*, and has an Active Germplasm Bank with 734 accessions. Six hundred and eight Brazilian accessions were identified, using the Geographic Information System (GIS), ArcView and Access programs, and 1:5.000.000 maps. It was observed that *Ananas ananassoides* occurs in the North and Central West of Brazil, on latosolic or podzolic soils, dense rain forest or savanna, plateau or depression relief, 0 to 200m altitude and 25°C average temperatures, while *A, bracteatus* occurs in the South, on litholitic soils or latosoils, semi deciduous or dense rain forest, plateau relief, 100 to 500m altitude and 19° C average temperature. *Ananas lucidus* and *A. parguazensis* occur in the North, on podzolic, gley or lato-soils, in transitional ecological areas, depression relief, 0 to 100m altitude and 25°C average temperature. *Ananas comosus* occurs as a cultivated form in all the country and rarely in the wild form, in podzolic, gley soils or latosoil, dense rain, deciduous or semi deciduous forest and savanna, plain relief and depressions, 0 to 100m altitude and average temperature of 25°C. These results may help to indicate new collecting areas.

CM94:A Smooth Cayenne Pineapple Selection for Improved Pineapple Processing in Eastern Cape, South Africa

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Distance from large national fresh produce markets and the relative absence or any genetic improvement to field run Cayenne pineapples planted in the Eastern Cape, has limited the local industry to focus almost entirely on the production of pineapples for

canning. For about 60 years, until recently, the canned product was sufficiently profitable (thanks to global demand and a weak local currency) to discourage interest in the fresh fruit market. Profitable pineapple processing, especially for small industries, is dependant on cost effective processing of the high priced products) demanded in different economies. The average size (number of units per tonne) and quality (shape, length, blemish) of the fruit passing through processing plants significantly influences profitability. Therefore, processors in South Africa have very specific market related fruit specifications for niche markets.This is reinforced with a Differentiated Fruit Pricing System whereby significant premiums for large fruit of good shape can boost profitability to the producer i.e. fruit length exceeding fruit diameter by 15%. As a result of prospecting for superior plant material within the local industry, commenced by research personnel in the early 1950's, a Bathurst gene pool of promising plant lines was in existence in 1980 before work in this direction was discontinued. Rescued from destruction and entrusted to the attention of a local producer, this mixed gene pool was systematically evaluated in relation to other local and overseas clones/selections over the period 1993 - 1999. Named CM94, this selection is today widely planted in the local industry for processing purposes.

Variability in Chemical Contents of Pineapple Germplasm at MARDI

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A total of 47 pineapple accessions were evaluated at the Malaysian Agricultural Research and Development Institute (MARDI) Research Station at Pontian. The objective of the study is to determine the genetic variability of some selected chemical contents in the pineapple germplasm and to identify potential accessions for commercialization or as parents for further breeding and improvement. In this study, fruits with harvesting index 2 to 3 were analyzed for moisture content (%), total soluble solids (TSS,%), acidity (pH), titratable acid (TTA,%), ascorbic acid (mg/100 g), Boron (ppm), Ca (%), Cu (ppm), K (%), Mn (ppm) and Zn (ppm). The results showed that the germplasm exhibited wide variation, with all the chemical contents having more than 30% coefficient of variation. The moisture content ranged from 80.33-92.18 %, TSS: 6.07-16.90 %, pH: 3.25-4.28, TTA: 1.0-3.65 %, Ascorbic acid: 6.27-46.21 mg/100 g, Boron: 4.38-9.19 ppm, Ca: 0.02-0.05 %, Cu 2.0-9.23 ppm, K: 0.53-4.52 %, Mn: 3.87-17.76 ppm and Zn: 2.25-38.03 ppm. The importance of the variation in correlation with fruit quality, disease and physiological disorders such as Blackheart is discussed.

Surround® WP Crop Protectant - For the Reduction of Sunburn Damage and Heat Stress in Pineapple

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Surround® WP crop protectant, jointly developed by Engelhard Corporation and the U.S. Department of Agriculture, is a new product for the protection of crops from the damaging effects of sunburn and heat stress. Surround contains specially sized and shaped particles of kaolin, a naturally occurring, soft, inert white mineral. Pineapple plants and fruits are susceptible to damage from high temperatures and solar radiation that can result in significant financial losses. Symptoms include external sunburn or bleaching and internal sunburn or "boiling". Pineapples with external sunburn show a bleached, yellow white skin that turns pale grey/brown with damage to the tissue underneath. Damaged areas are susceptible to disease infection. Sunburn is common during hot > 32°C, periods of the year. Internal sunburn, thought to be the result of high air temperatures, cannot be detected without cutting open the fruit and renders the fruit unfit for commercial use. Highly translucent fruit appear to be most susceptible to internal sunburn. Replicated trials in Australia, Costa Rica and South Africa showed that sequential applications of Surround significantly reduced the incidence of external and internal sunburn. In addition, in the hot dry conditions of Costa Rica, applications of Surround prevented leaf damage, resulting in a significant yield increase ($P>0.05$.).

Charteristics and the Status of the Brazilian Pineapple Industry

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In Brazil, more than 18,000 farmers and their families, mainly growing areas of less than 5.0 ha each, have contributed to the pineapple production of 1.4 million metric tons in 2003, according to FAO statistics, and about 1.96 million metric ton, based upon the more correct average fruit weight of 1.44 kg, as recently scientifically estimated. The latter would rank the country as the

first world producer. More than 70% of this production is coming from the Northeast, with emphasis to the States of Paraiba, Bahia and Rio Grande do Norte, and the Southeast, especially Minas Gerais State. 'Perola' accounts for about 80% of it, whereas 'Smooth Cayenne' for most of the other 20%. The domestic markets are consuming about 96% of the pineapples produced, around 65% as fresh fruit (about 5.4 kg/capita) and 35% as juice and other processed forms (3.0 kg/capita). Consumer preferences are for large (>1.5 kg), sweet and juicy fruits, with a good external appearance, including a partly yellow rind. Lower volume of fruits offered from February to April has determined higher prices on farmer and consumer levels. Exports have been rather low, representing the consumption as fresh and processed fruits of about 80,000 t or 4.0% of the production. Fresh fruits have traditionally been exported to the neighboring countries like Argentina, but the exports of 'Perola' pineapples to Europe are increasing. In 2003 started the exports of 'Del Monte Gold' to Europe, which should reach U$ 6 million in 2004 and higher values in the following years.

The History of Pineapple Production in the Kingdom of Swaziland, Southern Africa, Including the Impact of Recent Improved Production Technologies

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The mountain kingdom of Swaziland (27°S, 31°E) is separated from Moçambique by the Lebombo Mountains in the East and from South Africa by the northern extremity of the mighty Drakensberg Mountains. Approximately 180 kms in length, this fertile region boasts high altitude forestry in the cooler north, pineapples and other Subtropicals in the lower/warmer middle and sugarcane and other Tropicals in the lower southern regions. Pineapple production commenced in the 1950's with plant material from Bathurst, South Africa being moved by rail to the Malkerns area in the midlands of Swaziland; altitude 800 m. Traditionally a quality citrus processing company, Swaziland Fruit Canners Ltd (Swazican) have managed to fill the gap between the citrus seasons with processing of pineapple thereby spreading their fixed costs burden over a broader base. Swazican pineapple production has improved dramatically in recent years due to a better understanding of the basics of successful pineapple cultivation as well as measures aimed at reducing moisture stress, improved soil structure and balanced plant nutrition.◆

Reviews of Books and Book Chapters

Ten Bruggencate, Jan K. Hawai`i's Pineapple Century. A History of the Crowned Fruit in the Hawaiian Islands. Mutual Publishing, Honolulu, 2004, xii + 187 pp. Illustrated. Appendix. Index. $13.95.

This book on the history of pineapple in Hawaii contains a Foreword, Preface and the following chapters: The Early Years, The Pioneers, The Early Pineapple Companies, The Ten Postwar Companies, The Associations, Pineapple Plantation Practices, Working Pine, Labor Organization, Exodus, Adaptation, Appendix (Cultivating Pineapples), and Index. In this reviewer's opinion, the most outstanding feature of the book is the many photographs of people and cultural practices used in the industry, some from quite early in its development. There also is an eight-page full-color center section of photographs of some of the many labels applied to cans of pineapple shipped from Hawaii. The photographs are without attribution and the book has no bibliography or other references. These are serious shortcomings. The index provides links to many of the people, companies, and organizations covered in the book but is inconsistent in its coverage of material in Chapter six and beyond. Coverage of the pineapple companies is uneven with considerably more attention being given to Libby, McNeil and Libby (over 6 pages versus mostly 2 pages or less for all but Dole Co. Most of the statistics in the book are out-of-date with tabulations mostly ending in 1990. Since such information is now readily available on the internet, e.g. at www.fao.org, this may not be a serious shortcoming, but it also would have been relatively easy to obtain more current information. The book is a somewhat brief, interesting, but flawed book on the history of pineapple in Hawaii. The breadth of coverage in the book is particularly laudable but the brevity of treatment is disappointing. Duane P. Bartholomew
◆

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.
Dean W. Wheeler. 609 Buchanan St., Davis, CA 95616; E-mail: agresults@aol.com; www.agresuls.com.

Web Sites of Possible Interest

http://www.coleacp.org/

The COLEACP (Europe-Africa-Caribbean-Pacific Liaison Committee) is an inter-professional association of exporters, importers and other stakeholders of the EU-ACP horticultural trade. COLEACP aims to promote the competitive export of fresh fruit, vegetables, flowers and ornamental plants from the ACP. Its specialised information and advisory services are open to all ACP companies in the horticultural export sector and are financed by the European Commission in the framework of the Lomé Convention. Set up by the European Union at the request of the ACP Group of States, the Pesticides Initiative Programme (PIP), implemented by COLEACP, has two overriding objectives: to enable ACP companies to comply with European food safety and traceability requirements; and to consolidate the position of small-scale producers in the ACP horticultural export sector. **Ed Note: For PIP activities related to pineapple, go to the Pesticides Initiative Programme website and enter the word pineapple in the search box at the upper right of the page.**

http://www.ams.usda.gov/fv/mncs/

Market prices for pineapples in different markets in the United States can be found at "The Market News" portal at this web site.

http://www.tropentag.de/2003/proceedings/node254.html

Towards a Molecular Identification and Transfers of Fruit Quality in Indonesian Pineapple Land Races

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Pineapple (*Ananas comosus*) is amongst the important introduced fruits in Indonesia. This fruit is consumed both as fresh and processed product. Indonesia is not the center of origin of pineapple. Therefore, a wide hybridization between Indonesian pineapple land races that adapted to the Indonesian environment for centuries and newly introduced pineapple possessing quality of fruit, is one of the possible tools for improving Indonesian pineapple gene pool. The plant breeding lab of Padjadjaran University and Bogor Agriculture University started a collaborate pineapple breeding program since 1999. Both molecular analysis and hybridization were conducted. The breeding strategies are: i) Estimation of genetic distance based on morphological traits and DNA analysis, ii) Parental screening based on genetic distance and desired traits, iii) Hybridisation of selected parent, iv) Progeny selection, and v) Vegetatively propagation. Direct and indirect selection on fruit quality and yield was determined based on correlation between vegetative traits and fruit quality yield. Genetic distance of 35 pineapple genotypes had been estimated from morphological traits and RAPD. Four genotypes of Queen were selected to hybridize with local Subang pineapple (Cayenne) in order to improve the quality of subang pineapple. Reciprocal hybridization between Queen and Cayenne was also held in nursery of College of Agriculture, Padjadjaran University, Bandung, Indonesia. Indirect selection of progeny had been done based on length of leave, width of leave, and diameter of canopy since these three characters correlated with fruit weight, vitamin C, and sugar content of fruit. Selected progeny was planted and direct selection of yield and fruit quality would be done about ten months later.

http://www.brownbearcorp.com/homepage.htm

A major pineapple growing and canning company located in the south of the Philippines is utilizing three of the Brown Bear GM5000 machines to mulch and shred pineapple plants prior to land preparation. The new GM5000 units are custom designed and built to work the pineapple fields prior to land preparation. For more details, see web site.◆

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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.

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