Pineapple News

Issue No. 6 Newsletter of the Pineapple Working Group, International Society for Horticultural Science April, 1999

Contents

Pineapple Working Group

Working Group Issues

Duane Bartholomew

I believe the PWG would benefit from greater participation of the members in our organization. The first matter that needs our attention is to assist our colleagues in Mexico, the host country for the 4th symposium, in developing the best possible meeting with the widest possible participation. In particular, I believe we could help them raise funds to provide travel assistance to scientists with quality work to present so they could attend the symposium. However, if PWG members are to help raise travel funds, those members and donors also need assurance that any money raised will enhance the quality of and broaden participation in the symposium. A second matter is the possible future requirement that meeting proceedings published as Acta Horticulturae volumes will be peer reviewed.

A pro-active board and technical committee could help to assure a high quality meeting. The last two symposia had technical committees that were somewhat to minimally involved in overseeing important issues related to the PWG and to symposia. With high speed and inexpensive communication available to many PWG members, I believe the time has come when the PWG could benefit from a formal structure that includes a Board of Directors and a Scientific-Technical Committee, the latter perhaps being a subcommittee of a larger Board with additional memembers drawn from the scientific community. The Board could deal with policy matters while the Technical Committee could oversee the scientific aspects of our meetings and assure a high quality proceedings. Further, if peer reveiw of Acta volumes becomes a requirement of ISHS (see below for details), a technical committee would also be needed to review of papers submitted for publication in our proceedings. With the above as background and justification, I recommend the following procedures or some modification of them for your consideration.

1. The PWG will establish a board of directors of up to 15 members composed of representatives from the scientific community and from private industry. The Board shall consist of the PWG chairman/chairwoman, a representative from the country hosting the next pineapple symposium, and representatives from a minimum of six countries where pineapple is produced or from affiliated research organizations, e.g. CIRAD/FHLOR. PWG members from each country where pineapple is grown can nominate members for the board and no more than two board members can come from any one country.
2. Criteria for Board membership will include interest in and support of the PWG, membership in ISHS, knowledge of and experience in the science or culture, or both, of pineapple, and the support of the PWG membership.
3. The Board of Directors and PWG members in each country will, to the extent possible, assist in raising unrestricted funds to be used by the current symposium organizing committee to fund travel costs of worthy scientists interested in attending PWG symposia. Restrictions on the use of government money means most of this money would have to come from private industry.
4. The need for financial assistance by a potential symposium participant will be identified on a form in the symposium's 2nd announcement or at least one year before the symposium is to be held.
5. A Technical Committee of subject-matter experts appointed by the Board will evaluate and rank the abstracts submitted to the organizing committee in terms of their potential to contribute to the quality of the symposium. If needed, the Technical Committee will also provide peer review of papers to be published in the proceedings of the symposia.
6. The host country organizing committee will allocate available travel money to potential participants based on the ranking of their abstract and, to the extent funds are available, to PWG members from countries that would otherwise be

unrepresented. More detailed criteria may be developed by the Board of Directors.

The above proposal, which draws heavily on a process being followed by the International Soil Conservation Organization (ISCO), is presented in the form of a questionnaire on the last page of the newsletter. Members of the PWG (all readers of the Pineapple News) are asked to support this proposal or suggest alternatives to it, or both. If you support the proposal, at least in principle, please mail or E-mail your comments to Duane Bartholomew (duaneb@hawaii.edu) as soon as possible. We need to be prepared to help our colleagues in Mexico as they plan for the 4th Symposium. If we can have the above or an alternative policy established soon, we can assist our Mexican colleagues in developing a high quality symposium with participation from as many countries as possible.

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Third Pineapple Symposium

The Third International Pineapple Symposium, held in Pattaya, Thailand during November 17-20, 1998, was co-organized by the Thailand Departments of Agriculture and Agricultural Extension, the Department of Horticulture at Kasetsart University, the National Research Council of Thailand, and the Horticultural Science Society of Thailand and was convened under the auspices of the International Society for Horticultural Science. Mr. Prasert Anupunt, Director of Horticultural Research, Thailand Department of Agriculture, chaired the National Organizing Committee, which included Somchai Watanayothin, Suranant Subhadrabandhu, Onanan Lekagul, Sookwat Chandraparnik, Prateep Kunasol, Kumpoo Satantraipop, Jingtair Siriphanich, Ravie Sethpakdee, Pornprome Chairidchai, Peyanoot Naka, Yupin Kasinkasempong, Patchara Punjasamarnwong, Walaiporn Passornsiri, and Tosaphol Suneru. There were 181 participants from Thailand and 101 participants from 19 other countries (Australia, Brazil, China, Colombia, France, French Guyana, Guadeloupe, Honduras, Hong Kong, Japan, Kenya, Malaysia, Mexico, Netherlands, Philippines, Taiwan R.O.C., South Africa, Sri Lanka, Thailand, United States, and Viet Nam) and one international organization (FAO). Participants included scientists, growers, processors, and technical persons from firms that supply the needs of growers and processors. The meeting location and the warm hospitality extended by the host country representatives provided an excellent environment for this third symposium.

The comradery of the group grows with each symposium so this meeting was an enjoyable social occasion as well as an opportunity to learn about recent developments in pineapple science and culture. Summaries of that science and culture are presented at the end of the newsletter for the benefit of those unable to attend the meeting.

The meeting was opened with a welcoming address from his Excellency Mr. Pittipong Peungboon Na Aduthya, permanent secretary of Agriculture. Participants were welcomed on behalf of the ISHS by Duane Bartholomew, Chairman of the Pineapple Working Group of ISHS. Ananta Dalodom, Director-General, Thailand Department of Agriculture presented the report of the Organizing Committee and his Excellency Mr. Pongpol Adireksarn gave the inauguration speech. The technical program was opened by two keynote lectures; Duane Bartholomew spoke on *The pineapple working group of the International Society for Horticultural Science*, and Eric Maleziéux spoke on the topic *Global network for pineapple research*.

The technical program consisted of seven oral sessions with approximately 40 presentations and a poster session with about 40 additional papers. Five oral sessions and the poster session were held in the first two days. During a one-day field trip, participants toured the pineapple growing areas of Chonburi Province and visited one of two major pineapple grower-processors in the Province. After lunch, participants visited nearby cultural sites. That evening a farewell dinner was hosted by Cameco Co., a major manufacturer of pineapple spraying and harvesting equipment. The final day of the symposium included three additional technical sessions and the closing ceremonies.

The Sessions were: I Country Status Reports (Australia, Brazil, Malaysia, Mexico, Taiwan, Hawaii, and Thailand), chaired by Narong Chomchalow (FAO); II Genetic Engineering, chaired by Duane Bartholomew; III Breeding, chaired by Eric Malézieux; IV Poster Session, chaired by Chin Ho Lin; V Physiology, chaired by Suranant Subhadrabhandu; VI Soil & Nutrition, Cultural Practices and Propagation, chaired by Hirun Hirunpradit; VII Plant Protection chaired by Kenneth Rohrbach; and VIII Post Harvest, chaired by Sontas Nontachai. The broad scope of the meeting and wide ranging subject matter of the papers makes it difficult to summarize the meeting in a few paragraphs. Certainly among the highlights of the meeting were the country status reports and the prospects for solving some of the most costly pest (nematode) and disease (mealybug wilt) problems by genetic engineering. While the potential is great, genetic engineering solutions require a long-term outlook because of the time required to evaluate and propagate new varieties. Classical breeding programs continue in some countries, primarily with the goals of improving productivity (tons per hectare per year) and fresh fruit quality. Two studies of the effects of chlorophenoxy propionic acid on inhibition of natural flowering extended findings presented at previous symposia. The overriding theme of Session VI was nitrogen, with particular emphasis on reducing nitrate in fruit destined for the cannery. Papers on plant protection ranged from relatively basic studies of nematode damage thresholds and etiology of fruit diseases to very applied work on the efficacy of pre-planting herbicides. Papers in the post harvest session dealt exclusively with fruit and storage issues that affect fruit perishability. At the closing session, the contributed papers were summarized by Keith Chapman. Dr. Hiran Hiranpradit presented the closing address.

A business session was held on the evening of the second day to discuss organizational issues and to review potential sites for the next symposium. Daniel Uriza and Andres Rebolledo, the representatives from Mexico, announced that they had authorization from their government to invite participants to Mexico for the next symposium. Duane Bartholomew was also asked to continue to serve as chairman of the Pineapple Working Group. These items were adopted as recommendations, which were presented to participants on the last day of the symposium. The recommendations were adopted.

Exciting progress in being made on genetic engineering of pineapple. Genetic transformation of pineapple has been achieved and genes have been isolated that are believed to have the potential to solve some of the more expensive problems confronting pineapple growers. There is good progress on genetically engineering pineapple varieties resistant to the pineapple closterovirus(es) (PCV) believed to be responsible for mealybug wilt, and to nematodes. Work is also far along on shutting down polyphenol oxidase, the enzyme(s) believed to be

responsible for blackheart development and on inhibiting ACC synthase, the enzyme that produces ethylene in the plant, which may inhibit natural flowering. However, the excitement is tempered by the reality that: 1) it has not yet been reported that PCVs are the sole cause mealybug wilt and mealybugs may need to be controlled even if PCVs are inactivated, and 2) no one knows what the effect of inhibiting ACC synthase will be (Can plants still be forced to flower? Will fruits ripen normally?). Further, many years of selection likely will be required to recover desirable clones from transformed tissue culture. All reports to date indicate that plants regenerated from tissue culture include some obvious off types, usually only a few percent, but from the growers viewpoint, even 1% may be unacceptable. Evaluation of potentially valuable new cultivars may be necessary to assure that desirable characteristics were not lost or undesirable ones introduced in cloning plants from single cells. In addition to the time required for selection, scientists in Cuba estimate in an abstract in this issue of Pineapple News that it will take about ten years to build up a population of plants for release to growers, even with the aid of efficient meristem propagation techniques. Regardless of the time and reservations, the potential benefits of this new technology are so great that researchers must continue their work to develop these disease resistant, more easily managed cultivars.

It would be a serious omission not to mention again the wonderful hospitality extended to participants by our hosts. A particular highlight was the reception and dinner on the evening of the first day. Participants were treated to Thai delicacies both in the form of food and entertainment. Classical Thai music and dancing were featured in the first part of the program. This was followed, in some cases only after considerable encouragement and drink, by semi-impromptu presentations by small or large groups of participants from many of the representative countries. There was some remarkable talent among the symposium participants and the festivities brought the sense of comradery among participants to a higher level than has prevailed in the past. An objective of each symposium has been to improve communication among scientists, extension workers and producers and it was evident at this symposium that that objective has been achieved.◆

ISHS Issues and News

The most recent issue of Chronica Horticulturae (V 38, No. 4), the newsletter of the ISHS, reported on the challenges and changes facing horticulture. Of relevance to PWG members are the recent World Conference on Horticulture Research (WCHR) and a draft Strategic Plan for ISHS. The sessions at the WCHR were 1) Global Horticultural Impact, 2) Challenges of Horticultural Research, 3) Needs and Expectations of the Horticulture-Related Industry, 4) Policy Development, and 5) The Future of Horticultural Research.

Growers and processors who sell pineapple on the world market are well aware of how large fluctuations in the supply of precessed fruit affect profitability. The availability and quality of research and information on pineapple culture also affects growers and most growers have had to deal with changes in government policies with regard to food safety and environmental protection. Material on some of those issues can be found elsewhere in this issue of the newsletter.

The most important item in the draft of the **ISHS Strategic Plan** is that symposium proceedings to be published in Acta Horticulturae be peer reviewed. The draft states that ISHS should:

> ["*work towards improving the quality of our Actas with respect to their scientific content. We should adopt the long-term aim of developing this series by a stringent peer review system to the point that Acta articles will be included in the ISI Science Citation Index.*"]

This change could enhance the quality of our symposium proceedings but might reduce the number of papers that could be published and delay publication.

Section 3.3.2 of the ISHS Strategic Plan, relating to Working Groups, has no changes that will have a large impact on PWG members. Proposed Actions that may be of interest to PWG members include:

> *Encourage WG members to become members of ISHS; and*
> *Produce newsletters from the Working Groups.*

PWG members who are not members of ISHS should consider joining the organization; a reduced rate is charged for members from some countries. Grower participation in ISHS is especially important to help keep the society relevant and sensitive to the needs of growers. If you are not a member of ISHS, please consider joining the organization. Since we presently have a newsletter and a web site, I would like to thank PWG members for their contributions to the newsletter.

Section 3.5, Relationship with the horticultural industry, acknowledges that "*The Hort industry is the last and most important step in the chain of users of ISHS activities.*" Actions are proposed that will enhance the relationship between ISHS and the Hort industry. Perhaps the PWG is unique with regard to the extent of grower participation at symposia. But the technological expertise of pineapple growers also is exceptional.

Section 3.7, Symposia organization, states "*there is variation in the quality of the organisation and in the scientific merit among meetings.*" The proposed actions that will benefit or impact the PWG include:

1. *Improve the guidelines for conveners of ISHS symposia;*
2. *Establish a better co-ordination among symposia conveners, the ISHS secretariat and Section and Commission chairs.*

For those considering joining the International Society for Horticultural Science, it is an organization of individuals, organizations and governmental bodies interested in the field of Horticultural Research and Horticulture in general. The ISHS is registered as a society in the Netherlands. To inquire about membership in the ISHS or to order publications of the society, write to: ISHS Secretariat, K. Mercierlaan 92, 3001 Leuven, Belgium (E-Mail: info@ishs.org) or visit our organizations web site at http://www.ishs.org/.◆

Contributions to Pineapple News

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

1. All contributions should be written in English. Assistance with editing is provided.
2. Preferred contributions are timely news about the pineapple industry within a country or region and abstracts or summaries of research on issues related to culture, processing, storage, and marketing of pineapple.
3. If possible, contributions should be submitted by electronic mail or on floppy disks as DOS (ASCII) text files or as Word or WordPerfect documents prepared on computers running Microsoft DOS or Windows programs. Printed copy should be clean so it can be scanned to speed conversion to a wordprocessor format.

4. Columns in tables should be separated with tabs; do not use Tables features of word processing programs. Photographs or image files that can be printed in black and white with a good quality laser printer (600x600 dpi) are acceptable.
5. Mail contributions and inquiries to: **D.P. Bartholomew, Dept. of Agronomy and Soil Science, Univ. of Hawaii, 1910 East-West Rd., Honolulu, HI 96822 U.S.A.** (Phone (808) 956-8708; Fax (808) 956-6539; E-mail: duaneb@hawaii.edu. ***Pineapple News*** is posted on the Web after publication at: http://agrss.sherman.hawaii.edu/pineapple/pineappl.htm.
6. **Address correction:** Please send mailing and E-mail address corrections to D.P. Bartholomew at the above address.◆

News From Australia

1998 Pineapple Field Day

Friday, July 17, 1998

Abstracts prepared from the Field Day reports by D. Bartholomew. Near-complete articles on Pineapple Mealybug Wilt, Phytophthora Root and Heart Rot, and Root Health in Pineapple are included for the benefit of readers with limited knowledge about these important problems.

Finalisation of EDB Position and Alternatives for Nematode Control

Col Scott, Horticultural Manager, Golden Circle Limited

Ethylene dibromide (EDB) will be deregistered on December 1, 1998 and unused stocks will be collected and destroyed. As of that date, only Nemacur® 100G and 400 EC and Metham Sodium will be available to pineapple growers for the control of nematodes. Nemacur® is available for application prior to and after planting (as a postplant spray). It was recommended that nematode monitoring be done and to only apply nematicides when monitoring indicates a need to for control measures.

Metham Sodium is registered in Australia for non-residual preplanting treatments for control of weeds, nematodes, symphylids, fungi, and soil insects. Metham sodium decomposes in the soil into methyl isothiocyanate, a volatile gas, which is the active substance. In moist soil, decomposition occurs within 14-21 days; decomposition time is longer in cold (< 8 °C) soil. Optimum temperatures are 10-32 °C at a depth of 8 cm.

Metham Sodium is corrosive to copper, zinc, and brass, has an LD_{50} (rats) of 820 mg kg^{-1} body weight, is toxic to fish and non-toxic to bees when used as directed. Allowable amounts for nematode control in Australia are 225-450 L ha^{-1}. With respect to Metham Sodium use, DO NOT apply to dry soil; DO NOT exceed quantities specified; DO NOT use in high winds; and DO NOT apply in low numidity or when the temperature is above 32 °C. Additional details on usage can be obtained from sellers. No data were provided on cost or effacacy, but at least some of these data should also be available from the manufacturer.◆

Minor Use Chemical Registrations - Maintain

Col Scott, Horticultrual Manager, Golden Circle Limited

Cloneprop®, which is manufactured in South Africa, contains the active constituent chlorflurenol. Multiprop® applied at 1.6 and 3.2 L ha^{-1} was compared with Cloneprop® at 1.6 L ha^{-1} at 10, 12, and 14 days after flower induction. Propagules produced at different times after induction were similar while mean propagules per plant were slightly higher for Clonprop® than for either quantity of Multiprop®.

Ed Note: *It was not clear from the article if the study was conducted in Queensland or in South Africa, but it was stated that the compound would be tested under Queensland conditions, and if Clonprop® has the potential to replace Multiprop®, registration of the chemical would be sought.*◆

Minor Use Chemicals

Shauna Dewhurst, Environmental Policy Officer, Queensland Fruit and Vegetable Growers

The minor use problem is characterized by the "scarcity of registered products available to many horticultural industries primarily due to the costs of research, data generation and registration being greater than the economic return to the chemical manufacturer." In Australia, the National Registration Authority has made off-label permits available to minor use industries. However, the current process required to secure a minoruse permit has limitations and generally has not been well understood by growers, the DPI, or the chemical industry. Inadequate use of the minor use process tempts growers to use unregistered products, and such use can have potential food safety and trade implications and can seriously damage industry credibility. The current trends toward Quality Assurance and Food Safety programs such as Approved Supplier, SQF 2000, and ISO 9002 will mean that any food safety violation such as the use of an unregistered chemical can be traced directly to the grower responsible. Growers cannot afford to have this happen. The issues hindering minor use approvals include: 1) data requirements for registration; 2) Absence of data protection for chemical companies; 3) Chemical industry liability; 4) Fees and time frames; 5) Lack of national coordination; 6) Absence of data; 7) Little awareness of the system; 8) Inconsistent State "Control of Use" legislation; and 9) Lack of communicating outcomes. The QFVG established a state-based working group to work on resolving problems associated with the availability of chemicals for use on minor crops.◆

HACCP and Horticulture

David Licence, Senior Quality Assurance Officer, Centre for Food Technology, Dept. of Primary Industries

HACCP (Hazard Analysis and Critical Control Point) is a method that identifies, evaluates and controls hazards to product specifications. The major factors that may cause producers to implement a HACCP plan include;

- increased demand from consumers and regulators for 'safe' food;
- some buyers of horticultural products require suppliers to have a HACCP plan;
- an increase in the 'minimally processed' market, which requires greater controls on product safety;
- an increasing uptake of SQF 2000 (SQF stands for Safe, Quality Food and is a HACCP quality system developed by AGWEST, http://www.agric.wa.gov.au/programs/trade/) by horticulture producers;
- the impending National Food Hygiene Standards, which will require all 'food businesses' to have a food safety plan.

Additional sections covered included What makes up a HACCP plan, Who checks the HACCP plan, HACCP and quality systems (ISO 9002, SQF 2000), and How to implement a HACCP plan.

Pineapple Promotions - How the Market is Responding

Loreena Kuss, Promotions Manager, Queensland Fruit & Vegetable Growers

Based on limited consumer research, the major strengths consumers associate with pineapple are unique flavor, juciness, and price. Drawbacks identified include difficulty in preparation and unreliability in fruit quality, particularly internal browning and sour bitter flavor. Inconsistency in pineapple fruit quality was found to be the major barrier to purchase. If the market for pineapple is to grow, fruit of good and consistent quality needs to be sent to the market because for every consumer gained by promotions, another may be lost because of a bad experience with a poor quality fruit.◆

Mealybug Wilt of Pineapple

J.E. Thomas*, C.M. Horlock, K.G. Thomson, R.G. Dietzgen and D.S. Teakle. *QHI, DPI, 80 Meiers Rd., Indooroopilly, Qld 400689.

Mealybug wilt of pineapple (MBW) was first described from Hawaii in 1910. Around this time, growers in south-east Queensland were also experiencing crop failures possibly due to MBW. The disease is now regarded as one of the major field diseases of pineapple worldwide.

Symptoms

The first symptoms are usually a reddening of the leaves, changing progressively to pink or yellow. The leaf tips die back, the leaf margins roll under and the leaves and plant wilt. When young plants are affected, fruit size is reduced and when plants develop leaf symptoms at flowering, little or no fruit set can result. Symptoms can take a long time (2-5 months) to develop, and are usually more noticeable under hot, sunny conditions than cooler, cloudy conditions.

Symptoms of MBW can be difficult to distinguish from those of phytophthora root rot. However, although the roots cease to grow in plants affected by MBW, they do not disintegrate to the same extent as those infected with Phytophthora and anchorage often remains strong.

Historical Aspects

Originally, through the 1930s and 1940s, MBW was thought to be caused by toxins that were injected into the plant as mealybugs fed. However, the observations that MBW could be induced by the feeding of a single mealybug, and that some pineapples were "negative source plants" while others were "positive source plants", lead to the conclusion that the causal agent was probably a virus. It is now generally accepted that virus(es) play a fundamental, possibly causative, role in MBW.

Control

The disease MBW is intimately associated with the presence of mealybugs. Two main species are involved: the pink pineapple mealybug (*Dysmicoccus brevipes*) which is generally found on the lower portions of the plant near or below ground level, and the grey pineapple mealybug (*Dysmicoccus neobrevipes*) which inhabits the upper parts including the crown and fruit. A close association with ants is required for mealybugs to thrive. Ants remove the honeydew that mealybugs produce when feeding, reducing the detrimental effects of sooty mould. They also protect mealybugs from predators and build protective mud encasements. Ants also may physically carry mealybugs to new locations. However, windborne young mealybugs (crawlers) are probably the predominant means of natural dispersal.

In the past, control of ants and mealybugs has formed the basis of MBW control. The disease often appears to move in from the edges of fields, as ants invade from outside the crop. Physical barriers such as wooden boards, coated with creosote or insecticides and erected as fences parallel to plant beds, act as effective deterrents to the movement of ants. Chemical control of both ants and mealybugs is also possible, but the required organochlorine and organophosphate insecticides are toxic and many are already banned.

The use of clean planting material is difficult because MBW-affected plants can sometimes recover to appear essentially healthy, but they can still act as sources for the further spread of the disease.

Current Research on MBW

Viruses of Pineapple

In recent years a number of viruses have been found in pineapple. All these viruses have the potential to be transmitted by mealybugs, but so far no definite role for them in MBW has been established.

Pineapple mealybug wilt associated virus (PMWaV) was first found in Hawaii in 1989 and its presence later confirmed in Australia. Subsequently, this virus has been detected in over 15 countries and probably occurs everywhere pineapples are grown. In Australia, we have shown that PMWaV appears to be present in all commercial pineapples, regardless of cultivar or locality, and irrespective of symptoms of MBW.

Further work in Australia and Hawaii has shown that PMWaV may actually be a group of related closteroviruses, rather than a single entity. A similar situation occurs in other crops, such as citrus and grapevine, and indeed members of the grapevine leafroll closterovirus complex are mealybug-transmitted.

A second type of virus, pineapple bacilliform virus (PBV) was found in Australia, also in a range of cultivars and districts in symptomless and MBW-affected plants. We have also detected this virus from overseas samples, and it is probable that PBV is also widespread wherever pineapples are grown.

Possible causes of MBW

It is still most likely that mealybug-transmitted viruses are intimately involved with MBW and there are several possible scenarios to be considered.

- pineapples may be commonly infected by a mild strain of PMWaV, and reinfection by a severe strain of the virus may cause the onset of MBW.
- mixtures of particular strains of PMWaV and/or PBV may be required for the onset of disease.
- infection by PMWaV and/or PBV may weaken the plant or predispose it to other stresses such as mealybug feeding, environmental factors or other as yet unidentified pathogens.

One practical difficulty in examining these hypotheses is that all commercial pineapples and all breeding lines that we have tested are virus-infected. We are investigating means of obtaining virus-free plants, so that we can then re-infest them with various combinations of viruses to see if we can induce MBW.

Future Prospects For Control Of MBW

Control of MBW has traditionally relied on the control of ants and mealybugs, usually by chemical means, and the selection

of "healthy looking" planting material. As mentioned previously, the long term prospects for chemical control are limited due to the toxicity of the products. The use of healthy-looking planting material is fraught with danger due to the possibility of MBW-affected material going through a recovery phase, but still acting as a positive source of the disease for further spread.

Our research at DPI on control of MBW has focused on obtaining clean planting material. Earlier research from Hawaii suggested that hot water treatment (40˚C / 60 min or 50˚C / 30 min) of pineapple crowns eliminated PMWaV and resulted in improved yields of MBW-free plants. Unfortunately, the existence of PBV was not known at this stage. We were unable to verify this report, as all surviving plants treated, up to the most extreme conditions we tested (60˚C / 120 min), still contained both PMWaV and PBV.

A more likely means of virus elimination is via tissue culture and this method has been successful with similar viruses in other crops, e.g. grapevine. Preliminary experiments are underway. In the first round of experiments, pineapple plantlets derived from meristem tips, lateral buds and callus were all still infected with both PMWaV and PBV. The current round of experiments is examining the use of smaller meristem tips with and without growth at elevated temperatures for virus elimination.

Future Directions at DPIQ

The future aims of our research on MBW are twofold.

1. To clarify the number of distinct viruses infecting pineapple and developing diagnostic tests for each of these. This work is necessary to elucidate the cause of MBW and to be able to ascertain the virus status of pineapple plants.
2. Developing lines of virus-free pineapple. This work is important for two reasons. Firstly, virus infection per se, even in the absence of disease symptoms, usually causes yield losses. This means that regardless of the cause of MBW, producing virus-free pineapple planting material should result in yield benefits. Secondly, we require virus-free plants to study the relationship between mealybugs, viruses and MBW.

Acknowledgments

Garth Sanewski (DPIQ) for the supply of pineapple germplasm and seedlings, Mike Smith (DPIQ) for assistance with tissue culture, and Col Scott (Golden Circle) for the supply of planting material and hot water treatment facilities.◆

Phytophthora Root and Heart Rot

K.G. Pegg*, S.H. Soo** and A. Drenth**
*Queensland Horticulture Institute, Department of Primary Industries, Indooroopilly
**CRC for Tropical Plant Pathology, The University of Queensland, St Lucia

Introduction

Pineapple root and heart (top) rot was first recognised by pineapple growers at Nundah in 1872. Henry Tryon, the plant pathologist who investigated the disease in 1887, wrote "The history of the disease supports the conclusion that the baneful effects of unsuitable soil can alone be exerted when special meteorological conditions obtain". He observed the importance of improving soil drainage to minimise plant losses and suggested "planting along the summit of an elevation caused by throwing the furrows in ploughing".

There is a clear association between drainage and disease incidence and severity. Therefore improving soil drainage through mounding remains fundamental to the successful control of the disease. This is despite the availability of metalaxyl and phosphonate fungicides. As the pathogen is so dependent on free water for dispersal and infection, improving soil drainage remains the major control measure. In recent years with increased plant populations, there has been a tendency to reduce the height of beds, thus decreasing drainage. Also, in recent years, the industry has moved into more poorly drained soils for pineapple growing.

Chemical control

Phytophthora diseases have always been considered difficult to control. This changed dramatically in the 1970s and 1980s when the acylanilide (metalaxyl [Ridomil®] and phosphonate fungicides became available. Until recently, Phytophthora control in pineapples has been satisfactory but lately control of Phytophthora incited diseases has been of concern to some growers. The aim of a current project funded by Golden Circle Ltd. is to determine the reasons for this poor control. Poor disease control may be due to changes in the Phytophthora population with respect to metalaxyl resistance and insensitivity towards phosphonates. As part of this project 24 farms have been visited in the first part of 1998, their root health assessed and soil samples collected for baiting and isolation of Phytophthora for subsequent fungicide sensitivity testing. Only two farms exhibited no visible sign of root rot out of the 24 farms visited. On the other farms, the degree of root rot ranged from the rotting of a few root tips, total absence of secondary and tertiary root systems, to complete degradation of the cortex and absence of any functional roots. There was evidence that increasing the rate of application of phosphonate or Ridomil®did not necessarily improve disease control.

Metalaxyl (Ridomil®). Metalaxyl is highly water-soluble, has good mobility in soils and is taken up readily by the roots and moved upwards in plants in the transpiration stream. Metalaxyl acts directly on Phytophthora to inhibit its growth and sporulation. *Phytophthora* spp. can become resistant to metalaxyl. Also, in some soils, it biodegrades rapidly due to a build-up of a bacterial and fungal flora capable of metabolizing metalaxyl.

Phosphonate. Phosphonate has high water solubility and is translocated in both the xylem and phloem of plants. Phosphonates control Phytophthora incited diseases by a combination of direct fungitoxic activity and enhancement of host defence mechanisms. They do not suppress populations of Phytophthora in the soil, but they reduce the ability of the pathogen to infect and colonise host tissues. When present in the plant in high concentrations, it acts directly on the pathogen to inhibit mycelial growth; at lower concentrations it disrupts the fungal cell wall inducing a more rapid host defence response. We are thus exploiting the unique ability of this chemical to enhance the natural defences in the plant. Phosphonate remains essentially inert in plants and persists in treated tissues until diluted or lost as the plant grows and senesces. In 1997 isolates of *Phytophthora cinnamomi,* which are less sensitive to Phosphonate in vitro, were recovered from avocado trees that were continuously injected with Phosphonate for some ten years. Despite this, disease control in avocado orchards is still excellent, perhaps due to the ability of Phosphonate to enhance avocado defence mechanisms. Less sensitive isolates were also recovered from pineapple farms which reported poor Phytophthora control. Average EC_{50} (effective concentration giving 50% reduction in growth in vitro) of isloates for farm A was 6 while that for farm B was 132. It is

clear that the Phytophthora isolates recovered from farm A are highly sensitive to phosphonate whereas the isolates from farm B show a reduced sensitivity towards phosphonate. More farms have been sampled and additional testing is underway to assess if a decrease in sensitivity is responsible for difficulties in Phytophthora disease control.

Objectives of current project

1. Establish base line sensitivity, expressed as EC_{50}, of *P. cinnamomi* towards phosphonate and metalaxyl using isolates of *P. cinnamomi* that have not been exposed to chemicals.
2. Determine EC_{50} values for metalaxyl and phosphonate for *P. cinnamomi* isolates collected from pineapple fields.
3. Establish if there is a relationship between poor disease control and decreased sensitivity to either phosphonate or metalaxyl.
4. Confirm the lack of cross resistance towards phosphonate insensitivity and metalaxyl resistance in the *P. cinnamomi* population.

The in vitro assays of phosphonate sensitivity in this project are solely aimed at measuring the direct effect of phosphonate on mycelial growth. If significant differences in sensitivity are identified inoculation assays involving pineapple plants with sensitive and less sensitive isolates will be required to determine if a direct phosphonate sensitivity test can be used as an indicator of poor disease control.

Future options

Disease control for Phytophthora heavily depends on metalaxyl and phosphonate. Therefore Phytophthora disease control will remain a challenge and some of the future options may include:

1. Genetically engineer resistance against Phytophthora. The recent development of a transformation system now makes it possible to introduce foreign genes into pineapples. Host resistance genes to Phytophthora have not yet been identified. However, genes encoding proteins with broad antifungal activity have recently been described (e.g. AFPs). It is possible that high and tissue-specific expression of AFPs may result in the production of commercially acceptable root-rot resistant pineapples.
2. Further intensification of natural defence mechanisms through the use of novel elicitors. Plants can be rendered resistant by artificially turning on their natural defence mechanisms. New defence response elicitors are becoming available for testing.
3. Exploit the biological activity of antagonistic microorganisms by stimulating soil biological activity, in general.

Phytophthora spp. exhibit poor growth and have low competitive ability in the presence of other organisms. They are primary rather than secondary invaders that attack healthy intact roots or fresh wounds but do not invade tissue previously invaded by other microorganisms. For example, soils amended with chicken manure significantly reduce Phytophthora root rot due to the stimulation of antagonistic spore-forming bacteria and actinomycetes. Amended soils also have improved aeration and drainage which will improve root growth and reduce plant stress.

Acknowledgement
We thank Golden Circle Ltd for funding this project.◆

Root Health in Pineapple

Graham Stirling, Biological Crop Protection Ply. Ltd., Brisbane

This is a significant year for the Queensland pineapple industry. The withdrawal of EDB marks the end of a 30 year period in which soil has generally been fumigated prior to planting pineapples. As we move towards a future in which nematode pests will have to be controlled by other means, it is perhaps worth reflecting on the general health of pineapple root systems at the end of the EDB era.

Surveys of Root Health

In an attempt to obtain better information on root health in pineapple crops, Eric Sinclair, Col Scott, Doug Christensen and myself have examined roots from several fields on more than 20 farms. Five plants were carefully removed at each site and various root parameters were rated on a 1-5 scale. Ratings from 106 observations were between 1 and 3 for rooting depth, root volume, functional roots, feeder roots and new roots (Table 1) and are indicative of poor root health. For other measurements, higher values indicate a greater proportion of the roots are galled, rotted or branched.

Table 1. Average ratings (1-5 scale) for eight root health parameters in plant and ratoon crops.

Parameter	Plant crop	Ratoon crop
Rooting depth	2.8	2.5
Root volume	3.0	2.6
Functional roots	3.3	2.1
Fine feeder roots	2.8	1.6
New roots	2.0	1.4
Galled roots	1.4	1.7
Rotted roots	2.0	2.9
Branched roots	1.8	1.8

It is apparent from the data that despite the widespread use of EDB, root health is generally poor. Most plant crops have acceptable root systems, but signs that root deterioration has commenced are readily apparent. There are relatively few fine roots and some primary roots are already non-functional. In the ratoon crop, it is almost impossible to find a crop with a good root system. Many roots have rotted or are branched at the root tip, there are few new roots and the volume of soil explored by the root system is often relatively small.

In addition to assessing symptoms on roots, we attempted to find possible causes of the poor root health. Unfortunately, this is only possible for pests that produce relatively distinctive symptoms such as witches brooming (symphylids) or galling (root-knot nematode). Branching was attributed to white grubs if the pest was found in association with the symptom. A summary of the data (Table 2) shows that nematodes and arthropods are not the only cause of poor root health in pineapple, as they explain only about half the problems. The high number of rotted roots and the lack of feeder roots suggest, for example, that soilborne fungi such as Pythium and Phytopthora are active in many fields.

One important lesson to come from this work is that despite 30 years of soil fumigation, root health in pineapple is generally poor. In fact, someone observing pineapple roots for the first time would be surprised at the level of productivity that growers are achieving. Our better growers are producing good crops on relatively poor root systems, which is testimony to their management skills.

The poor state of pineapple root systems should be a major concern to the industry, as it is probably the main reason that maximum productivity is not always achieved. Under ideal growing conditions, plants with poor root systems may still

produce high yields. However, in years of low or erratic rainfall, or in situations where management is sub-optimal, such plants yield poorly because they do not have enough functional roots to cope with additional environmental stresses.

Table 2. Percentage of sites where specific pests can be identified as contributors to poor root health in pineapple.

Pest	% of sites
Root-knot nematode	49
Galls caused by root-knot nematode	56
Symphylids	3
White grubs	10

These pests do not account for all root health problems. Other factors (e.g. root rotting, poor drainage, soil compaction) must therefore be involved.

Lessons from the Queensland Sugar Industry

The chronic root health problem that occurs in pineapple is often seen in other monocultured crops. Yield decline in sugarcane in Queensland is a similar problem. In fact, the poor roots often seen under sugarcane are superficially similar to those found on pineapple.

A major research program involving 15 scientists and costing more than one million dollars per year is currently investigating the causes of yield decline in sugarcane. The pineapple industry is unlikely to be able to support such a large research program, but because the basic causes of poor root health are similar for all crops, it can learn something from the results..

There is now a general consensus that the following factors are associated with poor root health in sugarcane:

- repeated culture of the same crop in the same soil (i.e. monoculture)
- low levels of labile (i.e. readily available) organic matter
- degradation in soil structure
- soil compaction
- acidification of soil
- lack of soil microbial activity
- activity of root pathogens (particularly nematodes and fungal pathogens)

The most important outcome to date is a recognition that pests and pathogens are not the only factors involved in poor root health. Many years of monoculture, excessive cultivation, high chemical inputs and removal of trash have left the sugar industry with soils that provide an ideal environment for pathogens. The sugar industry cannot expect to solve its yield decline problem by concentrating only on controlling pests and pathogens.

Options for Improving Root Health in Pineapples

The loss of EDB in the pineapple industry has caused many growers to demand access to an alternative fumigant. While this is an understandable reaction, the industry needs to consider whether it can afford to become dependent on another soil fumigant. We have lost four soil fumigants in the last 20 years and it is questionable how long the remaining fumigants will survive. Some effort must therefore be put into developing pineapple cropping systems that are less reliant on broad-spectrum chemicals, as they are detrimental to beneficial soil organisms.

Research on other crops has demonstrated that it is possible to create a soil environment in which roots are less likely to be severely damaged by pests and pathogens. The key to improving soil health is to increase levels of organic matter so that microbial diversity and activity is increased. Pests and pathogens are less likely to increase to damaging levels in a biologically active soil because they must then compete with a wide range of natural enemies.

Practices that have been employed to improve soil health in other cropping systems include:

- crop rotation
- green manuring
- minimum tillage to conserve organic matter
- improved drainage
- controlled traffic to reduce compaction
- trash retention and organic mulching
- use of specific rather than broad-spectrum chemicals

The challenge of the future is to incorporate more of these practices into the pineapple cropping system. Growers willing to accept that challenge are likely to face some unexpected problems. but the reward will be a healthier soil and crops with improved root function.◆

News From Canary Islands, Spain

Current State of Pineapple Cultivation in the Canary Islands

V. Galán Saúco, Departamento de Fruticultura Tropical, Instituto Canario de Investigaciones Agrarias, Apartado 60, 38200 La Laguna, Tenerife, Spain

Some 80 ha of pineapple are under cultivation in the Canary Islands, producing around 1.3 million kg in 1998 and expected to rise to 2 million kg by the year 2000. The island of El Hierro is the main producing area, with a few small plantings on Tenerife and Grand Canary islands. Preliminary trials of organically managed plantations show promise. Planting material is mostly a local selection of Red Spanish, bearing an attractive red-skinned fruit of around 1.5-2.0 kg in weight. Although more acid than the fruit of other cultivars (e.g. Smooth Cayenne) winter production of this local selection, under the subtropical conditions of the Canaries, has a better acidity:sugar relationship. Using ethrel induction, fruit is produced all year around, with 40% produced between January and June, 30% between July and September, and 30% between October and December. Suckers weighing approximately 400 g are planted during late spring to early summer at a density of around 36,000 plants/ha, usually in double rows (at times, triple rows) with wide aisles (60 to 100 cm) between each set of rows. Replanting is done every three years after the second harvest (P crop + Ratoon 1). Fruit is classified by weight — category A for fruit over 1.5 kg, B for fruit between 1.0 and 1.5 kg, and C for fruit less than 1 kg — and packed in cardboard boxes containing 11.5 kg net weight. As with other tropical fruits, fresh pineapple cannot be imported into the Canary Islands, so grower prices are good throughout the year (1-2.11 Euros/kg), particularly between October and March at an average of 1.5 Euros/Kg. Limited quantities are currently exported to the Spanish Mainland and Portugal, fetching wholesale prices of 1.5 Euros/kg, and initial market surveys in England, Holland and Germany indicate good prospects. The Islands could eventually expand to a planting surface of 400 ha but appropriate marketing campaigns would be needed to target potential consumers. The main problem at present is the chronic shortage of replanting material: there are no local commercial nurseries capable of producing the necessary quantity of suckers

and import is prohibited by law. The obvious solution is tissue-culture material but commercial techniques need to be further refined before *in vitro* plants can be provided on the scale required.◆

News From Costa Rica

Pineapple in Costa Rica

Franklin Benamburg.

The two main varieties grown in Costa Rica are Cayena Lisa (Smooth Cayenne) and Monte Lirio. Hybrids of Cayena Lisa are also grown, among them one known as the MS-DOS. The main regions where pineapple is produced and the area planted are shown in Table 1.

Table 1. Area of production in hectares of Monte Liro (ML) and Cayena Lisa (CL) pineapple in Costa Rica.

Region	City	ML	CL
North	San carlos	593.73	81.50
	Grecia	394.07	131.55
	Los Chiles	2.40	58.50
	San Ramon	8.10	1.60
	Guatuso	21.80	160
	Sarapiqui	197.58	14.97
South	Buenos Aires	2622.60	0.00
	Perez Zeledon	20.00	0.00
Atlantic	Siquirres	46.85	0.00
	Central	5.25	0.00
	Matina	1.50	0.00
Total		3914	448

Data from the National Department of Agriculture and Cattle, for the year of 1993. The production for 1993 according to that department, was 159,770 MT.

Only the fruits that are not of first quality are processed in Costa Rica. Premium fruits are sold out of the county by multinational companies like Del Monte's PINDECO. PINDECO.is the number one exporter of fresh pineapple with a total area of production of 7000 acres. Most producers of pineapple in Costa Rica plant pineapple in single, twin, or three to four row systems. With these three systems they typically plant 80,000 pineapple plants ha^{-1}.

Scientific research:

In Costa Rica a lot of engineers and scientifics are working in different and clean ways of using agricultural wastes. Pineapple leaves, crowns and peel are wastes that can generate new sources of work for the country. Examples are:

The plastification of ligno-celulosic wastes from pineapple peel. This work was carried out by three professionals of the Chemistry Department of the National University of Costa Rica.

Morphological study of the crude and delignized pineapple peel fiber. This was a work of professionals from the National University of Costa Rica (UNA) and The University of Costa Rica (UCR).

Chemical modification of the pineapple cellulose and generation of the Cellulose acetate from delignized pineapple fiber. Chemistry Department of the National University of Costa Rica.

Generation of carboxymethyl cellulose from pineapple fiber. Chemistry Department of the National University of Costa Rica.

Generation of paper pulp from the crowns and leaves of pineapples. Thesis of Chemical Engineering of the University of Costa Rica (UCR).◆

News from Cuba

Purification Alternatives of Obtained Bromelain From Different Sources

Martha Hernández[1], Carol Carvajal[1], Ramón Santos[1], Margarita Márquez[2], María Blanco[1], Justo González[1], María Chávez[2]. ([1] Biochemistry Laboratory, Centro de Bioplantas. Universidad de Ciego de Avila. Carretera a Morón km 9, CP 69450. Ciego de Avila. Cuba; [2] Protein Laboratory, Facultad de Biología. Universidad de La Habana, calle 25, # 455, Vedado, C.P. 10400, Ciudad de La Habana. Cuba.

Abstract: Pineapple plants contain several cysteine proteinases, of which the major component in stem extracts is the so-called "stem bromelain". In recent years, applications of plant proteases in food, pharmaceutical and biotechnological industries have reached high levels. Therefore, considerable attention has been focused on the possibility of applying efficient plant tissue culture methods to isolate physiologically active enzymes. Bromelain crude extract from pineapple stems was obtained through a simple and novel experimental procedure, which was afterward purified by using Sephadex G-100 gel filtration chromatography. As a result, yields ranging 66.4% (2.1 pure) were reached. Alternative purification scheme based on CMC-52 cationic exchanger provided similar results as well as higher yields (77.13 %). These results were verified through a PAGE-SDS electrophoresis band close to 25 000 Da. An alternative procedure for bromelain isolation schedule was carried out, consisting of enzyme precipitation from liquid media used as temporary immersion system for pineapple propagation, leading to specific activity values of 0,59 U/mg protein. In addition, HPLC chromatograms showed few protein contaminants in TIS media, which means that of proteins in the TIS liquid media, therefore the obtained enzyme by this procedure have a similar isolated enzyme also a similar purity than former chromatographically obtained sample. (A copy of the full paper may be obtained from the authors.) ◆

News from Italy

Pineapple Mechanization Listserve

Dr. Francesco Garbati Pegna, Dipart. di Ingegneria Agraria e Forestale, Univ. degli Studi di Firenze, P.zle delle Cascine, 15 50144 Firenze, ITALY; E-Mail: garbati@diaf.agr.unifi.it

A pineapple mechanization listserver has been established at Univ. degli Studi de Firenze. Dr. Garbati Penga states "I think for a while it will be limited to a small number of persons, since pineapple mechanisation is not such a widespread subject, but I'm publicizing the list around." To subscribe to the listserve, send an E-Mail message to PINEMECH-L@UNIFI.IT with the word **subscribe** in the Subject area of the E-Mail window. If you want a list of the functions available just send the message HELP to the address LISTSERV@UNIFI.IT.◆

News From the United States (Hawaii)

Pineapple is Hawaii's Most Valuable Crop

Duane Bartholomew

Statistics of Hawaiian agriculture show that pineapple was Hawaii's most valuable crop in 1997, the latest year for which

data were available. Production for 1997 was 324,000 U.S. tons, a record low. Farm-gate value, the federal standard for valuing agriculture production before processing, was $91.7 million while sugarcane, the next most valuable crop, was valued at $85.5 million. Doug Schenk, President of Maui Pineapple Co. told a Honolulu Advertiser reporter that prices and demand for canned fruit remained high throughout 1998 and yields on the plantation's 10,000 acres were higher than expected. The production at Maui Pineapple Co. was only valued at $28.3 million in 1997 while revenues for the company were $91 million, reflecting the increase in value due to processing. In 1998, revenues increased to $98 million. Brian Nishida, Vice President at Del Monte Fresh Fruit Hawaii, told the Advertiser that Del Monte had expanded to 2,000 additional acres formerly used to grow sugarcane. Del Monte and Dole, both on Oahu, grow only for the fresh fruit market and farm approximately 11,000 acres. Del Monte's new 'Gold' hybrid is well accepted in the market place and Dole and Maui Pineapple Co. are scaling up plantings of new fresh fruit varieties.◆

Weed Management in Pineapple

In conjunction with the development of IPM guidelines for pineapple, Dr. **Joe DeFrank** (Weed Specialist, Dept. of Horticulture, Univ. of Hawaii, Honolulu, HI 96822) has written the following general guidelines for weed control in pineapple. While the recommended practices assume growers use plastic mulch and can promote weed germination with irrigation, the principles are applicable where the crop is rainfed and no mulch is used.

Apply pre-emergence herbicide in critical areas and before canopy closure: Pre-emergence herbicides (typically in Hawaii bromacil and diuron) should be applied after planting to the between row space on a field-by-field basis. Pre-emergence herbicides should be applied based on field scouting reports to match rates of application to areas where the most difficult to control weeds occur. Pre-emergence herbicide rates can be reduced by forcing weeds to grow after the in-row plastic mulch is installed but before planting pineapple. Many difficult to control weeds such as morning glory can be germinated with sufficient amounts of irrigation and then killed with a contact herbicide. Pre-emergence herbicides applied after weeds are killed will be more effective due to less weed seeds being present. Herbicide rates may be significantly reduced if current use patterns are based on the control of weeds that could be easily removed by this pre-plant treatment. Spot treat remaining open areas with pre-emergence herbicides after the majority of the field has achieved a closed canopy.

After the final crop harvest, prevention of seed formation from weed escapes is very important in reducing herbicide use in subsequent crops. Weeds should be killed with contact herbicides before the field is plowed or disced. Intact weeds will be more completely killed than weeds with disturbed roots caused by a disc harrow or similar tool. The plantation should consider chopping or mowing the standing pineapple to provide a surface mulch for long-term weed suppression during fallow periods. Mulched fields would also retain more moisture for subsequent crops, allow more rainfall infiltration, reduce runoff and help to mitigate fugitive dust.

Pre-emergence herbicides should not be applied to fallow fields unless there is assurance of activation with either rainfall or overhead irrigation. Pre-emergence herbicides applied and not activated within 2-3 weeks will be reduced in effectiveness via photo decomposition or volatilization. Pre-emergence herbicides applied to fallow fields can be easily lost to wind or water erosion. Soil particles laden with pesticide residue can represent a non-point source of pollution. Spot applications of contact herbicides to weeds would be preferred to blanket pre-emergence application in fallow fields.

Monitor and establish weed maps to determine which weeds are dominant in specific sites: Fields should be scouted to determine which weeds are dominant in specific sites. Individual weed species should be categorized with respect to sensitivity to registered preemergence herbicides. Herbicide rates should be adjusted for each field and based on weed populations present so that the minimum amount of herbicide is used at each location.

Use cover crops to minimize weeds that could host pineapple pests, or to depress nematode population, or to increase nitrogen levels: Cover crops can suppress weeds and soil-borne diseases during fallow periods. Brassica cover crops are used for nematode and disease suppression. Furthermore, Sudan grass cultivars are used as cover crops for the suppression of nematodes during the fallow period.

Calibrate sprayers accurately annually: Sprayer calibration is important for several reasons: 1) to obtain the performance of a pesticide as specified on the product label, 2) to be able to repeat successful procedures and minimize expenses, 3) to diagnose problems with failure in product performance or crop injury, 4) to be able to document legal doses applied when using "Restricted Use Pesticides."

For the accurate application of pesticides, certain considerations should be taken into account. This would include such things as: 1) volume required to cover a known surface area with a specific type of spray equipment, 2) amount of pesticides recommended on an area basis, 3) formulation or concentration of the commercial pesticide, 4) size of the tank from which the pesticide is being delivered, and 5) ability to maintain consistent spray pressure, ground speed and proper nozzle height for recommended overlap.◆

Efficacy of Telone II EC

Brent Sipes, Dept. of Plant Pathology, CTAHR, Univ. of Hawaii, Honolulu, HI 96822.

Efficacy of postplant Telone II EC is similar to standard plantation practices. Postplant Telone II EC treatments produce more fruit in the 2.5 and 2T ranges than untreated plots. The plant crop fresh fruit size distribution is also similar between Telone II EC treatments and standard plantation practices. DiTera, Nematrol, and Sincocin were compared to Nemacur for control of anthurium decline in two field tests. Reniform nematode and PMWaV affect pineapple growth more when they occur together than when either pathogen occurs alone.◆

Effect of Tebuconazole on Natural Flower Induction

Glenn Taniguchi, Dept. of Plant Pathology, CTAHR, Univ. of Hawaii, Honolulu, HI 96822

It was reported previously in Pineapple News (V. III, No. 1) that the incidence of natural flower induction (NI) of a Smooth Cayenne (SC) clone was reduced as a result of dipping crowns in

solutions containing the fungicide tebuconazole. However, the plots were relatively small and the incidence of NI was low in control plots. In a more recent test, crowns of SC and a hybrid clone were dipped in solutions containing 500, 250, 150, 75, 25, or 12.5 ppm (a.i.) tebuconazole to control Ceratocystis butt rot. Butt rot was controlled at the lowest concentrations used. Plant stunting was obvious at concentrations above about 75 ppm and increased in severity with increasing tebuconazole. No natural induction (NI) occurred in SC plots, but the hybrid, which was about one month older than SC, had nearly 100% NI in control plots. Mean NI percentages for the hybrid in the treatments were: 500 ppm, 48; 250 ppm, 90, 150 ppm, 94; 75 ppm, 98; and 25 ppm, 100. The higher levels of tebuconazole reduced the percentage of NI, but stunting was severe. Sucker production was induced in most plants treated with 500 and 250 ppm tebuconazole, suckers as well as mother plants initiated flower development, and fruit eye numbers are reduced at the highest levels of tebuconazole. Data on fruit weight will be collected in June of 1999.◆

Maui Pineapple Co. Achieves IPM Certification

Jari Sugano (suganoj@avax.ctahr.hawaii.edu) and Ronald F.L. Mau (maur@avax.ctahr.hawaii.edu). Dept. of Entomology, University of Hawaii, Manoa, Honolulu, HI 96822

As noted in Pineapple News (No. 5), the U.S. Department of Agriculture provides funds to help state extension programs work with growers to develop IPM programs. Hawaii's pilot project began as a partnership between the College of Tropical Agriculture and Human Resources (CTAHR) and Maui Pineapple Company. IPM guidelines were prepared jointly by CTAHR personnel and Maui Pineapple Co. To receive certification, growers must acquire 80% of the total points established in the program. It was recently announced after a review of progress at Maui Pineapple Co. that the company had received certification as an IPM grower. The primary motivation is environmental stewardship, but the potential exists for premium price incentives for growers meeting IPM standards. No other pineapple company is currently seeking certification as an IPM grower. Maui Land and Pineapple Co., the parent company, has a long history of environmental stewardship. The company recently set aside a large reserve in the West Maui mountains that is being jointly managed by the company and environmental organizations to protect habitat of endemic species there.◆

Chlorflurenol Available for Commercial Production of Pineapple Planting Material

N. Bhushan Mandava, Repar Corporation, Silver Spring, MD 20914, USA

Smooth Cayenne pineapple (*Ananas comosus* L. Merr) is self incompatible, producing seedless fruits. In the absence of seeds, pineapple must be propagated from vegetative parts, such as as slips or crowns. High yielding Smooth Cayenne varieties grown commercially produce very few slips. Therefore, the principal source of the planting material is the fruit crown.

Pineapple production systems can be broadly divided into two types, cannery and fresh fruit operations. In cannery operations in Hawaii, crowns removed from the fruit before processing commonly serve as a source of planting material. In fresh fruit operations, the crown is sold with the fruit so pineapple growers must rely on slips for their planting material.

Chlorflurenol is very useful for producing the planting material where most of the pineapple is sold fresh. Maintain® CF-125 (containing chlorflurenol as an active ingredient) is the only product registered in the United States for application to pineapple for the commercial production of sliplets for use as pineapple planting material. Currently, Maintain® CF-125 is used by pineapple growers in United States and a few countries in Central and South America.

Maintain® CF-125 is applied at 0.6 to 1.2 kilograms active ingredient in 2000 to 3000 liters of water per hectare to vegetatively mature plants in combination with ethephon. A second application may be made after about 10 days. Chlorflurenol is applied 6 to 8 months prior to harvesting the planting material.

Chlorflurenol (as Maintain®CF-125) results in the production of uniform and quality planting material. This chemical is a critical and cost-effective component in a fresh fruit production system. Chlorflurenol-induced production of pineapple planting material is a unique phenomenon in agriculture and is superior to non-chemical alternatives such as stump sectioning and meristem tissue culture. For further information on Maintain®CF-125 and Chlorflurenol, please contact: Repar Corporation, P.O. Box 4321, Silver Spring, MD 20914, U.S.A.; Telephone: 202-223-1424; Fax: 202-223-0141: E-Mail: mandava@compuserve.com.◆

Abbreviated Abstracts of 3rd Symposium

Abstract titles, authors and abbreviated summaries of the abstracts of scientific papers submitted for presentation at the 3rd International Pineapple Symposium are provided here for the benefit of readers who were unable to attend the meeting. Not all authors were able to attend the meeting. With apologies to the authors for errors of omission or misrepresentation of content, the abstracts were condensed to provide the maximum content in the limited of space available in the newsletter. Readers can contact the authors for more details or await publication of the proceedings in Acta Horticulturae.

Oral Presentations

Global Network for Pineapple Research

Eric Malézieux, CIRAD BP 5035, 34032 Montpellier, France

The pineapple market is now worldwide and highly competitive. However, resources for pineapple research have significantly decreased these last years in numerous countries, probably in relation to lower profits. In addition, public research do not always meet private needs for pineapple development. Biotechnologies might provide solutions for specific problems such as particular pest and disease susceptibility, flowering control or fruit quality problems. Countries like USA and Australia have invested significantly in this area. However, genetic engineering requires major investments and many intellectual and germplasm property issues are still unresolved. In the context of trade globalization, solutions will not be easy to find. On the other hand, conventional breeding is still of great importance for fresh fruit market growth and diversification. Private ownership of germplasm is a key issue for pineapple trade, and more specifically for the integration of the small farmer communities from developing countries in this world trade. Environmental issues are not high priorities in a most countries. Nevertheless, global pressure on agriculture should rapidly raise these questions in an increasing number of sites. Erosion, nitrogen and pesticides pollution are important risks in pineapple cultivation and pineapple-based farming systems should evolve significantly in this regard. Collaborative effort is needed to create common tools and methodologies to develop more environmentally friendly pineapple farming systems adapted to diverse environmental and socioeconomic conditions. In any case, integration of public effort and private needs

(companies, consumers and farmers) require specific attention in the future. The paper suggests collaborative priorities and mechanisms to enhance cooperation for pineapple research.

The Australian Pinapple Industry

G. Sanewski (Queensland Horticulture Institute (DPI), PO Box 5083, SCMC, Nambour, Qld. 4560) and C. Scott (Golden Circle Ltd. PO. Box 106, Virginia, Qld. 4014)

In Australia, 327 growers produce about 125,000 t of pineapple and 100,000 t are processed by one processor, Golden Circle Ltd. The remaining 25,000 t is sold on the domestic fresh market with about 70% being packed and marketed through 1 of 4 packhouses. Plantings for processing have declined over the last 4 years but have now stabilised. There are good prospects for expansion of the fresh sector. The industry has a strategic plan to guide its development through to the next century. The industry vision is "*To be recognised as an innovative and unified pineapple industry by improving existing and creating new and exciting products which delight customers, increase demand and continuously improve the sustainability of the Queensland pineapple industry and grower wealth*". The strategic plan addresses long and short term problems and opportunities and has a major emphasis on industry cohesion and quality assurance. Revitalisation of the fresh market sector is a major priority. However, the most pressing problem is the imminent withdrawal of the soil fumigants EDB and methyl bromide. Phytophthora control is an emerging issue. The major research and extension programs include, genetic improvement, quality assurance training (to SQF 2000 standard) for growers, EDB replacement, the development of nematode monitoring protocols, and research on mealy-bug wilt and Phytophthora root and heart rot control.

Status of the Pineapple Industry in Malaysia

Y.K.Chan (Horticulture Research Centre Malaysian Agricultural Research and Development Institute (MARDI) G.P.O. Box 12301, 50774 Kuala Lumpur, Malaysia)

Malaysia, one of the top pineapple producers in the world in the 60' s, has a relatively modest industry today. Currently only about 10,000 ha is planted to pineapple, half by two estates that grow pineapple for canning. Canned pineapple production from 1990-1996 ranged from 2.1-2.7 million standard cases and major export markets are Japan, USA and the Middle East. Fresh pineapple production involves only smallholders on 2 000 - 3 000 ha. Fresh pineapple export volume less than 30 thousand t/y, mostly to Singapore. However, with the introduction of the new hybrid Josapine in 1996, the market for fresh pineapple is expected to increase.

The Pineapple in Mexico: Current Status and Prospects

M.A. Rebolledo, D.E.A. Uriza and M.L. Rebolledo (Campo Experimental Papaloapan, CIRGOC, INIFAP, Apdo. Postal#43, CP95641, Cd. Isla, Veracruz, Mexico)

Mexico ranks 7th in the world in pineapple production with 540,000 t/y fruit produced in 10,500 ha (70% is consumed locally as fresh fruit, 25% is processed, and 5% is exported to USA and Canada). Main areas of production are Veracruz, Oaxaca and Tabasco states with 74, 12 and 10% of total production respectively. The main clone is 'Smooth Cayenne'. The supply of fruit is average from the end of October to May, fruit is scarce in August and September and excess fruit is available in June and July. There are about 2,500 pineapple producers in Mexico, each farming 2 to 5 ha and 100 producers and 5 pineapple companies with 25 to 300 ha. The planning, scheduling, and fruit sale are done independently by each grower. Average plant population on 80% of area is 27,500 plants per ha, 10% use 35,000 plants/ha and only 10% plant more than 50,000. About 10% of the area is irrigated and a spray boom is used on approximately 2,000 ha. In the future, more Mexican producers could grow pineapple because new technology allows competitive production and close proximity to the USA and Canada provides a ready market for fruit.

Pineapple Production and Industry in Taiwan

Chin Ho Lini (Department of Botany, National Chung Hsing University, Taiwan) and Chyn-Ching Chang (Department of Horticulture, Chiayi Agricultural Experiment Station, Taiwan Agricultural Research Institute, Chia-Yi, Taiwan, R.O. China)

The pineapple industry of Taiwan produced mainly canned product for export from 1956 to 1976 and production peaked around 1971. The industry now produces for the domestic fresh market and the varieties grown have changed from almost 100% Cayenne to only 75% today, with new varieties for fresh consumption comprising the balance. Industry challenges are international competition, environmental regulation, and market competition from other fruit crops.

The Hawaiian Pineapple Industry

Kenneth G. Rohrbach (University of Hawaii, Honolulu, HI, USA)

Hawaii's proportion of the world pineapple production has declined steadily during the past 38 years and in the last 15 years, its products have changed from canned to fresh market. Total fruit tonnage dropped from 884,000 in 1960 to 347,000 in 1996. Productivity increased from 11.8 tons per acre per year in 1960 to 17.3 tons in 1996. The pineapple industry currently is the second most important agricultural industry in the State with a 1996 annual farm gate value of $ 95,914,000 and a cultivated area of approximately 20,000 acres. The total value including fresh market and processed (farm gate plus value added) is approximately $ 135,000,000.

Pineapple Industry in Thailand

Prasert Anupunt and Pornprome Chairidchai (Horticulture Research Institute, Dept. of Agriculture, Bangkok 10900 Thailand), Aporn Kongswat (0ffice of Agricultural Economics, Bangkok 10900, Thailand), Somporn Isawilanon and Suranant Subhadrabhundu (Kasetsart University, Bangkok 10900, Thailand) and Smarn Siripat (SAICO, Rayong, Thailand)

The pineapple industry in Thailand started during the 1970s and is now one of the major producer and exporter of pineapple in the world. During the past 5 years, the average production is 2 million tons per year. Plantations and farms are located in thirteen provinces mainly on the east and the west coast of the Gulf of Thailand. Total area in crop is approximately 100,000 ha, smallholders make up more than 95% of the total producers and they occupy from 1 to 5 ha. of land. Eighty percent of the production is for canning and the rest is mainly for domestic fresh consumption. The production has been a free enterprise but gradually becomes a contract business. The Department of Agriculture, the major organisation conducting research, has prepared guidelines for good agricultural practices (GAP) for the growers. The guidelines aim at improving production efficiency while being environmentally safe. Thai pineapple factories have also adopted good manufacturing practices (GMP) and some of them have been awarded the ISO certificate.

Management of a Multiple Goal Pineapple Genetic Engineering Program

Kenneth G.Rohrbach, David Christopher, John Hut, Robert Paull, and Brent Sipes (University of Hawaii),
Chifumi Nagai (Hawaii Agriculture Research Center), Paul Moore (Agricultural Research Service, USDA), Mike McPherson and Howard Atkinson (University of Leeds), Calvin Oda (Del Monte), Herve Fleisch (Maui Pineapple Company, Ltd.), and Mike McLean (Dole Foods Hawaii)

The pineapple genetic engineering program, with goals of nematode resistance, pineapple mealybug wilt virus resistance, flowering and fruit ripening control, and fruit quality, was initiated in 1995. The program is a multi-institution, inter-disciplinary program that will be judged by how well the technologies being developed solve the problems being addressed. The Hawaii pineapple industry role in this program is crucial to the final product development (e.g. patenting and licensing).

Cloning and Characterization of a Novel Plant Gene Encoding a Copper Amine Oxidase

Andrew M Plume, Antonino S. Cavallaro and Jose R. Botella (Plant Genetic Engineering Laboratory, University of Queensland, Brisbane, Qld 4072, Australia)

We have isolated a novel cDNA clone (*acpcaol*) encoding a copper amine oxidase homologue (PCAO; EC1.4.3.6) from auxin induced pineapple leaf tissue by reverse transcription coupled to polymerase chain

reaction (RT-PCR) using degenerate primers. The potential application of this gene in pineapple molecular improvement is discussed.

The Development of Blackheart Resistant Pineapples Through Genetic Engineering

Michael Graham, Vanessa Hardy, and Marcelle Jobin (Qld Agricultural Biotechnology Centre, QDPI, Gehrmann Lab, Level 4, The University of Queensland, St Lucia, Qld, 4072, Australia),
Lien Ko and Mike Smith (Maroochy Research Station, QDPI, PO Box 5083 SCMC, Nambour, Qld, 4560, Australia), Simon Robinson and Brett Sawyer (CSIRO Division of Plant Industry, GPO Box 350, Adelaide, SA, 5001, Australia), Tim O'Hare (Gatton Research Station, QDPI, PO Box 241, Qld, 4343, Australia), and Janelle Dahler and Steven Underhill (Redlands Research Station, QDPI, PO Box 327, Cleveland, Qld, 4163, Australia)

Blackheart is induced by prolonged exposure to cool temperatures. Blackheart is induced by refrigeration and in Australia is induced in the field during cooler winter months. Tissue discolouration in horticultural crops is frequently associated with the activity of polyphenol oxidase (PPO). PPO activity increases dramatically in fruit in association with pulp discolouration, and the increased activity occurs only in discoloured pulp. Control of blackheart will be attempted by inhibiting PPO expression in transgenic pineapple plants. PPO genes have been isolated from pineapple tissues using PCR with redundant oligonucleotides and have cloned a cDNA that is specifically induced in blackheart affected fruit. Suitable promoters to drive gene expression in pineapple have been defined and constructs suitable for transformation have been prepared. An efficient plant regeneration system has been developed using callus from leaf bases of *in vitro* grown plantlets. Transformation is by micro-projectile bombardment of callus and on Agrobacterium-mediated gene delivery to leaf bases, from which we generate stable transformed regenerable callus. Several putative transformation events were obtained in two seperate experiments, transformation has been confirmed by PCR analysis and shoots have been regenerated from this material. For Agrobacterium, putative transformed callus has been regenerated that strongly expresses the GFP marker gene.

Study of Variability in the Genus *Ananas* and *Pseudananas* using RFLP

M.F. Duval and J.L Noyer (CIRAD, BP 5035, 34032 Montpellier, France), P. Hamon (USTL, Montpellier, France) and G. Coppens d'Eeckenbrugge (CIRAD-FLHOR/IPGRI, Cali, Colombie)

Of 500 colonies in the genus *Ananas* and *Pseudananas* studied by restriction fragment length polymorphism (RFLP), 25 were both polymorphic and represented low copy number sequences. First results for a set of 320 clones from CIRAD-FLHOR (Martinique, FWI) and EMBRAPA-CNPMF (Cruz das Almas, Brasil) collections, most from recent collecting trips in Brasil, French Guyana and Paraguay, analyzed by Nearest Neighbour Joining on Dice index show that variability is continuous. Species defined using Smith and Downs classification (1979) do not appear as separate entities and show large diversity intra-species, especially in the species *Ananas comosus* and *Ananas ananassoides*. Within *Ananas comosus*, varieties defined on the basis of leaf characters as piping or smooth do not appear homogenous. Thus, considering the high mutation rate in vegetative reproduction, this could be due to occurrence of similar mutations in different genetic backgrounds, or to sexual recombination.

Breeding for Early Fruiting in Pineapple

Y.K. Chan and H.K.Lee (Horticulture Research Centre Malaysian Agricultural Research and Development Institute (MARDI) G.P.O. Box 12301, 50774 Kuala Lumpur, Malaysia)

Fruit development in pineapple may be divided into the phases planting to 'forcing' (flowering hormone application)' 'forcing' to appearance of 'redheart' and 'red-heart' to fruit harvest. Early fruiting F^1 progenies were little different than standard cultivars in time from 'forcing' to 'red-heart' and also from 'redheart' to fruit harvest. Thus, early fruiting plants will have a reduced growing period from planting to 'forcing' and should, therefore, bear economic-sized fruit on small plant mass. For most pineapple genotypes evaluated, fruit weight was linearly related to plant weight. However, the hybrid A0416 was unique because it had the highest mean fruit weight but the smallest plant mass and a very high fruit to plant ratio of 0.6 while others usually have half this value. With A04-16, crop cycle time can be reduced because economically sized fruits were produced on relatively small plants. There is potential for an annual cropping pineapple by 'forcing' 6-7 months after planting and harvesting the fruits 5 months later.

Pineapple Breeding at CIRAD. Evaluation and Selection of 'Smooth Cayenne' x 'Manzana' Hybrids

Franck Marie and Geo Coppens d'Eeckenbrugge CIRAD-FLHOR, BP 153, Fort-de-France, Martinique, F.W.I.

Around 1990, 700 'Smooth Cayenne' x 'Manzana' hybrid clones were taken from Cote d'Ivoire to Martinique for further selection for the fresh fruit market or for processing. Many clones were discarded due to defects. The remaining 205 clones had good vigor, a shorter cultivation cycle, and high sugar content but all but 29 were discarded because of defects. Selected clones had less suckers at harvest, which was compensated by a faster growth and higher production of suckers after harvest. Shell and flesh maturation is uniform within the fruit, external color is highly variable, gustative quality is improved due to higher sugar than in 'Smooth Cayenne', while acidity is lower or equivalent Ascorbic acid is also higher, with 3 or 4 times values observed for 'Smooth Cayenne'. Hybrids often produce heavy fruits on long peduncles, which makes them susceptible to lodging. Most hybrids are susceptible to *Penicillium funiculosum*.

Brief Review of Some Methods to Obtain Pineapple Haploid Plants

Reinerio Benega, Aroldo Cisneros, Julia Martinez, Elizabeth Arias, Marcos Daquinta, Miguel Hidalgo and Miriam Isidron (Bioplants Center, Laboratorv for Genetic Improvement, University of Ciego de Avila (UNICA), 69450, Ciego de Avila, Cuba)

Anther and ovule culture, in situ parthenogenesis induced by irradiated pollen and intergeneric crosses are being used to develop haploid plants. Methods for anther and ovule culture include: developmental stage of the microspores and embryo sac, and media and culture conditions to get plantlet regeneration via callus induction. On *in situ* parthenogenesis the pollen viability and pollen tube length were dose dependent. The pollination, using pollen-irradiation has been done on Smooth Cayenne cv. 'Serrana' and Red Spanish. Doses up to 250 Gy were not adequate to get seeds showing embryos. Some plantlets regenerated in the different irradiation doses showed phenotypes with small and thin leaves and short internodes. The first haploid plantlets were achieved using intergeneric crosses, Smooth Cayenne cv. 'Serrana' as female parent and 'Curujey' (*Tillandsia fasciculata* Sw) as male parents.

Hybridization in Pineapple Results and Strategies to Save Time for Obtaining and Releasing New Hybrid Varieties for Growers

Reinerio Benega, Aroldo Cisneros, Miguel Hidalgo, Julia Martinez, Elizabeth Arias, Mayda Arzola, Carol Carvajal and Miriam Isidron (Bioplants Center, Laboratory for Genetic Improvement, University of Ciego de Avila (UNICA), 69 450, Ciego de Avila, Cuba)

The pineapple hybridization program in Cuba, started in 1991, included studies on synchronization in floral opening, time for hybridization and number of seed set in parents. The characteristics of twelve individuals obtained from Smooth Cayenne cv. " Serrana" and Red Spanish crosses on second vegetative generation have been identified. The modifications made on traditional selection schemes of hybrid production, using in vitro micropropagation techniques and temporary immersion systems from second and third vegetative generation will reduce the time to release of new varieties by more than five years; new hybrids could be available for growers after ten years.

The Pineapple *Ananas comosus* cv. Bouteille, A Guadeloupean Originality

Patrick Fournieri (Departement des Productions Fruiteres et Horticoles (CIRAD-FLHOR) Neuichateau - 97130 Capesterre Belle-eau-FWI), Emmanuel Collette (Association des Producteurs d'Ananas de Guadeloupe(APAG)Chambre d'Agriculture-Rond-point Destrellan-97122 Baie-Mahault - FWI), and Franck Marie (Departement des productions

Fruiteres et Horticoles(CIRAD-FLHOR) BP 153-97202 Fort-de- France Cedex-FWI)

The pineapple cv, bouteille is found only on the island of Guadeloupe and was presumably introduced from South America before 1492. This spiny variety has conical fruit weighing 1 to 1.5 kg, on average), a small crown, and many slips. The shell is usually green when the fruit are ripe, the flesh is deep yellow, low in acid with high sugar, and a short shelflife. Bouteille is grown on 100 small farmers for the fresh local market. The optimal plant density is 45,000 plants/ha.

Self Pollination in Pineapple

J.R.S. Cabral (EMBRAPA/CNPMF (National Research Center for Cassava and Tropical Fruit Crops, Caixa Postal 007, 443808-000 Cruz das Almas, Bahia, Brazil), G. Coppens d'Eeckenbrugge (CIRAD/IPGRI, A.A.6713, Cali, Columbia), and A.P. de Matos (EMBRAPA/CNPMF (National Research Center for Cassava and Tropical Fruit Crops, Caixa Postal 007, 443808-000 Cruz das Almas, Bahia, Brazil)

The high heterozygosity of cultivars used for hybridization and the great number of characters evaluated during selection have caused pineapple breeding programs to be inefficient in generating new cultivars. On selfing to reduce heterozygosity, seeds produced were 'Smooth Cayenne', 0, 'Perola', 2, 'Perolera', 2, 'Primavera', 7, and 'Roxo de Tefe', 105. Seeds were germinated in Petri dishes on water agar substrate in growth chamber at 26 to 28 °C with an 18 h photoperiod and 1600 lux of light. Only 16 seedlings of 'Roxo de Tefe' survived, and all are spiny and 12 have red leaves as their parents while 4 have green leaves. The 7 seedlings from 'Primavera' have spineless green leaves as the parents. The 2 seedlings from 'Perolera' have green leaves and one is spiny and the other spineless. The two seedlings from 'Perola' resembled their parents but died in the nursery.

The Physical-mechanical Properties of the Pineapple Fruits and its Relation With the Damages During the Manipulation

Lorenzo Dominico Daz and Eido Garca Aragon (Universidad Agrcol a de Ciego de Avila, Carretera a Moron, km 9. Ciego de Avila C.P. 69450, Cuba)

A study was conducted with Red Spanish to establish the functional dependence between fruit properties and mechanical damage.

Study on the Floral Induction, Growth and Development of Pineapple

Avila Maita,Teresa Martnez, Sara Perez and J. Nogueira (Facultad de Agonoma, Universidad de Ciego de Avila, CP 69450, Cuba)

Flordimex increased the percentage of floral buds after the first seven days with the maximum number of differentiated buds found between 21 and 28 days after application of the florigen. Induction is accompanied by a minimum level of growth promoter (GA_3) and maximum level of inhibitors (ABA), which takes place after 28 days of being induced. The growth promoter increased from 28 to 145 days but the values were not the same as those obtained in the stage of the pre-differentiation stage of the floral axis.

Artificial Flower Induction in Pineapple During Off Season

D.N.Hazarika and N.K. Mohan (Horticultural Research Station, Assam Agricultural University Azara, Guwahati-781017. Assam, India)

The peak season for availability of pineapple fruits in Assam is June to September, resulting in a glut in the market for 2 to 3 months and a shortage the rest of the year. To regulate flower induction in Kew pineapple in winter (off season), treatments were ethrel 100 ppm, ethrel 25 ppm + urea(2%) + $CaCO_3$ (0.04%), planofix 10 ppm, gibberellic acid 50 ppm, calcium carbide (1 g/plant), 2,4-D 10 ppm and control(water spray). The chemicals were applied in May June, July and August to produce fruits during the winter. In May, 68.1% of plants were induced decreasing to 64.3% in August. Plants induced in May had a shorter duration to flower emergence and fruit maturity than plants induced in August. Fruit weights were 1.83-1.86 kg for plants induced in May and June and 1.69 kg for plants induced in August. The highest (0.48) harvest index was recorded for the May induction and it decreased gradually in subsequent months. Plants treated with ethrel 25 ppm+ urea+ $CaCO_3$ and calcium carbide had the highest percentage of flowering and a shorter development period.

Inhibition of Natural Flowering Occurring During the Winter Months in Queen Ppineapple in Kwazulu-Natal, South Africa

E.C.Rabie, H.A. Tustin and K.T. Wesson (Pineapple Research Station, POBox 194, Hluhluwe, 3960, South Africa)

Natural flowering of Queen pineapple in the area of Hlahluwe, Kwazulu-Natal causes overproduction in December/January with subsequent low market prices. Swelpine [2-(m-chlorophenoxy),propionic acid], a product of Applied Chemical Products, was applied at 2, 3.5, 5 and 7 L/ha split into 3 sprays 2 wks apart. Higher dosage gave better control but 7 L/ha was phytotoxic; the efficacy of 3.5 and 5 1/ha was the same. Plant mass increased with increasing Swelpine dosage and, depending on planting time, also increased yield in the natural as well as the artificially-induced crop. Time of application was critical and the applications can be done from the middle of March (optimum at the end of April), but not later than the 10th of May.

The Physiology and Biochemistry of Pineapple Fruit Subjected to Blackheart-Inducing Conditions

Steven J.R. Underhill, Janelle M.Dahler, Yuchan Zhou and Lyndall G. Smith (Redlands Research Station, PO Box 327, Cleveland, Qld 4163, Australia)

Pineapple fruit of different varieties and fruit maturities were stored at13°C to induce blackheart (BH) or 22°C as a control, and visual, respirational and biochemical responses were investigated. Fruit of 'Smooth Cayenne' and '73-50', chilled 3 wks at 13°C followed by 7 d at 22°C, had increased polyphenol oxidase (PPO) activity in parallel with blackheart development. Fruit stored at 22°C had no BH or PPO activity increase. BH development and peroxidase (POD) activity were not related for either cultivar. The PPO activity of the skin and crown leaf tissue of recently harvested 'Smooth Cayenne' fruit was significantly higher than that in pulp. Pulp PPO increased significantly after chilling. Skin and leaf PPO of chilled and unchilled fruit were not significantly different. Immature 'Smooth Cayenne' fruit did not develop BH, while fruit of mid-range maturity were highly susceptible. More mature fruit developed severe translucent chilling injury, rather than BH. Fruit of the two most mature ranges had lower POD activity, and higher total phenol concentration, than less mature fruit. Total phenol concentration was higher after 3 wk storage at 10°C than in freshly harvested fruit, for all maturity ranges. Fruit of the middle maturity ranges had increased PPO after 3 wk storage at 10°C and 7 d at 25°C. Respiration generally increased in 'Smooth Cayenne' fruit as a consequence of chilling. A marked respiration peak was consistently recorded in the fresh immature fruits, but was absent after chilling. Ethylene production was extremely low and no trends were detected.

Rates of Fruitone CPA in Different Applications Number During Day Versus Night to Flowering Inhibition in Pineapple

M..A. Rebolledo, D.E.A. Uriza, and M. L. Rebolledo (Campo Experimental Papaloapan CIRGOC. INIFAP, Apdo. Postal #43. CP. 95641 Cd. Isla, Veracmz, Mexico)

Natural flowering, one of the most important problems in pineapple in Mexico, causes excess fruit in June and July and scarcity in August and September. Inhibition of flowering was studied in 4 experiments carried out in Isla, Veracruz, in 1995-96. Treatments were: 1) 40,000 plants per hectare and 2 kg per plant; 2) 40,000 and 1.2 kg; 3) 24,000 and 2 kg.; and 4) 24,000 and 1.2 kg. The experimental design was a randomized complete block in split plots with four replicates; main plots were 30 mg/L, 60 mg/L, 90 mg/L or 120 mg/L of 2-(3-cholophenoxy) propionic acid (Fruitone CPA) with 1, 2, 3 and 4 applications respectively. Every application was 30 mg/L and subplots were application times of 9:00, 14:00 and 16:00 h. The treatments began in October, at the same day for all experiments, but with different planting date. The applications were every 15 days, spraying 50 ml per plant. There was no significant effect ($p < 0.05$) of hour of application. Levels were highly significant ($p < 0.05$) and 90 mg/L was best for experiments 1, 3 and 4 with 78, 87 and 99 % of flowering inhibition, respectively, while the experiment 2 had 77% with 120 mg/L. The control had more than 90% of natural flowering. Fruitone CPA can be applied night or day on any planting densities with 90 mg/L split in 3 applications.

Increasing Pineapple Yield by Using VA Mycorrhizal Fungi

Supaporn Thamsurakul, Omsub Nopamornbodi and Sompecth Charoensoo (Soil Microbiology Research Group, Soil Science Division, DOA, Bangkok, Thailand)

Pineapple yield increased more with a combination of mineral fertilizer and mycorrhizal fungi than with mineral fertilizer or mycorrhizal fungi along.

Estimation of Biological Nitrogen Fixation Associated With Field-Grown Pineapple in Thailand

Shotaro Ando (Japan International Research Center for Agricultural Sciences, Tsukuba, Japan), SompongMeunchang (Soil Microbiology Group, Soil Science Division, Department of Agriculture, Thailand), Preecha Vadisirisak and Tadakatsu Yoneyama (National Agriculture Reseach Center, Tsukuba, Japan)

The average contribution of nitrogen fixation to total plant nitrogen of 26 pineapple samples was estimated to be 52%.

Nitrate and Molybdenum Availability as Affected by Ammonium Application in a Soil Growing Pineapple

Pornprome Chairidchai (Horticultural Research Center, Sawi, Chumphon 86130, Thailand)

The content of nitrate in pineapple was previously found to relate with molybdenum concentration of the plant. When soil was incubated with 3 levels of ammonium at 3 soil moisture levels for 10 days, nitrate increased whereas molybdenum decreased. The decrease in molybdenum content was due to the specific adsorption on the surfaces of the soil particles at low pH.

The Relationships Between Nitrate and Molybdenum in Pineapple Grown on an Inceptisol Soil

Pornprome Chairidchai (Chumphon Horticultural Research Center, Sawi, Chumphon. Thailand 86130)

Molybdenum (Mo) was applied at levels of 0, 250, 1250, 2500 and 5000 µg per plant. Nitrate in the crown and juice were correlated with Mo concentration in D-leaf. Crown nitrate increased linearly with Mo content in the leaf (r^2 = 0 7) whereas juice nitrate decreased quadratically with the Mo content (r^2 = 0.6). The nitrate in the fruit may have been due to Mo deficiency.

Effect of Fertilizers to the Content of Nitrate in Pineapple

Praphasri Chongpraditnun, Pratueng Luksanawimol and Pakorn Limsmuthchaiporn (Soil Science Division, Department of Agriculture, Bangkok 10900, Thailand), and Sasithorn Wasunun (Institute of Horticulture Research, Department of Agriculture, Bangkok 10900, Thailand)

There was a trend of a reduction of nitrate content in pineapple fruit where plants received fertilizer plus compost or KCI or Mg or Mo. Mo applied at 11.72 mg/plant increased Mo content of the D-leaf basal white tissue and significantly reduced nitrate accumulation in pineapple fruit, with no effect on fruit Brix or pH.

Pineapple Cultural Practice in Sindh, Pakistan

Farzana Panhwar (Sindh Rural Women's Uplift Group, 157-C, Unit No. 2, Latifabad, Hyderabad (Sindh), Pakistan)

Pineapple is grown in the coastal area of Sindh on a commercial scale only by few farmers because planting material and advice on how to grow the crop is not available.

Commercial Production of Pineapple Planting Materials Using Quartering Technique

M. Mohammed Selamat (Malaysian Agricultural Research and Development Institute [MARDI]
Post Bag No.525, 86-0-0-9 Kluang, Johore, Malaysia)

Results with JOSAPINE, which was released by MARDI in 1996 indicated that quartering is a viable propagation technique that could be adopted commercially.

Rotylenchulus reniformis Damage Thresholds on Pineapple

B. S. Sipes and D. P. Schmitt (Dept. of Plant Pathology, Univ. of Hawaii, 3190 Maile Way, Honolulu, HI 96822 USA)

Environmentally sound and sustainable plant-parasitic nematode management depends on accurate assessment of population densities and knowledge of damage thresholds. In a field experiment where preplant *Rotylenchulus reniformis* population densities ranges were 0-10, 40-70, 100-120, 300, and 1020-1360 nematodes/250 cm3 soil, D-leaf and root biomasses did not differ among the population ranges at 6 or 12 months *($p< 0.05$).* Average fruit weight was greatest (1.2 kg) in the 300 range plots and lowest (1.1 kg) in the 0-10 range plots. Fruit weight increased with increasing nematode population densities up to the 300 range but was lower at the 1020-1360 population range *($p> 0.01$).* Average fruit weight increased as soil calcium and magnesium levels increased except at the 1020-1360 range. The preplant damage threshold population of R. *reniformis* on pineapple lies between 1 and 5 nematodes/cm^3 soil.

Suppression of Renifrom Nematode, *Rotylenchulus reniformis* on Pineapple With Tropical Cover Crops

K. H. Wang and B. S. Sipes (Department of plant Pathology, University of Hawaii at Manoa, 3190 Maile Way, Rm. 305, Honolulu, HI 96822, USA)

Management of reniform nematode on pineapple is increasingly difficult because of loss of chemical alternatives. Cover-crops of sunn hemp *(Crotalaria juncea* L.), yellow mustard *(Sinapis alba* L.) or rape seed *(Brassica rapa* L.), and marigold *(Tagetes erecta* L.) were grown as (1) intercycle crops for 3 months, or as (2) an intercrop throughout the cropping cycle to test for suppression of *R. reniformis* in pineapple. In the intercycle study, cover crop effect was compared with weedy plots and 1,3dicholoropropene treated plots. *R. reniformis* population densities were determined before cover crop planting, 3 months after cover crop planting, 1 month after cover crop incorporation, and bimonthly after pineapple planting. *R. reniformis* population densities were reduced in all cover crop treatments during the intercycle period with the greatest reduction in S. *alba.* The *R. reniformis* suppression lasted until 6 monthsafter pineapple planting in the *C. juncea* plots with the lowest nematode numbers in the soil (P= 0.07) and pineapple roots (P= 0.05). Bacterial and fungal feeding nematodes, and mycorrhizal spore numbers were highest in the C. *juncea* rhizosphere ($p< 0.01$) 3 months after planting in a greenhouse test. *C. juncea* shows promise in suppressing *R. reniformis.*

On-Farm Aapproach of Pineapple Fruitlet Core Rot Disease in Martinique

F. Marie (CIRAD FLHOR, BP 153, 97202 Fort de France), E. Malezieux, J. Marchal and X. Perrier (CIRAD, BP 5035, 34000 Montpellier, France)

Fruitlet Core Rot (FCR) is an important disease affecting pineapple fruit development, but factors promoting the disease are not well known. A large on-farm survey, including soil, climatic, physiological and pathological variables at a field scale, and including spatial heterogeneity and temporal variability, was designed and conducted in the pineapple production area in Martinique. Fruit sampling analysis revealed that *Penicillium funiculosum* was involved in 95% of the observed cases. Although P. *funiculosum* was widespread in soils, no quantitative relation was established between inoculum in soil or on plants and the development of FCR. Fruit observations at harvest confirmed a high level of variation between fruits within a field but showed significant correlations between percentage of infected fruits within a field, average number of spots per fruit and their size. A global analysis of data showed that 1) climatic conditions during fruit filling strongly influence disease expression, 2) average ascorbic acid content in fruits is negatively linked with the percentage of infected fruits. The nutrition status of the plants, especially low levels of calcium and magnesium, or high levels of nitrogen, is also a significant promoting factor of the development of disease.

Effect of Temperature and Rainfall on the Incidence of *Fusarium subglutinans* on Pineapple Fruits

Aristoteles Pires de Matos, Jose Renato, Santos Cabral and Nilton Fritzon Sanches (Embrapa Mandioca e Fruticultura, CP 007, 44380-000 Cruz das Almas, Bahia, Brazil)

Fusarium subglutinans causes fusariosis and high pineapple production losses in Brazil. The pathogen infects propagative material,

plants and fruits, and losses showing strong seasonal variation. In a 4-year study of the effect of environmental conditions on the incidence of *F. subylutinans* on fruits of Perola, it was found that the higher the number of hours of temperature below 23 °C during flowering, and rainfall from flowering induction treatment to harvest, the higher the disease incidence on fruits. On the other hand, increasing number of hours over 28 °C during inflorescence development decreased the fusariosis incidence on pineapple fruits.

Reaction of Some Pineapple Hybrids and Clones to Nematode in Bukidnon, Philippines

A.G. dela Rosa (Del Monte Philippines, Inc., Phillips, Bukidnon, Philippines)

The reniform nematode, *Rotylenchulus reniformis* is the major nematode pest of pineapple in northern Bukidnon and about 70% of the Del Monte Philippines (DMPI) pineapple farm is infested with reniform and the rest with root knot. Infested fields are treated with nematicides to reduce crop losses. Selections/hybrids screened for resistance included Hybrid 270-67, Bathurst, East London, Tainung #4, MD 2, Espanola Roja, Perola, and Venezolana were screened for resistance to reniform nematode and the latter three were also screened for root know resistance. None of the selections/hybrids were resistant to the DMPI reniform nematode and plants so infested were severely stunted, purplish, and narrow D-leaf width. Bathurst, East London, MD 2 and Hybrid 270-67 appeared more susceptible to reniform nematode than the DMPI Cayenne clone and Tainung #4. It is recommended to fumigate or apply nematicide to all field plantings using these clones and hybrids. Espanola Roja, Perola, and Venezolana had excessive galling of the roots in plots infested with the *Meloidogyne javanica.* The DMPI clone appeared more tolerant to the two nematode species.

Ant Control in Pineapple Field

Chamnan Pitaksa, Anuwat Chantarasuwan and Auranuj Kongkanjana (Corn & Field Crops Insect Pest Research Group, Entomology & Zoology Division, DOA, Bangkok, Thailand 10900)

At least 6 species of ants were found on pineapple fields in Chonburi province, i.e. *Monomorium* sp., *Pheidole* sp., *Solenopsis* sp. Attended mealybugs, *Dysmicoccus brevipes* in pineapple fields. Pesticides to control ants included hydramethylnon, fipronil, carbaryl, and diazinon. Fipronil, diazinon and carbaryl were sprayed over pineapple leaves while hydramethylnon was applied in late afternoon to avoid photolysis. Treatment with fipronil, carbaryl, diazinon, and hydramethylnon significantly reduced ant populations below the control from day 1 to 63 after treatment. Ant density was reduced with hydramethylnon but they were not eliminated.

Weed Control for Cayenne Pineapple in South Africa

David N.A. Murray (I.T.S.C., Bathurst, South Africa)

Thiazopyr was applied with atrazine and diuron in 568 L of water/ha in November, 1995 over freshly planted pineapple crowns. A Standard Industry mix of bromacil, atrazine, and diuron were also applied. In August, 1996, booster herbicide applications were sprayed at 50% of initial amounts. Optimum pre-emergence grass control was achieved with thiazopyr at 2.0 L/ha; there was no benefit of higher water volumes. Thiazopyr (2.0 L/ha) + diuron gave comparable control as the Standard Industry mix. Thiazopyr did not control nutgrass (*Cyperus rotundas*). Thiazopyr at 2.5 L/ha induces no observable response in freshly planted crowns or 12 mo. old plants.

Efficiency of Pre-planting Herbicides on Weed Control and Growth of No-Tillage Pineapple *(Ananas comosus* L.)

K. Suwanarak and S. Kongsaengdao (Botany and Weed Science Div., Dept. of Agriculture, Chatujak, Bangkok lO900,Thailand), and S.Vasununde, (Petchaburi Horticultural Research Station, Petehaburi 76120, Thailand)

Weed control in no-tilled pineapple was studied at Rayong Field Crops Research Center and Petchaburi Horticultural Research Station. Herbicides were applied post-emergence 60 days after soil preparation and 30 days before planting. Bromacil, glyphosate, glyphosate+ diuron and paraquat+ dimethazone at 3.0, 1.5, 1.0+ 2.0 and 0.75+ 1.125 kg ai/ha, respectively, provided good weed control without phytotoxicity to the crop. Imazapyr at 0.15 kg ai/ha applied 60 days before planting gave excellent weed control for at least 5 months but severely reduced growth and yield of pineapple. However, tillage before planting provided better weed control than no-tillage and yield was 14.3% greater.

Sulfentrazone for Preplant Weed Control in Pineapple

Chesed M. Sison (Del Monte Philippines, Inc., Phillips, Bukidnon, 8705 Philippines)

Sulfentrazone suspension concentrate (450 g a.i./L), was applied preplant at 0, 125, 250, 500 and 1000 g a.i./ha in the Del lVIonte Philippines, Inc. plantation in Bukidnon, Philippines to study weed control, crop injury, herbicide residues, and yield of pineapple. Sulfentrazone also was applied at 500 g a.i./ha alone or in combination with either diuron or bromacil at 1820 g a.i./ha. Weeds per 36-m^2 plot was significantly reduced for 6 months with 500 and 1000 g a.i. /ha of sulfentrazone. Sedges were completely controlled starting at 250 g a.i./ha. Plant crop yield was significantly higher at 500 g a.i./ha versus the untreated control but lower than the standard plantation practice of bromacil + diuron at 3640 + 1820 g a.i./ha. Tankmixing sulfentrazone with diuron or bromacil further reduced weed population compared to sulfentrazone alone but was still significantly inferior to the standard plantation practice. Phytotoxicity to sulfentrazone was not observed and residues were not detected in fruit flesh or shell at 500 and 1000 g a.i./ha.

Quality of Pineapple Fruits Artificially Produced During Winter

D.N. Hazarika and N.K. Mohan (Horticultural Research Station, Assam Agricultural University
Azara, Guwahati-781017, Assam, India)

Pineapple (cv. Kew) fruits from plants induced in May had maximum juice(83.66%), pectin(0.156%), soluble solids (15.14%)and total sugar(14.09%) contents. Ascorbic and titratable acids in fruits were lower for plants induced in May and increased in fruits harvested later in winter.

Handling and Transportation Trial of Pineapple by Sea Shipment From Malaysia to the United Kingdom

H. Abdullahi, M.A.Rohaya (Malaysian Agricultural Research Development Institute (MARDI), GPO Box 12301,50774 Kuala Lumpur, Malaysia), H. Rosli (Malaysian Pineapple Industry Board (MPIs), Wisma Nanas, Jalan Padi, Mahsuri 12, Bander Baru Uda, 81200 Johor Bahru, Malaysia), and M. Mohamed Selamat (MARDI, GPO Box 12301,50774 Kuala Lumpur, Malaysia)

A trial sea shipment of pineapple cv. N36, a blackheart resistant cultivar, was conducted in October-November 1996. Fruits were harvested mature-green (162-165 days after induction). Fruits were temporarily stored at 8°C at FAMA Packinghouse Complex, Simpang Renggam. Fruits were shipped at 8 °C and arrived UK in excellent condition. Fruit quality changed very slowly depending on storage conditions at sites where they were evaluated. The response of the UK importer to this first-ever shipment of pineapple from Malaysia was very positive.

Development of a Postharvest Procedure for Sea Export of Queen Pineapples From South Africa to Europe

F.J. Kruger and E.C. Rabie (Institute for Tropical and Subtropical Crops, Private Bag X 11208, Nelspruit, South Africa)

The Queen Victoria pineapple produced in subtropical KwaZulu Natal, South Africa, is consumed fresh. Small fruits are exported to Europe by air because blackheart makes it impossible to store the fruit for the duration of an export voyage by sea. The effects of prestorage heat treatments (air and water), antioxidants and cell membrane stabilising agents, controlled/modified atmosphere and hypobaric storage, and elaborate temperature stepping regimes on storage were examined. Limited success was attained with heat treatments and storage atmospheric trials. Temperature stepping routines showed considerable potential as the onset of blackheart was sufficiently delayed during the simulations to permit export by sea; starting temperature, step magnitude, lowest holding temperature and rate at which the fruit are reheated were all relevant.

Changes in Sugar Content and the Activity of Sugar Metabolizing Enzymes in Pineapple Fruit Flesh During Development

Ching-Cheng Chen and Robert E. Paull (Department of Horticulture, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, 3190 Maile Way, Honolulu, HI 96822 USA)

The relationship between sugar contents and activities of the sugar metabolizing enzymes sucrose synthase (SS), sucrose phosphate synthase (SPS), neutral invertase (NI), vacuole acid invertase (VAI), and cell wall-acid invertase (CWAI) in fruit flesh were examined biweekly from 12 wk before harvest. In early development, glucose and fructose were the predominant sugars. Sucrose began to accumulate rapidly 6 wks before harvest, with more in fruitlet than in interfruitlet tissue, and ultimately exceeded glucose and fructose concentration. SS activity was high in young fruit, particularly in the fruitlet, and declined to very low activity with development; the activity of SPS was relatively low and constant throughout fruit development. The activities of the invertases were high in young fruit and declined to very low levels 6 wk before harvest when sucrose started to accumulate. However, the activity of CWAI increased again 4 wk before harvest, mainly in the fruitlet, while NI and VAI activities remained low. The activities of SS, NI and VAI are important in determining the compositions of stored soluble sugars in pineapple fruit flesh. Sucrose accumulation and the activities of SS, NI, and VAI were negatively correlated. High CWAI activity in the last 4 wk of fruit development favors apoplastic unloading and might be responsible for maintaining a pressure gradient between sink and source.

Poster Session

Application of Biotechnological and Traditional Methods in Cuban Pineapple Breeding Program

Miriam Isidron Perez, Reineiro Benega Garcia, Aroldo Cisneros Pena, Elizabeth Arias Valdes, Jose Carlos Lorenzo Feijo, Patricia Espinosa Artiles and Carlos G. Borroto Nordelo (Centro de Bioplantas, Universidad de Ciego de Avila. Carretera a Moron Km 9, CP 69450, Ciego de Avila, Cuba)

Cuba currently grows only 'Red Spanish'. The breeding program is based on hybridization and selection, somaclonal variations, ionizing radiation of tissue cultures and genetic transformation mediated by *Agrobacterium tumefaciens*. Promising hybrids of Smooth Cayenne x Red Spanish and Smooth Cayenne x Perolera were selected, and some are being micropropagated for testing. Somaclonal variants were induced in MS medium (Murashige and Skoog, 1962) supplemented with 2,4-D 0.2 mg/L + KIN 0.1 mg/L. Plants were regenerated using MS medium + AIB 0.2 mg/L + BAP 0.25 mg/L + AG_3 0.03 mg/L. Somaclonal variant P3R5 from Red Spanish cv., obtained from callus, had few spines on leaves, a beneficial agronomic character. Gamma rays from Co60 used on in vitro leaves, callus and pollen grains produced morphological variants and resistance to *Fusarium subglutinan* filtrates in preliminary tests. Materials obtained from in situ parthenogenesis induced by pollination with irradiated pollen are still in primary studies. Some haploid pineapple plants were obtained using intergeneric crosses. Protocol for genetic transformation mediated by *Agrobacterium tumefaciens* was obtained using somatic embryo system.

Isozyme Markers for Cultivars Identification of Pineapple

Boonhai Laempet (Chumphon Horticultural Research Center, Wisaitai, Sawi, Chumphon. 86130 Thailand), and Suchirat Saghuanrungsirikul, (Chanthaburi Horticultural Research Center, Phrew, Lamsing, Chanthaburi. Thailand)

Leaf extracts from 19 pineapple cultivars were analyzed for isozyme variation of 11 enzyme systems using PAGE. Polymorphism were presented in Peroxidase (PER,EC 1.11.1.7), Shikimate dehydrogenase (SKDH, EC 1.1.1.25), Malate dehydrogenase (MDH, EC 1.1.1.37), Alcohol dehydrogenase (ADH, EC 1.1.1.1), Phosphoglucose isomerase(PGI, EC 5.3.1.9). No polymorphism was found in 6-Phosphogluconate dehydrogenase (6-PGD, EC 1.1.1.44), Esterase (EST,EC 3.1.1.2), Phosphoglucomutase (PGM, EC 2.7.5.1), Lactate dehydrogenase (LDH, EC 1.1.1.27), Isocitrate dehydrogenase (IDH, EC 1.1.1.42), or Aldehyde oxidase (ALDO, EC 1.2.3.1). Peroxidase had the highest degree of polymorphism and hence accounted for most of the discriminating characters. Using the above 5 enzymes, we found 3 groups of *Ananas comosus* (L.) Merr. with identical banding patterns, i.e., 'Pattavia and Numpung, Tradsitong and Singkapropattavia, and Phuket and Sawi'. The identical isozyme profiles may indicate that they were the same cultivars. 'Manora' showed unique banding pattern and related to 'Tainan 41 and White Jewel'. These isozyme data supported the current taxonomic placement of the *Ananas spp.*. Those isozymes can provide useful genetic marker for cultivar identification.

Characterization and Evaluation of Pineapple *(Ananas comosus* (L.) Merr.) Germplasm

C.W.F. Santos and F.R. Ferreira (EMBRAPA/CENARGEN, S.A.I.N., Caixa Postal 02372,70770-900 Brasilia, DF, Brazil)

Despite the large variability presented by *A. comosus* and related species, more than 70% of the pineapple industry is based on 'Smooth Cayenne', which shows the vulnerability of this crop. Breeding programs must broaden genetic variability in the commercial cultivars. To facilitate cultivar development, this work aims to characterize and evaluate pineapple germplasm, and make the information available to users. At EMBRAPA/CENARGEN in Brasilia-DF, 49 accessions were characterized, 37 of A. *comosus,* 6 of *A. bracteatus, 5* of A. *ananassoides,* and 1 of A. *nanus.* The IBPGR pineapple descriptors were used, with few modifications, being 23 descriptors for the plant, 14 for the inflorescence, 23 for the fruit, 11 for the crown and 18 for the pulp, divided in measurable and no measurable descriptors totaling 89 descriptors. A large phenotypical variability among the accessions was observed. This variation was larger among accessions of different species than among accessions of the same species and variation in measurable characteristics was more significant than non measurable characteristics.

Perola vs Smooth Cayenne Pineapple Cultivars–Growth, Flowering, Pest Incidence, Yield and Fruit Quality in Brazil

D.H. Reinhardt, J.R.S. Cabral, L.F da S.Souza, N.F. Sanches, and A.P. de Matos. (EMBRAPA - CNPMF(National Research Center for Cassava and Fruit Crops), Caixa Postal 007, 44380-000 Cruz das Almas, Bahia, Brazil)

'Perola' is the most important pineapple cultivar in Brazil, but it is almost unknown in other countries. 'Smooth Cayenne' is the most grown cultivar in the world. A comparison between them over the past 20 years shows 'Perola' usually has a smaller stem with fewer roots and leaves, but the 'D' leaves are larger, longer, more erect and have margins covered with spines, The peduncle is longer, holding a narrower, longer, cone-shaped fruit, with a whitish, less fibrous flesh and edible central core, lower acidity and higher TSS/acids ratio and juice content. Its transport resistance is lower, their growth is similar, following a typical sigmoid curve. 'Perola' is more sensitive to environmental factors and plant growth regulators inducing flowering, but it is less susceptible to mealybug wilt disease and to the stem borer *(Austria icarus).* Its yield potential is lower due to a lighter fruit and usually lower planting density used. Its production costs are lower due to cheaper planting material and lower number of pesticide applications. 'Perola' produces much more slips, but its sucker formation occurs later, and is less uniform whereas the suckers are less well- fixed to the mother plants, making it more difficult to get a good ratoon crop yield.

The EU-Funded Project Evaluation and Utilization of Pineapple Genetic Resources From the Amazon to Breed Resistant Varieties

G. Coppens d'Eeckenbrugge, (CIRAD-FLHOR/IPGRI,AA6713, Cali, Colombia), J.R.S. Cabral (EMBRAPA-CNPMF,CP 007, 44380-000 Cruz das Almas, BA, Brazil), J. Carlier (Universidade do Algarve, Campus de Gambelas, 8000 Faro, Portugal), M.F. Duval (CIRAD, BP 5035,34032 Montpellier, France), F.R. Ferreira (EMBRAPA-CENARGEN,CP 040315, 70770-900 Brasilia DF, Brazil), F. Leal (UCV, Facultad de Agronomia, Maracay, Aragua, Venezuela), J. Leitao (), A.P. de Matos (), J.L. Noyer (CIRAD, BP 5035,34032 Montpellier,

France) and Z. Suarez (FONAIAP, zone universitaria, Edif. N 8, Maracay, Aragua, Venezuela)

This project aims to develop varieties resistant to the main diseases in South America, by (i) characterizing botanical and agromorphological description, nuclear and cytoplasmic DNA characterization of available genetic resources ,(ii) studying the genetic structure of the genus *Ananas, (iii)* developing and applying resistance screening techniques for fusariosis, fruitlet core rot, thecla, and nematodes, (iv) studying the heredity of agronomic traits, and (v) testing the potential of partial inbreds in breeding. In addition, establishment of a standard database will promote information and germplasm exchange between the partners, and later, between all the existing pineapple germplasm collections. The project, which started in 1997, has produced a first germplasm inventory, allowing exchanges and repatriation of lost germplasm. The list of descriptors has been revised, multivariate analysis of the first morphological description produced consistent results, molecular markers have been developed for characterization and genetic mapping, and new sources of resistance to fusariosis have been identified.

Pineapple Breeding at CIRAD Evaluation of Hybrid 282, a New Cultivar for the Fresh Fruit Market, as Compared to 'Smooth Cayenne'

Geo Coppens d'Eeckenbrugge and Franck Marie (CIRAD-FLHOR, BP 153, Fort-de-France, Martinique, F.W.I.)

Hybrid 282, a clone from 'Smooth Cayenne' x 'Manzana' progeny was tested against 'Smooth Cayenne' in Martinique. Relative to Smooth Cayenne, Hybrid 282 has smaller D leaf weight and less suckering, and is more compact and erect, with completely smooth leaves. Fruit size is more variable, and tends to be smaller, with a much shorter production cycle. The crown is lighter but long and erect, the peduncle is long but lodging is less than for 'Smooth Cayenne'. Fruit is uniformly bright orange to red color, regular and cylindrical in shape, flat with larger eyes, and a uniform golden yellow flesh. Core is thinner, flesh texture less fibrous and crisp, flesh sweet with higher sugar and comparable acidity and ascorbic acid content is higher. Hybrid 282 seems more susceptible to *Penicillium funiculosum* attacks. A proliferation of slips was observed which could be due to the preliminary in vitro multiplication phase.

The Australian Pineapple Fresh Market Breeding Program

G.M Sanewski (Queensland Horticulture Institute (DPI), PO Box 5083, SCMC, Narnbour. Qld.4560 Australia)

The Australian pineapple fresh market is supplied predominantly with Smooth Cayenne and to a minor extent with Queen. Cayenne is low in sugars, high in acid and prone to internal browning in the winter and 'green ripe' in the summer. Queen has low yield, is susceptible to disease and internal browning, and has spiny leaves. Breeding objectives include improved flavour, resistance to internal browning and green ripe, and attractive appearance. Parents include Cayenne, Queen, the PRI (Hawaii) hybrids 73-50, 53-116 and 59-656 and hybrid 24-80 from the Philippines. Of 50,000 seedlings, approximately 3.8 % were retained for further testing. Combinations of 53-116 x 73-50, and 24-80 x 73-50 have the highest breeding values for a subset of 8 important characters. Lowest breeding values were for Queen x Cayenne, 53-116 x Cayenne, and 59-656 x Cayenne, Queen or 73-50. The most useful cross was 73-50 x 24-80 crosses with 59-656 or Queen were least useful. Approximately 3.8% were retained for further testing. Crosses using hybrid parents generally produce seedlings with more commercially acceptable attributes and allow a smaller population to be used or higher minimum requirements to be applied.

Determination of Haploid Plants in Pineapple and Alternative Methods in the Evaluation of Ploidy Levels

Elizabeth Arias Valds, Reinerio Benega Garcia, Nadina Nieves, Rodriguez, Aroldo Cisneros Pena and Miriam Isidron Perez (Biolplants Center. Laboratory for genetic Improvement. University of Ciego de Avila (UNICA), 69450, Ciego de Avila, Cuba)

Chromosomes from hybrids of intergeneric crossing of Smooth Cayenne " Serrana" x *Tillandsia fasciculata* were counted to identify pineapple haploids. Two haploids (n = 25) and important changes in chromosome number were identifed. Alternative techniques to determine the ploidy levels were established using n = 25; 2n = 33; 2n = 41 individuals. There was a correlation between chromosome number and stomatic density and quantity of chloroplast by stomatic cell and Peroxidase and Esterase isoenzymes showed the similarity between parents and hybrids.

Mutation Induction in Pineapple Using ^{60}Co Gammarays

Aroldo Cisneros, Reinerio Benega, Orlando Borras, Julia Martinez, Mayda Arzola, Elizabeth Arias, Miguel Hidalgo and Miriam Isidron (Biolplants Center. Laboratory for genetic Improvement. University of Ciego de Avila (UNICA). 69450. Ciego de Avila. Cuba)

To obtain pineapple plants resistant to Fusariosis, plantlet leaves of Red Spanish were irradiated with a ^{60}Co source at doses 0, 10, 20, 30, 40, and 50 Gy. A slight increase in callus formation was achieved from vitroplantlet leaves at low doses. Morphological variation and resistance to *Fusarium subglutinans* were observed on some regenerated plantlets.

Pineapple Industry and Research in Brazil

D.H Reinhardt and J. da S. Souza (EMBRAPA - CNPMF (National Research Center for Cassava and Fruit Crops), Caixa Postal 007, 44380-000 Cruz das Almas, Bahia, Brazil)

Pineapple is the third most important tropical fruit in Brazil, and industry growth has been strong in this decade. Brazil ranked second in the world in 1997 (FAO, 1998), when 1.937 million MT (15.1% of world production) was harvested from 55,214 ha. About 76% of that volume was obtained from Paraiba and Minas Gerais. However, the North (South of Para and North of Tocantins States) has been the region of fastest growth in the 90's reaching 19% of the country's production. Most of the pineapple (about 98.6%) are consumed in the inland markets (around 11 kg/capita/year), about 65% as fresh fruit and 35% as juice and other processed forms. About 1% of the production is exported as fresh fruit, mostly to neighbor countries, and not more than 0.4% of the fruit volume produced was exported as juice. 'Perola', whose origin is in Brazil, is grown in about 80% of the area. A small part of that is due to the 'Perola Jupi' clone. 'Smooth Cayenne' is grown on about 20% of the area (mostly in Minas Gerais and Sao Paulo States), mainly for canning. In 1997 average pineapple yields were 23,382 fruits/ha for Brazilian Statistics (IBGE) and 35 t/ha for FAO. This yield increased by more than 160% from 1970 to 1997. Strong research and technology transfer efforts, carried out by EMBRAPA (Brazilian Corporation for Agricultural Research) and other institutes, have contributed to that good result. Some aspects of that research and development program and the approach to pursue further gains in yield and fruit quality will be presented.

Pineapple Production and Research in Sri Lanka

S.F.M. Sulaiman (Regional Agricultural Research & Development Centre, Makandura, Gonawila (NWP), Sri Lanka)

Sri Lanka is located between 5°55' and 9°51' N latitude and 79 42' and 81 53' E longitude. The island's 6.6 million ha is divided into wet, intermediate, and dry agroclimatic zones. Coconut is grown in the districts of Kurunegala, Puttalam, Gampaha and Colombo, popularly known as the 'coconut triangle. Pineapple is grown within this triangle. Total area in pineapple is about 4,750 ha producing a total yield of 35,000 t/yr, 70% of which is produced in the Kurunegala and Gampaha districts. Pineapple production has increased by 84% over the previous year 1996. Pineapple export increased by 99% in 1996 from the previous year and marketting has been largely to the USA and the Maldives. The common variety is 'Mauritius', a 'Queen' type with spiny leaves and golden-yellow flesh The fruit is consumed fresh in Sri Lanka. Some hybridization work has been carried out at RARDC, Makandura and a few promising lines have been selected.

Association of Polyphenol Oxidase (PPO) and Peroxidase (POD) Activities With Blackheart Development in Malaysian Pineapples

M. Pauziah[1], S. Underhill[2], J. Dahler[2]. and A..R. Abd. Shukor[1]
[1]Malaysian Agricultural Research Development Institute (MARDI), GPO Box 12301, 50774 Kuala Lumpur, Malaysia [2]Horticulture Postharvest Group, Queensland Department Of Primary Industries, 19, Hercules Street, Hamilton, Queensland, 4007, Australia

Fruits of Mauritius, Sarawak and N 36 pineapple were harvested and stored for 2-3 wk at 8°C and 1 week at 28°C to induce blackheart. PPO and POD activities were determined. A significant relationship was found between PPO and blackheart. Mauritius was more susceptible to blackheart than the other varieties. After 2 wk of induction, PPO activity was about 0.6 U vs. 0.04 U in control fruit; PPO activity stabilized after 3 wk of induction. In Sarawak, PPO was 0.1 U after 2 wk of induction and increased after 3 wk. N 36 did not develop blackheart and PPO activity was very low. POD activities were not associated with blackheart development.

Studies into the Effects of Temperature on Natural Flowering of Smooth Cayenne Pineapple in Southeast Queensland

G. M. Sanewski (Queensland Horticulture Institute, Maroochy Research Station, PO Box 5083, SCMC Numbour. Qld, 4560. Australia), E. Sinclair and M. Jobin-Decor (Golden Circle Ltd. PO Box 106, Virginia. Qld, 4014. Australia), and G. Dahler (Queensland Horticulture Institute, 19 Hercules St, Hamilton. Qld. 4007. Australia)

Natural flowering, a major problem in Australia, usually occurs in early winter. Shortening days and low temperature are thought to give rise to increased ethylene production in the stem apex and basal white leaf tissue which stimulates flowering. In the basal white of the D-leaf, ACC (1-aminocyclopropane-1-carboxylic acid), increased by 40 % over the early winter period with plants experiencing a mean minimum of 14.5 °C for the final month. However, the direct effect of low temperature is still unclear. Experiments using controlled temperature, and the natural lighting of early winter, indicate higher temperature may be important. A constant 10 °C and 15 °C for 2, 4, 6, 8, 10 or 12 wk followed by 2 wk at 28 °C failed to initiate flowering. Flowering was induced in 100% of plants held at 20 °C for 10 to 12 wk, 83 % of plants held 8 to 10 wk, 67 % for 4 wk, and 50% for 2 wk. In another experiment, large suckers were collected from the field in late winter and subjected to 5, 10, or 28 °C for 3 d followed by 6 h at 28 °C. Exposure to 28 °C for the 3 d and 6 h resulted in a 150% increase in ACC of the plant apex and induced flowering in 75% of plants. Suckers held initially at the lower temperatures did not show a large increase in ACC and did not flower. Winter in SE Queensland often has warm *(ca* 25 °C) sunny days following cool(< 10 °C) nights. In the field, natural flowering is more prevalent in plants on the outer edges of rows, especially on the northern edges of fields, suggesting diurnal warming of plants has a positive effect. Temperatures around 20 °C appear conducive to flower initiation. Higher temperatures around 28 °C also appear to have a positive effect, probably only after a period of exposure to low temperature. Further studies are required to better understand the effects of cyclical cooling and warming on natural flowering.

Early Growth and Development of Pineapple Hybrid cv.M 36

M. Mohammed Selamat (Malaysian Agricultural Research and Development Institute (MARDI),
Post Bag No.525, 86009, Kluang, Johore, Malaysia)

The growth of M 36 crowns was studied during the first 100 d after planting. Crowns averaging 184 g were planted singly in polybags in Jerangau Series sandy mineral soil. Crowns weighted about 547 g fresh weight after 100 days.

Crown Size Manipulation of Spanish Pineapple Using 3-CPA

M. Mohammed Selamat (Malaysian Agricultural Research and Development Institute[MARDI] Post Bag No.525, 86009, Kluang, Johore, Malaysia)

Crown size affects export packaging of pineapple. Gandul crowns, generally 25-30 cm long and weighing 170-250 g, are too big for fruits destined for fresh market. Crown size was reduced about 50 % by 3-CPA applied 85 days after flower induction. Crown length was reduced to about 50 % and weight to 30 % as compared to untreated fruits.

Characteristics of Nitrogen–Fixing Endopiiytic Bacteria Aassociated With Pineapple

Sompong Meunchang, Bunhan Tangchum, and Preecha Wadesirisak (Soil Microbiology Research Group, Soil Science Division, Department of Agriculture, Chatuchak,
Bankok 10900. Thailand), and Shotaro Ando (Japan International Research Center for Agricultural Sciences, Tsukuba, lbaraki, Japan)

Determination of natural nitrogen-15 abundance revealed the possibility of nitrogen fixation associated with pineapple. To study N fixation, roots and shoots of pineapple plants were sampled from several places in southwestern and eastern Thailand. Bacterial isolates were cultured on LGI medium with bromothymol blue acidified with citric acid to pH 5.5. to confirm the growth of bacteria. Isolated bacteria could grow and fix nitrogen at pH 5.5. The characteristics of cells at 48 h weresimilar to those of *Acetobacter diazotrophicus,* a N-fixing bacteria isolated endophytically from sugarcane, sweet potato and cameroon grass.

Nutrition (N & K) Requirements of Pineapple cv. Kew Under Rain-fed Conditions

S.K.Mitra, S.Sheet and T.K.Bose (Faculty of Horticulture, Dept. of Fruits and Orchard Management, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur 741252, Nadia, West Bengal,India)

To standardize the N and K required for rain-fed pineapple planted in North Bengal at 64,000 plants/ha, 6, 12 or 18 g/plant N was used with constant P_2O_5 (P, 8 g) and K_2O (K, 12 g). Growth increased with increasing N. Flowering was 12% higher at 18 than at 6 g N. Fruit weight and yield increased with N from 6 to 12 g, reaching 1.66 kg and 71.2 t/ha; fruit weight and yield declined at 18 g N to 1.51 kg and 67.0 t/ha. Maximum yield was associated with a leaf P:N ratio of 1:11 and an N:K ratio of 1:2.3 9 months after planting. The effect of N on fruit quality attributes was not significant. For K, 6, 12, or 18 g K/plant were applied with P constant at 8 g and N at 12 g. Plant height at flowering reached 138 cm and leaves were 52/plant at 18 g K. Flowering was delayed by 9 days at 18 g K relative to 6 g K and flowering reached 72.8 % at 18 g K. There were no significant effects to K level on fruit size, weight or total yield leaf P:N and N:K ratios at 9 months were similar to those; 12 g K resulted in the best fruit quality (TSS and sugar/acid ratio). Application of 12 g/plant N and K are recommended for Kew pineapple in West Bengal.

Soil Humidity and Fertilization Levels for 'Perola' Pineapple in Coastal Tableland Sreas of Brazil

L.F. da S. Souza, O.A.de Almeida, R.C. Caldas and D.H. Reinhardt (EMBRAPA- CNPMF (National Research Center for Cassava and Fruit Crops), Caixa postal 007, 44.380-000 Cruz das Almas, Bahia, Brazil)

The Coastal Tablelands of Brazil have a dry period causing water deficit to pineapple. Irrigation is needed to assure quality fruit production, even in the off-season. Yearly average rain is 1170 mm and mean temperature is 24.5 °C. The interactive effects of irrigation and fertilization were studied on a yellow latosol at EMBRAPA, Cruz das Almas, Bahia, Brazil.. A split-plot design was used with fertilization levels of 0, 0.5, 1, 2, and 3 times 250 kg N + 40 kg P_2O_5 + 120 kg K_2O per/ha (castor-oil cake, urea, simple superphosphate and KCl applied in the 2nd, 5th and 8th month after planting) and irrigation subtreatments of 608, 568, 525, 468 and 334 mm/year; planting density was 51,280 plants/ha. Effective precipitation was 671 mm/year during the experimental. The irrigation was done by in-line sprinklers spaced at 6 m. Flowering was forced at 10 months and fruit was harvested in the 16th month after planting. There was a significant effect of water on yield and fruit quality, but no irrigation by fertilizer interaction. Yields (t/ha) increased with fertilization from 33.9 to 51.4 and with irrigation from 35.8 to 49.6.

Implications of the Use of Excess Coir Dust Mulch in Pineapple Cultivation on the Mealybug Wilt Disease of Pineapple in Sri Lanka

S.F.M. Sulaiman (Regional Agricultural Research & Development Centre, Makandura, Gonawila (NWP), Sri Lanka)

The impact of clean weeding (T1), Slash weeding (T2) and Mulching with excess coir dust (T3) on ant/mealybug/spider population and fruit yield was studied. Each block had 966 plants per 694 m^2. Ant and spider numbers (all per plot per week) were monitored weekly with 12 pitfall traps/block for 2.8 y. Mealybugs, when incident, were counted weekly. Mean ants were higher in T3 (48) than in the T1 (26) orT2 (39). Mealybug numbers were also higher in T3 (480) than in T1 (264) or T2 (416). Mean numbers of the ant *Paratrechina longicornis* (Latereille), was higher in T3 (21) than in T1 (9) or T2 (8) plot, while *Camponotus* spp., were higher in T2 (13) than in T1 (7) or T3 (7). Fruit yield (kg/plot) in the first 14 months, was higher in T1 (2053) than in T2 (1103) or T3 (1970). To manage wilt, it is important to minimize ant numbers by clean weeding between rows.

Traditional Practices of Planting Pineapple on Slopeland Areas in the East Coast of Malaysia Peninsular

M. Mohammed Selamat (Malaysian Agricultural Research and Development Institute (MARDI), Post Bag No.525, 86009, Kluang, Johore, Malaysia)

Traditionally, pineapple in the east coast of Malaysia Peninsular is planted on mineral soils, commonly on slopeland. Sarawak, of Cayenne pineapple is normally grown without proper grading of its size. Land is prepared without tillage. Urea is applied as a foliar spray using and the population density is not more than 8,000 plants per acre. Mixed grade of plant materials are generally used and flowering is not induced or calcium carbide is used.

Sowing Method, Tilled Land Levels and Padded Plastic in Pineapple in Mexico

M.L. Rebolledo, D.E.A. Uriza and M.A. Rebolledo (Campo Experimental Papaloapan, CIRGOC, INIFAP, Apdo Postal #43, CP 95641 Cd Isia, Veracruz, Mexico)

Only 1200 mm of rain/y falls in south Veracruz State, and irrigation is not available on most plantations. Soil erosion is a serious problem, which avoid sustainability and several methods of sowing are used that have not been evaluated. The effect of sowing methods, tillage method (conventional, conventional plus bed and no-till) and three treatments with black plastic (on bed, on plane and without till). There was no significant effect of tillage method, but mulch had a highly significant ($p < 0.01$) effect on soil moisture, fresh plant weight, fruit weight and fruit diameter. Only the treatment with padded had available moisture during dry season. It is possible to establish a plantation without till in any sowing method and padded plastic increased yield 20 % except in the padded without till.

Pineapple *(Ananas comosus* (L.) Merr.) Micropropagation in Temporary Immersion Systems

M. Escalona, C. Lorenzo, B. Gonzalez, M. Daquinta, J. Gonzalez and C.G. Borroto (Centro de Bioplants, Universidad de Ciego de Avila Carretera a Mor6n Km 9 Ciego de Avila, CP 6945O, Cuba) and Y. Desjardins (Centre de Recherche en Horticulture, Faculte' des Sciences de l' Agriculture et de 1' Alimentation, Universite' Laval, Quebec, Canada, G1K 7P4)

Mass propagation of pineapple by temporary immersion involved shooting, bud differentiation and elongation. *In vitro* shoots obtained from established liquid culture were grown in solid, liquid or temporary immersion. Temporary immersion increased the multiplication rate and fresh and dry weight after 45 d. Paclobutrazol in liquid medium and temporary immersion promoted formation of compact bud clusters with limited leaf development. The multiplication rate was highest (68.8) when explants were cultured in shooting medium (MS + 2.1 mg/L BA + 0.3 mg/LI ANA) plus 1 mg/L PB for seven weeks. In a 10-L temporary immersion bioreactor, the highest number (191.8 plant/L) of competent and uniform plants was achieved when shoots were cultured 4 wk in shooting medium supplemented with PB.

Somatic Embryogenesis and Plants Regeneration in Pineapple *(Ananas comosus* (L.) Merr.) CV. Smooth Cayenne

Patricia Espinosa and Maritza Escalona (Centro de Bioplantas. Carretera a Moron km 9. Ciego de Avila. CP 69450)

The effects of 2.2, 6.6 and 11.0 µM Dicamba and 2.2, 4.4 and 6.6 µM BA on Smooth Cayenne pineapple callus maintenance and regeneration were studied. Both Dicamba and BA were effective at low concentrations. Morphogenetic capacity of callus was best in liquid medium, as opposed to solid, with 2.2 µM Dicamba. With the same purpose, the citokinins 2ip and kinetin at 2.2, 4.4 or 6.6 µM with 2.2 µM Dicamba were tested. Of solid, liquid and temporary immersion systems, callus maintenance and regeneration was the best in the temporary immersion system with 2.2 µM each of Dicamba BA.

Effects of Benzylaminopurine (BAP) on *In Vitro* Development of Pineapple Plantlets (*Ananas comosus* (L.) Merr.)

W.A.B. de Almeida and A.P. de Matos (Federal University of Bahia, Agronomy School, Department of Plant Sciences, 44380-000 Cruz das Almas, Bahia, Brazil), and A. da S. Souza (EMBRAPA - CNPMF, (National Research Center for Cassava and Fruit Crops), Caixa Postal 007, 44380-000 Cruz das Almas, Bahia Brazil)

The effects of 0.0, 1.0, 2.0, 3.0, 4.0 and 5.0 mgL^{-1} of 6-benzylaminopurine (BAP) on the *in vitro* development of plantlets of Primavera and Perola pineapple were studied in MS medium modified with 2.0 mgL^{-1} of IAA, 40 gL^{-1} of sucrose, 7.0 gL^{-1} of agar. At the multiplication stage a modified MS medium was used, without IAA and with 0.0, 1.0 or 2.0 mgL^{-1} of BAP. The same medium, without growth regulators, was used for rooting. Growing conditions were 28± 2 °C, 16 h photoperiod and 1500 lux light intensity. The best results were with 3.0 $mg.L^{-1}$ BAP for both varieties.

Effect of Different Plant Growth Regulators on the Dubculture of Pineapple Embryogenic Calli

Aroldo Cisneros, Reinerio Benega, Julia Martinez, Elizabeth Arias and Miriam Isidron (Bioplants Center. Laboratory for Genetic Improvement. University of Ciego de Avila (UNICA). Ciego de Avila. 69 450. Cuba)

Embryogenic calli from vitroplant leaves cv. Red Spanish pineapple were subcultivated on 2,4-D/BAP and BAP/Picloram containing-media. A slight increase in the analyzed parameters was observed with lower concentrations of 2,4-D/BAP whereas these decreased with highest concentrations. We observed genetic and phenotypic variation in the regenerated plants.

Mass Propagation of Pineapple Through *In Vitro* Culture

K. R. Shyamal, M. Rahman and P. Sinha (Department of Botany, Jahangirnagar University, Savar, Dhaka, Bangladesh)

Shoots excised from crown axillary buds of pineapple were cultured on MS medium with various amounts and combinations of Kinetin (Kn), BA, NAA and IBA. Culture of explants on MS medium with 2.5 BA+ 0.5 NAA (all mgL^{-1}) resulted in multiple shoot buds. These shoots proliferated through subcultures with about 20 shoots per transfer but shoots were too small to transfer to the rooting medium. With BA of 1.25 and NAA of 0.25, shoots were elongated and shoot number increased up to 60 per culture. When explants were cultured on MS medium with 1.5 NAA and 1.0 Kn, callus was initiated within 3 wk. Subculture of this callus in MS medium with 1.5 Kn+ 0.5 NAA, produced many shoots. After 4 weeks shoots plus calli were transferred to fresh medium where shoots elongated and new buds developed. Shoots excised and transferred to half strength MS medium with 2.0 IBA rooted within 2 wk and 80% of plantlets survived in the field.

Availability of Chlorflurenol for Commercial Production of Pineapple Planting Material

N. Bhushan Mandava (Repar Corporation, Silver Spring, MD 20914 USA)

With high yielding clones of Smooth Cayenne pineapple the principal source of the planting material is the crown. In fresh fruit operations, the fruit is sold with crowns so growers must rely on slips for planting material. Maintain CF-125 (chlorfurenol is the active ingredient)

is the only product available for the production of sliplets registered in the U S. for application to pineapple. Currently, Maintain CF125 is used by pineapple growers in United States and a few countries in Central and South America. Maintain CF-125 is applied at 0.6 to 1.2 kg a.i. in 2000 to 3000 Lha^{-1} of water to vegetatively mature plants in combination with ethephon. A second application may be made after about 10 days. When chlorfurenol is applied 6 to 8 months prior to desired planting material, it produces uniform planting material of high quality . Chiorfurenol-induced production of pineapple planting material is superior to non-chemical alternatives such as stump sectioning and meristem tissue culture.

Partial Purification of a Closterovirus-like Particle Associated With Pineapple Mealybug Wilt and its Use to Produce Monoclonal Antibodies

Eduviges G. Borroto Fernandez[1], Edel Reytor Saavedra[2], Maria Teresa Barcelo Avila[2], Mayra Cintra Vilar[1], Edel Torres Gomez[2], Reinaldo Blanco Aguila[2], Carlos G. Borroto Nordelo[3] and Pedro Oramas Frenes[3] ([1]Centro de Bioplantas, Carretera a Moron Km 9, ISACA, Ciego de Avila, Cuba CP 69450; [2]Centro de Ingenieria Genetica y Biotecnologia (CIGB), POBox 83, Sancti-Spiritus, Cuba CP 60200; [3]Centro de Ingenieria Genetica y Biotechnologia (CIGB), POBox 6162, Hubana, Cuba CP 10600)

Flexuos rod-shaped virus-like particles detected by transmission electron microscopy from partially purified samples of pineapple mealybug wilted plants has been observed in Cuba (similar to Hawaii and Australia). These particles (estimated length of 1,200-1,400 nm and width of about 12 nm) were observed from symptomatic plants with associated mealybugs *(Dysmicoccus brevipes)* but not from meristem culture propagated plants. Semi-purified samples using the modified procedure of Gunashinge and German's, analyzed by electron microscopy and SDS-PAGE, were used to obtain monoclonal antibodies against closterovirus-like particles associated with PMW. Hybridomas clones were screened by ELISA. The plants were separately coated with partially purified samples from wilt-affected and asymptomatic plants derived from meristem, cultivated in green house conditions. A set of monoclonal antibodies that reacted with symptomatic purified samples but not with virus-free samples obtained from the healthy plants was selected. Testing will be required to demonstrate that the antibodies could be used to study and diagnose PMW.

Nematodes Associated to the Pineapple Cultivation (cv. Samba de Chanchamayo) at Chanchamayo, Peru

Alberto Julca and Elsa Carbonelli (Universidad Nacional Agraria La Molina. Aptdo.456.La Molina Lima. Peru) and Segundo Bello (Fundo Italian-Jr. Apurimac 248. Chanchamayo.Peru). Study was done during agreement: INIA(Peru) and CIRAD-FLHOR(Francia)

In Chanchamayo, Central Peruvian jungle, the most important parasitic nematodes that were found associated with pineapple were *Helicotylenchus pseudorobustus, H. multicintus, H. dihystera, Pratylenchus brachyurus, P. coffeae, Meloidogyne incognita, Rotylenchulus reniformis, Rotylenchus, Tylenchorhynchus, Tylenchus, Trichodolus* and *Xiphinema.* The more heterogeneous populations were found in Pichanaki, followed by San Ramon, Satipo and Alto Kuyani; the most frequent genus *were Helicotylenchus, Pratylenchus and Meloidogyne.* Populations of *Helicotylenchus* and *Pratylenchus* in plantations of the first harvest were statistically similar to the second and the third harvest.

Correlation Between Plant Parasitic Nematodes and the Components of Production and Quality of Pineapple (cv. 'Samba de Chanchamayo') at Chanchamayo, Peru

Alberto Julcai and Elsa Carbonell (Universidad Nacional Agraria La Molina. Aptdo.456.La Molina Lima. Peru) and Segundo Bello (Fundo Italian-Jr. Apurimac 248. Chanchamayo.Peru); study was done during agreement: INIA(Peru) and CIRAD-FLHOR(Francia)

An experiment was installed in Pichanaki in the central Peruvian jungle(Chanchamayo) with granulated phenamiphos nematicide (5 %) applied three months after seed time to determine the relation between populations of parasitic nematodes and the components of production and quality of pineapple. The population of *Helicotylenchus; Pratylenchus; Meloidogyne, Rotylenchulus, Rotylenchus, Tylenchus* and *Trichodorus* were negatively correlated for 80 % of the components evaluated (weight and length leaf D, number leaves/plant, crowns/fruit, slips/fruit, fruit weight with crown and without crown, diameters of fruits and core, fruit height, brix, spot of fruit and maturity of fruit). Some of 98 correlations were statistically significant and only 20 % were positive.

Nematodes and Symphalids Control in Pineapple with Rates of Ethoprop in Different Formulations

D.E.A. Uriza, M.L. Rebolledo and M.A. Rebolledo (Campo Experimental Papaloapan CIRGOC INIFAP, Apdo Postal # 43 CP 95641 Cd. Isia, Veracruz, Mexico)

The control of nematodes and symphylids with Ethoprop (Mocap) on pineapple in Mexico was evaluated in 2 experiments (Expt. 1: Mocap 68% Gel in rates of 5, 7.5 and 10 L ha^{-1}; Mocap 10% G, 75 kg ha^{-1}, Oxamil 24, 7 L ha^{-1}, control; Expt. 2: Mocap 15% G 30, 40 & 50 kg ha^{-1}, Oxamil 24, 7 L ha^{-1}, control) in fields where pineapple had been grown for the last 8 years. Four samples of 5 plants/plot were uprooted monthly from every treatment and basal leaves and roots immediately reviewed. Symphylid and nematode counts were obtained. The best treatments were Mocap 68% Gel 5 L ha^{-1}, Mocap 15% and 10% G with a control period from 60 to 70 days, where symphylids were absent; nematode population decreased 91% in the first month and 28% in the second one. Nematode species found were: *Pratylenchus* 21%, *Tylenchus* 15%, *Tylenchorhynchus 9%, Helicolylenchus* 6%, *Criconemoides 5%* and a few of *Hemicicliophora.* Oxamil 24 had a similar effectiveness for nematodes, but did not control symplylids.

Effect of Pathogen and Environmental Factors on Fruit Quality of Marbling Pineapple

Yupin Kasinkasempong[1], Pairat Chauytem[1], Pichate Chaowattanawong[2], and Chai Korawis[1] ([1]Chumporn Horticulture Research Center, Sawi, Chumphon Province, Thailand 86130; [2]Entomology and Zoology Division, Department of Agriculture, Bangkok, Thailand 10900)

The causal agent of marbled fruit was *Erwinia herbicola cv* ananas. One hundred fruits sampled 2, 4, 6, 8, 10, 12, 14 and 16 wk after flowering showed that marbling began at 12 wk, which was the stage the fruit started to ripe, and continued until harvest. At this stage, fruit weight, ripeness and sugars increased rapidly while nitrate assimilated in fruit decreased. To study environmental effects, 1,000 slips were planted at twelve 2-wk intervals and after flower induction meteorological data were collected. The physical characteristics of 50 fruits were compared. Normal fruits were smaller but had higher TA and significantly lower pH than marbled fruits. The effect of environment on marbling was described by the equation $Y= 7884.969+ 37.763X_1-96.297X_2$ $R^2= 79.5$. (Y = % marbling, X_1 = mean of minimum temperature per day after flower induction to harvesting, X_2= mean maximum relative humidity per day after flower induction to harvesting.)

A Study of Some Factors Influencing Fruitlet Core Rot and Leathery Pocket of the Queen Victoria Pineapple in Reunion Island

Christian J.L. Lavigne (CIRAD BP 180, 97455 Faint Pierie Cedex Reunion Island)

Irrigation schedule and fertilization balance between potassium, calcium and magnesium strongly impact severity of fruitlet core rot and leathery pocket caused by the fungus *Penicillium funiculosum.* Maximum yield and optimal internal fruit quality are not linked to the same agronomic practices. Offseason production requires special attention to avoid high level of the disease.

Early Selection of Resistance Using Phytotoxin Produced *by Fusarium subglutinans* the Causal Agent of Fusariosis of Pineapple *(Ananas comosus* (L.) Merr.)

Orlando Borras Hidalgo[1], Aristoteles Pires de Matos[2], Renato Santos Cabral[2], Raul Tapia Tussel[1], Ramon Santos1[1], Mayda Arzola[1] and Maria Cristina Perez[1] ([1]Bioplants Centre, Phytopathology Laboratory,Carretera

de Moron Km9, Ciege de Avila, CP. 69450, Cuba; [2]National Research Centre for Cassava and Tropical Fruit Crops (CNPMF-EMBRAPA), Phytopathology Laboratory, Caixa Postal 007, 44380-Cruz das Almas, Bahia, Brazil)

Fusariosis, produced by *Fusarium subglutinans,* causes losses of up to 80% of marketable pineapple fruit, infects approximately 40% of propagules, and kills about 20% of plants prior to harvest. Pineapple varieties differing in resistance (Perolera (resistant), Spring (resistant), Roxo de Tefe (tolerant),Gueyana (tolerant), Smooth Cayenne (susceptible) and Perola (susceptible)) to fusariosis were exposed to *Fusarium subglutinans* culture filtrate, fusaric acid and fusaric acid + elicting protein isolated from *Fusarium subglutinans* culture filtrate. Cultivars resistance was assessed in tissue culture plantlets (by electrolyte leakage, placing the substances on wound leaf segments and displaying) and callus (inhibition of growth and plant regeneration). The possibility of using these methods as selection agents of resistance of hybrids also was evaluated. Susceptible cultivars were the most sensitive in each test, while resistant cultivars were less affected by the culture filtrate and fusaric acid + eliciting protein and their callus grew in the presence of high concentrations of this substance that were completely toxic to susceptible cultivars. Fusaric acid affected all the cultivars independent of level of cultivar resistance. As selection criteria, response of resistant plants to culture filtrate and fusaric acid + eliciting protein were similar to their response to the micro-organism as selection agent.

Benomyl Resistance of Pineapple Fusariosis

J.A. Ventura[1], B.A. dos Santos[2] and L. Zambolim[2] ([1]EMCAPA, Caixa Postal 391, Vitoria-ES, 29010-901, Brazil;
[2]UFV, Dept. Fitopatologia, Vicosa-MG, 36571-000, Brazil)

Fusariosis caused by *Fusarium subghltinans* f. sp. *ananas* is widespread in all growing areas in Brazil, with yield losses for Perola and Smooth Cayenne of 30-40%. Losses are reduced mainly by use of an integrated disease management program including cultural, chemical ( ) and genetic control methods. Benomyl fungicide at 0.05% a.i. is recommended to protect inflorescences after forcing. Recently, resistant isolates were found on benomyl treated commercial crops in the State of Espirito Santo, Brazil. Twenty two isolates of the fungus from different production areas of Espirito Santo and Bahia States, Brazil, were tested *in vitro* and *in vivo* to evaluate their resistance to benomyl. Four isolates showed resistance to benomyl at 1000 $\mu g\ ml^{-1}$. The LD_{50} of the isolates tested varied from 109 to 288. Thus, *F. subglutinans* f. sp. *ananas* has become resistant due to the constant use of benomyl on pineapple crops. Molecular DNA analysis by PCR-RAPD of isolates from differentiate regions showed 80% similarity, but did not differentiate between resistant and non-resistant fungal isolates. Significant differences in virulence were found among isolates of the pathogen on Perola slips, and the resistant isolate E272 was more virulent than non-resistant isolates. Pineapple cultivar Primavera was resistant to all pathogen isolates. New fungicide formulations such as captan, tebuconazole and iminoctadine significantly reduce fusariosis severity on the fruits suggesting integrated management of fusariosis is possible with new fungicides.

Effect of Pesticidal Pre-treatments of Pineapple Planting Material on the Incidence of the Mealybug Wilt Disease in Farmer Fields, Located in Two Different Agro-ecological Zones With a Different Soil Type in Each Zone

S.F.M. Sulaiman (Regional Agricultural Research & Development Centre, Makandura, Gonawila (NWP), Sri Lanka)

Sites in the Intermediate Low country (IL-1) zone with sandy alluvial red-yellow podzolic soil and in the Wet Low country (WL-3) zone with lateritic soil were selected to test the effficacy of pesticidal pretreatments on the incidence of pineapple mealybugs and ants. Pineapple is commonly grown in coconut land as a monocrop or mixed crop with banana and ginger. Pineapple was established in both locations in replicated plots as a monocrop under coconut. Butt ends of pineapple plants were treated with no chemical (Control, T1), Farmers' use (T2), Prothiofos (28 ml/10 L water)(T3) and Profenofos (28ml/10 L water) (T4). Pitfall traps were used to record ant/spider numbers and mealybugs on the crop were counted; data were collected weekly, for a period of two years. Mealybugs *(Dysmicoccus brevipes* Cockerell) were incident and built-up in numbers only in the WL-3 location. The ants tending the mealybugs were identified as *Pheidole sp, Camponotus* spp., and *Technomyrmex* nr.*albipes.* Mean mealybug numbers per week per treatment, were high in the farmer (228)and control (256) plots and low in Prothiofos (52) and Profenofos (22) plots, although mealybug numbers and fruit yield were not different in the treatments.

Preemergence Weed Control in Pineapple With Thiazopyr Combinations

Rungsit Suwanketnikom[1] and Tawatchai Wirojchewan[2] ([1]Agronomy Department, Kasetsart University, Bangkok lO90O, Thailand; [2]Rohm and Haas Chemical (Thailand) ltd. 29th floor, Thai Wah tower 2, South Sathorn road, Bangkok 1012O, Thailand)

Efficacy of thiazopyr was investigated in pineapple grown at Hauhin District, Prachuab Kirikhan Province southwest of Bangkok and at Sriracha District, Chonburi Province east of Bangkok. Thiazopyr at 180, 240, 360 and 480 g ai/ha were applied alone and in combination with diuron or atrazine. No phytotoxicity on pineapple plants or yield reduction were observed at either location. At Hauhin, thiazopyr at 180, 240 and 360 g ai/ha in combination with diuron or atrazine at 1,500 g ai/ha provided great weed control at 2 months after application, while single herbicide provided only fair control. Herbicide efficacy of combinations were reduced to fair control at 3 months after application. At Sriracha, thiazopyr at 240 or 360 g ai/ha in combination with diuron at 1,500 g ai/ha or thiazopyr at 360 g ai/ha in combination with atrazine at 1,500 g ai/ha gave great weed control at 2 months after application but thiazopyr at highest rate in combination with diuron at 1,500 g ai/ha gave good control of weeds 3 months after application.

Pre and Post-Harvest Studies for the Control of Internal Browning Due to Chilling Injury in Pineapple *(Ananas comosus CV* Mauritius)

H.M.W. Herath, S.Selvarajah and D.M.G. Abeysinghe Banda (Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka)

Internal Browning (IB), an important physiological disorder of pineapple caused by chilling, causes heavy losses for exporters in Sri Lanka. Pre-harvest treatments included the application of different levels of N, P, K and Ca as basal and top dressing and foliar application of potassium as K_2SO_4 and KCI with NAA and ethrel. Post-harvest treatments included studies on the effect of natural and synthetic wax coatings. Field experiments were conducted in three locations where pineapple is grown as an intercrop under coconut and the laboratory studies were conducted in the Department of Agricultural Biology, University of Peradeniya. Foliar application of K_2SO_4 and KCI with flowering hormones at 4 levels before harvesting increased the K content in fruit peel, flesh and crown. Application of K_2SO_4 with ethyphon slightly increased the fruit size and reduced the incidence of IB. Application of 150Kg/ha Ca to the soil reduced or totally controlled IB. This was mainly due to an increase in ascorbic acid content and lower peroxidase activity. Coating fruits with *Neollitea cassia* leaf extract significantly reduced weight loss during storage and a higher level of ascorbic acid and total soluble solids also reduced IB.

Effect of Low Temperature on Postharvest Pineapple Cell Wall Degradation

Hongxia Qu, Youlin Tang, Xinjie Tan, and Xiaoping Pan (South China Institute of Botany, Academia Sinica. Guang Zhou, China 510650)

Pineapple fruits were stored at room temperature, low temperature, low temperature and waxing. Microstructural and ultrastructural changes of pineapple cell wall were followed, and the activities of polygalacturonase (PG, EC 3.2.1.15), pectin esterase (PE, EC 3.1.1.11) and polyphenol oxidase(PPO, EC 1.14.8.1) were examined. Firmness, fresh weight loss, content of soluble uronides, total soluble solids and pigments in peel were tested. At the ultrastructural level, irregular thickening of the primary cell wall, dissolution of the middle lamella and disintegration of fibrillar material through out the cell wall were observed as the fruit softened, which is correlated with the increasing activities of PG and PK. Activity of PE was low, which implied a small

amount of esteristic pectin in pineapple cell wall. There was 2 to 3 fold more soluble polyuronide in blackheart tissue where high PPO activity existed than in the normal sample. A temperature of 12°C, in addition to waxing is effective in inhibiting black heart, one of the most common diseases in South China. The result is that the storage life of pineapple is extended for one or two wk.

Nondestructive Techniques for Quality Evaluation of Pineapple Fruits

T. Yantarasri (Mechanical engineering Dept., Engineering Faculty) and J Sornsrivichai (Biology Dept., Faculty of Science, Institute for Science and Technology Research and Development, Chaing Mai University, Chaing Mai 50200, Thailand)

Pineapple industry is the largest fruit industry in Thailand. Fresh fruit is graded based on eating quality of the flesh as the first and second grade which is related to its sinking-floating. First grade pineapple sinks in water due to specific gravity higher than 1. A higher flavor score and TSS/acid ratio of the first grade fruit was found to correlate well with sinking-floating characteristic but not with the skin colour. This characteristic of pineapple was related to its impact sound, which showed 100% accuracy in quality sorting, particularly on cv. Smooth Cayenne. Therefore, acoustic response sensing could be developed as the alternate method for quality grading of pineapple. In 'Nanglair', the correlation of the above parameters were less. X-ray computed tomography (CT) was used to produce a precise internal image of the fruit without having to cut open the fruit. Our recent research reveals that the intensity of the X-ray CT images and CT number show significant correlation with the translucency of the flesh which reflects the taste quality. The technique could identify other internal defects such as bruise and air pockets as well as identifying inferior fruit with non-symmetrical shape. Thus, the X-ray CT can be an effective nondestructive tool for internal quality evaluation.

Purification of Obtained Bromelain From Different Sources

Martha Hernandez[1], Maria A. Chavez[2], Carol Carvajal[1], Maria A. Blanco[1], Margarita Marquez[2], Justo Gonzalez, Ramon Santos[1], and Nadina Nieves[1] ([1]Laboratorio de Bioquimica, Centro de Bioplantas. Universidad Ciego de Avila. Carretera a Moron, km 9. CP 69450. Ciego de Avila. Cuba. Tel.24016; [2]Laboratorio de Proteinas. Facultad de Biologia. Universad de La Habana, cane 25,#455,Vedado, C.P. 1040O, Ciudad de La Habana. Cuba Tel.324830

Pineapple contains several cysteine proteinases. The major component in stem extracts is the so-called "stem bromelain." Plant proteases have applications in food, pharmaceutical and biotechnological industries. There is considerable interest in using tissue culture methods to isolate physiologically active enzymes. Bromelain was extracted from pineapple stem and purified. Bromelain also was precipitated from liquid media from a temporary immersion system (TIS) for pineapple plant propagation, leading to specific activity values of 0.59 U mg^{-1} protein and few protein contaminants.

Correlation Between Calcium Levels and Variation in Storage Quality of Two Varieties of Pineapple

R. S. Wilson Wijeratnam, I. G. N Hewajulige, M. Abeyesekere and H. A. Samaratunge (Post Harvest Technology Group, Industrial Technology Institute, P. O. Box 787, Colombo 7., Sri Lanka)

Calcium levels in Kew and Mauritius pineapples were compared. Fruits were harvested at three stages of maturity and mean Ca was determined in 5 regions of the fruit. Incidence and severity of the disorder before and after storage at 10 °C for 17 days followed by 48 hours at 28 °C. High Ca in Kew correlated with greater resistance to the disorder; significantly lower Ca were correlated with greater susceptibility Mauritius. Ca was higher in the crown and shell than in core and flesh. Levels in the core decreased after storage, with a corresponding increase in Ca in crown and shell in both varieties. A decrease in migration of Ca from the core occurred when fruits were waxed. Mature green fruits stage were most resistant to the disorder and had the most Ca while fruits harvested at the 10 and 20 per cent yellow had significantly lower Ca and were more susceptible to the disorder. Higher Ca and greater resistance to the disorder was observed in Kew pineapple.

Sample Size of Pineapple for Quality Testing

Juntra Bordeesorn[1], and Yupin Kasinkasempong[2] ([1]Planning and Technical Div., Dept of Agriculture, Chatuchak, Bangkok 10900, Thailand; [2]Chumphon Horticultural Research Center, Amphoe Sawi, Chumphon 86130, Thailand)

Pineapple sample size for testing for total soluble solid (TSS), pH, titratable acidity (TA), vitamin C (VC),and nitrate (NO_3^-) in fruit flesh was studied at Chumphon Horticultural Research Center. Pineapple variety"Pattawia" was grown in 30 plots (plots had 4 double-rows, 22 plants/row and 100x50x25 cm-spacings between beds, rows and plants, respectively. Ten pairs of fruit were sampled randomly from 2 double-rows in 12 small plots, excluding an outer border row in November 1996 and April 1997. At the 10% margin of error and 95% level of confidence, at least 8 pairs of fruit should be used for quality factor mentioned, except NO_3^-, for which no test was conducted.◆

References

This list includes papers published or located since the last issue of the newsletter was printed. **Please help** keep this section current by sending citations or copies of recent publications to D.P. Bartholomew .

Reprints of most of the publications listed below should be obtainable through any university library or by writing to: Library External Services, Hamilton Library Room 112, University of Hawaii, 2550 The Mall, Honolulu, HI 96822 U.S.A. Charges are approximately $14.00 per article plus postage for the first 20 pages and $0.25 per page over 20 pages.

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Pineapple on the Web

http://www.freshdelmonte.com/home.html
http://www.marketasia.org/news/1998/juices/pineapple.htm

Directory of Professionals

This listing is maintained as a convenience for those seeking the assistance of professionals with experience in pineapple production and processing. If you have such expertise and wish to have your name listed here in a future issue, please send your name, address, Email address, and a brief resume to D.P. Bartholomew at the address on page 1.

Adriaan Dolmans, Van Wassenaerlaan 31, 7218 AT Almen, The Netherlands; Phone: 31-575-431102; E-Mail: adolwaul@usa.net. Adriaan Domans is former Managing Director, Del Monte Kenya Limited, Thika, Kenya. Twenty two years of experience in Kenya in all facets of plantation, cannery, and fresh fruit export by sea.

Dean W. Wheeler, AgResults, Inc., 11015 S.W. 69th Ave. Rd., Miami, FL 33156, U.S.A.; Phone: ; E-Mail: agresults@aol.com. Offering advice on production, fresh produce packing, and post-harvest management of pineapple and other tropical crop. Thirty three years experience with Del Monte Corp. including pineapple production in Costa Rica, Hawaii, Kenya, and Philippines.
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Questionnaire on PWG Organization

1. The Pineapple Working Group Board should consist of :
   ❑15 members ❑Other; write in number (_____)
2. No more than two board members from any one country.
   ❑Agree ❑Disagree _____Indicate number
3. Criteria for Board membership should include:
   a. Size of pineapple industry in country of residence ❑ Agree ❑ Disagree
   b. Membership in ISHS ❑ Agree ❑ Disagree
   c. Experience/knowledge of pineapple ❑ Agree ❑ Disagree
   d. Access to E-Mail ❑ Agree ❑ Disagree
3. PWG and Board members should help find travel funds for the symposia.
   ❑ Agree ❑ Disagree
4. Board should appoint Technical Committee to judge abstract quality and provide peer review of papers.
   ❑ Agree ❑ Disagree
5. Until a board can be formally elected, I accept the following ad hoc board listed below.
   ❑ Yes ❑ No

Duane Bartholomew (Hawaii, PWG Chairman), Y.K. Chan (Malaysia), Nyuyen Minh Chau (Viet Nam), Geo Coppens d'Eeckenbrugge (Colombia), Anthony Hepton (Dole, USA), Miriam Isidron (Cuba), Leandro Lucas (Del Monte Philippines), Eric Malézieux (France), Aristoteles Pires de Matos (Brazil), Graham Petty (South Africa), Andrés Rebolledo (Mexico), Victor Galan Sauco (Canary Islands; Chairman, ISHS Commission on Tropical and Subtropical Crops), David Swete Kelly (Australia), Suranant Subhadrabhundu (Thailand), R.S. Wilson-Wijeratnam (Sri Lanka), Daniel Uriza (Mexico),

6. Please use the space below to comment on any of the above items or to suggest alternatives to the proposed organizational structure.

Mail to D.P. Bartholomew (Dept. of Agronomy and Soil Science, Univ. of Hawaii, 1910 East-West Rd., Honolulu, HI 96822 U.S.A. E-Mail to duaneb@hawaii.edu.