Pineapple News

Issue No. 10 Newsletter of the Pineapple Working Group, International Society for Horticultural Science May, 2003

Contents

Pineapple Working Group (PWG)

Dear PWG colleagues:

It recently occurred to me that this is the 10th anniversary of Pineapple News and I also overlooked the 10th anniversary of the PWG at the meeting in Mexico in April of 2002, just seven months shy of the anniversary date of the first symposium held in Honolulu in 1992. I would like to thank all who have supported the PWG and Pineapple News over these past ten years by your presence at symposia, and by your monetary and written contributions. We have seen both change and progress during the life of the PWG. Including some of the changes I have written about below, we have a new chair of thePWG (see next column). Progress is especially notable due to improved technology and expanded access to it. In particular, the newsletter has gone from no distribution over the internet to the point where more half of the newsletters are distriubed that way. It has made communication much faster and greatly reduced the expenses associated with producing and mailing the newsletter. Please note also that the web address of the newsletter has changed to http://tpss.hawaii.edu/pineapple/pineappl.htm.

Allen Duncan Chairs Pineapple Working Group

I am pleased to announce that Allen Duncan, Managing Director, Summperpride Foods Ltd., East London, South Africa, has agreed to chair the Pineapple Working Group. Allen attended the 4th International Pineapple Symposium and was one of those from South Africa who extended the invitation to participants at the Veracruz meeting to come together again in South Africa for the 5th symposium..

Allen's interesting background bodes well for a quality run as chairman of the PWG. Allen was born in Grahamstown, South Africa, and after attending school there went on to obtain a degree in agriculture management from Natal University, Pietermaritzburg. He returned to the family farm where he worked in partnership with his father from 1985 until his father's death in 1987. He continued a successful farming operation with his brother growing chicory, pineapples, canary seed, maize, and bonsmara cattle until he sold out to his brother in August of 2000. Allen became an executive member of the Pineapple Growers Association (PGA) in 1987 and became vice chairman from 1991-93. Allen was involved in the formation of the Pineapple Technical Work Group of the PGA, was elected vice chairman from its inception, and became chairman two years later. The groups focus was on controlling runoff and erosion from pineapple farms to prevent the government from closing them. Through research, grower education, liaison with government departments, and manufacture of machinery, run-off was controlled to such an extent that in the early 1990's the group was a world-wide leader in this field. The group was closed down in the mid 1990's because run-off control was no longer an industry problem.

In 1993 Allen resigned from the PGA to spend more time with the development of Summerpride Foods, which was formed in December of 1993. Allen was asked to take the position of Managing Director of Summerpride in 2000 at a time when the company was in severe financial distress. Allen was successful in negotiating with creditors and others to keep the company going and brought it back to profitability in 12 months, an accomplishment of which he says he is very proud. Summerpride currently processes 108000 tons of fruit, has a turnover of approximately R200 million and employs 570 permanent people with up to a maximum of 1,070 people on double shift. The company currently exports canned fruit and juice concentrates to 31 countries worldwide and supplies 90% of South Africa's canned pineapple needs.

Allen has also been involved in grower education and in 1998, organized a course for farmers to improve farmer business acumen. This then led to the formation of financial Study Groups and some spectacular results have been achieved.

With Allen's experience with pineapple and in managing public affairs and people, the successful planning of the next symposium seems assured.

Change in the Pineapple Industry

Over the past several months I have communicated via email with three scientists who spent the early part of their professional careers at the Pineapple Research Institute of Hawaii. All three are now over 80 years old but still very interested in what is going on in the world and with changes in pineapple culture and management. Dr. Donald Gowing worked at the PRI in the early 1950s before going overseas to work on sugarcane production in Iran. Dr. Gowing wrote a seminal paper on the effects of temperature and photoperiod on flowering of pineapple and little new information has been developed on the effects of those factors on pineapple flowering. Dr.

Marlow Thorne was head of the soils department at PRI and, among other things, conducted early studies of the effects of irrigation on pineapple. Dr. Thorne left the PRI in the 1950s and went on to a distinguished career in soil science at the University of Illinois. Dr. Don Smith, spent about 10 years at PRI working on a variety of soil fertility and plant nutrition issues. When Dr. Smith left PRI, he joined Del Monte Corporation where he worked until retirement.

I mention these gentlemen because it has been a pleasure to correspond with them, but also because in inquiring about changes in pineapple culture and management, they have reminded me of the extent to which the industry has changed since I first began working with pineapple in 1965. In 1965, 'Smooth Cayenne' was the principle variety being grown and most of the fruit were processed. Competition for the canned market intensified in the late 1960s with the expansion of the industry in the Philippines, and by the entry of Thailand as a major grower and processor of pineapple fruit. This expansion in countries where labor costs were low placed intense pressure on the canning industry in Hawaii and in the early 1980s Dole and Del Monte closed their canneries and shifted their main areas of production to Thailand and the Philippines. This shift and the development of refrigerated shipping resulted in a transition in Hawaii to fresh fruit production.

The shift to fresh fruit production brought with it a miriad of problems that had only been briefly explored by an industry focused on processing. Fruit grown for processing were harvested mostly in summer because fruit quality was best then. With an increased focus on fresh fruit production, the industry move to year-around production so as to provide fruit to the marketplace throughout the year. This resulted in new problems for the industry. Fruit harvested in the cooler months was of low quality because of high acidity. High translucency, a sought after characteristic for canned fruit, made fresh fruit more fragile and therefore was undesirable. The incidence of natural induction became a more serious problem as growers attempted to maintain plants in the vegetative state during the cooler winter months. Where rainfall was seasonal, irrigation was required to keep vegetative plants growing so fruit of acceptable size could be harvested on schedule. Nutrient and water management also became important components of practices designed to reduce natural induction.

In addition to changes in cultural practices required to sustain a viable fresh fruit operation, the early 1980s saw the beginning of a gradual shift in the fresh fruit market from 'Smooth Cayenne' to hybrids. In the Americas, Del Monte led this change when they took a hybrid pineapple named MD-2 to Costa Rica and began propagating it. The story of how this came about is a private one, but it seems likely that once plant performance was found to be acceptable, numbers of plants were increased. No doubt test marketing was carried out once sufficient fruits were available and perhaps this took place in the early 1990s. The fruit of MD-2 clearly were a success in the marketplace because the fruit of MD-2 is now widely available in the United States and Europe and growers have been, and perhaps still are, paid premium prices for it. Perhaps a decade after Del Monte's successful venture began, Dole began to expand production of their own low-acid hybrid pineapple. In the past several years, inquiries from Central America indicate that planting material of MD-2 has become a widely sought after commodity and fruit of this hybrid now appear to be more prevalent than 'Smooth Cayenne' in the markets of the U.S. and Europe, especially during the winter months.

Taiwan (see News from Taiwan), Australia, Brazil (see News from Brazil below) Malaysia, and perhaps other countries have also developed hybrid pineapples specifically for the fresh fruit market. This trend of new varieties of pineapple in the marketplace is completely consistent with the expanded variety of temperate fruits that can be found there. It is unfortunate that pineapple growers have had to confront the challenges associated with year-around production of fresh pineapples at the same time that support for research to investigate and understand some of the important problems has declined. Individual growers are at a particular disadvantage because they may not have the training or resources needed to conduct the controlled experiments needed to solve problems associated with new cultivars or changes in cultural practices required to support a successful fresh fruit operation. Regrettably, that situation does not appear likely to change in the foreseeable future.

TFNET Effort to Develop Organic Pineapple Technical Guidelines

The following information was provided by Jantien Emmons, Jantien.Emmons@fao.org, with minor changes and additions by D. Bartholomew

The International Tropical Fruits Network (TFNET), with financial and technical support from the Food and Agriculture Organization of the United Nations, convened an international workshop on technical guidelines for organic cultivation of tropical and sub-tropical fruits in July 2002. The workshop was attended by participants from Sri Lanka, Bangladesh (BRAC), Cuba (IIFT), Malaysia (TFNET, DOA, MARDI, private growers and NGO), AGRECOL, IFOAM and FAO. The overall conclusions of the workshop were:

1. It was recognised that farmers have difficulty finding practical information about the organic cultivation of specific fruit crops in the tropics and subtropics and that there is scope for collaboration among fruit crop specialists and the organic agriculture community in order to generate and disseminate production guidelines that will help farmers meet certification requirements and get returns.
2. It is important to recognise that the principles of organic agriculture imply a completely different approach to developing crop management systems; nonetheless, crop science in all its derivations offers much knowledge that can be adapted and used in this pursuit.
3. The mechanism of informal, flexible work groups, based on voluntary collaboration and sharing of information, was found to be appropriate for activating both editorial initiatives and research and technology generation to meet the specific needs of organic tropical fruit growers. It will be important to find ways of integrating the experience of pioneering organic farmers in the method of work adopted.
4. The joint sponsorship by FAO, IFOAM, and TFNET of these initiatives should be a significant message to potential collaborators, as well as sponsors and donors, and will help to impress upon the scientific, organic and trade communities the importance of collaboration for mainstreaming organic agriculture.

Workplans for compiling technical guidelines for the organic cultivation of citrus, mango, papaya, and pineapple were agreed upon. A detailed workplan has been developed for pineapple and the lead coordinator/writer for technical guidelines for pineapple was H.M.S. (Subha) Heenkenda of Sri Lanka (subhahee@sltnet.lk). It was projected that the guidelines would be completed by August, 2003.

Date of 5th Symposium in South Africa Fixed

Allen Duncan, chair, Pineapple Working Group, writes that an executive committee has been formed to organize the next pineapple symposium. Allen chairs the committee and the Scientific Division will be chaired by Dr. Piet Jobert of the ARC/ITSC. The date of the symposium will be 11-15 May, 2005. The venue is still under discussion and no doubt will be announced soon. The main pineapple growing area of South Africa is in the Eastern Province of South Africa, and a map of South Africa and of the Eastern Province can be found at the Summerpride Foods website at http://www.summerpride.co.za.

ISHS Membership and Benefits

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

For more information go to the ISHS web site or contact the society by writing to: ISHS Secretariat, P.O. Box 500, 3001 Leuven, Belgium (E-Mail: info@ishs.org).

Contributions to Pineapple News

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

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

Organic Pineapple Working Group

One Year after It's Formation, the Chair Discusses the Issues

Douglas Hinds, Chair, OPWG, Apdo. Postal No. 61, Cd. Guzman, Jalisco, 49000 Mexico; cedecor@gmx.net.

Just over a year ago, at the 4th International Pineapple Symposium held in Veracruz, Mexico and published soon afterwards in the 8th edition of Pineapple News, the existence of an Organic Pineapple Subgroup of the Pineapple Working Group (OPWG) chaired by this writer was announced. As a result of the announcement, inquiries and membership applications arrived from growers and researchers in Australia, Costa Rica, Cuba, Dominica, Guyana, Hawaii, India, Ivory Coast, Mexico, Papua New Guinea, the Philippines, South Africa, and Sri Lanka.

A little later, a Proposal for the OPWG's orientation, scope and activities was drafted and sent to all members, after the email addresses were provided for a few affiliates that didn't include that data in their membership applications, thanks to members and others who did us the favor of calling them in order to procure that data. In order to determine the current state of the art as practiced by our OPWG membership, the Proposal was followed by an Organic Pineapple Production Poll which was also sent to all members, many of whom responded in detail.

In order to provide a significant degree of support for the membership, the OPWG must successfully deal with a number of critical issues which have not yet been sufficiently defined by the members. These issues include: Information Sharing as contemplated in OPWG Policy and in Practice, the Design and Implementation of a Collaborative Research Project, Joint Promotion of the Organic Pineapple Industry and, the Feasibility of Group Marketing, all of which were put into focus. Two related issues are: Sharing Information with Non-members and, the Publication of Information Provided by Members.

Not all of these issues have been resolved to date, which has impeded our attacking together the underlying technical issues related to organic pineapple production. These issues include Flower Induction, Pest and Disease Control and Fertilization using both on-farm and off-farm sourced organic materials for Compost and Compost Tea fabrication, along with Crop Rotations, Green Manures, Companion Planting and for mineral requirements, Rock Dusts. Until these issues are resolved, the viability and functioning of the OPWG itself will be somewhat limited compared to what could be accomplished by a totally unified and open group of farmers and researchers..

Understandably, those group members already cultivating and marketing organic pineapple are not eager to share their knowledge and experience with their competitors. However, in many cases the wide geographic separation of members makes that danger a moot issue and the researchers within the group are much less subject to these kinds of impediments.

Partly in order to stay clear of the conflicts of interest and partly as a logical follow up to the formation of the group itself, the group's first steps concentrated on identifying each member's principle problems and the relative importance of each problem within his or her operation.

How Organic Agriculture Differs

Unlike conventional agriculture, which depends on synthetic agrochemicals, Organic Farming is an agricultural production system based on the presence and activity of living organisms. In addition to those microorganisms that inhabit the soil and facilitate the accessibility and assimilation of the nutrients crops require, a myriad host of beneficial organisms that include earthworms, birds, predators, parasites, pathogens, plants repellant to pests (the principle vectors for crop diseases), and plants attractive to pests are involved. Other accepted practices include the employment of natural hormones that attract pests to insect traps and the use of sterile male pests that on mating with their counterpart, leave no progeny. Compost teas, fairly recent additions to the organic growers arsenal, have been shown to control a number of plant pathogens. For more information on the subject, search the web using the key words compost tea and plant pathogen. (For more information on the subject see: http://attra.ncat.org, http://www.ibiblio.org/ecolandtech, http://www.soilfoodweb.com and http://www.ams.usda.gov/nop/indexIE.htm.)

At present, the demand for Organic Pineapple outstrips the fruit's availability and obviously, high quality organic pineapple is likely to procure a higher price than that brought by conventional .pineapple. In general, the yearly growth of the Organic Market is significantly higher than that occurring in the conventional produce industry and that should hold true for organic pineapple also, once the problem of supply has been resolved. At least one of the major players in the conventional pineapple industry is working toward developing and marketing an organic product.

Organic Production in Mexico

In Mexico, most pineapple growers are not land owners and must rent the few hectares they are able to finance pineapple production on, usually with governmental support. Most of this product is directed to the relatively unstable national market, which is frequently unable to assimilate large enough quantities of the product, once the season's peak has arrived.

Two years ago, in the aftermath of extremely serious losses suffered by pineapple growers after a glut caused the market to plummet, many who had grown pineapple all their lives ceased to plant that tropical fruit. The grave loss suffered by all growers was due to four principle factors: An excessively high dependency on expensive and contaminating agrochemicals that make pineapple an unusually expensive crop to produce; a total absence of industry-wide planning and corrupt leadership within the unions most poor pineapple farmers form part of, along with unstable national prices, which plunge whenever the national market becomes saturated.

There is no significant market for organic food in Mexico at present and this is not expected to change in the foreseeable future. Therefore, organic food is cultivated almost exclusively for distribution in the USA, Canada, Europe, Japan and increasingly, other economically important areas of Asia. The principle advantages of exporting pineapple are a far more stable price range and the ability of export markets to assimilate much larger quantities of fruit. However, at present, most pineapple grown in Mexico is consumed within the country and therefore, subject to the market aberrations mentioned above.

Furthermore, with a few notable exceptions, Mexico's pineapple production system is much less efficient that that found in the principle pineapple producing countries and both the yield (tons per hectare) and cannery yield (boxes per ton) are notoriously lower. Consequently, Mexico is unable to compete with Thailand, Vietnam, the Philippines, Malaysia and Indonesia within the conventional canned and frozen pineapple industry.

On the other hand, within the fresh pineapple industry, whether Conventional or Organic, Whole or Fresh Cut, Mexico is better able to compete within the international market, above all in the USA market; if only Mexico's pineapple growers could get together and organize a well planned pineapple production and marketing project–a goal that is included in the support we attempt to provide growers. At present, only eight per cent of the pineapple sold in the US market is of Mexican origin, despite the climatological, geographic and political advantages (i.e. trade agreements) Mexico enjoys in relation to the USA and Canada.

Although not required for organic certification, Fair Trade and an Equitable Treatment for farm workers are increasingly important as a necessary adjunct to organic food, since Social Responsibility is considered by many to be closely related to it's Ecological counterpart. However, a fair deal for poor pineapple growers is dependent in part on opening direct distribution channels, with fewer intermediaries found between the grower and the consumer. Consumers will also benefit, with lower prices and fresher pineapple that is picked riper, as a result.

For many other consumers, rather than any appreciation for it's ecological benefits, the demand for organic food is driven by it's certifiable absence of genetically modified organisms and the traceablity required by the organic certification process, which greatly augments the degree of food security associated with organic food in general.

We hope that growing organic pineapple will help improve the living conditions in the regions where pineapple is grown in Mexico, particularly since the economy of these regions depends almost exclusively on this one crop. Even the fountains in the town square of Loma Bonita, Oaxaca (a city whose economy depends more than 95% on it's pineapple production), are constructed in the shape of a pineapple, for instance.

Undoubtedly, a well organized organic pineapple production project that takes advantage of Mexico's potential could do wonders for the poor farmers in Mexico's Southeast, where the vast bulk of Mexico's pineapple production occurs on unirrigated land in the Papaloapan Basin. Along with chairing the OPWG, we hope to provide these poor farmers with all the support required to achieve that end.◆

News From Australia

2002 Pineapple Field Day

The Pineapple Field Day for 2002 was held at the Glasshouse Mountain Sports Club on July 19. The program was more limited in scope than those presented in past years and fewer of the presenters wrote up material for the Field Day Notes. The technical program included presentations on:

! Fresh pineapples and hybrids by Nick MacLeod, Golden Circle Ltd;
! Disease resistance screening in pineapples by Garth Sanewski, DPI;
! Technical update 1 by Doug Christensen, Golden Circle Ltd;
! Technical update 2 by Tim Wolens, Golden Circle Ltd;
! Commercialisation strategy for new pineapple hybrids by Chris Adriaansen, Business Manager, QHI, DPI;
! Farm safety courses by Peter Chapman, Workplace Health & Safety Advisor (Rural) Nambour;
! Report on diazinon residue trials; Andrew Kennett, Agristudies & Associates;
! Report on the Fourth International Pineapple Symposium, Mexico; Col Scott and Tim Wolens, Golden Circle Ltd;
! Future directions in land management issues by Stan Ward, DPI Forestry, Beerburrum;
! New Golden Circle website features for growers by Jonathan Davies, Golden Circle Ltd ;
! Farm budgeting by Gavin Crawley-Smith, ANZ bank.

Symphylid Chemical Observation Trial at Yeppoon

Tim Wolens and Doug Christensen, Golden Circle Limited

Trial Outline

An informal design to screen treatments for Symphylid.

The soil is a structured clay loam (Vertisol) at Cawarral with a pH of 5.3. Digging at the site found white grub and symphylid in existing crops and symphylids were easily found inside moist soil clods in the fallow soil before trial installation.

This trial was installed in October 2000, with Metham applied after significant rainfall allowed ideal soil moisture and planted with Smooth Cayenne slips three weeks after fumigation. The plant crop was harvested on 15 January 2002.

Treatments, Materials and Methods

Treatments where pre-plant soil incorporated by mini-spray boom attached to a rotary hoe, or in the case of Metham, blanket soil injection with cutter-bar boom to 0.3M depth. Small plots were hand-sprayed as a simulated boom spray. The plant population density was 43,391 plants ha^{-1}.

1. Main Treatment (Combination Treatment of Metham , Chlorpyrifos and Lindane). The commercial pineapple field was treated with chlorpyrifos (Lorsban 500EC) and lindane (Lindane 200SC) during early ground preparation and at hilling respectively. The Metham fumigation treatment was applied two weeks before hilling.
2. Test Strip – A test strip of Metham alone was installed alongside the combination treatment.
3. Small Plots – Randomised pairs of chlorpyrifos, lindane, fipronil (Regent 200SC) and bifenthrin (Talstar 100EC) where applied at the side of the commercial crop.

Note- There were no post plant applications for any treatment.

Main Results Summary

Table 1. Plant crop summer fruit (average process grade weight) and calculated process fruit yield.

Treatment	Wt., kg	Smalls, % juice	Yield, T ha^{-1}
Control	1.45	24	47.81
Lindane 200SC 1 1.25L	1.47	26	47.0
Lorsban 500EC 5L	1.57	17	56.42
Metham Sodium 600L	1.67	8	66.66
Lorsban and Lindane with Metham, rates as above.	1.92	0	83.31

Fruit yield per hectare was relatively low over-all due to the traditional low density planting style (wide bed spacing). But fruit size in the successful combination treatment of metham with residual pesticides (lindane and chlorpyrifos) was excellent.

Symphylid Chemical Observation Trial Discussion

There was strong evidence that the causal organism of crop damage was symphylid due to a conspicuous presence of this pest in the experimental area. Symphylid began to re-establish in the fumigated bed soil from two months after planting, but took five months to re-appear in the lindane treated areas. Control of the pest was most effective where the combination of metham fumigation and residual pesticides were applied.

The metham and metham combined with soil residual insecticide treatments related to commercial scale treatments and were visually very even and consistent by crop appearance and data sampling. However, the small plot areas looked to be subject to a high degree of environmental bias. Differences in small-plot results with the registered chemicals, Lindane and Lorsban in this case should be therefore treated with caution.

One strong assertion is that the rates of experimental insecticide used in this Yeppoon trial are very much inadequate for soil control of symphylid– results were similar to untreated (data not presented).

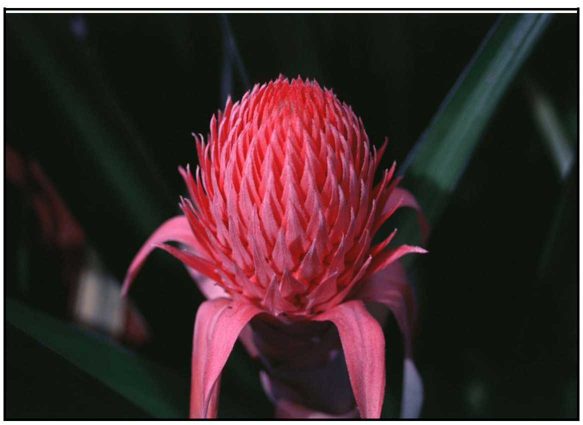
Subsequent trials at Gympie show early promise of good experimental control at much increased rates of the experimental pesticides, broadcast soil incorporated. This development has resulted in the installation of further fully replicated small plot trials by Cropcare for possible future registration applications for one experimental.

Also from other trials it would be expected that the lindane small plots should have responded to a greater degree than these small plot results.

Ornamental Pineapples

G. M. Sanewski, Maroochy Research Station, Nambour. Australia.

A small market exists for ornamental pineapples, either for the cut flower market or the landscape market. A small scale breeding program (approx 5,000 seedlings) conducted at Maroochy Research Station has developed varieties potentially suitable for either market. Three varieties will soon be released for the cut flower market and 3 varieties for the landscape market. *Ananas bracteatus* was used as a parent for the cut flower types because of its bright red cone. *A. lucidus* cv Selvagem 6 was used as a parent for the landscape types because of its chocolate/red leaf colour. The cut flower types generally have a bright red cone on a long, thin scape. One, an intergeneric cross, is bright pink. The landscape types are generally moderate in vigour with narrow, chocolate/red leaves and a small pink/red fruit on a long, thin scape. One is a dwarf, clumping type with green leaves. Varieties to be released include Anna Red, Anna Belle, Anna Rose, Anna Flame, Anna Pink and Anna Min.



News from Brazil

Alternative Technologies for the Cultivation of Pineapple

Getúlio A. Pinto da Cunha, Embrapa Cassava and Fruit Crops, P.B. 007, 44380-000 Cruz das Almas/BA - Brazil. getulio@cnpmf.embrapa.br

Pineapple is grown in Brazil mainly in the NE, SE and N regions, where it represents an important source of income and employment. In general, this crop is cultivated on small farms, usually less than 10 hectares, involving, in most of the cases, family labor. But there are also medium and large growers, all of them demanding technologies that can contribute to reducing the risks and increasing the productivity of the crop, both indispensable for increasing income and improving the farmer's quality of life.

Pineapple ranks third among the tropical fruits cultivated in Brazil, with production in 2001 of about 1,35 billion fruits produced on an area of 59,123 hectares (IBGE/LSPA, 2002). Pineapple was the first plant to have flowering artificially controlled on a commercial scale, and this made economical cultivation possible. However, the low efficiency of flowering control and the incidence of fruit sunburn, mainly in small plantings where the farmer doesn't have enough money to invest in technologies, increases the risks of growing pineapple. In the case of fruit sunburn, the losses can reach more than 70% of fruit production. Hence, the great importance of the use of alternative technologies that make the production of pineapple economical and improve fruit quality, which directly increases its commercial value.

The Technologies

1.Increase in the Effectiveness of the Treatment for Floral Induction (TIF) - TIF in pineapple culture aims at inducing uniform flowering and, thus, concentrating harvesting in a short period of time, improving the economics of production and scheduling production as a function of market demand. Ineffective control of flowering practically makes pineapple cultivation uneconomical.

The technology described here is based on the use of ethephon to force pineapple flowering. When applied to the plant, the ethephon is decomposed, liberating the ethylene, which then induces flowering. The amount of ethephon used, and thus the cost of flower induction, can be reduced by speeding up the decomposition of ethephon by raising the solution pH above 7.0. This can be done using low-cost substances such as calcium hydroxide ($Ca(OH)_2$) at 0.35 g L^{-1} of water. First, the $Ca(OH)_2$ is dissolved in a small amount of water along with sufficient urea to make a final diluted concentration of 2% . Water is added to make the final solution volume and 0.25 to 0.50 mL ethephon is added per liter of solution. Forcing is accomplished by applying 30 to 50 mL of the solution per plant. That represents a 25% to 40% reduction in the concentration used by growers. The higher amounts of ethephon (0.50 mL) should be used when the application time coincides with periods of the year that are unfavorable for floral induction (long and sunny days with high temperatures), and also in vigorous plants. The schedule of application should be the same used with other techniques (at night, early in the morning or in the late afternoon).

2. Protection of the Fruit against Sun Scald or Sunburn - Considered as a serious defect by the National System of Vegetal Classification /Brazilian Ministry of Agriculture, sunburn happens as the result of exposure of the fruit to direct sun, mainly in the period between 12 and 2 pm. Sunburn is more severe when the fruit bends over or lodges. Fruit sunburn occurs in all pineapple producing areas where harvesting coincides with the hotter time of the year, but mainly in the North region of the country. Sunburn decreases fruit quality and, if not controlled, causes losses of more than 70%, and may even make pineapple cultivation unfeasible. To avoid this problem, the fruit should be protected, mainly at the side the sun sets, with grass from weeding, with used newspaper or, with the leaves of the plant. In the latter case, three methods can be used: a) tying the longest leaves above the fruit with a string; b) fixing pickets along the planting lines spaced 2.50 to 3.00 m apart and along which parallel strings are passed and tied (crossed or in zigzag); those strings support the leaves in the vertical position and thus protect the fruits collectively; c) tear the longest leaf in the middle up to half its length and without detaching it from the plant wrap up the other leaves, which are lifted up around the fruit and tied above the crown. Under climatic conditions favorable to the occurrence of sunburn, the protection should be accomplished as soon as the fruit is formed.

Advantages and Impacts of the Technologies

The advantages and impacts of the technologies here described, are: 1. Yield increase (increase in the number of fruits harvested/area); 2. Improvement of fruit quality (absence of sunburn); 3. Decrease in production costs (smaller amount of floral inductor and no need of used newspaper), with consequent increases in the profitability of the culture (more fruits sold at better prices). In comparison with the usual techniques, the elevation of the pH of the ethephon solution decreases the amount of product required while the protection of the fruit with the plant's leaves reduces the cost of inputs. At present, in the areas where ethephon is used, the concentrations are very high, reaching from four to 16 times more than that recommended in this paper. The described technologies can be used, not only by small but also by medium and large growers, including agricultural enterprises, that cultivate pineapple with commercial purposes. Both technologies are of low cost and, therefore, accessible to all pineapple growers. Artificial floral induction is indispensable in all the producing areas where pineapple is cultivated in an economical way, while the protection against sunburn is already practiced in most of the areas where it occurs.

The technologies presented here received the "FRUTAL Technology Award/2002", during the 2nd. Symposium of Technological Innovations, accomplished in Fortaleza/CE-Brazil, September/2002.

'Imperial', a New Pineapple Variety from Embrapa

José Renato Santos Cabral (plant breeding), Arsitóteles Pires de Matos (plant pathology) and Domingo Haroldo Reinhardt (plant physiology, crop management), *Embrapa Cassava & Fruits*, Caixa Postal 7, 44.380-000, Cruz das Almas, Bahia; email: jrenato@cnpmf.embrapa.br

The pineapple varieties most cultivated in Brazil have been 'Pérola' and 'Smooth Cayenne', both susceptible to *Fusarium* disease, the main phytossanitary problem of this crop in the country. To minimize losses due to that disease it is very important to use healthy planting material, to eliminate contaminated plants as soon as possible and to do preventive chemical control, requiring at least three to four applications of fungicides before and during the flowering period of the plants. These practices increase costs and reduce considerably the chance of producing organic pineapples. However, the most efficient and economic method for controlling this disease is the use of genetically resistant cultivars.

Since 1984 *Embrapa Cassava & Fruits* has been carrying out a genetic improvement program to produce pineapple varieties resistant to fusariosis and that produce fruits of good quality that meet the markets' demands.

The 'Imperial' pineapple is a 'Perolera x Smooth Cayenne' hybrid obtained in 1998. In agronomic performance trials carried out in different Brazilian pineapple production areas, this hybrid has been superior to the other genotypes studied. It is not affected by fusariosis and produces fruits with a yellow pulp, high sugar content, and excellent flavor in sensorial analyses. Another desired character of this new variety is that its leaves don't have spines, just like the 'Perolera'. A summary of the most important characteristics of the 'Imperial' variety is given below in the Table 1.

In Brazil, the 'Imperial' variety is recommended for cultivation in regions with environmental conditions appropriate for the pineapple crop, especially where fusariosis has been a production-limiting factor. The cultural practices used for the other varieties may also be applied to this new one, except for those directed to control fusariosis. The variety produces fruits with qualities for both the fresh fruit market and for the canning industry.

Table 1. Plant and fruit characteristics of the 'Imperial' pineapple variety.

Characters evaluated	Values obtained†
Plant height (to fruit base, cm)	49.1
'D' leaf length (cm)	68.0
Peduncle length (cm)	20.8
Peduncle diameter (cm)	3.1
Leaf type	Smooth
Leaf color	Dark green
Slips per plant	9.0
Suckers per plant (at fruit harvest)	1.0
Fruit weight without crown (g)	1672
Fruit length (cm)	18.5
Fruit diameter (cm)	13.5
Crown weight (g)	120
Crown length (cm)	17.8
Fruit format	Cylindrical
Rind color (ripe fruit)	Yellow
Pulp color (ripe fruit)	Yellow
Fruit core diameter (cm)	2.4
Total soluble solids (TSS, °Brix)	15.8
Total titrable acidity (TTA, % as citric acid)	0.62
Ratio (TSS/TTA)	25.48
Reaction to Fusariosis	Resistant

†The values are averages obtained from several cycles of study at Cruz das Almas, Bahia, in a low fertility soil (yellow latossoil) and under rainfed conditions. At this site the climatic conditions are the following: averages annual rainfall, 1.150mm, with fewer rains in the summer; temperature of 24°C, with extremes ranging from about 17°C to 33°C; relative air humidity of 78% and sun radiation of 2.200 hours.

Fruit Pulp Quality Gradients in 'Pérola' Pineapple

Domingo Haroldo Reinhardt (plant physiology, crop management), Valdique Martins Medina (post-harvest physiology) and Ranulfo Correa Caldas (experimental statistics), Embrapa Cassava & Fruits, Caixa Postal 7, 44.380-000, Cruz das Almas, Bahia; email: dharoldo@cnpmf.embrapa.br
Alberto de Almeida Alves, (researcher) Agricultural Research Corporation of Bahia State (EBDA), Itaberaba region, Bahia; Pedro Paulo Simas Santos, president, Cooperativa dos Produtores de Abacaxi de Itaberaba (COOPAITA) and Rodrigo Estevam Herrera, undergraduate student, Agronomy College, Federal University of Bahia, Cruz das Almas, BA.

'Pérola', the most cultivated and consumed variety of pineapple in Brazil, has a relatively long fruit, which botanically is an inflorescence, generally composed by 50 to 150 individual fruits (fruitlets), each originated by parthenogenesis from one complete flower. As with the whole plant, the inflorescence is formed in a spiral and development begins from the base, so the fruitlets at the base of the inflorescence are physiologically older than those above. This age difference among fruitlets results in similar variation in fruitlet maturation.

The Brazilian Ministry for Agriculture, Livestock and Food Supply (MAPA) established the criteria of classification and patterns for commercial pineapple fruits in the country, including such specific qualitative requirements as their minimum sugar content (12 °Brix), size (weight) ranges, and degrees of apparent maturity (rind color). Taking into account the internal gradient in physiological age in pineapple fruits, quality control procedures strongly depend on correct methods of fruit sampling and evaluation. Specific knowledge of the internal fruit quality gradients is fundamental for the definition of those procedures.

In the 2002 'Pérola' pineapple production season, fruits were harvested from commercial fields in Itaberaba, the main production zone in Bahia. Analyses of the gradients in the most important pulp quality attributes were carried out at the Plant Physiology and Post-Harvest Technology Laboratory of *Embrapa Cassava & Fruits*, Cruz das Almas, BA. The first study was done on fruits of two size ranges (large – 1500 g to 1800 g; small – 900 g to 1300 g) and two apparent maturation stages corresponding to rind color stages (green-ripe, with up to 15% of yellow rind area; colored – with more than 40% of yellow rind area). In the second study fruits of intermediate size (1300 g to 1400 g) with less than 5% of yellow rind area (green-ripe) were used.

Regardless of fruit size and stage of maturation, rather large vertical gradients were measured in total soluble solids (TSS) contents, total titrable acidity (TTA), ratio (TSS/TTA) and vitamin C content. TSS contents were the highest in the lower one-third of the fruits (15.0 °Brix), reached 13.9 °Brix in the middle one-third, and 12.4 °Brix in the upper third resulting in an average difference between upper and lower sections of 21%. The vertical gradient for the TTA was smaller and in the opposite direction, i.e., decreasing from an average 0.53% equivalent citric acid in the top to 0.42% in the lower one-third of the fruit, an average difference of 26%. These same tendencies were observed for the vitamin C content, though with less regular differences than for the TTA. On average, the vitamin C content was 29% higher in the upper one-third of the fruit (20.3 mg 100 g^{-1} of juice) than in the lower third (15.7 mg 100 g^{-1}).

The ratio TSS/TTA followed the same trends as the TSS, being 25.6 in the upper, 34.3 in the middle, and 38.7 in the lower one-third of the fruits with a maximum average contrast of 51.2%. The TSS/TTA ratios of large (34.3) and small (31.4) fruits were similar, but TSS and TTA were higher for small fruits (14.8 °Brix and 0.50%) than for large ones (12.8 °Brix and 0.43%). Vitamin C content was higher for large fruits (20.4 mg 100 g^{-1}) than for small ones (14.9 mg 100 g^{-1}).

As expected, more mature fruits had a higher average TSS level (14.6 °Brix) and a lower TTA level (0.37%), resulting in a ratio (41,5) that was 71.9% higher than that of green-ripe fruits. However, the vitamin C content of colored fruits (13.4 mg 100 g^{-1}) was 62.6% lower than that of green-ripe ones (21.8 mg 100g^{-1}).

In the second study, transverse gradients in the fruit were analyzed. The TSS content was higher close to the central cylinder (on average, 11.8 °Brix) than in the area close to the rind (11.2 °Brix), giving a difference of 5.4%. In the area between the core and the rind (the central portion), the TSS was 11.3 °Brix.

The horizontal gradient of TTA was larger and in the opposite direction of that for TSS, i.e., decreasing from 0.67% near the rind to 0.49% near the core; the average value for the central portion was 0.58%. Thus there was an average difference of 36.7% between the flesh near the rind and that near the core. Like the TSS content, the ratio TSS/TTA also increased from an average of 17.7 near the rind, was 21.1 in the center of the flesh, and 25.7 near the core, resulting in an average difference between the rind and the the core of 45.2%.

The gradients observed for the most relevant internal quality attributes of 'Pérola' pineapple fruits and, above all, their amplitudes, showed the special attention that the sampling and the quality control analyses deserve. Preferably the rind should be removed and measurements should be made on well homogenized juice extracted from the whole fruit. However, if this is not possible due to operational problems (labor force, time consumption), a sample consisting of one-fourth of the upper half collected from one side of the fruit and one-fourth of the lower half collected from the opposite side of the fruit should be taken, homogenized, and analyzed.

Pineapple at the XVII Brazilian Fruitculture Congress

Domingo Haroldo Reinhardt (plant physiology, crop management) - *Embrapa Cassava & Fruits*, Caixa Postal 7, 44.380-000, Cruz das Almas, Bahia, Brazil; email: dharoldo@cnpmf.embrapa,br

The Brazilian Fruitculture Congress (CBF) has been the main scientific event on the fruit industry organized by the Brazilian Society of Fruitculture (SBF) every other year. The 17th Congress, held from November 18 to 22, 2002, was the first one held in the North (Amazon) region of the country, in this case in the city of Belém, capital of the State of Pará.

There were about a thousand participants from all Brazilian regions and some other countries. More than 600 posters were displayed, in addition to 60 oral presentations on selected papers, four conferences and 12 technical panels on the most actual and relevant issues of the fruit industry, R&D activities and educational aspects of fruitculture. Thirty papers addressed pineapple. Only citrus, banana and passion fruit were the objects of a higher number of papers than pineapple. The main themes addressed by the pineapple papers were the following: 7 on micropropagation (PBZ and other growth regulator effects, NaCl effects, micorhizae x plantlet growth), 3 on propagation (management of slips on plants and after their removal), 1 on genetic improvement (evaluation of new genotypes), 4 on fertilization and nutritional aspects (K and B x fruit quality), 2 on physiological aspects (salinity, natural flowering), 2 on pest control (control of fusariosis and fruit borer by mechanical protection of the inflorescence, control methods of the mealybug), 1 on irrigation (effects on quality of 'Pérola' fruits under conditions of a tropical subhumid climate), 2 on flower induction (efficiency in different seasons) and 7 on post-harvest management and processing (minimal processing, evaluation of juices). The papers presented at the Congress were printed on a CD and distributed to the participants. The CD should be available for purchase at the SBF (Sociedade Brasileira de Fruticultura), whose present address is: UFPEL/Faculdade de Agronomia, Caixa Postal 354, CEP 96001-970 Pelotas, RS, Brasil; phone/fax 0xx53 275 9371; email: sbfruti@ufpel.tche.br; web site at www.ufpel.tche.br/sbfruti.◆

News from Costa Rica

Latin America to Take Lead in the Organic Pineapple Market

Gabriela Centeno, Market Analyst, Sustainable Markets Intelligence Center (CIMS; http://www.cims-la.com), Alajuela, Costa Rica, Email: gabriela@cims-la.com.

The global consumption of pineapple has increased exponentially over the past decade. The demand for organic certified and more recently Fairtrade certified pineapple also shows an upward trend, even though production of this pineapple continues to be limited due to some technical issues. According to the FAO and ITC, the United States imported over $3,000,000[1] of pineapple certified as organic during 2001, representing nearly one percent of total pineapple imports.

In order to follow and understand the trends of the organic pineapple market, the Sustainable Markets Intelligence Center (CIMS, www.cims-la.com), recently conducted comprehensive research of the current and future situation of the supply of organic pineapple in Latin America. The most important results are presented below.

Commercial-scale production of organic pineapple in Latin America began in the late 1990's. However, many of the pioneer companies are no longer in business. Natural disasters such as Hurricane Mitch (which struck Honduran production areas), the high costs of certification[2], low prices paid to producers[3], as well as technical difficulties such as prohibition of ethylene for flowering induction, have influenced the industry and limited its expansion during the past three years.

From August to December of 2002, CIMS identified 350 small-sized farms and 10 processing companies working with organic pineapple in Latin America. CIMS contacted these companies and obtained detailed production information including volumes, market destinations, varieties and produce availability during the year.

The results obtained show that the region's total fresh organic pineapple production for 2002 exceeded 9,000 tons per year and the leading producing countries are Honduras and the Dominican Republic. Approximately 15 percent of the pineapple produced in Latin America is traded as fresh product, while only 85 percent is processed. Thirty four percent of the processed fruit is dehydrated and 66 percent is turned into juice, chunks, crush, marmalade, vinegar or wine.

The main market for Latin American organic pineapple is the European Union. Participating companies reported that 70 percent of the region's total organic production goes to European countries, 20 percent goes to the United States' market and small quantities (around 5 percent) goes to other markets such as Canada and Japan. The remaining organic pineapple that can not be exported is sold in local markets, usually without differentiation from the conventional fruit.

In addition to the companies currently engaged in the organic system, CIMS identified 110 small-sized farms and five new processing companies in a transition period to become organic certified. Based on the information gathered, CIMS projects significant growth of the Latin American supply of organic pineapple in the next two to three years. CIMS estimates that the region's total production of fresh organic pineapple in 2005 will exceed 15,000 tons per year, 85 percent above current production levels. Countries like Costa Rica, Nicaragua and Bolivia could become important suppliers.

On the demand side, CIMS has found that traders in the largest markets are seeking new suppliers of organic pineapple that fulfill all the requirements of the conventional fruit, as well as the organic standards. Consistent year-round supply is also a highly sought after supplier characteristic.

It is important to emphasize that farm gate prices for organic pineapple are about 20 percent higher than conventional product and 30 percent higher at the wholesale level. This price premium may change in the medium term as the international supply of organic pineapple continues to grow. For instance in Europe, leading importers claim that the market differential will level-off in the next two or three years for this kind of tropical fruit.

Certainly, the current global organic pineapple supply shortage is one of the main triggers for this projected growth, as well as the ethylene prohibition in the European Union. Furthermore, CIMS forsees a significant growth in the industry because some producers have discovered new ways to overcome technical constraints related to flowering induction and the former prohibition against using ethylene has been removed from the National Organic Program (NOP) in the United States[4]. The latter is also being debated within the European Union and the chances are high that this particular constraint will be removed there too[5].

[1]CCI (Centro de Comercio Internacional), CTA (Centro Técnico para la Cooperación Agrícola), FAO (Organización de las Naciones Unidas para la Agricultura y la Alimentación). 2001. Los mercados mundiales de frutas y verduras orgánicas. FAO. Roma, Italia. 334p.
[2]Consequence of the hard transition period (36 months for the United States legislation and 2 years and the first harvest for the European Union).
[3]Sometimes traders keep the entire premium price, paying to the producer as a conventional product.
[4]Van Es, M. 2003. Organic Certification Officer for Dole, Latin America.
[5]Jaén, B. 2003. Executive Director, Proagroin. Costa Rica.

CIMS is a non-profit business promotion organization based in Costa Rica that aims to facilitate trade of sustainable products and services within Latin American countries and from this region to the most developed markets. CIMS provides market information, consulting and research services.◆

News from Cuba/Italy

Evaluation of Different Soil Preparation Techniques for Pineapple Production

Jorge S. Pérez de Corcho Fuentes[1], Pedro Tomba Moreno[1], Massimo Zoli[2], and Francesco Garbati Pegna[2].
[1]Facultad de Ingeniería. Universidad de Ciego de Avila. Carretera a Morón, Km. 9. Ciego de Avila. CP 69450. Correos: jorpede@facmeca.unica.cu, ptomba@hotmail.com.
[2] Dipartimento de Ingegneria Agraria e Forestale. Università di Firenze. Piazzale delle Cascine, 15. Firenze. 50144. Italia. Correos: mzoli@unifi.it, garbati@unifi.it.

Although Cuba is no longer a major pineapple producer, pineapple growing is considered of paramount importance for the country's economy. It is hoped that production will expand considerably in the near future, with production planned for around 60,000 t per year. Production presently is well below that with an area under cultivation of only about 5,000 hectares and productivity is very low, consistently below 10 t per hectare over the last ten years. About 65% of that area is in the province of Ciego de Avila with the other main production areas in the provinces of Pinar del Rio, La Habana, Las Villas and Houlgin. The variety most grown is Espanola Roja, characterized by its tolerance of low fertility, its general resistance to major pests and diseases, and the good quality of its fruit. However, production of 'Smooth Cayenne' pineapple has been increasing in recent years.

Pineapple mechanization in Cuba follows the lines of other main producing countries, even though the particular social conditions here draw this sphere to assume prime importance. As far as the machinery used is concerned, most of it is made on the island because of the difficulty of purchasing on the international market, and they are generally rougher models of the original ones along which lines they are fabricated. There are also original adaptations to local conditions.

In the traditional pattern eliminating crop residues requires about two months. The residual vegetation, amounting to 100 to 200 t ha^{-1}, is roughly shredded by vertical axis mowing machines with rotating blades of about 1.5 m in diameter (Figure 2, Figure 3). Once the shredded residues have dried out, they are burnt. Ploughing and harrowing with disc instruments follows and is normally repeated for up to 10 times or until the plant residue particle size is reduced to the point that it no longer hinders subsequent field operations. While the use of the moldboard plough is not unusual, disc instruments are preferred on account of the minor drawbar pull needed. The main consequences of these practices are that the larger residues are not completely incorporated in the soil while the smaller ones are buried too deep. Further, the limited depth of tillage doesn't allow a favorable development of the plants.

Cuban researchers are now starting to tackle these problems and aim to achieve an overall technology for pineapple cultivation that is more sustainable. Special efforts are directed to improving soil preparation techniques, increasing soil conservation and organic matter content, and reducing compaction and energy inputs. Organic pineapple farming is also being considered. One fundamental step in this direction will be the improvement of the soil preparation phase, including chopping of the plant residue and tillage.

With these goals in mind the University of Ciego de Avila has evaluated alternative methods of chopping plant residue and of soil tillage. These methods, which also have been tested with the aim of convincing the farmers of their profitability, are already in use in some other producing countries, but they have not been evaluated in depth in this environment.

The trials, which took place in 2002, included the use of a model BNU-160 mulcher produced by the Italian firm Nobili and a subsoiler produced locally. The work was carried out in the Empresa Piña of Ciego de Avila. The morphology of the land in this area is flat and the soils are of the red ferralitic type. The trials were carried out in fields planted with 'Smooth Cayenne' pineapple with a spacing of 0.9 x 0.4 x 0.3 m, which corresponds to a density of 51,000 plants ha^{-1}. The residual plant mass was estimated to be 70 t ha^{-1}. The BNU-160 mulcher was coupled to an 80 kW Valtra Valmet 985 S tractor and tested at three different speeds while the improved tillage consisted of a first subsoiling followed by 2 passages with a tiller and a final disc harrowing. These operations were compared with the traditional soil preparation methods. Several trials were observed and a detailed description was presented at Unica 2002 (Pérez de Corcho, *et al*., 2002).

The main results were that one pass with the BNU mulcher (Figure 4, Figure 5) reduced the mass of pineapple plants to smaller particles compared to the mower. Also, tractor speed did not influence particle size so proceeding at higher speeds (~ 2 m/s) is more convenient. The higher cost of this implement is compensated for by its higher performance and increased hourly working capacity.

Concerning the cultivation techniques, although for technical reasons it was not possible to reach a depth greater than 0.24 m with the subsoiler, this reduced-tillage method left the chopped residues in a more superficial layer than the traditional one (Figure 1). As for mulching, keeping the residues in a well-amalgamated superficial layer helps to prevent erosion and to maintain soil moisture. As expected with this vertical action the soil structure was also better than with the traditional tillage and the water infiltration capacity higher. A rough economic evaluation of the two techniques was also favorable to the vertical tillage. Trials are still in progress to evaluate more precisely the energy requirements of the different technologies.

As a result of this first work the management of Empresa Piňa showed interest in these alternative techniques and encouraged further tests, with plans to adopt them in the next campaigns. Actually the performances of the BNU are still being tested in terms of power consumption and the soil structure is being analyzed periodically. In the future other soil preparation methods will be evaluated.

Reference

Pérez de Corcho J., Tomba Moreno P., Zoli M., Garbati Pegna F. 2002. Evaluación de tecnologías de acondicionamiento de suelos para la producción de piña en la provincia Ciego de Ávila, Cuba – V Conferencia Científica Internacional Unica 2002, Ciego de Avila, Cuba.

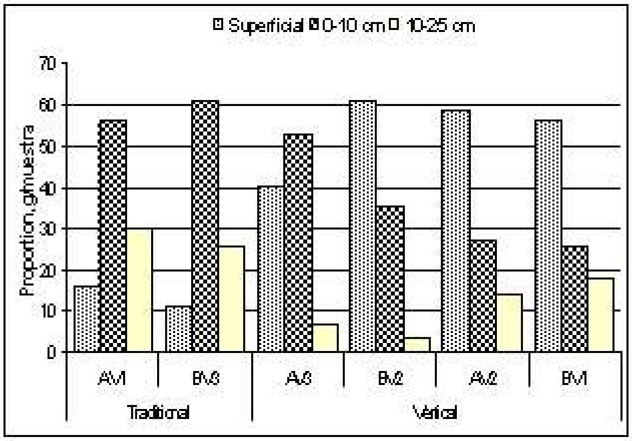


Figure 1. Effect of mulcher (A) and rotary mower (B) and travel speed (V1, 1.4 m/s; V2, 1.6 m/s; V3, 1.8 m.s) on distribution of pineapple residue with depth in soil.

Figure 2. Chopping residue in a weed-infested field with the CH-60 mower.

Figure 3. Residue size after one pass with the CH-60 mower.

Figure 4. Field chopped with BNU-160 mulcher.

Figure 5. Residue size after one pass with the BNU-160 mulcher.

News from India

Plant Regeneration from Basal Disc Slices of Second Generation (M_2) "Spineless Variants" of Pineapple Fruit Crowns

Minal Mhatre, Nuclear Agriculture & Biotechnology Division, Bhabha Atomic Research Centre, Trombay, Mumbai 400 085, India. email: mmhatre@magnum.barc.ernet.in

In vitro-derived pineapple explants were established in the field for trials. Spineless variant plants were identified and their performance was studied. Fruiting in spineless plants was found to be delayed, the fruits were smaller in size and weighed less than the spined plants. The crowns of the fruits of the spineless plants were also small and were devoid of spines. The dormant axillary buds from these crowns were too tender and difficult to isolate and did not sprout in culture. However, after removal of all of the crown leaves, the remaining basal disc (2-3 cm) was cut into thin slices and cultured on MS (Murashige and Skoog, 1962) medium supplemented with NAA, IBA and Kinetin. Sixty-two percent of the explants sprouted and produced multiple shoots (3-4 shoots in each explant). These were isolated, subcultured and maintained as second generation (M2) of the variant spineless line of pineapple. Shoots (5 cm) were rooted on RM-liquid rooting medium (Soneji *et al.*, 2002) and are ready for transfer. Their performance in the field will be evaluated with respect to the spineless character.

References

Murashige T. and Skoog F. (1962). A revised medium for the rapid growth and bioassays with tobacco tissue cultures. Physiologia Plantarum, 15: 473-97.

Soneji, J.R., Rao, P.S. and Mhatre, M. (2002). Somaclonal variation in micropropagated dormant axillary buds of pineapple (*Ananas comosus* L., Merr.). J Hort Sci & Biotech 77: 28-32.

Transformation of Pineapple Leaf Bases with the Megainin Gene Analogue, MSI-99

Minal Mhatre, Nuclear Agriculture & Biotechnology Division, Bhabha Atomic Research Centre, Trombay, Mumbai 400 085, India. email: mmhatre@magnum.barc.ernet.in

Megainin is a known antimicrobial peptide isolated from the skin secretions of the African clawed frog *Xenopus laevis*. Earlier, a synthetic substitution analogue MSI-99 was subcloned into plant expression vectors pMSI164 and pMSI168 and used successfully for banana and tobacco transformation to impart resistance to diseases (Chakrabarti et al., 2003). Leaf bases of pineapple (*Ananas comosus* L., Merr.) were transformed with pMSI164 and pMSI168 and selected on kannamycin and cefotaxime containing media. Only 6% explants produced callus and 2% explants produced multiple shoots. Callus as well as the shoots have been isolated and multiplied. DNA was isolated from the callus and PCR amplified using forward and reverse primers (168 and nos) and the plasmid as positive control. Although the transformed callus did not exhibit the 180 bp band as per expectations two non specific larger sized bands were observed. Confirmation of transformed nature of the callus as well as the shoots is being done with Southern hybridization.

Reference

Chakrabarti, A, Ganapathi, T.R., Mukherjee, P.K. and Bapat, V.A. 2003. MSI-99, a magainin analogue, imparts enhanced disease resistance in transgenic tobacco and banana. Planta 216: 587-596.◆

News from Malaysia

Pineapple Residues: from Burning to Products Development

O. H. Ahmed*, M. H. A. Husni, A. R. Anuar, and M. M. Hanafi, Department of Land Management, Faculty of Agriculture, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia. E-mail: osman60@hotmail.com

Introduction

Malaysia is perhaps the only country in the world that largely cultivates pineapple on peat. The usual way of recycling pineapple residues before subsequent replanting in mineral soils is through shredding and ploughing these residues into the soil. But probably due to the inability of peat to support heavy-duty tillage implements, pineapple residues on peat are managed through burning. Due to the ever-increasing awareness about environmental pollution, concerns have been expressed about the long-term effects of burning of crop residues, including those of pineapple. In line with this, some attempts have been made to develop a more sustainable means of handling pineapple residues. This paper communicates the progress made in managing these residues on and off peat.

Findings

The 1997 economic loss in the agricultural sector due to haze in South- East Asia necessitated the comparison of the economic viability of burning pineapple residues with removal of these residues before replanting. In their economic valuation study of pineapple residue, Husni et al. (1999) observed that the practice of removing pineapple residues before replanting was economically viable. Air pollution associated with burning was estimated to cost US$ 620 ha^{-1} against the cost of US$ 23.50 ha^{-1} associated with residue removal. This study, however, failed to address the issue of who or how to manage the residues after removal. This pressing issue might have prompted Ahmed *et al*. (2002) to investigate the feasibility of leaving pineapple residues to decompose in-situ rather than removing them. Ahmed *et al*. (2002) studied the economic viability of these residue management practices and concluded that the unburned practice was economically viable. The problem with the unburned practice is that about 5.5 Mg ha^{-1} of pineapple residue is produced per a cropping season (2 years). If this large amount of residue is left to decompose in-situ, it is anticipated that the adoption of this practice without a very careful handling of these residues could lead to fire, pests, and disease outbreaks. They observed that it took more than 10 months for the pineapple residues to start decomposing. Further, there is the problem of adding more organic matter to a poorly decomposed peat with time. In line with this, an idea of extracting humic substances from composted pineapple residues using potassium (KOH) produced from pineapple leaves was conceived. Besides the numerous agricultural benefits associated with humic substances, this product development approach ensures that pineapple residues will become more of an asset than a liability to plantation owners as the residues could be sold or exchanged for potassium-fulvate or potassium-humate as sources of slow release K. The preliminary information from this innovative idea is subsequently highlighted.

A KOH with about 50 % K and compost have been produced and a reaction between these two substances has enabled the production of about 20 % humic acid (Ahmed *et al*. 2003). and potassium-rich fulvic acid (43 % K) or potassium fulvate (Ahmed 2002). A reconstitution of humic acid has also led to the production of a potassium-rich humic acid or potassium humate that contains 38 % K (Ahmed *et al*. 2003). A scale up model of this study requires further studies on the slow-release nature of K and the economic use of these fulvate and humate as slow-release fertilizers.

References

Ahmed, O. H. 2002. Towards sustainable management of pineapple residues. Ph.D. thesis, Universiti Putra Malaysia, Malaysia.

Ahmed, O. H., M. H. A., Husni, A.R. Anuar and M. M. Hanafi. 2003. Production of humic acid from pineapple leaf residue. Journal of Sustainable Agriculture, (in press).

Ahmed, O. H., M. H. A., Husni, A.R. Anuar and M. M. Hanafi. 2002. Effect of residue management practices on yield and economic viability of Malaysian pineapple production. Journal of Sustainable Agriculture, 20:83-93.

Ahmed, O. H., M. H. A., Husni, A.R. Anuar and M. M. Hanafi. 2003. An alternative means of recycling pineapple leaf residue. Fuits 58(1): (in press)

Husni, M. H. A., O. H. Ahmed, and Awang Noor. 1999. Crop residue burning and the amendments of the Malaysian environmental quality regulations. In Proceedings. of the Soil Science Conference of Malaysia 1999, 21-22 April 1999, Seremban, Negri Sembilan.◆

News from Mexico

Postharvest Quality of Three Pineapple Cultivars in Different Planting Densities in Mexico

Daniel J. González-Ortiz, Teresa Martínez-Damián, Andrés Rebolledo-Martínez, Laureano Rebolledo-Martínez and Daniel Uriza-Ávila.

INIFAP-Campo Experimental Papaloapan. Km 66 carretera Cd. Alemán-Sayula, Apartado postal 43, C.P 95641, Isla, Veracruz, México. E-mail: cepap_mx@yahoo.com, andresrebo@hotmail.com

Three cultivars of pineapple, 'Smooth Cayenne of Mexico', 'Champaka' and 'MD-2', were grown at planting densities of 30,000, 45,000, and 60,000 plants ha^{-1} and the post-harvest behavior of their fruits was studied. The experiment was established in the south of Veracruz, state, Mexico, at 18 °N latitude in an Aw0 climate and Dystric Cambisol soil. The fruits were harvested from 11 to 24 May, 1999 and were stored for 16 days under laboratory conditions at a temperature of 22°C at noon. Physicochemical and physiological variables were evaluated every 4 days during the 16-day period, except weight, respiration and bottle form. The cultivar MD-2 presented the minimum grade of bottle form, and 'Champaka F-153' the maximum grade. The percentage of bottle-form fruit was greater at lower planting densities while the smallest fruits were harvested at the highest planting density. 'MD-2' had smaller fruit than 'Champaka F-153' and 'Smooth Cayenne of Mexico'. 'MD-2' fruit remained firm longer than did the fruit of the other cultivars and also had the lowest acidty. Fruits of 'Smooth Cayenne of Mexico' had the highest acidity. The TSS/acidity ratio was greater for 'MD-2', with initial values of 22.6 and dropping to 20 after 16 days, while fruit of 'Smooth Cayenne of Mexico' had initial values below 17 dropping to about 15 by day 16. The ascorbic acid level of 'MD-2' was five times that of 'Smooth Cayenne of Mexico' and 'Champaka F-153'. Fruit of 'MD-2' also had the highest respiration rate while that of 'Smooth Cayenne of Mexico' and 'Champaka F-153 were less than that of MD-2 and similar to each other. 'Smooth Cayenne of Mexico' and 'MD-2' had the lowest levels of production of acetaldehyde and ethanol, compared to 'Champaka F-153'. The greatest acetaldehyde and ethanol levels were observed in fruits from the lowest planting density.◆

News from Nigeria

Irrigation Efficiencies for Pineapple in Nigeria

Sabbas N. Asoegwu (sasoegwu@futo.edu.ng /asosab49@yahoo.com) and Julius C. Obiefuna (obiefuna@futo.edu.ng). Federal University of Technology, P.M.B. 1526, Owerri, Imo State, Nigeria.

Itroduction

Pineapple (*Ananas comosus*) is becoming an important commercial crop in Nigeria for both fresh market, export and as raw material for the local fruit juice industry (Asoegwu, 1987). Pineapple production in Nigeria is expanding from the traditional rainforest zone, where it is grown without irrigation, into the middle belt zone to the north, where irrigation is needed to obtain good yields. Rainfall in this zone ranges from 650 to 2100 mm y^{-1} with a 4 to 6 month dry season.

Pineapple growth in the dry season is limited and so will require irrigation. The main objectives of irrigated pineapple management are to get more stable and better fruit yields, to improve fruit quality (da Silva Souza and Reinhardt, 1998), and to produce fruit during the off-season in Nigeria when fruit prices are high, bringing a greater return to the farmers. To improve pineapple production in Nigeria, sprinkler irrigation as well as other technologies should be tried and improved upon. Because of the limited availability of water for irrigation, the efficiency with which this water is used to produce marketable yields of pineapple is important. A study was conducted to evaluate the efficiencies of: water conveyance (Wc), water application (Wa), water storage (Ws), and water use (WUE) of sprinkler-irrigated field-planted 'Smooth Cayenne' pineapples.

Experimental Procedure

The study was conducted on the sandy loam soil (Ultisol) in the National Horticultural Research Institute (NIHORT), Mbato Substation, Okigwe, Imo State, Nigeria (05° 35' N, 07° 23' E) at 330 m above sea level and average annual temperature is 25.8°C. The soil has a pH in calcium chloride of 4.9 to 5.9, low chemical fertility (in PPM, P, 17.9 to 19.5; K, 20.3 to 22.8; and N, 24.6 to 25.2) and a cation exchange capacity (CEC) of 12.0 mEq/100 g. The soil is well drained and deep with intermediate texture.

Four sprinkler irrigation treatments were given in which two received 50% of consumptive use less effective rainfall every 7 or 14 days (${}^{0.5}I_7$, ${}^{0.5}I_{14}$), a third received 100% of consumptive use less effective rainfall applied every three days (${}^{1.0}I_3$) and a non-irrigated control (I_o). The sprinklers had a throw of 7.0 m at the middle of each plot. The plots measured 6.0 x 6.0 m and were planted with suckers at the 10-leaf stage spaced 0.5 m x 0.5 m apart, totaling 121 suckers. The middle 49 suckers (leaving 2 outer rows round each plot) were used for analysis (Figure 1). The treatments were replicated four times.

The following parameters were measured using appropriate techniques: water from reservoir (Wr); water delivered to the farm (Wf); water stored in the root zone (Ws); runoff (Rf) and deep percolation (Df); water needed in the root zone prior to irrigation (Wn). The suckers were planted in April and harvested after 15 months with irrigation treatments applied for 6 months (October to March). At each irrigation, 25 mm of water was applied to the crop. NPK fertilizer was routinely applied at 100 kg ha^{-1} in 3 split doses. Weeding was done at the appropriate time.

Results and Discussion

Water conveyance efficiency (E_c) (Table 1) was between 66.0 and 67.0% for the irrigation treatments due to leakage from lateral joints in transporting water 3.2 km from the source to the field. A shorter conveyance distance would reduce leakages and improve conveyance efficiency. Water application efficiency (E_a) decreased from about 66.0% for the control (I_o) to about 59.0% for treatment ${}^{1.0}I_3$ due to the leakages during conveyance and greater runoff (Rf).

The water storage efficiency (E_s) increased with increasing irrigation from 68.4% at I_o to 74.4% at ${}^{1.0}I_3$ (Table 1). The deep soil with good texture resulted in increased water storage as irrigation increased. That the effective efficiency of water use (E_u) in the field decreased with increased irrigation (Table 1) showed that water losses due to runoff and deep percolation increased with irrigation frequency. This lost water did not reach plant roots and would affect harvested crop yield.

While the potential yield of pineapple in t ha^{-1} was estimated to be 131.2 for treatment I_o, 144.5 for treatment ${}^{0.5}I_{14}$, 158.1 for treatment ${}^{0.5}I_7$, and 192.5 for treatment ${}^{1.0}I_3$, actual yields for the four treatments were only 83.4%, 82.3%, 82.0%, and 81.8% of potential yields. This showed that more irrigation reduced the conversion ratio in pineapple. The field water use efficiency (WUE), which is the ratio of harvested yield to total water applied (W_t, field irrigation and rainfall), decreased with increasing irrigation from 0.5397 at I_o to 0.5196 at ${}^{1.0}I_3$ and the data were best fit by the equation $WUE=0.574 - 1.833^{-04} W_t$ (r = - 0.9488).

In terms of costs and benefits and taking the monetary values of cost items and yield (Table 2), more frequent irrigation increased costs and produced heavier fruits and more suckers. While the benefits increased with increasing irrigation, the benefit/cost ratio decreased from 2.305 in I_o to 1.364 in ${}^{1.0}I_3$. The benefit/cost ratio in I_o was about 69% higher than in ${}^{1.0}I_3$. However, if the E_a, E_c, E_s, E_u, and WUE are improved by reducing leakage, runoff, and deep percolation, the benefit/cost ratio of the irrigation plots may outstrip that of no irrigation. Also, reduced water application may reduce runoff and help improve efficiencies.

References

Asoegwu, S. N.(1987). Effect of irrigation and nitrogen on the growth and yield of pineapples (Ananas comosus) cv Smooth Cayenne. Fruits. Vol. 42, no. 9 p. 505-509.

da Silva Souza, L. F. and Reinhardt, D. H.(1998). Pineapple crop under irrigation is growing. Pineapple News. No. 5 p. 4.

Table 1: Data for irrigation efficiencies. Treatments are no-irrigation control (Io) and 0.5 or 1.0 times consumptive use with irrigation at 3 (I_3), 7 (I_7) or 14 (I_{14}) day intervals.

Parameter	Treatment				
	I_o	$^{0.5}I_{14}$	$^{0.5}I_7$	$^{1.0}I_3$	LSD
No. of irrigations (Ni)	0	13	26	60	
Wr* = Ni x 25 mm	0	325	650	1500	
Wf mm	0	215	432	1004	
Rain (Pmm, April-Dec.-June)	2027	2027	2027	2027	
Wt = Wf + Pmm	2027	2242	2459	3031	
Rf + Df mm	690	795	942	1243	
Ws = Wt - Rf - Df mm	1337	1447	1517	1788	
Wn = Ws + 617 mm	1954	2064	2134	2405	
Ec = (Wf / Wr) x 100%	0	66.2	66.5	66.9	ns
Ea = (Ws / Wt) x 100%	65.96	64.54	61.69	58.99	1.26
Es = (Ws / Wn) x 100%	68.42	70.11	71.09	74.35	0.69
Eu = (Wn / Wt) x 100%	96.4	92.06	86.78	79.35	2.35
Potential yield (t/ha) = Py	131.2	144.5	158.1	192.5	10.8
Harvested yield (t/ha) = Hy	109.4	118.9	129.6	157.5	6.5
Field (WUE) (t/ha-cm)	0.5397	0.5302	0.5269	0.5196	0.0027

*Abbreviations are Wr, water from reservoir; Wf, water delivered to the farm; Wt, total water applied; Ws, water storage in the root zone; Rf, runoff; Df, deep percolation; Wn, water needed in the root zone prior to irrigation; Ec, water conveyance efficiency; Ea, water application efficiency; Es, water storage efficiency; and Eu, effective efficiency of water use; WUE, water use efficiency.

Table 2. Benefit/Cost Analysis. Treatments are no-irrigation control (Io) and 0.5 or 1.0 times consumptive use with irrigation at 3 (I3), 7 (I7) or 14 (I14) day intervals.

Input Costs	I_o	$^{0.5}I_{14}$	$^{0.5}I_7$	$^{1.0}I_3$	
Fixed costs†	45,155	45,155	45,155	45,155	
Irrigation + labour (N 30/mm)	0	9750	19500	45000	
Total costs	45155	54905	64655	90155	
Income from yield (N)					
Income (fruits, N 1.25k/kg)	136750	148625	162000	196875	
Income (suckers, N 0.50k each)		12500	13150	14250	16250
Total income	149250	161775	176250	213125	
Profit or benefit	104095	106870	111595	122970	
Benefit/cost ratio	2.305	1.946	1.726	1.364	

†Fixed costs per hectare include 33612 suckers1@N0.5k each, land preparation costs @ N 5000, planting @ N 0.20k per sucker, weeding and fertilizing @ N 1,500, and harvesting @ N 0.45k per sucker.◆

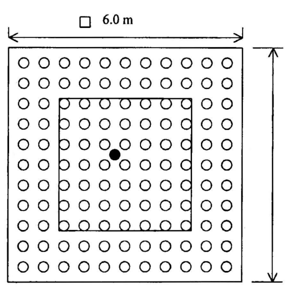


Figure 1. Plot layout with location of suckers (o) and the sprinkler (!); plants in the square were harvested.

News From Sri Lanka

Calcium and Potassium Fertilizers Affect Pineapple Fruit Quality

H.M.I. Herath, Postgraduae Inst. of Agriculture, Univ. of Peradeniya, Sri Lanka; D.C. Bandara, and D.M.G. Abeysinghe Banda, Dept. of Agricultural Biology, Faculty of Agriculture, Univ. of Peradeniya, Sri Lanka

Pineapple (*Ananas comosus* 'Mauritius') is the major fruit crop grown in Sri Lanka. The objective of this experiment was to control the development of Internal Browning (IB) of pineapple under cold storage by basal application of combinations of calcium and potassium fertilizer.

Field experiments were conduced at two locations in the major pineapple growing districts in Sri Lanka. The treatments consisted of 100, 125, and 150 kg ha^{-1} of calcium and 55, 110, and 220 kg ha^{-1} of potassium applied in nine treatment combinations. The control treatment was a plot without calcium or potassium. Pineapple 'Mauritius' was planted in a randomized complete block design with three replicates. Fruits were hervested at the 5% maturity stage and uniform sized fruits were stored in a cold room at 15°C and 80 to 85% relative humidity. The fruits were removed from the cold room at weekly intervals for four weeks and analyzed after 72 hours of storage at room temperature. The IB intensity was determined using a visual scale (0 to 5 where 0 = no IB and 5 = 100% IB). Ascorbic acid, total soluble solids (TSS), pH, fruit calcium, titratable acidity, and the percentage weight loss were determined.

IB development in fruits harvested form all the calcium and potassium treated plots were significantly lower than the control up to the fourth week of cold storage. Fruit calcium and potassium contents were higher in all the treatments than in the control. There were significant effects ($p<0.05$) of calcium and potassium levels on percentage weight loss, TSS, acidity, and pH up to the fourth week of storage. Pineapple fruits harvested from plots treated with 150 kg ha^{-1} calcium and 220 kg ha^{-1} of potassium had significantly higher ($p<0.05$) fruit calcium and potassium contents, reduced weight loss, and higher TSS up to the third week of cold storage. Ascorbic acid and titratable acidity were also higher in this treatment.

Effect of Different Calcium Fertilizers on Pineapple Fruit Quality

H.M.I. Herath, Postgraduae Inst. of Agriculture, Univ. of Peradeniya, Sri Lanka; D.C. Bandara, and D.M.G. Abeysinghe Banda, Dept. of Agricultural Biology, Faculty of Agriculture, Univ. of Peradeniya, Sri Lanka

The objective of the experiment was to investigate the effect of difference sources and amounts of calcium fertilizer on the control of Internal Browning (IB) development in pineapple (*Ananas comosus* 'Mauritius') fruit under cold storage.

Field experiments were conducted at two locations in the major pineapple growing districts in Sri Lanka. The calcium sources (1. lime, 2. CaO-fused magnesium phosphate and dolomite, and 3. $CaCO_3$•$MgCO_3$) were applied at 100, 125, and 150 kg ha^{-1}. The control was a plot without calcium. Pineapple 'Mauritius' was planted in a randomized complete block design with three replicates. Fruits were hervested at the quarter ripe maturity stage and uniform-sized fruits were stored in a cold room at 15°C and 80 to 85% relative humidity. They were removed from the cold room at weekly intervals for four weeks and analyzed after 72 hours of storage at room temperature. The IB intensity was determined using a visual scale (0 to 5 where 0 = no IB and 5 = 100% IB). Ascorbic acid, total soluble solids (TSS), pH, fruit calcium, titratable acidity, and the percentage weight loss were determined.

Fruits from all of the calcium treatments had significantly lower IB than did the control after the first week of cold storage. The fruits harvested from the 125 and 150 kg ha^{-1} treatments had significantly lower IB from the first to the fourth week of cold storage. The fruit calcium content of the two treatments were also significantly higher ($p<0.05$) than the control from the first to the fourth week. Ascorbic acid content of fruits from all the calcium treatments were significantly higher ($p<0.05$) than the control after the first week. Fruits from the 125 and 150 kg ha^{-1} lime treatments had significantly higher ascorbic acid contents from the first to the third week. The percentage weight loss was significantly lower ($P<0.05$) than the control from the first to the fourth week in the above two treatments. They also had significantly higher ($p<0.05$) TSS values from the first to the fourth week. Of all the treatments, lime at 125 and 150 kg ha^{-1} was most and equally effective in reducing IB development and enhancing fruit quality. From a cost standpoint, lime at 125 kg ha^{-1} was the most effective treatment.◆

News From Taiwan

Production News From Taiwan

Kuan San, Chiayi Agricultural Experiment Station, Chiayi, Taiwan (Email: kuansan@dns.caes.gov.tw), and communicated by Chin Ho Lin, National Chung Hsing University, Taichung, Taiwan (Email: chlin@mail.nchu.edu.tw).

The pineapple industry in Taiwan has been marked by a drastic change in the past 25 years. Pineapple products were mainly canned for export before 1976 with 'Smooth Cayenne' as the main variety. The industry has adjusted to changes in the international economic structure and shifted to domestic fresh market production. The important varieties and some of their characteristics in the current market for fresh consumption are shown in the table below.

Tainon fresh fruit hybrids in Taiwan.

Number	Variety name	°Brix	Acidity	Season
No.4	Sugar apple/peeling	19.5	0.43	March-May
No.6	Apple	15.5	0.34	April-May
No.11	Perfume	14.8	0.57	May-June
No.13	Winter honey	15.7	0.27	Aug-Feb
No.16	Sweet honey	18.0	0.47	April-July
No.17	Golden diamond	14.0	0.28	March-May, Sept-Nov
No.18	Golden osmanthus	14.1	0.39	April-July
No.19	Honey baby	16.7	0.46	April-July, Oct.-Nov

The common features of these varieties are, low acid, high sugar, fine quality with specific fragrance and specific ripening times. All those features helped the pineapple industry in Taiwan convert from processing of 'Smooth Cayenne' to year-around production of fresh market pineapple.

Due to the limited suitable habitat for pineapple production, the main production areas in Taiwan are south of Taichung and Chunghua. The 2001 statistics showed that pineapple was grown on 10,273 ha with yearly yield of 389,000 Tons.◆

News From Thailand

Thermal and Supercritical CO_2 Inactivation Kinetics of Bromelain in Pineapple Juice

Apiradee Sriwatanapongse (M.Sc.)

Bromelain, a proteinase present in pineapple, has many industrial uses. It is used widely to tenderize meat, chill-proof beer, and stabilize protein emulsifiers in latex paints. It has also many pharmaceutical properties. Bromelain is believed to cause soreness and discomfort of the mouth when excessive amounts of fresh pineapple is consumed. The presence of bromelain in pineapple juice also prevents gelatinization if the juice is used as an ingredient for gelatin. Therefore, commercial pineapple juice has to be pasteurized to inactivate the enzyme and reduce the number of microorganisms. However, a complete kinetic study with confirmation is not available. Moreover, understanding bromelain kinetics can help optimize processing to minimize the flavor loss during pasteurization. This study investigated thermal and Supercritical CO2 inactivation kinetics of fruit bromelain. Thermal inactivation kinetics parameters such as isothermal rate constants (ke) at specific temperatures, the frequency factor (A), and the energy of activation (Ea), were experimentally determined. A model for bromelain thermal inactivation was developed to predict the residual enzyme activity in response to any varying time-temperature treatment. Moreover, the effect of high pressure carbon dioxide treatment on bromelain inactivation in pineapple juice was explored. The thermal inactivation of bromelain was studied at 55, 60, 63, 65, and 67°C and was found to follow first order kinetics. The isothermal rate constants of bromelain at any specific temperature can be predicted by the Arrhenius equation. Using the kinetic parameters found, the bromelain inactivation models were developed and validated for both constant temperature and dynamic temperature histories. The Supercritical CO_2 treatment on bromelain in pineapple juice did not affect bromelain activity in our study at either 31 Mpa and 55°C for 2 hours, or at 34.5 Mpa and 46°C for 3 hours. Rather, the inactivation of bromelain was caused by heat but not by pressure or by carbon dioxide.

Editors Note: I regret that I lost the source information for this contribution.◆

News From the United States (Hawaii)

Pineapple Mealybug Wilt Associated-virus 1: An Example of Intergeneric Viral Recombination?

M.J. Melzer[1], A.V. Karasev[2],, and D.M. Sether[1] and J.S. Hu[1]
[1]Dept. of Plant and Environmental Protection Sciences, Univ. of Hawaii, Honolulu, HI 96822, U.S.A.
[2]Dept. of Microbiology and Immunology, Thomas Jefferson University

The plant virus family *Closteroviridae* is classified into three genera: *Closterovirus*, *Crinivirus*, and *Ampelovirus*, which are vectored by aphids, whiteflies, and mealybugs, respectively. Cladistical analysis using various viral genes also supports this classification. *Pineapple mealybug wilt-associated virus-1* (PMWaV-1) is a mealybug-transmissible closterovirus and therefore a putative member of the genus *Ampelovirus*. In this study, a 10 kilobase region of the PMWaV-1 genome was cloned from viral dsRNA and sequenced. The genome organization of PMWaV-1 was found to be that of a typical ampelovirus. Minor discrepancies, however, were evident in the 5'-terminal region of the genome. These included the position and putative mechanism of the open reading frame (ORF)1a/1b +1 ribosomal frameshift and lack of an intergenic region between the polymerase and p6 ORFs. The significance of these minor discrepancies became apparent after cladistical analyses were performed on ORFs in the 5'- and 3'-terminal regions of the genome. Analyses of ORFs from the 3'-terminal region placed this virus within the genus *Ampelovirus*, but analyses of ORFs from the 5'-terminal region placed this virus outside of the three current closterovirus genera. Therefore, PMWaV-1 may have a recombinant genome with the 3'-terminal region coming from an *Ampelovirus*, and the 5'-terminal region coming from an undescribed closterovirus genus.

Abstracts of Research on Mealy Bug Wilt of Pineapple

Diane Sether, Plant & Environmental Protection Science, University of Hawaii, Honolulu, HI 96822; E-mail: sether@hawaii.edu

Mealybug wilt of pineapple (MWP) is a devastating disease worldwide, the etiology of which is unknown. Two closteroviruses, Pineapple mealybug wilt associated virus-l (PMWaV-l) and PMWaV-2, were identified in pineapple from Hawaii and around the world. Both viruses are transmitted by pink pineapple mealybugs, *Dysmicoccus brevipes*, and grey pineapple mealybugs, *D. neobrevipes*. PMWaV-2 was shown to be an integral factor in MWP etiology. Typical MWP symptoms developed in pineapple plants infected with PMWaV-2 that were exposed to mealybugs. MWP did not develop in PMWaV-I-free or PMWaV-1-infected plants that were exposed to mealybugs or in plants infected with PMWaV-l, PMWaV-2, or both viruses if kept mealybug-free. MWP resulted in a 35% reduction in yield when compared to yields of PMWaV-free plants.

Yield reductions were dependent onl time of MWP symptom development; the earlier the expression of symptoms the greater the impact on plant crop fruit yield. Both PMWaV-1 and PMWaV-2 suppressed yield in the ratoon crop. Spatial analysis of PMWaV-2 spread and MWP symptom expression in mealybug-inoculated pineapple plots showed patterns of aggregation within rows and within beds but not between beds. Initial occurrence of MWP symptomatic plants showed upderdispersed which was consistent with the random occurrence ofPMWaV-2plants. After six months of mealybug exposure, patterns of both PMWaV-2 incidence and MWP were overdispersed. PMWaV-1 and PMWaV-2 were detected in MWP symptomatic and healthy looking pineapple samples from around the world but PMWaV-2 infection was correlated with 100% of the MWP symptomatic samples that were PMWaV-1-free. PMWaV-2 infection occurs at a lower frequency than PMWaV-1 infection in the Hawaiian grown pineapple selections and several hybrids. Infections of at least one PMWaV were found in 73% of the pineapple accessions maintained at the USDA-ARS National Clonal Germplasm Repository in Hilo, HI. No plants commonly found growing near or in pineapple fields were identified as hosts for PMWaV-1 and no pineapple gerrnplasm was immune to PMWaV-1. PMWaV-1 was eliminated through bud propagation Ifrom infected crowns.

Transmission of Pineapple Mealybug Wilt-associated Virus-1 by Two Species of Mealybug (Dysmicoccus Spp.)

Abstract

Closterovirus-like particles associated with mealybug wilt of pineapple were acquired and transmitted by the pink pineapple mealybug, *Dysmicoccus brevipes* (Cockerell), and the gray pineapple mealybug, *D. neobrevipes* Beardsley. Mealybugs acquired Pineapple mealybug wilt associated virus-1 (PMWaV-1) from infected pineapple plants or detached leaves from infected pineapple. The virus was detected in plants by tissue blot immunoassay and confirmed by immunosorbent electron microscopy. Plants exposed to mealybugs reared on PMWaV-1-free pineapple tissue remained uninfected. An increased rate of virus spread by *D. brevipes* was associated with the presence of ants. All stages of *D. neobrevipes* acquired PMWaV-1, although vector efficiency decreased significantly in older adult females. The probability of a single third instar immature transmitting virus was 0.04. Both species of mealybugs acquired and transmitted PMWaV-1 from infected pineapple material that had been clonaly propagated for decades and both species acquired PMWaV-1 from sources previously infected with the virus by the other mealybug species.

Differentiation, Distribution, and Elimination of Two Different Pineapple Mealybug Wils Associated Closteroviruses Found in Pineapple

Abstract

Surveys for Pineapple mealyubug wilt associated viruses-1 (PMWaV-1) and PMWaV-2 were conducted on pineapple samples from Hawaii and around the world. Tissue blot immunoassays (TBIAs) with two different monoclonal antibodies (Mab) specific to either PMWav-1 or PMWaV-2 indicated that both closterviruses are widely distributed throughout the pineapple growing areas of the world. In the worldwide survey, PMWaV-1 was found in 80% of the mealybug wilt of pineapple (MWP) symptomatic and 78% of the asymptomatic pineapple plants tested. A subset of plants was tested for PMWaV-2; 100% of the symptomatic plants and 12% of the asymptomatic plants were positive for this virus. A reverse transcription-polymerase chain reaction (RT-PCR) assay was developed to differentiate between PMWaV-1 and PMWaV-2. Oligonucleotide primers were designed using distinct regions of the HSP 70 homolog genes of the two viruses. PMWaV-1-and PMWaV-2-specific RT-PCR assays and TBIAs were used to screen pineapple accessions maintained at the USDA-ARS NCGR in Hilo, HI, for PMWaV infection; 73% of the accessions were found infected with at least one PMWaV. Pineapple accessions found PMWaV-free were challenged with viruliferous mealybugs to test for immunity to PMWaV-1. No immune germplasm was identified. Potential alternative virus hosts were screened for infection with virus-specific RT-PCR assays and TBIAs and were also challenged with viruliferous mealybugs. No alternate hosts of PMWaV-1 or PMWaV-2 were identified. PMWaV-1 infection was eliminated through axillary and apical bud propagation from infected crowns. Strategies to manage MWP are discussed.

Closterovirus Infection and Mealybug Exposure are both Necessary Factors for the Development of Mealybug Wilt of Pineapple Disease

Abstract

The roles of Pineapple mealybug wilt associated viruses (PMWaVs) and mealybug (*Dysmicoccus spp.*) feeding in the etiology of mealybug wilt of pineapple (MWP) were evaluated. Container-grown pineapple (*Ananas comosus*) plants from five commerically-grown Hawaiian proprietary selections and a field study utilizing a randomized complete block design were used to test four treatments for induction of MWP: 1) PMWaV-1-free and 2) PMWaV-1-infected plants maintained mealybug-free, and 3) PMWaV-1-free and 4) PMWaV-1 infected plants that received monthly applications of nonviruliferous mealybugs. A second closterovirus, PMWaV-2, was identified in some of the test plants during the course of these studies and shown to be an integral factor in MWP etiology. Typical MWP symptoms developd in plants infected with PMWaV-2 that were exposed to mealybugs. MWP did not develop in PMWaV-1-free or PMWaV-1 infected plants that were exposed to mealybugs or in plants infected with PMWaV-1, PMWaV-2, or both viruses if kept mealybug-free. Plants from all five Hawaiian proprietary selections of pineapple tested developed MWP when PMWaV-2 infected plants were exposed to mealybug feeding. A PMWaV-2 specific monoclonal antibody was produced that decorates the virus particles in immunosorbent electron microscopy and detects the virus in tissue blot immunoassays. PMWaV-2 was acquired and transmitted by pink and grey pneapple mealybugs (*Dysmicoccus spp.*) to pineapple plants which subsequently developed MWP symptoms while sustaining mealybug populations.

Yield Impact an dSpread of pIneapple Mealyug Wilt Associated Virus-2 and Mealybug Wilt of Pineapple in Hawaii

Abstract

The impacts of mealybug feeding and Pineapple mealybug wilt associated virus-1 (PMWaV-1) and PMWaV-2 infection on pineapple fruit yield and the spread of PMWaV-1 and mealybug wilt of pineapple (MWP) were evaluated under field conditions with a randomized complete block design. Plots of PMWaV-1-free or infected plants were maintained mealybug-free or inoculated with mealybugs (Dysmicoccus spp) at monthly intervals. Plants infected with PMWaV-2, an integral part of MWP etiology, were nested within plots that were maintained free of mealybugs and in the plots of PMWaV-1 infected plants exposed to mealybugs. MWP, which only developed in PMWaV-2 infected plants exposed to mealybugs, resulted in a 35% reduction in yield when compared to PMWaV-free plants. Yield reductions were dependent on time of MWP symptom development; the earlier the expression of symptoms the greater the impact on fruit yield. An interaction effect between PMWaV-infection, inclusive of both PMWaV-1 and PMWaV-2 infected plants, and mealybug exposure was detected in the plant crop ($P<0.02$) but not in the ratoon crop ($P>0.59$). This could be explained by the presence of MWP symptom expression during the plant crop and subsequent plant recovery in the ratoon crop. Virus infection, inclusive of PMWaV-1 and PMWaV-2, suppressed yield ($P<0.01$) in the ratoon crop. The commercially desirable fruit sizes were most frequently obtained from PMWaV-free plants. Spatial analysis of PMWaV-2 spread and MWP symptom expression in mealybug inoculated plots showed patterns of aggregation within rows and within beds but not between beds over the course of the study. Initial occurrence of MWP symnptom expression in mealybug inoculated plots was underdispersed indicating random occurrence of PMWaV-2 plants. After six months of mealybug exposure, patterns of both PMWaV-2 incidence and MWP were over dispersed.

Nematode Control Research in Hawaii

Brent Sipes, Dept, of Plant and Evnironmental Protection Science, University of Hawaii, Honolulu, 96822

Hawaii faces the continued loss of nematicides from the market. This past summer Bayer Chemical Co. announced that it will discontinue production of the organophosphate Nemacur®. To meet this challenge, we have been evaluating several promising alternatives. DiTera® and Actigard® lead the pack.

DiTera, from Valent BioSciences, is the fermentation product of the fungus *Myrothecium*. The behavior of this biologically-based product is somewhat different from that of the organophosphates. Application of 25 kg ha^{-1} is effective while amounts in excess of 45 kg ha^{-1} are ineffective. We are now investigating the efficacy of multiple applications of lesser amounts of DiTera. Some formulations of DiTera are applicable for organic pineapple production.

Actigard, from Syngenta, induces systemic acquired resistance in plants. In greenhouse experiments, a single dip or drench application of 100 ppm Actigard at planting reduced root-knot or reniform nematode reproduction by 50% 9 months later. Greater amounts of Actigard are phytotoxic and multiple applications of Actigard do not reduce nematode reproduction further. We are preparing to field-test Actigard and determine if yield is increased comparative to the reduction in nematode reproduction.

Idomethane is showing promise as a replacement soil fumigant. Our initial test gave good control of reniform nematode. This compound is a general biocide like methyl bromide but does not deplete ozone in the atmosphere. It’s chemical properties are slightly different from methyl bromide, but similar enough to require only slight adjustments in fumigation equipment and land preparation. Previously, idomethane was produced only in limited quantities and thus was prohibitively expensive. The chemical is now being produced commercially and sold under the tradename Midas®.

On the nonchemical front, we continue to investigate intercycle cover crops and genetic modification of pineapple cultivars for nematode control. Sunn hemp, *Crotalaria juncea*, is our most promising intercyle cover crop as an alternative to preplant fumigation. Also, pineapple genetically modified to express cystatine protease inhibitiors is showing promise. Some transformants support only 10% of the nematode reproduction that occurs on a non-transformed pineapple plant. However, most of the transformants do not grow as well as their non-transformed counterparts.

We have evaluated several reduced-risk nematicides in the greenhouse. In most cases, the reduced environmental risk has translated into reduced (i.e. negligible) nematode control. New products marketed as nematode controls will continue to be evaluated.

Micro-lepidoptera, A New Pest Problem on Pineapple in Hawaii

Glenn Taniguchi and Mark Wright, Dept. of Plant and Environmental Protection Sciences, Univ. of Hawaii, Honolulu, HI 96822, U.S.A.

During the past three years the pineapple industry of Hawaii has been dealing with at least two micro-lepidoptera (small-bodied lepidoptera), which have become serious problems at times. One pest that is well documented in the literature is *Neodecadarchis flavistrata* (Walsingham), family Tineidae, which is known to feed on dried leaf tissues. If the insect feeds on the dry leaf bracts that surround the base of the fruit and in the process damages the fruit epidermis, the fruit responds by producing a gummy exudate that darkens and blemishes it. A second micro-lepidoptera that has not been documented as a pest on pineapple in Hawaii is *Opogona sacchari* (Bojer), family Tineidae. The insect is known as a scavenger feeder on dead leaf tissue. In the past few years, it has become an important pest on newly planted crowns. The insect feeds on the dead basal leaves of the crown that are under the planting mulch. However, the larvae often bore into the core of the crown, thereby killing it. Losses have reached 30% in newly planted fields. Little is known about these pests and their association with pineapple.

A third micro-lepidoptera, which is well documented in the literature as being associated with pineapple, is *Pyroderces rileyi* (Walsingham), family Cosmopterigidae. However, there is little information in the literature regarding the nature of the damage the insect does to the plant or fruit. In Hawaii, the insect is abundant around the basal area of the fruit, but it usually does not cause significant damage to the fruit or plant.

Several other species of *Neodecadarchis* and other micro-lepidoptera are also mentioned in the literature as being associated with pineapple, but data on these species apparently have not been collected. All species of the micro-lepidoptera were recorded in Hawaii in the early 1900's, but were not considered to be important pests of pineapple. Their recent rise to prominence as pests of pineapple may be due to the shift from ‘Smooth Cayenne’ to hybrids. Casual observations indicate that the hybrids are more susceptible to insects than is ‘Smooth Cayenne’, and in particular, are more prone to produce gummy exudate, a visual defect, than is ‘Smooth Cayenne’. The recent problems associated with micro-lepidoptera could also be due to the gradual dissipation of residues of chlorinated hydrocarbon pesticides in the soil, which has allowed the populations of these insects to increase in pineapple fields. The life history of many of the micro-lepidoptera have not been well described so future research emphasis will be on insect life history studies and on the development of control measures.◆

News From Vietnam

Low-cost Micropropagation Procedure for Pineapple

Le Van Be, Department of Crop Science, College of Agronomy, Cantho University, Vietnam

Abstract

Micropropagation of pineapple (*Ananas comosus* (L.) Merr.) has been studied in Vietnam and other countries. In Vietnam, however, production of micropropagated plants can not become a popular practice in pineapple production because of its high cost. Multiplication and rooting stages can be carried on outside of a growth chamber with a low concentration of BA. Explants were transferred to MS proliferation medium supplemented with 0-1.0 mg L^{-1} of BA from which were obtained 0.8 to 8.6 useful shoots per explant and 1 mg L^{-1} of BA plus 0.5 mg L^{-1} of IBA from which were obtained 7.8 unsatisfactory shoots per explant after eight weeks of growth. The plantlets proliferated as well outside as inside the growth chamber. By proliferating plants outside the growth chamber, the cost of production of plantlets was reduced by 13%.

Introduction

The area of pineapple production in the Mekong Delta area belonging to South Vietnam is about 1,622 hectares (Lieu, 2002), mainly planted with the Queen variety. ‘Queen’ has been grown for many years and has degenerated and is seriously infected with mealybug wilt resulting in low yields of fruit of poor quality. Government projects aim at restoring the area through importing new varieties and renewing the old one. Conventional propagation practices are easy to apply but the multiplication rate is low when compared with *in vitro* micropropagation.

Studies of rapid proliferation of pineapple *in vitro* have been published in Vietnam (Uyen *et al.*, 1993; Phuong and Tram, 1997) as well as elsewhere (Mapes, 1973; Mathews, 1979; Pannetier and Lanaud, 1976; Wakasa, 1979; Mathews and Rangan, 1979; DeWald *et al.*, 1988; Fitchet, 1990; De Almeida *et al*,.1997; Daquinta *et al*., 1997). While the procedures for mass propagation of pineapple have been described, such plantlets are rarely used in Vietnam's commercial pineapple production. At a cost of 2,000 to 2,500 VND per plantlet, the price of plantlets is high compared with a return of 600 to 800 VND per kg of fruit 15 to 16 months after planting. So farmers cannot invest in micropropagated plants. Scientists have tried to find other procedures for reducing the cost of production, for instance, large scale production using the temporary immersion system (Escalona *et al*., 1999), automatic subculture (Hartney, 1986), or by using natural daylight to promote photoautotrophic growth (George, 1993).

In the study reported here, multiplication and rooting stages were carried out under ambient conditions in a net house (30-31°C and 6,000-8,000 lux). If pineapple plantlets can be grown as well outside of a growth chamber as in controlled conditions (24°C, 2,000lux), plantlets can be produced a less cost, the target of this study.

Materials and methods

Multiplication stage

Shoot proliferation on liquid basal MS medium was supplemented with 0.0, 0.2, 0.4, 0.6, 0.8, or 1.0 mg L^{-1} BA and 1.0 mg L^{-1} BA plus 0.5 mg L^{-1} IBA, 30 g L^{-1} sucrose, with 30 ml of media in vessels 3 cm in diameter and 17 cm high. Lateral buds cultured for 10 weeks on MS medium with 1.0 mg L^{-1} BA were used as starting material. Then the plantlets were partially immersed in media containing the different concentrations of BA so the vessels did not need shaking. The vessels were divided into two groups with one group placed in the growth chamber (24°C, 31.4 mmol m^{-2} s^{-1}, 12 h photoperiod) and the other group was placed in natural conditions in a net house (30-31°C, 94.2-125.6 mmol m^{-2} s^{-1}, 8-10 h daylight). Shoot increase, weight of shoot clumps, and height of plantlets were observed eight weeks after subculture. Chlorophyll a contents of the leaves was analyzed by Wellburn's (1994) method. Chlorophyll was extracted with 80% acetone and analyzed with a Shimadzu UV-1201V- spectrophotometer. The experiment was designed with two factors (BA concentrations and growing conditions) with eight replications, each vessel representing a replicate containing two shoots. The data were analyzed using SPSS v.10 software.

Rooting stage

After eight weeks of subculture, plantlets more than 2.5 cm were rooted *in vitro* with and without 1 mg L^{-1} NAA. Conditions for rooting were in the growth chamber and ambient conditions of the net house as described above. Each vessel contained 5 shoots with five replications per treatment.

Calculation of multiplication coefficient (K)

The propagation rate of shoots in culture (plants $year^{-1}$) could be calculated by the equation (George, 1993):

$$K = \left(\frac{N^{T/t}}{No}\right)$$

where **N** is the number of shoots or plants at the end, **No** is the number of propagules at the beginning of a subculture, **T** is the number weeks in the time interval of interest, and **t** is the interval in weeks between subcultures.

Results

Multiplication stage

Shoot number and clump weight all increased with increasing BA concentration from 0.2 to about 1.0 mg L^{-1} BA while shoot height only increased to 0.8 mg L^{-1} BA (Table 1). Adding 0.5 mg L^{-1} IBA did not produce more or taller shoots than BA alone but did produce a much greater clump weight. However, in that treatment there were many shoots less than 3 cm high that were not useful for the rooting phase of the study. Chlorophyll a content tended to decrease with increasing concentration of BA up to about 0.4 mg L^{-1}.

There was no significant effect of growing conditions on adventious shoot number, weight of shoot clumps, or height of shoots (Table 1). Chlorophyll a content was higher in natural light than in the growth chamber, presumably because the natural light level was greater than that in the chamber. Vessel contamination was 16% in the outside conditions but only 3% in the growth chamber.

Rooting stage

Treatments with 0 mg L^{-1} BA and 1.0 mg L^{-1} BA and 0.5 mg L^{-1} IBA were excluded because the shoots were not suitable for the rooting phase of the study. While BA concentration during shoot development had no effect on rooting, there was a significant difference in plantlet height among BA treatments used in the multiplication stage (Table 2).

Using 1.0 mg L^{-1} NAA had no significant effect on plantlet weight, root number or plantlet height but it did increase root length. Roots were significantly longer when plants were grown in the growth chamber (Table 2) but other plantlet parameters were unaffected by growing conditions. It was assumed that the stronger natural light reduced root growth. During rooting, 10% of the vessels became contaminated in natural conditions despite protection with plastic sheeting while only 2% were contaminated in the growth chamber.

Discussion

Jones and Murashige (1974) found genetic variation among micropropagated *Aechmea* plants (family Bromeliaceae). Addition of BA did not enhance shoot bud regeneration from callus but increased the appearance of albino types (Mathews and Rangan, 1981). Working with the cultivars Queen and Smooth Cayenne, Fitchet (1990) obtained an average of 6.0 plantlets per explant with 2.0 mg L^{-1} zeatin added to MS medium during the proliferation phase. Almeida *et al.* (1997) applied 2 mg L^{-1} BAP to get 4.7 plantlets per explant while Bhatia and Ashwathia (2002) obtained the highest multiplication rate with 2 mg L^{-1} BAP. Similar results were obtained in this study (Table 1) at the higher concentrations of BA. Numbers of adventious shoots increased greatly in 1 mg L^{-1} BA plus 0.5 mg L^{-1} IBA, with many unusable shoots, especially when shoots were poduced in the growth chamber. It was assumed that hyperhydricity was the cause of the excessive proliferation of unusable shoots because Debergh (2000) reported that raising the BA concentration of a liquid multiplication medium under conditions of low light density evokes hyperhydricity.

Rates of multiplication of pineapple *in vitro* are much higher than those achievable in conventional propagation systems, but high multiplication rates in conjunction with high levels of hormones in the growth medium can result in genetic instability and the production of "off-type" plants (Sharrock, 1992). New shoots were tallest with BA concentrations of 0.6 to 1.0 mg L^{-1} and it was thought that growth in height was stimulated more by higher concentrations of BA. Contrary to other results (George, 1993), a BA-auxin mixture in this study inhibited growth in height of shoots and resulted in callus formation at the base of the explant .

Proliferation *in vitro* in outside conditions was equal to growth in the growth chamber and such culture could reduce the cost of *in vitro* propagation. Further, plantlets grew well in both conditions during the rooting stage. The effect of BA concentration on plantlet height (Table 2) was significant; the event is unknown.

Multiplication rate

The multiplication coefficient from only one explant depends on the number of plantlets and the subculture interval time (Geogre, 1993). Drew (1980) obtained 1.25 million pineapple plantlets in six to eight months from 30 explants. Pannatier and Lanaud (1976) were able to obtain one million plantlets, in a one-year period, starting from only one explant. According to the data of Table 1, using 1 mg L^{-1} BA achieved an average 8.6 shoots per 8-week subculture interval. Applying the K coefficient, the multiplication rate is hypothetically about 1.2 million plantlets per year from one explant, not accounting for the 16% loss due to contamination.

Production cost

Productioin costs include those for the laboratory for production of plantlets during a period of one year plus the costs for facilities, supplies, energy, and labor to grow plants to the size required for planting in the nursery or field. The estimated cost per plant for 2.6 million plants over a one-year time period were 162 VND for the growth chamber and 147 VND for the shade house resulting in a savings of about 11% for the shade house relative to the growth chamber. Shade house costs were lower primarily because of reduced expenses for faciities, lamps, labor and energy. Growing plants in the shade house was feasible and significantly reduced the cost of plantlet production.

References

Almeida, W.A.B.de; A.P.de Matos; A. da S. Souza. 1997. Effect of benzylaminopurine on in vitro proliferation of pineapple (*Ananas comosus* (L.) Merr.). Acta Horticulturae 425: 235-242.

Bhatia, P., Ashwathia, N. 2001. Development of a rapid method for micropropagation of a new pineapple (*Ananas comosus* Merr.) clone, 'Yeppoon Gold'. Acta Horticulturae 575: 125-131.

Debergh, P. 2000. Tissue culture and biotechnology (hand out). State of Gent Uni. of Belgium. http://allserv.rug.ac.be/~pdebergh/ind/content.htm

Drew, R.A. 1980. Pineapple tissue culture unequalled for rapid multiplication. Queensland Agr. Journal. 106: 447-461.

Escalona, M., J.C. Lorenzo, B. Gonzalez, M. Daquinta, J. Gonzalez, Y. Desjardins, C.G. Borroto. 1999. Pineapple (*Ananas comosus* (L.) Merr.) micropropagation in temporary immersion systems. Plant Cell Reports, 18, 743-748.

Fitchet, M. 1990. Clonal propagation of Queen and Smooth Cayennene pineapples. Acta Hort. 275, 261-266.

George, E.F. 1993. Plant propagation by tissue culture. 2nd. Edition, Exergetics Limited.

Hartney,V.J. 1986. Commercial aspects of micropropagating eucalypts. P.14 in Somers et al. (eds.)1986(q.v)

Jones, J.B. and T. Murashige. 1974. Tissue culture propagation of *Aechmea fasciata* Baker and other bromeliads. Proceedings of the International Plant Propagators' Society. 24, 117-126.
Lam Ngoc Phuong and D.P. Tram. 1997. Proliferation of "Dai Nong No.4" pineapple (*Ananas comosus* (L.) Merr.) in vitro. Annual report of Cantho University, Vietnam. 145-149. (In Vietnamese).
Mapes, M.O. 1973. Tissue culture of bromeliads. The Intern.Plant Prop. Comb. Proc. 23, 47-55.
Mathews, V. H. and T.S. Rangan. 1979. Multiple plantplets in lateral bud and leaf explant in vitro cultures of pineapple. Scientia Horticulturae, 11, 319-328.
Mathews, V. H. and T.S. Rangan. 1981. Growth and regeneration of plantplets in callus cultures of pineapple. Scientia Horticulturae, 14: 227-234.
Nguyen Van Uyen. 1993. Plant tissue culture of crop selection. Agriculture, HCM city. (Vietnamese language)
Pannatier, C. and Lanaud, C. 1976. Divers aspects de l' utilization possible des cultures "in vitro" pour la multiplication vÐgÐtative de l' Ananas comosus L. Merr., varietÐ 'Cayenne lisse'. Fruits, 31. 739-750.
Pham Ngoc Lieu. 2002. Symposium of Science, technology and environment of South Vietnam at Mekong Delta territory, 18 st. I.121-I.132p (Vietnamese language)
Sharrock, S. 1992. In vitro propagation of pineapple (*Ananas comosus*) and plantain (Musa spp.) technical and economic considerations. Proceeding of the tenth annual conference, Grand Barbados Beach Resort, Barbados West Indies, Nov. 11-13, 1992. BSTA. 1992. p61-69.
Wakasa, K. 1979. Variation in the plants differentiated from the tissue culture of pineapple. Jap.J.Breed.29,13-22.
Wellburn, A.R. 1994. The spectral determination of chlorophyll a and b, as well as total carotennoids, using various solvents with spectrophotometers of different resolution. J. Plant Physiol. 144, 307-313.

Table 1. Effect of benzyladenine (BA) and growth conditions (GC) (growth chamber, 24°C, 31.4 mmol m^{-2} s^{-1}, 12 h photoperiod; outside, 94.2 to 125.6 mmol m^{-2} s^{-1}, 8-10 h daylight) on adventitious shoots of lateral buds cultured in liquid medium for eight weeks after subculture.

BA†	Number	Weight	Height	Chlorophyll,
0	0.8 a‡	2.08 a	1.97 b	5.00 a
0.2	4.0 ab	1.73 a	1.86 bc	3.17 b
0.4	5.2 bc	2.18 a	2.38 b	2.88 bc
0.6	5.4 bc	2.42 ab	3.45 a	2.78 bc
0.8	7.7 bc	3.11 ab	3.68 a	2.12 bc
1.0	8.6 c	3.75 b	3.57 a	2.72 bc
1.0+ 0.5 IBA	7.6 bc	6.46 c	0.91 c	2.47 bc
Chamber	5.2	3.07	2.52	2.6
Outside	6.1	3.15	2.57	3.2
F test BA	*	*	*	*
F test GC	–	–	–	*

†Categories are: concentration of benzyladenin (BA), or BA and indolebutyric acid (IBA), mg L^{-1}; average number of shoots; weight of shoot clumps in g; height of shoots in cm; and concentration of chlorophyll a in mg ml^{-1}.
‡Values followed by the same letter do not differ at P ≤0.05. The significance of the calculated F values are: –, not significant; *, significant at 0.05 level.

Table 2. Effects of naphthaleneacetic acid (NAA) concentrations and growth conditions (GC) (growth chamber, 24°C, 31.4 mmol m^{-2} s^{-1}, 12 h photoperiod; outside, 94.2 to 125.6 mmol m^{-2} s^{-1}, 8-10 h daylight) on rooting of plantlets after four weeks of subculture in liquid rooting medium. Values followed by the same letter do not differ at P £ 0.05. The analysis of variance gives the significance of the calculated F-values: -, not significant; *, a significant at 0.05 level.

BA†	Wt., g	Roots	L, cm	Height, cm
0.2	1.26	6.32	3.2	7.08 bc
0.4	1.22	6.23	2.7	6.76 c
0.6	1.16	5.97	3.1	8.59 a
0.8	1.07	5.84	3.0	7.76 ab
1.0	1.03	6.05	3.1	8.07 a
0 NAA	1.29	6.15	2.76	7.87
1.0 NAA	1.01	6.13	3.25	7.45
Chamber	1.22	6.4	3.3	7.96
Outside	1.09	5.8	2.7	7.37
F test BA	–	–	–	*
F test NAA	–	–	*	–
F test GC	–	–	*	–

†Categories are: concentration of benzyladenin (BA) in mg L^{-1} during the shoot multiplication stage; plantlet weight in g; Roots per plantlet; Root length (L), and Plantlet height.
‡Values followed by the same letter do not differ at P ≤0.05. The significance of the calculated F values are: –, not significant; *, significant at 0.05 level.◆

Notices

Web Sites of Possible Interest

1. Integrated pest management in Hawaii, including information on pineapple at http://www.extento.hawaii.edu/IPM/Default.asp.
2. Summerpride Foods in East London, South Africa http://www.summerpride.co.za/.◆

References

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

Abreu, C. M. P. de, C. D. dos Santos, S. J. de R. Chagas, and L. Costa 1998. Efeito da embalagem de polietileno e da refrigeracao no escurecimento interno e nas atividades da peroxidase e polifenoloxidase, durante a maturacao do abacaxi (*Ananas comosus* (L.) Merr cv. Smooth Cayenne) (Effect of polyethylene packaging and refrigeration on the internal darkening and activities of peroxidase and polyphenoloxidase during maturation of pineapples cv. Smooth Cayenne). Ciencia e Agrotecnologia 22, 454-465.
Agredo, C.E., J.I. Zuluaga Cardona, and E. Chaparro 1993. Importancia, identificacion, caracteristicas y danos de sinfilidos en pina, *Ananas comosus*, en el departamento del Valle (Colombia) (Importance, identification, characteristic and damages of sinfilidos in pineapple, *Ananas comosus*, in the de Valle department (Colombia)). In “Simposio Latinoamericano de Pinicultura. Cali (Colombia). 25-29 May 1993”, pp. 114-126. Instituto Colombiano Agropecuario, Cali (Colombia). Cali (Colombia).
Agredo, R.C.E., A.E. Chaparro, and J.I. Zuluaga Cardona 1988. Observaciones sobre caracteristicas, distribucion y danos de sinfilidos (Symphyla) y otros organismos del suelo en cultivos de pina, *Ananas comosus*, del Valle (Observations on characteristics, distribution and damages of symphylan (Symphyla) and other soil organisms in pineapple, *Ananas comosus*, cultivation of del Valle). Acta Agronomica (Colombia) 38, 65-73.
Ahmed, O. H., M. H. A. Husni, A. R. Anuar, and M. M. Hanafi 2002. Economic viability of modifying residue management and potassium application in pineapple cultivation. Tropical Science 42, 107-110.

Ahmed, O. H., M. H. A. Husni, A. R. Anuar, and M. M. Hanafi 2002. Effect of residue management practices on yield and economic viability of Malaysian pineapple production. Journal of Sustainable Agriculture 20, 83- 93.

Ahmed, O. H., M. H. A. Husni, A. R. Anuar, and M. M. Hanafi 2002. Nitrogen and pineapple residue use in pineapple production. Tropical Science 42, 174-177.

Alka, Shiva 2001. Harvesting of edible plant species: Actinidia chinensis, Aegle marmelos, *Ananas comosus*, *Annona squamosa*, *Artrocarpus lakoocha*, *Bambusa tulda*, *Borassus flabellifer*. MFP News 11, 9-11.

Almeida, O.A. de, L.F. da S. Souza, R.C. Caldas, and D.H. Reinhardt 2002. Efeito da irrigação sobre a produção e qualidade do abacaxi 'Pérola' em área de Tabuleiro Costeiro do Brasil (Effect of irrigation on 'Pérola' pineapple yield and fruit quality in Coastal Tableland area of Brazil). In "Congresso Brasileiro de Fruticultura", Vol. 17, pp. 5. Sociedade Brasileira de Fruticultura, Belém.

Almeida, O.A. de, L.F. da S. Souza, D.H. Reinhardt, and R.C. Caldas 2002. Influência da irrigação no ciclo do abacaxizeiro cv. Pérola em área de Tabuleiro Costeiro da Bahia (Influence of the irrigation on the cycle of 'Pérola' pineapple in Coastal Tableland area of Bahia, Brazil). Jaboticabal, Revista Brasileira de Fruticultura 24, 431-435.

Almeida, S. P. de 1998. "Cerrado: aproveitamento alimentar (Cerrado: food profit)," Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), Centro de Pesquisa Agropecuaria dos Cerrados, Planaltina, Brazil.

Amakura, Y., M. Okada, S. Tsuji, and Y. Tonogai 2000. High-performance liquid chromatographic determination with photodiode array detection of ellagic acid in fresh and processed fruits. Journal of Chromatography 896, 87-93.

Amanor-Boadu, V., J. Trienekens, and S. Willems 2002. Information and communication technologies, strategic power and inter-organisational relationships. In "Paradoxes in food chains and networks. Proceedings of the Fifth International Conference on Chain and Network Management in Agribusiness and the Food Industry, 6-8 June 2002." (J. H. Trienekens and S. W. F. Omta, eds.), pp. 908-918. Wageningen Academic Publishers, Noordwijk, Netherlands.

Angeles, D.E., and M.H. Constantino 1997. Establishment of sampling techniques in pineapple (*Ananas comosus* L.) using the rapid nitrate test. Philippine Journal of Crop Science 22(supplement no. 1), 31.

Anonymous 1998. "Cooperation in plant genomics at CIRAD,". Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement, Montpellier.

Anonymous 2001. Mycorrhizal dependency, Part 1: Selection of efficient mycorrhizal fungi. Mycorrhiza News 13, 2-16.

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

Arias, E., N. Nieves, G. Perez, M. Isidron, and R. Benega 1997. Variabilidad isoenzimatica en somaclones de pina (*Ananas comosus* (L.) Merr) (Isoenzimatic variability in pineapple somaclones (*Ananas comosus* (L.) Merr)). Cultivos Tropicales (Cuba) 18, 56-59.

Ay, ChYung 2000. Evaluating the internal quality of pineapple by acoustics, ASAE Paper No. 006113. In "ASAE Annual International Meeting, USA, 9-12 July", pp. 1-16. American Society of Agricultural Engineers, St Joseph, USA, Milwaukee, Wisconsin.

Bandith, Nikorn 1987. Effect of plant weight and age at flower induction on size, fruit quality and some characteristics of pineapple (*Ananas comosus* (L.) Merr), cv. smooth cayenne (Itthiphon khong namnak lae ayu ton thi raya rengdok to khanat khunnaphap phon lae laksana bangprakan khong sapparot phan Pattawia), Kasetsart University, Bangkok (Thailand).

Bartholomew, D.P., E. Malezieux, G.M. Sanewski, and E.R. Sinclair. 2002. Inflorescence, and fruit development and yield.pp. 167-202. In "The Pineapple: Botany, Production and Uses" (D. P. Bartholomew, R. Paull and K. G. Rohrbach, eds.), CABI Publishing, Wallingford.

Bergamaschine, A. F., O. J. Isepon, W. V. Valerio Filho, J. B. Alves, and E. Matsumoto 2000. Qualidade fermentativa, composicao bromatologica e degradacao "in situ" de silagens de plantas de abacaxi (Fermentative quality, chemical composition and "in situ" degradation of pineapple plant silages). Cultura Agronomica 9, 49-63.

Bhatia, Poonam, and Ashwath Nanjappa 2002. Development of a rapid method for micropropagation of a new pineapple [*Ananas comosus* (L.) Murr.] clone, 'Yeppoon Gold'. Acta Horticulturae, 575, 125-131.

Bhugaloo, R. A. 1999. Effect of different levels of nitrogen on yield and quality of pineapple variety Queen Victoria. In "Proceedings of the Third Annual Meeting of Agricultural Scientists, 17-18 November 1998" (J. A. Lalouette, D. Y. Bachraz and N. Sukerdeep, eds.), pp. 75-80. Food and Agricultural Research Council, Reduit, Mauritius, Reduit, Mauritius.

Boonma, Banjong 1991. "Identification of two pineapple [*Ananas comosus*] cultivars (cv. Bathavia and cv. Lakata) by vegetative and fruit characteristics (Kan chamnaek phan sapparot phan Batthavia lae phan Lakata duai laksana thang bai lae phon),". Dept. of Horticulture, Faculty of Agriculture, Kasetsart Univ., Bangkok 10903.

Borges, S. V., A. L. S. H. Reis, E. C. Jorge, P. R. Pinto, and V. M. Oliveiera 2002. Jugo de frutas tropicales deshidratado por spray drying (Tropical fruit juices dehydrated by spray drying). Alimentaria 39, 125-130.

Borras Hidalgo, O., M.C. Perez Penaranda, R. Santos Bermudez, R. Tapia, Y. Rodriguez Jimenez, and M. Mosqueda Frometa 1997. Influencia de filtrados de cultivos de Fusarium subglutinans en vitroplantas de pina (*Ananas comosus* (L.) Merril) (Influence of culture filtrates from Fusarium subglutinans on pineapple (*Ananas comosus* (L.) Merril) vitroplants). Cuadernos de Fitopatologia (Espana) 54, 150-152.

Borras, O., A.P. de Matos, R.S. Cabral, R. Tapia, R. Santos, M.C. Perez, and M. Arzola 1997. Influencia de filtrados concentrados de Fusarium subglutinans sobre segmentos de hojas de pina (*Ananas comosus* (L.) Merr) (Influence of concentrated filtrates from Fusarium subglutinans on segments of pineapple leaves (*Ananas comosus* (L.) Merr)). Cuadernos de Fitopatologia (Espana) 55, 186-188.

Bose, T. K., S. K. Mitra, and D. Sanyal 2001. "Fruits: tropical and subtropical.," Naya Udyog, Calcutta, India.

Botrel, N., V. D. de Carvalho, E. F. Oliveira, A. G. Soares, and S. A. Cenci 2002. Efeito da "mancha-chocolate" nas caracteristicas fisicoquimicas e quimicas de frutos de abacaxizeiro-'Perola' (Effect of chocolate stain on physico-chemical and chemical characteristics of fruits of Perola pineapple). Revista Brasileira de Fruticultura 24, 77- 81.

Botrel, N., L.F. da S. Souza, A.G. Soares, and V.M. Medina 2002. Influencia de la fertilización potásica en los tenores de acidez, vitamina C e índice de escurecimiento interno de la piña 'Pérola'. (Influence of potassium fertilization on fruit acidity, vitamin C content and internal browning of 'Pérola' pineapple). Simiente 72, 70.

Britz, H., T. A. Coutinho, M. J. Wingfield, and W. F. O. Marasas 2002. Validation of the description of *Gibberella circinata* and morphological differentiation of the anamorph *Fusarium circinatum*. Sydowia 54, 9-22.

Budu, A. S., D. C. Joyce, J. Aked, and A. K. Thompson 2001. Respiration of intact and minimally processed pineapple fruit. Tropical Science 41, 119-125.

Cabral, J.R.S., R.C. Caldas, A.P. de Matos, and L.F. da S. Souza 2002. Comportamento de genótipos de abacaxi no semi-árido baiano (Behavior of pineapple genotypes under semi-arid conditions of the State of Bahia, Brazil). In "Congresso Brasileiro de Fruticultura", Vol. 17, pp. 5. Sociedade Brasileira de Fruticultura, Belém.

Canlas, A.M., and F.B. Javier 1994. Multiple shoot formation, callus induction and plantlet regeneration of pineapple (*Ananas comosus* (L.) Merr. 'Queen') using axillary bud explants. Philippine Journal of Crop Science 19(Supplement no. 1), 39.

Carvalho, A. M. de 1998. Irrigation of pineapples. Informe Agropecuario (Belo Horizonte) 19, 58-61.

Carvalho-Lucia, Maria Jaeger de, Alberto Bentoda da Silva-Carlos, J.R. Gava, and F.D.B. Abadio 2002. Commercial sterilization of fruit juices by ultrafiltration/microfiltration membranes. Alimentaria 39, 123-127.

Carvalho-Lucia, Maria Jaeger de, Alberto Bentoda da Silva-Carlos, Ronoel-Luizde de Oliveira-Godoy, Americo A. Figueira-Jose, and Dias Bartolomeu Abadio-Fernanda 2002. Volatile compounds in hydrolyzed pineapple (*Ananas comosus* L. Merril) perola variety and clarified pasteurized juices obtained by solid-phase microextraction. Alimentaria 39, 129-132.

Carvalho-Nievola, Catarina, and Helenice Mercier 2001. Variacoes diurnas da atividade in vivo da redutase do nitrato em abacaxizeiro (*Ananas comosus* (L.) Merr.: Bromeliaceae) (Diurnal rhythm of in vivo activity of nitrate reductase in pineapple (*Ananas comosus* (L.) Merr.: Bromeliaceae)). Revista Brasileira de Botanica 24, 295-301.

Chan, Y. K. 2002. Fruit breeding at MARDI: a retrospect over three decades. Acta Horticulturae, 575, 279-286.

Chan, Y.K., G. Coppens d'Eeckenbrugge, and G.M. Sanewski 2002. Breeding and variety improvement. p. 33-55. In "The Pineapple: Botany, Production and Uses" (D. P. Bartholomew, R. Paull and K. G. Rohrbach, eds.). CABI Publishing, Wallingford.

Chang, WenHung, SuMing Chen, and ChiaChieh Tsai 1998. Development of a universal algorithm for use of NIR in estimation of soluble solids in fruit juices. Transactions of the ASAE 41, 1739-1745.

Chen, C. C., L. Zhou, N. J. Chen, and R. E. Paull 2001. Determinants of sweetness in papaya and pineapple. Acta Horticulturae, 553, 99-100.

Chen, LiSong, Qin Lin, and A. Nose 2002. A comparative study on diurnal changes in metabolite levels in the leaves of three crassulacean acid metabolism (CAM) species, *Ananas comosus*,

Kalanchoe daigremontiana and *K. pinnata*. Journal of Experimental Botany 53, 341- 350.
Chen, TarngPing, ShiHua Yang, and TeFang Pan 2001. A study on the technical efficiency of pineapple farms in Taiwan. Journal of Agricultural Research of China 50, 88-97.
Chen, YuShui, and WeiBin Pan 1999. Study on raising earthworm with plant residues. Journal of Guangxi Agricultural and Biological Science 18, 270-273.
Chundawat, B. S. 2001. Integrated nutrient management in tropical and subtropical fruits. Indian Journal of Horticulture 58, 59-69.
Coppens d'Eeckenbrugge, G., and F. Leal 2001. The application of the international code of nomenclature to pineapple cultivars. Tropical Fruits Newsletter, 40, 29-31.
Coppens d'Eeckenbrugge, Geo, and Freddy Leal 2002. Morphology, anatomy and taxonomy.p. 13-32. In “The Pineapple: Botany, Production and Uses” (D. P. Bartholomew, R. Paull and K. G. Rohrbach, eds.). CABI Publishing, Wallingford.
Corona, R., J. E. Manzano-Mendez, and R. Dris 2001. Shelf life of minimally processed pineapple (*Ananas comosus* L.) fruit products. Acta Horticulturae, 553, 707-708.
Cunha, G.A.P. da, J.T.A. Costa, and D. H. Reinhardt 2001. “Reguladores de crescimento na cultura do abacaxi. Massa foliar, fruto, mudas e colheita (Growth regulators on the pineapple crop. Leaf mass, fruit, slips and harvest),” Rep. No. Comunicado Técnico, 71. Embrapa Mandioca e Fruticultura, Cruz das Almas, BA.
Cunha, G.A.P. da, J.T.A. Costa, and D. H. Reinhardt 2002. “Fitorreguladores no controle da floração natural precoce do abacaxizeiro (Growth regulators on the control of precocious natural flowering of the pineapple plant),” Rep. No. Comunicado Técnico, 76. Embrapa Mandioca e Fruticultura, Cruz das Almas, BA.
Cunha, G.A.P. da, J.T.A. Costa, and D. H. Reinhardt 2002. “Inibição da floração natural do abacaxizeiro ‘Pérola' com reguladores de crescimento (Inhibition of natural flowering of the ‘Pérol' pineapple plant by growth regulators),” Rep. No. Comunicado Técnico, 75. Embrapa Mandioca e Fruticultura, Cruz das Almas, BA.
Cunha, G.A.P. da, J.T.A. Costa, and D.H. Reinhardt 2002. Alterações na massa foliar, produção de mudas e rendimento de colheita do abacaxizeiro ‘Pérola' causadas por reguladores de crescimento (Alterations of foliar mass, slips production and productivity of ‘Pérola' pineapple caused by growth regulators). In “Congresso Brasileiro de Fruticultura”, Vol. 17, pp. 5. Sociedade Brasileira de Fruticultura, Belém.
Cunha, S. C., J. O. Fernandes, and I. M. P. L. V. O. Ferreira 2002. HPLC/UV determination of organic acids in fruit juices and nectars. European Food Research and Technology 214, 67-71.
Dahler, J. M., S. J. Underhill, Y. Zhou, and J. E. Giles 2002. Biochemical changes associated with chilling in pineapple fruit. Acta Horticulturae, 575, 603-610.
Das, T. K., P. K. Sarkar, P. K. Dey, and A. K. Somchoudhury 2000. The chemical basis of resistance of pineapple plant to *Dolichotetranychus floridanus* Banks (Prostigmata: Tenuipalpidae). Acarologia 41, 317-320.
Dávila Solar, L.A. 1999. Cinética de la deshidratación osmótica a vacío y atmosférica de la piña (*Ananas comosus* L. Merr) (Cynetic of vacuum and atmosphere osmotic dehydratation of pineapple (*Ananas comosus* L. Merr)), Universidad Nacional Agraria La Molina, Lima.
Degla, P. 1998. “Agrarverfassung in Sudbenin: Probleme der Bodenordnung und ihre Auswirkungen Auf ausserlandwirtschaftliche Erwerbstatigkeit (Land tenure in South Benin: land tenure problems and their effects on off-farm activities),” Cuvillier Verlag, Gottingen, Germany.
Delaney, M. 1999. Field test of carbon monitoring methods for agroforestry in the Philippines. In “Field tests of carbon monitoring methods in forestry projects”, pp. 28-32. Winrock International Institute for Agricultural Development, Morrilton, USA.
Diaz Duque, R.O. 1993. Costos de produccion y rentabilidad del cultivo de pina (*Ananas comosus* L.): estudio de caso (Production costs and profitability of pineapple cultivation (*Ananas comosus* L.): case study). In “Simposio Latinoamericano de Pinicultura”, pp. 247-280. Memorias. Instituto Colombiano Agropecuario, Cali, Colombia.
Dickson, A. A., E. A. Allison-Oguru, and N. O. Isirimah 2002. Fertility capability classification based land evaluation in relation to socio-economic conditions of small holder farmers in Bayelsa State of Nigeria. Indian Journal of Agricultural Research 36, 10-16.
Djuniwati, S. 1998. Distribution of exchangeable K, Ca and Mg in several tillage intensities of pineapple (*Ananas comosus* L.) plantation in ultisol Terbanggi Besar, Central Lampung (Indonesia) (Distribusi Kalium, Calsium dan Magnesium dapat dipertukarkan pada beberapa tingkat pengolahan tanah pertanaman nanas (*Ananas comosus* L.) di tanah ultisol Terbanggi Besar, Lampung Tengah). Jurnal Tanah Tropika (Indonesia) 3, 99-110.
Dzogbefia, VP, E Amoke, JH Oldhan, and WO Ellis 2001. Production and use of yeast pectolytic enzymes to aid pineapple juice extraction. Food biotechnology 15, 25-34.
Endres, L, and H Mercier 2001. Influence of nitrogen forms on the growth and nitrogen metabolism of bromeliads. Journal of plant nutrition 24, 29-42.
Espinosa, P., J. C. Lorenzo, A. Iglesias, L. Yabor, E. Menendez, J. Borroto, L. Hernandez, and A. D. Arencibia 2002. Production of pineapple transgenic plants assisted by temporary immersion bioreactors. Plant Cell Reports 21, 136-140.
Esquivel R, E. 1995. “Enfermedades de la pina, *Ananas comosus* (L) Merr. y otros hongos asociados en el oeste de la Provincia de Panama (Diseases of the pineapple, *Ananas comosus* (L) Merr. and other associated fungi in the west of the Panama Province),” Rep. No. 9. North Star Co. Enterprises, Panama. Available from: IDIAP, CIDAGRO, Ap. 6-4391, El Dorado, Panama 6A - Panama.
Fabiani, A., A. Versari, G.P. Parpinello, M. Castellari, and S. Galassi 2002. High-performance liquid chromatographic analysis of free amino acids in fruit juices using derivatization with 9-fluorenylmethyl-chloroformate. Journal of Chromatographic Science. 40, 14-18.
Fazolin, M., A. da S. Ledo, and F. F. de Azevedo 2001. Niveis de infestacao de Thlastocoris laetus Mayr (Hemiptera: Coreidae) em quatro cultivares de abacaxi em Rio Branco, AC (Infestation levels of Thlastocoris laetus Mayr (Hemiptera: Coreidae) in four pineapple cultivars in Rio Branco, Acre, Brazil). Neotropical Entomology 30, 715-719.
Ferreira Colen, K. G., J. C. Moraes, L. V. C. Santa-Cecilia, R. Z. Bonetti Filho, and A. B. Carnevale 2001. Determinacao de injurias e danos da cochonilha pulverulenta Dysmicoccus brevipes (Cockerell, 1893) (Hemiptera: Pseudococcidae) ao abacaxizeiro (Determination of injuries and damages of the mealybug (Dysmicoccus brevipes (Cockerell, 1893) (Hemiptera: Pseudococcidae) on pineapple)). Ciencia e Agrotecnologia 25, 525-532.
Ferreira, P. F., and A. F. de S. L. Veiga 2000. Eficiencia do controle quimico do acaro alaranjado do abacaxizeiro, Dolichotetranychus floridanus (Banks, 1900) (Acari: Tenuipalpidae) em Pernambuco (Efficiency of the chemical control of orange mite of pineapple, Dolichotetranychus floridanus (Banks, 1900) (Acari: Tenuipalpidae), in Pernambuco State, Brazil). Revista de Agricultura (Piracicaba) 75, 153-162.
Feuser, S., R. O. Nodari, and M. P. Guerra 2001. Eficiencia comparativa dos sistemas de cultura estacionaria e imersao temporaria para a micropropagacao do abacaxizeiro (Comparative efficiency of stationary culture and temporary immersion systems for pineapple micropropagation). Revista Brasileira de Fruticultura 23, 6- 10.
Fillion, J., F. Sauve, and J. Selwyn 2000. Multiresidue method for the determination of residues of 251 pesticides in fruits and vegetables by gas chromatography/mass spectrometry and liquid chromatography with fluorescence detection. Journal of AOAC International 83, 698-713.
Fotso, N. D. O., M. A. Tita, and N. Niemenak 2001. Regeneration directe in vitro de l'*Ananas comosus* (L.) Merril var. Cayenne a partir de couronnes cultivees en milieu liquide (Direct in vitro regeneration of *Ananas comosus* (L.) Merril var. Cayenne from crowns cultivated in a liquid medium). Fruits (Paris) 56, 415-421.
Francis, D. 1999. Trade challenges for non-traditional fruits. IICA Quarterly Newsletter 5, 4-9.
Galan Sauco, V. 2002. Greenhouse cultivation of tropical fruits. Acta Horticulturae, 575, 727-735.
Galindo Alvarez, J.R. 1994. Peca o fusariosis (Fusarium moniliforme Sheld var. Subglutinans) WR y RE, en pina (*Ananas comosus*) (L. Merr) (Speck or fusariosis (Fusarium moniliforme Sheld var. Subglutinans) WR and RE, in pineapple (*Ananas comosus*) (L. Merr)). In “Sistemas de cultivo de la pina; tecnicas de produccion, areas de cultivo y manejo de plagas (Pineapple cultivation systems; production techniques, cultivation and pest management areas)”, pp. 43-50, Instituto Colombiano Agropecuario, Santafe de Bogota (Colombia).
Garcia Reyes, A. 1994. Tecnologia generada para el cultivo de la pina (*Ananas comosus* L) en los Santanderes (Technology generated for the cultivation of pineapple (*Ananas comosus* L) in Santanderes [Colombia]). In “Sistemas de cultivo de la pina; tecnicas de produccion, areas de cultivo y manejo de plagas (Pineapple cultivation systems; production techniques, cultivation and pest management areas)”, pp. 38-42. Instituto Colombiano Agropecuario, Santafe de Bogota (Colombia).
Garcia Reyes, A., and J. Mantilla Blanco 1993. Efecto de las distancias y sistemas de siembra en la produccion de pina *Ananas comosus* en la zona de Lebrija (Santander) (Effect of the distances and sowing systems in the pineapple production *Ananas comosus* in the zone of Lebrija (Santander) [Colombia]). In “Simposio Latinoamericano de Pinicultura. 25-29 May 1993”, pp. 322-334. Instituto Colombiano Agropecuario, Cali (Colombia).

Gehrig, HH, K Winter, J Cushman, A Borland, and T Taybi 2000. An improved RNA isolation method for succulent plant species rich in polyphenols and polysaccharides. Plant molecular biology reporter 18, 369-376.

Ghosh, S. P. 2001. Fruit research - present status and future thrusts. Indian Journal of Horticulture 58, 7-15.

Gogoe, S., A. Dekpor, and S. Williamson 2001. Prickly issues for pineapple pesticides. Pesticides News, 4-5.

Goswami, A. M., R. R. Sharma, and S. K. Saxena 2001. High density planting in tropical and subtropical fruit crops. Indian Journal of Horticulture 58, 23-27.

Gottardi, M.V.C., E.G.M. Lemos, and C. Ruggiero. 2001. Evaluation of matrix plants of pineapple Smooth Cayenne cultivar by RAPD and isozymes analysis (Avaliacao de plantas matrizes de abacaxizeiro cultivar Smooth Cayenne utilizando marcadores RAPD e padroes isoenzimaticos). Revista Brasileira de Fruticultura 23:463- 467.

Gottardi, M.V.C., E.G.M. Lemos, and C. Ruggiero. 2002. RAPD analysis of pineapple plants of Smooth Cayenne cultivar obtained by stem division and tissue culture (Avaliacao por RAPD de plantas de abacaxizeiro cultivar smooth cayenne derivadas do seccionamento do talo e cultura de tecidos). Revista Brasileira de Fruticultura 24:1-9.

Avaliacao de plantas matrizes de abacaxizeiro cultivar Smooth Cayenne utilizando marcadores RAPD e padroes isoenzimaticos. Revista Brasileira de Fruticultura 23, 463- 467.

Avaliacao por RAPD de plantas de abacaxizeiro cultivar smooth cayenne derivadas do seccionamento do talo e cultura de tecidos. Revista Brasileira de Fruticultura 24, 1-9.

Guedes, N.M.P., R.N.C. Guedes, and M.C. Picanco 1996. Effects of carbosulfan on pineapple (*Ananas comosus* (L.) Merr.) growth. Pesquisa Agropecuaria Brasileira (Brazil) 31, 283-286.

Guevarra, M. T. B., and L. N. Panlasigui 2000. Blood glucose responses of diabetes mellitus type II patients to some local fruits. Asia Pacific Journal of Clinical Nutrition 9, 303-308.

Hayashi, K., H. Hara, P. Asvarujanon, Y. Aoyama, and P. Luangpituksa 2001. Ingestion of insoluble dietary fibre increased zinc and iron absorption and restored growth rate and zinc absorption suppressed by dietary phytate in rats. British Journal of Nutrition 86, 443-451.

Helander, A., and M. Some 2000. Dietary serotonin and alcohol combined may provoke adverse physiological symptoms due to 5-hydroxytryptophol. Life Sciences 67, 799-806.

Hepton, A. 2002. Culture System.p. 109-142. In “The Pineapple: Botany, Production and Uses” (D. P. Bartholomew, R. Paull and K. G. Rohrbach, eds.). CABI Publishing, Wallingford.

Hepton, A., and A.S. Hodgson. 2002. Processing, p. 281-290, In D. P. Bartholomew, et al., eds. The Pineapple: Botany, Production and Uses. CABI Publishing, Wallingford.

Herath, H. M. I., D. C. Bandara, and D. M. G. A. Banda 2000. Effect of pre-harvest calcium application level for the post- harvest keeping quality in Mauritius pineapple. Tropical Agricultural Research 12, 408-411.

Herath, H. M. I., D. C. Bandara, and D. M. G. A. Banda 2001. Effect of basal application of different sources of calcium on the control of Internal Browning of Mauritius pineapple under cold storage. Tropical Agricultural Research 13, 231-238.

Huang, S. H., C. Y. Wong, and C. H. Cheng 2002. A newly recorded insect pest, pink pineapple mealybug (*Dysmicoccus brevipes* (Cockerell)) (Homoptera: Pseudococcidae), infesting on the roots of peanut in Taiwan. Plant Protection Bulletin (Taipei) 44, 141- 146.

Hung, Tung-Hsin, Ya-Min Chang, Hsien-Yi Sung, and Chen-Tien Chang 2002. Purification and characterization of hydrolase with chitinase and chitosanase activity from commercial stem bromelain. Journal of Agricultural and Food Chemistry 50, 4666-4673.

Isidron, M., R. Benega, G. Perez, and A. Cisneros 1995. Programa de mejoramiento genetico de la pina (*Ananas comosus* L.): genotipos obtenidos, logros y perspectivas (The breeding programme of pineapple (*Ananas comosus* L.): obtained genotypes, prospects and achievements). In “Simposio Internacional sobre Fruticultura Tropical y Subtropical. Fruticultura '95”, pp. 73-74, Estacion Nacional de Frutales. La Habana (Cuba).

Jayson, E. A. 1999. “Studies on crop damage by wild animals in Kerala and evaluation of control measures,”. Kerala Forest Research Institute (KFRI), Peechi, India.

Kar, P. L., A. Sema, C. S. Maiti, and A. K. Singh 2002. Effects of zinc and boron on fruit and quality traits in pineapple [*Ananas comosus* (L.)]. South Indian Horticulture 50, 44-49.

Kasirawat, Teerawat 1994. Genetic variation and clonal selection of pineapple cv. Smooth Cayenne (Khwam praepruan thang phanthukam lae kan khat luak saiphan sapparot phan Pattavia), Kasetsart Univ., Bangkok.

Kawano, S. 1999. Non-destructive methods for quality analysis - especially for fruits and vegetables. Deutsche Gesellschaft fur Qualitatsforschung (Pflanzliche Nahrungsmittel) 34, 5-12.

Kubiriba, J., J. P. Legg, W. Tushemereirwe, and E. Adipala 2001. Vector transmission of Banana streak virus in the screenhouse in Uganda. Annals of Applied Biology 139, 37-43.

Kubo, T., M. P. Yamamoto, and T. Mikami 2000. The nad4L-orf25 gene cluster is conserved and expressed in sugar beet mitochondria. Theoretical and Applied Genetics 100, 214- 220.

Leong, L. P., and G. Shui 2002. An investigation of antioxidant capacity of fruits in Singapore markets. Food Chemistry 76, 69-75.

Liao, TaChing, ChiiMing Jiang, MingChang Wu, JeanYu Hwang, and HungMin Chang 2001. Quantification of L-ascorbic acid and total ascorbic acid in fruits and spinach by capillary zone electrophoresis. Electrophoresis 22, 1484-1488.

Licsi, M.L.G. 1998. Vermifuge property of the semipurified glycosides from the leaves of pineapple (*Ananas comosus*, Linn., Family Bromeliaceae). In “Graduate and Faculty Studies (Philippines), 1995”, Vol. 39, pp. 7-8.

Lima, V. P. de, D. H. Reinhardt, and J. A. Costa 2002. Desbaste de mudas tipo filhote do abacaxi cv. Perola - 2. Analises de crescimento e de correlacoes (Thinning of seedlings of Perola pineapple.- 2. Analyses of growth and correlations). Revista Brasileira de Fruticultura 24, 101- 107.

Lima, V.P. de, D.H. Reinhardt, and J.A. Costa 2002. Desbaste de mudas tipo filhote do abacaxi cv. Pérola – 2. Análises de crescimento e de correlações (Thinning of ‘Pérola' pineapple slips – 2. Growth and correlation analyses). Jaboticabal, Revista Brasileira de Fruticultura 24, 01-107.

Lima, V.P. de, D.H. Reinhardt, and J.A. Costa 2002. O desbaste de mudas favorece o vigor do material de plantio e a produção do abacaxi ‘Pérola' sob irrigação (Slips thinning favors the vigour of planting material and the production of ‘Pérola' pineapple under irrigation). In “Congresso Brasileiro de Fruticultura”, Vol. 17, pp. 4. Sociedade Brasileira de Fruticultura, Belém.

Lin, XinLai 2002. “The contra-season growing technique for pineapple,”. Research Institute of Pomology, Xingcheng, China.

Litz, R. E. 2002. Biotechnology of tropical and subtropical fruit: cornucopia or forbidden fruit? Acta Horticulturae, 575, 35-46.

Lopez Lago, I., J. Diaz Varela, and F. Merino de Caceres 1996. Calidad de la pina tropical (*Ananas comosus* L. Merr) presente en el mercado (Pineapple (*Ananas comosus* L. Merr) quality presents in the market). Alimentaria (Espana), 272, 59-64.

Lopez, Laura M.I., Cynthia Sequeiros, Sebastian A. Trejo, Marcelo F. Pardo, Nestor O. Caffini, and Claudia L. Natalucci 2001. Comparison of two cysteine endopeptidases from Pseudananas macrodontes (Morr.) Harms (Bromeliaceae). Biological Chemistry 382, 875-878.

Maheswarappa, H. P., P. Anithakumari, and S. Remabai 2001. Cropping/farming system research in coconut root (wilt) affected gardens. Indian Coconut Journal 32, 2-5.

Mailawati, T., and C. Ginting 1999. Formulation of Bordeaux mixture to control bacterial heart rot on pineapple (Formulasi bubur bordo (Bordeaux mixture) untuk mengendalikan penyakit busuk hati bakteri pada tanaman nenas). Jurnal Penelitian Pengembangan Wilayah Lahan Kering (Indonesia), 22/23, 81-86.

Malezieux, E., and D.P. Bartholomew 2002. Plant nutrition.p. 143-165. In “The Pineapple: Botany, Production and Uses” (D. P. Bartholomew, R. Paull and K. G. Rohrbach, eds.). CABI Publishing, Wallingford.

Malezieux, E., F. Cote, and D.P. Bartholomew 2002. Crop environment, and vegetative physiology and growth.p. 69-107. In “The Pineapple: Botany, Production and Uses” (D. P. Bartholomew, R. Paull and K. G. Rohrbach, eds.). CABI Publishing, Wallingford.

Marie, F. 2001. Clonal selection and rapid multiplication in pineapple. Tropical Fruits Newsletter, 38, 5-11.

Marrero, A., and A. A. Kader 2001. Factors affecting the post-cutting life and quality of minimally processed pineapple. Acta Horticulturae, 553, 705-706.

Matsukawa, R., Y. Kawamitsu, and S. Murayama 1998. Estimation of CAM ability in vitro pineapple [*Ananas comosus*] by means with oxygen electrode. Science Bulletin of the College of Agriculture - University of the Ryukyus, 45, 17-28.

Mazzani, E., and V. Segovia 2001. Colecta de germoplasma en la ecoregion de la Peninsula de Paria, Estado Sucre, Venezuela (Germplasm collection in the ecoregion of Paria Peninsula, Estado Sucre, Venezuela). Plant Genetic Resources Newsletter, 126, 17-20.

McRae, S. R., J. T. Christopher, J. A. C. Smith, and J. A. M. Holtum 2002. Sucrose transport across the vacuolar membrane of *Ananas comosus*. Functional Plant Biology 29, 717-724.

Mendez Aldana, H. 1994. Fertilization of pineapple cultivars (*Ananas comosus* Merr) with major elements in soils of Santander department [Colombia] (Fertilizacion del cultivo de la pina (*Ananas comosus* Merr) con elementos mayores en suelos del departamento de Santander). In “Sistemas de cultivo de la pina; tecnicas de produccion, areas de cultivo y manejo de plagas (Pineapple cultivation systems; production techniques, cultivation and pest management areas)”, pp. 92-94, Instituto Colombiano Agropecuario, Santafe de Bogota (Colombia).

Model, N. S. 2000. Controle da cochonilha do abacaxizeiro *Dysmicoccus brevipes* (Cockerell, 1893) (Hemiptera; Sternorryncha; Pseudococcidae) no Rio Grande do Sul, Brasil (Controlling the pineapple mealybug *Dysmicoccus brevipes* (Cockerell, 1893) (Hemiptera; Sternorryncha; Pseudococcidae) in Rio Grande do Sul, Brazil). Pesquisa Agropecuaria Gaucha 6, 289-302.

Model, N. S., and G. R. Sander 2000. Nutrientes na biomassa, rendimento e qualidade de abacaxi na segunda colheita, em funcao do preparo do solo e tecnicas de plantio (Nutrients in biomass, yield and quality of pineapple second harvest - the effect of soil management techniques and planting techniques). Pesquisa Agropecuaria Gaucha 6, 7-18.

Modesto, J. C., J. D. Rodrigues, I. M. Murata, S. H. Hikida, M. R. Magurno, and W. A. Palota 1999. Efeitos de diferentes concentracoes de ethephon na inducao floral do abacaxizeiro (*Ananas comosus* (L.) Merril) cv. Smooth cayenne, em Paraguacu Paulista - SP (Effects of different concentrations of ethepon in induction of flowering in pineapple (cv Smooth cayenne) in Paraguacu Paulista - SP). Cultura Agronomica 8, 187-198.

Monaymem Miah, M. A., and S. A. Sabur 1998. Consumption pattern of fruits in a selected area of Bangladesh. Bangladesh Journal of Agricultural Economics 21, 101-109.

Morales Ruiz, M 2001. “Comportamiento fisiológico del fruto de piña nativa (*Ananas comosus* L. Merril) c.v. india bajo condiciones de almacenamiento (Physiological behaviour of pineapple native fruit (*Ananas comosus* L. Merril) c.v. india in storage conditions),”. Universidad Nacional de Colombia, Bogotá. Facultad de Agronomía, Bogotá (Colombia).

Murcia, M. A., A. M. Jimenez, and M. Martinez-Tome 2001. Evaluation of the antioxidant properties of Mediterranean and tropical fruits compared with common food additives. Journal of Food Protection 64, 2037-2046.

Myhara, R. M., and Sablani Shyam 2001. Unification of fruit water sorption isotherms using artificial neural networks. Drying Technology 19, 1543-1554.

Nagalakshmi, A. V. D., and M. U. Reddy 1999. Quality analysis of selected fruit juices sold by street vendors in Hyderabad city. Indian Journal of Nutrition and Dietetics 36, 78-83.

Nath, J. C. 2002. Prospects of coconut based high density multistoreyed cropping in Assam. Indian Coconut Journal 33, 10-11.

Neuteboom, L.W., W.Y. Kunimitsu, D. Webb, and D.A. Christopher 2002. Characterization and tissue-regulated expression of genes involved in pineapple (*Ananas comosus* L.) root development. Plant Science 163, 1021-1035.

Nickel, O., C. M. Chagas, and A. P. A. Vasconcelos 2000. Association of pineapple mealybug wilt with closterovirus-like particles and dsRNA in Bahia, Brazil. Fitopatologia Brasileira 25, 200-202.

Nigam, J.N., and M.C. Kakati 2002. Optimization of dilution rate for the production of value added product and simultaneous reduction of organic load from pineapple cannery waste. World Journal of Microbiology and Biotechnology 18, 301-305.

Normah, Omar, Hasnah Ku, and Abdullah Ku 2001. Pectin content of selected local fruit by-products. Journal ofTropical Agriculture and Food Science 28, 195-201.

Paula, J.M.C. de, J.P. Valente, J.G. de Abreu, W.E. Pereira, and D.H. Reinhardt 2002. Florescimento, produção e qualidade do fruto do abacaxi cv. Pérola em função da idade da planta na indução floral (Flowering, production and fruit quality of ‘Pérola' pineapple as a function of plant age at flower forcing). In “Congresso Brasileiro de Fruticultura”, Vol. 17, pp. 5. Sociedade Brasileira de Fruticultura, Belém.

Paula, M. B. de, H. A. de Mesquita, and F. D. Nogueira 1998. Nutricao e adubacao do abacaxizeiro (Nutrition and fertilization of pineapple). Informe Agropecuario (Belo Horizonte) 19, 33-39.

Paull, R.E., and Ching-Cheng Chen 2002. Postharvest physiology, handling, and storage of pineapple. p. 253-279. In “The Pineapple: Botany, Production and Uses” (D. P. Bartholomew, R. Paull and K. G. Rohrbach, eds.). CABI Publishing, Wallingford.

Pereira, C. D., and W. E. Kerr 2001. Genetic divergence among twelve genotypes of pineapple (*Ananas comosus* L, Merril.) estimated by RAPD markers (Divergencia genetica entre doze genotipos de abacaxizeiro (*Ananas comosus* L, Merril.) estimada por analise de marcadores RAPD). Revista Brasileira de Fruticultura 23, 335- 338.

Pereira, C.D., and W.E. Kerr 2001. Divergencia genetica entre doze genotipos de abacaxizeiro (*Ananas comosus* L, Merril.) estimada por analise de marcadores RAPD (Genetic divergence among twelve genotypes of pineapple (*Ananas comosus* L., Merril) estimated by RAPD markers). Revista Brasileira de Fruticultura (Brazil) 23, 335-338.

Pereira, F. D., M. F. Braga, M. E. L. de Sa, O. A. G. de Alcino, and I. C. Colenghi 2001. Influence of BAP and NAA on multiplication of pineapple cv. Perolera, from in vitro etiolated shoots (Influencia de BAP e NAA na multiplicacao de abacaxi cv. perolera a partir de brotos estiolados in vitro). Bioscience Journal 17, 49-60.

Perez Ponce, J. N., M. Suarez Castella, and P. Orellana Perez 2000. Posibilidades y potencial de la propagacion masiva de plantas en Cuba (Possibilities and potential of the massive propagation of plants in Cuba). Biotecnologia Vegetal, 1, 3-11.

Petty, G.J., G.R. Stirling, and D.P. Bartholomew 2002. Pests of Pineapple. In “Tropical Fruit Pests and Pollinators; Their Biology, Economic Importance, Natural Enemies and Control Methods” (J. E. Peña, J. Sharp and M. Wysoki, eds.), pp. 157-195. CAB International, Wallingford, England.

Piza, I. M. de T., G. P. P. Lima, and O. G. Brasil 2001. Reguladores vegetais na micropropagacao do abacaxizeiro (Growth regulators on pineapple micropropagation). Revista Ceres 48, 681-690.

Popp, M., H.-P. Janett, U. Lüttge, and E. Medina. 2003. Metabolite gradients and carbohydrate translocation in rosette leaves of CAM and C3 bromeliads. New Phytologist. 157: 649–656.

Potvivat, Aemorn 1991. “Identification of two pineapple cultivars (*Ananas comosus* (L.) Merr. cv. Trat See Thong and cv. Singapore - Bathavia) by vegetative and reproductive characteristics (Kan chamnaek phan khong sapparot phan Trat See Thong lae phan Singapore - Bathavia duai laksana thang bai lae phon),”. Dept. of Horticulture, Faculty of Agriculture, Kasetsart Univ., Bangkok 10903.

Prakongpan, T., A. Nitithamyong, and P. Luangpituksa 2002. Extraction and application of dietary fiber and cellulose from pineapple cores. Journal of Food Science 67, 1308-1313.

Ragoonath, J. 1992. Characteristics of pineapple varieties grown in Trinidad and Tobago. IICA Tropical Fruits Newsletter (Trinidad and Tobago), 9-10.

Ray, A. K., and D. V. S. Reddy 2001. Performance of areca-based high-density multispecies cropping system under different levels of fertilizer. Tropical Agriculture 78, 152-155.

Razzaque, A. H. M., and M. M. Hanafi 2000. Response of pineapple to phosphorus application on tropical peat soil. Indian Journal of Horticulture 57, 321-325.

Razzaque, A. H. M., and Hanafi Mohamed Musa 2001. Effect of potassium on growth, yield and quality of pineapple in tropical peat. Fruits (Paris) 56, 45-49.

Rebolledo-Martínez, A., D. Uriza-Avila, L. Rebolledo-Martínez, A.E. Becerril-Román, and L.D.M. Ruiz-Posadas 2002. Fruitone CPA para retardar la maduración en piña *Ananas comosus* (L.) Merr., cv. Cayena lisa, consechada en primavera (Fruitone CPA for delay the fruit maturity of pineapple *Ananas comosus* (L.) Merr. cv. Smooth Cayenne harvested in spring time). Revista Brasileira de Fruticultura (Brazil) 24, 354-358.

Redondo Echeverri, E., and F.E. Varon de Agudelo 1993. Identificacion y efecto parasitico de nematodos en el cultivo de la pina *Ananas comosus* L. (Merr.) (Identification and parasitic effect of nematodes in the cultivation of pineapple *Ananas comosus* L. (Merr.)). In “Simposio Latinoamericano de Pinicultura. 25-29 May.”. Instituto Colombiano Agropecuario, Cali (Colombia), Cali (Colombia).

Reindl, J., H. P. Rihs, S. Scheurer, A. Wangorsch, D. Haustein, and S. Vieths 2002. IgE reactivity to profilin in pollen-sensitized subjects with adverse reactions to banana and pineapple. International Archives of Allergy and Immunology 128, 105-114.

Reinhardt, D. H., J. R. S. Cabral, L. F. da S. Souza, N. F. Sanches, and A. P. de Matos 2002. Perola and Smooth Cayenne pineapple cultivars in the state of Bahia, Brazil: growth, flowering, pests, diseases, yield and fruit quality aspects. Fruits (Paris) 57, 43-53.

Reinhardt, D. H., and G.A.P. da Cunha 2001. “A floração natural do abacaxizeiro (The natural flowering of the pineapple plant),” Rep. No. Abacaxi em Foco, 21. Embrapa Mandioca e Fruticultura, Cruz das Almas, BA.

Reinhardt, D.H., J.R.S. Cabral, L.F. da S. Souza, N.F Sanches, and A.P. de M. Matos 2002. Pérola and Smoth Cayenne cultivars in Cruz das Almas, state of Bahia, Brazil - growth, flowering, pests, diseases, yield and fruit quality aspects. Fruits (Paris) 57, 43-53.

Reinhardt, D.H., A.P.M. Souza, R.C. Caldas, J. dos P Alcântara, and A.de A. Alves 2002. Práticas culturais pós-colheita não aceleram o desenvolvimento de filhotes de abacaxi ‘Pérola' durante a ceva (Post-harvest cultural practices don't accelerate the development of ‘Pérola' pineapple slips). In “Congresso Brasileiro de Fruticultura”, Vol. 17, pp. 5. Sociedade Brasileira de Fruticultura, Belém.

Reinhardt, D.H., L. F. da S. Souza, and J.R.S. Cabral 2001. Abacaxi irrigado em condições semi-áridas (Irrigated pineapple under semi-arid conditions). ed.1. Embrapa Mandioca e Fruticultura, Cruz das Almas.

Roa Moncada, M. 1994. Las malezas y la pina (*Ananas comosus* L. Merr var. Perolera) (Weeds and pineapple (*Ananas comosus* L. Merr var. Perolera)). In "Sistemas de cultivo de la pina; tecnicas de produccion, areas de cultivo y manejo de plagas (Pineapple cultivation systems; production techniques, cultivation and pest management areas)", pp. 70-72, Instituto Colombiano Agropecuario, Santafe de Bogota (Colombia).

Rodríguez de Francisco, L.E., Y. Santiago Bardón, Y. Rosales Simonot, Y. Igarza Castro, E. Fornet Hernández, M.V. González Guitian, A. Más Basnuevo, T. Castro Velázquez, R. Cantillo Ardeból, and R. Vega Pino 2001. Micropropagación de *Ananas comosus* (L.) Merr. (piña), cultivar Cabezona (Micropropagation of *Ananas comosus* (L.) Merr. (pineapple), cultivar Cabezona]. Cuadernos de Fitopatología (España) 67, 29-34.

Rohrbach, K.G., and M Johnson 2002. Pests, diseases and weeds. p. 203-251. In "The Pineapple: Botany, Production and Uses" (D. P. Bartholomew, R. Paull and K. G. Rohrbach, eds.). CABI Publishing, Wallingford.

Rohrbach, K.G., and F. Leal 2002. History, distribution and world production. p. 1-12. In "The Pineapple: Botany, Production and Uses" (D. P. Bartholomew, R. Paull and K. G. Rohrbach, eds.). CABI Publishing, Wallingford.

Roy, S., S. Raj, M. Choudhury, S. K. Dey, and M. A. Nazeer 2001. Intercropping of banana and pineapple in rubber plantations in Tripura. Indian Journal of Natural Rubber Research 14, 152-158.

Sa, M. E. L. de 2001. Propagacao in vitro de diferentes genotipos de abacaxizeiro por meio de seccionamento de plantulas (In vitro propagation of different pineapple genotypes by plantlet bisection). Revista Brasileira de Fruticultura 23, 17- 20.

Salam, M. A. 2001. Cashew and pineapple live in harmony. Cashew 15, 12-13.

Sanches, N.F., A. de A. Alves, R.B. Caldas, F.L.B. Ribeiro, K.L.N.P. Santos, E.F.A. Macedo, and E.S. Silva 2002. Murcha do abacaxizeiro: alternativas de controle pré-plantio (Pineapple wilt: alternatives for pre-planting control). In "Congresso Brasileiro de Fruticultura", Vol. 17, pp. 5. Sociedade Brasileira de Fruticultura, Belém.

Santa-Cecilia, L. V. C., and S. M. Chalfoun 1998. Pragas e doencas que afetam o abacaxizeiro (Pests and diseases which affect pineapple). Informe Agropecuario (Belo Horizonte) 19, 40-57.

Santa-Cecilia, L. V. C., R. de C. R. Goncalves-Gervasio, B. Souza, and J. R. da Silva 2001. Teores de fenois associados ao complexo cochonilha Dysmicoccus brevipes (Cockerell, 1893) (Hemiptera: Pseudococcidae) versus Murcha-do-abacaxizeiro (Phenolic contents associated with the bug Dysmicoccus brevipes (Cockerell, 1893) (Hemiptera: Pseudococcidae) versus pineapple plant wilt). Ciencia e Agrotecnologia 25, 467-470.

Santos, B. A., L. Zambolim, J. A. Ventura, and F. X. R. Vale 1999. Resistencia de Fusarium subglutinans f. sp. ananas ao benomyl (Resistance of Fusarium subglutinans f. sp. ananas to benomyl). Fitopatologia Brasileira 24, 436-439.

Santos, B. A., L. Zambolim, J. A. Ventura, and F. X. R. Vale 2002. Severidade de isolados de Fusarium subglutinans f. sp. ananas sensiveis e resistentes ao benomyl, em abacaxizeiro (Severity of isolates of Fusarium subglutinans f. sp. ananas resistant or not to benomyl on pineapple). Fitopatologia Brasileira 27, 101-103.

Santos, M. A. T. dos, I. A. dos S. Nepomuceno, C. M. P. de Abreu, and V. D. de Carvalho 2001. Stem and leaf polyphenol contents of four pineapple cultivars (Teores de polifenois de caule e folha de quatro cultivares de abacaxizeiro). Revista Brasileira de Fruticultura 23, 274-276.

Santos, S.A. dos 1995. "Efeito do tempo na composicao fisico-quimica, quimica e na atividade da bromelina do caule do abacaxizeiro *Ananas comosus* (L.) Merr. cv. Perola armazenado em condicoes com e sem refrigeracao (Effect of time on the physical-chemical, chemical composition and activity of bromelin of the pineapple plant stem (*Ananas comosus* L. Merr) cv. Perola stored under conditions with and without refrigeration),". Universidade Federal de Lavras, Lavras, MG (Brazil).

Sawano, Y., T. Muramatsu, K. Hatano, K. Nagata, and M. Tanokura 2002. Characterization of genomic sequence coding for bromelain inhibitors in pineapple and expression of its recombinant isoform. Journal of Biological Chemistry 277, 28222-28227.

Sether, D. M., and J. S. Hu 2001. The impact of Pineapple mealybug wilt-associated virus-1 and reduced irrigation on pineapple yield. Australasian Plant Pathology 30, 31-36.

Sether, D. M., and J. S. Hu 2002. Closterovirus infection and mealybug exposure are necessary for the development of mealybug wilt of pineapple disease. Phytopathology 92, 928-935.

Sether, D. M., and J. S. Hu 2002. Yield impact and spread of Pineapple mealybug wilt associated virus-2 and mealybug wilt of pineapple in Hawaii. Plant Disease 86, 867-874.

Sether, D. M., A. V. Karasev, C. Okumura, C. Arakawa, F. Zee, M. M. Kislan, J. L. Busto, and J. S. Hu 2001. Differentiation, distribution, and elimination of two different Pineapple mealybug wilt-associated viruses found in pineapple. Plant Disease 85, 856-864.

Sharrock, S. 1992. In vitro propagation of pineapple (*Ananas comosus*) and plantain (Musa spp.) technical and economic considerations. In "Proceedings of Barbados Society of Technologists in Agriculture (Barbados). no. 10", pp. 61-69, Grand Barbados Beach Resort, Barbados West Indies, Nov 11-13, 1992.

Shaw, P. E., M. Lebrun, M. N. Ducamp, M. J. Jordan, and K. L. Goodner 2002. Pineapple juice concentrated by osmotic evaporation. Journal of Food Quality 25, 39-49.

Siebeneichler, S. C., P. H. Monnerat, A. J. C. de Carvalho, and J. A. da Silva 2002. Composicao mineral da folha em abacaxizeiro: efeito da parte da folha analisada (Mineral composition of the pineapple leaf: effect of the part of a leaf analyzed). Revista Brasileira de Fruticultura 24, 194- 198.

Silva-Acuna, R., A.F. Costa, M. Barreto, S.K. de Alonso, and L. Zambolim 1995. Efeito da temperatura e do tipo de folha no desenvolvimento de lesoes de Fusarium subglutinans f. sp. ananas no abacaxizeiro "Perola" (Effect of temperature and leaf type on lesion development of Fusarium subglutinans f. sp. ananas on "Perola" pineapple). Fitopatologia Brasileira (Brazil). 20, 498-500.

Singh, D. B., and A. B. Manual 2000. Assessment of pineapple plants developed from micropropagation instead of conventional suckering. Tropical Science 40, 169-173.

Singh, R. S. 2000. "Diseases of fruit crops," Science Publishers, Inc.,, Enfield, USA.

Sipes, B. S., D. M. Sether, and J. S. Hu 2002. Interactions between *Rotylenchulus reniformis* and Pineapple mealybug wilt associated virus-1 in pineapple. Plant Disease 86, 933-938.

Siriphanich, J. 2002. Postharvest physiology of tropical fruit. Acta Horticulturae, 575, 623-633.

Smith, M. K., H. L. Ko, S. D. Hamill, and G. M. Sanewski 2002. Pineapple transformation: managing somaclonal variation. Acta Horticulturae, 575, 69-74.

Smith, M.K., G.M. Sanewski, and M.W. Graham 2002. Biotechnology. p. 57-68. In "The Pineapple: Botany, Production and Uses" (D. P. Bartholomew, R. Paull and K. G. Rohrbach, eds.). CABI Publishing, Wallingford.

Soares, A.G., N. Botrel, L.C. Trugo, L.F. da S. Souza, and V.M. Medina 2002. Avaliação da qualidade e do potencial de armazenamento refrigerado de abacaxi cultivado com diferentes concentrações e formas de aplicação de potássio (Quality and refrigerated storage potential of pineapple cultivated under different doses and forms of application of potassium). In "Congresso Brasileiro de Fruticultura", Vol. 17, pp. 5. Sociedade Brasileira de Fruticultura, Belém.

Soneji, J. R., P. S. Rao, and M. Mhatre 2002. Germination of synthetic seeds of pineapple (*Ananas comosus* L. Merr.). Plant Cell Reports 20, 891-894.

Soneji, J. R., P. S. Rao, and Mhatre Minal 2002. In vitro regeneration from leaf explants of pineapple (*Ananas comosus* L, Merr). Journal of Plant Biochemistry and Biotechnology 11, 117-119.

Soneji, J. R., P. S. Rao, and Mhatre Minal 2002. Somaclonal variation in micropropagated dormant axillary buds of pineapple (*Ananas comosus* L., Merr.). Journal of Horticultural Science and Biotechnology 77, 28-32.

Souza, A.P.M., D.H. Reinhardt, and R.C. Caldas 2002. Manejo de mudas na ceva e seu efeito sobre o crescimento e a produção do abacaxi 'Pérola' (Management of slips and its effect on growth and production of 'Pérola' pineapple). In "Congresso Brasileiro de Fruticultura", Vol. 17, pp. 4. Sociedade Brasileira de Fruticultura, Belém.

Souza, L.F. da S., O.A. de Almeida, R.C. Caldas, and D.H. Reinhardt 2002. Effect of soil moisture and fertilization on 'Pérola' pineapple in Coastal Tableland area of Brazil. Tropical Agriculture, Trinidad 79, 83-87.

Souza, L.F. da S., N.B. Gonçalves, R.C. Caldas, and A.G. Soares 2002. Influência da adubação potássica nos teores foliares de nutrientes do abacaxizeiro 'Pérola' (Influence of potassium fertilization on foliar nutrient contents of 'Pérola' pineapple). In "Congresso Brasileiro de Fruticultura", Vol. 17, pp. 4. Sociedade Brasileira de Fruticultura, Belém.

Sripaoraya, S., R. Marchant, J. B. Power, and M. R. Davey 2001. Herbicide-tolerant transgenic pineapple (*Ananas comosus*) produced by microprojectile bombardment. Annals of Botany 88, 597-603.

Stewart, R.J., B.J.B Sawyer, and S.P. Robinson 2002. Blackheart development following chilling in fruit of susceptible and resistant

pineapple cultivars. Australian Journal of Experimental Agriculture 42, 195-199.
Sun, GuanRong 2001. On the problems of tropical and subtropical fruit industry in China and some suggestion. China Fruits, 3, 44-46.
Suryanata, K. 2000. Products from paradise: the social construction of Hawaii crops. Agriculture and Human Values 17, 181-189.
Sutra, L., P. Prior, K. Perlemoine, J. M. Risede, P. Cao-Van, and L. Gardan 1999. Description of a new disease on Erythrina sp. in Martinique (French West Indies) and preliminary characterization of the causal agent as a novel Erwinia species. Plant Pathology 48, 253-259.
Sylos, C. M. de, and D. B. Rodriguez-Amaya 1999. Incidence of patulin in fruits and fruit juices marketed in Campinas, Brazil. Food Additives and Contaminants 16, 71-74.
Szeto, YimTong, B. Tomlinson, and I. F. F. Benzie 2002. Total antioxidant and ascorbic acid content of fresh fruits and vegetables: implications for dietary planning and food preservation. British Journal of Nutrition 87, 55-59.
Takagui, C.M., M.A.A. Tarsitano, and A.C. Boliani 1996. Custo de producao e analise economica da cultura do abacaxizeiro (*Ananas comosus* (L.) Merrill (cv. Smooth Cayenne) em Guaracai-SP (Production cost and economical analysis of the pineapple crop (*Ananas comosus* (L.) Merril) in Guaracai, Sao Paulo). Revista Brasileira de Fruticultura (Brazil) 18, 219-224.
Talukdar, S., and F. Ahmed 2002. Effect of pre-harvest chemical treatments on shelf life of pineapple fruit. Journal of Food Science and Technology (Mysore) 39, 53-54.
Tecson-Mendoza, E. M. 2002. Crop biotechnology in the Philippines. AgBiotechNet 4, 1-7.
Teixeira, L. A. J., A. Spironello, P. R. Furlani, and J. M. M. Sigrist 2002. Parcelamento da adubacao NPK em abacaxizeiro (Split application of NPK on pineapple). Revista Brasileira de Fruticultura 24, 219- 224.
Telis, V.R.N., and P.J.A. Sobral 2001. Glass transitions and state diagram for freeze-dried pineapple. Lebensmittel Wissenschaft and Technologie. 34, 199-205.
The, P. M. P., V. D. de Carvalho, C. M. P. de Abreu, R. de Pontes Nunes, and N. A. V. D. Pinto 2001. Efeito da temperatura de armazenamento e do estadio de maturacao sobre a composicao quimica do abacaxi cv. Smooth Cayenne L (Effect of storage temperature and stage of maturation on the chemical composition of pineapple cv. Smooth Cayenne L). Ciencia e Agrotecnologia 25, 356-363.
The, P. M. P., V. D. de Carvalho, C. M. P. de Abreu, R. de Pontes Nunes, and N. A. V. D. Pinto 2001. Modificacoes na atividade enzimatica em abacaxi 'Smooth Cayenne' em funcao da temperatura de armazenamento e do estadio de maturacao (Modifications on the enzymatic activity of pineapple cv. 'Smooth Cayenne' related to the storage temperature and stage of maturation). Ciencia e Agrotecnologia 25, 364-370.
Valente, M., F. Duprat, M. Grotte, and P. Lasaygues 2001. Non-destructive evaluation of firmness of fresh pineapple by acoustic method. Acta Horticulturae, 562, 391-396.
Vesco, L. L. D., A. de A. Pinto, G. R. Zaffari, R. O. Nodari, M. S. dos Reis, and M. P. Guerra 2001. Improving pineapple micropropagation protocol through explant size and medium composition manipulation. Fruits (Paris) 56, 143-154.
Vinson, J. A., X. Su, L. Zubik, and P. Bose 2001. Phenol antioxidant quantity and quality in foods: fruits. Journal of Agricultural and Food Chemistry 49, 5315-5321.
Waliszewski, K. N., J. L. Delgado, and M. A. Garcia 2002. Equilibrium concentration and water and sucrose diffusivity in osmotic dehydration of pineapple slabs. Drying Technology 20, 527-538.
Wang, K. H., B. S. Sipes, and D. P. Schmitt 2002. Management of Rotylenchulus reniformis in pineapple, *Ananas comosus*, by intercycle cover crops. Journal of Nematology 34, 106-114.
Wattanakorn, Kanlaya 1991. "Effect of decrowning on pineapple [*Ananas comosus*] fruit quality (Itthiphon khong kan plit chuk kap khunnaphap khong sapparot),". Dept. of Horticulture, Kasetsart University, Bangkok (Thailand).
Wen, L., and R. E. Wrolstad 2002. Phenolic composition of authentic pineapple juice. Journal of Food Science 67, 155-161.
Westerkamp, C., and G. Gottsberger 2000. Diversity pays in crop pollination. Crop Science 40, 1209-1222.
Yadav, I.S., P. Parvatha Reddy, R.D. Rawal, and A. Verghese 1999. Current pest problems in fruit crops and future needs. Indian Journal of Plant Protection 27, 109-125.
Yanes Paz, E., J. Gonzalez Olmedo, and R. Rodriguez Sanchez 2001. Empleo de giberelinas y fertilizacion foliar durante la aclimatizacion de vitroplantas de pina Cayena Lisa c.v. "Serrana" (Use of gibberellins and fertilizer sprays during the acclimatization of pineapple Smooth Cayenne cv. 'Serrana' vitro plants). Biotecnologia Vegetal 1, 23-28.
Yang, Karl X. 2001. Accurate determination of lead in canned pineapple juice by graphite furnace Zeeman background correction atomic absorption spectrometry. American Laboratory Shelton 33, 20; 22.
Yu, ZhiFang, ChongShun Chen, YouXing Zhao, and Ying Xu 2000. Effect of different fresh-keeping treatments on quality of ready-to-eat pineapple. Journal of Nanjing Agricultural University 23, 97-99.
Yusnita, Aprianita, and D. Hapsoro 1999. Effects of benzyladenine and naphthaleneacetic acid on in vitro shoot proliferation of pineapple (*Ananas comosus* L.) (Pengaruh benzyladenine dan naphthaleneacetic acid terhadap perbanyakan tunas nanas (*Ananas comosus* L.) in vitro). Jurnal Agrotropika (Indonesia) 4, 6-10.
Zhang, Jing, XinMao Yao, MingFu Li, and ZhongQing Ou 2000. Research on pineapple leaf fiber extraction and processing equipment. Transactions of the Chinese Society of Agricultural Engineering 16, 99-103.
Zhou, YuChan, M. Jobin-Decor, J. Dahler, R. Wills, S. Underhill, and M. W. Graham 2002. Optimising transient assays for studying the regulation of PPO gene expression in pineapple blackheart. Acta Horticulturae, 575, 595-601.
Zhu, Ye, and Qing X. Li 2002. Movement of bromacil and hexazinone in soils of Hawaiian pineapple fields. Chemosphere 49, 669-674.♦

Directory of Professionals

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

Ian Greig. Tel. 813-908-7698. email: iang@ag-consult.com; web: www.ag-consult.com. Management and technical services for all phases of pineapple production. Pineapple industry and market analysis.
Jerry D. Vriesenga; 194 Dole Road; Wahiawa, HI 96786; E-mail: hsvries@msn.com . Production and management of pineapple.♦

Commercial Services

Maintain CF 125 is available for use in plant propagation from Bhushan Mandava, Repar Corporation, P.O. Box 4321, Silver Spring, MD 20914 Tel: 202-223-1424 Fax: 202-223-0141
E-Mail: mandava@compuserve.com

Proprop (3-chloropropionic acid) for fruit enlargement and Multiprop (chlorflurenol) for plant propagation are available from Pieter J. Erasmus, ICON Chemicals (Pty) Ltd., P.O. Box 12245, Aston Manor, 1630 South Africa Tel: 2711-914-5762 Fax:: 2711-914-5763
E-Mail: perasmus@worldonline.co.za.♦

Pineapple News is published by the University of Hawaii, College of Tropical Agriculture and Human Resources, Dept. of Agronomy and Soil Science. Publication of the newsletter is made possible by monetary contributions from growers and researchers to the University of Hawaii Foundation. Reference to commercial products and services is made for the convenience of readers with the understanding that no discrimination is intended and no endorsement by the University of Hawaii and their employees is implied.