

Pineapple News

Newsletter of the Pineapple Working Group, International Society for Horticultural Science

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Table of Contents

From The Editor.....	Page 2
3rd International Pineapple Symposium.....	Page 2
Membership in ISHS.....	Page 2
Contributions to Pineapple News.....	Page 2
Pineapple Planting Material.....	Page 3
News From Australia.....	Page 4
PINEMAN.....	Page 4
The Australian Pineapple Industry.....	Page 5
Pineapple Industry Farm Field Day.....	Page 6
The Farmcare Project.....	Page 6
Evolution of Fresh Pineapple Quality Improvement.....	Page 6
Options for Managing Nematodes on Pineapple Following the Withdrawal of EDB.....	Page 7
May-June Ratoon Harvest from High Density Spring Crop.....	Page 7
F180 Re-Selection and New Clones.....	Page 7
Standard Herbicide Treatments.....	Page 7
Application Levels of Nitrogen and Potassium in Plant Crop.....	Page 7
Mocap in Pineapples for Control of Symphyla and Nematodes.....	Page 8
News from Columbia.....	Page 8
Evaluation and Utilization Pineapple Genetic Resources.....	Page 8
News from Costa Rica.....	Page 8
Costa Rica: Fresh, Processed Pineapple -- Pineapple Leads Costa Rican non Traditional Exports.....	Page 8
News from Cuba.....	Page 9
Brief Review of Tissue Culture of Pineapple.....	Page 9
News from India.....	Page 10
NPK Requirement in Ratoon Crop of Pineapple in Assam.....	Page 10
Different Sources and Levels of Potassium on Pineapple cv. Kew.....	Page 11
News from Malaysia.....	Page 11
'JOSAPINE': A New Pineapple Hybrid Developed at MARDI.....	Page 11
Research on Blackheart Disorder in Malaysian Pineapple.....	Page 11
International Conference on Tropical Fruits.....	Page 12
Effect of Oxygen and Carbon Dioxide Levels on Internal Browning and Composition of Pineapple.....	Page 12
Effect of Chemical, Organic Fertilizers and Trace Elements Application on Nitrate Content in Pineapple Fruit.....	Page 12
Suitable Storage Temperature of Okinawan Grown Pineapple.....	Page 12
Weed Control Recommendations for Pineapple Grown on Mineral Soil.....	Page 13
The Effect of Fruitone® Application on the Yield and Fruit Quality of cv. Gandul Pineapple in Malaysia.....	Page 13
Pineapple Nursery Setup and Production on Peatland Areas.....	Page 13
Black Heart Disorder, Electrolyte Seepage and Calcium Content in Kew and Mauritius Pineapples Grown in Sri Lanka.....	Page 13
Rapid on-farm Propagation Techniques for Plantain, Bananas and Pineapples.....	Page 13
Photosynthesis and Water Relations of Drought Stressed Pineapple Plants.....	Page 14
News from South Africa.....	Page 14
Growth Regulators for Pineapple Crop Control.....	Page 14
News from Sri Lanka.....	Page 14
Pineapple Research Activities in the Department of Agriculture.....	Page 14
Pineapple Improvement Program in the Dept. of Agriculture, Sri Lanka.....	Page 15
Mealybug Wilt Disease.....	Page 15
Postharvest Studies on Black Heart Disorder of Pineapple.....	Page 15
News from the United States (Hawaii).....	Page 16
Study of Etiology of Pineapple Mealybug Wilt.....	Page 16
Pineapple Nematode Control: Summary of 1996 Activities.....	Page 17
Comparison of Consumer Acceptability of Hawai'i Gold and Smooth Cayenne Pineapple Varieties.....	Page 18
The Pineapple Industry in Hawaii.....	Page 18
Effects of Tebuconazole on Fruit weight and Precocious Flowering.....	Page 18
News from Venezuela.....	Page 19
References.....	Page 19
Directory of Professionals.....	Page 25

From The Editor

I would like to thank the readers who took the time to respond to the **Reader Feedback** form in the last issue of the newsletter. A common comment was that the preferred language for articles was English. In that regard, I would particularly like to thank Marcos Daquinta for taking the time to translate his tissue culture paper, which appears below, from Spanish to English. Communication by E-mail made polishing the paper relatively easy. The other suggestion was to do more to encourage the submission of technical abstracts of current work rather than to publish full-length papers. I fully agree with that, but had not established any policy regarding what to include in the newsletter. In this issue, I have included some guidelines for submissions to the newsletter. The most time-consuming task has been getting submissions to the newsletter, I expect partly because it is such a new medium for communicating information about pineapple.

It might be appropriate to review the intent in initiating a pineapple newsletter. That intent was an outgrowth of the objectives for holding the 1st International Pineapple Symposium in 1992; our main objective was to improve communication among researchers and growers of pineapple. Ken Rohrbach and I particularly believed that the wide separation of researchers, the relatively small numbers, and language barriers all worked to impede the exchange of information about pineapple. We both believed there was a need to improve the communication and provide a medium for continued communication of information about the crop. Continued interest in holding symposia confirms that others believe as we do.

The Pineapple Page on the World Wide Web has brought many interesting questions and comments. Over the past year, the most sought after item was information on companies that process pineapple and prices for pineapple juice concentrate and other processed products. I am told the interest probably is the result of high prices for pineapple juice during the past year or so. It should be no surprise that market information for the crop is difficult to obtain when the export market is dominated by a relatively small number of large and highly competitive companies that process fruit primarily in Indonesia, Philippines, and Thailand. As a convenience to readers, I have included an alphabetical listing of companies known to me that process pineapple on the web page.

Earl J. Anderson: It is with much regret that I inform those of you who knew Dr. Earl J. Anderson, Plant Pathologist at the Pineapple Research Institute of Hawaii from 1945 until 1966, that he died at his home in Montrose, Colorado on June 11, 1996, three days after celebrating his 88th birthday. Dr. Anderson was at the Pineapple Research Institute of Hawaii (PRI) from 1945 until 1966, headed the department of Plant Pathology, later the Department of Pest Control, from 1950 to 1966, and was an affiliate faculty member at the University of Hawaii. Among the notable accomplishments during the time I knew him while working at PRI, was the demonstration, in cooperation with Dr. Anthony Hepton of Dole, that a fungal pathogen was involved in the development of the fruit disease now known as interfruitlet

corking or IFC. After leaving the PRI, Dr. Anderson worked with Dole Company in the Philippines and Cameroon and as a consultant to Saim Food Products before retiring completely in 1975.

3rd International Pineapple Symposium

The first notice of the Third International Pineapple Symposium has been mailed. The symposium is scheduled to be held in Pattaya, Thailand from November 24-27, 1998. Those wishing to receive the second notice of the symposium should contact Mr. Somchai Watanayothin, Horticulture Research Institute, Chatuchak, Bangkok 10900, Thailand (phone: 66-2-5798553; Fax: 66-2-561-4667; Email: hortdoa@mozart.inet.co.th). The meeting is to be organized under the auspices of: The International Society for Horticultural Science; Horticultural Science Society of Thailand; Department of Agriculture, Ministry of Agriculture and Cooperation; and Kasetsart University. The sessions are open to researchers, specialists and growers. Contributions of a basic and applied nature on all aspects of pineapple culture, management, and marketing are invited. The official language of the symposium is English. Field trips of local pineapple factories and plantations are being planned and more details will be available in the second announcement.

Membership in ISHS

The International Society for Horticultural Science is an organization of individuals, organizations and governmental bodies interested in the field of Horticultural Research and Horticulture in general. The ISHS is registered as a society in the Netherlands. To inquire about membership in the ISHS, write to: International Society for Horticultural Science, Englaan 1, 6703 ET Wageningen, Netherlands (Email: ISHS@agr.kuleuven.ac.be).

Contributions to Pineapple News

Readers comments about the last issue cause me to adopt the following guidelines for contributions to **Pineapple News**. All contributions for the newsletter must be written in English. I have and will continue to assist writers whose native language is not English to prepare contributions for the newsletter. Contributions submitted by E-mail or on floppy diskettes formatted using Microsoft DOS or Windows programs are preferred. Since the objective of the newsletter is to promote communication among pineapple researchers, specialists, and growers, the preferred contributions are abstracts or summaries, including only essential tables and figures, of research in progress or completed. Also of interest are overviews of pineapple production and processing within a country or region, and brief review papers in the writers area of expertise. Because of cost, photographs cannot be printed. News articles from a country are arranged in **Pineapple News** alphabetically by the name of the submitting author. Please submit all contributions and inquiries to: D.P. Bartholomew, Dept. of Agronomy and Soil Science, Univ. of Hawaii, 1910 East-West Rd., Honolulu, HI 96822 U.S.A. (Phone (808) 956-8708; Fax (808) 956-6539; E-

mail: duaneb@hawaii.edu. *Pineapple News* is on the Web at: <http://agrss.sherman.hawaii.edu/pineapple/pineappl.htm>.

Pineapple Planting Material

D.P. Bartholomew

This summary was prompted by the many issues that relate to establishment of plants in the field. Two current issues are the availability and quality of tissue cultured plants and the use of tissue culture in the development of genetically engineered plants. There is continuing interest in engineering plants that produce little or no ethylene in hopes of inhibiting natural induction of flowering and that have disease or nematode resistance, or both. It was fortuitous that M. Daquinta chose to summarize recent work on tissue culture of pineapple for this issue.

The following discussion applies mainly to Smooth Cayenne pineapple because it is the most widely grown of the pineapple groups, which probably accounts for the fact that there is relatively little published information on planting material from other pineapple groups. Also, the Spanish and Queen types (see Maerere A.P., *Acta Horticulture* 425 in the **References** section) produce relatively large numbers of slips and suckers so the supply of planting material may not be the limiting factor that it can be with Smooth Cayenne clones, especially those that produce few or no slips.

Sources: The common sources of planting material (propagules) are suckers, slips, and crowns. Suckers are shoots that develop from buds in the leaf axils. Sometimes a distinction is made between suckers and ground suckers, the latter being suckers that develop on the stem at or below ground level. Other sources include suckers produced by decapitation of vegetative plants (see Heenkenda in the **References** section), hapas, which are shoots produced below the fruit but on the fruit peduncle, sliplets produced by treating plants with chlorflurenol (for a new source of this material, see **News from South Africa**) just after forcing, tissue cultured plants, and plantlets produced by vertical sectioning or vertical and horizontal sectioning of the stems of crowns, suckers, and plant and ratoon crop stems.

The number and size of sliplets produced by chlorflurenol varies with the amount of chemical applied. Relatively wide use of such sliplets in Hawaii is evidence that they represent an excellent source of planting material. Heenkenda (see **References** section) has recently examined the factors influencing the number of suckers produced by decapitation.

Tissue culture provides a rapid method for propagating plants, but past results have been unpredictable. A variety of source material has been used in the production of tissue cultured plants (see *Pineapple News* from Cuba in this issue), and if variability is to be kept to a minimum, apparently plants should only be produced from meristem tissue. The many reports of variability in tissue cultured plants suggests that such plants only be purchased from laboratories with a proven record of producing plants true to the parent material. At the 2nd Symposium in Martinique, participants visited a grower who had selected plants, which were then cloned by Vitropic (Vitropic, ZAF LES AVANTS, 34270 Saint-Mathieu de Treviers, FRANCE; Fax : # 011 33 67 55 23 05). The grower stated that

he was very satisfied with the result. I have recently heard that Agribiotecnologia Costa Rica (Fax: 506-441-9609; Email agribio@fractal.icr.co.cr) also does good work. If any readers know of commercial tissue culture laboratories that have a proven capability to produce plants that are true to type, I would appreciate hearing from you.

Selection: Wide experience has shown that selection to improve clonal purity results in increased yields, or improved fruit characteristics, or both. Selection needs to be practiced to establish and to maintain clonal purity and to minimize variation within the field. Experience in Australia (see information from D. Christensen on F180 selection below), shows that considerable variation can develop within a clone. Selections such as F180-7, which produces such large numbers of slips and suckers that yield is reduced, have a further disadvantage in that the prolific production of propagules rapidly increases the proportion of such plants in the field population.

Selection is also practiced to reduce the variability in size or quality of planting material within a row, block, or field. Propagules from fields that differ in climate, e.g. elevation, or cultural practices, should be kept separate to minimize variation in physiology (stored organic or nutrient reserves) or other characteristics that could cause them to develop at different rates. Until a definitive study showing that types of planting material of the same mass do not differ in growth rate, suckers, slips, and crowns, even if of the same weight, should not be mixed. Likewise, within a propagule type, propagules should be sorted into different size classes to minimize variation in the field, and the higher the plant population density, the more critical such sorting becomes. Several studies done with slips at the Pineapple Research Institute of Hawaii showed that variation in fruit size increased when slips of different sizes were mixed in the field. Since weighing of individual propagules is impractical, sorting is done visually or, as in Hawaii, by a grading machine that separates crowns into size categories such as large, medium, and small.

Propagule mass: Suckers have the greatest mass and potentially the greatest weight range because they grow continuously until harvested or until flowering occurs. Slips weigh from 250 to 450 g, depending on the length of time they remain on the plant after the fruit is harvested. Crown weight typically varies with the season and can weigh from 100 to about 350 g at different times of the year.

The literature related to propagule type and mass is confusing at best. Many authors report that suckers produce larger fruit than do slips, and slips produce larger fruit than do crowns. Unless plant size at flowering is measured or controlled, such studies only confirm that after some fixed period of growth, large propagules produce larger plants and fruit than do smaller ones. They also confirm the well-known high correlation between plant mass at induction and fruit mass at harvest.

Propagule mass is important because it determines the initial leaf area and storage reserves of the new plant. Within a given environment, regardless of the type of planting material, the time required to reach a desired plant weight at some future time is shorter for large than for small propagules. The standard recommendation is that propagule types should not be mixed even if they have the same mass. Where planting is done the

year around, farmers in cooler environments usually avoid planting large suckers near the time flowering occurs because they are more likely to flower naturally than are other types of propagules.

Other considerations: The cost of planting material may influence the propagule used in commercial plantings. Suckers are expensive to harvest because they are difficult to remove from the plant and collection is a separate operation. Slips are easily harvested, but also are collected in a separate operation some weeks after the fruit are harvested. In many areas, crowns are the preferred planting material because they can be collected at the same time the fruit are harvested. A disadvantage of crowns and sliplets is that their small size increases the time from planting to the desired plant weight for forcing.

Farms that grow pineapple solely for the fresh market require other sources of planting material. These sources can include sliplets produced using chlorflurenol or a ratoon crop grown primarily to supply planting material. Sliplets produced by chlorflurenol treatment are smaller than crowns, result in loss of the fruit, and require a separate harvesting trip. However, they apparently are cheaper to produce and harvest and provide more uniform planting material than do suckers, especially on clones that produce few or no slips, as is true for most clones grown in Hawaii. Plants produced by sectioning or tissue culture need to be grown in a nursery until they reach a size suitable for planting in the field.

Storage can affect plant mass and the quality of propagules. Prolonged storage is undesirable because propagule storage reserves are utilized. Growth of the stem continues during storage and the stem diameter decreases with time in storage. The resulting plant may be weakened and susceptible to lodging.◆

News From Australia

PINEMAN

Simon Newett, Maroochy Research Station, Nambour, Queensland, Australia

The PINEMAN program is a management analysis service for pineapple growers aimed at improving management efficiency in an industry where high production costs can critically reduce the profit margin.

The program, operated by the Department of Primary Industries in Queensland (DPI) began in 1991 with the development of appropriate software. The prototype was initially tested by six growers. Today there are 39 growers participating in the program which represents more than 30% of Queensland's pineapple production by volume.

Growers use PINEMAN as a management tool. Individual farm performance is compared with averages of other growers using local and state-wide averages. The program is almost infinitely variable, the range of comparisons is only restricted by the number and diversity of participants. In addition, information can be expressed in several ways to suit individual grower requirements. Available comparisons can be obtained on aspects

such as gross margin, net returns, fertiliser costs, chemical costs, repairs, fuel, tonnage, yield and labour costs.

In order to access information, growers must complete an input sheet detailing their own data which includes costs, returns and size of crop data. The input sheet can be prepared either by growers themselves, or with the help of their accountant (the PINEMAN team in DPI will help new participants prepare their first input). All information supplied remains completely confidential and is not linked to any network, a point which DPI staff who operate the program from the Maroochy Research Station, are anxious to emphasise. Nor do growers need a computer to use the service. In fact grower input is minimal, restricted to completing the input sheet, which requires two to four hours once a year. What's more, the service is completely free, financed by the DPI, Horticultural Research and Development Corporation (HRDC) and grower levies.

Currently the PINEMAN team consists of three people all of whom are stationed at the Maroochy Horticultural Research Station in Nambour. Mr. Simon Newett, an extension horticulturist leads the project, Mr Shane Mulo, a decision support systems horticulturist who wrote the software programme, and Mr Tim Smith, an extension horticulturist, who works as a part time assistant. Tim was employed primarily to make on-farm visits to explain and demonstrate the service and to help new participants with their input sheets.

PINEMAN participants generally receive two confidential reports a year. The first is sent out soon after the input sheet has been received and shows progress of the individual farm over a period of time and comparisons with average data received to date. The second is sent out at the end of the season when it is assumed all the input sheets for the year have been received, and thus contains a more comprehensive set of comparisons for that season. These reports instantly enable growers to assess their own performance and compare it with averages of others. Such comparisons can be critical for improving profitability. Although the DPI will, if required, indicate above or below averages and areas that may need attention, the results embodied in the reports Tim Smith explains, tend to speak for themselves and growers are able to see quite clearly those defects in their management which are adversely affecting profitability.

Tim says one of the main benefits of the service is that participants can very quickly identify problems. For example some growers are spending up to 3 times more than others on labour. The results of the PINEMAN program to date clearly indicate that resources directed towards improving labour efficiencies have the greatest potential for reducing production costs.

Another important trend identified by PINEMAN is that farms with the best yields don't necessarily show the highest gross margins. As Tim Smith says, "Those with the highest gross margin may be sacrificing some yield to obtain their higher profits".

Other significant differences among grower operations revealed by PINEMAN comparisons (reckoned on per tonne of fruit produced) include: gross margin - a range of more than \$150/tonne; chemicals - a four fold variation in expenditure; fertilisers - a five fold variation; fuel and oil - a three fold variation; repairs and maintenance - a seven fold variation; yields - from 50 to 130 tonnes per hectare; tonnage produced/person/year ranges from 120 to 400 tonnes.

PINEMAN has now built up a considerable database and this information enables the analysis of trends and correlations for the industry, providing valuable information which should improve international competitiveness as well as a greater domestic efficiency. Simon Newett and Tim Smith point out that as well as maintaining the confidentiality of individual grower information, access to certain industry-wide data is also restricted so that sensitive Australian industry information is not publicized outside of the country.

The more growers taking part in PINEMAN, the more comprehensive the service which can be offered. Such information would include planting density versus yield for different growing regions, yields vs growing regions, fertiliser expenditure vs. yields, yields vs. gross margins, the economics of growing fruit for the cannery vs. the fresh market etc.

Simon Newett and Tim Smith see the next step for PINEMAN participants as forming local productivity groups which could discuss their yardsticks and provide members with a chance to learn from and build on each other's efficiencies, thus following in the footsteps of the pig and dairy industries. Such groups can be suitable forums for making PINEMAN findings and insights available industry-wide.

With 30% of the pineapple industry by volume throughout Queensland already participating in PINEMAN, feedback to date appears very positive. Most of those using the service say it has improved profitability by helping them prioritise areas within their operations which need attention.

According to a report on the project prepared by DPI staff, what growers like best about the program is the ability to compare their individual operation with those of other groups. Other items that have earned particular grower approval are gross margin per tonne, cost per tonne and fertiliser and chemical comparisons. Another popular feature was the listing of averages of the top four growers to provide yardsticks for others to aim for. Some growers have indicated that they expect significant increases in gross margin per tonne due to PINEMAN participation. Expectations ranged from below \$20 per tonne to above \$75 per tonne.

The Australian Pineapple Industry

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

The Australian pineapple industry is relatively small by world standards ranking at number 15 in terms of production (Anon, 1994). It is strongly orientated towards the domestic market with very little exported. It is one of the few pineapple industries that is not based in a tropical region with access to cheap labour. To compensate for the high labour costs the industry has had to embrace technology and mechanisation.

Early history: The first pineapples are thought to have been introduced to Australia from India in 1838 by a German missionary, although some records indicate pineapples were grown near Sydney as early as 1824. The first commercial plantings were established in Nundah, now a suburb of Brisbane in the early 1840's (Lewcock, 1939). Cannon (1963) considered this first commercial plantings to have probably been rough-leaved pineapples (Queen type) with Smooth Cayenne coming at

a later date from Kew Gardens in England. Collins (1960) indicates this importation from England probably occurred around 1858.

Pineapples were initially grown close to Brisbane as the fruit had to be transported to market by horse-drawn conveyances. Production of pineapples increased gradually as new areas opened up in the Sunshine Coast hinterland (100 km north of Brisbane) and rail lines were established. Production was however still limited to demand by the fresh market. It was not until supply exceeded demand that consideration was given to establishing a processing facility. Production increased dramatically from the 1920's onwards when the State Government established a cannery in Brisbane (Lewcock, 1939). Records from 1929 show fresh production at 8,881 tons exceeded cannery production at 5,258 tons (Lewcock, 1939).

Production: From the early days pineapple farms in Australia have traditionally been smaller family operated businesses. Cannon (1963) reports that the average farm size at that time was 15 to 30 acres. The industry has changed in profile since those early days with the loss of small farms being compensated for to a certain extent by the increase in size of the larger farms. The industry reached a maximum production of 154,000 tonnes (from 6,660 ha) in 1988 (Castle, 1995). There are now less than 6,000 ha of pineapple grown in Queensland by about 330 farmers. Annual production is about 125,000 tonnes. Farm size ranges from 2 ha to about 120 ha. The largest farms produce about 2,000 tonnes of fruit per year with a maximum of about 5,000 tonnes. The importation of cheaper processed product from S-E Asia is the principal cause of the decline in production over the last 10 years.

Growing regions: Within Australia, pineapple is grown almost exclusively in Queensland. However, small plantings also exist in northern New South Wales and the Northern Territory. In Queensland, the most northerly plantings are at Cooktown in North Queensland (15 S Lat) and the most southerly are within the outskirts of Brisbane (27 S Lat). Early in the history of the industry, plantings existed as far south as Port Macquarie in NSW 31 S Lat (Kebby, 1957). Because pineapple is susceptible to frost and sunburn, plantings are grown only along the coastal strip, never more than about 40 km inland (Scott, 1995).

The Queensland industry can be divided into 3 main regions. The South Queensland region is the main region. About 70% of pineapple for processing and 60% of pineapple for the fresh market is grown here. The Australian industry is therefore centred in a sub-tropical climate. Most farms are in the Wamuran-Caboolture and Beerwah-Glasshouse Mtns districts about 100 km north of Brisbane. The Central Queensland region centred mainly around Yeppoon, near Rockhampton, produces about 30% of the processors intake as well as 20% of the fresh market. The North Queensland industry produces only for the fresh market. Here freight costs and transport time prevent supply to the processor. North Queensland growers supply fresh fruit for the Townsville and southern capital city markets. The northern industry supplies about 20% of the fresh market, principally in the winter period when supply from southern districts is of poorer quality.

In S-E QLD, pineapple are grown on a 4 year cycle. The plant crop takes 18 months to 2 yrs and the ratoon crop a further 12 to 18 months.

Fresh fruit sector: There are about 70 growers who produce solely for the fresh market. However many cannery growers also supply the fresh market depending on prices. Most fresh fruit is sold on the domestic market but a small quantity is exported to New Zealand. Many fresh fruit growers now supply 1 of the 4 pineapple packing and marketing facilities which exist in Queensland. Australian fresh market pineapple growers do not compete in any significant way in world pineapple markets because their costs of production, principally labour, are too high and they are too distant from the major fresh fruit markets.

Processing sector: Golden Circle Ltd, a grower-owned unlisted limited company, is the principal processor. Growers supply this market on the basis of shares they own in the company. The shares work like a quota system with 100 shares allowing the supply of a specified quantity of fruit per year. Incentives are paid for fruit supplied during the times of the year when the fruit is at its best quality. About 50% of processed pineapple is produced by only 66 growers. Golden Circle Ltd also processes a range of other fruits and vegetables.

In the early 1950's a cannery was also established in Cairns in North Queensland but it failed to be profitable and was closed (Grattidge and Wait, 1989).

Clones/Cultivars: The Australian pineapple industry is based almost completely on selected clones of Smooth Cayenne. Clonal selection commenced in 1939 and culminated in the early 1970's when the Department of Primary Industries released 4 clones, 8, 10, 13 and 30. In addition, the Hawaiian clone F180 was imported by Golden Circle Ltd in 1972. Today the industry is converted almost totally to clonal planting material. Clones 10 and F180 are probably the principal clones grown.

Smooth Cayenne, is grown for both the processing and fresh markets. However, about 60 ha of Queen types are grown in North Queensland, specifically for the winter fresh fruit market when Smooth Cayenne is low in eating quality. Imported and locally developed hybrids are being tested to fill this market niche.

References

- Anon (1993). FAO Yearbook Vol 47. Rome.
- Cannon, R.C. (1960). Pineapple research, 1955-60. *Queensland Agricultural Journal*. **86**(10):635-42.
- Cannon, R.C. (1963). Pineapple is big business in Australia. *Indian Farming*. **12**(10):20-2.
- Castle, I. (1995). Year Book Australia. Australian Bureau of Statistics. Report No 77. Canberra.
- Collins, J.L. (1960). The pineapple. Interscience Publishers Inc New York. 295 p.
- Grattidge, R., and Wait, A.J. (1989). Growing pineapples for the fresh fruit market in North Queensland. DPI Publication. 52 p.
- Kebby, R.G. (1957). Pineapple growing. NSW Dept Agriculture Bulletin. 20 p.
- Lewcock, H.K. (1939). Pineapple culture in Queensland. *Queensland Agricultural Journal*. (Dec):614-32.

Scott, C. (1995). "Pineapples" in Horticulture Australia. Morescope Publishing Pty Ltd. 618 p.

Pineapple Industry Farm Field Day

The Pineapple Industry Farm Field Day, co-sponsored by Queensland Fruit & Vegetable Growers, Golden Circle Inc., and Queensland Department of Primary Industries, was held on 19 July, 1996 at the industry farm at Beerwah. The meeting was opened by Alan Smerdon, Chairman for the day, followed by an opening address by Ken Buchanan, Chairman of the Pineapple Subcommittee, Queensland Fruit and Vegetable Growers. After lunch at the Big Pineapple, a tourist spot near Nambour, growers viewed field demonstrations and trade displays at the industry farm at Beerwah.

Ed Note: I have abstracted below items that I thought might be of interest to readers.

The Farmcare Project

Chris Lindsay, Farmcare Project Officer, Queensland Fruit and Vegetable Growers, presented the goals of the Farmcare project, which are to: 1) assist Queensland growers to develop industry guidelines for the production of fruit and vegetables while minimizing impacts on the surrounding environment and, 2) maximize growers adoption of socially and environmentally acceptable farm management practices to secure consumer and community confidence in Queensland produce.

The project acknowledges that many farmers use practices that are friendly to the environment, documents those practices, and helps the industry develop other guidelines for good farm management. To reach the Farmcare goal, growers are informed about what having a 'duty of care' for the environment means, they are supported in the development of guidelines, and the finalized guidelines will outline practices that meet environmental obligations while permitting growers to maintain profitability. Farmcare issues include: maintaining soil "health" and preventing erosion; applying fertilizer that meets crop requirements; using water wisely to prevent salt buildup and groundwater contamination; using all possible pest control practices (along side pesticides); managing dust, spray drift, odors and other impacts on air quality; managing noise where the farm is close to sensitive areas; controlling feral animals and managing native animals on farm; and properly disposing of plastics, chemicals and chemical containers. Mr. Lindsey noted that Farmcare is needed to ensure the long term future of horticulture in the state because consumers want fruits and vegetables that are grown in ways that make them safe to eat, the wider Queensland community is interested in the health of all natural resources, and State Government legislation outlines the 'duty of care' all Queenslanders have towards the environment. Additional details were provided about Queensland Government legislation related to the 'duty of care,' the Environmental Code of Practice for Agriculture, and described the support provided to growers the help them develop their own guidelines.

Evolution of Fresh Pineapple Quality Improvement

Nick Macleod, Senior Extension Horticulturist at Rockhampton, writes of the quality improvements made in fresh fruit marketing

since 1988. Marketing groups have been organized in both Northern and Southern Queensland, brand names have been established for market identity, and more than 50 farmers are marketing through the major packing houses. Standards for Premium and Class 1 grades were established in 1994 for Australia and New Zealand. As a result of grower training and feedback from growers and packers, at least 70% of all fresh pineapples are now marketed through marketing groups under the quality program.

Options for Managing Nematodes on Pineapple Following the Withdrawal of EDB

Graham R. Stirling, Principal Nematologist at Dept. of Primary Industries, reviewed the current status of nematode control in Queensland and the prospects for control by alternative measures. Ethylenedibromide (EDB) will be lost for nematode control on June 30, 1997 and the alternative is primarily fenamiphos, which is more expensive than EDB. It is estimated that the cost for pre-plant treatment (20 kg active ingredient/ha; a.i./ha) would be about \$A1,300 per ha and post-planting sprays (5 sprays of 2.4 kg a.i./ha prior to flower initiation) would cost about \$A1,160. Acceptable ratoon crop yields were obtained with 2 sprays of 4.8 kg/ha a.i. after plant crop harvest. Dr. Stirling states that because of cost and concerns for groundwater contamination, the most effective program should include surveying to first determine the need for nematode control. Nematode infestations vary across fields and farms and use of chemical controls should be based on nematode population densities high enough to cause economic damage. Current knowledge indicates that nematode populations in pineapple can be determined with sufficient accuracy so that a monitoring system will provide an adequate recommendation in at least 70% of the cases. Plans are underway to conduct a pilot monitoring service for the pineapple industry over the next several years to determine whether it is feasible to develop a commercial monitoring service for the industry. Tables at the end of the article reviewed chemical and possible non-chemical alternatives and their advantages and disadvantages for nematode control, relative to EDB. Some of the proven options include: 1) extended clean fallow for 4-6 months; 2) growing only the plant crop; 3) growing non-host green manure crops, e.g. sorghum or velvet bean, in the inter-cycle. A number of other more limited options were given but space doesn't permit their being listed here.

May-June Ratoon Harvest from High Density Spring Crop

D. Christensen of Golden Circle Ltd. reported that in a trial where plant population ranged from 62,500 to 93,700 plants/ha (25,000 to 38,000 plants/a), the highest plant crop yield (142 tonnes/ha) was obtained at 69,400 plants/ha (28,000 plants/a). Ratoon yield decreased with increasing plant population so the total yield was greatest at a population of 69,400 plants/ha. D. Christensen stated that 28,000 plants/a is the absolute planting limit and expected that the best fruit quality and ripening behavior would be in crops at populations less than that number.

F180 Re-Selection and New Clones

D. Christensen stated that uniform planting material is a must and stressed the importance of maintaining clonal purity by selection

of planting material. Three pure F180 clones are available, but only two are agronomically suitable. Selection F180-5 has a higher average fruit weight than F180-1, but the latter clone has better fruit shape. F180-7 is reported to be vigorous to a fault with slip and sucker growth so prolific that fruit size and shape are adversely affected. Queensland clone C40 was recently released; the clone has a high average fruit weight but planting material was variable and so resulted in quite large variation in fruit weight. Other recently released Queensland clones were also mentioned but details on their characteristics were not provided.

Ed Note: F180, actually Champaka F-180, is a Pineapple Research Institute of Hawaii accession that was shipped to Australia many years ago. Both Champaka F-153 and F-180 were introduced to Hawaii in the 1930s, reportedly from the same location in India, and were supposedly either similar or identical. However, Champaka F-180 apparently did not perform well in Hawaii while Champaka F-153 has become a dominant clone here. In Australia, F-153 did not perform as well as F-180, suggesting that F-180 is better adapted to the cooler climate of Southern Queensland.

Standard Herbicide Treatments

Because some growers reported problems with weed control, Eric Sinclair of Golden Circle Ltd. established an experiment to retry the standard weed control methods. Bromacil (Hyvar 800) was applied at 0, 2, 4, or 8 kg/ha of product and diuron (Diurex 900) was applied at 0, 2.5, or 5 kg of product/ha. All combinations of the chemicals were sprayed by knapsack sprayer over newly planted crowns at 3000 L/ha. Weeds were counted and removed by hand from all plots from planting through plant crop harvest. Control was best with 4 or 8 kg bromacil and improved as the amount of diuron increased. Neither average fruit mass or yields were affected significantly by herbicide treatments. It was concluded that the standard treatment still provides good control and failures are likely due to poor or delayed application or loss of treated soil by wind or water erosion. It was emphasized that land preparation must kill mature weeds, as the chemicals are most effective in controlling germinating weed seeds. A follow-up diuron spray 6 to 8 weeks after planting is recommended and both bromacil and diuron should be used to protect the ratoon crop.

Application Levels of Nitrogen and Potassium in Plant Crop

Trials were established by Eric Sinclair to compare current Golden Circle Ltd. (GCL) recommendations for application of nitrogen (N) and potassium (K) with those of a grower. Foliar vs. sidedressed fertilizers were also compared. The GCL recommended practice is to supply relatively more K than N early during growth. One comprehensive experiment included 616, 711, or 770 kg/ha of N and 785 or 950 kg/ha of K in all possible combinations. The fertilizers were applied monthly as foliar sprays or bimonthly as sidedressings for 10 months and then monthly as foliar sprays. Gentle rainfall within days of each sidedress provided ideal conditions for this application method. Leaf mass increased as both N and K increased, but there was no effect of application method. Fruit mass was significantly higher at the highest level of N and was significantly higher for

sidedressed than for foliarly fertilized plots. Fruit yield (MT/ha) increased with increasing N from 103.9 at 616 kg/ha N to 111.6 at 770 kg/ha. Increased yield more than paid for the cost of increased fertilizer. There was no significant effect of K or the method of applying K on yield. Juice nitrate level was below the 8 ppm considered critical for canned products. It was emphasized that the GCL recommendations of about 600 kg/ha N and 785 kg/ha K provide a good return per unit of cost while providing a margin of safety for juice nitrate levels and environmental quality. The data and observations show that providing less N early in the crop will result in smaller plants with some yellowing, but plants will catch up as greater amounts of N are applied later in the crop and will produce yields close to those obtained with greater amounts of N.

Mocap in Pineapples for Control of Symphyla and Nematodes

Richard Bull, Field Research Scientist, Rohne-Poulenc, reported on several studies that compared the efficacy of Mocap with EDB + Lindane for symphyliid and nematode control and with Nemacur EC at 2x12 L/ha for nematode control. Preplant treatments were 40 kg/ha Mocap 100G. On one farm where nematodes were the major pest, though the difference was not statistically significant, the Mocap 100G treatment alone produced 16.6 MT/ha more fruit in the plant crop plus ratoon than did the untreated control. Postplanting treatments consisted of 10, 20, or 30 L of Mocap 200EC applied in 4,500 L/ha at 3-5 months after planting and at 6,000 L/ha when plants had closed in, and to ratoons at 6,000 L/ha when new growth was observed after harvest and 3-5 months later. The Mocap 100G treatment gave nematode and symphyliid control equal to EDB+ lindane. Where symphyliids were the major pest in ratooned pineapple, Mocap EC treated plants had significantly greater average fruit mass and produced higher yields than untreated plants and yields were slightly but not significantly greater than those from plants treated with Nemacur. Mocap EC at 10 L/ha applied twice during the plant and ratoon crop was the optimum treatment for control of symphyliids (*Hanseniella* sp.). Mocap EC at 20 L/ha applied twice in 4,500 to 6,000 L/ha during the plant or ratoon crops was the optimum treatment for control of nematodes. Where nematodes were the the major ratoon crop pest, plants treated with Mocap had significantly higher yields than untreated plants and had slightly but not significantly greater yields than plants treated with Nemacur. ♦

News from Columbia

Evaluation and Utilization Pineapple Genetic Resources

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A 4-year project entitled "Evaluation and Utilization Pineapple Genetic Resources from Amazon to Breed Resistant Varieties" has been submitted to the INCO-DC (International Cooperation - Developing Countries) European research program, and approved in 96. It involves CIRAD-FLHOR, EMBRAPA, FONAIAP and Universidade do Algarve and it is starting in

February 97. It will focus on the characterization and evaluation of pineapple germplasm from the collections of Martinique, Brazil and Venezuela, with particular emphasis on fusariosis, Thecla, nematodes and fruitlet core rot. It also includes molecular characterization through DNA markers. Marie-France Duval has already moved to Montpellier to prepare the work by developing DNA marker techniques.

The European project gives a breath to the germplasm collection for the next 4 years, as part of the evaluation costs are covered by the project. ♦

News from Costa Rica

Costa Rica: Fresh, Processed Pineapple -- Pineapple Leads Costa Rican non Traditional Exports

The following report was obtained from the USDA Foreign Agricultural Service web site at <http://ffas.usda.gov/ntdb/agwrl/htmlfiles/cs5011.html>. It was from Scott E. Bleggi, Agricultural Attache and drafted by AGSPEC:V. Gonzalez/Gedes:T.Quiros in 1995 and posted on 01/30/96.

General Summary

Costa Rican exports of pineapples have become during the past few years one of the most important non-traditional agricultural products. Emphasis is being placed on production of these products, away from coffee, bananas and sugar. According to Costa Rican trade data, the value of pineapple exports amounted to just \$31,156,100 in 1988. In 1994 the export value of this fruit climbed to \$57,920,000. During the period January - April 1995, pineapple exports reached \$20.6 million, compared to \$17.4 million during the same period a year earlier, and at the current pace 1995 exports will exceed \$60 million. If realized, this represents a doubling in value in less than eight growing seasons. The major export markets for Costa Rican pineapples are the U.S., Germany and Italy, in that order.

The majority of the pineapples are planted in the South of the country in an area called Buenos Aires. Most of the plantations in Buenos Aires are owned by PINDECO, a subsidiary of Del Monte. Pineapples are also grown in the Northern region of the country in San Carlos. More recently, new areas have been established in Cobano, in the province of Guanacaste, although these new areas are still small and belong to small producers.

The varieties planted for export are Cayena Lisa and Champaca (about 90 percent of the area planted) and Monte Lirio for domestic consumption (this variety is concentrated around Pital de San Carlos in the North). Large producers obtain between 60 and 120 MT of pineapples per hectare with the Cayena Lisa variety. Yields are between 35 and 45 MT per hectare for the Monte Lirio variety. The last available figures indicate an area of some 8,000 hectares overall, with about 60 percent in the main producing area, and the balance spread between the two new growing areas in the North.

Currently, most of the pineapple areas have been planted by PINDECO or by medium and large independent producers. Smaller producers have not been very active because of the high costs of production and because of a lack of technical producers

realize that pineapple production does not require large areas and is a profitable alternative to crops with declining revenues such as those grown in the Southern part of the Nicoya Peninsula. Here, a group of 15 medium and small producers with assistance from the government of the Netherlands, have been producing pineapples for two years. This European investment project is expected to give additional stimulus to new producers, given the positive results obtained so far by the farmers. If this is the case, pineapple will continue to be Costa Rica's number one non-traditional agricultural crop, both in terms of production and export value.◆

News from Cuba

Brief Review of Tissue Culture of Pineapple

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Pineapple (*Ananas comosus* (L.) Merr) is a perennial, monocotyledonous, succulent, terrestrial, herbaceous plant. The place of origin is in the area including Central and Southern Brazil, Northern Argentina and Paraguay. The cultivated varieties may be classified according to their characteristics into five groups: Spanish, Queen, Cayenne, Abacaxi and Maipure. World pineapple production exceeded 12 million tones in 1995 (1).

Micropropagation techniques have great advantages for plants such as pineapple that produce few or no seeds and that have insufficient vegetative propagules. Tissue culture techniques have application in variety development too.

Micropropagation: Although lateral buds on the main stem and suckers can provide a source of explants for *in vitro* propagation of pineapple, axillary buds from the crown are more commonly used. The crown leaves are removed and the stem is washed with detergent and plenty of tap water. The crown stem is sterilized with calcium hypochlorite and then buds, including a portion of basal tissue, are removed and established in the culture medium.

Once a shoot has developed, multiplication is accomplished by separating the shoot from the basal tissue, the apex of the shoot is injured to break apical dominance and promote lateral bud development, and it is put in Murshige and Skoog (MS) medium modified by the addition of 6-benzylaminopurine (BAP) and naphthaleneacetic acid (NAA). Each six weeks new shoots are separated and returned to the same medium. To promote rooting of the plantlets, they are transferred to a medium without BAP. Once plants develop roots, they are removed from the culture medium and replanted in peat moss medium and placed in a greenhouse where they are grown for approximately four months (adaptation phase).

Recently, the effect of eight strains of *Azotobacter* (*Chroococcum* sp.) on the growth and development of pineapple vitroplants during the adaptation phase was evaluated. The growing medium was inoculated with *Azotobacter* at the time the plantlets were transplanted to it. All *Azotobacter* strains increased the vitroplant growth and reduced the adaptation period to four months. Native strains isolated from Red Ferrallitic soil collected in Cuba proved to be the most beneficial (2).

The effectiveness of six endomycorrhizal fungi in promoting the growth and development of micropropagated Smooth Cayenne pineapple plants was evaluated during the adaptation phase. *Glomus manihotes*, *Glomus occultum* and *Glomus mosseae* were the strains most effective in promoting growth of pineapple vitroplants (3). The use of vesicular arbuscular micorrizae fungus reduced the length of the adaptation phase of vitroplants.

A new micropropagation method utilized *in vitro* shoot elongation in a medium containing NAA and incubated in the dark at $25 \pm 2.0^\circ\text{C}$ for 30 to 40 days. The elongated shoots were cut at the nodes and the cuttings were placed on N6 medium supplemented with kinetin and BAP. This technique was demonstrated for Smooth Cayenne and Red Spanish plants (4). Shoot regeneration was observed along the nodal segments.

The *in vitro* proliferation of Smooth Cayenne and Red Spanish shoots was obtained using 0.5 to 10 mg/L PBZ (inhibits gibberellin synthesis) in the culture medium without auxins or cytokinins. In two cultivars, leaf size decreased and shoot numbers increased, showing the positive effect of this product.

Tissue sources for explants and callus: In looking for new sources of explants for *in vitro* multiplication of pineapple, leaves were obtained from *in vitro* plantlets. The youngest leaves from nearest the apex of plantlets of Smooth Cayenne (cvs. 'Serrana' and 'Mexico') produced shoots when cultured in MS medium that included several plant growth regulators. When the same kind and quantity of growth regulators were used, the response was greater for varieties from Mexico.

Callus can be produced from a variety of different pineapple explants, syncarpic and axillary buds, hybrid embryos, *in vitro* grown plantlets, and meristem tips of crown sections with and without buds. However, plant regeneration was by indirect adventitious embryogenesis and not as a result of somatic embryogenesis.

In South Africa (6), researchers were unable to produce callus from leaves isolated from *in vitro* grown plantlets. Contrary to those results, in Cuba when solid MS medium was supplemented with 2.5 mg/L 3,6 dichloro-2-methoxybenzoic acid (Dicamba) and 0.5 mg/L BAP, more than 50 % of the youngest leaves of Smooth Cayenne *in vitro* plants produced callus (7). The initiation and proliferation of nodular callus from the leaf base was affected by Dicamba concentration higher than 2.5 mg/L in the culture medium. The best combination of Dicamba-BAP for callus formation and plant regeneration was higher when the callus was transferred to a culture medium without auxins (8). In the nodular callus we observed semi-organized structures on callus surfaces. Histological studies showed the callus origin perivascular tissue formed from the leaf base, the embryogenesis aggregates were composed of meristematic cells in active division with dense cytoplasm and a great nucleus in the cell center. Close similitude between zygotic and somatic embryos was observed too.

For pineapple, which is a vegetatively propagated species with a high level of heterozygosity, the induction of haploids could bring about a significant advance in genetic improvement. The production of homozygous pineapple plants could be used in breeding programs and should allow the development of new varieties in a relatively short time. Haploid and dihaploid plants would also be useful in providing access to homozygous

recessive genes, whenever they are economically advantageous as in the case of deleting marginal spines and for biotechnological manipulations.

Anthers from several genotypes with microspores at about the uninucleate stage were cultivated in MS medium and different growth regulators. After nine weeks of culture, the anther walls broke and calli sprouted from within the anthers. They appeared mainly near the zone where the filaments were removed. The calli had a yellowish-white or yellow color and a hard and nodular appearance. Some calli continued to grow and turned light green on plant regeneration media. However, they developed roots but no shoots in these culture conditions. Plant regeneration from them has been unsuccessful. Perhaps, the plant growth regulators used to achieve this objective were inadequate. The plant regeneration from pineapple anther calli will require additional studies, as has been recommended for other plants (9).

Unfertilized ovules from four pineapple genotypes were cultivated *in vitro*. Four concentrations of sucrose and Dicamba and BAP as a hormonal combination were tested. Callus formation was obtained in all sucrose concentrations with 'Serrana' Smooth Cayenne, 'PiZa blanca' and Red Spanish varieties. In 'Perolera', callus formation did not occur. Plant regeneration was best with Red Spanish, but rooting was observed in 'Serrana' Smooth Cayenne and 'PiZa blanca' (10).

Techniques for genetic breeding.

Protoplasts were isolated from the third and fourth leaves of *in vitro* cultured 'Perolera' plantlets maintained in the dark or light for 24 hours (11). The leaf ribs were scratched on the abaxial surface with a scalpel, pre-plasmolysed, and then incubated with a mixture of enzymes to degrade the cell walls. The protoplasts obtained were then washed and centrifuged up to four times to remove debris.

Callus cultures have been used in a program of genetic improvement. Variation among somaclonal plants regenerated from callus of Red Spanish cultivars made it possible to select P3R5, a clone with few leaf spines that was similar in other respects to the original Red Spanish cultivar. The characters of the somaclone were stable over five consecutive generations. The possibility of selecting cultivars of pineapple from calli and vitroplants that are resistant or tolerant to *Fusarium* is being explored (12, 13).

The North American Company DNAP-Plant Technology collaborated with Agribiotecnologia de Costa Rica researchers regarding advanced micropropagation methods for pineapple and other crops. A similar project was developed with Fitotek, an Indonesian company specializing in micropropagation (14). An efficient and economical method for commercial micropropagation of Smooth Cayenne pineapple was achieved by DNAP-Plant Technology. Longitudinal sections of shoots on leaf bases were used as the explants to regenerate shoots. Additional multiplication was achieved inside a 10-L Nalgene vessel with shoots immersed in liquid medium for only six minutes every hour (period immersion bioreactor). Using the above regeneration method, 6,000 to 8,000 plants were produced from 32 initial shoots within 4-5 months (15).

References

1. Laei Ullet. D. Le marche mondial de l'ananas frais et transforme. 2nd Symposium International Ananas. Martinique, 1995.
2. Gonzalez. R, Q. Dominguez, L.A. Exposito, J.L. Gonzalez, T. Martinez y M. Hidalgo. Effectiveness of eight strains of *Azotobacter* in the adaptation of pineapple vitroplants (*Ananas comosus* (L.) Merr), cv. Smooth Cayenne. 2nd Symposium International Ananas. Martinique, 1995.
3. Exposito, L.A, Q. Dominguez, R. Gonzalez, T. Martinez, M. Hidalgo y J.L. Gonzalez. Efectividad de seis hongos MVA en vitroplantas de pina (*Ananas comosus* (L.) Merr), cv. Cayena lisa. Revista Brasileira de Fruticultura. 16(2):41-47, 1994.
4. Kiss. E, J. Kiss, G. Gyulai y L.E. Heszky. A novel method for rapid micropropagation of pineapple. HortScience. 30(1):127-129, 1995.
5. Daquinta. M, T. Martinez, R. Castillo, R. Benega y J. Rodriguez. Estimulacion del ahijamiento en vitroplantas de pina con paclobutrazol. Centro Agricola. 21(2):75-82, 1994.
6. Fitchet. M. Organogenesis in callus cultures of pineapple (*Ananas comosus* (L.) Merr). Acta Horticulturae. 275:267-274, 1990.
7. Daquinta. M, R. Castillo, J.C. Lorenzo, I. Lunas, M. Escalona, R. Trujillo y C.G. Borroto. Formacion de callos en pina (*Ananas comosus* (L.) Merr). Revista Brasileira de Fruticultura. 16(2): 83-91, 1994.
8. Daquinta. M, A. Cisneros, Y. Rodriguez, M. Escalona, M.C. Perez, I. Luna y C.G. Borroto. Somatic embryogenesis in pineapple (*Ananas comosus* (L.) Merr). 2nd Symposium International Ananas. Martinique, 1995.
9. Benega. R, M. Isidron, A. Cisneros, E. Arias, M. Daquinta, L. Companioni y J. Martinez. Induccion de callos en anteras de pina. Cultivos Tropicales. 17(1):72-74, 1996.
10. Benega. R, M. Isidron, E. Arias, A. Cisneros, J. Martinez y C.G. Borroto. Regeneracion de plantas a partir de ovulos de pina. Acta Cientifica Venezolana. 46:210-211, 1995.
11. Pinho. N.M, L. Zambolin, J. Maria, y J.A. Ventura. Protoplasts isolation of *Ananas comosus* (L.) Merr. cv. 'Perolera'. 2nd Symposium International Ananas. Martinique, 1995.
12. Borrás. O, B. Companioni, A. Cisneros, R. Santos, Y. Rodriguez, M. Mosqueda, M. Arzola, R. Tapia, R. Benega y R. Gonzalez. Influence of culture filtrates of *Fusarium moniliforme* shield var. subglutinans WR & RG on pineapple callus. Advances in Modern Biotechnology. Vol. 3, 1995.
13. Borrás. O, M.C. Perez, R. Santos, R. Tapia, Y. Rodriguez y M. Mosqueda. Empleo de tecnicas conductimetricas para la seleccion precoz de resistencia a *Fusarium subglutinans* en vitroplantas de pina. Rev. Brasileira de Fruticultura. Vol. 3, 1995.
14. Anonimo. Fitotek investigates the plant bioreactor. A. challenge to increase market share. Biolink. 2(1):1-3, 1994.
15. Firoozabady. E, J. Nicholas, N. Gutterson. In vitro plant regeneration and advanced propagation methods for pineapple. 2nd Symposium International Ananas. Martinique, 1995.♦

News from India

NPK Requirement in Ratoon Crop of Pineapple in Assam

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Since pineapple is a perennial crop, ratooning is a regular feature in its cultivation in Assam. The crop yield is only economical up to second ratoon due to poor management, particularly lack of fertilization. The application of NPK had a significant effect on growth parameters of the plant viz. plant height, number of leaves, leaf area, and total dry matter production. But there was little effect on length and breadth of 'D' leaf, leaf area index and average number of suckers and slips.

However, for each increase in level of NPK, there was an increased trend in all the growth parameters. Also, applied nutrients had no effect on time taken for flowering but there were significant differences in time taken for harvesting. However, application of NPK had a prominent effect on yield and yield attributes. Fruit quality in terms of acidity, TSS/acid ratio, reducing sugars and moisture content showed significant effect due to application of nutrients.

Estimation of cost benefit ratio indicated that 40 percent of the recommended dose of plant crop i.e. 4.8 g N, 0.8 g P₂O₅, and 4.8 g K₂O per plant per year gave a better return than did other treatments. Hence, 40 percent of the recommended dose of the plant crop is suggested for the ratoon crop of pineapple in Assam.

Different Sources and Levels of Potassium on Pineapple cv. Kew

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An experiment was carried out to evaluate the response of Kew pineapple planted at 64,000 plants/ha to 4, 8, or 12 g/plant of potassium nitrate (KNO₃), potassium sulphate (K₂SO₄), or potassium chloride (KCl). Plants were provided with, in g/plant, 12 nitrogen and 8 phosphorus. At 12 g KCl, a greater number of plants flowered increased average fruit weight and yield. Application of K₂SO₄ at 12 g resulted in greater total soluble solids and sugar contents of fruit and reduced fruit acidity. the highest yield of 71.2 tonnes/ha was obtained with 12 g/plant per year of KCl along with a normal dose of N and P. ♦

News from Malaysia

'JOSAPINE': A New Pineapple Hybrid Developed at MARDI

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JOSAPINE is a new pineapple hybrid officially released by the Malaysian Agricultural Research and Development Institute (MARDI) on 5 August 1996. It is so named because it was derived from 'JOhore' and 'SARawak' parents. It has its origin from a systematic hybridisation programme started at the MARDI Integrated Peat Research Station in Pontian in 1984. The programme, headed by Dr. Chan, Y.K. and assisted by Mr Lee, H.K., involved four cultivars representing the three major groups of pineapple, i.e., Sarawak (Cayenne), Moris (Queen), Johor (Spanish) and Masmerah (Spanish). These were crossed in a complete diallel to generate about 50,000 F₁ progenies. This hybrid population was evaluated and 300 selections were subsequently made. These selections were further evaluated, trimmed down to 13 in 1989 and further reduced to six in 1991. These six potential hybrids were tested over three environments i.e., Pontian, Bukit Tangga and Kluang from 1991-1994, to establish the hybrids' performance and stability. The results of the trial showed that one of the hybrids, A25-34 (later called Josapine), has good yield, a strong aroma and a high, stable TSS %, and is suited for table fruit. Further, its attractive fruit

cosmetics, improved storage life and tolerance to black heart disorder also make it a good candidate for export.

Research on Blackheart Disorder in Malaysian Pineapple

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Pineapple in Malaysia is cultivated mainly on peat soil in the state of Johor to cater to the needs of both the cannery and the fresh fruit market. Currently, the total area in pineapple production in Peninsular Malaysia is estimated at around 13,500 hectares. The most commonly grown are pineapple of the 'Cayenne', 'Queen' and the 'Spanish' groups. For fresh consumption, the Mauritius and Sarawak cultivars, of the Queen and Cayenne group respectively, are the most popular. The Gandol cultivar (N19) of the Spanish group is also consumed as a fresh fruit although it is produced mainly for processing.

Fresh pineapple is mainly consumed locally. A small percentage of the fresh fruit is exported to Singapore and West Asia especially Saudi Arabia and the United Arab Emirates. Development of an appropriate postharvest handling system is required in order to expand the fresh pineapple market to more distant countries, especially in Europe. Research in this area has been conducted mainly by MARDI.

Generally, most Malaysian pineapple cultivars can be stored for 3-4 weeks at 8-10°C. However, the storage life at low temperature is shortened by blackheart (BH) disorder. BH has been reported and observed in three important cultivars namely Mauritius, Sarawak and Gandol. The disorder can develop in fruits stored at temperatures between 5-20°C, which also includes the optimum temperature range for storage. In Sarawak pineapple, fruit stored for 1, 2 and 3 weeks at 10°C developed the symptoms after 3 days exposure at ambient temperature (28°C). However, BH can be observed in the fruit stored for 4 weeks at 10°C without any exposure to higher temperature. This observation is in agreement with the works reported by other workers in Hawaii, Ivory Coast and Australia.

BH in pineapple has been associated mainly with a reduction in ascorbic acid content. In the Mauritius cultivar, the ascorbic acid content remained at high levels and decreased slightly only after four weeks which also marked the initial stage of BH development. After a week holding period at 28°C, the ascorbic acid content dropped significantly to a very low level. Fruits affected by BH were also lower in total soluble solids.

Several studies have been conducted to overcome the BH problem. Harvesting the fruit at an earlier maturity stage delays the onset of BH development, but BH can still occur if the exposure period at ambient temperature is extended after low temperature storage. Less mature Mauritius pineapple tend to contain higher concentrations of ascorbic acid, which probably acts as an anti-oxidant in delaying the browning of the flesh. Although the ascorbic acid content was maintained during low temperature storage, the level decreased significantly once the fruit are transferred to the higher ambient temperature. In the Mauritius cultivar, the ascorbic acid concentration decreased to the same low level after 4 days at ambient following low temperature storage despite the maturity stage at harvest.

Heat treatment for 24 hours at 38-42°C before, during or after storage was effective in controlling BH. This is similar to the method reported earlier for Hawaiian pineapple, but with a lower heating temperature range i.e. 32-38°C. However, heat treatment is very costly and not economical for use in Malaysia. Also, heat treatment will cause excessive weight loss and severe crown dessication.

Modified atmosphere packaging (MAP) of Malaysian pineapple at low concentrations of oxygen (2-10%) at 8°C delayed skin yellowing and BH development for up to 5 weeks. However, BH develops once the fruit is exposed to normal atmospheric ambient condition. Also, the fruit can develop an off-flavour if the storage period is extended to more than 3 weeks.

Several fruit coating formulations such as 'Samperfresh', 'Stafresh' and 'Brogdex' have been tested but none was effective in controlling BH in Malaysian pineapple. Surface coating delays or inhibits fruit ripening, but can also result in off-flavour development. BH can be effectively controlled by minimizing the time of fruit exposure to low temperature and by using or selling the fruit as soon as possible after it is removed from the cold room. This approach was used in the first trial shipment of pineapple from Port Klang to Jeddah, Saudi Arabia in 1992. However, the most effective approach is by using a BH-resistant cultivar. Recently, two BH-resistant pineapple cultivars have been developed in Malaysia namely N36 and Josapine (A25-34 developed by MARDI); N36 is now being exported regularly to the West Asian market. Preparation is now being made to carry out the first trial shipment of N36 pineapple by sea from Malaysia to the United Kingdom.

One of the interesting facts about the BH-resistant cultivars is the content of ascorbic acid, which is not significantly higher than in BH-susceptible cultivars. It has been proposed that pineapple with a higher content of ascorbic acid is less likely to develop BH. However, our studies have proven very clearly that this hypothesis is incorrect since cultivars known to be susceptible to BH such as Mauritius and Sarawak have higher concentrations of ascorbic acid than the BH-resistant cultivars.

The latest approach being studied in overcoming BH is through molecular strategies. A joint research project has been set-up by Queensland Department of Primary Industry and MARDI to look into this matter. The project is financially supported by the Australian Centre for International Agricultural Research (ACIAR). Besides BH, the group will also look into crown deterioration, which has not been given enough emphasis in past studies.

Publications on Postharvest Physiology of Pineapple in Malaysia (See Abdullah, 1993; Abdullah and Rohaya, 1983; Abdullah et al., 1983, 1986, & 1996; Suhaila & Safiah, 1993; and Wills et al. 1985 in the **References** section)

International Conference on Tropical Fruits

This Conference was organised by MARDI and was held from 23 - 26 July 1996 at the Kuala Lumpur Hilton. About 400 delegates from 42 countries attended the conference, which received 190 papers. Two volumes of the proceedings are presently available at US \$20 per volume. The third volume is

being compiled and will be available at the end of 1996. Enquiries and orders can be directed to:

The Secretariat, International Conference on Tropical Fruits, MARDI, GPO Box 12301, 50774 Kuala Lumpur, Malaysia. (Attn.) Dr Chan, Y.K.

The following are abstracts of papers on pineapple presented at the Conference.

Effect of Oxygen and Carbon Dioxide Levels on Internal Browning and Composition of Pineapple (Smooth Cayenne) After Low Temperature Storage

Ratiporn Haruenkit¹ and A.K. Thompson² ¹King Mongkut's Institute of Technology, Ladkrabang, Bangkok 10250, Thailand ²Silsoe College, Cranfield University, Bedford MK45 4DT, U.K.

Fresh pineapple were stored under controlled atmosphere consisting of 1.3%, 2.2%, 5.4% and 21% O₂ with and without 11.2% CO₂ balanced with nitrogen. After 3 weeks of storage at 80°C the fruits were transferred to 20°C for 5 days. The internal browning (IB) was scored by rating from 0 (none) to 5 (maximum). The flesh was analysed for °Brix, titratable acidity, vitamin C and pH. Development of IB was least at 2.2% but maximum at 5.4% O₂. CO₂ played no role in IB development. At low O₂ levels plus elevated CO₂ the °Brix and titratable acidity were relatively low. pH was clearly affected by elevated CO₂. Ascorbic acid was significantly higher in pineapple stored under the controlled atmosphere condition.

Effect of Chemical, Organic Fertilizers and Trace Elements Application on Nitrate Content in Pineapple Fruit

Chongpraditnun, P., Laksanawimol, P. and Limsmutchaipom, P. Soil Science Div., Dept. of Agriculture, Bangkok 10900, Thailand

To clarify a problem of nitrate accumulation in the pineapple fruit causing detinning in pineapple can industry, the cultivation of pineapple with the application of N-P-K; 12-12-15 (control) and the combinations of N-P-K with either trace elements (Mo, Mn, Mg) or compost was conducted. At the harvesting stage, nitrate content, % brix and pH of pineapple fruit and soil changes were analyzed.

There was a tendency of 25-70% reduction of nitrate content in fruit due to some trace elements, especially Mo at the rate of 625 g. Mo/ha. Moreover, a delay application of excess N after flower induction 2.5 and 4.5 months induced a higher nitrate accumulation in fruit up to 2.5 times of Control's.

Suitable Storage Temperature of Okinawan Grown Pineapple

Akinaga, T., Tajiri, T., Kawasaki, S. and Kohda, Y.

College of Agriculture, University of the Ryukyus, 1 Senbaru
Nishihara, Okinawa 903-01, Japan

This study was carried out to determine the suitable shipment and storage temperature of pineapple fruits (summer, autumn and winter crops). To measure the respiration rates, pineapple fruits were stored at 5 to 40°C. Temperatures and respiration rates were plotted to produce Arrhenius curves to determine the temperature dependencies on respiration rates of pineapple fruits. After that, pineapple fruits were stored at three different temperatures to evaluate their qualities during the storage. The result showed that a low temperature storage is suited to maintaining the quality of pineapples. In addition, the suitable storage temperature differs according to the harvest season. It was found that 5°C for summer crops, 8°C for autumn crops, and 10°C for winter crops were the best storage temperature to keep their freshness.

Weed Control Recommendations for Pineapple Grown on Mineral Soil

Abdul Rahman, H. MARDI Bukit Tangga, 06050 Bukit Kayu Hitam, Kedah, Malaysia

Weed control is the main problem in pineapple cultivation on mineral soils. A combination of both herbicide applications and plastic mulching is recommended for its weed control. During the dry seasons, the pre-emergent herbicide Diuron was found to be the most effective providing control for 4 to 6 months while Gesapex for only 1 to 1.5 months. The effectiveness of these pre-emergent herbicides was much reduced during the rainy season. Weed control using herbicides were compared with that using black plastic sheet mulch. Besides preventing weed growth, the usage of plastic mulch also had a positive effect on the growth and yield of pineapple.

The Effect of Fruitone® Application on the Yield and Fruit Quality of Pineapple cv. Gandul Grown on Deep Peat Soil in Malaysia

Mohammed Selamat, M.¹ and Abdul Rahim, M.² ¹MARDI, P.B. 525, 86009, Kluang, Johore, Malaysia. ²MARDI, P.B. 43, 33077, Koala Kangsar, Perak, Malaysia

The effects of various concentration of Fruitone® [Sodium 2-(3-chlorophenoxy) propionate] applied 80 and 100 days after flower induction were studied on Gandul cultivar. The main objective was to find the optimum dosage of application in order to obtain the maximum yield. Results of the study indicated that the optimum dosage of Fruitone® application was 1 ml per litre of water. Average of the maximum fruit weight was 1.68 kg.

Fruit qualities were affected by Fruitone® application. Increasing rate of Fruitone® reduced the soluble solid concentration (SSC) thus the sugar content. However, fruit acidity increased as the rate of Fruitone® application was increased. Treated fruits were generally larger than the control. They also had smaller crown size. However, harvesting period was delayed due to the delay in fruit maturity.

Pineapple Nursery Setup and Production on Peatland Areas

Mohammed Selamat, M. Horticulture Research Centre, MARDI, P.B. 525, 86009 Kluang, Johore, Malaysia

Establishment of a pineapple nursery is an important activity for a new plantation. The planting system and management of a ten hectare nursery area are described. The development and operational costs of setting-up the nursery are also discussed. The suckers estimate is also listed. Cash flow for the proposed pineapple nursery of a ten year period is given.

Methods for the vegetative propagation of the nursery are discussed. These include the quartering technique, leafbud cutting technique and stump sectioning. The speed of multiplication for each technique is discussed.

The advantages of setting-up the pineapple nursery on peatland areas are highlighted since most of the pineapple growing areas for both canning and fresh eating cultivars are located on such land. It is observed that a pineapple nursery is not only required for a new plantation but also for the requirement of rapid multiplication of a newly released cultivar. Quality of the planting materials produced can also be monitored closely and effectively.

Studies on Black Heart Disorder, Electrolyte Seepage and Endogenous Calcium Content in Kew and Mauritius Variety Pineapples Grown in Sri Lanka

Wilson Wijeratnam, R.S., Abeyesekere, M., Hewajulige, I.G.N. and R. Suganthini Ceylon Institute of Scientific & Industrial Research, 363, Bauddhaloka Mawatha, Colombo 7, Sri Lanka

A correlation between the incidence of black heart symptoms, electrical conductivity and endogenous calcium levels was observed in both Kew and Mauritius variety pineapple subjected to storage at 10°C for 14 days. Low levels of calcium were observed in Mauritius fruits along with high incidence of the disorder, while high levels of calcium were observed along side low incidence of the disorder in Kew. Significant differences in free and bound calcium levels were observed in core and flesh samples before and after storage in Mauritius pineapple while core and flesh samples of Kew showed no such differences.

Electrical conductivity in both regions was significantly higher in Mauritius variety after storage, compared with Kew where conductivity was significantly higher only in the core.

Rapid on-farm Propagation Techniques for Plantain, Bananas and Pineapples

Adelaja, B.A.
Fruits Division, National Horticultural Research Institute, P.M.B. 5432, Ibadan, Nigeria

Plantain, bananas and pineapple are among the five most important tropical fruits produced in West Africa. However,

inavailability of planting material poses a serious limiting factor to production. This poster presents two new methods for the on-farm propagation of plantain, bananas and pineapples that can be adopted directly by the farmer.

Photosynthesis and Water Relations of Drought Stressed Pineapple Plants

Marler, T.E and Lawton, P.D. CALS-AES, University of Guam, UOG Station, Mangilao, Guam 96923 USA

Water was withheld from container-grown, 13 month-old 'Smooth Cayenne' pineapple plants to determine the photosynthetic and water relations responses to water deficit in the climate of Guam. In the absence of water deficit, net CO₂ assimilation (Pn) became positive by about 17:00 h and remained positive until about sunrise. Water deficit delayed the time at which Pn became positive until about 20.00 h. After 5 weeks of withholding water, Pn remained positive for only 4 h during the evening. Maximum Pn of the water-stressed plants was about 5% of the well-watered plants. Water-stressed plants were not sensitive to high light stress, as chlorophyll fluorescence did not differ among the watering treatments. Water deficit did not influence leaf osmotic potential, but reduced root osmotic potential about 20% below that of well watered plants. Relative leaf water content decreased in a quadratic fashion over 5 weeks of withholding water. ♦

News from South Africa

Growth Regulators for Pineapple Crop Control

Leon Steyl, Applied Agricultural Products (Pty) Ltd (AAP). P.O. Box 13150, Witfield, 1467, South Africa; Phone: 27 11 826-6441; fax: 27 11 826-1727; email: ab23@solo.pipex.co.za.

AAP has been supplying pesticides and growth regulators to the local pineapple industry for the past 40 years. The company manufactures some of the specialised growth regulators used by the pineapple industry, including ethephon, and recently began manufacturing [2-(3-chlorophenoxy) propionic acid], which is formulated and sold under the trade name CLOPROP. The product has traditionally been used by the local industry as a crown inhibitor and shows some promise as an inhibitor of natural flowering (see references in this issue by Min and Bartholomew, 1996; Rebollo et al., 1996, Acta Horticulturae 425; and Scott, 1993). Similar research is currently being done in South Africa.

Likely to be of particular interest to readers is the fact that AAP has been successful in producing chlorflurenol-methyl ester, the active ingredient used to formulate Maintain®¹ and Multiprop®², which were used to induce multiple tops on pineapples. Neither product is currently available in Australia, Hawaii, or South Africa. Depending on customer requirements AAP will formulate a generic product using this active ingredient. Further information on any of the above products can be obtained by contacting Mr P. Erasmus at AAP.

¹Maintain is the registered trade mark of Uniroyal.

²Multiprop is the registered trade mark of Shell Agrar GmbH & Co. ♦

News from Sri Lanka

Pineapple Research Activities in the Department of Agriculture

S.F.M. Sulaiman, Deputy Director (Research), Regional Agricultural Research and Development Centre, Makandura, Sri Lanka.

1. The pineapple mealybug in Sri Lanka was identified as the pink pineapple mealybug, *Dysmicoccus brevipes* (Cockerell), by Dr. W. Carter and Prof. J. Beardsley. Fortunately, there is no record of the presence of the gray pineapple mealybug, *D. neo brevipes* (Beardsley), in our fields as yet. Ant species tending *D. brevipes* in our fields are:

- i. *Technomyrmex* sp. (group of *albipes* Smith)
- ii. *Paratrechina longicornis* (Latreille)
- iii. *Pheidole* sp.
- iv. *Crematogaster* sp.
- v. *Camponotus sericeus* (Fabricius)
- vi. *Camponotus* sp. (rufoglaucus group) and
- vii. *Polyrhachis exercita* (Walker)

The increase and spread of the pink mealybug population is very high when attended on by *Technomyrmex* nr. *albipes* in our fields. Studies on total ant density (using pitfall traps) in relation to weed management showed that the ant density was significantly lower in clean weeded plots than in slash weeded and unweeded plots. High rainfall reduced ant populations in the field as measured in pitfall traps. Sequel to a decline in ant populations, the mealybug populations also declined.

Fruit yield was significantly higher in the clean weeded plots than in the slash weeded and unweeded plots. Lycosid spiders were significantly higher in number (in pitfall traps) than those of other families. Total spider numbers were higher in the unweeded and slash weeded plots than in the clean weeded plots.

2. Presently a replicated field experiment is being carried out in which the pineapple wilt disease was induced using gross colonies of pineapple mealybugs amounting to 10,000 in number, over a period of six months. The control plants were not infested with mealybugs. ELISA test carried out on leaf samples with and without disease symptoms and those un-infested showed that the quantity of virus particles present in all the leaf samples are more or less similar. Further work is in progress.

Pineapple Improvement Program in the Dept. of Agriculture, Sri Lanka

M.F.S.W. Fernando, Research Officer and L.P. Somadasa, Research Officer, Regional Agricultural Research and Development Center, Makandura, Gonawila (NWP), Sri Lanka.

In Sri Lanka, pineapple is grown mainly as an intercrop in coconut land. It gives an extra income, reduces expenditure on weed control and improves soil and moisture conservation in coconut land. At present, there are two varieties grown in the

island, namely Kew (Cayenne group) and Mauritius (Queen group). The variety Kew is preferred in industry due to its shape and average fruit size and the Mauritius variety is popularly grown here to cater to the local market. The hybridization program in Sri Lanka was initiated at Regional Agricultural Research and Development Center (RARDC), Makandura, Gonawila (NWP), since this Centre is responsible for the National Pineapple Program. There is need to develop a variety with spineless leaves and fruits as nearly cylindrical as possible with high sugar and low acid. Variety Mauritius was reciprocally crossed with the variety Kew, and UNK-1, UNK-2 introductions. Pollination was done during the midday. Self incompatibility was observed in all these types, thus emasculation was not practiced prior to hand-pollination. But flowers were bagged before and after pollination to prevent contamination with unknown pollens. Presently crosses are made at RARDC, Makandura in three different stages. Some lines are in the preliminary fruiting stage. Some of these lines show very vigorous growth and broad D leaf when compared with parents. A promising line with smooth leaves and mauritius fruit quality has been identified. Further work is in progress.

Mealybug Wilt Disease

Ed Note: The following was received with the above material but no author was indicated. The file was partially corrupted in transfer so it is presented with some minor editing.

Mealybug wilt of pineapple is known to occur in most of the tropical and sub tropical areas of the world where pineapples are grown commercially (Carter 1973). In Hawaii this wilt was reported to be transmitted by mealybugs (Illingworth 1931, Carter 1932) and commercial control was achieved primarily by eliminating the field ants (Carter 1973).

In our pineapple agro-ecosystem the following questions remain unanswered:

1. What are the ant species that prevail in the pineapple crop when planted as a mono crop or mixed crop and what are the species of ants that attend the mealybugs?
2. What are the cultural practices that increase or decrease the ant/mealybug/spider densities in the system? Effect of climatic parameters on the ant/mealybug/spider densities? Safe and effective control measures that could be adopted for ant control?
3. How do cultural practices affect the fruit yield of the mono as well as mixed crop?
4. An IPM package to manage the disease?

The objective of this study was to find the answers to the above questions. In this experiment, the impact of three different weed management methods - clean weeded, slash weeded, and unweeded conditions on the ant/spider density were studied.

Over a three year study period in this field several hundred pitfall trap samples were collected and the key fauna in all of them - ants and spiders were collected and identified. Some of the beetles collected were also identified. The mealybugs were also counted, as and when they appeared. Mealybug samples collected were taken to the University of Hawaii at Manoa and identified.

The mealybug in the pineapple agro-ecosystem in Sri Lanka was identified as *Dysmicoccus brevipes* (Cockerell). Fifteen species of ants, some of which were not recorded by previous

researchers in our pineapple fields, were collected in the traps and identified with help from the University of Hawaii and IIE, London, as follows:

1. *Technomyrmex* sp. (group of *albipes* Smith)
2. *Paratrechina longicornis* (Latreille)
3. *Pheidole* sp.
4. *Crematogaster* sp.
5. *Camponotus sericeus* (Fabricius)
6. *Camponotus* sp. (*rufoglaucus* group)
7. *Polyrhachis exercita* (Walker)
8. *Lophomyrmex quadrispinosus* (Jerdon)
9. *Pheidolegeton diversus* (Jerdon)
10. *Tetramorium lanuginosum* (Mayr)
11. *Myrmecaria brunnea* (Saunders)
12. *Leptogenys processionalis* (Jerdon)
13. *Diacamma rugosum* (LeGuillou)
14. *Pachycondyla tessarinoda* (Emery)
15. *Anoplolepis longipes* (Jerdon)

Of the above ant species, the first seven were commonly observed to attend on the pineapple mealybug, *D. brevipes*. In this field, one or two species of ants would be observed to tend the pineapple mealybug colonies at a time. But the tending ant species would vary from time to time. *Pheidole* sp. would be observed in large numbers at one time and later, another species like *P. longicornis* and *Technomyrmex* sp. would be observed. *Technomyrmex* sp. was quite commonly observed to be tending along with *Paratrechina longicornis* and was also found to tend the mealybugs along with *Camponotus* sp.

On very rare instances, *L. quadrispinosus* was observed to attend on the pineapple mealybug. *P. diversus* moved about in large armies and, when caught in the pitfall traps, were present in several hundreds to several thousands. Most of the peaks in the time series curve of average ants per trap, were due to the migration of this ant species in large numbers. Other ant species observed, were caught in relatively smaller numbers.

Of the 7 tending ant species, the first 4 species are all small black ants while the next 3 species are large black ones. In this mixed crop experimental area, the ant species tending the mealybugs were most frequently the small black ants, *Pheidole* sp., *Crematogaster* sp., *P. longicornis* and *Technomyrmex* sp.

Ants in relation to Weed Management: In this mixed crop system the lowest ant density was observed in the clean weeded plots (T1), a constantly disturbed system. The unweeded plots (T3) with least disturbance and significantly higher dry mass of weeds m² ($F = 97.7^{**}$) had the highest ant density, while ant density was also fairly high in the slash weeded plots (T2) which had a significantly higher weed density ($F = 116.87^{**}$). T2 plots were also often disturbed by the slashing process; however, a well pruned grass mat was retained in these plots and ant density was fairly high. Weed density was high in T2 plots, probably due to the high chance of reseeding while slashing and to a high percentage germination of weed seeds in comparison to the T3 plots. Ants being attracted to weed seeds apparently find this environment very conducive and so forage here in fairly high numbers.

The mixed crop experiment was replicated 4 times and in each replicate the treatment blocks were adjacent to each other and therefore ants/spiders being highly mobile organisms, were able to move from one treatment block to the other. This is

reflected in the results where the T1 plots had a comparatively lower ant density than did the T2 and T3 plots.

Ant/mealybugs: In this experiment, mealybug infestations were observed only during the third year of the crop. Analysis showed that mealybug numbers were relative to ant density and their numbers declined as ant densities declined in the pit fall traps. The T2 plots had highest number of mealybugs. Surprisingly, the T3 plots had fewer mealybugs than did the T1 plots. In the T3 plots, pineapple growth was poor due to weed competition and also spider numbers were high. So it is possible that the few mealybugs occurring in these plots were subjected to higher predation. Also weed density in the T3 plots was lower than in the T2 plots and this along with poorly grown pineapple plants could have accounted for the lower mealybug numbers in the T3 plots.

Effect of rainfall: High rainfall reduced ant populations in the field. Pitfall trap counts were low during high rainfall periods and tending ant colonies on the crop were observed to be washed away. Sequel to a decline in ant populations, the mealybug populations also declined.

In this experimental field the wilt disease was not observed even by the 3rd year of the crop. A few plants however, showed signs of stress without wilting. Plants in such condition recovered after heavy showers. Carter (1942) observed that the incidence of the disease was low on virgin lands rich in organic matter and in areas of high rainfall without extreme temperatures. Our data on declining ant/mealybug populations with heavy rainfall seem to tally Carter's (1942) observations.

Fruit yield & weed management: In the mixed crop experimental field, fruit yield was significantly higher in the T1 plots than in the T2 plots ($F = 9.13^*$).

Spider density: Spiders belonging to the families *Lycosidae*, *Salticidae*, *Gnaphosidae*, *Corinidae*, *Zodaridae* and a few others collected in the pitfall traps were identified with help from the Natural History Museum, New York. Spider population data from pitfall traps in this experiment showed that spider density was higher in the T3 and T2 than in T1 plots. Also, spider numbers were positively correlated to ant density in all treatment blocks. This is at variance with the findings of Jahn (1990) who found a negative correlation. Further, we note that the spider density did not decline with the heavy rains. On the contrary the spider population and spider numbers tended to increase with the rains. In the T2 and T3 plots of this system, the spider numbers peak to a maximum of more than 4 spiders per trap.

Chemical control: The baited formulation of hydramethylnon sold as "Amdro" was tested in the experimental area. The bait in its original form was initially broadcast in the field and then small amounts of the bait were placed in sample tubes or in small plastic cups on plants where tending ant colonies were observed in large numbers. The bait, in its original form, was accepted only by the *Pheidole* sp. and a few other species like *Lophomyrmex* sp., which do not normally tend mealybugs. In the case of the other ant species, the bait was accepted only after it was sweetened by the addition of a little treacle. The bait/treacle mixture in the sample tubes were renewed every week until

tending ant colonies were not visually observed on the pineapple plants and hence bait consumption decreased with time. This method reduced the tending ant population for a period of more than ten weeks, unlike in the case of direct spray applications carried out in later experiments.

Postharvest Studies on Black Heart Disorder of Pineapple

Wilson Wijeratnam, R. S., Abeyesekere, M., Hewajulige, I. G. N. and R. Suganthini
Ceylon Institute of Scientific & Industrial Research, 363, Buddhaloka Mawatha, Colombo 7, Sri Lanka.

A correlation between the incidence of black heart symptoms, electrical conductivity and endogenous calcium levels was observed in both Kew and Mauritius variety pineapples subjected to storage at 10°C for 14 days. Low levels of calcium were observed in Mauritius fruits along with a high incidence of the disorder, while high levels of calcium were observed alongside low incidence of the disorder in Kew. Significant differences in free and bound calcium levels were observed in core and flesh samples before and after storage in Mauritius pineapples while core and flesh samples of Kew showed no such differences. Electrical conductivity in both regions was significantly higher in Mauritius variety after storage, compared with Kew, where conductivity was significantly higher only in the core. Dr. Wilson Wijeratnam reports "We are currently investigating endogenous calcium content in the above varieties during low temperature storage specific controlled atmosphere conditions."♦

News from the United States (Hawaii)

Study of Etiology of Pineapple Mealybug Wilt

John Hu and Diane Sether, Department of Plant Pathology, University of Hawaii - Manoa, Honolulu

Mealybug wilt of pineapple (MWP) is a serious disorder that nearly destroyed the pineapple industry in Hawaii in the early 1900s. Although this disease has been reported throughout the world and has posed a significant threat to the pineapple industry for more than 80 years, its etiology is still unknown. Several hypotheses have been proposed regarding possible causes of MWP; one suggested that mealybugs secreted a toxin during feeding and another proposed a virus entity. In 1989, closterovirus-like particles from diseased pineapple tissue in Hawaii were purified and partially characterized. Later, serologically related pineapple closterovirus-like virions (PCV) were purified from diseased pineapple in Australia. The etiological role of PCV in MWP is unknown.

Detection and transmission of PCV: We recently produced specific monoclonal antibodies (MAb) to PCV (Hu et al.1996 (see References section)). We used MAb against PCV in a tissue blotting immunoassay (TBIA) to detect PCV in more than 700 plant samples with and without MW symptoms. Overall, 99% of the samples with MW symptoms tested positive for PCV,

whereas 31-35% of the samples from asymptomatic plants tested positive. More than 20,000 MW symptomless samples from 8 cultivars and hybrids were also tested. One cultivar tested 100% positive for PCV and another around 90%. Others fell into ranges near 60%, 35-43%, and 13-20%. One hybrid was PCV negative in all samples. PCV was detected in pineapple samples collected from more than 15 countries.

Using specific monoclonal antibodies to PCV, we have identified pineapple plants with and without PCV, and mealybugs with and without PCV. Experiments to determine the role of PCV and mealybug "toxins" in mealybug wilt of pineapple are underway. Results from our preliminary experiments showed that mealybugs were able to transmit PCV from PCV-infected pineapple to healthy virus-free pineapple plants.

Hypothesis of MWP etiology: Our results show that PCV is widespread in pineapple, and could support the hypotheses that PCV alone does not cause MWP and that the disease has a complex etiology involving more than one organism (e.g. another virus) or interactions between PCV and stress caused by mealybug feeding (i.e. insect toxins). We propose the following hypothesis for the etiology of MW. Pineapple cultivars tolerant to PCV have been selected and propagated over many years of pineapple production. These pineapple cultivars do not develop MW under normal conditions although they are infected by PCV. However, when mealybug-induced stress arises, plants become weakened and are no longer tolerant to PCV, resulting in MW symptom development. When crowns are collected from wilted plants and removed from stress, plants become symptomless again. We are currently testing the hypothesis directly.

Pineapple Nematode Control: Summary of 1996 Activities

Brent J. Sipes, Dept. of Plant Pathology, University of Hawaii - Manoa, Honolulu

Alternative Products: Several alternative products for nematode control have been or are being evaluated. Nematrol®, a ground sesame product, and Clandosan®, a chitin-based product, were evaluated for reniform and rootknot control using basil as the test crop. Telone II, included as the standard treatment, was most effective in controlling reniform nematode and reducing rootknot galling. Rootknot, while lower at the start of the experiment, surpassed reniform numbers by the end. Final numbers of nematodes in the field did not differ among the treatments. Nematrol, which appeared to promote plant growth and reduced galling, will be further evaluated. Clandosan had no effect on the nematode population.

An Abbott Laboratory product, ABG-9008, recently labeled for pineapple, was tested in the greenhouse using crowns planted in infested soil. Plants were treated with solutions of 14, 28, 56, and 84 kg/ha at 2 and 4 months after planting. This fungal based product does not appear to be phytotoxic on pineapple. The experiment will be terminated in March 1997 and final nematode and plant growth parameters recorded. A field experiment has been recently established to evaluate this product for effects on pineapple yield.

Kosgrow AFB® is also being evaluated in the greenhouse in the same experiment as ABG-9008. No phytotoxicity nor growth

enhancement has been observed on the pineapples. The experiment will be terminated in March and final data collected.

PCV-Nematode Interaction: Greenhouse and field experiments were undertaken to determine if the Pineapple Closterovirus (PCV) and the reniform nematode interact. Preliminary results suggest no interaction between PCV-positive crowns and nematode numbers after 6 months. The growth of PCV-positive and PCV-negative crowns infected with reniform nematode was not different.

A field experiment was planted with crowns in November, to ascertain if PCV and nematodes interacted to affect yield. Some plots were fumigated with Telone II and others were not. Nematode populations and pineapple growth will be monitored and plant-crop yield recorded to determine the nematode and PCV interaction, if any.

Emulsifiable 1,3-D for Nematode Control in Pineapple: Field experiments were recently established in Del Monte and Maui Pineapple fields. In the Del Monte test, emulsifiable 1,3-D was applied preplant at 238 or 318 l/ha. It will be applied postplant at trimonthly intervals at 80 l/ha. Emulsifiable 1,3-D will also be applied in some plots as a single treatment following plant-crop harvest. In the Maui test, only postplant applications are being evaluated. The 1,3-D will be applied through the irrigation system when the nematode soil population density reaches 100 per 250 cm³ soil.

Biofumigation: A small field test was conducted at the Waimanalo Experiment Station to determine the effects of intercycle cover crop incorporation on nematode soil populations. Three mustard cultivars, reported to have high levels of glucosinolates, were planted in reniform infested soil. The plants were grown for 2 months and incorporated into the soil. The plots were covered with plastic mulch to retain the plant decomposition volatiles and cowpeas were planted in the plots two weeks later.

The mustards did no more effective than the bare fallow control in reducing reniform nematode soil population densities. The plots were irrigated automatically, consequently, the soil was always moist. The moistness of the soil probably reduced efficacy of nematode extraction from the soil in the postfumigation sampling.

Crop-Loss Assessment: Plots were established in a Dole field with initial nematode population density ranges of 0-10, 40-70, 100-120, 300, and 1020-1360 per 250 cm³ of soil. Plant growth will be recorded and used to determine damage threshold levels of the reniform nematode on pineapple. The data will allow us to determine how low the preplant nematode population must be to provide effective control.

D-leaf weights from 6-month-old plants in the different plots were not differ. Root biomass decreased with increasing nematode populations to 100-120, and then increased with increasing nematode populations densities. No differences were detected in plant height at 6 months.

Intercycle Cover Crops: Four cover crops (sunhemp, bearded wheat, supersweet corn, and glycine) were evaluated for their ability to reduce reniform nematode population densities in the

field. Sunhemp and supersweet corn reduced the nematode populations the most (Figure 1). Pineapple has been planted in the plots and will be monitored for nematode population development and plant growth.

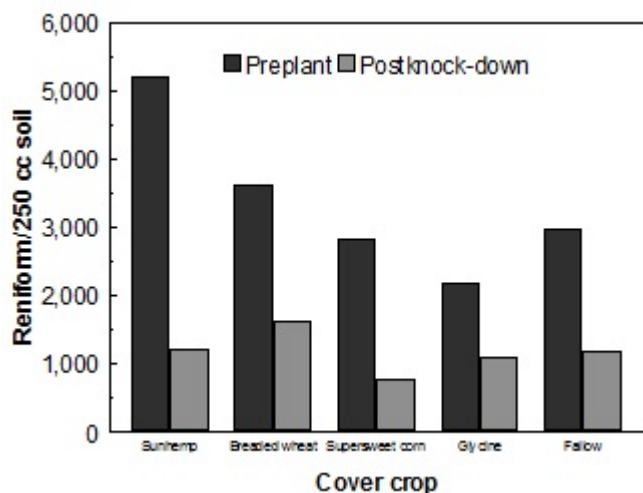


Figure 1. Reniform nematode population decline under four cover crops.

Comparison of Consumer Acceptability of Hawai'i Gold and Smooth Cayenne Pineapple Varieties

Raymond Ramsaroop and Aurora Hodgson, Dept. of Food Science and Human Nutrition, University of Hawaii - Manoa, Honolulu

A relatively new pineapple variety, Hawai'i Gold (HG) has been introduced to the US and European markets. Its acceptability by consumers has not been documented to date. This research attempted to evaluate its acceptability using the most common variety and the current industry standard, the Smooth Cayenne (SC). Samples of fresh fruits were evaluated by over 265 consumer panelists as whole unpeeled fruit and as peeled fruit spears. Fruit characteristics used for assessment were color, overall appearance, aroma, firmness, overall texture, juiciness, sweetness, tartness, pineapple flavor, stringiness, and overall quality. Almost 60% of the panelists preferred whole unpeeled HG fruit more than whole unpeeled SC fruit. On a rating scale of "extremely like" to "extremely dislike," peeled HG spear samples were rated significantly higher ($P < 0.05$) than peeled SC spears on all of the characteristics assessed, except tartness. Results of similar analyses of single strength juice using approximately 300 panelists indicated that HG received significantly higher ratings ($p < 0.0001$) than

SC for all the qualities assessed. Consumer acceptability results indicate that HG may be able to Compete well with SC.

The Pineapple Industry in Hawaii

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The number of pineapple growers and the area in crop declined from many years, but appears to have stabilized. Hawaii production declined from 575,000 U.S. tons produced on 30,900 acres in 1990 to 347,000 tons produced on 20,000 acres in 1996. Currently there are fifteen farms that produced 347,000 tons of pineapple in 1996. There are six farms on the island of Hawaii, three on Kauai, four on Maui/Molokai, and two on Oahu, and these numbers have changed little since 1993. The major growing regions of the state are Oahu where Dole Fresh Fruit and Del Monte Fresh Produce Hawaii have a combined acreage of 11,500 and Maui where Maui Pineapple Company has an acreage of 10,800. Production on Oahu is packed and shipped fresh with some excess and cull fruits processed into frozen juice concentrate. Production on Maui is destined primarily for the cannery with a small percentage being air-shipped fresh, primarily to the U.S. mainland. The farm price in 1996 was approximately \$117 per ton for fruit destined for the cannery and \$598 per ton for fruit sold fresh, resulting in a farm-gate value of \$95,914,000. The total market value of fresh and processed product was reported to be \$135,000,000 (1995).

Sources: 1995 Statistics of Hawaiian Agriculture, and, Statistics of Hawaiian Agriculture-Hawaii Pineapples: Annual Summary, Release date 3/6/97.

Effects of Tebuconazole on Fruit weight and Precocious Flowering

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When crowns were dipped in Elite® (tebuconazole), plants were very stunted early in the crop cycle. The stunting was observed for 10-12 months or until forcing. After forcing, plants started to out grow the stunting effects and by harvest, plants were comparable in height and size to the check plants. No significant effects of the treatments on average fruit weight were observed (Table 1).

In one instance at a test site in Kunia, casual observations were taken on the effects of Elite in inhibiting precocious flowering. At the 100 ppm level, precocious flowering was inhibited completely. Crowns treated with the standard Bayleton dip had a higher percentage of precocious flowering (18%) than the untreated controls (4.0%) (Table 2).

Table 1. Effects of Elite® (ppm) on fruit weight at harvest(pounds).

Treatment	Dole	Del Monte
Check	--	4.6
Elite 10	3.6	4.2
Elite 25	3.7	4.3
Elite 50	3.5	4.0
Elite 75	3.2	4.1
Elite 100	3.2	4.2
Bayleton 100	3.5	4.4

Table 2. Effects of Elite® on percentage of precocious flowering.

Check	4
Elite 10	6.7
Elite 25	7.3
Elite 50	6
Elite 75	2
Elite 100	0
Bayleton	18

◆

News from Venezuela

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On a recent consultancy visit to Venezuela to advise on pineapple production, the writer made the following observations. The best pineapple producing regions appeared to be at about 400 m elevation. Pineapple plant and fruit size decreased as elevation increased up to 1,200 m. This observation agrees with Collins' (1960) observations for other areas of the world.

Growers at the lower elevations have developed an almost organic, pesticide free method of growing pineapple. This includes a three-crop, five to six year growing cycle with a five year secondary forest fallow, or sporadic rotation crops of cassava, pigeon pea, etc. The first and second ratoon crops are vigorous with strong sucker roots and few visible signs of nematode, fungal, or insect problems. Red Spanish, the variety grown, suckers low on the stump and reroots into the soil. This is aided sometimes by hilling and by a giant ant that hills soil up around the plant. Future studies should investigate the hilling practice and genotypes that develop low suckers.

At higher elevations, more problems occur! These include nematodes and other root parasites; fertility problems; an insect that bores into the fruit and then travels down the stump to the soil and often kills the plant; precocious fruiting on small plants; interfruitlet cracking, etc.

Red Spanish appears to have some inherent selection variation, but not as much as Smooth Cayenne. Growers have done some of their own selecting for such variables as spineless leaves, fruitlet number, and fruit size.

One perplexing observation was that larger fruits were often associated with multiple crowned fruits (i.e. large crown with crownlets). This does not agree with Hawaiian studies, which showed that fruits with multiple crowns were reduced in size.

Since Venezuela is the one of the reputed homes of Smooth Cayenne (Collins, 1960, etc.) More work should be done in evaluating Venezuelan genotypes in different parts of the world.

Venezuelan farmers told of wild pineapple growing near the Caribbean coast, and large pineapple-type bromeliads were seen growing in the undergrowth. Freddy Leal and his co-workers in Venezuela have apparently selected a number of pineapple genotypes and species adapted to a wide range of climatic conditions (from somewhat cold tolerant to tropical).◆

References

This section contains references published or supplied since the last newsletter. Please help keep this section up-to-date by sending copies of recent publications to the editor at the address on page 1 of the newsletter. All Acta Horticulture references with the volume number 425 are from the 2nd International Pineapple Symposium held in Martinique in 1995. The volume was in press at the time the newsletter was printed.

Reprints for the publications listed below should be obtainable through any university library or by writing to: Library External Services, Hamilton Library Room 112, University of Hawaii, 2550 The Mall, Honolulu, HI 96822 U.S.A. Charges in 1996 were \$14.00 plus postage for the first 20 pages and \$0.25 per page over 20 pages.

- Abdul Rahman, H. 1996. Weed control recommendations for pineapple (*Ananas comosus* (L.) Merr.) grown on mineral soils. pp. 261-266. In *International Conference on Tropical Fruits, Proceedings*, eds. S. Vijayasegaran, M. Pauziah, M.S. Mohamed & S. Ahamad Tarmizi, Vol. I, Malaysian Agricultural Research and Development Institute, Kuala Lumpur.
- Abdullah, H. (1993). Postharvest handling of pineapple in Malaysia. In *Proc. Australasian Postharvest Conference*, ed. A. Story, Univ. of Queensland Gatton College. Brisbane, pp. 225-228.
- Abdullah, H. & Rohaya, M. A. (1983). The development of black heart disease in Mauritius pineapples (*Ananas comosus* cv. Mauritius) during storage at lower temperatures. *MARDI Research Bulletin*, **11**, 309-319.
- Abdullah, H., Rohaya, M. A. & Abd. Aziz, I. (1996). Quality changes in pineapple (*Ananas comosus* cv. N36) stored at low temperature. *MARDI Research Journal*, **24**(1), In press.
- Abdullah, H., Rohaya, M. A. & Zaipun, M. Z. (1986). Storage study of pineapple (*Ananas comosus* cv. Sarawak) with special emphasis on black heart disorder. *Mardi Research Bulletin*, **14**, 132-138.
- Abdullah, H., Subari, S. & Rohaya, M. A. (1983). Control of black heart in Mauritius pineapple by heat treatment. *Teknologi Pertanian MARDI (in Bahasa Malaysia)*, **4**, 189-196.
- Achinewhu, S.C. Effect of processing and storage on the ascorbic acid (vitamin C) content of some pineapple varieties grown in the Rivers State of Nigeria. *Acta Horticulturae*, **425**.
- Adu-Amankwa, P. Effect of time of harvest on the fruit quality characteristics of pineapples in two growing areas of Southern Ghana. *Acta Horticulturae*, **425**.
- Akinaga, T., Tajiri, T., Kawasaki, S. & Kohda, Y. 1996. Suitable storage temperature of Okinawan grown pineapple. pp. 479-488. In *International Conference on Tropical Fruits, Proceedings*, eds. S. Vijayasegaran, M. Pauziah, M. S. Mohamed & S. Ahamad Tarmizi, Vol. I, Malaysian Agricultural Research and Development Institute, Kuala Lumpur.
- Albrecht, W. 1987. Occupational exposure to 1,3-dichloropropene (Telone II) in Hawaiian pineapple culture. *Arch Environ Health*, **42**, 286-91.
- Aleman, G.D., Ting, E.Y. & Torres, J.A. 1996. Pulsed ultra high pressure treatments for pasteurization of pineapple juice. *Journal of food science*, **61** n 2, 388.
- Anonymous. 1996. Garden to Garden. *Organic gardening*, **43** n 1, 68.

- Anonymous. 1996. Recovering waste materials in pineapple processing. *Asia Pacific tech monitor.*, **13 n 1**, 42.
- Anonymous. 1996. Home Remedies. *Natural health*, **26 n 3**, 114.
- Anonymous. 1996. New Products. *Prepared foods*, **165 n 8**, 43.
- Arroyo-Renya, A., Hernandez-Arana, A. & Arreguin-Espinosa, R. 1994. Circular dichroism of stem bromelain: a third spectral class within the family of cysteine proteinases. *Biochemical journal*, **300 n 1**, 107.
- Arroyo-Reyna, A. & Hernandez-Arana, A. 1995. The thermal denaturation of stem bromelain is consistent with an irreversible two-state model. *Biochimica et biophysica acta, Protein structure*, **1248 n 2**, 123.
- Atse, Y. Evaluation of the first hybrids Cayenne x Perolera at the end of the selection process. *Acta Horticulturae*, **425**.
- Aubery, B. Pineapple production in the north of Martinique. *Acta Horticulturae*, **425**.
- Barbeau, G. & Marie, F. Pineapple production in the Spanish and English speaking Caribbean. *Acta Horticulturae*, **425**.
- Bartolome, A.P., Ruperez, P. & Fuster, C. 1996. Non-volatile organic acids, pH and titratable acidity changes in pineapple fruit slices during frozen storage. *Journal of the science of food and agriculture.*, **70**, 475.
- Bartolome, A.P., Ruperez, P. & Fuster, C. 1996. Changes in soluble sugars of two pineapple fruit cultivars during frozen storage. *Food chemistry.*, **56**, 163.
- Bartolome, A.P., Ruperez, P. & Fuster, C. 1996. Freezing rate and frozen storage effects on color and sensory characteristics of pineapple fruit slices. *Journal of food science.*, **61**, 154.
- Baur, X. & Fruhmman, G. 1979. Allergic reactions, including asthma, to the pineapple protease bromelain following occupational exposure. *Clin Allergy*, **9**, 443-50.
- Beardsley, J.W. 1993. The pineapple mealybug complex; Taxonomy, distribution, and host relationships. *Acta Horticulturae*, **334**, 383-386.
- Beaudreau, C. & Yasunobu, K. 1966. Heme proteins. VI. Crystalline pineapple peroxidase B. *Biochemistry*, **5**, 1405-12.
- Bello, A. S. (1989). El cultivo de pina (*Ananas comosus* L. Merr.) en la selva central del Peru y algunos estudios realizados para mejorar su tecnologia. In *Agronomy*, UNALM. Lima, pp. 118.
- Bello, A. S. (1991). El cultivo de la pina en la selva central del Peru. INIAA. 15, 46 pages.
- Bello Amez, S. & Julca Otiniano, A. (1994). *Determinacion del ciclo biologico de la "Broca de la Pina" (Thecla basilides Geyer) bajo condiciones de Chanchamayo - Peru*. Ministerio de Agricultura, Instituto nacional de Investigacion Agraria, Lima.
- Bello Amez, S. & Julca Otiniano, A. (1994). *Influencia de epocas de plantacion tipos de hijuelos e induccion floral en el crecimiento y desarrollo del cultivo de pina (Ananas comosus L. Merr.) cv 'samba' bajo*. Ministerio de Agricultura, Instituto Nacional de Investigacion Agraria, Lima.
- Bello Amez, S. & Julca Otiniano, A. (1995). *Influencia de la epoca de plantacion, tipo de material de propagacion e induccion floral en el crecimiento y desarrollo del cultivo de pina (Ananas comosus L. Merr.) cv. 'Cayena Lisa' bajo condiciones de la zona de Chanchamayo*. Ministerio de Agricultura, Instituto Nacional de Investigacion Agraria, Lima.
- Bello, S., Villachica, H. & Julca, A. Resistance of several pineapple clones to fruit borer *Thecla basilides* Geyer in Chanchamayo - Peru. *Acta Horticulturae*, **425**.
- Blood, F., Wright, M., Darby, W. & Elliott, G. 1966. Feeding of irradiated chicken, beef, and pineapple jam to dogs. *Toxicol Appl Pharmacol*, **8**, 241-6.
- Benega, R., Isidron, M., Arias, E., Cisneros, A., Companioni, L., Martinez, J. & Borroto, C.G. Plant regeneration from pineapple (*Ananas comosus* (L.) Merr.) ovules. *Acta Horticulturae*, **425**.
- Benega, R., Isidron Minez, J., Hidalgo, M. & Borroto, C.G. In vitro germination and callus formation in pineapple (*Ananas comosus* (L.) Merr.) hybrid seed. *Acta Horticulturae*, **425**.
- Benega, R., Isidron, M., Arias, E., Daquinta, M., Dominguez, Q., Borroto, C. G. & Hidalgo, M. Comparative study between two pineapple (*Ananas comosus* (L.) Merr.) cultivars. *Acta Horticulturae*, **425**.
- Bernasconi, B., Marie, F., Risede, J.M. & Mourichon, X. Fruitlet core rot and leathery pocket diseases of pineapple: pathogen quantification in a sample of farmers' fields. *Acta Horticulturae*, **425**.
- Bevenue, A., Ogata, J., Tengan, L. & Hylin, J. 1975. Mirex residues in wildlife and soils, Hawaiian pineapple-growing areas--1972-74. *Pestic Monit J*, **9**, 141-9.
- Boland, F., Blomquist, V. & Estrin, B. 1972. Chemical composition of Mexican pineapple. *J Assoc Off Anal Chem*, **55**, 200-1.
- Borland, A.M. & Griffiths, H. 1989. The regulation of citric acid accumulation and carbon recycling during CAM in *Ananas comosus*. *Journal of experimental botany*, **40 n 210**, 53.
- Bouwstra, J., Spoelstra, E., De, W. P., Leeftang, B., Kamerling, J. & Vliegthart, J. 1990. Conformational studies on the N-linked carbohydrate chain of bromelain. *Eur J Biochem*, **190**, 113-22.
- Burroughs, S. & Calloway, D. 1968. Gastrointestinal response to diets containing pineapple. *J Am Diet Assoc*, **53**, 336-41.
- Cabral, S. J. R. (1985). Caracterizacao e avaliacao de cultivares de abacaxi. *Inf. Agropec, Belo Horizonte*, **11**(130), 14-16.
- Cabral, J.R.S., de Matos, A.P. & Coppens D'Eeckenbrugge, G. Segregation with respect to fusariose, leaf colour and leaf margin type within the EMBRAPA pineapple hybridization program. *Acta Horticulturae*, **425**.
- Cha, J.-S., Pujol, C. & Kado, C.I. 1997. Identification and Characterization of a *Pantoea citrea* gene encoding glucose dehydrogenase that is essential for causing pink disease of pineapple. *Applied and environmental microbiology.*, **63 n 1**, 71.
- Chan, Y.K. Performance of new pineapple hybrids in g x e trials in Malaysia. *Acta Horticulturae*, **425**.
- Chan, Y.K. 1993. Recent advancements in hybridization and selection of pineapple in Malaysia. *Acta Horticulturae*, **334**, 33-44.
- Chongpraditnun, P., Luksanawimol, P. & Limsmuthchaiporn, P. 1996. Effect of chemical, organic fertilizers and trace elements application on nitrate content in pineapple fruit. pp. 229-241. In *International Conference on Tropical Fruits, Proceedings*, eds. S. Vijayasegaran, M. Pauziah, M. S. Mohamed & S. Ahamad Tarmizi, Vol. I, Malaysian Agricultural Research and Development Institute, Kuala Lumpur.
- Coppens d'Eeckenbrugge, G., M-F., D. & Van Miegroet, F. 1993. Fertility and self-incompatibility in the genus *Ananas*. *Acta Horticulturae*, **334**, 45-51.
- Coppens D'Eeckenbrugge, G., Bernasconi, B., Messiaen, B. & Duval, M.F. Incompatibility alleles as genetic markers to identify pineapple varieties. *Acta Horticulturae*, **425**.
- Coppens d'Eeckenbrugge, G., Leal, F. & Duval, M.F. 1996. Germplasm resources of pineapple. *Plant Breeding Reviews*, in press.
- Cote, F.X., Folliot, M. & Andre, M. 1993. Photosynthetic Crassulacean acid metabolism in pineapple: DIEL rhythm of CO₂ fixation, water use, and effect of water stress. *Acta Horticulturae*, **334**, 113-129.
- Cote, F., Domergue, R., Jourdan, I., Duval, M.F. & Malezieux, E. Micropropagation of local pineapples cultivars collected in the Amazonian region and the South Brazil. Interest of cryopreservation methods for this germ plasm conservation. *Acta Horticulturae*, **425**.
- Cote, F.X., Andre, M. & Folliot, M. 1989. CO₂ and O₂ Exchanges in the CAM Plant *Ananas comosus* (L.) Merr. Determination of total and malate-decarboxylation-dependent CO₂-assimilation rates; study of light O₂-uptake. *Plant physiology*, **89 n 1**, 61.

- Cunha, G. A. P. (1985). Inducao da floracao na cultura do abacaxi. *Inf. Agropec., Bela Horizonte*, **11**(130), 56-58.
- Dabeka, R., McKenzie, A. & Albert, R. 1985. Atomic absorption spectrophotometric determination of tin in canned foods, using nitric acid-hydrochloric acid digestion and nitrous oxide-acetylene flame: collaborative study. *J Assoc Off Anal Chem*, **68**, 209-13.
- Dalldorf, E.R. 1993. The effect of plant population and nitrogen fertiliser on growth, yield and fruit quality of Smooth Cayenne pineapple. *Acta Horticulturae*, **334**, 221-226.
- Dalldorf, D.B. 1993. Fungicidal control of *Phytophthora* species on Queen and Cayenne pineapples. *Acta Horticulturae*, **334**, 429-437.
- Daquinta, M., Cisneros, A., Rodriguez, Y., Escalona, M., Perez, M.C., Luna, I. & Borroto, C.G. Somatic embryogenesis in pineapple (*Ananas comosus* (L.) Merr). *Acta Horticulturae*, **425**.
- De Matos, A.P. & Costa, J.L. Patterns of diurnal and seasonal airborne spore concentrations of *Fusarium subglutinans* in a pineapple orchard. *Acta Horticulturae*, **425**.
- De Matos, A. P. & Mourichon, X. 1993. Development of resistance to infection by *Fusarium moniliforme* var. *subglutinans* in wounds of pineapple plantlets. *Acta Horticulturae*, **334**, 423-428.
- De Almeida, W.A.B., De Matos, A.P. & Souza, A. Effects of benzylaminopurine (bap) on in vitro proliferation of pineapple (*Ananas comosus* (L.) Merr.). *Acta Horticulturae*, **425**.
- Dickson, S.R. & Bickerstaff, G.F. 1991. Pineapple bromelain and protein hydrolysis. *Journal of biological education*, **25** n 3, 164.
- Dickson, S. & Bickerstaff, G. 1992. Properties of immobilised bromelain. *Biochem Soc Trans*, **20**, 23S.
- Doko, M.B., Basani, V. & Casadebaig, J. 1991. Preparation of proteolytic enzyme extracts from *Ananas comosus* (L., Merr, fruit juice using semipermeable membrane, ammonium sulfate extraction, centrifugation and freeze-drying processes. *International journal of pharmaceuticals*, **76** n 3, 199.
- Dominguez, Q., Pena, H., Exposito, L. A., Gonzales, R. & Martinez, T. 1993. Efecto de diferentes epocas de plantacion y peso de los vástagos en el rendimiento y calidad de la pinea cv. Espanola Roja. *Primer Simposio Latinoamericano de Pinicultura*, Cali, Colombia.
- Dominguez, Q., Velazquez, A.A., Pena, H., Exposito, L.A. & Gonzalez, R. Effect of different planting densities with and without black polyethylene cover in the pineapple (*Ananas comosus* (L.) Merr.) culture, cv. Red Spanish. *Acta Horticulturae*, **425**.
- Dominico, L., Montano, A. & Carballo, E. The quality losses of pineapple during their manipulation and transportation. *Acta Horticulturae*, **425**.
- Dominquez, Q., Gonzales, B.L., Borroto, C.G., Exposito, L.A., Gonzales, R., Rodriguez, Y. & Gonzales, J.L. Effect of magnetism application upon the shoot production in pineapple vitroplant in the multiplication phase. *Acta Horticulturae*, **425**.
- Dronawat, N., Stanley, R., Cobb, E. & Morita, K. 1966. Effect of feeding limited roughage and a comparison between loose and pelleted pineapple hay on milk production, milk constituents, and fatty acid composition of milk fat. *J Dairy Sci*, **49**, 28-31.
- Duval, M.-F. & Coppens D'Eeckenbrugge, G. 1993. Genetic variability in the genus *Ananas*. *Acta Horticulturae*, **334**, 27-32.
- Duval, M.F., Coppens D'Eeckenbrugge, G., Ferreira, R.F., Cabral, J.R.S. & Bianchetti, L. d. B. First results from joint EMBRAPA-CIRAD *Ananas* germplasm collecting in Brazil and French Guyana. *Acta Horticulturae*, **425**.
- El-Swaify, S.A., Zhang, J., Palis, R., Rose, C.W. & A., C.C.A. 1993. Erosion problems and conservation needs of pineapple culture. *Acta Horticulturae*, **334**, 227-239.
- Feffer, J. & Norton, R. 1976. Letter: Dissolution of phytobezoar using pineapple juice. *JAMA*, **236**, 1578.
- Ferreira, F.R., Cabral, J.R.S., Duval, M.F. & Coppens D'Eeckenbrugge, G. Occurrence and distribution of *Ananas* and *Pseudananas* in Brazil. *Acta Horticulturae*, **425**.
- Ferreira, F.R. & J.R.S., C. 1993. Pineapple germplasm in Brazil. *Acta Horticulturae*, **334**, 23-26.
- Firoozabady, E., Nicholas, J. & Gutterson, N. In vitro plant regeneration and advanced propagation methods for pineapple. *Acta Horticulturae*, **425**.
- Fitchet-Purnell, M. 1993. Maximum utilization of pineapple crowns for micropropagation. *Acta Horticulturae*, **334**, 325-330.
- Fournier, P., Bouffin, J. & Vanniere, H. Cultivation of pineapple Queen Victoria at a very high density in Reunion: Intra-plot variability. *Acta Horticulturae*, **425**.
- Freda, B. 1996. Hawaiian twists. *Pizza today*, **14** n 11, 30.
- Galan Saucó, V. & Cabrera Cabrera, J. Current status and prospects of the pineapple in the Canary Islands. *Acta Horticulturae*, **425**.
- Gonzales, R., Dominquez, Q., Exposito, L.A., Gonzales, J.L., Martinez, T. & Hidalgo, M. Effectiveness of eight strains of *Azotobacter* in the adaptation of pineapple vitroplants (*Ananas comosus* (L.) Merr.). cv Smooth Cayenne. *Acta Horticulturae*, **425**.
- Guillemin, J.P., Gianinazzi, S. & Gianinazzi-Pearson, V. Endomycorrhization of micropropagated pineapple (*Ananas comosus* (L.) Merr). *Acta Horticulturae*, **425**.
- Guong, V.T., Tinh, T.K., Trang, T.T. & Moi, L.T. Effect of phosphorus, lime and potassium fertilization on aluminum uptake and pineapple yield in acid sulphate soils in the Mekong Delta. *Acta Horticulturae*, **425**.
- Gutierrez, I.R., Perez, G. & Guevara, M.A. PIEX - An expert system to pineapple varieties classification. *Acta Horticulturae*, **425**.
- Harrach, T., Eckert, K., Schulze-Forster, K., Nuck, R., Grunow, D. & Maurer, H. 1995. Isolation and partial characterization of basic proteinases from stem bromelain. *J Protein Chem*, **14**, 41-52.
- Hartley, R. 1978. The lignin fraction of plant cell walls. *Am J Clin Nutr*, **31**(10 Suppl), S90-S93.
- Haruenkit, R. & Thompson, A.K. 1996. Effect of oxygen and carbon dioxide levels on internal browning and composition of pineapple (Smooth Cayenne). pp. 343-358. In *International Conference on Tropical Fruits, Proceedings*, eds. S. Vijayasegaran, M. Pauziah, M.S. Mohamed & S. Ahamad Tarmizi, Vol. I, Malaysian Agricultural Research and Development Institute, Kuala Lumpur.
- Hatano, K.-i., Kojima, M. & Takahashi, K. 1996. Solution structure of bromelain VI from pineapple stem: structural similarity with Bowman-Birk trypsin/chymotrypsin inhibitor from soybean. *Biochemistry*, **35** n 17, 5379.
- Hatano, K., Tanokura, M. & Takahashi, K. 1996. Tertiary structure comparison of bromelain inhibition VI from pineapple stem with bovine pancreatic trypsin inhibitor. *Proceedings of the Japan Academy. Series B, Ph*, **72** n 5, 104.
- Heckathorn, J. & Napier, A.K. 1996. Calabash: preserved pineapple. *Honolulu*, **31** n 2, 14.
- Heenkenda, H.M.S. Effect of plant density and establishment method on sucker promotion in 'Kew' pineapple by mechanical decapitation. *Acta Horticulturae*, **425**.
- Heenkenda, H.M.S. 1993. Effect of plant size on sucker promotion in 'Mauritius' pineapple by mechanical decapitation. *Acta Horticulturae*, **334**, 331-336.
- Heinrikson, R. & Kezdy, F. 1976. Acidic cysteine protease inhibitors from pineapple stem. *Methods Enzymol*, **45**, 740-51.
- Hepton, A. Problems of the pineapple industry from the point of view of the international companies. *Acta Horticulturae*, **425**.
- Hepton, A. & Ingamells, L. 1993. Pineapple plant and fruit growth and development in fertilized native soil and artificial root medium. *Acta Horticulturae*, **334**, 131-139.
- Hu, J.S., Sether, D.M. & Ullman, D.E. 1996. Detection of pineapple closterovirus in pineapple plants and mealybugs using monoclonal antibodies. *Plant pathology*, **45** n 5, 829.
- Hu, J.S., Sether, D. & Ullman, D.E. Mealybug wilt of pineapple: pineapple viruses and two-step treatment of pineapple crowns. *Acta Horticulturae*, **425**.

- Hu, J.S., Gonsalves, A., Sether, D. & Ulman, D.E. 1993. Detection of pineapple closterovirus, a possible cause of mealybug wilt of pineapple. *Acta Horticulturae*, **334**, 411-416.
- Iglesias, R. (1980). Influencia de la epoca de plantacion y peso de los hijos en el crecimiento de la pinea (*Ananas comosus* L. Merr.) var. Expanola Roja. *Cultivos Tropicales - La Habana ano*, **2**(3), 84-101.
- Iglesias, R. (1985). Influencia de algunos productos quimicos y momentos de aplicacion sobre la floracion de la pina (*Ananas comosus* L. Merr.) cv. Espanola Roja. *Cultivos Tropicales*, **7**(4), 47-55.
- Jaizme Vega, M.C. & Azcon, R. 1991. Effect of vesicular-arbuscular mycorrhizal fungi on pineapple [*Ananas comosus* (L.) Merr.] in the Canary Islands. *Fruits.*, **46 n 1**, 47.
- Julca-Otiniano, A. & Bello-Amez, S. (1993-1994). La "broca de la pina" *Thecla basilides* Gey. en la selva central del Peru. *Rev. per. Ent.*, **36**, 61-62.
- Kamphuis, I., Drenth, J. & Baker, E. 1985. Thiol proteases. Comparative studies based on the high-resolution structures of papain and actinidin, and on amino acid sequence information for cathepsins B and H, and stem bromelain. *J Mol Biol*, **182**, 317-29.
- Kehe, M., Gnonhou, P. & Adiko, A. Evolution of infestation of symphilids *Hanseniella ivorensis* and nematodes *Pratylenchus brachyurus* in pineapple cultivation in Cote d'Ivoire. *Acta Horticulturae*, **425**.
- Kim, H.-J. & Taub, I.A. 1991. Specific degradation of myosin in meat by bromelain. *Food chemistry.*, **40 n 3**, 337.
- Kinjo, K. 1993. Flowering habit of pineapple in Okinawa. *Acta Horticulturae*, **334**, 179-186.
- Kinjo, K. 1993. Inheritance of leaf margin spine in pineapple. *Acta Horticulturae*, **334**, 59-66.
- Ko, M. P. & Schmitt, D.P. 1993. Pineapple inter-cycle cover crops to reduce plant-parasitic nematode populations. *Acta Horticulturae*, **334**, 373-382.
- Lacoeuille, J.-J. (1984). Pineapple. In *Plant Analysis as a Guide to the Nutrient Requirements of Temperate and Tropical Crops*, eds. P. Martin-Prevel, J. Gagnard & P. Gautier, Lavoisier Publishing Inc. New York, Paris, pp. 600-623.
- Langworthy, J. & Maligro, D. 1987. Survey of occupational injuries on a large pineapple plantation during the harvesting season. *Hawaii Med J*, **46**, 52-55.
- Leach, P.L., Elder, R.J. & Newby, R. The relationship between the false spider mite (*Dolichotetranychus floridanus* (Banks) Acari: Tenuipalpidae), soil moisture and pineapple (*Ananas comosus*) crown growth. *Acta Horticulturae*, **425**.
- Leal, F. & Coppens d'Eeckenbrugge, G. 1996. Pineapple. In *Fruit Breeding. I. Tree and tropical fruits*, eds. J. Janick & J. N. Moore, Vol. I, Wiley and Sons New York, pp. 515-557.
- Leal, F. & Medina, E. 1995. Some wild pineapples in Venezuela. *Journal of the Bromeliad Society.*, **45 n 4**, 152.
- Leal, F. & Amaya, L. 1991. The curagua *Ananas lucidus*, Bromeliaceae crop in Venezuela. *Economic botany.*, **45 n 2**, 216.
- Lenarcic, B., Ritonja, A., Turk, B., Dolenc, I. & Turk, V. 1992. Characterization and structure of pineapple stem inhibitor of cysteine proteinases. *Biol Chem Hoppe Seyler*, **373**, 459-64.
- Liew, K.L. & Wagimen, B. 1996. Low input cultivation of pineapple on acid sulphate soil in Malaysia. pp. 279-285. In *International Conference on Tropical Fruits, Proceedings*, eds. S. Vijayasegaran, M. Pauziah, M. S. Mohamed & S. Ahamad Tarmizi, Vol. I, Malaysian Agricultural Research and Development Institute, Kuala Lumpur.
- Loeillet, D. The world pineapple market: the importance of Europe. *Acta Horticulturae*, **425**.
- Loison-Cabot, C. 1990. The characterisation, origin and validity of the groups defined the species *Ananas comosus*. *Fruits*, **45 n 6**, 559.
- Lommerse, J., Kroon-Batenburg, L., Kroon, J., Kamerling, J. & Vliegthart, J. 1995. Conformations and internal mobility of a glycopeptide derived from bromelain using molecular dynamics simulations and NOESY analysis. *J Biomol NMR*, **6**, 79-94.
- Lommerse, J., Kroon-Batenburg, L., Kamerling, J. & Vliegthart, J. 1995. Conformational analysis of the xylose-containing N-glycan of pineapple stem bromelain as part of the intact glycoprotein. *Biochemistry*, **34**, 8196-206.
- Lotz-Winter, H. 1990. On the pharmacology of bromelain: an update with special regard to animal studies on dose-dependent effects. *Planta Med*, **56**, 249-53.
- Maerere, A.P. Axillary buds development as it determines suckering in Queen Victoria and Smooth Cayenne pineapple. *Acta Horticulturae*, **425**.
- Malézieux, E. 1993. Dry matter accumulation and yield elaboration of pineapple in Cote D'Ivoire. *Acta Horticulturae*, **334**, 149-157.
- Marie Alphonsine, P., Moutoussamy, G. & Marie, F. Development of pineapple small farms in Martinique. *Acta Horticulturae*, **425**.
- Marie, F., Bernasconi, B. & Aumont, C. A methodology to survey the pineapple fruitlet core rot and leathery pocket diseases in Martinique. *Acta Horticulturae*, **425**.
- Marler, T.E. & Lawton, P.D. 1996. Photosynthesis and water relations of drought-stressed pineapple plants. pp. 81-87. In *International Conference on Tropical Fruits, Proceedings*, eds. S. Vijayasegaran, M. Pauziah, M.S. Mohamed & S. Ahamad Tarmizi, Vol. II, Malaysian Agricultural Research and Development Institute, Kuala Lumpur.
- Martin-Prevel, P. 1993. Network research on pineapple in and with the CIRAD-FLHOR. *Acta Horticulturae*, **334**, 467-471.
- Masson, M. 1995. Bromelain in blunt injuries of the locomotor system. A study of observed applications in general practice. *Fortschr Med*, **113**, 303-6.
- Maurer, H.R., Harrach, T. & Eckert, K. 1995. Isolation and partial characterization of basic proteinases from stem bromelain. *Journal of protein chemistry.*, **14 n 1**, 41.
- McCann, E. 1981. Of pillows and pineapple juice. *Am J Nurs*, **81**, 1354.
- Medina, E., Ziegler, H. & Francisco, M. 1994. Light conditions during growth as revealed by $\delta^{13}\text{C}$ values of leaves of primitive cultivars of *Ananas comosus*, an obligate CAM species. *Functional ecology.*, **8 n 3**, 298.
- Melendo, J.A., Beltran, J.A. & Roncales, P. 1996. Limited proteolysis of myofibrillar proteins by bromelain decreases toughness of coarse dry sausage. *Food chemistry.*, **57 n 3**, 429.
- Min, X.-j. & Bartholomew, D.P. 1996. Effect of plant growth regulators on ethylene production, 1-aminocyclopropane-1-carboxylic acid oxidase activity, and initiation of inflorescence development of pineapple. *Journal of plant growth regulation*, **15 n 3**, 121.
- Min, X.-J. & Bartholomew, D.P. Temperature affects ethylene metabolism and fruit initiation and size of pineapple. *Acta Horticulturae*, **425**.
- Min, X. & Bartholomew, D.P. 1993. Effects of growth regulators on ethylene production and floral initiation of pineapple. *Acta Horticulturae*, **334**, 101-112.
- Mitra, S.K. & Bose, T.K. Agrotechniques for quality improvement of pineapple cv. Kew in Terai region of West Bengal, India. *Acta Horticulturae*, **425**.
- Mohammed Selamat, M. & Abdul Rahim, M. 1996. The effect of Fruitone application on the yield and fruit quality of pineapple cv. Gandul grown on deep peat soil in Malaysia. pp. 311-315. In *International Conference on Tropical Fruits, Proceedings*, eds. S. Vijayasegaran, M. Pauziah, M. S. Mohamed & S. Ahamad Tarmizi, Vol. I, Malaysian Agricultural Research and Development Institute, Kuala Lumpur.
- Mohammed Selamat, M. 1993. A survey on the yield profile of pineapple cv gandul grown under high density planting on deep peat soil in Malaysia. *Acta Horticulturae*, **334**, 187-190.

- Mohammed Selamat, M. & Ramlah, M. 1993. The response of pineapple cv gandul to nitrogen, phosphorus, and potassium on peat soil in malaysia. *Acta Horticulturae*, **334**, 247-254.
- Mohammed, M. & Wickham, L.D. Biochemical changes and sensory evaluations in pineapple during storage at refrigerated and non-refrigerated temperatures. *Acta Horticulturae*, **425**.
- Mohanty, A.K., Misra, M. & Tripathy, P.C. 1996. CeIV-n-acetylglucine initiated graft copolymerization of methyl methacrylate onto chemically modified pineapple leaf fibres. *Polymer-plastics technology and engineering*, **35 n 3**, 403.
- Mohanty, A.K., Parija, S. & Misra, M. 1996. CeIV-n-acetylglucine initiated graft copolymerization of acrylonitrile onto chemically modified pineapple leaf fibers. *Journal of applied polymer science*, **60 n 7**, 931.
- Montes, C., Amador, M., Cuevas, D. & Cordoba, F. 1990. Subunit structure of karatsin, the proteinase isolated from *Bromelia plumieri* (karatas). *Agric Biol Chem*, **54**, 17-24.
- Morton, S., Eadie, T. & Llewellyn, G. 1979. Aflatoxigenic potential of dried figs, apricots, pineapples, and raisins. *J Assoc Off Anal Chem*, **62**, 958-62.
- Montilla, I. & Catayo, A. Effect of the association of crops and mulch on the production of pineapple (*Ananas comosus* (L.) Merr. at Lara State, Venezuela. *Acta Horticulturae*, **425**.
- Mootoo, A. & Henry, G. A survey of post-harvest handling practices for pineapples in Trinidad W.I. *Acta Horticulturae*, **425**.
- Mourichon, X. Fruitlet core rot (black spot) and leathery pocket: review and perspectives. *Acta Horticulturae*, **425**.
- Murachi, T., Tsudzuki, T. & Okumura, K. 1975. Photosensitized inactivation of stem bromelain. Oxidation of histidine, methionine, and tryptophan residues. *Biochemistry*, **14**, 249-55.
- Nguyen Minh, C. Pineapple production in the south of Vietnam: constraints and potentials. *Acta Horticulturae*, **425**.
- Noyer, J.L. & Lanaud, C. RFLP analysis of rDNA in genus *Ananas*. *Acta Horticulturae*, **425**.
- Obiefuna, J.C. & Asoegwu, S.N. 1993. Pineapple for ground cover management and erosion control in Southeastern Nigeria. *Acta Horticulturae*, **334**, 255-259.
- Ofori, F. Prospects and constraints of the pineapple industry in Ghana. *Acta Horticulturae*, **425**.
- Oleghe, P.E. & Fawusi, M.O.A. 1993. Effect of soil moisture potential and plant weight on early growth of pineapple (*Ananas comosus* (L.) Merr.). *Acta Horticulturae*, **334**, 141-148.
- Oleghe, P.E. & Fawusi, M.O.A. Growth and yield of pineapple as a function of planting material and soil moisture. *Acta Horticulturae*, **425**.
- Olesen, T.D. & Bailey, G.J. 1995. Acclimation of pineapples to nightlength. *Australian journal of plant physiology*, **22 n 3**, 387.
- Osseni, B., Sarah, J.L. & Hugon, R. Effect of soil ph on the development of *Pratylenchus brachyurus* Godfrey populations in pineapple roots and on the growth and yield of the plant. *Acta Horticulturae*, **425**.
- Ota, S., Muta, E., Katahira, Y. & Okamoto, Y. 1985. Reinvestigation of fractionation and some properties of the proteolytically active components of stem and fruit bromelains. *J Biochem (Tokyo)*, **98**, 219-28.
- Ota, S. 1966. On a minor component of proteolytic enzymes contained in the pineapple fruit. *J Biochem (Tokyo)*, **59**, 463-8.
- Owusu-Bennoah, E., Ahenkorah, Y. & Nutsukpo, D. Effect of different levels of N:K₂O ratios on the yield and quality of pineapple in forest-savanna ecotone of Ghana. *Acta Horticulturae*, **425**.
- Pan, T.M. & Lin, S.H. 1993. Studies on the utilization of immobilized papain or/and bromelain for beer chillproofing (In Chinese). *Chung-kuo nung yeh hua hsueh hui chih*, **31 n 1**, 106.
- Paull, R.E. 1993. Postharvest handling of Smooth Cayenne pineapple in Hawaii for the fresh fruit market. *Acta Horticulturae*, **334**, 273-285.
- Perez, G., Isidron, M., Arias, E. & Perez, S. Phenotypic, biochemical and cytogenetic characterization on pineapple plants obtained from somaclonal variation and mutagenesis. *Acta Horticulturae*, **425**.
- Perrier, X., Lacoëuilhe, J.J. & Malézieux, E. 1993. An expert system for pineapple disorder diagnosis. *Acta Horticulturae*, **334**, 197-204.
- Petty, G.J. & Tustin, H. 1993. Ant (*Pheidole megacephala* F.) - mealybug (*Dysmicoccus brevipes* Ckll.). Relationships in pineapples in South Africa. *Acta Horticulturae*, **334**, 387-395.
- Pinho, N.M., Zambolim, L., Maria, J. & Ventura, J.A. Protoplast isolation of *Ananas comosus* (L.) Merr. Cv. Perolera. *Acta Horticulturae*, **425**.
- Pinon, A. Pineapple in the Andin area. *Acta Horticulturae*, **425**.
- Rabie, E. Preplant control of nematodes in pineapple. *Acta Horticulturae*, **425**.
- Rabie, E. Lesions on pineapple fruit due to cracking between individual fruitlets. *Acta Horticulturae*, **425**.
- Rebolledo, A., Uriza, D.E., Rebolledo, L. & Aguirre, L.A. Ethephon as pineapple flowering inductor in Mexico's weather conditions. *Acta Horticulturae*, **425**.
- Rebolledo, A.M., Uriza, D.E.A. & Aguirre, L.A.G. Flowering inhibition in pineapple with different rates of Fruitone CPA on two planting densities. *Acta Horticulturae*, **425**.
- Rebolledo-Martínez, A., Mosqueda-Vazquez, K.R., Becerril-Roman, A.E., Rebolledo-Martínez, L. & Uriza-Avila., D.E. 1993. Growth analysis of Smooth Cayenne pineapple grown under four fertilizer rates in Veracruz, Mexico. *Acta Horticulturae*, **334**, 159-169.
- Reddy, M., Keim, P., Heinrikson, R. & Kezdy, F. 1975. Primary structural analysis of sulfhydryl protease inhibitors from pineapple stem. *J Biol Chem*, **250**, 1741-50.
- Reimer, N. J. & Gonzalez-Hernandez, H. 1993. Evidence for colony founding by haplometrosis in the big-headed ant, *Pheidole megacephala*. *Acta Horticulturae*, **334**, 397-405.
- Reyes, J.J. Premature flowering of pineapple (*Ananas comosus* (L.) Merr) cv Smooth Cayenne from two types of planting material with five planting dates in Loma Bonita, Oaxaca. *Acta Horticulturae*, **425**.
- Rhainds, M., Griers, G. & Morales, J.L. 1996. Oviposition deterrence in pineapple borer females (*Thecla basilides* Lepidoptera: lycaenidae). *Ecological entomology*, **21 n 1**, 105.
- Ritonja, A., Rowan, A., Buttle, D., Rawlings, N., Turk, V. & Barrett, A. 1989. Stem bromelain: amino acid sequence and implications for weak binding of cystatin. *FEBS Lett*, **247**, 419-24.
- Rivadeneira, C. & Cazon, M.I. Advances in the control of the pineapple fruit rot in the department of Santa Cruz, Bolivia. *Acta Horticulturae*, **425**.
- Rohrbach, K.G. Pineapple research and development in a world market. *Acta Horticulturae*, **425**.
- Rohrbach, K.G. 1993. Pineapple research and development strategic planning. *Acta Horticulturae*, **334**, 459-466.
- Rouge, B. Pineapple in West and Central Africa. *Acta Horticulturae*, **425**.
- Rowan, A. & Buttle, D. 1994. Pineapple cysteine endopeptidases. *Methods Enzymol*, **244**, 555-68.
- Salas, J. Fruit borer insect pests of pineapple in Venezuela: biology and damage. *Acta Horticulturae*, **425**.
- Sanches, F. N. (1985). A broca-do-fruto do abacaxi. *Inf. Agropec., Belo Horizonte*, **11**(130), 43-46.
- Sarah, J.L., Mesnildrey, L., Marguerite, E. & Boisseau, M. Laboratory screening of pineapple germplasm for resistance to the lesion nematode *Pratylenchus brachyurus*. *Acta Horticulturae*, **425**.
- Schneider, R.C., Green, R.E. & Apt, W.J. 1993. Management of drip-applied nematicides in pineapple. *Acta Horticulturae*, **334**, 351-360.

- Schneider, R.C., Sipes, B.S., Green, R.E., Schmitt, D.P. & Oda, C.H. Management of the fumigant 1,3-dichloropropene in Hawaii pineapple. *Acta Horticulturae*, **425**.
- Scott, C.H. 1993. The effect of two plant growth regulators on the inhibition of precocious fruiting in pineapple. *Acta Horticulturae*, **334**, 77-82.
- Selamat, M. The effect of plant density on the growth development, yield and fruit quality of pineapple cv Gandul grown on peat soil in the humid tropics of Malaysia. *Acta Horticulturae*, **425**.
- Selamat, M. The effect of size of planting materials on the growth, yield and fruit quality of pineapple cv. Gandul grown on deep peat soil in the humid tropics of Malaysia. *Acta Horticulturae*, **425**.
- Selamat, M. The current cultural practices of planting pineapple on tropical peatland areas in the humid tropics of Malaysia. *Acta Horticulturae*, **425**.
- Sherlock, J. & Smart, G. 1984. Tin in foods and the diet. *Food Addit Contam*, **1**, 277-82.
- Shiina, T., Ijiri, T., Matsuda, I., Ohoshiro, N., Sato, T. & Kawano, S. 1993. Determination of brix value and acidity in pineapple fruits by near infrared spectroscopy. *Acta Horticulturae*, **334**, 261-272.
- Silveira, E.T.F., Rahman, M.S. & Buckle, K.A. 1996. Osmotic dehydration of pineapple: kinetics and product quality. *Food research international*, **29** n 3/4, 227.
- Silverstein, R. & Kezdy, F. 1975. Characterization of the pineapple stem proteases (bromelains). *Arch Biochem Biophys*, **167**, 678-86.
- Sinclair, E.R., Wassman, R.C., Bartholmew, D.P., Broadley, R.H., Swete Kelly, D. E., Pegg, K. G., Waite, G. K. & Stirling, G. R. 1993. Pineapple pests and disorders - A book for pineapple farmers. *Acta Horticulturae*, **334**, 455-458.
- Sinclair, E.R. 1993. A computer-based farm-management package for pineapple farms. *Acta Horticulturae*, **334**, 191-196.
- Sinclair, E.R. 1993. Pineapple growth in Southeast Queensland. *Acta Horticulturae*, **334**, 171-178.
- Sipes, B. & Schmitt, D.P. 1996. Control of *Rotylenchulus reinformis* on pineapple with emulsifiable 1,3-dichloropropene. *Plant disease*, **80** n 5, 571.
- Sipes, B.S. & Schmitt, D.P. 1995. Evaluation of ethoprop and tetrathiocarbonate for reniform nematode control in pineapple. *Journal of nematology*, **27** n 4 supp, 639.
- Sipes, B.S. & Schmitt, D.P. Preplant and postplant pesticides for nematode control in pineapple. *Acta Horticulturae*, **425**.
- Sipes, B.S. Population behavior of reniform nematode in pineapple. *Acta Horticulturae*, **425**.
- Sison, C.M. & Mendoza, S.P. 1993. Control of wild sugarcane in pineapple on the Del Monte Philippines, Inc. Plantation. *Acta Horticulturae*, **334**, 337-339.
- Smith, L.G. 1993. Optimisation of fresh-market pineapple eating quality in Queensland. *Acta Horticulturae*, **334**, 287-294.
- Soler, A. West African pineapple quality. *Acta Horticulturae*, **425**.
- Soler, A. 1993. Enzymatic characterization of stress-induced translucence of pineapple flesh on the Ivory Coast. *Acta Horticulturae*, **334**, 295-304.
- Stirling, G.R. & Nikulin, A. 1993. Rational nematode management practices for the Australian pineapple industry. *Acta Horticulturae*, **334**, 341-349.
- Strydom, D. 1977. Homology of functionally diverse proteins. *J Mol Evol*, **9**, 349-61.
- Suhaila, M. & Safiah, A. K. (1993). Maintaining the colour, texture and vitamin C of cold stored pineapples through shrinkwrapping and surface coating with liquid paraffin. *Pertanika Journal of Tropical Agricultrual Sciences*, **16**(3), 201-208.
- Sulaiman, S.F.M. Impact of weed management on ant density and fruit yield in the control of the pineapple wilt disease. *Acta Horticulturae*, **425**.
- Suwunnamek, U. 1993. Effect of paclobutrazol, thiourea, and pendimethalin alone or in combination on the induction of suckering in pineapple. *Acta Horticulturae*, **334**, 83-99.
- Suwunnamek, U. & Lao-Sinwattana, C. Effect of paclobutrazol on pineapple growth. *Acta Horticulturae*, **425**.
- Swete Kelly, D.E. & Bagshaw, J. 1993. Effect of fruit handling and fruit coatings on blackheart (internal brown spot) and other aspects of fresh pineapple quality. *Acta Horticulturae*, **334**, 305-316.
- Szilagyi, S. & Szilagyi, E. 1978. Apparent sequence homology among leguminosae small molecular weight, cystine rich protease inhibitors and pineapple stem bromelain inhibitors. *Acta Biochim Biophys Acad Sci Hung*, **13**, 293-8.
- Taussig, S. & Batkin, S. 1988. Bromelain, the enzyme complex of pineapple (*Ananas comosus*) and its clinical application. An update. *J Ethnopharmacol*, **22**, 191-203.
- Tavares, J.F.P. & Silva, M. The pineapple in the Azorean Islands. *Acta Horticulturae*, **425**.
- Ting, K., Root, G. & Tichelaar, G. 1980. Gas-liquid chromatographic determination of bromacil residues. *J Assoc Off Anal Chem*, **63**, 43-6.
- Tomankova, O. & Kopecky, J. 1995. Prediction of feed protein degradation in the rumen with bromelain. *Animal feed science and technology*, **53** n 1, 71.
- Torres, C.Q. 1993. Control of pineapple diseases by bacterial antagonists. *Acta Horticulturae*, **334**, 417-422.
- Truong, N. T. Influence of the mode of bank construction on chemical properties and pineapple behavior in acid-sulfate soils of the Mekong Delta. *Acta Horticulturae*, **425**.
- Turnbull, C.G.N., Anderson, K.L., Shorter, A.J., Nissen, R.J. & Sinclair, E.R. 1993. Ethephon and causes of flowering failure in pineapple. *Acta Horticulturae*, **334**, 83-92.
- Ullman, D.E., Hu, J.S., Sether, D., Gonsalves, A., Williams, D.D.F. & Fleisch, H. 1993. Heat treatment of pineapple: subsequent growth and occurrence of mealybug wilt of pineapple. *Acta Horticulturae*, **334**, 407-410.
- Ventura, J.A., Zambolim, L. & Chaves, G.M. 1993. Integrated management system for pineapple Fusarium disease control. *Acta Horticulturae*, **334**, 439-453.
- Ventura, J.A., Zambolim, L. & Chaves, G.M. Tissue culture technique for rapid clonal propagation of pineapple cultivars. *Acta Horticulturae*, **425**.
- Verawudh, J. 1993. Effects of micronutrients on growth, nutrient content in D-leaf, and yield of pineapple. *Acta Horticulturae*, **334**, 241-245.
- Villachica, H. Black spots on pineapple fruits: galleries associated with *Melanolella canopilosum*. *Acta Horticulturae*, **425**.
- Villegas, V.N., Pimentel, R.B., Siar, S.V. & Barile, E.B. Preliminary evaluation of promising pineapple hybrids. *Acta Horticulturae*, **425**.
- Vizcarra, J.L., Del Angel, A.L., Uriza, D.E., Reyes, J.J., Rebolledo, A. & Mosqueda, V.R. Pineapple crop diagnostic in Los Robles, Veracruz, Mexico. *Acta Horticulturae*, **425**.
- Wakman, W., Thompson, K.G., Horlock, C.M., Teakle, D.S., Thomas, J.E., Dietzgen, R.G. & Scott, C. H. Newly discovered viruses infecting pineapple in Australia. *Acta Horticulturae*, **425**.
- Wills, R. B. H., Hassan, A. & Scott, K. J. 1985. Effect of storage time at low temperature on the development of black heart in pineapples. *Trop Agric*, **62**(3), 199-200.
- Wilson Wijeratnam, R.S., Abeysekera, M. & Surjani, S. 1993. Studies on black heart disorder in pineapple varieties grown in Sri Lanka. *Acta Horticulturae*, **334**, 317-324.
- Wilson Wijeratnam, R.S., Absesekere, M. & Hawajulige, I.G.N. Studies on the controlled atmospheric storage of Mauritius variety pineapples. *Acta Horticulturae*, **425**.
- Wilson Wijeratnam, R.S., Abeysekere, M., Hewajulige, I.G.N. & Suganthini, R. 1996. Studies on the black heart disorder, electrolyte leakage and endogenous calcium content in Kew and Mauritius variety pineapples grown in Sri Lanka. pp. 423-430. In

- International Conference on Tropical Fruits, Proceedings*, eds. S. Vijayasegaran, M. Pauziah, M.S. Mohamed & S. Ahamad Tarmizi, Vol. I, Malaysian Agricultural Research and Development Institute, Kuala Lumpur.
- Wolt, J.D., D.L., H., Batzer, F.R., Balcer, A.J.L. & J.R., P. 1993. Dynamics of nematicide distribution and degradation in soil subjected to long-term pineapple culture. *Acta Horticulturae*, **334**, 361-371.
- Yamada, F., Takahashi, N. & Murachi, T. 1976. Purification and characterization of a proteinase from pineapple fruit, fruit bromelain FA2. *J Biochem (Tokyo)*, **79**, 1223-34.
- Yao, N., Osseni, B. & Godefroy, J. Changes in a ferrallitic soil fertility previously under different types of fertilizers. Assessment of four cycles of pineapple cultivation. *Acta Horticulturae*, **425**.
- Youlin, T., Youchen, Z. & Xingjie, T. A study on factors of inducing blackheart in postharvest pineapples. *Acta Horticulturae*, **425**.
- Vilardebo, A., Guerot, R. & Sanogho, M. (1969). Tests insecticides avec *Dysmicoccus brevipes* Ckl. cochinille farineuse de l'ananas. *Fruits*, **21**(1), 5-18.
- Villachica, L., Bello, S. & Julca, A. (1991). Informe de dos anos del proyecto "mejoramiento del cultivo de pina en la amazonia del Peru". 16.
- Zee, F., Aradhya, M., Manshardt, R. & Sui, L. 1996. Utilization of isozyme markers for evaluation of tropical fruit and nut germplasm at the USDA/ARS Clonal Germplasm Repository. pp. 191-202. In *International Conference on Tropical Fruits, Proceedings*, eds. S. Vijayasegaran, M. Pauziah, M. S. Mohamed & S. Ahamad Tarmizi, Vol. I, Malaysian Agricultural Research and Development Institute, Kuala Lumpur.
- Zhang, J., Malézieux, E. & Bartholomew, D.P. ALOHA-Pineapple v.2.1: a computer model to predict the growth, development and yield of pineapple. *Acta Horticulturae*, **425**.
- Zhang, J. & Bartholomew, D.P. 1993. Simulation of pineapple growth, development, and yield. *Acta Horticulturae*, **334**, 205-219.
- Zhang, J. & Bartholomew, D.P. Planting density effects on growth and dry matter partitioning of pineapple. *Acta Horticulturae*, **425**.
- Zhou, Y.C., Tang, Y.L. & Tan, X.J. Mechanism of blackheart development induced by low temperature and gibberellic acid in pineapple fruit. *Acta Horticulturae*, **425**.
- Zhu, J., Bartholomew, D.P. & Goldstein, G. Effects of temperature, CO₂, and water stress on leaf gas exchange and biomass accumulation of pineapple. *Acta Horticulturae*, **425**.
- Zhu, J., Bartholomew, D. P. & Goldstein, G. 1997. Effect of elevated carbon dioxide on the growth and physiological responses of pineapple, a species with Crassulacean acid metabolism. *J. Amer. Soc. Hort. Sci.*, **122**, 233-237.◆

Directory of Professionals

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India

Sisir Mitra, B-8/30, Kalyani 741235, Nadia, West Bengal, India. Tel: 0091-33-828-407; Fax: 0091-33-824-460. **Education:** M.Sc. (Hort), Ph.D. (Pomology). **Expertise:** Agronomy of pineapple, mango and litchi; 18 years experience.

Sri Lanka

Romola Shanthi Wilson Wijeratnam, Manager, Post Harvest Technology Group, Ceylon Institute of Scientific and Industrial Research, 363, Baudhaloka Mawatha, Colombo 7, Sri Lanka. Tel: (94) 1-693-807-9; Fax: (94) 1-686-567; Email: shanthi@cisir.ac.lk. **Education:** Ph.D. **Expertise:** Post harvest management, fruits and vegetables, including control of black heart of pineapple. Bio Data in Pineapple Corresp. File.

United States

John F. Cykler, BS, MS, PE, Retired. 2816 140th Ave. N.E., Bellevue, WA 98005. Tel: 206-869-5521. **Experience:** 35 years in research, design, development of irrigation, field and processing machinery for pineapple, sugarcane, rice macadamia, forage grasses.

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