Pineapple News

I.S.H.S. Pineapple Working Group Newsletter
Volume I No. 2 March, 1995

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From the Editor

This is the first substantial issue of the Pineapple Newsletter. Many thanks to those who have contributed to this issue and supported the newsletter. This issue also includes semi-annual progress reports from researchers here in Hawaii. Most University of Hawaii researchers make such reports to administrators and members of the pineapple industry so they represent readily available material to keep readers up-to-date with what is being done in Hawaii. I plan to make these progress reports a regular feature of the newsletter. If others in the pineapple research community write progress reports to satisfy administrators or growers that can be made available to the public, I would very much appreciate receiving copies to include in the newsletter. It would help immensely if contributions to the newsletter could be sent as ASCII text files on floppy diskettes. If that is not possible, then crisply printed text suitable for scanning would be preferred. I am finding it very difficult to find time to type summaries of work myself. I don't have a secretary available to type in text most of the time. I will return diskettes with the next copy of the newsletter. Readers can also send material to me or requests for information by electronic mail using the email address at the end of this section.

What would you readers like to see in the newsletter? Are you satisfied with research reports? Would growers like to see management issues discussed in the newsletter? I visited Puerto Rico on my way to attend the 2nd International Pineapple Symposium and questions there indicated there might be interest in including practical information on crop management issues. The topics that immediately come to mind as a result of discussions I had with growers on the trip include selection of planting material both for superior performance as well as for uniformity of size, propagation methods, and nutrient management practices. I also fielded questions about weed control, an area I am not particularly familiar with. So please send me your contributions, suggestions, and questions for the next issue of the newsletter. The target month for the next issue is September, 1995.

Direct all correspondence related to Pineapple News to:

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2nd International Pineapple Symposium

The 2nd Pineapple Symposium was held in Fort de France, Martinique from February 20-24, 1995. Martinique is a beautiful place to hold a meeting because of the scenery and the people. The meeting was well organized and run and many interesting papers were presented. CIRAD-FLHOR scientists did an excellent job of organizing the meeting and finding support for scientists from countries not, or not well, represented at the 1st Symposium. I particularly enjoyed meeting people I had corresponded with over the last few years. One interesting challenge for the organizing committee and participants was a bank workers strike that made it difficult to obtain currency. Charge cards made it possible to pay for rooms and eat, but I suspect participants did not contribute to the local crafts industry to the extent they might have if money had been more readily available.

The meeting program shows there were 144 participants, though I think the count at the meeting was nearer 160. These people came from 41 countries, territories, or regions. Africa and Central and South America were quite well represented while South East Asia representatives, particularly the very large growers and canners from Indonesia, Philippines, and Thailand were mostly absent. The presentations began on Tuesday morning, February 21st and continued through Wednesday. On Thursday, participants had a chance to see the countryside as we traveled by bus to visit the Socomor Factory where pineapple, bananas, and other fruits are processed. Juice packaging and banana drying equipment were operating but the pineapple lines were closed. We then visited the Chalvet Mansion, the largest pineapple farm on the island. This modern and progressive grower rotates pineapple, sugarcane, and bananas to minimize pest problems on the farm. The grower had his equipment working in the field to show participants his pineapple crop management practices. After a wonderful lunch at Leyritz, an old sugar factory, we traveled to the Gradis Mansion, another large and progressive grower, to view fields and fruit disease study sites being monitored by CIRAD-FLHOR scientists. We then wound our way along the coast back towards Fort de France with an early evening stop and Clement Mansion where we learned about rum making and sampled some of their products and some excellent hors d'oeuvres. Oral and poster sessions were completed on Friday, followed by a wrap-up and some discussion about when and where to hold the next symposium. In the three days of formal meetings, about sixty six papers were presented in seven oral sessions and 33 posters were presented in five sessions.

Planning for the 3rd Symposium

Planning for the 3rd Symposium was only just begun at the meeting. A 3rd Symposium organizing committee consisting of Dr. Anthony Hepton, convener (Dole Foods, 5795 Lindero Canyon Road
West Lake Village, CA 91362), Dr. Y. K. Chan (Fruit Research Division, Malaysian Agric. Res. & Devl. Inst. (MARDI), P.O. Box 12301, General Post Office, 50774 Kuala Lumpur, Malaysia), Mr. Max Stephenson (Twin View Pines, Powell Road, Wamuran, Qld. 4512, Australia), Dr. Suranant Submadrabmandhu (volunteered by Dr. Pierre Martin-Prevel) (Department of Horticulture, Kasetsart University, Bangkhen 10900, Bangkok, Thailand), and Mr. Valentin Quiros Q. (Frutas Tropical Venecia S.A., P.O. Box 499-4050, Alejuela, Costa Rica). The committee was given the charge of identifying the site of the next symposium. The locations mentioned include Costa Rica, Malaysia, and Thailand. If readers have opinions about the location or time of the next symposium, I am sure the organizing committee would appreciate hearing from you. Some at the 2nd symposium thought that there should be

more than two years between meetings but no there was no discussion on the subject.◆

Pineapple News from Australia

Queensland Fruit and Vegetable Growers Pineapple Field Day

The Pineapple Industry Farm Field Day was held on 15 July, 1994. Scientific presentations in the a.m included:

The Role of Monitoring in Nematode Management by Graham Stirling, Principal Nematologist, Department of Primary Industries (DPI), Brisbane;

PINEMAN (a pineapple management program jointly developed by Golden Circle Canneries and DPI scientists) Comparisons Hit the Spot by Simon Newett, Extension Horticulturist, DPI, Nambour;

Update on the Fruit Nitrate Situation, Horticultural Staff, Golden Circle Ltd.;

Soil Conservation for Sustainable Pineapple Farming, Cyril Ciesiolka, Senior Soil Scientist, DPI, Toowoomba;

Quality Assurance for Pineapples, Margie Milgate, Economist,, Queensland Fruit and Vegetable Growers (QFVG), Brisbane;

1994-95 Marketing Promotion of Fresh Pineapples by QFVG, Ann Duggan, Retail Promotions Co-Ordinator & Nutritionist; and

Chemical Residue Monitoring in Fruit, Ian Walker, Senior District Inspector, Standards Branch, DPI.

During the lunch break, there was an opportunity to view posters on Conservation Farming, Mealybug Wilt Research, and PINEMAN. Videos on In-store promotion, PINEMAN, and Soil Conservation were also available for viewing and QFVG Product-educators were available to show how in-store pineapple promotions and product use demonstrations were done.

The afternoon program consisted of:

Density trials, Doug Christensen, Horticulturist, Golden Circle Ltd.;

Canning and Fresh Pineapple Breeding Update, Garth Sanewski, Senior Horticulturist, DPI, Nambour;

Cloche covers for Pineapples, Col Scott, Horticultural Manager, Golden Circle Ltd.; and

Phosphorus Nutrition, Eric Sinclair, Horticulturist, Golden Circle Ltd.◆

Summaries of Selected Presentations Follow

Role of Monitoring in Nematode Management

Three nematode scenarios prevail on Queensland pineapple farms; 1) nematodes are not economically important, 2) nematode populations can build up to the point where they damage the crop but can be controlled by fumigation, and 3) scenario 2 except that populations are not adequately controlled by preplant fumigation so post-plant nematicides must be used. More than one scenario can occur on a single farm and growers presently have no way of knowing which of the scenarios prevail on their farm so as a precaution, nematicides are routinely applied as a precautionary measure. Economic and community pressures will dictate that pineapple growers apply chemicals only when nematode population densities are high enough to indicate that economic losses are likely. Sampling should be done: 1) at the end of the ratoon crop to estimate the potential for damage to the next crop (if population is high, a longer fallow period could be used); 2) prior to planting to determine the need for pre-plant fumigation; 3) 12 months after planting (in southern Queensland, nematodes are first detected about this time) to determine if nematicides should be used post-planting and 4) at plant crop harvest to determine whether the nematode population is high enough to justify applying a nematicide after the harvest. Sampling for nematodes needs to be done systematically the author recommended taking at least 50 and not more than 100 cores from each 0.5 to 0.75 ha area. The cores would be bulked, thoroughly mixed, and subsampled for extraction. Preliminary data suggests that when rootknot nematode populations exceed 10 per sample, ratoon yields begin to decrease dramatically and the yield can be reduced approximately 60% when populations exceed 100 per sample. Costs of a nematode monitoring program were estimated at $160 ($40 per sample times four samples) for a 0.6 ha field. Benefits could include: 1) saving of $560 for nematicide if monitoring shows no nematicide is needed; 2) a net return of $300 to $2000 due to increased production if monitoring indicates nematicides should be used; and 3) the satisfaction of knowing that nematodes are not causing undetected losses, or that nematicides are not being applied unnecessarily.◆

PINEMAN

PINEMAN offers growers an opportunity to contrast the profitability or efficiency of their farm with an average for groups of other similar farms. Growers complete and send an input sheet to Mr. Simon Newett, DPI, Nambour, once a year and comparisons are returned to them postage paid. A "top grower" profile comprised of the average performance of the top four participating growers is available to farmers to use as a performance indicator. All data are kept confidential and industry-wide data are not published. (Editors Note: This interesting computer software package was developed by Golden Circle Ltd. and Queensland DPI scientists. It seems most appropriate for extension specialists and consultants rather than for individual farms. If you are interested in its availability, you should write to Mr. Newitt at Maroochy Horticultural Research Station, P.O. Box 5083, SCMC, Nambour, Qld. 4560, Australia.)◆

Nitrate Trials

Three large experiments were established on grower farms to examine the effect of nitrogen applications on plant growth, leaf and fruit nitrate levels, and fruit weight and yield. Detailed methods of the studies were not provided so there was no information on method and frequency of fertilizer application or type of nitrogen fertilizer used. Plant density was approximately 57,300 plants ha^{-1}. In the three experiments, combinations of pre- and post-planting applications of nitrogen fertilizer were applied to the plant crop; post-planting applications were made "early" (from planting to approximately 8 months) and "late" (from approximately 8 months up to and including flower induction) during vegetative growth. From 0 to 330 kg ha^{-1} of fertilizer was applied preplant. "Early" applications ranged from 50 to 800 kg ha^{-1} while "late" applications ranged from 40 to 900 kg ha^{-1} and total nitrogen applied in the treatments ranged from 300 to 1915 kg N ha^{-1}.

Low and very high levels of nitrogen fertilizer can reduce plant growth and fruit weight. Sampling of sections of the leaf from basal white to various portions of the green leaf showed that leaf nitrate levels decreased from base to tip and nitrate in the basal white tissue was approximately proportional to N applied. Leaf nitrate levels in the basal white tissue five months prior to induction of fruiting ranged from 1158 to 4113 mg kg^{-1} (ppm, wet weight basis assumed). It was concluded that there is no benefit to sampling a separate tissue for the determination of N in leaf tissue, since differences between white and green tissues were small and inconsistent. Levels of nitrate N in the leaf basal white tissue mirror different levels of nitrogen fertilization only if very low amounts of applied N are compared to medium or high amounts. Nitrate in the basal white tissue decreased with increasing plant age and decreased further as temperatures decreased with the onset of winter. Decreases occurred despite increasing applications of N. Although increasing the amount of applied N increased nitrate levels in fruit, nitrate N levels at all sampling times were not correlated with juice nitrate levels. Mean yields in the three tests ranged from 61.9 to 118.6 tons ha^{-1}. Differences among the treatments varied with the experiment and are not easily explainable. The highest yields were obtained when 500 to 600 or more kg N ha^{-1} were applied and when the fertilizer was split between early and late applications or was all applied late.

It was concluded that leaf nitrate measurements were of limited use as an aid in managing the crop. Growers were encouraged to keep accurate records of nitrogen applications and pay careful attention to plant color, the widely accepted index of nitrogen deficiency.◆

Soil Conservation for Sustainable Pineapple Production.

Detailed instructions were provided to permit calculation of erosion losses using the Universal Soil Loss Equation (USLE). The equation is:

A = RKLSCP where:

A = Acceptable soil loss in t ha^{-1} (10 t ha^{-1} year^{-1} = approximately 1.0 mm depth of soil per year).

R = Rainfall Factor = Erosivity of rain which is calculated using rainfall intensity and duration as measured by a pluviometer.

K = Erodibility Factor = Erodibility of soil based on particle or aggregate size distribution, soil texture, organic matter and permeability.

L = Slope Length Factor = The catchment area contributing runoff; this factor increases as slope length increases. Thus volume of runoff and its stream power increases with slope length.

S = Slope Angle Factor = Increases in slope steepness have been associated with greater soil erosion due to higher flow velocities of runoff water and effects of gravity.

C = Cover Factor = Any material that intercepts rainfall or retards flowing water is cover. Natural cover comprises all types of organic material or stones located on the soil surface.

P = conservation Factor = Conservation structures and field operations that retard runoff such as contour cultivation.

Studies were conducted on two farms to determine the erosion potential of lands with different slopes planted to pineapple and tables were provided to permit calculation of soil erodibility. With all other factors held approximately constant, erosion losses ranged from 213 to 1.02 due to changes in soil cover.◆

Performance of High Density May Plant Crop for Different Graded Planting Material. Test No. 722.

Plant population densities of 62,500 (I), 69,400 (II), 78,100 (III), 82,500 (IV), and 93,700 (V) plants ha^{-1} (25,000 to 38,000 per acre) and large (201 ±27 g), medium (175 ±30 g), small (115 ±25 g) and mixed (159 ± 39 g) crown sizes were used in the experiment. Spacing between two-row beds (center to center) was approximately 1.05 m and width between rows on the bed was 0.35 m. Within-row spacing was 0.30, 0.27, 0.24, 0.22, and 0.20 m. The experiment was planted August, 1992, induced on October 1993, and harvested in May, 1994. Problems encountered included a dry spring, which slowed establishment, and an intense rain that eroded soil, exposing roots. It was noted that such problems are often encountered by growers. The crop was managed according to conventional farm practice. At 12 months after planting, plant mass declined with increasing density from 2.7 to 2.1 kg; total plant mass per unit area in tons ha^{-1} was estimated to be 167 for I, 179 for II, 203 for III, 204 for IV, and 197 for V. At induction, leaf nutrients in all treatments were at good levels and ranges were, in mg kg^{-1} fresh weight, P, 230 to 251; K, 2900 to 3100; Ca, 172 to 198; and Mg, 277 to 307. The same amount of fertilizer was used for all treatments and there were no significant effects of density on nutrient levels. The author emphasized that nutrient requirements change with plant mass per unit area rather than with planting density. Fertilization apparently was adequate to meed the requirements of a 22% greater plant mass per unit area at the higher densities. Although average fruit mass for crown treatments ranged from 1.64 (115 g crown mass) to 1.71, no differences were significant. Average fruit mass for planting density treatments I to V (see above) was 1.76, 1.79, 1.71, 1.63, and 1.56 (LSD 5% =0.14 kg). Percentage undersize fruit for canning (not stated but apparently fruit weighing <1.7 kg) for treatments I - V was 13, 17, 22, 24, and 27 (LSD 5% = 7). Even though total tons of fruit increases with increasing planting density, yields of cannery-grade fruit were similar for all but the lowest density. Small crowns yielded significantly less per unit area than did larger crowns. (Editor's note: Growers should plan to adjust the length of the vegetative growth period to compensate for differences in size of planting material. Assuming uniform treatment and growing conditions, plant mass at some fixed time after planting is directly proportional to the mass of material planted. Thus, large planting material reaches a suitable size for forcing sooner than small planting material.) Data on differences in crown abnormalities and harvest date in the different treatments were collected but were not reported in the paper.◆

Fresh Market Pineapple Breeding Program

(See below)◆

Cloche Covers

Cloche covers consist of clear plastic sheeting that is rolled over the top of plants and anchored by tying down with the leaves of plants. These covers form a "glasshouse" over plants and raise temperature and humidity during colder winter months and may also provide frost protection. In a trial, the major difference due to cover was a 0.22 kg higher average fruit weight compared with uncovered plants. Fruit on covered plants had squarer "shoulders" and flatter eyes. Covers should not be left on after temperature begins to rise.

Phosphorus Nutrition

The primary purpose of the study was to examine the suitability of a number of phosphorus-containing materials for foliar application. It was stated that one should not attempt to meet plant phosphorus (P) requirements by foliar application of P, but foliar sprays can help meet plant requirements when leaf tissue levels are low. Mono- and di-ammonium phosphate (MAP, DAP) are suitable sources for foliar application, if available. In Australia, these materials are available only as coated granules, which cannot by applied by foliar spray. In the study, a 0-P check was compared with pre-plant DAP followed by industrial-grade phosphoric acid (concentration of solution not given but the pH was 2.7), MAP, or one of a number of soluble materials containing P (not mentioned here because only trade names were provided). Four foliar applications of 15 kg P ha^{-1} were applied in November, February (1 each) and September (2 applications). Leaf P was higher at 200 mg kg^{-1} fresh weight in leaf basal tissue using phosphoric acid than with other materials in early stages of the test but similar after 11 months. Differences in average fruit weight and yield were small, but the highest yield was obtained with phosphoric acid. It was concluded that phosphoric acid produced the best results at least cost but some minor injury was noted on plant leaves and the low pH could corrode spray equipment and cause compatibility problems if applied with other chemicals.◆

Development of a Transgenic Blackheart Resistant Pineapple

This physiological disorder is estimated to cost the Queensland pineapple industry about $2.6 million/year. Since most growers produce for the cannery and for the fresh fruit market, it is reported to be essential that new blackheart-resistant selections of pineapple retain the characteristics of Smooth Cayenne. The objective of the project, if funded, would be to directly inhibit the enzyme(s), specifically polyphenol oxidase, associated with injury expression using anti-sense gene constructs. The work will be done in collaboration with scientists in Malaysia and will require 6 to 8 years to complete.◆

Mealybug Wilt of Pineapple

The symptoms and cause of mealybug wilt are described. It is stated that a closterovirus, probably the same as the pineapple closterovirus (PCV) found in Hawaii, has been found in virtually all tested plants of the Hawaii-developed hybrid 53-116, Smooth Cayenne clones 10, 13, 30, and F-180 and in Queen, whether the plants were wilted or healthy. The virus has also been detected in plants from Taiwan, Brazil, Malaysia, and France. In clone 10 and 53-116, the concentration of PCV particles was much higher in roots than in leaves, crown, or fruit. Heat treatments using conditions reported from Hawaii failed to eliminate PCV from pineapple crowns. A pineapple bacilliform virus (PBV), not reported elsewhere in the world at the time the report was printed, was found in some plants of clones 53-116, 10 and Queen. Most bacilliform viruses are mealybug-transmitted, as are some members of the closterovirus group. Tests are underway to establish whether PBV and PCV are transmitted by mealybugs and their role in mealybug wilt.◆

Borax or Solubor for Ethrel Induction?

The objective of adding a boron-containing compound to an Ethrel solution is to raise the pH and increase the speed of Ethrel degradation to ethylene. Since borax improves the effectiveness of induction of flowering when induction is difficult, it is assumed that a rapid release of ethylene accounts for the improved effectiveness of Ethrel during these times. Borax also supplies boron, which reduced fruit defects where soil levels are too low to meet plant requirements. Borax (10% B) and solubor (20% B) are equally effective in raising the Ethrel solution pH. For summer forcing in Australia, 2,500 to 3,000 liters of a solution containing 0.5% borax or 0.25% solubor, 5% urea, and 2.5 L Ethrel are applied per ha. Growers were cautioned that for ripening of fruit, 2.5 liters per 1,000 liters of water with no urea or borax added are applied per hectare.◆

F180 - Is it a Better Ratooner Than Qld Clones?

The Smooth Cayenne clone F-180 was compared with Queensland clones C13, C15, C30, C33, C34, C39, and C40. Plant crop yields of the clones were not significantly different. Ratoon and total (plant crop plus ratoon) yield of C13 was significantly less than for the other clones. Clone C30 had a lower yield that many of the clones but the difference was not significant. It was concluded that F-180 was not superior to most of the Queensland Smooth Cayenne clones in producing ratoon crops.◆

The Australian Fresh Market Pineapple Breeding Program

G. M. Sanewski, Queensland Department of Primary Industries, Maroochy Horticultural Research Station, PO Box 5083 SCMC, Nambour, Qld. 4560. Australia.

The Australian pineapple fresh market is supplied predominately with Smooth Cayenne. Small, almost insignificant quantities of the Queen type are marketed in the winter period. While Smooth Cayenne produces high yields and is ideal for canning, it has several major quality problems with respect to its use as a fresh market fruit, particularly in the winter period.

Winter fruit is high in acid (1.20 to 1.60 % citric acid equivalent), low in sugars (8 to 12%) and prone to internal browning (blackheart). It is this poor and variable eating quality that is undoubtedly the most serious constraint to the further development of the Australian fresh pineapple market. A new cultivar, selected specifically for the fresh market, is an essential requirement for a successful fresh market.

The Australian pineapple breeding program is moderate to small by world standards with a target population of 50 000 seedlings. The program relies heavily on advanced hybrids from other breeding programs for use as parental material. The Hawaiian PRI hybrids 53-116 and 73-50 have been used extensively, either together or back crossed to Cayenne. Other parents used, but to a lesser extent, are Queen, Perolera and the fusarium and phytophthora resistant PRI hybrid 59-656.

The cultivar 73-50 is close to what the program hopes to achieve except it is susceptible to blackheart, is slightly high in acidity and has a tendency to go translucent very quickly. 53-116 is our only parent with demonstrated blackheart resistance.

The breeding program is in its fourth year and the first series of selections have commenced.

Clonal Selection Program for Canning Pineapple

In addition to our fresh market pineapple breeding program, DPI also maintains a clonal selection program for canning pineapple. This program has been on-going for over 25 years and has produced our predominant clones.

Initially the program aimed to establish specific clones from field run plantings. This was hugely successful. The program now concentrates on re-selecting from these established clones. Re-selection of old clones is necessary to avoid proliferation of inferior off types. This program has been extended to include the Hawaiian clone F180.

The main improvements have been in elimination of basal knobs, reduction in slips and an increase in fruit size. In the future we hope to extend the criteria to include early maturing types. It is expected our clonal selection program will continue at a low level for many years.◆

Pineapple Research Projects in Australia

Funding: (A) provided by Pineapple Sectional Group Committee/Horticulture Research & Development Corporation, and organisations mentioned below. (As of 18 Jan 1995)

FR112 Breeding new fresh market pineapple cultivars. Mr. Garth Sanewski, Qld Department of Primary Industries - $11,000

FR214 Chemical control for symphyla in pineapple. Mr. G.K. Waite, Qld Dept Primary Industries

FR217 Management of nematodes in pineapples. Dr. G. Stirling, Qld Dept Primary Industries. $10,000

FR304 Selection of superior smooth cayenne clones. Mr. G. Sanewski, Qld Dept Primary Industries. $4,000.

FR322 Detection and control of mealybug wilt. Dr. J.E. Thomas, Qld Dept Primary Industries. $27,000

FR407 Management analysis services for growers. Mr S. Newett, Qld Dept Primary Industries. $4,000

FR424 Manipulation of flowering physiology in pineapple. Mr. G. Sanewski, Qld Dept Primary Industries.

(B) University of Queensland. Developing the sub-systems required for mechanical harvesting of pineapple. Mr. Michael Buchanan, Mechanical Eng. Dept. Special Project Grant QDPI, MSc/PhD

(C) Central Queensland University, Rockhampton. Pineapple Red Mite Studies. Dr. Newby. $20,000

Assessment of Fruit Quality using IR methods. Dr. K. Walsh, $35,000

Nutrient Trials in Central Queensland soils. Dr. K. Walsh, $5,000

Flower and Fruit Synchronisation using hormones. Mr C. Scott, Golden Circle

(D) Golden Circle Ltd. Research into any aspect of pineapple culture and management and processing as problems arise. Salary and support for various horticulturalists and chemists.◆

Mealybug Wilt and Viruses of Pineapple in Queensland

John Thomas, Principal Plant Pathologist, Queensland DPI, Plant Pathology Building, DPI, 80 Meiers Rd, Indooroopilly, Qld., Australia

Project Objectives:

1) To develop diagnostic tests for viruses of pineapple, based on monoclonal antibodies, cDNA probes or PCR.
2) To investigate the role of viruses in mealybug wilt disease.
3) To determine the success of heat therapy and tissue culture in eliminating viruses from planting material and assessing possible beneficial effects on productivity.

Progress Report:

Two types of particles have been found in both mealybug-wilt affected and asymptomatic pineapple leaves. Closterovirus-like particles were present in most, if not all, samples and bacilliform particles were also occasionally found.

A rabbit polyclonal antiserum trapped and decorated closterovirus-like particles (1700-1900 nm long) in immunosorbent electron microscopy (ISEM). In some leaf samples, decorated and undecorated closterovirus-like particles were present, indicating the presence of more than one virus.

Bacilliform particles measuring 33x133 nm also reacted in ISEM with our pineapple virus antiserum and antisera to several other badnaviruses. Degenerate primers were designed from conserved sequences of other badnaviruses and used in PCR. Using partially purified virus preparations, a 448 bp DNA fragment was amplified from a region in the reverse transcriptase and ribonuclease H genes. The PCR product was cloned and sequenced and shown to be distinct from other published badnavirus sequences. It has been labelled with digoxigenin for use in dot blot hybridisation.

Heat therapy, tissue culture and seed transmission experiments are underway to explore the feasibility of virus elimination from pineapple clones.

Funding: This research has been funded by the Australian International Development Assistance Bureau, the Horticultural Research and Development Corporation, Golden Circle Ltd. and the Queensland Fruit and Vegetable Growers.

Research Staff:

In addition to Dr. Thomas, others involved in the project include:

Dr. Ralf Dietzgen, Senior Plant Pathologist, DPI-QABC, Gerhmann Laboratories, University of Queensland, Brisbane, Q 4072.

Dr. David Teakle, Department of Microbiology, University of Queensland, Brisbane, Q 4072.

Graduate students

Mr. Wasmo Wakman, PhD student (completed December 1994)

Ms. Karen Thomson, PhD student (current)

Ms. Christine Horlock, PhD student (current)

(The above material was provided by Dr. Eric Sinclair, Golden Circle Ltd. and transmitted via electronic mail by Steve Underhill, QDPI Hamilton Laboratory.)◆

Pineapple News From Cuba

Marcos Daquinta (Republica no. 431, ciego de Avila 3, Cuba 65300) reports that:

Fitotek Investigates the Plant Bioreactor: A Challenge to Increase Market Share. Fitotek found that the total number of harvestable pineapple plantlets from one 10-L bioreactor vessel is 3,400 (generated from 32 initial shoots). Source: Biolink 2/1:1-3/. (Other material was received from Cuba but there was no time to include it in this issue of the newsletter.)◆

Pineapple News from France

The Fresh Pineapple Market in Europe
The world's largest importer

Extract from the monthly Journal FruiTrop, issue No 1. Publication of the Observatoire des marchés, CIRAD-FLHOR

Fresh pineapple - the second major tropical fruit imported into Europe after banana - is very much in the news at the beginning of 1994. There has been a series of production reorganisation announcements (see the second Close-Up article) and considerable media coverage of consumption.

The 1992 world pineapple production was up by 2% at about 10.5 million tonnes. Nearly two-thirds of production is in Asia, in particular in Thailand, the Philippines, China, India and Vietnam. Kenya, the leading African producer, is only in tenth position ahead of Côte- d'Ivoire. Africa supplies only 12% of world production - in fourth position after Asia (60%), Central America (14%) and South America (13%).

Four-fifths of processed pineapple production (juice and canned products) are shipped from Thailand and the Philippines. Three countries stand out in the world fresh pineapple market: the Philippines, Côte d'Ivoire and Costa Rica. Between them, they account for nearly two-thirds of world trade, estimated by the FAO to total 620 000 tons and $US 200 million.

The European Union - the largest import market in the world

The EU, which probably handled over 200,000 tonnes in 1993, is the largest fresh pineapple import market in the world. France alone takes 30% of this, followed by Germany, Italy and Spain.

Pineapple consumption mode is typically exotic today with peaks at Christmas and the New Year and at Easter. Consumption is at its lowest in the summer. The 12-month distribution pattern has remained practically unchanged over the years. However, distribution has changed completely. Hypermarkets and supermarkets have increased their share of sales of fruits and especially of pineapple. Over 60% of the pineapple sales to French shoppers in 1992 took place in large and medium-sized stores. This has increased constraints in terms of homogeneity, price stability and efforts in promotion. African production has not been able to meet these requirements and, as a result, pineapples have not had the importance that they merit in hypermarkets and supermarkets.

Strong fall in price

Another important change on the pineapple market has been the price of fresh fruits at import stage. This has fallen considerably in recent years. Significant falls in price of nearly F 0.30 per kg have been observed in France, the leading European market. The main causes of this weakening include a considerable decrease in fruit quality, disorganised marketing and extremely strong pressure from Central American pineapples.

Côte d'Ivoire: a giant with clay feet

Development of the fresh pineapple market in Europe is closely linked to that of pineapple growing in Côte d'Ivoire, which has been the leader on the European market since the 1960s. Nevertheless, its influence has tended to wane since 1985, as can be seen from the pattern of European pineapple imports since 1970. 1986 marked the start of serious difficulties for Côte d'Ivoire pineapples. Growth of the European fresh pineapple market was directly linked with an increase in Côte d'Ivoire exports until 1985. Subsequently, especially after the collapse in 1988, Europeans started importing from other sources. In 7 years, Côte d'Ivoire's share in EC fresh pineapple imports fell from 92% (in 1985) to 53% (in 1992). The weakening of Côte d'Ivoire's position is set against a background of strong movement of the EC market. Average increase in growth has been 10% per year since 1988. What other market for fruits can boast such performance today ?

With the weakening of Côte d'Ivoire, market shares have gone to Central American and Caribbean sources which possess the production, marketing and promotion structures of multinational fruit companies. Costa Rica, Honduras and the Dominican Republic increased their market share by a third to 39% between 1988 and 1992.

Green pineapple and the European consumer: a marriage of reason

The European fruit sector has several images of Côte d'Ivoire pineapples: comparatively high price, considerable variation in quality, too large a gap between physiological ripeness of fruits and skin colour caused by over-use of ethephon.

In this context, the green pineapples grown in the West Indies and Central America benefit from numerous comparative advantages such as relatively low price, the efficient distribution channels of multinational fruit companies, considerable promotion back-up, tariff preferences due to trade agreements between producer countries and the European Union and steady quality.

The multinationals are using the handicaps of Côte d'Ivoire to promote their green pineapples. Advertising campaigns are very revealing on this point - and in particular in their attacks on poor use of ethephon. This harmless cultural practice is nevertheless necessary for optimum crop management. The campaigns also play on a new consumer trend. The 'natural' or even 'organic' criterion and the taste aspect play a considerable role once again in the behaviour of European households.

European consumers resist

In spite of considerable promotion and efforts at all stages of marketing, the multinationals are finding it difficult to place their produce on a large scale. European consumers are only moderately attracted and still have a 'coloured pineapple' reflex. Nevertheless, the European market should not be left vacant for too long as this would allow Latin American producers to continue to progress.

The entire African production and exporting sector must reconquer - first and foremost through quality - the market in northern Europe, the main segment attracted by green fruits. Coloured pineapples have to regain their traditional natural outlet. **Denis Loeillet, CIRAD-FLHOR◆**

Pineapple Program in CIRAD-FLHOR

The research center is located at Avenue du Val de Montferrand, BP 5035, 34032 Montpellier cedex 1, France (phone 33 67 61 58 00; fax 33 67 61 58 71). The department conducts research and provides technical/economic support to promote the development of fruit and horticultural product sectors in tropical and Mediterranean zones. The main focuses of CIRAD-FLHOR are genetic resources, biotechnology, crop and environmental protection, production systems, and agro-industrial processing of products and marketing. **Production research** is focused on: a) choice of species and varieties, b) production and quality improvement, c) development of techniques adapted to different cropping systems, d) productivity optimization and forecasting, and e) variety diversification and creation, disease resistance. **Food industry** topics include: a) development of new processing techniques, b) agroindustrial evaluation of new species and varieties, and c) studies on new industrial product-enhancement techniques. Emphases in the area of distribution and consumption include: a) better choice of new fruit and fruit qualities, and b) development of reliable marketing techniques for fresh products. There is also an active program on **enhancing environmental biodiversity and maintenance** that includes characterization, management and development of wild fruit germplasm from the Andes and Amazon regions.

The program has broad scope with activities in many countries in Africa, Latin America, the Caribbean, Southeast Asia, Indian Ocean and French overseas departments and territories, including Martinique, Guadeloupe, Reunion and New Caledonia. Partnerships have been established with scientific organizations in France and Europe and with many foreign organizations. These many collaborative activities lead to projects conducted jointly with development agents including development companies, producer groups, private partners, agroindustries, etc.◆

Pineapple News from India

Dr. Sisir Mitra, B-8/30, Kalyani-741235, Nadia, West Bengal, India, provided information on production of pineapple in India (Table 1) and some of the research topics being investigated in various parts of the country.

Following is a partial list of universities and institutes in India doing research on pineapple (not exhaustive)

1. Kerala Agricultural Univ., Trichur, Kerala
2. Assam Agricultural Univ., Jorhat, Assam
3. Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal

   Research projects at Bidhan Chandra Krishi Viswavidyalaya include

   1. Evaluation of germplasm.
   2. Standardisation of planting materials.
   3. Standardisation of optimum plant density.
   4. Nutritional requirements for optimum plant density.
   5. Standardisation of sources of nutrients and time of application.
   6. Chemical weed control.
   7. Regulation of flowering.
   8. Standardisation of maturity standards.
   9. Post harvest physiology and storage studies.
4. School of Agricultural science and Rural Development, Nagaland
5. Manipur Agricultural College, Manipur
6. Indian Institute of Horticultural Research, Bangalore.

Table 1. State-wise area and production of pineapple in India (1987)

States/UT	Area (000 ha)	Production ('000 tonnes)
Arunachal Pradesh	0.88	4.28
Assam	3.78	37.80
Goa, Dam, Diu	0.04	6.60
Manipur	7.78	112.80
Meghalaya	6.75	54.48
Mizoram	0.19	4.81
Nagaland	2.10	5.65
Tamil Nadu	0.90	34.10
West Bengal	9.00	225.00

◆

Pineapple News from the Philippines

Information about a new pineapple clone.

Received from Dr. Faustino P. Obrero (Research & Development Manager, Bukidnon Resources Col, Inc., Diklum, Manolo Fortich, Bukidnon, Philippines).

Soft fruit and green shell with high internal translucence (green overripe) are major problems of pineapple fruit in the Philippines, Thailand, Indonesia, and other warm, low elevation pineapple growing areas. These fruit defects are common in the Philippines during the months of June to August, which are high rainfall months that follow the dry months of February through April. These also occur during times of the year of intermittent heavy rains that occur during long dry spells.

Losses in fruit recovery in the cannery caused by this problem are estimated to reach as high as 40%. Fresh pineapple for export are also affected resulting in green shell with high internal ripeness and softer fruit that are susceptible to bruising.

Three plants with fruit having shell color 4 to 5 with internal ripeness of 3 to 4 were selected under soft fruit and green ripe conditions. The crowns and stumps (stems) were sectioned wile the slips and suckers were planted to determine if the fruit produced from these planting materials will come out true-to-type, which they did. In comparison, fruit of the standard variety were harvested at shell color 1 and 2 and had internal ripeness of 3 to 5. Other attributes of the variety include: 1) Medium size plant with relatively large fruit (Type 1); 2) Appears to be early fruiting, hence can be forced earlier; 3) Has yellow flesh without white pattern, a problem with Cayenne clones grown in Bukidnon, Philippines; 4) Uniform yellow flesh from bottom to top of fruit, hence a greater number of premium slices; 5) Stable juice pH of 5 to 6.◆

Pineapple News from the United States (Hawaii)

National Clonal Germplasm Repository

Francis Zee (Curator, USDA/ARS,, P.O. Box 4487, Hilo Hawaii 96720 U.S.A., Phone (808) 959-5833; Fax (808) 959-3539)

Since the publication of "In Vitro Storage of Pineapple (*Ananas* spp.) Germplasm" in HortSci 27(1):57-58, 1992, we noticed that most of the *Ananas* species other than *A. comosus*, preferred an initiation medium with ¼ Murashige and Skoog basic salts rather than the full strength as recommended. A list of these accessions are provided. Pineapple accessions "Hana 9" (Cayenne M263) and "Hana 81" (Cv. Rondon) were difficult to initiate regardless of the type of medium used.◆

Hawaii Research Progress Reports

Reports for the period July 1 - December 31, 1994.

Development and Evaluation of Nematicide Management Strategies for Control of Reniform and Rootknot Nematodes in Pineapple.

B. S. Sipes

Objectives:

1. Evaluate the efficacy of pre- and post plant nematicides for the control of reniform *(Rotylenchulus reniformis)* and root knot *(Meloidogyne javanica)* nematodes in pineapple.
   a) Compare the efficacy of solarization, an oat cover crop, and bare fallow for reduction of population densities of R *reniformis* during the inter cycle fallow period.
   b) Determine the rate of reniform and root knot nematode development on newly rooted pineapple plants in the greenhouse.
2. Develop and enhance application techniques and methodologies to minimize environmental impacts of nematicide application in pineapple production.
   a) Conduct a field scale comparison of an emulsifiable formulation of 1,3-dichloropropene to the standard liquid formulation for efficacy, distribution in the soil, and volatilization into the air.
   b) Determine the toxicity of metam-sodium to reniform nematode in the laboratory and greenhouse.
   c) Determine the distribution and efficacy of metam-sodium in small field plots when applied with a chisel injection and drip irrigation method.

Progress and Achievements:

Solarization with the standard 1 mil thick black plastic was slightly better at reducing reniform nematode population densities in the 0-15 cm soil profile than bare fallow or an oat cover crop after 3 months (September - December). No differences in nematode population reduction were detected among mulched, oat cover, or bare fallow at the 15-30 cm soil depth.

Population development of the reniform nematode on newly planted pineapples (within the first 4 months aver planting) was very low. A few egg producing females were observed within 4 weeks after planting but total eggs numbers always remained below 50 per plant. The pineapple plant may prevent nematode development because of a toxic compound or lack of necessary nutrients, alteration of the root environment thus prohibiting nematode penetration, or retardation of nematode development.

An emulsifiable formulation of 1,3-D, conducted in cooperation with DowElanco, Del Monte and R. Green, demonstrated preplant efficacy similar to the standard liquid formulation, Telone II. Nematode control 30 days after treatment was slightly better with the Telone II formulation according to a mist assay of viable nematodes (98% vs 96% control in Telone II and XRM, respectively). Telone II gave better control in the 15-30 cm soil depth than XRM (99% vs 97%). However, XRM gave better control in the 0-15 cm soil depth (99% vs 98%).

Metam-sodium efficacy was evaluated in a drip application experiment in the field. Overall nematode control at 30 days was only slightly lower than the Telone II standard (98% vs 89%). Nematode control was comparable between the two treatments in the 0-15 and 15-30 cm soil depth. Control at the 30~5 cm depth was very poor in the metam-sodium treatment (only 71% as determined from the mist assay).

Project Summary Abstract:

1,3-D is an effective nematicide when formulated and applied as an emulsion in drip irrigation. Metam-sodium is also an effective alternative for preplant nematode control in pineapple in the upper soil depths. Environmental resistance to nematode development on newly planted pineapples offers a potential for novel control strategies. A 3-month oat cover crop grown during the inter cycle fallow period was as effective as a bare fallow in reducing nematode population densities. A longer fallow period under oats may have produced greater population reductions. Soil solarization with the black plastic mulch was also similar to bare fallow in reducing nematode population densities during the fall months. Solarization during the sunnier, warmer summer months may prove to be more efficacious. Further development of these techniques could eliminate preplant fumigation for nematode control.◆

Development of New Management Tactics for the Control of Plant-parasitic Nematodes in Pineapple.

B. S. Sipes, M.P.Ko, D. P. Schmitt

Objectives:

1. Develop microorganisms or their products as biological control agents of nematodes.
2. Incorporate host-plant resistance and tolerance to reniform and root knot nematodes~
R reniformis and M. *javanica,* into cultivars of pineapple.
3. Evaluate selected crop plants for nematode control in pineapple.
4. Determine and capitalize on weaknesses in nematode life cycles to reduce initial
population densities.

Progress and Achievements:

Several isolates of *Pasturia penetrans* collected from Oahu and Kauai are being developed as potential biological control agents. These isolates were found in soil collected form wet, low elevation sites composed of introduced plant species. The isolates have shown activity against root knot, spiral, and lesion nematodes. No isolate was recovered which could infect reniform nematodes. An extramural grant has been secured for continued support and development of P. *penetrans* as a biological control agent.

A small molecular weight pep tide with toxicity to fungi and bacteria was evaluated for effects against nematodes. The burrowing nematode was selected as a study organism and the pep tide was tested for toxicity at 1-100 ppm over 24 hours. The pep tide appeared to stimulate nematode movement at the rates evaluated, however, the untreated nematodes did not migrate as much as was expected. Further experiments, using refined techniques will be conducted to determine toxicity of the pep tide against nematodes.

Seeds of potential inter cycle cover crops are being procured to establish a greenhouse evaluation of *R. reniformis* development on these hosts. Plants which do not support nematode development will be evaluated in the field during the winter fallow period as an alternative to chemical fumigation for nematode control. An intramural grant was awarded to support this research.

Rotylenchulus reniformis females have been subjected to Randomly Amplified Polymorphic DNA (RAPD) analysis using PCR. Females collected from Kunia show strong banding patters using primer OP-A3. This same primer highlights differences among populations of *R. reniformis* from Hawaii, Texas, and Mississippi. An additional 1000 primers will be evaluated for their ability to separate and define populations of R *reniformis* in the field. This technique will be used to determine the degree of similarity among populations from different fields which may impact the deployment of host-based genetic resistance in pineapple.

Project Summary Abstract:

Endemic isolates of *Pasturia penetrans,* a potential biological control agent against nematodes, have been collected from Hawaii. A pep tide toxic to fungi and bacteria has not demonstrated toxicity to movement of burrowing nematodes after 72 hour exposure at up to 100 ppm. *Rotylenchulus reniformis is* amenable to investigation using RAPD markers and the Polymerase Chain Reaction (PCR). Aver a screening of only 10 primers, differences among nematode isolates from Hawaii, Texas, and Mississippi are detectable with the RAPDs.◆

Pineapple Root Rot in Hawaii: Etiology and Control

Scot Nelson, Glenn Taniguchi

Objectives:

Objective 1. To determine the identity and distribution of pathogenic Pythium species attacking pineapple in Hawaii.

1a. To identify all pathogenic species
1b. To compare virulence, aggressiveness among species
1c. To determine species distribution on plantations
1d. To determine the effect of temperature on virulence

Objective 2. To determine the efficacy of pre-plant applications of Aliette and Ridomil for control of root rot caused by Phytophthora and Pythium spp.

Objective 3. To determine the efficacy of Aliette, Ridomil and Fluazinam for control of pineapple root rot caused by Pythium spp. under controlled conditions.

Objective 4. To assess the efficacy of Fluazinam for control of Phytophthora and Pythium rootrot under plantation conditions.

Objective 5. To determine the optimum frequency of application of Aliette for control of pineapple root rot in Hawaii.

5a. To determine the rate of degradation of Aliette in pineapple crowns.
5b. To determine the potential for Aliette to control root rot after infection.
5c. To asses the effects of soil moisture and temperature upon efficacy of Aliette.

Objective 6. To determine if current levels of Aliette are causing pineapple phytotoxicity.

Objective 7. To determine if chemical plant stresses increase susceptibility to Pythium or other root-rotting fungi.

7a. To determine if the use of Ethrel during forcing increases pineapple susceptibility to Pythium and/or Phytophthora species.
7b. To determine if phytotoxicity due to Aliette or use of Aliette increases pineapple susceptibility to Pythium species.

Progress and Achievements:

Objectives 1a and 1c

Surveys for root pathogen distribution were continued at two pineapple plantations (Del Monte at Kunia/Oahu and Maui Land and Pine, Maui). Five Pythium species have been identified as root pathogens at the Del Monte pineapple plantation at Kunia, Oahu: P. aphanidermatum, P. arrhenomenes, P. aristosporum, P. splendens, and P. myriotylum. P. myriotylum has not been reported previously as a pineapple root pathogen in Hawaii. The most common and widespread root rot pathogen at Maui Land and Pine in P. arrhenomenes. Maps of species occurrence and distribution are being produced.

A training program was established in October 1994 to enable employees of Maui Land and Pine to assay knockdown soil samples for the presence/absence of pathogenic Phytophthora and Pythium spp.

Objectives 1b and 1c

A controlled environment plant growth chamber has been purchased to address these objectives, but the growth chamber has not been installed.

Objective 2

Block-size experiments were initiated in May and June, 1993 to accomplish this objective. Fungicides were applied as pre-plant dips in the following treatments: Aliette only, Ridomil only, and Aliette + Ridomil. Soil samples indicate that Pythium spp. are present. No plant death or disease symptoms were been observed. Harvest of one replication was completed in December, 1994; the other replication is scheduled for harvest in January, 1995. Thus, yield data are being collected and analyzed.

Objective 3

This objective has been accomplished and reported upon in earlier progress reports. In summary, data indicate that the fungicide, Aliette, provides little to no control of root rot of pineapple caused by Pythium spp. The fungicide, Ridomil (metalaxyl), provided little to no significant control of Pythium root rot under greenhouse conditions, depending on the species of Pythium. Tests with the fungicide, Fluazinam, were suspended due to its phytotoxicity to pineapple.

A field experiment was initiated in October 1994 at Maui Land and Pine (Maui) to examine the efficacy of pre-plant dip and drip-tube applications of the fungicide, Ridomil, for control of pineapple root rot caused by Pythium arrhenomenes. The experimental design includes replications of the study to be established at several locations which differ in temperature and amount of annual rainfall.

Objective 4

This objective has been suspended due to phytotoxicity of Fluazinam to pineapple.

Objective 5

No progress to report on this objective.

Objective 6

Aliette was not phytotoxic to pineapple when applied as a pre-plant dip in a greenhouse experiment conducted in 1994. The fungicide apparently caused a slight stimulation of pineapple growth in the initial weeks after its application.

Objective 7a

An experimental planting of pineapple in Phytophthora parasitica-infested soil at the Magoon research facility at the University of Hawaii has been established to study the effects of Ethrel on susceptibility to root rot caused by this pathogen.

Objective 7b

Suspended due to lack of phytotoxicity of Aliette to pineapple.

Progress Summary Abstract:

A more complete understanding of the ecology and management of the pineapple root rot disease complex is emerging as data on the distribution and importance of Pythium spp. and their response to management strategies are obtained.◆

Etiology of Pineapple Mealybug-wilt and Optimization of Heat Treatment for Enhanced Pineapple Growth

John S. Hu

Objectives:

1) Pineapple closterovirus detection.

2) Determine the etiology or cause of MWP.
3) Optimize heat treatment methods for enhancing pineapple growth.

Progress and Achievements:
Objective 1. Pineapple closterovirus (PCV) detection.

Specific monoclonal antibodies to PCV were produced using partially purified virus. From about 300 cell lines, 38 were found to be promising. Eight of them were selected for cloning. Four clones were selected for production of as cites. Three of the monoclonal antibodies were found to be specific to the PCV.
Objective 2. Determine the etiology or Cause of MWP.

The PCV was detected from mealybugs associated with the diseased pineapple plants. Studies are in progress to address the role of PCV in the dies ease complex.

Recently, using partially purified virus samples in EM studies, we also found a badnavirus from pineapple samples. The pineapple badnavirus may be important to mealybug-wilt etiology and will be part of continuing investigation.
Objective 3. Optimize heat treatment methods for enhancing pineapple growth.

Previously, we have shown that a 2-step heat treatment procedure can be used to treat pineapple crowns. It has been shown in the past that crowns treated at 50°C or 60°C exhibited increased vigor and yield but also displayed serious damage. Our results showed that pretreatment at 30 C allowed later treatments of 50 C with significant reduced damage. The 2-step heat treatment experiment was repeated and the two step treatment provided significant damage reduction. Thermotolerance stimulated by pretreatment at 30 to 40 C peaks approximately 8 hours after pretreatment and remains active for at least 24 hours. We have begun working with HARC to determine the impact of these treatments on pineapple growth and yield.

Progress Summary Abstract:

Specific monoclonal antibodies were produced to the pineapple closterovirus (PCV). PCV was detected in mealybugs associated with pineapple mealybug wilt disease. A badnavirus was found- in pineapple in Hawaii. A two-step heat treatment procedure was proved to be useful to treat pineapple crowns to reduce crown damage.◆

Pineapple Pesticide Evaluation

Glenn Taniguchi, Scot Nelson

Objectives:
1. Evaluate fungicides for pre-plant seed treatment.
2. Evaluate fungicides for control of post harvest fruit diseases.
3. Evaluate insecticides for control of mealybugs.
4. Evaluate insecticides/baits for control of ants.

Progress and Achievements:
Objective 1: No progress during this period.
Objective 2: No progress during this period.
Objective 3:

The insecticides Lorsban (Chlorpyrifos), Provado (Imidoclorprid), Sevin (Carbaryl) and Diazinon were evaluated for their effectiveness in controlling the pineapple mealybug. All insecticides tested had excellent initial control except Provado. Diazinon was the only insecticide which provided a minimum of 30 days of residual effects.
Objective 4:

After 8-9 months of testing Amdro (Hydramethylnon) and Bushwacker (Boric Acid) for control of the Big-headed ant, *Pheidole megacephala* on Oahu and Maui, the trials are complete. Bushwacker was not able to provide acceptable levels of control. The control of *P. megacephala* by Amdro is very cost- effective with acceptable levels of control.

Progress Summary Abstract:

Of all the insecticides tested for control of the pineapple mealybug *(Dysmicoccus brevipes* and *Dysmicoccus neobrevipes*), Diazinon was the only insecticide which provided a minimum of 30 days of residual effects.

In comparing ant baits Amdro (Hydramethlnon) and Bushwacker (Boric Acid) for control of the Big-headed ant, *Pheidole megacephala*, only Amdro was able to provide cost-effective levels of control.◆

Effects of Environment on the Growth, Flowering, and Fruiting of Pineapple

Duane P. Bartholomew

Objectives:
1) To characterize the effects of environment on vegetative growth of pineapple and to define the minimum data set required for this characterization.
2. To characterize the effects of plant population and plant size at forcing on plant growth and yield.
3. To characterize the effects of environment on fruit development of pineapple.
4. To develop or refine computer-based models for the prediction of vegetative growth, fruit development, and yield.
5. To improve the control over the flower initiation process. a. To develop methods to inhibit natural flowering. b. To develop methods for improving control over growth regulator-induced flowering.

Progress and Achievements
Objective 1. No work has been conducted on this objective during this period.
Objective 2. No work has been conducted on this objective during this period.
Objective 3.

To determine the effect of water stress (waterlogging and water deficit stress) on flower induction of pineapple, 11-month-old plants were waterlogged for 2, 7 and 14 days or water was withheld for 5 or 8 weeks (May and June, 1994). Leaf titratable acidity (a good but simple measure of dark CO2 fixation) were measured at dawn and dusk and tissue ethylene production, which circumstantial evidence suggests may be one factor controlling natural flowering of pineapple, was measured at the end of the treatment period. Both waterlogging (7 and 14 days) and water deficit stress significantly reduced night accumulation of titratable acids. Waterlogging had no effect on tissue ethylene production, but water deficit stress significantly decreased tissue ethylene production. Neither waterlogging nor water deficit stress induced natural flowering of pineapple. Our results show that water is not a major factor affecting the natural flowering of pineapple.

To study the effects of water deficit and waterlogging on fruiting, plants were treated with 10 mg of ethephon to force flower development immediately after plants in pots were flooded or after water had been withheld for 3 and 6 weeks. Control plants were watered once every 10 days. Both waterlogging and water deficit reduced leaf relative water content and leaf titratable acidity. However, a greater decrease in leaf relative water content and leaf titratable acidity resulted from exposure of plants to water deficit stress. After rewatering of water-deficit treated plants or draining water from waterlogged plants, leaf relative water content and leaf titratable acidity returned to normal levels more quickly in water deficit than that in waterlogging treatments. Fruit let number was decreased more by water deficit than by waterlogging while waterlogging reduced fruit size more than did water deficit stress, presumably because of severe damage to the root system caused by waterlogging.

Objective 4. No work was done on this objective during this period.

Objective 5.

Plants were treated with aminooxyacetic acid (AOA), an inhibitor of ethylene synthesis, silver thiosulfate (STS), an inhibitor of ethylene action, and daminozide, uniconazole and paclobutrazol, inhibitors of gibberellin synthesis, in the winter of 1993 to examine the effect of the chemicals on natural flowering of pineapple. While AOA, STS, and daminozide had no effect on pineapple flowering, paclobutrazol and uniconazole significantly delayed or inhibited it. Ethylene production by leaf basal tissue one and two months after treatment was inhibited by uniconazole and paclobutrazol while ethylene production by stem apical tissue was unaffected or even increased. Decreased ethylene production by leaf basal tissue could be one factor responsible for delayed flowering in treated plants. Tests were installed at Kunia and on Maui in early December, 1994 to examine the effects of uniconazole and paclobutrazol on natural flowering under field conditions. Fruit one, a growth regulator used to enlarge fruit, and aminoethoxyvinylglycine, also an inhibitor of ethylene production, were also included in the test. Flowering and fruit development data will be collected in the Spring of 1995.

Progress Summary Abstract:

Water stress and waterlogging can reduce fruit yield greatly. The growth regulators uniconazole and paclobutrazole delay or inhibit natural flowering of pineapple. The efficacy of these growth regulators is being tested in the field.◆

Nematicides in Pineapple: Assessment of Efficacy and Analysis of Movement and Degradation

Richard E. Green, Randi C. Schneider, Brent S. Sipes

Objectives:

1. Assist pineapple producers in developing management practices for nematicides which will meet nematode control and environmental quality objectives.
2. Evaluate potential impacts of 1,3-D use in pineapple on ground water and air quality by modeling its movement and dissipation in various soils with various management alternatives.

Progress and Achievements:

Objective 1:

Our nematicide research has focused on the fumigant nematicide, 1,3-dichloropropene (1,3-D). We have completed a series of field experiments to evaluate the soil distribution of 1,3-D under different management practices. A series of application methods were tested to minimize emission of 1,3-D to ambient air above treated fields. These methods included chisel injection (single and double chisel methods), the use of wide mulch films, and application of an emulsifiable formulation of 1,3-D (XRM-5053) through drip irrigation systems. In addition to air monitoring studies, we conducted detailed soil gas and soil profile distribution studies to characterize the spatial distribution of 1,3-D both vertically in the soil and horizontally across the pineapple bed - inter bed regions. These data were then related to nematode control on a spatial basis. Nematode populations were monitored prior to 1,3-D application and again at 30 days after fumigation. Nematode populations were assayed using mist extraction, elutriation, and a bioassay using Cowpea seedlings.

We recently completed a large scale field experiment in collaboration with DowElanco and Del Monte where chisel-injected Telone II was compared with drip applied 1,3-D (XRM-5053). The experiment was conducted in Del Monte Field 4005 beginning in August 1994; an application rate of 24 GPA was used. The experimental sub-objectives were (1) to monitor 1,3-D air emissions from the two treatments (DowElanco contribution); (2) to use 1,3-D concentration in soil gas and soil profiles to compare the distribution of the two formulations; and (3) to assess nematode control on a spatial basis with the two formulations. The data from sub-objective (2) will be used in conjunction with the air quality data and the nematode data to evaluate volatilization losses and nematicide efficacy. A preliminary assessment of the measured air concentrations suggests that the first-day concentration is higher for the drip applied 1,3-D, but the total quantity of 1,3-D emitted to the atmosphere over the 2-week period after application was greatest for the shank-injected 1,3-D. We can also draw preliminary conclusions from the temporal and spatial distribution of 1,3-D in soil gas and soil profiles. The use of a new "winged shank" injector to inject Telone II to 18 inches was successful in achieving a near-uniform distribution of 1,3-D over the 0-18 inch depth range in the pineapple bed. As a result of deep chisel injection in the center of the bed, good land preparation, and low soil moisture, very low concentrations of 1,3-D in soil gas were measured in the inter bed region in the Telone treatment. In the drip treatment, XRM-5053 was applied with 3/4 inch of water. The drip formulation was metered continuously into the irrigation water over a 6-hour period to the 1.27-acre treated area. Drip irrigation application resulted in a 1,3-D soil profile with a peak concentration at 12-18 inches depth, and a significant amount of the fumigant in the 18 to 24-inch depth range. We estimate that ½ inch of irrigation water would result in an equivalent soil distribution to that of the Telone II formulation (0-18 inches depth). Due to the diffuse distribution of 1,3-D in soil with drip irrigation, the peak 1,3-D concentrations in soil were one third of those measured in the Telone II treatment. It is unclear at this time how these differing soil distributions will affect nematode control.

Objective 2:

The model LEACHV, which was previously developed and tested on this project, was further evaluated with published DBCP volatilization data obtained in the laboratory. Model performance was better at low water content than at higher water contents. Subsequent tests of LEACHV for a wide range of soil conditions indicated that the present form of the model is not sufficiently robust to be of practical value for the range of field conditions of interest. The principal value of the model thus far is in identifying the important processes which affect the volatilization of fumigants; for the first time we have found barometric pressure change to be a major factor affecting fumigant transport to the above-ground atmosphere.

Progress Summary Abstract

A field scale evaluation of 1,3-D movement in soil for two important alternative application methods, shank injection and application via drip irrigation, was conducted in cooperation with DowElanco and Del Monte Corporation. Both methods provided good distribution of 1,3-D in the soil and were successful in mitigating major volatilization losses to the atmosphere. A volatilization model was useful in identifying environmental and soil factors which are important to vapor losses to the atmosphere.◆

Coordination of Pineapple Pesticide Activities

Mike Kawate, Kenneth G. Rohrbach

Objectives:

1) Coordinate activities involving pesticides of importance to the pineapple industry;

Progress and Achievements:

Completed the field phase of an IR-4 residue study for malathion in pineapple. Additional residue data are needed to support continued registration, i.e., reregistration of malathion in pineapple. Coordinated activities with the pineapple industry and implemented a residue study in Haliimaile, Maui (Maui Pine), on 21 June 1994. Samples were harvested on 12 July 1994 and sent to an IR-4 Satellite laboratory in Virginia for analysis on 18 July 1994. A final field phase report was submitted to IR-4 on 18 August 1994.

2) Act as liaison between pineapple industry, pesticide manufacturers, regulatory agencies, and the University of Hawaii for any pesticide matters of importance to the pineapple industry;

Progress and Achievements:

Re-checked the status of IR-4's quizalofop (ASSURE® II) project. The petition is still in preparation at IR-4 Headquarters; it has been in this phase since May 1994. According to the Study Director, the petition will be sent to DuPont for review in the first quarter of 1995; this petition continues to have a high priority in IR-4.

Progress Summary Abstract:

A residue study to maintain the registration of malathion in pineapple was completed. Samples were harvested on 12 July 1994 and sent to an IR-4 laboratory in Virginia for analysis on 18 July 1994. The tolerance petition for quizalofop in pineapple is being prepared at IR-4 Headquarters; upon completion (first quarter 1995), it will be sent to DuPont for review.◆

References

This sections contains references published mostly since 1989. The references were obtained from the database Uncover, which is available from the U.S. mainland through the University of Hawaii library. References are arranged as provided by the database search and so are in chronological order by year. The list is provided for the convenience of readers who may not have ready access to current references.

This will be a regular section of Pineapple News and will include all readily available references since the last newsletter. Readers can help keep this section up-to-date by sending me copies of references or publications. Please send references or information about new publications to the address given on page 1 of the newsletter.

I regret that I have neither the time or the resources to provide copies of the listed references. In some cases, reprints can be obtained by writing directly to the authors. If you are unable to locate the author's address, I may be able to provide you with the address from the Pineapple News mailing list.
One source, though an expensive one, is:
Library External Services
Hamilton Library Room 112

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Listing

Abllah, N. F. N., Lee, A. H. 1991. A batch activated sludge study of pineapple wastewater using a bioaumentation process. Water science and technology, 24:233.

Akinyele, I.O., Keshinro, O.O., Akinnawo, O.O. 1990. Nutrient Losses During and After Processing of Pineapples and Oranges. Food chemistry, 37:181.

Alvarez, C.E., Carracedo, A.E., Iglesias, E. 1993. Pineapples cultivated by conventional and organic methods in a soil from a banana plantation. A comparative study of soil fertility, plant nutrition and yields. Biological agriculture & horticulture: an inte. 9:161.

Angeles, D.E. 1991. Application of diagnosis and recommendation integrated system (DRIS) to diagnose the nutritional requirements of pineapple. The Philippine agriculturist, 74:387.

Anonymous. 1989. Thai Pineapple Co Ltd: Canning more growth and diversification. Business review, 18:(229)89.

Anonymous. 1993. Coleta encontra abacaxi de 8 kg. Cenargen Informa AIII, No. 11, February, p. 10.

Anonymous. 1994. Caça ao abacaxi. Coleta de variedades preserva diversidade genética da fruta. Ciéncia Hoje, April, p. 63-64.

Aradhya, M. K., Zee, F., Manshardt, R. M. 1994. Isozyme variation in cultivated and wild pineapple. Euphytica, 79:87.

Aziz, T., Yuen, J.E., Habte, M. 1990. Response of Pineapple to Mycorrhizal Inoculation and Fosetyl-Al Treatment. Communications in soil science and plant analysis, 21:2309.

Bartholomew, D.P. and E. Malézieux. 1994. Pineapple. pp. 243-291. In. B. Schaffer and P. Anderson (ed.) Handbook of Environmental Physiology of Fruit Crops, Vol. I. Subtropical and Tropical Crops. CRC Press, Inc., Boca Raton (In Press).

Bhattacharyya, R. K., Bhattacharyya, A. P. 1992. Crop Production and Harvest Index of Kew Pineapple as Affected by Foliar Application of Micronutrients. Acta horticulturae, n 296, 161.

Binder, Ronald G., Flath, Robert A. 1989. Volatile Components of Pineapple Guava. Journal of agricultural and food chemistry. 37:734.

Booth, Cathy. 1992. Canned Pineapple. The new republic, 206:(13)13.

Bouffin, J. 1991. Pineapple in South Africa. Fruits, 46:35.

Cabot, Chantal 1989. Genetic improvement of pineapple. II. Aims of the variety breeding programme in Cote d'Ivoire and techniques used. Fruits, 44:183.

Cabot, Chantal. 1989. Pineapple breeding. III. Selection of new varieties from Cayenne-Perolera progeny with the use of phenotypical selection index. Fruits, 44:655.

Carnal, Nancy W., Black, Clanton C. 1989. Soluble Sugars as the Carbohydrate Reserve for CAM in Pineapple Leaves Implications for the Role of Pyrophosphate: 6-Phosphofructokinase in Glycolysis. Plant physiology, 90:91.

Caswell, E. P., Apt, W. J. 1989. Pineapple Nematode Research in Hawaii: Past, Present, and Future. Journal of nematology, 21:147.

Chan, T.L., Tsai, W.C. 1989. Ion chromatography analysis of nitrate in pineapple. Chung-kuo nung yeh hua hsueh hui chih, 27:187.

Damayanti, M., Sharma, G. J., Kundu, S. C. 1992. Gamma Radiation Influences Postharvest Disease Incidence of Pineapple Fruits. HortScience, 27:807.

Dasbiswas, S., Biswas, B., Mitra, S.K. 1990. Effect of plant density on yield, fruit weight, canning ratio and quality of pineapple CV. KEW. Indian food packer, 44:5.

De Wald, M.G., Moore, G.A., Sherman, W.B. 1992. Isozymes in Ananas (Pineapple): Genetics and Usefulness in Taxonomy. Journal of the American Society for Horticultura, 117:491.

Dickson, Sandra R., Bickerstaff, Gordon F. 1991. Pineapple bromelain and protein hydrolysis. Journal of biological education, 25:164.

Dizy, M., Martin-Alvarez, P. J., Cabezudo, M. D. 1992. Grape, Apple and Pineapple Juice Characterisation and Detection of Mixtures. Journal of the science of food and agriculture, 60:47.

Duodu, Y.A., Thompson, W. 1992. Management of ant-mealybug complex in pineapple fields in Guyana. FAO plant protection bulletin, 40:82.

Euler, P. 1993. Espécie nativa no Brasil, o abacaxi conquista o mundo. Correio da Terra, May, p. 4.

Feller, C., Balesdent, J., Chevignard, T. 1989. Samples preparation of pumices soils for the study of soil organic matter. Application to pineapple cultivated soils in Martinique. Fruits, 44:385.

Ferreira, F.R., Giacometti, D.C., Bianchetti, L..B. e Cabral, J.R.S. 1992. Coleta de germoplasma de abacaxizeiros (Ananas comosus (L.) Merrill). Rev. Bras. Frutic., Cruz das Almas 14:5-11.

Folliot, M. 1990. Determination of the leaf area of pineapple and banana using a non-destructive method on in vitro culture tissue during the acclimatization phase. Preliminary technical report. Fruits, 45:245.

Folliot, M., Marchal, J. 1990. Influence of the culture support on the growth of pineapple vitroplants in the acclimation phase. Fruits, 45:367.

Fontana, A.J., Howard, L., Criddle, R.S. 1993. Kinetics of deterioration of pineapple concentrate. Journal of food science, 58:1411.

Francis, P. 1992. The Maverick Pineapple. American forests, 98:58.

Frolich, J., Raga, N., Philemon, E. 1993. Annellolacina pandanicol sp. nov. with notes on A. dinemasporiodes from pineapple. Mycological research, 97:1433.

Gardner, E.T., Enabulele, O.I., Ajerio, K.O. 1989. Studies on the microbiology and production of pineapple (*Ananas comosus*) wine. Microbios, 59:85.

George, J., Joseph, K., Bhagawan, S.S. 1993. Influence of short pineapple fiber on the viscoelastic properties of low-density polyethylene. Materials letters, 18:163.

German, Thomas L., Ullman, Diane E., Gunashinghe, U.B. 1992. Mealybug Wilt of Pineapple. Advances in disease vector research, 9:241.

Ghosh, T.K., Das, M.K., Tamang, Y. 1992. Evaluation and utilization of unwilted and wilted pineapple top silage in goats. The Indian journal of animal sciences, 62:183.

Guillemin, J.-P., Gianinazzi, S. 1994. Contribution of arbuscular mycorrhizas to biological protection of micropropagated pineapple (*Ananas comosus*)(L.)Merr) against Phytophthora cinnamomi Rands. Agricultural science in Finland, 3:241.

Guinchard, Dominique. 1990. The world market for fresh and processed pineapple. Fruits, 45:469.

Gunasinghe, U. B., German, T. L. 1989. Purification and Partial Characterization of a Virus from Pineapple. Phytopathology, 79:1337.

Hadi, Prajogo U. Prospects of Supply on Marketing Margins : The Case of South Sumatra's Fresh Pineapple. Acta horticulturae, 369:180.

Hawkins, Richard A. 1989. The Pineapple Canning Industry during the World Depression of the 1930s. Business history, 31:(4)48.

Heenkenda, H.M.S., Bondad, N.D. 1991. Note: Improving the efficiency of flower induction in pineapple with ethephon. The Philippine agriculturist, 74:395.

Hirimburegama, K., Wijesinghe, L.P.J. 1992. In vitro growth of *Ananas comosus* L. Merr. (pineapple) shoot apices on different media. Acta horticulturae, 319:203.

Hubinger, M., Memegalli, F. C., Aguerre, R. J. 1992. Water vapor adsorption isotherms of guava, mango and pineapple. Journal of food science, 57:1405.

Ishikawa, Lisa. 1994. Greener Acres? Hawaii business, 39(11):12.

Itoua Gassaye, S., Davin, A., Mietton Peuchot, Martine. 1991. The advantages of membrane techniques in the production of tropical fruit juices (the case of clarified pineapple juice) A - The evolution of filtration fluxes during the process. Fruits, 46:251.

Itoua Gassaye, S., Davin, A., Mietton-Peuchot, Martine. 1991. The advantages of membrane techniques in the production of tropical fruit juices. (The case of clarified pineapple juice). B - Evolution of organoleptic characteristics during the process. Fruits, 46:453.

Iversen, E., Wilhemsen, E., Criddle, R. S. 1989. Calorimetric examination of cut fresh pineapple metabolism. Journal of food science, 54:1246.

Khaleque, Kibriaul, Gold, Michael A. 1993. Pineapple Agroforestry: An Indigenous System Among the Garo Community of Bangladesh. Society & natural resources, 6:71.

Kiss, E., Kiss, J. Gyulai, G. And Heszky, L.E. 1995. A novel method for rapid micropropagation of pineapple. HortScience, 30:127-129.

Komesmuneeborirak, Prapaporn 1990. Thai Pineapple: Meeting demand. Business review, 19:(237)143.

Kongsiriwarakul, Chaowawan. 1990. Siam Food: Pineapple pioneer. Business review, 19:(237)148.

Krueger, Dana A., Krueger, Rae-Gabrielle, Maciel, Jeanne 1992. Composition of Pineapple Juice. Journal of AOAC International, 75:280.

Lacoeuilhe, J. J., Sarah, J.-L. 1990. Notes on pineapple growing in Zululand. Fruits, 45:577.

Lang, S.J., Rosman, K.J.R. 1990. Determination of lead in fresh and canned pineapple by isotope dilution mass spectrometry and isotope systematics. Analytica chimica acta, 235:367.

Leal, Freddy. 1989. On the History, Origin and Taxonomy of the Pineapple. Interciencia, 14:235.

Lenarcic, B., Ritonja, A., Turk, B. 1992. Characterization and Structure of Pineapple Stem Inhibitor of Cysteine Proteinases. Biological chemistry Hoppe-Seyler, 373:459.

Leon-Guerrero, Ephraim D., Loague, Keith, Green, Richard E. 1994. Wellhead Treatment Costs for Groundwater Contaminated with Pesticides; A Preliminary Analysis for Pineapple in Hawaii. Environmental management, 18:93.

Liu, L.C., Acin-Diaz, N.M. 1993. Two grass herbicides for pineapple fields. The Journal of agriculture of the University of Puerto Rico, 77:45.

Lin, B-Y., Ritschel, P.S., e Ferreira, F.R. 1987. Número Cromossômico de Exemplares da Família Bromeliaceae. Rev. Bras. Frutic., Cruz das Almas (BA) 9:49-55.

Loison-Cabot, Chantal. 1990. Pineapple genetics: the heredity of certain characters and their stability during vegetative cycles. Fruits, 45:447.

Loison-Cabot, Chantal. 1990. Pineapple prospection in Venezuela. Fruits, 45:251.

Loison-Cabot, Chantal. 1990. State of botanical, cytogenetic and biological knowledge on pineapple reproduction. Fruits, 45:347.

Loison-Cabot, Chantal. 1991. Management of the genetic resources of pineapple conservation collection, evolutionary collection and evaluation of accessions. Fruits, 46:23.

Loison-Cabot, Chantal. 1992. Origin, phylogeny and evolution of pineapple species. Fruits, 47:25.

Low, Nicholas H., Brause, Allan, Wilhelmsen, Eric. 1994. Normative Data for Commercial Pineapple Juice for Concentrate. Journal of AOAC International, 77:965.

Lozano-De Gonzalez, P G., Barrett, D M., Wrolstad, R E. 1993. Enzymatic browning inhibited in fresh and dried apple rings by pineapple juice. Journal of food science, 58:399.

McIntyre, Sheri, Aleman, Giovanna. 1994. A Research Note: Ultra-High Pressure Pasteurization of Fresh Cut Pineapple. Journal of food protection, 57:931.

Malezieux, E. 1990. The distribution and evolution of the water shortage on South-East Cote d'Ivoire. Application to pineapple growing. Fruits, 45:457.

Malezieux, E. 1991. Study on relationships between plant biomass, leaf area and solar radiation interception on pineapple. Fruits, 46:523.

Malezieux, E., Lacoeuilhe, J. J. 1991. Analysis of yield variability in pineapple (*Ananas comosus* L. MERR.). 1. Characterisation, under the conditions of Cote d'Ivoire, of seasonal fluctuations in yield and certain factors related to fruit quality. Fruits, 46:227.

Malezieux, E., Lacoeuilhe, J. J. 1991. Analysis of yield variability in pineapple (*Ananas comosus* L. Merr.) II. - Relations between the climatic sequence and the functioning of the plant population under the conditions of Cote d'Ivoire. Fruits, 46:441.

Malezieux, Eric, Zhang, Jingbo, Bartholomew, Duane P. 1994. Predicting Pineapple Harvest Date in Different Environments, Using a Computer Simulation Model. Agronomy journal, 86:609

Marchal, J., Guillemin, J.-P., Gianinazzi, S. 1994. Control by arbuscular enomycorrhizae of *Pratylenchus brachyurus* in pineapple microplants. Agricultural science in Finland, 3:253.

Matos, A. P. de, Mourichon, X., Lapeyre, Fabienne. 1991. Reaction of pineapple accessions to inoculation with *Fusarium moniliforme* var. subglutinans. Fruits, 46:647.

Matos, A. P. de, Mourichon, X, Pinon, A. 1992. Occurrence of *Fusarium moniliforme* var. subglutinans on pineapple in Bolivia. Fruits, 47:33.

Medina, E. 1991. Gas Exchange and Acid Accumulation in High and Low Irradiance Grown Pineapple Cultivars. Photosynthetica, 25:489.

Mohamed, S, Kyi, K. M. M., Sharif, Z. M. 1993. Protective Effect of Cysteine-HCl on Vitamin C in Dehydrated Pickled/Candied Pineapples and Guava. Journal of the science of food and agriculture, 61:133.

Mohamed, Suhaila, Safiah Abdullah Khir. 1993. Maintaining the Colour, texture and Vitamin C of cold-stored pineapples through Shrinkwrapping and surface-coating with liquid paraffin. Pertanika, 16:201.

Mondal, Abdul H., Kaul, J.L. 1988. Pineapple production in Meghalaya State -- An economic analysis. Agricultural marketing, 31:21.

Mustaffa, M. M. 1989. Effect of phosphorus applications on fruit yield quality and leaf nutrient content of Kew pineapple. Fruits, 44:253.

Napper, A. D., Bennett, S. P., Shames, S. L. 1994. Purification and characterization of multiple forms of the pineapple-stem-derived cysteine proteinases ananian and comasain. Biochemical journal, 301:727.

Nettleton, Joyce A. 1994. A Food Safety, Pineapple, and HACCP. Food technology, 48:27.

N'Guessan, A. E., Osseni, B. 1989. Relationship between net and solar radiation in Southern Cote d'Ivoire. An example for monocropped or intercropped pineapple and capiscum. Fruits, 44:321.

Nisperos-Carriedo, Myrna O., Shaw, Philip E., Baldwin, E.A. 1990. Changes in Volatile Flavor Components of Pineapple Orange Juice As Influenced by the Application of Lipid and Composite Films. Journal of agricultural and food chemistry, 38:1382.

O'Connor-Shaw, R.E., Roberts, R., Nottingham, S.M. 1994. Shelf life of minimally processed honeydew, kiwifruit, papaya, pineapple and cantaloupe. Journal of food science, 59:1202.

Obiefuna, J. C. 1991. Establishment of pineapple orchards and soil loss control systems for erodible tropical ultisols of Southeastern Nigeria. Fruits, 46:145.

Oki, Delwyn S., Giambelluca, Thomas W. 1989. Groundwater Contamination by Nematicides: Influence of Recharge Timing Under Pineapple Crop. Water resources bulletin, 25:285.

Osei-Kofi, F., Adachi, T. 1993. Effect of cytokinins on the proliferation of multiple shoots of pineapple in vitro. SABRAO journal, 25:59.

Parker, Robert D. 1990. Atomic Absorption Spectrophotometric Method for Determination of Polydimethylsiloxane Residues in Pineapple Juice: Collaborative Study. Journal association of official analytical chem., 73:721.

Phanindra, H.S., Jayathilakan, K., Vasundhara, T.S. 1991. Factors affecting the quality of freeze dried pineapple juice powder. Indian food packer, 45:5.

Ploetz, R.C., G.A. Zentmyer, W.T. Nishijima, K.G. Rohrbach, and H.D. Ohr. (ed.) Compendium of Tropical Fruit Diseases. APS Press, 3340 Pilot Knob Road, St. Paul, MN 55121-2907 U.S.A. 1994.

Rahman, A.H.M.M., Huq, Dilruba, Ahmed, Rafiq. 1993. Carboxymethylation of Pineapple Wastes. Bangladesh journal of scientific and industrial, 28:110.

Ramteke, R.S., Eipeson, W.E. 1991. Studies on concentration of pineapple juice-evaluation of suitability of different types of evaporators. Indian food packer, 45:7.

Reimer, Neil J. 1991. Bait Efficacy, Reinfestation Rates, and Colony Composition for *Pheidole megacephala* (F.) in Pineapple in Hawaii. Research extension series 134, 16 pp.

Reimer, Neil J., Beardsley, Jr. J. W. 1990. Effectiveness of Hydramethylnon and Fenoxycarb for Control of Bigheaded Ant (Hymenoptera: Formicidae), an Ant Associated with Mealybug Wilt of Pineapple in Hawaii. Journal of economic entomology, 83:74.

Rowan, Andrew D., Buttle, David J., Barrett, Alan J. 1989. Ananain: A Novel Cysteine Proteinase Found in Pineapple Stem. Archives of biochemistry and biophysics, 267:262.

Rowan, A.D., Buttle, D.J., Barrett, A.J. 1990. The cysteine proteinases of the pineapple plant. Biochemical journal, 266:869.

Ruggiero, C., Ventura, J.A., Martinez, Jr., M. Zambolim, L., Chaves, G.M., Nogueira Filho, G.C. and Cottardi, M.V.C. 1994. Controle integrado da fusariose do abacaxizeiro. Fundação de Estudos e Pesquisas em Agronomia, Medicina Veterinária e Zootecnia, Jaboticabal, SP, 81 p.

Saha, S. C., Das, B. K., Ray, P. K. 1990. SEM Studies of the Surface and Fracture Morphology of Pineapple Leaf Fibers. Textile research journal, 60:726.

Saha, S.C., Das, B.K., Ray, P.K. 1991. Infrared Spectra of Raw and Chemically Modified Pineapple Leaf Fiber. Journal of applied polymer science, 43:1885.

Saha, S.C., Das, B.K., Ray, P.K. 1993. Some Physical Properties of Pineapple Leaf Fiber (PALF) Influencing Its Textile Behavior. Journal of applied polymer science, 50:555.

Saha, S.C., Ray, P.K., Pundey, S.N. 1991. IR and X-Ray Diffraction Studies of Raw and Chemically Treated Pineapple Leaf Fiber (PALF). Journal of applied polymer science, 42:2767.

Samal, R.K., Bhuyan, B.L. 1994. Chemical Modification Lignocellulosic Fibers I. Functionality Changes and Graftcopolymerization of Acrylonitrile onto Pineapple Leaf Fibers; Their Characterization and Behavior. Journal of applied polymer science, 52:1675.

Sarah, J. L., Hugon, R. 1991. Population dynamics of Pratylenchus brachyurus in pineapple growing in Cote d'Ivoire. Fruits, 46:241.

Schenck, Susan. 1990. Correlations of *Rotylenchulus reniformis* Population Densities with 1,3-Dichloropropene Dosage Rate and Pineapple Yields. Journal of nematology, 22:supp., 735.

Schmitt, D.P., Sipes, B.S. 1994. Population Fluctuations of Rotylenchulus reniformis in Pineapple Fields and the Effect of the Nematode on Fruit Yield. Plant disease 78:895.

Schneider, R.C., Green, R.E., Apt, W.J. 1990. Field Movement and Persistence of Fenamiphos in Drip-Irrigated Pineapple Soils. Pesticide science, 30:243.

Shrestha, G.K., Thapa, S.K. 1989. Comparative performance of growth regulators on flora induction in pineapple in Nepal. International journal of tropical agriculture, 7:190.

Sian, Ng Kok, Ishak, Soleha. Carotenoid and Anthocyanin Contents of Papaya and Pineapple: Influence of Blanching and Predrying Treatments. Food chemistry, 39:175.

Sipes, B. S., Schmitt, D. P., Oda, C. H. 1993. Comparison of Single- and Double-chisel Injection Methods for the Control of *Rotylenchulus reniformis* in Pineapple. Journal of nematology, 25:773.

Smith, L.G. 1991. Effects of ethephon on ripening and quality of freshmarket pineapples. Australian journal of experimental agriculture, 31:123.

Smith, Margi 1994. Welcoming Pineapple. Pizza today. 12 (11) 56.

Soler, A. 1990. Advantages and limits of the use of 3CPA (2-3-chlorophenoxy propionic acid) in pineapple growing in Cote d'Ivoire. Fruits, 45:357.

Soler, A. 1992. Ethephon metabolism in the pineapple (*Ananas comosus*.(L.) Merr.) shell. Fruits, 47:471.

Soler, A. 1994. Yellowing or translucence: ripening deviation in pineapple. II. Enzymatic characterization. Fruits, 49:83.

Steele, Julia. 1994. Land Grab. Honolulu 29(3) 40.

Stirling, G.R., Nikulin, A. 1992. Population dynamics of plant parasitic nematodes in Queensland pineapple fields and the effects of these nematodes on pineapple production. Australian journal of experimental agriculture, 33:197.

Sullivan, John J., Hollingworth, Thomas A., Wekell, Marleen M. 1990. Determination of Total Sulfite in Shrimp, Potatoes, Dried Pineapple, and White Wine by Flow Injection Analysis: Collaborative Study. Journal association of official analytical chem., 73:35.

Sumner, M. E., Angeles, D. E. 1990. Nutrient Balance and the Yield and Quality of Pineapple. Communications in soil science and plant analysis, 21:1431.

Takeoka, Gary R., Buttery, Ron G., Teranishi, Roy. 1991. Indentification of Additional Pineapple Volatiles. Journal of agricultural and food chemistry, 39:1848.

Thomas, K. Jesy, Mukundan, K. 1989. Marketing of Pineapple in Trichur district, Kerala. Agricultural marketing, 32:(3)8.

Timmn, E.J., Brown, G.K. 1991. Impacts Recorded on Avocado, Papaya, and Pineapple Packing Lines. Applied engineering in agriculture, 7:418.

Tiwari, S.C., Tiwari, B.K., Mishra, R.R. 1989. Microbial community, enzyme activity and CO2 evolution in pineapple orchard soil. Tropical ecology, 30:265.

Tiwari, S.C., Tiwari, B.K., Mishra, R.R. 1994. Succession of microfungi associated with the decomposing litters of pineapple (*Ananas comosus*). Pedobiologia, 38:185.

Tournas, Valerie, Traxler, Richard W. 1994. A Research Note: Heat Resistance of a *Neosartorya fischeri* Strain Isolated from Pineapple Juice Frozen Concentrate. Journal of food protection. 57:814.

Ulmann, D. E., German, T. L., Gunasinghe, U. B. 1989. Serology of a Closteroviruslike Particle Associated with mealybug Wilt of Pineapple. Phytopathology, 79:1341.

Ullman, Diane E., German, Thomas L., McIntosh, Carl E. 1991. Effect of Heat Treatment on a Closterovirus-like Particle Associated with Mealybut Wilt of Pineapple. Plant disease, 75:859.

Umano, Katsumi, Hagi, Yukio, Nakahara, Kazuaki. 1992. Volatile Constituents of Green and Ripened Pineapple (*Ananas comosus* [L.] Merr.). Journal of agricultural and food chemistry, 40:599.

Van Elsacker, L., Walraven, V. 1994. The spontaneous use of a pineapple as a recipient by a captive bonobo (Pan paniscus). Mammalia; morphologie, biologie, systematique d, 58:159.

Vega-Mercado, H., Barbosa-Canovas, G.V. 1993. Comparison of moisture sorption isotherm models in freeze-dried pineapple pulp. The Journal of agriculture of the University of Puerto Rico, 77:113.

Vega-Mercado, H., Barbosa-Canovas, G.V. 1993. Heat of sorption and free energy change of freeze-dried pineapple pulp. The Journal of agriculture of the University of Puerto Rico, 77:101.

Wakman, W., Teakle, D.S., Thomas, J.E. and Dietzgen, R.G. (1995) Presence of a clostero-like virus and a bacilliform virus in pineapple plants in Australia. Australian Journal of Agricultural Research 46(5), in press.

Wakman, W., Thomson, K.G., Horlock, C.M., Teakle, D.S., Thomas, J.E., Dietzgen, R.G. and Scott, C.H. (1995) Newly discovered viruses infecting pineapple in Australia. Abstracts for the 2nd International Pineapple Symposium, Trois-Ilets, Martinique, 20-24 February 1995.

Wu, Ping, Kuo, May-Chien, Hartman, Thomas G. 1991. Free and Glycosidically Bound Araoma Compounds in Pineapple (*Ananas comosus* L. Merr.). Journal of agricultural and food chemistry, 39:170.

Zee, Francis T., Munekata, Mark. 1992. Biotechnology: In Vitro Storage of Pineapple (Ananas spp.) Germplasm. HortScience, 27:57.

Zimacheva, A.V., Ievleva, E.V., Mosolov, V.V. 1994. Protease from the Proliferating Top of Pineapple (*Ananas comosus* L.). Applied biochemistry and microbiology, 30:172.

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