Pineapple News

Issue No. 13 Newsletter of the Pineapple Working Group, International Society for Horticultural Science May, 2006

Table of Contents

Pineapple Working Group (PWG)

Dear Colleagues:

You will find an interesting collection of articles in this issue of the newsletter. I believe this is only the second issue that includes contributions from growers. Other interesting reports have come in from various parts of the world where pineapple is grown and I have included below parts of a report of work that was done in the early 1980s to explore the potential to develop a pineapple industry in the southern part of China.

It is with a sense of some sadness that I report the closing of another pineapple plantation in Hawaii. Del Monte Fresh Produce Hawaii announced early in the year that they would cease planting pineapple in February of 2006 and would discontinue all operations in Hawaii by 2008. The closure of this plantation will mean the loss of employment for about 600 workers and a further drop in acreage planted to pineapple of approximately 3,000 acres. A report on the local industry is included in News from the United States (Hawaii).

Measurements of Growth and Determining Appropriate Sample Sizes

Donald P. Gowing, Seattle, WA

Dr. Donald P. Gowing spent a significant part of his professional career at the Pineapple Research Institute of Hawaii. One of his last jobs was project manager for a start-up pineapple operation in southern China in the early 1980s. Dr. Gowing wrote a project report for the company while working in China and some of the work done there was not new to this former PRI researcher but may be new to at least some readers and, therefore, was deemed of sufficient note to be reproduced in the newsletter. I received the material from Don in 2005 and obtained his permission to include selected portions of his report in the newsletter. Some background material has been included to provide context for subsequent material or to provide insight into the utility of particular techniques. Some minor editing was done for the sake of brevity and calculation methods for estimating samples sizes were updated to include references to widely-availabe personal computer software. Planting material shipped from Australia for this project was a 'Smooth Cayenne' selection. Errors of omission and commission are the responsibility of the editor.

A. Measurements of leaf growth

The plantings made in early 1982 grew very slowly in the summer, because of the unfavorable distribution of rainfall, and the plantings made in late summer made only a little growth before the cooler weather set in. And then the frost at the end of December killed a considerable amount of foliage, so that it was March of 1983 before any satisfactory measurements of growth were made.

Usually, leaf growth is measured by weighing the longest mature leaf on the plant, the D-leaf. But in March the D-leaves still had frost-killed tissue, so younger leaves were used, and their elongation measured, rather than their weight. The range of values obtained in 1982 and 1983 are provided below. Figure 6 gives some data and each point represents averages usually of four to six field blocks (fewer in the 1982 plantings after late summer).

Range in leaf growth, sets of 5 plants, cm plant^{-1} day^{-1}:

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
1982 plantings											
Lowest	0.05	0.18	0.41	0.50	0.50	0.81	0.49	0.76	0.67	0.11	0.00
Highest	0.29	0.44	0.88	0.99	0.88	1.01	0.72	0.98	0.16	0.19	0.06
1983 plantings											
Lowest				0.39	0.32	0.57	0.28	0.35	0.40	0.12	0.00
highest				0.70	0.62	0.89	0.91	0.99	0.58	0.58	0.13

Leaf growth appears to have been limited chiefly by temperature, although rainfall does have some influence, of course, and extended dry periods do reduce leaf growth. However, the pineapple plant characteristically maintains a fairly constant moisture within the white tissue at the base of the young leaves at the expense of moisture in the older plant parts. It is within this basal white tissue that cell enlargement takes place, when there is sufficient moisture to maintain cell turgor to stretch the cell walls. Hence, elongation of pineapple leaves can continue slowly under conditions of soil moisture that would cause near cessation of growth in many other plants, and the plant will survive (without much growth) even severe droughts.

From our data, it can be seen that older plants (1982 plantings) showed a higher growth rate than young plants (1983 plantings). This was expected, as the growth rate of plants commonly follows a flattened 'S' shaped or sigmoid curve when the physiology is not over-ridden by other factors such as temperature. Also, the highest average growth rate attained in any one set of five leaves was 1.01 cm per day, in August, and 0.98 cm per day for the averages of the several sets on one date of

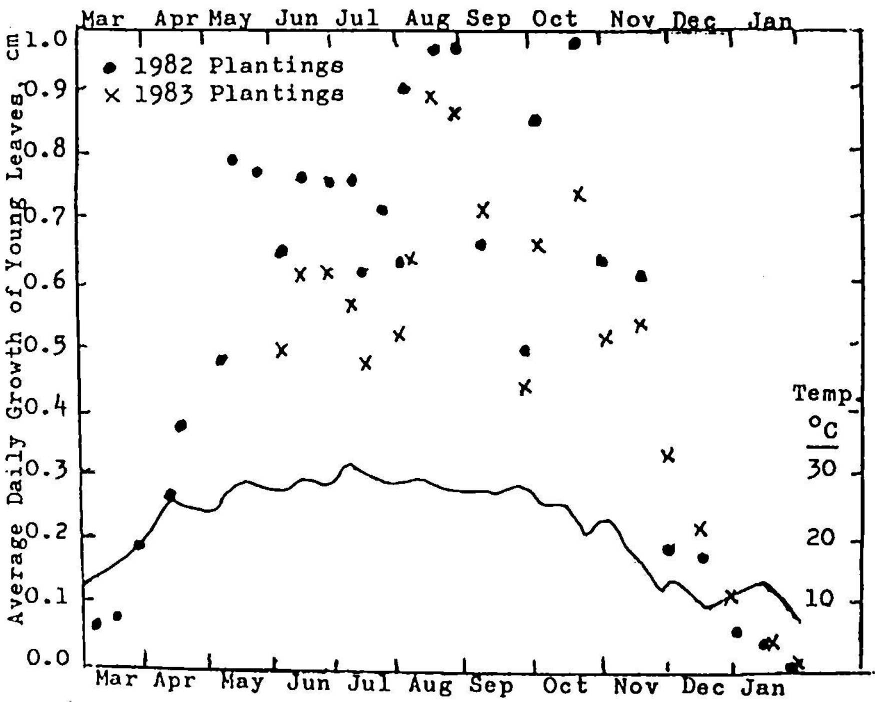


Figure 6. Growth of young leaves of the 1982 (!) and the 1983 (X) plantings. Data points are averages for several sets of 5 plants each in field blocks of different ages.

measurement in mid-October. Immediately afterward, the growth rate fell, and in mid-January 1984 it averaged only 0.04 cm per day. Note also that in March 1983 the growth rate had been only 0.05 cm per day, and it is clear that there is very little growth during the cool months.

The apparent drop in growth rate in September resulted from a change to measuring growth on nearly mature leaves, rather than in young leaves. The data may be disregarded, as it would be more usual to measure, and to compare, growth rates on the approximately linear portion of the sigmoid growth curve. However, the data probably represent the rate of growth of leaves on the plantation reasonably well this year. We do make measurements of plant growth which are more meaningful for commercial cropping purposes, by taking plant weights and D-leaf weights in the crop log, as discussed in section IV later.

A few further points should be mentioned. It seems clear that the low rate of growth in January 1984 (data points indicated by the 'x' symbol above Jan in Figure 6) was wholly a response to temperature, rather than to the limited rainfall in that month. In the previous March (1982), under 75 mm of rain, growth was also limited by temperature. Indeed, for the last two weeks of January, no leaf growth was detectable in many of the plants measured. In the young leaves, the average elongation was less than 0.01 cm per day in the 1982 plantings (which had been forced in November). And the average growth in the 1983 plantings (which had been covered with straw for protection from frost) was only 0.02 cm per day.

After the older plants were forced in November, their growth rate was less than that of the 1983 plantings, in contrast to the situation earlier in the year. After forcing, plants produce no new leaves, and those already formed grow somewhat less rapidly, apart from the influence of the cold weather.

The well-known data of Watanabe on root growth, and of Farden on growth of pineapple leaves, in relation to temperature (Sanford, W.G. 1962. Pineapple crop log-concept and development. Better Crops Plant Food 46:32-43.), is shown in figure 7. The experimental conditions under which these data were obtained were not those of our field conditions, but some interesting comparisons can be made.

Soil temperatures at 15 cm depth averaged 30 to 31 °C in the summer, and these fall to 17 to 18 °C in November and temperatures were below 12 °C at 15 cm depth during periods in December and January, and of course cooler than that at 5 cm depth in the soil. Reduced root growth would be expected at such temperatures, but probably no reduction would be expected by very high soil temperatures in the summer. Growth of leaves may not be reduced as much as that shown by temperatures above 32 °C. Although such temperatures are very rarely met in commercial fields in Hawaii, they are common at the Tan Lo Farm. But our data indicate that here, the growth rate is still high, supported perhaps by the high humidity in our summers. In Hawaii, summers are drier, and Farden's data may have reflected that as well, by less growth. **(Ed note**: It is believed that the data of Farden were collected in a controlled-environment chamber at constant day and night temperatures whereas diurnal fluctuations in temperature at the Tan Lo Farm may provide more favorable conditions for growth.)

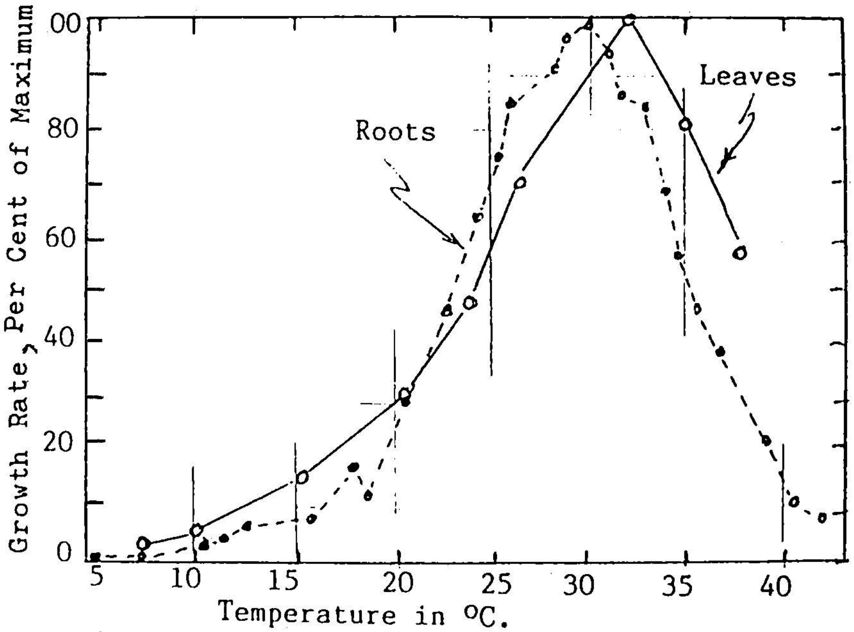


Figure 7. Growth of pineapple leaves after Farden and of pineapple roots after Watanabe in relation to temperature.

B. Other Measurements in Plant Development – Sample Size

1. There are occasions when it is necessary to determine the mean of items relating to pineapple culture, as the average number of suckers per plant, or mean slip length or weight, or mean fruit size, etc. How many items should be counted or measured to find the mean? It is important to use a large enough sample to have confidence in the accuracy of the determination, but the sample should not be unnecessarily large, to avoid the extra time and expense. Some data have been collected on various measurements, and these can be used to calculate the size of future samplings.

Consider, for example, a sampling of a number of individual fruit weights, which can be used to calculate the mean ($\bar{x}$) and a standard deviation (S.D.) of 2.23±0.19 kg. The result shows that about 2/3 of similar samples from the same populations will have means of $\bar{x}$ ± 1 S.D. or between 2.23-0.19 = 2.04 kg and 2.23+0.19 = 2.41 kg. About 95% of such samples will have means of $\bar{x}$ ± 2 S.D., i.e, between 1.85 and 2.61 kg, and about 99% of such samples will have means of $\bar{x}$ ± 3 S.D., i.e., between 1.66 and 2.80 kg. These days, many pocket calculators have an S.D. key, and the statistics are easily calculated. (**Ed note**: Spreadsheet software on the personal computer also makes the calculation of the statistics easy. In Microsoft Excel, click 'Tools' and 'Data Analysis' to calculate basic statistics such as the mean and S.D. If the 'Data Analysis' item does not appear on the menu, add it by clicking on 'Add Ins' in the Tools menu.)

Further, the coefficient of variation (C.V.) of the individual measurement is the S.D. as a percentage of the mean, i.e. C.V.% = S.D./$\bar{x}$ • 100. Either the C.V. or the S.D. may be used in calculation of the number of measurements needed. Of course, the smaller the coefficient of variation or the standard deviation, the smaller the variation in the population, and the fewer the number of measurements or samples that are needed to determine the mean to the desired confidence level.

2. For future reference, typical means for data for 'Smooth Cayenne' pineapple are given in the following section with their respective S.D. and C.V. values. These data are followed by the method for estimating sample size from such data.

a. How much planting material is there in a field block treated with Maintain or Multiprop for production of slips? Determine the number of pieces to within 10% of the true mean with a confidence of 99%. The average C.V. for samplings in ten field blocks was 51.6%. Since the measurement is easy to make, we concluded that columns of 200 plants selected at random per block would usually be sufficient. (**Ed note**: When collecting any sample from a field, statistical randomness is an important concept. The objective of random sampling is to produce accurate estimates of the population mean. When collecting random samples, it is important to be sure that bias on the part of the sampler is avoided. Samples should be collected in such a way that they are representative of the field or, if considerable variation within a field is observed, a particular section of the field.)

Slips, mean/plant	S.D.,±	C.V.,%	Plants to be counted (n)
7.62	3.23	42.4	123
5.93	3.16	53.2	192
4.03	1.92	47.6	155

b. What is the slip size in a shipment of material as determined to within 5%, with a confidence of 99%? (This material was sorted for length at the time of shipment about 50 days earlier.) Since it was somewhat dry at the time of measurement, the slip weight variability may not be strictly comparable to that in fresher planting material. Slip length and base diameter would not have changed greatly. We measured 100 units in the sampling, and apparently this was sufficient for the purpose. Measurements of internal diameters of slips averaging 264 g fresh weight, 25 cm long, showed a mean internal stem width of 2.93 cm, C.V. of 10.8%. The internal stem diameter of pineapple crowns (tops) averaged 3.48 cm, C.V. 8%, in a group 25 cm long, weighing 308 g, average.

	Mean/plant	S.D.,±	C.V.,%	Plants to be counted (n)
Slip length, cm	26.65	3.15 4	11.8	48
Base diameter, cm	3.67	0.547	14.9	63
Slip weight, g	175.98	35.18	20.0	110

c. How many units are necessary to determine yield in terms of fruit weight, slips, and suckers per plant? Some data from a large-scale experiment in Hawaii can be useful (99% confidence, within 5%). These field plots were unusually uniform as to plant size, and the C.V. in fruit weight was unusually low. About 20 fruits per block would be safer to start with. This was a trial involving natural fruiting and forcing agents, with different dates of harvest. Hence, the slip counts were rather low, and the C.V. for slips a little higher than usual.

	Mean/plant	S.D.,±	C.V.,%	Plants to be counted
Plant crop fruit weight, kg	2.01	0.082	4.1	8
Slips/plant, plant crop	1.38	0.373	27.0	198
Suckers/plant, plant crop	1.32	0.165	12.5	45
Ratoon crop fruit weight, kg	1.59	0.094	5.9	13

d. Nanning Complex uses the number of leaves longer than a particular minimum to determine whether a field block is ready to force. How many plants should be used in this count? Here are some data on the number of leaves, per plant, more than 30 cm in length. The average C.V. for 10 samplings in different field blocks was 29.3%. The range in "n" needed was from 64 to 263 plants, to determine the mean to within 5% with a confidence of 99%. The mean "n" was 137. All plants within each block were of the same kind of planting material, and all plants were the same physiological age. If slips and suckers and crowns are mixed in the same block, the C.V. can be expected to be larger.

Mean/plant	S.D.,±	C.V.,%	Plants to be counted
24.1	5.66	23.5	87
18.8	5.43	28.9	131
13.6	5.59	41.2	263

e. Some data from the crop logging in 1983 are also of interest in this connection. A sample of 10 D-leaves is taken from among the 100 plants per block from which plant size is estimated. How many items should be measured to determine the means to within 5% with a confidence of 99%. Root anchorage is kg required to pull the plant from the ground, a test of root health.

		Mean/plant	S.D.,±	C.V.,%	Plants to be counted
D_leaf weight, g	June	10.5	1.140	10.8	35
	June	21.8	2.802	12.8	47
	Oct	45.2	5.512	12.2	43
Plant weight, kg	June	0.51	0.090	17.6	86
	October	1.34	0.124	9.3	28
Root anchorage, kg	June	15.6	2.229	14.4	59
	October	33.3	1.241	5.5	11

And, for leaf tissue analyses:

	Mean/plant	S.D.,±	C.V.,%	Plants to be counted	
% Ca in D-leaves	October	0.020	0.0035	17.7	(In basal white tissue of
% Mg	October	0.019	0.0029	10.0	the D-leaves)
% P	October	0.013	0.0017	12.7	
%K	October	0.253	0.0203	8.0	

3. The calculation to determine the number of items to be measured in not complicated. In the equations below, ‘n’ = the calculated sample size at the specified confidence level and $\mathbf{S.D.^2}$ and $\mathbf{C.V.^2}$ are the means of three or more S.D. or C.V. values squared and then averaged.

$$n = \mathbf{S.D.^2} \bullet Z^2/E^2 \text{ or } n = \mathbf{C.V.^2} \bullet Z^2/P^2$$

Here, ‘Z’ is the number of standard deviations for the desired level of confidence taken from a table of ‘t’ statistics in a textbook. If a 99% confidence level is desired in the count, Z = 2.79 for n = 25, Z = 2.68 for n = 50, or Z = 2.63 for n = 1000. ‘E’ is the allowable error. Hence, take E = 0.05($\bar{x}$) for an allowable error of 5%, or E = equals 0.10($\bar{x}$) for an allowable error of 10%. In the formula using the C.V., “P” is the allowable error expressed in percent; use 5 for 5%, etc.

If the S.D. is not known from previous work, take a reasonable number for a sampling and determine the S.D., using ‘Z’ for the number of items measured. Calculate ‘n’, and if different from the ‘n’ used, recalculate using Z for the new ‘n’, until Z and n are consistent. This will then give the best estimate of the number of items to be measured the next time. The arithmetic is readily done with a pocket statistical calculator, and the improvement in the quality of the data is well worth the small effort invested.

In our work, we usually calculate an analysis of variance in connection with our field experiments. The S.D. for the experimental plots is the square root of the error mean square, and the C.V. of the individual measurement is calculated from the S.D. and the overall mean, $\bar{x}$. Spreadsheet software also makes it easy to calculate analysis of variance.

f. And finally, when the calculation shows that an unusually large number of items is to be measured or counted, consideration should be given to some convenient transformation of the data, if this will give meaningful results. This was the case in columns of the number of roots per plant, the data being taken on various types of setts which were planted at the end of the season in 1982. There was an interest in how readily the different planting materials were rooting, as it appeared that the suckers were behind the slips in this respect. Further, root development in September appeared to be as fast as that obtained earlier in the summer under higher temperatures. Earlier in the summer there had been some dry periods, and there was a good series of rains in the first 20 days of September 1982, and then again during October. Data were taken for 100 plants in each group. The number has been calculated to show the number of items required to determine the mean to within 10%, with a confidence of 99%.

	Data for 100 plants	Mean cm	Range no.	S.D. cm, ±	C.V. %	n
Crowns, planted 8 Oct	Length, cm	22.83	12-36	±3.58	15.6	20
	Diameter, cm	4.06	2.8-4.9	±0.36	8.9	9
	Root number	5.03	0-20	±4.05	75.5	430
	√x + 0.5†	2.19	0.71-4.53	±0.87	39.7	108
Slips, planted 8 Oct	Length, cm	36.30	24-31	±6.53	18.0	25
	Diameter, cm	3.99	2.9-5.1	±0.45	11.9	12
	Root number	6.68	0-24	±5.65	84.6	475
	√x + 0.5	0.48	0.71-4.95	±1.43	57.8	223
Suckers, Planted 28 Sep	Length, cm	29.14	19-41	±4.72	16.2	21
	Diameter, cm	3.18	2.5-4.1	±0.32	10.0	10
	Root number	2.47	0-11	±2.76	111.8	>500
	√x + 0.5	1.55	0.71-3.39	±0.74	48.0	154
slips, planted 28 Sep	Length, cm	29.10	26-59	±7.36	25.3	46
	Diameter, cm	4.00	2.5-5.7	±0.60	15.0	19
	Root number	4.66	0-33	±6.86	147.2	> 500
	√x + 0.5	3.33	0.71-5.78	±1.04	31.3	68

†To be read as the square root of the sum x+0.5.

Note the very high numbers of plants to be counted to find the average number of roots, and the considerable reduction in the coefficient of variation and numbers required after the data were transformed to √ x+0.5. In root counts at this stage, the lowest possible number is zero, and the data were not distributed normally, in the statistical sense of the word. (This possibility should also be examined in determinations of the numbers of slips and suckers per plant in estimating the amount of planting material for collection.) Some transformation of the data to normalize the distribution, can then usually be justified, and the √ x+0.5 transformation is often convenient when there are a lot of zeros in the data. We did conclude that slips and crowns rooted more rapidly than suckers, and this is often found to be the case.

Pineapple Issues in Ghana

Condensed from the original at www.freshplaza.com

It was reported that Ghanaian pineapple exporters had "difficulties in pricing for their Smooth Cayenne pineapple" for the last three years, at least in part due to their inability to supply the pineapple hybrid widely known as MD2. At the time the report was written, ‘Smooth Cayenne' represented greater than 95% of Ghanaian pineapple exports. The Ghana Export Promotion Council

(GEPC) received a request in 2003 for assistance in obtaining MD2 planting materials to help save the industry and maintain Ghana's presence as an exporter of fresh pineapple. In response to a GEPC request for funding of the purchase of MD2 planting material, the government in a 2004 budget statement offered $2.0 million for purchase of planting material. Various agencies were assigned to oversee the acquisition, including ascertain the performance of existing MD2 material and evaluate the capacity and competence of proposed suppliers and make recommendations. In the meantime, the Directors of GEPC decided that tissue cultured plantlets were the most suitable for scaling up production of MD2 pineapples in the country. The plan was that planting materials obtained would be used for production of suckers rather than for commercial production. Inability to supply MD2 pineapple could place Ghana's 11% share of the export market from developing countries to the European Union in jeopardy if MD2 is not available to farmers. It was stated that the MD2 variety "currently controls about 75% of the EU market and is priced at about 2 Euros per kg."

Proceedings of The 5th International Pineapple Symposium Published

The proceedings of the 5th International Pineapple Symposium held in Port Alfred, South Africa, was published in February 2006 as Acta Horticulturae Volume 702. Participants at the symposium in Port Alfred should soon receive a copy of the proceedings in the mail. Those wishing to purchase the proceedings can do so at the ISHS web site (www.ishs.org; click the “Publications” link. Citations for the papers published in the proceedings are included in the reference list at the end of the newsletter.

Pineapple News Reference List

In response to a readers request about an index to Pineapple News, I have not taken the time to prepare a comprehensive index but did compile a list of references in the newsletter. The list can be found at the end of this issue of Pineapple News. The list was prepared using EndNote, a reference database software program. Please contact the editor if you would like to have a copy of the EndNote database or a copy in another format. The version of EndNote I currently use has the capability to export a file as text as well as in rich text, HTML and XML format.

ISHS

As you have read here before, the ISHS is one of the foremost organizations promoting cooperation and communication among researchers, growers and consumers in the horticultural industries. The ISHS provides the structure under which our Pineapple Working Group functions and provides for the publication of meeting proceedings in a volume with high visibility. An important benefit of membership is to support an organization with the goal of improving horticulture across the globe. Detailed information about ISHS and the benefits of membership can be found at http://www.ishs.org of you can write to the ISHS Secretariat, P.O. Box 500, 3001 Leuven, Belgium (E-Mail: info@ishs.org).

News From Australia

Living/Dead Mulch in Pineapples

David Flewell-Smith (topend1@bigpond.com)

Background

Soil erosion losses (organic matter/nutrients and microbes) of up to 150 tons/ha in the first 12 months of growing pineapples is not sustainable. Work by Mr Cyril Ciesiolka of the Department of Natural Resources indicated soil losses could be reduced to under 10 tons/ha with the use of 35 tons/ha of pineapple trash covering the sides of the hills and walkways. The legume Pinto's Peanut (*Arachuis pintoi*) has been grown successfully in walkways - with a high level of timely management - on Mr David Flewell-Smith's organic pineapple farm.

Recent Research

Dr Graham Stirling of Biological Crop Protection has demonstrated the need to reduce tillage, along with planting pangola grass on reformed hills in the fallow, to reduce soil erosion via covering the soil with pangola grass as well as to increase biological activity in the soil (nematode predators etc.) and improved soil tilth. Research in vegetable crops has shown cover crops to be useful, with the resulting dead mulch replacing the use of plastic mulch. In sub-tropical areas, a decreased soil temperature is a potential problem when replacing black plastic mulch with this natural variety.

Current work with a living dead mulch

Precision planting of a nematode-resistant sorghum in summer up the side of and in walkways at planting (see photos and explanation below) can reduce soil erosion. The sorghum was killed off after five weeks of growth with a contact herbicide (haloxyfop R, Dow Chemical Co.'s Verdict R). The stalks dried off, then laid down, providing excellent cover for the base and sides of the walkways, while the pineapple plants looked good. This scene looks a bit scary five weeks after planting with the paddock looking like a crop of sorghum. At week eight however, the paddock looks like a standard crop of pineapples with a brown mulch in the walkways. The normal post plant application of bromacil and diuron is left out, which offsets the cost of the living/dead mulch.

Photos. Top right, standard pineapple paddock without any mulch; note silt in walkways. Top right, pineapple paddock at three weeks after planting sorghum in walkways. The poor germination of sorghum in foreground is due to a lack of moisture. Bottom left, Living mulch in pineapples at nine weeks, having been mulched at seven weeks. Bottom right: pineapple paddock at nine weeks, four weeks after being sprayed with haloxyfop.

Future Work

It would be nice to have a Brown Bear (http://www.brownbearcorp.com/GM%205000.htm) mulching machine to reduce tillage. Planting the living mulch six weeks before planting would provide good ground cover at planting. Here at Top End Pineapples, we are pleased with the results to date. For Further Information, contact the author or Tim Wolens (twolens@goldencircle.com).◆

News From Brazil

The Next International Pineapple Symposium (IPS)

Domingo Haroldo Reinhardt E-mail: dharoldo@cnpmf.embrapa.br

As decided during the V International Pineapple Symposium at Port Alfred, SA, Brazil will be the venue for the VI IPS to be held at João Pessoa city, capital of the state of Paraiba, located at the Northeast coast of the country. João Pessoa is a nice city of about 600,000 people, with several rather characteristic denominations, such as "city where the sun shines first" (it is the uttermost point to the East of America), "the city with the most beautiful beaches" (in the municipality of João Pessoa there are about 25 km of very nice Atlantic Ocean beaches with colorful, clean and warm waters during all seasons, being the beaches of Tambaú, Manaíra, Cabo Branco, Sol, Penha and Seixas the most visited), the "third oldest city in Brazil" (the Portuguese João Tavares built the Fortress of São Felipe in 1585, the site of birth for the development of the city) and finally also "one of the greenest cities in the world" (there are many trees along the roads and a very large protected tropical forest in the city area). In addition, there are very nice people and good food, both fish and great meat dishes (cattle, sheep). And what is most important for all pineapple fans, most of the Paraiba State pineapple fields can be found within a half circle of just about 20 to 80 km around the capital João Pessoa.

Paraiba is the largest pineapple producer in Brazil. In 2005, more than 320 million fruits were harvested during the year, even though a major part is produced during the second semester, with higher volumes from September to December. Most of the production comes from small farmers and hence a very large number of people is involved in this pineapple production chain. The fruits are from the typical Brazilian 'Pérola' variety, certainly an exceptional cultivar for fresh consumption. And the tropical subhumid climate (average temperature of about 25.5 ºC, yearly rainfall of about 1,200 mm to 1,400 mm, more than 2,200 hours per year of bright sunshine and a relative air humidity close to 80% on average) seems to be a great mixture of environmental conditions, resulting in pineapple fruits that are preferred by most of the Brazilians.

The contract with the International Society of Horticultural Science has recently been signed by Dr. Domingo Haroldo Reinhardt, convener of the VI IPS. The period set for the VI IPS is November 4 to 9, 2007. Efforts have been started in order to prepare an event that certainly will be worth a visit to Brazil in general and to João Pessoa in particular.

Scale Insect Pests of Pineapple and Associated Ants: Progress Report on Pineapple Research in Espírito Santo, Brazil

Mark Paul Culik and José Aires Ventura
Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural - INCAPER
Rua Afonso Sarlo 160, CEP 29052-010, Vitória, Espírito Santo, Brasil
markculik3@yahoo.com, ventura@incaper.es.gov.br

Pineapple is an important crop for small farmers in the Brazilian state of Espírito Santo (ES) with the cultivar Pérola grown almost exclusively and yields averaging about 22 t ha^{-1} on 3000 ha. Until recently, pineapple cultivation has been centered around the municipality of Marataízes in the southern part of the state, but there is great potential for expansion of production based on favorable growing conditions and there is interest in the development of pineapple cultivation in the northern part of the state in the municipalities of Linhares, Sooretama, and Pinheiros.

As in other pineapple producing regions, mealybug wilt is one of the most important pest problems of pineapple in Espírito Santo, but there is a lack of information on management options for this disease in this state. Therefore, as part of efforts for development of integrated production of pineapple, this research is being conducted to better understand factors affecting pineapple mealybug wilt in this area. Initial objectives in this part of the research are to determine what species of mealybugs and other scale insects occur on pineapple and identify the ants associated with scale insect pests of pineapple in Espírito Santo.

Preliminary Results - Review of Literature

Efforts during 2005 were made to conduct a complete review of the scientific literature to determine what scale insect pests and ants have been recorded from pineapple worldwide. Based on this review, an index of scale insect pests of pineapple has been prepared containing information on 27 scale insects that have been identified from pineapple, including their scientific and common names, host plants, geographic distribution, occurrence in Brazil, and associated references for each species. We hope to publish this index in the future. Of interest to note is that most of the scale insect species known from pineapple worldwide occur in Brazil (22, 81%) but few have been recorded on pineapple in this country (8, 30%). Likewise, most of the sixteen species of mealybugs that have been recorded from pineapple are known to be present in Brazil, but only two mealybug species (*Dysmicoccus brevipes* and *Planococcus citri*) have been identified from pineapple in this country (or three, if a reference to *D. neobrevipes* that we were unable to confirm is also counted). A similar index with information on about 30 ant species that have been associated with scale insects and pineapple has also been prepared.

Information for identification of scale insect pests of pineapple (species descriptions, identification keys, methods and techniques for working with and studying scale insects etc.) was also collected during this literature review to enable us to accurately identify the insects collected or at least confidently make tentative identifications in this research. Together, this information serves as the base for our ongoing work here to identify the scale insects and ants of pineapple collected and to obtain additional information about the insects found in this research.

Insect Sampling and Identification

Initial sampling (2005 to present) has been limited to preliminary collections from INCAPER experimental farms in Domingos Martins (pineapple cultivars Pérola, Smooth Cayenne, and various hybrids), and Sooretama (a hybrid of 'Smooth Cayenne' x 'Primavera'), several commercial 'Pérola' fields in Marataízes from which samples were obtained in August and October 2005, and collections from 'Pérola' fruits purchased at a weekly street fair in the capital city of Vitória, ES, during 2005 and 2006 (including fruits probably originating from Marataízes).

Mealybugs (Pseudococcidae)

Mealybugs (and mealybug wilt symptoms) were common on pineapple plants in commercial fields in Marataízes from which samples were obtained in August and October 2005. Based on males collected, the mealybugs have been identified as *Dysmicoccus brevipes*. Mealybugs were also relatively common on the pineapple fruits purchased in Vitória on various dates between June 2005 and February 2006. The fruits apparently had been grown in the area of Marataízes and the mealybugs were found around the crown and base of the fruits and also were common within closed blossom cups of the fruits. Mealybugs were also collected from an infested pineapple plant from an INCAPER research farm in Sooretama in December 2005. All of the female mealybugs collected from these pineapple fruits and plants that have been examined so far appear to be *D. brevipes* (~20 slide mounted specimens examined from 8 samples of the 3 sites or sources).

Armored scales (Diaspididae)

Diaspis bromeliae was identified from pineapple plants from Domingos Martins, Espírito Santo collected in February 2005 and Marataízes in August 2005 (identifications by Dr. Vera R. dos S. Wolff, Fundação de Pesquisa Agropecuária - FEPAGRO). Diaspidids that appeared to be *D. bromeliae* and/or *Diaspis boisduvalii* were common on pineapple plants in Marataízes sampled in October 2005 with most (75%) of the plants lightly infested. Another species, probably *Gymnaspis aechmeae*, was also found on a few (2) of the pineapple plants from Marataízes that were examined. These diaspidid specimens are being further studied to confirm these identifications.

Ants (Formicidae)

Five species of ants associated with mealybugs on pineapples: *Brachymyrmex* sp.1, *Brachymyrmex patagonicus*, *Pheidole* sp.1, *Pheidole* sp.2, and *Tapinoma melanocephalum*, were identified by Dr. O.C. Bueno, Universidade Estadual Paulista - UNESP (from nine samples collected from pineapple plants in commercial fields in Marataízes in October 2005). *Brachymyrmex* sp.1 and *B. patagonicus* were the most common ants found (present in more than 50% of the samples).

Preliminary Conclusions and Ongoing Research

Our initial observations confirm that *D. brevipes* is common on pineapple in Espírito Santo and these preliminary results also appear to confirm that other species of mealybugs are either rare or not present on pineapple in this area.

During 2006 our plans are to conduct more widespread sampling of the scale insect pests and ants of pineapple in the major pineapple producing areas of the state. The main goals are to determine the levels of infestation of *D. brevipes* commonly present on pineapple in this area and to identify the species of ants commonly associated with mealybugs here, as well as to verify if other species of mealybugs, besides *D. brevipes*, occur on pineapple in Espírito Santo.

Behaviour of Wild Pineapple Genotypes under in Vitro Conservation

Fernanda Vidigal Duarte Souza, José Renato Santos Cabral, Denis Alves Benjamim[1]. Embrapa Cassava and Tropical Fruits, Caixa postal 007, Cruz das Almas, Bahia, Brazil. E-mail: Fernanda@cnpmf.embrapa.br, jrenato@cnpmf.embrapa.br
[1]Undergraduate Student, Agronomy College, Federal University of Bahia, Cruz das Almas, BA, Brazil

In vitro techniques are widely used for germplasm conservation of a number of wild and crop plant species. The advantages of this conservation are improved plant health and reduced costs. Conservation of genetic resource under field conditions are subject to risks resulting in losses of accessions. The main causes of these losses are the lack of adaptation of the wild genotypes to the local environmental conditions and the incidence of pests.

An in vitro pineapple germplasm bank has been established at Embrapa Cassava and Tropical Fruits since 2002 as a backup of these genetic resources (Souza et al., 2004). More than 25% of the genotypes from the bank have already been introduced to in vitro conditions. The strategy used has been to establish the conditions for minimum plant growth for long-term conservation in order to reduce maintenance labour of the collection. This work has to be accelerated, but some limitations have been detected for the in vitro establishment of some wild genotypes, which have been addressed by some studies.

One of the main limitations has been the differential response of wild accessions to the basic protocols used for their in vitro culture and conservation. In vitro plant development mostly depends on growth regulators and environmental conditions. Several experiments have been carried out at Embrapa, including those on the evaluation of plant growth regulators such as ABA (abscisic acid) and PBZ (paclobutrazol) together with salt reductions in the medium and the incubation of explants at low temperature and light (Souza et al., 2005). The effect of these conditions is being evaluated on the micropropagation rates of these genotypes and on their behaviour in the acclimatisation period.

Establishment Phase

Some accessions are presenting problems in the establishment phase with a variation from 30 to more than 300 days until first plant emergence and first subculture (Figure 1). Among the pineapple genotypes studied the Ananassoides, Bracteatus and Macrodontes varieties have taken the longer periods for their in vitro establishment.

One of the strategies applied to some genotypes with good results has been to make the first subculture at 45 days after introduction, regardless of plant emergence. In the case of Ananassoides, an additional problem is the very small size of its buds and a tendency to excrete large quantities of phenolic substances into the culture medium. To solve this problem anti-oxidants such as ascorbic acid and citric acid have been added to the culture medium. Another alternative is the addition of activated charcoal, which has given better results for the Ananassoides.

In the establishment phase, the plants were kept in a growth chamber with light intensity of 400 μE m^{-2} s^{-1}, temperatures of 27 ºC ± 1°C and a 16 h photoperiod. The medium consisted of Murashige & Skoog (1962) (MS) basal salts and vitamins supplemented with 0.01 mg L^{-1} of naphthaleneacetic acid (NAA) and 0.1 mg L^{-1} of benziladenine (BA) (Souza et al, 2004). Only one accession had endogenous bacterial contamination, which was found at three months after beginning in vitro cultivation.

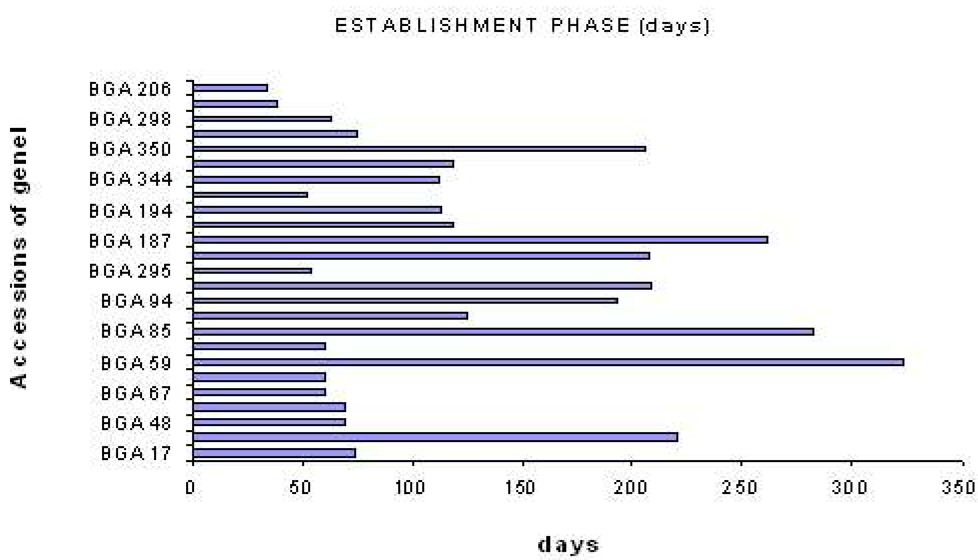


Figure 1. Time period for the establishment phase of some accessions of the Active Pineapple Genebank (APGB) at *Embrapa Cassava and Tropical Fruits*. Cruz das Almas, BA, Brasil (2005).

In Vitro Conservation Period

Accessions were placed into a conservation medium with lower concentrations of mineral salts of MS at a temperature of 21ºC, light intensity of 300 μE m^{-2} s^{-1} and a 12 h photoperiod.

The initial cultivation of pineapple accessions under in vitro conservation conditions started in March 2004. A significant extension of the interval between subcultures is one of the most important goals in this kind of work in order to reduce labour and costs. Until now, results based on a still low number of accessions studied have shown a rather large variation of the time period for their in vitro conservation, presenting intervals of 230 to almost 750 days between subcultures (Figure 2). Two years can be considered as a rather good time period for this type of conservation of pineapple plants, but more studies are needed to determine the effect of extended storage periods on their recovery ability and genetic stability. It is very important to know the most appropriate time interval between subcultures for each accession, not only to monitor the material under storage, but also to plan the management of the genebank. Studies on all steps of in vitro conservation are needed to reach this goal. A large amount of data has been obtained during the introduction phase of pineapple genotypes into in vitro storage conditions, including those on plant morphology, contamination rates, plant viability and vigour, in addition to information on details of the operations being carried out and the material and labour resources consumed.

The next step will be to develop a computerised databank in order to manage these data and to assist in the management of the genebank. This will also aid the daily tasks directed to the in vitro collection by listing items such as the identity of cultures that should be transferred on a particular date as recommended by the IPGRI (Hodkin, 2005).

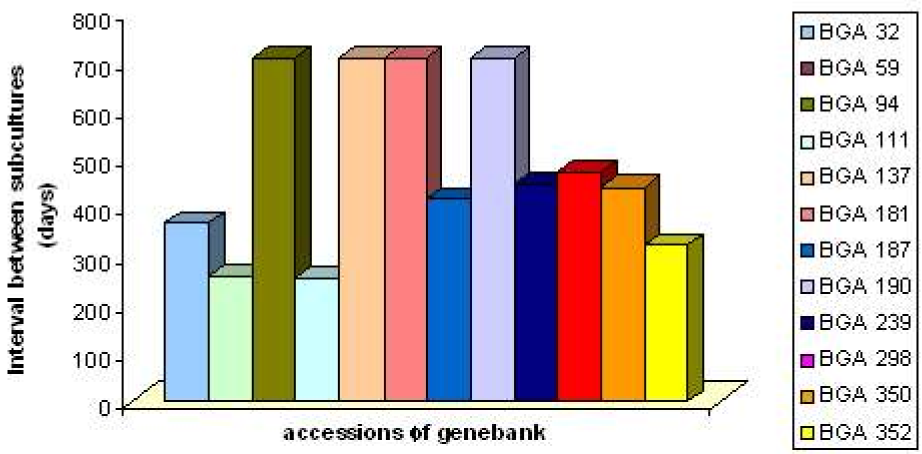


Figure 2. In vitro conservation period (days) of several pineapple accessions from the Active Pineapple Genebank (APGB) at *Embrapa Cassava and Tropical Fruits*. Cruz das Almas, BA, Brasil (2005).

References

Hodgkin, T. (IPGRI). Some current issues in the conservation and use of plant genetic resources - IPGRI, Rome, Italy. In: http://www.ipgri.cgiar.org/ - 21/02/06

Murashige, T. and F. Skoog. 1962. A revised medium for rapid growth and bioassays with tobacco tissue cultures. Physiol. Plant. 15, 473-97.

Souza, F.V.D., Cabral, J.R.S., Almeida, J.V. In vitro conservation of pineapple germplasm at Embrapa Cassava and Fruits. Pineapple News. Newsletter of the pineapple working group, International Society for Horticultural Science, No 11, p.21-22, May, 2004.

Souza, F.V.D., Cabral, J.R.S., Cardoso, J.L., Benjamin, D.A. Minimum growth conditions for the in vitro conservation of pineapple germplasm. In: 5th International Pineapple Symposium, 5, 2005, Port Alfred. Proceedings...Port Alfred, ISHS, 2005, p.49.

Acclimatization of Pineapple Plants from in Vitro Conservation

Taliane Leila Soares[1], Fernanda Vidigal Duarte Souza[2], Everton Hilo de Souza[3]
[1]Graduate Student, Agronomy College, Federal University of Bahia, 44.380-000, Cruz das Almas, BA, Brazil.
[2]Researcher, Ph.D., Embrapa Cassava and Tropical Fruits, C.P. 007, 44.380-000, Cruz das Almas, BA, Brazil, fernanda@cnpmf.embrapa.br
[3]Undergraduate Student, Agronomy College, Federal University of Bahia, Brazil

The in vitro germplasm conservation is one of the alternatives currently used in the preservation of genetic resources of a large number of species. It is based on the culture of plant collections under laboratory conditions, using tissue culture techniques that may vary depending on the species and its reproduction. These plant conservation procedures include some steps that need adjustments, considering the differential response of some genotypes. Among the in vitro conservation strategies, there is the slow-growth technique, which has been the most used in order to extend to a maximum the interval between subcultures. In some cases, the plants suffer excessive stress during the in vitro conservation affecting their development and viability during the following ex vitro acclimatization period.

At Embrapa Cassava and Tropical Fruits studies have been carried out in order to define protocols that enable the creating of a security copy for the genotypes that integrate the large field pineapple genebank (Souza et al., 2004, Canto et al., 2004). Some experiments have been carried out aiming at improving the techniques used at different stages of the in vitro conservation of pineapple genotypes (Souza et al., 2005). A large interval between subcultures together with good performance of the plants during their regeneration and ex vitro acclimatization have been the main objectives of the most recent studies.

The acclimatization is the period of transition of plants from their in vitro to their ex vitro condition and is one of the most important stages in tissue culture of plants (Díaz et al., 2004). The fragility of this stage is due to physiological, nutritional and anatomical disorders that are rather common aspects for in vitro plants (Corsato and Crocomor, 2002). Little research has been done on the residual effect of growth regulators used at the in vitro conservation period on the acclimatization of pineapple plants. One of the trials being carried out by Embrapa Cassava and Tropical Fruits has been the evaluation of the effect of ABA (abscisic acid) and PBZ (paclobutrazol), in combination with different concentrations of MS salts, on the growth limitation of in vitro pineapple plants for long-term conservation (data not shown). This paper presents preliminary results of those treatments on plant survival and development during the ex vitro acclimatization period.

The plants used for the acclimatization assay were obtained from two experiments. In Experiment 1 the treatments followed a factorial scheme with three concentrations (0, 1.89, 3.78 and 7.56 μmol L^{-1} of ABA) and four concentrations of MS (Murashige and Skoog, 1962) salts (full, ½ MS, 1/3 MS, ¼ MS). In Experiment 2 the same concentrations of MS salts also followed a factorial scheme with three concentrations of PBZ (0, 0.85, 1.70 and 3.40 μmol L^{-1}). The culture medium in both experiments was complemented with 3% of sacharose and solidified with 8 g L^{-1} of agar. Incubation occurred at 22 ± 1ºC, light intensity of 300 μE m-2 s^{-1} and photoperiod of 12 h. In order to determine the best treatment to limit the in vitro plant growth some parameters as root volume and shoot and root fresh and dry weight, and roots were assessed for one year (Souza et al., 2005). After this period some five plants per treatment were micropropagated to evaluate the effect of these treatments on the rescue of these plants and their in vitro multiplication rate (data not published). The other five plants of each treatment have been directed to acclimatization. The plants were removed from the culture medium, rinsed in water to remove the agar and avoid contamination and cultivated in boxes (4.5 x 14.5 cm) containing Plantmax® as substrate. The survival rate (%), height (cm) and leaf number were evaluated at 60 and 120 days. The experiment was conducted under greenhouse conditions, (about 90% relative air humidity, temperatures around 25˚C and artificial nebulization).

No loss of plants occurred in the treatments studied in both experiments, except the one with 3.40 μmol L^{-1} of PBZ + ¼ MS which had an excessive growth limitation. The percentage of dead plants was high, reaching 40% at 60 and 100% at 120 days of the acclimatization period (Table 1). In general, this behavior of the plants during acclimatization was expected. The influence of PBZ on the gibberelic acid (GA3) content has been studied in many plant species. It is known that PBZ affects the synthesis of the GA3, inhibiting plant growth and causing abnormal development, these effects usually being reversible (Canto et al., 2004), but in this study the rather low concentrations of MS salts together with a rather high PBZ concentration resulted in plant death. Other interaction effects of PBZ and MS salts can be seen in Table 1.

Table 1. Effects of the in vitro treatments on plant height (PH) and leaf number (LN) during the acclimatization period.

Treatments	60 days		120 days	
	PH	LN	PH	LN
T1 - Control	8.20 ± 0.51	21.80 ± 1.30	13.24 ± 1.45	24.20 ± 2.77
T2- MS + 0.85 PBZ*	8.58 ± 1.94	20.60 ± 4.97	14.46 ± 0.77	24.80 ± 2.59
T3 - MS + 1.70 PBZ	7.74 ±1.83	21.00 ± 6.96	7.88 ± 2.24	23.00 ± 5.15
T4 - MS + 3.40 PBZ	9.12 ± 1.75	22.00 ± 2.00	12.98 ± 2.15	27.20 ± 2.68
T5 MS/2 + 0.0 PBZ	8.54 ±1.39	19.00 ± 2.55	11.88 ± 1.06	18.40 ± 3.36
T6 MS/2 + 0.85 PBZ	8.22 ± 0.66	15.00 ± 1.26	12.25 ± 0.97	22.00 ± 2.16
T7 MS/2 + 1.70 PBZ	3.96 ± 1.11	22.60 ± 4.39	5.32 ± 0.94	21.00 ± 7.35
T8 MS/2 + 3.40 PBZ	5.00 ± 2.09	13.00 ± 2.22	13.20 ± 0.85	18.25 ± 1.26
T9 MS/3 + 0.0 PBZ	8.28 ± 1.70	18.60 ± 1.14	9.28 ± 5.12	22.25 ± 5.50
T10 MS/3 + 0.85 PBZ	7.42 ± 1.12	16.00 ± 2.00	14.66 ± 1.19	19.40 ± 0.55
T11 MS/3 + 1.70 PBZ	6.90 ± 1.73	16.60 ± 3.05	12.93 ± 1.35	18.25 ± 3.59
T12 MS/3 + 3.40 PBZ	2.10 ± 0.40	12.40 ± 4.98	12.25 ± 0.07	13.50 ± 0.71
T13 MS/4 + 0.0 PBZ	6.40 ± 1.01	17.60 ± 1.67	13.12 ± 1.96	23.00 ± 2.00
T14 MS/4 + 0.85 PBZ	3.92 ± 1.03	13.40 ± 1.95	6.48 ± 1.73	17.80 ± 3.83
T15 MS/4 +1.70 PBZ	4.48 ± 0.97	15.20 ± 3.96	10.06 ± 3.52	18.00 ± 3.54
T16 MS/4 + 3.40 PBZ	1.67 ± 0.51	4.67 ± 2.08	-	-

*Concentrations of PBZ (μmol L^{-1})

Plants coming from in vitro treatments with the higher concentrations of MS salts, independent of the PBZ concentrations, were taller, especially at 60 days of acclimatization (T4, T12). As expected, an increase in PBZ concentration reduced plant height, with stronger effects at lower concentrations of MS salts.

Similar results could be observed for leaf number, but the reduction effects of lower salts and higher PBZ concentrations were smaller than those observed for plant height (Table 1). A larger number of leaves usually favors plant development, especially after the first several days of the acclimatization period when leaves reach their true photosynthetic capacity and have reduced water loss by transpiration due to the development of protective structures on their surfaces (wax, cutine).

The interactive effects of ABA and MS salts during the in vitro period on pineapple plant growth at the acclimatization period can be seen in Table 2. As compared to PBZ effects, ABA had less of an impact on plant growth and morphology. Even the leaves of plants showing lack of chlorophyll in their leaves due to ABA and low concentration of MS salts turned green during acclimatization. In this study the lowest plant heights and leaf numbers were obtained for 1/3MS + 7.56 μmol L^{-1} of ABA both at 60 and 120 days of acclimatization. These plants showed normal morphology. The results show that ABA can keep in vitro growth rates low, increasing the intervals between subcultures, without inducing negative effects on plant development during the period of acclimatization.

Table 2. Effect of the in vitrot treatments on height of plant (PH) and leaf number (LN) of pineapple plants during the acclimatization periods.

Treatments	60 days		120 days	
	PH	LN	PH	LN
T1 - Control	7.34 ± 1.42	19.4 ± 3.97	12.82 ± 1.69	24.20 ± 4.71
T2- MS + 1.89 ABA1	7.88 ± 1.61	19.6 ± 3.27	14.50 ±4.11	24.00 ± 4.36
T3 - MS + 3.78 ABA	8.34 ± 1.88	18.2 ± 4.21	12.68 ± 4.01	21.20 ± 5.02
T4 - MS + 7.56 ABA	8.78 ± 1.26	19.4 ± 1.52	15.66 ± 1.05	22.00 ± 1.58
T5 MS/2 + 0.0 ABA	7.72 ± 1.17	20.4 ± 2.70	13.64 ± 3.16	24.60 ± 3.71
T6 MS/2 + 1..9 ABA	7.98 ± 1.18	23.8 ± 2.39	12.68 ± 2.33	29.75 ± 1.26
T7 MS/2 + 3.78 ABA	6.60 ± 2.66	19.2 ± 2.95	14.26 ± 1.25	21.40 ± 2.70
T8 MS/2 + 7.56 ABA	6.90 ± 1.08	18.2 ± 2.95	12.38 ± 2.40	21.25 ± 3.20
T9 MS/3 + 0.0 ABA	9.70 ± 1.18	21.0 ± 2.00	14.04 ± 1.39	26.20 ± 1.92
T10 MS/3 + 1.89 ABA	9.70 ± 0.73	20.6 ± 2.19	15.14 ± 1.44	24.40 ± 2.61
T11 MS/3 + 3.78 ABA	7.60 ± 1.29	18.4 ± 1.14	13.48 ± 1.73	23.00 ± 2.45
T12 MS/3 + 7.56 ABA	4.74 ± 1.30	14.0 ± 4.30	6.10 ± 1.27	14.50 ± 4.95
T13 MS/4 + 0.0 ABA	6.56 ± 0.86	16.2 ± 2.17	10.95 ± 4.26	20.75 ± 4.11
T14 MS/4 + 1.89 ABA	7.68 ± 1.58	17.4 ± 2.07	13.22 ± 1.03	23.00 ± 1.58
T15 MS/4 + 3.78 ABA	8.26 ± 1.04	17.4 ± 1.04	10.90 ± 4.22	19.40 ± 6.91
T16 MS/4 + 7.56 ABA	7.06 ± 0.98	15.8 ± 0.98	11.08 ± 2.01	19.00 ± 1.73

1 Concentrations of ABA1 (μmol L^{-1})

Results have also shown that the MS salt concentrations seemed to be more determinant on pineapple plant development during the acclimatization period than the concentrations of the growth regulators used.
The studies will be continued in order to evaluate the effects of these treatments on plant development under field conditions and to detect the occurrence of any somaclonal variation.

References

Canto, A. M. M. E., Souza, F. V. D., Costa, M. A. C. Souza, A. S., Silva, Ledo, C. A. S., Cabral, J. R. S. Conservação in vitro de germoplasma de abacaxi tratado com paclobutrazol. Pesq. Agropec. Bras. v. 39, n. 7, p. 717-720, 2004.

Corsato, C. E., Crocomor, O. J. Aclimatação de vitroplantas de morangueiro em presença de fungos endomicorrízicos. Unimontes Científica. v. 3, n. 3. 2002.

Díaz, L. P., Medina, L. F., Latife, J., Digonzelli, P. A., Sosa, S. B. Aclimatacion de plantas micropropagadas de caña de azucar utilizando el humus de lombriz. RIA, v. 33 n. 2, p.115-128, 2004.

Souza, F.V.D., Cabral, J.R.S., Almeida, J.V. In vitro conservation of pineapple germplasm at Embrapa Cassava and Fruits. Pineapple News. Newsletter of the pineapple working group, International Society for Horticultural Science n.11.p.21-22, May, 2004.

Souza, F.V.D., Cabral, J.R.S., Cardoso, J.L., Benjamin, D.A. Minimum growth conditions for the in vitro conservation of pineapple germplasm. IN: 5th International Pineapple Symposium, 5, 2005, Port Alfred. Proceedings...Port Alfred, ISHS, 2005. p.49.

Breeding for Ornamental Pineapple

José Renato Santos Cabral, Fernanda Vidigal Duarte Souza. Embrapa Cassava and Tropical Fruits, Cruz das Almas, Bahia, Brazil, jrenato@cnpmf.embrapa.br , fernanda@cnpmf.embrapa.br

The sector of floriculture and ornamental plants has moved annually a total of about US $16 billions in the world, with about US $8 billions of that in the international market. Brazil shares 2.5% of this market, but could easily increase its share if its potential would be used in relation to the ecological conditions and the genetic resources available.

Among the tropical ornamentals, pineapple has conquered its market share and consumer preference. In Brazil the production of ornamental pineapple is still rather small and mostly concentrated on one variety. However, there is a large genetic variability in the genus *Ananas* in Brazil, with a great potential for the creation of new varieties by breeding programs or even to be used directly as ornamental plants.

The Active Pineapple Germplasm Bank (APGB) of Embrapa Cassava and Tropical Fruits, located at Cruz das Almas, Bahia, Brazi, has a total of 678 accessions under field conditions belonging to the genus *Ananas* and other bromeliaceae. It is one of the largest pineapple collections in the world, probably containing a rather large portion of the genetic variability available in nature. There are several genotypes with ornamental potential exhibiting beauty, rusticity and above all originality. They present a large source of colors, forms and sizes of inflorescences, fruits and crowns, as well as different plant architectures.

The first step of this work at Embrapa Cassava and Tropical Fruits was the identification and selection of genotypes with potential for ornamental use. The genebank accessions were evaluated with respect to the beauty of their inflorescence, plant architecture, absence of spines, crown/fruit sizerelation and peduncle length. Based upon these characteristics the following genotypes have preliminarily been selected: LBB -1448 (BRA-012882), FRF-223 (BRA-004936), FRF-221 (BRA-004898), Selvagem-6 (BRA-001627), Curauá Roxo (BRA-013323), Silvestre-25 (BRA-002020), Pseudananas x Rondon (BRA-003948) and São Bento x Local de Tefé (BRA-003981). These genotypes have potential for direct use as ornamentals and hence will be multiplied and submitted to acceptance tests among producers and consumers.

Crossings have been carried out among plants of the species *Ananas comosus* var comosus, *Ananas comosus* var. erectifolius, *Ananas comosus* var. bracteatus, *Ananas comosus* var. ananassoides and *Ananas macrodontes*. A total of 5,104 plants from seven crossings have been obtained as shown in Table 1. The plants of the first progenies are now in the phase of evaluation under field conditions. One genotype from the crossing between Ananás São Bento (*Ananas comosus* var. *bracteatus*) and 'Primavera' (*Ananas comosus* var. *comosus*) has been selected for the beauty of its inflorescence and its spineless leaves (Figure 1A). The plants obtained from the crossings done in 2005 are still in the growth phase under screenhouse conditions (Figure 1B). The next step will be their evaluation in the field and the selection of genotypes with characteristics according to the criteria defined.

Figure 1. Plant selected as ornamental one from the crossing Ananás São Bento x Primavera (A); progenies from crossings with ornamental purposes growing in the screenhouse (B) – Cruz das Almas, Bahia, Brasil.

Table 1. Number of plants obtained from crossings between parent plants of different species, looking for ornamental pineapples. Cruz das Almas, BA, 2005.

Crossing	Number of plants
Ananás São Bento x Primavera	34
FRF-1387 x FRF-223	1,100
G-44 x FRF-1387	720
Curauá Roxo x Tricolor	300
(FRF-1392 x FRF-32	920
FRF-22 x FRF-1387	1,830
Silvestre 25 x Primavera	200
Total	**5,104**

Integrated Pineapple Production In Brazil: An R&D Project

Aristoteles Pires de Matos[1], Luiz Francisco da Silva Souza[2], Nilton Fritzons Sanches[2], José Elias Júnior[3], Fernando Antonio Teixeira[4]
[1]Coordinator of Integrated Pineapple Production, National Research Center on Cassava and Tropical Fruits, apmatos@cnpmf.embrapa.br; [2]National Research Center on Cassava and Tropical Fruits; [3]State of Tocantins Secretariat of Agriculture and Supply (SEAGRO); [4]Agricultural Cooperative of Pedro Afonso (COAPA), Tocantins.

Introduction

"Integrated production is defined as a system based on sustainability, employment of natural resources, and regulations that ensure the substitution of polluting agents, employment of adequate monitoring instruments and the traceability of the whole process. This makes production economically viable, environmentally safe and socially fair".

In order to cope with consumers' requirements regarding fruit quality, sustainability of the production system and social fairness to workers, the Brazilian Ministry of Agriculture Livestock and Food Supply set up an Integrated Fruit Production Program with the following goals: organization of the production bases; better quality products with added value; profit increase; reduction of production costs; competitiveness; guarantee of high quality and healthy food; residue levels in accordance to national and international standards; sustainability of production systems and post-harvest management.

In August 2004, the Integrated Pineapple Production Project was approved to be conducted in the State of Tocantins with the following objectives: training pineapple growers on good agricultural practices towards integrated pineapple production; establishing an integrated pest management system; monitoring occurrence of pests and diseases in order to achieve adequate control and maximum economic benefits; keeping residue levels within national and international requirements; monitoring soil chemical properties and nutritional status of pineapple plants; and reducing environment and health risks, among others. By August 2005, another project was approved to be conducted in the States of Bahia and Paraíba, and a third one to be carried out in Rio de Janeiro. The present communication reports the activities performed in the State of Tocantins since September 2004.

Pineapple Crop In The State Of Tocantins

Pineapple was introduced as a commercial crop in Tocantins in 1987. Since then the area cultivated has increased from 268 hectares in 1992 to 2,733 ha in 2004. Pineapple is considered the most important fruit crop in Tocantins where it is grown in several regions, ranging from smallholders production with just one hectare or less, up to large orchards with about 100 hectares. In those regions the soil and climatic conditions are favorable for pineapple crop development and production. In addition, those conditions make it possible to concentrate the harvest in the off-season of the Brazilian production, resulting in a higher income for growers. Fruit quality is also good and 'Pérola' pineapples have been exported from Tocantins to the European Union from 2000, reaching a volume of about 3,000 tons in 2004.

Almost all pineapple fields in Tocantins are planted with the cultivar Pérola. At the end of the cycle crop residues are either chopped and left as surface mulch or incorporated into the soil. After a fallow period the field is plowed and harrowed. The total phosphorus is applied as a pre planting fertilization. Planting of slips is done by hand and the population density is just about 28,000 plants per hectare, as large fruit size is a market requirement. Nitrogen and potassium fertilization is divided into up to four fractions applied during the vegetative phase of the crop cycle. Micronutrients are usually supplied during crop development. Weeds are controlled with herbicides, usually by pre-emergence application complemented by hoeing. Pesticides are sprayed during flowering to control pests and diseases; no IPM recommendations are used. Few pineapple growers use sprinkler irrigation during the dry season to sustain plant growth.

Project Activities – 2004/2005

Participatory diagnostic survey. A participatory diagnostic survey identified weed management and fertilization as the main constraints to pineapple crop production in Tocantins. Field trials were designed to study the effect of cover crops, such as pearl millet (*Pennisetum glaucum* (L.) R. Br.) and indian goosegrass (*Eleusine indica* (L.) Gaertn), planted between pineapple rows, on the suppression of both weeds and soil borne diseases. Field trials were also designed to determine nutrient levels for the pineapple crop in Tocantins. Currently five trials are addressing fertilization and another one cover crops.

Meetings. One of the first steps of this project was to hold meetings to motivate growers on the integrated pineapple production system focusing on sustainability, environmental protection, economic viability and social fairness. A preliminary version of the regulating norms for integrated pineapple production has been widely discussed, elaborated and made available to pineapple growers.

Training. Considering that integrated fruit production is a relatively new concept for Brazilian pineapple growers, training activities have been carried out in order to disseminate this production concept and to prepare growers to conduct orchards in accordance with regulating norms specific for integrated pineapple production. Eight training events dealt with the subjects: Integrated Fruit Production: pineapple crop; Safe Use and Application of Pesticides on the Pineapple Crop; Integrated

Management of Pineapple Pests and Diseases; Good Agricultural Practices for Pineapple Production; and Integrated Pineapple Production.

Recommended fertilization

One of the most important contributions of this project to the pineapple industry in Tocantins has been the compilation of a document containing fertilization recommendations for the pineapple crop. For a population density of about 28,000 plants/ha, these recommendations, which depend on the soil analysis data are: total phosphorus (90 kg/ha) supplied at planting; nitrogen (260 kg/ha) and potassium (520 kg/ha) supplied during the vegetative cycle, fractionated in four applications. Micronutrients are also supplied. As stated elsewhere, field trials are being conducted to study plant nutritional requirements. The results of these studies will provide additional information to support further adjustment, if necessary, in the current recommendation for pineapple fertilization in Tocantins.

Field activities

During the growing season 2004/2005 only one grower volunteered to conduct a 10 ha orchard in accordance with the regulating norms specific for the integrated pineapple production. Activities consisted of: 1. soil testing prior planting; 2. liming and fertilizer application as recommended by soil analysis; 3. weed management/control; 4. monitoring mealybug wilt (pineapple mealybug wilt associated virus), heart rot (*Phytophthora nicotianae* var. *parasitica*), fusariose (*Fusarium subglutinans*) and pineapple fruit borer (*Strymon megarus*).

Weed management has consisted of growing cover crops, spraying contact herbicides and keeping mulch (dry leaves and straws) in the space between rows. This management reduced to half the number of herbicide applications during the crop cycle. In addition to providing weed control, surface mulch is expected to retain soil moisture, allow more rainwater infiltration and reduce runoff, thus improving soil properties. Surface mulch may also mitigate dust, a common problem during the windy season in Tocantins where pineapple is grown on coarse-textured (sandy) soils.

Monitoring mealybug wilt, heart rot and fusariose started two months after planting and ended just before artificial induction of flowering. Monitoring of the pineapple fruit borer has been done from the sixth week after forcing up to the dry petal stage. During the whole crop cycle cultural control measures have been carried out in order to keep the incidence of pests and diseases at a low level. Neither insecticide nor fungicide applications have been performed during the vegetative phase of the crop cycle, since pest/disease incidence has not reached critical levels. Considering that fusariose incidence in fruits reached about 13%, fungicide spray to developing inflorescences may be required, depending on the environmental conditions after forcing.

In general, as already mentioned, at the end of the crop cycle the pineapple plants are destroyed and after a fallow period a new field is started. However, at least one pineapple grower in Tocantins adopted a fairly interesting crop rotation system, based on his own experience. The rotation consists of cultivating soybeans followed by melon, watermelon and finally pineapple. Using this crop rotation system does not require a fallow period before planting a new pineapple field.

Project Activities – 2005/2006

During the 2005/2006 growing season eight additional growers joined the project and the cultivated area increased from 10 hectares in 2004/2005 to 112 hectares spread over six pineapple growing regions in Tocantins.

Partnership

The National Research Center on Cassava and Tropical Fruits, the leading institute of the integrated pineapple production project, is located in the State of Bahia, around 1,400km from the region in Tocantins where the project is being carried out. This is due to a rather well organized R&D network involving several organizations such as the Ministry of Agriculture Livestock and Supply, the Ministry of Science and Technology, the State of Tocantins Secretariat of Agriculture and Supply (SEAGRO), the Federal University of Tocantins (UFT), the State of Tocantins Development Agency (RURALTINS) and the State of Tocantins Sanitary Agency (ADAPEC), among others. In addition to government institutes, private organizations such as the Amazonia Fruit, Agricultural Cooperative of Pedro Afonso (COAPA) and individual pineapple growers have also been very important partners.◆

News From Costa Rica

Costa Rica: Becoming Differentiated in a Demanding Market

Gabriela Centeno, Sustainable Markets Intelligence Center - CIMS

One of the most polemic products during 2005 was the pineapple, and there is no doubt controversy will continue to surround this fruit,. The multinational Del Monte Corp. began large-scale pineapple production in Costa Rica in the mid 1990's. Although, the producing sector is currently constituted of producers all sizes, Del Monte continues at the forefront of pineapple trade at the international level. This places the company in a prestigious position worldwide, extensive now to the country that became the largest exporter of fresh pineapple in the world.

Moreover, fresh pineapple consumption continues to grow in the main market destinations. Imports of this product to the United States reached almost 578 thousand tons during 2005, for a CIF value (cost, insurance and freight) of 266 million dollars. The most surprising fact is that these numbers represent an increase of 103% in the volume of fresh pineapple and only 15% increase in value (USDA, 2006). The CIF value of every ton decreased 44% with respect to the previous year (2004), however, it returned to the levels of ten years ago.

In the European Union, imports volume increased 18%, reaching 419 thousand tons (data until September, 2005). The CIF value also increased 11%, representing 348 million euros (to September, 2005). The average CIF value per unit went from 880 euros/ton (01-09/2004) to 830 euros/ton (01-09/2005) (Eurostat, 2006).

At the same time, Costa Rica has lost market share (in percentage terms), during the last couple of years due to gain in participation of traditional players such as Ecuador (increase of 11% in the US market) and Guatemala (increase of 85% in the US market), who are already exporting the Gold variety; as well as the entrance of new players such as Panama (increase of 114% also in the US market). Other traditional exporters have also suffered from the increase in exports, such as Honduras (-4.5%).

These and some other reasons have lead many representatives of the industry to wonder about the panorama for the coming years. How will the companies differentiate themselves and remain competitive in this environment? Will the prices recuperate to the previous levels or will they continue the downward trend? Will Del Monte move their pineapple division to other countries or they will take advantage of the facilities and positioning that they already have in Costa Rica? These are some of the issues that will be further touched on in this article.

There is no doubt that the current situation of Costa Rica as the preeminent exporter of fresh pineapple to the United States will remain unsurpassed by its competitors in the short and medium terms. Even more, because Del Monte has decided to establish the plantations of the new variety Honey Gold in this country utilizing all the resources that they have already developed.

In addition, Costa Rican fruit commands a premium price in the international market, mainly due to its high quality. However, the Costa Rican pineapple prices have decreased significantly during the last years, especially during the last term of 2005. In the middle of 2005 some packinghouses paid the lowest prices in the history of the Gold variety of US$0.30/kg to the producers. However, the prices have increased reaching US$0.45/kg in September. During 2006 it is hoped to see again the maximum prices in March and April, of at least US$0.48/kg.

A fact that threatens market stability is the continuous expansion of the areas planted to pineapple in the country, which is already at 25,000 ha. This trend has led to talk by experts about an eventual over-supply situation in 2007. If this occurs, a fall in price will be inevitable.

To avoid suffering from this conjuncture in the massive market of fresh pineapple, companies need to identify and implement comparative advantages to their production and to look for new/alternative ways to sell their fruit. According to Prof. Pánfilo Tabora, expert in this subject at EARTH University, this can be done by adding value or differentiation. Value can be added in two main forms:

- Slightly processing (pealing, cutting, dicing): The new consumption trends promote the sales of "ready to eat" products, which save time and effort. There is no doubt that the commercialization of fresh pineapple would adjust to this trend, and affecting the price at the same time, reducing quality losses and extending the product's shelf life.
- Fruit processing (juiced and canned): In this way competition among those countries trading fresh pineapple (mainly in Latin American) is diminished. However, one would be competing against the giants of the processing industry, such as Thailand and the Philippines. At the product level, it has the same characteristics as slightly processed fruit.

Another possibility could be a change of variety. Del Monte is already implementing this measure; its Honey Gold that will enter the market this year. According to Tabora, the Queen variety and other smaller varieties already used in Asia and Africa also represent good alternatives.

Another solution for differentiation consists in becoming certified with some sustainability seal, such as the organic or Fairtrade. After the approval of the use of ethylene in the United States (2002) and Europe (2005), organic-scale production became more feasible. Organic markets, therefore, represents a good alternative for many producers and exporters.

Moreover, Fairtrade certification works with minimum prices, which insures some stability in this market and in the price paid for the fruit. Many producers in Ghana and Costa Rica already enjoy the benefits of this system.

Finally, regardless of the choice a company decides to implement, it is very important, especially for smaller growers, to start using mechanisms of market intelligence. Market intelligence allows for opportune decision taking to help growers to remain competitive in a market that grows more demanding every day.◆

News From Cuba

‘Red Spanish’ Continues to be "the Queen" of Pineapples Cultivated in Cuba

Miriam Isidrón Pérez 1, Aroldo Cisneros Peña 2, Yamila Rosales Simonnot3, Argelio Pi Ferrer Escalona3 .
1. Laboratorio de Biotecnología, Facultad de Agronomía, Universidad Agraria de La Habana, Cuba. biotec@isch.edu.cu
2. Centro de Bioplantas, Universidad de Ciego de Ávila, Cuba.
3. Jardín Botánico, Ministerio de Ciencia y Tecnología, Holguín, Cuba.

In a national national effort to identify the pineapple cultivars being grown in Cuba, prospecting was done throughout the country and 59 accessions were collected. The collecting expeditions were made between 1998 and 2005 in 13 of the 14 provinces in the country and included 24 municipalities. The sampling showed that 'Red Spanish' was the main cultivar present in the fields in the country. More than 92% of the prospected areas (including governmental enterprises, small or larger farms and small family yards) support their pineapple production growing 'Red Spanish'. There were two principal clones of ‘Red Spanish’ and both have reddish green leaves, an oval fruit shape, and deep eyes. The *Camagüeyana* type can be distinguished from the *Pinareña* type by the more regular and curved spine distribution on the leaf margins and the greater vigor shown by this clone. Some differences in crown forms were observed, particularly the presence of small crowns adjacent to the principal one, but there were no fasciation in any of the ‘Red Spanish’ accessions. Soils used in pineapple farms in Cuba are very diverse and include sandy, loam, and red and black clays. Some soils are over limestone rocks or other parent materials, but we always found well-developed 'Red Spanish' plants if there were no drainage problems, nutritional deficiencies or high pH conditions in the field. We found commercial plantings of 'Red Spanish' pineapple growing from sea level up to 1200 m, but better plants grow around 25 to 250 m. No chemical fertilization is frequently used by farmers, organic composts and mulches were used in some places, and irrigation practices are not usual. Some other pineapple cultivars were found in prospecting work including 'Smooth Cayenne', 'Cabezona', 'Piña Blanca' and 'Piña de Cuba', but none of the plantings were of commercial size. 'Piña de Cuba' is threatened because no more than 150 plants were encountered throughout the country, but that is a theme for another comment. All results indicated that 'Red Spanish' represents a very well adapted pineapple genotype in Cuba.

Estimating the Weight of Pineapple Fruits

Ing. Lorenzo Donis García and Dr. Oscar Fernández García, Univercidad de Ciego de Ávila, Cuba. E-mail: pfa_lorenzod@agronomia.unica.cu

Abstract

From 2002 to 2004, a series of experiments was conducted to develop a methodology for the estimation of the weight of pineapple fruits, this being one of the elements of major importance in the forecast of short-term production. The current practice was totally empirical, resulting as a consequence in high costs for crop production and marketing, since it is impossible to plan without good information of the volume of fruit available for harvesting. Vegetative and reproductive organs were evaluated at the time of induction of flowering and about 50 days later when the flowers at the base of the inflorescence were opened. The use of the reproductive parameters provided estimates of high precision in both ‘Espanola Roja’ and ‘Smooth Cayenne’ and the diameter of the inflorescence was of major practical precision and reliability. The use of the weight of the ‘D’ leaf also provided good estimates but was more complex and costly in its practical execution.

Introduction

Pineapple (*Ananas comosus*. L Merrill) is cultivated in all the tropical and subtropical countries (Loeillet, 1997). The qualities of pineapple fruits in the diet, its exquisite flavor, high digestibility and incomparable beauty has given it a premier place among the world’s fruits. Pineapple is cultivated in commercial quantities in a great number of countries, including Thailand, The Philippines, Brazil, China, and India. In recent years Costa Rica, Ecuador and Colombia have been highlighted while the volume of production in Mexico has declinded (FAOSTAT, 2004).

A principal problem of the agricultural sector is the lack of information about the volume of production of fruit that is harvested. Without such information, planning the volume of production that will produce a profit is difficult and overproduction can dramatically harm the producer. At the present time, production is estimated by calculating the number of fruits across a representative portion of the block and the product of this number and the density provides an estimate of the number of fruits produced. The weight of the fruit is predicted empirically based on the personal experience of the producer. The ‘D’ leaf is reported to provide a good estimate of plant and fruit weight (Pelegrin, 1982; Peña and Legón, 1983; Domínguez, 1985) but its use is relatively complex and costly in practical execution. According to Wiliams (1971), Kantorowitz et al., (1971), and Fernandez (1990) the particularities of forecasting are determined by the culture in which one works.

The objectives of this study were to: 1) evaluate the organs of the plant that are best suited to the estimation of fruit weight and, 2) find a practical and precise method to estimate the weight of the fruits.

Materials and Methods

During the years 2002-2004 we developed with the pineapple company in the province of Ciego de Avila, experiments to level of production of 'Smooth Cayenne', in a Red Ferra lítico soil. The attentions fitotecnia were realized bearing the orientated in mind for the instructive technician for the culture(culturing) of the pineapple. (Minagri, 1999). The layout of the plantation field was 1 / 0.40 / 0.30 m with blocks of 12 double rows for the cultivation of 'Smooth Cayenne' and of 1 / 0.40 / 0.30 for 'Espanola Roja'. In the first two campaigns vegetative and reproductive parameters were evaluated in 6 blocks of each cultivar. At the time of floral induction, there were marked three points of 10 m in every block. 'D' leaves were then removed from approximately 60 plants and weighed immediately with an analytical scale.

To the 45 later ones to the floral induction in the selected plants the following measurements were realized: Diameter of the peduncle (DP); Height of the peduncle (AP); Height of the inflorescence (AI); Diameter of the inflorescence (DI); and Weight of the 'D' leaf (PH).

A slide gauge was used to measure the diameter of the peduncle at the base of the fruit, the diameter of the central part of the inflorescence and its height from the base to the base of the crown. At the time of harvest, the weight of the fruits with and without the crown as well as the diameter and height of the fruit was determined from 60 plants. This information was evaluated statistically using SPSS and EXEL.

In the last campaign ten blocks cultivated similarly as above and the vegetative and reproductive parameters were evaluated in a similar form. The information obtained was used to validate the equations obtained with the results of the previous campaigns.

Results and Discussion

Correlation analysis is usually employed to find the possible dependence of one factor on another one. Correlation among the various measured parameters for 'Espanola Roja' is presented in Table 1 and those for 'Smooth Cayenne' in Table 2.

Table 1: Correlation between (among) the parameters studied in 'Espanola Roja'.

Parameter	PCC	PSC	DF	AF
PHD*	0.91264235	0.91789	0.89254	0.86253
DI	0.98401645	0.96312073	0.91190675	0.89610073
AI	0.72680036	0.69845123	0.69643764	0.67521277
DP	0.5226378	0.50036524	0.48287165	0.45963551
AP	0.5920845	0.54921347	0.57452437	0.5214783

*Parameters are PHD, D-leaf weight; DI, inflorescence diameter; AI, inflorescence height, DP, peduncle diameter; AP, peduncle height. (**Ed note**: Column parameters were not defined but PCC appears to be fruit weight with crown.)

Table 2. Correlation of the parameters studied in 'Smooth Cayenne'.

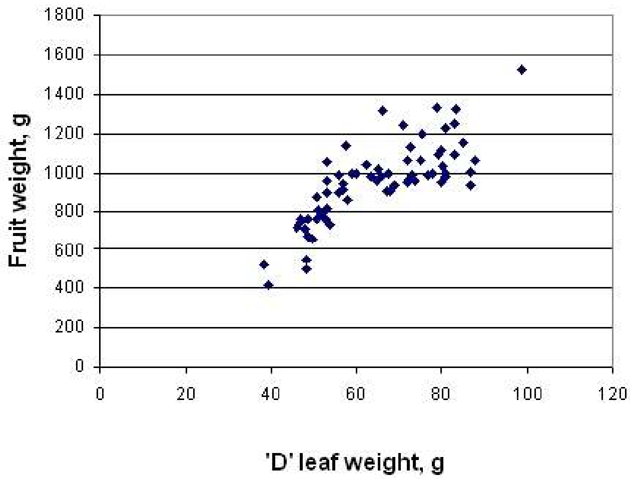
Parameter	PCC	PSC	DF	AF
PHD*	0.9419	0.9288	0.9078	0.7867
DI	0.9743	0.9515	0.8988	0.8783
AI	0.8883	0.8183	0.8032	0.8153
DP	0.7874	0.7447	0.7039	0.6575
AP	0.5061	0.5872	0.5243	0.5486

*Parameters are PHD, D-leaf weight; DI, inflorescence diameter; AI, inflorescence height, DP, peduncle diameter; AP, peduncle height. (**Ed note**: Column parameters were not defined but PCC appears to be fruit weight with crown.)

The coefficients of correlation indicate that there is a high degree of dependence of one factor on the other, suggesting that it was possible to estimate fruit weights from the measurement of some one from these parameters. Nevertheless it is important to emphasize that for both 'Espanola Roja' and 'Smooth Cayenne', the highest correlation coefficients were obtained between inflorescence diameter and fruit weight. The results confirm those of Py and Pelegrin (1958), Peña and Legón (1983) and Domínguez (1985) with regard to the relationship between 'D' leaf weight and the weight of the fruit (Table 1 and 2, Figure 1), but the correlation between fruit weight and other parameters is not as high.

The good relationship between 'D' leaf weight or fruit diameter at flowering and final fruit weight with crown is shown in Figures 1 and 2. The data indicate that regression analysis might be used in these cases because the distribution of the data points shows us a positive dependence and appear to simulate a straight line. Peña and Legón (1983), found that the relationsip between 'D' leaf weight and fruit weight represents a parabola because 'D' leaf weight does not exceed 100g while fruit weight continues to increase as plant weight increases.

In the equations of Table 3, all the coefficients of regression and the exact coefficients of regression are high. The values of the coefficient of Dudpan and Watson (DW) are not guessed right. (**Ed. Note**: The authors may be referring to the Durbin-Watson test, a test for serial correlation. Its relevance here was not commented on.) Nevertheless it appreciated that the equation of better adjustment is that of the diameter of the inflorescence with the high mas coefficients of regression. The actual fruit weights and those estimated using the various parameters are shown in Table 4.



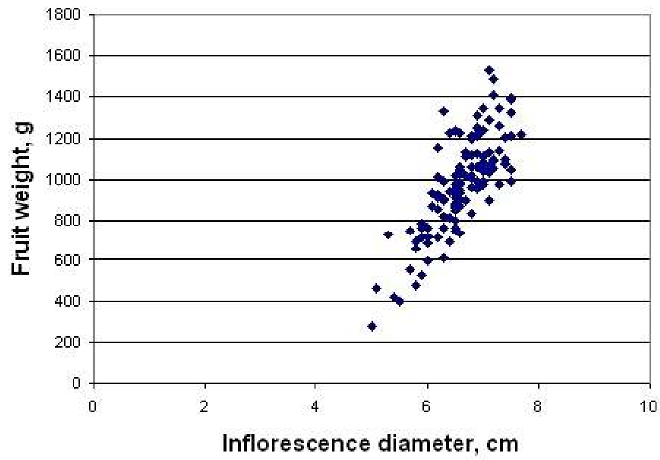


Figure 1 (left). Relationship between 'D' leaf weight and the weight of the fruit with crown at harvest for 'Espanola Roja'.
Figure 2 (right). Relationship between fruit diameter at flowering and the weight of the fruit with crown at harvest for 'Espanola Roja'.

Table 3. Equations of regression.

Y*= - 1274.8975265 + 41.63218645 X (Inflorescence diameter) 'Smooth Cayenne'
R^2= 0.98254 r^2 a= 0.97123 DW= 1.352Y=-21.987487+15.324550X (Inflorescence height) Red Spanish
R^2= 0.95482 r^2 a = 0.94256 DW= 1.789
Y= - 602.4641595 + 23.694627 X(weight of 'D' leaf) 'Smooth Cayenne'
R^2= 0.9763 r^2 a= 0.96327 DW= 1.563
Y=149.058177+30.094768X (Peduncle height) Red Spanish
R^2= 0.86562 r^2 a= 0.84236 DW= 2.691
Y= - 668.756546 + 51.066355 X (Peduncle diameter) 'Smooth Cayenne'
R^2= 0.82357 r^2a= 0.81368 DW= 2.964

Y* = Weight of the fruit with crowN and X is the indicated independent variable.

Table 4. Actual and estimated fruit weights for 'Smooth Cayenne' and 'Espanola Roja' pineapple.

Cultivar	Actual	DI*	'D' leaf	DP	AI	AP
'Smooth Cayenne'	858	890	927	939		
'Espanola Roja'	730				698	479

*Parameters are: DI, inflorescence diameter; AI, inflorescence height, DP, peduncle diameter; AP, peduncle height.

Without doubt the best estimation for both cultivars results from the use of the equation based on the diameter of the inflorescence, without discarding the rest of the equations. As previously mentioned, the weight of the 'D' leaf also provides a good estimate of fruit weight but the use of this organ requires trained workers to identify it and more sophisticated and cumbersome equipment.

Conclusions

- The use of the equations of regression turns out to be a precise method and of easy execution.
- The equation fitting the diameter of the inflorescence and the weight of the fruit provides results that are more precise and is eminently practical.

Bibliography.

Domínguez Martín, Quintín. 1985. Effects of different methods of application of the phosphorus and the potassium in the culture of pineapple (*Ananas comosus* L. Merr) C.V. 'Espanola Roja. Work of Diploma (ISACA), 1985.

FAO: http://faostat.fao.org/, 2004

Fernandez García, Oscar R: 1990. Prediction of production in citrus fruits. Thesis Presented for the doctor's scientific degree in Agricultural sciences (ISACA).

Kantorowwitz, M. Regen, H. and Buch, E. 1971. Citrus crop forescasting in Israel. Methodology Technical publication No. 35 Central Bureau of statistics. Israel. Pp: 30.

Loeillet, D. 1997. Panorama du Marche mondial de l'ananas: l'importance de l'Europe. Acta Horticulturae 425:37-48.

Peña Alderí, Héctor and C. Legon. 1983. Influence of the age of the induction of the flowering in plants of Pineapple var. 'Espanola Roja'. Tropical Cultures(Culturing), 5: 235-245.
Py, C. and P. Pelegrin: 1958. Previsión de recorte en culture d' ananas. Fruits.13: 243-251.
Williams, S. R: 1971. Forescasting Florida citrus production Methodology and development. Florida. Crop and Livestock Reporting Service, Orlando Fla., 96 pp.

Ed Note: Apologies for errors in editing are extended to the authors. The above represents my best effort to understand what the authors intended to convey. There are some unintelligible sentences, which have been left as they originally appeared because the paper was revised without the authors assistance. Communication with people in Cuba is often difficult and at the time of editing, email queries to the senior author were returned. Despite some anomalies, the work is of interest because the methods appear to be well-studied, the recommended technique is simple, and only one other study of fruit weight estimation prior to harvest for the purpose of predicting yield (Donis García, H., and R. Moya Consuegra. 2005. Determination of the variables to use in the prediction of the pineapple production to cultivate Cayena lisa. Acta Hort. 666:343-347) was found among over 6,500 references on pineapple. This study expands on that earlier work.◆

News From Egypt

Overcoming Cold Stress by Intercropping of Pineapples under Banana Plantations

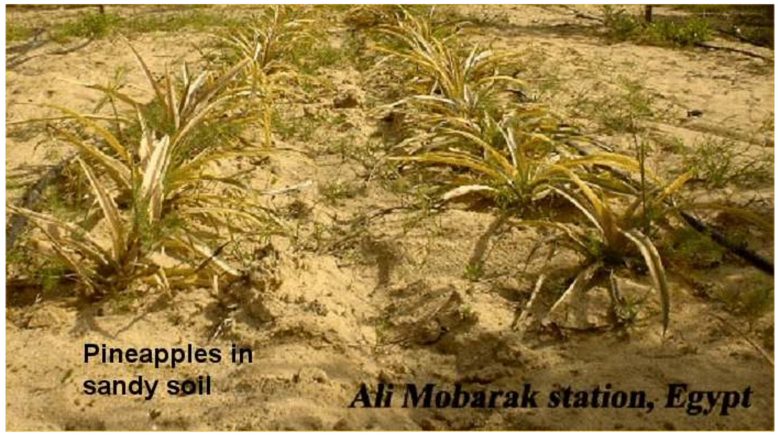
Adel Ahmed Abul-Soad, Tropical Fruit Department, Horticulture Research Institute, Agriculture Research Centre, Egypt. E-mail: adelaboelsoaud@gmail.com

Although pineapples are one of the most important tropical fruit species and Egyptian consumers like this kind of food, there is no area cultivated with pineapples in Egypt. Pineapple fruits have been imported from other countries but the price of fresh fruits is high. Thus, production of pineapples in Egypt is important and may lower the cost of these fruits in the country. Some successful experimental trials have been made on cultivation of pineapples in a greenhouse. But the cost of production was high so the trials were ended. A number of experiments also were performed on cultivation of pineapples in the open field. All of these trials failed and the final conclusion was that you can't cultivate pineapples in the open field in Egypt.

The coastal area of Egypt, with a temperature in summer around 25 ºC, is believed to provide a desirable climate for the growth of pineapples. Recently, a new trail to cultivate pineapples in the open field under Egyptian conditions was carried out at the Horticulture Research Institute of Egypt. The cultivars Queen and Smooth Cayenne were micropropagated through tissue culture (Photo A). The shoot tip of a crown was used for the initial explant and several thousand plants were produced within one year. All plantlets were transplanted into pots containing peat-moss and grown in a greenhouse. Plantlet survival was better in peat moss than in other kinds of soil. After 18 to 24 months, the pineapple plants were distributed to three areas representing the main climatic regions of Egypt. The study aimed to investigate the effect of different soil types and ambient conditions, especially relative humidity, on pineapples grown in the open field at Ali Mobark Station located on the Cairo-Alexandria desert road, Sids Station at Beni-Sweef (upper Egypt) where the summer day temperature is high (30 ˚C) and there is a large difference between the day and night temperature, and as an intercrop under bananas at Kanater Station. Planting took place in March with the harvest

projected for 18 months later in September.

In December, an unexpected obstacle emerged. The winter season caused cold damage on the plants being grown at Ali Mobark and Sids Stations. Initially mature leaves turned red in color due to anthocyanin formation but continued exposure to cold stress produced white leaves. The leaves also became narrow and smooth and no or slow growth also was observed during the winter season. However, intercropping of pineapple plants under banana plantings at Kanater Station was effective in preventing cold stress (Photo B). Under banana plants, the mature leaves of pineapple remained green and healthy. It seems that the big leaves of banana protect pineapple plants from low temperature. The mean temperatures at night ranged from 8 to 13 ºC through the winter season but on some nights in some areas the temperature reached 5.5 ºC. The outer leaves of banana will be safely removed to allow direct lighting in the next summer.



When planting pineapple plants in the field, plants were placed on the two edges of terraces. Plants obtained their nutrients from usual fertilization of banana. The intercropping of pineapple with banana is expected to save a lot of costs for fertilization. No interaction was observed in water requirements between the needs of both crops.

The cultivation of pineapple in the open field in Egypt is economical and very important. Cold stress in the winter season was the big problem but intercropping under banana overcame this problem. Other means that could be used to overcome cold stress include the cultivation of pineapples under low plastic tunnels, which could be easily anchored in sandy soils (See photo), intercropping with maize, and covering the surface of the soil with rice straw. Rice straw from rice cultivation is considered as waste in Egypt and it is cheap and easy to use. Covering the surface of the soil could help keep the root environment warm and thus help to reduce cold stress.

This experimental work was done at the Sids station (Beni-Sweef governorate), which is located beside the Nile river where the relative humidity ranges from 40 to 60 % and the temperature in summer ranges between 30 and 35 ºC. Finally, research to overcome cold stress using different techniques was carried out in different areas of the country. Overcoming other obstacles to spread pineapples in Egypt is our target in near future.

News From France

Pineapple Multiplication: Practical Techniques for Small Farms

Alain Soler and Bernard Dole, CIRAD-PRAM, Martinique. E-mail: alain.soler@cirad.fr.

Introduction

Selecting and multiplying pineapple plants for fruit quality and yield, vigor of the plants, fast sucker production or introducing new varieties, require fast multiplication of planting material. This may be a major constraint for small farmers or small organizations of producers. All techniques described below rely on the development of buds in leaf axils (just above the point of leaf attachment). Even though each leaf covers a bud that potentially may give a new plant, the buds are dormant due to strong apical dominance (Py et al, 1984). Nevertheless, different techniques based on vegetative multiplication exist with advantages and drawbacks for each of them. (For an extensive review see Py, 1979).

The modern technique of micro propagation is the ultimate technology for fast expansion and introduction of new varieties, but it is not very convenient for small farmers. With this technique, it is possible to produce thousands of plants (generally for pineapple a correct multiplication factor is 1:1000) from very few original plants. And even with the recent improvements that have been brought to this technique (González-Olmedo et al, 2005), it still has several drawbacks. These include a time-lag of one year between the beginning of the tissue culture and the production of the first in vitro plants as well as an additional 6 months for hardening and growth before plantlets are ready to be transplanted into the field. The cost is relatively high for small amounts of plants. Finally, several genetic variations such as spiny leaves or multiple slips at the base of the fruits inducing deformations, may appear during the first generations of plants.

Another common technique used is the application of phytohormons (like chlorfurenol) mixed with ethephon at forcing or just after. This technique, first developed by Sanford (1973), allows a rapid production of slips on the peduncle of the fruit or the transformation of the fruitlets into small crowns. The plantlets obtained need to be grown in beds before they are transplanted into the fields. The results in terms of type of plantlets and size are not very consistent and difficult to control. Nevertheless this technique is the basis for rapid pineapple propagation in many countries while in others it is not allowed because of the restrictions about the use of phytochemicals in pineapple cultivation.

Practical techniques for small farms in French West Indies

All of the techniques but the first one described below are used in French West Indies and other Caribbean islands for expansion of new varieties. Table 1 below provides a comparison of the timing and production of the different propagation techniques.

1) Removal of the flowers: Two months after flower induction on young plants (4 to 6 months old), the young inflorescence is broken off (castration), which destroys apical dominance and boosts sucker production. Additional cultural practices such as cutting off the old leaves and applying fertilizers will also promote faster growth. Six to seven suckers per plant may be harvested during the following 12 months depending on the size of suckers the producer is looking for. The plant density may be increased up to 100,000 plants/ha resulting in the production of 500,000 plants/ha in 18 months, which includes the time required for growth of mother plants. But this technique requires a previous multiplication for new varieties or for multiplication of selected plants. Finally the technique is very similar to the classical production of suckers after harvesting fruit.

2) Crown leaf budding: This technique has been used for many years and many alterations of the original technique have been tested (K.K.Seow *et al.*, 1970; C.K.Lee *et al.*, 1978; H.C.Dass *et al.*, 1984). Each crown leaf in the pineapple plant covers a bud on the stem at its base. The first step is to remove and discard the base of the crown and any dry leaves. Each green leaf of the crown can then be carefully removed along with a small piece of the stem just under the bud (Figure 1A). The top portion of the crown with associated leaves is too soft to permit the removal of single buds so the whole top is just split vertically into four pieces. The cuttings are then dipped into a sodium hypochlorite solution followed by a fungicide dip to protect against rotting and then planted into flats containing moistened sand, a mixture of black soil and peat (Figure 1B), or agarose (agar medium). One month after the transfer to the growing medium the buds develop into plantlets. The stages of development can be seen in Figure 1D. No fertilizer application is required at this stage.

After two to three months of growth, the plantlets are transferred into propagation trays (sheet pots) Figure 1D) or into beds in a greenhouse. The growing media used at this stage consists of 45% black peat, 40% white peat, 15% clay and 4 kg Osmocote 10-11-18+2 per m^3 (Osmocote may be replaced by other fertilizer compounds). The propagation trays are installed under shade (40%) and irrigated with small sprinklers just to maintain the soil wet (Figure 1E). After three additional months of growth under light shade, i.e. when they are five to six months old, they are ready to be transplanted into the field. One crown can give up to sixty plantlets depending on the variety of pineapple.

3) Young plant or crown apex destruction: Destroying the apex of young plants or crowns by gouging (Figure 2A) allows for the fast development (3 months) of 10 to 15 plantlets even directly in the field. The apex is destroyed manually and then disinfected with a fungicide (Aliette for example). Young plants must be about 25-30 cm high before gouging as the stem is very small and it is difficult to remove the apex correctly. The stems of crowns are much larger so gouging is much more easily done, even on a small crown. After disinfection, the plants or crowns are planted and grown as usual but at a density of 75,000 plants/ha. Plastic mulch reduces contamination of the new plantlets by soil. In three months, about 10 to 15 plantlets can be removed from the mother plants (Figure 2B) and grown separately in propagation trays or in beds under shade to accelerate emergence of the new plantlets with the same fertilizer applications and irrigation as described for crown leaf budding.
They also can be left in place to grow up to the size suitable for transplanting into the field (Figure 2C). If the plantlets are kept on the "mother" plant until they reach a size allowing transplantation into the field, the number of plantlets will be reduced to 5 or 6 per crown. Development of the plantlet is promoted as described above for crown leaf budding, either in sheet pots or in beds under shade (Figure 1E).

4) Stem splitting: The stems of mature plants can be prepared for fast multiplication after harvest of the fruit and of one or two suckers. This classical technique allows the production of 20 to 40 plantlets per stem. The old leaves must be removed from the stem after which it is split in half (Figure 3A) or cut into slices 1 cm thick. After being disinfected (insecticide and fungicide dips), stem halves are laid over a medium of perlite + vermiculite (50% each) and irrigated by misting three times a day for 2 minutes. A sand bed also works fine. Too much moisture leads to stem rotting, so accurate control of irrigation is needed. The plantlets are grown under shade (same device as for leaf budding or even simple tunnels under shading tissue (Figure 3E) may be sufficient). Foliar applications of fertilizer mixed with insecticide every 2 weeks promote more rapid growth. Buds start developing into small plantlets after 2-3 weeks (Figure 3B). The stronger the shading the more plantlets while more light results in fewer but much more vigorous plantlets. The plantlets (Figure 3C, 3D) may be transplanted into sheet pots as explained for leaf budding or left on the stem until they reach a size suitable for transplanting into the field (about 3-4 months). In the latter case, the emergence of new plantlets will be delayed. The main drawback of the technique is that it is time consuming for the preparation of the stems. An optimization of the method has been developed in Antigua (M.A.SIROY, 1996).

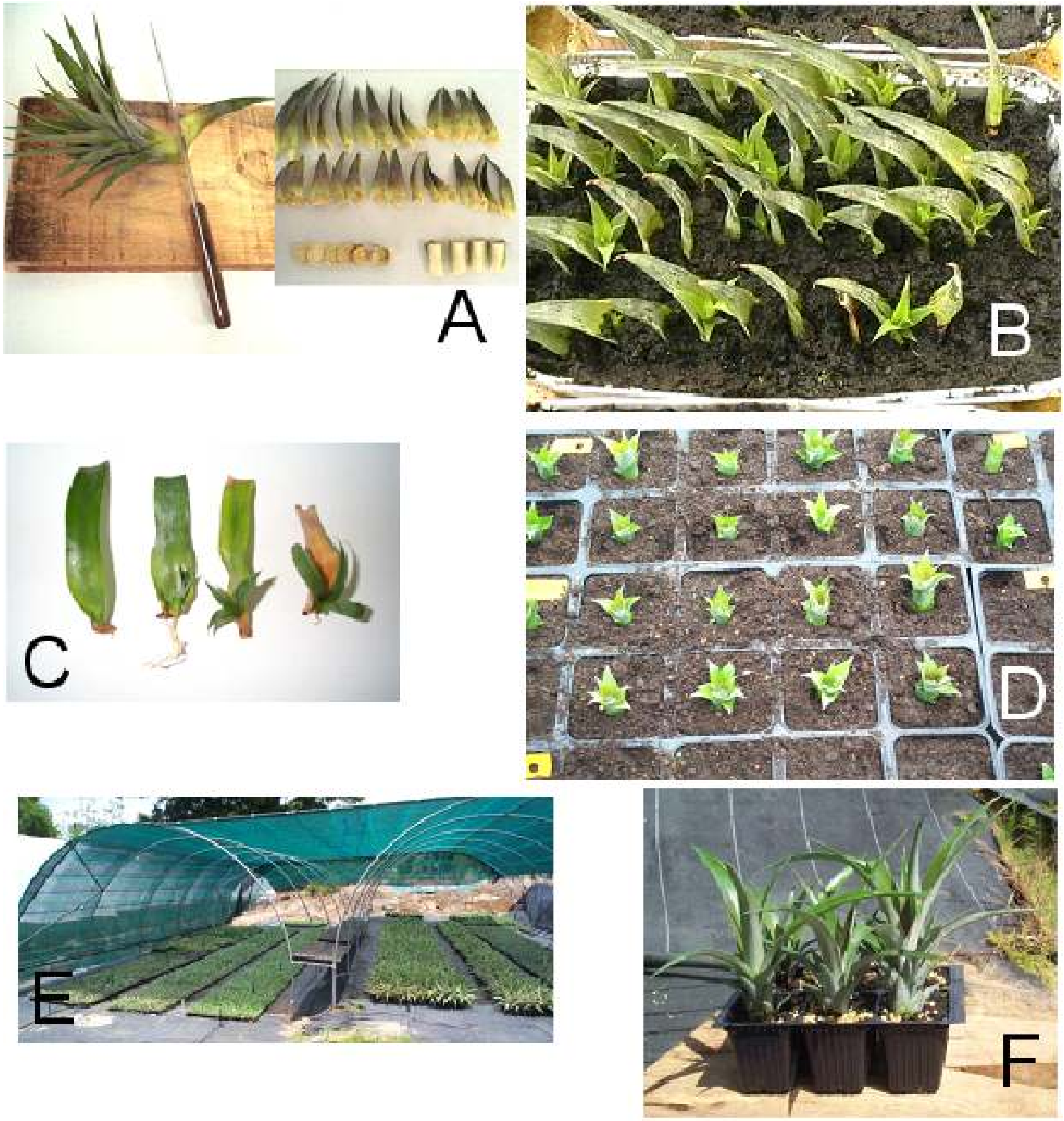


Figure 1. Crown leaf budding. A. Separating leaf buds from the crown. B. Leaves growing in the planting medium. C. Four stages of bud development. D. Plantlets transferred into small pots. E. Plantlets under shade and irrigated with small sprinklers. F. Plantlets ready to be transferred to the field.

Figure 2. A. Destruction of the stem apex by gouging. B. Plantlets produced by gouging. C. Plantlets left on the mother plant (crown.

Table 1. Timing and production of plantlets for different propagation techniques to obtain 50 000 plants for 1 ha.

Method	Mutliplier	Initial material	Mother plant growth†	Plantlet production	Plantlet growth	Total growth
Tissue culture	1000	50	-	12	6	18
Chlorfurenol	10	5000	6	6	6	18
Plant castration	5	10000	6		12	18
Leaf budding	50	1000	-	3	5	8
Stem splitting	25	2000	-	3	5	8

†This and other columns to the right are time in months. The "Total" column is considered to be the minimum time.

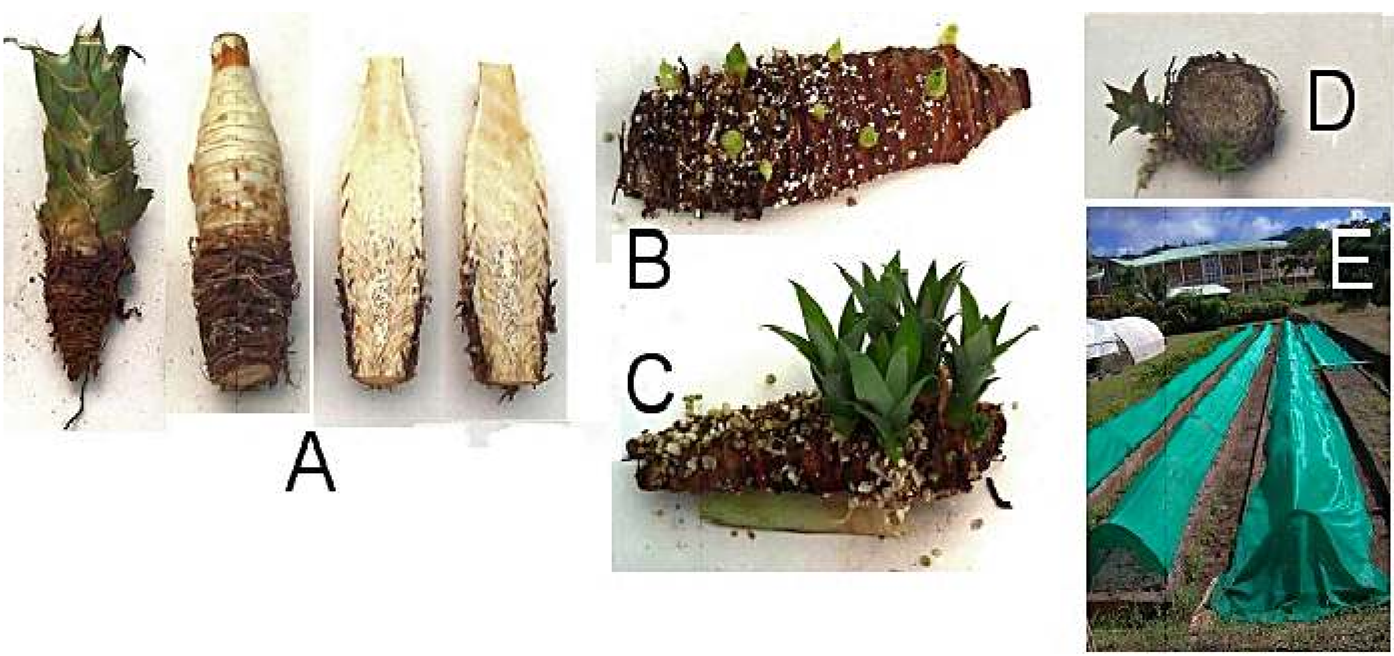


Figure 3. A. Stems cleaned and split into halves prior to disinfection. B. Stem half with growing buds. C. Stem with plantlets ready to be picked. D. Stem slice with growing plantlet. E. Stems in sand beds covered by shade cloth.

Conclusion

Multiplication factors and timing of plant production depend on environmental conditions and varieties. The 3 propagation techniques described as more practical techniques must be adapted to local conditions, particularly manpower cost, availability of greenhouses or similar structures or even availability of chemicals. The choice for a particular technique depends on the goal of the producers. The techniques showing the higher multiplication factors are more sophisticated and may require special infra-structures with higher costs and so they are useful for development of new varieties or multiplication of specifically selected plants. With the others, the classical infra-structures of production are sufficient, and so are more convenient for farm expansion.

References

Dass, H.C.; Sohi, H.S;; Reddy, B.; Prakash, G.S. 1977. Vegetative multiplication by leaf cutting of crowns in pineapple (*Ananas comosus* L.). Current Science, 46 (7), p241-242.

Gonzalez-Olmedo, J. L; Fundora, Z.; Molina L. A.; Abdulnour J.; Desjardins Y.; Escalona M. 2005. New contributions to propagation of pineapple (*Ananas comosus* L. Merr) in temporary immersion bioreactors. In Vitro Cellular & Developmental Biology Plant; 41; 1; p87-90.

Lee, C.,K.; Tee, T.S. 1978. Plantlet Quartering - A rapide propagation technique in pineapple. XXth International Congress, Sybney, Australia.

Py, C. 1979. Production accélérée de matériel végétal de plantation. Fruits, 34 (2) , p107-116.

Py, C. ; Lacoeuilhe, J.J. ; Teisson, C. 1984. The pineapple cultivation and uses. Maisonneuve et Larose, Paris ; 568p.

Sandford, W.G. 1973. Growth regulator may speed pineapple propagation. Hawaï farm science,3 , p8.

Seow, K.K.; Wee, Y.C. 1970. The leaf bud method of vegetative propagation in pineapple. Malaysian Agricultural Journal, 47, p 499-507.

Siroy, M.A. 1996. Development of pineapple in Antigua : Optimization of a rapid multiplication technique. IICA Publication , 44p.

Forcing in Pineapples: What is New ?

Alain Soler[1] alain.soler@cirad.fr, Claude Teisson[2], claude.teisson@cirad.fr, Bernard Dole[1], bernard.dole@cirad.fr, and Paul-Alex Marie-Alphonsine[1], paul-alex.marie_alphonsine@cirad.fr

[1] Cirad Pram BP214 97285 Lamentin cedex 2 (Martinique -F.W.I)

[2] Cirad-Flhor Montpellier Avenue Agropolis, 34398 Montpellier Cedex 5 France

Introduction

Successful forcing is a key point for economical sustainability for pineapple farms. Ethylene, the natural hormone controlling pineapple flowering, is the best forcing agent. On that basis, the following different techniques have been developed and are still in use.

- Gaseous ethylene injected into water with activated charcoal is the most widely-used technique on large scale farms with a high level of mechanization (Py et al., 1984). Night applications are required as the pineapple stomata through which the plant absorbs the gas are closed during the day.
- Calcium carbide after contact with water produces acetylene, a gas with a chemical structure very close to ethylene (Abeles, 1973) that can force pineapple (Py et al., 1984). The explosive nature of acetylene limits this efficient technique to smaller farms with manual application of a water-saturated solution (Abutiate, 1977). The technique also requires night application.
- Ethephon, an ethylene releasing agent, has become the most popular technique over the world as it may be used by large or small farms and the chemical can be applied during the day, ethylene being released slowly in the plant (Cooke et al., 1968). The main limitation of this technique is poor efficiency during hot climatic conditions (season or equatorial areas).
- Cold water (5˚C) has been used on organic farms as other methods were prohibited. The technique gives results only on plants very susceptible to natural induction such as plants under stress (nutritional or mechanical stresses); the stresses enhance the natural production of ethylene by the plants. The results are very low and this method is scarcely used.

Recently European regulation (CE 1138/2005 as a complement of Annex II regulation CEE N° 2092/91) and following the US regulation (http://www.ams.usda.gov/nop/NationalList/FinalRule.html, § 205.601 Synthetic substances allowed for use in organic crop production; (k) As plant growth regulators, Ethylene - for regulation of pineapple flowering) allows the use of ethylene, and ethylene only, as a forcing agent for organic pineapple production. This alteration of the European regulation may be considered as a good opportunity for many small farmers, the main suppliers of organically produced pineapple on the markets, providing that adequate techniques are developed for the use of gaseous ethylene with minimal equipment. For this we developed the following two strategies.

1. Adaptation of the injection of gaseous ethylene into water with activated charcoal as a small device handled by a single operator.
2. Enrichment of dry activated charcoal with ethylene.

Material and Methods

1. Small equipment for injection of gaseous ethylene into water: For this development we took into consideration the typical conditions of application in large fields: 680g to 2500g of ethylene (or 0.8 to 3 L) in 6000 to 7000 L of water with 0.5 % active charcoal in suspension. Spraying is done at night when stomata are open, and the treatment replicated 2 to 3 days after the first application.

2. Dry activated charcoal enriched with ethylene: This technique is based on the fact that ethylene is extremely efficient when applied directly into the heart of the plant. In experimental conditions a quantity as low as 0.16 ml/plant induces flowering (Dass et al, 1975). Another fact is that activated charcoal has the capability to fix gases.

2.1. Enrichment of the activated charcoal: Activated charcoal is placed inside a plastic bag or other vessel and enriched with ethylene under vacuum. Three to four successive cycles of vacuum application for 2 minutes at 9.0 mBar max (1.7m^3/hr by a Vacuubrand® pump, model MZ 2C), each followed by breaking the vacuum by injection of pure ethylene into the bag. The ethylene and charcoal stay in contact at atmospheric pressure for 3 minutes before a new cycle starts. At the end of the last cycle the plastic bag or vessel containing the activated charcoal is quickly sealed or tightly closed after the atmosphere has been saturated with ethylene. *The technique of enrichment of activated charcoal with ethylene was set up by F.Lebeau from Faculté des Sciences Agronomiques of Gembloux (Belgium).*

2.2. Different forms of activated charcoal: Different forms and quality of activated charcoal have been prepared: Powder (mesh100-400) and granules (0.5-2mm). According to the quality of the activated charcoal, the amount of ethylene fixed may vary from 1% to 6% by weight.

2.3 Finally two modes of application were tested: Application of dry powder in the heart of the plant or liquid application after mixing the activated charcoal powder in water. Two experimentations were set up, one in Cameroon and the other in Martinique.

2.3.1. Cameroon: A high quality dry activated charcoal powder with ethylene enrichment of 6% was applied into the heart of the plant or mixed with water. Only one application was made early in the morning (7:00 a.m.). There were 200 plants per treatment in two plots and the plant D-leaf weight ranged from 65 to 78g.

2.3.2 . Martinique: An industrial quality activated charcoal powder enriched with 1.0 and 2.0% ethylene was mixed in water. One application, 50 ml in the heart of the plant, by a 15 L knapsack sprayer was made early in the evening (7:00 p.m.). There were 140 plants per treatment in two plots and plant D leaf weight averaged 80g. Comparison was made with the standard ethephon treatment (Ethrel 400ppm + 5% urea in water - 50ml/plant).

Results

1. Description of a small equipment for injection of gaseous ethylene into water: The system is based on alteration of a small boom sprayer placed on a tractor (Figure 1). The main alteration of the classical system is the use of a double hose mounted on a hose reel (Figure 2) and with a double nozzle sprayer that allows the treatment of a double pineapple row, the boom staying outside the plot.

The two key points of the system are:

- The pumping system must allow the mixture "water/activated charcoal" (but not ethylene) to recirculate constantly towards the tank in order to keep the mixture homogeneous, and must have the appropriate pressure regulator;
- The ethylene injection device (Figure 3) is specifically required to allow the gas to be injected into water and form very small bubbles to increase the efficiency of gas take up by the mixture.

2. Dry activated charcoal enriched with ethylene: Preliminary analysis of the amount ethylene fixed on the activated charcoal and its stability showed that when the enriched charcoal is left in open air it loses half of the fixed ethylene in about 15 minutes. This provides enough time to prepare the suspension in water and to spray it on the plants. Using this data we could evaluate the actual amount of ethylene applied during the different treatments. Data are shown together with the percentage of plants forced in the following tables.

2.1 Experiment in Cameroon: The forcing was relatively good (Table 1) but not completely successful (a range between 80 and 90% of plants flowered) for most of the treatments with ethylene, regardless of whether a water suspension or dry powder was used. The exception was treatment where 2 mg/plant of ethylene was used.

Figure 1. Tractor-mounted sprayer and double-nozzle applicator.

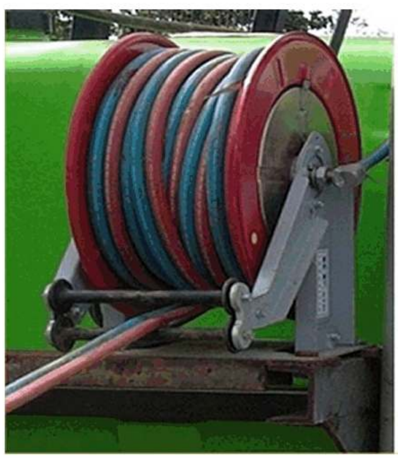


Figure 2 (left). Reel with double hose.
Figure 3 (right). Ethylene injector (Air Liquide).

Table 1: Pineapple forcing by activated charcoal enriched with 6% ethylene (Dry powder or Water suspension)

Treatment	Activated Charcoal mg/plant	Ethylene mg/plant‡	Plants forced %
Control (no application)	0	0	0.6
Dry powder*	690	42/21	84.5
Dry powder	350	21/10	84.8
Water suspension†	1180	71/35	89
Water suspension	430	26/13	80
Water suspension	232	14/7	84
Water suspension	55	4/2	42.5

*The indicated quantity of dry activated charcoal powder was poured directly into the heart of the plant.
†The activated charcoal was suspended in water and 50 ml were poured into the heart of the plant.
‡Estimation of amount of ethylene just after enrichment and at the end of the application.

2.2 Experiment in Martinique: The forcing with ethylene was excellent (almost 100%) for most of the treatments (Table 2), except for ethylene at 1.4 mg/plant. The standard technique with ethephon also gave excellent results.

Table 2: Pineapple forcing by activated charcoal enriched with 1 and 2 % ethylene (Water suspension).

Treatment	Activated Charcoal mg/plant	Ethylene mg/plant†	Plants forced %
Control (Standard Ethephon application)	0	400ppm/50ml	97.1
Water suspension charcoal enrich.1%*	570	5.7/2.8	100.0
Water suspension charcoal enrich.1%	285	2.8/1.4	98.6
Water suspension charcoal enrich.1%	142	1.4/0.7	93.6
Water suspension charcoal enrich.2%	570	11.4/5.7	98.6
Water suspension charcoal enrich.2%	142	2.8/1.4	75.7

*The activated charcoal powder was suspended in water enriched with 1 or 2% ethylene by weight and applied as a spray at 50 ml/plant.
†Estimation of amount of ethylene just after enrichment and before application .

Discussion

1. Small equipment for injection of gaseous ethylene into water: The equipment as designed allows forcing of pineapple for small farms with the same efficiency as on large farms. Basically the technology is the same but it has been adapted to the mechanization capabilities of small farmers. Nevertheless, it requires a minimum level of equipment: tractor, small boom sprayer (600 to 1000L), access to bottled ethylene, the ethylene injector, and finally activated charcoal.
2. Dry activated charcoal enriched with ethylene: In Cameroon and Martinique, except for the lowest quantities of ethylene, all the results were good, even if we take into consideration that the activated charcoal was applied only once. In some treatments, the amount of ethylene applied was far beyond what is physiologically required to force pineapple. For field applications the forcing may be correct with levels of ethylene as low as 5 mg when applied into the heart of each plant.

The differences between the results in Cameroon and those from Martinique may result from the sensitivity of the plants at the time of the treatments. It is well known, but not clearly understood, that many factors such as growth of the plants, phytosanitary conditions, climatic conditions, particularly the difference between day and night temperatures (Conway et al., 1982), are all key factors controlling the response of pineapple plants to ethylene or ethylene releasing agents. These factors alter the sensitivity of the plants to the forcing treatment. Another factor to be taken into account is the stability of the enriched charcoal. Charcoal enrichment for Cameroon was prepared in Belgium a relatively long time before use while charcoal enrichment for Martinique was done two days before treatment.

Conclusion

The two techniques reported here offer small farmers better control of the cycle of pineapple making their work easier and making pineapple farming economically more sustainable. These two techniques were developed for small growers but with the alteration of the European regulation regarding forcing in organic farming we realized that these results would be of special interest to organic growers who previously could not force their pineapples and typically harvested fruit in a given field over a five to six month period. These techniques make the forecasting of cultural practices and harvesting as feasible in pineapple organic production as it is for a large industrial farm.

Former studies showed that other ethylene releasing agents in dry powder or dry pellet forms (Ethylene chlatrate by Air liquide) were very efficient in forcing pineapple. They could not be developed commercially where usage was limited to only pineapple forcing. Activated charcoal does not have this constraint as it is a cheap component and has many other uses mainly as a basic component of water or gas cleaning filters. Further studies are required to develop a commercial product that is easy to formulate and apply and that is stable and cheap enough to be used by small farmers.

Acknowledgements

In Cameroon the experiments were set up with the technical support of Mr J.P.Imele from Biotropical Cameroon, and Faculty of Agronomy of Gembloux, and sponsored by PIP (Pesticide Initiative Program), EU implemented by Coleacp. In Martinique experiments were set up by CIRAD in its own experimental field.

References

Abeles F.B.; 1973. Ethylene in plant biology - Academic Press, New York, 302p.
Abutiate W.S.; 1977. The effects of concentration and periods of day application of calcium carbide on the flower induction of Pineapple in Ghana. Acta Horticulturae, 53, 273-278.
Conway M.J. 1982. Effects of plant age and night temperatures on the susceptibility of pineapple to floral induction with ethephon. M.S. Thesis. Univ. of Hawaïi, Honolulu, U.S.A.
Cooke A.R. , Randall D..I; 1968. 2-haloethanephosphonic acid as ethylene releasing agent for the induction of flowering of pineapples. Nature 218, 974-975.
Dass, H.C., Randhawa, C.S., Negi, S.P. 1975. Flowering in pineapple as influenced by ethephon and its combinations with urea and calcium carbonate. Scientia Horticulturae 3 (3) 231-238.
European regulation CE 1138/2005 - complement of Annex II regulation CEE N° 2092/91)

Py, C., Lacoeuilhe, J.J. and Teisson, C. 1984. The pineapple cultivation and uses. Maisonneuve et Larose, Paris. 568p.◆

News From Indonesia

Pineapple Root Health Problem in Indonesia

Contributed by Dudy Arfiain, PT Great Giant Pineapple Company, Indonesia. E-mail: OomAulia@ggpc.co.id
Formatted and edited by D. Bartholomew.

Mr. Arfian wrote a few months back asking about a root health problem on the PT Great Giant Pineapple Co. farm in Indonesia and included pictures of plant injury (see photograph below showing plant with a poor root system on the left and one with a healthy root system on the right). Mr. Arfian reports that the possible pest problems such as symphlids, *Phythopthora*, *Pythium*, nematodes and white grubs in fields did not exceed the economical limit. Dudy reports the following.

- Al saturation is very high in a lot of areas (average 63.97% or 45% above 70% Al saturation)
- Poor internal drainage, which results in poor aeration and an increase in Al toxicity in the root system. Root development is very poor and the colour of root tips is more brownish than white.
- Lime application of approximately 1.78 tons/ha was not too effective in controlling the Al saturation, only reducing it by about 50%.
- Average soil parameters were, pH, 3.76; CEC, 2.81; Al saturation, 63.97%; nutrients (me/100 g) were P, 11.76; K, 0.21; Ca, 0.46, Mg, 0.34; Al, 1.80. Average leaf analysis for plant nutrient elements, N as percentage and all others as ppm, from 90 locations were as follows: N, 0.19; P, 256; K, 3760; Ca, 54; Mg, 166; Fe, 18.4; Zn,3.21.
- Liming reduced Al saturation and increased exchangeable Ca but not significantly affect levels of exchangable Mg, P and Fe.

Dudy closed by saying “I hope other readers can share with us their experience”. Please contact Mr. Arfian directly at the email address above.

News From Israel

Pineapple Production in Israel

Yoav Krayn, Israel. E-mail: krayny@013.net.

Pineapple production in Israel became established in the 1980's. The fruit is grown for fresh market consumption only and is considered an exotic fruit. Israel's climate is subtropical and limits production. Production is predominantly in greenhouses and growers must contend with a fragmented market.

Pineapple production was established in Israel by a small group of farmers in the beginning of the 1980's on very small plots. Production is scattered throughout Israel and ranges from the arid region in the south all the way to the cooler northern areas, mainly on the coastal plain at sea level. These diverse growing areas have marked climactic differentials as well. Minimum temperatures can reach freezing at times (some regions experience an occasional frost). Generally, minimum temperatures on the coast may reach 5 °C. There is also a threat of hail and strong winds. Maximum temperatures in the summer may exceed 40 °C.

For most farmers, pineapple is an additional production line. To this day production operations are very small (miniscule in relation to world production). An average farm cultivates about 1.5 ha. There are roughly 50 growers in Israel and the dominant cultivar being grown is Queen. There are other varieties in cultivation but information is hard to come by.

The main planting material used is suckers. Planting densities vary and are site specific. In general the time from planting to harvesting is 18 months (and from planting to flower induction treatment 12 months). After each plant crop is harvested and suckers are produced, the field is replanted. Rattoon crops are not the norm.

Locally grown pineapples are sold for fresh consumption. Pineapples enjoy an exotic aura and are a specialty item. The local climate is not hospitable to pineapple growing and they are produced by intensive methods (greenhouses etc…). Many of the problems mentioned in the literature related to subtropical climates are manifested in Israel, including significant natural flower induction, cold damage and sunburn. There are no known growth regulators that are used to mitigate the effects of natural flowering. Information on this and other subjects is sketchy at best and therefore, difficult to assess. Owing to the pronounced effect of the climate, fruit quality varies significantly.

Farmers usually face marketing problems on their own since the market is fragmented and marketing information is not shared. The summer months (July -September), are usually the time of year when there is a glut in the market (because of natural flowering) and prices plummet.

Pineapples are and will continue to be a wholesome part of Israeli fruit production. There is room for improvement in production standards and market information free flow. However, since local production is relatively small, government agencies are not involved in research and market forces make it very difficult for single farmers to conduct the kind of research needed.◆

News From South Africa

.*Production of Organic Pineapple in the Eastern Cape 2002 - 2010*

Contributed by David Murray, ARC-ITSC, Bathurst, Eastern Cape, South Africa; Email, pga@

Introduction

Globally, pineapple in both fresh and processed forms are readily available - availability is just a matter of logistics and affordability. Since its discovery in 1494, production techniques and materials have evolved to counter most of the production hazards resulting in fewer crop failures. Today, transportation and packaging innovations can distribute superior tasting fruit across the World in pristine condition throughout the year. The "exotic" status of the pineapple is gone and suppliers are focusing on ways and means of creating and maintaining their respective competitive edges in the market place.

Del Monte Corporation and their hybrid MD2 pineapple has been a good example of this for the past decade. Some of the old pineapple mystique still lives on in the Organic Pineapple arena and the latest financial reports indicate an attractive competitive edge for those brave enough to open this door. Strangely enough, there exists a market even for conventionally processed Organic Pineapple! Perusal of the limited information available indicates that Costa Rica and Honduras are the market leaders with collectively some 250+ producers who have the potential for approximately 15,000 tons per annum Organic Pineapple in the future.

Organic Pineapple Research & Development: South Africa

Funded by the Eastern Cape Pineapple Growers Association and the ARC-Institute for Tropical and Subtropical Crops, Nelspruit, organically certifiable Cayenne Pineapple production has been a focus since 2002 (Table 1). The Development Strategy revolves around 3 separate sequential phases, all centered at the Industry Research farm at Bathurst. The cultivation method evolved must be "producer friendly' - apart from company-owned pineapple production, the SA producers are some of the largest private producers in the World today and need no further complications of their tasks.

Table 1. Time scale for organic pineapple production.

Phase	Time Scale	Site - Bathurst	Soil
Phase I	2002 - 2005	No recent pineapple cultivation	Well rested soil
Phase II	2005 - 2008	Recent pineapple cultivation	Medium fertility
Phase III	2007 - 2010	Current pineapple cultivation	Poor fertility/soil type

In the first two years following trash incorporation, each site goes through a conditioning/detoxification process using approved techniques, materials, biological stimulants etc, before being established to the local CM94 Cayenne Selection at 45,000 plants/ha on double row ridges. Once analytical and subjective soil analyses indicate the "desired" structural, mineral and biological status, then and only then, does the trial commence. Ideal soil parameters (Table 2) are closely allied to those found in the Albrecht Papers - these seem to be the starting point for most organic gurus.

Table 2. Ideal composition of soil for most crops.

Soil component	
M	45% Minerals
M	5% Humus
M	25% Air
M	25% Water
Ideal plant nutrient contents are: Calcium, 60 - 70%; Magnesium, 10 - 15%; Potassium, 3 - 5%; Sodium, 1 - 3%, Phosphate, 25 - 130 mg kg^{-1}; Iron, 100 250 mg kg^{-1}; Manganese, 40 - 240 mg kg^{-1}; Sulphur, 20 - 30 mg kg^{-1}; Zinc, 6 - 20 mg kg^{-1}; Copper, 2 - 10 mg kg^{-1}; and Boron, 1 - 2 mg kg^{-1}	

Certified off-the-shelf organic products (Table 3) have been utilized in an effort to foster the producer-friendliness of this exercise. This results in the following approach:

- Initially biological stimulants/inoculants to detox and enrich the soil
- Follow with chicken manure and other organic mineral soil supplements
- Followed by soil building ley crops (Sorghum) and more biological amendments
- A comprehensive soil incorporated dose of preplant plant food immediately prior to planting
- Thereafter the minimum of postplant sidedressings and sprays.

In Phase I, the CM94 plant material was slips, all dipped in organic pesticide/fungicide. All post plant applications were based on subjective plant and root inspection and/or leaf analyses.

Table 3. Fertilizers used in the various treatments, all are in terms of amounts applied per hectare (ha).

Treatment	Description
A1	2.0 T Talborne (www.talborne.co.za): Vita Veg 6:3:4 (14) sustained release (SR) source of N, P_2O_5 + K_2O Top dressing of 1.0 T Talborne Vita Nitro Boost 4:1:1 (14) SR source of N, P_2O_5 + K_2O.
A2	Soil Systems (Pty) Ltd., Australia: 30 T composted chicken manure, 2.5 T dolomitic lime, 2.5 T gypsum, 10 kg copper sulphate, 3.5 kg boric acid, 250 g sodium molybdate, 250 g colbalt sulphate.
A3 - A6	Inorganic industry standard: 1.5 T dolomitic lime, 500 kg gypsum, 100 kg potassium chloride, 25 kg copper sulfate, 25 kg manganese sulphagte, 15 kg Boronat, 4 kg zinc sulphate, 4 L chlorpyrifos, 100 L Telone, Hyvar-X, diuron, Atrazine
B	Full organic soil preplant program: 15 T composted chicken manure, 2.0 T dolomitic lime, 1.0 T Talborne Vita Veg 6.3.4 (14), 1.0 T soft rock phosphate, 30 L Humic Acid (18% wt/vol Organic Humate and 29 g/L Organic K, pH 11 - 12), 50 L animal molasses, 40 kg Biocult (Invam Biocult (Pty) Ltd, RSA; biocult@freemail.absa.co.za), 8 kg zinc chelate, 10 kg copper sulphate
C	50% organic soil preplant program: 7.5 T composted chicken manure, 1.0 T dolomitic lime, 500 kg Vita Veg 6.3.4 (14), 500 kg soft rock phosphate, 15 L Humic Acid, 25 L animal molasses, 20 kg Biocult, 4 kg zinc chelate, 5 kg copper sulphate
D	Perspective block: Nil preplant fertiliser, nil nematicide, 1 x sidedressing (N:K), 2 x foliar sprays, conventional herbicides

Post Plant Applications : Organic Treatments B & C in Table 3.

- Beetle traps baited with kairomone attractant placed at 200 m^2 intervals
- 3 x Talborne 6.3.4 (14) sidedressings @ 500 kg/ha per application.
- 4 x Talborne Biotrissol + Pyrol + Molasses foliar sprays
- 9 x manual hoeings (total 807 man hours/ha)
- Ice block induction in 2004 unsuccessful
- Harvest period (22/3/2005 - 2/11/2005)

Nutrient analysis are shown in Table 4.

Table 4. Final leaf analysis (Received 8/6/2004).

Orchard		N	P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn	B
		- - - - - - - - - - - - %- - - - - - - - - - - - - - -					- - - - - - - - - - - - - - - - mg/kg- - - - - - - - - - - - - -					
Full Organic AV	White	1.53	0.20	3.02	0.42	0.21						
	Green					154	45	268	3	8	11	
Full Organic+N	White	1.48	0.23	3.09	0.46	0.23						
	Green						131	48	225	3	10	11
Full Organic+M	White	1.53	0.20	2.95	0.45	0.19						
	Green						140	44	249	5	10	10
Organic Non Plastic	White	1.41	0.16	3.08	0.31	0.18						
	Green						138	49	257	4	9	13
Organic Plastic	White	1.68	0.21	3.49	0.48	0.27						
	Green						132	60	311	5	12	10
Half Organic AV	White	1.47	0.22	2.83	0.50	0.20						
	Green						141	44	196	4	12	10
Half Organic+N	White	1.48	0.19	2.68	0.41	0.19						
	Green						167	42	230	4	11	11
Half Organic+M	White	1.57	0.25	2.97	0.45	0.22						
	Green						143	47	231	4	10	11
Industry AV	White	1.53	0.22	2.89	0.58	0.23						
	Green						172	52	325	5	42	13

Please note: White = white basal section of D-leaf; Green = green basal section of D-leaf, M =Mycorrhiza, and N = Neem Oil.

Loss of Apical Dominance in Pineapple

Col Scott, Summerpride Foods Ltd., East London, South Africa. E-mail: scottch@border.co.za

I am seeking comments regarding a problem that appears to be specific to the Eastern Cape pineapple industry in South Africa. This disorder is most commonly found in young plants due to be forced in early summer. The first indication of the problem usually appears in late winter or early spring when affected plants tend to display off-centre heart leaves. At this stage, if the plant is bisected, a necrotic area can be seen below the growing point (Fig. 1). Ground suckers develop as a result and become obvious a few months later (Fig. 2).

At the time of plant crop harvest, these ground suckers are sufficiently mature to initiate when Ethephon is applied as a ripening agent. The resulting fruit are mostly small but more importantly, are out of synchronization with the first ratoon crop. This phenomenon accounts for some serious losses in first ratoon yield.

There are many schools of thought as to what causes the problem but it does appear to be closely associated with low temperatures as the highest incidence occurs on Southern slopes after a short period of cold maximum and minimum temperatures in early to mid winter. Others are convinced that it is caused by fertilizer burn as a result of side dressing with ammonium sulphate. However, trials comparing side dressing and foliar sprays demonstrated quite clearly that both forms of treatment produced similar levels of the disorder.

Growers began to observe the problem in the early nineties, a time when the industry switched from urea to UAN as its main source of foliar nitrogen. A little over twelve months ago, the industry reverted to urea again and this year, the level of incidence is much reduced. However, the winter of 2005 was also quite mild. If the problem is related to foliar nitrogen source, we really need a typical Eastern Cape winter to test the hypothesis. In the meantime, we will be installing trials comparing urea and UAN to see if in fact these products do have an influence.

Ed note: Please respond directly to Col at the email address above. Perhaps Col will provide an update on this work for the next issue of the newsletter.

Pineapple "D-Leaves" - Useful Indicators of Plant Health and Growth Status in the Smooth Cayenne Cultivar

Graham Petty, ARC - Institute for Tropical and Subtropical Crops, Private Bag X1, Bathurst, 6166, South Africa. Tel/Fax: 046 625 0946; E-mail: grahamp@imaginet.co.za

In the Eastern Cape almost all commercially grown pineapples are of the Smooth Cayenne cultivar. In this and other cultivars, the leaves are arranged in a spiral fashion around the central axis/stump, with oldest leaves closest to the soil and youngest leaves closest to the apical meristem. The D-leaf is the youngest fully mature leaf on a plant and is generally the longest leaf. It is used in chemical analyses to determine plants nutrient status. D-leaves are also commonly used as a measure of plant size. The determination of pineapple plant size is of great importance for a number of reasons, including:

1. Deciding when plants are large enough to force (induce flowering).
2. In research, to compare the efficacy of experimental treatments.
3. In the annual Industry competition, to determine the winner of the Bertie Gibson Trophy, which is awarded to the grower with the best 12 month old pineapple plantation.

Determining plant mass, by weighing whole plants after removing from the soil, is destructive, laborious and time consuming. These problems are particularly relevant when judging for the Bertie Gibson Trophy as data on a very large number of plants is desirable. If valid judgment of plant size can be based on D-leaf mass, then larger samples can be taken in time available and plants are not destroyed. To this end a study was undertaken to clarify the relationship between D-leaf mass and plant mass.

Method

A sample of 57 twelve-month old plants (Figure 1) , categorized as small, medium and large were sampled from a Bathurst pineapple plantation in November 2005. The masses of each plant, and its D-leaf, were determined. A scatter diagram was drawn with D-leaf mass as the independent variable on the X axis, and plant mass as dependent variable on the Y axis. Pearson's correlation coefficient, r, was calculated to determine the strength of the relationship between the two variables - D-leaf mass and plant mass. The linear regression equation was calculated and the regression line fitted to the scatter diagram, giving the nature of the relationship and a means whereby plant mass can be estimated from D-leaf mass.

Results and Discussion

Data were fitted by linear regression (see equation for the graph on Figure 2) and the resulting R^2 indicates that 95% of the variation in plant mass can be explained by D-leaf mass. It should be noted that the coefficient r, and the regression equation, are applicable to plants of a particular age and location, and are subject to variation for different ages and geographical locations.

Summary

For year-old Cayenne pineapple plants in the Bathurst district it is possible to estimate the mass of these plants by determining the mass of their D-leaves, and applying the regression equation of Figure 2 where y = plant mass and x = D-leaf mass. By this means, much larger samples can be taken per unit time and destruction of productive pineapple plants is avoided. Plant mass is an important indicator of maturity and is useful in making management decisions. It is also of importance in points allocation in judging for the annual Bertie Gibson Trophy competition. In addition, mass is important in evaluating experimental treatments in pineapple research.

Figure 1. A typical 12-month old 'Smooth Cayenne' plant.

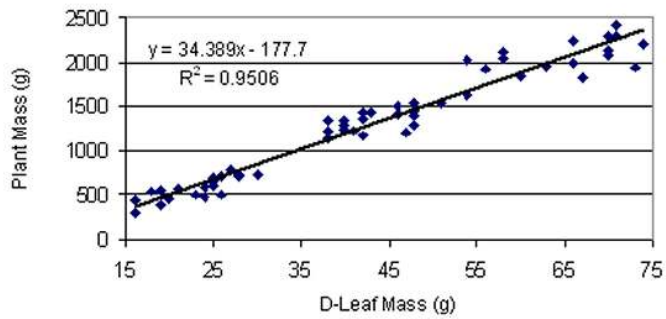


Figure 2. Relationship between plant mass and 'D' leaf mass.

Attracting and Trapping Popillia bipunctata, a White Grub Pest of Pineapples in South Africa's Eastern Cape, for Monitoring and Control

G. J. Petty, ARC - Institute for Tropical and Subtropical Crops, Private Bag X1, Bathurst, 6166, South Africa.
Tel/Fax: 046 625 0946; E-mail: grahamp@imaginet.co.za

Introduction

Pineapples, *Ananas comosus* (L.) Merr. are damaged to a greater or lesser extent in the Eastern Cape of South Africa by the larvae (white grubs) of more than 12 species of scarabaeid beetles. One of these species, *Popillia bipunctata*, (Figure 1) has been responsible for severe pineapple damage in the Bathurst - Grahamstown area. This species is closely related to the Japanese beetle, *Popillia japonica*, a notorious crop pest in a number of countries including the USA where it has been successfully managed with kairomone (feeding attractant) baited traps. Some of the kairomones, which have been shown to be most attractive to the Japanese beetle, were evaluated against *P. bipunctata* beetles on pineapple farms in the Bathurst - Grahamstown area.

Initial tests were carried out with "home-made" traps (Figure 2) based on the principles of the Ellesco trap which is for the Japanese beetle. In subsequent tests, modified commercially available traps (Figure 3) were used and these, together with different kairomone dispensing methods, were evaluated and compared on the basis of numbers of *P. bipunctata* beetles caught. Apart from *P. bipunctata*, all other insect species collected in the traps were identified and recorded.

Method and Materials

In a 2003 - 2004 study kairomones evaluated for attractiveness to *P. bipunctata*/Popillia beetle included the following: Cinnamyl alcohol, Nerolidol, ß. phenethyl butyrate, Geraniol and ß ionone. Each of these "floral attractants" were mixed in the ratio 9 parts to 1 part Eugenol (vol/vol). Subsequently, Cinnamyl alcohol and Eugenol were mixed in an 8:2 ratio, respectively, to prevent solidification of the mixture at low temperatures. Tests were carried out at three different sites but results presented here are for one site, where highest counts occurred.

Figure 2 shows the construction of the "home-made" trap used in the initial 2003 - 2004 studies when the efficacy of the different kairomones was evaluated. The trap is comprised of a 3 L plastic jar with screw-on lid, through which passes the stem of a large yellow funnel. Into the funnel are fitted two plastic fins at 90˚ to each other. Resting in the upper section of the fins is a 50 ml vial containing the kairomone which is released into the atmosphere via an absorbent wick.

Traps, each with its own kairomone mixture, were placed 10 m apart in pineapple fields in a line at right angles to the direction of the prevailing wind. This was to minimize interaction between different kairomones. The tops of the funnels were at the height of the plant canopy. Beetles were collected and counted from 30 September 2003 to 3 March 2004.

In a 2004 - 2005 study, a commercially available bucket-funnel insect trap was obtained and modified by placing fins in the funnel section, as shown in Figure 3. Also, different sulphur-yellow and dark-green colour combinations were evaluated i.e. traps were all yellow, or all green, or yellow with green fins.

An important aspect of these traps is the mechanism by which the kairomone is released into the atmosphere. Three possibilities were investigated.

Figure 1 (left). Adult Popilla beetles, 13 mm long by 7 mm wide, are easily idintified by two white prominent spots on the terminal abdominal tergites. Males and females are difficult to distinguish from external appearance.
Figure 2 (right). "Home-made" trap used in initial attractant studies.

1. The vial-wick method, with two variations
   a. a commercially available form, and
   b. a 50 ml vial fitted with a lamp wick or a cotton dentist roll as wick.
2. A commercially available "balloon" dispenser containing the liquid kairomone. The microporosity of this dispenser can be varied by the manufacturer to increase/decrease the release rate.
3. A commercially available sachet with the kairomone in a solid state wafer. Here, too, the release rate can be set in the manufacturing process to give increased/decreased rates.
4. With the above mentioned variations in design, colour and dispenser, eight different trap types were evaluated for effectiveness, (See Table 2). Traps were sited in pineapple plantations on eight farms. The results obtained at one such site will be given here.

Figure 3. Modified commercial bucket trap with fins in the top (funnel) section. A vial with wick dispenser is sitting on the right.

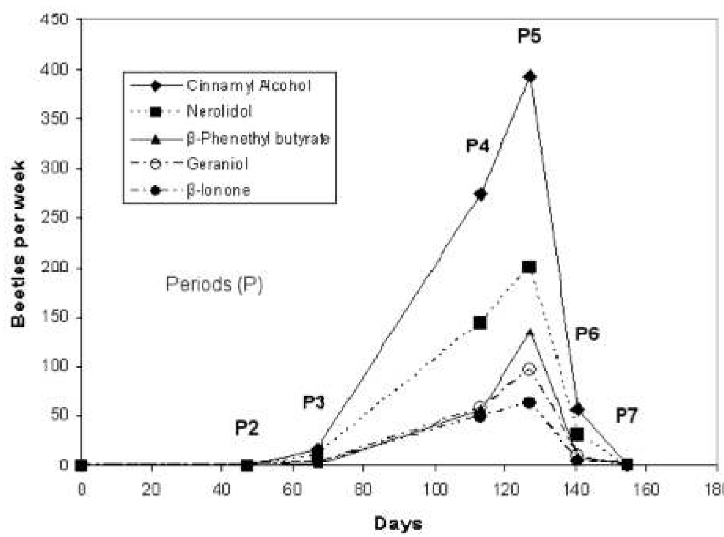


Figure 4. *Popillia bipunctata* beetles per week for different periods from September 2003 to March 2004 attracted to different kairomone mistures at 9:1 eugenol at Ford location.

Results and Discussion

2003 - 2004 Flight Season

The results given for beetles per trap in Table 1, ranked from most effective to least effective kairomone, show the Cinnamyl alcohol mixture to be almost twice as effective as the second best, Nerolidol, with 46% and 24% respectively. The remaining three kairomones were less than half as effective as Nerolidol and of similar efficacy.

Table 1. The number of adult *Popillia bipunctata* beetles collected per trap baited with five different kairomone mixtures (9 parts : 1 part Eugenol) for the three month period : 15 November 2003 to 17 February 2004.

Kairomone	Beetles per trap	Percentage of total
Cinnamyl alcohol	2760	46
Nerolidol	1450	24
ß Phenethyl butyrate	667	11
Geraniol	608	10
ß Ionone	485	8
Total	5970	

In Figure 4, the periods (P) in days vary in length and are: Period 3, 20 days; Period 4, 46 days; Periods 5, 6 and 7, 14 days each. In terms of beetles collected over time between September and March, the greatest activity occurred during Period 4, i.e., between 20 January and 3 February, when almost 400 beetles/week were collected by Cinnamyl alcohol and 200 beetles/week by Nerolidol.

2004 - 2005 Flight Season

The number of beetles collected by trap type (1-7, one of each) placed in the field from 25 November 2004 to 28 February 2005, and type 8 from 28 January 2005, gave the following total numbers of Popillia beetles (Table 2).

Table 2. Total number and percentage of Popillia caught in Trap type 1 - 8.

Trap type	Number of beetles	Percentage of total
1a	1790	15
1b	1983	16
2	968	8
3	779	6
4	1630	13
5	2000	16
6	1166	10
7	1950	16
8	150	

1. "Home-made"; 2. Commercial - all yellow + balloon dispenser; 3. Commercial - yellow with green fins + balloon dispenser; 4. Commercial - all yellow + glass vial - dental roll wick dispenser; 5. Commercial - yellow with green fins + glass vial - dental roll wick dispenser; 6. Commercial - yellow + sachet dispenser; 7. Commercial - yellow with green fins + sachet dispenser; 8. Commercial - all green + commercial vial - wick dispenser.

The above 9 traps collected 12,266 beetles. With an equal sex ratio this represents 6,133 egg laying females which could, potentially, produce 245,320 eggs and white grubs. The 150 beetles for Trap type 8 represents 14% of catch for the limited period it was in the field.

Conclusions

From total beetle counts it is apparent that:-

1. Most effective kairomone tested was the Cinnamyl alcohol - Eugenol 8:2 mixture.
2. Traps should be placed from the beginning of December to the end of February.
3. A colour combination of sulphur yellow bucket and dark green fins is generally more effective than an all yellow trap.
4. The commercial traps in their presently modified form are at least as effective as the original (Type 1) traps, and can be factory mass produced, thus reducing costs.
5. The recently developed commercial vial-wick dispenser is more effective than the commercial sachet dispenser or balloon dispenser. An added advantage is that the vials can be resealed, preserving the remaining kairomone for the following season.

With this kairomone trapping system, one of two different objectives may be achieved:

1. With a low number of traps, widely dispersed, the threat posed by Popillia beetles can be monitored and timely action taken before eggs are laid and grubs become a problem.

2. With a greater number of traps per unit area, it may be possible to keep beetle numbers below the economic threshold. At the present time it is not known how many traps per unit area are required to achieve this objective.◆

News From the United States (Hawaii)

The Hawaii Pineapple Industry, It's Problems and Potential

L. Douglas McCleur, Senior Management (Retired), Maui Pineapple Company, Haliimaile, HI

The Hawaii Pineapple Industry production has gone from 76,000 crop acres in the 1970's to probably less than 12,000 acres today. The reasons for this declining in production are many but the primary causes are as follows.

1. When Del Monte established a pineapple cannery in the Philippines in the 1930's where they had good cheap labor, a good port, and pretty good conditions for growing canned and fresh pineapple, Del Monte became the low-cost producer of pineapple in the world. Consequently, Dole felt it too needed to have an operations in Asia and started an operation in Mindanao and Thailand in an effort to compete with the canned and fresh fruit produced by Del Monte.

With these moves, the industry started to cut back on support for the Pineapple Research Institute of Hawaii and spread the technology for producing ‘Smooth Cayenne’ pineapple and their varieties all over the world. Soon locally owned operations started all over Asia, Africa and Central America. Some of these companies died but others have continued to flourish, particularly in Thailand, Indonesia, Malaysia, Africa and Central America.

2. In the 1990's the consumer started to request more fresh fruit and less canned products. Thus, canned fruit demand fell while major packers tried to shift production to plastic cups and glass. The "Whole Fresh" fruit industry grew to meet this increasing demand utilizing the superior fresh fruit varieties developed by the Pineapple Research Institute of Hawaii.

3. Del Monte took one of these varieties to Costa Rica, named it Del Monte Gold, developed refined growing and packaging techniques, refined the shipping techniques and established a major business in the United States. About the same time both Dole and Del Monte were developing a market in Japan for fresh fruit and fresh cut pineapple products. Thus, the "New Fresh Fruit Varieties" spread through out the world as the business flourished.

The problem now for Hawaii producers is that the market is accepting these fresh pineapple varieties being grown in areas of the world with lower growing costs and less distanced to markets than is the case for Hawaii. Thus, Hawaii's production continues to shrink as production in Mexico and Central America increases. While Hawaii producers continue to promote a Hawaii name, the major producers in Hawaii also have operations in Central America and I expect can produce a case of finished goods at considerably lower cost than from Hawaii. Hawaii struggles to compete with these areas of low cost production.

Another dilemma for Hawaii is that it takes so long to produce a new variety and without the Pineapple Research Institute or other major crop breeding program, it is difficult to produce a truly superior "Hawaiian" variety. The varieties now in the market were developed over 30 years ago. New varieties are being developed by scientists throughout the world but they are often doing it using the new crop development techniques utilizing "Genetic Modification". These techniques have a great chance for success in producing a new superior variety that will have disease and pest resistance as well as have great acceptance in the market place. It is my opinion that the major marketers of pineapple will have to review their stance on being anti GMO or others will be able to make great inroads with the consumer and thus the market.

The other dilemma for Hawaii producers is the high value of the farm land on which their crops are grown, similar to what has happened to farm land in much of the United States. With tourism now the leading industry in our state, and with the high real estate values, there is great temptation for the land owners to develop the land into resorts, golf courses and high priced housing.

Possible solutions for the Hawaii Pineapple industry might be as follows.

1.Utilized the abundant available pineapple land for crop rotation and thus reduce the nematode populations naturally, thereby reducing the reliance on expensive nematode control.

2. Invest in research and capital to utilize optics, quality control automation and automate grading and packing. This could reduce the cost of Hawaii's expensive labor while at the same time improving the product quality to the consumer.

3. Start a major research program to produce a true "Hawaii" variety that would differentiate the Hawaii producer from the rest of the world.

4. Utilize Hawaii's great land to develop and research the growing techniques to produce a superior "Organic" pineapple to meet the growing demand for this type of product in the premium-priced United States market.

The worlds consumers are getting used to having their goods and services come from all over the world. In this environment, the challenge for Hawaii is to keep the pineapple industry a strong vital part of our landscape and economy.

Nematode Control Research in Hawaii

Brent Sipes, Depart. Plant and Environmental Protection Sciences, 3190 Maile Way, Univ. of Hawaii, Honolulu, HI 96822

Some of our efforts have continued to focus on systemic acquired resistance (SAR) as a potential tool for nematode control in pineapple. The expression of PR-1 gene (a SAR marker) 1, 7, 14, and 21 days following application by acibenzolar-s-methyl was followed. Pineapples were uprooted, washed, RNA extracted, first strand cDNA generated, and a regular PCR performed using primers specific to the pineapple PR-1 gene. A 266 bp band, indicative of PR-1 induction, was present in acibenzolar-treated pineapple up to 21 days post treatment. In another test, 1, 7, 14, or 21 days post acibenzolar application, 40,000 eggs of *R. reniformis* were inoculated onto pineapples. Nematode reproduction on pineapples treated with 100 or 200 mg L^{-1} acibenzolar was 55% lower than that on pineapples treated with 0 or 50 mg L. Nematode reproduction on pineapples treated with the same concentrations but inoculated at different times was not significantly different ($P > 0.05$). Anecdotal evidence suggested that imidochlorprid, an insecticide, might also induce SAR or the related induced systemic resistance. Crowns were dipped into a solution of imidochlorprid or water, planted, inoculated with nematodes, and then harvested 9 months later. The plants grew very poorly and at harvest had a small to nonexistant root system. We isolated *Pythium* spp. from the soil and roots. We will need additional tests to determine if imidochlorpid induces SAR in pineapple. We have also been evaluating compost tea and Paceilomyces lilacinus as potential for biological control type agents. These test were just started and there are no visible differences among treatments yet. We are preparing to screen a new set of transgenic plants for nematode resistance. Previous plants proved to not be transgenic and had not greater resistance to nematodes than their wildtype parents.

Phytophthora updates from Hawaii

Glenn Taniguchi, Dept. of Plant and Environmental Protection Sciences,

In a study trial designed to look at fruitlet core rot/black spot disease, commercial hybrid cultivars from Hawaii were planted. Crowns were dipped in Ridomil Gold at label rate before planting. Four months after planting all hybrid cultivars sustained severe heart rot from *Phytophthora nicotiana*. 'Smooth Cayenne' was not affected. This study for fruitlet core rot/black spot was a disaster but Phytophthora heart rot data was collected as an informational fact. The following table is presented.

Table 1. Percent mortality by Phytophtora nicotiana on crowns dipped in Ridomil Gold before planting, at 4 months post plant.

Hybrid	Percent Mortality
73-114 (also known as MD-2)	97.5
9-70	20.0
D-10	20.0
73-50	20.0
Cayenne	0

For added information a second test was installed with no pre-plant fungicide treatment to determine cultivar susceptibility to Phytophthora heart rot. Four months after planting all hybrid cultivars sustained 100 percent heart rot from *P. nicotiana*. 'Smooth Cayenne' sustained only 30 percent heart rot. Table 2.

Table 2. Percent mortality by Phytophthora nicotiana on untreated crowns, at 4 months post plant.

Hybrid	Percent Mortality
73-114 (also known as MD-2)	100.0
9-70	100.0
73-50	100.0
Cayenne	30.0

In summary, it appears that Ridomil Gold only provides a maximum of 80% protection under heavy disease pressure. All commercial hybrid cultivars are extremely susceptible to Phytophthora heart rot. 'Smooth Cayenne', a rather resistant variety, benefits from a Ridomil Gold dip treatment. An advisory statement from the makers of Ridomil Gold say that protection from disease infection will be compromised if plants are planted in a heavy disease pressure area, susceptible varieties are planted, or heavy nematode populations are present.

Time Course of PR-1 Gene Expression in Pineapple Foliar Applied with Acibenzolat-smethyl and its Effects to Reproduction of Reniform Nematodes.

B. Chinnasri[1], T. Borsics[2], D. Christopher[2], and B. Sipes[1]. [1]Departments of Plant and Environmental Protection Sciences and [2]Molecular Biosciences and Bioengineering, Univ. of Hawaii, Honolulu, HI 96822

Systemic acquired resistance (SAR) is an intrinsic ability of plants to defense themselves against pathogens and characterized by the coordinated expression of pathogenesis-related genes (Prgenes). In our study, the expression of PR-1 gene (SAR marker) 1, 7, 14, or 21 days following application by acibenzolar-s-methyl (a potent SAR inducer) and the effect of the SAR induction on *Rotylenchulus reniformis* were investigated. Pineapple crowns were planted onto 15-cm diameter clay-pots. One month later, pineapple plants were foliar applied with a solution of 100 mg acibenzolar L^{-1} of water (10 ml per plant). One, 7, 14, or 21 days post application, pineapples were uprooted, washed, and RNA extracted. First strand cDNA was generated and a regular PCR was performed using the two primers specific to pineapple PR-1 gene. A 266 bp band, indicative of PR-1 induction, was present in acibenzolar-treated pineapple up to 21 days post treatment. To determine the effect on nematodes, a separate set of pineapples were grown and treated with acibenzolar at 0, 50, 100 or 200 mg L^{-1} of water. One, 7, 14, or 21 days post application, 40,000 eggs of *R. reniformis* were inoculated onto pineapples. The result showed that reproduction of nematode on pineapples treated with 100 or 200 mg L^{-1} was 55% lower than that on pineapples treated with 0 or 50 mg acibenzolar L^{-1}. Nematode reproduction on pineapples treated with the same concentrations but inoculated at different times was not significantly different ($P > 0.05$). SAR was induced in pineapple as early as 24 hours after acibenzolar application, remained activated for at least 21 days post application, and reduced nematode reproduction at rates above 100 mg L^{-1}.

Molecular Characterization of Two Pineapple Mealybug Wilt-associated Viruses Reveals an Early Divergence Within the Genus Ampelovirus.

Michael Melzer, Diane Sether, and John Hu. Department of Plant and Environmental Protection Sciences, Univ. of Hawaii, Honolulu, HI 96822

The family Closteroviridae represents a diverse assemblage of plant viruses and includes members that are responsible for diseases of great economic importance. The family is currently composed of three genera: Closterovirus, Crinivirus, and Ampelovirus, whose members are vectored by aphids, whiteflies, and mealybugs, respectively. In this study, the genomes of two Pineapple mealybug wilt-associated ampeloviruses (PMWaVs), PMWaV-1 and PMWaV-3, were partially sequenced from viral RNA. Orthologous open reading frames (ORFs) identified in the PMWaV-1 and PMWaV-3 genomes had moderate (63-72%) amino acid identity and a similar organization. This organization, however, differed from the genomes of other ampeloviruses with the lack of an intergenic region between the RdRp and p6, and the presence of a novel ORF downstream of the putative coat protein (CP). The 28.1 kDa PMWaV-1 CP and 28.8 kDa PMWaV-3 CP are by far the smallest identified among the ampeloviruses. The putative ORF1a/1b +1 ribosomal frameshift sequence of PMWaV-1 and PMWaV-3 also differed from other ampeloviruses. Phylogenetic analyses placed PMWaV-1, PMWaV-3, and select grapevine leafroll-associated viruses in a monophyletic group that diverged from other ampeloviruses early in their evolution. Overall, the distinctions between these two ampelovirus groups are equivalent to the differences observed between genera, and ultimately warrant the establishment of a second mealybug-transmissible genus within the family Closteroviridae.

Development of Transgenic Pineapple Plant with Resistance to PMWaV-2

E.A. Perez[1], H. Ma[1], M J. Melzer[1], D.M. Sether[1], W.B. Borth[1], K. Cheah[1], C. Nagai[2], and J.S. Hu[1]. Department of Plant and Environmental Protection Sciences, Univ. of Hawaii, Honolulu, HI 96822[1] and Hawaii Agricultural Research Center,Aiea, HI[2].

Pineapple mealybug wilt associated virus-2 (PMWaV-2) infection and mealybug feeding are involved in the etiology of mealybug wilt of pineapple (MWP), a serious disease of pineapple worldwide. The PMWaV-2 coat protein (CP) gene was engineered in sense and inverted repeat orientations into pCAMBIA 1300 transformation vector and introduced into pineapples using either leaf bases and *Agrobacgterium tumefaciens* (CP sense gene) or protocorm-like bodies (plbs) and biolistic bombardment (CP inverted repeat gene). Primary transformants from leaf
bases were regenerated on Murashige and Skoog's (MS) media containing 1 mg L^{-1} of benzylamino purine (BAP) with or without 16 mg L^{-1} of hygromycin B and those from plbs were regenerated on MS media containing 0.5 mg L^{-1} BAP with increasing antibiotic concentration of 16 to 25 mg L^{-1} of hygromycin B. Plants regenerated from the two transformations were further selected in stepped increases of 25, 35, and 50 mg/l of hygromycin B. CP gene sequences were detected in plants after the third selection cycle, confirming the integration of the CP gene into

the pineapple genome. At least seven lines of putatively transgenic pineapple plants that are resistant to PMWaV-2 infection have been produced after multiple challenges with viruliferous mealybugs and they have not developed MWP symptoms after several months.

Characterization of Bacterial Strains to Trace Origins of a Pineapple Heart Rot Disease Outbreak in Hawaii.

Glorimar Marrero, Wendy Kaneshiro, Benjamin Vine, John Berestecky, and Anne Alvarez. Plant and Environmental Protection Sciences, Univ. of Hawaii, Honolulu, HI 96822

Erwinia chrysanthemi, causal agent of bacterial heart rot disease of pineapple, was isolated from diseased pineapple planting stocks in Hawaii, in December 2003. This was the first report of bacterial heart rot in the state; therefore, the origin of the disease was of interest. Additional strains of *Erwinia* and other bacteria were isolated from local plants, irrigation water, and pineapple planting stocks originating from Hawaii, Costa Rica, Honduras, and the Philippines. Strains were initially characterized using bacteriological tests, metabolic profiles, 16SrDNA sequence analysis, reactivity with monoclonal antibodies (MAbs) and rep-PCR. Subsequently, additional MAbs were produced against *E. chrysanthemi* and used to screen and compare their reactivity against other bacterial strains isolated from plant and environmental samples. One MAb, clone no. 19C2G4, does react with strains from Costa Rica, Honduras, and Hawaii field plants, but not with closely related subspecies of *Erwinia* or non-*Erwinia* saprophytes. The combined results from bacteriological tests, rep-PCR, 16SrDNA sequence analysis and serological tests provide evidence that supports the conclusion that pineapple bacterial heart rot disease was not introduced to Hawaii from the Philippines, but rather from Central America.

Update on Hawaii Production – Del Monte Announces Plans to Close

D.P. Bartholomew, Dept. of Tropical Plant and Soil Science, University of Hawaii, Honolulu, HI 96822

Del Monte, in its current incarnation, Del Monte Fresh Produce Hawaii, has been in Hawaii for more than 100 years. On February 1, 2006 Del Monte Fresh Produce Hawaii announced that they would close their Kunia plantation and cease all operations in Hawaii. Del Monte said it was no longer economically feasible to continue producing pineapple in Hawaii because of increased planting of pineapple at lower costs in other parts of the world. The closure of the plantation will eliminate at least 700 jobs, more than one-third of Hawaii's 1,800 jobs in the pineapple industry. All planting is scheduled to stop on February 19 and other operations will be phased out over the next three years with complete closure scheduled for mid-2008. The closure will leave only Maui Pineapple Co. and Dole Food Co. as Hawaii's remaining pineapple growers. Both growers own the land on which they grow pineapple, which may reduce their costs of operation.

At present Del Monte leases 5,100 acres of land and grows pineapple on 3,100 acres. Del Monte representatives said that high costs, increased competition and the inability to obtain a long-term extension of their land lease were causes for the closure. Maui Pineapple Company has indicated an interest in the land depending on the cost. Maui Pineapple Co. plans to focus on a niche market for premium fresh pineapple, and government and institutional markets for processed pineapple. The compnay is modernizing its processing facility in Kahului to reduce costs and is building an adjacent $17.5 million fruit grading and packing facility that is expected to be ready in June.

In 2005, pineapple output was 212,000 U.S. tons, a 4% decline from the 220,000 tons produced in 2004 according to the USDA, NASS, Hawaii field office. Fresh sales represented 50% of the total production, which was a decline from the 116,000 tons processed in 2004. Acreage in pineapple in 2004 was 14,000, an 8% increase from the previous year. The farm value of pineapple harvested in 2005 was estimated at $79.3 million. The farm value of pineapple for processing was $148 per ton while that for fresh fruit $600 per ton, down from $634 per ton in 2004.◆

Reviews of Books and Book Chapters

The Pineapple

King of Fruits
Fran Beauman
336pp. Chatto and Wimdus. £16.99.

November, 2005

Lovers of pineapple the fruit or pineapple the crop, as well as lovers of good books, will enjoy reading Fran Beauman's wonderful book. This delicious history of pineapple begins in Central and South America but much of the story is centered in Europe, particularly England but also in the Netherlands and France, where the fruit was relatively unavailable until fast ocean-going ships were invented. Notably, history is about the unusual rather than the common and pineapples were unusual in Europe and they have a surprisingly rich history there. In tropical countries where pineapple fruits were common, their history is more sparse, presumably in part because the fruit was quite ordinary. Hawaii may be the exception to the limited history of pineapple in the tropics because of its unique role in leading the world in the mechanized production and processing of pineapple. The canning industry that developed in the early 20th century in Hawaii had access to capital, a highly organized and well-funded, at least for the time, research effort, and the rapidly growing United States markets. As a result, money was poured into research and the contributions those early research efforts made to the development of the industry is quite well documented. But the story of pineapple in Hawaii makes up only a small portion of this interesting book.

Fran Beauman has thoroughly researched the world's literature on pineapple in preparation for writing this well documented book that focuses on the social history of pineapple. There is enough botany to introduce readers to the important physical attributes of the pineapple plant and fruit but the intrigue surrounding the history of pineapple is mostly not in its botany. This history of pineapple is much about the culture of Europe, and in particular of England, during the period from shortly after the discovery of pineapples in Central America by the Spanish to its fall from kingly status when it began to be shipped in quantity to both Europe and the United States after the invention of the steam engine and the development of steam-driven ships. The author attributes the kingly status of the pineapple among the rich and royal of Europe to its limited availability and exotic qualities, including even the presence of a crown. This exotic appearance and its high status caused its peculiar shape to be enshrined on the tops of gate posts, mirrors, mantels, and bed posts. Wedgwood even made earthernware in the shape of pineapples. The use of the pineapple as a symbol in art and architecture may have been what caused people to think of pineapple as a symbol of hospitality. However, Beauman argues convincingly that it was more a symbol of status than of hospitality because only the very wealthy had access to the fruit until at least the middle of the 19th century.

Beauman writes that when pineapple was most sought after, the wealthy of England, and later of America, spent the equivalent of £5,000 in today's money to grow a single pineapple fruit in one of England's many "pineries". Matthew J Reisz (http://enjoyment.independent.co.uk/books/reviews/article337336.ece) wrote in his review of the book that "it is stuffed with astonishing, tirelessly researched and skilfully presented information about everything from the design of pineries to Victorian costermongers, from early gardening weeklies to the marketing of Hawaii." The final chapter summarizes information about the recent and very rapid growth of pineapple as a fresh fruit in Europe and the United States following the introduction of hybrid 73-114, which was bred and selected at the Pineapple Research Institute of Hawaii but first grown in quantity in Costa Rica by Del Monte Fresh Produce. You won't learn how to grow better pineapples from reading this book but you will certainly have a greater appreciation of its social and cultural history in much of the world and be throughly entertained in the process. Other, perhaps more scintillating, reviews can be found on the internet.
D. Bartholomew◆

Notices

Commercial Services

Maintain CF 125 continues to be available for use in pineapple plant propagation. A renewal letter for registration of the product was received in 2003. For further information, contact Bhushan Mandava, Repar Corporation, P.O. Box 4321, Silver Spring, MD 20914 Tel: 202-223-1424 Fax: 202-223-0141; E-Mail: mandava@compuserve.com

Directory of Professionals

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

No new names were received in 2006.

Web Sites of Possible Interest

http://www.cims-la.com/ES/ (Available in Spanish and English)
http://www.freshplaza.com/ (An internet newsletter on and about fresh fruits and vegetables)

http://www.ers.usda.gov/Briefing/Organic/ (USDA Economic Research Service)
http://www.talborne.co.za/ (Supplier of certified organic fertiizers)◆

References

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

Acedo, A.L., Jr., T. Akinaga, and T. Tanabe. 2004. Inhibition of chilling injury and quality changes in pineapple fruit with prestorage heat treatment. Journal of Food, Agriculture & Environment 2:81-86.

Achard, R., E. Malezieux, P. Robin, and J. Ganry. 2004. Role and status of plantain in agroforestry systems of South West Cameroon: which pathways to productive and sustainable system? Acta Horticulturae 638:101-108.

Ando, S.G., M.; Meunchang, S.; Thongra-ar, P.;, and T.H. Fujiwara, H.; Yoneyama, T. 2005. Detection of nifH sequences in sugarcane (*Saccharum officinarum* L.) and pineapple (*Ananas comosus* [L.] Merr.). Soil Science and Plant Nutrition 51:303-308.

Anonymous. 2004. *Unaspis citri* (Paper describes a diagnostic protocol for *Unaspis citri*). Bulletin OEPP 34:299-301.

Antoniolli, L.R., B.C. Benedetti, M.d.S.M.d. Souza Filho, and M.d.F. Borges. 2004. Evaluation of vanillin as an antimicrobial agent on fresh-cut 'Perola' pineapple (Avaliacao da vanilina como agente antimicrobiano em
abacaxi 'Perola' minimamente processado). Ciencia e Tecnologia de Alimentos 24:473-477.

Antoniolli, L.R., B.C. Benedetti, M.d.S.M.d. Souza Filho, and M.d.F. Borges. 2005. Effect of sodium hypochlorite on the microflora of fresh-cut 'Perola' pineapple (Efeito do hipoclorito de sodio sobre a microbiota de abacaxi 'Perola' minimamente processado). Revista Brasileira de Fruticultura 27:157-160.

Barros, S.T.D.M., E. S.; Peres, L. 2004. Influence of depectinization in the ultrafiltration of West Indian cherry *(Malpighia glabra* L.) and pineapple (*Ananas comosus* (L.) Meer) juices. Ciencia e Tecnologia de Alimentos 24:194-201.

Beauman, F. 2005. The Pineapple King of Fruits Chatto and Windus. 336 pp.

Bell, D., R. Ortiz V., C. Scott, and N. Phillips. 2006. Surround® Crop Protectant – for the Reduction of Sunburn Damage and Heat Stress in Pineapple. Acta Horticulturae 702:179-184.

Borges, C.D., J.F. Chim, A.M. Leitao, E. Pereira, and M.d.M. Luvielmo. 2004. Production of pineapple juice obtained from the residues of the conserve industry (Producao de suco de abacaxi obtido a partir dos residuos da industria conserveira). Boletim do Centro de Pesquisa e Processamento de Alimentos 22:25-34.

Brito, C.A.K.d., H.H. Sato, A. Spironello, and W.J. Siqueira. 2005. Biochemical characteristics of peroxidase from pineapple (*Ananas comosus* (L.) Merrill): cultivar IAC Gomo-de-mel and clone IAC-1 / (Caracteristicas da atividade da peroxidase de abacaxis (*Ananas comosus* (L.) Merrill) da cultivar IAC Gomo-de-mel e do clone IAC-1). Ciencia e Tecnologia de Alimentos 25:244-249.

Budu, A.S., and D.C. Joyce. 2005. Effect of modified atmosphere packaging on the quality of minimally processed pineapple cv. 'Smooth Cayenne' fruit. Journal of Horticultural Science and Biotechnology 80:193-198.

Carlier, J.D., D. Nancheva, J.M. Leitão, and G. Coppens d'Eeckenbrugge. 2006. Genetic Mapping of DNA Markers in Pineapple. Acta Horticulturae 702:79-86.

Catunda, M.G., S.P. Freitas, J.G. Oliveira, and C.M.M. Silva. 2005. Effects of herbicides on the photosynthetic activity of pineapple (*Ananas comossus*) (Efeitos de herbicidas na atividade fotossintetica e no crescimento de abacaxi *(Ananas comossus*)). Planta Daninha 23:115-121.

Chan, Y.K. 2006. Hybridization and Selection in Pineapple Improvement: the Experience in Malaysia. Acta Horticulturae 702:87-92.

Chen, L., and A. Nose. 2004. Day-night changes of energy-rich compounds in crassulacean acid metabolism (CAM) species utilizing hexose and starch. Annals of Botany 94:449-455.

Chinnasri, B., D.A. Christopher, and B.S. Sipes. 2006. Evidence for the Induction of Systemic Acquired Resistance (Sar) by Acibenzolar in Cultivated Pineapple. Acta Horticulturae 702:151-156.

Colin, J.P. 2004. The land lease market in an African context. A case study from Cote d'Ivoire (Le marche du faire-valoir indirect dans un contexte africain. Elements d'analyse). Economie Rurale 282:19-39.

Contini, E. 2003. Old Europe, new foods (Velha Europa, novos alimentos). Agroanalysis 23:41-42.

Cunha, Getúlio Augusto Pinto da. 2005. Applied aspects of pineapple flowering. Bragantia,.64: 499-516

Dang, V.T.T., V.V. Ngo, and A. Drenth. 2004. Phytophthora diseases in Vietnam, p. 83-89, In A. Drenth and D. I. Guest, eds. Diversity and management of Phytophthora in Southeast Asia Canberra. Australian Centre for International Agricultural Research, Canberra.

de Matos, A.P., and J.R.S. Cabral. 2006. Evaluation of Pineapple Genotypes for Resistance to *Fusarium subglutinans*. Acta Horticulturae 702:73-77.

de Matos, A.P., J.R.S. Cabral, C.M.B. Querino, and R.C. Caldas. 2006. Preliminary Report on Systemic Acquired Resistance in Pineapple Plants to Control *Fusarium subglutinans*. Acta Horticulturae 702:167-171.

Degi, K., S. Nagatomi, M. Shoda, and H. Ikemiya. 2004. A mutant variety, “Pineapple Okinawa No. 16” induced by chronic gamma-ray irradiation in the gamma greenhouse [Online]. Available by Institute of Radiation Breeding and Nago Branch, Okinawa Prefectural Agricultural Experiment Station (verified February 3).

Deka, B.C., V. Sethi, and A. Saikia. 2005. Changes in quality of mango-pineapple spiced beverage during storage. Indian Journal of Horticulture 62:71-75.

Deliza, R., A. Rosenthal, F.B.D. Abadio, C.H.O. Silva, and C. Castillo. 2005. Application of high pressure technology in the fruit juice processing: benefits perceived by consumers. Journal of Food Engineering 67:241-246.

Dhaliwal, M., and C.K. Hira. 2004. Effect of storage on physico-chemical and nutritional characteristics of carrot-spinach and carrot-pineapple juices. Journal of Food Science and Technology (Mysore) 41:613-617.

Dhanapal, R., A.C. Mathew, and C. Palaniswami. 2005. Efficacy of soil and water conservation measures in coconut plantations of West Coast Region. Indian Coconut Journal 35:3-6.

Dufresne, B., P. Blaise, and M. Marion. 2004. Retail guide for fresh fruits and vegetables (Argumentaire de vente des fruits et legumes frais) Centre Technique Interprofessionnel des Fruits et Legumes, Paris.

Elss, S., C. Preston, C. Hertzig, F. Heckel, E. Richling, and P. Schreier. 2005. Aroma profiles of pineapple fruit (*Ananas comosus* [L.] Merr.) and pineapple products. Lebensmittel-Wissenschaft und -Technologie 38:263-274.

Ezeronye, O.U. 2004. Nutrient utilization profile of *Saccharomyces cerevisiae* from palm wine in tropical fruit fermentation. Antonie van Leeuwenhoek 86:235-240.

Falade, K.O.O., I.; Adegoke, G. O. 2004. Adsorption isotherm and heat of sorption of osmotically pretreated and air-dried pineapple slices. European Food Research and Technology 218:540-543.

Fávero, A.P., F.R. Ferreira, J.R.S. Cabral, and S.E. Noronha. 2006. Identifying and Mapping the Area of Occurrence of Five Species of Ananas in Brazil. Acta Horticulturae 702:99-104.

Gamez-Pastrana, R., Y. Martinez-Ocampo, C.I. Beristain, and M.T. Gonzalez-Arnao. 2004. An improved cryopreservation protocol for pineapple apices using encapsulation-vitrification. CryoLetters 25:405-414.

Ganeshamurthy, A.N., Y.T.N. Reddy, K. Anjaneyulu, and S.C. Kotur. 2004. Balanced fertilisation for yield and nutritional quality in fruit crops. Fertiliser News 49:71-80, 83-86, 114.

Gangopadhyay, G., T. Bandyopadhyay, R. Poddar, S.B. Gangopadhyay, and K.K. Mukherjee. 2005. Encapsulation of pineapple micro shoots in alginate beads for temporary storage. Current Science 88:972-977.

Ghosh, S. 2004. Shelf-life extension with solid enrichment and water encapsulation of fruits. Journal of Food, Agriculture & Environment 2:45-46.

Gondim, T.M.d.S., and F.F.d. Azevedo. 2002. Floral differentiation of the pineapple cv. SNG-3 in function of the plant age and of the calcium carbide application. Rev. Bras. Frutic. 24:420-425.

Gonzalez-Aguilar, G.A., S. Ruiz-Cruz, H. Soto-Valdez, F. Vazquez-Ortiz, R. Pacheco-Aguilar, and C.Y. Wang. 2005. Biochemical changes of fresh-cut pineapple slices treated with antibrowning agents. International Journal of Food Science & Technology 40:377-383.

Gonzalez-Olmedo, J.L., Z. Fundora, L.A. Molina, J. Abdulnour, Y. Desjardins, and M. Escalona. 2005. New contributions to propagation of pineapple (*Ananas comosus* L. Merr) in temporary immersion bioreactors. In Vitro Cellular & Developmental Biology - Plant 41:87-90.

Granada, G.G., R.C. Zambiazi, and C.R.B. Mendonca. 2004. Pineapple: products, market and by-products (Abacaxi: producao, mercado e subprodutos). Boletim do Centro de Pesquisa e Processamento de Alimentos 22:405-422.

Hanafi, M.M., and A. Halimah. 2004. Nutrient supply and dry-matter partitioning of pineapple cv. Josapine on sandy tin tailings. Fruits 59:359-366.

Hernandez, M., C. Carvajal, M. Marquez, and M.d.l.A. Chavez. 2004. Isolation of proteolytic enzymes from pineapple harvest remains (Aislamiento de enzimas proteoliticas a partir de restos de cosecha de pina). Cultivos Tropicales 25:95-102.

Hong, Y., S. Lin, Q. Lin, and L. Lu. 2004. In vitro propagation from segments of flower and crown bud of pineapple. Fujian Journal of Agricultural Sciences 19:178-180.

Huang, L. 2004. Study on promoting fruit bud differentiation of pineapples. South China Fruits 33:41-42.

Islam, S.A., M. Mostofa, M.A. Awal, and K.A. Khan. 2004. Efficacy of pineapple leaf extract compared with modern anthelmintics against ascariasis in calves. Bangladesh Veterinarian 21:9-13.

Islam, S.A., M.M. Rahman, M.A. Hossain, M.G.A. Chowdhury, and M. Mostafa. 2005. Comparative efficacy of some modern anthelmintics and pineapple leaves with their effects on certain blood parameters and body weight gain of calves infected with ascarid parasites. Bangladesh Journal of Veterinary Medicine 3:33-37.

Jaya, S.V., N.; Kennedy, Z. J. 2004. Inactivation of microorganisms in the fruit juice using pulsed electric field. Journal of Food Science and Technology (Mysore) 41:652-655.

Joshi, V.K.S.S.S.B.D., and Attri. 2004. Alcoholic fermentation. Fruit-based alcoholic beverages, p. 335-345, In A. Pandey, ed. Concise encyclopedia of bioresource technology. Food Products Press, Binghamton (USA).

Kehlor, R.R. 1992. The history of Del Monte Pineapple in Hawaii Robert R. Kehlor, Honolulu.

Keller, P., and U. Luttge. 2005. Photosynthetic light-use by three bromeliads originating from shaded sites *(Ananas ananassoides*, *Ananas comosus* cv. Panare) and exposed sites (*Pitcairnia pruinosa*) in the medium Orinoco basin, Venezuela. Biologia Plantarum 49:73-79.

Khan, M.R. 2005. Hosts and non-hosts of reniform nematode, *Rotylenchulus reniformis* Linford & Oliveira, 1940 -- a critical review. Environment and Ecology 23:124-140.

Kuan, C., C. Yu, M. Lin, H. Hsu, D.P. Bartholomew, and C.-H. Lin. 2005. Foliar application of aviglycine reduces natural flowering in pineapple. HortScience 40:123-126.

Lebrun, M., and M.N. Ducamp. 2004. Development of a technique to sample and quantify pineapple internal atmosphere. Fruits 59:431-435.

Ledo, A.d.S., T.M.d.S. Gondim, T.K.d. Oliveira, J.R.d.S. Negreiros, and F.F.d. Azevedo. 2004. Floral differentiation of RBR-1, SNG-2 and SNG-3 pineapple cultivars in Rio Branco-Acre, Brazil (Efeito de indutores de florescimento nas cultivares de abacaxizeiro RBR-1, SNG-2 e SNG-3 em Rio Branco-Acre). Revista Brasileira de Fruticultura 26:395-398.

Li, Z. 2004. The impact of the different degree of bamboo vinegar on the different ornamental plant growth. Acta Horticulturae Sinica 31:395-396.

Lin, C.-H., C.-S. Kuan, Y.-M. Hsu, M.-L. Lin, H.-T. Hsu, C.-W. Yu, and D.P. Bartholomew. 2006. Delaying Natural Flowering in Pineapple. Acta Horticulturae 702:63-70.

Linden, U.M.v.d. 2004. Pineapple juice and concentrate -- a versatile and complex tropical submarket. Fruit Processing 14:428-433.

Litz, R.E. 2005. Biotechnology of fruit and nut crops, p. xxiv + 723 pp., In R. E. Litz, ed. Biotechnology in Agriculture Series, No. 29. CAB International, Wallingford.

Liu, Y., Y. Zhong, H. Yang, and L. Xu. 2004. The in vitro propagation techniques for pineapples. South China Fruits 6:55-57.

Lloyd, S.W., C.C. Grimm, M.A. Klich, and S.B. Beltz. 2005. Fungal infections of fresh-cut fruit can be detected by the gas chromatography-mass spectrometric identification of microbial volatile organic compounds. Journal of Food Protection 68:1211-1216.

Lousada Junior, J.E., J.N.M.R. Neiva, N.M., J.C.M. Pimentel, and R.N.B. Lobo. 2005. Intake and dry matter digestibility of byproducts of fruit processer in sheep (Consumo e digestibilidade de subprodutos do processamento de frutas em ovinos). Revista Brasileira de Zootecnia 34:659-669.

Lu , L.-L. 2005. Preliminary study on the preservation of pineapple pollen. Acta Agriculturae Shanghai 21:95-97.

Madruga, M.S., W.H.d. Sousa, M.D. Rosales, M.d.G.G. Cunha, and J.L.d.F. Ramos. 2005. Quality of Santa Ines lamb meat finished with different diets (Qualidade da carne de cordeiros Santa Ines terminados com diferentes dietas). Revista Brasileira de Zootecnia 34:309-315.

Manicom, B.Q., E.C. Rabie, and H.A. Tustin. 2006. Further Investigation of the Effects of Thioflo on Black Spot of Pineapples. Acta Horticulturae 702:157-162.

Martinez Damian, M.A., and J.A. Vargas Oropeza. 2004. An almost ideal demand system (AIDS) applied to eleven fruits in Mexico (1960-1998) (Un sistema de demanda casi ideal (AIDS) aplicado a once frutas en Mexico (1960-1998)). Revista Fitotecnia Mexicana 27:367-375.

Martinez-Ferrer, M., and C. Harper. 2005. Reduction in microbial growth and improvement of storage quality in fresh-cut pineapple after methyl jasmonate treatment. Journal of Food Quality 28:3-12.

Mattson, J.W., and W.W. Koo. 2003. U.S. agricultural trade with Latin American countries and effects of the Free Trade Area of the Americas on specific commodities. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Melo, A.S.d., P.R.A. Viegas, D.L.M.F.d. Melo, L.A.S. Costa, and M.P.P. Gois. 2004. Yield, fruit quality and net income of pineapple (cv. Perola) under different plant densities (Rendimento, qualidade da fruta e lucratividade do abacaxizeiro cv. Perola em diferentes espacamentos). Revista de Ciencias Agrarias 41:185-192.

Moyle, R., J. Ripi, D.J. Fairbairn, M. Crowe, and J.R. Botella. 2006. The Pineapple Est Sequencing and Microarray Project. Acta Horticulturae 702:47-50.

Napier, D.R., and N.J.J. Combrink. 2006. Aspects of Calcium Nutrition to Limit Plant Physiological Disorders. Acta Horticulturae 702:107-116.
Olorunfemi, O.B., and F.C. Adetuyi. 2005. Isolation of baking yeast from naturally fermented pineapple. Journal of Food, Agriculture & Environment 3:115-117.
Paull, R.E., and N.J. Chen. 2004. Tropical fruit postharvest: the impact of biotechnology. Acta Horticulturae 632:303-308.
Pena, W.L., J.d.A. Faria, and P.R.d. Massaguer. 2004. Development of a predictive model on the growth of the spoilage mould, *Paecilomyces variotii*, in pineapple juice. Fruit Processing 14:420-426.
Pereira, C.C., J.R.M. Rufino, A.C. Habert, R. Nobrega, L.M.C. Cabral, and C.P. Borges. 2005. Aroma compounds recovery of tropical fruit juice by pervaporation: membrane material selection and process evaluation. Journal of Food Engineering 66:77-87.
Perez, E.P., D.M. Sether, M.J. Melzer, J.L. Busto, C. Nagai, and J.S. Hu. 2006. Characterization and Control of Pineapple Mealybug Wilt Associated Ampeloviruses. Acta Horticulturae 702:23-27.
Petty, G.J., H.A. Tustin, and H.M. Dicks. 2006. Control of Black Spot Disease/Fruitlet Core Rot in Queen Pineapple with Integrated Mealybug, Pineapple Fruit Mite and Fungus Control Programmes. Acta Horticulturae 702:143-149.
Pinheiro, N.M.d.S., E.A.T.d. Figueiredo, R.W.d. Figueiredo, G.A. Maia, and P.H.M.d. Souza. 2005. Evaluation of microbiological quality of fruits minimally processed commercialized in supermarkets in Fortaleza (Avaliacao da qualidade microbiologica de frutos minimamente processados comercializados em supermercados de Fortaleza). Revista Brasileira de Fruticultura 27:153-156.
Pouch, T. 2004. France in the fruit and vegetables market (La France dans le marche des fruits et legumes). Chambres d'Agriculture 936:5-8.
Prado, M.E.T.C., A. B.; Bonnas, D. S.;, and A.C.M. Pinheiro. 2004. Biochemical modifications of pineapple minimally processed under modified atmosphere (Transformacoes bioquimicas de abacaxi minimamente processado armazenado sob atmosfera modificada). Revista Brasileira de Fruticultura 26:428-432.
Rabie, E.C., and H.A. Tustin. 2006. Winter Blotching of Queen Pineapple (*Ananas comosus*): a Study on the Occurrence and Possible Cause. Acta Horticulturae 702:191-199.
Ramallo, L.A.S., C.; Mascheroni, R. H. 2004. Mass transfer during osmotic dehydration of pineapple. Food Science and Technology International 10:323-332.
Ramos, M.J.M., P.H. Monnerat, A.J.C. de Carvalho, J.L.A. Pinto, and J.A. da Silva. 2006. Nutritional Deficiency in 'Imperial' Pineapple in the Vegetative Growth Phase and Leaf Nutrient Concentration. Acta Horticulturae 702:133-139.
Rao, M.A.R., and G.V.N. Rao. 2004. Biological control of *Ceratocystis paradoxa* -- the incitant of pineapple disease of sugarcane. Journal of Mycology and Plant Pathology 34:105-106.
Rashmi, H.B., G.I.N. Doreyappa, and G.K. Mukanda. 2005. Studies on osmo-air dehydration of pineapple fruits. Journal of Food Science and Technology (Mysore) 42:64-67.
Rattanathanalerk, M., N. Chiewchan, and W. Srichumpoung. 2005. Effect of thermal processing on the quality loss of pineapple juice. Journal of Food Engineering 66:259-265.
Reddy, N.Y. 2005. Biofibers from agricultural byproducts for industrial applications. Trends in Biotechnology 23:22-27.
Reinhardt, D.H.M., V. M.; Caldas, R. C.; Cunha,, and F.H. G. A. P. da; Estevam. 2004. Quality gradients in 'Perola' pineapple in function of fruit size and maturation stage (Gradientes de qualidade em abacaxi 'Perola' em funcao do tamanho e do estadio de maturacao do fruto. Revista Brasileira de Fruticultura 26:544-546.
Reinhardt, D.H., C.O. de Almeida, and L. da Costa Vilar. 2006. Characteristics and Status of the Brazilian Pineapple Industry. Acta Horticulturae 702:53-59.
Ritzinger, R.R., C. H. S. P. 2004. Occurrence of internal cavity in pineapple fruits in the state of Acre, Brazil. Fruits 59:215-218.
Rohn, S., H.M. Rawel, and M.K. Rober, J. 2005. Reactions with phenolic substances can induce changes in some physico-chemical properties and activities of bromelain -- the consequences for supplementary food products. International Journal of Food Science & Technology 40:771-782.
Rojas Acuna, L.A., and G. Camacho Buberth. 2004. Pineapple (*Ananas comosus* L. Merr) cultivation under minimum tillage and conventional tillage in San Carlos, Costa Rica (Pina (*Ananas comosus* L. Merr) sembrada en labranza minima y labranza convencional en San Carlos, Costa Rica. Agronomia Mesoamericana 15:161-172.
Roty, C. 2004. The seasonality of fresh fruits. How do consumers react? (La saisonnalite des fruits frais: comment les consommateurs reagissent?). Infos-Ctifl 205:18-20.
Sangchote, S., S. Poonpolgul, R. Sdoodee, M. Kanjanamaneesathian, T. Baothong, and P. Lumyong. 2004. Phytophthora diseases in Thailand, p. 77-82, In A. Drenth and D. I. Guest, eds. Diversity and management of Phytophthora in Southeast Asia. Australian Centre for International Agricultural Research, Canberra.
Santa-Cecilia, L.V.C.B., V. H. P.; Prado, E. 2004. Development of the pineapple mealybug *Dysmicoccus brevipes* (Cockerell) (Hemiptera: Pseudococcidae) on two pineapple cultivars (Desenvolvimento de *Dysmicoccus brevipes* (Cockerell) (Hemiptera:Pseudococcidae) em duas cultivares de abacaxi). Ciencia e Agrotecnologia 28:1015-1020.
Santos, J.C.B., E.V.d.B.V. Boas, M.E.T. Prado, and A.C.M. Pinheiro. 2005. Evaluation of quality in fresh-cut 'Perola' pineapple stored under modified atmosphere / Avalicao da qualidade do abacaxi "Perola" minimamente processado armazenado sob atmosfera modificada. Ciencia e Agrotecnologia 29:353-361.
Santosa, E., N. Sugiyama, S. Hikosaka, T. Takano, and N. Kubota. 2005. Intercropping practices in cacao, rubber and timber plantations in West Java, Indonesia. Japanese Journal of Tropical Agriculture 49:21-29.
Sanz, M.L.V., M.; Martinez-Castro, I. 2004. Inositols and carbohydrates in different fresh fruit juices. Food Chemistry 87:325-328.
Sawano, Y., K. Hatano, and M. Tanokura. 2005. Susceptibility of the interchain peptide of a bromelain inhibitor precursor to the target proteases bromelain, chymotrypsin, and trypsin. Biological Chemistry 385:491-498.
Schmidt, R.E.B., G. K. 2004. Leaf anatomy in Bromeliaceae subfamily Bromelioideae -- I. Historical perspectives. Vidalia 2:11-22.
Sether, D.M., M.J. Melzer, J. Busto, F. Zee, and J. Hu. 2005. Diversity and mealybug transmissibility of ampeloviruses in pineapple. Plant Disease 89:450-456.
Sherman, W.B., and T.G. Beckman. 2003. Climatic adaptation in fruit crops. Acta Horticulturae 622:411-428.
Shyu, D.J.H., C. Chyan, J.T.C. Tzen, and W. Chou. 2004. Molecular cloning, expression, and functional characterization of a cystatin from pineapple stem. Bioscience, Biotechnology and Biochemistry 68:1681-1689.
Silva, J.A., R. Hamasaki, R. Paull, R. Ogoshi, D.P. Bartholomew, S. Fukuda, N.V. Hue, G. Uehara, and G.Y. Tsuji. 2006. Lime, Gypsum, and Basaltic Dust Effects on the Calcium Nutrition and Fruit Quality of Pineapple. Acta Horticulturae 702:123-131.
Singh, S.B., S.V. Ngachan, and L.K. Mishra. 2004. Cost-benefit analysis of potential agri-silviculture systems on sloping lands of Meghalaya. Indian Journal of Hill Farming 17:86-90.
Sipes, B.S. 2006. Nematode Control for the Early 21st Century. Acta Horticulturae 702:163-166.
Sipes, B.S., E.P. Caswell-Chen, J.L. Sarah, and W.J. Apt. 2005. Nematode parasites of pineapple, p. 709-731, In M. Luc, et al., eds. Plant parasitic nematodes in subtropical and tropical agriculture (Ed.2). CABI Publishing, Wallingford.
Soares, L.M.V., K. Shishido, A.M.M. Moraes, and V.A. Moreira. 2004. Mineral composition of Brazilian concentrate fruit juices (Composicao mineral de sucos concentrados de frutas brasileiras). Ciencia e Tecnologia de Alimentos 24:202-206.
Soares, A.G., L.C. Trugo, N. Botrel, and L.F.d.S. Souza. 2005. Reduction of internal browning of pineapple fruit (*Ananas comusus* L.) by preharvest soil application of potassium. Postharvest Biology and Technology 35:201-207.

Soler, A., and P. Fournier. 2006. Determination of Anthocyanin Biosynthesis in the CIRAD Pineapple Hybrid 'Flhoran 41'. Acta Horticulturae 702:117-122.

Souza, F.V.D., T.L. Soares, J.R.S. Cabral, D.H. Reinhardt, J.L. Cardoso, and D.A. Benjamin. 2006. Slow-growth Conditions for the in Vitro Conservation of Pineapple Germplasm. Acta Horticulturae 702:41-45.

Souza, F.V.D., J.R.S. Cabral, J.A. dos Santos-Serejo, A.P. de Matos, D.H. Reinhardt, G.A.P. da Cunha, F.R. Ferreira, and J.A. Pereira. 2006. Identification and Selection of Ornamental Pineapple Plants. Acta Horticulturae 702:93-97.

Sripaoraya, S., S. Keawsompong, P. Insupa, M.R. Davey, J.B. Power, and P. Srinives. 2006. Evaluation of Transgene Stability, Gene Expression and Herbicide Tolerance of Genetically Modified Pineapple under Field Conditions. Acta Horticulturae 702:37-40.

Stanfield, P. 2004. Frozen fruits and fruit juices: product description, p. 461-472, In Y. H. Hui, et al., eds. Source: Handbook of frozen foods New York. Marcel Dekker Inc., Twin Falls, Idaho.

Taira, T., N. Toma, and M. Ishihara. 2005. Purification, characterization, and antifungal activity of chitinases from pineapple (*Ananas comosus*) leaf. Bioscience, Biotechnology and Biochemistry 69:189-196.

Taniguchi, G., T. Thompson, and B.S. Sipes. 2006. Prevention and Control of the Big-headed Ant, *Pheidole megacephala* (Hymenoptera: Formicidae) in Pineapple Cultivation Using Bait Stations with Amdro. Acta Horticulturae 702:173-177.

Ten Bruggencate, J.K. 2004. Hawaii's Pineapple Century. Mutual Publishing, LLC, Honolulu.

Trusov, Y., and J.R. Botella. 2006. Delayed Flowering in Pineapples (*Ananas comosus* (L.) Merr.) Caused by Co-suppression of the Acacs2 Gene. Acta Horticulturae 702:29-36.

Varga, L.S., S. A.; Csoka, M. 2004. Preservation of fruits with home-made dehydration part II. Dehydration of tropical and subtropical fruits (Gyumolcsok vizelvonasos tartositasa hazi aszalassal II. resz Tropusi es szubtropusi gyumolcsok aszalasa). Elelmezesi Ipar 58:201-202.

Weerahewa, D., and N.K.B. Adikaram. 2005. Heat-induced tolerance to internal browning of pineapple (*Ananas comosus* cv. 'Mauritius') under cold storage. Journal of Horticultural Science and Biotechnology 80:503-509.

Williamson, S. 2005. Breaking the barriers to IPM in Africa: evidence from Benin, Ethiopia, Ghana and Senegal, p. 165-180, In J. Pretty, ed. The pesticide detox: towards a more sustainable agriculture. Earthscan Publications Ltd, London.

Wilson Wijeratnam, R.S., I.G.N. Hewajulige, and M.G.D.S. Perera. 2006. The Control of Black Rot Disease and the Application of a Novel Wax Formulation for Extending Storage Life of Pineapple. Acta Horticulturae 702:185-189.

Wilson Wijeratnam, R.S., I.G.N. Hewajulige, R.L.C. Wijesundera, and M. Abeysekere. 2006. Fruit Calcium Concentration and Chilling Injury During Low Temperature Storage of Pineapple. Acta Horticulturae 702:203-208.

Winter, K., J. Aranda, and J.A.M. Holtum. 2005. Carbon isotope composition and water-use efficiency in plants with crassulacean acid metabolism. Functional Plant Biology (4th International Congress on Crassulacean Acid Metabolism (CAM-2004)) 32:381-388.

Xie, W.D., D.-M. Xing, H. Sun, W. Wang, Y. Ding, and L.-J. Du. 2005. The effects of *Ananas comosus* L. leaves on diabetic-dyslipidemic rats induced by alloxan and a high-fat/high-cholesterol diet. American Journal of Chinese Medicine 33:95-105.

Yanes Paz, E., K. Gil, L. Rebolledo, A. Rebolledo, D. Uriza, O. Martinez, M. Isidron, and J. Simpson. 2005. AFLP characterization of the Mexican pineapple germplasm collection. J. American Society for Horticultural Science 130:575-579.

Pineapple News Reference List (1993-2005)

Pineapple News was published with both a volume number (1-3) and issue number, in parentheses, until 1997. At the recommendation of librarians, only an issue number has been used since 1998. Please contact the author if you wish to have a text, HTML, or XML file of this index.

Abdullah, H. 2000. Physiological Study on the Crown and Fruit of Pineapple During and after Storage at Low Temperatures. Pineapple News (7):11-12.

Ahmed, O.H., M.H.A. Husni, A.R. Anuar, and M.M. Hanafi. 2003. Pineapple Residues: from Burning to Products Development. Pineapple News (10):10-11.

Almeida, O.A.d., L.F.d. Souza, D.H. Reinhardt, and R.C. Caldas. 2001. Influence of Irrigation on the Cycle of 'Pérola' Pineapple in Coastal Tableland Area of Brazil. Pineapple News (8):11.

Anonymous. 1995. Role of Monitoring in Nematode Management. Pineapple News 1 (2):3.

Anonymous. 1995. Pineman. Pineapple News 1 (2):3.

Anonymous. 1995. Nitrate Trials. Pineapple News 1 (2):3-4.

Anonymous. 1995. Performance of High Density May Plant Crop for Different Graded Planting Material. Test No. 722. Pineapple News 1 (2):4-5.

Anonymous. 1995. Cloche Covers. Pineapple News 1 (2):5.

Anonymous. 1995. Phosphorus Nutrition. Pineapple News 1 (2):5.

Anonymous. 1995. Development of a Transgenic Blackheart Resistant Pineapple. Pineapple News 1 (2):5.

Anonymous. 1995. Mealybug Wilt of Pineapple. Pineapple News 1 (2):5.

Anonymous. 1995. Borax or Solubor for Ethrel Induction? Pineapple News 1 (2):5.

Anonymous. 1995. F180 - Is it a Better Ratooner Than Qld Clones? Pineapple News 1 (2):5.

Anonymous. 1995. Pineapple Research Projects in Australia. Pineapple News 1 (2):6.

Anonymous. 1996. Notes on Pineapple Crop in Brazil. Pineapple News 2 (2):5.

Anonymous. 1996. Current Pineapple Research Projects in Brazil. Pineapple News 2 (2):5.

Anonymous. 1997. Standard Herbicide Treatments. Pineapple News 3 (1):5.

Anonymous. 1997. Application Levels of Nitrogen and Potassium in Plant Crop. Pineapple News 3 (1):5.

Anonymous. 1997. Costa Rica: Fresh, Processed Pineapple -- Pineapple Leads Costa Rican non Traditional Exports. Pineapple News 3 (1):6.

Anonymous. 1997. Mealybug Wilt Disease (Sri Lanka). Pineapple News 3 (1):12-13.

Anonymous. 1999. Abbreviated Abstracts of 3rd Symposium. Pineapple News (6):11-23.

Anonymous. 2000. New Book on Pineapple (Brazil). Pineapple News (7):4.

Anonymous. 2002. Abstracts From 4th Symposium (Pineapple). Pineapple News (9):16-32.

Anonymous. 2004. Hortivar: Horticulture Cultivars Performance Database. Pineapple News (11):29-30.

Anonymous. 2005. Abstracts of the 5th International Pineapple Symposium. Pineapple News (12):30-44.

Asoegwu, S.N., and J.C. Obiefuna. 2003. Irrigation Efficiencies for Pineapple in Nigeria. Pineapple News (10):11-12.

Bartholomew, D.P. 1995. From the Editor. Pinepple News 1(2):2-3.

Bartholomew, D.P. 1995. Effects of Environment on the Growth, Flowering, and Fruiting of Pineapple. Pineapple News 1 (2):12-13.

Bartholomew, D.P. 1996. Factors Influencing Fruit Size of Pineapple. Pineapple News 2 (2):2.

Bartholomew, D.P. 1996. Natural Flowering. Pineapple News 2 (2):2-3.

Bartholomew, D.P. 1997. Pineapple Planting Material. Pineapple News 3 (1):1-2.

Bartholomew, D.P. 1998. Impact of the Computer Revolution. Pineapple News (5):1-2.
Bartholomew, D.P. 1998. Third Pineapple Symposium. Pineapple News (5):2-3.
Bartholomew, D.P. 1999. Working Group Issues. Pineapple News (6):1-2.
Bartholomew, D.P. 1999. Pineapple is Hawaii's Most Valuable Crop. Pineapple News (6):9-10.
Bartholomew, D.P. 2001. Problems With Iron Sulphate. Pineapple News (8):1-2.
Bartholomew, D.P. 2001. John W. Beardsley, In Memorium. Pineapple News (8):2-3.
Bartholomew, D.P. 2001. Organic Pineapple. Pineapple News (8):3.
Bartholomew, D.P. 2001. Control of Natural Flowering. Pineapple News (8):21.
Bartholomew, D.P. 2002. More on Organic Pineapple. Pineapple News (9):2.
Bartholomew, D.P. 2002. New Book on Pineapple to be Published (CAB International book on pineappl). Pineapple News (9):16.
Bartholomew, D.P. 2003. Allen Duncan Chairs Pineapple Working Group. Pineapple News (10):1.
Bartholomew, D.P. 2003. Change in the Pineapple Industry. Pineapple News (10):1-2.
Bartholomew, D.P. 2004. Changes in the Pineapple Industry. Pineapple News (11):2-3.
Bartholomew, D.P. 2004. Suranant Subhadrabandhu, In Memorium. Pineapple News (11):3.
Bartholomew, D.P. 2004. Plans for the 5th Symposium Move Forward. Pineapple News (11):3.
Bartholomew, D.P. 2004. Changes in the Pineapple Industry. Pineapple News 11:2.
Bartholomew, D.P. 2005. Zululand Pre-Symposium Tour. Pineapple News (12):2-4.
Bartholomew, D.P. 2005. Hawaii Pineapples - 2004 Production Takes a Sharp Drop. Pineapple News (12):29.
Bartholomew, D.P. 2005. Reviews of Books and Book Chapters. Pineapple News (12):44.
Bartholomew, D.P., and X.J. Min. 1996. Effects of Environment on the Growth, Flowering, and Fruiting of Pineapple. Pineapple News 2 (2):23-24.
Baruah, K. 1996. Pineapple News from India - Assam. Pineapple News 2 (2):12.
Baruah, K. 1997. NPK Requirement in Ratoon Crop of Pineapple in Assam. Pineapple News 3 (1):8.
Be, L.V. 2003. Low-cost Micropropagation Procedure for Pineapple. Pineapple News (10):15-17.
Benamburg, F. 1999. Pineapple in Costa Rica. Pineapple News (6):8-9.
Benega, R., M. Isidrón, E. Arias, M. Daquinta, Q. Domínguez, C.G. Borroto, and M. Hidalgo. 1996. Estudio Comparative entre dos Cultivares de Piña (*Ananas comosus* (L.) Merr). Pineapple News 2 (2):6-10.
Benega, R., J. Martínez, E. Arias, M. Daquinta, M.M. Hidalgo, L. Yabor, and M. Isidrón. 2000. Brief Review of Some Methods to Obtain Pineapple Haploid Plants. Pineapple News (7):6-8.
Benega, R., M. Isidrón, E. Arias, A. Cisneros, I. Torres, J. Martínez, M. Hidalgo, and C.G. Borroto. 1996. Germinación in vitro y formación de callos en semillas híbridas de piña (Ananas
comosus (L.) Merr.). Pineapple News 2 (2):10-12.
Blanc, J., J.-L. Noyer, J.-P. Horry, and M.F. Duval. 2004. Characterization and Diversity of Pineapple Varieties Using Microsatellite Markers. Pineapple News (11):30-32.
Bull, R. 1997. Mocap in Pineapples for Control of Symphylaand Nematodes. Pineapple News 3 (1):5-6.
Cabral, J.R.S., and D.H. Reinhardt. 2004. Selfing in Pineapple Breeding. Pineapple News (11):20-21.
Centeno, G. 2003. Latin America to Take Lead in the Organic Pineapple Market. Pineapple News (10):7-8.
Chan, Y.K. 1997. 'JOSAPINE': A New Pineapple Hybrid Developed at MARDI. Pineapple News 3 (1):8-9.
Chan, Y.K. 1997. International Conference on Tropical Fruits (abstracts of papers on pineapple). Pineapple News 3 (1):9-11.
Chen, C.-C., and R.E. Paull. 1998. Changes in Sugar Content and Activities of Sugar Metabolizing Enzymes and
Translucency in Pineapple Fruit Flesh. Pineapple News (5).
Chen, C.-C., and R.E. Paull. 2000. Fruit Sugars, Temperature and Crown Removal on the Occurrence of Pineapple Fruit Translucency. Pineapple News (7):14-15.
Chen, N.J., R. Paull, and A. Hodgson. 2000. High Pressure Treatment of Pineapple Slices. Pineapple News (15).
Christensen, D. 1996. Quality, Efficiency and Yield. Pineapple News 2 (2):5.
Christensen, D. 1997. May-June Ratoon Harvest from High Density Spring Crop. Pineapple News 3 (1):5.
Christensen, D. 1997. F180 Re-Selection and New Clones. Pineapple News 3 (1):5.
Christensen, D. 2000. Metham fumigation–Yes or No? Pineapple News (7):3.
Christensen, D. 2001. Industry Assessment of Symphylid Problem. Pineapple News (8):6-7.
Christensen, D. 2001. Soil Fumigation Update. Pineapple News (8):7.
Christensen, D. 2001. Recent Metham Trial Results. Pineapple News (8):7.
Christensen, D. 2004. White Grubs and Other Incidental Pests of Pineapple. Pineapple News (11):14-16.
Christensen, D., and E. Sinclair. 1996. Sources of Magnesium Preplant Fertiliser. Pineapple News 2 (2):4-5.
Contreras, R. 2004. Pineapple Marketing and The Export Potential for Ecuadorian Fresh Pineapple to the United States Market. Pineapple News (11):25-29.
Coppens d' Eeckenbrugge, G. 1996. A Brief Overview on Pineapple Breeding Work from the Communications Presented at the Second Pineapple Symposium. Pineapple News 2 (2):14-16.
Coppens d' Eeckenbrugge, G. 1997. Evaluation and Utilization Pineapple Genetic Resources. Pineapple News 3 (1):6.
Coppens d'Eeckenbrugge, G., and F. Leal. 2000. The Application of the International Code of Nomenclature to Pineapple Cultivars. Pineapple News (7):10-11.
Corcho Fuentes, J.S.P.d., P.T. Moreno, M. Zoli, and F.G. Pegna. 2003. Evaluation of Different Soil Preparation Techniques for Pineapple Production. Pineapple News (10):8-9.
Cunha, G.A.P.d. 2001. Inhibition Of Natural Flowering In Pineapple, Cv. Perola, With Growth Regulators. Pineapple News (8):8-9.
Cunha, G.A.P.d. 2003. Alternative Technologies for the Cultivation of Pineapple. Pineapple News (10):5-6.
Cunha, G.A.P.d. 2003. Alternative Technologies for the Cultivation of Pineapple. Pineapple News (10):5.
Cunha, G.A.P.d., and D.H. Reinhardt. 2001. Higher Planting Density of 'Smooth Cayenne' Pineapple Crop. Pineapple News (8):10.
da Cunha, G.A.P. 2005. Brazilian Pineapple: Law Regulates Fruit Classification. Pineapple News (12):14-17.
Daquinta, M. 1995. Pineapple News From Cuba: Fitotek Investigates the Plant Bioreactor:. Pineapple News 1 (2):7.
Daquinta, M., and R. Benega. 1997. Brief Review of Tissue Culture of Pineapple. Pineapple News 3 (1):6-8.
Daquinta, M., A. Cisneros, Y. Rodríguez, M. Escalona, C. Pérez, I. Luna, and C.G. Borroto. 1996. Somatic embryogenesis in pineapple (*Ananas comosus* (L.) Merr). Pineapple News 2 (2):5-6.
de Almeida, C.O., and D.H. Reinhardt. 2004. The Brazilian Pineapple Industry: in Search of New Markets. Pineapple News (1):22-24.
de Corcho Fuentes, J.S.P., F.G. Pegna, and C.I. Coronel. 2005. Physical Properties of Pineapple Stumps in Relation to Cutting. Pineapple News (12):20-22.
DeFrank, J. 1999. Weed Management in Pineapple In conjunction with the development of IPM guidelines for pineapple. Pineapple News (6):10.
Devadas, V.S. 2002. Commercial Cultivation of 'Mauritius' Pineapple in Kerala State. Pineapple News (9):8-9.
Dewhurst, S. 1999. Minor Use Chemicals. Pineapple News (6):4.
Duval, M.F., G. Coppens d'Eeckenbrugge, A. Fontaine, and J.P. Horry. 2001. Ornamental Pineapple : Perspective from Clonal and Hybrid Breeding. Pineapple News (8):12-13.
Duval, M.F., G.S.C. Buso, J.R. Santos Cabral, L.d.B. Bianchetti, F.R. Ferreira, and M.E. Ferreira. 2000. Phylogenetic Relationships in

Ananas and Related Genera Using Chloroplast Dna Restriction Site Variation . Pineapple News (7):5.
Emmons, J. 2003. TFNET Effort to Develop Organic Pineapple Technical Guidelines. Pineapple News (10):2.
Escalona, M., J.C. Lorenzo, B. González, Q. Domínguez, Z. Fundora, C.G. Borroto, P. Espinosa, D. Espinosa, E. Arias, and M.E. Aspiolea. 1998. New System for In-vitro Propagation of Pineapple (*Ananas comosus* (L.) Merr). Pineapple News (5):5-7.
Fernando, M.F.S.W. 1997. Pineapple Improvement Program in the Dept. of Agriculture, Sri Lanka. Pineapple News 3 (1):12.
Ferreira, F.R., and P.G. Bustamante. 2001. Domestication and Use of Ananas Lucidus by the Indians of Amazonia. Pineapple News (8):8.
Galán Saúco, V. 1999. Current State of Pineapple Cultivation in the Canary Islands. Pineapple News (6):8.
Gambley, C. 2004. Pineapple Mealybug Wilt Disease in Australia. Pineapple News (11):13-14.
Gambley, C. 2005. An Update on the Etiology of Pineapple Mealybug Wilt Disease in Australia. Pineapple News (12):8-10.
Garbati Pegna, F. 1999. Pineapple Mechanization Listserve. Pineapple News (6):9.
García, G.P., M. Isidrón Pérez, and R. Benega. 2000. Analisys of Somaclonal Variation in Pineapple (*Ananas comosus* (L) Merr) Plants Regenerated from Callus in the Field. Pineapple News (7):8-10.
Gonzalez-olmedo, J.L., F. Coll, and M. Nuñez. 2005. A Role for Brassinosteroids During Acclimatization of Pineapple Plantlets. Pineapple News (12):17.
González-Ortiz, D.J., T. Martínez-Damián, A. Rebolledo-Martínez, L. Rebolledo-Martínez, and D. Uriza-Ávila. 2003. Postharvest Quality of Three Pineapple Cultivars in Different Planting Densities in Mexico. Pineapple News (10):11.
Green, R.E., R.C. Schneider, and B.S. Sipes. 1995. Nematicides in Pineapple: Assessment of Efficacy and Analysis of Movement and Degradation. Pineapple News 1 (2):13-14.
Harris, W. 2002. Summary of Study Tour & Produce Marketing Association Convention. Pineapple News (9):2.
Hassan, A. 1997. Research on Blackhert Disorder in Malaysian Pineapple. Pineapple News 3 (1):9.
Heenkenda, H.M.S. 1996. Pineapple News From Sri Lanka - Pineapple research activities at the Department of Agriculture. Pineapple News 2 (2):16-17.
Herath, H.M.I., D.C. Bandara, and D.M.G. Abeysinghe Banda. 2003. Calcium and Potassium Fertilizers Affect Pineapple Fruit Quality (10):12.
Herath, H.M.I., D.C. Bandara, and D.M.G. Abeysinghe Banda. 2003. Effect of Different Calcium Fertilizers on Pineapple Fruit Quality. Pineapple News (10):12-13.
Hernández, M., C. Carvajal, R. Santos, M. Márquez, M.a. Blanco, J. González, and M.a. Chávez. 1999. Purification Alternatives of Obtained Bromelain From Different Sources. Pineapple News (6):9.
Hewajulige, I.G.N., R.S. Wilson Wijeratnam, and M. Abeyesekere. 2000. Pre-harvest Application of Calcium and the Development of Black Heart Disorder
Symptoms in Mauritius Pineapples. Pineapple News (7):12.
Hewajulige, I.G.N., R.S. Wilson Wijeratnam, H. Samarathunghe, and M. Abeyesekere. 2000. Correlation Between Calcium Levels and Variation in Storage Quality of Two Varieties of Pineapple. Pineapple News (7):12.
Hidalgo, O.B., A.P.d. Matos, J.R. Santos Cabral, R.T. Tussel, R. Santos, M. Arzola, and M.C. Perez. 1998. Influence of Fusarium subglutinans Culture filtrate on Pineapple (*Ananas comosus* (L.) Merr.) Callus growth and Plant Regeneration. Pineapple News (5):7.
Hinds, D. 2003. One Year after It's Formation, the Chair Discusses the Issues. Pineapple News (10):3-4.
Hu, J.S. 1995. Etiology of Pineapple Mealybug-wilt and Optimization of Heat Treatment for Enhanced Pineapple Growth. Pineapple News 1 (2):11-12.
Hu, J.S., and D. Sether. 1997. Study of Etiology of Pineapple Mealybug Wilt. Pineapple News 3 (1):13-14.
Hu, J.S., and D. Sether. 1998. Transmission, Epidemiology, and Management of Viruses in Mealybug Wilt of
Pineapple. Pineapple News (5):10-11.
Hu, J.S., D. Sether, M. Melzer, E. Perez, and J. Busto. 2000. Mealybug Wilt of Pineapple and Associated Viruses. Pineapple News (7):13-14.
Hurov, H.R. 1997. News from Venezuela. Pineapple News 3 (1):16.
Johnson, M.W. 2001. Update on Recent Pineapple Mealybug Management in Hawaii. Pineapple News (8):20-21.
Johnson, M.S., and H. Gonzalez-Hernandez. 1996. Ecology and Control of Ants and Mealybugs in Hawaiian Pineapple Fields. Pineapple News 2 (2):18-21.
Kawate, M. 1995. Coordination of Pineapple Pesticide Activities. Pineapple News 1 (2):14.
Khan, S., A. Nasib, and B.A. Saeed. 2005. Pineapple Propagation: Pakistan's New Venture. Pineapple News (12):23-26.
Ko, L., and M. Smith. 1998. Controlling Blackheart by Genetic Engineering. Pineapple News (5):3.
Ko, K.-H., and B.S. Sipes. 1998. Intercycle Cover Crops for Nematode Management in Pineapple. Pineapple News (5):11.
Kruger, J. 1998. Investigation into Fruit Handling and Grading. Pineapple News (5):3.
Kuss, L. 1999. Pineapple Promotions - How the Market is Responding. Pineapple News (6):4-5.
Licence, D. 1999. HACCP and Horticulture. Pineapple News (6):4.
Lin, C.H. 2000. Introduction of a New Line of Pineapple in Taiwan. Pineapple News (7):13.
Lin, C.H. 2001. Tainon #19, a New Pineapple Variety. Pineapple News (8):17.
Lin, C.H. 2002. Workshop on Pineapple Variety Improvement, Disease and Pest Management. Pineapple News (9):14.
Lin, C.H. 2005. 2004 Pineapple Symposium Held at Chia-yi University (Includes Abstracts). Pineapple News (12):26-28.
Lin, C.-h., C.-s. Kuan, and Y.-M. Hsu. 2004. Delaying natural flowering in pineapple. Pineapple News (11):33-34.
Lindsay, C. 1997. The Farmcare Project. Pineapple News 3 (1):4.
Lindsay, C. 1998. Pineapples and Farmcare Guidelines for the Environment. Pineapple News5):2-3.
Loeillet, D. 1995. The Fresh Pineapple Market in Europe The world's largest importer. Pineapple News 1 (2):7-8.
Macleod, N. 1997. Evolution of Fresh Pineapple Quality Improvement. Pineapple News 3 (1):4.
Macleod, N. 2002. Providing What the Customer Wants? Pineapple News (9):3.
Mandava, N.B. 1999. Chlorflurenol Available for Commercial Production of Pineapple Planting Material. Pineapple News:6.
Marín, F., and A. Sáenz. 2005. A Characterization of Monte Lirio Pineapples from Costa Rica. Pineapple News (12):17.
Mathure, S. 2001. Organic Pineapple in India. Pineapple News (8):13-15.
Mathure, S. 2001. Pineapple Processing Equipment for Small Canning Operations. Pineapple News (8):16.
McBride, J. 2000. Bromelain, Health Food for Dairy Cows? (Abstracted from Bromelain– Health Food for Bossy). Pineapple News (7):17.
McCleur, L.D. 2004. The Pineapple Industry in the U.S. and Asia from the Perspective of an Old Farmer. Pineapple News (11):34-35.
Melzer, M.J., A.V. Karasev, D.M. Sether, and J.S. Hu. 2003. Pineapple Mealybug Wilt Associated-virus 1: An Example of Intergeneric Viral
Recombination? Pineapple News (10):13-14.
Mhatre, M. 2003. Plant Regeneration from Basal Disc Slices of Second Generation (M2) "Spineless Variants" of Pineapple Fruit Crowns. Pineapple News (10):9.
Mhatre, M. 2003. Transformation of Pineapple Leaf Bases with the Megainin Gene Analogue, MSI-99. Pineapple News (10):9.
Mhatre, M., and P.S. Rao. 2002. Effect of Ethylene Inhibitors on Pineapple Shoot Multiplication. Pineapple News (9):9-10.
Mhatre, M., and P.S. Rao. 2002. High Efficiency Regeneration of Multiple Shoots and Plantlets in Dormant Axillary Buds of Pineapple. Pineapple News (9):10-11.
Mhatre, M., and P.S. Rao. 2002. Studies on Synthetic Seeds of

Pineapple. Pineapple News (9):11-12.
Mhatre, M., and P.S. Rao. 2002. Influence of Physical and Chemical Mutagens on Pineapple Shoot Cultures. Pineapple News (9):12-13.
Mitra, S. 1995. Pineapple News from India. Pineapple News 1 (2):8-9.
Mitra, S.K., and K. Besra. 1997. Different Sources and Levels of Potassium on Pineapple cv. Kew. Pineapple News 3 (1):8.
Mitra, S.K., S. Sheet, and T.K.O. Bose. 1996. N and K requirements of pineapple under rain-fed conditions. Pineapple News 2 (2):13.
Murray, D. 2000. News from South Africa. Pineapple News (7):12-13.
Natav, Y. 1996. Propagating Plants with Paclobutrazol. Pineapple News 2 (2):13.
Nelson, S. 1996. Pineapple Root Rot in Hawaii: Etiology and Control. Pineapple News 2 (2):22-23.
Neuteboom, l., and d. Christopher. 2002. Pineapple Codon Usage Table. Pineapple News (9):14-15.
Newett, S. 1997. PINEMAN. Pineapple News 3 (1):2-3.
Newett, S. 2004. 2003 Pineapple Field Day. Pineapple News (11):4.
Newett, S. 2005. 2004 Pineapple Field Day. Pineapple News (12):5-6.
Newett, S. 2005. Pineapple Study Group/Best Practice Project Progress. Pineapple News (12):6-8.
Nissen, G. 1998. Golden Circle Looks Forward after Fifty Years. Pineapple News 5(2.
O'Hare , T.J., J. Dahler, L.G. Smith, and L.S. Wong. 2002. Paclobutrazol Fails to Reduce Pineapple 'Blackheart' Expression Associated with a Putative Gibberellin-controlled PPO Gene. Pineapple News (9):4-6.
Obrero, F.P. 1995. Information about a new pineapple clone. Pineapple News 2 (1):9.
Pandey, R.R., and M.S. Johnson. 2002. Development Of Anagyrus ananatis Gahan (Hymenoptera: Encyrtidae) at Constant Temperatures. Pineapple News (9):15.
Paull, R. 1996. Genetic Engineering of Pineapple. Pineapple News 2 (2):24.
Paz, E.Y., J.G. Olmedo, and R.R. Sánchez. 2000. A Technology of Acclimatization of Pineapple Vitroplants. Pineapple News (7):5.
Paz, E.Y., J.G. Olmedo, and R.R. Sánchez. 2000. Light Management During Acclimatization of Pineapple (*Ananas comosus* (L.) Merr.) cv. Cayena lisa 'Serrana' Vitroplants. Pineapple News (7):5-6.
Pegg, K.G., S.H. Soo, and A. Drenth. 1999. Phytophthora Root and Heart Rot. Pineapple News (6):6-7.
Pegna, F.G., and J.S.P. de Corcho Fuentes. 2005. New Possibilities for Field Clearing in Pineapple Cultivation. Pineapple News (12):22-23.
Petty, G.J. 1996. White grubs in pineapples: a new strategy for management of the problem (Coleoptera: Scarabaeidae). Pineapple News 2 (2):16.
Petty, G.J. 2002. New Book In Print (Pests and Beneficial Arthorpods of Tropical and Non-citrus Subtropical Crops in South Africa). Pineapple News (9):13.
Petzler, A., and D. Christensen. 2004. Pineapple Growers' Best Practice Project – Sustainable Farming. Pineapple News (11):12-13.
Phillips, N., and D. Bell. 2004. Surround WP Crop Protectant for the Reduction of Sunburn Damage in Pineapple. Pineapple News (11):8-9.
Porter, I. 2000. Is There a Future for Fumigants for Soil Disinfestation in Australia? Pineapple News (7):2.
Ramsaroop, R., and A. Hodgson. 1997. Comparison of Consumer Acceptability of Hawai'i Gold and Smooth Cayenne
Pineapple Varieties. Pineapple News 3 (1):15.
Razzaque, A.H.M., M.M. Hanafi, A.R. Anuar, and S.K. Koh. 1998. Nutrient Requirements of Pineapple on Tropical Peat in Malaysia. Pineapple News (5):9-10.
Reinhardt, D.H. 1998. Pineapple Production and Research in Brazil. Pineapple News (5):4-5.
Reinhardt, D.H. 2000. Management and Evaluation of 'Pérola' Pineapple Ratoon Crop under Semiarid
Conditions. Pineapple News (7):4.
Reinhardt, D.H. 2001. Pineapple Played a Major Role in the XVI Brazilian Fruitculture Congress. Pineapple News (8):11.
Reinhardt, D.H. 2001. Slip Thinning - a New Cultural Practice for 'Pérola' Pineapple. Pineapple News (8):9.
Reinhardt, D.H. 2002. XVII Brazilian Congress on Fruitculture. Pineapple News (9):8.
Reinhardt, D.H. 2003. Pineapple at the XVII Brazilian Fruitculture Congress. Pineapple News (10):7.
Reinhardt, D.H. 2004. XVIII Brazilian Congress on Fruitculture. Pineapple News (11):25.
Reinhardt, D.H., and G.A.P.d. Cunha. 2000. Natural Flowering Control in Pérola Pineapple Domingo Haroldo and. Pineapple News (7):4.
Reinhardt, D.H., and V.P.d. Lima. 2001. Slip Thinning - a New Cultural Practice for 'Pérola' Pineapple. Pineapple News (8):9-10.
Reinhardt, D.H., and J.d.S. Souza. 2001. Why Off-season Offer of Pineapple Has Increased in Brazil. Pineapple News (8):10-11.
Reinhardt, D.H., and L.d.C. Vilar. 2002. Evolution of Brazil's Pineapple Production. Pineapple News (9):6.
Reinhardt, D.H., and L.d.C. Vilar. 2002. Paraiba's Pineapple Industry on Fast Recovery. Pineapple News (9).
Reinhardt, D.H., and G.A.P.d. Cunha. 2004. Inhibiting Natural Flowering on Pineapple.
Reinhardt, D.H., R.C. Caldas, and A.P.M. Souza. 2002. 'Pérola' Pineapple Slips Grew Better on Mother Plants than in Nursery. Pineapple News (9):7.
Reinhardt, D.H., R.C. Caldas, and A.P.M. Souza. 2002. No Need for Fertilizing Slips of Vigorous 'Pérola' Plants. Pineapple News (9):8.
Reinhardt, D.H., V.M. Medina, and R.C. Caldas. 2004. Rind Color and Fruit Quality of 'Pérola' Pineapples under Ethephon Treatment. Pineapple News (11):19-20.
Reinhardt, D.H., A.P.d. Matos, L.F.d. Souza, and L.d.C. Vilar. 2001. Brazilian Program for Improvement of Pineapple Commercialization and Package Standards. Pineapple News (8):11.
Reinhardt, D.H., G.A.P.d. Cunha, R.C. Caldas, and A.P.M. Souza. 2002. Pérola' Nursery Slips and Stem Plantlets Grew and Produced as Well as Conventional Slips. Pineapple News (9):7-8.
Reinhardt, D.H., R.C. Caldas, A.d.A. Alves, P.P. Simas Santos, and R.E. Herrera. 2003. Fruit Pulp Quality Gradients in 'Pérola' Pineapple. Pineapple News (10):6-7.
Reinhart, A. 2001. Dairy Manure as a Pre-Plant Fertilizaer for Pineapple. Pineapple News (8):17-19.
Rohrbach, K.G. 1997. The Pineapple Industry in Hawaii. Pineapple News 3 (1):15.
Rohrbach, K.G. 2000. Pineapple Research and Development Program. Pineapple News (7):13.
San, K., and C.H. Lin. 2003. Production News From Taiwan. Pineapple News (10):13.
Sanches, N.F., R.d.S. Carvalho, E.S. Silva, and I.P. Santos. 2001. Evaluation of the Predacious Capacity of Cryptolaemus montrouzieri on Dysmicoccus brevipes. Pineapple News (8):12.
Sanches, N.F., R.C. Caldas, A.d.A. Alves, I.G. Bonfim, and E.S. Silva. 2001. Control of Underground Termites Amitermes Sp. on the Pineapple Crop in the Semiarid Zone of Northeast Brazil. Pineapple News (8):12.
Sanewski, G.M. 1995. The Australian Fresh Market Pineapple Breeding Program. Pineapple News 1 (2):6.
Sanewski, G.M. 1997. The Australian Pineapple Industry. Pineapple News 3 (1):3-4.
Sanewski, G.M. 1998. Role of New Varieties in Developing the Australian Pineapple Industry. Pineapple News (5):3.
Sanewski, G.M. 2001. Pineapple Fresh Fruit Breeding Program (Australia). Pineapple News (8):4-5.
Sanewski, G.M. 2002. Developing a Commercialisation Strategy for New Pineapple Cultivars. Pineapple News (9):3.
Sanewski, G.M. 2002. Imported Hybrid Cultivar Comparisons. Pineapple News (9):3-4.
Sanewski, G.M. 2003. Ornamental Pineapples. Pineapple News (10):5.
Sanewski, G.M. 2004. A Method for Screening Pineapple Genotypes for Resistance to Phytophthora Cinnamomi. Pineapple News (11):16-17.
Sanewski, G.M., and D. Christensen. 2005. Commercialisation of DPI&F Pineapple Varieties. Pineapple News (12):12.
Sanewski, G.M., and N. Macleod. 2005. Commercialisation of DPI&F

Ornamental Pineapple Varieties. Pineapple News (12):12-13.
Santos Cabral, J.R., and A.P.d. Matos. 1998. Pineapple Breeding for Resistance to Fusariosis in Brazil. Pineapple News (5):5.
Santos Cabral, J.R., and D.H. Reinhardt. 2000. Evaluation of Pineapple Hybrids in Different Ecosystems of Brazil. Pineapple News (7):4-5.
Santos Cabral, J.R., A.P.d. Matos, and D.H. Reinhardt. 2003. 'Imperial', a New Pineapple Variety from Embrapa. Pineapple News (10):6.
Saradhuldhat, P., and R. Paull. 2005. Pineapple Fruit Organic Acid Accumulation and Metabolism During Growth and
Development. Pineapple News (12):28-29.
Schueller, J.K. 1996. Spatially-variable Agriculture. Pineapple News 2 (2):3-4.
Scott, C. 1998. Minor Use Chemical Registrations - Maintain. Pineapple News (6):4.
Scott, C. 1999. Finalisation of EDB Position and Alternatives for Nematode Control. Pineapple News (6):4.
Scott, C. 2000. Effect of Sodium Molybdate on the Juice Nitrate Concentration of Pineapples. Pineapple News (7):3-4.
Scott, C. 2001. Effect of Molybdenum Applications on the Juice Nitrate Concentration of Pineapples. Pineapple News (8):7.
Selvarajah, s. 2002. Pre and Postharvest Treatments for Reducing the Incidence of Chilling Injury in Pineapple. Pineapple News (9):13-14.
Sether, D.M. 2003. Abstracts of Research on Mealy Bug Wilt of Pineapple. Pineapple News (10):14-15.
Sheet, S., and S.K. Mitra. 1996. Effect of plant density on growth, yield and fruit quality of pineapple. Pineapple News 2 (2):12.
Sheet, S., and S.K. Mitra. 1996. Assessment of the stage of physiological maturity of plant for forcing. Pineapple News 2 (2):13.
Silva, J.A., R. Hamasaki, R. Ogoshi, R.E. Paull, D.P. Bartholomew, N.V. Hue, S. Fukuda, G. Uehara, and G. Tsuji. 2004. Effect of Calcium Sources and Basaltic Dust on Pineapple Nutrition and Production. Pineapple News (11):35-37.
Silva Souza, L.F.d., and D.H. Reinhardt. 1998. Pineapple Crop Under Irrigation is Growing. Pineapple News (5):4.
Sinclair, E. 1998. Weather Summary for 1996/1997. Pineapple News (5):3-4.
Sinclair, E. 2000. Weather Summary for 1998/1999. Pineapple News (7):4.
Sinclair, E. 2001. Soil Health Action Group (SHAG): the First 2 Years. Pineapple News (8):5.
Sinclair, E. 2001. Erosion Control What's Available and Being Developed. Pineapple News (8):7-8.
Sipes, B.S. 1995. Development and Evaluation of Nematicide Management Strategies for Control of Reniform and Rootknot Nematodes in Pineapple. Pineapple News 1 (2):9-10.
Sipes, B.S. 1996. Development of Nematicide Management Strategies for Control of Nematodes in
Pineapple. Pineapple News 2 (2):17-18.
Sipes, B.S. 1997. Pineapple Nematode Control: Summary of 1996 Activities. Pineapple News 3 (1):14-15.
Sipes, B.S. 1999. Efficacy of Telone II EC. Pineapple News (6):10.
Sipes, B.S. 2000. Alternative Chemicals for Control of Nematodes. Pineapple News (7):15-16.
Sipes, B.S. 2003. Nematode Control Research in Hawaii. Pineapple News (10):15.
Sipes, B.S. 2004. Current Nematode Control Research in Hawaii. Pineapple News (11):35.
Sipes, B.S. 2004. Reviews of Books and Book Chapters. Pineapple News (11):37.
Sipes, B.S. 2004. Fifth International Pineapple Symposium. Pineapple News (12):4.
Sipes, B.S., M.P. Ko, and D. Schmitt. 1995. Development of New Management Tactics for the Control of Plant-parasitic Nematodes in Pineapple. Pineapple News 1 (2):10.
Sipes, B.S., M.P. Ko, and D. Schmitt. 1996. Development of Management Tactics for the Control of Plant-parasitic Nematodes in Pineapple. Pineapple News 2 (2):17.
Smith, T.J., and G.J. Petty. 1996. Description and identification of white grubs (Coleoptera: Scarabaeidae) attacking pineapple crops in South Africa. Pineapple News 2 (2):16.
Smith, M., L. Ko, and R.G. Dietzgen. 2004. Gm Pineapples: What Are the Specific Licence Conditions Set by the Office of the Gene Technology Regulator? Pineapple News (11):14.
Smith, M., L. Ko, K. Kretschmann, P. Campbell, and T. Holton. 2005. Genetic Engineering of Pineapple for Blackheart Resistance and Control of Natural Flowering. Pineapple News (12):10-12.
Soo, S.H., A. Drenth, and K.G. Pegg. 2000. Phytophthora Survey Results. Pineapple News (7):2-3.
Souto, R.F., and J.F. Durigan. 2004. Pérola' Pineapples as Influenced by Maturation Stages, Thermal Treatment, Refrigeration and Modified Atmosphere. Pineapple News (11):24-25.
Souza, F.V.D., J.R.S. Cabral, and J.V. de Almeida. 2004. In Vitro Conservation of Pineapple Germplasm at Embrapa Cassava & Fruits. Pineapple News (11):21-22.
Sriwatanapongse, A. 2003. Thermal and Supercritical CO2 Inactivation Kinetics of Bromelain in Pineapple Juice. Pineapple News (10):13.
Steyl, L. 1997. Growth Regulators for Pineapple Crop Control. Pineapple News 3 (1):11.
Stirling, G.R. 1996. Can we Make More Informed Decisions on When to Apply Nematicides. Pineapple News 2 (2):4.
Stirling, G.R. 1997. Options for Managing Nematodes on Pineapple Following the Withdrawal of EDB. Pineapple News 3 (1):4-5.
Stirling, G. 1998. Nematode Management of Pineapples Following the Withdrawal of EDB. Pineapple News (5):4.
Stirling, G. 1999. Root Health in Pineapple. Pineapple News (6):7-8.
Stirling, G. 2000. Role of Organic Matter in Root Health. Pineapple News (7):3.
Stirling, G. 2000. Current Nematicide Trials in Pineapple. Pineapple News (7):3.
Stirling, G. 2000. Nematode Monitoring: An Aid to Managing Nematodes on Pineapples. Pineapple News (7):3.
Stirling, G. 2001. Nematode Situation Review. Pineapple News (8):5.
Stirling, M. 2002. Effects of Phosphonate on Phythopthora Root Rot of Pineapples. Pineapple News (9):3.
Stirling, G. 2002. Results of Field Trials on the Costs and Effectiveness of Nemacur in Pineapples. Pineapple News (9):4.
Stirling, G. 2004. Manipulating the Soil Biology to Suppress Nematode Pests. Pineapple News (11):4-8.
Stirling, G., and M. Stirling. 2004. Snippets on Nematodes and Phytophthora. Pineapple News (11):9-12.
Sugano, J., and R.F.L. Mau. 1998. Hawaii Integrated Pest Management (IPM) Goals. Pineapple News (5):11-12.
Sugano, J., and R.F.L. Mau. 1999. Maui Pineapple Co. Achieves IPM Certification. Pineapple News (6):11.
Sulaiman, S.F.M. 1997. Pineapple Research Activities in the Department of Agriculture. Pineapple News 3 (1):11-12.
Taniguchi, G. 1995. Pineapple Pesticide Evaluation. Pineapple News 1 (2):12.
Taniguchi, G. 1996. Pineapple Pesticide Evaluation. Pineapple News 2 (2):21-22.
Taniguchi, G.Y. 1997. Effects of Tebuconazole on Fruit weight and Precocious Flowering. Pineapple News 3 (1):15-16.
Taniguchi, G. 1998. Efficacy Studies With New Formulations of Amdro For Control of the Big-headed Ant, Pheidole megacephala. Pineapple News (5):12.
Taniguchi, G. 1999. Effect of Tebuconazole on Natural Flower Induction. Pineapple News (6):10-11.
Taniguchi, G. 2000. Control of the bigheaded ant, Pheidole megacephala, in Hawaii with ant bait
stations. Pineapple News (7):16-17.
Taniguchi, G. 2001. A New Safe Fungicide for Control of Chalara paradoxa. Pineapple News (8):19.
Taniguchi, G. 2001. Update on the Control of the Big-headed Ant, Pheidole megacephala, in Hawaii with Ant Bait Stations. Pineapple News (8):19.
Taniguchi, G., and S. Nelson. 1995. Pineapple Root Rot in Hawaii: Etiology and Control. Pineapple News 1 (2):10-11.
Taniguchi, G.Y., and M. Wright. 2003. Micro-lepidoptera, A New Pest Problem on Pineapple in Hawaii. Pineapple News (10):15.

Thomas, J. 1995. Mealybug Wilt and Viruses of Pineapple in Queensland. Pineapple News 1 (2):6-7.
Thomas, J.E., C.M. Horlock, K.G. Thomson, R.G. Dietzgen, and D.S. Teakle. 1999. Mealybug Wilt of Pineapple. Pineapple News (6):5-6.
Villachica Vivanco, J.H., B. S.A.C., and C.A. Cadenas Giraldo. 2004. Prevention of Pineapple Black Rot by Chemical Treatment. Pineapple News (11):32-33.
Vitelli, R. 1998. Nemacur® Demonstration Sites. Pineapple News5):3.
Vorsino, A.E., and M. Wright. 2005. Perspectives on a Pesky Pest of Pineapple; The Biology and Management of Opogona sacchari Bojer (Tineidae). Pineapple News (12):29.
Walsh, K. 2005. Sorting on Internal Quality Attributes. Pineapple News (12):13-14.
Wang, K.-H., and B.S. Sipes. 2000. Cover Crop for Nematode Management. Pineapple News (16).
Wang, K.-H., and B.S. Sipes. 2001. Sunn Hemp for Reniform Nematode Management. Pineapple News (8):19.
Wilson Wijeratnam, R.S., M. Abeyesekere, I.G.N. Hewajulige, and R. Suganthini. 1997. Postharvest Studies on Black Heart Disorder of Pineapple. Pineapple News 3 (1):13.
Wilson-W ijeratnam, R.S. 2004. Protocol for Post-Harvest Management of Mauritius Pineapple. Pineapple News (11):33.
Wolens, T., and D. Christensen. 2001. The Re-emergence of Symphylids. Pineapple News (8):5-6.
Wolens, T., and D. Christensen. 2003. Symphylid Chemical Observation Trial at Yeppoon. Pineapple News (10):4-5.
Zarad , S.S. 2005. The Effect of Planting Dates , Size of Plant Materials and Water Stress on Vegetative Growth, Yield and Fruit Quality of Pineapple. Pineapple News (12):22.
Zee, F. 1995. National Clonal Germplasm Repository. Pineapple News 1 (2):9.◆

Contributions to Pineapple News

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

Pineapple News is published by the University of Hawaii, College of Tropical Agriculture and Human Resources, Dept. of Tropical Plant and Soil Science. The contributions of Valent Biosciences and by various individuals to the University of Hawaii Foundation help support the costs associated with the publication of the newsletter. Reference to commercial products and services is made for the convenience of readers with the understanding that no discrimination is intended and no endorsement by the University of Hawaii and their employees is implied.