Pineapple News

Issue No. 15 Newsletter of the Pineapple Working Group, International Society for Horticultural Science June, 2008

Table of Contents

News of General Interest, Pineapple Working Group News

Dear Colleagues:

Another year has passed and you are now reading the 15th issue of Pineapple News. The number of contributions to the newsletter were down significantly this year, a typical occurrence the year after a pineapple symposium has been held. The VIth International Pineapple Symposium was convened in Joa Pessoa, Brazil in November of 2007 and D. Haroldo Reinhardt, the chair of the organizing committee, has kindly provided a report of the symposium below. You will find the abstracts of the many interesting papers presented at the meeting at the end of the newsletter. Editing of papers for the proceedings is moving forward but is not complete at the time this is being written. It is likely that it will be at least a few months before the proceedings is published and distributed to participants and available for purchase at the ISHS web site.

While the number of contributions to the newsletter is down, I hope you will find something of interest in those that have been submitted. In addition to the contributions below, I only recently discovered the CIRAD web site on marketing of tropical fruits, including excellent articles on pineapple marketing, has been up and running for quite a few years. The most recent articles are only available for a fee but older articles can be downloaded as pdf files at no cost. You will find the web link (URL) in the "Web Sites of Possible Interest" at the end of the newsletter.

The papers presented at the VIth symposium suggest that the area planted to Pineapple Research Institute of Hawaii (PRI) hybrid 73-114, (MD2 or as originally named by Del Monte MD-2) continues to expand. Some information on MD-2 and its sibling was included in the CABI book on pineapple published in 2003, but detailed information about PRI hybrids 73-114 (to avoid any confusion) and 73-50, which you may have read in Pineapple News No. 14 is the main fresh fruit variety in Australia, has never been published. Robert Paull in Hawaii and Garth Sanewski in Australia began the characterization process and Glenn Taniguchi and D. Bartholomew have attempted to provide a summary of what is known about these two hybrids. The public information available to date and photos of some characteristics can be found in the news sections for Australia and United States (Hawaii). If anyone having experience with either of the two hybrids can provide additional information, please send it to duaneb@hawaii.edu so the list of characteristics can be updated in a future issue of the newsletter.

Dr. Jimmie Bob Smith. In Memorium

Dr. Jimmie B. Smith died in the hospital near his home in Walnut Creek, California on April 9, 2008. Jim received his Ph.D. degree from Cornell University and in 1956 accepted a position in the Botany Department at the University of Hawaii. He later chaired both Botany and a newly established Genetics Department. In 1964 Jim joined the Pineapple Research Institute of Hawaii as head of plant breeding. He was appointed Director of the Institute in 1968 while continuing to lead the plant breeding program. Jim was involved in the development of a pineapple breeding program that led to the development of the "Gold" varieties, one of which has become a world-wide fresh fruit variety. Jim left PRI in 1971 to join Dole Pineapple Company as Vice President for Research and Quality Control. He later left Dole and formed his own international pineapple and tropical fruits consulting practice, which he maintained until the mid 1990s. He attended the first and second pineapple symposia and after that retired to Walnut Creek as he refocused his life on grandchildren and other retirement activities. He was 80 years old at the time of his death.

Estimating Plant Weights

This note was prompted by discussions with growers in two different countries in 2006 and 2007 regarding the use of 'D' leaf length or weight to estimate plant weight. Problems encountered when using 'D' leaf weight or length to estimate plant weight suggested there it could be worth reviewing the subject to provide a synopsis of the various methods that have been used to estimate plant weight and its value to the pineapple grower.

Why estimate plant weight

In a modern pineapple farm or plantation, a primary objective is to schedule fruit production to make efficient use of resources and labor and to provide a regular and manageable supply of fruit to the fresh fruit market or the cannery. Scheduling of fruit harvest is approximately set at the time of planting. Planting material should be graded by size and type so that the planting material in a given field is as uniform as possible. Without this initial uniformity, it is difficult to assess how plants are developing and also to establish forcing and approximate harvest dates. If planting is done during periods with little or no rainfall, plants should be irrigated at least a few times if water and equipment are available. Irrigation helps get plants off to a quick and uniform start. Any variation that is introduced into the field at the time of planting is accentuated over time, which makes it difficult to assess the progress of growth over time and to schedule forcing to obtain a fruit of marketable size at harvest.

Estimates of plant weight made before the date of forcing provide information about the progress of growth, i.e. are plants developing normally or is some unrecognized problem delaying growth. If the estimated plant weight indicates that plant growth is ahead of or behind what would normally be expected, forcing of plants can be rescheduled based on that information. If growth is progressing normally, forcing can occur on schedule, fruit harvest date can be predicted with reasonable accuracy, and the yield will also meet expectations. Many studies (for example Py, 1953; Py and Lossois. 1962; Wee, et al., 1979) have shown that fruit weight at harvest is highly correlated with plant weight, plant leaf number and even 'D' leaf weight (Soler, 2008) measured at the time of forcing. Average fruit weight determines the number of fresh fruits that can be packed in a box and the number of boxes produced per unit of land area. Average fruit weight also provides information on the potential recovery of choice and other slice grades in the cannery. Estimated plant weight can also be a decision aid when planning forcing schedules.

The relationship between plant weight at forcing and fruit weight at harvest is stable for a given cultivar within a particular environment but the relationship developed for one area may not be suitable for another area with a different average temperature. As an example, Fournier et al. (2007) state that a 2.5 kg plant at forcing will produce a 1.5 kg fruit at harvest in tropical Cote d'Ivoire while the ratio plant weight at forcing to fruit weight at harvest is nearly 1:1 for 'Smooth Cayenne' in Hawaii. For the typical grower, the effect of environment is of little consequence once the plant weight (or 'D' leaf weight or length)-fruit weight relationship has been established for a particular farm or growing area. However, if fields on one farm or growing area are located across a wide range of elevations, as is the case in Cameroun (Aubert, et al., 1973) and Hawaii, the relationship should be evaluated at more than one elevation to insure plant weight-fruit weight relationships are as accurate as possible.

Average temperature is the main factor that influences the relationship between plant weight at forcing and fruit weight at harvest. This relationship provides a measure how efficiently a pineapple plant is in converting dry matter to fruit. Pineapple plants grown in cooler climates are more efficient at accumulating dry matter in stems and in converting dry matter to fruit than is the case in warmer climates. Few studies show this environmental effect better than that of Hepton et al. (1993) and Hepton, (2003). The work was done using the same 'Smooth Cayenne' clone at pineapple plantations operated by Dole Co. in Hawaii, Honduras, Philippines, and Thailand and so includes both subtropical and tropical climates. The research showed that as average minimum temperature increased, both stem dry matter and harvest index (in the case of pineapple, defined as the ratio of fruit weight at harvest to plant weight at forcing) decreased. However, as average temperature decreases, plants grow more slowly so it will take longer for plants to reach the target weight at the time of forcing. So it is clear that plant weight at forcing can be used to estimate fruit weight at harvest within a given environment. The next question is, what methods are available to reliably estimate plant weight.

Methods used in estimating plant weight

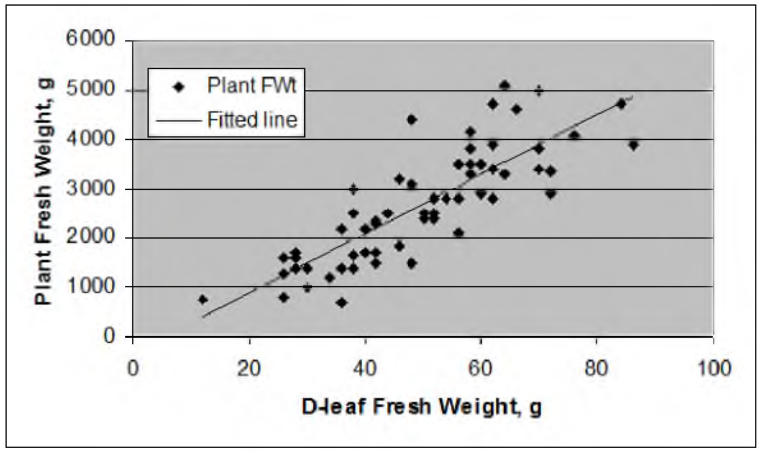
Estimated plant weight

One of the earliest methods for estimating plant weight was developed as part of the pineapple crop log, a concept apparently first introduced in the sugarcane industry in Hawaii and then adapted to pineapple by Nightingale (1936, 1942a,b) and later summarized by Sanford (1962). A method similar to that described below but based on estimated foliar mass was developed by Py, and Lossois (1962). Foliar mass of vegetative plants represents approximately 80% of a plant's fresh weight so the method is basically another measure of plant weight. The pineapple crop log usually involves establishing logging stations containing 100 plants at representative locations within uniform fields. Estimating plant weights at logging stations is fairly laborious. However, once the technique is learned, an experienced practitioner of the method can estimate plant weights very quickly. A very experienced practitioner of the method in Hawaii enjoyed demonstrating to skeptics his ability to quickly estimate average plant weight with an accuracy of 0.1 pounds (45 g).

It is critical that the plants in the logging station be representative of the plants in the area surrounding it. On farms where the field variability due to soil type and topography is high, more logging stations would be required than where field variability is low. Once logging stations have been selected, plant weights are estimated as follows: 1) Plants in the field are visually classified by approximate size. Where the amount of variation in plant size in the field is small, plants are assigned to the relative size classes small, medium and large; if the variability in plant size in the field is large, the relative size classes very small, small, medium, large, and very large are used; 2) One plant correspond to each size class is pulled from the soil outside of the logging station, the plant is weighed and the weight is recorded; 3) The number of plants of each size class is counted in the logging station and the total count should equal the number of plants in the logging station, e.g. 100; 4) The number of plants in each size class is multiplied by the weight of the representative plant for that size class; 5) The total weight for the three or five classes is summed and the total divided by 100 (or the number of plants in the logging station if greater than 100). The result is the average plant weight for the field. The average plant weight can be estimated once near the time of forcing or the progress of vegetative growth can be assessed at monthly or bimonthly intervals.

The 'D' leaf as an indicator of plant weight

The 'D' leaf is defined as the youngest physiologically mature leaf on the plant and also is the tallest leaf on the plant. The 'D' leaf is always easy to pull from the plant and has leaf margins that are more-or-less parallel all the way to the leaf base. Mature ('C') leaves are difficult to pull from the plant and have basal margins that are much wider than the margins of the upper part of the leaf. The margins of immature ('F') leaves taper inward at the base. Sampling of 'D' leaves can indicate how growth is progressing as well as providing tissue for analysis of plant nutritional status. As pineapple plants grow, 'D' leaves get progressively longer and heavier and 'D' leaf weight at the time of forcing was highly correlated with fruit weight at harvest for 'Baronne de Rothschild' but less well correlated for 'Smooth Cayenne' (Py and Lossois, 1962; Fournier et al., 2007). Soler (2008) recently reported that 'D' leaf weight was used as a forcing index for various pineapple cultivars in three different countries. As was noted for plant weight, the relationship between 'D' leaf weight or length at forcing and fruit weight at harvest likely will not be the same for all cultivars or for all countries or locations.



Assuming that the 'D' leaf has been correctly identified, the leaf is simply pulled from the plant and the weight or length is measured. Portable battery-powered electronic balances are relatively inexpensive, making it quick and easy to measure 'D' leaf weight. 'D' leaf length is measured with a rule, which seldom needs to be more than 1.0 m in length. The 'D' leaf sample size can be relatively small if variation in plant size is small but a larger sample size is required where variation is larger. Books on statistical procedure illustrate the technique for obtaining the suitable sample size. Once the sample size is known, 'D' leaves can be pulled from plants and systematic sampling, i.e. pulling very 5th or 10th 'D' leaf in a few or several rows to obtain the desired sample size, assures that the person doing the sampling does not bias the result. The leaves can be weighed together and divided by the total number to obtain the average 'D' leaf weight for the field. There usually is no need to obtain individual leaf weights as long as the sample size is adequate.

Variability in plant and 'D' leaf weights (and length) will always be found in the field and it is useful to know about these sources of variability. Some issues related to 'D' leaf variability are discussed below. The existence of such variation should not deter the grower from using average 'D' leaf weight (or length) to estimate the time to force plants to achieve a target fruit weight.

The 'D' leaf and plant weight data of Figure 1 were collected from plants of the Pineapple Research Institute of Hawaii (PRI) hybrid 73-114 (MD-2) growing on a farm near the equator. At first glance, the data points appear to cluster fairly closely about the fitted line and seem to indicate that 'D' leaf weight is well correlated with plant weight. However, on careful examination, the relationship is at best inconsistent. Plants weighing less than 1.0 kg and more than 3.0 kg, a more than three-fold difference, have similar 'D' leaf weights and similar other examples can be found on the graph. When such plants were placed next to each other, it was obvious that the plant weighing less than 1.0 kg was much smaller than the one that weighed 3.0 kg. The explanation for the large differences in plant weight became clear when the two plants were carefully examined. Starting at the base of the stem, leaves pulled from the small plant showed an orderly progression of increasing length (and weight) from the base of the plant up to the 'D' leaf. Leaves pulled from the 3.0 kg plant increased in an orderly progression from the base upward but then length began to decrease so the 'D' leaf weighed less than older leaves below it. Obviously, the plant had come under stress as the 'D' leaf was growing. Something had interfered with the growth of leaves after the plant had become well established.

Another much larger data set showing the relationship between plant weight and 'D' leaf length is shown in Figure 2. These data are for 'Smooth Cayenne' pineapple and were collected in a different country than those of Figure 1. It is clear from the data that 'D' leaf length was not closely related to plant weight. It is possible that the poor relationship between 'D' leaf length and plant weight resulted from improper sampling, i.e. sampling leaves older or younger than the 'D' leaf; however that is assumed to be unlikely. So what possible explanations are there for the variation seen in the data in Figures 1 and 2?

In collecting the data of Figure 1, the 'D' leaf was always the tallest leaf on the plant. However, a 'D' leaf pulled from a large plant that was shorter and lighter in weight than leaves below it could only result if the plant came under stress, with water stress being the most obvious cause. Water stress can be due to drought or to damage to the root system caused by pests or diseases. Leaf growth is very sensitive to water stress and cessation of leaf growth is the first physiological effect of water stress. Young, actively growing leaves are the ones most affected by water stress. Leaf growth is much more sensitive to water stress than is photosynthesis so mature leaves will continue to carry out photosynthesis and accumulate dry mass even though the growth of younger leaves is slowed or stopped by stress. Under such conditions, plant fresh and dry weights will continue to increase even though leaf growth has slowed or even ceased. When water again becomes avialable to a plant, leaf growth will resume but leaves initiated during the early part of the stress period will not fully elongate. The data make it clear that 'D' leaf length and weight are only good indicators of plant weight if leaf growth is not inhibited by stress.

There is no obvious explanation for the large amount of variability in the data of Figure 2. A stress explanation is also possible but another possibility is that the large number of samples were collected from a large area that was not uniform, either due to variability in soil characteristics or topography or to the use of highly variable planting material. For example, it is hard to understand how plants weighing about 1.0 kg could have 'D' leaf lengths of more than 70 cm unless large suckers had been used as planting material. 'D' leaves are only good estimators of plant weight where uniform planting material was used, where plants within a field were uniformly established, i.e. by use of irrigation to promote root development, and where growth continued without interruption by stresses. If these conditions of uniformity are met, 'D' leaf data will be useful in monitoring growth and estimating fruit weight at harvest.

There is one other situation where the 'D' leaf is not a good indicator of plant weight. Note that in Figure 2 there are no leaves that exceed a length of about 100 cm, which is approximately the upper limit of leaf length for 'Smooth Cayenne' pineapple. If vegetative growth is not checked by forcing or natural induction of flowering, leaf weight and length eventually reach a maximum even though plant weight continues to increase as new leaves are produced. Stem dry matter content also usually continues to increase. In most commercial fields, the time when leaves reach their maximum length is seldom encountered because plants either flower naturally or are forced before they grow to such a large size. Fruits produced on very large plants likely are too large to be in high demand and some research shows that fruit weights on very large plants can be smaller than those produced on smaller plants, a result probably due to intense mutual shading between large plants.

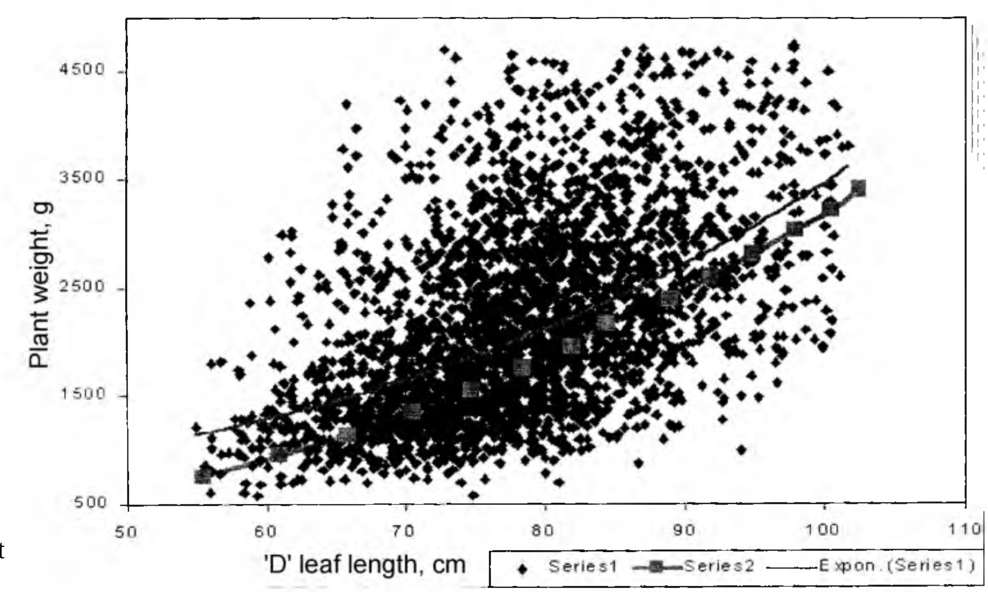


Figure 2. Relationship between plant fresh weight and 'D' leaf length for 'Smooth Cayenne' pineapple.

Leaf number as an indicator of plant weight

Py (1953) appears to be one of the first researchers to explore the relationship between leaf number and fruit weight of forced pineapple plants, Dass et al. (1977) standardized the procedure for use in India with ethephon as the forcing agent, and recently Fournier et al. (2007) showed that at a given plant weight leaf number varied with the cultivar. The use of leaf number is another way of estimating the above-ground mass of a pineapple plant because as noted above, about 80% of the vegetative mass of pineapple plant is of green leaves. However, on a large farm or plantation, it is much quicker and easier to sample 'D' leaves or estimate plant weights using the procedure outlined above than it is to count the number of leaves.

Summary

Estimated plant weight or 'D' leaf weight or length can be used to monitor the progress of growth and can also be used as a decision tool for determining when to force plants to obtain a targeted average fruit weight. The ideal situation is where in-field variation in plant weights is small due to the use of uniform planting material, cultural practices are used that assure that roots are initiated rapidly and uniformly and vegetative growth is not checked by stresses. An average weight of plants or 'D' leaves is calculated and the sample size on which the average is calculated should increase as the variability in the field increases.

References

Aubert, B., J.P. Gaillard, P. Lossois, C. Py, and J. Marchal. 1973. Influence de l'altutude sur le comportement de l'ananas "Cayenne Lisse". Essais realises au pied du mont Cameroun. Fruits 28:203-214.

Dass, H.C., H.P. Singh, K.M. Ganapathy, and G.S. Randhawa. 1977. Standardization of optimum leaf number for induction of flowering in pineapple. Indian J Hortic 34:24-25.

Fournier, P., A.Soler, and P.A. Marie-Alphonsine 2007. Growth characteristics of the pineapple cultivars 'MD2' and 'Flhoran 41' compared with 'Smooth Cayenne' pineapple New 14, p. 18-20.

Hepton, A. 2003. Culture System, p. 109-142, In D. P. Bartholomew, et al., eds. The Pineapple: Botany, Production and Uses. CABI Publishing, Wallingford.

Hepton, A., L. Ingamells, E. Macion, J. Gonzales, and D. Sampongse. 1993. Pineapple plant and fruit growth and development in fertilized native soil and artificial root medium. Acta Horticulturae 334:131-139

Nightingale, G.T., and C.A. Farden. 1936. Recording growth status of pineapple plants. Pine News 10:113-119. Nightingale, G.T. 1942. Nitrate and carbohydrate reserves in relation to nitrogen nutrition of pineapple. Botanical Gazette 103:409-456.

Nightingale, G.T. 1942. Potassium and phosphorus nutrition of pineapple in relation to nitrate and carbohydrate reserves. Botanical Gazette 104:191-223.

Py, C. 1953. Les hormones dans la culture de l'ananas. Ann Inst Fruits Agrumes Colon 6:46.

Py, C., and P. Lossois. 1962. Prevision de recolte en culture d'ananas. Etudes de correlations. Deuxieme partie. Fruits 17:75-87.

Sanford, W.G. 1962. Pineapple crop log-concept and development. Better Crops Plant Food 46:32-43.

Solar, A. 2008. Considerations on growth characteristics of different pineapple varieties in Côte d'Ivoire, La Reunion and Caribbean Islands. Abstract, VI[th] International Pineapple Symposium. Joa Pessao, Brazil.

Wee, Y.C., T.H. Tay, and K.S. Chiew. 1979. Correlation studies of leaf characteristics with fruit size in the Singapore Spanish pineapple. Malay Agric J 52:39-42.

Control of fruit sunburn in Taiwan

This short note on the control of fruit sunburn in Taiwan was added as a complement to an article from Costa Rica on the subject (see below). Most of the cultivars grown in Taiwan are hybrids developed at the Chiayi Agricultural Experiment Station, Chiayi, Taiwan. Tainon 17 or 'Golden diamond', is a hybrid from a cross of 'Smooth Cayenne' by rough leaf (probably 'Queen') parents and currently is the main fresh fruit variety grown in the country. A list of the hybrids grown in Taiwan was printed in Pineapple News No. 10 in 2003.

Figure 1

Figure 2

Two methods for controlling fruit sunburn were observed in Taiwan. One practice (Figure 1) is common elsewhere and involved tying the longer leaves over the fruit to shade it. The other method (Figure 2) appeared to be less labor intensive and though more costly in terms of materials, might allow the covers to be used more than once. The two methods were seen on different farms so the method used for fruit protection may be determined by grower preference.

Use of Gibberellic Acid (GA) on Pineapple

A press release available at http://bicol.da.gov.ph/News/2006news/press/7aug_2.html announced that a study "Yield Response of Queen Pineapple to the Application of Gibberellic Acid" conducted by Inocencio Q. Obrero, Senior Agriculturist and Agricultural Programs Coordinating Officer of Department of Agriculture in Camarines Norte, won the Best Paper award in the 18th Regional Symposium on RD&E Highlights held August 4, 2006. 'Queen' pineapple is exported from Camarines Norte to Korea and Mr. Obrero reported that GA helped farmers meet fruit size and weight specifications of the Korean market. Mr. Obrero's results showed that GA applied at the dry petal stage of fruit development significantly increased fruit weight, length, and diameter. It also lengthened shelf life and delayed ripening or peel color change. Application of GA had no effect on the sugar content of the fruit or on crown or sucker growth. The GA spray solution was prepared by dissolving three-fourths of a Berelex tablet (1.0 g GA kg^{-1}), a GA-containing product, in 16 L of water. Smaller yield increases were obtained when only one-half of a tablet was used. The larger amount of GA when applied as a spray during the wet season resulted in a significant yield increase of 5,096 kg ha^{-1}.

GA is approved by the United States Environmental Protection Agency for use on pineapple to: 1) increase fruit size ; 2) improve fruit uniformity and maturity; and 3) to maintain crown quality, delay dessication and discoloration and improve appearance. The label for the use of Progibb, a product of Valent Biosciences U.S.A., on pineapple provides the following recommendations. To increase fruit size, apply 125-250 g a.i. per acre per application after flowering and two applications applied at a three to five week interval are recommended. Sprays should be directed to the fruit and sufficient water is used to provide coverage. GA is also approved for the improvement of uniformity of fruit maturity and harvest efficiency.

The recommended practice is to apply 12 to 24 g a.i. per acre per application; applications are repeated at 3 to 4 weeks intervals. Treatment of the crown after harvesting and prior to packing with a 250 to 500 ppm spray directed to the crown is said to delay dessication, discoloration, browning, and improve overall appearance during transit, storage and shelf life. Be sure to follow label directions when using any material registered as a pesticide.

A Further Note on Slashing and Sucker Production

Col Scott, formerly with Golden Circle in Queensland and more recently with Summerpride in South Africa sent the following note related to slashing and sucker production. Col wrote: A comment regarding hand slashing of plants in your article on Ghana (Pineapple News No. 14). I did some work years ago using tractor mounted slashers to cut off plants after harvest. We found that it does make it easier to harvest the suckers that form but more importantly, this process stimulated the plants to produce more suckers. This allowed more than one harvest of planting material. Once we had agreed on the size at which we wanted to remove the suckers, we were able to harvest that size sequentially over two to four harvests.

7th International Pineapple Symposium

At the Pineapple Working Group meeting at the VIth Symposium it was agreed that the VIIth International Pineapple Symposium would be held in 2010. The symposium is to be organized by the Malaysian Pineapple Industry Board (MPIB) and the Malaysian Agricultural Research and Development Institute (MARDI) with the support of the Ministry of Agriculture and Agro-based Industry Malaysia (MOA). Malaysia has quite a long history of organizing such meetings and it can be expected that the meeting will be well organized and run. Malaysia is an interesting country to visit and offers many amenities as well as beautiful and unique local crafts to visitors.

ISHS

As you have read here before, the International Society for Horticultural Science 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 (http://www.ishs.org/science/T07.php) 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 or you can write to the ISHS Secretariat, P.O. Box 500, 3001 Leuven, Belgium (E-Mail: info@ishs.org).

D. Bartholomew (duaneb@hawaii.edu), Editor ◆

News From Australia

The Effect of Cut Style Pollination on Seed Set in Selfed Pineapple

G. M. Sanewski. Department of Primary Industries & Fisheries, Maroochy Research Station, Nambour, Qld. Australia. E-mail: Garth.Sanewski@dpi.qld.gov.au

Introduction

Modern domesticated pineapple varieties are generally considered to be highly heterozygous. Large populations and long time periods are needed to produce improved genotypes of commercial importance using conventional out-crossing strategies. Selfing has been proposed as a way of producing more homozygous segregating populations thus improving breeding efficiency. Most varieties of commercial significance, and hence most desirable as parents, are self incompatible (Coppens d'Eeckenbrugge et al, 1993). In *Ananas*, this self-incompatibility (SI) is known to be expressed in the upper one third of the style (Majumder et al, 1964).

Coppens d'Eeckenbrugge et al (1997) considered the incompatibility genes in pineapple to be highly stable and polymorphic. However, this SI system does not prevent fertilization 100% of the time. Even in highly self-incompatible cultivars of pineapple, pollen tubes from selfing were occasionally observed to grow through the full length of the style (Majumder et al, 1964). This is considered either a breakdown in SI due to environmental influence, or a result of mutation to compatible alleles (Collins and Kerns, 1937; Kerns and Johannsen, 1964). Attempts to overcome SI in pineapple have mostly met with failure although 1% NAA (Bhomik, 1980) and irradiation (Marr, 1964) are claimed to give a small degree of success.

SI is a form of pre-fertilisation barrier and techniques to overcome pre-fertilisation barriers might have application with SI. Several pollination techniques have been used by various workers to overcome pre-fertilization barriers. Techniques include cut-style pollination (CSP), placental pollination, mentor pollination and style grafting (Tuyi, 1997). CSP has proved very effective for developing interspecific crosses in *Lilium* sp (Kim YoungJin et al, 2001; Omiya et al, 2004) and for minimising selfed progeny in *Eucalyptus* sp (Patterson et al, 2004).

Some of these pollination techniques have been tried in Bromeliaceae with limited success. CSP was shown to reduce pollination efficiency in otherwise compatible crosses but did allow some pollination (Vervaeke et al, 2002). The best success was obtained where the style was left as long as possible to allow a beneficial pollen-pistil interaction but presumably trimmed enough to avoid SI. CSP was tested here to establish it's suitability for overcoming SI in pineapple.

Material and Methods

Three fresh market varieties of pineapple, Aus-Jubilee, Aus-Carnival and 73-50 were used. 73-50 is the female parent to Aus-Jubilee and male parent to Aus-Carnival. Aus-Jubilee and Aus-Carnival are half siblings.

Three syncarps were used for each treatment and the syncarps were protected with a fine gauze mesh prior to anthesis. A mean of 70 flowers were pollinated on each syncarp. The exact number was recorded for each syncarp. Four severities of style trimming were used; nil removed, only the tip removed, half of the style removed or the entire style removed. The trimming was performed using a scalpel and forceps. Crosses were either selfings or fertile backcrosses.

Results

Where CSP was not used, selfing produced very little seed in the 3 varieties tested (Table 1). Seed numbers from selfed flowers ranging within the means of 2-6 seed per 100 flowers. The back-crosses were very fertile producing a high number of seed. Where CSP was used, regardless of the severity it did not improve seed set in any of the three selfed varieties (Table 2). Although not demonstrated, it is more likely that CSP will reduce fertilisation in selfed plants as there was a definite decrease in seed set in a parental backcross where the styles were trimmed to half their length (Table 3).

Table 1. Seed/flower for selfing and backcross combinations.

Female	Male	Seed/flower
Aus-Jubilee	Aus-Jubilee	0.0593
Aus-Carnival	Aus-Carnival	0.0284
73-50	73-50	0.0210
Aus-Carnival	73-50	22.390
73-50	Aus-Jubilee	18.710
Lsd		2.230

Table 2. Effect of severity of cut style pollination (CSP) on seed set in selfed varieties.

Variety	Severity of trimming	Seed/flower
Aus-Jubilee	Nil removed	0.0594
Aus-Jubilee	Tip removed	0.0076
Aus-Jubilee	Half removed	0.0146
Aus-Jubilee	All removed	0.0077
Aus-Carnival	Nil removed	0.0284
Aus-Carnival	Half removed	0.0083
73-50	Nil removed	0.0210
73-50	Half removed	0.0035
73-50	All removed	0.0109
Lsd		NS

Table 3. The effect of cut style pollination (CSP) on seed set in the fertile cross Aus-Jubilee (♂) X 73-50 (♀).

Severity of trimming	Seed/flower
Nil removed	18.710
Half removed	7.963
Lsd	4.3

Discussion

CSP did not overcome SI in pineapple but rather reduced seed set even in fertile crosses. Some seed set will however occur when the style is trimmed indicating pollination, while enhanced by the presence of the stigmas, is not reliant on them.

Admittedly, it is still possible that the stylar incompatibility is overcome by CSP but that severe inbreeding depression results in abortion of the fertilised ovule. This aspect was not studied here. Nevertheless, CSP does not appear to be a promising technique for overcoming SI in selfed pineapple.

The literature indicates there are various means of improving the effectiveness of CSP in species where it has a demonstrated use or that there are better alternative techniques. Pre-pollination with compatible pollen improved the success of CSP in *Lilium* sp. (Li TongHua et al, 1996). Style grafting was better than CSP for intergeneric Bromeliad hybridisation (Vervaeke et al, 2002). So while CSP has not been successful to date for selfing pineapple, there are additional techniques worth investigation, including style grafting and pre-pollination in combination with CSP.

References

Bhomik, G. (1980). Selection of male parents on the basis of male gametophyte for pineapple breeding. Indian J. Agric. Sci. 50(10), 753-756.
Collins, J. L., and Kerns, K. R. (1937). Studies on the causes of seediness in the Cayenne pineapple. Proc. Hawaii. Acad. Sci. 31, 1.
Coppens d'Eeckenbrugge, G., Duval, M-F., and van Miegroet, F. (1993). Fertility and self-incompatibility in the Genus Ananas. Acta Horticulturae. 334, 45-51.
Coppens d'Eeckenbrugge, G., Bernasconi, B., Messiaen, B., and Duval, M-F. (1997). Using incompatibility alleles as genetic markers to identify pineapple varieties. Acta Horticulturae. 425, 161-169.
Kerns, K. R., and Johannessen, G. A. (1964). Possible use of the bloomless leaf character for measuring extent of natural crossing in pineapple. PRI News. 12(3), 80-81.
Kim YoungJin, Park SungMin, Kim JongHwa. (2001). Pollination methods for overcoming pre-fertilisation incompatibility in interspecific crosses between Lilium longiflorum 'Gelria' and L. cernuum native in Korea. Korean Journal of Horticultural Science & Technology. 19 (3), 373-377.
Li TongHua, Niimi, Y., and Nakano, M. (1996). Pollen tube growth and seed set in stigmatic and cut-style pollinated Lilium longiflorum 'Georgia' flowers as influenced by pre-pollination. Journal of the Japanese Society of Horticultural Science. 65 (1), 135-144.
Majumder, S., Kerns, K. R., Brewbaker, J. L., and Johannessen, G. A. (1964). Assessing self-incompatibility in pineapple by pollen fluorescence technique. American Society for Horticultural Science. 84, 217-223.
Marr, G. S. (1964). Study of self-incompatibility in the pineapple. Agric. Res. Nos 2-6, 561-62.
Omiya, T., Tamagake, H., Tsutsui, S., Kikuchi, H., Ubukata, M. N., and Nunome, A. (2004). A new small-flowered Asiatic hybrid lily variety "Kitakirari". Bulletin of Hokkaido Agricultural Experiment Stations. 87, 1-8.
Patterson, B., Gore, P., Potts, B. M., and Vaillancourt, R. E. (2004). Advances in pollination techniques for large scale seed production in Eucalyptus globulus. Australian Journal of Botany. 52 (6), 781-788.
Tuyl, J. M. van. (1997). Interspecific hybridisation of flower bulbs: a review. Acta Horticulturae. 430, 465-476.
Vervaeke, I., Parton, E., Maene, L., DeRoose, R., and Deproft, M. P. (2002). Pollen tube growth and fertilisation after different vitro pollination techniques of Aechmea Fasciata. Euphytica. 124, 75-83.

Imported Hybrid Cultivar Comparisons

G. M. Sanewski. Queensland Horticulture Institute, Maroochy Research Station, Nambour, Queensland. E-mail: Garth.Sanewski@dpi.qld.gov.au

The importation and testing of imported cultivars is an important part of the pineapple fresh market breeding program. To date the most promising of the imported cultivars have come from the Pineapple Research Institute of Hawaii (PRI) breeding program which operated in Hawaii until the early 1970's. Several PRI cultivars have been imported by a range of individuals and organisations. Three of these hybrids have been compared here with Cayenne. Two, 53-116 and 73-50, have been commercialised in Australia to different degrees.

Hybrid 53-116 was imported by Golden Circle Ltd from Hawaii in 1972. It is an intergroup hybrid from the early PRI breeding program. This hybrid was planted over several hundred acres in Hawaii before displaying a serious physiological disorder called 'Gland Base Defect' (Williams and Fleisch, 1992). It is known to have good resistance to endogenous browning (Sanewski et al, 1995; Wassman, 1983) but is considered susceptible to drought compared to Cayenne due to poor leaf water storage capabilities (Broadley et al, 1993) and can have as much as 20% of fruit without a crown (Wassman, 1983). It has been grown commercially on a small scale in Australia and sold on the domestic market under the name 'Hawaiian Gold'.

Hybrid 73-50 is also an intergroup hybrid from the Hawaiian program. It was imported into Australia in 1987 by J. Grigg. Its parentage includes 54% Cayenne, 20% Mordilona, 13% Pernambuco, 13% Red Spanish and 3% Queen. It was considered by PRI breeders to be a high yielding cultivar with low acidity and high vitamin C (Williams and Fleisch, 1992). This selection is being grown on a small but increasing scale in Australia under various names.

Hybrid 58-1184 is another PRI selection, imported into Australia in 1992 by QHI. While it has not been commercialised in any country it reputedly has characteristics similar to 53-116, such as blackheart resistance, and was worth including in the comparison.

Two trials were conducted (Table 1). The first was a winter plant crop comparing 73-50 and 53-116 with Cayenne. The second trial was a summer plant crop comparing 73-50 and 58-1184 with Cayenne. These 2 trials were conducted on different farms in SE Queensland in different years. Some of this data has been presented previously but is included here for completeness.

Table 1. Trials of hybrid during the winter and summer in Queensland.

Cultivar	Fruit wt, kg	Crown wt, kg	Multi-tops %	TSS†	Acidity %	BAR†	Transl rating*	Firmness kg cm^{-1}	Slips	Suckers Plant	Suckers Ground	Stem (cm) length	Stem (cm) width
Winter plant crop (Late May, Wamuran).													
73-50	2.0	0.27	0	13.6	0.7	18	2.4	10.1	1.0	0.9	0.6	31	24
F180	2.6	0.35	3	12.6	1.3	10	2.0	9.6	0.0	0.8	0.7	23	27
53-116	1.9	0.29	17	13.2	0.6	21	2.8	11.5	0.1	0.5	0.7	28	23
April Ratoon													
73-50	1.1	0.25	15	2.3	9.0								
F180	1.3	0.31	15	2.2	8.7								
53-116	1.2	0.16	16	2.1	11.5								
Summer Plant Crop (Feb, Nambour)													
73-50	1.8	0.37	0	15.7	0.3	54	2.0	9.7	2.0	0.6	0.6	15	26
F180	2.4	0.29	0.1	14.7	0.5	33	3.4	9.6	2.3	0.7	0.4	17	27
58-1184	1.7	0.27	0	14.3	0.3	58	3.4	11.1	2.1	0.7	0.6	15	26

†TSS, total soluble solids; BAR, the ratio of TSS to acidity.

*A rating of 2 is eating ripe stage, 3 is slightly translucent and 4 is totally translucent.

73-50

73-50 is consistently about 23% smaller than F180 ('Smooth Cayenne') in plant crop. It does not produce multiple crowns but can sometimes develop small slips around the crown. The crowns are moderate in size in winter but can be very large in summer, particularly early summer. 73-50 is only marginally sweeter than Cayenne (1% TSS) but is much lower in acidity. While the acidity of 73-50 is only about half that of F180 in early winter, it can still be marginally high for optimum eating quality. 73-50 can at times also develop translucency substantially diminishing its normally very aromatic flavour. While the data is not shown here, 73-50 has a slightly smaller core than Cayenne in comparison to the fruit width, and the flesh is more yellow but noticeably more porous. 73-50 is not substantially firmer than Cayenne.

73-50 does not normally produce large numbers of slips. During winter 73-50 can produce marginally more slips than F180 but a similar number of suckers. During summer it can produce fewer slips than Cayenne, a similar number of suckers and slightly more ground suckers.

The fruit stem of 73-50 is a similar length and width to Cayenne in summer but can be too long and thin in winter, and in combination with the larger fruit, results in greater breakage.

Data not shown here indicates 73-50 has a useful level of field resistance to blackheart which may be related to its exceptionally high vitamin C levels. The vitamin C content of 73-50 is about 5 times greater than Cayenne in winter (Sanewski and Giles, 1997).

73-50 may be marginally more susceptible to natural flowering compared to Cayenne.

53-116

The high incidence of multiple crowns and translucency in 53-116 make it unreliable as a commercial cultivar. Like 73-50 it is marginally higher in TSS compared to F180 but much lower in acidity giving it a higher BAR. Its vitamin C content is about 2.5 times greater than F180 in winter and it has very good resistance to blackheart (Sanewski and Giles, 1997). It is a reasonably firm fruit compared to Cayenne. It does not sucker well.

58-1184

58-1184 is a small fruit with low TSS and low acidity, yellow flesh and pleasant flavour. It however is prone to translucency which in combination with its normally low acidity substantially reduces its eating quality. While it does not produce any multiple crowns it does produce a large frequency of crown slips (data not shown). The crowns are very difficult to remove from the fruit. Like 53-116, the fruit is reasonably firm. 58-1184 is not superior to 73-50 but somewhat similar to 53-116.

Data not presented here indicates 58-1184 is much more susceptible to natural flowering than Cayenne when grown on a winter cycle. Natural flowering can occur in up to 30% of plants compared to none in Cayenne.

Summary

73-50 is clearly the best of the imported hybrids tested and this is reflected in its increasing popularity. A yield reduction of around 25% compared to F180 would however need to be considered in assessing potential profitability. The acidity is slightly higher than optimum and it may not be suitable for winter production on very cool slopes in SE Qld. Neither 53-116 or 58-1184 are suitable for significant commercial production.

Acknowledgments

I would like to thank Horticulture Australia Ltd. and Queensland Fruit and Vegetable Growers for financial support.

Reference

Sanewski, G.M., and J. Giles. 1997. Blackheart resistance in three clones of pineapple [Ananas comosus (L.) Merr.] in subtropical Queensland. Australian journal of experimental agriculture 37:459-461.◆

News From Brazil

Sixth International Pineapple Symposium

Domingo Haroldo Reinhardt and Getúlio Augusto Pinto da Cunha, Embrapa Cassava & Tropical Fruits, Caixa Postal 7, 44380-000 Cruz das Almas, Bahia, Brazil, emails: dharoldo@cnpmf.embrapa.br, getulio@cnpmf.embrapa.br

The VIth International Pineapple Symposium was held in João Pessoa, capital of the State of Paraíba, in the Northeast region of Brazil, on November 18 - 23, 2007. The Symposium was organized by the Brazilian Agricultural Research Corporation (EMBRAPA) through its National Research Center on Cassava and Tropical Fruits (Embrapa Cassava & Tropical Fruits), located in Cruz das Almas, Bahia, and the Secretary for the Development of Agriculture, Livestock and Fishery (SEDAP) of the Paraiba State Government, under the auspices of the International Society of Horticultural Sciences (ISHS). About 220 participants from 30 countries (Figure 1) representing all five continents and eighteen Brazilian States provided an exceptional audience with active participation during the Symposium held at the convention center of the Tropical Tambaú Hotel, located at the famous beach of Tambaú.

Figure 1. Photo of participants at the VIth International Pineapple Symposium.

The central theme of the event was Pineapple - Diversity and Sustainability. The genetic and botanical diversity of this species was shown in several talks and posters, addressing from the evolution of the genus Ananas and the domestication of pineapple to the rich composition of many germplasm banks, as for example the one kept by Embrapa Cassava & Tropical Fruits with about 700 accessions of the genus Ananas and other bromeliaceae, representing the diversity existing in Brazil, the country of origin of the pineapple plant.

Diversity of uses of the pineapple plant was also pointed out in a special session. Very recent and already rather successful research efforts carried out in Australia and Brazil are exploiting the ornamental potential of this plant. Embrapa's research team intelligently used the presence of people from so many different countries and cultural backgrounds to make a survey on consumer preference of ornamental pineapples. In addition was shown the work done in Brazil on the "carauá" (*Ananas comosus* var.

erectifolius), a hygrophilous species from the Amazon region, which has been classified as a newcomer fiber for industrial applications.

Crop management diversity, although rather natural and common due to many factors, was shown to be very evident in Brazil. The strong regional characteristics of pineapple production practices, from planting to harvest, could be seen during two full day field trips carried out during the Symposium. In the first one all participants could see and discuss in four sequential stations the main aspects of 'Pérola' pineapple cultivation under family agriculture conditions, whereas in the second one a smaller group of about 70 people observed the pineapple growing practices on a larger farm with higher investment capabilities.

Sustainability of pineapple production and business was addressed in several sessions of the Symposium. Concerns on the reduction of negative environmental impacts of the activity, together with the improvement of all aspects of fruit quality, with emphasis on its healthiness, could be observed as the main background of many papers presented by scientists coming from different countries and continents. New production systems were shown that may minimize or even totally avoid the application of synthetic pesticides, as for example the integrated pineapple production system being developed in some Brazilian States, such as Tocantins, Paraiba and Bahia, carried out under the auspices of the Ministry of Agriculture, Livestock and Food Supply, or the South African and French strategies towards the production of organic pineapples or "zero pesticide" pineapples. A major help for reaching these goals could be the use of natural plant extracts, such as tannins and other substances, instead of synthetic products in the control of pests and diseases, as those mentioned in some studies on fusariosis and black rot diseases, as well as the development of new cultivars with genetic resistance or tolerance to important pests and diseases, as for example the new Brazilian cultivars 'Imperial' and 'Vitória' which are resistant to fusariosis. In addition was emphasized the need of non-chemical prophylactic measures for reduction of risks of nematode incidence and of losses due to mealybug and viruses associated wilt incidence.

Important advances have been obtained by biotechnological studies and approaches towards a better knowledge on some of the most common problems faced by pineapple growers all over the world, such as natural and irregular flowering and the mealybug wilt associated viruses. Fortunately it seems that those long-term research efforts have opened the perspectives for a much more effective control of those problems in the future. In this context has also been proposed a new interesting strategy to control plant parasitic nematodes using host delivered RNAi.

In the post-harvest management session were shown the new challenges in production and maintenance of quality offered by the introduction of low acid types of pineapples in the fresh fruit markets of USA, Japan and Europe, as well as the main results already obtained to make adjustments in the pre- and post-harvest management practices of those fruits. And the last technical session of the Symposium brought interesting information on general aspects of the Brazilian pineapple agribusiness, traditional and new marketing strategies and on the trends and perspectives of pineapple processing.

The Pineapple Working Group held its traditional meeting during the Symposium, with the presence of Dr. Jack Ganry, chair of the ISHS Section of Tropical and Subtropical Fruits. Obeying the criteria of alternance among countries and continents, Johor Bahru in South Malaysia was approved as the venue for the VII International Pineapple Symposium in 2010 to be organized by the Malaysian Pineapple Industry Board (MPIB) and the Malaysian Agricultural Research and Development Institute (MARDI) and supported by the Ministry of Agriculture and Agro-based Industry Malaysia (MOA).◆

News From Canada and Panama

Review on the Potential of Computer Models to Support Soil Conservation and Erosion Evasion Initiatives for Pineapple Crops in the Panama Canal Watershed

Jordan Oestreicher, Dept. of Bioresource Engineering, Neotropical Environmental Option, McGill University, Montreal, Canada.
E-mail: jordan.oestreicher@mail.mcgill.ca

Introduction

The objective of this article is to highlight the special circumstances of the expanding pineapple culture in the Panama Canal Watershed, to introduce a conservation program which aspires to provide farmers with incentives to reduce erosion-causing activities, and to discuss the hydrological and crop models which can support program planning.

Context

The Central American Republic of Panama is best known for the Panama Canal, an economic pillar of the Panamanian and global economies. The canal, a testament to the marvels of human engineering, is being expanded to accommodate larger freighters and so that Panama may maintain their monopoly as the only inter-oceanic passageway. The watershed surrounding the Panama Canal supplies freshwater used to transit ships, to generate hydroelectricity and to provide urban populations with potable water; yet sedimentation of reservoirs also threatens to reduce their water storage capacity. Water flows into canal reservoirs during the wet season (from about May to December) and its storage is essential to ensuring that canal operations continue and local population needs are met throughout the dry season. However, due to both natural and human-induced sedimentation of the reservoirs (PMCC, 1999), the Autoridad del Canal de Panamá (Panama Canal Authority, ACP) must continually dredge sediment to maintain a sufficient reservoir depth. Consequently, reducing sedimentation, as well as closely monitoring water yield and flow timings, is a primary concern of the ACP and other political bodies.

The Tinajones, Caño Quebrado, and Los Hules River Basin: the epicentre of pineapple production in the Panama Canal Watershed

Most titled land in the Panama Canal Watershed is used for livestock grazing and remaining forests are protected (PMCC, 1999). The Tinajones, Caño Quebrado, and Los Hules River (TCH) basins are located in the central region of the Panama Canal Watershed and have a total catchment area of 154 km^2 (about 4.5% of the greater watershed area) and directly outlet into the Lago Gatun reservoir. Since 2001, pineapple plantations have been rapidly cropping up in the TCH area (Figure 1), and this rapid land transition has caught the attention of watershed monitors. In fact, in the last eight years the area planted to pineapple has roughly tripled and it is projected to continue to increase at similar rates (Martez and Vergara, April 2004). The increasing land area under pineapple cultivation has left many wondering what long-term impacts of this expansion could have in terms of increased sediment generation and water flows.

There are a total of 27 towns and hamlets in the area with a population of about 4100 (Marín and Yee, 2004). Sixty-six percent of the population works in the agricultural sector (Marín and Yee, 2004), many of whom work on pineapple plantations or in one of the three nearby pineapple packing plants. Due to the growing number of pineapple plantations and the increased need for labour, many workers have been contracted from other remote provinces, earning an average pay of about 3-4 US$ per day (IDIAP, 2007b).

Figure 1. Expanding pineapple plantation in Panama.

Soils in the area are principally fine clays or clay-loams of the Ultisol soil class and the Udult suborder (IDIAP, 1996, USDA and NSCR, 2005) - or Humic Acrisols of the FAO soil classification system (FAO and UNESCO, 2003). Although, in general, high clay content soils are not particularly susceptible to erosion, soils of the area are assumed to be of kaolinitic clay origin with clayey B horizons which are structurally unstable, prone to crusting - which has been observed in TCH during the dry season -, and are easily compacted by cultivation (Lal, 1990). Such changes in soil properties and structure can lead to high runoff rates and are important features in assessing the vulnerability of soils to erosion. Nevertheless, further analyses are required to assess soils in the area and their erosion vulnerability.

The climate is characteristic of the sub-humid tropics, with an average annual rainfall of 1887 mm (AED, 2004) and two distinct seasons: the wet season - May to December - and the dry season - January to April. The most intense storms are in October, while monthly average precipitation in February and March commonly approaches zero. Average annual temperatures are 26°C, however, diurnal temperatures range from 33°C to 23°C; temperatures do not significantly fluctuate seasonally. Seventy five percent of the area is less than 100 meters above sea level, while some of the highest points surpass 200 meters.

While geography and climate make the region ideal for pineapple cultivation, other prevailing issues, in addition to unstable soils, make the area prone to erosion. Intense seasonality means extreme dry seasons, which can cause cracking on degraded soils and lead to high surface runoff rates, and heavy storms in the wet season, which can expose soils with no vegetative cover to rainfall impact. As in all areas, adequate vegetative cover is a key element in reducing soil erosion. This can, of course, be achieved with appropriate crop choices and planting patterns; however farmers in the TCH area do not appear to use such strategies (Figure 2).

It is for these reasons that the effects of the expansion of pineapple farms on sediment and water flow and quality in the TCH basins have been under enquiry by the ACP and other agencies since the expansion began. While a lack of historical data renders an analysis unfeasible, the general assumption has been that sediment yield in the TCH basins is on the rise due to the expansion of pineapple farms.

Figure 2. Rows oriented along the slope in the Tinajones, Caño Quebrado, and Los Hules River basins area, Panama.

Sustainable Management Practices and Erosion Prevention

Pineapple production in the TCH basins is intense and farmers do not generally employ soil conservation (erosion prevention) techniques (Figure 2, Figure 3) (Martez and Vergara, 2004). In 2004, Martez and Vergara (2004) documented erosion on all pineapple farms in TCH, classifying 33% of farmland as severely eroded. According to their survey, all pineapple farmers (with the exception of one) identified erosion and its severity as an important issue. Considering soils in the area are susceptible to degradation and that the landscape topography of the area is largely of undulating slopes (average slope 8%, maximum 49%) (Figure 2 and Figure 3), reducing erosion in the area will largely hinge on crop cover, cropping patterns and planting in appropriate areas.

In addition to soil characteristics and climatic conditions, land management practices can contribute to soil erosion prevention or exacerbation in any agroecosystem. Given the circumstances of the Panama Canal Watershed and its vulnerability to increased reservoir sedimentation, soil conservation techniques must be employed on pineapple farms in the TCH if sediment yields are to be controlled. Several methods may be applied to agricultural landscapes, such as mulching, planting along contour lines, terracing, inter alia, which can effectively reduce erosion by minimizing raindrop impact and/or retarding surface runoff velocity (Lal, 1990).

Mulching, which covers soil with a protective layer, has successfully reduced erosion in pineapple fields. Plastic mulch, a widely used mulching material, was the most effective erosion control measure in Hawaii (Wan and El-Swaify, 1999). Organic residues (biomass), such as rice husks, have been successfully used in Asia (Sarma and Medhi, 1997), while green mulching materials (cover crops), such as cassava (*Manihot esculenta*) or pigeon pea (*Cajanus cajan*) have been applied on pineapple farms in South America (Montilla and Catayo, 1995). In addition to reducing the vulnerability of soils to erosion, mulching with almost any material increases pineapple fruit yield when compared to bare soils (Kuruvilla et al., 1988, Obiefuna, 1991, Dominguez et al., 1995). Mulching increases plant growth efficiency (Rebolledo-Martinez et al., 2005) by increasing soil humidity, organic matter, and nutrients (with biomass mulching) (Montilla and Catayo, 1995).

When farming sloping lands, planting along contour lines or on terraces are common methods used to manage erosion because they direct runoff flows and reduce runoff velocity. On extreme slopes, however, these measures alone may not be the absolute solution to erosion control. In Taiwan, researchers found that cultivating pineapples at high planting densities, with biomass mulch, and along contours reduced erosion 13 fold and runoff by 8 fold compared to straight up and down planting patterns (Liao and Wu, 1987).

Crops or vegetation planted around the border of an agricultural field can also reduce erosion. In the TCH basins, strip barriers or hedges, which consist mostly of grasses such as citronella grass (*Cymbopogon nardus*), lemon grass *(Cymbopogon citrates*), or koronivia grass (*Brachiaria humidicola*), are one of the few erosion prevention measures employed (Figure 4), although used only by 17% of pineapple producers (Martez and Vergara, 2004).

Figure 3. A typical pineapple farm in the Tinajones, Caño Quebrado, and Los Hules River basins. Evidence of erosion can be seen at the left side of the photo.

Beyond land management, mechanical disturbances can also significantly contribute to erosion and must be considered in erosion prevention planning. The primary source of erosion in Hawaiian pineapple fields was dirt roads and tillage practices during the early growing season (El-Swaify et al., 1993). Erosion from dirt roads may be partially attributed to the soil disturbance caused by vehicles and the two to three fold increase in runoff potential when compared to pineapple fields alone (Cooley and Lane, 1982). While roads contribute to erosion, altering or eliminating tillage practices can reduce erosion in pineapple fields up to 1/14 the levels associated with conventional tillage (Sugahara et al., 2001). The different erosion prevention techniques should be tailored to the local conditions and in many cases, a combination of erosion prevention techniques will be the most sustainable choice. For example, because a closed pineapple canopy protects soils from erosion and reduces runoff potential (Obiefuna and Asoegwu, 1993) (Cooley and Lane, 1982), it is imperative that erosion prevention measures be employed at the commencement of the pineapple crop cycle; these measures would become increasingly less effective as the crop canopy matures. Similarly, planting vegetation around the border of fields (as done in TCH) may only marginally reduce erosion (Sugahara et al., 2001), implying that a combination of techniques is likely the best means to maximizing erosion prevention.

Developing watershed management strategies in the Panama Canal Watershed would largely benefit from an analysis of the advantages of using the above-mentioned soil conservation techniques in the TCH. This would allow watershed managers to find an ideal combination of methods or identify which methods are most effective at controlling/reducing erosion. A first step to achieving this will involve quantifying or modeling the sediment produced from unsustainably managed farms and from areas using erosion prevention techniques. The comparative advantages of different soil conservation mechanisms could then be examined and the extent to which sediment yields in the area are reduced could be estimated, allowing managers to identify the most effective techniques and plan conservation strategies.

Payment for Ecosystem Services

The economic costs of increased reservoir sedimentation are potentially high[1] , so identifying the causes of unsustainable practices and ensuring reductions in erosion-causing activities within the Panama Canal Watershed are main objectives of the ACP and other political bodies. The unsustainable management of pineapple farms in the TCH is perhaps due to a lack of information on sustainable farming practices or because such practices (preparing land for planting along contour lines or on terraces) are labour intensive and require money, time and accessibility to tools and other resources. Although a majority of pineapple farms in the area are large-scale commercial plantations (Martez and Vergara, 2004) that may have such resources, there are also a number

[1] Another concern is the maintenance of water yields and flow timings, services that may be threatened by climate change as well as land degradation due to unsustainable cattle grazing or agricultural practices.

of small-scale pineapple farmers in the area who may not have similar access. In addition to resource and information access, the fact that farmers have no incentive to adhere to the regulations outlined in the best management practices guide for pineapple farming in Panama (OIRSA, 1999), is also of paramount importance.

A promising conservation program, payment for ecosystem services, is expected to be implemented in the TCH basins and will attempt to provide both pastoralists and farmers with incentives to use soil conservation techniques. The TCH basins are just one of many areas that will take part in a payment for ecosystem services pilot project to assess the feasibility of applying such a program in the greater Panama Canal Watershed. In order to describe the inner-workings of the payment for ecosystem services mechanism, such services must first be defined. The Millennium Ecosystem Assessment (MEA) defines ecosystem services as the benefits people obtain from ecosystems. These can be broadly subdivided into 4 categories: (i) provisioning services, which are products obtained from the ecosystem; (ii) regulating services, which are benefits obtained from the regulation of ecosystem processes; (iii) cultural services, which are the non-material benefits provided by ecosystem services; and (iv) supporting services, which are the services essential to production of all other services (MEA, 2005). According to the MEA, the high demand for ecosystem services has resulted in trade-offs among the benefits received; for example, the conversion of forested land to an agricultural field will increase provisioning services, such as food supply, but may decrease regulatory services, such as water regulation and quality of erosion control.

The concept of payment for ecosystem services merges markets with ecosystem services to provide economic incentives for resource conservation. The payment for ecosystem services mechanism functions in a manner whereby beneficiaries of ecosystem services remunerate the service providers, in this case pineapple growers and ranchers, for conserving soil and water resources. In the Panama Canal Watershed, regulating and provisioning services, such as flow timings, erosion control and fresh water provisions, are vital services which could be conserved via a payment for ecosystem services mechanism. Service buyers, such as the ACP, could pay pastoralists and pineapple farmers for adopting management practices that reduce erosion. Decreased erosion would reduce the amount the ACP spends on dredging operations, thereby freeing up funds that could be used to reimburse the agriculturalist for the costs of erosion control. The benefits of the erosion-prevention measures should outweigh the costs of dredging operations and payments must surpass the opportunity cost of land. Other versions of this scenario can be explored, for example water consumers paying farmers to reduce fertilizer use to improve water quality or the government providing incentives to reforest land to improve dry season flow and reduce erosion[2] , and many others. (See Fotos et al., 2007 for a detailed assessment of demand for ecosystem services in the Panama Canal Watershed).

In the context of the expanding pineapple culture in the TCH basins and the looming threat of increasing sedimentation of canal reservoirs, sustainable agroecosystems are a necessity and are attainable; yet the information, resources, and incentives must be simultaneously provided to farmers and ranchers in order for such changes to occur and solidify. Moreover, a practical tool is needed to predict the effects of the current pineapple cultivation practices and to simulate the potential impact of the above-mentioned erosion prevention measures; this will support the incentive-based conservation method which may help reduce sediment yield in the TCH basins.

Computer Models

Accurate prediction of watershed-scale sediment production and the effects of erosion-prevention activities will be a paramount factor for the successful implementation of the payment for ecosystem services pilot project. Moreover, modeling the harvest yield of pineapple crops under different management practices (reduced fertilizer use, shifting cropping schedules, change in terrain preparation techniques, etc.) will be crucial for the estimation of opportunity costs and calculation of payments.

Soil and Water Assessment Tool

To assist in the planning and implementation of a payment for ecosystem services program, the hydrological model Soil and Water Assessment Tool (SWAT) (Arnold et al., 1998) is being adapted to simulate the effects of different management practice scenarios on sediment and water yields in the TCH basins. SWAT is a physically based semi-distributed simulation watershed model that runs on a daily time-step. It relies on climatic, soil property, topographical, vegetative and land management input data to predict the impacts of land management practices on water, sediment and agricultural chemical yields in large watersheds over long periods of time.

SWAT is a powerful tool and has been used as a support system for environmental management decision and policy making in the tropics. For example, SWAT was successfully used to implement an inter-state water allocation program in India to conserve water resources (Singh and Gosain, 2007). Schuol et al. (2007) used SWAT to identify regions of potential water scarcity in West Africa, providing a regional perspective of water flows. SWAT has also been applied, with acceptable performance, to model the effects of hypothetical land-use change scenarios (primarily deforestation and reforestation of

[2]Evidence of reforestation restoring dry season flows is not universally accepted. In fact, there have been cases where reforestation decreases dry season flow, as eloquently detailed in Bruijnzeel (2004). Moreover, erosion reduction of forested lands will depend the management of the system (i.e. poorly managed forestry plantations or natural forested systems).

croplands) on flow, sediment, and nutrient yields in Honduras (Rivera and Martinez, 2003), Costa Rica (Benavides and Veenstra, 2005), Brazil (Barsanti et al., 2003), Kenya (Jacobs et al., 2003a, Jacobs et al., 2003b), and China (Ouyand et al., 2007).

Soil and Water Assessment Tool: Plant Growth Model

The SWAT model can simulate plant growth and crop yields and includes data for more than 90 different crop, grass, shrub, and tree species. Plants not included in the SWAT model, such as the pineapple, may be modeled if the plant-specific parameters necessary to mathematically describe plant growth are available. Parameters required by the model include leaf-area-index (total plant leaf area per unit land area) change, radiation-use efficiency (dry biomass produced per unit of intercepted radiation), phosphorus and nitrogen up-take, harvest index (ratio of total to harvested dry biomass), optimum-growth and base temperatures, and stomatal conductance, among others. Input values for these parameters can be obtained from field data as well as from a review of the literature.

SWAT simulates plant growth from the basic components leaf-area index (LAI) development, intercepted solar radiation, and accumulation of biomass. Leaf-area index is assumed to follow a sigmoidal development curve and is driven by the number of heat units accumulated in a given day. Heat units are accumulated following the standard convention of summing daily mean temperature-degrees above some base temperature and are calculated by the equation:

$$HU_i = \overline{T}_i - T_{base} \text{ when } \overline{T}_i > T_{base} \qquad \text{Equation 1}$$

Where HU_i is the number of heat units accumulated on day *i* and $\overline{T}_i$ is the average temperature on day *i*. T_{base} is the temperature at which no development occurs and is a user-specified variable. Thus, the rate of change of the LAI can be calculated if the total number of heat units needed to bring a plant maturity is known.

In SWAT, 50% of radiation is assumed to be photosynthetically active and light interception per unit land area is dependent on LAI. Absorption of intercepted radiation is estimated by a simple Beers Law (Equation 2) model that assumes horizontal and vertical leaf-distribution is equal, which results in a light extinction coefficient K of -0.65. In the equation:

$$H_{photo} = 0.5 \cdot H_{day} \cdot (1 - e^{K \cdot LAI}) \quad \text{Equation 2}$$

H_{photo} is the amount of photsynthetically active radiation intercepted by the plant, H_{day} is the total daily solar radiation and K and LAI are as described above. Biomass accumulation is then calculated as a function of LAI and the user-defined radiation-use efficiency parameter, a fixed ratio for the conversion of light to biomass by the equation:

$$\Delta BM = RUE \cdot H_{photo} \qquad \text{Equation 3}$$

where ΔBM is maximum potential increase in biomass for a given day and RUE is the radiation-use efficiency parameter. The biomass accumulated for any plant is the sum of all daily maximum potential increases of biomass over the simulated growth period.

Although this model has accurately simulated growth for many species (Neitsch et al., 2002), the SWAT model framework appears to limit its applicability to pineapple growth simulations. For example, SWAT assumes that plant growth is directly proportional to temperature increases and does not account for the harmful effects of extreme temperatures, high or low, on plant growth. Furthermore, factors which appreciably affect pineapple growth in situ, such as nutrient availability or soil-water content, are not modeled by SWAT.

Finally, an important limitation of SWAT for the pineapple is that plants which grow over a two calendar-year period cannot be simulated because SWAT, by default, forces all simulated crops to be harvested by the end of each calendar-year (December). The default harvest operation appears to be the result of model development in the United States where most crops are harvested before the end of the year. The problem can be solved by reworking the SWAT model program code[3]. In TCH, the pineapple crop takes, on average, 372 days to reach maturity (IDIAP, 2007b), so the crop cycle in general cannot be simulated within one calendar-year. This implies that a calibration and validation of the crop growth model cannot be effectively performed at this time since observed yields cannot be compared to yields simulated under similar growing conditions. Of principal importance is the accurate recreation of climatic conditions, given that plant growth simulations in SWAT are principally based on solar radiation and temperature.

Soil and Water Assessment Tool: Additional Features

For use in the TCH basins, it is necessary to have a model which can satisfactorily simulate basin-wide sediment and water yields and the effects of different land management practices (erosion prevention methods) on these yields. Given that soil erosion in agroecosystems is largely a factor of canopy cover and root development, it is important to have a good plant growth simulation

[3]There exists some discussion in the SWAT-user community on this subject matter (SWAT FORUM, 2007; Google Groups, Accessed December 2007. http://groups.google.com/group/swatuser) and there is speculation that the SWAT developers or a benevolent SWAT-user will modify the program code in order to remove the automatic harvest and kill operation.

model. The model must also be able to simulate plant growth in different locations across the watershed (under varying topographies, soil types, etc.) which will help identify areas that are best suited for pineapple culture or areas that are most susceptible to erosion.

Beyond plant growth, simulating crop yields under different land management scenarios (employing different erosion prevention methods) would assist in the calculation of remuneration amounts to be paid to agriculturalists in a payment for ecosystem services project. Predicting the revenue farmers currently earn and comparing that with revenues potentially earned from alternative management practices which may conserve soil or water resources (i.e. at higher planting densities, reduced fertilizer use), will be a keystone in the development of a payment for ecosystem services project.

Also, the effects of different land preparation techniques, such as tillage, and different planting patterns, such as planting along contours, must be able to be simulated. Considering mechanical disturbances are a significant source of sediment yield and many farmers use straight up-and-down cropping patterns, the model must be able to simulate the effects of these practices and the benefits of erosion prevention measures (conservation tillage, using contours, etc.). SWAT cannot, however, simulate the sediment produced from roads. Satellite imagery analysis could help identify areas where roads appear to be a source of erosion and could consider this in model construction and calibration.

Although SWAT can simulate all of these important and necessary elements, it alone may not be sufficient to meet the specific needs of the TCH case. While amending the SWAT program code could remedy the default harvest operation in December of each simulated year, the SWAT model framework appears to be a factor which would limit accurate pineapple growth and crop yield simulations. Confirming or denying this statement would require constructing the pineapple growth model component of SWAT and calibration and validation of the completed model. Currently, data collection is underway in the TCH basins and an evaluation of the SWAT pineapple crop model will soon be assumed, pending the resolution of the default harvest operation.

The Aloha-Pineapple model, Comparison with SWAT

A discussion of the ALOHA-Pineapple model v.2.1 (Zhang et al., 1997), a CERES (Crop Environment REsource Synthesis) based crop growth simulation program, is included here because there appear to be significant limitations to SWAT for pineapple growth simulation. The ALOHA model has successfully simulated the effects of environmental factors and land management practices on pineapple growth and crop yield in Hawaii, Australia, and Cote D'Ivoire (Zhang and Bartholomew, 1993, Zhang et al., 1997). Despite a lack of data with which to evaluate and compare the SWAT and ALOHA models at this time, it is clear ALOHA is a more complex and comprehensive model that may be better equipped to accurately simulate pineapple plant growth and crop yields than SWAT. Unresolved is whether it would be more cost and time effective to modify the simulation procedure of SWAT to reflect the physiology of pineapple or to modify SWAT to accept the output of ALOHA Pineapple. The following discussion highlights the differences between the two models, a first step in the process of deciding how best to proceed in any effort to modify SWAT for use in estimating sediment yield from lands planted to pineapple.

The general approaches taken by the SWAT and ALOHA models to simulate growth are similar, but there are also some important differences. The similarities include the simulation of leaf-area development, light interception, and biomass accumulation as modeled by equations 1 - 3, although ALOHA has other important modifications. For example, while the total potential biomass accumulation in SWAT is assumed to contribute, unrestrained, to plant growth[4] , ALOHA uses four parameters to account for the effects of inter-plant competition: temperature, drought stress, nitrogen deficiency, and plant density factors. These parameters are used to calculate the actual biomass accumulation on a given day from the maximum potential biomass accumulation (Equation 3).

To ensure accurate plant growth simulation, ALOHA considers the differences in growth of planting material due to weight and type (slip, crown, or sucker). While all planting materials appear to have similar leaf areas (Bartholomew et al., 2003), heavier planting material grows more rapidly and crowns produce more roots than suckers (Py et al., 1987). SWAT can consider the initial LAI of the planting material but assumes growth will continue along the optimal growth curve from thereinafter. In contrast, ALOHA incorporates a subroutine that divides plant growth into seven phenological stages to allow for better prediction of plant growth rates before and during such stages. This allows the model to consider the differences in growth of the plant at the various stages, for example, the arrest of leaf-area development after induction of reproductive development and allocation of biomass to fruit development thereinafter.

A vital factor in erosion modeling is the accurate simulation of canopy cover and root development. ALOHA partitions biomass into individual plant components (leaves, roots, fruit, crown, etc.) and models this process according to phenological stage. In pineapple, roots do not appear to comprise more than 10% of the biomass at any time. The only biomass partitioning that SWAT considers is in root development, assuming that biomass allocated to roots varies from 40% at emergence to 20% at

[4] Actually, SWAT can model the effects of increased atmospheric carbon dioxide concentrations on radiation-use efficiency and, thus, on biomass accumulation.

maturity. Root development, however, is not only a function of the growth cycle but is also dependent soil temperature, which ALOHA considers via the temperature effects of plant density.

Environmental factors affect both plant development and crop yield, thus simulating plant response to a changing environment will also be essential to support erosion modeling in the TCH basins. Unlike SWAT, ALOHA includes factors to account for the effects of drought stress, nitrogen deficiency, and temperature on plant growth. ALOHA also is able to model the effects of resource competition and planting density on biomass accumulation. High planting densities, such as those observed in TCH, - on average 60,000 plants/ha (IDIAP, 2007b, Martez and Vergara, 2004) - increase the number of heat-units required for plants to reach a particular phenological phase (Zhang, 1992). This is because increased canopy cover will, presumably, result in a reduction in the heat transported to the meristem (the point of growth) which will thus reduce leaf appearance (Zhang, 1992). ALOHA calculates a plant competition factor from the planting density (LAI) and reduces the time between elongation of successive leaves, or phyllochron, accordingly (Zhang, 1992). SWAT does not account for competition and considers that all plants within a delimited parcel of land react[5] homogeneously and that plant growth and resource availability, such as light and water, are limited only by climate conditions.

The ALOHA model clearly employs a sophistication far superior to that currently available in SWAT. Although it is only speculative, ALOHA does appear to be a better prospect for pineapple growth simulations than the SWAT growth model, as is. Some of the attributes of ALOHA discussed above could probably easily be incorporated into the SWAT crop growth model and may enhance simulated predictions. Because much of the input and output data are comparable for both models, a link between the two models would be possible but would require a substantial modification of the program coding, yet it could prove to be very useful for this and other studies. It would be this combination of programs which would be best suited for the needs of the TCH basins.

Conclusions

The possibilities for future applications of the ALOHA and SWAT model duo are many, in particular for helping support erosion modeling, the determination of the benefits of erosion prevention activities, and the payment for ecosystem services program development in TCH. In order to implement such a program, it must first be decided if the implementation of erosion-reducing activities on pineapple farms in TCH will be practical in terms of reducing overall sediment movement in the subbasins. The SWAT hydrological model combined with the ALOHA pineapple crop model will be an essential tool in the prediction process and support program planning and implementation. If the results show that erosion prevention on pineapple farms significantly reduces sediment movement, farmers could be earning income for conserving soils and reducing erosion.

However, if these processes cannot be satisfactorily modeled or if the hydrological and economic model results indicate the impact of these practices is economically unfeasible, conversion of pineapple farms to forestry plantations, secondary forest growth of native species or to other land-uses may occur. Because there is evidence that reforestation causes dry season flow to decrease (Bruijnzeel, 2004), there are doubts as to whether reforestation is the best course of action for protection of the Panama Canal Watershed (Fotos et al., 2007, Anderson, 2007). It is for this reason that researchers are promoting well managed agroecosystems as an alternative to reforestation endeavours, in particular agroforestry projects (Anderson, 2007, Fotos et al., 2007). While there is evidence that pineapples have been successfully incorporated into agroforestry systems, modeling the effects and calculating opportunity costs on pineapple farms may prove to be much more difficult than for silvopastoral systems. Considering that pasture constitutes most of the agricultural land in the Panama Canal Watershed and that planting native tree species on pasture lands would not directly compromise cattle grazing, this may be a more feasible and simpler option to consider.

In the end, a payment for ecosystem services project may result in the loss of some pineapple farms in the Panama Canal Watershed. However, the option to move farms elsewhere in the country exists, and many plantations are rapidly expanding in other provinces (Gomez, 2007). In fact, pineapple culture has recently been acclaimed as the newest "campasino" life-style of western Panama and, according to one article, is the emergent agricultural product of choice for Panama (Gomez, 2007). Thus, regardless of the outcome of the payment for ecosystem services project, Panama will likely continue to be an up-and-coming competitor on the international pineapple market.

Nevertheless, the SWAT-ALOHA duo will be a useful tool beyond this study; for farmers (to predict planting and forcing dates and harvest yields) and for researchers and students who wish to simulate physical processes in agricultural watersheds which include pineapple farms.

Acknowledgements
I would like to thank Dr. Robert Bonnell of McGill University and IDIAP (Instituto de Investigaciones Agropecuarias de Panamá; The Panamanian Institute of Agricultural Research) for their support.

[5] The basic unit in SWAT is called a hydrologic response unit (HRU), which is a delimited area where land-cover and soil type are homogenous. Runoff, erosion, and plant growth are calculated at the HRU level.

References

AED (2004) Estudio Hidrogeologico en las subcuencas de los Hules, Tinajones y Caño Quebrado. Panama, Academy for Educational Development and USAID.

Anderson, K. (2007) Existing Supply of Watershed Services in the Panama Canal Watershed. In Gentry, B., Newcomer, Q., Anisfeld, S. & Fotos, M. (Eds.) Emerging Markets for Ecosystem Services: A case of the Panama Canal Watershed. Haworth Press.

Arnold, J. G., Srinivasan, R., Mittiah, R. S. & Williams, J. R. (1998) Large Hydrologica Modeling and Assessment Part I: Model Development. Journal of the American Water Resources Association, 34, 73 - 89.

Barsanti, P., Disperati, L., Marri, P. & Mione, a. (2003) Soil erosion evaluation and multitemporal analysis in two Brazilian basins. 2nd International SWAT Conference. Bari, Italy, ASAB.

Bartholomew, D. P., Paull, R. E. & Rohrbach, K. G. (2003) The pineapple: botany, production and uses, Wallingford, UK, CABI Publishing.

Benavides, F. & Veenstra, J. N. (2005) The Impact of Tropical Deforestation on River Chemical Pollution. Global NEST Journal, 7, 180 - 187.

Bruijnzeel, L. A. (2004) hydrological functions of tropical forests: not seeing the soil for the trees? Agriculture, Ecosystems and Environment, 104, 185 - 228.

Cooley, K. R. & Lane, L. J. (1982) Modified runoff curve numbers for sugarcane and pineapple fields in Hawaii. J Soil Water Conserv, 37(5), 295-298.

Dominguez, Q., Velazquez, A. A., Pena, H., Exposito, L. A. & Gonzalez, R. (1995) Effect of different planting densities with and without black polyethylene cover in the pineapple (*Ananas comosus* (L.) Merr.) culture, cv. Red Spanish. 2nd Symposium International Ananas, Abstracts. Trois-Ilets, Martinique.

El-swaify, S. A., Zhang, J., Palis, R., Rose, C. W. & Ciesiolka, C.A. (1993) Erosion problems and conservation needs of pineapple culture. Acta Horticulturae, 334, 227-239.

FAO & UNESCO (2003) Map of World Soil Resources. Rome, Italy.

Fotos, M., Chou, F. & Newcomer, Q. (2007) Assessment of Existing Demand for Watershed Services in the Panama Canal Watershed. In Gentry, B., Newcomer, Q., Anisfeld, S. & Fotos, M. (Eds.) Emerging Markets for Ecosystem Services: A case of the Panama Canal Watershed. Haworth Press.

Gomez, B. (2007) Agronoticas: La Pina Endulza la vida de chiricanos. La Prensa. Panama City.

IDIAP (1996) Proyecto de Muesto de Suelos.

IDIAP (2007a) Peso de la Pina. Panama, IDIAP.

IDIAP (2007b) Resultados de las entrevistas del los pineros. Panama, IDIAP.

Jacobs, J., Angerer, J., Srinivasan, R., Kaitho, R., Stuth, J., Vitale, J. & Clarke, N. (2003a) Integrating ground and charm weather data with the SWAT hydrological model to assess reforestation impacts in the Upper Tana River Basin of Kenya. Center for Natural Resource Information Technology.

Jacobs, J., Angerer, J., Vitale, J., Srinivasen, R., Kaitho, R., Stuth, J. & Clarke, N. (2003b) Exploring the Potential Impact of Reforestation on the Hydrology of the Upper Tana River Catchment and the Masinga Dam, Kenya. Center for Natural Resource Information Technology.

Kuruvilla, V., Pillai, G. R., Mathew, J., Santhakumari, G., Gopi, C. S. & Varughese, K. (1988) Effect of irrigation and mulching on the growth and yield of pineapple (Ananas comosus L.). Agricultural Research Journal of Kerala, 26, 85-91.

Lal, R. (1990) Soil Erosion in the Tropics: principles and management, USA, McGraw-Hill.

Liao, M.-C. & Wu, W.-L. (1987) Soil conservation on steeplands in Taiwan. Taipei, Taiwan, Chinese Soil and Water Conservation Society.

Malezieux, E. (1993) Dry matter accumulation and yield elaboration of pineapple in Cote D'Ivoire. Acta Horticulturae, 334, 149-157.

Malezieux, E., Zhang, J., Sinclair, E. & Bartholomew, D. P. (1994) Predicting pineapple harvest date in different environments, using a computer simulation model. Agronomy Journal, 86, 609-617.

Marín, M. D. & Yee, C. (2004) Diagnóstico de las condiciones de saneamiento básico en las subcuenceas Los Hules, Tinajones y Caño Quebrado. Panama, Academy for Educational Development, Comisión Interinstitucional de la Cuenca Hidrográfica del Canal.

Martez, J. A. L. & Vergara, L. K. (2004) Caracterización de la actividad piñera de las subcuencas Los Hules, Tinajones y Caño Quebrado. Panama, Academy for Educational Development, Commisión interinstitutional de la cuenca hídrografíca del Canal de Panamá.

Martez, J. A. L. & Vergara, L. K. (April 2004) Caracterización de la actividad piñera de las subcuencas Los Hules, Tinajones y Caño Quebrado. Panama, Academy for Educational Development, Commisión interinstitutional de la cuenca hídrografíca del Canal de Panamá.

MEA (2005) Ecosystems and Human well-being, Island Press.

Montilla, I. & Catayo, A. (1995) Effect of the association of crops and mulch on the production of pineapple Ananas comosus (L.) Merr. at Lara State, Venezuela. 2nd Symposium International Ananas, Abstracts. Trois-Ilets, Martinique.

Neitsch, S. L., Arnold, J. G., Kiniry, J. R., Srivivasan, R. & Williams, J. R. (2002) Soil and Water Assessment Tool Users Manual - Version 2000.

Obiefuna, J. C. (1991) Establishment of pineapple orchards and soil loss control systems for erodible tropical ultisols of southeastern Nigeria. Fruits Paris, 46, 145-151.

Obiefuna, J. C. & Asoegwu, S. N. (1993) Pineapple for ground cover management and erosion control in southeastern nigeria. Acta Horticulturae, 334, 255-259.

OIRSA (1999) Manual Técnico: Buenas Practicas de Cultivo en Pina. Panama, El Organismo Internacional Regional de Sanidad Agropecuaria.

Ouyand, W., Hao, F., H.g.cheng & Wang, X. L. (2007) Non-point source pollution responses simulation for conversion of cropland to forest in mountains by SWAT in China. 4th International SWAT Conference. Delft, The Netherlands, UNESCO-IHE.

PMCC (1999) Panama Canal Watershed Monitoring Project. Panama, USAID, STRI, ANAM.

Py, C., Lacoeuilhe, J. J. & Teisson, C. (1987) The pineapple. Cultivation and uses, Paris, Editions G.-P. Maisonneuve.

Rebolledo-Martinez, A., Angel-Perez, A. L. D., Becerril-Roman, A. E. & Rebolledo-Martinez, L. (2005) Growth analysis for three pineapple cultivars grown on plastic mulch and bare soil. IN Rebolledo-artinez, A. (Ed. Interciencia.

Rivera, S. & Martinez, W. N. (2003) The Effect of land use dynamics on stream flow fluctuations: A SWAT simulation conducted in a third-order watershed of central Honduras. IN SALEH, A. (Ed. TMDL Environmental Regulations - II. Albuquerque, New Mexico, ASAE.
Sarma, R. & Medhi, G. (1997) Relative efficacy of different mulches on weed control in pineapple (Ananas comosus L Merr.). Journal of the Agricultural Science Society of North East India, 10, 145-149.
Singh, A. & Gosain, A. K. (2007) Water Allocations using GIS based Hydrolgical Modelling. 4th International SWAT Conference. Delft, The Netherlands, UNESCO-IHE.
Sugahara, K., Ohwaki, Y. & Banzai, K. (2001) Erosion control in pineapple fields on the island of Ishigaki. Japan Agricultural Research Quarterly, 35, 91-96.
SWAT FORUM (2007). Google Groups, Accessed December 2007. http://groups.google.com/group/swatuser.
Swinton, S. M., Lupi, F., Robertson, G. P. & Landis, D. A. (2006) Ecosystem services from agriculture: looking beyond the usual suspects. American Journal of Agricultural Economics, 88, 1160 - 1166.
USDA & NSCR (2005) Global Soil Regions Map. Washington, D.C.
Wan, Y. & El-swaify, S. A. (1999) Runoff and soil erosion as affected by plastic mulch in a Hawaiian pineapple field. Soil and Tillage Research, 52, 29-35.
Zhang, J. (1992) Computer simulation of pineapple growth, development and yield. University of Hawaii at Manoa, 1992.
Zhang, J. & Bartholomew, D. P. (1993) Simulation of pineapple growth, development, and yield. Acta Horticulturae, 334, 205-219.
Zhang, J., Malezieux, E. & Bartholomew, D. P. (1997) ALOHA-Pineapple v.2.1: a computer model to predict the growth, development and yield of pineapple. Acta Horticulturae, 425, 287-296.
Zhu, J., Bartholomew, D. P. & Goldstein, G. (1997) Effects of temperature, CO2, and water stress on leaf gas exchange and biomass accumulation of pineapple. Acta Horticulturae, 425, 297-308.◆

News From Costa Rica

Saran Shade Cloth to Prevent Sunburn in Pineapple Fruit

Alejandro Chavarría G.[1] and Freddy Ramirez E.[2] Compañía Agrícola BC S.A., Upala, Costa Rica.
[1]Agriculture Manager and Member of the examining jury; E-mail: alechava@hotmail.com
[2]Department of Agriculture and author of the final work of graduation presented to the Agronomy Department of ITCR; E-mail: framirez@agricolabcl.com

The damage caused by sunburn in pineapple production areas in the world where this fruit is harvested can be very important in periods when solar radiation is high. Percentages of reject fruit because of this damage can be over 40% in some months of the year if preventative actions are not taken. The prevention of sunburn is essential if high yields are to be obtained. Different methods are used by the growers to protect pineapple fruits against sunburn, with some being better than others. Since 2004, Mr. Cecilio Barrantes, owner of Companía Agrícola BC S.A., decided to use saran shade to decrease this fruit rejection cause after a quick comparative cost-profit analysis. With the interest to know more about the efficacy of saran shade to protect against sunburn, I proposed a test to evaluate sunburn protection using saran and six other methods in fields of this company.

This test was made during the period March 22 to May 14 in the north zone of Costa Rica, altitude 70 m, using hybrid 73-114 with a population of 65,000 plants per hectare. The precipitation average was 3,000 mm y^{-1} and the average temperature of 26.5° C. The treatments (Figure 1) were: Vapor Gard® (96% di-l-p-menthene), Protecsol® (65% oxide of silica), Surround® WP (95% Caolin), Ecofrut DC ® (12% triacyglicerols and fatty acids), saran shade 30%; white plastic bags with holes, newspaper sheets, and the control. Depending on the treatment, all treatments were placed or applied 100 days after flowering induction. Fruits were evaluated to determine the percentage of sunburn and other variables 53 days later when the fruits were harvested.

Cumulative daily solar radiation received during the treatment period and fruit temperatures over most of that same period are shown in Figure 2 (Note that the X-axis scales of the two graphs are not the same). Fruit temperature was measured daily between 2:00 and 3:00 p.m. beginning on day 128 after forcing, which was 25 days before harvest. The temperature of four fruits was measured on the sunny edge of each treatment with a Sensitech PT-2 thermocouple probe inserted into the fruit flesh. Solar radiation and fruit temperature reached their highest levels on day 138. Fruit temperature on that day reached nearly 42 °C.

Average fruit temperature in relation to the treatments is shown in Table 1. Average fruit temperature was highest in the control treatment and was only slightly less in the Vapor Gard® treatment. The percentage of sunburned fruit increased with the average fruit temperature and was lowest for the saran shade cloth treatment where fruit temperature only averaged 31.5 °C. An interesting result was that sugar accumulation was slower in fruits covered with shade cloth than in most other treatments. At the time of degreening, TSS was about 1% less in saran-covered fruit than in the other treatments. Fruit translucency also was lower in fruits covered with saran shade cloth. It was concluded that where saran shade cloth was used to protect fruit, degreening should be delayed to allow the fruit to achieve the same TSS level measured in the treatments where average fruit temperature was higher.

A typical application of shade cloth for sunburn protection on the farm is shown in Figure 3.

Figure 1. Treatments applied to pineapple hybrid 73-114 (MD-2) to evaluate their potential for controlling sunburn.

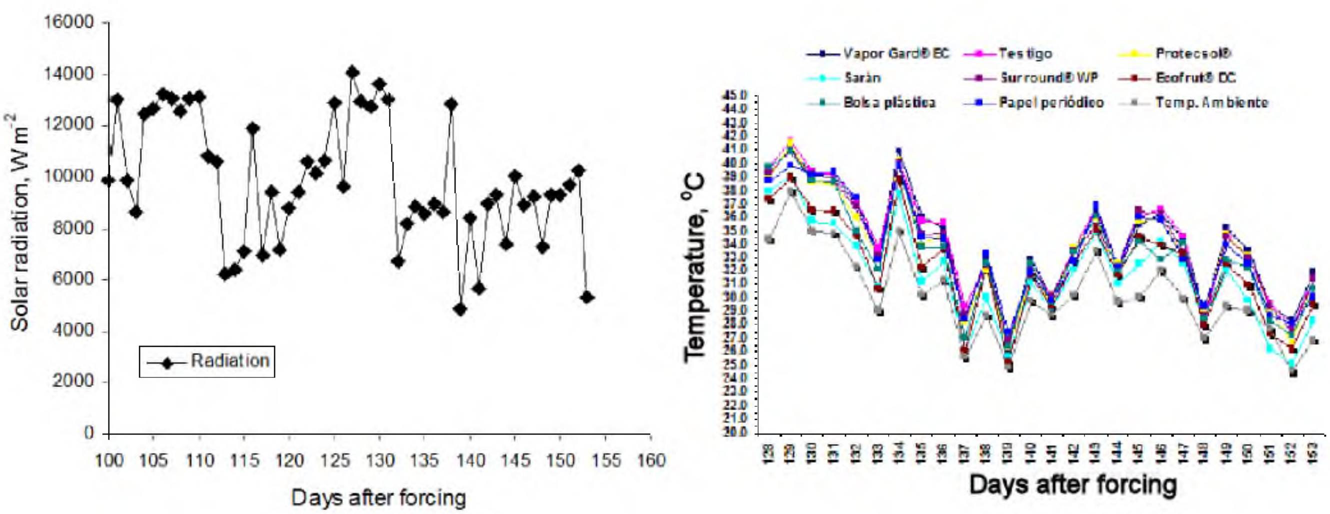


Figure 2. Solar radiation during the fruit development period and fruit temperature measured with a thermocouple probe between 2:00 and 3:00 p.m. for the different treatments.

Table 1. Product, dose and timing of application/positioning for the protection of fruit against solar radiation and their influence on percentage sunburn damage of pineapple hybrid 73-114 (MD-2) at Compañía Agrícola B.C.L, Upala, 2007.

Treatment	Weeks of application	Number of applications	Volume, L	Dose ha^{-1}	Avg. fruit temp., °C	Sunburn, % %
Control	*	*	*	*	34.2	15.9
Vapor Gard® EC	12-15**	2	2000	20 L	34.1	11.5
Protecsol®	12-15	2	2000	50 kg	33.6	8.9
Saran shade	12	*	*	*	31.5	0.3
Surround® WP	12-15	2	2000	50 kg	33.9	8.1
Ecofrut® DC	12-15	2	2000	6 L	32.3	5.4
White plastic bag	12	*	*	*	33.2	7.9
Newspaper	12	*	*	*	33.7	8.3

Figure 3. A typical shade cloth installation on the Compañía Agrícola BC S.A. farm in Upala, Costa Rica.

News From Cuba

Evapotranspiration of Pineapple (Ananas comosus L. Merr) in Cuba

Eng. Camilo Bonet[1], Eng. I. Acea[1], DPh M. Hernández[2]
1. Irrigation and Drainage Research Institute, Cuba
2. University of Camagüey, Cuba

Abstract

Research on water use by 'Smooth Cayenne' pineapple crops in various regions of the tropics show that evapotranspiration is very low and oscillates between 2 and 3 mm d^{-1}. In a field experiment conducted with 'Española Roja' (Red Spanish) in the region of Ciego de Avila, Cuba, it was demonstrated that evapotranspiration (ET) of this cultivar was less than 3 mm d^{-1} and reached maximum values during the physiological stages of flowering and fruit development. ET was greatest if these physiological stages coincided with the period of highest evaporation. It was also demonstrated that ET was greatly influenced by the soil water level.

Introduction

Pineapple is one of the most important tropical fruit crops in the world. It has excellent nutritive qualities and good taste and these characteristics result in a fruit that is in great demand in the international market. From an economic point of view the pineapple crop is attractive due to the high price that it can bring as a fresh fruit or when processed as a canned fruit or juice.

The cultivation of pineapple in Cuba reached its pinnacle of development toward the end of the decade of the 1950s. In 1960 pineapple production in Cuba ranked ninth among world producers with 100,000 tons, and Cuba was ranked in the top three countries in the world as an exporter of fresh fruit. Since that time, national production has declined and its rescue requires application of the best agricultural techniques used by the main world producers but adapted to the conditions of this country.

One of the aspects not sufficiently studied for this cultivation in Cuba are the water requirements and plant behavior under irrigated conditions. Some research on this subject has been conducted elsewhere. For example, in Hawaii it has been reported that the daily water requirement of the pineapple oscillates between 1,25 and 2,00 mm (Py, 1967). In regions where precipitation is well distributed during the year, precipitation between 1200 and 1500 mm is considered good; below this range or in regions where rainfall is not well distributed, water becomes a limiting factor. In such regions, it is necessary to use irrigation to prevent significant reductions in yield.

When pineapple is subjected to drought, plants survive because transpiration is virtually suspended and water reserves in the leaf aquifer tissue helps to keep cells hydrated. However, when a drought is extended, plants do begin to show the symptoms of drought. The consequences of drought depend on the stage of plant development at which it occurs. If a water deficit occurs during the initial stages of vegetative growth it will be necessary to establish a high soil water status if the shoots are to recover quickly. If a drought takes place 4 to 6 months after planting, the crop cycle will be lengthened, but yield will not be greatly reduced. If a soil water deficit takes place between inflorescence initiation and the beginning of fruit development, yield can be significantly reduced. (Py, 1967).

Ekern (1965) found that in Hawaii a full pineapple plant canopy effectively suspended water vapour exchange by midday. This restriction of water loss was accomplished despite a leaf area index of nearly 6. The control of transpiration was a direct physiological function of the pineapple leaf, which is well designed for the control of gaseous exchange. Huang and Lee (1969) recommend that when planning an irrigation program for pineapple fields it is important to consider that this plant can resist a long drought period, but it is very sensitive to a water deficit during the period of vegetative development when the fruit size is determined. They also stated that a moderate supply of water during the flowering stage promoted the formation of the fruit and also resulted in more uniform maturation. However, an excessive supply of water in this period can result in the formation of a large peduncle, which is unfavorable for the container during the harvest. These authors found that sprinkler irrigation of pineapple fields in Taiwan at intervals of 2, 4 or 6 weeks during the dry season significantly increased the weight of the plant and mature fruit in proportion to the watering frequency.

Peña (1984) showed that periods of greater precipitation and higher soil moisture were associated with a greater rate of leaf production as well as a greater D-leaf weight. Also, higher yields were obtained during periods of high temperature and high soil moisture. Chapman, et al. (1983) irrigated a 'Smooth Cayenne' clone to field capacity at varying intervals during a four-month period from planting and found that as the watering interval increased, the weight and length of the leaf D and the weight of the plant decreased. Also, as the leaf water deficit increased in the crop, the dry weight of tops, fruit, peduncle, leaves, butt, and roots were smaller, and leaf area and the increment of dry matter fell. The weight of the fruit was commercially unacceptable when watering frequencies were monthly or bimonthly although the number of eyes and the potential of size of the fruit were not affected by the watering frequency.

In a normal year, Du Plessis (1987) reported a low crop factor of 0.3 between class A pan evaporation and transpiration of pineapple, which represents 30 mm of irrigation for each 100 mm of evaporation. Kuruvilla, et. al. (1988) irrigated pineapple using cumulative pan evaporation (CPE) as an index. Irrigation water (IW) was supplied at IW/CPE ratios of 0.3, 0.6 and 0.9 or not irrigated (control). The best treatment was at an index of 0.6, which required 5 to 6 waterings at 22-day intervals during the dry months. A yield of 47.5 tons ha^{-1} was obtained for the irrigated crop compared with 23.0 tons ha^{-1} in the control.

Sether and Hu (2001) found that infection with a mealybug wilt-associated virus or reduced watering had no significant effects on the weight of 'Smooth Cayenne' pineapple fruit in Hawaii in the plant crop. In the ratoon crop, infected plants and plants receiving reduced irrigation produced smaller fruits while plants subjected to both stresses produced the smallest fruits. Souza, et. al. (1998) reported that in the coastal plateau of Brazil, water deficits in pineapple occur in the dry period and watering is necessary to assure the quality of the production. In a study of the effects of irrigation and fertilization, there was a significant effect of irrigation on the yield and fruit quality, but no watering by fertilization interaction; irrigation increased fruit yield from 35.8 to 49.6 tons ha^{-1}. They estimated yield with a quadratic production function and reported that estimated maximum yield was 54.9 tons ha^{-1} for a watering level of 596 mm and fertilization at 2.5 times the level recommended for rain-fed conditions. Asoegwu (1987) in Nigeria found that among watering intervals of 3, 7 and 14 days, the best yields were obtained with a 7-day interval.

The overall objective of this research was to study the response of pineapple to irrigation and soil water content. The specific objectives in the region of Ciego de Avila, Cuba were: 1, To determine pineapple evapotranspiration; and 2, To determine the coefficients for the irrigation program.

Materials and Methods

The investigation was carried out in a red ferralitic compact soil, which predominates in the principal pineapple production area in Cuba. Soil depth exceeds 30 cm, water content at field capacity in 10 cm increments averages about 30%, and soil apparent density is 1.34. The main meteorological variables (evaporation, rainfall) were measured during the experimental period. The 'Red Spanish' cultivar was used because it is the most important one in Cuban production fields. Suckers weighing between

250 and 350 g were planted at a depth of about 10 cm with 1.20 m between the centers of double rows, 0.30 m between rows and 0.40 m between plants in the rows, resulting in a plant population of 33,333 plants ha^{-1}. The suckers were disinfected before planting with a mixture of captan (1%) and malathion (0.14%) and then planted through black polyethylene plastic mulch.

Soil preparation and control of weeds, pests and diseases were done according to the technical instructions for pineapple production in Cuba. Irrigation was applied post planting for 3 months to the whole experiment to assure the suckers were well established. Irrigation was with small sprinklers and the irrigation system was calibrated in order to know the coefficient of uniformity (method of García et. al., 1970). Rainfall intensity also was measured.

The irrigation treatments, which because of good uniformity and for convenience were unreplicated, were, A, Irrigate when the soil water content reached 80% of field capacity (FC); B, Irrigate when the soil water content reached 70% of FC; C, Irrigate when the soil water content reached 70% of FC during the dry season; and D, Without irrigation. There were five replications within each irrigation treatment, each experimental plot was 68 m^2 and data were collected from 32 m^2. Forcing was carried out using Flordimex (200 ml ha^{-1}), sodium carbonate (600 g ha^{-1}) and urea (30 kg ha^{-1}).

The data collected included: 1) ET, which was estimated by gravimetric measurement of the soil moisture three times a month; 2) plant height; 3) number of leaves; 4) diameter of the peduncle; 5) fruit weight; 6) relationship between fruit length and diameter; 7) yield; 8) acidity, soluble solids and vitamin contents; and 9) number of suckers and slips.

Results and Discussion

There was a significantly greater number of irrigations applied to treatment A than to treatments B and C (Table 1). This is because the soil water content quickly decreased from 80% of FC, principally during the dry season; however, but it took a long time to decrease to 70% of FC. This is a reflection of the decrease in ET when the soil water content descends. As a result of the application of irrigation water according to the treatments, it was possible to maintain the soil water content within the established limits for each treatment. The average soil water content during the whole experiment for the respective treatments was: A, 87.4%; B, 79.7%; C, 77.8%; and D, 72.6%.

Table 1. Number of irrigations and volume of water applied in three cycles for the four irrigation treatments.

	Cycle 1		Cycle 2		Cycle 3	
Treatment†	No.	Vol.	No.	Vol.	No.	Vol.
A	16	4160	11	2860	10	2080
B	6	2280	5	1900	5	1890
C	5	1875	4	1512	4	1488
D	0	0	0	0	0	0

†A, irrigated at 80% of field capacity (FC); B, irrigated at 70% of FC; C, irrigated at 70% of FC during dry season; D, not irrigated.

The soil water level (SWL) greatly influenced vegetative development, which is reflected in increases in the weight of the D-leaf and leaf number. As a result, the theoretical weight of the leaves (TWL) was greater when the soil moisture content did not decrease below 80% (Figure 1A) and the extent of influence was determined mainly by the water supply and climatic conditions of the year.

Fruit yield (Figure 1B) and its components decreased progressively with decreasing water supply with fruit yield being lowest in the unirrigated treatment. Yield was a function of fruit weight and fruits harvested per unit area. Fruit quality also is determined by fruit shape, which is determined by fruit length and diameter. Fruit quality as indicated by the percentage of fruits that were of first, second or third quality (Figure 2A) was better as length and diameter increased. Fruit quality is also determined by sugar and acid concentrations and the Brix was higher and acidity was lower where soil water content was higher (Figure 2B). In spite of that, the Brix/acidity ratio in all the treatments was between 1.02 and 1.20, all values that are considered acceptable.

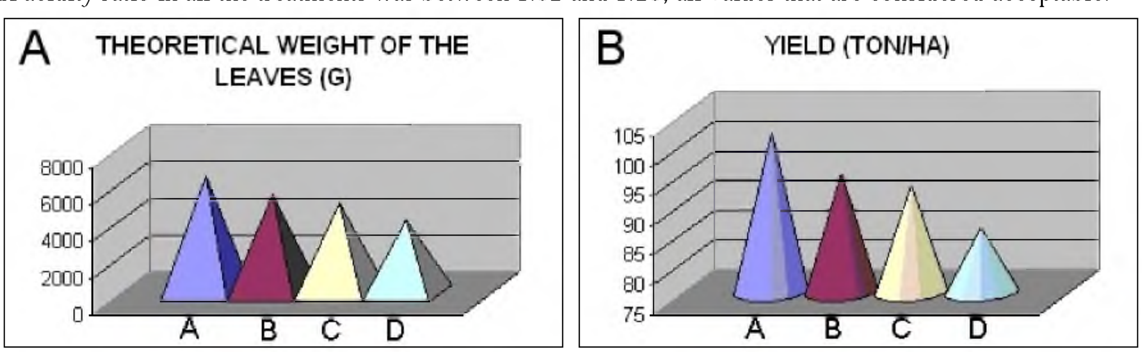


Figure 1. Effect of irrigation to 80% of field capacity (FC, A), 70% (B), 70% only during the dry period (C) or not irrigated (D) on A, Theoretical weight of leaves and B, Fruit yield.

During the experiment, the period of fruit development coincided with the dry season, which should have enhanced the difference between the watering treatments and the control. However, the potential yield was already determined because as it was seen, the TWL was significantly greater in the treatment watered to 80% of FC; therefore, the conditions were created to obtain bigger yields in that treatment.

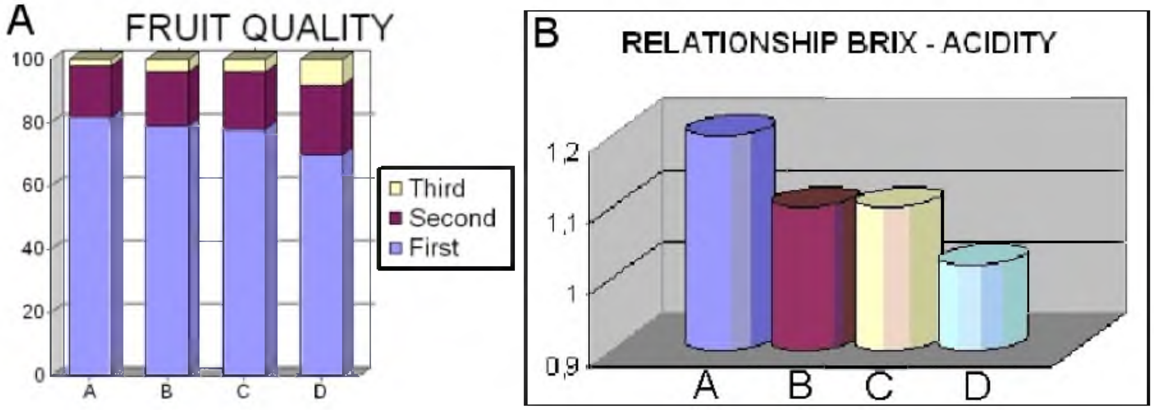


Figure 2. Effect of irrigation to 80% of field capacity (FC, A), 70% (B), 70% only during the dry period (C) or not irrigated (D) on A, percentage of fruits of first, second or third quality and B, Brix-acid ratio.

Crop evapotranspiration (ET) was significantly greater when an adequate soil water level was guaranteed. ET increased immediately after a rain or irrigation, which reaffirms the assumption that in this crop water use is influenced by the soil water content. When water uptake is limited by a low soil water content, pineapple leaves utilize protective mechanisms and "economize" on water use. Therefore, crop ET was greater where the soil water content was maintained near field capacity, while crop ET was lower in the unirrigated treatment where abrupt increases in soil water content occurred, mainly in the rainy period of the year.

Unquestionably, managing soil water content by the timing and quantity of water applied offers the possibility of regulating water consumption. Pineapple plants can resist long periods of drought, but drought stress is reflected in reduced plant development and fruit production. When a higher soil water content was guaranteed, plant growth and fruit yield were superior.

The average daily ET was 2.26 mm, with 2.50 mm day^{-1} in the "A" treatment and 1.57 mm day^{-1} in the "D" treatment. ET was mainly from the top 20 cm of the soil, which reached 79.8 % of FC in the "D" treatment and 80.8 % in the "A" treatment. In the different treatments an increment of the ET takes place during the January - May period, these results are attributed to the climatic characteristics of this period (increment of evaporation) and to the phenological stage of the crop (flowering - fruit development).

Analyzing the water consumed, 76.9% of the water used during the experimental period came from rain. This result reaffirms that pineapple can use small amounts of precipitation, including dew, efficiently. In normal years in the area of this study, the soil water content is maintained above 70% of FC during the rainy period without irrigation. The rest of the water consumed by the plants was contributed by irrigation, which occurred when the soil water content reached the lower limit established for each treatment.

Pineapple plants use water very efficiently, as was shown by analyzing yield and its relationship with the ET. The ratio ET/Ev was 0.37 for the treatment irrigated to 80% of FC when the leaf canopy was fully developed. Crops lacking the physiological mechanisms to harvest carbon at night via Crassulacean acid metabolism when evaporative demand is at its lowest and reduce carbon to carbohydrate during the day with the stomata closed typically have an ET/Ev ratio nearer to that of Ev, i.e a ratio of 1.0.

The results of the research work show that in spite of the resistance of pineapple to drought, pineapple growth and development, yield, and fruit quality all respond positively to irrigation. The influence of irrigation is reflected fundamentally in the first two aspects, but it is necessary to consider the various stages of physiologic development of the crop in order to foresee the possible influence of irrigation on pineapple production. When the increment of ET during the period from forcing to fruit maturity coincides with the dry months, irrigation is required to reach the yield potential of the plant, i.e. fruit yield will be reduced significantly by drought relative to that produced by an irrigated crop. During the rainy period of the year, irrigation can complement the rains. However, attention should not be limited to the period from forcing to fruit maturity because the potential yield at harvest is established at the time of forcing and depends on the average plant weight at this moment. Plant mass was always greater in the irrigated treatments and so, subsequently, was yield.

Conclusions

1. The influence of the soil moisture level (SHL) is reflected in the development of the plants, in the yield and in the quality of the production. The critical stage with respect to the water requirement is during the period of flowering and fruit development.
2. Pineapple Evt is very influenced by the SHL, and Evt increased measurably when SHL was high. As SHL decreased, the plant used protective mechanisms to economize water. The Evt oscillated from a maximum of 3.04 mm d^{-1} in the treatment irrigated to 80% of FC to a minimum of 1.57 mm d^{-1} in the unirrigated treatment.
3. The dynamics of SHL for this pineapple crop was totally restricted to the first 30 cm of soil, and mainly to the first 20 cm.
4. The pineapple plants present physiologic characteristics (CAM metabolism, superficial root system, form and display of leaves, presence of aquifer tissue in leaves) that together make it possible for plants to economize water consumption while allowing them to resist long periods of drought and make efficient use of precipitation during dry periods of the year.
5. The most favorable effect of irrigation is obtained when the SHL does not go below 80% of FC; at 70 % of FC the results decrease although they continue being favorable. The average ET:Ev ratio was 0,37 for the 80 % of FC treatment.

References

Asoegwu, S.N. 1987. Effect of irrigation and nitrogen on the growth and yield of pineapples (*Ananas comosus*) cv Smooth Cayenne. Fruits 42:505-509.

Chapman, K.R., J.D. Glennie, and B. Paxton. 1983. Effect of five watering frequencies on growth and yield of various plant parts of container grown Queensland Cayenne pineapples. Queensland Journal Of Agricultural And Animal Sciences 40:75-81.

Du Plessis, S. 1987. Irrigation of pineapples (Besproeiing van pynappels). Inform Bull, Citrus And Subtropical Fruit Res Inst, South Africa 173:7.

Ekern, P.C. 1965. Evapotranspiration of pineapple in Hawaii. Plant Physiology 40:736-739.

García, E., A. Estupiñán and H. León. 1970. Metodología para la evaluación hidráulica de aspersores. Ciencias Técnicas. Serie Ingeniería Hidráulica. ISPJAE (3) 103 - 117.

Huang, C.C., and L.C. Lee. 1969. "Effect of Irrigation on Pineapples." Taiwan Agriculture Quarterly 5, no. 2:50-58.

Kuruvilla, V., G.R. Pillai, J. Mathew, G. Santhakumari, C.S. Gopi, and K. Varughese. 1988. Effect of irrigation and mulching on the growth and yield of pineapple (*Ananas comosus* L.). Agricultural Research Journal of Kerala 26:85-91.

Peña, A. H. 1984. Efecto de la fertilización NPK y la edad alcanzada por la planta en el momento de la floración sobre el rendimiento y producción de la piña (*A. comosus* L. Merr). Cultivar Española Roja. Disertación de Candidatura, Universidad de Ciego de Avila.

Py, C. La Piña. 1967, Instituto Cubano del Libro, La Habana, Cuba. 11 - 74.

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

Souza, L.F.d.S., O.A.d. Almeida, R.C. Caldas, and D.H. Reinhardt. 1998. Soil Humidity and Fertilization Levels for 'Perola' Pineapple in Coastal Tableland Sreas of Brazil (Abstract). 3rd International Pineapple Symposium, Pattaya, Thailand.◆

News From the United States (Hawaii)

Characteristics of the Pineapple Research Institute of Hawaii Hybrids 73-50 and 73-114

Glenn Taniguchi. Dept. of Plant and Environmental Protection Sciences, 3190 Maile Way, Honolulu, HI 96822. Email: gtani@hawaii.edu

Garth M. Sanewski, Queensland Horticulture Institute, Maroochy Research Station, Nambour, Qld., Australia. E-mail: Garth.Sanewski@dpi.qld.gov.au

D.P. Bartholomew and R.E. Paull. Dept. Of Tropical Plant & Soil Science, University of Hawaii, Honolulu, HI 96822. E-mail: paull@hawaii.edu; duaneb@hawaii.edu

The remarkable and continued expansion of the area planted to the Pineapple Research Institute of Hawaii (PRI) hybrids 73-50, named CO-2 in United States patent Plant 8,863, which patent is no longer supported, and especially 73-114, also and perhaps more commonly known at MD-2 (or MD2), is the primary motivation for this article. We thought it useful to characterize as completely as possible the known attributes of the two hybrids so current and future growers would be aware of the qualities that have caused these hybrids to become so popular, but also to alert growers to the potential problems that might be encountered in growing these hybrids. Where information was available, the hybrids are compared with each other and with ‘Smooth Cayenne’ to provide contrast to characteristics that tend to be qualitative and vary with pest and disease pressure or with the environment.

The area planted to ‘Smooth Cayenne’ has declined precipitously as consumers substituted fresh fruits and vegetables for canned or frozen products and also as they became aware of the consistently higher year-around quality of the PRI hybrids relative to ‘Smooth Cayenne’. For a number of years after its introduction, fruit of 73-114 commanded a significant premium to ‘Smooth

Cayenne' fruit in the marketplace. As 'Smooth Cayenne' fruit disappeared and fruits of 73-114 came to dominate the marketplace, at least in Germany, France, England and the United States, the premium has all but disappeared. The principle area of production for this hybrid is Costa Rica but it is also being grown in Ecuador, Brazil, Philippines, and in countries in tropical Africa.

There is a much smaller area planted to 73-50 but it is being grown in commercial quantities in Hawaii and Australia and is reported to have piqued the interest of growers in Malaysia. In Australia, the two major chain stores refuse to take fruits of 'Smooth Cayenne' so fruits of that cultivar are now sold only through smaller independent retailers (which collectively still take a reasonably quantity). Most of the fresh market demand in that country is now for 73-50.

Some data have been collected on the two hybrids (see references at the end of the article; Tables 1-4); however, readers should be aware that some of the information on the two hybrids presented here is anecdotal because much of the research on the two hybrids has been done by the companies engaged in growing pineapples for profit. Relative to the interest in and area planted to the hybrids and particularly 73-114, regrettably publicly funded research efforts are small.

PRI Hybrid 73-50. In Hawaii and U.S. markets as Maui Gold and Dole Premium Select.

Parentage

The hybrid's parentage is 58-1184 x 59-443 resulting in more than 50% 'Smooth Cayenne' but it also incorporates genes from other pineapple cultivars. The composition is 'Smooth Cayenne' 17, 'Smooth Guatemala' 6, 'Pernambuco' 4, 'Ruby' (a 'Singapore Spanish' clone) 4, and 'Queen' 1 (Williams and Fleisch, 1993).

Plant characteristics

This hybrid is relatively weakly rooted due to poor root initiation from the crown and even poorer from slips under less than ideal conditions. Casual observations indicate plants grow poorly, relative to 'Smooth Cayenne' and PRI hybrid 73-114, in soils having higher soil pH, however, no quantitative data were found. When the hybrid is compared with 'Smooth Cayenne' and 73-114 in the sub-tropical environment of Queensland (Table 1, Table 2), plant height and other vegetative characteristics were similar, but 73-50 is not as robust or as vigorous as 'Smooth Cayenne' or 73-114 and extra care is needed to ensure uniform establishment and growth if good yields are to be obtained. Plants are relatively more susceptible to drought than are those of 73-114 and 'Smooth Cayenne', possibly due to reduced leaf thickness (less water storage tissue), poor root development or to higher transpiration, or perhaps all of the foregoing. Poor root development can result in lodging of ratooned plants, which has resulted in strongly curved crowns on fruits in Honolulu markets.

Table 1. Plant and D-leaf data (Autumn plant crop) collected in SE Queensland, Australia (Data of G. Sanewski).

Variety	Plant ht, cm	Leaf No.	D-leaf			
			length (cm)	width (mm)	weight (g)	area (cm^2)
73-50	58.1	52.0	96.9	4.4	72.2	373
Cayenne	49.7	45.3	92.7	5.0	69.0	372
Lsd	7.0	9.7	14.0	0.69	27.0	120

Table 2. Hybrid plant characteristics data for a summer plant crop in SE Queensland, Australia (Data of G. Sanewski).

Cultivar	Plant ht	No leaves	No slips	No. plant suckers	Sucker length (cm)
73-50	47.5a	38.8	1.7 a	0.7 a	50.3 a
MD2	46.7a	38.7	2.0 a	1.1 b	51.2 a
Lsd	3.7	ns	0.5	0.3	1.18

Notes: Sucker length was measured approximately one month after harvest. MD2 has long suckers because many fruit initiated naturally and hence earlier allowing more time for sucker development.

The leaves of this hybrid contain anthocyanin (red) pigments and are not readily distinguishable from those of 'Smooth Cayenne' except that the small spines at the tips of leaves, including crown leaves, typical of 'Smooth Cayenne' are completely lacking. The leaves are readily distinguished from those of 73-114 (MD-2) due to the presence of anthocyanin pigments and 'piping' leaves, a characteristic present in some smooth-leafed cultivars where the lower epidermis is folded over the leaf edge and extended over the upper surface, producing a narrow silvery stripe (Collins, 1960). In Queensland it was observed that leaves of 73-50 do not mutate to spiny.

This hybrid is better suited to sub-tropical climates than is 73-114 mainly because of its reduced susceptibility to natural induction of reproductive development (natural induction). However, it is more susceptible to natural induction than is 'Smooth Cayenne'. 73-50 grows well at elevations up to about 600 m on the island of Maui but natural induction during the winter can be a serious problem at such elevations, much more so than for 'Smooth Cayenne' at the same elevation. When grown in adjacent sections of the same field at about 250 m on Oahu, 73-50 was less susceptible to natural induction than was 73-114 (Figure 1). All fruits in the photo are the result of natural induction.

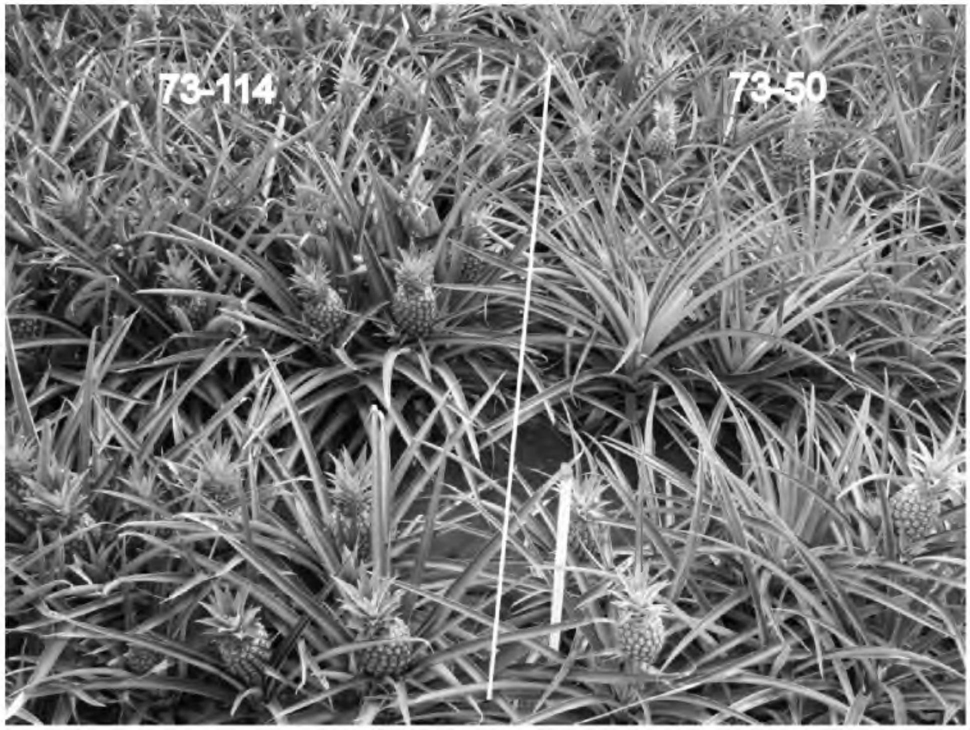


Figure 1. Comparison of natural fruiting of the PRI hybrids 73-114 and 73-50 at about 250 m in Hawaii in 2008.

The "bud" color (bract color below the syncarp) of 73-50 is "salmon" whereas that 'Smooth Cayenne' is red and the bud color of 73-114 is pale green (Figure 2). In Hawaii, the peduncle length of 73-50 is longer to much longer than that of 73-114 or 'Smooth Cayenne' (Figure 2). In Queensland, the peduncle of 73-50 is similar in length and width as Cayenne in summer but longer and thinner in winter. The long peduncle of 73-50 causes fruit to be susceptible to lodging and to breakage during harvesting.

During winter in Queensland 73-50 will produce marginally more slips than 'Smooth Cayenne' but a similar number of suckers. During summer it can produce fewer slips, a similar number of suckers but more ground suckers; 73-50 produced a similar number of slips and slightly fewer suckers than did 73-114 in a summer plant crop in Queensland (Table 2). The hybrid produces few to no slips in Malaysia (Y.K. Chan, personal communication) and it is more difficult to force than is 'Singapore Spanish'. Slip production of 73-50 is reported to be higher in Hawaii (Oahu, 300 m and below) than for 73-114 throughout the year. Vigorous plants of 73-50 growing on the edges of a plantation field on Oahu had as many as 6 to 8 slips while other adjacent plants of similar size produced none. We speculate that this could be variation introduced during tissue culture propagation of the hybrid. Slip number is a genetically determined trait and considerable variability in slip numbers also exists among 'Smooth Cayenne' clones.

Few data are available on plant nutrient requirements for 73-50; however, when grown in the same fields in Queensland as 'Smooth Cayenne' and subjected to the same fertilizer treatment, 73-50 accumulated greater basal leaf levels of the cations Ca and Mg.

Fruit characteristics

The flavor of the fruit of 73-50 are considered the best of the fresh fruit varieties grown in Hawaii. The fruit is juicy and generally has a good balance between sugars and acids. However, it can be a bit acidic in winter though acidity is always lower than that of 'Smooth Cayenne' in the same environment. The fruit has a delightful flavor, as good as the best of 'Smooth Cayenne' and better than that of 73-114. 73-50 has a very aromatic flavor sometimes described as floral or reminiscent of coconut. While the hybrid is often described as very sweet, 73-50 has a total soluble solids content only about 1 unit above 'Smooth Cayenne' (Table 3) but usually has a much lower acidity. Fruit of 73-50 ripened in Hawaii had total soluble solids of 15 to 16.7% and titratable acidity of 0.42 to 0.91 g citric/100 ml, and vitamin C content of 30.8 to 55.5 mg/100 ml (3 to 4 times that of 'Smooth Cayenne'). In Queensland, the acidity of 73-50 can be up to about 50% less than 'Smooth Cayenne' in winter (SC = 1.3%; 73-50 = 0.70%). In tropical regions, the acidity can be too low resulting in a bland flavor, a characteristic of most pineapple cultivars grown at tropical temperatures. The fruit has been canned in Hawaii and fruits having a high sugar content appear dull yellow to light brown in comparison to 'Smooth Cayenne'.

The external shell of fruits of 73-50 are susceptible to desiccation and must be waxed within 24 hours of harvesting. Crown desiccation can detract from fruit appearance. Data from Queensland and anecdotal reports from a grower in Hawaii indicate that fruits of 73-50 are less translucent than are fruits of 73-114 (Table 3, Table 4). However, post-harvest storage characteristics of 73-50 are better than 'Smooth Cayenne'. When compared to 73-114, 73-50 shows more skin scuffing and is much more susceptible to chilling-related internal browning. 73-50 developed internal browning symptoms in the winter in fields at high elevation in Hawaii (G. Taniguchi, personal observation) but showed good field resistance to the disorder in Queensland. Under refrigeration, the fruit of 73-50 is less susceptible to internal browning than are fruits of 'Smooth Cayenne' but more susceptible than are fruits of 73-114, especially after prolonged storage.

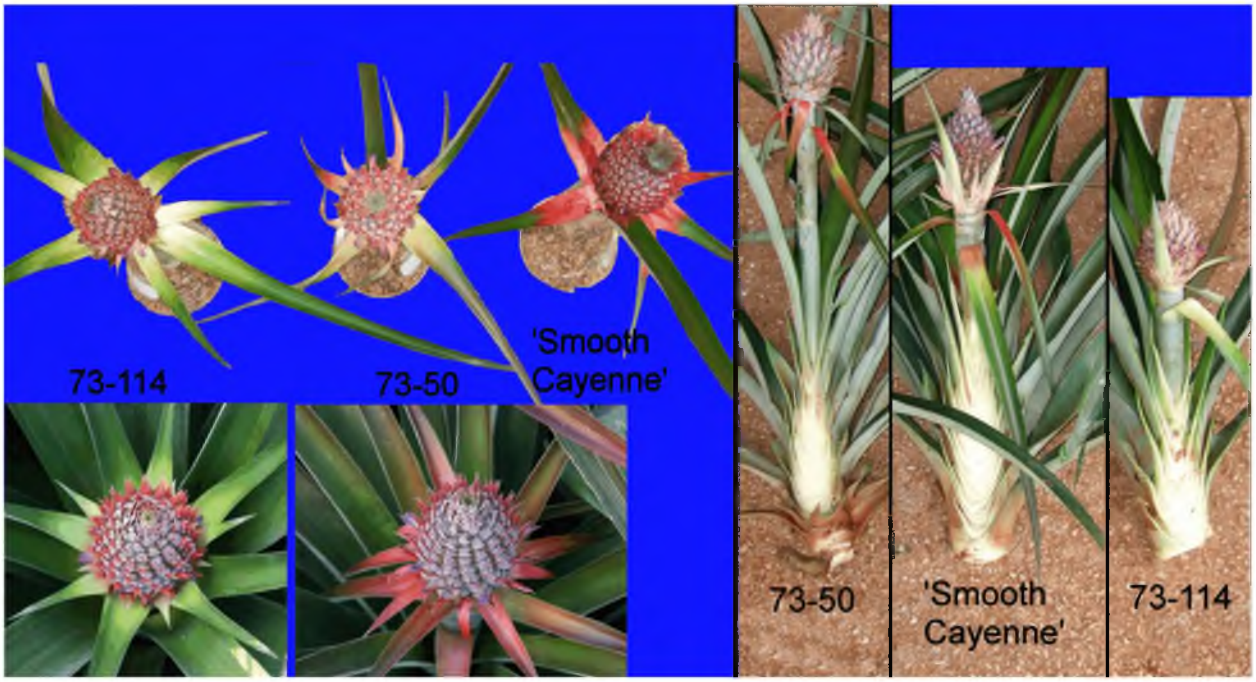


Figure 2. Photos showing the color of syncarp and bracts of 73-114, 73-50 and 'Smooth Cayenne'. The two photos on the lower left were taken by G. Sanewski in Queensland; all others were taken on Oahu, Hawaii.

Table 3. Fruit data for 'Smooth Cayenne' and two hybrids from a summer plant crop in SE Queensland, Australia.

Variety	Crown		Fruit	TSS	Fruit	Fruit	Core	Knobs	Firm-	Transl.3	Flesh	Flesh
	Type1	wt, g	wt, g	(%)	diam, mm	len, mm	ratio2		ness kg/0.5 cm^2		porosity4	color5
73-50	1.0a	277c	1525c	17a	125b	162c	6.4a	0.0a	8.8a	2.2c	2.2c	2.8a
Cayenne	1.3b	219a	1818a	16b	129a	177a	5.9b	0.1b	8.0c	2.9b	2.7b	2.1b
MD2	1.2b	244b	1665b	16b	125b	169b	6.3a	0.07b	8.4b	3.4a	2.9a	2.2b
Lsd	0.1	18.0	103	0.6	2.8	5.4	0.2	0.07	0.3	0.2	0.1	0.1

1 - Crown type: single=1, double=2, triple=3 and multiple=4.
2 - Core ratio = fruit diameter/core diameter.
3 - Translucency rating: 1=immature, 2=eating ripe, 3=slightly translucent, 4=fully translucent.
4 - Flesh porosity rating: 1=very porous, 2=slightly porous, 3=solid.
5 - Flesh colour rating: 1=white, 2=pale yellow, 3=yellow, 4=dark yellow.

In Hawaii, the fruit weight range for 73-50 is 2.86 to 5.71 lbs. (1.3 - 2.6 kg) and yields were 4 to 37% more than 'Smooth Cayenne' under similar growing conditions. In Queensland, fruit are often approximately 20% smaller than 'Smooth Cayenne' from a summer plant crop (Table 3) and similar in weight to those of 73-114. Experience in Queensland shows that the hybrid does not produce multiple crowns but can develop small shoots around the base of the crown if the crown is damaged. In Queensland, crowns are moderate in size in winter but can be very large in summer and crown size variation is similar in Hawaii with crowns on fruit ripening in summer sometimes requiring gouging to reduce their size.

Table 4. Hybrid characteristics for a summer plant crop in SE Queensland, Australia (Data of G. Sanewski).

Variety	Crwn length	Crwn wt	Crwn base dia	Fruit len	Ped scar diam	TSS	Juice	Fruit		Fruitlet				Flesh		Core	Firm-	Fibr-	Por-
								wt	dia	no	wt	ht	width	color	transl1	dia	ness	osity2	osity3
	mm	g	mm	mm	mm	%	%	g	mm		g	mm							
73-50	321	285	27	162	25	16	49	1505	125	97	15	28	26	4.9	1.3	19	8.2	3.4	5.1
MD2	268	248	22	158	22	16	46	1542	126	91	17	30	27	4.4	2.2	18	8.7	4.6	7.0

1 - Translucency rating: 1=immature, 2=eating ripe, 3=slightly translucent, 4=fully translucent.
2 - Flesh porosity rating: 1=very porous, 2=slightly porous, 3=solid.
3 - Flesh colour rating: 1=white, 2=pale yellow, 3=yellow, 4=dark yellow.

73-50 has a slightly smaller core than Cayenne and the flesh is more yellow and more porous and flesh firmness is comparable to or slightly greater than for 'Smooth Cayenne', but not as firm or as fibrous as that of 73-114 (Table 3, Table 4). Flesh color is not uniform but with more yellow ovary tissues. Fruitlet size is noticeably larger than 'Smooth Cayenne' but similar to that of 73-114 (Table 4). In Hawaii (D.D.F. Williams, personal communication) and Queensland, Australia, cannery recovery (slices per ton of fruit) of 73-50 was better than that of 'Smooth Cayenne', presumably because the fruit has a more uniform rectangular shape than do 'Smooth Cayenne' fruits.

Pests and Diseases

73-50 is highly susceptible to *Phytophthora nicotiana* and *Phytophthora cinnamomi* root and heart rot diseases and much more susceptible than 'Smooth Cayenne' (Taniguchi, 2003). The fruits are moderately susceptible to fruitlet core rot/black spot disease caused by *Fusarium guttiforme* and also to woody fruit disease, the causal agent of which is unknown. Fruits are susceptible to fruit rot caused by *Chalara paradoxa* and to fruit shell and butt mold caused by *Penicillium* sp. and *Cladosporium* sp. Mealybug wilt symptoms have been seen on plants of this hybrid.

73-50 also is susceptible to a physiological disorder referred to a seasonal skin russeting (Figure 1) (Sanewski, 2007). No cause of the disorder has been identified. Russeting has been observed on fruits of 73-50 in Queensland and also in Hawaii on plantations on Maui and Oahu.

Figure 3. The left photo shows a comparison between an unrusseted fruit protected by a paper sleeve (note the large 'eye' size) next to a slightly russeted fruit that was not covered. The right photo is a closeup of a slightly russeted fruit. Photos of G. Sanewski.

PRI Hybrid 73-114. In the markets as Del Monte Gold, Dole Premium Select, MD2 or MD-2 (the latter being the original name given by Del Monte Fresh Produce Hawaii, Inc.), assorted company names, often in conjunction with Gold and MD-2.

A particularly notable feature of Pineapple Research Institute of Hawaii (PRI) hybrid 73-114 is its immense popularity with consumers such that within approximately 10 years it almost completely replaced 'Smooth Cayenne' pineapple in the supermarket fresh fruit counters in much of Europe, England and the United States. The story of how this happened has yet to be told but it has been said that the hybrid was taken by Del Monte researchers from Oahu to Costa Rica in the early 1980s when Del Monte Fresh Produce Inc. was in the process of expanding the area planted to pineapple for fresh fruit production in Central America. The story goes that the company plan was to grow the 'Smooth Cayenne' clone Champaka F-153 in Costa Rica. However, initial tests indicated that clone was not doing as well as expected so other alternatives were sought. Several PRI hybrids were released to its member companies (Del Monte Fresh Produce and Maui Pineapple Company) in the early 1980s and those companies had begun to expand the area planted to hybrids by conventional vegetative propagation as part of the process of further evaluating their commercial potential. One of those hybrids was 73-114 and it was taken to Costa Rica for evaluation of its potential there and it apparently proved to be well adapted to the Costa Rican environment. To speed up the expansion of the area planted to 73-114, Del Monte shipped container loads of planting material from Hawaii to Costa Rica. It is assumed that taste testing of the hybrid was begun when semi-commercial quantities of the fruit became available. Commercial quantities of fruits of 73-114 became available in the market place in approximately 1996 and the fruit was so popular that Del Monte was able to charge a significant premium for MD-2 fruit. This popular pineapple fruit was eventually re-branded and sold as Del Monte Gold and 10 years after its initial introduction to the main markets of Europe, England and the United States it had almost completely replaced 'Smooth Cayenne'. Small amounts of other pineapple cultivars can still be found on supermarket shelves in these countries but the dominant fruit by far is 73-114.

Parentage

The PRI hybrid 73-114 is a sibling of hybrid 73-50 and the parents were PRI hybrids 58-1184 x 59-443. Thus the hybrid's composition is 'Smooth Cayenne' 17, 'Smooth Guatemala' 6, 'Pernambuco' 4, 'Ruby' (a 'Singapore Spanish' clone) 4, and 'Queen' 1.

Plant Characteristics

Hybrid 73-114 is a vigorous plant, comparable to 'Smooth Cayenne' in that regard, and from the point of view of vegetative growth is well adapted to locations where 'Smooth Cayenne' pineapple is grown. Because of its vigorous growth and productivity on a per plant basis, plant populations of up to 70,000 ha^{-1} are recommended (Anonymous, 2005). However, because the plant harvest index (fruit weight at harvest/plant weight at forcing) declines as average temperature increases (Hepton, 2003), plant populations probably should not be that high in environments where average temperature is at or above 25 C. Root initiation from crowns and slips is excellent. The hybrid produces an adequate number of slips, which makes it well suited as a fresh fruit cultivar. However, on Oahu (300 m and below), it is reported that slip production is lower in November through March than in the warmer months of the year. In Hawaii, both slip and sucker production are reduced or delayed, or both, when small plants are forced or are naturally induced. Relative to its sibling 73-50, 73-114 has good tolerance to soils having higher pH values and to soils with a high calcium content.

Plant and crown leaves have small spines on their tips similar to the leaves of 'Smooth Cayenne'. The leaves are thicker than those of 73-50 and have a thicker water storage tissue typical of 'Smooth Cayenne'. 73-114 can mutate to spiny leaves similar to Cayenne and spiny-leafed mutants are commonly seen where plants are produced by tissue culture. An interesting characteristic that makes it possible to distinguish between 73-114 on the one hand and 73-50 and 'Smooth Cayenne' on the other is the complete absence of athocyanin (red) pigment in the leaves. Bracts below the syncarp also are pale green (Figure 2), which make it easy to distinguish between this hybrid and 73-50 and 'Smooth Cayenne'. The peduncle length of 73-114 is short (Anonymous, 2005) and comparable to or shorter than that of 'Smooth Cayenne' when grown in the same conditions (Figure 2).

A serious "physiological" weakness of this hybrid is its susceptibility to natural induction of reproductive development (natural induction) under even moderately cool subtropical conditions. 73-114 is more susceptible than 73-50 and much more susceptible than is 'Smooth Cayenne'. The problem is said to be "manageable" in Costa Rica but in cooler locations such as Mexico and Hawaii and even more so in southern Queensland, natural induction poses a serious management problem for growers. The problem has led to very active efforts to locate growth regulators that will help to control natural induction during the winter months in these environments (Bartholomew and Uruu, 2008; Kuan, et al., 2005; Lin, et al., 2006; Rebolledo, et al., 2008). The period from forcing to fruit harvest for 73-114 is shorter than that for 'Smooth Cayenne', and in Ghana is 130 days for the former and 135 days for the latter.

Yields in Hawaii and Costa Rica are said to be higher than for 'Smooth Cayenne' where as in sub-tropical Queensland 73-114 produces a much lower yield than Cayenne on a summer plant crop though the fruit are of good size, in the range of 1.8 kg. Plants of 73-114 grown as a summer plant crop in Queensland can also produce several ground suckers. The fruit is held low in the plant similar to or lower than 'Smooth Cayenne' so there is no problem with lodging. Observations in Queensland are that 73-114 will produce multiple crowns when damaged (Table 2). In tropical regions it is a vigorous plant with good yield and fruit appearance but care is still needed to ensure crop control.

Fruit Characteristics

Fruits of 73-114 are similar in shape to those of 73-50, having "square shoulders" and little or no taper. The fruitlet size is slightly larger than that of 73-114 (Table 4) and also larger than that of 'Smooth Cayenne'. The fruits of this hybrid are almost always are mildly "crippled", especially larger ones, in Hawaii and in Ghana (D. Bartholomew, personal observation). 'Smooth Cayenne' fruit have a consistent pyllotaxy with 8 "gently sloping spirals" and 13 steeper spirals that slope in the opposite direction (Ekern, 1968). The 8 gently sloping spirals can be found quite consistently in fruit of 73-114 (highlighted by black dots from left to right in Figure 3) but the 13 steeper spirals are more difficult to follow (upper portion highlighted with black dots in Figure 3) and fruitlets are sometimes missing or incomplete (Figure 3, circled fruitlets). This altered phyllotaxy may account at least in part for the fact that fruit harvested in Queensland in summer are often misshapen, presumably due to cold weather during early flower development.

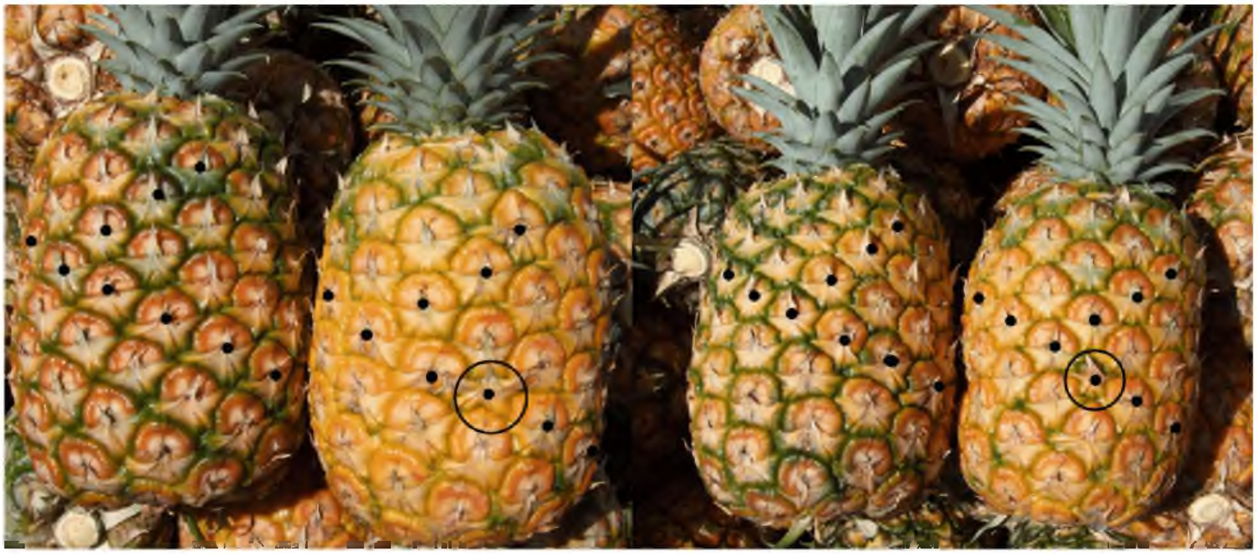


Figure . Fruits of PRI hybrid 73-114 showing a well-defined and easily recognizable "long spiral (dots sloping from left to right) and short spirals that are difficult to follow and two fruit with deformed fruitlets (circled), a not uncommon instance in this hybrid..

Fruits of 73-114 have moderate flesh fiber content and are firmer and more fibrous than those of 'Smooth Cayenne' (Table 3). The flesh is more yellow and translucent than that of both 73-50 and 'Smooth Cayenne' (Table 3, Table 4) and fruit translucency can be a problem in Hawaii, particularly in the months of April, May and June. The higher level of translucency may account for the fruits reported high susceptibility to bruising (Anonymous, 2005). The fruit has very good flavor, though somewhat less pleasant and aromatic than is 73-50. As is true for most pineapple cultivars grown in the warm tropics, fruit of this hybrid produced in tropical Ghana have adequate total soluble solids but have very low acidity and lack flavor. The average percentage of total soluble solids (TSS) in the hybrid is 1 to 2% higher than 'Smooth Cayenne' (though not necessarily in Queensland (Table 3)) under the same fruit maturation conditions. The acidity is lower than that of 'Smooth Cayenne' in all seasons of the year in Hawaii so the consumers perception is that the fruit is sweet with a moderate TSS/acid ratio during the summer months and considerably less acidity than 'Smooth Cayenne' during winter months in Hawaii. The Vitamin C content of 73-114 is higher than 73-50 in Queensland.

An very outstanding strength of 73-114 is its high resistance to the physiological browning (variously referred to as endogenous brown spot (EBS), internal browning (IB)) that is prevalent in 'Smooth Cayenne' and 'Queen' fruits, and to a lesser extent in PRI hybrid 73-50. This internal browning is not found in fruits grown in natural field conditions or in refrigerated storage. The fruit has an extremely long shelf-life because of its resistance to EBS and its low to moderate susceptibility of shell to desiccation.

When processed and canned, fruit appearance is comparable to that of 'Smooth Cayenne' but the flavor is rated as poor when compared to canned fruits of 'Smooth Cayenne'.

Pests and Diseases

Hybrid 73-114 is highly susceptible to *Phytophthora nicotiana* and *Phytophthora cinnamomi* root and heart rot diseases and is much more susceptible than 'Smooth Cayenne' (Taniguchi, 2003; Anonymous, 2005). Mealy bug wilt symptoms have not been seen. Both the plants and fruit are susceptible to bacterial rot caused by *Erwinia chrysanthemi*. Bacterial rot can be a serious disease because there is no effective chemical control available. The disease was found only recently in Hawaii (Alvarez et al., 2007) and while it can be found in fields of 73-114, it affects less than 1% of plants in fields where it can be found and to date is considered to be a minor problem. The hybrid is more tolerant of *Rotylenchulus reniformis* than is 'Smooth Cayenne' (Soler, et al., 2008).

Fruit of 73-114 are extremely resistant to fruitlet core rot/black spot disease caused by *Fusarium guttiforme* but are susceptible to fruit rot caused by *Chalara paradoxa* and to fruit shell and butt mold caused by *Penicillium* sp. and *Cladosporium* sp.. Fruits are also susceptible to fruit gummosis caused by micro-lepidoptera feeding on the basal portion of the fruit (Taniguchi and Wright, 2003).

Summary

73-50 is more suited to sub-tropical climates than 73-114 but is less susceptible to natural induction than is 73-114, a serious weakness in the latter hybrid. Both hybrids are equally and significantly more susceptible to Phytophthora root and heart rot than is the 'Smooth Cayenne' cultivar. 73-50 has a more aromatic flavor than does 73-114 with a lower acidity. Fields of 73-50 can be a little uneven and care is needed during ground preparation and plant establishment. Hybrid 73-114 is well suited to tropical climates where it yields well and has a good sugar and acid balance. In these environments it has a glossy appearance and is well-shaped with square shoulders. Because of the high susceptibility of 73-114 to natural induction, scheduling of fruiting can be difficult with this hybrid even in tropical environments.

References

Alvarez, A., M. Burger, W. Kaneshiro, A. De Silva, B. Vine. 2007. First report of bacterial heart rot of pineapple in Hawaii. Pineapple News No. 15, p. 23.

Anonymous. 2005. PIP MD2 Pineapple Variety Production Guide. http://coleacp.org/FO_Internet/Pip/Default.asp.

Bartholomew, D.P. and G. Uruu. 2008. Pineapple control of flower studies. Pineapple News 15, p 32.

Fournier, P., A.Soler and P.A. Marie-Alphonsine. 2007. Growth characteristics of the pineapple cultivars 'MD2' and 'Flhoran 41' compared with 'Smooth Cayenne'. Pineapple News No. 14, p. 18.

Fournier, P., C. Dubois and A.Soler. 2008. Considerations on growth characteristics of different pineapple varieties in Côte d'Ivoire, La Reunion and Caribbean Islands. Abstract, VIth International Pineapple Symposium (below, this issue of Pineapple News).

Hepton, A. 2003. Culture System, p. 109-142, In D. P. Bartholomew, et al., eds. The Pineapple: Botany, Production and Uses. CABI Publishing, Wallingford.

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.

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.

Rebolledo, M. Laureano, Uriza Á. Daniel E., Del Ángel P Ana Lid, Rebolledo M. Andrés. 2008. Inhibitors of MD-2 pineapple natural flowering in Mexico: rate, number and date of application. Abstract, VIth International Pineapple Symposium (below, this issue of Pineapple News).

Sanewski, G.M. 2007. Skin russeting in the pineapple variety 73-50. Pineapple News No. 14, p. 9-12.

Soler, A., P.A. Marie-Alphonsine, P. Topart, P. Queneherve. How to evaluate the resistance or tolerance of pineapple varieties to nematodes? Abstract, VIth International Pineapple Symposium (below, this issue of Pineapple News).

Taniguchi, G. 2007. An update on pineapple root rot diseases. Pineapple News No. 14, p. 24.

Taniguchi, G. and M. Wright. 2003. Micro-Lepidoptera, a new pest problem on pineapple in Hawaii. Pineapple News, No. 10, p. 15.

Williams, D.D.F. and H. Fleisch. 1993. Historical review of pineapple breeding in Hawaii. Acta Hort.334: 67-76.

Pineapple Control of Flowering Studies

Duane Bartholomew and Gail Uruu. Dept. of Tropical Plant & Soil Science, University of Hawaii at Manoa, Honolulu, HI 96822. E-mail: duaneb@hawaii.edu

Natural induction of flowering (natural induction) of pineapple is a serious problem for pineapple growers during the approximately four-month period from December to the end of March. Natural induction disrupts the orderly scheduling of fresh fruit for the marketplace, can reduce average fruit size if small plants are naturally induced, and greatly spreads the harvest peak, which increases harvesting costs. Natural induction can also delay the development of the ratoon crop and increase the variability in the size of ratoon suckers (shoots). The problem has become much more serious in recent years in Hawaii as growers have shifted production from 'Smooth Cayenne' to the Pineapple Research Institute of Hawaii (PRI) hybrids 73-50 and particularly 73-114, better known internationally as MD-2 (or MD2). The latter variety is very susceptible to natural induction and especially so when subjected to any stress during the season when natural induction occurs.

Two materials were evaluated in the 2007-08 season for their efficacy in preventing natural induction. ReTain® (Valent BioSciences, Corp.) contains aviglycine, an inhibitor of ethylene biosynthesis. ReTain® was registered for use in preventing natural induction of pineapple in the United States and in Hawaii late in 2007. The compound 1-methylcyclopropene (MCP), which blocks the action of naturally produced ethylene in plant tissue, is available from AgroFresh, a division of Rohm & Haas, as a wettable powder designated AFxRD-038, which contains 3.8% of MCP. AFxRD-038 when dispersed in water releases MCP within a few minutes. It is generally assumed that ethylene is the main compound responsible for the natural induction of pineapple flowering. Since MCP blocks the action of naturally produced ethylene it may have the potential to control natural induction of pineapple. The compound is used commercially to block the action of ethylene-induced senescence of fresh fruits, vegetables and flowers but is not currently registered for any use on vegetative pineapple plants. In 2003, a small test was conducted to determine if the MCP contained in SmartFresh, a wettable powder with a lower concentration of MCP than is present in AFxRD-038, would be taken up by pineapple plants. Plants were treated with MCP by or before 8:30 a.m. and then forced with ethylene the evening after treatment, two days after treatment and eleven days after treatment. Plants were forced by ethylene only at eleven days after treatment indicating that MCP was blocking ethylene binding sites for at least two days but not for eleven days. Blocking of ethylene action with MCP may inhibit natural induction in vegetative pineapple plants. The general description of the ReTain and AfxRD-038 tests and the results for each product are provided below.

Evaluation of ReTain® for Control of Natural Induction of Flowering

ReTain® has been registered for several years for use on some tree fruits to reduce pre-harvest fruit drop. Registration for use in controlling natural induction of flowering of pineapple (natural induction) was obtained by Valent Biosciences late in 2007. ReTain was tested for its efficacy in controlling natural induction of the PRI hybrid 73-114 at three locations on a pineapple plantation in Hawaii. Although treatments were applied at all three locations, two of the tests were later abandoned when it became obvious that natural induction had commenced before the treatments were begun. The results presented below are based on the one test where a significant treatment effect was obtained.

The treatments (Table 1) were based on conditions established by the approved label as well as general recommendations from scientists at Valent Biosciences. The treatments were designed to test the efficacy of weekly vs. biweekly application of ReTain and to evaluate the effect of various adjuvants on natural induction under less than ideal (biweekly) conditions. Treatment 7 was abandoned because reliable temperature data were unavailable.

Table 1. ReTain treatments applied to test the efficacy of aviglycine to control natural induction of flowering of pineapple in Hawaii in a trial conducted from December 2007 to May, 2008.

Treatment	mg L^{-1}‡	Frequency	Gal acre^{-1}	Additives/notes
T1	0			
T2	100	7-day	125	0.10% non-ionic surfactant
T3	100	14-day	125	0.10% non-ionic surfactant
T4	100	7-day	250	0.10% non-ionic surfactant
T5	100	14-day	250	0.10% non-ionic surfactant
T6	100	14-day	250	No additives
T7	100	Temp drop	250	0.10% surfactant; on predicted T<18 °C†
T8	100	14-day	250	2% urea
T9	100	14-day	250	2% urea + 0.10% non-ionic surfactant
T10	100	14-day	250	Adjust pH to 3.0 with phosphoric acid
T11	100	14-day	250	Adjust pH to 3.0 + 0.10% non-ionic surfactant

‡Aviglycine concentration.

†Total volume of solution applied per application per acre.

The experimental design was a randomized complete block with three replications and the plot size was two beds (4 rows) by 60 feet. The treatments were applied to two beds with a mini-boom constructed of one-half inch PVC pipe. Four 4 TeeJet Conejet nozzles were arranged uniformly across the mini-boom and spray was delivered from the supply tank with a constant-pressure electric pump. Coverage of the two beds was good but there was some spray-cone overlap between inner and outer pairs of nozzles, which could have resulted in poorer coverage of the two outer rows of each plot. To minimize any variability introduced by the coverage issue, data were collected by row so the row effect, if any, could be accounted for.

The treatments were first applied on December 3, 2007 and, to the extent that weather permitted, on a weekly or biweekly schedule through January 28, 2008, which was the 9th application to the weekly treatments. A 10th weekly treatment, the maximum allowed by the label, was planned for February 4 but was delayed one week by rain.

Bud counts were first taken on February 5, 2008, but the percentage of vegetative plants was greater than 90% in most plots and the variation among treatments was small so the data were not analyzed further. A final detailed bud count by flowering stage was taken March 5, 2008 (Table 1). The results (Table 1), which are arranged by treatments within each of the three replications, are the mean percentages of 130 to 140 vegetative plants in the center two rows of the two bed plots.

Irrespective of treatment, there were more vegetative plants on the up-slope side (Table 1, bed numbers 20 and higher) of the experiment, an unforeseen and undesirable situation for a randomized complete block experimental design. Data on plant height were collected later in March to explore the potential of using covariance analysis to remove some of the within-block variation but no trends were found. There was no obvious explanation for the across-block variation.

The data were analyzed using SAS Statiscal Analysis software and the results are summarized in Table 2. Treatments 2 and 4 are the only ones where the percentage of vegetative plants was significantly greater than that of the control. Orthogonal comparisons, results not shown, were made among various treatment combinations and none of the potential adjuvants used in this test significantly increased the efficacy of ReTain®. Based on the results and their analysis, weekly applications of 100 mg L^{-1} of aviglycine (treatments 2 and 4), the active ingredient in ReTain®, provided better control of natural induction than did biweekly applications (treatments 3 and 5). While the effect of spray volume was not significant, there was some indication that the higher spray volume (treatment 4) provided better control of natural induction than did a lower one (treatment 2).

Table 1. Percentage of vegetative plants by treatment within each replication in the ReTain® test on March 5, 2008. Of particular interest are treatments 1, 2, 3, 4, and 5.

(Up-slope side of block)

Bed nos.	Rep 1 Trt.No.	Veg, %	Rep 2 Trt. No.	Veg, %	Rep 3 Trt. No.	Veg, %
31-32	8	61.2	2	90.6	4	98.4
29-30	2	96.2	7	77.7	6	87.4
26-27	11	85.7	10	61.5	3	70.6
23-24	4	90.1	9	73.4	10	52.3
20-21	9	68.2	8	58.7	5	73.4
17-18	5	37.5	1	3.1	8	44.5
14-15	1	7.8	3	20.2	7	25.2
11-12	6	13	6	21.6	2	40
8-9	3	18.1	5	18.1	11	21.4
5-6	10	28.3	11	28	1	10.9
2-3	7	37.6	4	86.6	9	48.8

(Down-slope side of block)

Evaluation of 1-MCP for Control of Natural Induction of Flowering of Pineapple

The objective of this trial was to evaluate the potential of regular applications of 1-MCP released from the complexing agent in AFxRD-038 to control natural induction of pineapple. Because 1-MCP, a gas, is released from the complexing agent over a relatively short period of time, all treatments were applied before 8:30 a.m. to assure that the leaf stomata were open at the time of application. Though the precise time of stomatal closure is not known, pineapple stomata close relatively quickly after sunrise. While 1-MCP may penetrate the plant cuticle, having the stomata open assures a pathway for gas entry into the leaves. Because no information was available on the potential of 1-MCP to control natural induction, the treatments were applied at intervals of 7 and 14 days. 1-MCP irreversibly blocks the ethylene binding sites in plant tissue and it was assumed that at ambient temperatures these active sites would be regenerated within 14 days.

The treatments consisted of 1) Control (untreated); 2) weekly spray of 1.0 mg L^{-1} of 1-MCP; 3) biweekly spray of 10.0 mg L^{-1} of 1-MCP; 4) weekly spray of 10.0 mg L^{-1} of 1-MCP; 5) biweekly spray of 10.0 mg L^{-1} of 1-MCP; 6) treatment to be applied on temperature drop; the treatment was abandoned as unworkable because temperature data could not be obtained. The amount of spray solution applied to the two-bed by 25 foot long plots was 4.3 L. The solubility of 1-MCP in water is reported to be 137 mg L^{-1} at 20 °C with no pH effect. The spray volume per plot was approximately equal to 250 gallons of spray per acre (2337 L ha^{-1}). Sil-Wet 77 surfactant was added at 0.26 mL L^{-1}. A two-bed (four rows) border was established between all plots to minimize diffusion of 1-MCP between treated plots. The experimental design was a randomized complete block with three replications. Spray solutions were applied with a gas-pressurized constant-pressure sprayer with a 4-nozzle boom. The application guidelines provided by AgroFresh, Inc. for mixing and applying AFxRD-038 were carefully followed.

The spray treatments were first applied on January 7, 2008 and according to the treatment schedule thereafter. Although there was considerable variation in size among plants in the treated area, plant fresh weights were estimated to be between 4.5 and 5 pounds at the time treatments were begun. Despite the relatively late start in early January, there was no evidence of natural induction in the experimental area. Treatments were suspended after January 28, 2008 because the area was forced with ethephon by the plantation.

Detailed bud counts were taken in all plots on February 27, 2008 and the percentage of vegetative plants for each replication are presented in Table 3. A major problem in evaluating the efficacy of the treatments was the very high variation and inconsistent response among treated plots and especially treatments 3 and 4 (Table 3) across the replications.

The ANOVA results (Table 4) show that 1-MCP did not significantly increase the percentage of vegetative plants relative to the control. The inconsistent response to the treatments in the three replications indicates that when plant sensitivity to natural induction is high, e.g. Replication 3, 1-MCP has very little effect on natural induction. The effect of 1-MCP at the concentrations used in this trial on natural induction was small.

The ReTain® and 1-MCP trials were run in adjacent sections of the same block and were adjacent to each other. It is possible that higher concentrations of 1-MCP could result in greater control of natural induction. However, it is clear from the above trials with ReTain® and 1-MCP that the best treatments with ReTain® were more effective in controlling natural induction than were the 1-MCP treatments.

Conclusions

ReTain® was most effective in inhibiting natural induction of pineapple when applied weekly and in a higher rather than a lower volume. The greater effectiveness of weekly applications confirm results obtained by Rebolledo et al. (2008) in Mexico. While the difference between the high (250 gpa, 2337 L ha^{-1}) and low volume treatments was not significant, it has been reported that a volume higher than 125 gpa (1169 L ha^{-1}) provided better control of natural induction at other locations (J. Lopez, personal communication). ReTain® is presently registered in the United States and in Hawaii for use in the control of natural induction of pineapple. The active ingredient in ReTain® is a natural product produced by fermentation so it also is likely to be accepted for use in organic agricultural production.

The trial with 1-MCP did not show the same level of control over natural induction as did the one with ReTain®. It is possible that starting application of 1-MCP in early December, as was the case for ReTain, or higher concentrations of 1-MCP, or both, would increase its efficacy. Further study to confirm that seems warranted. However, there are a number of disadvantages with 1-MCP for control of natural induction of pineapple. The current formulation of 1-MCP would be difficult to handle under plantation conditions because the application protocol specifies that all spray solution must be delivered withing five minutes after mixing in the spray tank and dispersion by swirling rather than vigorous stirring is recommended so as to minimize the speed of release of 1-MCP from the complexing agent. Instructions also specify that the water used to formulate the spray solution must be clean and free of copper and activated charcoal because the 1-MCP molecule is relatively unstable and will degrade spontaneously in the presence of such materials. It might be interesting to combine 1-MCP with ReTain if the two materials are compatible as a mixture in the spray tank since they have different modes of action. We hope to obtain further results with this interesting compound, which has proven so valuable in post-harvest storage of fresh commodities.

Table 2. ANOVA of treatment effects on the percentage of vegetative plants of hybrid 73-114 present on March 5, 2008 in a plant-crop field. The reatments are as indicated in Table 1.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	14369.50242	1436.95024	2.30	0.0501
Error	22	13769.90000	625.90455		
Corrected Total	32	28139.40242			
Coeff of Var, 49.85187					

Below is the Waller-Duncan K-ratio t Test for treatment effects on percentage of vegetative plants. Means with the same letter are not significantly different. Of primary interest are means for treatments 1, 2, 3, 4, and 5.

Waller Grouping			Mean	N	Treatment
	A		91.70	3	4
B	A		75.60	3	2
B	A		63.47	3	9
B	A	C	54.80	3	8
B	A	C	47.37	3	10
B	A	C	46.83	3	7
B	A	C	45.03	3	11
B	A	C	43.00	3	5
B	A	C	40.67	3	6
B		C	36.30	3	3
		C	7.27	3	1

Table 3. Percentage of vegetative plants by treatment within each replication in the Plant Crop 1-MCP test on February 27, 2008.

(Up-slope side of block)

Bed nos.	Rep 1 Trt.No.	Veg, %	Rep 2 Trt. No.	Veg, %	Rep 3 Trt. No.	Veg, %
22-23	6	51.0	4	13.4	6	12.6
18-19	2	82.6	1	27.8	3	9.2
14-15	5	69.9	3	21.2	2	23.0
10-11	1	58.2	6	43.6	5	13.1
6-7	3	72.6	2	87.7	4	37.6
2-3	4	92.4	5	71.0	1	6.0
Mean		75.2		49.1		12.9 (5% LSD - 22.7)

(Down-slope side of block)

Table 4. Table 2. ANOVA of effects of MCP treatments on the percentage of vegetative plants of hybrid 73-114 present on February 27, 2008 in a plant-crop field. Treatment 6 in Table 3 was not included in the analysis.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Treatments	4	2229.52	557.380	2.29	0.147
Replications	2	9762.19	4881.09	20.09	0.001

Treatment/Rep	MCP, mg L^{-1}	Frequency	Vegetative plants, %
1-Control	None	None	30.70
2-MCP-1	1.0	Weekly	64.46
3-MCP-2	1.0	Biweekly	34.31
4-MCP-3	10.0	Weekly	47.83
5-MCP-4	10.0	Biweekly	51.34
SE(N= 3)	8.999	5%LSD, 8 df	29.34

Acknowledgements

The access to fields and the technical support of staff of Dole Pineapple Co. is gratefully acknowledged.

Reference

Rebolledo, M. Laureano, Uriza Á. Daniel E., Del Ángel P Ana Lid, Rebolledo M. Andrés. 2008. Inhibitors of MD-2 pineapple natural flowering in Mexico: rate, number and date of application. Abstract, VI^th International Pineapple Symposium (see details below).

Abstracts of the VI^th International Pineapple Sympoium

November 18 to 23, 2007 at João Pessoa, Paraíba, Brasil

I) Oral presentations

Session of Technical Opening: Pineapple in Brazil: characteristics, research and perspectives

Aristoteles Pires de Matos, Domingo Haroldo R. C. Reinhardt. Embrapa Cassava & Tropical Fruit, Caixa Postal 007, 44380-000 - Cruz das Almas, Bahia, Brazil. Phone (55 75) 3621 8094, (55 75) 3621 8082; apmatos@cnpmf.embrapa.br, dharoldo@cnpmf.embrapa.br

In Brazil there are over 76,000 hectares devoted to the cultivation of pineapple, thus placing it among the most important fruit crops of that country. Pineapple crop in Brazil plays a very important role in both economical and social aspects, since it generates employment and income besides contributing to keep the rural population. The Brazilian pineapple industry is composed basically of two cultivars: 'Pérola' the most widespread throughout the country; and 'Smooth Cayenne', mainly in the Southeast Region. Other cultivars such 'Jupi' and 'MD-2' are currently showing significant increase in cultivated area. Many local varieties are grown in Brazil, especially in the Amazon Region. The pineapple breeding program of Embrapa Cassava & Tropical Fruits generated several hybrids, and after evaluation two of them were selected and recommended for planting:'Imperial' and 'Vitoria', which present horticultural characteristics that attend consumers' preference and are resistant to fusariose, the main phytossanitary constraint of the Brazilian pineapple crop. In spite of ranking number one in world pineapple production, Brazil' share in pineapple international trade is rather small, as the major volume goes to the national market. The development of the Brazilian pineapple industry has been supported by technologies generated by research institutes. Despite its development and importance for the Brazilian agribusiness, the pineapple crop is affected by phytossanitary and cultural problems that reduce its acceptance, specially in the international market. Consumer's demand for high quality food, without pesticide residues and produced under sustainable conditions imposed changes in the production process. In this regard, the Brazilian Ministry of Agriculture, Livestock and Supply started a program on integrated fruit production, including pineapple, to attend that demand. The integrated pineapple production aims at producing high quality fruits in accordance with specific procedures that are environmentally safe. In order to reach that requirement an integrated pest management program has been established as well as monitoring the nutritional status of pineapple plants and the development of pesticide resistant pineapple pests. Such a procedure enabled reduction in pesticide use as follows: insecticides, 37%; and fungicides, 20%. In addition, weed management by growing cover crops in pineapple orchards, or trimming native weed and using mulch enabled a 47% reduction of herbicide use, thus contributing to environmental protection and reduction of production costs without interfering with fruit quality. Fertilization based on soil analyses also resulted in production costs. Training activities, such as specific courses, technical meetings, field days, and so on proved to be very effective on the adoption of the integrated pineapple production by the growers. Financial support: Brazilian Ministry of Agriculture, Livestock and Supply (MAPA).

Session I: Genetic Resources, Breeding and Micropropagation

Pineapple genetic improvement in Brazil

Jose Renato Santos Cabral, Aristoteles Pires de Matos, Davi Theodoro Junghans, Fernanda Vidigal Duarte Souza. Embrapa Cassava & Tropical Fruit, Caixa Postal 07, 44380-000, Cruz das Almas, Bahia, Brazil. Phone (55 - 75) 3621 8027 - jrenato@cnpmf.embrapa.br

Pineapple genetic improvement in Brazil started with taxonomic studies on the genes Ananas and description of species and cultivars present in the country. Thereafter, works related to germplasm evaluation, cultivars evaluation, obtaining and evaluation of hybrids were carried out by the Empresa de Pesquisa Agropecuária do Estado do Rio de Janeiro and by the Instituto Agronômico de Campinas from 1978 to 1997. The most complete program of pineapple genetic improvement in Brazil is the one carried out by the Embrapa Cassava & Tropical Fruit since 1978. The objectives of that program are to develop pineapple cultivars resistant to the fusariosis disease, main constraint of the pineapple crop in Brazil, with good fruit quality and spineless leaves. Some of the relevant results already obtained are: establishing and maintaining the Pineapple Active Germplasm Bank, composed by 627 accessions under field conditions and 146 accessions under in vitro preservation; development of a technique for early evaluation of pineapple resistance to fusariose based on artificial inoculation; identification of 122 sources of resistance to fusariose; recommendation of the cultivars Primavera and Perolera, both resistant to fusariose; creation of 60.537 hybrids; field evaluation of 30.462 hybrids that showed resistance to fusariosis; preliminary selection of 49 promising hybrids that are under several evaluation phases; recommendation of the cultivars Imperial and Vitoria, resistant to fusariosis. The model of genetic herdability was determined and currently studies related to selection of molecular markers to identify resistant genotypes at seedling stage are under conduction. From 2002, backcrosses and crosses between selected hybrids began to be performed and the progenies already obtained are under evaluation. Several self pollinated genotypes were obtained from the cultivars Perolera, Primavera, Roxo de Tefé and Smooth Cayenne that are under evaluation and that will be used as parentals in crosses, aiming at obtaining progenies with lower segregation level. By 2004 it was started a breeding program to generate ornamental pineapple cultivars. Up to now 22 ornamental genotypes were selected and are under evaluation, all of them showing potentialities to be recommended as new ornamental pineapple cultivars.

Pineapple hybridization and selection in Thailand

Suneerat Sripaoraya. Faculty of Agriculture, Rajamangala University of Technology Srivijaya, Nakhonsithammarat Campus, Tungyai, Nakhonsithammarat 80240 Thailand, suneerat.s@rmutsv.ac.th

Conventional pineapple breeding was done in two phases at Faculty of Agriculture, Rajamangala University of Technology Srivijaya, NakhonsiThammarat, Thailand. The first phase was during 1993-1996 for hybridization and the first selection. The second phase, from 2002 to 2006, was dedicated to the second crop of selection and micropropagation. 'Cayenne' and 'Queen' pineapple groups were used both for direct and reciprocal crosses. In addition, both groups were selfed. There are three objectives of this research: to produce F1 hybrids between 'Queen' and 'Cayenne' groups, to study heredity of leaves and to select F1 hybrids which have good characters. As result 296 F1 hybrids from direct cross ('Queen' X 'Cayenne') and 131 F1 hybrids of reciprocal cross were produced. However, no seeds could be obtained from selfing in both groups. From the total of 427 F1 hybrids were selected in the first phase of selection the following ten hybrids: HQC34, HQC36, HQC324, HQC421, HQC426, HQC827, RC132, RC212, RC216 and RC319. In the second crop of selection, two clones (HQC34 and RC212) confirmed their good agronomic characteristics and yield. In addition, they showed resistance to root rot and fruits of good quality. These selected F1 hybrids have been propagated using tissue culture for increasing the number of plantlets. In the heredity study, have been observed the ratios of 162:134 and 71:60 for spiny and piping leaf types in the Queen X Cayenne and Cayenne X Queen crossings, respectively. Their ratios were not significant by the chi-square test based on a 1:1 hypothesis. Hence it was confirmed that there is one pair of genes having 2 alleles, S (spiny) and s, whose genotype ss is spiny and genotype Ss is piping.

Evolution of genus Ananas and domestication of pineapple

F. R. Ferreira (1), J. R. S. Cabral (2), F. V. D. Souza (2)
(1) Researcher, Embrapa Genetic Resources and Biotecnology, CP 02372, CEP 70.770-900, Brasilia, DF, Brazil, Phone: 61 34484614, Fax: 61 33403624, fricardo@cenargen.embrapa.br, (2) Researchers, Embrapa Cassava and Tropical Fruits, C.P. 007, CEP 44.380-000, Cruz das Almas, BA, Brazil.

The evolution of species depends on nature and also on human action, being the evolutionary process a result of the interaction between these two factors. In the specific case of pineapple there is a theory that the evolution of this species ocurred from some species of Bromelia which present plants similar to pineapple, but are more rustic and aggressive, with large infrutescences and isolated fruitlets. Over time some plants may have presented some anomalies with fruitlets fusion producing infrutescences with grouped fruitlets to give rise to Ananas macrodontes. This species is very similar to Bromelia, being a very rustic plant with long leaves, aggressive spines and with presence of stolons. It produces infrutescences with grouped frutilets forming a fruit similar to pineapple, but without crown and with excessively large bracts. From this, other species of wild pineapple were formed. Thus a high genetic variability developed, that by the process of speciation and mainly by the domestication, that is, the human interference in the evolutionary process, led to the tasty and wonderful pineapple. Among the various attributes of quality which this fruit has, it also presents apomixy, that is, the lack of seeds, becoming even more appreciated for fresh consumption.

Effects of exogenous calcium on root growth and endogenous hormone contents in pineapple seedlings

He Yingdui (1), Liang Lihong (2), Sun Guangming (1)
(1) South Subtropical Crop Research Institute, Chinese Academy of Tropical Agricultural Sciences, Zhanjiang, Guangdong 524091, China, gm-sun@163.com (2) Tropical Crops Genetic Resource Institute, Chinese Academy of Tropical Agricultural Sciences, Danzhou Hainan 571737, China

As an essential element calcium plays a key role in plant development. The present study aimed at assessing the effects of exogenous calcium on root activity, plant growth and endogenous hormone contents in pineapple seedlings. Major experimental methods included hydroponic culture with six concentrations (0, 5, 10, 20, 40, 80 mg/L) of Ca^{2+} and use of high performance liquid chromatography (HPLC) for determining plant endogenous hormone contents. After cultivating for 48 days, the seedlings were sampled and the reduction of TTC (2,3,5-triphenyltetrazolium chloride) method was determined to assess the root activity, and the determination of endogenous hormone contents was carried out by HPLC. Results showed that shoot fresh weight, root activity, root length and root weight increased significantly in response to 20 mg/L Ca2+ treatment, and values of all these parameters seemed to be reduced at higher Ca2+ concentrations. The contents of endogenous estrogen ZT, GA3 and IAA were higher at 40 mg/L Ca2+, with ZT, GA3 and IAA reaching values as high as 2.31, 31.48 and 16.57 µg/g, respectively, while the highest concentration of ABA (0.026 µg/g) appeared at 5 mg Ca2+/L concentration.

Introduction of new pineapple varieties in traditional systems of production in Guadeloupe

Jean-Claude Govindin (1) and Emmanuel Collette (2)
(1) CIRAD Dpt PERSYST UR26 : Système de culture Bananier, Ananas et Plantain 97130 Capesterre Guadeloupe, jean-claude.govindin@cirad.fr
(2) Directeur, sica des producteurs de Guadeloupe Tournant Césarion 97170 Petit Bourg Guageloupe, direction.sicapag@orange.fr

The introduction of new varieties and particularly a CIRAD hybrid, Flhoran41, has deeply modified the pineapple industry in Guadeloupe. Traditionally based on the production of a single variety (local name "Bouteille") for the local market, the industry has recently developed several new varieties. The production system is characterized by high technical skills which will eventually set out to the export market. Beyond the propagation of innovative techniques, the development of new varieties has helped to federate the farmers into associations for the marketing and planning of the production looking for consistency in term of quality. The new varieties, with its specific agricultural practices including the use of minimum pesticides, contribute to environmental protection and food safety. The new variety is an essential factor for the propagation of innovative techniques, respectful of the environment.

Pineapple micropropagation in double-phase culture system and leaf anatomy of plants produced

T.L. Silva (1), F.H.S. Costa (2), P.C.P.Fermino Jr. (3), J.E.Scherwinski-Pereira (4)
(1) Embrapa Acre/CNPq, Laboratory of Morphogenesis and Molecular Biology CP 321, CEP 69.908-970, Rio Branco, AC, Brazil, tathiloureiro@hotmail.com, (2) D.Sc. student in Phitotechny - Federal University of Lavras, MG, Brazil, fredericohenrique@yahoo.com.br; (3) Prof.of Agricultural Science department of Federal University of Acre - Rio Branco, Brasil, e-mail: paulofermino@ufac.br, (4) Embrapa Acre, Laboratory of Morphogenesis and Molecular Biology, LABMOL, C.Postal 321, CEP 69.908-970, Rio Branco, AC, Brasil, e-mail: jonny@cpafac.embrapa.br

This work aimed at optimizing micropropagation of pineapple cultivars from occidental Amazon region by the use of a double-phase system, as well as at describing the anatomy of plants produced. The works were carried out at the Laboratory of Morphogenesis and Molecular Biology, LABMOL in Embrapa Acre, Rio Branco, AC, Brazil. In vitro shoots of pineapple were placed in MS medium containing 2 mg.L-1 of BAP and 0.25 mg.L-1 of NAA. The treatments were formed by three cultivars: Rio Branco (RB), Senador Guiomard (SG) and Quinarí (QN) and two culture systems (semi-solid and double-phase culture). Every 40 days of cultivation, during four subcultures, the multiplication rate was evaluated. The double-phase treatment consisted of the addition of 30 ml of liquid medium to the initial semi solid medium at 40 day-intervals, synchronized with the subcultures performed in the semi solid medium. The latter treatment was evaluated only at the end of the experimental period. From de micropropagated plants of pineapple were made paradermic sections of the adaxial and abaxial surfaces, as well as cross sections of the mesophyll. In general the double-phase system promoted a higher number of shoots when compared to the semi solid medium. Total production in the double-phase system for the cultivars RB, SG and QN was 486, 417 and 339 shoots/bottle respectively, values significantly higher than those observed on semi solid medium: 296, 285 and 205 shoots/bottle, respectively. With respect to leaf anatomy, it was found that the leaves are epiestomatics with anomocytic stomata. The mesophyll is dorsi-ventral with chlorophyllated parenchyma and aquifer hypoderm towards to the adaxial face with an uni-stratificated and non chlorophyllated epiderm. The conclusion is that the use of a double phase culture system promotes a high efficiency in the in vitro production of pineapple shoots and that the leaves from the micropropagated plants are not abnormal.

Efficience of an alternative protocol for 'Imperial' pineapple micropropagation

M. da C. Santos (1), S. B. S. C. Barboza (2), P. R. A. Viégas (3), A. da S. Ledo (4), R. Daniel (5)
(1) Student, scholarship of Deagro/ Federal University of Sergipe (UFS), São Cristóvão, SE, tel.(79)32191144, micacostal@hotmail.com; (2) Researcher Deagro, Embrapa Coastal Tablelands, m-box 44, Zip 49025-040, Aracaju, SE, tel. (79)40091362, sarah@cpatc.embrapa.com.br; (3) UFS Professor, tel. (79) 32126929, pviegas@ufs.br; (4)Researcher, Embrapa Coastal Tablelands, analedo@cpatc.embrapa.br; (5) M.Sc Student , Agricultural Engeneering UFCG, rossini_eng@hotmail.com

Propagation methods that make possible fast multiplication with less occurrence of genetic variability are very important to make available plantlets of new genotypes. In this context studies were carried out to evaluate the efficiency of an alternative protocol for micropropagation of the new pineaple cultivar Imperial, resistant to Fusarium disease. The in vitro etiolation of the plants was done in assay tubes wrapped with aluminum foil and kept under controlled environmental conditions. In a completely randomized design with six treatments and three replications, the MS medium was used, without plant growth regulator, added with NAA 1.86mg.L-1; IAA 1.75 mg.L-1; IBA 2.03mg.L-1 and GA3 1.73 mg.L-1 and 0.86mg.L-1. After sixty days the length of the etiolated sprouts and the number of nodes per sprout were the double of that ones obtained at thirty days with no significant difference among the treatments. To evaluate the potential of sprout proliferation in nodal etiolated segments, was used the MS medium, without plant regulator, added with BAP 1.0mg.L-1; BAP 2.0mg.L-1; BAP 1.0mg.L-1+ NAA 0.93mg.L-1; BAP 2.0mg.L-1+ NAA 1.83mg.L-1; Kinetin 5.4mg.L-1; 7.5mg.L-1 and 9.7mg.L-1. The design was a completely randomized one with eight treatments and seven replications. After evaluation of the number of nodes with bud proliferation at 30 and 60 days, all materials were transferred to the MS medium without plant growth regulator for sprout elongation. Fifty days after the transference was assessed the multiplication rate per node and per etiolated section, during one cultivation cycle (etiolation, proliferation into node sections and elongation of the sprouts). The rates of multiplication per node and per etiolated section were higher when was added BAP alone or combined with NAA. The increase of NAA concentration to 1.83mg.L-1 and BAP to 2mg.L-1 gave an increment of about 68% to the results obtained in a smaller NAA concentration. Considering all multiplication rates obtained in the different treatments studied over several cultivation cycles, it was shown that 61% of the total of the sprouts produced proceeded from the medium added with NAA 1.83mg.L-1 + BAP 2.0mg.L-1.

Effects of sucrose concentrations and culture period on in vitro rooting of *Ananas comosus* var. *erectifolius*

Ana Cristina Portugal Pinto de Carvalho (1), Cinthya Fontenele Vieira (2), Felipe de Sousa Barbosa (3), João Paulo S. de Morais (1)
(1) Embrapa Tropical Agroindustry (CNPAT), Rua Dra. Sara Mesquita 2270, Bairro Pici, CEP 60511-110, Fortaleza, Ceará, Brazil, cristina@cnpat.embrapa.br, (2) CNPq/ Embrapa Tropical Agroindustry, Rua Dra. Sara Mesquita 2270, Bairro Pici, CEP 60511-110, Fortaleza, Ceará, Brazil, cinthya.fontenele@hotmail.com (3) Federal University of Ceará, Campus do Pici, CEP 60455-760, Fortaleza, Ceará, Brazil, felipesbarbosa@gmail.com

The development of a root system efficient in absorption of water and nutrients is basically due to the factors that stimulate still in vitro the pre-adaptation to the autotrofic condition. Some strategies can be employed to make the plants more resistant to environmental stresses, increasing the survival rate during the acclimatization step. Changes in sucrose concentration in the culture media are frequently used to promote better rooting. The aim of this work was to evaluate the effect of sucrose concentrations and the culture period on in vitro rooting of micropropagated plants of Ananas comosus var. erectifolius. Three time periods of culture (35, 50 and 65 days) were studied, in the MS medium with 0.1 mg L-1 of ANA (naftalenoacetic acid), supplemented with three concentrations of sucrose (10, 20 and 30 g L-1). The experimental design was a completely randomized one with factorial scheme (3 x 3), with five replications and 20 explantes per plot. The evaluations were carried out at the final of the in vitro culture, based upon size of the largest root, average number of roots and fresh plant weight. Data were submitted to variance analysis (ANOVA) and the averages compared by the Tukey test at 5%. Results showed that for both parameters average number of roots and fresh mass plant, the best concentration of sucrose was 20 g L-1 and the best culture period was 50 days. For the size of the largest root, the higher value was recorded at 65 days. There was no statistical difference between levels of sucrose. Therefore, it is recommended for in vitro rooting of A. comosus var. erectifolius the use of 20 g L-1 sucrose and the culture period of 50 days.

Sucrose concentration effect in culture media and permanence time upon *Ananas comosus* var. *erectifolius* in vitro rooting

Ana Cristina Portugal Pinto de Carvalho (1), Cinthya Fontenele Vieira (2), Felipe de Sousa Barbosa (3), João Paulo Saraiva Morais (1)
(1) Embrapa Tropical Agroindustry (CNPAT), Rua Dra. Sara Mesquita, 2270, Bairro Pici, CEP 60511-110, Fortaleza, Ceará, Brazil, cristina@cnpat.embrapa.br, (2) CNPq/Embrapa Tropical Agroindustry, Rua Dra. Sara Mesquita, 2270, Bairro Pici, CEP 60511-110, Fortaleza, Ceará, Brazil, cinthya_fontenele@hotmail.com, (3) Federal University of Ceara, Campus do Pici, CEP 60455-760, Fortaleza, Ceará, Brasil, felipesbarbosa@gmail.com

The formation of an efficient root system for water and nutrient absorption is basically due to factors which promote an in vitro pre-adaptation to autotrophic condition. Some techniques can be employed to render plants more resistant to environmental stresses, what raises their survival rate throughout acclimatization stage. Sucrose concentration changes in the culture media are often used to improve rooting. The aim of this work was to evaluate the effect of different sucrose concentrations and in vitro permanence time at the rooting stage upon micropropagated shoots of Ananas comosus var. erectifolius. Three permanence times were tested (35, 50 and 65 days) in MS (Murashige & Skoog, 1962) culture media added of 0.1 mg L-1 of NAA (Naftalaneacetic Acid) and supplemented with three sucrose concentrations (10, 20 and 30 g L-1). The used experimental design was entirely randomized at factorial schema (3 x 3), with five repetitions and 20 explants per plot. The evaluations were made at the end of in vitro culture. The evaluated parameters were: average length of the longer root, average root number and plant fresh mass. Variance analysis of the data was carried out and means were statistically compared using Tukey's test at 0.05 of significance. By the obtained results, the fitter sucrose concentration was 20 g L-1 and permanence time was 50 days for average number root number and plant fresh mass. The longer average root length was recorded at 65 days and there was no statistical difference among the sucrose concentrations. Thus, it is recommended the use of 20 g L-1 of sucrose and permanence of 50 days for in vitro rooting of A. comosus var. erectifolius.

Session II Crop Management

MD-2 pineapple in Mexico: introduction, evolution and perspectives

Ana Lid del Ángel-Pérez, Andrés Rebolledo-Martínez. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, Campo Experimental Cotaxtla, km 34.5 Carret. Veracruz-Córdoba, Apartado postal 423, C.P. 91700, Medellín de Bravo, Veracruz, México. Tel: (228) 9348354, 9342926, rebolledoandres@yahoo.com.mx.

During the last 15 years, the global economy has determined new challenges for developing countries. In Mexico, the Free Trade Agreement with different economies has opened distant markets, especially for farming products. This situation has had impact on the pineapple production and has allowed some pineapple growers to access international markets, mainly in the United States. Ten years ago, Mexico cultivated just 'Smooth Cayenne' pineapples, and fresh fruit export did not exceed 4% of national production. At that time started the introduction of the MD-2 pineapple hybrid, the 'suckers' being obtained from Costa Rica and Guatemala. Now, there are 3500 ha cultivated with this variety, 30% of it in the reproductive phase and 70% in the vegetative phase, representing 25% of the total pineapple area in Mexico (14000 ha). There are 105 producers with large areas, representing 90% of the total pineapple area. As there are some differences in technological demands between 'Smooth Cayenne' and 'MD-2' pineapples, appropriate adjustments of cultivation practices have been worked out for local environmental conditions and will be addressed in the presentation. About 30% of the volume harvested has a direct fresh export channel, normally to the U.S.A., whereas the remaining volume is being sold to local exporting companies. In the domestic markets 'MD-2' fruit quality has often not been appreciated on the same level of international markets and prices have been rather similar to those of 'Smooth Cayenne' fruits, what has turned investments for 'MD-2' cultivation less attractive. Perhaps a stronger promotion scheme should be carried out. Nevertheless, a few companies have been successful in selective local markets. In addition to promotion measures, some other actions could contribute to increase 'MD-2' production in Mexico: credits for investments in packing houses, machinery and infrastructure, farms certification, technical and administrative training, searching of international market niches, and schemes of environmental protection. It can be estimated that until 2010 the area cultivated with 'MD-2' in Mexico should reach about 7000 ha, but the success of this business will depend on the capacity to compete with the Central American producers, to penetrate more into the markets of USA and Europe, to develop a stronger domestic market and to improve organization of the pineapple growers.

Cultivation of pineapple for upliftment of rural economy in Nagaland, India

Akali Sema. Reader & Head, Department of Horticulture, SASRD, Nagaland University, India, akali_chishi@yahoo.co.in

Nagaland, the 16th state of India, situated in the North Eastern part of the country, is known for its potentiality to grow all kinds of horticultural crop. Pineapple is one of the main focused crops with emphasis being given for commercialization in the state by the government. Pineapple cultivation is proving its potentiality in improving the livelihood of the rural people in the state. In Nagaland, pineapple has been growing since long traditionally, however with low productivity and scattered production. Pineapple fruits grown in the state are of excellent quality in terms of size, appearance, TSS and other aspects. The soil and climatic conditions are very congenial for its cultivation. In addition to this, pineapple has been cultivated organically by default. This has provided a great opportunity for a more organized organic pineapple cultivation focusing the global market. Progress has been made in cultivation and commercialization of pineapple in the state and many rural people have shifted from paddy cultivation, an age-old practice, to pineapple production and their livelihood has been improved to a great extent. In fact, many districts of Nagaland have now taken up pineapple cultivation on a commercial scale. With large-scale production of pineapple fruits the implantation of a processing unit has become viable and the state has opened perspectives to become a global player in organic pineapple trade. A case study on success stories will be presented in this work, showing the potentiality of pineapple to contribute to economic upliftment of the rural poor and improving their livelihood.

Net CO_2 exchange on 'D' leaf of 'MD-2' pineapple plants during a night-day cycle in Buenos Aires, Costa Rica

Alvaro Segura (1), Juan L. Morales (2), Fulvio Arias (2), Milton Vásquez(2)
(1) Bayer CropScience, San José, Costa Rica. P.O. Box 10018-1000, Phone (506) 243-6037, fax (506) 258-8594, alvaro.segura @bayercropscience.com. (2) Corporación de Desarrollo Agrícola Del Monte, Buenos Aires, Costa Rica. P.O. Box 4084-1000, Phone (506) 730-0155, fax (506) 730-0113, jlmorales@cr.freshdelmonte.com, farias@cr.freshdelmonte.com, mvasquez@cr.freshdelmonte.com

Field data were collected in order to assess the C assimilation by pineapple plants cv. MD-2 during a night day-cycle. The experiment was conducted in a commercial farm belonging to Del Monte Fresh Fruit Company, located in Buenos Aires, Puntarenas, Costa Rica (9°10´ N). A pineapple plantation (72,300 plants ha^{-1}) of the variety MD-2 with 7.7 months of age, planted on a typical Paleustults soil, was selected for the experiment. The CO_2 and H_2O exchange of the middle section of the 'D' leaf was continuously monitored every 30 minutes for 24 h from 11:09 h of November 25 to 11:09 h of November 26 of 2006. An ADC ® Infrared Gas Analyzer (IRGA) model LCA-4 was utilized for the field evaluations of the CO_2, H_2O and incoming Photosynthetic Active Radiation (PAR) as well. In addition, air temperature, global radiation, rainfall, and air humidity were assessed. The soil (10 cm depth) and leaf temperature (left section of the 'D' leaf) were monitored through an electronic sensor Marathon® model Echo F146-4K. There was a positive exchange of CO_2 (226.26 µmol m^{-2}) from 17:09 to 5:09 h. During this period two phases were identified. The first one from 17:09 to 24:09 h, with a total value of CO_2 assimilation of 156.64 µmol m^{-2} (66% of the total). The second phase, extended from 24:09 h to 5:39 h, with a total value of CO_2 assimilation of 69.62 µmol m^{-2} (34% of the total). Besides, there was a negative exchange of CO_2 (-203.79 µmol m^{-2}) from 6:09 h to 16:39 h. During this period two other phases were detected. During phase three, extended from 6:09 h to 12:09 h, there was a loss (-187.34 µmol of CO_2 m^{-2}). Finally, in the forth phase, extended from 12:39 h to 16:39 h, there was a negative exchange of -16.45 µmol of CO_2 m^{-2}. It was suggested that the negative balance of CO_2, observed during the day period, was probably produced by the night respiration plus CO^2 post-illumination burst. The total balance of the C exchange during the night/day cycle was 22.47µmol of CO_2 m^{-2}.

Recent evolution of pineapple research program at Cirad to meet consumers needs

A. Soler. UR26 Système de culture Bananier, Ananas et Plantain CIRAD-PRAM, Dpt PERSYST BP214 97285 Lamentin cedex2 Martinique, alain.soler@cirad.fr

Intensive agricultural practices have been developed for pineapple in most of the producing countries. Pineapple is a high density crop, up to 100 000 plants per ha ('Queen' in La Reunion Island), with yields over 100 tons of 'Smooth Cayenne' per ha (for processing). Sophisticated practices have been developed for crop management from land preparation to harvest, including planting material production and preparation, parasite control, fertilizer application and more. They also include different prophylactic means to reduce the initial infestation by parasites and to limit the use of pesticides. In many areas, pineapple means high productivity, high levels of fertilizer application and pesticides. And the intensive use of pesticides recommended by the researchers themselves has become an easy way to control the parasite multiplication enhanced by the high density of plants. Meanwhile, at farm level, producers tend to forget the simple prophylactic measures established long time ago. In our country, French West Indies, such a system of production has led to many problems as strong pollution of soils and water resources and human beings contamination. Under the pressure of consumers in order to preserve health and environment, the use of pesticides on pineapple farms has to be strongly reduced and is practically forbidden in EU territories according to the new EU regulations. Now the question for us is : How to produce good quality pineapple under reasonably intensive system of production and with virtually no pesticide ? We are trying to develop "zero pesticide" and/or "organic" systems of production for pineapple adapted to local requirements (farmer needs, cost of labour, consumers needs, specific environment on small islands). Different components of these systems of production are presently studied in CIRAD : - Development of new varieties with the same organoleptic quality but more tolerant to biotic and a-biotic stresses through a new program of hybridization and the study of the mechanisms of tolerance and resistance to soil born parasites and fruit cold storage for fruit. - Development of agricultural practices with no pesticides and particularly strong prophylactic measures and use of mulch; - Rotation of crops to improve soil health and characteristics; - And finally integrative studies through plant development modeling in relation with soil content in organic matter, nitrogen and other nutrients, and in relation with parasite populations. As researchers or extension agents, we need to bring a quick answer to these questions or pineapple industry may simply disappear from our areas.

Physical and chemical manipulation of flowering in pineapple

Chin Ho Lin. Department of Life Science, National Chung Hsing University, Taiwan, Republic of China, chinho@dragon.nchu.edu.tw

Forcing (induction of flowering) is an important agricultural practice in pineapple cultivation. Ethylene, a plant hormone, is responsible for the induction of flowering in pineapple. Hence by manipulating the ethylene production, flowering can be induced throughout the year irrespective of the weather factors. Gas chromatography (GC) analysis showed that the shoot apex was the most sensitive organ for the cold treatment (ice crystal) than the 'D' leaf. The shoot apex treated with ice particles showed two times higher ethylene liberation than the untreated plants. However, treating the pineapple plants with 1-2 applications of ice or ice water did not induce flowering under field conditions possibly due to inadequate dosage. Hence, additional experiments are required to find the optimum dose of ice or ice water to effect the desired forcing in 'Tainon 17'. Results of another experiment with chemical agents showed that a minimum of two applications (at weekly interval) of 1.0% CaC2 was found to be essential for complete forcing of 'Tainon 17'. However, the addition of activated charcoal (0.5-2.0%) did not show any significant effect on the bolting (inflorescence emergence). Based on these preliminary results, experiments are underway with 0.5% activated charcoal + different concentrations of CaC2 (0.25%, 0.5% and 1.0%) in order to find the cost-effective combination of activated charcoal (carbon) and the forcing agent.

Inhibitors of MD-2 pineapple natural flowering in Mexico: rate, number and date of application

Rebolledo M. Laureano, Uriza Á. Daniel E., Del Ángel P Ana Lid, Rebolledo M. Andrés. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Campo Experimental Cotaxtla-Sitio Experimental Papaloapan. Kilómetro 66 carretera Cd. Alemán-Sayula. Apartado Postal 43. Isla, Veracruz. México. rebolledo.laureano@inifap.gob.mx, uriza.daniel@inifap.gob.mx, rebolledo.andres@inifap.gob.mx, Phone/Fax (283) 8740443, Phone (229) 9384456

The objective of this work was to evaluate rates, number and dates of applications of Aviglycine (AVG) Aminoethoxyvinylglycine hydrochloride and CPA (Cloprop) 2-(3-chlorophenoxy) propionic acid for the inhibition of natural flowering (NDF) of MD2 pineapple. Two experiments were established by INIFAP in the pineapple farms of "Carmelita" and "Pinicola" located in Veracruz State. Site-1 had six months old plants, at density of 52000 plants ha^{-1}, with irrigation; Site-2 had eleven months old plants, at density of 31500 plants ha^{-1} and non- irrigated. At the beginning of the treatments, the fresh plant weight was 1.8 kg. The commercial products were ReTain at 15% AVG and for CPA and Cloprop, Fruitone and Pinoñe 8%. The experimental design was a randomized blocks one with four replications. At Site-1, the applications initiated October 25 (2006) and in Site-2 October 31; in both experiments, treatments 3, 4, 8 and 9 were scheduled to begin 14-days later. In total, 10 treatments were evaluated as follows indicated by product brand / application number / interval in days / rate in mg L^{-1}: 1) AVG/12/7/100; 2) AVG/6/14/100; 3) AVG/12/7/100; 4) AVG/6/14/100; 5) CPA-Fruitone /3/14/32; 6) CPA-Piñone/3/14/32; 7) CPA-Piñone/6/7/16; 8) CPA-Piñone/3/14/32; 9) CPA-Piñone/6/7/16; 10) Control. Foliar applications were made from 07:00 to 09:00 at 1750 L ha^{-1}. Although the plants at both Sites had similar weights but different densities, the results indicated for Site-2 an increase of the natural flowering in the control from 91% to 95% and 98% for January 23, February 30 and March 21, 2007 sampling dates, respectively, whereas under more favorable conditions in Site-1 results were 47%, 59% and 75%, respectively. In general, AVG was superior to CPA in inhibition and delayed premature natural flowering. Treatments 1 and 3, with most frequent applications were the best resulting in 12% and 6%, respectively, compared to the control at 75% for the accumulated sampling date of March 21 at Site-1. For CPA, treatment 6 resulted as the best at 44% at the same accumulated date. In both experiments, the inhibition treatments for natural flowering were significantly delayed by a minimum of 30 days. The commercial presentations of CPA Fruitone and Piñone had similar results.

A classification system for potassium availability in soils for growing pineapple in Guangxi

Hongwei Tan, Liuqiang Zhou, Xianhua Wang, Rulin Xie, Meifu Huang. Institute of Soil and Fertilizer, Guangxi Academy of Agricultural Sciences, 530007, China, hongwei_tan@163.com

For the study 37 field experiments were carried out on pineapple. Pineapple plant response to K as affected by the K status (available K) was measured and statistically analyzed. Calculated critical values depended on the soil texture, characterized as sands, loam soils and clays. For pineapple, primarily grown on light textured loamy sands, the critical value for available K was 43 mg kg^{-1}. The supply classes established for pineapple comprised < 43 mg kg^{-1} for low, 43-73 mg kg^{-1} for medium and >73 mg kg^{-1} for high K supply.

Preliminary DRIS norms for 'Smooth Cayenne' pineapple and derivation of critical levels of leaf nutrient concentrations

L.A.J. Teixeira (1), J.A. Quaggio (2) and F.C.B. Zambrosi (3)
(1) IAC/Centro de Solos e Recursos Ambientais. PO Box 28, 13012-970, Campinas (SP), Brazil, teixeira@iac.sp.gov.br. (2) IAC/Centro de Solos e Recursos Ambientais. PO Box 28, 13012-970, Campinas (SP), Brazil, quaggio@iac.sp.gov.br. (3) IAC/Centro de Solos e Recursos Ambientais. PO Box 28, 13012-970, Campinas (SP), Brazil, zambrosi@iac.sp.gov.br.

Preliminary diagnostic and recommendation integrated system (DRIS) norms and leaf nutrient critical levels (NCL) for 'Smooth Cayenne' pineapple growing in plantations of Sao Paulo State (Brazil) are presented. DRIS norms and NCL were established from a data bank of leaf nutrient concentration (N, P, K, Ca and Mg) and fruit yield with 104 samples. Data bank comprises information from four fertilizer experiments with 'Smooth Cayenne' conducted on a sandy and low fertility Alfisol located at the city of Agudos (22º30'S; 49º03'W) typical for this important pineapple production region in Brazil. The data were divided into high-yielding (>65 t/ha) and low yielding (<65 t/ha) sub-populations and norms were computed using standard DRIS procedures. These norms were developed with data from only one cropping region, so they should be considered as preliminary, probably requiring some modification as more data become available. The regression between nutrient balance index and fruit yield was significant (R2=0.44; p<0.0001). The NCLs were derived using multiple linear regression relating the foliar nutrient concentration with DRIS indices of all nutrients. The NCL for N, P, K, Ca, and Mg were 12.0, 0.92, 21.4, 4.0, and 2.8 g/kg, respectively. These values were similar to those presented in the literature, except for Ca whose value is lower for local conditions.

Development of a certifiable organic pineapple cultivation strategy for the Eastern Cape Region of South Africa

Dave N.A. Murray (1), Barry Manicom (2)
(1) Agricultural Research Council - Institute for Tropical and Subtropical Crops, E-mail, pga@albanynet.co.za; (2) Agricultural Research Council - Institute for Tropical and Subtropical Crops, barry@arc.agric.za

Globally, fresh and processed pineapple is readily available. The "exotic" status of pineapple is gone and its suppliers focus on creating and maintaining their respective competitive edge in the market place. Del Monte and their hybrid MD2 pineapple have been an example of this for some time now. A lucrative niche market has emerged for organic pineapple at both national and international levels. Strangely enough there even exists a sustained request for processed organic pineapple. Requested by the local Pineapple Growers Association, Eastern Cape, RSA, the development of a certifiable organic pineapple production strategy has been a recent focal point. In order that such a strategy be widely embraced by the small number of large local commercial producers, a "producer friendly" strategy was requested i.e. a possible reduction in the number of operations and the utilization of off-the-shelf certified inputs. Designed and developed over three separate phases, the strategy commences with a two year soil detoxification/conditioning period. Ideally, planting of vigorous, large slips will only occur once the desired soil health status has been achieved. Phase I natural plant crop harvest occurred in 2005/6 across various treatments aimed at root protection, insect and disease prevention and weed control. Plant crop organic production ranged between 104 and 71 t ha^{-1} whilst standard industry production averaged 73 t ha^{-1}. 1st ratoon harvest has commenced. Phase II trial, planted September 2007, will focus mainly on the possible benefits of lay crops and soil-life innoculation.

Response of pineapple 'Cayenne Champac' to inoculation with diazotrophic bacteria and organic fertilization in irrigated orchard with tropical sapota intercropping

O. B. Weber, C. T. Bandeira, R. N. de Lima, L. A. Crisóstomo, A. C. P. P. de Carvalho, J. de A. D. de Freitas, F. R. de Miranda .
Embrapa Tropical Agroindustry, Rua Dra. Sara Mesquita, 2270, Pici, CEP 60511-110, Fortaleza, Ceará, weber@cnpat.embrapa.br, clodion@bandeira.com, rlima@cnpat.embrapa.br, lindberg@cnpat.embrapa.br, cristina@cnpat.embrapa.br, ari@cnpat.embrapa.br, fabio@cnpat.embrapa.br

Fruitculture has been prominent in the Brazilian Northeast because of favorable weather conditions, the infrastructure to support the production and export incentives. Among various species exploited in the region, mainly on irrigated areas, the pineapple crop is cited. The objective of this work was to obtain pineapple 'Cayenne Champac' (Champaka) plantlets and to evaluate their response to diazotrophic bacterial inoculation and organic fertilization in an irrigated orchard. After proliferation and the elongation of explantes on artificial medium (MS), they were transferred to a mixture of vermiculite and earthworm compost (ratio 2:3) of tubets (288 cm^3) in greenhouse. After that they received a inoculum containing Asaia bogorensis (108 cells $plant^{-1}$). After five months of acclimatization in the greenhouse (September, 2005), controls and inoculated plants were planted into soil by using double rows (1.10m x 0.25m x 0.40m) within the interspace of na tropical sapota orchard. The basic fertilization was applied in grooves (May, 2005) and coverage (March and September, 2006) and consisted of three doses (2.5, 5.0 and 7.5 L linear m^{-1} on double row) of three composts. Shortly before transferring to field conditions, the plant-bacteria association was confirmed, and inoculated plants weighed 152g (12.6g dry mass), while non-inoculated weighed 116 grams. The plant survival during the acclimatization phase and under field conditions was over 99%. Inoculated plants presented longer leaves when compared to controls, until flowering phase in the field. The highest dose of compost aplied into planting grooves and as coverage resulted in better plant vigour and produced fruits weighing more than three kilograms. These results may suggest that the production of organic pineapple is an alternative to be considered under irrigated conditions in Northeast Brazil. Finacial support: BNB, Bonafrux and Embrapa.

Leaf nutrient concentration and yield of 'MD-2' pineapple as a function of NPK fertilization

André Guarçoni M.(1), Víctor Hugo Alvarez V.(2), José Aires Ventura (3), Joelson Sutil Jesus Ferreira (4)
(1) Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural - INCAPER, CRDR-Centro Serrano, CEP 29.375-000, Venda Nova do Imigrante - ES, Brasil, guarconi@incaper.es.gov.br; (2) Departamento de Solos, Universidade Federal de Viçosa, Av. PH Rolfs, sn. CEP 36570-000, Viçosa - MG, Brasil, vhav@ufv.br; (3) INCAPER - Sede, CEP 29001-970, Vitória - ES, Brasil, ventura@incaper.es.gov.br; (4) INCAPER, CRDR - Linhares, CEP 29900-97

The pineapple 'Gold' ('MD-2') has attracted attention in Brazil aiming at exportation. However, there is little local scientific information on nutritional management of this particular cultivar. This work had the objective to determinate the effect of NPK fertilization on leaf primary macronutrients concentrations, at floral induction time, and on crop yield. It was carried out in Sooretama, Espirito Santo State - Brazil, in a dystrophic Red-Yellow Latosol after liming at 0-20 cm depth. Planting spacing was 0.90 x 0.40 x 0.30 m (51,280 plants/ha) and crop was irrigated by a sprinkle system. Five doses of N (urea, four fractions), five doses of P_2O_5 (triple superphosphate, at planting) and five doses of K2O (KCl, four fractions) were studied, as combined according to an experimental matrix Plan Puebla III (2k + 2k + 1), plus one treatment (without NPK application), with minimal and maximum limits of 0 to 1,000 (N), 0 to 400 (P_2O_5) and 0 to 1,000 kg/ha (K_2O), comprising 16 treatments. N, P and K concentrations of 'D' leaves were determined at flowering forcing date. Fruit diameter (FD) and fresh mass with (FFMC) and without (FFM) crown, as well as crop yield using FFMC data wer also determined. Statistical models were tested to relate those characteristics with N, P_2O_5 and K_2O doses. For crop yield, FFMC and FD was observed a positive linear effect of P and K and a square effect of N, being the maximum values reached with N doses of 620.15, 620.15 and 570.13 kg/ha, respectively. Considering these N doses, and also using the highest P_2O_5 and K_2O doses, the maximum yield estimated was 68.6 t/ha, with FFMC of 1,340 g and FD of 11.73 cm. Phosphorus did not show significant effect for FFMC, but there was a positive linear effect of K and squared one of N, with maximum N dose of 635,1 kg/ha of N and maximum FFMC of 1,054 g. In order to reach maximum crop yield, 'D' leaf concentrations of N, P and K were estimated to be 1.54, 0.20 and 3.72%, respectively.

Pineapple 'MD-2' fruit quality as affected by NPK fertilization

André Guarçoni M. (1), Víctor Hugo Alvarez V. (2), José Aires Ventura (3), Joelson Sutil Jesus Ferreira (4).
(1) Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural - INCAPER, CRDR-Centro Serrano, CEP 29.375-000, Venda Nova do Imigrante - ES, Brasil, guarconi@incaper.es.gov.br; (2) Departamento de Solos, Universidade Federal de Viçosa, Av. PH Rolfs, sn. CEP 36570-000, Viçosa - MG, Brasil, vhav@ufv.br; (3) INCAPER - Sede, CEP 29001-970, Vitória - ES, Brasil, ventura@incaper.es.gov.br; (4) INCAPER, CRDR - Linhares, CEP 29900-970, Linhares - ES, Brasil.

The pineapple 'Gold' ('MD-2') has attracted attention in Brazil aiming at exportation. However, there is little local scientific information on the effect of NPK fertilization on fruit quality. This work had the objective to determinate the effect of NPK fertilization on the total tritable acidity (TTA) and total soluble solids (TSS) in pineapple fruits. It was carried out in Sooretama, Espirito Santo State - Brazil, in a dystrophic Red-Yellow Latosol after liming to 0-20 cm depth. The crop was spaced by 0.90 x 0.40 x 0.30 m (51,280 plants/ha) and irrigated by a sprinkle system. Five doses of N (urea, four fractions), five doses of P_2O_5 (triple superphosphate, at planting) and five doses of K_2O (KCl, four fractions) were studied, as combined according to an experimental matrix Plan Puebla III (2k + 2k + 1), plus one treatment (without NPK application), with minimal and maximum limits of 0 to 1,000 (N), 0 to 400 (P_2O_5) and 0 to 1,000 kg/ha (K_2O), comprising 16 treatments. Right after fruit harvest its TTA (% citric acid) and TSS were determined. Statistical models were tested to relate those characteristics with N, P_2O_5 and K_2O doses. Fruit acidity was reduced as N doses increased. A squared effect of P and K on TTA was observed and maximum values were reached with 205.8 kg/ha P_2O_5 and 703.4 kg/ha K_2O. For TSS, there was observed a positive linear effect of P and K, and a quared one of N, with 299.2 kg/ha N as maximum estimated dose. The maximum values estimated for TTA and TSS were 0.47% and 16.26 ºBrix, respectively.

Foliar fertilization before and after flowering forcing in 'Pérola' pineapple plants in the region of Miracema do Tocantins, Brazil

Diego Noleto Luz Pequeno, Susana Cristine Siebeneichler, Rogério Braga Maciel Garcia, Miréia Aparecida Bezerra Pereira, Gentil Cavalheiro Adorian, Rogério Lorençoni, Ana Flávia Santos Coelho . Universidade Federal do Tocantins - UFT-TO, Fone 63 33113532, Fax 63 33113501, diegopequeno@uft.edu.br, susana@uft.edu.br, abacaxi_rogerio@hotmail.com, mireiaaparecida@yahoo.com.br, gentil.cav@uft.edu.br, rogeriolorenconi@uft.edu.br, anaflavia@uft.edu.br.

The pineapple crop has great economic expression in the State of the Tocantins, however its production system is based on cultural practices used in other pineapple growing regions of Brazil. It is well known that some of those practices are not adjusted to the environmental conditions of that State. In this work the effects of number and time of application of foliar fertilization were studied. The experiment was carried out in a randomized block design with factorial scheme 2x5, with four replications. Two periods of applications were evaluated: (a) from sixth month after the planting up to flowering forcing, and (b) from 21 days after forcing, both with duration of four months, and five treatments varying in the number of applications. Planting was performed by the end of November/2004 and 10g SSP, 10g of Yorin® and 4g of FTE® were supplied per plant. Three fertilizer applications, 15g/plant of the formula 20-05-20, were carried out at the third, fourth and fifth months after planting. Foliar fertilization (acid boric, 0.0%; zinc sulfate, 0.04%; magnesium sulfate, 2%; urea, 4%; and potassium chloride, 4%), 400L ha^{-1}, were performed as follows: T1: 21 applications; T2: 16 applications; T3: 11 applications; T4: 6 applications and T5: no applications. Evaluation was based on qualitative and quantitative parameters. Samples, three fruit per plot, total of 12 fruits per treatment, were collected for qualitative evaluation. In general, fertilizations after flowering forcing treatment showed no significant effect on yield. On the other hand, total soluble solid (TSS) concentration, total tritable acidity (TTA) and crown weight increased, independent on number of applications. Regarding to foliar fertilization before flowering induction it was observed that 21 applications contributed to increase fruit weight without crown, thus increasing yield. It was observed significant reduction of crown weight due to 16 applications before treatment to induce flowering. Regardless ot time of fertilization, 16 applications increased the fruit juice content. In general, foliar fertilization before flowering forcing treatment did not influence fruit qualitative characteristics evaluated (TSS, TTA, relation TSS/ATT and fruit juice content).

Modelling of potassium fertilization for 'Pérola' pineapple crop using FERTCALC®-Abacaxi

A.P. Silva (1), A.P. Souza (2), A.A.Rodrigues (3), R.M.N. Mendonça (2), D. Santos (2), L. P.F. Lima (4)
(1) PRODOC-CAPES of Graduation Programa of Soil and Water Management (PPGMSA), Areia, PB, Brasil, paivadasilva@gmail.com, (2) Universidade Federal da Paraíba, Areia, PB, Brasil, adailson@cca.ufpb.br, rejane@cca.ufpb.br, santosdj@cca.ufpb.br, (3) Agronomy GraduationProgram, Centro de Ciências Agrárias, Areia, PB, Brasil, alessaagro@gmail.com (4) Bolsista PIBIC/CNPq, Universidade Federal da Paraíba, Areia, PB, Brasil luizpaulopp@yahoo.com.br

The use of Systems or Models for recommendation, as for example the FERTCALC®-Abacaxi, is a promising alternative to improve the efficiency of potassium fertilization of pineapple crops, but there is a need for calibration and validation of the system under especific environmental conditions. The objectives of this work were: a) to evaluate the effect of potassium fertilization on 'Pérola' pineapple yield; b) to evaluate the performance of FERTCALC®-Abacaxi under the environmental conditions of the mesoregion of Santa Rita, Paraiba, Brazil. The experiment was carried out under rainfed conditions in a soil classified as Ironcarbic Espodosol, of sandy texture and with low K content (29,1 mg/dm3). The experimental design was in randomized blocks with three replications. Five K doses recommended by FERTCALC®-Abacaxi were studied for obtaining yields of 15; 30; 45; 60 and 75 t ha^{-1}. Potassium doses were applied as potassium chloride at two, six and nine months after planting and corresponded respectively to 0; 180; 390; 622 and 878 kg ha^{-1} of K_2O. At harvest, data of total fruit production were obtained and adjusted to regression equations as function of doses. The performance of FERTCALC®-Abacaxi was assessed by means of comparitions between simulated and quantified productivities of the experiment. The increase of the K dosis promoted significant effects ($p < 0,01$) on total production of fruits. Production data adjusted themselves to the linear regression model ($y = 51,41 + 0,0072^{**}K$; $R^2 = 0.98$) reaching at the highest dosis the maximum production of 57.73 t ha^{-1}. The FERTCALC®-Abacaxi system subestimated yields at the lower doses, registering reductions of 70; 42 and 17% of the yields simulated by FERTCALC®-Abacaxi , respectively for the doses of 0; 180 and 390 kg ha^{-1} of K_2O in relation to the ones quantified in the experiment. At the highest doses of K (622 and 878 kg ha^{-1} of K_2O) the system superestimated the quantified yields by 7.0 and 30%, respectively. Results demonstrated a better prediction capacity of the system at higher doses and the need for reevaluating its structure in order to improve the recommendation quality.

Pineapple sugar metabolism and accumulation during fruit development

Zhang Xiumei (1,2), Du Liqing (1), Xie Jianghui (1), Li Jiangui (2), Sun Guangming (1)
(1) South Subtropical Crop Research Institute, Chinese Academy of Tropical Agricultural Science, Zhanjiang Guangdong 524091 China, gm-sun@163.com. (2) College of Horticulture, South China Agricultural University Guangzhou, Guangdong 510642 China

Developmental changes in pineapple fruit sugar accumulation were determined for the cultivars Yellow Mauritius and Tainung 11. The contents of sucrose, glucose, fructose and the activities of sucrose-metabolizing enzymes, including acid invertase (AI), neutral invertase (NI), sucrose synthase (SS) and sucrose phosphate synthase (SPS) during fruit development were measured and the correlation between the sugar accumulation and the enzymes activity was systemically analyzed. Results showed that the patterns of sugar accumulation for 'Yellow Mauritius' and 'Tainung 11' were similar, sugar accumulations in both cultivars were very slow during the first stage of fruit development. Sucrose accumulated sharply during ripe stage, while the contents of fructose and glucose reduced slightly. The correlations between the sucrose content and the activities of SS and SPS were significant or extremely significant in both cultivars. The content of sucrose presented an extremely significant negative correlation with NI activities in both cultivars. The correlation of the sucrose content and the AI activities was significantly different between the two cultivars.

Key-words: Ananas comosus var. comosus, invertase, sucrose synthase, sucrose phosphate synthase.

Session III Plant Protection

Molecular diversity of pineapple mealybug wilt associated viruses and pineapple badnaviruses in Hawaii

Sether, D. M., Melzer, M. J., Subere, C.V.Q., and Hu, J. S. University of Hawaii at Manoa, Department of Plant and Environmental Protection Sciences, Honolulu, HI 96822 USA, johnhu3002@gmail.com

Pineapple mealybug wilt associated virus-1 (PMWaV-1), PMWaV-2, and PMWaV-3 are mealybug transmitted Ampeloviruses that infect pineapple plants. The complete genome of PMWaV-1 contains seven open reading frames (ORFs). The genome organization of PMWaV-1 was distinct from PMWaV-2 and other ampeloviruses with the lack of an intergenic region between the RNA dependent RNA polymerase (RdRp) and p6 ORFs, a small coat protein (CP), and the absence of a duplicate CP. PMWaV-3 shares 63.9%, 72.5%, and 79.2% amino acid (aa) identity with PMWaV-1 for the RdRp, small hydrophobic protein, and HSP-70h ORFs, respectively. Tentative PMWaV-4 shares 86.8%, 31.9%, and 72.0% aa sequence identity in the HSP-70h with PMWaV-1, PMWaV-2, and PMWaV-3, respectively. Based on the 1818 bp of sequence available, PMWaV-4 is a distinct virus from PMWaV 1, 2, and 3. Phylogenetic analyses placed PMWaV-1, PMWaV-3, PMWaV-4, Plum bark necrosis stem pitting associated virus, and some Grapevine leafroll associated viruses in a distinct clade within the genus Ampelovirus. Bacilliform-shaped particles morphologically similar to Badnaviruses (Caulimoviridae) have been identified in pineapple. Oligonucleotides degenerate for the conserved sequences in the reverse transcriptase, RNase H, and protease regions of badnaviruses were used in PCR assays to identify badnavirus-like sequences from commercially-grown pineapple plants in Hawaii. Sequences of resulting amplicons revealed the presence of at least four different clades, designated A, B, C, and D. Sequence similarity of the 200 amino acids spanning the RT/RNase H region within each clade is above 98% and between clades ranges from 46% to 86%. Sequences associated with the B clade contain a stop codon, suggesting a nonfunctional sequence, and possible integrated remnants of a pararetrovirus or retroelement. Specific PCR and DIG-based assays have been developed to detect and distinguish the variants amplified from field pineapple samples. The phylogenetic relatedness of clades A, B, C, and D to other badnaviruses, other Caulimoviridae members, and retro-like elements, and the survey data are presented and discussed.

Identification of RAPD markers linked to a major fusariosis resistance gene in pineapple

Davi Theodoro Junghans (1), Helison Santos Brasileiro (2), Lívia de Jesus Vieira (3), José Renato Santos Cabral (1)
(1) Embrapa Mandioca e Fruticultura Tropical. Cruz das Almas - BA CEP 44380-000. Phone: 55 75 3621 8062, davi@cnpmf.embrapa.br, jrentato@cnpmf.embrapa.br (2) Agronomy student. Universidade Federal do Recôncavo da Bahia, Cruz das Almas - BA, Brasil, helcomgeo@yahoo.com.br (3) Biological Sciences student. Faculdade de Ciências e Tecnologia, Salvador, BA, Brasil, liviabiol@gmail.com

Fusariosis, caused by the fungus *Fusarium subglutinans* f. sp. ananas, is the main pineapple disease in Brazil. The incidence in fruits can be higher than 80% in wet and cold conditions. ´Pérola` and ´Smooth Cayenne` (SC), the most planted cultivars in Brazil, are both susceptible to the disease. Genetic resistance is the most efficient measure to control this disease. Resistant materials have been identified and used in the pineapple breeding program at Embrapa. Recently it was established that a major and dominant gene controls the genetic resistance to fusariosis. A major gene is observed in cvs. Perolera (PE) and Primavera (PRI). Two backcrossed populations with different sources of resistance, (PE x SC-73) x SC, with 192 plants and (PRI x SC-11) x SC, with 388 plants, were used to identify RAPD molecular markers genetically linked to the resistance locus. Bulked segregant analysis was used to speed up the polymorphic molecular markers detection. Four DNA bulks were used: two of resistant plants (R) and two of susceptible plants (S). A total of 763 primers were evaluated and 60 of them generated polymorphic markers between R and S DNA bulks. These primers were evaluated again in each individual that composes the bulks. Five primers confirmed the linkage between polymorphic markers and the resistance gene. None of them amplified markers linked to the two sources of resistance, indicating that ´Perolera` and ´Primavera` have different resistance genes. The primers OPX-09 and OPM-6 generated markers in repulsion to the major resistance gene in (PRI x SC - 11) x SC population. The primers OPAL-14, OPAH-13 and OPY-06 generated markers in coupling to the major resistance gene in (PE x SC - 73) x SC population. For measuring the genetic distances between these markers and the major resistance gene all the individuals of each population will be evaluated with the selected primers. The RAPD markers genetically closer to the major resistance gene will be converted into SCAR markers. These markers could be used in an early selection of resistant pineapple genotypes.

Alternative control of pineapple fusariosis

R.A. Carvalho, E.F.de Oliveira, J.T.de Lacerda, M.B. Neto, J.X. de Araújo
Empresa de Pesquisa Agropecuária da Paraíba (EMEPA-PB), Rua Eurípedes Tavares, 210 João Pessoa, Paraíba, Brasil, remuloc@hotmail.com

Brazil is the largest pineapple producer in the world with high yields and excellent fruit quality. However, despite the development of technologies for the pineapple crop, huge losses still occur due to high incidences of fusariosis disease, a devastating fruit rot caused by the fungus Fusarium subglutinans f. sp. ananas which attacks not only the fruit, but also the whole plant and its slips which are used as planting material. Traditionally, the control of this disease is based on preventive applications of chemical fungicides. An alternative control program for pineapple fusariosis has been carried out since 1996 at the Pineapple Experimental Station at Sapé, Paraíba, Brazil, in which tannins of medicinal trees have been tested against the fungus F. subglutinans in laboratory and field experiments. However, despite the existence of many tree species rich in tannins in Brazilian rainforests, severe environmental regulations prohibit their utilization in agricultural IPM programs. Therefore, this research had the objective to study the effect of tannins from the cultivated black wattle tree (Acacia mearnsii) and of citrus extracts (traded as Ecolife) on the control of pineapple fusariosis. A field experiment was carried out in a randomized block design with 16 treatments and 4 replicates during the raining season, which favours the disease. Black wattle tannins and citrus alternative products (rich in vitamins and phytoalexins) were applied as aqueous extracts during the flowering period in substitution to fungicides. Evaluations at harvest showed a significant reduction in the incidence of fusariosis from 25.77% in the control treatment to 6.52% in the citrus extracts treatment and to 3.32% in the black wattle tannin treatment. Therefore, this research has shown that an environment friendly alternative control of pineapple fusariosis disease can be achieved by using vegetable extracts rich in tannins and vitamins which are natural plant defence substances.

How to evaluate the resistance or tolerance of pineapple varieties to nematodes?

A.Soler (1), P.A. Marie-Alphonsine (1), P. Topart (2), P. Queneherve (2)
(1) UR26 : Système de culture Bananier, Ananas et Plantain, Dpt PERSYST, Cirad -PRAM, BP214, 97285 Lamentin cedex2 , Martinique, alain.soler@cirad.fr. (2) UMR IRD-CIRAD-UM2 "Résistance des plantes aux bioagresseurs", Pôle de Recherche Agroenvironnemental de la Martinique, BP 214, 97285 Le Lamentin, Martinique

Under the pressure of consumers, the use of nematicide on pineapple farms must be strongly reduced and is presently forbidden in EU territories according to the new EU regulations. Different ways to control soil born parasites are under investigation and the research for tolerant or resistant varieties to nematodes is one of them. In Martinique a screening method is being developed based on greenhouse cultivation in tanks. The behaviour of different varieties from CIRAD germplasm is observed either after the development of specific nematode population *(Rotylenchulus reniformis*) through multiplication on *Vigna* sp before pineapple planting, either after nematode eradication by a 2-months flooding period in the tanks. Growth characteristics and nematode populations are observed during six months covering the classical two flushes of root development observed in our tropical conditions. ´D` leaves weight and length as well as plant opening are measured every month, plant weight and root system are measured at six months after planting. Preliminary results indicate that plants of the reference cultivar Smooth Cayenne show a sensitive pattern with strong vegetative growth reduction, meanwhile MD-2 plants show a tolerance pattern with a high multiplication of nematodes but a relatively reduced effect on growth. Among *Anassoïdes* sp, one variety shows a strong resistance pattern with little impact on vegetative growth, and another one shows a behaviour similar to the MD-2 one. CIRAD hybrids show also different patterns from high sensitivity to good tolerance. This method will be used to detect potential parents for the breeding programme, to evaluate new hybrids and to identify well-contrasted behaviours in order to study resistance/tolerance mechanisms to nematodes in pineapple.

Host Delivered RNAi: An effective strategy to control plant parasitic nematodes

David J. Fairbairn, Antonino S. Cavallaro, Margaret Bernard, Janani MahalingaIyer, Michael W. Graham, José Ramón Botella
Plant Genetic Engineering Laboratory, Department of Botany, School of Integrative Biology, University of Queensland, Brisbane 4072, Australia, Phone (+61) 7 3365 1128, Fax (+61) 7 3365 1699, j.botella@uq.edu.au

Root-knot nematodes (*Meloidogyne* spp.) are obligate, sedentary endoparasites that infect many plant species causing large economic losses worldwide. They have the ability to infect hundreds of plant species, which often lack natural resistance. Available nematicides are being banned due to their toxicity or ozone-depleting properties and alternative control strategies are urgently required. We have produced transgenic tobacco (*Nicotiana tabacum*) plants expressing different dsRNA hairpin structures targeting a root-knot nematode (*Meloidogyne javanica*) putative transcription factor, MjTis11. We provide evidence that MjTis11 was consistently silenced in nematodes feeding on the roots of transgenic plants. The observed silencing was specific for MjTis11, with other sequence-unrelated genes being unaffected in the nematodes.

Those transgenic plants able to induce silencing of MjTis11, also showed the presence of small interfering RNAs. Even though down-regulation of MjTis11 did not result in a lethal phenotype, this study demonstrates the feasibility of silencing root-knot nematode genes by expressing dsRNA in the host plant. Host Delivered RNA Interference-triggered (HD-RNAi) silencing of parasite genes provides a novel disease resistance strategy with wide biotechnological applications. The potential of HD-RNAi is not restricted to parasitic nematodes but could be adapted to control other plant-feeding pests.

The effect of different cover crops (green manure) on nematode populations and yield in Queen pineapple cultivation

E.C. Rabie, H.A. Tustin. ARC-Institute for Tropical and Subtropical Crops, Hluhluwe Pineapple Research Station, P.O. Box 194, Hluhluwe 3960, South Africa, Tel +27 355620352, Fax +27 355620008, erabie@mtuba.co.za

In Queen pineapple cultivation a huge amount of vegetative material is removed as suckers for new plantings and very little is put back into the soil. A standard practice is to leave the land fallow for three years, followed by fumigation with EDB before replanting with pineapples. Later in the season, chemical nematicides are used for nematode control. In this trial, the effect of inter cropping with a cover crop to enhance soil fertility and/or control nematodes was determined. Four crops (velvet bean - *Stizolobium* sp., dolichos bean - *Dolichos* sp., cow peas - *Vigna* sp., sunn hemp - *Crotolaria* sp.) and a control (fallow) were planted in a randomized block design. After incorporating the green material of each cover crop into the soil, half of each plot was fumigated with EDB. Results showed that fumigated plots performed better than the non-fumigated plots both for yield and nematode control. The sunn hemp + EDB treatment had the highest yield with 73.2 t/ha followed by fallow + EDB with a yield of 71.6 t/ha. In the non-fumigated treatments, fallow produced the highest yields with 49.39 t/ha followed by sunn hemp with 39.1 t/ha. In the non-fumigated treatments, nematode numbers ranged from 120 nematodes in 10g roots in sunn hemp to 2000 nematodes in 10g roots in dolichos bean, having a direct effect on yield. Only sunn hemp can be considered in a rotation system. Velvet bean which is supposedly resistant to *Pratylenchus brachyurus* proved to be susceptible and was not able to keep the nematode numbers down in the pineapple crop.

Use of surround as protector of 'MD-2' pineapple fruits against solar radiation

Uriza Á. Daniel E., Rebolledo M. Laureano, Del Ángel P Ana Lid, Rebolledo M. Andrés. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Campo Experimental Cotaxtla-Sitio Experimental Papaloapan. Apartado Postal 43 Km 66 carretera Cd. Alemán-Sayula. Isla, Ver. México, rebolledo.laureano@inifap.gob.mx; uriza.daniel@inifap.gob.mx; rebolledo.andres@inifap.gob.mx.

In Mexico, the pineapple growers have to protect the fruit against the solar radiation throughout the year. In spite of the costs involved, fruits have to be covered with paper or with the plants leaves. The objective of this work was to evaluate the effectiveness of the Surround product for the protection of pineapple fruits against the solar radiation. The experiment was carried out in Veracruz, Mexico, at 18º06' latitude North, 95º31' longitude West and 50 m of altitude. The product was applied on March 2006 on 'MD-2' pineapple plants, grown at density of 50000 plants ha^{-1}. The experimental design was a randomized blocks one in split plot with three replications; in the large plots were studied application forms of the product: 1) total (on plant and fruit) and 2) only on the fruit. In the small plots the treatments were the following: 1) Control, 2) 25 kg ha^{-1} of Surround 3) 50 kg ha^{-1} of Surround, 4) 100kg ha^{-1} of Surround, 5) Protection of fruits with the own leaves of the plants, 6) 60 kg ha^{-1} of $Ca(OH)_2$ and 7) 120 kg ha^{-1} of $Ca(OH)_2$. The variables evaluated were: a) fruit skin damage based on the following levels: one, light damage, not accepted on the export market; two, intermediate damage, not accepted on both export and local markets; and three, strong damage, not accepted on any market; b) relative water content and c) temperatures on the east and west sides of the plant and fruit. The temperature was taken at 14:00 p.m. with an infrared thermometer. Results showed that the treatment with leaves protection did not permit any damage to the fruits while the others presented solar radiation damage (p=0.05), 34% of it type level one, 55% was level two and 11% level three. The temperature on the fruit west side in the treatment with leaves protection was 38.6ºC, while in the other treatments the temperature was 3.6ºC higher. There was no significant difference (p=0.05) among treatments for relative water content, with values ranging around 85%.

Session IV Alternative Uses

Breeding *Ananas* for the cut-flower and garden markets

G.M. Sanewski. Department of Primary Industries and Fisheries, Maroochy Research Station, PO Box 5083 SCMC. Nambour, Qld. Australia, Ph: +61 7 54449650. Fax: +61 7 54412235, garth.sanewski@dpi.qld.gov.au.

The Bromeliaceae plant family contains many spectacular ornamentals. *Ananas* is the only genera that has not been exploited significantly in this way, but is used mainly for fruit production and to a lesser extent fibre and pharmaceuticals. Only small quantities of *Ananas* have been marketed as cut flowers or for garden use. There have been, until very recent times, no breeding programs to develop ornamental characteristics and hence the choice of varieties has been limited mainly to semi-domesticated selections or those developed by amateur enthusiasts. Interest in developing *Ananas* selections specifically for the ornamental market is now increasing and a small program has operated in Australia since 1995. In this program, a total of 4,700 seedlings were produced over three generations using various parental combinations including *Ananas comosus* var. *comosus*, *A. comosus* var. *bracteatus*, *A. comosus* var. *ananassoides*, *A. comosus* var. *erectifolious* and *Ananas macrodontes*. Several varieties have been selected for the garden and cut flower market. Selected lines include varieties having a bright pink or red syncarp, dark red-brown foliage and a dwarf, clumping habit. While a surprising display of ornamental diversity exists within *Ananas*, the genus is very limited in comparison with the other Bromeliaceae. Opportunity might exist however, to introgress characteristics such as additional foliage colours and morphology and syncarp colours from other genera into *Ananas*.

Curaua - A newcomer fiber for industrial applications

Alcides Lopes Leão, Isaac Stringueta Machado, Sivoney Souza. UNESP - Campus de Botucatu; Faculdade de Ciências Agronômicas, alcidesleao@fca.unesp.br

In textile world curaua is a new emerging fibre, with small yet applications. Nevertheless other applications are largely used, mainly automotive industry and in the past for hammocks and fishing nets. To widen the use of curaua and to find new applications for that natural cellulosic fibre in textiles we have to consider all parameters important in spinning and in yarn processing. The present paper shows the similarities and differences between curaua and well-known vegetable fibres like flax, hemp, ramie, jute, sisal and abaca. So, curaua is similar to all bast and leaves fibres in length, strength and elongation being of higher linear mass (similar to jute and sisal, yet stronger than the last two fibres. The plant, CURAUA - *Ananas comosus* var. *erectifolius* - is a hydrophylous species from the Amazon region. Its leaves are hard, erect and have flat surfaces. The leaves are about one meter long, or more, and 4 cm wide. The plant requires 2,000 mm or more of annual precipitation, preferring silil-humus soils, but also grows in clay-sillic soils. It is commonly used by the indigenous as a favorite plant for fibers utilization for hammocks and fishing lines. Eight months old leaves can reach up 1.5 m in length, and 50-60 leaves per year. The dry fiber content in leaves is about 5-8%. The fiber is commonly extracted by a primitive process called "forca" (hanger), washed and beaten with a circular rod and left in water in order to mercerize for 36 hours. They are again washed and allowed to dry. In the presentations are described the main constraints and advantages of the utilization of curaua fibers in composites, as well the production aspects, such as in vitro cultivation, production and fiber processing, aiming textiles and composites applications. Natural curaua fiber (wet) shows an average elongation of 4.5%, MOE of 10.5 GPa, and MOR 439 MPa. Dry fiber (OD) values are respectively 3.2%, 27.1 GPa, and 117 MPa. Cutted and defibred the values are respectively 3.7%, 9.7 GPa, and 428 MPa. Cutted, defibred and dried (OD), the values are respectively 4.3%, 11.8 GPa, and 502 MPa. UNESP have been developing a large program of in vitro cultivation for the seedlings production based on positive characteristics useful for the industrial applications. On the other hand several trials have been made in the industrial side to demonstrate for the auto industry that curaua fibers is a viable alternative to replace not only glass fibers but as well as polypropylene and blends of polypropylene with talc. In this case, Volkswagen of Brasil and Pematec Triangel of Brasil are UNESP partners in the development of interior parts, mainly for the FOX models.

Evaluation of new hybrids of ornamental pineapples

Fernanda Vidigal Duarte Souza (1), José Renato dos Santos Cabral (1), Janay Almeida dos Santos-Serejo (1), Francisco Ferreira Ricardo (2), Olívia dos Santos Nepomuceno (2), Everton Hilo de Souza (3)
(1) Embrapa Mandioca e Fruticultura Tropical, Caixa Postal 007, CEP 44380-000, Cruz das Almas, Bahia, Brasil, Phone 55 75 3621 8059, Fax 55 75 3621 8096, fernanda@cnpmf.embrapa.br (2) Embrapa Recursos Genéticos e Biotecnologia, Caixa Postal 02372, CEP 70.770-900, Brasilia-DF, Brasil (3) Undergraduate Student of Agronomy, Universidade Federal do Recôncavo da Bahia (UFRB), CEP: 44380-000, Cruz das Almas, Bahia, Brasil.

Several hybridizations have been caried out at Embrapa Cassava and Tropical Fruits involving the botanical varieties: *Ananas comosus* var. *erectifolius*; *A. comosus* var. *bracteatus* and *A. comosus* var. ananassoides. The plants generated are under field conditions and some evaluations have been done aiming at selecting hybrids with specific characteristics to be used as pot plants, cut flowers, landscape plants and ornamental mini fruits. Some variables have been taken into account such as plant size, colour of leaves and fruits, ratio between crown and fruit length and peduncle length. In addition specific morphological descriptors have been applied to validate their use to characterize ornamental plants and subsequent intellectual property rights. Results showed that crossings between *A. comosus* var. *bracteatus* and *A. comosus* var. *erectifolius* provide a significant number of plants to be used as landscape plants due to an expressive variability mainly in colour and size of plants. Some genotypes are very tall plants (giants) with special architecture for squares and gardens. However, few genotypes have been selected for use as cut flowers due to the specific characteristics demanded by this kind of product, such as peduncle without deformation and with a length close to 50 cm. On the other hand, some genotypes may be used as pot plants and as suppliers of ornamental mini fruits. The crossing between *A. comosus* var. *bracteatus* x *A. comosus* var. *ananassoides* resulted in a significant number of genotypes to be used as cut flowers. The genotypes selected are currently under clonal evaluation to determine the stability of the selected traits.

Influence of freezing processes on bromeline activity of pineapple

G.M.F.Abílio (1), E.A.Carvalho (2), H.J.Holschuh (3)
(1) Universidade Federal da Paraíba, João Pessoa, Brasil, gisely_abilio@yahoo.com.br (2) Universidade Federal da Paraíba, João Pessoa, Brasil, elckcarvalho@gmail.com (3) Universidade Federal da Paraíba, João Pessoa, Brasil, hj.holschuh@ct.ufpb.br

Brazil has been one of the major world producers of pineapple, with a production higher than 2.0 million tons a year. On the national scene, Paraiba State has been standing out as one of the major producers for many years. Pineapple presents considerable contents of carbohydrates, proteins and bromeline, which is a proteolitic enzyme with diverse uses, such as in the food and pharmaceutical industries. In the latter, bromeline figures as active ingredient of drugs that act by facilitating digestive processes, and under this focus it may be used by consumers in natura, but at low concentrations. In order to supply consumers with more information on the influence of the freezing process on the bromeline activity, this work analysed in a pilot study samples of 'Pérola' pineapples in natura (A1), frozen in domestic refrigerator (-15ºC) (A2), and quickly frozen with liquid nitrogen and then stored in domestic refrigerator (A3). In all samples both pulp and rind were analysed. The rough extract of the enzyme was obtained as suggested by Lopes et. al. (2005), and the activity of the bromeline determined according to the methodology proposed by Kunitz (1947) and Walter (1984). The following activities of bromeline were obtained for 100 mg samples: Pulp A1, 3012,586U; Pulp A2, 2448,929U, Pulp A3, 2397,013U, Rind A1, 3368,579U, Rind A2, 2739,00U and Rind A3, 1877,856U. In relation to the specific activity the same samples presented the following results: Pulp A1, 10,57U/mg; Pulp A2, 7,20 U/mg, Pulp A3, 4,49 U/mg, Rind A1, 3,41 U/mg, Rind A2, 3,29 U/mg and Rind A3, 1,54 U/mg. The samples, both for pulp and for rind, presented higher proteolitic activity for in natura fruits. What belongs to the samples submitted to freezing, the fruits frozen in domestic refrigerator (-15ºC) determined less loss of proteolitic activity, when compared to samples quickly frozen with liquid nitrogen and then kept in domestic refrigerator. The results of this pilot study evidenced to be necessary to carry out more complete studies on this issue.

Session V Post-Harvest Management

Pineapple production for quality and postharvest handling

Nancy Jung Chen (1), Ching-Cheng Chen (2), Parson Saradhuldhat (3) and Robert E. Paull (1)
(1) Department of Tropical Plant and Soil Sciences, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, Honolulu, Hawaii USA, paull@hawaii.edu (2) Department of Horticulture, National Chung Hsin University, Taichung, Taiwan, and, (3) Department of Horticulture, Faculty of Agriculture at Kampaengsaen, Kasetsart University, Nakorn Pathom, 73140 Thailand

The development of pineapple cultivars for fresh fruit consumption has been a recent major focus of breeding and selection programs. New hybrids developed for the fresh fruit market have been introduced in Hawaii, Australia, Malaysia and Taiwan. These low acid types have become the preferred types and have expanded rapidly to supply the fresh fruit markets of the USA, Japan and Europe. The newer cultivars present new challengers in production and maintenance of quality. In Hawaii, natural flowering, which can significantly increase harvest costs and production losses, translucency and too low acid levels are quality issues all tied to production practices. Postharvest chilling injury appears to be less of a problem, though shell scuffing is an issue with some clones. Translucency is correlated with susceptibility to mechanical injury and non-pathogenic fungal growth on the broken peduncle both are of concern with marketers and consumers. Our fruit quality research focus has been on translucency and inconsistent fruit quality throughout the year due to variation in the sugar to acid balance, the major fruit flavor component. In the warm season there are fruits with too low acids and high sugars, and more desirable balance of acids and sugars occurs in the cool season. Flesh translucency is possible due to photosynthetate competition between the crown and the fruit during the initial period of crown growth. Alternatively, insufficient calcium uptake during the fruit growth make the fruit flesh more "leaky". The low acid hybrids during fruit growth accumulate high levels of titratable acidity. This acidity peaks at a higher level than the canning variety and declines rapidly as the fruit approach maturity. The decline in acidity is associated with two acid metabolism enzymes. Sugars are rapidly accumulated about six weeks before harvest just before the acid levels decline. The sugar accumulation appears to be via an apoplastic pathway utilizing neutral and cell-wall invertases. For this non-climacteric fruit, eating quality is determined before harvest. Cultivar and field management, such as fertilization and irrigation practices, developed for canning may not be the most appropriate for the production of low acid hybrids used for fresh fruit.

Storage of 'Pérola' pineapple harvested with good agricultural practices and treated with biodegradable coatings

S.M. Silva (1), E.C. B. de Medeiros (2), L.P. Martins (3)
(1) Universidade Federal da Paraíba, Centro de Ciências Agrárias, Areia, Paraíba, Brasil, silvasil@cca.ufpb.br (2) Universidade Federal da Paraíba, Centro de Tecnologia, Areia, Paraíba, Brasil (3) Universidade Federal da Paraíba, Centro de Ciências Agrárias, Areia, Paraíba, Brasil, martinslp@bol.com.br

Pineapple is a tropical fruit widely produced and consumed. Presently, however, the consumption of fresh fruits requires especial criteria for production, harvest and handling which should assure quality and consumer health. In addition, pineapple is very perishable, demanding alternatives of conservation, especially when destined to long distances markets. The use of Good Agricultural Practices (GAP) at harvest has been the most applied tool for fruits destined for exportation in order to reduce initial contamination and minimize losses of quality due to incorrect handling at pre and post-harvest. On the other side, the use of biodegradable coatings has presented positive effects on the environment and the increase of fruit shelf life. This work had the objective to evaluate the influence of application of GAP at harvest and of biodegradable coatings based upon cassava starch and carnaúba wax on 'Pérola' pineapple conservation. Fruits in the green-ripe (fruitlets totally green) maturation stage were harvested in a commercial orchard located in Sapé, Paraiba State, Brazil. The application of GAP consisted in the use of sanitized knives, masks and gloves at harvest and the conventional system of harvest (without GAP). Fruits with and without GAP were dipped into a solution of active chloride for two minutes, dried in air and submitted to the treatments studied, consisting of immersion of the fruits for three minutes into a suspension of cassava starch at $30 g.L^{-1}$, carnaúba wax at 30% and control (without coating). Fruits were stored under environmental conditions (24 ± 1 ºC and 85 ± 2% RU). Results showed that the combination of GAP with carnaúba wax was the most efficient treatment in relation to fruit shelf life increase. Fruits handled and treated by this way kept their firmness, presented lower mass and soluble solid losses and better appearance, giving an additional six days period of storage when compared to the fruits of the other treatments studied. Finacial support: BNB and CNPq.

Physico-chemical changes of pineapple submitted to different mechanical injuries

R. A. Kluge (1), J. Saavedra del Aguila (2), L. S. Heiffig (2), M. C. Roulet (1), M. das G. Ongarelli (1)
(1) Universidade de São Paulo (USP) - Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ) - Departamento de Ciências Biológicas, Caixa Postal 9, 13418-900, Piracicaba, SP, Brasil; Fone (19) 3429-4136, rakluge@esalq.usp.br (2) USP-ESALQ - Departamento de Produção Vegetal.

The pineapple, besides presenting numerous sensorial qualities, shows high dietary value. The purpose of this work was to evaluate some physico-chemical changes of 'Pérola' pineapples submitted to different types of mechanical injuries, simulating, thus, the main damages suffered by this fruit from harvest to commercialization. Fruits were submitted to the following treatments: T1: non-injured fruit (control); T2: one 60 cm free fall; T3: four longitudinal cuts (7 cm long and 2 mm deep); T4: eight perforations (3 x 2 mm) in the fruit base; and T5: compression for 30 minutes (equivalent force of 160 Newton). After the application of the treatments, fruits were stored during 15 days at 11 °C and 85% RH. Every five days were determined fresh mass loss (%), pulp translucency (on a scale from 0 to 4, where 0 = opaque pulp and 4 = 100% of translucent pulp), juice percentage (%), acidity (% citric acid) and skin color (L*, a* and b*). The compression treatment showed a significant fresh mass loss during storage, reaching loss of 7.20% after 15 days. Differences were not observed for fruit translucency as a function of the treatments. The juice percentage that initially was 48.6% decreased to values between 38% and 41% after 15 days of storage. The acidity that initially was 0.49% citric acid increased to 0.76%. For the values of L *, a* and b* no differences were observed among the treatments. It was

considered that the most harmful postharvest mechanical injury for 'Pérola' pineapples is the compression, usually, happening during fruit transport.

Ripening and post-harvest behaviour of two regional pineapple cultivars of the Amazonas region in Venezuela

A. Guadarrama (1), M Carreño (2)
Universidad Central de Venezuela-Facultad de Agronomía-Instituto de Botánica Agrícola-Laboratorio de Fisiología Post-cosecha-Maracay-VENEZUELA guadarramaa@agr.ucv.ve

The aim of this work was to evaluate loss of fresh weight, soluble solids contents, titratable acidity, pH, texture and external colour, as characteristic features of ripening of two pineapple cultivars (´Gobernadora' and 'Brasilera') produced in an indigenous community of Amazon State, Venezuela. In order to evaluate the post-harvest handling in a comparative way of the two cultivars, the index of suitable harvest was determined. Some qualitative and quantitative characteristics of the pulp and the crown were determined by means of morphometric descriptions. In addition the subjective quality (texture and external colour) was determined in two simulated conditions of sale: at temperatures of 8°C and 75- 80% of relative air humidity and 29 ±3°C and 60-70% of relative air humidity. The experimental design was a completely randomized one and data obtained were analysed by the test of Mann-Whitney and Student. Titratable acidity, pH, total soluble solids and the relation total soluble solids / titratable acidity constituted indicators of maturity degree for harvest. The cool treatment at 8°C and 75-80% of relative air humidity allowed a significant reduction in loss of fresh weight and maintenance of the characteristics of commercial quality and a shelf life of 16 days. Most of the characteristics evaluated showed similarities between the two cultivars.

Session VI Market and Trade

Pineapple agribusiness in Brazil

Clóvis Oliveira de Almeida
Embrapa Cassava & Tropical Fruit, Caixa Postal 07, 44380-000, Cruz das Almas, Bahia, Brazil, calmeida@cnpmf.embrapa.br.

In this speech the following topics are presented: Brazilian and international pineapple markets, as well as the insertion of Brazil into the international pineapple trade. The topic regarding to Brazilian pineapple market shows the geographic distribution of production and of the pineapple cultivars planted in the country, with predominance of the cultivar Pérola in the North East Region. The ten most important pineapple producing states are mentioned, with emphasis to the States of Pará and Paraíba that together were responsible for 42% of the Brazilian pineapple production in 2006. The evolution of the amount of fruits commercialized belonging to the cultivars Pérola and Smooth Cayenne in the largest trading center in Brazil (Ceagesp), is also presented, making clear the predominance of 'Pérola' from 2000 on. The trend of the average price of pineapple fruits in the most important trade centers in Brazil is also presented. Based on price seasonality and on pineapple harvest periods in some producing states, period form January to March is identified as the market window in which prices in Brazil are above annual average, but with trends for decreasing differences and narrowing of that window. The reason for that is the increase of pineapple production in the states of Pará and Tocantins, both located in the North Region of Brazil, in which harvest occurs during a period of low national fruit supply. Regarding the topic International Market the most important pineapple producing countries, as well as importers and exporters are referred to. Information on imported and exported pineapple products (juices, fresh fruit, canned, and so on) are also mentioned. Additionally it is presented the trend of fresh pineapple consumption in the most important markets, the consumption sazonality in the European Union and the most important traders. Informations on the most commercialized cultivars and their life cycle in the market are also presented. The last topic deals with the Brazilian insertion into pineapple international market.

Marketing strategies of pineapple in Brazil

Anita de Souza Dias Gutierrez. Centro de Qualidade em Horticultura da Companhia de Entrepostos e Armazéns Gerais de São Paulo (CEAGESP), São Paulo, SP, Brasil, adias@ceagesp.gov.br

During the past few years fresh pineapple commercialization in Brazil has passed through significant transformations, with emphasis on the following: Introduction of pineapple 'MD-2', unknown by Brazilians; entrance of large international and national companies into pineapple production, dominated by small and intermediate-scale growers; pineapple cultivation with focus on exportation; introduction of more transparent commercialization systems as the one used by brokers linked to the Bolsa de Comércio de Pernambuco (Trade Agency of Pernambuco); elaboration of the Pineapple Classsification Norms of the Brazilian Program and its use in pineapple marketing by the Bolsa de Comércio de Pernambuco; creation of the Technical Regulation of Identity and Quality of Pineapple by the Brazilian Ministry for Agriculture, Livestock and Food Supply (MAPA); sale increase of peeled pineapple, protected by transparent material, as stimulated by the uncertainty of consumers of acquisition of sweet pineapple; sale growth of 'Pérola' pineapples in place of 'Smooth Cayenne' ones in the States that produce the latter; offer increase of 'Jupi' pineapples, which belongs to the 'Pérola' group, but is of cylindrical shape; on farm pineapple packaging, even with use of individual fruit protections such as small nets by some producers, whereas the majority of pineapples still travel unpackaged from production area and is classified and packaged in the wholesale market; the establisment of the Flavor Warranty Program by a partnership between the Brazilian Institute of Quality in Horticulture and Bayer Cropscience, with support of the Quality Center in Horticulture of CEAGESP. There will also be addressed the main factors that determine maturation and consumption quality of pineapples, as well as aspects of fresh pineapple commercialization in the wholesale market of the Terminal Entrepôt of São Paulo of CEAGESP.

Industrial processing of pineapple - Trends and perspectives

Axel Reinhardt. Döhler America Latina Ltda, Limeira, São Paulo, Brasil, axel.reinhardt@doehler.com.br, www.doehler.com.br

Pineapple is a very well known fruit all over the world and within the tropical fruits represents certainly the highest processed volume, generating several kinds of products like canned and frozen pineapple (in slices and pieces) and juice (single strength and concentrate). Brazil is one of the largest growers of pineapple in the world, but is insignificant as industrial processor. The Asian producers focus on the total usage of pineapple, that is primarily fresh fruit combined with canning and juice production, where juice is basically a byproduct. In South America, fresh fruit is also main usage, but canning industry is not well developed and juice is produced from the whole fruit. Pineapple juice concentrate is applied to produce ready-to-drink pineapple juice or nectar and as main constituent in blends for multi fruit juices, nectars and drinks. Reason for that is that pineapple juice is considered as "cheap juice solids" compared to other fruit juice concentrates available, and as the concentrate is relatively neutral, it fits very well for blending with other tropical and exotic fruit juices of higher added value. Prices for juice concentrates on the international market are historically in the range of 1.000 to 1.200 US$/ton EXW processor, what means a huge challenge for efficiency in the whole industrial chain. Considering an annual world production of pineapple around 16 Million tons, we estimate share of industrial processing below 20% and specifically for juice in the range not higher than 13 to 15%.To further promote pineapple for industrial processing and value addition, several factors are crucial: integration of grower and processing industry, fruit type versus application, product portfolio, processing technology, logistics, marketing and promotion, and long term planning.

II) Posters

Session I Genetic Resources, Breeding and Micropropagation

Distribution and characteristics of pineapple germplasm collected in Cuba

Isidrón Miriam (1), Rodríguez Daymara (1), Valera Evelyn (1), Roque Ariannys (1), Isaac Elizabeth (2) , Carvajal Carol (3)
(1) Universidad Agraria de La Habana, Autopista Nacional km 23, San José de Las Lajas, La Habana, Cuba, (2) Centro de Magnetismo, Universidad de Oriente, Cuba. (3) Centro de Bioplantas, Universidad de Ciego de Ávila, Carretera a Morón km 9, Ciego de Ávila, Cuba, biotec@isch.edu.cu

National expeditions for collecting pineapple germplasm in Cuba were carried out from 1998 to 2005. Farms of thirteen provinces have been visited, involving 24 municipalities. It was detected that in more of 92% of the prospected areas pineapple production is based upon the cultivar Red Spanish, independently of the size and characteristics of the farms: large governmental ones, all sizes of farmer owned ones and even family yards. There are, however, two different types or clones: ¨*Pinareña*¨ and ¨*Camagüeyana*¨, both similar in leaf colour and fruit shape, "eye" depth, but different in spine distribution on the leaf borders. Some differences in crown forms occur, but there were no fasciations of any type. 'Smooth Cayenne' is present in just 8% of the cultivated area. Its clones 'Hilo', 'Serrana' and 'Habanera' are the most common ones, presenting some fasciations with different forms. 'Piña Blanca' or 'Piña de Cuba', is a very sweet cultivar ("Pernanbuco" type), which is in risk of extinction because there are just few farmers cultivating a low number of plants. Some differences in pulp quality have been observed, especially in relation to vitamin C and total soluble solid contents and sugar/acid rate. 'Cabezona', a triploid cultivar is present only in a local farm in "La Resbalosa", near to "Gibara" city, in Holguín province. Some other accessions belonging to the Bromeliaceae family were collected too. Some graphic information will be presented in the paper.

The effect of different levels of inbreeding on self-incompatibility and inbreeding depression in pineapple

G.M. Sanewski. Department of Primary Industries and Fisheries, Maroochy Research Station, PO Box 5083 SCMC. Nambour, Qld. Australia, Ph: +61 7 54449650. Fax: +61 7 54412235, garth.sanewski@dpi.qld.gov.au.

A high level of heterozygosity in domesticated pineapple is one of the main obstacles hindering the efficient development of new varieties. Selfing has been proposed as a strategy to minimise this heterozygosity through the development of parentals with a greater level of homozygosity. Selfing and a range of lesser levels of inbreeding were evaluated for their effects on seed production and inbreeding depression in the early growth of seedlings. Selfing produced few seed, and very few viable seedlings. The paternal backcross and several half-sib combinations exhibited minimal effects on seed development or early growth and in some cases were similar to the outcross. Sibcrosses were generally unsuccessful. The highest inbreeding coefficient that was not associated with severe inbreeding depression was approximately 0.250. The effect of inbreeding depression and the level of homozygosity is now being assessed for several quantitative traits including those related to fruit quality within the inbred populations.

Chromosome analysis in *Ananas comosus*

Everton Hilo de Souza (1), Janay Almeida dos Santos-Serejo (2)
(1) Graduando em Engenharia Agronômica, UFRB/Campus Cruz das Almas, CEP 45380-000 Cruz das Almas, Bahia, fone (75) 3634-2543, e-mail: hilosouza@gmail.com; 2Pesquisadora da Embrapa Mandioca e Fruticultura Tropical, Rua Embrapa, s/nº, CP. 007, CEP 44.380-000, Cruz das Almas, Bahia, fone (75) 3621-8072, e-mail: janay@cnpmf.embrapa.br

The Pineapple Germplasm Bank at Embrapa Cassava and Tropical Fruits is set up by 678 accessions, including different botanical species. The present work aimed at characterizing the karyotype of accessions of *Ananas comosus* var. *comosus* by chromosome number determination. Root tips were pre-treated with 2 mM 8-hydroxyquinoline for 24 hours at 10°C and fixed in Carnoy (3:1). Chromosome preparations were obtained by hydrolysis in HCl 1N at 55°C, for 15 minutes, thereafter the root tips were macerated in 45% acetic acid and stained with 2% acetic carmine or 1% hematoxylin. Twenty accessions of *A. comosus* var. *comosus* were analyzed: 04 (Fazenda Barreiro), 05 (Guiana), 09 (Smooth Cayenne), 10 (Alto Turi), 177 (Jupi), 161 (Pérola x Perolera), 572 (FRF-1002), 343 (FRF-609), 344 (FRF-632), 350 (FRF-737), 352 (Rondon 3), 360

(LBB-596), 362 (LBB-612), 387 (FRF-770), 425 (LBB-1374), 432 (LBB-1384), 441 (LBB-1383), 444 (LBB-1396), 457 (LBB-1413) and 473 (LBB-1444). The genotypes studied have extremely small chromosomes and the visualization of chromosome details like the primary and secondary constrictions is difficult. All the accessions analyzed have 2n=50, except the accession 04 (Fazenda Barreiro) that presented cells with 50 and 75 chromosomes in the same plant.

Molecular characterization of pineapple germplasm

Cabral, J.R S. (1) , Vilarinhos, A.D. (1), Martins, M.S. (2), Santos, V.J. (2), Ledo, C.A.S. (1), Castellen, M.S. (1)
(1) Embrapa Cassava and Tropical Fruits, Cruz das Almas, Bahia, Brazil - Zip Code 44.380-000. Phone number: 00.55.75.36218025; jrenato@cnpmf.embrapa.br, vila@cnpmf.embrapa.br, ledo@cnpmf.embrapa.br, milene@cnpmf.embrapa.br, (2) Graduation student, Universidade Federal do Recôncavo da Bahia - UFRB.

Brazil is the first pineapple world producer harvesting around 2,29 millions of tons in 2005 and the value of the Brazilian pineapple production was estimated to represent more than USD 400 millions. In addition to its economic importance, the pineapple plant is also distinguished for being originary of South America, more specifically of the Amazon region. The Brazilian Southeast is considered as a secondary center of diversification. For all these reasons is strategically important for the country to have full knowledge on the potential of the pineapple genetic resources. The objective of this work was to carry out the molecular characterization of 100 germplasm accessions of *Ananas comosus* var. *comosus*, already characterizated morphologically. These accessions belong to the Active Pineapple Germplasm Bank of Embrapa Cassava and Tropical Fruits, Cruz das Almas, Bahia. This characterization was carried out using 22 RAPD primers. The data evaluation was done using the "GENES" software. A total of 222 bands were generated, 179 (80.63%) of them monomorphic and the other 43 (19.37%) polimorphic ones. The data of genetic distance had allowed to identify 17 groupings where the genetic similarity was equal or superior to 90%. These groups had from 2 to 12 accessions, in a total of 58 individuals. Results have also shown that five pairs of accessions (FRF - 11 and FRF - 1226), (FRF - 156 and FRF - 235), (FRF - 250 and FRF - 160), (FRF - 640 and FRF - 652) and (Huitota and FRF - 609) had 100 % of genetic similarity. These first results appoint for a reduction of the number of germplasm accessions based on the high genetic similarity and/or duplicity of accessions. However, it will be necessary to confront these results with that from agronomic and morphologic characterizations. Finacial support by FAPESB and CNPq.

Heritability and genetic progress of characteristics used in the selection of pineapple hybrids

Ledo, C. A. da S., Cabral J. R. S., Junghans, D. T. Embrapa Mandioca e Fruticultura Tropical, Cruz das Almas - BA, Brazil, ledo@cnpmf.embrapa.br, jrenato@cnpmf.embrapa.br, davi@cnpmf.embrapa.br

Very little is known about pineapple genetic breeding. Most genetic studies are concentrated on the inheritance of few qualitative characteristics such as leaf color and spines. Works regarding the inheritance of quantitative characteristics have been rare and precise quantitative standards and information available in the literature have mostly been limited to simple statistics such as averages. Forty-one hybrids from the genetic breeding program at Embrapa Cassava and Tropical Fruits were evaluated. The analysis of variance was carried out and the heritability and the expected genetic progress at selection were assessed considering an intensity of selection of 10% for the following characteristics: fruit weight, peduncle length, total soluble solids and total tritatable acidity. The heritability values varied from 89.73% to 93.08% for fruit weight and total soluble solids, respectively. The genetic progress, considering an intensity of selection of 10%, varied from 3.97% to 589.59%, for peduncle length and total tritatable acidity, respectively. Direct selection for fruit weight resulted in negative gains for the other characteristics studied, with total impact of 93.74%. Direct selection based on total soluble solids also resulted in negative gains of the values for the remaining characteristics. Results showed that knowing the phenotypic variability is important for defining breeding methods to be used in breeding programs, as well as that the genetic pineapple breeding program at Embrapa Cassava and Tropical Fruits has been efficient in producing new genotypes with superior agronomic characteristics.

Pineapple seed germination in different temperature regimes

Davi Theodoro Junghans (1), Elyabe Monteiro de Matos (2), Emanuel Alves Batista (3), Marcelo Schramm Mielke (2), Tatiana Góes Junghans (1)
(1) Embrapa Mandioca e Fruticultura Tropical. Cruz das Almas, BA, Brasil, CEP 44380-000, Phone: 55 75 3621 8062, davi@cnpmf.embrapa.br; tatiana@cnpmf.embrapa.br, (2) Departamento de Ciências Biológicas, Universidade Estadual de Santa Cruz, Ilhéus - BA, Brasil, elyagro@gmail.com; msmielke@uesc.br; (3) Acadêmico de Agronomia, Universidade Estadual do Sudoeste da Bahia. Vitória da Conquista - BA, Brasil

Pineapple seeds are obtained from interespecific and intervarietal crosses in breeding programs aiming at developing new cultivars. A study was carried out under growth chamber conditions with the objective of verifying the best temperature regime for pineapple seeds germination. The seeds were from crossing of Perolera (PE) x Primavera (PRI) and from two backcrossed populations obtained among selected hybrids (PE x SC - 56 and PE x SC - 60) crossed with Smooth Cayenne (SC) cultivar. The germination were evaluated using a completely randomized experimental design with four temperature regimes (constant temperature of 25°C and alternated of 25-20°C, 30-20°C and 35-25°C), with 14 hours of photoperiod. The experimental design was a completely randomized one in a 4x3 factorial with four replications of 75 seeds per treatment. The germination rates were evaluated twice a week at intervals of three or four days, from 21 to 75 days after sowing. The results showed that the regime of 25/25°C was more efficient in PE x PRI and (PE x SC - 56) x SC populations up to 42 days after sowing. For (PE x SC - 60) x SC population, the regime of 25/25°C was always superior to the other treatments for seed germination.

Performance of pineapple hybrids resistant to fusariosis in Bahia State

Getúlio Augusto Pinto da Cunha, José Renato Santos Cabral, Aristoteles Pires de Matos, Ranulfo Corrêa Caldas. Embrapa Cassava and Fruit

Crops, Cruz das Almas, CP 007, getulio@cnpmf.embrapa.br

Bahia was always one of the main producing states of pineapple in Brazil. Within that state, the county of Coração de Maria stood out as a pineapple producer and, until the 80's, presented the largest planted area and produced a fruit of excellent quality. However, the high incidence of fusariosis (*Fusarium subglutinans*), besides other aspects, promoted the decadence of the culture, with a great economical-social negative impact. In order to revitalize the pineapple agribusiness in that county, an experiment was carried out involving the evaluation of the behavior of two hybrids resistant to the fusariosis - 'Imperial' and 'PExSC-60' -, originated from the Program of Genetic Improvement of Pineapple, of Embrapa Cassava and Fruit Crops, in comparison with the cultivars Jupi, Gold and Perola (control). The experimental design was in randomized blocks, with five treatments and six replications. The following data were collected: mass, size, diameter, total soluble solids and total acidity of the fruit; mass and size of the crown; number of slips per plant; occurrence of pests; and yield. The results were evaluated by the variance analysis and F test, with comparison of the averages by the test of Scott-Knot, at 5%. The discrimination of the genotypes by the referred test evidenced different groups among them, independent of the processed variables, as follows: I. fusariose incidence: A) 'Gold' 40,5%; 'Perola' 39,6% and 'Jupi' 35,5%; B) 'Imperial' 0,0% and 'PExSC60' 0,0%; II. average masses of fruits with crown: A) 'Gold' 1,489.7 g; B) 'Perola' 1,306.2 g and 'Jupi' 1,274.8 g; C) 'Imperial' 763,0 g and 'PExSC60' 743,5 g; III. length of the fruit: A) 'Pearl' 18,5 cm and 'Jupi' 17,5 cm; B) 'Gold' 14,5 cm; C) 'Imperial' 11,6 cm and 'PExSC60' 11,4 cm; IV. average diameter of the fruit: A) 'Gold' 12,3 cm; B) 'Pearl' 10,1 cm; 'Jupi' 10,7 cm; 'Imperial' 9,7 cm and 'PExSC60' 9,7 cm; V. total soluble solids: A) 'PExSC60' 17,8 °Brix; B) 'Imperial' 15,9 °Brix; C) 'Gold' 14,5 °Brix; 'Pearl' 14,6 °Brix and 'Jupi' 13,6 °Brix; VI. acidity in citric acid: A) 'PExSC60' 0,65% and 'Imperial' 0,61%; B) 'Gold' 0,49%; C) 'Pearl' 0,35% and 'Jupi' 0,31%. The results confirmed the resistance of the hybrids to the fusariose (0,0 % incidence), and they constituted a group different from the ones of the other cultivars. Regarding the mass of the fruits, the values presented by the hybrid were smaller than the expected. That because the hybrids were micro-propagated and they did not grow enough to produce a fruit with commercial pattern. However, they presented the best percentages of total soluble solids, an important variable for the composition of the quality of the fruit and for the selection of a new cultivar. Financial support: FAPESB.

Quality of 'Imperial' pineapple harvested at three maturation stages

L.P. Martins (1), S.M. Silva (2)
(1) Universidade Federal da Paraíba, Centro de Ciências Agrárias, Areia, Paraíba, Brasil, martinslp@bol.com.br (2) Universidade Federal da Paraíba, Centro de Ciências Agrárias, Areia, Paraíba, Brasil, silvasil@cca.ufpb.br

The 'Imperial' pineapple developed by Embrapa Cassava and Tropical Fruits, originated from the cross between 'Perolera' and 'Smooth Cayenne', is a fruit of yellow pulp, which may be destined to the fresh fruit market and to processing, due to its characteristics of shape, flavor and colour. For this new cultivar it is, however, necessary to determine the qualitative changes during fruit maturation in order to define its best harvest point to meet consumers demand. This work had the objective to evaluate changes during maturation and the quality of 'Imperial' pineapples grown under environmental conditions of the Coastal region of Paraiba. Fruits were harvested at maturation stages I (fruits with 25% yellow rind), II (fruits with 50% yellow rind) and III (fruits totally yellow) on a farm localized in the municipality of Conde, Paraiba, Brazil. The variables evaluated were: fresh fruit mass, pulp/rind ratio, firmness, soluble solids (SS), titrable acidity (TA), ratio SS/TA, ascorbic acid, reducing and not reducing sugars and acceptance of external appearance and flavor. The experimental design was a completely randomized one with three replications and the experimental plot set up by twelve fruits. 'Imperial' pineapples of maturation stage III presented the lowest TA (0.407% citric acid), higher ratio SS/TA (38.01) and larger pulp/rind ratio. Maturation stage I fruits had the largest fresh mass (1124.7 g), higher firmness and ascorbic acid content (92,02 mg.100g^{-1}). There was observed a reduction of reducing sugars and an increase of non reducing sugars with progress of maturation. The 'Imperial' pineapple was evaluated as a fruit of good appearance and very good flavor at maturation stage III and good at maturation stage II.

'Vitória': new pineapple cultivar resistant to fusariose

José Aires Ventura (1), José Renato Santos Cabral (2), Aristóteles Pires de Matos (2), Hélcio Costa (1)
(1 Instituto Capixaba de Pesquisa Agropecuária e Extensão Rural (INCAPER), Rua Afonso Sarlo 160 (Bento Ferreira), 29052-010, Vitória, ES, Brasil, ventura@incaper.es.gov.br, helciocosta@incaper.es.gov.br (2) Embrapa Mandioca e Fruticultura Tropical, Rua Embrapa s/n, Cruz das Almas, BA, Brasil, jrenato@cnpmf.embrapa.br, apmatos@cnpmf.embrapa.br

Among the problems that limit pineapple yield in Brazil, fusariose caused by the fungus *Fusarium subglutinans* f.sp. *ananas* (Syn.: *F. guttiforme*), is the most serious one with losses commonly estimated to be 30 to 40% in marketable fruits, and 20% for propagative material (slips and suckers). The prevalent commercial cultivars Pérola and Smooth Cayenne are susceptible to fusariose. Control of this disease is based on the integration of cultural practices and the use of fungicides from the early stages of inflorescence development until the flowers closure. Use of resistant varieties, besides being an alternative of economic and more efficient control is also an environmentally safe approach. In this sense, the national pineapple breeding program was initiated in 1984, coordinated by Embrapa Cassava & Tropical Fruits, located at Cruz das Almas-BA, with the objective to identify and obtain resistant hybrids with desirable horticultural characteristics, good yield and fruit quality for the market, that could be recommended as commercial cultivars. In this work were generated hundreds of hybrids between cv. Primavera (PRI) and cv. Smooth Cayenne (SC). After preliminary evaluations under controlled conditions, some promising hybrids were introduced to the Experimental Farms of Incaper. A Recurring Clonal Selection of the hybrid PRIxSC-08 was carried out during the past 10 years, originating the Incaper access EC-099, that gave rise to the cv. Vitória, released to growers in November of 2006. Based on evaluations done in distinct regions of Espírito Santo State (Marataízes, João Neiva, Cachoeiro do Itapemirim and Sooretama), the new cultivar is resistant to fusariose, has better fruit quality and agronomic characteristics similar or superior to those of cvs. Pérola and Smooth Cayenne. The plants have spineless leaves, which facilitates cultural management. The fruits have cylindrical shape, skin of yellow color when ripe, weighing around 1.5 kg, high sugar content (15.8 ºBrix), good acid content, flesh firmness and excellent flavor in sensory analyses, being suitable both for fresh market and for processing. The resistance to fusariose eliminates the use of fungicides, reducing production costs and risks of negative environmental impact. This new resistant cultivar with desirable characteristics has been released to farmers in the Espírito Santo State and if grown with the same cultivation system currently used by local growers it may enable pineapple yield to increase from about 21 t/ha to over 42 t/ha. Financial support: FINEP, BNB/Fundeci, FAPES and CNPq.

Imperial, a new pineapple cultivar resistant to fusariosis

José Renato Santos Cabral, Aristoteles Pires de Matos. Embrapa Mandioca e Fruticultura Tropical, CP 0007, 44380- 000 Cruz das Almas, Bahia, Brasil, Telefone (75) 3621-8027, jrenato@cnpmf.embrapa.br

The pineapple disease known as fusariosis is the most important constraint of the pineapple industry in Brazil. Its control is based upon integration of several cultural practices associated with chemical control, and growing resistant cultivars. In order to do that, Embrapa Cassava & Tropical Fruits has been conducting a pineapple breeding program since 1984 aiming at obtaining fusariosis resistant cultivars. That breeding program has already generated and evaluated 53,397 hybrids. Among them, the hybrid PE x SC-56, that showed good quality fruits, besides being resistant to fusariose, was released as a new pineapple cultivar in 2003, named 'Imperial', and recommended for planting mainly in regions where that disease is the limiting factor for pineapple production. The 'Imperial' pineapple plant is of intermediate height, with spineless dark green leaves. The fruit is small, cylindrical, yellow peel at ripening. The pulp is yellow, with high sugar content, moderate acidity, high level of ascorbic acid and very good flavor. 'Imperial' also shows resistance to internal browning. The following characteristics may be considered as unfavorable: slow growth of the plant, peduncle with small diameter, small fruit (1.6 kg), rough fruit surface due to unflat fruitlets, slips eventually attached to the fruit base. Growing 'Imperial' pineapple does not require fungicide application to control fusariose, thus resulting in reduction of production costs (pesticide and labor). Additionally growing 'Imperial' pineapple contributes for environmental protection and safe fruit production.

Micropropagation, production of synthetic seeds and evaluation of utilization for in vitro conservation of pineapples

Oliveira, J.P. (1), Maciel, S.A. (2), Silva, T.L. (2), Alves, L.S. (2), Costa, F.H.S. (3) Scherwinski-Pereira, J.E. (4).
(1) Universidade Federal do Acre, UFAC, Pós-Graduação em Agronomia, Rio Branco, AC, Brazil; (2) Bolsistas PIBIC/DTI/CNPq/ Embrapa Acre; (3) UFLA, Depto de Fitotecnia, Lavras, MG, Brazil, (4) Embrapa Genetic Resources and Biotechnology, Parque Estação Biológica - PqEB - s/n, Av. W5 Norte (final), Caixa Postal 2.372, CEP 70770-900 - Brasília - DF - Brazil. E-mail: jonny@cenargen.embrapa.br

This work was carried out at the Laboratory of Morphogenesis and Molecular Biology, LABMOL in Embrapa Acre, Rio Branco, AC, Brazil. Initially the in vitro multiplication rates were determined for eight pineapple cultivars of Western Amazon: 'Rio Branco' (RB), 'Xapuri' (XA), 'Quinari' (QN), 'Cabeça de Onça' (CO), 'Senador Guiomard' (SG), 'Pérola' (PER), BRS-1 and SNG-4. The culture medium was formed by salts of MS, added of NAA (0.25 $mg.L^{-1}$) and BAP (2,5 $mg.L^{-1}$). For five subcultures of 40 days, the multiplication rate of each cultivar was evaluated. For the production of synthetic seeds, shoots of SG and RB cultivars measuring 0.3 to 0.5 cm height, were dipped into solution of MS added of sodium alginate (2%) and captured with an automatic pipette. For encapsulation, a solution of $CaCl_2$ was used for 15 minutes. Soon after, the encapsulated units were submitted to three washes in distilled and sterilized water and taken for conservation at temperature of 8ºC for 0, 30 and 60 days. For descomplexation and conversion, the capsules were dipped into solution of KNO_3 for 15 minutes and transferred to flasks with MS medium. The evaluations of conversion rate and shoot height were done every 15 days. For in vitro multiplication, a significant interaction was observed among cultivars from the 2^{nd} subculture. In the 3^{rd} subculture it was observed that SG, SNG-4 and RB cultivars reached maximum multiplication rates of 104, 98 and 83 shoots/explant, respectively. During the conservation of encapsulated microshoots, it was observed that in general the increase of the storage period of the capsules influenced the conversion and growth of the shoots negatively. The period of exposure of the synthetic seeds to the temperature of 8°C caused damages to the cellular structures of the microshoots, indicating the need to test higher temperatures to improve the process.

Proteolitic activity in enzymatic extracts of in vitro pineapple plants

(1) N. S. Leite, (2) S. B. S. C. Barboza, (3) R. R. de Souza, (4) A. da S. Ledo
(1) Bolsista UFS/Deagro, Embrapa Tabuleiros Costeiros, Aracaju, SE, Brasil nadjma@cpatc.embrapa.br; (2) Pesquisadora Deagro, Embrapa Tabuleiros Costeiros, Caixa Postal 44, CEP 49025-040, Aracaju, SE, Brasil, fone (79) 4009-1362, sarah@cpatc.embrapa.br (3) Professor titular do Departamento de Engenharia Química da Universidade ederal de Sergipe, Av. Marechal Rondon, s/n Jardim Rosa Elze, CEP 49100-000, São Cristóvão, SE, Brasil, rsouza@ufs.br (4) Pesquisadora Embrapa Tabuleiros Costeiros, analedo@cpatc.embrapa.br

The in vitro propagation technique is a rapid cloning system when compared with the conventional propagation system, because allows to obtain thousands of plants from just one axillary bud, within a relatively short time. The pineapple plant is one of the main sources of the proteolitic enzyme bromeline, a product of high commercial value, which is not produced in Brazil. The bromeline is rather much utilized in food, textile, beer and pharmaceutical industries, as well as in medicine. The solid-liquid type of extraction applied to the separation of biomolecules is a very important technological field, being one of the techniques used for production of biomolecules. The objective of this work was to quantify the enzymatic activity of bromeline in different pineapple plant parts developed in vitro. Evaluation were done for stems and leaves of cvs. Pérola and Imperial, after three and eight months of in vitro cultivation in MS medium without growth regulator. The plant material was macerated in potassium phosphate buffer at different pHs (5.7; 6.7; 7.7). For determination of the proteic content Bradford Method (1976) was used and for enzymatic activity the method of caseine digestion according to Kunitz (1947), with preliminary modifications. In both cultivars better results were obtained for pH 5.7 in the extraction medium. In cv. Pérola bromeline activity was higher in leaves at three months of in vitro culture (0,0194 $\mu mol.min^{-1}.mL^{-1}$), whereas in cv. Imperial higher activity was obtained in stems of eight months culture (0,0179 $\mu mol.\ min^{-1}.mL^{-1}$). The cv. Imperial presents higher bromeline activity than the cv. Pérola in both stems and leaves.

Aclimatization of micropropagated 'Imperial' pineapple plants

Ester Alice Ferreira (1), Frederico Henrique da Silva Costa (2), Moacir Pasqual(2)
(1) Empresa de Pesquisa Agropecuária de Minas Gerais (EPAMIG), CTTP C.P.351 Uberaba 38060040, Phone 34 3321 6699, ester@epamig.br, (2) Tissue Culture Lab of Federal University of Lavras C.P. 3037 Lavras MG 37200 000, mpasqual@ufla.br

'Imperial' is a cultivar with a high potential for cultivation in Brazil, mainly due to its resistance to fusariose, the most important disease in pineapple crops in the country. The large demand for planting material has been one of the limitation in pineapple production and in this context tissue culture is an interesting alternative for production of qualified planting material in quantity. The acclimatization is one of the most important stages in the micropropagation system since it is the step that ensures the plant survival in ex vitro condition. The aim if this work was to evaluate the effect of different substrates on the acclimatization of 'Imperial' pineapple plants. The work was carried out in a greenhouse near the Tissue Culture Lab of the Agricultural Department, Federal University of Lavras, with the following combinations of substrates: Plantmax, vermiculite and carbonized rice straw with fertilizer Osmocote in the following concentrations: 0, 3, 6, 9 and 12 $g.m^{-3}$ in a factorial scheme. The experimental design was in randomized blocks with ten treatments and four replications. After 120 days the following characteristics were evaluated: root number and root and shoot dry weight. There were no effects of the treatments studied on root number and the substrate Plantmax was superior to the others, promoting better performance for the other variables studied.

Growth of micropropagated *Ananas comosus* var. *erectifolius* plantlets in different substrates under screenhouse conditions

Diva Correia (1), Maria Valderez Ponte Rocha (2), Genilze Costa Alvez (2)
(1) Embrapa Tropical Agroindustry, Rua Dra. Sara Mesquita 2270, Bairro Pici, CEP 60511-110, Fortaleza, Ceará, Brasil, dcorreia@cnpat.embrapa.br, (2) Federal University of Ceará (UFC), Fortaleza, Ceará, Brasil

Ceará State is the first national exporter of cut flower ornamental pineapples, which are mainly sent to the Netherlands, United States, Germany, Portugal, Denmark and French. Ornamental pineapple crops are now present in many States of the Brazilian Northeast, as well as in Goiás and Tocatins States. The use of the micropropagation technique has helped to multiply plants with better uniformity and phytosanitary quality. These characteristics, as well as the use of adequate substrates, contribute to plantlet growth in nursery and to reduce losses during field establishment. The aim of this work was to evaluate the growth of micropropagated ornamental pineapple plantlets in different substrates. Plantlets with 3 cm to 5 cm height and cylindrical containers (capacity 120 cm^3) were used in this experiment carried out under screenhouse conditions with 50% of shading. The experimental design was in randomized blocks with six treatments, four replications and 18 plantlets per plot, with a factorial scheme of 3 (substrates) x 2 (presence or absence of fertilizer). The following substrates were used: carbonized rice husk (50%) and worm compost (20%) with 30% of the components: (S1) - ripe coconut mesocarp dust; (S2) - Plantagro®; (S3) - vermiculite. Each substrate was supplemented with or without slow liberation fertilizer (Polyon 14:14:14 - 3,6 kg/m^3). After a 120 days experimental period, the following was observed: a) average leaf number was larger in substrates supplemented with fertilizer (25) than in its absence (23); b) larger root and shoot fresh masses were achieved in S2 and S3 with fertilizer; c) easier plantlet removal from containers was observed for S3 and d) in S3 and S2 were observed the best root aggregation to the substrates.

Cuban experience on new pineapple hybrids micropropagation

Rodríguez Daymara (1), Isidrón Miriam (1), Moya Beatriz (1), Rodríguez Reina Mragarita (3), Martínez Marcos (2), Martínez Julia (2), Arzola Mayra (2), Bidot Igor (4), Valera Evelyn (1), Roque Ariannys (1)
(1) Universidad Agraria de La Habana, Autopista Nacional km 23, San José de Las Lajas, La Habana, Cuba, (2) Centro de Bioplantas, Universidad de Ciego de Ávila, Carretera a Morón km 9, Ciego de Ávila, Cuba, (3) Filial Universitaria de La Isla de la Juventud, Nueva Gerona, Cuba, (4) Universidad de Guantánamo, Cuba, biotec@isch.edu.cu

The present work shows some experiences of joint collaboration between biotechnology labs, belonging to Cuba's Universities, as a contribution to the propagation and introduction of new Cuban pineapple hybrids into some provinces. New genotypes were obtained in previous research works within the National Pineapple Breeding Project, using traditional and biotechnological methods. The hybrids came from crosses between Smooth Cayenne and Red Spanish cultivars: CBCE-74, CBCE-116, CBCE-201 and CBCE-203. All of them have shown better qualities than 'Red Spanish' and are well adapted to local conditions, but needed to be quickly multiplied and distributed to the farmers in the country. Universities biotechnology laboratories facilities, located in different provinces, have been used to multiply these hybrids and each center has developed different strategies for in vitro propagation and acclimatization. The use of bio-products, such as Oligopectate (Pectimorf) at 1, 5 and 10 $mg.L^{-1}$, in partial or total substitution of BAP and ANA, increased the growth rate of the plantlets at both the multiplication and acclimatization phases, especially when combined with 1 $mg.L^{-1}$ of GA3 in the latter stage. Some other products, such as the Brassinosteroid compound (BB-16), at 0.01 and 0.05 $mg.L^{-1}$, have been tested and shown very good results at the lowest concentration for the in vitro multiplication rate. Different substrates for acclimatization have also been studied, such as humus, zeolite, arbuscular endomychorrizae (*Glomus* sp.), coconut waste and soil at several proportions, depending on local possibilities. As a result of the strategy used, four new pineapple varieties have been introduced within just sixteen months into five provinces of Cuba. In addition, university students have worked on these projects and acquired much experience in the use of micropropagation techniques for pineapple multiplication.

Session II Crop Management

Some sustainable practices in pineapple cultivation in Cuba

Isidrón Miriam (1), Rodríguez Daymara (1), Valera Evelyn (1), Roque Ariannys (1), Isaac Elizabeth (2), Hinds D (3)
(1) Universidad Agraria de La Habana, Autopista Nacional km 23, San José de Las Lajas, La Habana, Cuba, (2) Centro de Magnetismo, Universidad de Oriente, Cuba, (3) Organic Pineapple Working Group.(OPWG-ISHS), Guadalajara, México, biotec@isch.edu.cu

Pineapple cultivation has been a tradition of Cuban farmers since 1850 or even before that; stories counted by old farmers said that it was one of a well appreciated food for Cuban fighters, in the liberation war developed two centuries ago. The main cultivar used is cv. Red Spanish. There are two main clones of Red Spanish: ¨*Pinareña* type¨ and ¨*Camagüeyana* type¨, both with reddish green leaves and oval fruit shape, deep "eyes", but different in spine distribution on leaf margins (more regular and curved in ¨*Camagüeyana*¨) and more vigorous plants in the same type. Soils used on pineapple farms in Cuba are very diverse: sandy soils, loam, red or black clay soils, someones over limestone rocks or other different ones. Propagation materials are mainly slips, collected three-five months after fruit harvest. Chemical fertilization is not a common practice, but organic products are used such as humus, "cachaza" (a by-product from sugar cane waste). Weed control and moisture conservation is favoured by mulching with squashed sugar cane stems placed between pineapple plants rows. Some biological control practices of pests are rather frequent, as for example: *Trichoderma viridis* for control of *Phytophthora parasitica* var. *nicotianae*, the main fungal disease in Cuban pineapple plantations. Other serious diseases such as *Penicillium* sp or *Fusarium subglutinans* have not been detected in Cuba. Some insects from Simphylia class and the fruit borer *Strymon megarus* have also not been seen so far. Some types of Scarabicidae family (*Phylophaga*, *Ciclosephala* and *Anomala*) are well represented, being named as named "Gallegos" by the farmers, who use simple light traps to catch the adults of these pests at night, with very good results. The biological control with *Beauveria bessiana* is also sometimes used. Some other practices are related to intercropping with banana, plantain, other fruit plants (mango, avocado, annonaceae) or tropical tubers (cassava, sweet potatoes or yam), mostly done under family agriculture conditions on farms called "conucos". These are often located on hilly lands, where level curves are used to avoid soil erosion. Some of these practices have helped farmers to produce pineapple at lower costs and under more sustainable conditions.

Sustainable pineapple production in West Bengal, India

S.K.Mitra, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur-741252, Nadia, West Bengal, India, sisirm@vsnl.net

Pineapple is the third most important fruit of West Bengal after mango and banana covering an area of 14,400 ha with an average production of 29.8 t/ha. Pineapple research was initiated in 1977 and over the years sustainable production technology for the region has been standardized. The commercial variety of the state is 'Kew', suitable for canning while 'Queen' is cultivated in about 10% of pineapple area to use as table fruit. Planting of suckers (400-450g) at a density of 64,000 plants/ha (25cm x 35cm x 90cm) is suggested for optimum yield (90-100 t/ha) and quality of fruit. Sequential planting between July and December and application of Ethephon at 365-420 days after planting is suggested for round-the-year harvesting of fruit. The critical leaf ('D'-leaf) nutrient standards before flowering was suggested as N=1.5-1.7%; P=0.09-0.12%; K=0.80-1.00%; Ca=0.30-0.50% and Mg=0.25-0.40%. The recommended fertilizer levels for West Bengal pineapple growers are nitrogen 600 kg, phosphorus 200 kg and potassium 600 kg per hectare for a plant density of 64,000 plants/ha. The fertilizer mixture is suggested to apply in four equal splits at 1, 3, 6 and 11 months after planting. Pre-emergence application of Bromacil at 3kg/ha was found effective to control weeds for six months after planting. Winter harvested fruits are low in TSS/acid ratio which could be improved by spraying of ethephon on developing fruits at 75 days after end of anthesis.

Development of pineapple crop in family agriculture units of the Extreme South Bahia region: Actions and result Arlene M.G. Oliveira (1), Jackson L. de Oliveira (2), Carlos E. L. Cardoso (1), José Renato S. Cabral (1), Domingo H. Reinhardt (1), Luiz Francisco da S. Souza (1), Maria das Graça C. de Sena (3), Gerson S. de Jesus (4), Nelson L. Pereira (4), Karina Christo (5), José G. do Couto Filho (6)
(1) Pesquisador, Embrapa Mandioca e Fruticultura Tropical, Caixa Postal 007, 44380-000 Cruz das Almas, BA, arlene@cnpmf.embrapa.br (2) Analista A, Embrapa Recursos Genéticos e Biotecnologia, Caixa Postal 202, 45810-970 Porto Seguro, BA, (3) Analista A, Embrapa Mandioca e Fruticultura Tropical, (4) Extensionista, EBDA, Casa da Agricultura, 45812-000 Eunápolis-BA, (5) Engenheira Agrônoma, Secretaria de Agricultura, 45807-000- Santa Cruz Cabrália, BA, (6) Economista, Agente de Desenvolvimento, BNB, 45820-000 Eunápolis, BA.

Several actions have been carried out since 2001 involving family agriculture farmers of the Extreme South region of Bahia State, Brazil. In the action plan "Implantation of alternative systems of sustenible pineapple production", participatory research activities gave the following results: 1) transfer of production to periods of improved fruit prices; 2) planting density change from 25000 to 38000 plants/ha; 3) elaboration of fertilization recommendation table based upon soil analyses; 4) more efficient control of fusariosis by improved crop management. Thereafter have been under development the projects "Insertion and competitivity of family agriculturists of the Extreme South Bahia in pineapple and cassava business", and "Organic cultivation of cassava and pineapple in family agriculture units of Extreme South Bahia. There were already done: 1) Fast participatory diagnosis, 2) Participatory planning, 3) Training in cultivation practices, 4) Survey on pineapple production costs. The latter one identified two modal systems which differ with respect to adopted technologies. Based upon prices of June 2006, the traditional system presented an average cost of R$ 0.37/fruit (US$ 0.20/fruit) and benefit/cost (B/C) ratio of R$ 0.89. The modified system, which incorporates some technologies recommended by research, presented average cost of R$ 0.29 and B/C ratio of 2.52, with 70% and 30% of fruits sold in the retail, respectively, at R$ 0.80/fruit and R$ 0.60/fruit. Under execution are: 1) experiments on fertilization, evaluation of varieties resistent to fusariosis, use of organic practices and studies on planting dates; 2) market studies and 3) elaboration of a production system. Actions have been carried out in partnership with agricultural offices of local municipalities, Agricultural Developmant Company of Bahia (EBDA) and Brazilian Northeast Bank (BNB) of Eunápolis town. The settlements involved were Imbiruçu de Dentro (78 families), São Miguel (86 families) and Lajedo Bonito (52 families), located in the municipalities of Porto Seguro, Santa Cruz Cabrália and Guaratinga, respectively. Financial support: Prodetab, Embrapa and CNPq.

Integrated production of pineapple in Paraíba and Bahia - Brazil

Getúlio Augusto Pinto da Cunha (1), Silvanda de Melo Silva (2), Rejane Maria Nunes Mendonça (2), Jamir Mascena (3), Leôncio da Costa Vilar (4), José Teotônio de Lacerda (5)
(1) Embrapa Cassava and Tropical Fruit Crops, Cruz das Almas, CP 007, (2) UFPB-CCA; (3) SFA/MAPA; (4) EMATER/BA; (5)

EMEEPA/PB), getulio@cnpmf.embrapa.br

The pineapple culture is in expansion in Brazil (current first world producer - 61.790 ha and 2.292.470 t of fruits), where the Northeast Region is the main producer (24.914 ha, 1.050.000 t of fruits). In that region, the project of Integrated Production / INP of Pineapple is being conducted, more precisely in the States of Paraíba (11.466 ha and 514.936 t of fruits), and Bahia (5.310 ha and 201.163 t of fruits) - respectively, the second and fourth main producing states of pineapple in Brazil. The works are being accomplished in the main producing regions of those states - counties of Santa Rita, Itapororoca and Conde / Paraíba (with about 50% of the state production), and Real Rio/Bahia, North Coast (2nd producer of the state) -, that presented significant increments in the planted area and production in the last two years. The Pineapple INP in Paraíba and Bahia is an institutional project, coordinated by Embrapa Cassava and Tropical Fruit Crops, with the collaboration of several similar states institutions. For a job of that nature it is indispensable a net of public and private partnerships. In the present case, among the involved institutions the following stand out: SEAGRIs, SFA/MAPA-PB, EMATER/PB, EMEPA/PB, EBDA/BA, ADAB/BA. In 2005, several meetings were accomplished for diffusion of the INP system, and selected the farms where the INP and Conventional management plots would be carried out for comparing both systems. Data about the productive and social infrastructure, production processes, post-harvesting, commercialization, administration and work relationships were gathered, for characterization of the profile of the producers of INP/PB. The Specific Technical Norms for pineapple INP were concluded and put in practice. The concepts, methodology and results obtained until the moment have been spread out through lectures, folders, summaries and posters in technical events, and also by means of other types of publications and in the media. The field works began in 2006 and replicated in 2007, in the counties of Santa Rita, Conde and Itapororoca/PB (in three farms), and Rio Real/BA (in two farms). Besides, several technical visits, meetings and three courses on pest management and good agricultural practices were accomplished, as well as: a) Specific Technical Norms validation; b) validation of field notebook to allow traceability; c) implementation of pest monitoring at the Comparative Plots - base for the System of Pest Alert in the field; d) beginning of evaluation of the Comparative Plots based on the performance and sanity of the plants and fruit quality; and g) writing of reports. Financial support: MAPA.

Silencing of the ACC synthase gene ACACS2 causes delayed flowering in pineapple

Yuri Trusov, José Ramón Botella. Plant Genetic Engineering Laboratory, Department of Botany, School of Integrative Biology, University of Queensland, Brisbane 4072, Austrália, j.botella@uq.edu.au

Flowering is a crucial developmental stage in the plant life cycle. A number of different factors, from environmental to chemical can trigger flowering. In pineapple, and other bromeliads, it has been proposed that flowering is triggered by a small burst of ethylene production in the meristem in response to environmental cues. We have cloned an ACC synthase gene from pineapple (ACACS2), which is induced in the meristem under the same environmental conditions that induce flowering. Two transgenic pineapple lines have been produced containing co-suppression constructs designed to down-regulate the expression of the ACACS2 gene. Northern analysis revealed that the ACACS2 gene was silenced in a number of transgenic plants in both lines. Southern hybridization revealed clear differences in the methylation status of silenced versus non-silenced plants by the inability of a methylation sensitive enzyme to digest within the ACACS2 DNA extracted from silenced plants indicating that methylation is the cause of the observed co-suppression of the ACACS2 gene. Flowering characteristics of the transgenic plants were studied under field conditions in South East Queensland, Australia. Flowering dynamics studies revealed significant differences in flowering behavior, with transgenic plants exhibiting silencing showing a marked delay in flowering when compared with non-silenced transgenic plants and control non-transformed plants. We argue that the ACACS2 gene is one of the key contributors towards triggering 'natural flowering' in mature pineapples under commercial field conditions.

Considerations on growth characteristics of different pineapple varieties in Côte d'Ivoire, La Reunion and Caribbean Islands

P.Fournier (1), C.Dubois (2), A.Soler (3)
(1) CIRAD , Dpt PERSYST UR26 : Système de culture Bananier, Ananas et Plantain; Station de Bassin Plat - BP 180 - 97455 Saint-Pierre Cedex - Réunion Tél : +262 2 62 96 97 38 - patrick.fournier@cirad.fr
(2) CIRAD - UMR Multiplication végétative Avenue Agropolis - TA A-75 / 02 (Bât. 3, Bur. 114) 34398 Montpellier Cedex 5
(3) UR26 Système de culture Bananier, Ananas et Plantain CIRAD-PRAM, Dpt PERSYST BP214 97285 Lamentin cedex2 Martinique

Tendency in pineapple markets is to offer more and more varieties to the consumers as it is done for other products. Beside the references of 'Smooth Cayenne' and today 'MD-2' varieties, 'Queen' and new hybrids are also proposed for commercial production to the farmers. As consistency in production and quality is a key point for markets, it is important to know the behaviour of the different varieties at field level. Growth characteristics of 'MD-2', 'Smooth Cayenne' and 'Queen Victoria' have been assessed in different areas, such as on one hand in Côte d'Ivoire for 'Smooth Cayenne', 'MD-2', and on the other hand 'Queen Victoria' in La Reunion; additional data from Martinique have also been used for all varieties. Plant weight increases in a similar pattern for 'Smooth Cayenne', 'MD-2' and 'Flhoran 41', but is slower for the 'Queen' variety. 'D' leaves growth shows the classical sigmoid pattern for all the varieties. 'D' leaves weight is used as an index for forcing date determination. In Côte d'Ivoire on 'Smooth Cayenne' and 'MD-2', forcing is done when 'D' leaves reach 80 g fresh weight. At this stage plant weight is 2,0 kg and expected average fruit weight is 1.5 kg (standard for export). 'Flhoran 41' for the same plant weight, has a larger number of leaves and ´D` leaves weight is 75 g to harvest a fruit of 1.5 kg. 'Queen' shows a 'D' leaf weight of 50 g for a plant weight of 1.0 kg giving an average fruit weight of 700 g (air freight standard in La Reunion). The data give also a confirmation, if needed, that whatever the variety is, aerial suckers have faster growth than slips and the last ones have a faster growth than fruit crowns. A tentative growth model based on sum of temperature is proposed. It may be useful for determination of the date of forcing under standard growth conditions.

Influence of irrigation on fruit quality of 'Pérola' pineapples

Otavio Alvares de Almeida (1), Luiz Francisco da Silva Souza (2), Domingo Haroldo Reinhardt (2)

(1) Analyst A of Embrapa Cassava and Tropical Fruits, Post office box 007, 44380-000, Cruz das Almas, Bahia, Brazil otavio@cnpmf.embrapa.br (2) Researcher of Embrapa Cassava and Tropical Fruits, Post office box 007, 44380-000, Cruz das Almas, Bahia, Brazil, lfranc@cnpmf.embrapa.br, dharoldo@cnpmf.embrapa.br.

The pineapple plant although being quite resistant to water deficit demands a good supply of water if the objective is to produce fruits with good commercial acceptance. For this reason, irrigation becomes frequently necessary for the pineapple crop, with the objective of correcting the insuffiency of rainfalls in volume or distribution. Special care should be taken on the management of irrigation in the period close to fruit harvest, because the excess of water in that phase may affect fruit quality, which may become too watery. As there is little scientific information on this subject, the present study was carried out at Embrapa Cassava and Tropical Fruits, Cruz das Almas, Bahia, Brazil, seeking to define the best moment for suspension of irrigation before fruit harvest. The treatments consisted of fruit harvest at the second, fourth, sixth, eighth and tenth day after suspension of irrigation, followed by evaluation of fruit quality characteristics. It was observed that as the time interval between the last application of irrgation water and fruit harvest increased, the contents of total soluble solids (SST) and the ratio TSS /acidity, also increased linearly, while the total titrable acidity of the fruits decreased linearly. It is concluded that the interval between last irrigation and fruit harvest is of great importance for pineapple fruit quality characteristics.

Trends of dry mass and nutrients accumulation in 'Yellow Mauritius' pineapple plants

Chen Jing (1), Zang Xiaoping (1), Lu Xinhua (1), Liang Lihong (2), Sun Guangming (1)
(1) South Subtropical Crops Research Institute, Chinese Academy of Tropical Agricultural Science, Zhanjiang Guangdong 524091 China, gm-sun@163.com
(2) Tropical Crops Genetic Resource Institute, Chinese Academy of Tropical Agricultural Science, Danzhou Hainan 571737 China

Some research has shown that fruit weight is directly related to dry mass of pineapple plant. Knowing the trends of dry mass accumulation is important to take decisions on cultural practices, such as amounts and dates of fertilizers to apply. Little information exists on dry mass and nutrients accumulation of 'Yellow Mauritius' pineapple plants. Hence a field work was carried out in Zhanjiang Guangdong on this cultivar in order to determine dry mass and nutrients accumulation in the different plant organs at different growth periods and time intervals. At each evaluation time six to ten plants were sampled in each of eight replications, dissected into their different organs, weighed and analysed. Major findings were: 1.Total plant dry mass increased with growth showing three peaks: the largest one between flower forcing and small fruit stage (2.04 g/d), the second one between fast vegetative growth and flower forcing, and the third one between metaphase (II) and anaphase of fruit development. 2. From flower forcing to small fruit stage was the period of fastest leaf and root dry mass accumulation (1.59 g/d and 0.10 g/d, respectively); that of the stem was between small fruit stage and metaphase (I) of fruit development (0.38 g/d). Both leaf and root dry mass accumulation stopped after the small fruit stage and that of the stem after the metaphase(I), whereas negative accumulation appeared after the metaphase(I) of fruit development for leaf and stem. The period of fastest accumulation of fruit dry mass was between metaphase(II) and anaphase of fruit development (1.9 g/d); for the slips it was in the anaphase. The accumulation of dry mass in fruit peduncle coincided with plant growth before metaphase(I) and stopped after metaphase (II). 3. From young plant stage to flower forcing, the accumulation of N,P,K showed an increasing trend with plant growth, the largest accumulation taking place in the period between slow growth II and flower forcing, reaching values of 17.5 mg/d, 1.6 mg/d and 43.7 mg/d, respectively. The second fastest accumulation was in the period between slow growth I and fast vegetative growth. It was concluded that there are different peaks for dry mass and nutrients accumulation for different organs and the whole plant, and that the ratios of N,P,K show some variations according to the different plant cycle stages.

Boron deficiency in 'Pérola' pineapple plants cultivated in containers for two cycles

Siebeneichler, S.C. (1), Monnerat, P.H. (2), Silva, J.A.da. (2), Carvalho, A.J. C. de (2)
(1) Universidade Federal do Tocantins (UFT), Gurupi, TO, Brasil Fone: 63 3311 3532, Fax: 63 3311 3501 susana@uft.edu.br (2) Universidade Estadual do Norte Fluminense (UENF), Campo dos Goytacazes, RJ Fone: 22 2726 1425, monnerat@uenf.br; jaccacio@uenf.br; almy@pq.cnpq.br

The symptomatology of nutrient deficiency in plants is related to the interaction of its physiology and the environment in which the plant lives. In addition, the 'Pérola' pineapple plant may present unique responses to nutrient deficiency because of its genetic pattern. Hence twenty 'Pérola' pineapple plants were cultivated in plastic containers of 10L in a greenhouse with the objective to characterize the visual symptoms of boron (B) deficiency in plants and fruits. Containers were filled with river sand washed five times with water and then twice with deionized water. Ten plants were irrigated with a complete solution and from the other ten plants B was depleted from the solutions from five months after planting. Plants showed a normal vegetative growth and formed normal fruits. It was observed that plants grown without B formed more slips than those grown with B. In the ratoon cycle and in suckers grown without B, boron deficiencies were observed only in the reproductive period of the plants. B deficiency symptoms were characterized by deformed and smaller fruits, with formation of a cortical outgrowth or resin secretion between fruitlets, as well as cracklings between fruitlets filled out with cortical excretion. B deficient plants did not present fruit crowns. Slips of ratoon plants showed leaves with failure at the margins and dry extremities.

Effects of sucrose and urea on boron mobility in pineapple plants

Janice Guedes de Carvalho (1), Rodrigo Pereira de Assis (2), Paulo Jorge de Pinho (3).
(1) Professora titular DCS/UFLA, janicegc@ufla.br, (2) Bolsista do CNPq de Iniciação Científica, Departamento de Ciência do Solo/UFLA, rdgpereira@gmail.com, (3) Doutorando, Departamento de Ciência do Solo/UFLA, pinhopj@yahoo.com.br.

An experiment was carried out with plantlets (300 g) of 'Imperial' pineapple in a complete nutrient solution containing 1µmol L^{-1} of boron (B) in order to reduce its concentration in the tissues, using a completely randomized experimental design. After 45 days, four plants (T0) were harvested and the remaining ones divided into two treatments: B and B+sucrose+urea (BSU), which were applied for three consecutive days at a concentration of 10 mmol L^{-1}, by brushing both faces of leaf number 20. At start of B foliar application its supply by nutrient solution was halted. One day after the third foliar application four plants were harvested from each treatment (T1) and after 60 days all the remaining plants were harvested (T2). Plants were fractioned into their different parts for posterior determination of B contents. For both treatments the highest B contents were found in the older parts of the plant (root, stem and leaves below the foliar treatment) in T0 and T1; contents reduced in T2 and kept at similar level in the newer parts of the plant, indicating translocation of this nutrient within pineapple plants. In addition, plants did not show deficiency symptoms during the two months period under B submission from the nutrient solution. In both treatments studied there was translocation of about 15% to the new leaves emitted after foliar application of B. Treatment with B had 7% more B accumulated in the parts above the leaf treated. Plants treated with foliar B had a better distribution of B in the the whole plant, whereas in the BSU treatment happened a large accumulation in the leaves below the leaf treated and a large reduction of accumulation in roots and stem.

Production and quality of 'Pérola' pineapple fertilized with boron

José Félix de Brito Neto (1), Walter Esfrain Pereira (2), José Alves Barbosa (2), Damon Pereira dos Santos (1), Rafael Alves (1), Vinícius Batista Campos (1), Daniel de Oliveira Alves (1)
(1) Mestrando em manejo de solo e água, Centro de Ciências Agrárias, Universidade Federal da Paraíba (CCA/UFPB), Areia-PB, Fone 83 3362 2300, Fax 83 3362 2259, netobritopb@bol.com.br, damondos@yahoo.com.br, viniciuspgmsa@hotmail.com, danielvieiraagro@hotmail.com.
(2) Prof. Dr. DCFS/CCA/UFPB, Areia-PB, CEP 58397-000, Fone 83 3362 2300, Fax 83 3362 2259, wep@cca.ufpb.br, jotabarbosa2000@yahoo.com.br.

The nutritional state of pineapple plants influences significantly plant growth and, consequently, its productivity and fruit quality. Boron (B) has direct effect on the processes of mitosis, differentiation and cellular elongation, also acting in the distribution and metabolism of carbohydrates, besides facilitating sugar transport under the form of sugar-borate complexes. In order to evaluate the effect of the application of four doses of B, as well as the influence of slips thinning, in two planting spacings, on the production and the quality of 'Pérola' pineapples, was carried out an experiment in Sapé, Paraiba State, Brazil, from April 2005 to November 2006, in a soil of flat topography and intermediate texture. The experimental design was in randomized blocks, with a factorial 2 x 4 x 2, referring to two spacings (0.80 m x 0.30 m and 0.80 m x 0.40 m), four doses of borax (0.0, 2.0, 4.0 and 6.0 g plant-1), supplied by two applications in solid form as sidedressing, and in absence and presence of slips thinning, with four replications. The experimental unit was formed by three plants. During the cultural cycle, plants were fertilized with 60 g of NPK. Evaluations were done on plant height and width, 'D' leaf length, fruit production per plot, fruit diameter and length without crown, crown length, weights of fruit rind, pulp and central cylinder and total soluble solids content. Data were submitted to analyses of variance, followed by contrasts for test F comparison of means. The spacing and slips thinning treatments did not influence the variables studied. The absence of boron decreased fruit size, while 2.0 and 4.0 g $plant^{-1}$ of borax resulted in larger values of crown weight, fruit length and pulp weight, when compared with 6.0 g $plant^{-1}$. The application of 2.0 g $plant^{-1}$ of borax allowed to obtain the largest fruits. Positive correlations were observed between pulp weight, cylinder weight and the productivity per plot.

Micronutrient levels in 'Pérola' and 'Smooth Cayenne' pineapple cultivars in Paraiba State

A.A. Rodrigues (1), R.M.N.Mendonça (2), S.M. Silva (2), A.P. Silva (3), J.T. Lacerda (4), L.C. Vilar (5)
(1) Programa de Pós Graduação em Agronomia, Centro de Ciências Agrárias (CCA), Universidade Federal da Paraiba (UFPB), Areia, PB, Brasil, alessaagro@gmail.com, (2) UFPB/CCA, Areia, Brasil, rejane@cca.ufpb.br, silvasil@cca.ufpb.br, (3) PRODOC-CAPES/PPGMSA, Areia, Brasil, paivadasilva@gmail.com, (4) EMEPA-PB, João Pessoa, Brasil, teotoniojp@ig.com.br, (5) EMATER-PB, João Pessoa, Brasil, comosus@terra.com.br

Information on fertilization and mineral nutrition with micronutrients for pineapple cultivars grown in Paraiba State is little. The objective of this work was to evaluate the fertilization with micronutrients of pineapple cultivars Pérola and Smooth Cayenne in the environmental conditions of the microrregion of João Pessoa in Paraiba State, Brazil. The experiments were carried out from June 2003 to May 2004, using completely randomized blocks design with five replications. Plants were cultivated in a simple row planting system (0.80 × 0.30 m), without irrigation and received the fertilization NPK (513-188-513 kg/ha), 1,5 kg/ha of B (borax), 2 kg/ha of Fe and Mn (iron and manganese sulfates) and 4 kg/ha of Cu and Zn (copper and zinc sulfates). The doses of Cu, Fe, Mn and Zn were applied by foliar spraying at 4, 6, 8 and 10 months and the doses of B at 11 months after planting. The foliar levels of B, Cu, Fe, Mn, Zn and Na were determined in the 'D' leaf at 4, 8 and 12 months after planting. The levels of Cu and Zn for both cultivars, of B and Na for ´Pérola' and Mn for ´Smooth Cayenne' were not influenced by the sampling date. The levels of Fe for 'Pérola' were higher at 4 and 8 months and the ones of Mn at 4 months after planting. The levels of B and Fe for 'Smooth Cayenne' were higher at 4 and 8 months while the ones of Na at 4 months after planting. The levels of B and Mn were usually higher for 'Pérola' and levels of Cu, Fe, Zn and Na were higher for 'Smooth Cayenne'. With exception for levels of Mn, Zn and N, both cultivars showed foliar levels of micronutrients below the ones considered adequate for pineapple crop.

Canonic correlations between variables of growth and nutrient contents in pineapple crop

A. A. Rodrigues (1), R. M. N. Mendonça (2), S. de M. Silva (2), A. P. da Silva (3), W. E. Pereira (2), A. P. Souza (2), J. M. de Sousa (4)
(1) Student of the Agronomy Graduate Program, Universidade Federal da Paraíba, Centro de Ciências Agrárias (CCA/UFPB), Areia, PB, Brasil alessaagro@gmail.com (2) Prof. Dr. CCA/UFPB, CEP: 58397-000, Areia, PB, Brasil rejane@cca.ufpb.br (3) Bolsista PRODOC/CAPES, DSER/CCA/UFPB, Areia, PB, Brasil (4) MAPA/SFA-PB, Estrada de Cabedelo S/N, Cabedelo, PB, Brasil

The objective of this work was to evaluate by canonic correlations the relationship between shoot characteristics, root system characteristics and nutrient contents in 'D' leaf of pineapple plants. Two experiments were carried out, using the cvs. Pérola and Smooth Cayenne, in the municipality of Santa Rita, Paraiba State, Brazil. The experimental design was in randomized blocks with five replications. Plant growth was determined by root, stem and leaf length, diameter, fresh and dry weight, at 4, 6, 8, 10 and 12 months after planting. The nutritional status (macro and micronutrients) was evaluated at 4, 8 and 12 months after planting. The canonic correlations between shoot growth and root growth variables of 'Pérola' plants were significant ($P < 0.01$) for one canonic pair (0.95), indicating higher values of leaf dry mass (cc=1.79) with larger fresh root mass (cc= -2.83). For 'Smooth Cayenne' plants, the correlations were high and significant ($P< 0.01$) for two canonic pairs. In the first one, the coefficients were high and positive for leaf (cc = 1.51) and stem fresh mass (cc = 1.37) and the fresh mass of the root system (cc = 0.49), indicating positive correlations between these characteristics. In the second one, the stem fresh mass (cc = 2.76) was higher, with larger root length (cc = 1.10). The correlations between growth variables and nutrient contents were high and significant ($P < 0.01$) for two canonic pairs. In the first one, the coefficients were high and positive for leaf fresh mass (cc = 1.1) and stem dry mass (0.57) with Mn contents (cc = 1.20). In the second one, higher values were observed for stem fresh mass (cc = 1.8) and lower ones for root fresh mass (- 1.22) with higher foliar contents of N (cc = 0.69) and B (cc = 0.50).

Post-harvest quality of 'Pérola' pineapple as a function of NPK fertilization in the microrregions of Santa Rita and Sapé, Paraiba State

A.P. Silva (1), A.P. Souza (2), S.M. Silva (2), V.H Alvarez V. (3), A.A. Rodrigues (4), G.B. Silva (2), J.T. Lacerda (5)
(1) PRODOC-CAPES do Programa de Pós Graduação em Manejo de Solo e Água, Areia, Brasil, paivadasilva@gmail.com (2) Universidade Federal da Paraíba, Centro de Ciências Agrárias, Areia, PB, Brasil, adailson@cca.ufpb.br, silvasil@cca.ufpb.br (3) Universidade Federal de Viçosa, Viçosa, MG, Brasil, vhav@ufv.br (4) rograma de Pós Graduação em Agronomia, Centro de Ciências Agrárias, Areia, PB, Brasil, asaagro@gmail.com (5) Empresa Estadual de Pesquisa Agropecuária do Estado da Paraíba (EMEPA), João Pessoa, PB, Brasil.

Mineral fertilization is an important pre-harvest factor in a pineapple crop, as the adequate nutritional supply affects positively yield and post-harvest quality of the fruits. The objective of this work was to evaluate the effect of NPK fertilization on yield and post-harvest fruit quality of 'Pérola' pineapple, under the environmental conditions of the microrregions of Santa Rita and Sapé, Paraiba State, Brazil. The experiments were carried out under rainfed conditions, from March 2004 to August 2005, using the design of randomized blocks with three replications and six treatments: T1 - N0P0K0 (control); T2 - N0P1K1 (without N); T3 - N1P0K1 (without P); T4 - N1P1K0 (without K); T5 - N1P1K1 (low level of NPK); T6 - N2P2K2 (high level of NPK). The levels of fertilization corresponded to the rates of 0, 250 and 500 kg/ha of N (urea); 0, 80 and 160 kg/ha of P2O5 (triple superphosphate) and of 0, 300 and 600 kg/ha of K2O (potassium chloride). Slips were planted in a simple rows system with a spacing of 0.80 × 0.30 m. Treatments were evaluated based upon the following variables: total production, fruit weight, length and diameter, crown length and weight, pH, total soluble solids (TSS), total titrable acidity (TTA) and ratio TSS/TTA. Treatments affected significantly ($p < 0,05$) all variables evaluated, except for total production, pH and TSS of fruits from Santa Rita. With exception of the values of TTA in both microrregions and of crown length in Sapé region, the highest values of the variables studied in both microrregions were obtained for the highest level of fertilization (N2P2K2). Fruits produced in Santa Rita presented higher values of total production, fruit weight, length and diameter, TSS and ratio TSS/TAA, whereas fruits from Sapé region showed higher values for crown weight and length, pH and TTA. Results emphasized the importance of fertilization to get higher yields and better fruit quality, as well as the need for different fertilization recommendations for the two microrregions studied.

Mineral composition of 'MD-2' pineapple plants in response to liming

M.G.V. Rodrigues, D.D. Pacheco, M.S.C. Dias, R.P.D. Souza, D.P. Ribeiro, L.G.F. Veloso, M.D.L. Gonçalves, A.A.N. Franco
Empresa de Pesquisa Agropecuária de Minas Gerais (EPAMIG), Centro Tecnológico do Norte de Minas (CTNM), Caixa Postal 12, Nova Porteirinha, MG, Brasil CEP 39525-000. magevr@epamig.br

There is an incentive for pineapple production in the North of Minas Gerais State, Brazil, stimulated by the introduction of agroindustries into the region, and also in the Jequitinhonha river Valley due to the drought tolerance of this crop. However, new varieties made available by research institutes have still not been tested under environmental conditions of these regions. The best pH range for the development of pineapple plants may vary as a function of the cultivar used. This work aimed at evaluating the nutritional status of 'MD-2' pineapple plants grown in acid soil in response to aplication of CAO and MgO. Using the method of aluminum neutralization and elevation of the Ca and Mg contents, were studied the doses of 0.0; 0.4; 0.8; 1.2; and 1.6 times the needs of liming (NC) under the form of CaO, and 0.0; 0.1; 0.3; 0.5; and 0.8 times the NC under the form of MgO, combined according to the double square experimental matrix, in a randomized blocks design with three replications. The planting material were in vitro plants, previously aclimatized in a screenhouse, and transplanted to pots containing 15 dm^3 of soil under greenhouse conditions. Flowering was forced at 10 months after transplanting using ethylene. 'D' leaves were harvested at seven months after transplanting and right before forcing. Leaves were divided into achlorophyl tissue (leaf basis) and chlorophyl tissue and for both the accumulation of dry mass and the composition in macro and micronutrients were determined. Data were submitted to regression analyses. The concentrations and contents of nutrients showed diverse responses to the doses of CaO and MgO studied, with adjustments to positive linear, quadratic and root square models. The responses were more common to the factor MgO, especially when the mineral composition of the leaf basis was considered in comparison to the chlorophyl tissue.

Nutritional diagnosis of pineapple 'MD-2' cultivated under the nutrients omission technique

D.D. Pacheco, R.P.D. Souza, M.G.V. Rodrigues, M.S.C. Dias, D.P. Ribeiro, A.A.N. Franco, L.G.F. Veloso, M.D.L. Gonçalves
Empresa de Pesquisa Agropecuária de Minas Gerais (EPAMIG), Centro Tecnológico do Norte de Minas (CTNM), Caixa Postal 12, Nova Porteirinha, MG, Brasil CEP 39525-000, dd-pacheco@epamig.br

'MD-2' pineapples are a recent alternative for the cultivation in the North of Minas Gerais State, Brazil. The appropriate fertilization is important for obtaining greater productivity and fruits of good quality. However, little it is known about the nutritional demands of that variety under the local conditions. The present work aimed at determining the mineral composition of pineapple 'MD-2' cultivated in greenhouse, under the nutrients omission technique. The nutritional reserve exhaustion of the soil (Typic Quartzipsamment) was done, cleaning it three times with water and doing a corn cultivation before the treatment application. The complete supply of nutrients; individual omissions of N, P, K, Ca, Mg, B and Zn; and complete omission were studied, totaling nine treatments, in a design of randomized blocks, with three replications. The slips were from tissue culture, previously acclimated in a screenhouse, and transplanted to pots with 15 dm3 of soil. 'D' leaves were collected for content and matter quantification of macro and micronutrients at six months after transplanting. Those leaves were divided in tissue with and without chlorophyll (sheath). The plants chemical composition was affected by the nutrients subtraction. Larger accumulation happened in the plants grown under complete supply of nutrients. There was strong decrease in N accumulation in treatments of complete omission of nutrients and with N omission. The effects were more accentuated when the analysis of tissue without chlorophyll was considered.

Deficiency symptoms of 'MD-2' pineapple plants cultivated under the nutrients omission technique

D.D. Pacheco, M.G.V. Rodrigues, M.S.C. Dias, R.P.D. Souza, D.P. Ribeiro, L.G.F. Veloso, M.D.L. Gonçalves, A.A.N. Franco
Empresa de Pesquisa Agropecuária de Minas Gerais (EPAMIG), Centro Tecnológico do Norte de Minas (CTNM), Caixa Postal 12, Nova Porteirinha, MG, Brasil CEP 39525-000. dd-pacheco@epamig.br

Controlled cultivations, using nutrients omission technique, are one of the ways to define symptoms of nutritional deficiencies in plants. Those symptoms may present variations in function of the climatic conditions and genetic materials used. A recent introduction of pineapple in the North of Minas Gerais was the cultivar MD-2, with potential for in natura and industrial consumption. The present study aimed at determining the deficiency symptoms of 'MD-2' pineapple plants grown in greenhouse under the nutrients omission technique. Before the treatments, the nutritional depletion of the soil, Typic Quartzipsamment, was done by washing it three successive times, and by growing corn on it. The complete supply of nutrients; individual omissions of N, P, K, Ca, Mg, B and Zn; and complete omission were tested, totaling nine treatments, in a design of randomized blocks, with three replications. Plantlets from tissue culture were used, previously acclimated in a screenhouse, and transplanted to pots with 15 dm3 of soil. The description of visual symptoms of mineral deficiencies was done. Visually, the most characteristic symptoms were: generalized chlorosis in plants with subtraction of N; and necrosis of the leaves extremities, mainly of those older ones, in plants with hunger in K, being observed, in both situations, a smaller development in comparison to plants with complete supply of nutrients. The plants grown with complete omission of nutrients manifested generalized chlorosis and board necrosis in the oldest leaves, indicating the association of hunger of N and K. The subtractions of P, Ca, Mg, B and Zn did not induce visible symptoms of deficiencies in the period of six months of treatment application.

Foliar nutrient contents of 'MD-2' pineapple plants in response to nitrogen fertilization

M.S.C. Dias, D.D. Pacheco, M.G.V. Rodrigues, R.P.D. Souza, D.P. Ribeiro, L.G.F. Veloso, M.D.L. Gonçalves, A.A.N. Franco
Empresa de Pesquisa Agropecuária de Minas Gerais, Centro Tecnológico do Norte de Minas (EPAMIG/CTNM), Caixa Postal 12, Nova Porteirinha, MG, Brasil CEP 39525-000. mariodias@epamig.br

Nitrogen nutrition is important to define the productive potential of pineapple plants and their susceptibility to diseases. The purpose of this work was to evaluate the effect of nitrogen fertilization on nutritional aspects and the susceptibility to Fusarium of 'MD-2' pineapple plants. The experiment was carried out in the field, under irrigation, at Fazenda Experimental de Mocambinho, EPAMIG-CTNM, in the Projeto Jaíba, MG. The doses of 0, 6, 12, 18 and 24 g of N / plant, as urea, in the absence and presence of mulch, were studied. Brachiaria grass was used as mulch, applied to the soil. 'D' leaves were harvested as indicators of the plants nutritional state, at ten months after planting of slips obtained by tissue culture, and their dry matter accumulation and macro and micronutrients contents were determined. Data were submitted to regression analysis, considering the information of contents and concentrations of nutrients as variables dependent of the N doses studied in both crop managements, with and without application of soil mulching. As the dosis of urea applied increased, also increased the foliar contents of N. There were also variations in the contents and concentrations of the other nutrients studied in response to doses of the nitrogen fertilizer, although, in most of the situations, less pronounced than those observed for N.

Growth and flowering of 'Imperial' pineapple under deficiency of macronutrients and boron

M.J.M. Ramos (1), P.H. Monnerat (2), L.G.da R.Pinho (2), J.L.de A. Pinto (2)
(1) Empresa Mato-Grossense de Pesquisa, Assistência e Extensão Rural S/A EMPAER/MT), Rua 2 , S/n, Edifício Ceres- CPA- Cuiabá-MT, fone (65) 36131721, majumota@ig.com.br, (2) Universidade Estadual do Norte Flumiense (UENF)/CCTA, Av. Alberto Lamego, 2000, Campos do Goytacazes-RJ, fone (22) 27261425, monnerat@uenf.br, pinho@uenf.br, jaccacio@uenf.br

This work was carried out under greenhouse conditions to evaluate the influence of macronutrient and boron deficiencies on growth and flowering of 'Imperial' pineapple plants. 48 plants were used, distributed in casualized blocks with six replications and the following treatments: Complete, - N, - P, - K, - Ca, - Mg, - S and - B. The experimental unit was set up by one plant in a plastic pot containing 14 kg of beach sand previously purified. Evaluations were done on fresh and dry weight, length and width of 'D' leaves, foliar area and number of leaves at forcing date and percentage of flowering plants in response to forcing. In addition the foliar concentrations of macronutrients and boron were determined. N deficiency reduced leaf number, foliar area and 50% of flowering rate; K deficiency reduced leaf width and that of S increased foliar area. All plants deficient in P, Ca and S flowered at 40 days after forcing treatment. At 45 days after forcing, 83.3% of plants of the complete treatment flowered, the same happened with plants of Mg deficiency at 50 days. The average adequate and deficiency contents of nutrients in g kg^{-1} at forcing date were the following: N - 14.8 and 6.6; P - 1.37 and 0.70; K - 23.0 and 11.6; Ca - 4.40 and 1.30; Mg - 2.30 and 0.90; S - 1.54 and 0.56 and B (mg kg^{-1}) - 20.0 and 5.6. Results suggested that the leaf number is the best indicator to determining the flowering forcing date for 'Imperial' pineapple plants.

Morphological characteristics of 'Imperial' pineapple fruits under macronutrient and boron deficiencies

Maria José Mota Ramos (1), Pedro Henrique Monnerat (2), Leandro Glaydson da Rocha Pinho (2), Almy Junior Cordeiro de Carvalho (2), José

Accacio da Silva (2)
(1) Empresa de Pesquisa Agropecuária e Extensão Rural do Mato Grosso do Sul (EMPAER/MT), Rua 2 , S/n, Edifício Ceres- CPA-Cuiabá-MT, fone 65 36131721, majumota@ig.com.br, (2) Universidade Estadual do Norte Flumiense (UENF)/CCTA, Av. Alberto Lamego, 2000, Campos do Goytacazes-RJ, fone (22) 27261425, monnerat@uenf.br, pinho@uenf.br, almy@uenf.br, jaccacio@uenf.br

A work was carried out under greenhouse conditions to evaluate the influence of macronutrient and boron deficiencies on morphological characteristics of 'Imperial' pineapple fruits. The experimental unit consisted of a plastic pot containing 14 kg of previously purified beach sand and one pineapple plantlet. The treatments were: Complete, - N - P; - K, - Ca, - Mg, - S and - B, applied as nutrient solutions, distributed in a randomized block design with six replications. At harvesting time, the following data were obtained: crown weight, fruit weight with and without crown, length of crown, fruit and stalk, diameter of stalk and fruit, and rind thickness. Inaddition were determined the leaf macronutrient and boron concentrations at 5, 7, 9 and twelve months after planting. Except for S, all deficiencies reduced fruit weight and diameter. Nitrogen deficiency reduced the weight of the fruit with crown by 58.6% and, without crown, by 65.7% and fruit length by 44.4%. Potassium deficiency reduced the stalk diameter by 23.4%, and boron deficiency reduced the stalk length by 35.0%, in relation to the complete treatment. Sulfur deficiency reduced the length of the crown. There was no effect of any nutritional deficiency on fruit rind thickness. The leaf concentration of any nutrient under deficiency was significantly lower than that of the complete treatment in all four sampling dates.

Nutrient contents in 'Smooth Cayenne' pineapple juice as a function of nitrogen fertilization and type of planting material

S.J. Freitas, S.S. Berilli, D.C. de Faria, A.J.C. de Carvalho, G.A.P. Dutra, P.C. Santos, L.C. Lopes, C.M. Martins, L.B. Sousa
Universidade Estadual do Norte Fluminense Darcy Ribeiro (UENF), Campos dos Goytacazes, RJ, Brasil, CEP 28013- 600, almy@pq.cnpq.br

Pineapple is a fruit of large world interest and the cultivar Smooth Cayenne is the most grown and of largest commercial interest. Studies on determination and evaluation of juice nutrient contents, which may be of interest not only for nutritional but also for crop management purposes, as for definition of fertilization doses, have been rather incipient. This work had the objective to evaluate the contents of P, K, Ca, Zn, Fe and Mn in 'Smooth Cayenne' pineapples as a function of type of planting material used and of nitrogen fertilization doses. The experimental design was in randomized blocks with factorial scheme 4 x 6, represented by four doses of nitrogen (4, 8, 12 and 16 g de N planta-1 cycle-1), using urea as source, and six types of planting materials: 1. Crowns 250 to 400 g; 2. Slips 200 to 350 g; 3. Slips 350 to 500 g ; 4. Suckers 300 to 450 g; 5. Suckers 450 to 600 g; 6. Suckers 600 to 750 g, with four replications. In general, there was a reduction of P, Fe and Cu contents in the juice for increasing doses of N, whereas K contents also increased. N fertilization did not affect Ca, Zn and Mn contents in pineapple juice. Fruits from plants originated by suckers presented the highest contents of K and Cu, whereas those form crowns (250 to 400 g) and from slips (200 to 350 g) presented lower contents of P, Fe e Zn. For Ca and Mn no differences were observed as affected by planting material types.

Nutritional evaluation of 'Smooth Cayenne' pineapple plants as a function of nitrogen fertilization and planting material type

D.C. de Faria (1), A.J.C. de Carvalho (1), R.I. Coelho (2), L.M. da S. Soares (1), A. Fornazier (1)
(1) Universidade Estadual do Norte Fluminense (UENF), Campos dos Goytacazes, RJ, Brasil, faria@uenf.br, almy@pq.cnpq.br, (2) Universidade Federal do Espírito Santo (UFES), Centro de Ciências Agrárias (CCA), Alegre, ES, Brasil, ruimario@cca.ufes.br

As N is the main nutrient responsible for plant vegetative growth, the vegetative growth of pinepple plants were studied in response to nitrogen fertilization levels and types and weights of planting material. The effect of four levels of N on foliar concentrations of N, P, K, Ca, Mg, S, Zn, Fe and Mn in plantas originated from different types of 'Smooth Cayenne' planting materials. The experimental design was in randomized blocks, in a factorial scheme 4 x 6, being four doses of N (4, 8, 12 and 16 g plant^{-1} cycle^{-1} of N), under the form of urea, and six types of planting material: 1. Crowns 250 to 400 g; 2. Slips 200 to 350 g; 3. Slips 350 to 500 g ; 4. Suckers 300 to 450 g; 5. Suckers 450 to 600 g; 6. Suckers 600 to 750 g, with four replications. 'D' leaf concentrations of nutrients were determined at four dates during the vegetative phase of the plant: Nov./05, Jan./06, Mar./06 and May./06. Throughout the vegetative growth of the pineapple plant, the concentrations of all nutrients analyzed showed significant variation depending on the phenological phase of the plant. Nitrogen fertilization influenced the concentrations of N, P, K, Ca and Mg, but did not affect those of S, Zn, Fe and Mn. For N and K, leaf contents increased during plant growth, with different variations for the types of planting material studied. In relation to P, Ca and Mg leaf concentrations, they reduced with plant age, independent from the planting material used. 'D' leaf concentrations of Zn and Mn increased with plant age, those of S and Fe decreased, and those of F were the only ones influeneced by the planting material used.

Root growth and macronutrient concentration of three pineapple cultivars at different planting densities

Andrés Rebolledo-Martínez, Ana Lid del Ángel-Pérez y Laureano Rebolledo-Martínez
Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, Campo Experimental Cotaxtla, km 34.5 Carret. Veracruz-Córdoba, Apartado postal 423, C.P. 91700, Medellín de Bravo, Veracruz, México. Tel: (228) 9348354; 9342926, rebolledoandres@yahoo.com.mx

In Mexico, about 20% of the 14000 ha of pineapple are cultivated with the hybrid MD-2, in order to fortify the fresh fruit export. There is not enough information about root system development in this crop, especially for 'MD-2' pineapple plants; for this reason, it was carried out a study with the objective of assessing root growth and its macronutrient dynamics from planting to harvest. This work was done in Veracruz, Mexico, in a subhumid tropical climate and acrisol ortic soil. The experimental design was a randomized blocks one in split plot with four replications. The large plots represented planting density: 30000, 45000 and 60000 plants ha^{-1}; and the small ones the cultivar: Smooth Cayenne, Champaka and MD-2. Nine samplings of roots were carried out along the crop cycle and root dry matter, length, volume and number determined, as well as its concentrations of nitrogen, phosphorus, potassium, calcium and magnesium. Results showed that the density of 30000 plants gave the largest production of dry matter at plant flowering date; and also presented the largest volume (cm3) and root density (g m-1). Root length did not differ statistically for 30000 and 45000 plants ha^{-1}. There were no significant differences in concentrations of nitrogen, phosphorus, potassium, calcium and magnesium for planting density. The hybrid MD-2 had lower root dry matter, number and density (mg cm^{-3} of soil) than the other cultivars. The root length was statistically similar for the three cultivars over the cycle. In relation to the nitrogen concentration, there were just significant differences between cultivars a month before harvest, where 'MD-2' was superior to 'Champaka' and this one to Smooth Cayenne, with values varying during the vegetative growth phase from 5 to 10 mg g^{-1}; in phosphorus differences occurred at plant flowering forcing stage and 'MD-2' presented the highest values from 0.3 to 0.7 mg g^{-1}; root potassium concentration in ten months old plants was the highest for 'MD-2'; at the other sampling dates, there were no significant differences among varieties for this element (values from 3 to 8 mg g^{-1}); varieties did not differ significantly for root calcium and magnesium concentrations, with values varying from 3 to 5 mg g^{-1} and from 1.8 to 3 mg g^{-1} respectively.

Production of fruits and slips of 'Pérola' pineapple submitted to different planting spacings

Victor Martins Maia (1), Antônio Braz de Almeida Júnior (2), Dilermando Dourado Pacheco (3), Gisele Polete Mizobutsi (4), Edson Hiydu Mizobutsi (5)
(1) Universidade Estadual de Montes Claros. Rua Reinaldo Viana 2630, Bairro Bico da Pedra, Janaúba, MG, 39440-000. Brasil, victor.maia@unimontes.br; (2) Universidade Estadual de Montes Claros. Rua Reinaldo Viana 2630, Bairro Bico da Pedra, Janaúba, MG, 39440-000. Brasil, brazesp@yahoo.com.br (3) Empresa de Pesquisa Agropecuária de Minas Gerais. Rodovia MGT, 122, km 155 - Caixa Postal 12, Zona Rural. Nova Porteirinha, MG, CEP 39525-000, Brasil, dd-pacheco@epamig.br (4) Universidade Estadual de Montes Claros. Rua Reinaldo Viana 2630, Bairro Bico da Pedra, Janaúba, MG, 39440-000. Brasil, gisele.mizobutsi@unimontes.br 5) Universidade Estadual de Montes Claros. Rua Reinaldo Viana 2630, Bairro Bico da Pedra, Janaúba, MG, CEP 39440-000, Brasil, edson.mizobutsi@unimontes.br.

Pineapple is a tropical fruit that requires special attention for the choice of the planting density. The best planting density in a certain region should satisfy the demands of the producer and consumers in relation to productivity and fruit quality, as well as the production of slips. This work aimed at evaluating the influence of different planting spacings on the productivity and production of 'Pérola' pineapple slips, in the North of Minas Gerais. The study was carried out at Fazenda Cachoeira do Salto, in Verdelândia district, North region of Minas Gerais, Brazil, on a red-yellow latossoil of flat tography, with average annual rainfall of 600 mm and average annual temperature of 26.3 °C. The experiment presented a design of randomized blocks, with four treatments, four replications and eight useful plants per plot. The treatments and their respective populations were the following: T1 - 0.80 x 0.40 x 0.30 m (55.555 plants ha^{-1}), T2 - 0.90 x 0.40 x 0.30 m (51.282 plants ha-1), T3 - 1.0 x 0.40 x 0.30 m (47.620 plants ha-1) and T4 -1.2 x 0.40 x 0.30 m (41.666 plants ha^{-1}). The central pivot irrigation system was used. The flowering induction was done at eleven month after planting. Fruit mass with and without crown, the productivity, the number of slips and suckers per plant and the total number of slips per hectare were evaluated. Data were submitted to the variance analysis and mena values of treatments compared by Tukey's test at 5% of probability. Significant effect of the treatments was not observed on fruit mass with and without crown, slips and suckers numbers per plant. The treatment with spacing of 0.80 x 0.40 x 0.30 m (55.555 plants ha^{-1}) presented larger productivity and larger production of slips per hectare. Support: FAPEMIG.

Quality of 'Pérola' pineapples produced in different spacings

Victor Martins Maia (1), Antônio Braz de Almeida Júnior (2), Dilermando Dourado Pacheco (3), Gisele Polete Mizobutsi (4), Edson Hiydu Mizobutsi (5)
(1) Universidade Estadual de Montes Claros. Rua Reinaldo Viana 2630, Bairro Bico da Pedra, Janaúba, MG, 39440-000, Brasil, victor.maia@unimontes.br; (2) Universidade Estadual de Montes Claros. Rua Reinaldo Viana 2630, Bairro Bico da Pedra, Janaúba, MG, 39440-000, Brasil, brazesp@yahoo.com.br; (3) Empresa de Pesquisa Agropecuária de Minas Gerais. Rodovia MGT, 122, km 155 - Caixa Postal 12, Zona Rural. Nova Porteirinha, MG, Brasil CEP: 39525-000, dd-pacheco@epamig.br; (4) Universidade Estadual de Montes Claros. Rua Reinaldo Viana 2630, Bairro Bico da Pedra, Janaúba, MG, 39440-000, Brasil, gisele.mizobutsi@unimontes.br; (5) Universidade Estadual de Montes Claros. Rua Reinaldo Viana 2630, Bairro Bico da Pedra, Janaúba, MG, 39440-000, Brasil, edson.mizobutsi@unimontes.br

The best planting density in a certain region should satisfy the requirements of the producer and consumers concerning to quality of the fruits. The goal of this work was to evaluate the quality of 'Pérola' pineapple produced in different spacings, in the North of Minas Gerais Sate, Brazil. The study was carried out at Fazenda Cachoeira do Salto, in the Verdelândia district, on soil of flat tography, and climate with an average annual rainfall of 600 mm and average annual temperature of 26.3°C. The experiment presented a design in randomized blocks with four treatments, four replications and eight useful plants per plot. The treatments and their respective populations were the following: T1 - 0.80 x 0.40 x 0.30 m (55.555 plants ha^{-1}), T2 - 0.90 x 0.40 x 0.30 m (51.282 plants ha^{-1}), T3 - 1,0 x 0,40 x 0,30 m (47.620 plants ha^{-1}) and T4 - 1,2 x 0,40 x 0,30 m (41.666 plants ha^{-1}). The irrigation system used was one moved by a center pivot. The flowering induction was done at eleven month after planting. The diameter, length, circumference, firmness and total soluble solids of the fruits were evaluated. Data were submitted to the variance analysis and means compared by the Tukey test at 5% of probability. There was no significant effect observed for the treatments studied on any of the variables evaluated. Support: FAPEMIG.

The influence of nitrogen and potassium doses on 'Pérola' pineapple fruit quality in the state of Tocantins

Saboya, R. C. C. (1), Siebeneichler, S. C. (2), Lorençoni, R. (3), Adorian, G. C. (3), Pires, L. P. M. (3), Souza, L. F. da S. (4), Caldas, R. C., (4) Matos, A. P. de (4)
(1) Researcher, Embrapa Cerrados, Caixa Postal 66, R. Badejos, Lt.07, Chácaras 69/72, Zona Rural, Gurupi, TO, Brasil, CEP: 77402-970, Fax: 3311-3501, cassia@cpac.embrapa.br, (2) Prof. PhD., Universidade Federal do Tocantins (UFT), Curso de Agronomia, Campus de Gurupi, Caixa Postal 66, CEP: 77402-970, Gurupi-TO, susana@uft.edu.br (3) Students, Agronomic Engineer Course from UFT, Campus de Gurupi, TO rogeriolorenconi@uft.edu.br, gentil.cav@uft.edu.br (4) Researchers, Embrapa Mandioca e Fruticultura Tropical, Caixa Postal 007, CEP: 44380-000, Cruz das Almas,BA,lfranc@cnpmf.embrapa.br,rcaldas@cnpmf.embrapa.br,apmatos@cnpmf.embrapa.br

In the state of Tocantins, because of the lack of local studies, the fertilization practice is still based on recommendations used in other regions, under different environmetal conditions. The objective of this work was to determine more appropriate doses of N and K for the 'Perola' pineapple crop in the state of Tocantins. The experiment was carried out in the municipality of Pedro Afonso under rainfed conditions, using a randomized blocks experimental design with five replications. For the composition of the treatments, the experimental matrix Plan Puebla III was used, defining intervals for N (26 to 494 $kg.ha^{-1}$) and K_2O (40 to 760 $kg.ha^{-1}$), giving ten treatments. The side dressing fertilization was divided in four fractions applied before floral induction. At harvest were sampled two large, intermediate and small fruits for each plot, giving 24 fruits per treatment, used for laboartory analyses of the following variables: fruit weight, with and without crown, fruit size with and without crown, fruit diameter, total soluble solids (TSS), total titrable acidity (TTA) and the ratio TSS/TTA. Treatments influenced fruit size and also its quality, mainly in the fruits considered small (< 1.100 g). Overall, there was a significant effect of nitrogen fertilization on fruit physical variables. The effect of potassium was observed for physical-chemical variables studied in fruits considered small. The average contents of total soluble solids varied from 13.4 to 14.4 ºBrix, and these values were according to commercial standards mentioned.

'Perola' pinapple in intercropping systems in Tocantins, Brazil: Vegetative and nutritional aspects of the 'D' leaf

Lorençoni, R. (1), Adorian, G.C. (1), Siebeneichler, S.C. (1), Pereira, M.A.B. (1), Pequeno, D.N.L. (1), Garcia, R.B.M. (1), Monnerat, P.H. (2), Silva, J.A.da. (2)
(1) Universidade Federal do Tocantins (UFT), Gurupi-TO, Brasi Fone: 63 3311 3532, Fax: 63 3311 3501, susana@uft.edu.br, gentil.cav@uft.edu.br, rogeriolorenconi@uft.edu.br, mireia@uft.edu.br, diegopequeno@uft.edu.br, abacaxi_rogerio@hotmail.com, (2) Universidade Estadual do Norte Fluminense (UENF), Campo dos Goytacazes-RJ, Fone: 22 2726 1425, monnerat@uenf.br, jaccacio@uenf.br.

The pineapple plant is a monocotyledon, herbaceous, perennial plant with rigid and slightly concavous leaves. The same ones are classified in accordance with its format and position in the plant. 'D' leaf, located at 45º of the plant axis, is the youngest among adult leaves and is the most active physiologically, reason for which it is used in nutritional evaluations of the plant. The objective of this work was to evaluate the effect of four crop associations on the vegetative and nutritional aspects of the pineapple plant. The experimental design was in randomized blocks with four replications. Slips and associated crops were planted in December 2005, on the Cedro farm, Miracema, Tocantins State, using the following treatments: T1: pineapple + *Panicum maximum* cv. Massai; T2: pineapple + *Cynodon dactylon*; T3: pineapple + *Canavalia ensiformis*; T4: pineapple + spontaneous plants, and T5: pineapple in monoculture. Pineapple plants were distributed in a double rows system with spacing of 1.50 x 0.50 x 0.45 m, and the plants of the associated crops were placed into the space between the double rows. 'D' leaf dry mass, width and its concentrations of nutrients were determined right before floral induction. Intercropping with *Canavalia ensiformis* reduced the 'D' leaf dry mass and width at 180 and 240 DAP (days after planting). At 360 DAP, 'D' leaves of plants in monoculture were larger than those of pineapple plants in intercroppings with *Canavalia ensiformis* and spontaneous plants. Treatments T1 and T3 presented an increase in organic N content in relation to the control. Treatments T1 and T2 differed from the control in relation to chlorine concentration. The foliar concentrations of the macronutrients were below those recommended, while among the micronutrients only boron, copper and manganese presented contents within the standards established in all treatments of intercropping.

'Perola' pineapple in intercropping systems in Tocantins, Brazil: Production aspects

Adorian, G.C., Lorençoni, R., Siebeneichler, S.C., Pereira, M.A.B., Pequeno, D.N.L., Garcia, R.B.M., Gonçalves, K.C.G., Souza, C.M.de.
Universidade Federal de Tocantins, (UFT), Gurupi-TO, Brasil, Fone: (63) 3311-3532, Fax: (63) 3311-3501, susana@uft.edu.br; gentil.cav@uft.edu.br; rogeriolorenconi@uft.edu.br; mireia@uft.edu.br; diegopequeno@uft.edu.br; abacaxi_rogerio@hotmail.com.

Tocantins is a good ranking State in the national and international pineapple production, marketing fruits with a quality usually above the average national one. The sales on the international market have been stable in the last years, being an excellent option for 'Pérola' pineapple marketing, but the requirements of the markets have taken local producers to adjust to the new reallities. Amongst the requirements the main point is fresh fruit certification by the official stamp of integrated fruit production (PIN), which among crop management systems, gives emphasis to soil covering and control of its erosion. The objective of this work was to evaluate the production aspects of 'Pérola' pineapples under intercropping systems. Planting was carried out in December 2005, at Cedro Farm, Miracema do Tocantins, applying the following treatments: T1 - pineapple + massai grass; T2 - pineapple + *Cynodon dactylon* grass; T3 - pineapple + pork beans (*Canavalis ensiformis*); T4 - pineapple + small native plants, and T5 - pineapple in monoculture. Pineapple plants were distributed in a double rows system with a spacing of 1.5 x 0.5 x 0.4m, and the associated crops were set up within the double rows. The experimental design was in randomized blocks with four replications. The following variables were determined: Productivity, fruit weight, total soluble solids (SST), total titrable acidity (ATT) and the ratio SST/ATT; in addition fruits were separated by size following the official Brazilian rules. There was no significant difference between the treatments studied for productivity, SST, ATT and ratio SST/ATT, but fruit weight was rather low for the T3 treatment, with a higher percentage of small fruits than observed for the other treatments. This may be attributed to the larger size and the aggressive growth behavior of Canavalia ensiformis when compared with the other intercrops studied, resulting in a stronger competition for nutrients and luminosity with the pineapple plants, especially during the first months of its cycle.

Cover crops on weed management in integrated pineapple production plantings

Aristoteles Pires de Matos (1), Nilton Fritzons Sanches (1), Luiz Francisco da Silva Souza (1), Fernando Antônio Teixeira (2), José Elias Júnior (3)
(1) Embrapa Mandioca e Fruticultura Tropical, Caixa Postal 07, 44380-000, Cruz das Almas, Bahia, Brasil, Telefone 75 3621 8094, apmatos@cnpmf.embrapa.br, (2) Cooperativa Agropecuária de Pedro Afonso, Rodovia TO-235, km 01, Pedro Afonso, Tocantins, Brasil, (3) Secretaria da Agricultura, Pecuária e Abastecimento do Tocantins, Caixa Postal 104, 77003-020, Palmas, Tocantins, Brasil

Weed control in pineapple orchards in Brazil is traditionally performed manually an spraying herbicides as well, thus aggressive to the environment. The objective of this work was to evaluate the effect of *Cynodon dactylon* and *Pennisetum americanum* as cover crops on the weed management in pineapple orchards under integrated production system in comparison with the conventional system. The cover crop management consisted of spraying post emergence herbicide at bloom and cut down, allowing the cover crop residue to remain on the soil as mulch, and making direct planting of the cover crop as many times as possible, depending on environmental conditions. Weed control in the conventional system was performed by six manual interventions and four pre emergence herbicide sprays. On the other hand, no conventional weed control was performed in the pineapple orchards where *C. dactylon* and *P. americanum* were used as cover crops. Evaluation of nutritional status of the pineapple plants, based on D leaf analyses prior to the treatment to induce flowering, besides showing no competition of either *C. dactylon* or *P. americanum* with the cash crop, showed also higher nutrient levels than those of the conventional planting. Pineapple fields conducted in association with cover crops produced higher percentage of fruits weighing over 1,500g than that where weeding was performed as conventional system. Additionally using *P. americanum* as cover crop resulted in production of high number of large fruits, over 1,800g, in comparison with association with *C. dactylon* as cover crop and the conventional weed management.

Evaluation of economic and environmental impacts of the integrated pineapple production in the State of Tocantins-Brazil

Clóvis Oliveira de Almeida (1), Aristóteles Pires de Matos (1), Carlos Estevão Leite Cardoso (1), Nilton Fritzons Sanches (1), Fernando Antônio Teixeira (2), José Elias Júnior (3)
(1) Embrapa Mandioca e Fruticultura Tropical, Caixa Postal 07, 44380-000, Cruz das Almas, Bahia, Brasil, Telefone 75 3621 8094, calmeida@cnpmf.embrapa.br, (2) Cooperativa Agropecuária de Pedro Afonso, Rodovia TO-235, km 01, Pedro Afonso, Tocantins, Brasil, (3) Secretaria da Agricultura, Pecuária e Abastecimento do Tocantins, Caixa Postal 104, 77003-020, Palmas, Tocantins, Brasil

Integrated pineapple production in Brazil initiated in the States of Tocantins, Paraiba and Bahia. In Tocantins where the system advanced more, integrated production reached commercial level: 150 hectares in 2007, conducted by 15 pineapple growers in 11 municipalities. Evaluation of economic and environmental impacts was performed according to the "System Ambitec-Agro", composed by a pool of indicators and components related to technology efficiency, environmental preservation and recovery. Eight growers were surveyed, all of them at the same integrated production level, as well as three experts that work on the project. In conventional production system pesticides are applied in a preventive way, usually there are nine insecticide applications and six fungicide applications during the crop cycle. In the integrated production system, the decision to spray pesticide is based on the monitoring of pests and diseases. Besides promoting the use of less toxic pesticides, the practice of the integrated pineapple production reduced the amount and the number of pesticide applications, thus resulting in lower production costs in comparison with the conventional system. Reductions in pesticides were as follows: herbicides, 47%, insecticides, 37% and fungicides, 20%. The use of herbicide decreased from four pre-emergence applications to two post-emergence applications during the crop cycle. The positive effect of the integrated pineapple production on the environment was due to the improvement on soil quality and reduction on pesticides applications, resulting in an index equal to 2.34, on a scale ranging from -15 to +15. Finacial support: MAPA.

Evaluation of social impact of the Integrated Pineapple Production in the State of Tocantins-Brazil

Clóvis Oliveira de Almeida (1), Aristóteles Pires de Matos (1), Carlos Estevão Leite Cardoso (1), Nilton Fritzons Sanches (1), Fernando Antônio Teixeira (2), José Elias Júnior (3)
(1) Embrapa Mandioca e Fruticultura Tropical, Caixa Postal 07, 44380-000, Cruz das Almas, Bahia, Brasil, Telefone 75 3621 8094, calmeida@cnpmf.embrapa.br, (2) Cooperativa Agropecuária de Pedro Afonso, Rodovia TO-235, km 01, Pedro Afonso, Tocantins, Brasil, (3) Secretaria da Agricultura, Pecuária e Abastecimento do Tocantins, Caixa Postal 104, 77003-020, Palmas, Tocantins, Brasil

The evaluation of the social impact of the Integrated Pineapple Production in the State of Tocantins, Brazil, was performed according to the "System Ambitec-Social" developed by Embrapa Environment. Evaluation was carried out in three phases. The first one refers to the identification of the activities of the farm, in order to establish the impact achievements, the importance of the components and indicators, according to the characteristics of the activity and of the site, level of occurrence in the farm and around it. The second phase consisted on either interviewing or inspecting the field conditions that was performed with pineapple growers (or with the farm manager) and with experts who know the level of adoption of the technologies related to integrated pineapple production. During this phase a system ponderation matrix was filled, creating partial index and impact aggregates. In this evaluation eight pineapple growers were interviewed, all of them in the same level of adoption of the integrated production technology (out of fifteen that are engaged in the project) as well as three experts who work in the project. The third phase deals with the analysis and interpretation of those indexes. The evaluation of social impact includes four aspects related to the impact characterization: employment, income, healthy, and administration management. The aggregated index of the social impact of the integrated pineapple production technology in the State of Tocantins, applied to the eight farms shows a positive value equal to 3.65 on a scale ranging from -15 to +15. No indicator component of the methodology showed negative value; all of them were positive and different from zero. The indicators that showed the highest impacts were: institutional relationship, safe food production, training, and dedication and profile of the project coordinator. Finacial support: MAPA.

Microbiological indicators of soil quality in area cultivated with pineapple under different fertilization systems

Aldo Vilar Trindade (1), Isabel Cristina Silva Maia (2), Domingo Haroldo R. C. Reinhardt (1)
(1) Embrapa Mandioca e Fruticultura Tropical, caixa postal 007, Cruz das Almas, Bahia, Brasil, CEP 44.380-000, Brasil, aldo@cnpmf.embrapa.br, dharoldo@cnpmf.embrapa.br, (2) Eng. Agrônoma, isabelmaiam@bol.com.br

The pineapple agribusiness in Bahia, whose main producer is the municipality of Itaberaba, may have its sustentability threatened if the environmental cost, especially the destruction of natural vegetation and degradation of the soil cultivated, will not be reduced. Under the lens of microbiology and biochemistry, soil quality has mainly been evaluated by the use of the following variables and processes: total microbiological activity, microbiological C biomass, metabolic quotient obtained from the two previous indicators, and enzymatic activity. More recently, people have been worked on indicators of microbial diversity and the use of glomaline, a glicoprotein associated exclusively with arbuscular mycorrhizal fungi. In this work are addressed the effects of conventional, organic and natural cultivation systems of 'Pérola' pineapples on the microbiological and biochemical soil characteristics, seeking to relate them to soil quality, under conditions of the Coastal Table Land ecosystem. The study area is located in Cruz das Almas, Bahia, Brazil, where four systems were implanted, two of them as controls (one without mineral fertilization and chemical control of diseases and pests and the other one with mineral fertilization and chemical control of fusariosis), organic cultivation system (organic manures, especially BioNatus - PP and castor bean cake, complemented by foliar spaying of cow urine) and natural cultivation system (fertilization by Bokashi organic fertilizer and cocktail of EM4 microorganisms applied to the soil; and EM4 sprays on shoot during inflorescence development). Planting was carried out on May 2003, with six replications. During three years were done four soil samplings in the months of February/2004, August/2005, January/2006 and August/2006, aiming at the evaluation of microbiological and biochemical variables. The organic system stimulated a higher soil quality index, taking into account the four sampling dates, but the index tended towards the same level among treatments at the last sampling date, when the crop was already at the end of its cycle.

Chlorflurenol as Maintain® CF-125 for commercial production of pineapple planting material

N. Bhushan Mandava. Repar Corporation, Silver Spring, MD 20914, USA, Phone: 202-223-1424, Fax: 202-223-0141, mandava@compuserve.com

´Smooth Cayenne` pineapple is a perennial plant which is grown commercially in Hawaii and other parts of the world. It is self incompatible in producing seedless fruits. In the absence of seeds, pineapple must be propagated from vegetative parts, referred to as slips and crowns. High yielding ´Smooth Cayenne` clones grown commercially produce very few slips. Therefore, the principal naturally occurring source of the planting material is the crown of the pineapple. In fresh fruit operations, the fresh fruit is sold with crowns and as a result, the pineapple growers must rely on slips as a source for planting material. Chlorflurenol is an active ingredient in Maintain® CF-125 which has been found to be very useful for producing sliplets which are used as the pineapple planting material. This product is now registered in the United States for application to pineapple. Maintain® CF-125 is applied at 0.6 to 1.2 kilograms active ingredient in 2000 to 3000 liters of water per hectare to vegetatively mature plants in combination with ethephon. A second application may be made after about 10 days interval. Chlorflurenol is applied 6 to 8 months prior to desired planting material.

Session III Plant Protection

Scale Insects (Hemiptera: Coccoidea) of pineapple in the State of Espírito Santo, Brazil

Mark Paul Culik, José Aires Ventura, David dos Santos Martins
Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural - INCAPER Rua Afonso Sarlo 160, CEP 29052-010, Vitória, ES, Brasil (27)3137-9874; ventura@incaper.es.gov.br

Pineapple is an important crop in Espírito Santo, Brazil, and there is a need for increased pest management information for the crop in this state. Scale insects (Hemiptera: Coccoidea), especially mealybugs, are major pests of pineapple throughout the world but very little is known of the scale insects that occur in Espírito Santo. Therefore, this research was conducted to determine what species of scale insects occur on pineapple and other plants in Espírito Santo to obtain a better understanding of the potential pests of pineapple (and other crops) in the state. Insects were collected from pineapple and other plants from various locations throughout the state from 2003 to 2006. Coccoidea were identified from about 200 plant samples representing at least 30 species in 20 plant families (mainly of tropical fruits and ornamentals). Eleven scale insect species that are potential pests of pineapple were recorded for the first time in the state: *Aspidiotus nerii*, *Diaspis boisduvalii*, *Diaspis bromeliae*, *Melanaspis smilacis*, *Pinnaspis strachani*, *Pseudaonidia trilobitiformis*, *Unaspis citri*, *Coccus viridis*, *Phenacoccus madeirensis*, *Pseudococcus jackbeardsleyi*, and *Pseudococcus longispinus*. Other scale insects observed in this survey that are known or potential pests of pineapple were the following: *Dysmicoccus brevipes*, *Dysmicoccus grassii*, *Ferrisia virgata*, *Planococcus citri*, *Planococcus minor*, *Pseudococcus viburni*, and *Praelongorthezia praelonga*. Although at least 18 scale insect species that are potential pests of pineapple are present in the Espírito Santo, only *Diaspis boisduvalii*, *Diaspis bromeliae*, *Dysmicoccus brevipes*, and *Pseudococcus jackbeardsleyi* were collected from pineapple plants and currently only *Dysmicoccus brevipes* is known as a major pest of pineapple in the state. Information obtained in this study may provide a basis for development of integrated pest management methods for pineapple in Espírito Santo. Financial support: FINEP, FAPES and CNPq.

Fruit borer (*Strymon megarus*) causes severe losses in young 'Perola' and 'Smooth Cayenne' pineapple plants in the North of Rio de Janeiro State, Brasil

D.C. de Faria (1), A.J.C. de Carvalho (1), R.I. Coelho (2), J.C. de Oliveira Júnior (3)
(1) Universidade Estadual do Norte Fluminense (UENF), Campos dos Goytacazes, RJ, Brasil, faria@uenf.br, almy@pq.cnpq.br, (2) Universidade Federal do Espírito Santo (UFES), Centro de Ciências Agrárias (CCA), Alegre, ES, Brasil, ruimario@cca.ufes.br, (3) Empresa de Assistencia Técnica e Extensão Rural (EMATER-RJ), ESLOC-JP, São Francisco do Itabapoana, RJ, Brasil, eslocjp@yahoo.com.br

The North region was in 2004 responsible for 98.1% of the pineapple produced in the state of Rio de Janeiro, harvested in an area of 2.572 ha. The pineapple crop plays an important role in the economical and social area of this region, generating jobs and income for family agriculture. Aiming at evaluating the effect of nitrogen fertilization and types of planting material on the vegetative development and on sanitary and productive aspects of 'Pérola' and 'Smooth Cayenne' pineapple crops, was set up an experiment in the municipality of São Francisco do Itabapoana, Rio de Janeiro. The experimental design was in randomized blocks with a factorial scheme 4 x 9. Four doses of N (4, 8, 12 and 16 g plant-1 cycle-1) were studied, using urea as source, as well as nine types of planting material, being six of 'Smooth Cayenne' (Crowns 250 to 400g; slips 200 to 350g; slips 350 to 500g; suckers 300 to 450g; suckers 450 to 600g, and suckers 600 to 750g) and three of 'Pérola' (crowns 150 to 250g; slips 200 to 350g, and slips 350 to 500g), with four replications. The evaluation of initial plant growth until 120 days after planting showed positive effects of the nitrogen fertilization. From 120 to 140 days after planting, there was a very intense attack of fruit borer larvae (*Strymon megarus*) on plants of all treatments studied. The highest losses were observed in the cv. Smooth Cayenne for plants originated from 600 g to 750 g suckers and from crowns, with death indices of 74.5% and 25.5%, respectively. The same occurred for plants of cv. Pérola originated from 200 to 350 g slips and crowns, with death indices of 47.8% and 22.7%, respectively. Such high losses turned impossible the continuation of this experiment. It was shown that under certain circumstances the pineapple fruit borer may also be a severe pest for pineapple plants in their vegetative phase.

Monitoring of pineapple wilt in fields conducted under integrated pineapple production system in the State of Tocantins - Brazil

Nilton Fritzons Sanches (1), Aristóteles Pires de Matos (1), Fernando Antonio Teixeira (2), José Elias Júnior (3)
(1) Embrapa Cassava & Tropical Fruit, CP 07, 44.380-000, Cruz das Almas, Bahia, Brazil. Phone (55-75) 3621-8054, sanches@cnpmf.embrapa.br; (2) Cooperativa Agropecuária de Pedro Afonso, Rodovia TO-235, km 01, Pedro Afonso, Tocantins, Brazil. (3) Secretaria da Agricultura, Pecuária e Abastecimento do Tocantins, CP 104, 77.003-000, Palmas, Tocantins, Brazil.

Brazil is one of the most important pineapple producing countries, and the majority of the Brazilian states grow that crop. Among the phytosanitary problems that affect pineapple in Brazil the pineapple mealybug wilt, associated to *Dysmicoccus brevipes* (Ckll, 1893), is one of the most serious, since it may cause high yield losses if no control measure is adequately implemented. Preventive insecticide spray is still the way used by pineapple growers to control that pest. Such a practice besides being expensive is not environmentally safe. The objective of this work was to evaluate the incidence of mealybug wilt, associated to *D. brevipes*, in pineapple orchards, cv. Pérola, conducted under integrated pineapple production system in several pineapple production regions of the state of Tocantins. Monitoring activities were performed from March to November, 2006, in eleven farms located in eight municipalities, in pineapple fields varying from 0.5 to 39 hectares. In orchards up to five hectares monitoring were carried out by evaluating ten samples, 50 plants each, 500 plants in total. In orchard larger than five hectares evaluations were performed in 20 samples, 50 plants each, total 1,000 plants. Monitoring was performed every other month by evaluating each pineapple plant for wilt symptoms. Despite being present in all pineapple field evaluated, the highest proportion of wilted plants observed during all the evaluating period was 4.4%. In four out of the eleven pineapple fields mealybug wilt incidence reached the control level (>1%) and due to that chemical control was recommended. Implementing this proppoсed integrated management of the pineapple mealybug wilt resulted in 37% reduction on insecticide application to control that pest, thus contributing for environmental protection promoting reduction on production costs.

Control of black rot in 'Pérola' pineapples by natural extracts

José Alves Barbosa (1), Silvanda de Melo Silva (1), Walter Esfrain Pereira (1), Raffael Alves Rocha da Silva (2), Daniel de Oliveira Vieira (3), Diego Alves de Andrade (3), Ovídio Paulo Rodrigues da Silva (3), Talita Stephanie Alves da Costa (3), Valdênia Cardoso da Silva Ferreira (3), Andrew Rodrigues Alexandre (3)
(1) Prof. Dr., Departamento de Ciências Fundamentais e Sociais/Centro de Ciências Agrárias/Universidade Federal da Paraíba (DCFS/CCA/UFPB), 58397- 000, Areia - PB, Brasil, jotabarbosa2000@yahoo.com.br, silvasil@cca.ufpb.br, wep@cca.ufpb.br, (2) Engenheiro Agrônomo, Laboratório de Biologia e Tecnologia Pós-Colheita, DCFS/CCA/UFPB, (3) Estudantes de graduação em Agronomia, DCFS/CCA/UFPB, Areia - PB

'Pérola' is the most produced and consumed pineapple in Paraiba State and is of large socio-economic importance as source of jobs and income and due to its contribution for human fixation in rural zones of the Coastal and Forest regions of this State. Pineapple harvest usually occurs from September to January, peaking in December. Off-season pineapples from irrigated fields supply fresh markets with significant value aggregation. However, these fruits are usually offered on the regional markets at maturation stage with more than 50% of fruitlets being totally yellow. These fruits require an application of fungicide for black rot (*Chalara paradoxa*) control. The use of natural extracts may be an alternative for controlling this rot without toxicity risk represented by synthetic fungicides. The objective of this work was to evaluate the effect of extracts of neem (*Azadirachta indica*), anise (*Pimpinella anisum*), citronella grass and control (without extract) on minimization of black rot incidence and severity in pineapples harvested at the 75% yellow rind maturation stage. Fruits came from off-season fields in Itapororoca municipality. In the laboratory fruits were dipped into a 50 ppm active chloride solution and dried in the air. The extracts were prepared at 3% in water and applied onto the fruit base with a brush. The variables evaluated were fruit mass loss, soluble solids (SS), titrable acidity (TA), ratio SS/TA, reducing and not reducing sugars, ascorbic acid content, as well as incidence and severity of fungi growth on fruits kept under environmental conditions. The application of the extracts influenced mass loss and non reducing sugar contents. Fruits treated with neem extract presented lower incidence and severity of fungi growth in comparison with the other extracts studied. Financial support: BNB and CNPq.

Alternative control of black rot of pineapples

R.A. Carvalho, J.T. de Lacerda. Empresa de Pesquisa Agropecuária da Paraiba -EMEPA-PB, Rua Eurípedes Tavares, 210 João Pessoa, Paraíba, Brasil, remuloc@hotmail.com

The black rot of pineapple is an important post-harvest disease which is common in almost all producing areas of the world. It is caused by the fungus *Chalara (Thielaviopsis) paradoxa* which penetrates mainly through wounds made on the fruit base during harvest. Infection is rapidly followed by large dark lesions and rot which characterize this disease. Black rot of pineapple is traditionally treated with preventive application of fungicides. Different from other pineapple pests and diseases which are treated with pesticides some months before the harvest, the control of black rot of pineapple requires the application of fungicides immediately after the harvesting process, leaving a short time between spraying and consumption with high risks of contamination. This work had the objective of studying the effect of alternative products on the control of this disease, including the use of liquid wax, tannins, citrus extracts, bordeaux mixture and food preservatives (used in bakery and fruit juice industries). This research was carried out at the Pineapple Research Station in Sapé, Paraíba, Brazil, in a completely randomized experimental design. Most of the alternative products were incapable of preventing the development of the disease. However, it was found that the use food preservatives significantly reduced the size of black rot pineapple lesions from 12.66 cm in the control treatment to 0.43 cm in the sodium metabisulphite treatment and to 0.33 cm in the sodium benzoate treatment.

Evaluation of activity of resistance inducers, chemical fungicide and natural plant extracts on black rot of ´Pérola` pineapple

Mônica Danielly de Mello Oliveira (1), Luciana Cordeiro do Nascimento (2), Rodrigo Pereira Leite (3), Emmanuelle Rodrigues Araújo (3), Noelma Miranda de Brito (1)
(1) Post Graduate Student, Post Graduate Program in Agronomy, CCA/UFPB, Areia, PB, Brazil. (2) Prof. DSc. of Post Graduate Program in Agronomy, CCA/UFPB, C.P. 04, 58.397-000, Phone 83 3362-2300, Areia, PB, Brazil. (3) Graduate Student, Graduate Program in Agronomy, CCA/UFPB, Areia - PB, Brazil. monicadmportella@hotmail.com

Black rot of pineapple, caused by *Chalara paradoxa* is a post-harvest disease responsible for high losses of fruits destined both for fresh fruit markets and for processing. The penetration of the fungus into cells occurs through wounds causing infection. The objective of this work was to evaluate the effect of resistance inducers, the chemical fungicide Derosal (carbendazim) and natural plant extracts on black rot of pineapple. ´Pérola` pineapple fruits were disinfested for five minutes with sodium hypochlorite at 4%. After drying at room temperature, fruits were treated, by spraying, with the following treatments: 1) Distilled water (control), 2) Derosal 3) BION® (Acibenzolar-S-methyl); 4) Ecolife; 5) Agromos; 6) *Allium sativum* extract at 20%; 7) *A. cepa* at 20% and 8) *Azadirachta indica* at 20%. Treated fruits were incubated in a humid chamber with polyethylene bags during 24 hours before inoculation procedure using a mycelia disk added to a wound on the fruit skin epidermal area. Disease progress was evaluated using the following scale: 1- no symptoms, 2- black rot on fruit skin covering 1-5 simple fruitlets, 3- black rot on fruit skin covering 6-10 simple fruitlets, 4- internal yellow rot, 5- black rot and disintegration of more than 50% of internal area. The experimental design was a completely randomized one with eight treatments and five replications, using general linear models with multinomial distribution and media compared by Tukey test at 5%. The treatment that showed higher potentiality for black rot disease control on pineapple was Ecolife, allowing a longer post-harvest life period of fruits and retarding the appearance of disease symptoms.

Evaluation of infection with *Fusarium subglutinans* on ´Pérola` pineapple leaves

M. D. M. Oliveira (1), L. C. Nascimento (2), R. P. Leite (3), E. R. Araújo (1), N. M. Brito (1)
(1) Post Graduate Student, Post Graduate Program in Agronomy, CCA/UFPB, Areia, PB, Brazil, monicadmportella@hotmail.com (2) Prof. DSc. of Post Graduate Program in Agronomy, CCA/UFPB, C.P. 04, 58.397-000, (083) 3362-2300, Areia, PB, Brazil, luciana.cordeiro@cca.ufpb.br (3)Graduate Student, Graduate Program in Agronomy, CCA/UFPB, Areia, PB, Brazil, rodrigo.agro@bol.com.br

The main problem concerning disease on pineapple plant in Brazil is fusariosis, caused by *Fusarium subglutinans* f. sp. *ananas*, causing severe losses on fruits production. The present work had as objective to study the effects of methods of leaf basis inoculation on disease development based upon symptoms evaluation in short time. ´D` leaves from ´Pérola` pineapple plants were collected from commercial areas using integrated fruit production system, in Santa Rita, Paraíba, Brazil. Leaves were detached, disinfested with sodium hypochlorite at 2,0% for 10 minutes and washed with distilled water. Inoculations were done at two and five centimeters from the leaf basis. The following treatments were: 1) toothpick with fungus - perpendicular position; 2) toothpick with fungus - longitudinal position; 3) disk of fungus colony on a wound; 4) disk of fungus colony on a wound + humid cotton (on leaf); 5) disk of fungus colony on wound + humid cotton (leaf border); 6) disk of fungus colony on wound + protection with adhesive tape; 7) cotton with inoculum suspension. Evaluations were done 15 days after inoculation, based upon lesion area. Higher lesion development was observed in treatment with disk of fungus colony on wound + humid cotton (leaf border). Inoculation position did not have significant effects on symptoms development.

Genetic diversity in strains of the causal agent of fusariosis on pineapple

Cristiano S. Lima (1), Sarah S. Costa (1), Natália C. Crespo (1), José Aires Ventura (2), Ludwig H. Pfenning (1)
(1) Departamento de Fitopatologia, Universidade Federal de Lavras, Caixa Postal 3037, 37200-000, Lavras, MG, (2) INCAPER, Rua Afonso Sarlo 160, Bento Ferreira, 29052-010, Vitória, ES, ludwig@ufla.br

F. guttiforme (Fusarium subglutinans f. sp. *ananas*), is the causal agent of fusariosis on pineapple in Brazil. Despite the importance of the disease, the genetic diversity of populations of the pathogen is not well understood. The genetic diversity was assessed for 20 monosporic *Fusarium* strains obtained from cv. Pérola plants showing symptoms of fusariosis in Espírito Santo State, through vegetative compatibility analysis (VCG), and sequencing and phylogenetic analysis of a portion from the ß-tubulin gene. The pathogenicity of the strains was tested by inoculation in pineapple leaves and plantlets. The strains were grouped in nine VCGs. The VCG1 contained seven strains from Jegoriuma, Marataízes and Presidente Kennedy localities, while VCG2 contained four strains from Brejo dos Patos and Presidente Kennedy. VCG3, VCG4, VCG5, VCG6 were composed by no more than two strains each, all from Presidente Kennedy. VCG7, VCG8 and VCG9 were single-member VCGs from Marataízes. Through phylogenetic analysis three distinct clades were observed among the strains studied. F. guttiforme Group I contained the majority of strains of VCG1 and one strain of VCG2, while in Group II assembled one strain of VCG1, VCG2, VCG3, VCG7 and VCG9, each. In Group III strains from the VCGs 2, 4, 5, 6 and 8 were found. Strains from all clades were pathogenic to pineapple. The presence of three phylogenetic groups and a high number of VCGs in the *Fusarium* population from Espírito Santo evidenced a high genetic diversity of the pathogen that causes the fusariosis on pineapple which can be explained by a possible sexual reproduction in this population. Better knowledge of the genetic diversity of *Fusarium* populations that causes fusariosis on pineapple will contribute to the improvement of breeding programs, looking for more durable resistance against the disease. Financial support: FAPEMIG (CAG 1476/06) and FAPES.

An improved method to produce pineapple propagative material free of pests and diseases

Cesare Antônio Maria Pace (1) Celso Merola Junger (1), Aristóteles Pires deMatos (2)
(1) Ministério da Agricultura, Pecuária e Abastecimento, Superintendência Federal de Agricultura, Av. Rodrigues Alves, 129, CEP 20081-250 - Rio de Janeiro, RJ (55 21) 2291 4141, pacecesar@hotmail.com, celsomerola@agricultura.gov.br; (2) Embrapa Mandioca e Fruticultura Tropical, CP 07, CEP 44380-000, Cruz das Almas, BA, (55 75) 3621 8094, apmatos@cnpmf.embrapa.br

Fusariosis, a pineapple disease caused by the fungus *Fusarium subglutinans*, constitutes the main constraint of that crop in Brazil. That pathogen is able to infect both the popagative material and the fruits. If accidentally introduced in a given pineapple growing region in infected planting material, the fusariosis is disseminated by biotic and abiotic agents and may result in epidemics depending on the environmental conditions and the crop management. Considering the importance of the sanitary quality of the propagative material on the fusariosis integrated management, this work was carried out aiming at maximizing the process of producing propagative material by the stem sectioning technique by promoting some modifications thus improving the production of healthy planting material. After harvest, selected pineapple plants cultivar Smooth Cayenne were pulled out of the soil, all leaves were removed, the stem cut both longitudinally and transversally to generate sections about 5 cm long. These sections were planted in trays with sand and kept under greenhouse conditions. Desirable humidity for bud development was kept by mist spraying water. All developing buds were removed from the stem section and transferred to tubets and kept under greenhouse conditions. Fertilizations were performed during plantlets development. Preventive pesticide sprays were eventually carried out to assure plantlets sanitary quality. From six to eight months after transfer the plantlets were ready to be brought to field. The improvement on the stem sectioning technique developed in this work showed an average production of 30 plantlets per stem in comparison with up to eight plantlets obtained when the conventional stem sectioning technique was used.

Fusariosis integrated management in pineapple fields under integrated production system

Aristoteles Pires de Matos (1), Nilton Fritzons Sanches (1), Fernando Antônio Teixeira (2), José Elias Júnior (3)
(1) Embrapa Mandioca e Fruticultura Tropical, CP 07, 44380-000, Cruz das Almas, Bahia. Telefone (55-75) 3621 8094. apmatos@cnpmf.embrapa.br; (2) Cooperativa Agropecuária de Pedro Afonso, Rodovia TO-235, km 01, Pedro Afonso, Tocantins; (3) Secretaria da Agricultura, Pecuária e Abastecimento do Tocantins, CP 104, 77003-020, Palmas, Tocantins.

The pineapple fusariosis, caused by *Fusarium subglutinans*, is the main constraint of that crop in Brazil. Traditionally the disease is controlled by preventive fungicide applications during inflorescence development. The objective of this work was to evaluate integrated management practices to control the fusariosis in pineapple fields managed under integrated production system. Monitoring of fusariosis was performed every month, starting three months after planting and continuing up to the treatment to induce flowering. Sampling for fusariose incidence depended on size of planting; in fields of up to five hectares, five hundred plants were evaluated while in larger than five hectares fields evaluations were performed in one thousand plants. During monitoring fusariosis infected plants were eradicated. Chemical control was only recommended in fields with fusariose incidence of 1% or higher. No fungicide application was recommended when inflorescence development occurred under unfavorable conditions for fusariosis incidence. During the vegetative cycle, the number of fusariose infected plants increased progressively up to the eighth evaluation, tending to stabilization. The lowest percentage of infected plants at the first evaluation was 0.4% and the highest 2.0%. Evaluations performed immediately before the treatment to induce flowering showed percentage of fusariose infected plants varying from 1.2% up to 16.6%. Fusariosis incidence in fruits varied according to the harvest time. In most of the pineapple fields, the proposed integrated management practices to control fusariose enabled complete control of the disease on fruits. On the other hand, harvest performed under favorable conditions for fusariosis development showed up to 46.5% of infection. Additionally the proposed fusariosis integrated management made possible the reduction of fungicide application by 20%, thus reducing production costs and contributing for environmental protection.

Protection of 'MD-2' pineapple fruit against solar radiation with different products

Rebolledo M. Laureano, Uriza Á. Daniel E., Del Ángel P Ana Lid, Rebolledo M. Andrés
Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Campo Experimental Cotaxtla-Sitio Experimental Papaloapan. Apartado Postal 43 Km 66 carretera Cd. Alemán-Sayula. Isla, Ver. México,
rebolledo.laureano@inifap.gob.mx; uriza.daniel@ inifap.gob.mx; rebolledo.andres@inifap.gob.mx.

The pineapple fruit protection against the solar radiation in Mexico has to be carried out throughout the year; in order to reduce the cost of this practice, pineapple growers use for fruit protection mostly paper or the leaves of the own pineapple plant. There are, however, other options that could be evaluated in the environment of the Mexican pineapple area for avoiding this problem. The objective of this work was to determine the effectiveness of different type of shadings for protecting the pineapple fruit against the solar radiation. The experiment was carried out in Veracruz, Mexico, at 18º06' latitude North, 95º31' longitude West and 50 m of altitude. The experimental design was a randomized blocks one with three replications; the treatments studied were: 1) protection with polyethylene plastic (stock market), 2) mesh screen shade, 3) paper, 4) protection with the leaves of the own plant, 5) Surround at 100 kg ha^{-1} and 6) Control. The planting density was 50000 plants ha^{-1}. The treatments were established in the period of larger solar radiation. The variables evaluated were: a) fruits skin damage based upon the following levels: light damage, fruits not accepted at the export market; level two, intermediate damage, not accepted by both local and export markets and; level three, strong damage, without any commercial chance; b) relative water content; c) temperatures on the east and west sides of plant and fruit. The temperature was taken at 14:00 p.m. with an infrared thermometer. The results showed significant differences (p=0.05) among treatments. Fruits treated with Surround 100 kg ha^{-1} and not treated ones (control) presented the worst damage with values of 20% and 30% respectively; all other treatments did not show any damage. The temperature on the fruit west side in the control treatment was 42ºC, in the treatment with mesh screen was 37ºC while in the other treatments the temperature was 39.7ºC (p=0.05).

Session IV Alternative Uses

Influence of mineral nutrition on development and coloration of *Ananas comosus* var. *erectifolius* plants

Marta Taluana Santos (1), Luis Francisco da Silva Souza (2), Olívia Silva Nepomuceno dos Santos (3), Fernanda Vidigal Duarte Souza (2)
(1) Mestranda em fitotecnia da Universidade Federal do Recôncavo da Bahia (UFRB), Cruz das Almas, Bahia, Brasil (2) Pesquisadores da Embrapa Mandioca e Fruticultura Tropical, Caixa Postal 007, Cruz das Almas, Bahia, Brasil, CEP44380-000,lfranc@cnpmf.embrapa.br, fernanda@cnpmf.embrapa.br (3) Engª.Agrônoma, Universidade Federal do Recôncavo da Bahia (UFRB), olivianepomuceno@yahoo.com.br

This work had the objective to evaluate the influence of nutrients on the development and coloration of ornamental pineapple plants *Ananas comosus* var. *erectifolius*. The work was carried out at a greenhouse of Embrapa Cassava and Tropical Fruits under a completely randomized experimental design with eight treatments: 1- Control (without fertilizers), 2- Complete (macronutrients and micronutrients), 3- Absence of N, 4- Absence of P, 5- Absence of K, 6- Absence of Mg, 7- Absence of micronutrients and 8- Absence of limestone, with six replications. Each experimental plot was set up by one plant, in 10 kg pots with soil. As plant material were used in vitro plants of 18 cm height ('D' leaf). Plants were taken from the tubetes and their roots cut 4 cm from the base, before planting. The soil, except for that of treatment 8, was adjusted to increase the base saturation (V) to 50%. The fertilization, under liquid form, was divided into four fractions, the first one being done at three months after planting and the other ones at 60 day-intervals. 30 days after the last nutrient aplication, when the first evaluations of size and colour were done, there was a clear difference of leaf colour, more intense for absence of N (leaves more reddish than those observed in tretament 2), whereas in plants grown in absence of Mg the leaves were green. There was an influence of nutrients on plant height and emission of buds. These preliminary results showed the possibility to influence development and coloration of leaves of ornamental pineapples by managing their mineral nutrition.

Natural and artificial flowering of ornamental pineapple as influenced by nutritional deficiencies

Olívia Silva Nepomuceno Santos (1), Luiz Francisco da Silva Souza (2), Marta Taluana dos Santos (3), Fernanda Vidigal Duarte Souza (2)
(1) Agronomist, Federal University of Reconcavo of Bahia (UFRB), olivianepomuceno@yahoo.com.br, (2) Researchers, Embrapa Cassava and Fruit Crops, PO Box 007, Cruz das Almas, 44380-000, lfran@cnpmf.embrapa.br, fernanda@cnpmf.embrapa.br (3) MS student, Plant Science, Federal University of Reconcavo of Bahia (UFRB), Cruz das Almas.

Within the tropical flower crops, the ornamental pineapple excels as a plant of exotic beauty and high rusticity. However, there is little information on the agricultural management of these plants. This work aimed at evaluating the effect of mineral deficiencies on the natural and artificial flowering of the ornamental pineapple *Ananas comosus* var. *erectifolius*. The work was carried out in greenhouse, at Embrapa Cassava and Fruit Crops, with in vitro plants in order to standardize the initial material. The plants were cultivated in plastic pots with capacity for 10 kg, filled in with Yellow Latossol of low fertility. The experimental design was a completely randomized one in a 8 x 2 factorial arrangement, with eight treatments and three replications, comprising the following nutritional situations: 1 - control (without nutrients); 2 - complete (all nutrients); 3 - lack of N; 4 - lack of P; 5 - lack of K; 6 - lack of Ca; 7 - lack of Mg; and 8 - lack of micronutrients, all of them in combination with the application or not of Ethephon (2-chloroetilfosfonic acid, commercial product at 24% a. i.). The artificial induction was carried out 12 months after planting, with Ethephon (concentration of 1 mL of p.c. / L of water) applied by pulverization of 30 to 50 mL of the solution per plant, with a knapsack sprayer. Regarding to the natural flowering, some plants with deficiency of potassium flowered without artificial induction, while the others at 45 days after forcing treatment presented full flowering. Thirty days after the induction, the plants deficient in calcium and phosphorus had not flowered yet, indicating a possible influence of these nutrients on the flowering process. The plants cultivated with deficiency of N and micronutrients did not flower naturally, but presented a good response to the induction with Ethephon, as also observed on plants with deficiency of magnesium.

Proteolitic activity in stems of 'Vitória', 'Smooth Cayenne' and 'Pérola' pineapple plants

Helber Barcellos da Costa (1), Frederico da Silva Fortunato (1), Samara Gomes Delboni (1), José Aires Ventura (2)
(1) Faculdade Brasileira-UNIVIX, Rua José Alves, 301(Goiabeiras), 29075080 - Vitória-ES, Brasil, Tel.: 27 33271500, farmhel@yahoo.com.br; tdf.vix@terra.com.br e lemoa_ita@hotmail.com) (2) Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural (INCAPER), Rua Afonso Sarlo 160 (Bento Ferreira), 29052-010, Vitória, ES, Brasil, Tel 27 31379874, ventura@incaper.es.gov.br

Pineapple is a very important fruit crop, not only due to the production of fruits either for fresh market or for processing, but also due to its subproducts such as bromelin, that is a mixture of proteolitic enzymes very important for the pharmaceutic and food industries. In order to overcome phytosanitary problems, research institutes have been developing and recommending to growers new pineapple cultivars, such as the cv. Vitoria, recommended in November 2006, in the State of Espirito Santo. This pineapple cultivar shows resistance to fusariose, the main constraint of the pineapple crop in Brazil, and it has also horticultural characteristics similar or better than those of the commercially grown cultivars Pérola and Smooth Cayenne. The objectives of this work were to determine total protein content, and to evaluate proteolitic and specific activities of bromelin from stems of 'Vitória', 'Pérola' and 'Smooth Cayenne' pineapple plants. Plants were cultivated in the Experiment Station of Incaper, located in Sooretama-ES and samples were processed and analyzed in the Analytic Chemistry Laboratory of the Faculdade Brasileira-UNIVIX, from July to November, 2006, using standard analyses techniques recommended in the official literature. No significant difference was observed for total protein content of the three pineapple cultivars, values varying from 2.932 to 2.940 g/Kg. Regarding to proteolitic activity, samples from the cvs. Smooth Cayenne and Vitória did not show significant difference for the obtained values, 19,716.6 and 20,246.6 U/ml respectively, both of them significantly lower than that of the cv. Pérola (26,473.5 U/ml). The enzyme specific activities were 6,705.36 and 6,904.66 U/mg respectively, for cvs. Smooth Cayenne and Vitória, showing similar behavior with respect to proteolitic activity, while cv. Pérola presented 9,705.03 U/mg. Results showed that the cv. Vitória, besides having resistance to fusariose, has similar behavior to 'Smooth Cayenne' regarding to protein and enzyme in the stem tissues.

Extraction and partial purification of pectinmethylesterase in industrial residues of 'Pérola' pineapple pulp

Elck Almeida Carvalho, Biano Alves de Melo Neto, Gisele Abílio, Heinz Johann Holschuh
Federal University of Paraíba, Jardim Cidade Universitária, S/N, CEP 58051-900, João Pessoa, PB, Brasil, elckcarvalho@gmail.com, hj.holschuh@ct.ufpb.br

The pectinmethylesterase (PME), a pectinase enzyme, has a great potential to offer to the food industry, since it is able to degrade pectic substances, important structural components of plant cell wall. It has several applications, being able to act in reduction of viscosity of fruit pulp, improving extraction, filtration and clarification of juices, in fermentation of tea and coffee, and in obtaining pectin of lower methoxylation power. Despite its large production potential, Brazil is still a importer of enzymes, thus making necessary studies on economic manners of extraction, as well as on physical properties and best conditions of action. The objective of this work was to evaluate PME activity in peel, fiber and juice of the pineapple cultivar Pérola in several concentrations of sodium chloride at the extraction procedure, and to purify the portion with the highest specific activity. PME activity was evaluated in the concentrations of 0; 0.2; 0.4; 0.6; and 0.8 mol NaCl/mL of buffer. On the other hand, purification of enzymatic extract was performed by fractionation due to ammonium sulfate addition (60 to 80%) followed by dialyses and filtration in Sephadex G-100 gel. The highest PME specific activity was observed in the 0.5 mol of NaCl/mL of buffer in all portions. In the crude extract it was observed higher PME specific activity in the fiber portion from the juice extraction process, reaching a 6.7 value. It was also observed in the crude extract, activities of 1.9 U/mg of proteins in the juice and of 0.7 U/mg of proteins in the peel. Related to PME partial purification, it was obtained a purification factor equal to 55.6 fold, after filtration through Sephadex G-100 gel. The elution chromatograms in this gel and the electrophoresis results indicated the presence of at least three isozymes in the dialyzed extract of the analyzed sample. Using NaCl in the extracting buffer increased significantly PME specific activity (45%) and the purification level obtained was considered intermediate in comparison with those found in the literature about PME, extracted under the same conditions of this work, with other fruit crops.

Evaluation of pineapple crops used as firebreaks in Roraima, Amazonia

M.R. Xaud (1), H.A.M. Xaud (1), M.Mourão Jr (1), A.B. Bendahan (1), A.L.M. Carvalho (2)
(1) Embrapa Roraima - BR 174 km 8, Distrito Industrial, Boa Vista, Roraima, Brasil, maris@cpafrr.embrapa.br (2) Universidade Federal de Roraima, Campus do Cauamé

Firebreaks are areas around fields with economic activities where vegetation is removed or modified in order to make difficult fire propagation, protecting these areas from fire damage. Hedgerow used as firebreaks are a group of plants with the capacity of becoming green and humid during the dry season. The use of hedgerow has been studied in Amazonia, especially in regions prone to forest fires, as a consequence of the intensive use of burnings in the region, which causes large ecological, social and economic damage. The objective of this work is to evaluate the potential of pineapple (*Ananas comosus* var.*comosus*) crops, commonly used in rural areas in Amazonia, as firebreak hedgerows in fire prone regions in Roraima. In order to compare the suitability of pineapple crops, other groups of herbaceous species (*Desmodium ovalifolium* and *Arachis* sp.), commonly used in rural areas in Amazonia, were tested. The experiment was conducted in Serra da Prata Experimental Area, belonging to Embrapa Roraima, in a randomized blocks design with three replications and six treatments. The plots measured 25 m2 (5m x 5m). After 22 months, biomass and humid values from live and dead material in the plots were measured and fire was set to the plots. The burned area and the time of burning were evaluated. Results indicated that the treatments with *Ananas comosus* var. *comosus* (pineapple) not only grown dense crop system but also in the traditional one, didn't allow fire propagation. This is consequence of the high humidity in the aboveground biomass and good soil coverage of pineapple crops, that increase the burning time in the plots, avoiding fire propagation. The treatments of *Desmodium ovalifolium* presented low humidity in aboveground biomass and in litter material, although with high soil coverage, increasing thus fire propagation. On the other hand, the treatments of *Arachis* sp. presented low soil coverage, allowing the development of spontaneous species, indicating that this species didn't have enough biomass in the dry season to become a hedgerow firebreak. Finally, the experiment indicated that pineapple crops have the desired characteristics to avoid fire propagation, differing significantly from the other treatments studied.

Session V Post-Harvest Management

Development and maturation physiology of 'Imperial' pineapple

A.F. dos Santos (1), S.M. Silva (2), R.M.N. Mendonça (2), A. P. da Silva (3), A.A. Rodrigues (1), E. F. de Araújo (4), L. da C. Vilar (5), J. Mascena (6), J. T. de Lacerda (4)
(1) Aluno do Programa de Pós-Graduação em Agronomia, Universidade Federal da Paraíba, Centro de Ciências Agrárias CCA/UFPB, Areia, PB, Brazil, adrefesantos@yahoo.com.br (2) Prof. Dr. CCA/UFPB, Caixa Postal 04, CEP: 58397-970, Areia, PB, Brazil, silvasil@cca.ufpb.br (3) Bolsista PRODOC/CAPES, DSER/CCA/UFPB, Areia, PB, Brazil; (4) EMEPA-PB, Rua Eurípedes Tavares, 210 - Tambiá, Centro, CEP: 58013-290, João Pessoa, PB, Brazil (5) EMATER-PB, Estrada de Cabedelo S/N, Cabedelo, PB, Brazil (6) MAPA/SFA-PB, Estrada de Cabedelo S/N, Cabedelo, PB, Brazil

The objective of this work was to evaluate the phases of growth and maturation of 'Imperial' pineapple fruits, as the first step towards the establishment of maturity indexes to be used as criteria for harvesting, storage, and processing. Fruits were harvested from experimental plots located at João Pessoa, PB. Plants were marked at floral induction. Fruit development was followed at nine regular evaluation intervals, from floral induction until the fruit reached its physiological maturity. After their harvest, fruits were transported to the Biology and Technology Postharvest Laboratory of CCA/UFPB, where physical and physical-chemical evaluations were carried out. A completely randomized experimental design was applied for the nine evaluation data, using three replications. 'Imperial' pineapples took 155 days from floral induction treatment to their complete maturation. Their developmental period could be divided into three phases: primary and secondary growth phases and maturation. There was an increase of fruit fresh and dry weights, length and diameter along the maturation period, observing a simple sigmoid growth pattern type. Changes in the contents of soluble solids, ascorbic acid and titrable acidity characterized the evolution of the maturation process. In addition was observed that, in the first stages of fruit development, the chlorophyll content presented fast reduction, followed by a tendency of stabilization at the beginning of the maturation phase, together with an increase in the carotenoids content.

Quality of 'Pérola' pineapple treated with chilling shock and 1-methylcyclopropene

L.P. Martins (1), S.M. Silva (2), E. de O. Silva (3).
(1) Universidade Federal da Paraíba, Centro de Ciências Agrárias, Areia, Paraíba, Brasil martinslp@ol.com.br (2) Universidade Federal da Paraíba, DCFS/CCA/UFPB, Caixa Postal 04, CEP 58397-970, Areia, Paraíba, Brasil silvasil@cca.ufpb.br (3) Embrapa Agroindústria Tropical, Rua Dra. Sara Mesquita, 2270, Pici, CEP: 60-511-110, Fortaleza, CE, Brasil, bene@cnpat.embrapa.br.

'Pérola' pineapple is a fruit widely cultivated in Paraíba State and considered of high quality in the markets of South and Southeast Brazil. 'Pérola' pineapple presents potential for exportation to countries in Latin America by refrigerated transport. The exposure of pineapples to low temperature, however, may cause modifications in metabolism of phenilpropanoids, determining physiological disorders, as for example chilling injury, which result in quality loss. In pineapple chilling injuries are characterized by pulp darkening, abnormal colour development, loss of aroma and flavor, usually becoming more intense at presence of ethylene. The application of chilling shock may increase fruit resistance to susceptibility to chilling injury. The 1-MCP, which has demonstrated efficiency in blocking the action of ethylene, may be effective in the control of pulp darkening in refrigerated 'Pérola' pineapples. This work had the objective to evaluate the influence of chilling shock and 1-MCP applications on 'Pérola' pineapple quality. The experiment was carried out at the Laboratory of Biology and Post-harvest Technology of CCA-UFPB. Pineapples were harvested at the green-ripe stage in a commercial field in the municipality of Sapé, Paraiba. Fruits were submitted to the following treatments: T1 (fruits without control); T2 (fruits exposed to 5 ºC/12 hours); T3 (fruits not exposed to 5 ºC and treated with 150 ppm of 1-MCP/12h); T4 (fruits exposed to 5ºC/12 hours and treated with 150 ppm de 1-MCP/12h). The experimental design was a completely casualized one with three replications. Fruits were kept under environmental conditions (25 ± 2 °C and 75 ± 2% RH) during 30 days. Fruits submitted to 5 ºC/12 hours (T2) presented chilling symptoms from day 5 of storage. The treatment with 1-MCP minimized the incidence of pulp darkening. 1-MCP was more efficient in pulp darkening control when associated with a chilling shock at 5 ºC/12 hours.

Physico-chemical characteristics of minimally processed 'Pérola' pineapples treated with antioxidants and edible coatings

E.S. Viana (1), F.G.F. Silveira (2), F.A. Santana (2), T.S. Amorim (1), L.A. Oliveira (1), D.H. Reinhardt (1)
(1) Embrapa Mandioca e Fruticultura Tropical, Rua Embrapa s/n, Centro, 44380-000, Cruz das Almas, Bahia, Brasil, eliseth@cnpmf.embrapa.br, dharoldo@cnpmf.embrapa.br (2)Universidade Federal do Recôncavo da Bahia, CCAAB/UFRB, CEP 44380-000, Cruz das Almas, Bahia, Brasil.

More than 90% of pineapples produced in Brazil are consumed in natura, with losses estimated in 10% to 15% of the product harvested. These lossses may be partly due to the the lack of convenience of this fruit, requiring difficult peeling, in addition to the incidence of liquid leakage and the demand for adequate packaging for transport. As it is a delicious fruit largely accepted by consumers, it presents great potential for minimum processing (MP). This work aimed at evaluating the effect of the use of combined post-harvest treatments on the physico-chemical characteristics of 'Pérola' pineapples minimally processed, harvested at two apparent maturation stages. After harvested in the maturation stages of "green-ripe" (colour change from dark green to light green at the lower part of the fruit) and "painted" (fruit rind with less than 25% yellow area) from a commercial orchard in Itaberaba, Bahia, Brazil, fruits were submitted to MP, including dippping into suspensions of antixodants and edible coatings with cassava starch containing gelatine or sorbitol. Fruits were stored in a cold room at 5 ºC for eight days and analysed every two days in relation to firmness, total soluble solids (TSS), pH, total titrable acidity (TTA), the ratio TSS/TTA and the contents of total and reducing sugars. The experimental design was a completely randomized one with three replications. Fruits at "painted" maturation stage presented firmness of 8 to 9 N, values lower than those obtained for "green-ripe" fruits. TSS varied from 11 to 13 ºBrix (green-ripe fruits) and 14 to 15 ºBrix ("painted" fruits). TTA was 0.64 g of citric acido per 100 g of pulp for green-ripe fruits and 0.44 g /100 g pulp for "painted" fruits. There was a small increase of acidity along the storage period, as a consequence of pH decrease. MP 'Pérola' pineapples, at both maturation stages studied, presented an increase of total and reducing sugar contents along the storage period. All changes observed along the storage period of the fruits could be attributed to the difference in their maturation stages and not to the their treatments with antioxidants and coatings.

Appearance of minimally processed 'Pérola' pineapples treated with antioxidants and edible coatings

E.S. Viana (1), F.G.F. Silveira (2), F.A. Santana (2), T.S. Amorim (1), L.A. Oliveira (1), D.H. Reinhardt (1)
(1) Embrapa Mandioca e Fruticultura Tropical, Rua Embrapa s/n, Centro, 44380-000, Cruz das Almas, Bahia, Brasil, eliseth@cnpmf.embrapa.br, dharoldo@cnpmf.embrapa.br (2)Universidade Federal do Recôncavo da Bahia, CCAAB/UFRB, CEP 44380-000, Cruz das Almas, Bahia, Brasil.

Pineapple minimum processing (MP) has been conquering an increasing market space as long as consumers demand products with quality, convenience and praticity. Edible coatings are applied aiming at increasing the shelf life of minimally processed vegetables and keeping their quality. This work had the objective to evaluate the influence of five treatments under MP of 'Pérola' pineapples: T1- control in distilled water; T2- 0,5% citric acid+1% ascorbic acid+0,25% $CaCl_2$; T3- 0,5% citric acid+1% ascorbic acid+0,25% $CaCl_2$+5% cassava starch; T4- 0,5% citric acid+1% ascorbic acid+0,25% $CaCl_2$+5% cassava starch+2% gelatine; T5- 0,5% citric acid+1% ascorbic acid+0,25% $CaCl_2$+5% cassava starch+2% sorbitol. The experiment was carried out at the Laboratory for Food Science and Technology of Embrapa Cassava and Tropical Fruits. Fruits were harvested at maturation stages "green-ripe" (colour change from dark green to light green at the lower part of the fruit) and "painted" (fruit rind with less than 25% yellow area) from a commercial orchard in Itaberaba, Bahia, Brazil. Fruits were stored in a cold room at

5 ºC for eight days and analysed every two days for their appearance, using the following scale: 1 - good (fresh appearance), 2 - regular (wilting symptoms and or beginning of softening), 3 - bad (wilted and dehydrated, colour change and soft). The experimental design was a completely randomized one with three replications. It was observed that MP pineapples harvested at the green-ripe stage kept the appearance of fresh fruit over the entire storage period (8 days), for all treatments studied. However, fruits harvested at the "painted" stage presented a shorter shelf life, showing alterations from the second day of storage for the control and from the fourth day of storage for treatment 2. Although the treatments based upon cassava starch have given the desired visual effect, there was a softening of the slices, which became more intense along the storage period. Considering visal evaluations it is possible to recommend to use green-ripe fruits for minimum processing of 'Pérola' pineapples, with minimum soluble solids content of 12 ºBrix and conservation at 5 ºC.

Post-harvest conservation of 'MD-2' pineapples at maturation stage M3, combining 1-MCP application with use of wax

Francisca Ligia de Castro Machado (1), Rafaela Maria Temoteo Lima (2), Ricardo Elesbão Alves (3), Raimundo Wilane Figueiredo (4)
(1) Graduate student of plant science doctoral course, Universidade Federal do Ceará (UFC), ligiacmachado@yahoo.com, Fone 85 3257 5966, (2) Undergraduate student of Food Technology course, UFC, (3) Researcher, Embrapa Agroindústria Tropical, (4) Professor, Departamento de Tecnologia de Alimentos, UFC.

The maintenance of 'MD-2' pineapple quality after treatment with 1-MCP applied before and after wax was evaluated. Fruits were harvested at the Baixo Acaraú Irrigation District and selected by size, shape, health and maturation stage M3 (fruit physiologically ripe, with 50% of fruitlets yellow). 1-MCP was applied after fruit pre-cooling at 8 °C, which were treated or not with wax. Fruit transport and its storage for the first 12 day-period was under refrigeration at 8 °C, period estimated for fruits to reach the European market. Thereafter the fruits were transferred to temperature similar to that of the sale environment (22 °C, 75-80%RU), where they stood for the following nine days. Evaluations were done after harvest and at 12, 15, 18 and 21 days of storage. The experimental design was a completely randomized one, in split-plots, with four treatments (control, application of wax, application of 1-MCP before the wax and application of 1-MCP after the wax) and five replications. The variables studied were external appearance, evolution of rind colour, mass loss, fruit firmness, luminosity, chromaticity and Hue angle of the pulp, soluble solids (SS), titrable acidity (TA), pH, vitamin C, total soluble sugars and reducing sugars and sensorial acceptance. Wax application presented a very positive effect on the conservation of fruit external appearance, standing out in comparison with the other treatments from the simulation of transport (at 8 °C) to the sale period (at 22 °C), showing also efficiency in relation to fruit mass loss, when compared with fruits with application of 1-MCP and the control. This treatment also delayed yellow rind colour development. The values of pH, TA, luminosity, chromaticity, and pulp Hue angle increased along the storage period, whereas firmness, vitamin C and total and reducing sugars decreased. The evaluation by tasters suggested a very good acceptance of M3 fruits until nine days under specific commercialization conditions.

Post-harvest conservation of 'MD-2' pineapples at maturation stage M4, combining 1-MCP application with use of wax

Francisca Ligia de Castro Machado (1), Rafaela Maria Temoteo Lima (2), Ricardo Elesbão Alves (3), Raimundo Wilane Figueiredo (4)
(1) Graduate student of plant science doctoral course, Universidade Federal do Ceará (UFC), ligiacmachado@yahoo.com, Fone 85 3257 5966, (2) Undergraduate student of Food Technology course, UFC, (3) Researcher, Embrapa Agroindústria Tropical, (4) Professor, Departamento de Tecnologia de Alimentos, UFC.

The maintenance of 'MD-2' pineapple quality after treatment with 1-MCP applied before and after wax was evaluated. Fruits were harvested at the Baixo Acaraú Irrigation District and selected by size, shape, health and maturation stage M4 (fruit physiologically ripe, with 75% of fruitlets yellow). 1-MCP was applied after fruits pre-cooling at 8 °C, which were treated or not with wax. Fruit transport and its storage for the first 12 day-period was under refrigeration at 8ºC, period estimated for fruits to reach the European market. Thereafter the fruits were transferred to temperature similar to that of the sale environment (22 °C, 75-80%RU), where they stood for the following nine days. Evaluations were done after harvest and at 12, 15, 18 and 21 days of storage. The experimental design was a completely randomized one, in split-plots, with four treatments (control, application of wax, application of 1-MCP before the wax and application of 1-MCP after the wax) and five replications. The variables studied were external appearance, evolution of rind colour, mass loss, fruit firmness, luminosity, chromaticity and Hue angle of the pulp, soluble solids (SS), titrable acidity (TA), pH, vitamin C, total soluble sugars and reducing sugars and sensorial acceptance. Wax application was efficient in conserving the external appearance of the fruits, but the advanced fruitlet dehydration from three days after transfer of fruits to sale environmental conditions showed the importance of keeping them under refrigeration at this stage. Wax use delayed yellow rind colour development until three days under temperature of commercialization, when the fruits reached 100% yellow rind colour, for all treatments. The values of pH, TA, luminosity, chromaticity and Hue angle of the pulp increased along the storage period, whereas firmness, vitamin C and total and reducing sugars decreased. The evaluation by tasters suggested a very good acceptance of this matuartion stage until six days under specific commercialization conditions.

Post-harvest behaviour of pineapple affected by sources and rates of potassium

J.A. Quaggio (1), L.A.J. Teixeira (2), H. Cantarella (3), E.V. Mellis (4)
(1) IAC/Centro de Solos e Recursos Ambientais. PO Box 28, 13012-970, Campinas (SP), Brazil. quaggio@iac.sp.gov.br. (2)IAC/Centro de Solos e Recursos Ambientais, PO Box 28, 13012-970, Campinas (SP), Brazil, teixeira@iac.sp.gov.br; (3) IAC/Centro de Solos e Recursos Ambientais, PO Box 28, 13012-970, Campinas (SP), Brazil, cantarella@iac.sp.gov.br; (4) IAC/Centro de Solos e Recursos Ambientais, PO Box 28,13012-970, Campinas (SP), Brazil, evmellis@iac.sp.gov.br

Potassium is the foremost nutrient required for pineapple crop and the lack of this nutrient reduces plant growth, fruit yield and affects negatively fruit quality. A field experiment was conducted in order to determine the response of 'Smooth Cayenne' pineapple to sources and rates of potassium fertilization. The experiment presented a complete factorial design with four rates (0, 175, 350, and 700 kg K_2O/ha) and three combinations of K sources (100% KCl, 100% K_2SO_4, and 40% K_2SO_4 + 60% KCl). The fruits were picked when bottom eyes turned from pale-green colour to yellow and stored for 28 days at 10+-1ºC and 85 - 90% RH for post-harvest evaluations. The total soluble solids (TSS) of the fruit pulp varied significantly as a function of K rates. There was no difference between K sources until three-week of storage, when it was observed that TSS of fruits treated with KCl decreased significantly in comparison to other sources. The ascorbic acid content (AC) of fruits was affected by K rates and sources and decreased during fruit storage in all treatments. The differences between K sources on AC content extended during the storage and the lowest values were observed for K_2SO_4. Total titratable acidity (TTA) increased in response to K application, especially with KCl, decreasing the ratio between TSS and TTA. The use of K_2SO_4 resulted in better fruit ratio, mainly at higher K rates. The effects of K rates on fruit translucence were not significant and a small difference between sources was observed only just after harvest. Despite the long storage time, it was not observed any symptoms of fruit internal browning. The fruit firmness decreased along the fruit storage. This effect was less intensive without K application, but it was observed with all sources, especially with KCl.

Session VI Market and Commercialization

Fruit quality of pineapple marketed by COOPERFRUTO - Miranorte, Tocantins

Siebeneichler, S.C., Pereira, M.A.B., Lorençoni, R., Adorian, G.C., Silva, J.C. da, Garcia, R.B.M., Pequeno, D.N.L., Coelho, A.F.S., Souza, C.M. de
Universidade Federal do Tocantins (UFT), Gurupi, TO, Fone: 63 33113532, Fax 63 33113501, susana@uft.edu.br, mireia@uft.edu.br, rogeriolorenconi@uft.edu.br, gentil.cav@uft.edu.br, juciellec@yahoo.com.br, abacaxi_rogerio@hotmail.com, diegopequeno@uft.edu.br, anaflavia@uft.edu.br, clovis@uft.edu.br

The pineapple production of Tocantins State has increased and so did the consumers demands in relation to fruit quality. Hence growers have to pay attention to maintain or even improve the pattern of fruit quality in order to facilitate sales. This work aimed at evaluating fruit quality of pineapples sold by the cooperative Cooperfruto of Miranorte, Tocantins, Brazil, and to check if these fruits present properties within the standards required for fresh fruit sales. Data were collected from November 2006 to May 2007 on a monthly base. The physical and chemical characteristics were determined for fruits coming from several municipalities that supply the cooperative. The variables studied were: Fruit weight with and without crowns, crown weight, fruit length with and without crowns, fruit diameter, pH, juice yield, total titrable acidity (TTA), total soluble solids (TSS) and the ratio TSS/TTA. It was observed that the fruits marketed by the cooperative Cooperfruto during the evaluation period were of good quality and fulfill the minimum standards required for fresh pineapples in Brazil.

Evaluation of production costs and economic analysis of 'Vitoria' pineapple

Levy Heleno Fassio, José Aires Ventura, Hélcio Costa. Instituto Capixaba de Pesquisa e Agroecuária e Extens Rural (INCAPER), Rua Afonso Sarlo 160 (Bento Ferreira) 29052-010, Vitória, ES, Brasil, ventura@incaper.es.gov.br, helciocosta@incaper.es.gov.br

On November 2006 was launched the cultivar Vitória which stands out due to its resistance to fusariosis, fruit quality and agronomic characteristics simlar or even superior to those of the cvs. Pérola and Smooth Cayenne. In this work was determined the production cost of cv. Vitória in comparison with that of the cvs. Pérola and Smooth Cayenne. According to the features of the main pineapple production region in Espirito Santo State, Brazil, were determined the stable and variable costs of the technical coefficients, as well as the opportunity cost and the alternative cost. As variable costs were considered the expenses with planting material, fertilizers, pesticides, growth regulator, labour-force, mechanical services and variable taxes. The total average cost was confronted with the average income, which was composed by fruit and planting material sales. It has been estimated that cv. Vitória may increase yield by 76.7% and 48.9%, respectiveley when compared with the cvs. Pérola and Smooth Cayenne. In the double row planting system, with higher planting density, the production increase could be even larger as compared to 'Pérola' pineapple cultivation in simple rows, reaching up to 143.3%. On the other side, the variable costs presented a share of more than 90% in the total cost, being labour-force and acquisition of planting material the most expensive itens. The cultivation of 'Vitória' pineapple requires a higher investment in planting material, whose share of production costs reached 39,89% and 46,82% respectively for simple and double rows plantings. This fact is due to the low availability of planting material for meeting the demand, resulting in its high price in comparison to those of cvs. Pérola and Smooth Cayenne. The fusariosis resistance, main characteristic of the new cultivar, implies in a significant reduction of costs of fungicides and labour-force. The economic results, in total values, for each hectare cultivated in the different conditions analysed for simple and double row plantings, showed that the cv. Vitória may give a profit 342,4% higher than that of cv. Pérola and 268% higher than that of cv. Smooth Cayenne, if planted in double rows. This perspective turns the new cultivar more competitive and determines a tendency to become a substitue for the traditional cultivars in Brazil. Finacial support: BNB/Fundeci, FINEP, FAPES and CNPq.

Deterministic and under risk condition cost analyses of pineapple production systems used by family farmers

Carlos Estevão Leite Cardoso (1), Arlene Maria Gomes Oliveira (2), Jackson Lopes de Oliveira (3), Enéas Santos Melo (4), Ernani Macedo Pedreira (5), Gerson Silva de Jesus (6)
(1) Embrapa Mandioca e Fruticultura Tropical, invited researcher of Cepea/Esalq/USP, Cruz das Almas, BA, Brasil, estevao@cnpmf.embrapa.br (2) Embrapa Mandioca e Fruticultura Tropical, Cruz das Almas-BA, Brasil, arlene@cnpmf.embrapa.br (3) Analista A, Embrapa Recursos Genéticos e Biotecnologia, Porto Seguro, BA, Brasil, jackson@cenargen.embrapa.br (4) Undergraduate student of agronomy, UFRB, bolsista PIBIC/CNPq, eneasmelo@yahoo.com.br (5) Undergraduate student of agronomy, UFRB, bolsista Fapesb ernani_mp@hotmail.com (6) Extensionist, Empresa Baiana de Desenvolvimento Agrícola (EBDA), Eunápolis, BA, Brasil, gesije@hotmail.com

Pineapple crop has been an option for small farmers of southern Bahia State, Brazil. However, sometimes, without economical return due to low productivity, *Fusarium* disease incidence and production within low profit season. In addition, farmers have used lower planting densities than the recommended ones. In order to minimize these problems, new technologies were introduced and economically evaluated under deterministic and risk conditions, aiming at the insertion of these farmers into pineapple the agribusiness chain. Using panel or focal interviews, two modal production systems were identified: the traditional one and the modified one. These systems differ regarding to technologies adopted and were compared by the average cost of production. In the deterministic analysis, considering the prices (product and inputs) of June/2006 and a loss percentage of 20%, the traditional system showed an average cost of R$ 0.44/fruit. The modified system, which incorporates some recommended technologies, showed an average cost of R$ 0.35/fruit. In the analysis under risk condition, using the Monte Carlo´s simulation method, the loss percentage varied from 10% to 30% (being the most likely 20%), and the labour cost varied from R$ 13.50 to R$ 17.50 per day/man, being the most likely R$ 15.00. The simulation results showed that the traditional and modified systems presented, respectively, unit costs varing from R$ 0.40 to R$ 0.50/fruit and from R$ 0.32 to R$ 0.39/fruit. It was also found that there is a probability of 56.9% for the average cost to be higher than R$ 0.44 in the traditional system, and 53.1% to be higher than R$ 0.35 in the modified production system.

Forms of commercialization of the pineapple and level of organization of the producers in the State of Paraíba

José Félix de Brito Neto (1), Rosivaldo Gomes de Sá Sobrinho (2), Walter Esfrain Pereira (2), José Alves Barbosa (2), Diógenes de Souza Costa (3), José Soares Lacerda (3), Damon Pereira dos Santos (3)
(1) Mestrando em Manejo de Solo e Água/CCA/UFPB, Areia-PB, Fone: (83) 3362 2300; Fax: (83) 3362 2259; E-mail: netobritopb@bol.com.br; damondos@yahoo.com.br. (2) Prof. Dr. DCFS/CCA/UFPB, Areia-PB, CEP: 58397-000; Fone: (83) 3362 2300; Fax: (83) 3362 2259; E-mail: rosivaldosobrinho@gmail.com, wep@cca.ufpb.br, jotabarbosa2000@yahoo.com.br, (3) Aluno de graduação em Agronomia CCA/UFPB, Areia-PB, j_slacerda@yahoo.com.br; diógenes_s_costa@yahoo.com.br.

Pineapple is consumed in the whole world as fresh and processed fruit. In Brazil, the main producing states of pineapple are Pará, Paraíba, Minas Gerais and Bahia. For many years Paraíba was the largest producer, but the lack of incentives, taxes and other factors contributed to its drop in national ranking from 1996 to 1998. However from 2005, Paraíba came back to dispute the leadership of the national ranking producing more than 300 million fruits a year. In spite of that, the producers, mainly the small ones, face many problems that limit the activity. Hence a survey on its status is of basic importance for planning of the activities and for the public politics directed to the pineapple crop. This work had as objective to determine the forms of commercialization and the level of organization of pineapple producers. Data were collected in six municipalities, totalizing 60 family agriculture producers and, or, larger ones. It was observed that the majority of the producers is dependent of the action of brokers in the commercialization process, becoming their dependents. The sales carried through the stock market of agricultural commercialization of Pernambuco State provides greater profitability and security in the negotiation to the pineapple producers. The region of Santa Rita presents the most developed organizational level of pineapple growers, mostly in cooperatives, who have contributed to the expansion of pineapple crop in Paraíba. It was also observed that 50% of pineapple growers do not take account of their production costs and profits.

Microeconomic and macroeconomic analyses of pineapple industry in the State of Tocantins

Jose Elias Junior, Denise Coelho Gomes. Secretaria da Agricultura, Pecuária e Abastecimento (SEAGRO), Esplanada das Secretarias, Praça dos Girassóis - AANE, CP 104, 77003-020, Palmas, Tocantins, Brazil. Phone (55 63) 3218 2170; Fax (55 75) 3218 2191. dfs@seagro.to.gov.br

The world pineapple production in 2005 was around 12 million metric tons. Brazil, having favorable soil and climate conditions, is the leading country followed by the Philippines and Thailand. Those three countries together hold about 40% of the pineapple world production. In the past ten years the pineapple crop in the State of Tocantins, Brazil, showed an 1,080% increase in harvested area. According to the Brazilian Institute of Geography and Statistics (2007) the State of Tocantins contributes with 2.49% of the Brazilian pineapple production, but the average yield in that state is 39.5 metric ton/ha, lower than the Brazilian pineapple yield that is 53.8 metric ton/ha. This is due to low level of production technology available such as irrigation and fertilization. Pineapple is a very important crop for the economy of the State of Tocantins since it generates jobs as well as increases the income of small, intermediate and large pineapple growers. The use of adequate production technology enables pineapple growers to program harvest for periods when there is no fruit offer in the market, thus resulting in better income for the growers. The land where pineapple fields are established in Tocantins have not had aggregated value due to the fact that pineapple crop occupies low fertility soils. In the State of Tocantins the pineapple crop does not require too much infrastructure, only mechanization. In the municipality of Miranorte, Tocantins, and there is a pineapple processing unit, 120,000 metric ton/month capacity, devoted to concentrated pineapple juice.

Way of development for small pineapple growers in Mexico: Production and marketing

Ana Lid del Ángel-Pérez y Andrés Rebolledo-Martínez. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, Campo Experimental Cotaxtla, km 34.5 Carret. Veracruz-Córdoba, Apartado postal 423, C.P. 91700, Medellín de Bravo, Veracruz, México. Tel: (228) 9348354; 9342926, rebolledoandres@yahoo.com.mx.

One of the most important problems in pineapple business in Mexico is the convergence of the intermediarism in a scene where most of the producers have a lsmall pineapple surface. The inefficient marketing has a strong negative impact on the technology used and the margin of profitability is reduced until 30%. At least 85% of the pineapple producers do not have any possibility for buying enough inputs and machinery for their plantations because are too expensive. So far, the small producers sale their fruits through brokers ("coyotes") as they do not control information and infrastructure (trucks, warehouses, contacts with the head offices of supply, supermarkets); in addition the producers do not control their production because there are different technological levels. The productive dynamics in Mexico involves changes of the production system, cultivars diversification and incorporation of domestic and international markets. All this, has oriented the pineapple growers to look for new forms of organization; one of them is the association of different levels of capital, where small producers seek to associate with exporting businessmen, where they converge interests as a route for placing the product directly on different markets; in this way the level of intermediation is eliminated and the sold fruit has high quality. Exporting company and small producers set up a legalized agreement; they use the same technology, with a program of managing plantation for avoiding market saturation and commitments of programmed sale, projecting prices of sale. The importance of this association is to take advantage of the capacities of every type of producer, since the businessman has information, contacts, infrastructure, suppliers of agrochemical products and the capital, whereas the small producers land and labour force. The training for the producer is very important to achieve a similar technology and to obtain fruit with the quality demanded by the market. The critical points in this scheme are the establishment of the sale prices and the fulfillment of the commitments of both parts, which are easily surmountable if the contents of the agreement is respected.

Pineapple grower study groups - an effective extension practice

Simon D. E. Newett (1), Timothy Wolens (2), Julie Moore (3)
(1) Department of Primary Industries and Fisheries, Maroochy Research Station, PO Box 5083 SCMC, Nambour 4560, Queensland, Australia. Ph: +61 7 54449619. Fax: +61 7 54412235, simon.newett@dpi.qld.gov.au (2) Golden Circle Ltd, 260 Earnshaw Rd, Northgate 4013, Queensland, Australia +61 7 3266000, twolens@goldencircle.com.au (3) Growcom, PO Box 202, Fortitiude Valley 4006, Queensland, Australia +61 7 36203844, jmoore@growcom.com.au

Australian pineapple production is spread along the Queensland east coast, from Brisbane (27° Latitude South) in the south to Cairns (17° Latitude South) in the north, a distance of about 1700 km. A three year extension project to improve the technical knowledge of the approximately 150 growers in Queensland and thus improve the productivity and fruit quality of the farms was commenced in 2006. A total of nine regional study groups were formed to cater for growers in all production regions. To help organise the meetings a grower was nominated from each group as the leader. Leaders were taken through a leadership course consisting of three 3-day modules and this has been the catalyst for the growers to take a greater responsibility for their industry. Not only was the leadership instruction beneficial but the time that the growers spent together over each 3-day module proved invaluable in allowing an interchange of ideas for their industry. It has led to the formation of a new industry representative group and moves are now underway to implement a research and development levy. The project is a joint initiative of horticulturists from the Queensland Department of Primary Industries and Fisheries, Golden Circle Ltd and Growcom and the study group meetings are facilitated by them. Emphasis is placed on grower ownership of the groups - growers set the agenda, venue and dates for meetings. Typically, meetings are held on a different farm each time and include a discussion session focussing on a particular topic (e.g. *Phytophthora* control), sometimes with a guest speaker, a break for refreshments to allow time for networking and small group discussion and culminating in a tour of the farm led by the owner. Groups are quite small (about 12 individuals) which encourages participation. Detailed illustrated minutes are prepared from the workshop and distributed to growers to reinforce the information covered. A total of ten workshops are planned for each group over the duration of the project. As the project progresses more trips are taken to visit other production regions. Attendance has been good, growers are taking a greater role in the planning of the meetings and the direction of their industry and the improved communication is drawing the industry closer together.◆

Services

The listings under Commercial Services and Directory of Professionals is maintained as a convenience to readers and should in no way be construed as an endorsement of those providing commercial or professional services. Those offering specialized services to pineapple growers or researchers are invited to contact the editor for possible inclusion in the listings below.

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

Centro de Bioplantas. Dr. Justo L. Gonzalez Olmedo, Director of Foreign Affairs Office, Centro De Bioplantas. Universidad De Ciego De Avila, Carretera a Moron Km 9. Cp69450. Cuba. Centro De Bioplantas offers certificates of authenticity for pineapple material propagated in their tissue culture facility. Web site: http://www.Bioplantas.cu

LAMERSA, Dole's meristem laboratory in Honduras. Contact John T. Mirenda PhD, Dole Fresh Fruit International Ltd., San Jose, Costa Rica. Phone: 506 287 2175. Fax: 506 287 2675. E-mail: Jmirenda@la.dole.com. The laboratory can produce meristematically-derived plants of pineapple as well as banana and other crops.

Thai Orchids Lab, Dr. Paiboolya Gavinlertvatana. Horticulture/ agriculture/ forestry tissue culture laboratory with exports to Australia, U.S.A., Africa, and Asia. MD2 pineapple available (open to acquiring additional varieties) or confidential exclusive contract propagation. Phone: +1 510 931 7865 Fax: +66 2510 9452 Website: http://www.tolusa.com/ E-mail: info@tolusa.com.

Vitropic, Zone d'Activités Economiques des Avants, 34270 Saint Mathieu de Tréviers France; Tel: + 33 (0)4 67 55 34 58; Fax: + 33 (0)4 67 55 23 05. E-mail : vitropic@vitropic.fr. Web site: www.vitropic.fr. Vitropic proposes the best individuals from the CIRAD FHLOR selected clones including: Cayenne Group, Queen Group, Perolera Group, MD2, Ornamentals pineapples. The range is continuously extending, do not hesitate to ask for more information.

Professional Services

Mr. Wilbert Campos Alvarado. M.Sc. Tropical Soils & Crop Mgmt. Experience in all stages of production (soil preparation, plant nutrition, diseases & pest control, PGR use, etc) of pineapple for the fresh fruit production market as well as experince in packing plant management and in postharvest treatment. Also worked in pineapple R&D for several years under different climate conditions (Costa Rico, Guatemala, Ecuador).

Ing. Alejandro Chavarría. APDO 4437-56 Pital, San Carlos. Alajuela, Costa Rica. Tel: (506) 88-20-79-55 / (506) 24-73-40-00, alechava@hotmail.com . I have worked like an International Pineapple Consulting in México, Costa Rica and Brazil. Experienced in project feasibility, plantation design, agricultural machinery, all aspects of farm crop management, post harvest management and establishment of good agricultural practices.

Dr. Mark Paul Culik. INCAPER, Rua Alfonso Sarlo 160, CEP 29052-010, Vitoria, ES, Brazil; Tel: 27-3137-9874; markculik3@yahoo.com. Experience: PhD in Entomology with more than 25 years of agricultural pest management experience in crops ranging from apples to papaya and pineapple, identification of pests and beneficial arthropods ranging from Collembola to fruit flies, and current work on scale insects with emphasis on pineapple mealybugs. Areas of specialization: Entomology, Insect and Pest Identification, Integrated Pest Management.

Dr. Francisco Gomez (E-mail: fgomez1@cablecolor.hn) and **Jose R. Vasquez**, MBA (E-mail: jrva46@excite.com). Golden Pacific Ag Services, PO.Box 15088, Lomas Miraflores, 4a. Calle, 1a Avenida # 4326, Tegucigalpa, Honduras. Phone: 504 230 1120; 504 969 5568. Experience: Pineapple and melon production, from seed propagation-planting-field maintenance-forcing-harvesting-post-harvest management and commercialization.

Mr. Ian Greig. Greig and Associates, P.O. Box 273508, Tampa, FL 33688. Phone: (813) 908-7698; Fax: (813) 963-6229. E-mail: iang@ag-consult.com. Web site: www.ag-consult.com. Services for all phases of pineapple production but emphasis is on pineapple industry and market analysis.

Mr. L. Douglas MacClure. 360 Hoopalua Dr., Pukalani, Hawaii, U.S.A. E-mail: norfolkldm@aol.com.
Experience: More than 39 years with Maui Pineapple Company heading plantation and diversified agriculture operations and started the Royal Coast Tropical Fruit Company in Costa Rica. Collected and summarized production information in Asia and Central America. Also consulted on pineapple for companies and growers in El Salvador, Australia, Thailand and Indonesia.

Mr. Graham J. Petty 13 Somerset Place, Lambert Road, Port Alfred, 6170, Republic of South Africa. Phone: +27 (0) 46 624 4868; Tel/Fax: +27 (0) 46 625 0946; E-mail: grahamp@imaginet.co.za. Experience: M.Sc. (Agric) Pretoria : Pr. Sci. Nat. . Researcher and advisor to the South African Canning Pineapple Industry on matters of Pest Management in pineapple culture, for 34 years. Economic entomology and management of biological control agents have received particular attention.

Mr. Col Scott. E-mail: scottch45@bigpond.com. Mobile: +61 488092442; Phone: +61 7 34252417; Fax: +61 7 34252417. Over 37 years experience in all aspects of pineapple agronomy and research in Australia (32 years with Golden Circle Ltd) and South Africa (5 years with Summerpride Foods Ltd). Experience includes working with growers, researchers and fertilizer and agricultural chemical suppliers. Other production areas visited include Hawaii, Central America, Thailand, Indonesia and Malaysia.

Dr. José Aires Ventura. Incaper, Rua Afonso Sarlo 160 (bento Ferreira), 29052-010, Vitoria-ES, Brazil. E-mail: ventura@incaper.es.gov.br; Tel.: 55-27-31379874. www.incaper.es.gov.br. Area of Specialization: Plant Pathology (research in pineapple diseases management; Fusarium diagnosis, diseases resistance).

Mr. Dean Wheeler. AgResults Inc., 609 Buchanan Street, Davis, California, U.S.A. 95616. Phone/fax: 530-758-4620 Residence: 530-758-3354. Email: agresults@aol.com. Web page at http://agresults.com/.

Book Reviews and Web Sites

Book Reviews

No reviews were provided for this issue.

Web Sites of Possible Interest

1. The CIRAD Market News Service website is http://passionfruit.cirad.fr/index.php/(html)/fruitrop/fruitrop.html. The services journal FruiTrop can be found at the web site and many publications are available either for a fee and older issues are available as pdf files at no cost.
2. Abacaxi on-line at http://www.cnpmf.embrapa.br/informativos/abacaxi/abacaxi_online_v5_3_07.pdf
3. Mandioca e Fruticultura Tropical at http://www.cnpmf.embrapa.br/. Publications (in Porutgese) on abacaxi (pineapple) are

available from the Publições link.
4. XVIth International symposium on Horticulture Economics at http://muresk.curtin.edu.au/conference/ishsem/
5. Vth International Symposium on Horticulture Research, Training and Extension at http://muresk.curtin.edu.au/conference/ishsem/.
6. http://www.proexant.org.ec/HT_Piña.html.
7. http://coleacp.org/FO_Internet/Pip/Default.asp.

◆

References

The list below includes papers published or located since the last issue of the newsletter was printed. Often, abstracts of the papers listed below can be found on-line and of course all abstracts of paper published in Acta Horticulturae are available from info@ishs.org. 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.

Abdul Khalil, H.P.S., M. Siti Alwani, and A.K. Mohd Omar. 2007. Cell wall structure of various tropical plant waste fibers. Mokchae Konghak = Journal of the Korean Wood Science and Technology 35:9.
Adewumi, B.A. 2007. Effect of fruit size and machine shaft speed on juice extraction efficiency and capacity of a modified screw type juice extractor. Journal of Food Science and Technology (Mysore) 44:44.
Agbogo, E.A., N.E. Tiku, M.J. Bime, and S.O. Abang. 2007. Analysis of seasonal price trend of pineapple in Cross River State, Nigeria. Journal of Food, Agriculture & Environment 5:339.
Ahmad, B., and R.H. Khan. 2006. Studies on the Acid Unfolded and Molten Globule States of Catalytically Active Stem Bromelain: A Comparison with Catalytically Inactive Form. Journal of biochemistry 140:501-508.
Ahmed, O.H., and M.H.A. Husni. 2006. Exploring the nature of the relationships among total, extractable and solution phosphorus in cultivated organic soils. International Journal of Agricultural Research 1:331.
Ahmed, O.H., M.H.A. Husni, and M.M. Hanafi. 2006. Phosphorus loss of phosphorus fertilizer applied to tropical peat soils in pineapple cultivation. International Journal of Soil Science 1:85.
Ahmed, O.H., M.H.A. Husni, M.M. Hanafi, S.R. Syed Omar, and A.R. Anuar. 2006. Elucidating how the capacity of cultivated tropical peat soils to supply phosphorus relates to available phosphorus forms in pineapple production. International Journal of Soil Science 1:44.
Antoniolli, L.R., B.C. Benedetti, J.M.M. Sigrist, M.d.S.M. Souza Filho, and R.E. Alves. 2006. Metabolic activity of fresh-cut 'Perola' pineapple as affected by cut shape and temperature. Brazilian Journal of Plant Physiology 18:413.
Antoniolli, L.R., B.C. Benedetti, J.M.M. Sigrist, and N.F.d.A. Silveira. 2007. Quality evaluation of fresh-cut 'Perola' pineapple stored in controlled atmosphere. Ciencia e Tecnologia de Alimentos 27:530.
Asare-Bediako, E., F.A. Showemimo, J.N. Buah, and A.O. Ntow-Manu. 2007. Quality of pineapple fruits as influenced by floral induction in Ghana. American Journal of Food Technology 2:100.
Azevedo, P.V.d., C.B.d. Souza, B.B.d. Silva, and V.P.R.d. Silva. 2007. Water requirements of pineapple crop grown in a tropical environment, Brazil. Agricultural Water Management 88:201.
Aziz, M.A., and M.M. Feeroz. 2007. Damage to agricultural crops by mammalian fauna at the fringes of Lawachara National Park, Bangladesh. Tigerpaper 34:29.
Baez, R., M.T.P. Lopes, C.E. Salas, and M. Hernandez. 2007. In vivo antitumoral activity of stem pineapple (Ananas comosus) bromelain. Planta Medica 73:1377.
Basir, A., and R.H. Khan. 2006. Studies on the acid unfolded and molten globule states of catalytically active stem bromelain: a comparison with catalytically inactive form. Journal of Biochemistry (Tokyo) 140:501.
Be, L.V., and P.C. Debergh. 2006. Potential low-cost micropropagation of pineapple (Ananas comosus). South African Journal of Botany 72:191.
Bengozi, F.J., A.C. Sampaio, A.D.d.S. Gutierrez, V.M. Rodrigues, and M.L. Pallamin. 2007. Analysis of the market of pineapple commercialized in the CEAGESP-Sao Paulo / Analise do mercado do abacaxi comercializado na CEAGESP - Sao Paulo. Revista Brasileira de Fruticultura 29:494.
Bengozi, F.J., A.C. Sampaio, M.H.F. Spoto, M.M. Mischan, and M.L. Pallamin. 2007. Physico chemical quality of pineapple commercialized in the CEAGESP-Sao Paulo / Qualidades fisicas e quimicas do abacaxi comercializado na CEAGESP - Sao Paulo. Revista Brasileira de Fruticultura 29:540.
Bennici, A., B. Mori, C. Tani, and B. Bussi. 2007. Callogenesis and organogenesis in pineapple: a histological and ultrastructural study of developing callus and morphogenic processes. Advances in Horticultural Science 21:19.
Biswal, P.K., B.D. Mishra, and S.S. Mohapatra. 2007. Management of fungi causing post harvest rotting of pineapples in Orissa. Journal of Plant Protection and Environment 4:103.
Bonilla-Zavaleta, E., E.J. Vernon-Carter, and C.I. Beristain. 2006. Thermophysical properties of freeze-concentrated pineapple juice. Italian Journal of Food Science 18:367.
Borroto-Fernandez, E.G., J.A. Torres-Acosta, and M. Laimer. 2007. RT-PCR detection and protein-protein interaction of viral components of Pineapple mealybug wilt-associated virus 2 in Cuba. Journal of Plant Pathology 89:435.
Brito, L.K.F.L.d., G.E.D.D. Moura, C.P. Martins, M.A.I. Aloufa, C.E.C. Macedo, D.B. Lopes, and P.A.V. Barroso. 2007. Pineapple somaclones response to in vitro cultivation in presence of NaCl / Cultivo in vitro de somaclones de abacaxizeiro na presenca

de NaCl. Revista Brasileira de Engenharia Agricola e Ambiental 11:279.
Budu, A.S., D.C. Joyce, and L.A. Terry. 2007. Quality changes in sliced pineapple under controlled atmosphere storage. Journal of Horticultural Science and Biotechnology 82:934.
Carlier, J., G. Coppens d'Eeckenbrugge, and J. Leitão. 2007. Pineapple, p. 343-351 Genome Mapping and Molecular Breeding in Plants. Vol. 4. Fruits and Nuts, Vol. 4. Springer, Berlin.
Chamchong, M., V. Sangsom, and N. Charoeamkitti. 2007. Computer-based on-line assessment of sterilizing value for canned food. Kasetsart Journal, Natural Sciences 41:764.
Chang, R., C. Tai, D. Dent, and S. Ou. 2006. Selection of acetic acid bacteria for fermenting pineapple vinegar. Taiwanese Journal of Agricultural Chemistry and Food Science 44:351.
Cherian, T.T. 2006. Black rot disease of pineapple (Ananas sp.) caused by Thielaviopsis paradoxa(de Seynes) Hoehn. Journal of Plant Disease Sciences 1:212.
Chinnasri, B., D.P. Schmitt, and B.S. Sipes. 2006. Effects of inducers of systemic acquired resistance on reproduction of Meloidogyne javanica and Rotylenchulus reniformis in pineapple. Journal of Nematology 38:319-325.
Chonhenchob, V., Y. Chantarasomboon, and S.P. Singh. 2007. Quality changes of treated fresh-cut tropical fruits in rigid modified atmosphere packaging containers. Packaging Technology & Science 20:27.
Chuenboonngarm, N., N. Juntawong, A. Engkagul, W. Arirob, and S. Peyachoknakul. 2007. Changing in TSS, TA and sugar contents and sucrose synthase activity in ethephon-treated 'Pattavia' pineapple fruit. Kasetsart Journal, Natural Sciences 41:205.
Coelho, R.I., A.C.d. Carvalho Junior, C.S. Marinho, J.C. Lopes, and P.G.d.O. Pessanha. 2007. Response to fertilization with urea, potassium chloride and boric acid in the 'Smooth Cayenne' pineapple plants / Resposta a adubacao com ureia, cloreto de potassio e acido borico em mudas do abacaxizeiro 'Smooth Cayenne'. Revista Brasileira de Fruticultura 29:161.
Cortes-Aguado, S., N. Sanchez-Morito, F.J. Arrebola, A. Garrido Frenich, and J.L. Martinez Vidal. 2008. Fast screening of pesticide residues in fruit juice by solid-phase microextraction and gas chromatography-mass spectrometry. Food Chemistry 107:1314.
Costa, F.H.d.S., M.A.A. Pereira, J.P.d. Oliveira, and J.E.S. Pereira. 2007. Effect of alternative gelling agents in culture medium in the in vitro cultivation of pineapple and banana / Efeito de agentes geleificantes alternativos no meio de cultura no cultivo in vitro de abacaxizeiro e bananeira. Ciencia e Agrotecnologia 31:41.
Costa, J.M.C.d., E.M.d.F. Felipe, G.A. Maia, I.M. Brasil, and F.F.H. Hernandez. 2007. Comparison of physicochemical and chemical parameters of food powders obtained from pineapple residues / Comparacao dos parametros fisico-quimicos e quimicos de pos alimenticios obtidos de residues de abacaxi. Revista Ciencia Agronomica 38:228.
Costa, R.G., M.X.C. Correia, J.H.V.d. Silva, A.N.d. Medeiros, and F.F.R.d. Carvalho. 2007. Effect of different levels of dehydrated pineapple by-products on intake, digestibility and performance of growing goats. Small Ruminant Research 71:138-143.
Dacera, D.d.M., and S. Babel. 2007. Heavy metals removal from contaminated sewage sludge by naturally fermented raw liquid from pineapple wastes. Water Science and Technology 56:145.
Datta, M., and N.P. Singh. 2007. Growth characteristics of multipurpose tree species, crop productivity and soil properties in agroforestry systems under subtropical humid climate in India. Journal of Forestry Research 18:261.
Deka, B.C., J. Saikia, A. Saikia, and R.K. Pal. 2007. Physico-chemical changes of pineapple at different stages of maturity. Indian Journal of Horticulture 64:464.
Dionello, R.G., P.A. Berbert, M.A.B.d. Molina, A.P. Viana, V.d.O. Carlesso, and V.A.V. Queiroz. 2007. Osmotic dehydration of sliced pineapple in sucrose and in inverted sugar syrup / Desidratacao por imersao-impregnacao de abacaxi em solucoes de sacarose e em xarope de acucar invertido. Ciencia e Tecnologia de Alimentos 27:701.
Dolinski, C., and L.A. Lacey. 2007. Microbial control of arthropod pests of tropical tree fruits. [electronic resource]. Neotropical entomology 36:161-179.
Ellinger, W. 2007. The markets for fruits and vegetables and the market regulation for fruits, vegetables and bananas. Part 1 The market for fruits / Der Markt fur Obst und Gemuse und die Marktordnungen fur Obst, Gemuse und Bananen: Teil 1: Der Markt fur Obst. Agrarwirtschaft 56:71.
Escalona, M., C.A. Aragon, I. Capote, D. Pina, I. Cejas, R. Rodriguez, M.J. Canal, J. Sandoval, S. Roels, P. Debergh, Y. Desjardins, and J. Gonzalez-Olmedo. 2007. Physiology of effects of Temporary Immersion Bioreactor (TIB) on micropropagated plantlets. Acta Horticulturae:95.
Fari, M.G., M. Laszlo, T. Kertesz, and Z. Varga. 2006. Design of a revert rotary plant micropropagation bioreactor -- '3R' system: application for research, possibilities of scaling-up and limitations. Acta Horticulturae 725:561.
Femenia, A., S. Simal, C. Garau Taberner, and C. Rossello. 2007. Effects of heat treatment and dehydration on pineapple (Ananas comosus L. Merr) cell walls. International Journal of Food Engineering 3:8.
Firoozabady, E., M. Heckert, and N. Gutterson. 2006. Transformation and regeneration of pineapple [electronic resource]. Plant cell, tissue and organ culture 84:1-16.
Fold, N. 2008. Transnational Sourcing Practices in Ghana's Perennial Crop Sectors [electronic resource]. Journal of agrarian change 8:94-122.
Fu, G. 2006. Ecological footprint analysis on agricultural products composing optimization in Hainan Province. Research of Agricultural Modernization 27:389.
Furmaniak, S., G. Rychlicki, P.A. Gauden, and A.P. Terzyk. 2007. Applicability of the generalised D'Arcy and Watt model to description of water sorption on pineapple and other foodstuffs [electronic resource]. Journal of food engineering 79:718-723.
Gabas, A.L., J. Telis-Romero, P.J.A. Sobral, and V.R.N. Telis. 2007. Effect of maltodextrin and arabic gum in water vapor sorption thermodynamic properties of vacuum dried pineapple pulp powder [electronic resource]. Journal of food engineering 82:246-252.
Gibbon, P., and S. Bolwig. 2007. The economics of certified organic farming in tropical Africa: a preliminary assessment. Danish

Government Institute of Seed Pathology for Developing Countries, Copenhagen.
Gitanjali, D. 2007. Community analysis of plant-parasitic nematodes in pineapple ecosystem in Meghalaya. Indian Journal of Nematology 37:106.
Grizotto, R.K., R.E. Bruns, J.M.d. Aguirre, and H.C.d. Menezes. 2007. Technological aspects for restructuring concentrated pineapple pulp. LWT - Food Science and Technology 40:759.
Guaipatin, C. 2007. Public-private cooperation as an instrument of development: lessons from six agroindustrial agglomerations in Latin America / La cooperacion publico-privada como instrumento de desarrollo: lecciones de seis aglomeraciones agroindustriales en America Latina 0924-0608.
Hale, L.P., D.J. Fitzhugh, and H.F. Staats. 2006. Oral immunogenicity of the plant proteinase bromelain. International Immunopharmacology 6:2038.
Hemavathi, A.B., K.S.M.S. Raghavarao, and H.U. Hebbar. 2007. Reverse micellar extraction of bromelain from Ananas comosus L. Merryl [electronic resource]. Journal of chemical technology and biotechnology 82:985-992.
Hernandez Hernandez, R., G.d. Vallin, and D. Hernandez. 2006. Plant parasitic nematode diagnosis in fruit crop soils / Diagnostico de fitonematodos en suelos de cultivos frutales. Fitosanidad 10:261.
Hoque, A.T.M.R., S.M.S. Huda, and M.A. Rahman. 2007. Possibilities of non timber forest products based enterprises to improve socio-economic conditions of Tanchangya community of Rangamati Hill District in Bangladesh with locally grown species. International Journal of Forest Usufructs Management 8:35.
Hujuri, U., A.K. Ghoshal, R. Uppaluri, and S.K. Chattopadhay. 2008. Effect of maleic anhydride grafted polypropylene on the mechanical and morphological properties of chemically modified short-pineapple-leaf-fiber-reinforced polypropylene composites [electronic resource]. Journal of applied polymer science 107:1507-1516.
Kaewrawang, A., S. Swatdiponphallop, and A. Siritaratiwat. 2007. Study on complex permittivity of tropical Thai fruits. Journal of Applied Sciences 7:1009.
K. Khawmee (ed.) 2007. Proceedings of the 45th Kasetsart University Annual Conference, Bangkok, Thailand, 30 January-2 February 2007. Subject: Plants, Bangkok. Kasetsart University.
Kinsuat, M.J., and S.V. Kumar. 2007. Polymorphic microsatellite and cryptic simple repeat sequence markers in pineapples (Ananas comosus var. comosus) [electronic resource]. Molecular ecology notes 7:1032-1035.
Koutchma, T., B. Parisi, and E. Patazca. 2007. Validation of UV coiled tube reactor for fresh juices. Journal of Environmental Engineering and Science 6:319.
S. Likhitekaraj (ed.) 2007. Proceedings of the 45th Kasetsart University Annual Conference, Bangkok, Thailand, 30 January-2 February 2007. Subject: Plants, Bangkok. Kasetsart University.
Lima, C.R., G.A. Maia, J.M.C.d. Costa, L.d.S. Oliveira, A.E.C. Fai, and M.C. Goncalves. 2006. A study on the stability of a minimally processed pineapple placed in a vacuum pack in a supermarket / Estudo da estabilidade do abacaxi perola minimamente processado e embalado a vacuo, nas condicoes operacionais de uma empresa supermercadista. Higiene Alimentar 20:85.
S. Limkanjanawat (ed.) 2007. Proceedings of the 45th Kasetsart University Annual Conference, Bangkok, Thailand, 30 January-2 February 2007. Subject: Plants, Bangkok. Kasetsart University.
Liu, L., L. Wu, and P. Liu. 2006. The fruit trade situation and its prospect in China. China Fruits 5:60-63.
Liu, C., C. Hsu, and M. Hsu. 2007. Improving the quality of fresh-cut pineapples with ascorbic acid/sucrose pretreatment and modified atmosphere packaging. Packaging Technology & Science 20:337.
Lombard, G.E., A. Andres, P. Fito, and J.C. Oliveira. 2008. Osmotic dehydration of pineapple as a pre-treatment for further drying [electronic resource]. Journal of food engineering 85:277-284.
Lu, L., X. Xu, D. Sun, P. Luo, and X. Dong. 2007. Conservation of pineapple germplasm in vitro. Acta Botanica Boreali-Occidentalia Sinica 27:834.
Manuwong, S., A. Uthairatanakij, and P. Jitaree. 2007. Effects of hot water and sodium hypochlorite treatments on survival of Salmonella spp. and qualities of fresh-cut pineapple. Acta Horticulturae 746:401.
Marques, L.G., A.M. Silveira, and J.T. Freire. 2006. Freeze-drying characteristics of tropical fruits. Drying Technology 24:457.
Marques, G., J.C.d. Rio, and A. Gutierrez. 2007. Chemical Characterization of Lignin and Lipophilic Fractions from Leaf Fibers of Curaua (Ananas erectifolius) [electronic resource]. Journal of agricultural and food chemistry 55:1327-1336.
Martelleto, L.A.P., M. Sudo-Martelleto, C.D. Ide, J.C.d.S.M.d. Barros, and A.d. Goes. 2006. The use of organic and biological products in the propagation of pineapple by stem splitting / Uso de produtos organicos e biologicos no processo de propagacao por seccionamento do talo de abacaxizeiro. Comunicado Tecnico - Empresa de Pesquisa Agropecuaria do Estado do Rio de Janeiro.
Mészaros, A., K. Kalai, E. Domokos-Szabolcsy, M.G. Fari, and K. Halasz. 2006. An efficient micropropagation system: 3R bioreactor. Acta Horticulturae 725:621-626.
Model, N.S., R. Favreto, and A.E.C. Rodrigues. 2006. Soil preparation and planting techniques effects on weed biomass production in pineapple culture / Efeito do preparo de solo e de tecnicas de plantio na composicao botanica e biomassa de plantas daninhas no abacaxizeiro. Pesquisa Agropecuaria Gaucha 12:57.
Mondal, G.K., S.K. Pal, and A. Roy. 2006. Characterisation of acidity under different land use patterns in Tarai soils of West Bengal. Agropedology 16:21.
Ngarmsak, M. 2007. Antifungal activity of vanillin on fresh-cut tropical fruits. Acta Horticulturae 746:409.
Olanyan, A.A., and J.A. Fagbayide. 2007. Soil Nutrients Balance in Sweet Orange Intercropped with Some Arable Crops. Journal of plant nutrition 30:335-350.
Oliveira, A.R.G.d., S.V. Borges, R.K. Faria, E. Endo, and S.R. Gregorio. 2007. Influence of the spray drying conditions on sensorial characteristics of the dehydrated passion fruit (Passiflora edulis flavircarpa) and pineapple (Ananas comosus) juice / Influencia das condicoes de secagem por atomizacao sobre as caracteristicas sensoriais de sucos maracuja (Passiflora

edullis) e abacaxi (Ananas comosus) desidratados. Revista Ciencia Agronomica 38:251.
Oliveira, A.C.G.d., M.H.F. Spoto, S.G. Canniatti-Brazaca, C.P.d. Sousa, and C.R. Gallo. 2007. Effects of heat treatment and gamma radiation on the characteristics of pure sugarcane juice and mixed with fruit juices / Efeitos do processamento termico e da radiacao gama na conservacao de caldo de cana puro e adicionado de suco de frutas. Ciencia e Tecnologia de Alimentos 27:863.
Oliveira, N.T.E., J.B. Fonseca, R.T.R.N. Soares, C.T. Lombardi, and M.B. Mercadante. 2007. Metabolizable energy for different foodstuffs tested in Japanese female quails / Determinacao da energia metabolizavel de diferentes alimentos testados em codornas japonesas femeas, pp. 210, In N. T. E. Oliveira, (ed.) Arquivo Brasileiro de Medicina Veterinaria e Zootecnia, Vol. 59.
Onweremadu, E.U. 2007. Availability of selected soil nutrients in relation to land use and landscape position. International Journal of Soil Science 2:128.
Othman, Z., M.S. Madom, A. Osman, and S. Mohamed. 2006. The post harvest sensory and chemical characteristics of cold-stored pineapples pretreated with different Fruitone concentrations [electronic resource]. Journal of the science of food and agriculture 86:2067-2075.
Peiro-Mena, R., N. Martinez-Navarrete, and M.M. Camacho. 2007. Compositional and physicochemical changes associated to successive osmodehydration cycles of pineapple (Ananas comosus) [electronic resource]. Journal of food engineering 79:842-849.
Pereira, J.d.P. 2007. Agroforestry systems with rubber / Sistemas agroflorestais com a seringueira. Informe Agropecuario 28:32.
Poelman, A., S. Sefa-Dedeh, D. Lyon, and J. Mojet. 2008. The influence of information about organic production and fair trade on preferences for and perception of pineapple [electronic resource]. Food quality and preference 19:114-121.
Rampersaud, G.C. 2007. A Comparison of Nutrient Density Scores for 100% Fruit Juices [electronic resource]. Journal of food science 72:261-266.
Ranjan, T., and S.N. Ghosh. 2006. Effect of nitrogen levels on yield, fruit quality and foliar status of pineapple grown as intercrop in laterite soil. Orissa Journal of Horticulture 34:110.
Rao, D.V.R., M. Kalpana, and B. Srinivasulu. 2006. Effect of recyclable farm waste on soil fertility and yield of coconut in coconut based cropping systems of Andhra Pradesh. Journal of Plantation Crops 34:300.
Ravindran, C., K. Anshuman, and B.N.S. Murthy. 2007. Fruit production in India. Chronica Horticulturae 47:21.
Ravindranath, S., V.S. Dhokane, S.N. Hajare, S. Arun, and J.R. Bandekar. 2007. Effectiveness of radiation processing for elimination of Salmonella typhimurium from minimally processed pineapple (Ananas comosus Merr.). Journal of Food Science 72:98.
Robles-Sanchez, M., S. Gorinstein, O. Martin-Belloso, H. Astiazaran-Garcia, G. Gonzalez-Aguilar, and R. Cruz-Valenzuela. 2007. Minimal processing of tropical fruits: antioxidant potential and its impact on human health / Frutos tropicales minimamente procesados: potencial antioxidante y su impacto en la salud. Interciencia 32:227.
Rodrigues, P.H.V., M.d.F.B. Dutra, O.A. Faria, and E.M.P. Lima. 2006. Somaclonal variation in micropropagated plants of ornamental pineapple plant Ananas bracteatus Schultes var. striatus / Variacao somaclonal em mudas micropropagadas de abacaxizeiro ornamental, Ananas bracteatus Schultes var. striatus (Bromeliaceae). Revista Brasileira de Horticultura Ornamental 12:122.
Rogerio, M.C.P., I. Borges, J.N.M. Neiva, N.M. Rodriguez, J.C.M. Pimentel, G.A. Martins, T.P. Ribeiro, J.B. Costa, S.F. Santos, and F.C. Carvalho. 2007. Nutritive value of pineapple byproduct (Ananas comosus L.) in diets for sheep. 1. Intake, apparent digestibility, energetic and nitrogenous balance / Valor nutritivo do residuo da industria processadora de abacaxi (Ananas comosus L.) em dietas para ovinos. 1. Consumo, digestibilidade aparente e balancos energetico e nitrogenado. Arquivo Brasileiro de Medicina Veterinaria e Zootecnia 59:773.
Rosnah, S., W.D. Wan Ramli, M.S. Takriff, and H. Osman. 2007. Physicochemical properties of the Josapine variety of pineapple fruit. International Journal of Food Engineering 3:9.
Rovio, S., H. SirÃ©â™n, and J. Yli-Kauhaluoma. 2007. Determination of neutral carbohydrates by CZE with direct UV detection [electronic resource]. Electrophoresis 28:3129-3135.
Ruben, R., M.v. Boekel, A.v. Tilburg, and J. Trienekes. 2007. Tropical food chains: Governance regimes for quality management Wageningen Academic Publishers, Wageningen.
San Jose, J., R. Montes, and N. Nikonova. 2007. Seasonal patterns of carbon dioxide, water vapour and energy fluxes in pineapple. Agricultural and Forest Meteorology 147:16.
San Jose, J., E. Cabrera-Bisbal, and R. Montes. 2007. Nitrogen Budget in a Pineapple Crop Growing in the Orinoco Lowlands. Communications in soil science and plant analysis 38:423-447.
San Jose, J., N. Nikonova, and R. Montes. 2007. Diurnal patterns of carbon dioxide, water vapour, and energy fluxes in pineapple (Ananas comosus (L.) Merr. cv. Red Spanish) field using eddy covariance [electronic resource]. Photosynthetica 45:370-384.
Santoshkumar, P., and A.B. Patil. 2006. Isolation and characterization of wine yeast from pineapple fruits. Karnataka Journal of Agricultural Sciences 19:558.
Santoshkumar, P., and A.B. Patil. 2006. Wine production from pineapple must supplemented with sources of nitrogen and phosphorus. Karnataka Journal of Agricultural Sciences 19:562.
Saradhuldhat, P., and R.E. Paull. 2007. Pineapple organic acid metabolism and accumulation during fruit development. Scientia Horticulturae 112:297.
Sarmah, R., A. Arunachalam, D. Adhikari, and M. Majumder. 2006. Indigenous technical knowledge and resource utilization of Lisus in the south eastern part of Namdapha National Park, Arunachal Pradesh. Indian Journal of Traditional Knowledge 5:51.
Schulbach, K.F., C.A. Sims, and K.M. Portier. 2007. Evaulation of overall acceptability of fresh pineapple using the regression tree approach [electronic resource]. Journal of food quality 30:993-1008.

Serrano, E.P. 2006. Postharvest management of fruit and vegetables in the Asia-Pacific Region Philippines (1) 9283323696. Asian Productivity Organization (APO), Tokyo.
Shashidhar, R., A. Sharma, J.R. Bandekar, V.S. Dhokane, and S.N. Hajare. 2007. Effectiveness of Radiation Processing for Elimination of Salmonella Typhimurium from Minimally Processed Pineapple (Ananas comosus Merr.) [electronic resource]. Journal of food science 72:m98-m101.
Sheehan, V.M., P. Ross, and G.F. Fitzgerald. 2007. Assessing the acid tolerance and the technological robustness of probiotic cultures for fortification in fruit juices. Innovative Food Science & Emerging Technologies 8:279.
Silva, J.M.d., J.P. Silva, and M.H.F. Spoto. 2007. Physiological and enzymatic analyses of pineapple subjected to ionizing radiation / Analises fisiologicas e enzimaticas em abacaxi submetido a tecnologia de radiacao ionizante. Ciencia e Tecnologia de Alimentos 27:602.
Silva, J.M.d., M.H.F. Spoto, and J.P. Silva. 2007. Effect of the ionizing radiation in the sensorial characteristics of the pineapple / Efeitos da radiacao ionizante nas caracteristicas sensoriais do abacaxi. Ciencia e Tecnologia de Alimentos 27:710.
Silva, A.B.d., M. Pasqual, J.B. Teixeira, and A.G.d. Araujo. 2007. Micropropagation methods of pineapple / Metodos de micropropagacao de abacaxizeiro. Pesquisa Agropecuaria Brasileira 42:1257.
Simal, S., A. Femenia, A. Castell-Palou, and C. Rossello. 2007. Water desorption thermodynamic properties of pineapple [electronic resource]. Journal of food engineering 80:1293-1301.
Singh, R., and S. Singh. 2007. Design and development of batch type acetifier for wine-vinegar production. Indian Journal of Microbiology 47:153.
Singh, S.P., V. Chonhenchob, Y. Chantarasomboon, and J. Singh. 2007. Testing and evaluation of quality changes of treated fresh-cut tropical fruits packaged in thermoformed plastic containers. Journal of Testing and Evaluation 35:522.
Siregar, U.J., A. Rachmi, M.Y. Massijaya, N. Ishibashi, and K. Ando. 2007. Economic analysis of sengon (Paraserianthes falcataria) community forest plantation, a fast growing species in East Java, Indonesia. Forest Policy and Economics 9:822.
Slongo, A.P., and G.M.F.d. Aragao. 2006. Factors affecting the thermal activation of Neosartorya fischeri in pineapple and papaya nectars. Brazilian Journal of Microbiology 37:312.
Souza, C.B.d., B.B.d. Silva, and P.V.d. Azevedo. 2007. Growth and yield of pineapple under climatic conditions of the Coastal Table Lands of Paraiba State / Crescimento e rendimente do abacaxizeiro nas condicoes climaticas dos Tabuleiros Costeiros do Estado da Paraiba. Revista Brasileira de Engenharia Agricola e Ambiental 11:134.
Sriwichailamphan, T. 2007. Global food chains and environment: agro-food production and processing in Thailand, Wageningen Universiteit (Wageningen University), Wageningen.
Sruamsiri, S. 2007. Agricultural wastes as dairy feed in Chiang Mai [electronic resource]. Animal science journal 78:335-341.
Stepek, G., R.H.C. Curtis, B.R. Kerry, P.R. Shewry, S.J. Clark, A.E. Lowe, I.R. Duce, D.J. Buttle, and J.M. Behnke. 2007. Nematicidal effects of cysteine proteinases against sedentary plant parasitic nematodes. Parasitology 134:1831.
Stirling, G. 2007. Susceptibility of sugarcane varieties to two species of root-knot nematode (Meloidogyne javanica and M. incognita), and implications for crops grown in rotation with sugarcane. Sugar Cane International 25:3.
Surabhi, R., R.K. Pal, and K.S. Jayachandran. 2007. Optimization of process parameters for osmotic dehydration of pineapple slices. Indian Journal of Horticulture 64:304.
Tamaki, V., and H. Mercier. 2007. Cytokinins and auxin communicate nitrogen availability as long-distance signal molecules in pineapple (Ananas comosus) [electronic resource]. Journal of plant physiology 9:1543-1547.
Tancharoensukjit, S., and S. Chantanawarangoon. 2007. Antioxidant capacity of peels, cores and pulps of pineapples (var. Pattavia and Phuket), pp. 656, In S. Tancharoensukjit, (ed.) Proceedings of the 45th Kasetsart University Annual Conference, Kasetsart, 30-January - 2 February, 2007. Subject: Agricultural Extension and Home Economics. Kasetsart University, Bangkok.
Tansakul, W., and S. Sringam. 2007. Coconut protein beverage, pp. 586, In W. Tansakul, (ed.) Proceedings of the 45th Kasetsart University Annual Conference, Kasetsart, 30-January - 2 February, 2007. Subject: Agricultural Extension and Home Economics. Kasetsart University, Bangkok.
Tecson-Mendoza, E.M. 2007. Development of functional foods in the Philippines, pp. 179, In E. M. Tecson-Mendoza, (ed.) Food Science and Technology Research, Vol. 13.
The, P.M.P., N. Botrel, R.d.P. Nunes, and V.D.d. Carvalho. 2006. Influence of postharvest treatments over enzymatic activity of pineapple cv. Smooth Cayenne / Influencia de tratamentos pos-colheita sobre a atividade enzimatica de abacaxi cv. Smooth Cayenne, pp. 423, In P. M. P. The, (ed.) Boletim do Centro de Pesquisa e Processamento de Alimentos, Vol. 24.
Tournas, V.H., J. Heeres, and L. Burgess. 2006. Moulds and yeasts in fruit salads and fruit juices, pp. 684, In V. H. Tournas, (ed.) Food Microbiology, Vol. 23.
Tran, A.V. 2006. Chemical analysis and pulping study of pineapple crown leaves [electronic resource]. Industrial crops and products 24:66-74.
Ubi, W., C.P.E. Omaliko, M.U. Ubi, V.E. Osodeke, and S. Ekpe. 2007. The effect of plant population density on the dry matter accumulation of two pineapple cultivars (Ananas comosus) in the coastal acid sands, pp. 97, In W. Ubi, (ed.) Global Journal of Agricultural Sciences, Vol. 6.
Ubi, W., M. Ubi, U. Mike, and V.E. Osodeke. 2007. The influence of three hormones on the induction of flowering and yield of two pineapple cultivars (Ananas comosus), pp. 151, In W. Ubi, (ed.) Global Journal of Pure and Applied Sciences, Vol. 13.
Ubi, W., V.E. Osodeke, C.P.E. Omaliko, and W. Ubi. 2007. Effect of age and time of transplanting suckers on the vegetative performance of pineapple in the basement complex soil of Cross River State, pp. 157, In W. Ubi, (ed.) Global Journal of Pure and Applied Sciences, Vol. 13.
Ubi, W., and V.E. Osodeke. 2007. Root activity pattern of pineapple (Ananas comosus) determined with radioactive phosphorus during the dry season, pp. 463, In W. Ubi, (ed.) Global Journal of Pure and Applied Sciences, Vol. 13.
Uscanga, M.G.A., R.C. Garcia, J.G. Rodriguez, and B.I.E. Abarca. 2007. Carbon sources and their effect on growth, acetic acid

and ethanol production by Brettanomyces bruxellensis in batch culture [electronic resource]. Journal of food process engineering 30:13-23.

Veerawaitaya, W., R. Chaveesuk, P. Parthanadee, T. Wasusri, and C. Khompatraporn. 2007. Status of pineapple production for pineapple processing industry in Prachuap Khiri Khan province, pp. 242, In W. Veerawaitaya, (ed.) Proceedings of the 45th Kasetsart University Annual Conference, Bangkok, Thailand, 30 January-2 February 2007. Subject: Plants. Kasetsart University, Bangkok.

Vilanova, M., and F. Vilarino. 2006. Influence of geographic origin on aromatic descriptors of Spanish Albarino wine, pp. 373, In M. Vilanova, (ed.) Flavour and Fragrance Journal, Vol. 21.

Vuthy, T., S. Agarie, and A. Nose. 2007. Regulatory properties of phosphoenolpyruvate carboxylase in Crassulacean acid metabolism plants: diurnal changes in phosphorylation state and regulation of gene expression, pp. 171, In T. Vuthy, (ed.) Plant Production Science, Vol. 10.

Walker, M., and C.A. Phillips. 2007. The growth of Propionibacterium cyclohexanicum in fruit juices and its survival following elevated temperature treatments. Food Microbiology 24:313-318.

Wang, R.H., S. Maruthasalam, C.H. Lin, Y.M. Hsu, and D.P. Bartholomew. 2007. Delaying Natural Flowering in Pineapple Through Foliar Application of Aviglycine, an Inhibitor of Ethylene Biosynthesis. HortScience : a publication of the American Society for Horticultural Science 42:1188-1191.

Willems, S. 2007. Meeting and beating market requirements: competing in the big league, pp. 69, In S. Willems, (ed.) Tropical food chains: Governance regimes for quality management. Wageningen Academic Publishers, Wageningen.

Xie, W., W. Wang, H. Su, D. Xing, G. Cai, and L. Du. 2007. Hypolipidemic mechanisms of Ananas comosus L. leaves in mice: different from fibrates but similar to statins, pp. 267, In W. Xie, (ed.) Journal of Pharmacological Sciences, Vol. 103.

Yahia, E.M. 2006. Modified and controlled atmospheres for tropical fruits, pp. 6, In E. M. Yahia, (ed.) Stewart Postharvest Review, Vol. 2.

Yan, Z., F.A.R. Oliveira, and M.J. Sousa-Gallagher. 2008. Shrinkage and porosity of banana, pineapple and mango slices during air-drying [electronic resource]. Journal of food engineering 84:430-440.

Zah, R., R. Hischier, A.L. Leao, and I. Braun. 2007. Curaua fibers in the automobile industry -- a sustainability assessment, pp. 1032, In R. Zah, (ed.) Journal of Cleaner Production, Vol. 15.

Zhang, X., L. Du, G. Sun, D. Gong, J. Chen, W. Li, and J. Xie. 2007. Changes in organic acid concentrations and the relative enzyme activities during the development of Cayenne pineapple fruit, pp. 381, In X. Zhang, (ed.) Journal of Fruit Science, Vol. 24.

Zulueta, A., M.J. Esteve, I. Frasquet, and A. Frigola. 2007. Vitamin C, vitamin A, phenolic compounds and total antioxidant capacity of new fruit juice and skim milk mixture beverages marketed in Spain, pp. 1365, In A. Zulueta, (ed.) Food Chemistry, Vol. 103.

Zulueta, A., A. Frigola, and M.J. Esteve. 2007. Carotenoids and Color of Fruit Juice and Milk Beverage Mixtures [electronic resource]. Journal of food science an official publication of the Institute of Food Technologists 72:457-463.◆

Instructions to Contributors to Pineapple News

All contributions should be written in English. We will gladly provide assistance with editing.
Preferred contributions include:

- Timely news about research on issues related to culture, processing, storage, and marketing of pineapple.
- New, interesting, or unique problems encountered by growers.
- Country or status reports on the local pineapple industry.
- If uncertain about the suitability of material for the newsletter, contact the editor.

If possible, please send contributions by E-mail as attached files in MS Word or rich text format or on floppy disks. When sending printed copy, be sure that it is clean and sharp so it can be scanned to speed conversion to a wordprocessor format.

Article length: Papers usually should be no longer than 4 double-spaced pages in 12 point font or equivalent, not including tables, figures and photos. If longer than 4 pages, please contact the editor. There is no limit on the number of articles that can be submitted. However, acceptance and publication is at the discretion of the editor.

Tables: The preferred table format is columns separated by tabs. Authors may be asked to revise tables not in the requested format.

Photographs: Submit photographs that can be scanned or provide digital files in jpeg format with a minimum resolution of 300 dpi so they can be printed with acceptable resolution in grey scale with a laser printer.

Mail contributions and inquiries to: **D.P. Bartholomew, Dept. of NREM, Univ. of Hawaii, 1910 East-West Rd., Honolulu, HI 96822 U.S.A.** (Phone (808) 956-7568; Fax (808) 956-6539; E-mail: duaneb@hawaii.edu.

Pineapple News is available on the Web at: http://tpss.hawaii.edu/pineapple/pineappl.htm.◆

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.