Pineapple News

Issue No. 9 Newsletter of the Pineapple Working Group, International Society for Horticultural Science May, 2002

Contents

Pineapple Working Group (PWG)

Dear PWG colleagues:

This is the last time that I will be both chair of the PWG and editor of Pineapple News. I plan to continue to publish the newsletter for the foreseeable future as long as there are sufficient contributions to make a newsletter worthwhile. I will step down as chair of the PWG as soon as a new chair is named.

The Fourth International Symposium on Pineapple (FIPS2002) held from April 16-19, 2002 in Veracruz, Mexico is now history. The 92 abstracts submitted for presentation at the symposium are included at the end of the newsletter for the benefit of those who were unable to attend the meeting. Not all of the papers were presented because some who submitted abstracts were unable to obtain funds to travel to Mexico. There were 298 participants from 29 countries, which I believe makes this the largest meeting convened to date. As with the two previous symposia, there were more from within the region (Americas and adjoing areas) than from outside of it, which underscores the value and desirability of holding each symposium in a different region of the world. Rotation of the symposium venue to different parts of the world expands the opportunities for researchers and growers to participate in a pineapple symposium.

Technical papers on all aspects of pineapple science and culture were presented during the first, second, and fourth days of the meeting. During the third day, participants traveled by bus to the major pineapple growing region in the state of Veracruz. The buses traveled south along a semi-arid coastline for the first part of the trip. Along the coast, there were many small farms where pineapple appeared to be a main crop, but cultural practices were of low intensity. Once the buses turned inland, the area became more humid and sugarcane and livestock were the main crops of the area. The buses then traveled through an uplands area where the vegetation was lush and tropical. A brief stop was made in the highlands area so the participants could enjoy a boxed breakfast. After the break, the buses traveled into the Papaloapan River basin where much of the Mexican pineapple is grown. The scale of production was much larger than was seen along the coast and cultural practices were more intensive. It was interesting to note that plant population densities in all of the areas visited was low compared to those used in Hawaii and Southeast Asia. The explanation given for the lower planting density was that much of the fruit was being grown for the local market. It was explained that in Mexico, a typical family might comprise 8 or 9 people so these consumers prefer a fruit that weighs about 3 kilograms.

South Africa to Host 5th Symposium

The Pineapple Working Group session was convened on Wednesday, April 17. The meeting was hosted by our colleagues from Mexico who showed us how to drink tequila and make real tacos. The main topic of discussion was the location of the next symposium. Our colleagues from South Africa proposed to hold the 5th Symposium in their country and painted such an inviting picture that it was impossible to resist their invitation. David Murray (pga@intekom.co.za) issued a formal invitation to those attending the symposium on Friday and spoke of plans to host the 5th Symposium in 2005. David spoke of tentative plans that would include a symposium and a tour package that would assure that participants had an opportunity to hear the latest information about pineapple and see the best that is South Africa. David Murray, Elmarie Rabie (erabie@futurenet.co.za), and Allen Duncan (allen@sumpride.co.za) are the three who have volunteered to take on the task of organizing this next symposium. I wish them great success and hope to see all of you there in 2005.

More on Organic Pineapple

Organic Pineapple Subgroup: I wrote in issue No. 8 of Pineapple News that I would be interested in including information about well-documented organic practices in future newsletters. I have nothing further to add to that invitation, but am pleased to inform readers interested in the subject that Douglas Hinds (Centro para el Desarrollo Comunitario y Rural, Asociacion Civil, Cordoba, Veracruz, Mexico; E-mail: cedecor@gmx.net) has agreed to chair an Organic Pineapple Subgroup of the PWG. Douglas and I are in agreement that it would be better to have a PWG Subgroup than to create a separate entity dealing only with organic pineapple issues. Douglas invites those with similar interest to contact him. Perhaps in the future we can have a section of the newsletter devoted to issues related to organic pineapple production.

Flower Induction Technique That Meets Organic Standards: While I was at the 4th Symposium, Dr. Calude Teisson, responsible for pineapple at CIRAD?FHLOR in France, shared with me the information that a grower in Cote d'Ivoire was forcing pineapple with with 95% or greater success by applying 50 cc of cold (5°C) water per plant. Dr. Teisson stated that the plants must be quite stressed for nitrogen (be yellow in color) in order for the technique

to be successful in Cote d'Ivoire. Cote d'Ivorie is nearly on the equator so it has warm night temperatures, which are known to result in pineapple plants that are relatively more difficult to force. Stressing plants for nitrogen was a common practice when it was common to rely on natural induction to bring plants to flowering. It may be that less severe or perhaps even no nitrogen stress would be required in environments where pineapple is easier to force.

It seems likely that the cold-shock caused by applying water at 5°C stimulates the pineapple plant to produce ethylene, as has been reported for other plants (Chin-Ho Lin, personal communication). We and others plan to initiate work on this issue because it may help to define the conditions critical for natural induction and may also be useful in testing for the success of a genetic transformation designed to shut down natural ethylene production and inhibit natural flowering. Double applications of ethephon are commonly used in environments where plants are difficult to force. If the optimum conditions for stimulation of ethylene production by cold water can be identified, it may be that multiple applications of cold water at optimum intervals will improve the success of induction without having to impose severe nitrogen stress.

New Benefits to ISHS Membership

The ISHS is one of the foremost organizations promoting cooperation and communication among researchers, growers and consumers in the horticultural industries. The aim of the ISHS is to promote and encourage research and to facilitate the cooperation of scientific activities and knowledge transfer on a global scale by means of its publications, events and scientific structure. The ISHS provides the structure under which our Pineapple Working Group functions and provides for the publication of meeting proceedings in a volume with high visibility. An important benefit of membership is to support an organization with the goal of improving horticulture across the globe. If you have internet access, please visit the ISHS web site at http://www.ishs.org and see the new enhancements there. In additiona to comprehensive information about ISHS, the web site now provides free access to all titles and abstracts of all issues of Acta Horticulturae. In additiona, the complete contents of the Acta volumes are available from the web site. A valuable new benefit to members of ISHS is access to up to 10 Acta articles at no cost. To inquire about membership in the ISHS or to order publications of the society, visit the web site above or write to: ISHS Secretariat, P.O. Box 500, 3001 Leuven, Belgium (E-Mail: info@ishs.org).

Contributions to Pineapple News

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

1. All contributions should be written in English. Assistance with editing will be provided.
2. Preferred contributions are timely news about research on issues related to culture, processing, storage, and marketing of pineapple, new, interesting, or unique problems encountered by growers, and status reports on the pineapple industry within a country or region.
3. If possible, please send contributions by E-mail as attached files in MS Word or WordPerfect format or on floppy disks. Printed copy should be clean and sharp so it can be scanned to speed conversion to a wordprocessor format.
4. Columns in tables should be separated with tabs. Do not use Tables features of word processing programs. Photographs or image files that can be printed in grey scale with a laser printer at 600 dpi are acceptable.
5. Mail contributions and inquiries to: **D.P. Bartholomew, Dept. of NREM/TPSS, 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://agrss.sherman.hawaii.edu/pineapple/pineappl.htm.
6. **Address corrections:** Please send mailing and E-mail address corrections to D.P. Bartholomew at the above address.◆

News From Australia

2001 Pineapple Field Day

The Queensland Fruit and Vegetable Growers Pineapple Field Day was held on Friday, July 20, 2001. The main theme of the field day was "Future Directions."

Summaries or excerpts, or both, of articles presented in the Pineapple Field Day Notes and considered to be of interest to readers of Pineapple News were prepared by D. Bartholomew. Sincere apologies to the authors for any significant omissions or changes in meaning.

Summary of Study Tour & Produce Marketing Association Convention

Summarised for Gavin Scurr and Peter Blackwood by Wendy Harris, QFVG

A study mission to the Produce Marketing Association Conference in the USA and associated industry visits was conducted in October/November 2000. The key recommendations include the following.

- Changes in the value chain and how best to manage new relationships: Growers need to be pro-active and take responsibility for and participate in the value chain. The industry needs to continue to develop a formal and consolidated approach to value chain development to meet customer and consumer requirements. Industry investment in activities to support retail sales needs to be increased.
- Consumer behaviour and the latest trends: That growers and industry invest in consumer research and developing value chains that continually seek consumer information and provide innovative products to meet consumer requirements.
- Opportunities for small and medium sized businesses in these new marketing systems: That small and medium sized business develop a strategic approach to focus on market opportunities and establish an alignment and role in a value chain.
- Quality and food safety initiatives and programs in the US and elsewhere: That food safety systems are an essential part of doing business and that Australian food safety systems need to align themselves with those of the world wide retail players as they will be likely to have an impact on the retailing sector.
- Organics and eco-labelling - new developments and consumer responses: That growers and industry seek out opportunities in the organics and whole-foods area.
- E-commerce: That industry become e-aware and prepared and use it as a tool to add value to the business.

- International trade: That industry invest in preparing for the next round of WTO negotiations.
- GMOs: Industry should focus onconsumer benefits of biotechnology and provide the community with factual information for and against GMOs.

Providing What the Customer Wants?

Nick Macleod, Golden Circle Ltd.

Pineapple fresh fruit consumption in Australia has reremained approximately constant at 35,000 tons since 1987 while per capita consumption has declined. Macleod and Sweet Kelly in 1987 concluded that blackheart and inconsistent quality were the major impediments to expansion of fresh fruit consumption. The fresh industry was based on Smooth Cayenne, an unsuitable variety being grown in a climate that results in an unsuitable product 6 months of the year. Growers have addressed the problem in three ways. Moving production northward to a more favorable climate, changing varieties, and value adding. Some growers have moved production northward to the Mareeba district to obtain better and more consistent fruit quality throughout the year. Growers have also changed varieties, growing "Bethonga Gold" or rough leaf (Queen) pineapple in response to consumer demand. to better meet consumer demand. Peeling/coring machines were introduced in fruit stores in 1987 and fruit sales in those stores increased by 60% with no reduction in whole-fruit fresh sales. In 1994, Golden Circle commenced producing minimally processed pineapple. A significant amount of porduct is now available for customers seeking a ready-to-eat product. Work on new hybrid varieties that are sweeter and less acid continues. Expansion of the industry will depend on the ability to supply the customer with a product they want.

Effects of Phosphonate on Phythopthora Root Rot of Pineapples

Marcelle Stirling, Biological Crop Protection Pty. Letd., 3601 Moggill Rd., Moggill, Qld.

Recent surveys show that *Phytophthora* root rot can be found in most fields. The results of two experiments clearly show that root rot caused by phosphonate-sensitive isolates of *Phytophthora* can be reduced when low concentrations (2-8 $\mu g\ g^{-1}$) of phosphonate are present in pineapple root tips. Control was not improved by levels of phosphonate 40-80 fold higher. Although phosphonate is effective against sensitive isolates, early works suggests it is less effected against tolerant isolates of *Phytophthora*. The results were obtained in a glass house and need to be confirmed in the field.

Developing a Commercialisation Strategy for New Pineapple Cultivars

G.M. Sanewski, Queensland Horticulture Inst., Maroochy Research Station, Nambour, Qld.

New cultivars probably will be protected by Plant Breeders Rights and a royalty will be applied, likely on fruit sold rather than on planting material. Grower access to new cultivars would be through licensed marketers. It is likely that both tissue culture and multiprop would be used to expand available planting.

Imported Hybrid Cultivar Comparisons

G.M. Sanewski, Queensland Horticulture Inst., Maroochy Research Station, Nambour, Qld.

To date the most promising imported cultivars have come from the Pineapple Research Institute (of Hawaii, PRI) breeding program. The hybrids 53-116, 58-1184, and 73-50 were compared with 'Smooth Cayenne'. When compared to 'Smooth Cayenne', 73-50 was consistently about 23% smaller in plant crop, did not produce multiple crowns but can sometimes develop small slips around the crown, crowns are moderate in size in winter but can be large in summer, has about 1% higher TSS and much lower acidity, about half that of Cayenne in winter, though still marginally high for optimum eating quality, produces marginally more slips and a similar number of suckers, but more ground suckers, peduncle lengths are comparable in summer but can be too long in winter, resulting in greater lodging; level of field resistance to blackheart is useful, has a 5-fold higher vitamin C content and may be marginally more susceptible to natural flowering.

When 53-116 is compared to 'Smooth Cayenne', it has a high incidence of multiple crowns, high translucency, marginally higher TSS, much lower acidity, a higher Brix-acid ratio, has 2.5 times the vitamin C content in winter and good resistance to blackheart, is more firm, but does not sucker well.

A comparison of 58-1184 and 'Smooth Cayenne' shows that the hybrid has a smaller fruit, lower TSS and acidity, yellow flesh and pleasant flavour, is prone to translucency, does not produce multiple crowns, but does produce a large frequency of crown slips, crowns are difficult to remove, fruit is reasonably firm, and fruit is most similar to 53-116. The hybrid is much more susceptible to natural flowering (up to 30% vs. 0 in 'Smooth Cayenne') when grown on a winter cycle; 53-116 is clearly the best of the imported hybrids.

Results of Field Trials on the Costs and Effectiveness of Nemacur in Pineapples

Graham Stirling, Biological Crop Protection Pty. Ltd., Brisbane

The efficacy and cost-effectiveness of various components of the Nemacur program currently registered on pineapple was examined in three field trials. In the first trial, nematode populations remained low throughout the plant and first ratoon crop. Nemacur treatment did not increase yield and there was a net loss of between \$1,000 and \$2,000 ha^{-1} when Nemacur was applied. The second site was a clay loam soil where nematodes had always been known to cause problems. Nematicide treatment did not prevent galling and nematode populations remained relatively high throughout the plant and ratoon crops. Nevertheless, Nemacur increased yield by an average of 22.5 t ha^{-1} over the whole crop cycle. The most cost-effective treatment was four foliar sprays of Nemacur at 6 L ha^{-1}, with this treatment producing a net return of more than \$2,000 ha^{-1}. At the third site on a sandy, nematode-infested soil, the pre-plant treatment (Nemacur 100G applied as granules at 100 kg ha^{-1}) was ineffective but the post-plant treatment (6 foliar sprays of Nemacur 400 at 6 L ha^{-1}) increased total yield by 17% and provided a net return of about \$1,00 ha^{-1}. Returns from Nemacure were even greater when the nematicide was applied following soil fumigation. These results indicate that there is no economic benefit from applying Nemacur when nematode densities are low. Such situations are common in the th pineapple industry and can be identified by monitoring. When densities of root-knot nematode are high enough to cause damage, Nemacur produces nett returns of between \$1,000 and \$2,500 ha^{-1}. The most cost-effective way of

using the nematicide is to apply 2-4 foliar sprays, with the number of sprays and their timing depending on the seveity of the nematode infestation. In soils where symphyla are likely to cause problems and situations where there is a chronic nematode infestation, the highest returns are obtained when Nemacur is used in conjunction with soil fumigation. Such fields should be treated with an appropriate fumigant and then monitored for nematodes 9-12 months after planting and at plant crop harvest. If the results show that nematodes have begun to re-infest the treated area, foliar sprays of Nemacur may be applied judiciously to keep nematode populations at relatively low levels.

Paclobutrazol Fails to Reduce Pineapple 'Blackheart' Expression Associated with a Putative Gibberellin-controlled PPO Gene

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Key-words: browning, polyphenol oxidase, chilling, promoter response elements

Introduction

Pineapple fruit are subject to a chilling injury known as 'blackheart' when exposed to storage temperatures lower than 20°C (Teisson, 1972; Smith, 1983). Internal tissue near the fruit core turns brown, associated with de novo synthesis of polyphenol oxidase (PPO) (Stewart et al., 2001). Recently, the promoters for the two genes responsible for PPO synthesis in pineapple were identified (Zhou et al., 2000). Putative response elements for gibberellin were found to be located within the sequence of both promoters. This, together with observations that blackheart can be directly induced by exogenous gibberellin (Tan et al., 1989; Tang et al., 1997; Zhou and Tan, 1997), leads to the possibility that blocking gibberellin synthesis through the use of an anti-gibberellin could block blackheart expression in pineapple fruit.

Experimental Procedure

Mature-green pineapples (cv. Smooth cayenne) were stored at 10°C or 23°C after immersion in water, gibberellic acid (GA3) (150 ppm) or the anti-gibberellin, paclobutrazol (1000 ppm) for two minutes. Previous studies (Tang et al., 1997; Zhou and Tan, 1997) have shown dipping to be an effective vector. One half of fruit were pre-treated with a prochloraz dip (0.55 mL.L-1 Sportakâ for 1 minute) the day before treatment to minimise fungal rots during storage. Fruit were allowed to air-dry overnight.

Fruit were stored at 10°C or 23°C for three weeks and then for a further one week at 23°C. During storage, fruit were covered with plastic sheeting to minimise dehydration. External changes in skin colour (1 = green; 2 = green-yellow; 3 = yellow) and disease incidence were monitored weekly. Blackheart (0 = nil; 1 = slight; 2 = moderate; 3 = severe; 4 = very severe) was assessed after 4 weeks storage by cutting fruit longitudinally along the core.

Results

All fruit stored at 10°C developed moderate to severe blackheart symptoms after 3 weeks, regardless of immersion treatment (Fig. 1b). Paclobutrazol failed to alleviate blackheart and GA3 did not aggravate symptoms. At 23°C, blackheart was artificially induced by GA3, but only in fruit that had been previously treated with the fungicide prochloraz (Fig. 1a). Severity of GA3-induced blackheart symptoms was considerably milder than that induced by low temperature.Disease incidence was generally low in fruit, with prochloraz having little impact on disease incidence. Disease tended to be greater in fruit held at 23°C, especially towards the end of the trial, but rots generally were confined to the base of fruit near the cut surface of the peduncle, seldom overlapping with blackheart symptoms.

No significant difference in skin colour existed between paclobutrazol-treated and control fruit at either storage temperature. Gibberellic acid however, delayed the development of skin yellowing at 23°C (Fig. 2a) and at 10°C following removal of fruit to 23°C (Fig. 2b). During storage at 10°C all fruit remained green.

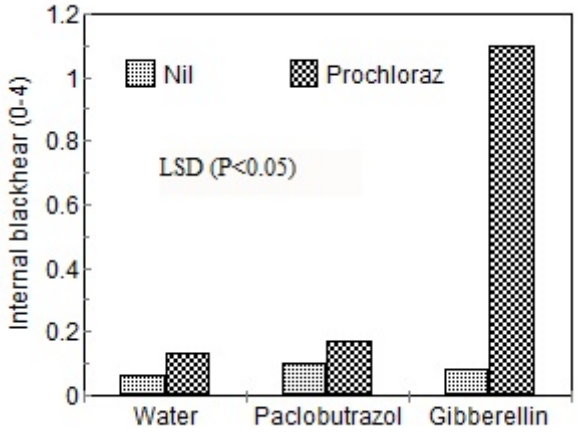

Figure 1a. Blackheart severity in pineapple fruit stored at 23°C for 4 weeks.

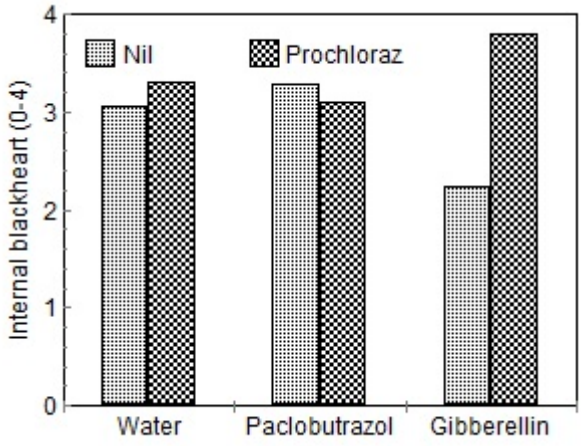

Figure 1b. Blackheart severity in fruit stored at 10°C for 3 weeks followed by 1 week at 23°C. Treatment effects were not significant.

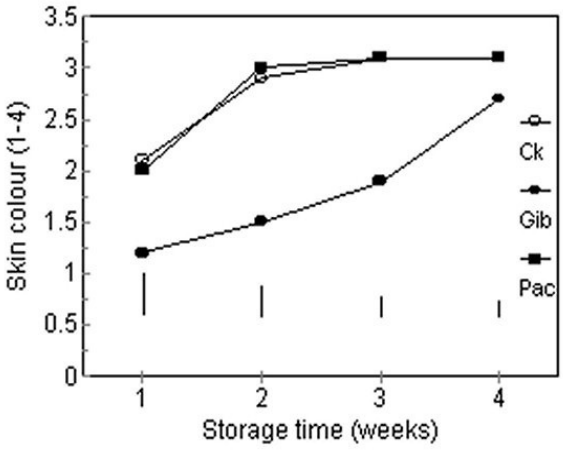

Figure 2a. Skin colour development in fruit stored at 23°C for 4 weeks. Vertical bars indicate LSD at P<0.05.

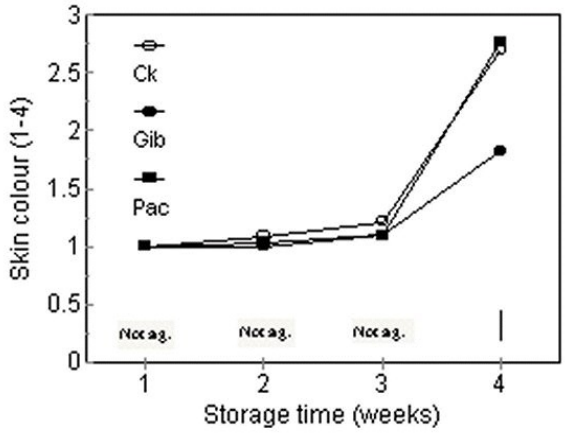

Figure 2b. Skin colour development in fruit stored at 10°C for 3 weeks followed by 1 week at 23°C. Vertical bars indicate LSD at P<0.05.

Discussion

Although gibberellic acid was able to induce blackheart under non-chilling conditions in some circumstances, the converse of paclobutrazol being able to inhibit blackheart under chilling conditions did not occur. The failure of paclobutrazol to significantly reduce the expression of blackheart symptoms may have been due to a number of reasons. Firstly, it is possible that response elements other than those for gibberellin may exist in the pineapple PPO promoter. For example, a promoter element responding to specific molecules released in the cell after chilling injury would initiate transcription of the PPO gene regardless of the presence of gibberellin.

Secondly, pre-existing gibberellin may have been present in sufficient amounts prior to paclobutrazol application to initiate transcription. Paclobutrazol acts by blocking synthesis of gibberellins (Dalziel and Lawrence, 1984), rather than blocking its action. Consequently, if gibberellins were present prior to treatment and more effectively bound to the response elements at lower temperature, then paclobutrazol would be ineffective. This possibility could only be discounted by blocking gibberellin action with an inactive analogue, or to establish that no gibberellins were present at the time of treatment.

Finally, it is possible that paclobutrazol penetration into the fruit may have been insufficient to reach the inner fruit tissue where blackheart occurs. However, this seems unlikely in the present trial, as the corresponding methodology with gibberellin was able to induce blackheart.

It is unclear why gibberellic acid was only effective in inducing blackheart in fruit that had been previously treated with prochloraz. Other studies (Tang et al., 1997; Zhou and Tan, 1997) reported induction of symptoms with gibberellic acid alone, although Zhou and Tan (1997) applied double the concentration (300 ppm) to that used in the present trial. It is possible that the synergistic action prochloraz and gibberellic acid may have been due to the wetting action of prochloraz. The latter is inherently 'waxy' and may have improved penetration of gibberellic acid through the skin and into the pulp of the fruit.

Apart from its ability to induce blackheart, gibberellic acid had a secondary effect of retarding skin yellowing at higher temperature. Unlike blackheart, this effect was not reliant on prochloraz treatment, which lends support to the hypothesis that prochloraz enhanced gibberellic acid induction of blackheart by improving its penetration through the skin.

Conclusions

Although gibberellic acid can be used to induce blackheart independently of chilling temperatures, use of the anti-gibberellin paclobutrazol to block gibberellin synthesis is not an effective means of eliminating blackheart symptoms. The reasoning behind this is not clear, but could be due to the presence of additional response elements on the PPO promoter unrelated to gibberellins, or to sufficient levels of endogenous gibberellins present (prior to paclobutrazol application) to bind to response elements under chilling conditions. The mode of the synergistic action of prochloraz with gibberellic acid in inducing blackheart is also unclear, but is likely to be due to the physical effect of prochloraz aiding penetration of gibberellic acid through the skin and into the pulp. Further research is needed to elucidate these observations.

Acknowledgments: This work was funded as part of ACIAR Project PHT 9940 “Genetically Engineering Pineapple with Blackheart Resistance”.

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News from Brazil

Evolution of Brazil's Pineapple Production

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According to data from IBGE (Instituto Brasileiro de Geografia e Estatística – Brazilian Institute for Geography and Statistics), the official organ for general statistics in Brazil, the pineapple industry in this country has expanded very significantly since 1990. The area harvested jumped from 32,092 ha in that year to 57,899 ha in 2001, a 80.4% increase. During the same period production grew from 724.03 million fruits (1.01 million t) to 1.398 billion fruits (1.958 million t), a 93% increase. Yield also improved somewhat, from 22,561 fruits/ha (31.5 t/ha) to 24,156 fruits/ha (33.8 t/ha), a 7.3% increase. From 2000 to 2001, increases registered were area harvested, 3.9%; volume produced, 8.2%; and productivity, 4.1%.

Data given by FAO (Food and Agriculture Organization of the United Nations) show some differences. FAO gave the following data for the year 2000: area harvested – 56,031 ha; production – 1,353,480 t; yield – 24.156 t/ha. The numbers supplied by IBGE are: 55,749 ha; 1,292,797,000 fruits and 23,189 fruits/ha. There is not much difference in the area harvested, but the values given for production and yield are rather different. Tthis may result from the conversion factors used to transform fruit number into tons. There are no hard data available to define an average weight for all pineapple fruits harvested in Brazil. However, the practical experience and the table of classification of the fruits by weight used in most of the Food Supply Centers (CEASAs) located in most of the Brazilian capitals, clearly indicate that 'Pérola' pineapple fruits have an average weight of about 1.2 to 1.4 kg, which is the weight of an intermediate fruit, as the category IV fruits weigh more than 1.8 kg and the category I fruits weigh from 900 g to 1.2 kg. 'Smooth Cayenne', the other major variety in use in the country, produces heavier fruits than Pérola. The fruit weight can go up to category VI with a weight above 2.5 kg. The general average fruit weight could be about 1.4 – 1.6 kg. Pérola is much more planted than 'Smooth Cayenne', which is almost not present in the Brazilian North and Northeast regions, which are responsible for more than 65% of the country's production.

Taking all this aspects into account, the general average fruit weight of a Brazilian pineapple may be about 1.4 kg. Using this factor, the Brazilian production in 2000 was 1,809,915,800 kg (1,292,797,000 fruits x 1.4) or 1,809,915 tons, a 33% higher value than that indicated by FAO (1,353,480 t). Following the same method, average yield would be 32.5 t/ha instead of 24.15 t/ha as indicated by FAO.

Paraiba's Pineapple Industry on Fast Recovery

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Pineapple from Paraíba is a label that sells best among fresh pineapples in Brazil. Many dealers offer their fruits coming from different production zones in Brazil as being pineapple from Paraíba, what usually stands for a good quality sweet 'Pérola' pineapple.

In spite of that great competitive advantage Paraíba´s pineapple production decreased during several years in the mid-nineties, when that State lost its position as first producer in Brazil. Many reasons accounted for that, such as losses caused by diseases, especially fusariosis, soil fertility decline and increasing costs of fertilizers and other inputs, low investments in research and technical assistance, and the increasing transport and post-harvest losses and costs, among those the payment of high taxes on fruits sold inside (17%) and outside (12%) Paraíba.

At the same time other pineapple producing areas in North (Tocantins, Pará) and Northeast Brazil (Maranhão, Bahia, Rio Grande do Norte) greatly increased their production and captured an important share of the Brazilian markets, especially in the large capitals of the Southeast region. However, from 1997 onward, there was a strong effort by EMATER-PB to revitalize the State's pineapple industry. The first big step forward was the elimination of the sale taxes mentioned above, representing a very important additional income for growers and middlemen.

Technical assistance in narrow partnership with research institutions, mainly Embrapa Cassava and Fruits, Cruz das Almas, Bahia, on a national basis and the Agricultural Research Corporation of Paraíba (EMEPA), intensified training and other activities that helped to improve pineapple cultivation techniques and production systems used by the farmers, increasing the productivity and the percentage of good quality fruits harvested. Financial support given by banks like the Banco do Nordeste do Brasil, with special lower annual interest rates offered by the Federal Government's National Program for Family Agriculture Support (PRONAF), also stimulated cultivation of the crop and gave access to it for a large amount of small growers without land that depend on areas rented from large farmers.

Other relevant measures taken to fortify Paraíba´s pineapple industry were related to an improved organization of post-harvest procedures and commercialization. First an agreement with the Stock Market of Pernambuco (Bolsa de Mercadorias de Pernambuco) created the Pineapple Stock Market of Paraíba, that assumed the commercialization of an important part of the State's production, using up-to-date information technology and giving almost total warranty to the growers. In addition, this service allowed for a 30% to 45% gain in fruit prices at grower's level.

Second, more recently was begun the transport and inland commercialization of pineapple fruits in special hardpaper packages, similar to those used for export. The additional costs are being paid by the buyers, mostly large supermarkets, but the acquisition of the packages has initially been financed by funding from the Paraíba State Government (Secretariats for Agriculture and Industry & Commerce). This new pineapple handling system has allowed fruits to arrive at their far inland destinies, such as Rio de Janeiro and São Paulo, cities located more than 2000 km from Paraíba, with better quality and much lower post-harvest losses that before were estimated to be over 20%.

All those efforts gave good results. The State's production steadily grew from 137 million fruits or about 164,000 t (1998) obtained from a harvested area of 6,445 ha to 308 million fruits or

about 370,000 t (2001) from 10,444 ha. Productivity also increased from 21,200 fruits/ha (about 25.5 t/ha) to 29,515 fruits/ha (about 35 t/ha) in the same period of time. Paraíba, after dropping to the third place recaptured first place in productivity among the Brazilian States and the second position behind Minas Gerais State in production volume, based upon on a much stronger technological and general support structure, which should strengthen this industry even more in the coming years. In this context should be mentioned, first the constitution of the Paraíba Pineapple Forum, responsible for political and technological support to the fruit's production chain, and second, that pineapple also became a symbol for the Paraiban tourist industry, an important fact to assure governmental and private attention to the local pineapple industry for the future.

'Pérola' Pineapple Slips Grew Better on Mother Plants than in Nursery

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Several studies have been carried out by Embrapa Cassava & Fruits, Cruz das Almas, Bahia, during the past few years aiming at improving management of planting material of 'Pérola' pineapple and increasing the availability of good quality, healthy material, which has been a problem in many production regions.

A 'Pérola' pineapple plant produces several slips. The larger, more vigorous ones are used as planting material, whereas the smaller ones are discarded, even when they are healthy and could become more vigorous if kept on the plant for some more time. Less vigorous plants tend to form also less vigorous slips. Hence in a poor pineapple crop with a high percentage of low vigor plants, there may be rather large losses of planting material.

In the first study evaluated the possibility of transforming low-vigor slips into useful planting material and comparing their development in a nursery with that obtained when they are kept attached to the mother plants. This comparison was done for different slip sizes (6-10 cm, 11-15 cm, 16-20 cm), using a completely randomized design (2 x 3) and 30 replications, each one represented by the slips of one plant. Half of the slips from each plant were transferred to field nursery beds planted in a 15 cm x 15 cm spacing, fertilized and regularly watered during the experimental period. The other slips were maintained on their mother plants. Slip growth was evaluated at 60 and 120 days after transplanting to the nursery or after determination of the initial sizes and fresh weights for those kept on the mother plants.

Data showed statistically significant effects for both slip size and site of their development (mother plant vs. nursery). The largest slips had higher growth rates, especially when expressed as weight, with increasing differences to the other two sizes studied as the experimental period advanced. Slips kept attached to the mother plants showed a faster growth than those in the nursery, both when expressed as size and as weight. Data suggest that the transplanting causes a certain shock that retards the development of the slips.

'Pérola' Nursery Slips and Stem Plantlets Grew and Produced as Well as Conventional Slips

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This study was carried out in the experimental area of Embrapa Cassava & Fruits, Cruz das Almas, Bahia, in the Recôncavo Baiano region, at 12º 40' 19'' South latitude and 39º 06' 22'' West longitude, 220 m above sea level, with an average annual rainfall of 1,170 mm and average temperature of 24.5 ºC. The soils are Yellow or Yellow-red Latosoils, of mostly intermediate to high acidity (pH in water equal to 4.5 to 5.5), low chemical fertility (P <10 mg dm^{-3}; K from 30 to 90 mg dm^{-3}; calcium < 2.0 cmolc/dm3; magnesium < 1.2 cmolc/dm3; bases saturation from 40 to 60%; with 0.0 to 0.5 cmolc/dm3 of aluminum), usually deep, well drained, with an intermediate texture.

The objective was to determine if small slips grown in a nursery until reaching adequate size and vigor for planting in the field (height >25 cm and fresh weight >180 g), show an agronomic performance similar to that of conventional slips (directly transplanted to the field after harvest from their mother plants). In addition the behavior of plantlets obtained from stem pieces in nurseries (stem plantlets) was observed. All three types of planting material were studied for two sizes (25 – 34 cm and 36 – 44 cm), using a randomized blocks design with a factorial scheme (3 x 2) and five replications.

Larger planting material had significantly greater 'D' leaf dimensions and weight at 4, 6, 8 and 10 months after planting. Among the planting material types, stem plantlets resulted in plants with higher vigor, as expressed by those same variables for most of the evaluation dates, than those coming from nursery slips, with an intermediary position for plants originated from conventional slips, without statistical differences between that one and the other two planting material types used.

The vegetative development differences among the treatments studied resulted also in some similar ones for production variables. The productivity was higher for larger planting material and for stem plantlets, partly determined by slightly larger fruit weights obtained for those treatments. No significant differences for that variable were observed between conventional and nursery slips. There were no significant differences among treatments for fruit dimensions, crown length and fresh weight, number of slips, total soluble solids and titrable acidity of the pulp. It was concluded that stem plantlets (produced from stem pieces in a nursery) and nursery slips (slips of low vigor on mother plants recuperated after a period under nursery conditions) show field performances, respectively, superior and similar to those of conventional slips, and may be used as planting material in commercial 'Pérola' pineapple orchards under environmental conditions similar to those of the Recôncavo Baiano region (Coastal Tableland of Bahia State, Brazil). Whenever possible, should be given preference to the use of large planting material (35 cm – 45 cm length), that usually presents more vigorous growth and higher yield.

No Need for Fertilizing Slips of Vigorous 'Pérola' Plants

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Usually pineapple growers in Brazil do not apply any cultural practices to 'Pérola' pineapple plants during the post-harvest development period of slips. In the semi-arid region of Itaberaba, Bahia, where pineapple are grown under rainfed conditions and hence frequently suffer periods of drought stress, the supply of liquid fertilizers may help slips to develop faster.

To evaluate the need of fertilizing and other cultural practices during the slip development period on their mother plants, was the main objective of a study carried out by Embrapa Cassava & Fruits and EBDA (Empresa Baiana de Desenvolvimento Agrícola – Corporation for Rural Development of Bahia) in that region. The experiment was started right after end of the fruit harvest in a commercial field with vigorous plants and a high number of slips per plant.

The treatments studied were number (2, 4, 6) of foliar applications of nitrogen (urea) and potash (KCl), alternating with N-K-Mg + micronutrients, at 14-day intervals, one solid fertilizer application (N, K) and two applications of growth regulators (gibberelic acid at 50 mg/L, tebuconazole at 150 mg/L), also at 14-day intervals. The experimental design was a completely randomized blocks one with four replications. The development of the slips in relation to their status at the beginning of the treatments was evaluated after 60, 90 and 120 days, based upon their length and fresh weight.

There were no significant effects of the treatments on slip development. The general growth rate was rather high; at 60 days slips had already reached a size and fresh weight appropriate for their use as planting material (average size of 47.7 cm and average fresh weight of 269 g).

XVII Brazilian Congress on Fruitculture

Promoted and organized by the Brazilian Society of Fruitculture – SBF, Embrapa Oriental Amazon and the Government of Pará State, the XVII Brazilian Congress on Fruitculture (Congresso Brasileiro de Fruticultura - CBF) will take placein the city of Belém, capital of Pará, Brazil, from August 26 to 30, 2002. This will be the first Congress of SBF carried out in the Amazon region since the foundation of that scientific society on October 19, 1970. The CBFs have been the most important technical and scientific events on fruit crops in Brazil for the past 30 years, usually gathering about a thousand participants from all over the country and from other countries, too.

The Executive Committee of the event is led by Dr. Dilson Augusto Capucho Frazão (dilson@cpatu.embrapa.br), researcher at Embrapa Oriental Amazon, Belém, PA. March 30, 2002, was the final date for receiving papers to be presented. Information on the event may be obtained by e-mail at xviicbf@cpatu.embrapa.br. For information on the Brazilian Society of Fruitculture (Sociedade Brasileira de Fruticultura – SBF) and the Brazilian Fruitculture Jornal (Revista Brasileira de Fruticultura), edited by SBF, send e-mail to sbfruti@asbyte.com.br and access the site www.asbyte.com.br/sbfruti.◆

News from India

Commercial Cultivation of 'Mauritius' Pineapple in Kerala State

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Commercial cultivation of pineapple var. "Kew" was prevalent in Kerala during the sixties and seventies, and it gradually vanished with the decline of canning factories. During the eighties, the enthusiastic farmers of a village "Vazhakulam" in the Ernakulam district started cultivating the pineapple variety Mauritius for fresh fruit use as a dessert. Gradually its cultivation spread throughout the district, all over the state and even to adjoining states like Karnataka and Tamil Nadu. Recently serious occurrence of different pest and diseases are posing problems. However, at present pineapple cultivation and related activities are the means of life for thousands of people in Kerala, and it has played a significant role in the socio-economical development in the Vazhakulam village over the past two decades.

The package of practices and recommendations available in Kerala Agricultural University was standardized based on the studies conducted during the '70s on Kew. Of late, 'Mauritius' is grown commercially by the farmers of Kerala due to its shorter crop cycle, early harvest (10-12 months after planting), better fruit quality, better transportability and storability and better market price, whereas Kew is grown only for industrial and processing purpose. As 'Mauritius' is entirely different from the Kew, it is necessary to have a separate package of practices of recommendations for this variety. Based on the results obtained from farmer-participatory research conducted by the Pineapple Research Station, Vazhakulam, several recommendations have been developed for 'Mauritius' and this article gives a brief outline of them..

Commercial varieties: Maurtius plants are spiny and its fruits are conical in shape with deep eyes. 'Kew' takes 15 to 20 months from planting to first harvest, fruits are oblong is shape and have shallow eyes, and the leaves lack spines.
Season: Though pineapple is cultivated throughout the year, the main season of planting is April-May and August- September. Planting is done in all months except in heavy monsoon season. If planted in summer months, irrigation is given three weeks after planting for proper establishment.
Land preparation: Pineapple is cultivated in garden and in wet lands in Kerala. In garden lands or uplands, it is grown in the open as a mono crop, or as an inter-crop in coconut and newly planted rubber. In wet lands or paddy fields, alternate bunds and channels are formed and it is planted on bunds.
Garden land — Pure crop: The land is prepared by weeding, and digging at 90 cm width in rows or strips, leaving the interspaces undisturbed. Suckers are planted in paired rows and may be planted in triangular fashion in the paired rows. Interspace between the paired rows is kept at 150 cms. Contour planting is recommended in sloping areas.
Inercropping in coconut plantations: Land preparation, spacing and planting are the same as described above. In a coconut

plantation of 8 x 8 m spacing, three paired rows of pineapple can be planted in between two rows of coconut.

Intercropping in newly planted rubber plantations: The system of planting is in paired rows. Only one paired row of pineapple can be planted in between two rows of rubber.

Wet lands/low lands: Pineapple is highly sensitive to water stagnation and high moisture regimes. Hence it is important to provide good drainage, if grown in wet lands. In paddy lands, pineapple is planted in paired rows on bunds 60 to 90 cm in height, depending on the water table and drainage requirement. The width of the ridges vary from 120-150 cm.. Wherever water stagnation and poor drainage are expected, a wider and deeper channel is given between the bunds or ridges.

Selection of suckers and planting: Suckers are the commercial planting material. Crowns and slips are not used for the Mauritius variety. Suckers are selected from high yielding, disease-free plots. Before planting, suckers are graded into small (500 to 750 g) and large (750 to 1000 g). The graded suckers are planted in different blocks or plots, to assure uniformity in growth and flowering. Bigger suckers attain physiological maturity earlier and give early yield.

After preliminary land preparations, a basal dose of farm-yard manure and rock phosphate are applied. Then suckers are planted at a spacing of 45 cm between rows and 30 cm between suckers in small pits 10-15 cm deep.

Manuring: The annual recommendation for pineapple is 25 tons ha-1 of farm-yard manure and chemical fertilizers (NPK) in ratio of 8:4:8 g per plant. The basal dose of manure and 4 g P2O5 per plant of phosphatic fertilizer are applied. Nitrogenous and potassium fertilizers are applied as top dressings in four equal splits of 2 g N and 2g K2O each per plant. The first dose may be applied 40-50 days after planting and thereafter at 60-70 days interval.

Irrigation: Supplementary irrigation is given, if irrigation facilities are available, in summer months at two to three week intervals, to get bigger fruits and high yield. If it is not possible to provide irrigation, the planting and flower induction are scheduled so fruits are harvested before the peak summer season.

Weed control: A pre-emergence (with in a few weeks after planting) spray of Diuron at 1 kg ha-1 in 600 L of water can keep the field free of all kinds of weeds for about four months. Subsequent weed growth can be controlled by application of Glyphosate @ 0.8 kg./ha. or a mixture of 2,4-D +Paraquat (0.5 kg. and 0.4 kg ha-1, respectively).

For controlling Mikania micrantha (Vayara valli or American valli) growing over the pineapple plants, spot application of 2,4-D at 2 g L-1 of water or glyphosate 5 mL L-1 of water may be given. Care should be taken to avoid over doses and over wetting of pineapple plants.

Flower induction: In order to induce uniform flowering, an 50 mL of an aqueous solution containing 25 ppm ethephon, 2% urea and 0.04% calcium carbonate is poured into the heart of the each plant. Hormone application is done when the plants attain physiological maturity, about 7-8 months after planting and have 39-42 leaves.

Flowering starts by 30 days and completes with in 40 days of growth regulator application. Fruits will be ready for harvest by 130-135 days after growth regulator application and harvest over different months/seasons can be obtained by adjusting the time of planting and the growth regulator application.

Plant protection: The developing fruits are protected from scorching sun in summer season by putting dried coconut or arecanut fronds or grasses over the fruits.

Among diseases, root rot, heart rot and fruit rot caused by Phytophthora parasitica and leaf spot disease caused by Phytophthora are common. Spraying and soil drenching of 1 % Bordeaux mixture, after field sanitation is recommended for the control of these fungal diseases. Leaf spot can be controlled by spraying of 1% Bordeaux mixture, or 0.2% Zineb or Mancozeb or Ziram.

Mealy bugs and scales are the major pests of pineapple and they become common in summer months. Spraying Quinalphos 0.025% or Fenthion 0.05% or Phenitrothion 0.05% on leaves and bottom portion of plants is recommended to control the pests.

Selection of healthy suckers and their scientific curing and treatment before for planting , field sanitation, including weed control and control of ants, are the precautionary measures recommended to control the pest and diseases.

Effect of Ethylene Inhibitors on Pineapple Shoot Multiplication

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Silver nitrate ($AgNO_3$), cobalt chloride ($CoCl_2$), o-acetyl salicylic acid (o-ASA) and o-coumaric acid (o-CA) are known to be potential inhibitors of ethylene action (PIEA) in plants (Pua and Chi, 1993). It has been observed that addition of these compounds to the basal medium enhances the shoot regeneration capacity of many plant species such as pearl millet (Pius *et al*., 1993), *Brassica* (Eapen and George, 1997), cucumber (Mhatre *et al*., 1998), and cowpea (Brar *et al*., 1999). The results of studies on the effect of these compounds on the rate of shoot multiplication in pineapple are presented in this report.

In vitro shoots obtained from cultures grown from dormant axillary buds of fruit crowns of pineapple were used for this study. Two experiments were conducted. In one, the PIEAs were added to hormone-free MS (Murashige and Skoog, 1962) medium + 2% sucrose and in the other, PIEAs were added to the standard shoot multiplication medium (SMM, comprised of MS basalmedium + 2% sucrose + 0.54 µM NAA + 9.84 µM IBA + 9.29 µM Kinetin). Each PIEA was tested at two concentrations ($AgNO_3$ at 29.41 and 58.82 µM; $CoCl_2$ at 18.25 and 36.50 µM; o-ASA at 36.23 and 72.46 µM) and o-CA at 30.49 and 60.98 µM). The *in vitro* shoots were cultured (one per flask) in 250 ml conical flasks with the added PIEA in 40 to 50 ml of liquid medium. The cultures were kept on a gyratory shaker at 100 rpm for the induction of multiple shoots. Multiple shoots were produced in all the media tested and the number of shoots produced on these media were documented (Table 1, 2). The shoots obtained from all the treatments were subcultured onto W (White, 1954) basal medium supplemented with 1% sucrose, 0.54 µM NAA and 1.97 µM IBA for root induction. Rooted shoots were hardened in cups containing Soilrite (Soilrite mix, TC; mixture of 75% Irish peatmoss and 25% expanded Perlite, M/s Chougule Industries Ltd., Mumbai) for 4 weeks and then transferred to the field.

When the PIEAs were added to hormone-free MS medium, shoot production was grerater than the control (Table 1). An interesting aspect of the study was that when the PIEAs were added to SMM, the number of shoots formed was less than in the control (Table 2). This could be because SMM already contained a high concentration of growth regulators and the addition of PIEAs did not complement any further action of the growth regulators already present in the medium.

Table 1. Effect of ethylene inhibitors on shoot multiplication of pineapple.

Treatment	Concentration (µM)	Shoots‡
Control†		3.83
Silver nitrate	29.41	5.83
	58.82	8.33
Cobalt chloride	18.25	4.33
	36.50	5.83
o-acetyl salicylic acid	36.23	5.67
	72.46	9.83
ortho-coumaric acid	30.49	4.83
	60.98	7.50

†Hormone-free MS basal medium.
‡Means of 24 replicates after 12 weeks in culture.

Table 2. Effect of SMM + ethylene inhibitors on shoot multiplication of pineapple.

Treatment	Concentration (µM)	Shoots‡
Control†		64.58
Silver nitrate	29.41	29.17
	58.82	34.33
Cobalt chloride	18.25	17.17
	36.50	26.83
o-acetyl salicylic acid	36.23	20.50
	72.46	26.83
ortho-coumaric acid	30.49	22.67
	60.98	26.67

†MS basal medium supplemented with9.67 µM NAA, 9.84 µMIBA and 9.29 µM kinetin.
‡Means of 24 replicates after 12 weeks in culture.

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High Efficiency Regeneration of Multiple Shoots and Plantlets in Dormant Axillary Buds of Pineapple

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Pineapple (*Ananas comosus* L., Merr.) is an important fruit crop of the world. However, it is susceptible to several diseases (Devi et al., 1997) and there is a growing need for planting material that is not met by conventional cultivation practices. Micropropagation of pineapple has been attempted to meet this requirement (Devi et al., 1997; Escalona et al., 1999). Extensive expansion of micropropagation requires an improved regeneration and acclimatization protocol (Kitto, 1997).

Dormant axillary buds (one at the base of each leaf of the crown) excised from crowns of pineapple (*Ananas comosus* L., Merr., cv. Queen) were used for *in vitro* studies. The axillary buds were surface sterilized by immersing them in 0.1% $HgCl_2$ (mercuric chloride) for 2 min. The buds were then rinsed three to four times in sterile tap water. The buds were cultured onto germination medium comprised of growth regulator free N (Nitsch, 1951) salts and vitamins. After 8 to 10 days the sprouted buds were cultured on several media compositions of MS (Murashige and Skoog, 1962 medium) supplemented with (MSi) 9.67 µM naphthalene acetic acid (NAA), 9.84 µM indole-3-butyric acid (IBA) and 9.29 µM kinetin (Kin); (MSii) 53.37 µM NAA, 15% coconut milk and 0.04% (w/v) casein hydrolysate; (MSiii) 0.90 µM 2,4-dichlorophenoxyacetic acid (2,4-D) and 0.98 µM 6-(g-g-dimethylallylamino) purine (2iP); and (MSiv) SH (Schenk and Hildebrandt, 1972) medium supplemented with 0.90 µM 2,4-D and 23.23 µM Kin, for induction of multiple shoots.

Multiple shoots were proudced in all four media. The maximum number of shoots per explant was obtained on Pin1 medium. Young shoots isolated from tufts of multiple shoots were transferred to liquid medium (maintained on a gyratory shaker at 90-100 rpm) of the same respective combination for further proliferation. Each young shoot isolated from the tuft of multiple shoots upon transfer to liquid medium of the same respective composition proliferated rapidly. Liquid medium as described in " i " was more conducive to the formation of multiple shoots and gave rise to the highest number of shoots. Medium " i " not only produced maximum number of multiple shoots but the length of the shoots was longer than observed on the other media. Multiple shoots appeared as tiny crowns (1-2 mm) amongst elongated longer shoots. These tiny crowns, when transferred to fresh medium continued to produce secondary crowns. Therefore, a cyclic production of shoots was possible, leading to continuous cultures and production of large number of shoots.

In vitro shoots were isolated and cultured on filter paper supports in media (liquid media) such as W (White, 1951) medium and full and half strength MS medium supplemented with 0.54 mM NAA and 1.97 mM IBA, for the induction of roots. The above media were supplemented with 1 or 2% sucrose. Almost 95-100% of the cultures showed root initiation within 8-10 days. Acclimatization of regenerated plants was carried out in the greenhouse (30-35 ^{0}C, 70-80 % humidity) in cups with Soilrite (Soilrite mix, TC; mixture of 75% Irish peatmoss and 25% expanded Perlite, M/s Chougule Industries Ltd., Mumbai). After four weeks of hardening in cups, the plants were transferred to the field.

The present study addresses the requirement for rapid *in vitro* multiplication of pineapple via dormant axillary buds. Liquid media were found to be more conducive to shoot proliferation than solidified media. A cyclic production of shoots was possible leading to high frequency plant recovery without loss of regenerative capacity. Thus, from a single bud ~ 200 shoots could be obtained in 12-15 weeks. Each of these shoots could again be subcultured to produce more multiple shoots. From this it can be speculated that from a single crown it is possible to obtain around 10,000 plants in six months. The plants have flowered and set fruits in 16-18 months. Three plants have been identified to fruit earlier than the rest (14 months). Dormant axillary buds excised from the crowns of these early fruiting selections have been cultured separately as ***EF*** (early flowering) lines. The weight of the

harvested fruit of tissue culture derived plants has been found to be in the normal range (~0.8 – 1Kg) and so is the texture and taste.

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Studies on Synthetic Seeds of Pineapple

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The encapsulation technique is an important application of micropropagation that improves delivery of *in vitro*-derived plants to the field or to the greenhouse (Piccioni and Standardi 1995). Most of the studies on encapsulation have been carried out using somatic embryos as the encapsulated propagule (Castillo *et al.* 1998; Ara *et al.* 1999). Few studies have used meristematic shoot tips or axillary buds for the production of synthetic seeds as reported in banana (Ganapathi *et al.* 1992), mulberry (Bapat *et al.* 1987) and apple, kiwifruit, blackberry (Piccioni and Standardi 1995). In the present study, tiny (2-5 mm) in vitro shoots of pineapple were used as propagules for the preparation of synthetic seeds.

Single tiny (2-5 mm) shoots isolated from shoot cultures of pineapple, growing on Pin 2 = MS (Murashige and Skoog, 1962) basal medium containing 2% sucrose + 9.67 mM NAA (naphthalene acetic acid) + 9.84 mM IBA (indole butyric acid) + 9.29 mM kinetin were used for the preparation of synthetic seeds. Each single shoot was blot dried on a filter paper, mixed in a gel of either 3% or 4% sodium alginate (Sigma Chemical Company, St. Louis, MD) prepared in hormone-free MS basal medium supplemented with 2% sucrose (Pin1), Pin2, W (White's 1954) basal medium supplemented with 1% sucrose, 0.54 M NAA and 1.97 M IBA (Pin3), tap water or distilled water and then picked up by a pair of forceps and gently dropped into $CaCl_2.2H_2O$ (1.36 g per 150 ml) solution in which they were allowed to stand for 30 minutes for complexing. At the end of 30 minutes, the $CaCl_2.2H_2O$ solution was carefully decanted off and the encapsulated shoots were washed 3 to 4 times with sterile tap water, blot dried on sterilized filter paper and cultured on either Pin1, Pin2, Pin3 media or moistened soil or Soilrite (Soilrite mix, Tissue Culture; mixture of 75% Irish peatmoss and 25% expanded Perlite, Messrs Chougule Industries Ltd., Mumbai, India), to study their germination.

Sodium alginate (3%) prepared in Pin1 medium produced seeds with a coat firm enough for handling and also allowed the seeds to germinate. Use of 4% sodium alginate produced hard coated seeds which slowed germination. Shoots encapsulated in sodium alginate prepared in either tap or distilled water did not show shoot emergence and were dehydrated after 5-6 days of culture. Each synthetic seed prepared using a single tiny shoot converted to a shoot but did not produce roots. These shoots needed to be subcultured onto liquid Pin3 medium for the induction of roots. Hence, pretreatment of shoots prior to encapsulation was carried out to induce simultaneous root and shoot development in the synthetic seeds.

Tiny isolated shoots were pretreated by soaking them in liquid Pin3 medium and agitated on a gyratory shaker at 100 rpm for either 6, 12, 24, 36 or 48 hr followed by encapsulation in 3% sodium alginate prepared using Pin1 medium. Synthetic seeds produced using shoots pretreated in Pin3 medium developed into plantlets. Initially only the shoot emerged from the synthetic seed on Pin1, Pin2 and Pin3 medium and after 10-12 days a few roots were observed to protrude from the gel matrix. Since germination of the synthetic seeds to plantlets appeared to depend on the hormonal concentration of the pretreatment medium, the concentration of NAA and IBA in W basal medium was increased to 10.8 M and 39.4 M, respectively (Pin4 medium).

Synthetic seeds produced using shoots pretreated by soaking in Pin4 medium, showed shoot emergence on Pin1, Pin2 and Pin3 medium and within 5 to 6 days of shoot emergence, roots were also observed to protrude from the gel matrix. One hundred percent conversion of synthetic seeds to plantlets was obtained when the shoots were pretreated for 12 hr in Pin4 medium and subcultured on Pin2 medium.

Synthetic seeds prepared using pretreated shoots could be stored at 4^0C for 15 to 30 days and their germination was between 45 to 75 %. After 45 days storage at 4^0C the rate of germination was affected drastically (~ 20 %). However, after storage of 90 days the synthetic seeds lost their viability. Post germination, the plantlets could be recovered and planted in paper cups. Our studies emphasize the possibility of using tiny shoots as a substitute for somatic embryos for the preparation of synthetic seeds in pineapple. Synthetic seeds prepared using untreated shoots could be rooted upon transfer to rooting medium for the regeneration of complete plants. The pretreatment of the shoots induced simultaneous rooting thereby eliminating the need of transfer to a root inducing medium thus making the synthetic seeds of pineapple analogous to a true seed.

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Influence of Physical and Chemical Mutagens on Pineapple Shoot Cultures

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Pineapple is a vegetatively propagated fruit crop. It is highly heterozygous, and its genetics is not well understood. It is one of the few crops in which most cultivars are derived from spontaneous mutations and natural evolution without controlled breeding (Osei-Kofi *et al*., 1997). Mutation breeding is a suitable technique to improve vegetatively propagated crops like pineapple.Our findings on the influence of gamma rays and ethyl methane sulphonate on shoot cultures of pineapple are documented.

Shoot cultures were raised from dormant axillary buds on MS (Murashige and Skoog, 1962) basal medium supplemented with 2% sucrose, 9.67 mM 1-naphthalene acetic acid (NAA), 9.84 mM indole-3-butyric acid (IBA) and 9.29 mM kinetin (Kin) for the induction of multiple shoots. In the first set of experiments, six week old shoot cultures were irradiated with gamma rays at 5, 10, 20, 30, 50, 70 and 100 Gy. The source of radiation was ^{60}Co, Gamma Cell-220 unit. After irradiation the shoots were cultured (one per flask) in 250 ml conical flasks in 40-50 ml of liquid MS basal medium supplemented with 2% sucrose, 9.67 mM NAA, 9.84 mM IBA and 9.29 mM Kin.

In the other set of experiments, the *in vitro* shoots were treated with 0.1, 0.5 and 1.0 % ethyl methane sulphonate (EMS). For exposing to EMS, the shoots (one per flask) were cultured in 250 ml conical flasks in 40-50 ml of liquid MS basal medium supplemented with 2% sucrose, 9.67 mM NAA, 9.84 mM IBA, 9.29 mM Kin and EMS (0.1 or 0.5 or 1 %) and allowed to remain for 1, 2, 4, 6, 8, 10, 12, 24, 36 and 48 hr. After exposure, the medium containing EMS was decanted, the plants were rinsed with autoclaved tap water and EMS-free fresh medium of the same composition was added to the flasks. The cultures were then allowed to grow.

The shoots obtained from both the treatments were subcultured onto W (White, 1954) basal medium supplemented with 1% sucrose, 0.54 mM NAA and 1.97 mM IBA for root induction. Rooted shoots were hardened in cups containing Soilrite (Soilrite mix, TC; mixture of 75% Irish peatmoss and 25% expanded Perlite, M/s Chougle Industries Ltd., Mumbai) for 4 weeks and then transferred to the field.

Enhancement in the number of multiple shoots was observed at 5, 10 and 20 Gy doses, but as the dose rate increased the number of multiple shoots formed decreased (Table 1). Doses of 70 and 100 Gy proved lethal since the explants necrosed 15-20 days after exposure to the higher doses. The irradiated shoots were subcultured onto W basal medium supplemented with 1% sucrose, 0.54 mM NAA and 1.97 mM IBA for the induction of rooting. Complete plantlets were hardened and transferred to the field. In the field, they showed slow vegetative growth but flowered and fruited within the same time frame, 10 to 11 months, as the control plants. The effect of radiation on shoot multiplication ratios revealed that the rate of multiplication was enhanced at lower doses (5-20 Gy), was low at 30 Gy and at 50 Gy it was lowest. Osei-Kofi et al. (1997) observed that a dose of 80 Gy was lethal to shoot tip explants in 'Smooth Cayenne' and 'Sugar Loaf' varieties of pineapple. In our studies, cultures exposed to 5 – 70 Gy did not exhibit morphological changes even at plantlet stage. However a dose of above 70 Gy was found to be lethal. Treatment of shoots with 0.1 % EMS for 1-6 hr resulted in an increase in the number of multiple shoots formed while treatment beyond 6 hr resulted in a decrease in the number of shoots formed (Table 2). After 8 and 10 hr treatment, moderate numbers of multiple shoots were formed. After 12-48 hr treatment, the explants showed a low response. Treatment of shoots with 0.5% EMS again showed a correlation between the number of multiple shoots formed and the hours of exposure to EMS (Table 2). After 1 hr treatment, the number of multiple shoots formed were comparable to the control. After 2 hr treatment, the number of multiple shoots formed were slightly lower. After 4-12 hr treatment, shoot formation decreased drastically (Table 2). Shoots treated with EMS for 24-48 hr did not show any shoot multiplication and the explants necrosed after 15-20 days of exposure.

Shoots treated with 1% EMS exhibited a decrease in the number of multiple shoots formed as the treatment period increased (Table 2). The number of shoots formed after 1 hr of exposure were less than control. The number of shoots further decreased after 2-12 hr exposure. Shoots treated for 24-48 hr did not show any shoot multiplication and necrosed after 8-10 days of exposure. The EMS treated shoots were subcultured onto W basal medium supplemented with 1% sucrose, 0.54 M NAA and 1.97 M IBA for the induction of roots. Plantlets were hardened and transferred to the field. In the field, they showed normal flowering and fruiting.

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Table 1: Effect of gamma rays on in vitro shoots of pineapple.

Dose (Gy)	Shoot number
Control	64.58
5	65.33
10	67.50
20	71.83
30	57.33
50	29.50
70	0
100	0

Data scored after 10 weeks of culture. There were 24 replicates per treatment.

Table 2: Effect of ethyl methane sulphonate (EMS) exposure time and concentration on number of in vitro shoots of pineapple.

Exposure time (h)	0.1%	0.5%	1%
Control	64.58	64.58	64.58
1	76.50	62.83	57.17
2	72.83	55.17	50.33
4	67.50	48.17	46.50
6	64.67	38.83	37.50
8	62.00	34.17	27.17
10	57.83	27.50	19.67
12	53.17	17.67	14.00
24	49.33	0	0
36	44.83	0	0
48	38.22	0	0

Data scored after 10 weeks of culture. There were 24 replicates per treatment.

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News from South Africa

New Book In Print

Graham Petty, Institute for Tropical & Subtropical Crops, Bathurst, South Africa

The book P*ests and Beneficial Arthorpods of Tropical and Non-citrus Subtropical Crops in South Africa*, which was described in some detail in Pineapple News No. 8, has been published. A major
section of the book is devoted to pineapple, and although the pests covered are those in South Africa, these species occur in most other pineapple growing countries of the world. It is therefore applicable to these other countries. The book includes 400 color and 20 monochrome figures, and contains 525 pages. The book can be purchased from Director ITSC, Private Bag x 11208, Nelspruit, 1200 South Africa (E-mail: iris@itsc.agric.za). The cost is R350.00 plus a R70.00 banking cost and an estimated R170.00 for shipping.

The book '*Tropical Fruit Pests and Pollinators ' Biology, Economic Importance, Natural Enemies and Control* is scheduled for publication by CAB International in September 2002. The book, which was written by leading authors from around the world and is edited by Jorge E. Peña, University of Florida, reviews the injurious and beneficial organisms and how they might be controlled to enhance fruit production and quality. The book has one chapter devoted to pineapple pests and another with significant content on pineapple in it. The price is estimated to be approximately $120.00.

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News From Sri Lanka

Ed Note: The following was submitted in August of 2000 and overlooked in collating material for the 2001 issue of Pineapple News. Sincere apologies are extended to the author and Prof. Senanayake who submitted the material for inclusion in Pineapple News.

Pre and Postharvest Treatments for Reducing the Incidence of Chilling Injury in Pineapple

S. Selvarajah. Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka

Mauritius is the main variety of pineapple presently grown in Sri Lanka for the local market as well as for export. Internal browning (IB) disorder in pineapple is a common problem encountered by exporters as a result of cold storage during sea shipment. This study was carried out to minimize or prevent the IB disorder and extend the storage life of pineapples *(Ananas comosus* cv Mauritius).

Field experiments followed by cold storage investigations of fruits were carried out to study this phenomenon. Three field experiments were carried out in different locations and treatments consisted of three levels of urea, potassium, calcium, fused magnesium phosphate and the flowering hormones ethephon and naphthaleneacetic acid (Planofix) in a randomized complete block design. Fruits from all experimental locations were stored in a cold room (15C and 80-85% RH) immediately after harvesting for four weeks. Biochemical parameters of fruits were determined immediately after harvest and at weekly intervals followed by three day s exposure at room temperature.

In the first experiment, mucilaginous press-sap of *Neolitsea cassia* (L) Kostermans ('Dawul Kurundu') leaves was applied as a surface coating on fruits and treated and untreated fruits were stored in a cold room. In another experiment, fruits were sealed in polypropylene, polyethylene bags and stored at 8, 10, 20°C and room temperatures. Effects of temperatures of 8, 10, 20°C and room on IB and pre-heat treatment were also examined in the post-harvest experiments. In the pre-heat experiment, weighed fruits were stored in an incubator at temperatures of 32, 34, 38, 42, 46, and 50°C for 24 hours and then transferred to a cold room at 15°C for further storage for three weeks. A set of weighed fruits were dipped in hot water at 55°C for 10 minutes and stored in the cold room at 15°C for three weeks.

For the above experiments, evaluations of quality changes of the fruit and some physical (weight, texture, colour), physico-chemical (pH, titratable acidity, soluble solids), chemical (ascorbic acid), and biochemical (polyphenoloxidase activity (PPO), peroxidase (POD) activity, phenylalanine ammonia-lyase activity, free sugars) characteristics and sensory attributes (colour, firmness) of pineapple fruits were studied at weekly intervals. Prior to measurements, the fruits were removed from cold storage and kept for three days at ambient temperature.

Percentage weight loss, ascorbic acid content and IB of coated fruit were significantly different from control fruit after cold storage. The incidence of IB symptoms was less when a heat pre-treatment was combined with edible coating. Fruits packed in sealed polypropylene bags and stored at 8 and 10C had significantly less weight loss and intensity of IB development and higher ascorbic acid content than did the control. However, as storage period was extended to the third week, IB intensity increased and the fruits had an unacceptable odour, taste and flavour.

Fruits stored at 8 and 10°C had the best taste and quality ratings, but after 14 days of storage, IB was observed and intensity increased with storage time. Storage for four weeks at 15°C resulted in a lower development of the disorder than was observed at 8 and 10°C. At 20°C, moderate levels of decay developed after two weeks and with time there were changes in the shell, flesh colour, a slight fermentation odour developed, and taste changed.. After seven days of storage at room temperature, ripening was accelerated, there was increased colour development of the shell and the flesh became.

The pre-heat treatment decreased the activities of PPO, POD, ascorbic acid and spoilage rate. The hot water treatment reduced the development of IB during the later stages of storage compared to other treatments. Fruits in the control showed more intensity of IB than treated fruits.

Fruit with IB had low ascorbic acid content and total soluble solids and higher titratable acidity than unaffected fruit. The role of pH on IB was not clear. The relationship between the intensity of IB (X) with ascorbic acid content (Y_1) and total soluble solids (Y_2) could be expressed as: $\log Y_1 = 0.7842 - 0.0052X$; $Y_2 = 12.6401 - 0.445X$.

The interactive effect of nitrogen and flowering hormones on internal browning was not statistically significant. However, double the recommended level of urea increases the size of fruits and the intensity of IB. Fused magnesium phosphate also significantly decreased IB intensity. Fruits harvested from plants treated with 75 kg ha^{-1} calcium (CaO) and stored for 1, 2, 3, and 4 weeks at 15°C followed by three days at room temperature had significantly lower IB than the controls. With 150 kg ha^{-1} calcium, there was no IB up to the fourth week of storage at 15°C.◆

News From Taiwan

Workshop on Pineapple Variety Improvement, Disease and Pest Management

Chin-Ho Lin,

A full-day pineapple workshop, in honor of Mr. Chin-Chyn Chang at his retirement, was held on December 6, 2001, at Chia-Yi Agricultural Experiment Station, Taiwan. Mr. Chin-Chyn Chang, a quiet, shy and dedicated pineapple breeder, spent his entire professional career working for a single employer, Taiwan Agricultural Research Institute. He made outstanding contributions to the Taiwan pineapple industry by successfully breeding five pineapple varieties for fresh fruit marketing, i.e., Tainung 13,16,17,18 and 19. These five varieties are currently the main cultivars for fresh fruit market in Taiwan.

The workshop was co-sponsored by the Chinese Horticultural Society, Council of Agriculture, and Taiwan Agriculture Research Institute. The proceedings of the workshop, which is in Chinese, has been published. Mr. Chin Chyn Chang officially retired on January 16 ,2002. Papers presented at the workshop include:

1. Pineapple variety improvement, a review and prospective.
2. The impact of joining WTO on the pineapple industry and measures of response.
3. Pineapple production and marketing, its improvement and development.
4. Pineapple insect damage and control.
5. Nematode control in pineapple.
6. A review on the pineapple disease control in Taiwan and current control measures.
7. Differential competence of Taiwan pineapple industry -A study on the production region, variety , production season and fruit quality.
8. Factors correlated to the occurrence of pineapple flesh translucency
9. A shortcut to the pineapple marketing.◆

News From the United States (Hawaii)

Pineapple Codon Usage Table

L. Neuteboom and D.A. Christopher, University of Hawaii, Department of Molecular Biosciences and Bioengineering, 1955 East-West Rd. Rm. 218, Honolulu, HI 96822.

New codon usage frequency for genes from pineapple (*Ananas comosus*) derived from the DNA sequence analysis of over 28 cDNAs. AA = amino acid, N = number of codons counted, /1000 = number of codons occurring per 1000 codons, F= fraction. Codon usage preferences will assist in optimizing transgene expression in pinepple.

Codon table

AA	Codon	N	/1000	F
Gly	GGG	892	15.69	0.20
Gly	GGA	95	16.75	0.21
Gly	GGT	105	18.51	0.24
Gly	GGC	156	27.50	0.35
Glu	GAG	179	31.55	0.59
Glu	GAA	126	22.21	0.41
Asp	GAT	139	24.50	0.45
Asp	GAC	168	29.61	0.55
Val	GTG	167	29.44	0.40

Codon table (continued)

AA	Codon	N	/1000	F
Val	GTA	60	10.58	0.14
Val	GTT	89	15.69	0.21
Val	GTC	105	18.51	0.25
Ala	GCG	104	18.33	0.22
Ala	GCA	85	14.98	0.18
Ala	GCT	123	21.68	0.26
Ala	GCC	153	26.97	0.33
Arg	AGG	48	8.46	0.19
Arg	AGA	45	7.93	0.17
Ser	AGT	62	10.93	0.13
Ser	AGC	90	15.86	0.19
Lys	AAG	224	39.49	0.70
Lys	AAA	94	16.57	0.30
Asn	AAT	112	19.74	0.36
Asn	AAC	197	34.73	0.64
Met	ATG	143	25.21	1.00
Ile	ATA	71	12.52	0.22
Ile	ATT	75	13.22	0.23
Ile	ATC	177	31.20	0.55
Thr	ACG	51	8.99	0.18
Thr	ACA	49	8.64	0.17
Thr	ACT	74	13.04	0.26
Thr	ACC	109	19.21	0.39
Trp	TGG	100	17.63	1.00
End	TGA	6	1.06	0.29
Cys	TGT	41	7.23	0.43
Cys	TGC	55	9.70	0.57
End	TAG	10	1.76	0.48
End	TAA	5	0.88	0.24
Tyr	TAT	71	12.52	0.32
Tyr	TAC	152	26.79	0.68
Leu	TTG	47	8.28	0.13
Leu	TTA	29	5.11	0.08
Phe	TTT	103	18.16	0.44
Phe	TTC	133	23.44	0.56
Ser	TCG	96	16.92	0.20
Ser	TCA	61	10.75	0.13
Ser	TCT	82	14.45	0.17
Ser	TCC	85	14.98	0.18
Arg	CGG	41	7.23	0.16
Arg	CGA	27	4.76	0.10
Arg	CGT	32	5.64	0.12
Arg	CGC	66	11.63	0.25
Gln	CAG	111	19.57	0.54
Gln	CAA	94	16.57	0.46
His	CAT	36	6.35	0.43
His	CAC	48	8.46	0.57
Leu	CTG	65	11.46	0.18
Leu	CTA	30	5.29	0.08
Leu	CTT	38	6.70	0.10
Leu	CTC	154	27.15	0.42
Pro	CCG	78	13.75	0.27
Pro	CCA	59	10.40	0.20
Pro	CCT	70	12.34	0.24
Pro	CCC	84	14.81	0.29

Development Of Anagyrus ananatis Gahan (Hymenoptera: Encyrtidae) at Constant Temperatures

Raju R. Pandey* and Marshall W. Johnson, Dept. of Plant and Environmental Protection Sciences

Pink pineapple mealybug, PPM, *Dysmicoccus brevipes* (Homoptera: Pseudococcidae) is one of the most widely distributed mealybugs around the world. In association with pineapple mealybug wilt associated closterovirus, PPM can lead to the expression of mealybug wilt disease. *Anagyrus ananatis* Gahan (Hymenoptera: Encyrtidae), a solitary endoparasitoid, is the most commonly distributed biological control agent of PPM in Hawaiian pineapple fields. Two experiments were conducted to determine the effects of constant temperature on the development of *A. ananatis*. In the first experiment, parasitized PPMs were incubated at five different constant temperatures (T), viz.14.6ºC, 19ºC,

23.8ºC, 28.9ºC and 31ºC. Time (D) taken to complete the life cycle (from oviposition to adult emergence) was noted. A new variable, DT, was calculated and analyzed by regression analysis of DT with T. The lower temperature threshold ($T_{o)}$ was determined to be 12.68ºC with a total heat requirement of 271Degree days (DD) above T_o for *A. ananatis* to complete its life cycle. A typical pineapple plantation accumulated 4311 DD of heat above 12.68ºC annually, where *A. ananatis* could complete about 16 generations per year. In the second experiment, parasitized PPMs were incubated at 23.5ºC and 20 mealybugs dissected at 24 hours interval to determine the life cycle of *A. ananatis*. Results showed that egg began to eclose after 2 days of oviposition and completed hatching in four days. Larvae were observed from two days after oviposition to until nine days after oviposition, prepupa stage observed from 8 to 12 days, and pupa stage from 10 to 25 days from oviposition. Adult emergence began after 24 days of oviposition and completed in 26 days. These findings are useful in the development of mass rearing techniques for *A. ananatis* for augmentative biological control of *D. brevipes*.

New Book on Pineapple to be Published

For many years, the standard book on pineapple culture has been T*he Pineapple: Cultivation and Uses* by C. Py, J.J. Lacoeuilhe and C. Teisson, which was last published in 1987. Unfortunately, that book is no longer in print and two of its authors have retired. In about 1998, a collaborative effort was begun among a number of researchers working on pineapple to produce a book on pineapple comparable in quality and comprehensiveness to the book by Py *et al*., but also would bring the knowledge base up to date. The manuscripts for the book were completed and are now with CABI Publishing for editing. The projected publication date of *The Pineapple: Botany, Production and Uses* in November 2002. The book can be ordered now at a 10% discount when reference **AZX** is quoted when ordering, resulting in a special-offer price is $126.00. Contact CAB International, Wallingford, Oxon, OX10 8DE, UK for ordering information or by E-mail at orders@cabi.org.

The book is aimed at researchers, professional horticulturists, and growers of pineapple. It is edited by D.P. Bartholomew, R.E. Paull and K.G. Rohrbach. The chapters are written by world authorities on the subject and include:

- History, Distribution and World Production, K G Rohrbach, F Leal, Facultad de Agronomia, Venezuela and G Coppens d'Eeckenbrugge, IPGRI/CIAT, Colombia
- Morphology, Anatomy and Taxonomy, G Coppens d'Eeckenbrugge, IPGRI/CIAT, Colombia and F Leal, Facultad de Agronomia, Venezuela
- Breeding and Variety Improvement, Y K Chan, MARDI, Kuala Lumpur, G Coppens d'Eeckenbrugge, IPGRI/CIAT, Colombia and G M Sanewski, Maroochy Research Station, Australia
- Biotechnology, M K Smith, H-L Ko, S D Hamill, G M Sanewski, Maroochy Research Station, Australia and M W Graham, Queensland Agricultural Biorechnology Centre, Australia
- Crop Environment, and Vegetative Physiology and Growth, E Malézieux, AGER, CIRAD, France, F Côte, CIRAD, France and D P Bartholomew
- Cultural System, T Hepton, Dole Food Company, USA
- Plant Nutrition, E Malézieux, AGER, CIRAD, France and D P Bartholomew
- Inflorescence, and Fruit Development and Yield, D P Bartholomew, E Malézieux, AGER, CIRAD, France, G Sanewski, Maroochy Research Station, Australia and E Sinclair, Golden Circle Ltd, Australia
- Pests, Diseases and Weeds, K G Rohrbach and M Johnson, Plant and Environmental Protection Sciences, USA
- Postharvest Physiology, Handling, and Storage of Pineapple, R E Paull and Ching-Cheng Chen
- Processing, A S Hodgson, Tropical Plant and Soil Sciences, USA and A Hepton, Dole Food Company, USA

Hawaii Researchers Present Results at 4th Symposium

Four Hawaii researchers attended that 4th International Pineapple Symposium at Veracruz, Mexico. The abstracts of the research of John Hu, Brent Sipes, Robert Paull, and Duane Bartholomew and their students are included below and so are not duplicated here.◆

Abstracts From 4th Symposium

Abstracts of Papers Submitted for Presentation at the Fourth International Pineapple Symposium

1. Pineapple Diagnostic

Diagnosis of Pineapple Crop *Ananas comosus* (L.) In Nayarit, Mexico

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Pineapple is grown in a surface area of 1,000 hectares in Nayarit, Mexico. Seven hundred hectares are grown to a landrace pineapple and 300 hectares to the Smooth Cayenne cultivar. The objective of this study was to make a survey to find out the distribution, agronomic management and problems faced by both pineapple types. To get the information, several sites were surveyed. It was found that the landrace pineapple is grown in Ruiz and Santiago Ixcuintla counties. This crop is cultivated under rainfall conditions with an annual precipitation of 1,800 mm and an annual mean temperature of 24-26ºC. The soils are rocky shallow ones on hilly terrain having slopes of 10-25%. The landrace pineapple is cultivated under the shadow of leguminous trees at a very low population density. So, the yield is very low . The main pests are mites, fruit weevils, ants, symphylids and soil worms. The main diseases are fruit heart rot and brown spot rot. There are also problems with broad leaf weeds and drop of price for the fruit because of harvest concentration from April to June. On the other hand, the 'Smooth Cayenne' is grown in Compostela county in almost flat soils with slight slopes of 2-4%. The main problems are the low technology use, the high production costs and the low yield and quality. Even though the crop is grown under irrigation; deficient irrigation and fertilization practices are common. The phytosanitary problems are similar to those found in the landrace pineapple, the only difference is the problem with narrow leaf weeds. If growers would use the available technology, they could increase the yield and quality of this fruit in at least 40%, and also reduce production costs.

Diagnostic and Perspectives of Pineapple Activity in Mexico

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Pineapple is known in México since prehispanic ages; Smooth Cayenne cultivar, was introduced into Hawai at the beginning of the XX century, which is the most widely cultivated around the world. Up to this date Mexico ocuppies the seventh position at world level with 600, 000 ton of fruit per year, harvested in 11 000 ha with an annual oscillation of 3000 ha. Eighty percent of this production is located at the lower basin of the Papaloapan river, in Southern Veracruz and northern Oaxaca; followed by Tabasco, Nayarit and Quintana Roo states. There are at least 3,000 pineapple growers in such regions, representing a greater complexity to program planting and harvesting dates, as well as marketing. The cannery industry, has an installed capacity of 200,000 ton, but is only using 20% of their total capacity because they are not linked to the growers. In spite of our close ubication to the country which is the greater pineapple consumer in the world, México only exports around 5% of its total production eventhough some people foresee significant, whereas the national fresh market consumes 80%, and the complement is for the cannery industry. Traditional market channels depend a lot on national brokers: this situation is however changing toward a more direct relationship between the grower and the big chain supermarkets. Most pineapple surface area depends on rainfall, with planting densities of less than 30,000 plants

ha^{-1}, with a high use of hand labor, looking for fruits heavier than 2.4 kg. By the last five years a significant increase of mechanized surface, with higher planting densities or with irrigation representing about 30, 25 y 20% of the total, respectively. Soil deterioration, pests, diseases, nutrimental unbalances, defficient control of flowering and fruit ripening as well as drought negative effects, are the main problems in commercial plantings, which are aggravated by the defficient fruit postharvest handling. Lack of credit, insurance, technical asistance and defficient organizational estructures, are the main limitting socioeconomical factors. Drastic fluctuations on fruit prices in the domestic market, as well as the aggressive sale strategies at the free world market can be only overcome by an efficient organizational policy that establish an armonic relationship between growers and the industry and market people. The role of government should be to induce and facilitate consolidation of such a relationship. The needed production technology to support these efforts is available.

Edaphic Characterization of Pineapple Growing Regions in Mexico

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Ninety five percent of pineapple growing lands in Mexico are located in Veracruz, Tabasco and Oaxaca states. The objective of this work is to characterize the edaphic status at the low basin of the Papaloapan river region, where 74% of the pineapple total area is cultivated in México. According to the soil classification system of FAO, these soils correspond to distic and umbric Cambisol orders; and also ortic, plintic, and humic Acrisols. These soils have developed from alluvial deposits during Pleistocene under a tropical sub-humid climate, with pluvial and thermic regimes oscillating from ustic to udic isohiperthermic. Its topography is slightly waved with slopes of 2-10%. With the exception of umbric Cambisols that might present up to 40% of clay, the rest is characterized by a sandy loam texture (70% of sand, 20% silt and 40% clay). Besides, they present a strong lack of structure and low water-holding capacity. Some of their chemical characteristics are: low organic matter content (1-2%), without salinity problems (0.06-0.5 dSm m-1); pH of 3.8-5.5 (H2O, 1:2) but with a low exchangeable aluminum content (<1.0 meq/100 g of soil) with a maximum capacity of 0.05-0.176mg/g of P. Nevertheless, these soils are poor (1-60 ppm) regarding their Phosphorus content (Bray 1) and extremely poor of exchangeable bases to the point to present values of CEC not greater than 19.8 meq/100 g of soil. These characteristics cause the necessity of using high amount of fertilizers and soil amendments to maintain a sustainable crop production. The integrated soil management has demonstrated to be the only viable strategy to accomplish this goal.

Comparative Economic Analysis of Different Technologies for Pinneaple Production in Veracruz, Mexico

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Six technologies for pineapple production currently performed in the State of Veracruz, México were analyzed in order to determine their current financial profitability and to compare their advantages based on different parameters. Two of the technologies are used by regional growers: (1) Low Technology; (2) Medium Technology; while the other four were developed by INIFAP: (3) National market, non-mechanized type; (4) National market, mechanized type; (5) Export market, mechanized type; (6) Export market, high technology. Each one of the evaluated technologies had its different technological components. The analytical method used was that of incomes, since it allows to verify the performance of the production units in a particular cycle of production. Furthermore, it is possible to evaluate yield over capital and labor invested, at current prices, including assets depreciation. Two matrices, one for technical coefficients and another one for private prices, were developed. Based on them, a budget was calculated in order to determine the financial profitability. Results showed that, considering production, INIFAP technologies had a higher performance than those of pineapple growers, non-mechanized 27 % vs mechanized 21, 30 and 54%. Considering costs, INIFAP technologies were close to 50 % of the total investment costs, whereas growers technologies ranged from 35 to 45%. Net income per hectare was more attractive using INIFAP technologies. Even though INIFAP technologies profitability vary from 36 to 53 %, those of growers were higher (42 to 61 %). Nevertheless, cash generated by INIFAP technologies to the agriculture sector is higher than those of pineapple growers. A sensitivity analysis showed that INIFAP technologies had more tolerance to price fluctuation and labor scarcity, the two regional leading problems. It is concluded that although all of the analyzed technologies were profitable, those of INIFAP are oriented to different production objectives and markets, increasing product quality when technologies 5 and 6 are used.

Land Suitability for High Pineapple Production *Ananas Comosus* in the State of Veracruz, Mexico

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The state of Veracruz is the main pineapple producer in México. The actual cropped area is about 7,300 has. However, the most suitable regions to produce high pineapple yield with excellent quality and being ecologically sustainable, have not been delimited. Using Geographical Information Systems (GIS) techniques, the optimun regions to produce pineapple were delimited based on the following variables: height above sea level: 0-800 m; 2) Average annual temperature 23-27° C, 3) Average annual rainfall: 700-1000 mm, 4) Potencial soil erosion: none-light; 5) Land use : agriculture- agriculture + grassland.Based on daily weather data, updated to year 2000, and a 90 x 90 m pixel resolution of the Digital Elevation Model in raster format, it was concluded that in the state of Veracruz, about 44,000 ha, have high potential to produce pineapple, with excellent quality and high yields in a sustainable way.

2. Plant Resources and Breeding

Conservation, Enrichment and Characterization of Venezuela's Collection of *Ananas*

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Venezuela has a large diversity of plant genetic resources, including about 16,700 plant species. It is the center of origin and/or diversity of some of them. There are five species within this group belonging to the genus *Ananas*: pineapple, which is a fruit with exquisite taste; "curagua", plant whose leaves are used to extract fiber from which hand crafts are made; "montañero" pineapple; "piñuela" and "ananai", all of these last three species are appreciated from an ornamental point of view. This germplasm is actually endangered by genetic erosion. For this reason the "Centro Nacional de Conservación de Recursos Fitogenéticos" of the "Ministerio del Ambiente", has a collection of *Ananas* whose fundamental objective is to conserve, enrich and characterize them. These plants may be used in future genetic improvement programs for a sustainable use of biodiversity.

The Cirad Pineapple Germplasm Database

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Cirad pineapple genebank was established in Martinique in 1985 and now rise above 600 accessions. Considerable data — origin, botanical description, agronomic behaviour — have been collected. However, data are underused, due to mixed recording materials (hard copies, notebooks, and informatics' spreadsheets).To overcome this drawback, in year 2000, we undertook the development of a user-friendly database under Microsoft Access. In 2001, a trial version was provided to some potential users. Within the database, each accession is documented according to the IPGRI plant descriptors: a) *Passport descriptors*: information related to the origin of the accession, collecting data, parameters recorded prior to the introduction in genebank. b) *Characterization descriptors*: traits generally highly heritable, easily seen by the eye and equally expressed in all environments. Mainly qualitative standardized characters are included here, constituting a botanical description. Each trait leads to a single record in the database. c) *Evaluation descriptors*: these descriptors include quantitative characters on yield and agronomic performance as well as biochemical traits. They are susceptible to environmental differences. Therefore, series of observations carried out in the course of time can not be merged and are recorded separately in order to be statistically exploited. d) *Management descriptors*: descriptors of the accession within the genebank: accession number, location, status, scientific name. In addition, a set of indicators gives information about data reliability and representativeness (particular climatic conditions in a given year, dubious observations of some variables, abnormal data suggesting a misidentification …). These indicators can be used as filters for queries. The database is intended for the use of researchers in charge of the genebank and for genetic resources end-users working in genetics, breeding, development or training. Through the user interface, curators have access to data input and management frames. End users can consult the database through several pre-set forms: rough or extended list of germplasm, accession data sheets illustrated with photographs. Any other kind of queries can be developed with Microsoft Access software.Meanwhile, IPGRI was mandated to develop a global pineapple database. Cirad's strategy focuses on developing standardized data frames to allow information exchange between the databases.

National Pineapple Germplasm Prospection in Cuban Republic

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Cuba is not placed in pineapple original area, but fruits were present before Spanish colonization, presumably from *La Española* or another near Caribbean lands. The collect was organized diving in three parts: west, central and east regions (one by year), during June - July (1999 -2001), in natural fruiting time. The aims were collecting by means of national prospecting the pineapple genotypes in our country and rescue the biggest part of genetic diversity in the specie. A number of 67 accessions were collected, many of them are described for the first time. Accessions collected could be included in three fundamental groups: Red Spanish, Cayenne and Pernambuco. The domain variety is Red Spanish c.v. "Pinareña" and "Camagüeya", but differences in spiny leaves, fruit color and sucker presence are presents. The "Piña Blanca" or Cuban pineapple, a very sweet and soft genotype, but is enclosed to a few farmers, that is why its perpetuity could be in danger. Some types of Smooth Cayenne were collected, "Serrana" well adapted clon and "Cayena de Oriente" with radish leaves. "Cabezona" is only grown in Holguín and Guantánamo local farm. The biggest prospected areas belongs to farmers with very good tradition in pineapple culture and also we included wild areas for same purpose. The accessions placed in the National Pineapple Germplasm Bank, at the University of Ciego de Avila will be conserved for its study and used on present and future genetics breeding works.

Strategies and Progress of Pineapple Breeding in Malaysia

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The Malaysian Agricultural Research and Development Institute (MARDI) is involved in most of the pineapple research in the country. Formed in 1969, it took over the pineapple research from the Malaysian Pineapple Industry Board (MPIB) in 1975. A decade later, the Institute released the first hybrid pineapple 'Nanas Johor' to the canning industry. The methodology of hybridization and clonal selection of the segregating F1 progenies in the development of 'Nanas Johor' was further used to develop the 'Josapine' a fresh fruit cultivar released in 1996. This cultivar has attractive fruit cosmetics, early maturation and resistance to black heart disorder associated with storage at low temperatures. 'Josapine' is successfully adopted by farmers and had gradually replaced the conventional Queen variety for fresh fruit production. Studies on tissue culture of Josapine suggested that this method might be suitable for rapid multiplication of planting materials, which is now the major restraint in expansion of 'Josapine' acreage. Future breeding strategy for improvement of fresh pineapple will be aimed at 'fine-tuning' the 'Josapine' cultivar using mutation and somaclonal methods to reduce occurrence of multiple crowns and improving resistance to bacterial heart rot. The decline in vigour and yield of Gandul, the conventional canning cultivar when continuously cropped on peat soils, had become a major concern and the focus for future pineapple breeding. Recent results obtained from segregating F1 populations in hybridization suggests the possibility of dramatically improving earliness in fruiting (shortening it to annual cycle), developing new cultivars with very high sugar content for canning in natural juice and improving plant form and vigour. These novel characters will be crucial for improving the local canning breed to maintain a competitive edge in the global pineapple market.

Main Results from the Eu-funded Project 'Evaluation and Utilization of Pineapple Genetic Resources from the Amazon to Breed Resistant Varieties'

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This project aimed at obtaining knowledge and tools for the development of cultivars resistant to the main diseases in South America, by (i) characterizing and evaluating available genetic resources, (ii) studying the genetic structure of the genera *Ananas* and *Pseudananas*, (iii) developing and applying resistance screening techniques for important pests and diseases in the region, (iv) studying the heredity of agronomic traits, and (v) testing the potential of partial inbreds in breeding. In addition, a standard database is being established in collaboration with IPGRI, to promote information and germplasm exchange. The project, which started in 1997 and ended in 2001, has produced an inventory of the germplasm held in the partners' field collections, allowing exchanges and repatriation of lost germplasm. The list of descriptors has been revised. Multivariate analyses of the morphological data have produced consistent results. Molecular characterization, based on RFLP of genomic DNA and PCR-RFLP of cpDNA has confirmed the proximity of *Ananas* and *Pseudananas*, the absence of interspecific barriers in *Ananas*, the importance of a geographic component of variation, and the existence of a higher genetic diversity in the North of South America. Pineapple taxonomy has been revised. Genetic mapping was based on isozyme, RAPD, AFLP and ISSR markers and carried out on a hybrid progeny between *A. bracteatus* and *A. comosus*, following the pseudo-testcross approach. It resulted in a first map of 336 and 154 DNA markers distributed in 46 and 31 linkage groups for these two species. New sources of resistance to fusariosis have been identified, some of which show other interesting traits for the Brazilian producers. According to the first inheritance studies, this resistance seems monogenic and dominant, a result still to be confirmed. Self-progenies obtained from the cultivars Perolera, Primavera, and Roxo de Tefé, showed inbreeding depression, but normal segregation for major leaf traits (spininess, color).

Variation for Main Quantitative Traits in the Seedling and Vegetative Cycles of Pineapple Hybrids

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Data from the EMBRAPA breeding program, involving 425 seedlings from progenies of 17 crosses, and 108 clones established from selected seedlings, were submitted to univariate and multivariate analysis, including correlation and principal components analysis of quantitative traits, comparisons and correlations between the seedling cycle and the following vegetative cycles. All traits showed a continuous, unimodal distribution, except for the number of slips that followed a bimodal one, with peaks for zero and five slips. Plants with no slips were only found in the families involving cultivars with the same characteristic. These two observations indicate that a single gene plays a major role in the production of a limited number of slips. The 17 progenies differed significantly for the other traits, except for total soluble solid content (TSS) and sucker production. Difference of segregation for the reciprocal crosses involving 'Smooth Cayenne' and 'Primavera' showed a maternal effect on peduncle length, crown size, fruit acidity, and sucker production. No significant differences were observed between seedlings and the clones derived from them through traditional vegetative multiplication, except for sucker production, which was much higher in the seedlings. Fruit size in the seedling stage, which is the variable with major contribution to total variation, is not significantly correlated with fruit size in the following vegetative cycles. Fruit shape, TSS, number of slips, and peduncle length, are much better criteria for the selection of seedlings. The correlation values between fruit size on one hand and crown size, fruit axis diameter, and TSS on the other hand are low, so they should pose no problems in the selection of superior recombinants.

Using Chloroplast Dna Markers to Understand *Ananas* and *Pseudoananas* Genetic Diversity

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Diversity has been examined in *Ananas* and *Pseudananas* using PCR-RFLP of chloroplast DNA (cpDNA). Ninety seven accessions representing all valid species of both genera were included in the study, and accessions of other *Bromeliaceae* were added to constitute an out-group for studying phylogenetic relationships. Eight primers designed from cpDNA were used for generating fragments. Restriction by 18 endonucleases generated 255 variable fragments for the whole sample and 52 for *Ananas* and *Pseudananas*. Dissimilarities were calculated from the resulting matrix using the Sokal & Michener index and the Neighbor-Joining method was used to reconstruct the diversity tree. Phylogenetic reconstruction was attempted using Wagner Parsimony. Both phenetic and cladistic analyses gave consistent results. *Ananas* and *Pseudananas* form a monophyletic group, in which chloroplast data allow three strongly supported sub-groups to be identified, two of which are geographically consistent. The majority of *A.parguazensis* accessions constitute a northern group restricted to the Rio Negro and Orinoco basins. The tetraploid *Pseudananas sagenarius* is joined to the diploid *A.fritzmuelleri* to constitute the southern group. The third and largest group is the most widespread, as its distribution overlaps those of the northern and southern groups, and gathers all remaining species plus some *A.parguazensis* and other accessions of intermediate phenotypes. *A.ananassoides* is dominant in this sub-group and highly variable. Its close relationship to all cultivated species supports the hypothesis of this species being the progenitor of the domesticated pineapple. The data indicate the existence of gene flow, common within this group and scarcer with both the first and second groups. Comparison of cpDNA data with genomic DNA point to the hybrid origin of *A.bracteatus* and support the autopolyploidy of *Pseudananas*. Comparison between molecular and collecting data point to the Guiana region as the probable center of domestication of *A.comosus* and indicate a second diversity center in the western region of the Amazon.

Morphologic and Bromatologic Characterization of Pineapple Fruits from Active Germplasm Bank of "Centro De Bioplantas"

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Any program of germplasm conservation needs an agronomic and bromatologic evaluation of its accessions with the aim of later utilize it either for improvement programs or multiplication of the conserved cultivars. The study of the physical characteristics and chemical components of juice is essential to define the fresh fruit consumption and industrialization. The analyzed sample from the active pineapple germplasm bank of "CENTRO DE BIOPLANTAS" evaluates a group of accessions from a germplasm national collection carried out in Cuba, from donation of "Centro Nacional de Pesquisas para Mandioca y Frutales" (CNPMF) at Cruz Das Almas, Brazil and from other countries. In the same way, other materials obtained from pineapple improvement using biotechnology in "Centro de Bioplantas" are included in this group. All of these accessions may be included in four of the five groups reported by Py *et al* (1987): Cayena, Española Roja, Maipure and Pernambuco. The evaluated traits were: length and weight of fruit with and without crown, fruit diameter, fruit heart diameter, eye depth, fruit shape, external and internal color, vitamin C content and ° Brix, among others. Within Española Roja, accession Colorada del Caney outstands because of its higher fruit weight and ° Brix. Within Cayenas, those from Kenya and the national selection Serrana showed higher fruit weight, the accession Cayena un borde liso showed the higher ° Brix. It was interesting to observe that the vitamin C content (50-60 mg100 ml^{-1}) of the three accessions of Pernambuco group was significantly higher than the rest of the evaluated materials. The cultivars Primavera and Perola showed the lowest values of acidity and total soluble solids content. Other characteristics of this group and most important differences in its behavior are discussed.

Conservation and Use of Pineapple Genetic Resources in Brazil

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Brazil is a very large country where many pineapple progenitor species, as well as landraces and wild relatives are found. It is one of the most important centers for genetic diversity of *Ananas* and *Pseudananas*. Since 1979 Embrapa has been conducting an important project on pineapple germplasm collecting and exchange. As a result of this policy it was established a rich pineapple gene bank at Embrapa Cassava and Tropical Fruit (National Cassava and Tropical Fruit Research Center - CNPMF), in Cruz das Almas, state of Bahia, where there is a total of 731 accessions of seven species of *Ananas* and one species of *Pseudananas*, are maintained in the field. Half of this material was duplicated at the Embrapa Genetic Resources and Biotechnology (National Genetic Resources and Biotechnology Research Center - CENARGEN), in Brasilia, Federal District, and it is also under conservation in the field. Both collections are under evaluation and characterization, using the IBPGR descriptors that were modified recently by Brazilian and French researchers. The whole project is partially funded by the European Union and carried out by many organizations, such as: Cirad, France; University of Algarve, Portugal; and Fonaiap, Venezuela in cooperation with Embrapa; The Embrapa breeding program has been using the pineapple germplasm under conservation, for the production of several thousands of seedlings. After screening the material for *Fusarium* resistance, the plants are also evaluated for agronomic characteristics and fruit quality. As a result of the breeding work, 10 hybrids were obtained, and are under regional tests.

Varietal Behavior and Genetic Stability of Eight Pineapple Genotypes Obtained by Micropropagation under the Conditions of Brasilia

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Brazil is the fourth pineapple producer worldwide with 1,353,400 tons of fruit. Most of the cultivated area is planted to 'Perola' and 'Smooth Cayenne', both of them are susceptible to *Fusarium*, which in Brazil is a limiting problem for production. EMBRAPA, Recursos Genéticos and Biotecnología looking for a way to obtain planting material of a good quality and free of pests, and after demonstrating the effectiveness of an *in vitro* micropropagation system with bioreactors of temporal immersion with eight genotypes of *Ananas comosus*, produced the basic material for this trial. The objective of this work was to carry out a field evaluation of the micropropagated plantlets, while its genetic stability and varietal behavior is studied under the conditions of Brasilia. The genotypes are: 'Perola', 'Perolera', 'Primavera', 'Smooth Cayenne', FRF 820, FRF 632, FRF 168 and Comum. After these materials were micropropagated, they were acclimatized in a greenhouse with a survival rate of 100%. Comum, 'Perola', FRF 632 and FRF 168 showed the best growth, while 'Smooth Cayenne', FRF 820, 'Perolera' and 'Primavera' showed the worst growth. In regard to plant vigor, 'Perola' was best followed by FRF 632, Comum, FRF 168, 'Smooth Cayenne', FRF 820, 'Perolera' and at last 'Primavera'. The number of plants with normal development ranged from 81 to 96 % except for 'Perola' which showed 63% due to a large number of dead plants (*Fusarium*). The number of plants with less development ranged from 1 to 16%, 'Primavera' and 'Perolera' had the higher values. The presence of slips at the base of the crown was observed in the genotypes Comum and FRF 632. Plants are in fruiting stage and it has not been observed any effect of somaclonal variation.

Characterization of Pineapple Germplasm (*Ananas* Spp) by Mean of Aflps

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AFLPs technique (Amplified Fragment Length Polymorphism) was evaluated in forty accessions of pineapple (*Ananas* spp), all of them belonging to the collection of Campo Experimental Papaloapan, Veracruz. The main objective was to determine the level of polymorphism within accessions, to characterize them and to detect duplicity of accessions inside the collection. The primers combination to selective amplification Msel +CAT with EcoRI + ACA was the one that best results had with the evaluated accessions with 100 total bands and 95% of these were polymorphic. We did not detect duplicity within accessions inside the collection except for Hawaii 4 and Hawaii 9 accessions, which resulted to be the same. The clusters generated showed that *Ananas comosus* accessions were grouped together and were separated from the wild species. These results agree with those obtained in a previous work with ISSRs and RAPDs (Tapia, et al., 2001). Variation can be due to species self incompatibility, mutation rate and somaclonal variation.

3. Biotechnology

Effectiveness of IC-10 as a Growth Bioestimulant for Pineapple Plantlets *Ananas Comosus (L.) Merr.* Cultivar Smooth Cayenne from Mexico Obtained by *in Vitro* Culturing, in Nursery Areas

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An experiment was carried out in order to evaluate the effect caused by Therapeutic and Prophylactic treatments of the Biological Pesticide IC-10 to *in vitro* produced pineapple plants of Smooth Cayenne cultivar from Mexico, in a typical red ferralitic soil. A split plot design with ten replications was used. The product was applied as a Prophylactic treatment, at a dosage of 5 L/ha. The Therapeutic treatment was a weekly application at a dosage of 60 L/ha., besides, the control without any product. A multifactorial analysis was done for the number of leaves produced per plant, length, width and weight of "D" leaf, as well as, the climatic variables. Temperatures influenced positively the "D" leaf width. Relative humidity and rainfall had an effect on the number of leaves produced per plant and the width and weight of "D" leaf. Statistically significant differences were obtained between both treatments and the control for the variables of growth and development of pineapple plants. The Therapeutic applications of the IC-10 had the greater effectiveness.

Preliminary Results on Application of Enerplant and Other Bioregulators in the Acclimatization Process on Pineapple Vitroplants

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Nowadays, the need for utilizing micropropagation techniques to release a new pineapple variety is almost a must, given the high rate of multiplication that is obtained with this method, compared with the multiplication rates that can be achieved by using the traditional macropropagation method. Pineapple is one of the plant species, in which vitroplants require more time to adjust all their structures and physiological mechanisms, once they have been taken out from the *in vitro* culture flasks. Different substrates, using organic sources and the application of endomycorrhizae were evaluated with the aim of finding ways to reduce this time and also to get better acclimatized seedlings to be planted under field conditions. Bioregulators such as: ENERPLANT, LIPLANT, PECTIMORF, BIOBRAS and RIZBEL were also evaluated. Up to this moment a very favorable behavior of the different factors evaluated has been observed and a large-scale application of the best treatments is foreseen.

Pineapple: High Efficiency *in vitro* Regeneration, Field Performance and PCR/RAPD Evaluation of Regenerants

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The average rate of production in pineapple *Ananas comosus* (L.) Merr., a commercially important fruit crop of the tropical and subtropical belts is 5-7 propagules per year. Slow conventional methods do not meet the growing demand of planting material. Inbreeding induces sterility limiting the establishment of genetically uniform lines to be used for trait evaluation and results in segregating lines of mixed traits. Pineapple is also a difficult plant to improve via traditional breeding. Therefore when a desirable line is identified it needs to be selected and vegetatively mass propagated. High efficiency micropropagation was achieved using dormant axillary buds excised from the leaf axils of spined pineapple crowns and a cyclic production of plants year round was possible on defined media. On an average, 1000 plants could be regenerated from each axillary bud. After 4-6 weeks, 900 plants were transferred to the field of which 7.6% were identified to be spineless and 92.4% were spined plants. Ten clonal pineapple plants bearing the variant "spineless" phenotype and ten bearing the normal "spined" phenotype were selected from the field population for RAPD analysis using 58 random primers. RAPD primers OPA 02,03,04,06 and 08 produced bands polymorphic to the spined phenotype whereas OPA 01,03,04 07 08 and 09 produced bands polymorphic to the spineless phenotype. RAPD pattern of individual spineless and spined plants using OPA 04 produced one band polymorphic to the spined plants and two bands polymorphic to the spineless plants. A total of 914 bands were scored with an average of 5-8 fragments per primer. The highest similarity co-efficient between spineless and spined regenerants was obtained with primer OPA2 and lowest with OPA3 and OPA4. Seventeen primers exhibited a similarity co-efficient ranging between 0.75 – 0.88, eight between 0.6 – 0.5 and eight less than 0.5. Primarily in this study we have used RAPD markers to generate a characteristic "fingerprint" for each probe and have narrowed down the significant markers. This has emphasized the genetic variability of spined vs. spineless plants. The marker bands generated by these primers can be used to study the molecular basis of spinelessness in pineapple.

Incidence, Loss Estimation and Management of Fungous Pathogen Control in Pineapple *Ananas Comosus* (L.) Merr. Vitroplant Propagation Systems

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Strong rotting injuries causing the death of acclimatizing MD2 hybrids of Smooth Cayenne pineapple *Ananas comosus* L. vitroplants were observed at some areas of the Center of Bioplants, from the University of Ciego de Avila from March to June, 2001. In order to diagnose the presence of plant pathogens, to determine the loss magnitudes and to establish opportune phytosanitary measures, plants showing rotting tissue were counted, the rotting symptoms were characterized and a laboratory analysis was performed in order to identify the fungous pathogens causing the rotting problem. *Phytophtora nicotianae* Breda de Haan, *Rhizoctonia solani* (Whezel y Arthur) and *Fusarium subglutinans* (Wr & Reink), P. E. Nelson, T. A. Tousson & Marasas were identified as the organisms causing the high mortality rates, being *P. nicotianae* the most important; the phase II of the acclimatization period is the most affected by the pathogens and the losses reached $ 248.10 during the analyzed period, giving an annual estimation of $ 2977.20 if effective phytosanitary measures are not implemented. For that reason it is proposed the implementation of an integrated management system establishing the previous requirements for working with vitroplants, plant, chemical and biological control measures.

Bromelain and Phenolic Production During Pineapple Micropropagation in Temporary Immersion Bioreactors. I. Dynamics and Role of Gibberellic Acid

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Temporary immersion bioreactor (TIB) has been found an important tool to promote *in vitro* plant proliferation. In addition, TIB can be used for secondary metabolite production in a controlled environment as it mainly involves highly differentiated and specialised plant cells. Although, TIB has been reported for pineapple micropropagation, to our knowledge, this is the first information about the use of TIB to obtain bromelain and phenolics. Changes of endogenous and excreted levels were measured during pineapple shoot elongation (0-28 days). The maximum excreted bromelain was recorded at 21 days of culture (0.065 U/mg of protein) while the endogenous bromelain levels did not vary markedly (0.0035 U/mg of protein). The lowest phenolic level in the medium was recorded at 28 days of culture (17.90 mg/g of fresh weight). Cell wall-linked phenolics also decreased with the course of the experiment. On the other hand, the endogenous free phenolic concentration did not seem to depend on duration of shoot elongation phase. A second experiment trying different gibberellic acid concentrations (0-2 mg/L) was performed. One and a half mg/L-treatment was able to: increase bromelain specific activity in the culture medium, endogenous free phenolic level, and cell wall-linked phenolic content; and decrease phenolic level in the culture medium. The bromelain endogenous specific activity was not gibberellic acid-dependent.

Pineapple *Ananas Comosus* (L.) Merr Transformation Mediated *Agrobacterium tumefaciens*: Temporary Immersion Bioreactor-assisted Pineapple Transgenic Plant Selection

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Pineapple *Ananas comosus* (L.) Merr. is the most important plant in the Bromeliaceae family. This annual yields of this crop are seriously reduced by the incidence of different diseases, among them, the most important are the fusariosis caused by *Fusarium subglutinans* and the rotting of the heart by *Phytophthora parasitica*, both fungal diseases. The used of genetics transformation has helped to solve these problems. The present work points out a procedure for pineapple (*Ananas comosus* (L) Merr) genetic transformation. Pineapple embryogenic calli were cocultivated with *Agrobacterium tumefaciens* (AT2260 and LBA4404). Different co-cultivation periods (0-120 hours) were assayed to evaluated transient GUS expression. The 24 hour-treatment produced the highest percentage of GUS^+ calli (40%) disregarding the bacterium strain tested. The effect of cefotaxime (0-600 mg/L) on plant regeneration from pineapple callus after co-culture with *Agrobacterium tumefaciens* was also evaluated. High cefotaxime concentrations (400 and 600 mg/L) reduced percentage of plant regenerating-calli. *Agrobacterium* contamination was only eye-detectable in Luria Bertani culture medium but not in the cefotaxime-containing pineapple plant regeneration medium. The results indicated that *Agrobacterium* remained latent after co-culture when concentrations lower than 600 mg/L were used. Three selection agents (kanamicyn, hygromycin, phosphinotricin) were tested in two systems for shoot formation (conventional micropropagation and temporary immersion bioreactor) to record the endogenous resistance of pineapple shoots. Non-transformed pineapple shoots seemed to be resistance to kanamycin since they proliferated in both culture systems even with 125 mg/L. Hygromycin affected shoot proliferation disregarding the micropropagation form. However, phosphinotricin was found to be more effective in temporary immersion bioreactors. A large scaled transformation experiment showed 6.6 % efficiency. Pineapple transgenic plants (PCR^+ and Southern $Blot^+$) are being evaluated in the field conditions to measure their agronomic performance.

Application of Cryopreservation Techniques on Pineapple *Ananas comosus* (L.) Merr. Apices and Calluses

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The application of cryopreservation techniques to pineapple apices and calluses could help to overcome various problems. Cryopreservation of apices is the only option for long-term conservation of pineapple germplasm. It is also of high interest for this crop in the framework of biotechnology programs to preserve calluses, which are employed for *in vitro* screening to fusariose disease and transformation works. The aim of current presentation is to report the suitability of application cryopreservation protocols for pineapple apices and calluses. The vitrification technique was experimented with apices sampled from *in vitro* plants and a simplified freezing process was used with calluses. With apices, optimal conditions included a 2-d preculture on solid medium supplemented with 0.3M sucrose, loading for 25 min at 25°C in liquid medium with 0.4M sucrose + 2M glycerol, treatment with PVS3 vitrification solution at 0°C for 7h before immersion in liquid nitrogen. This method allowed achieving 45, 33 and 25% survival with varieties Smooth Cayenne, Cabezona and Red Spanish, respectively. Fully developed plantlets could be obtained from cryopreserved apices. Calluses were pretreated with a cryoprotective solution containing 15% DMSO and 0.5M sucrose for 1-h at 0°C. Cryotubes were transferred in an alcohol bath which was placed in a –40°C freezer, thus allowing a freezing rate of 0.4-0.6°C/min between 0°C and –40°C, then immersed in liquid nitrogen. This method resulted in 67 and 75% survival for calluses of varieties Smooth Cayenne and Perolera, respectively.

New Contributions to Pineapple *Ananas comosus* L. Merr Propagation in Temporary Immersion Biorreactors

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The use of Temporary Immersion Biorreactors (TIB) generates higher plant quality than the traditional micropropagation methods, due to the better *in vitro* environment and nutrition handling. However, even the TIB conditions can be improved, by favoring the photomixotrophism as an intermediate link of the photoautotrophic growing, which is characteristic of the *ex vitro* acclimatization, and these are the objectives of this research. The effects of light and sucrose and CO_2 concentrations on the CO_2 evolution in the culture flasks were evaluated, showing a reduction in the light and a rising in the dark between each one of the immersions. In this way the photomixotrophisms of pineapple shoots propagated in TIB was increased, and it was demonstrated that the light was the factor which more affected the quality variables. However, under these conditions the pineapple shoots seem to utilize more the culture medium nutrients than their own photosynthates to elaborate the reserve substances. The propagation pathway for propagating pineapple by using TIB follows three phases: proliferation, pre-elongation and final shoot growth. In these phases culture growth conditions were determined to replace the autoclave sterilization, to improve the plant quality, to improve the process efficiency and to reduce the cost of production. The G1 formulation for liquid medium was utilized in each one of the phases. The shoots that grew up in the temporary immersion in the presence of this compound had the best growth indicators. Shoot leaf area and dry weight were increased by four and ten times, respectively as well as chlorophyll content.

Application of Biotechnology Techniques in Pineapple Improvement in Cuba

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Results obtained at the Bioplants Center from 1993 up to this moment and related to the pineapple improvement by using different traditional and biotechnological techniques are presented. A somaclone of the cv. Española Roja P3R5 was obtained by using the callus culture. This somaclone maintained the character related to the presence of few spines on the leaves during the production period, being similar in the other characters to the donor variety. The perfection of *in vitro/ex vitro* selection techniques, using the culture filtration of *F. subglutinans*, allowed the selection of some resistant mutants, which were obtained by applying Co^{60} Gamma radiation in explants of the variety Española Roja. The clonal selection of the national germplasm of Cayena Lisa Serrana allowed its *in vitro* multiplication and release to agriculture. Sexual hybridization was used to obtain and select promising hybrids, reducing 5.5 years with the use of biotechnology techniques. At present, 12 promising hybrids from the breeding between Cayena Lisa Serrana x Española roja Pinareña type were obtained; they show a higher yield and better characteristics than the local clone. For the first time, methodologies were developed to obtain haploid plants from *in vitro* anthers and isolated ovule cultures, the *in situ* parthenogenesis induced by pollination with irradiated pollen and the interspecific breeding with *Tillandsia.* Haploid pineapple plants were obtained by using *in vitro* and *in vivo* haploidization techniques, from which isogenic lines can be generated and incorporated to obtain commercial hybrids in a short period of time. Protocols for the genetic transformation of the pineapple by *A. tumefaciens* have been perfected and the first clones with resistance to fungus have been obtained.

Production of Pineapple *Ananas comosus* (L.) Merr Haploid Plants Through Anther and Isolated Ovule Culture

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The possibility of producing haploid plant using *in vitro* anther and isolated ovule culture was explored for five pineapple [*Ananas comosus* (L.) Merrill] genotypes. The experiments included the use of several combination of plant growth regulator (PGR) for callus formation and plantlet regeneration. The best results on callus and haploid embryo formation were obtained using Dicamba as PGR. Thidiazuron 1.0 and 1.5 $mg.L^{-1}$ was better than other tested cytokinins to achieve plant regeneration from embryogenic callus as anther culture as isolated ovule culture. Haploid plantlets were obtained from 3 of 5 tested genotypes. The plantlets derived from the haploid embryo were different in the morphology or ploidy level from those from non-haploid culture. The use of haploid and doubled haploid (DH) plants in pineapple breeding is discussed.

Quick Releasing of New Pinneaple *Ananas comosus* (L.) Merr. Hybrids for Growers Using Biotechnological Methods

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Hybridization is the most important method for pineapple breeding. This method is time consuming because of it requires at least 15 years for releasing new selected varieties to growers. Modifications of the conventional schemes for obtaining and selecting promising hybrids by means of *in vitro* techniques and Bioreactor Immersion System (BIT) are showed. The modification allows reducing 5.5 years or more the conventional schemes for breeding. The hybrids CBCE-03; CBCE-21; CBCE-54; CBCE-70; CBCE-74; CBCE-96; CBCE-116; CBCE-201; CBCE-203; CBCE-287; CBCE-676 and CBCE-677 were selected from F_1V_1 up to F_1V_4 according to the their most important characteristics. They were obtained from crosses between Smooth Cayenne c.v. "Serrana" and Red Spanish cultivars. The twelve individuals selected were better than Red Spanish because they had the best characters of their parents. Hybrids began to be introduced for growers after 9.5 years began the pineapple-breeding program.

Approaches to Improve Pineapple Resistance to Fusariosis Through Involved Microbial Metabolites

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Microbial metabolites involved on plant-pathogen interaction were isolated and the main phytotoxic compound was identified as fusaric acid, a non-specific toxin wolrd-wide in *Fusarium* species. Using several chromatographic approaches was purified a 25-kD acidic protein that induces a differential response of pineapple tissue toward the action of toxin. The isolated proteins contained on crude culture filtrated produced *in vitro* by the micro organism exactly not only protect the resistant cultivars tissue at toxin inoculation site, but rather, a systemic protection was appreciated on the adjacent leaves, while in susceptible cultivars this effect is more delayed, with a protection only partial. The toxin causes significant damages on the cytoplasm membrane from both cultivars (resistant and susceptible), while the action of proteins plus toxin evidenced a differential response among susceptible and resistant genotypes. Closely related with the influence of these metabolites on the cytoplasm membrane, the toxin plus microbial proteins exercised a differential phytotoxic effect depending on resistance grade for different cultivars, evidenced on the growth and regeneration of pineapple callus and about the growth of the buds *in vitro*. The employment of the toxin jointly with the microbial proteins provides an efficient agent for early selection and open new possibilities for the development of molecular tools in support to the pineapple-breeding programme. A gene for gene and a protein-to-protein approach are being used to isolate resistance genes, at the time that the tentative products of avirulence genes will be employee for the molecular diagnosis of *Fusarium subglutinans* races.

Control of Flowering in Pineapple via Genetic Engineering

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Smooth Cayenne accounts for approximately 70% of the world production of pineapple, being the main variety used for processed and fresh pineapple. Production and processing practices are highly developed for Smooth Cayenne. To be acceptable to growers and processors new cultivars must be very similar to Smooth Cayenne in agronomic and processing attributes. Because Smooth Cayenne is highly heterozygous and exhibits considerable transgressive recombination, conventional breeding is unsuitable for developing new processing types if the outcomes are to be achieved in a reasonable time frame. Genetic engineering is ideally suited to improve Smooth Cayenne as it allows specific changes to be made to target genes without rearranging the entire genome. Natural flower induction is a major industry problem, usually occurring when shortening days and low temperatures give raise to increased ethylene production in the leaf tissue and plant stem apex which in turn stimulates flowering. Natural flowering fruit matures 4 to 6 weeks ahead of the normal summer harvest. This results in the need for extra harvest passes (and hence extra costs), and in most cases yield is reduced due to a percentage of over mature or immature fruit. Harvesting costs account for approximately 34% of growing cost. Ethylene is produced through the sequential action of ACC synthase and ACC oxidase. Our team has cloned an ACC synthase gene from pineapple, expressed in meristems and activated under the environmental conditions that induce flowering in nature (ACACS1). Genetic constructs have been produced containing ACACS1 in sense orientation to induce silencing of the gene in the plant by sense-suppression mechanisms. Transgenic plants have been produced and field trials conducted in Queensland for three years in order to study the characteristics of the transgenic lines. Promoter constructs driving the expression of the GUS gene has also been tested in the field trial. We have recently identified a number of transgenic lines with promising behavior that seem to have natural flowering inhibited.

4. Physiology

Effects of Flooding and Water Deficit on Ethylene Metabolism, Titratable Acidity and Fruiting of Pineapple

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The effects of intermittent (three times daily) and continuous flooding and water deficit on tissue ethylene production, 1-aminocyclopropane-1-carboxylic acid (ACC) oxidase activity, leaf titratable acidity (TA), leaf relative water content (RWC), and fruiting of 'Smooth Cayenne' pineapple were studied using pot-grown plants. With intermittent flooding, ethylene production and ACC oxidase activity of leaf basal white tissue (leaf tissue) increased relative to control plants while that for stem apical tissue (top 1 cm, stem tissue) was not different. With continuous flooding, ethylene production by leaf and stem tissue were not different from the control, but ACC oxidase activity in stem tissue decreased. With water deficit stress, ethylene production and ACC oxidase activity of leaf and stem tissues were less than those of control plants. Leaf RWC and TA measured at dawn decreased linearly and significantly with increased duration of all stress treatments. Recovery of RWC and TA to control-plant levels after 35 days of water deficit stress took about one week while plants flooded continuously for more than seven days took more than four weeks. None of the treatments promoted natural flowering of pineapple. Plants forced with ethephon after continuous flooding or water deficit stress had significantly smaller fruit weights than did control plants.

Relationship among Growth Regulators and Flowering, Yield, Leaf Mass, Slip Production and Harvesting of 'Perola' Pineapple

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Natural flowering is very inconvenient and has caused, with increasing intensity, significant losses in all pineapple producing regions around the world. The objective of this work was to determine the role of substances which inhibit the vegetative growth of the plant, in different seasons of the year, on the inhibition, reduction or delay of natural flowering, and also their effects on leaf mass, yield, slip and fruit production and quality, and harvesting of pineapple, cv. Perola. The experiment was conducted at the experimental field of Embrapa Cassava and Tropical Fruit Crops, in Cruz das Almas/Bahia, Brazil, during the years of 1998-1999. The growth substances and concentrations (total active ingredient) were the following: 2 – (3–chlorophenoxy) propionic acid – ACP (C.P. 7,5%): 90 – 120 mg L^{-1}; paclobutrazol – PCB (C.P. 21,5%): 240 – 320 mg L^{-1}; tebuconazole – TBZ (C.P. 20%): 60 – 120 mg L^{-1} and propaconazole – PPZ (C.P.25%): 120 mg L^{-1}. The treatments (two to four split applications), were applied fortnightly (7-9 a.m.), from April to June, period favorable to natural flowering in the region. Despite the variation observed in the effects and efficiency of the used growth regulators, the results showed that ACP and PCB are capable of inhibiting, reducing and delaying the natural flowering of pineapple, in the concentrations of 90 to 240 mg L^{-1}, and also, influencing leaf mass, slip production, yield and harvesting period. The better results were obtained when the growth regulators were applied during the months of April and May. The other products did not affect the natural flowering neither the vegetative growth and fruiting of the pineapple.

Slips Size to Pineapple Flowering Inhibition and to Determinate Time of Flowering Forced

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A field experiment was carried out with Cayenne Smooth variety, in order know the influence of age at flowering induction and slip weight upon the production pineapple. Using a split-plot design and randomized block design. Treatments were: plant age (six, seven and eight months) at Flowering Induction Treatments (FIT), combined with three slip weights (200-499 g, 500-1000 g and 1001-1500 g). Induction was with solid calcium carbide (CaC_2), with 1 Kg in 100 L water; 50 ml of the solution was applied in the heart each plant. The highest flowering percentage was obtained at seven and six month old with slip weight (500-1000 g) and (1001-1500 g). The plant size achieved at the moment of flowering induction from different slip weight resulted highly significant, which influenced on the fruit length, principally in plants form with slip weight small induced to flower the six and seven months old. It was found that the fruits weight and yield to increased when the flowering induction older, although it wasn't found significantly differences. The leaf "D" weight at the moment of flowering induction presented highly significantly differences. It wasn't found significantly differences in the brix grades.

Photosynthesis and Water Relations During Drought in Pineapple Grown at Ambient and Elevated CO_2 at Three Day/night Temperatures

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Pineapple plants were grown in large pots in controlled environment chambers at day/night temperatures of 35/25, 30/25, and 30/20 C and 350 (ambient) and 700 (elevated) mol mol^{-1} CO_2. After six months of growth, water was withheld from treated plants for 70 days. Net CO_2 assimilation decreased substantially after 10 days of drought, particularly at elevated CO_2 where stomatal conductance was lower than at ambient CO_2. Due to the lower stomatal conductance of plants grown at elevated CO_2, both well-watered and droughted plants had higher daily water use efficiency (WUE) than plants grown at ambient CO_2. Leaf titratable acid accumulation (TA) at night after 40 days of drought was only about 10% of pre-drought levels where plants were grown at 35/25 and 30/25 C. Plants grown at 30/20 C maintained about 35% of their pre-drought TA at night at both ambient and elevated CO_2 after 70 days of drought. Diurnal changes in TA at ambient and elevated CO_2 and 35/25 and 30/25 C continued during the last 20 days of drought even though the stomata were tightly closed. The data indicated the plants were re-fixing respired CO_2, a well-known attribut of CAM plants. Leaf water content and osmotic potential during drought decreased more slowly for plants grown at elevated than at ambient CO_2 so plants in elevated CO_2 had higher predawn leaf water potential and turgor pressure at the end of the drought period than did plants in ambient CO_2.

Effect of Ethrel-480 on Flowering Induction in Pineapple *Ananas Comosus* (L.) Merr. Cayena Lisa Cv. "Serrana". I. Changes In Protein, Carbohydrate And Polyamine Levels

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The floral induction in plants is today a paradigm in the plant physiology development. This research had the objective to know the Ethrel-480 applications effect on the behavior of some biochemical indicators such as the proteins, carbohydrates and polyamines in Smooth Cayenne c.v. "Serrana". The Ethrel-480 caused increases after 60 hours in protein levels of treated buds. This effect was more evident in carbohydrate content (total sugars and sucrose). It was also demonstrated the polyamines participation in the floral induction process. Putrescine was accumulated in a proportion greater than all other polyamines in plants treated with this growth regulator.

Maintain Cf-125 for Commercial Production of Pineapple Planting Material

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Smooth Cayenne pineapple *Ananas comosus* L. Merr 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. Slips are leafy structures that develop on the fruit. High yielding Smooth Cayenne varieties grown commercially produce very few slips. Therefore, the principal naturally occurring source of the planting material is the crown of the pineapple. The pineapple production systems can be broadly divided into two types, cannery and fresh fruit operations. In cannery operations, crowns are removed from the fruit before processing. These crowns may serve as a source for planting material. 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. MaintainÒ CF-125 which contains chlorflurenol as an active ingredient has been found to be very useful for producing the planting material, especially in situations where most of the pineapple productions goes into fresh fruit operations. It is the only commercially available product on the market for the production of sliplets which are used as the pineapple planting material. This product is registered in the United States and also in Australia and Costa Rica for application to pineapple. Currently, MaintainÒ CF-125 is used by pineapple growers in United States and a few countries outside the United States. MaintainÒ CF-125 is applied at 0.6 to 1.2 kilograms active ingredient in 2000 to 3000 liters or 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. It has been shown that the application of MaintainÒ CF-125 would result in the production or uniform and quality planting material which in turn would contribute to the quality of the farm operations. Chlorflurenol serves as a critical component in producing high quality sliplets which will yield superior pineapple fruit in a cost effective manner. Maintain-induced production of pineapple planting material is a unique phenomenon in agriculture and is superior to non-chemical alternatives such as stump sectioning and meristem tissue culture. These will be discussed in detail.

The Effect of Different Levels of Fertilizers and Artificial Floral Inductor on Some Yield Characteristics and Fruit Quality of Pineapple *Ananas comosus* (L.) Merr. Variety Montserrat

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NPK fertilizers at five levels A1 ($N_{14}P_0K_0$), A2 ($N_7P_{3.5}K_{11}$), A3 ($N_{14}P_7K_{21}$), A4 ($N_{21}P_{11}K_{32}$) and A5 ($N_{28}P_{14}K_{42}$) and ethephon at two levels B1 (25ml l^{-1}) and B2 (50ml l^{-1}) were applied to pineapple plants. The results indicated that fertilizers alone did not affect the number of days to 50% flowering, the number of basal slips on each plant, the weight of the crown, nor the diameter of the fruit. However, it affected the days to 100% flowering and fruit weight. Treatment A3 had 100% flowers earlier than treatment A1 (p=0.05) and treatment A4 had the heaviest fruits being significantly heavier than treatments A1, A3 and A5. Treatment A2 had significantly lower pH and higher Brix values than treatment A5. Ethephon significantly influenced the time to 50% flowering, the number of basal slips per plant and fruit weight. The plants with the higher level of etephon, B2, did better than those receiving the lower level of ethephon, B1 for these parameters. Interactions between fertilizer rate and ethephon indicated that that A5B2 flowered significantly earlier than treatment A1B1. In addition, the number of basal slips was significantly greater at all fertilizer levels when ethephon at 50ml l^{-1} (B2) was used. Plants that received fertilizer treatment A4 at both levels of ethephon had the heaviest fruits being significantly heavier than those receiving fertilizers and etephon at the following rates A1B1, A2B1 and A3B1. Treatment A2B1 had significantly lower pH than treatments all the other treatments except treatment A2B2 and higher Brix value than treatment A5B2.

Some Physiological Characteristics of Three Pineapple Cultivars Grown under Two Different Production Systems

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The 'Smooth Cayenne' is the pineapple cultivar must widely used in Mexico however, the study of others cultivars before being introduced to our country is imperative. In this work some features related with the drought resistance were determined under two growth conditions: plastic mulch and bare soil; in each treatment the cultivars 'Smooth Cayenne', 'Champaka and 'Oro' were evaluated under a randomized blocks design with four replicates, in split plot. Samplings were performed: in the drought season, at the beginning of the rainy season, just before forcing and during bloom. The results showed that the pineapple cultivars behaved as a typical CAM plant. In the early development stage and during bloom, the CO_2 fixation was similar in plastic mulch and bare soil treatments however, at forcing, plastic mulch treatment had higher values. In the early development stage cv. Oro was more efficient in the CO_2 fixation, but this happened only in the early morning. There was also an inverse relationship between pH and malic acid content. During the dry season the RWC (relative water content) was smaller in bare soil than in the plastic mulch treatment. RWC values obtained for 'Smooth Cayenne' and 'Champaka' were higher than those obtained for cv. Oro. The cv. Oro had the greater chlorophyll content and the fewer stomatal number although they where bigger than in the other cultivars.

Nutrimental Analysis of Three Pineapple Cultivars at Three Planting Densities

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The objective of this study was to determine the dynamic and rates of nutrimental uptake (RNU) of N, P, K, Ca and Mg of three pineapple cultivars at different planting densities. The experiment was set up in an Aw_0 climate and a Dystric Cambisol soil, laid out in a randomized complete blocks design with treatments arranged in split-plots and three replications. Large plots were planting densities; 30, 45 and 60 thousand plants ha^{-1}. Small plots were pineapple cultivars: Ckampaka, Oro and Smooth Cayenne. Eight samplings were done during the crop cycle for each treatment determining N, P, K, Ca and Mg in: roots, stem, leaves, fruit peduncle, crown, fruit shell and flesh. The estimated nutrient uptake curves per plant were calculated by adding the total element for each plant part for every sampling date. These nutrient content data were transformed to logarithmic scale and by step wise regression a model was fit, the best fitted one resulted a third degree polynomial. A test of hypothesis was done to find out whether the adjusted curves were the same or not for each one of the factors evaluated, the only one significant difference was between planting densities. By using the content equations fit to each nutrient element the RNU (mg of nutrient uptaken per meter of root per day) were estimated. The nutrimental uptake dynamics for all evaluated elements followed the same trend than total biomass production, but was different between planting densities, being slower for the higher planting densities, since plants were also smaller. The nutrimental assimilation rates behaved similarly for all five nutrients measured but they drastically decreased up to seven months of plants age and from this stage on, the rate was slower, because of the dynamic of plant growing that were producing more dry matter per uptaken nutrient.

Vegetative Growth of Pineapple Plants Cultivated with Plastic Mulching and Different Planting Densities at Acayucan, Veracruz, Mexico

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Pineapple is one of the important crops in Southern Veracruz because of its high production and profitability. Growers of this crop require however, better technologies than the ones they currently use to improve their competitivity. Plastic mulching and higher planting densities are components with an increasing importance as strategies to improve pineapple yield and fruit quality. Basic information is lacking about the effect of such factors on pineapple plant growth in this region. The objective of this study was to define biomass production and to diagnose nutrient status for each treatment. The experiment was carried out at FISPA-UV in an Aw_2 climate and a fluvisol soil. Treatments were 30,50 and 70 thousand plants ha^{-1}, with and without plastic mulching. A randomized complete blocks design in split-plots was laid out. Evaluated variables were: number of leaves, fresh and dry weight of leaves and stem, as well as foliar analysis per treatment. Plant sampling was done at floral induction stage. Results indicated that plastic mulching treatment was better than without mulching, significant differences were shown for: number of leaves (62 vs. 56), fresh weight of leaves (2.0 vs. 1.7 kg), dry weight of leaves (207 vs. 181 g) and fresh weight of stem (232 vs. 196 g). The interaction between plastic mulching x 30 thousand plants ha^{-1} resulted best for number of leaves. For fresh weight of stem and dry weight of leaves the better ones were plastic mulching x 30 and 70 thousand plants ha^{-1}. Regarding the foliar analyses of D leaf excepting by K, most of macro and micronutrients resulted within normal ranges as defined for this crop.

5. Soil and Water Management

Effect of Two Mulches under Greenhouse and Rainfall Simulation on Soil Losses and Runoff in Soils Cropped to Pineapple at Lara State, Venezuela

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In Venezuela the state of Lara is the main pineapple (*Ananas comus* (L) Merr) producer. In 1997 the cropped area and production represented 44 and 53 % respectively (Mac, 1999). Most of the area with this crop is located in semiarid zones characterized by: a scarce and erratic rainfall with high intensity, high temperature during day time, sloping terrains, acid soils with natural low fertility and a low socioeconomic level of the pineapple growers. The crop management (particularly during the early stages when the soil is bare) along with high slopes and rainfall characteristics lead to soil erosion and water loss. The objective of this work was to evaluate in greenhouse and under simulated rainfall the effect of two mulches on soil and water loss. Soils (A, B and C) from three grower's plots were selected. These plots are located at El Caimito, Iribarren municipality, Lara state. The research was carried out in the soil physics laboratory of the Universidad Central de Venezuela. Two mulches were evaluated: *Canavalia ensiformis* and sisal (*Agave sisalana*) (the fleshy part left after the extraction of the fiber). Each one of these mulches was applied at the rate of 0, 2.5 and 5 $Mgha^{-1}$ with three replications. The rainfall simulator used was described by Pla (1977). Plot dimensions were 50x30x20 cm. Results show that, although soil loss was low, the effect of both mulches was positive to reduce both soil and water losses. Evaluation of C factor (soil loss with mulch/soil loss of bare soil) shows that both mulches have an important effect on soil loss (Canavalia 0.45-0.00; sisal 0.44-0.04). In the same way, the runoff coefficient shows a substantial reduction on runoff depth (Canavalia 38.3-1.21 %; sisal 41.4-8.86 %) which means an increase on water infiltration. These results show that although both mulches have a beneficial effect, the Canavalia mulch have better behavior than sisal. Five $Mgha^{-1}$ of Canavalia mulch is adequate to significantly reduce soil loss.

Effect of Soil Moisture Content, N and K Doses on Growth Factors and Pineapple Fruits Quality in Semiarid Brazil

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A trial was carried out from July 1995 to November 1996 at EPAMIG Mocambinho research station located at the north of Minas Gerais, Brazil. The experimental site is located 500 m above sea level with an average annual rainfall and temperature of 895.5 mm and 25 ° C respectively. The objective of this work was to evaluate the effects of soil moisture levels and the application of N and K at different doses on growth factors and fruit quality of pineapple cultivar Perola. Results are expected to define the optimum soil moisture content, as well as N and K levels to meet the pineapple requirements under the climate and soils of semiarid Brazil. The experimental design was a randomized complete blocks in split plots. Soil moisture levels comprised the larger plots. Treatments were: 20% (T1), 40% (T2), 60% (T3) and 80% (T4) of soil moisture depletion. N and K comprised the smaller plots. Treatments were: N_0=0, N_1=5, N_2=10 and N_3=15 grams of N / plant and K_0=0, K_1=5, K_2=10 and K_3=15 grams of K_20 / plant in an axial distribution: N_0K_2, N_1K_2, N_3K_2, N_2K_2, N_2K_0, N_2K_1 and N_2K_3. Flowering induction occurred by the tenth month after planting, while harvest was done between the sixth and seventh month after flowering induction. Results indicated significant effect of soil moisture levels on fresh and dry weight of D leaf and on number of slips located at the base of fruits. The average values of these variables ranged from 96.4(T4) to 82.0(T3) grams, from 15.3(T4) to 13.9(T3) grams and from 7.4(T2) to 6.9(T1) respectively. Accordingly, the best treatment was 80% (T4) of soil moisture depletion. Fertilization had a statistical significant effect on slip number, fruit acidity, total soluble solids (TSS) and on the TSS/ fruit acidity relationship, with extreme values from 7.6(N_2K_0) to 5.9(N_0K_2); from 7.85(N_0K_2) to 5.60 ml of NaOH 0,1N (N_2K_0); from 14.5 (N_0K_2) to 13.7 ° Brix (N_2K_1) and from 2.56 (N_2K_0) to 1.90 (N_0K_2) respectively. Accordingly, the lack of N is adverse to slip production and to the ° Brix/ fruit acidity relationship. K raised the ° Brix. It was also evident that there were no interaction effects between the studied treatments.

Effect of Soil Moisture Content, N and K Doses on Productivity and Quality of Pineapple in Semiarid Brazil

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The objective of this work was to evaluate the effects of soil moisture levels and the application of N and K at different doses on the productivity and quality of pineapple, cultivar Perola. Results are expected to define the optimum soil moisture content, as well as N and K levels to meet the pineapple requirements under the climate and soil conditions of semiarid Brazil. The trial was carried out from July 1995 to November 1996 at EPAMIG Mocambinho research station located at the north of Minas Gerais, Brazil. The experimental site is located 500 m above sea level, with an average annual rainfall and temperature of 895.5 mm and 25 °C respectively. The experimental design was a randomized complete blocks in split plots. Soil moisture levels comprised the larger plots. Treatments were: 20% (T1), 40% (T2), 60% (T3) and 80% (T4) of soil moisture depletion. N and K comprised the smaller plots. Treatments were: N_0=0, N_1=5, N_2=10 and N_3=15 grams of N/ plant and K_0=0, K_1=5, K_2=10 and K_3=15 grams of K_20 / plant in an axial distribution: N_0K_2, N_1K_2, N_3K_2, N_2K_2, N_2K_0, N_2K_1 and N_2K_3. Flowering induction occurred by the tenth month after planting, while harvest was done between the sixth and seventh month after flowering induction. Results indicated significant effect of soil moisture levels on fruit yield (ton ha^{-1}), average fruit weight (g) and percentage of large fruits, with average values ranging from 59.4(T4) to 54.6(T1) ton ha^{-1}; from 1,249 (T4) to 1,156(T3) grams and from 49.16(T4) to 40.68(T3) percent respectively. Accordingly the best treatment was 80% of soil moisture depletion. Fertilization had a statistical significant effect on fruit yield, average fruit weight, and percentage of large and small fruits, with average values ranging from 59.2(N_3K_2) to 53.4(N_0K_2) ton ha^{-1}; from 1,235 (N_1K_2) to 1,119 (N_0K_2) grams; from 48.33 (N_2K_2) to 35.90 (N_0K_2) percent and from 23.83 (N_0K_2) to 14.49 (N_1K_2) percent respectively. Accordingly, the lack of N upsets the fruit yield. Results also evidenced that there were no interaction effects between the studied treatments.

Evaluation of Different Organic Manures on Yield and Quality of Pineapple Var. Mauritius

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Influence of various organic manures and biofertilizers was compared to select the most suited manure for maximum yield and quality of pineapple var. Mauritius in farmers' fields during 2000-2001. Farm yard manure (600g/plant), poultry manure(250g), vermi compost (250g), neem cake (50g), azospirillum (625mg) and phosphobacteria (625g/plant) were tested along with the recommended dose of chemical fertilizers (N,P2O5, K2O - 8:4:8 g /plant), against a no-organic manure control (N, P_2O_5, K_2O - 8:4:8 g /plant alone) treatment. Data recorded on the vegetative growth of plants, yield and quality parameters of fruits indicated that the different treatments were on par and had no significant influence in the first year (plant crop) of the experiment. However, plots applied with 250g poultry manure + azospirillum and phosphobacteria - 650 mg each along with N, P_2O_5, K_2O - 8: 4: 8 g per plant, recorded higher values in terms of growth of plants, juice percentage and quality parameters of fruits. Soil fertility parameters such as available P and K of the experimental plots increased after one year. Organic carbon of soil also increased significantly, when compared to the control plots.

Effect of Two Mulches on Macronutrients Availability in a Soil Cropped to Pineapple in Lara State, Venezuela.

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Pineapple production is carried out in Venezuela by small growers facing many difficulties to cope with production costs. As fertilization is one of the most expensive activities, an evaluation of mulches as an alternative to improve soil fertility was done. The trial was carried out at Altos de Tequere de Bobare within the municipality of Iribarren, Lara state. This state of Lara is the first pineapple producer and in Bobare 60% is produced. Two mulches were evaluated: leaves of "mata ratón" (*Gliricidia sepium* (Jack) Sand) and the fleshy part of Sisal (*Agave sisalana*) obtained after the extraction of the fiber. Each one of these materials were applied far and wide along the pineapple rows and on a 0.5m wide stripe located beside the pineapple rows. Four treatments were evaluated: "mata ratón" mulch placed far and wide along the rows (T1), "mata ratón" mulch on a 0.5m wide stripe (T2), sisal placed far and wide along the rows (T3) and sisal on a 0.5m wide stripe (T4). The experimental design was a randomized complete blocks with three replications. Soil samples were taken in three different stages: before application of treatments, six months after that and when the crop was 18 months old, after harvest. Macronutrients, organic matter and pH were determined. Results showed that P increased only with T3 (11.6-12.3-36.6 ppm); K increased by the second sample and then decreased, but with values higher than the initial one; T3 showed the highest value at the end of the crop cycle compared to the initial value (129.3-326-205.3 ppm). Ca increased along the three samples reaching the highest values with T3 (386-813-1746 ppm). Organic matter showed a slight tendency to decrease. With the sisal treatments, pH increased along the crop cycle, T3 showed an inconvenient increase of pH (4.5-5.7-7.0). It may be pointed out that sisal applied far and wide along the rows produced the best effects on soil fertility. However, more research is needed to adjust doses in order to avoid an exaggerated increase of pH.

Growth, Yield and Quality of Pineapple Cv. Josapine as Affected by Density and Fertilizer Rate Grown on Sandy Soil in Malaysia

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Since its release in 1996, Josapine, a table-pineapple hybrid cultivar has been extensively grown on peat soils. In order to fulfill the growing demand for this cultivar on mineral soils, a study was conducted to determine the performance of the cultivar on a sandy mineral soil. Therefore the response of this cultivar to plant density and fertilizer rate was studied on a sandy mineral soil in Kelantan, Malaysia. The study was carried out from September 1997 to October 1998. Four planting densities (i.e. 10,759; 12,911; 21,578; and 25, 822 plants/ha) and two fertilizer rate of 40 and 60 gm/plant ($N:P_2O_5:K_2O:MgO$=12:12:17:2) were tested. Experiment was conducted using the Randomized Complete Block Design with four replications. Results obtained showed that the number of leaves and plant height at 9 months after planting (just before flower induction) were not significantly affected by the treatments. However, the width of D-leaf was significantly smaller for the plants grown under higher density of more than 20,000 plants/ha. At harvest, 13 months after planting (122 days after flower induction) the total plant fresh weight was not significantly affected by the treatments. Estimated fruit yield was significantly higher with higher densities although the fruit sizes were significantly smaller. The highest yield of 29.58 mt/ha was obtained with plant density of 25,822 plants/ha and received 60 gm/plant fertilizer rate, while the lowest was 14.51 mt/ha for treatment with 10,758 plants/ha and received 40 gm/plant fertilizer rate. The crown length, crown weight, sugar content and acid content of the fruits were not affected neither by densities nor fertilizer rate. However, the fruit length and fruit diameter were significantly smaller for crops grown with higher densities and higher fertilizer rate. The implication of the results was discussed with respect to the potential benefits for the local growers to maximize their incomes.

Influence of Applied Potassium on Pineapple Quality *Ananas comosus* L. Cultivar Perola

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Brazil is distinguished as one of the three main pineapple producer countries, with an estimated production of 1,63 million tons in 1998. The internal browning of the pineapple pulp, is the most important physiological disturb. Low temperatures, decaying the fruit, mainly that one for export, inducing this browning. It happens frequently in the refrigeration shipment transport. The Potassium is most important mineral for the quality of pineapple. The objective of this work was evaluating the influence of potassium on the some quality parameters of the fruit. Fruits of Perola cultivar were harvested with two mature stages and eight different levels of potassium: 1 - 0g K_2O/plant; 2 - 4g K_2O/plant; 3 - 8g K_2O/plant; 4 - 12g K_2O/plant; 5 - 16g K_2O/plant; 6 - 20g K_2O/plant; 7 - 8g K_2O/plant; 8 - 16g K_2O/plant. The treatment 1, 2, 3, 4, 5 and 6 the potassium were applied three times. The treatment 7 and 8 were applied four times. In the mature green fruits, no significative differences were detected among the treatments neither for weight, size and diameter of fruit or for firmness of skin, texture of pulp and ºBrix. The weight of crown, total acidity and pH showed significative differences among the treatments. For total titratable acidity the fruits applied with potassium were better than those ones were not applied. The mature fruit presented significative differences, among the treatments, for weight of crown, firmness of skin, total titratable acidity and pH. In the other parameters no significative differences were detected.

Determination of the Optimum Plot Size and Influence of the Border in Fertilizer Experiment for Pineapple

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The use of an appropriate size and shape of plot is a very important requirement to carry out field trials. Usually, big plots have larger variance, due to heterogeneity of the soil, and higher cost of the research, since they increase the size of the experimental area. On the other hand, very small plots can contribute to the increase of the experimental error. Therefore, an optimum plot size is preponderant factor for the efficiency, experimental precision, and reduction of the costs of the research works. Borders of the plots also can increase the experimental area, the variance, and the costs of the research. The elimination of borders, since they do not affect the treatments, will also be able to reduce the undesirable effects of the extensive experimental areas. The objective of this work was to evaluate the effects of the size of the plot and of the borders in experiments of fertilizers for pineapple. The experiment was carried out at the Experimental Field of Irará, Bahia, Brazil, on a Yellow Distrophic Latosol, of sandy texture, with the following chemical characteristics: pH in water = 5.3; P (Mehlich extractor) = 6 mg/dm³, K (Mehlich extractor) = 27 mg/dm³, Ca^{++} = 9 $mmol_c$/dm³, Mg^{++} = 5 $mmol_c$/dm³, Al^{+++} = 0 $mmol_c$/dm³. The cultivar Pérola was used in a spacing of 0.90m x 0.35m (31,700 plants/ha), and an experimental design of randomized blocks, with eight treatments and six replications, in factorial 2^3 (two doses of nitrogen: 0 and 240 kg of N/ha; two doses of phosphorus: 0 and 45 kg of P_2O_5/ha; two doses of potassium: 0 and 105 kg of K_2O/ha). The fertilizers were applied during the 2nd, 5th and 8th month after planting. The treatment for flower induction was done in the 12 month after planting. Each experimental unit was formed by 15 plants. The evaluation was based on the yield (t/ha, estimated from the weight of the fruits harvested in each experimental unit). The coefficient of variation, in relation to the different plot sizes, were the following: 15 plants/unit, CV = 15,5%; 30 plants/unit, CV = 12,4%; 60 plants/unit, CV = 10,2%; 120 plants/unit, CV = 9,1%. Since there was not considerable reduction of the CV, when the number of plants/unit increased from 60 to 120, it can be indicated 60 experimental plants /plot as appropriate size for pineapple field experiments on fertilizers. Influences of the borders were not observed on the experimental results.

Standardisation of Leaf Sampling for Nutrient Analysis in Pineapple Var. "Mauritius"

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Leaf nutrient analysis is a tool to assess the plant's requirement for nutrients, and for scientific nutrient management of crops. Investigations were carried out to find out the best leaf portion for nutrient analysis in pineapple var. Mauritius. D leaf (youngest physiologically mature, fourth leaf from the apex) samples collected from plants of 14 treatments of a fertilizer trial were used for the study. Leaf nutrient status of N, P and K were analysed from tip, middle and basal portions of the D leaf. Basal portion of leaf contained significantly higher amounts of nutrients than tip and middle portions. The study indicates that basal portion of D leaf is the best for leaf nutrient analysis.

Soil Erosion and Degradation in the Pineapple Production Region at the Papaloapan River Basin

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The main pineapple production region in Mexico is located at the lower basin of the Papaloapan river, where about 80 % of the total national production of this fruit is obtained; so it is an economically and socially very important crop. Pineapple is also agroecologically important, because its management is closely related to environmental deterioration. This paper is a review of the research carried out by INIFAP at the already mentioned pineapple growing region about the effects of this crop on agricultural systems and their relationship to soil deterioration. This river basin region belongs partially to Veracruz and Oaxaca states and is part of the physiographic area called "Llanuras de Sotavento". This area has soft hilly terrains with a slope of 3 %. Experimental evidence indicates that soil losses due to water runoff range from 19.5 to 230 Mg ha^{-1}. Just considering an average soil loss of 30 Mg ha^{-1} $year^{-1}$, the associated nutrient losses have been estimated at 165, 65 and 66 kg ha^{-1} of exchangeable Ca, K and Mg respectively, that represent 7.0, 3.6 and 7.7 % of these three nutrients content at the surface layer of the soil (0-20 cm). Such a nutrient loss is closely related to the soil acidifying process, that for pineapple crop lands up to two units of pH decreases have been observed per crop cycle (18 months). The need for enhancing technology transfer actions to allow a sustainable pineapple production are discussed.

6. Pest and Disease Management

Phytosanitary Survey to Identify and Describe the Main Pineapple Insect Pests and Diseases at Paramo Negro, Lara State, Venezuela

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Paramo Negro encloses a community that belongs to Municipio Iribarren, Parroquia Aguedo Felipe Alvarado, of Lara State and is located at 500/850 m altitude. Natural vegetation corresponds to tropical dry forest where pineapple is the crop production system that supports the main economical activity of this community inhabited by 60 families. A rural survey performed during 2000 showed that crop losses are caused by insect pests, which motivates the excessive and uncontrolled application of pesticides to assure pineapple production. Pesticides are considered as a threat for families' health and environment. Based upon the survey results, a research project was established with the objective to identify and to describe the insect pests and diseases of economical importance affecting the pineapple production, in order to develop and promote integrated pest management strategies. Another survey was carried out in pineapple plantings in this community. The insect pests collected were identified and preserved; the plant pathogen identification was based upon Castaño-Zapata methodology. The most important insect pests identified were: the pineapple black weevil *Metamasius dimidiatipennis* (Coleoptera); mealy bugs *Dysmicoccus brevipes* (Homoptera) and termites (Isoptera). Among the plant pathogens *Thielaviopsis paradoxa* (De Sienes) Moreu., was found; with an overall incidence of 42% affecting mainly suckers and fruits. Some vertebrates as birds and rats were occasionally reported as causing economically important crop damage.

Pineapple Integrated Pest Management in Hawaii

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Environmental and food safety concerns have focused attention on integrated pest management (IPM). The concept of IPM is to employ several techniques simultaneously to solve specific pest and disease problems for the long term rather than in the short term. Success relies on an in depth understanding of the pineapple production system and the ecology and biology of each pest or disease and associated organisms (e.g., vectors, natural enemies, etc.). In order to evaluate the importance of the pest or disease against yield or quality, efficient techniques are needed to monitor changes in populations of pests and levels of diseases or pathogen populations. An IPM verification program for pineapple in Hawaii has been established which was modeled after the U.S. National IPM protocol for potatoes. Multi-disciplinary teams including members from industry, research and extension identified key pests and diseases and recommended IPM practices. IPM protocols were developed based on establishing the best management approaches. Verification of producer practices was done by farm visits and review of records in order to assign points in relation to each IPM protocol. High scores allowed producers to use IPM as a marketing tool and to better educate consumers as to the value of products grown under IPM principles. Current and potential monitoring techniques are described along with management strategies.

Development, Validation and Transference of an Integrated Pineapple Insect Pests and Diseases Management Program at Lara State, Venezuela

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The problems with insect pests and diseases have been increasing during the last decade in pineapple *Ananas comosus* (L) Merr in the Lara state and all over the country. Among them outstand two weevils, already taxonomically identified, *Metamasius dimidiatipennis* (Jekel) and *Cholus vauriae* O'Brien with damage

symptoms and economical importance preliminarily evaluated, along with the already known, as the mealy bug *Dysmicoccus brevipes* (Homoptera: Pseudoococcidae) (mealy bug-wilt vector), and other fruit borers *Baris* sp. (Coleoptera: Curculionidae) and *Techla echion* (Lepidoptera: Lycaenidae). On the other hand, the fruit borer *Melanoma viatrix* Handel (Diptera: Richardidae) has recently appeared in the country. Among the plant pathogens, the bacterial disease known as pineapple basal soft rot on Española Roja variety, caused by *Pseudomonas marginalis* (Broun) Stevenz is recently appearing in Venezuela, along with a plant collar rot caused by *Pytophthora parasitica* Dastur and other diseases as fruitlet core rot and the pineapple brown rot caused by *Fusarium subglutinans* and *Penicillium funiculosum*, fruit rot and damages in several plant structures caused by *Thielaviopsis paradoxa* (*Ceratocystis paradoxa*) and the pineapple heart rot caused by *Phytophthora cinnamoni* Rands and *Pythium* sp., represent a wide disease spectrum. The insect pests and diseases are increasing the limitations for a healthy crop production to small pineapple growers who are lacking of economical resources to afford the high price and the so questioned chemical pest control using organ-synthetic products. Because of these reasons, it was decided to initiate and continue with research, validation and transference projects about this priority area, with the goal to design an integrated management program with active participation of pineapple growers, and incorporating different pest control alternatives than traditional chemical control, to achieve a sustainable agroecosystem.

Pineapple Mealybug Wilt Associated Virus (Pmwav) and Mealybug Wilt of Pineapple (MWP)

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The long-term goals of our research on MWP are to understand the interactions between viruses, vectors and host plants, and to use this information to develop strategies to manage this important disease. Our recent work shows that pineapple mealybug wilt associated virus (PMWaV) is a complex of closteroviruses. We have produced specific monoclonal antibodies against two distinct PMWaVs. A reverse transcription-polymerase chain reaction assay was developed to detect and distinguish these two viruses. The entire genome of PMWaV-2 was cloned and its sequence determined. The genome contains 10 open reading frames and is typical of the monopartite closteroviruses. PMWaV-1 has also been cloned and ten kilobases have been sequenced. The two PMWaVs are distinct and share less than 50% nucleic acid homology with each other based on available sequences. Both PMWaVs can be acquired and transmitted by mealybugs (*Dysmicoccus* spp.). We have shown in transmission experiments that the presence of PMWaV-2 and mealybug exposure is necessary for the induction of MWP. Mealybug feeding on pineapple plants in the absence of the PMWaVs, or the presence of the PMWaVs in the absence of mealybug feeding, does not induce MWP symptoms. Meristem propagation in tissue culture has been shown to produce PMWaV-free plant material. Various constructs of the PMWaV 2 genes are being introduced into pineapple to develop MWP-resistant transgenic plants by inducing gene-silencing mechanisms.

Effect of a Systemic Acquired Resistance Inducer on Nematode Infecting Pineapple

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The effect of acibenzolar-S-methyl, a systemic acquired resistance inducer, on root-knot, *Meloidogyne javanica*, and reniform, *Rotylenchulus reniformis*, nematode in pineapple was determined in the greenhouse. Foliar application of acibenzolar-S-methyl at 100 and 200 mg/L at planting, 1 month, and 3 months after planting reduced nematode egg production about 40% in 12 months. Pineapple treated with 100 mg/L acibenzolar-S-methyl grew normally; average shoot and dry root weights of treated pineapple were 549 g and 29 g as compared to 579 g and 32 g in non treated plants. However, acibenzolar-S-methyl at 200 mg/L was phytotoxic; stunting and lowering pineapple shoot and root weights. To confirm the phytotoxicity of acibenzolar-S-methyl, another experiment was established using acibenzolar-S-methyl at concentrations ranging from 0, 50, 100, 200, and 400 mg/L. The results were similar to the first experiment. Foliar application of acibenzolar-S-methyl at 100 mg/L may activate intrinsic resistance of pineapple to M. javanica and R. reniformis as shown in a study with cowpea. The mechanisms of the induced resistance are subject to further investigation but may be similar to the result obtained from cowpea which showed that acibenzolar-S-methyl did not pose direct toxicity on the nematodes or inhibit nematode root penetration but delayed nematode development and reduced nematode fecundity.

Protease Inhibitors and Reproduction of *Rotylenchulus reniformis* in Pineapple

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Protease inhibitors (PIs) are thought to serve as defense compounds against pathogen attack in many plant systems. PIs have been found in pineapple roots and populations of *Rotylenchulus reniformis* remain untypically low for 6-9 months after pineapple planting. A pot experiment was conducted to determine whether PIs present in pineapple roots affect nematode reproduction and could account for the observed field population dynamics. Pineapple plants with and without *R. reni*formis were harvested monthly. Roots were removed from the plant, weighed, shaken in NaOCl to determine number of nematode eggs, then chopped into 1 cm pieces. Roots were homogenized in EDTA/phosphate buffer at pH 6.0 to extract protease inhibitors. An aliquot of the root extract was added to purified papain and colorimetric protein substrate, and inhibition activity determined. Pineapple PI activity increased for the first 6 months after planting, and was higher in nematode infected plants. Nematode reproduction was not correlated to protease inhibitor activity. A pot experiment was conducted to determine whether protease inhibitor concentrations in pineapple roots vary along root length in the presence and absence of nematodes. Similar methods were used to determine nematode population densities and PI activity. PI activity increased in the presence of nematodes and this increase was concentrated in the basal portion of the roots where nematode densities were highest.

Reaction of Four Venezuelan Pineapple Accessions to Nematode *Meloidogyne incognita* Strain 1 Attack

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Meloidogyne is one of the parasitic nematodes genera present in pineapple crop *Ananas comosus* which is considered as a crop limiting factor, so that this work had the objective to evaluate the susceptibility of several pineapple materials to nematode attack, specifically to *Meloidogyne incognita* strain1. Four accessions of *Ananas comosus* from the Amazonian region which were donated by the Centro National de Recursos Fitogenéticos, identified as CRF-037, CRF-048, CRF-008 and CRF-040, were propagated *in vitro* in the Biotechnology laboratory of the Centro Nacional de Investigaciones Agropecuarias at Lara state. The one-year-old plants were inoculated with 10000 nematodes per kg of soil. Two treatments were considered: inoculated plants and non inoculated plants, with five replications per treatment. The fresh and dry weight of the above-ground and root plant structures, and the nematode reproduction factor (RF) were determined four months after inoculation. Plants with RF≤1 were considered as resistant. The results showed that CRF-008 was affected in its dry and fresh weight of both above-ground and root tissues. The inoculated plants showed less weight than the non inoculated ones; there were no statistical difference among the other three plant accessions (Tukey 5%). The RF was less than 1 for all four accessions, so that CRF-037, CRF-048, and CRF-040 could be considered as nematode resistant or tolerant as their agronomic quality was not affected. Therefore, the accession CRF-040 was considered as resistant but not tolerant because some of its quality variables were affected. This work is part of the project INCO-CT96-0118.

Evaluation of Four Pineapple Accesions for Their Resistance to P*ratylenchus brachyurus*

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One of the more frequent phytosanitary problems in pineapple plantings is the presence of nematodes; one of them is *Pratylenchus brachyurus*, which causes damage to the cortical parenchyma, enhancing other pathogenic microorganisms to enter into the plant tissue, and then killing the plant. One way to control *P. brachyurus* is the use of plant resistance. Four accessions from the Centro Nacional de Recursos Fitogenéticos de *Ananas comosus* identified as CRF-037, CRF-048, CRF-139 and CRF-372 were evaluated. The plants were nematode inoculated by adding 200 nematodes per kg. of soil. A completely randomized design was used, considering 5 replications each for inoculated plants and non inoculated plants (control). The response variables were fresh and dry weight of both above-ground and root tissue that were evaluated four months after inoculation. The nematode reproduction factor was also evaluated, determined by the relation between final population in soil and roots, and the initial population (200 nematodes per kg of soil), (RF=Pf/Pi). A plant was considered as nematode resistant if RF ≤ 1. All but CRF-139 showed less dry weight when inoculated, this CRF-139 also showed the lesser nematode reproduction at the end, so that this accession was considered as nematode resistant. This work is part of project INCO-CT96-0118.

An Integrated Approach to Nematode Control in Queen Pineapple in Northern Kwazulu-natal, South Africa.

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In Northern KwaZulu-Natal, South Africa, *Pratylenchus brachyurus* is causing considerable yield losses in the production of the Queen pineapple,

especially on the sandy soils. It is endemic to this region and therefore land not previously cultivated can be infested with nematode numbers at damaging levels. Unto date soil fumigation has been the main nematode management strategy in Queen pineapple production in Northern KwaZulu-Natal. Recent research has focused on the evaluation of other non-volatile nematicides to act as a potential alternative for EDB. Two nematicides were registered consequently. To be able to follow an integrated nematode management program, the population dynamics of *P. brachyurus*, the effect of cultivation practices such as the application of lime to modify soil pH, preplant land preparation and thrash incorporation was studied. It was found that the pH of the soil has an influence on the development of *Pratylenchus* populations and that the method of land preparation influences the severity and rapidness of nematode infestation after planting.

Biological development of *Metamasius callizona* (Coleoptera: Curculionidae) on pineapple stems

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Metamasius callizona (Chevrolat) oviposited in bag-shaped excisions made by the females in pineapple leaves, in the laboratory of Biological Control from the Entomology and Nematology department at the University of Florida. Environmental conditions were, average temperature of 26°C and at regimes of 14:10 photoperiod (L:D). Egg sizes were 1.98 x 0.97 mm and their incubation took 8.3 days (average) at 82% relative humidity. Fed to a diet of pineapple stems the five instars completed development in 37.4 days to reach pupal stage. The pupa stage lasted 11.8 days and the pupa weighted 0.12 g. The total development from egg to adult took 8 weeks.

Cholus vaurieae 0' Brien and *Metamasius dimidiatipennis* (JEKEL) (Coleoptera: Curculionidae), Weevils Attacking Pineapple Crop in Venezuela

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The neotropical *Cholus* is the largest genus of the subfamily Cholinae, with more than 170 species inhabiting Mexico, Central America, The Antillas and South America, meanwhile the distribution of *Metamasius dimidiatipennis* (Jekel) covers south Mexico, Central America, Guyana and northern of Brazil, including from the west coast of South America to Perú. *Cholus vaurieae* was described in Venezuela by 0' Brien in 1994, who dedicated it to Patricia Vaurie as recognizance of her extensive taxonomical work with Curculionidae. On the other hand, *M. dimidiatipennis* was registered in Venezuela in 1996 and identified by C. W. 0' Brien. Both species were collected at Pico Pico (10° 21'45"N, 69°14'40"O, 80 m), Mariara (10º22'45"N, 69°20'55"W, 800 m) at Municipio Crespo and Santa Lucía del Páramo (10º19'30"N, 69°20'30"O, 1000 m) at Municipio Iribarren of Estado Lara. Both species cause damage of economical importance to pineapple *Ananas comosus* L., at the northern region of Lara state. The females of *C. vaurieae* generally oviposit at the lower end of the floral peduncle, being able to oviposit in different parts of the peduncle, at the bottom of the crown and basal slips. Females make a hole using their mouth parts laying a single egg inside the peduncle. The larva feeds from the internal tissue of the floral peduncle, moving upward or downward from the oviposition perforation. Occasionally, the female may perforate the central and rough parts of the fruit. The larva may cause the destruction of the internal tissue of the floral peduncle, which affects the normal fruit development preventing the crown development. When a ripening fruit is attacked it may become rotten. The weevil adults feed on leaves making holes using their mouth parts, this damage can easily be recognized by the presence of black borders surrounding the holes A sticky exudation comes out from the holes, when the basal parts of the leaves are attacked,. When weevils are in high population numbers, they may attack small developing pineapple fruits. Larvae of *M. dimidiatipennis* mostly attack the base and root of the plant, causing the leaves to dry off and then the pineapple death, although the presence of larvae inside the floral peduncle and fruit or on the above-ground plant structures are less frequently seen.

Preliminary Report about Genera of Coleoptera, Family Scarabaeidae Occurring in Pineapple Plantings at Ciego De Avila Province, Cuba

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The present work was carried out at the 8 de Octubre UBPC which belongs to Ciego de Avila, Cuba pineapple Enterprise between May and June, 2001. Five kinds of light traps were set up for four times from 8:00 at night until 6:00 at dawn. The insect caught in the traps were collected and kept following the methodology of MINAG, (1985) and after that the insects were classified. It was found that there are 7 genera of Scarabaeidae order Coleoptera and also that there are more Cyclocephala than Phyllophaga in proportions around 6 to 1 at pineapple Enterprise locations.

Blackspot Control in Queen Pineapple: the Effect of Leathery Pocket Mite Control with Endosulfan

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Blackspot (fruitlet core rot) is a common disease in many pineapple producing countries. In the Queen pineapple industry in South Africa blackspot can cause severe losses in that as much as 98% of the harvest can be infected with one or more blackspots per fruit. While symptoms are not visible from the outside, buyers' resistance is experienced and poor prices are obtained. Leathery pocket mite (*Steneotarsonemas ananas*) occurs in all pineapple plantings in Zululand and infestations can reach high numbers on the plant as well as on the inflorescence and especially in the floral cavities of the fruit. A positive correlation was found to exists between leathery pocket mite (lpm) numbers and leathery pocket disease in Cayenne pineapple in the Eastern Cape production area of South Africa. Despite the high numbers of lpm in Zululand, leathery pocket is not a major problem in Queen pineapples. In some cases it was found that with control of leathery pocket mite a reduction in blackspot infection was found. This was not confirmed for Queen pineapple. Observational trials were established to determine whether leathery pocket mite control with endosulfan will reduce mite numbers and the occurrence of blackspot in Queen pineapple fruit. Data from one season's trials indicated that endosulfan sprays controlled leathery pocket mite but increased blackspot incidence.

Systemic Fungicide Efficacy to Control Fungal Pathogens under Pineapple Nursery Conditions and Advantages of Using Them in Management Systems

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Two assays were carried out at the pineapple Enterprise located at the province of Ciego de Avila, Cuba, to find out the efficacy of fungicide treatments to control the plant pathogens *Fusarium subglutinans, Phytophthora nicotianae* and *Chalara paradoxasa,* causal agents of important diseases to nursery pineapple plant production. One assay included propamocarb at a dosage of 1.04 g a. i. / L; triadimenol at 0.5 g a. i. / L; propiconazol, tebuconazol and hexaconazol at dosages of 0.05 g a. i. / L each; the combination of propamocarb with the triazol compounds mentioned above at dosages of 0.78 + 0.375 g a. i. / L; metiran and polijón at 3 g a. i. / L. The second assay included the same active ingredients and dosages than the first one, but the substitution of propamocarb by metalaxyl at a dosage of 1 g i. a. / L alone and 0.75 g a. i. / L when mixed. The fungicides that probed to be the more effective ones were triadimenol (76.2 %) and the mixture of triadimenol + propamocarb (80.9 %) that showed significant differences with all other treatments including the reference, in the first assay. Besides the triadimenol, metalaxyl + propiconazol and metalaxyl + tebuconazol all three with 84.2 % and the metalaxyl + triadimenol and metalaxyl alone with an efficacy of 78.9 and 73 % respectively without significance among them at the second. For all these treatments the protecting time was more than 30 days. The mixtures of metalaxyl + triazoles and propamocarb + triadimenol resulted effective in providing a wide spectrum control over the different fungi species preventing any effect on population selection of plant pathogens present.

Chemical Control of the "Fruit Spot" in Pineapple Cv. `Smooth Cayenne´, in Chanchamayo (Peru).

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A field trial was carried out in order to determine the effect of different chemical fungicides on the incidence of the "fruit spot" in pineapple cv. Smooth Cayenne in the Peruvian Central Rain Forest (Chanchamayo). Cercobin (methyl thiophanate), Tilt (propiconazol), Folicur (tebuconazol), Tecto 60 (thiabendazol) and Benlate (benomyl) were evaluated and compared with a non-applied check. A Randomized complete block design was used with 6 treatments and 4 replications. Each experimental plot (e.p.) was conformed by four 14-plant rows. Evaluations were made at harvest time, 10 fruits were harvested from each of the 2 central rows (20 fruit/e.p.) and each fruit was cut in a transverse way, to determine the different types of "fruit spot" [Dry Black Spot (DBS), Black Spot (BS) and Gallery Spot (GS)] at the lower, medium and upper sections of the fruit. Two fungicide applications were made by using a manual backpack sprayer at 9 and 14 weeks after the flower induction treatment. Each time the products were applied at 0.5% and inflorescences were completely covered. All of the fungicides controlled the

disease at the different sections of the fruit that were evaluated. All products had a similar effect at the lower and upper sections; on the other hand, at the medium section, the best performance was obtained with Benlate, being statistically similar to Tecto 60 and Folicur. Likewise, all of the evaluated fungicides significantly controlled the incidence of the three different "fruit spot" types, found in the experimental location. Tecto 60 had the highest effect on DBS, but its effect was statistically similar to those of Cercobin and Benlate. Except for Cercobin, all other products had a similar effect on BS; while the best GS control was obtained with Folicur, but it was similar to those of most of the evaluated products. The total disease incidence (DBS+BS+GS) in the non-applied check plot (21.945%), was significantly higher than that quantified in the plots treated with Cercobin (17.915%); Tilt (16.39%), Folicur (14.305%); Tecto 60 (13.75%) or Benlate (13.61%).

Mechanical Protection of the Inflorescences or Fruits of Pineapple *Ananas comosus* (L.) Merr. cv. `Smooth Cayenne´ and its Effect on the "Fruit Spot" in Chanchamayo - Peru

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A field trial was carried out in order to determine the effect of the mechanical protection of the inflorescence or fruits of the pineapple cv. Smooth Cayenne on the incidence of the "fruit spot" at the Peruvian Central Rain Forest (Chanchamayo). Inflorescences were protected at 75 (T1), 105 (T2), 135 (T3) and 165 (T4) days after the treatment for flowering induction (TFI) and a non-protected check (T5) which was harvested at 185 days after TFI was included for comparison. The trial was conducted in a 0.5 ha commercial plot. Twenty plants of each treatment were randomly selected and protected with a commercial PVC mesh No. 32/14x14. A Completely Randomized Design with 5 treatments and 20 replications was used. The gallery spot (GS) had the higher incidence, followed by the dry black spot (DBS) and the black spot (BS). The incidence of GS in the treatments T5 (95%) and T4 (74%) was statistically similar, and was followed by T3 (19%), which was statistically lower. A complete control of the disease was obtained when inflorescences were protected at 75 (T1) and 105 (T2) days after the TFI. Fruits of treatments T1 and T2 did not have "fruit fly" (*Melanoloma canopilosum*) larvae, but those of T3, T4 and T5 did. A trend was observed in which the number of larvae/fruit increased as the number of days between the TFI and the time of inflorescence protection was longer, however there were not significant differences between the different treatments. The correlation between the number of "fruit fly" larvae and the GS was significant (r = 0.6656**), as it was with the BS (r = 0.3032*), but it was not with DBS (r = 0.1548). The protection of the inflorescences or fruits had no effect on the characteristics of the fruit that were evaluated in this experiment.

Effects of Legumes Rotation on Pineapple Root Diseases, in Huimanguillo, Tabasco, Mexico

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Quick decline in productivity, induced among other factors to soil-borne diseases, is a characteristic of agroecosystems established throughout tropical regions in the world. Successful strategies for the management of root diseases, that allow the recovery of the suppressive capacity of soils to locally important root diseases, based on the beneficial effects of the rotation with legume plants have been reported for corn. Pineapple production in the majority of the worlds productive regions is carried out as monocrop and major epidemic have been reported of mealy bug wilt (virus), heart and root rot (*Phytophthora* spp) (fungus), root gall and root lesions (nematodes). The apparent stability resulting from the rotation with tropical legumes, evidenced by higher values of vigor parameters in pineapple, could be partly explained by the lower incidence of root infections and higher root weight, particularly in *Mucuna'*s rotation. Pineapple plant height and root weight were significantly higher for *Mucuna* rotation (40.8 cm and 23.67 g, respectively), compared to *Canavalia'*s rotation (28.9 cm and 7 g., respectively) and the control, (31,74 cm and 8.14 g respectively). *Phytophthora* sp. was more frequently isolated than *Pythium*, and the species, more likely is *P. citricola*. Significant differences were detected for frequency of isolation of *Phytophthora* sp. where the higher incidence was for plants from the non-rotation treatment, followed by *Canavalia* and last for *Mucuna*. Significant differences were also observed for *Pratylenchus* populations among treatments, where the higher populations were detected for the control and *Canavalia* rotation, both in soil and roots.

New Methods for Control of Thielaviopsis Fruit Rot of Pineapple

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Alternate means of controlling Thielaviopsis fruit rot of pineapple caused by the pathogen *Thielaviopsis paradoxa* (de Seynes) Höhnel (Teleomorph Syn *Ceratocystis paradoxa* (Dade) Moreau., were initiated due to increased consumer pressure against the use of chemicals, and the bans imposed in many countries on the fungicides that are currently in use for this purpose. Treatments tested included, exposure to gamma irradiation, hot water dip treatment and the application of two generally regarded as safe (GRAS) compounds sodium benzoate(10%), and acetic acid (0.15%) respectively. These treatments were compared with a 0.6 % solution of the fungicide Benlate (benomyl 50w/w) which is known to control the disease. It was observed that irradiation treatments were not effective in preventing the incidence of disease in inoculated fruits and resulted in severe cosmetic damage to fruits at doses above 0.25 kGy. Application of sodium benzoate to stems at 10% concentration was effective at 10°C but not under warm ambient temperature conditions, while inoculated stems dipped in a solution of 1.5% acetic acid showed a high degree of infection. Hot water dip treatment at 54 °C for 3 minutes however, was observed to prevent incidence of Thielaviopsis black rot in pathogen inoculated pineapple stems at ambient as well as at 10°C.

Reaction of Pineapple Genotypes to Artificial Inoculation with *Fusarium subglutinans*

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Fusarium subglutinans, the causal agent of the pineapple fusariosis is the most serious problem of that crop in Brazil, inciting yield losses that vary according to the season of harvest and the region of production. Considering the potential of genetic resistance as a control measure for that disease, two experiments were carried out at Embrapa Cassava & Fruits, under screen house conditions, in a randomized design with five replicates. Ninety pineapple genotypes, all of them obtained from the Pineapple Active Germoplasm Bank, were evaluated for resistance to *F. subglutinans*, through the wounding and dipping technique. As reference genotypes there were used the cultivars Pérola, susceptible, and Perolera and Primavera, resistant. Evaluation performed four months after inoculation, showed that 46 genotypes expressed resistance to the pathogen as characterized by no presence of fusariosis symptoms, similar to those shown by 'Perolera' and 'Primavera', reference genotypes for resistance. The remaining 44 genotypes, identified as susceptible, showed variable disease severity, from very light symptoms to death of inoculated plants, thus suggesting different levels of resistance to *F. subglutinans*. All inoculated plants of the cultivar Pérola, reference genotype for susceptibility, were dead when the experiments were evaluated.

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Natural Enemies of Mealybugs on Pineapple in Hawaii

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Almost anywhere in the world where pineapple is grown, the pineapple mealybugs, the pink *Dysmicoccus brevipes* (Cockerell) and the gray *D. neobrevipes* Beardsley (Homoptera: Pseudococcidae), are associated with the pineapple red wilt disease (mealybug wilt of pineapple). High population densities of these insects enhance the development of this disease, which limits pineapple production. The population of mealybugs reaches economical thresholds wherever

ants are present, particularly the longheaded ant *Pheidole megacephala* (Fabricius), resulting in the highest occurrence of the disease. Four studies were carried out from July 1992 to November 1993, to define the role of biological control agents on the suppression of the two mealybug species populations. Field sampling on abandoned pineapple fields at the Hawaiian Islands, Oahu and Maui, showed that the mealybug populations averaged from 22 to 157 insects per plant where *P. megacephala* was the predominant ant. Five natural enemies, previously introduced to Hawaii to control mealybugs on pineapple, were associated with *D. brevipes* and *D. neobrevipes*. The parasitoid *Anagyrus ananatis* (Hymenoptera: Encyrtidae) was most commonly associated with *D. brevipes.* The predators *Nephus bilucernarius* Mulsant (Coleoptera: Coccinellidae) and *Lobodiplosis pseudococci* (Felt.) (Diptera: Cecidomyiidae) may have some potential as biological control agents. A field study using the method of biological interference evaluation suggests that *A. ananatis* was the natural enemy responsible for the population decrease of *D. brevipes* in absence of ants. The methods of biological interference and exclusion with odd box were combined, showing that in absence of the ant *P. megacephala* the mealybug *D. brevipes* population densities were strongly affected by the natural enemies and probably by the absence of sanity or by the absence of honeydew removal by ants. At laboratory studies with *D. brevipes*, *P. megacephala* significantly reduced the parasitic proportions and reduced the prey proportion by adults of *A. ananatis* and *N. bilucernarius* by 73 and 48% respectively.

Nematode Population Densities of Three Genera on Pineapple Plantings at Veracruz State, Mexico

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Veracruz is the main pineapple producer state in Mexico, where about 8,000 ha are grown to this crop. Fifty percent of such area belongs to "Isla" municipality. The main parasitic problems of pineapple plantings are three genera of nematodes: *Meloidogyne*, *Pratylenchus* and *Helicotylenchus.* The objective of this study was to make a survey in order to measure population densities of these three genera of nematodes on pineapple plantings. Soil and pineapple roots samples were taken from pineapple planting lands, which were classified as "new", "intermediate" and "old" according to the number of pineapple crop cycles grown on each one of them, as well as at different phenological stages like: "just planted", "floral induction", "harvest" and "ratoon crop". Random samples were taken at a depth of 0-30 cm; they were kept in plastic bags into an ice box before they were transfered to the laboratory. They were then processed by screening and centrifugation techniques. Results indicated that *Meloidogyne* populations reached values ranging from 0 to 2467 with a mean of 169 +/- 350, *Pratylenchus* from 0 to 376 with a mean of 38 +/- 57, and *Helicotylenchus* ranged from 0 to 8064 with a mean of 598 +/- 1227. Regarding planting cycles there were only significant differences (p= 0.05) for *Helicotylenchus* at "new" and "intermediate". Whereas for the phenological stages highly significant (p=0.01) differences were shown for *Pratylenchus* between "just planted" and "harvest", and between "harvest" and "ratoon crop". Similarly, for *Meloidogyne* a highly significant (p=0-01) difference was found between "just planted" and "harvest", and only significant (p=0.05) between "harvest" and "ratoon crop".

7. Production Systems

A Land Race Pineapple *Ananas comosus* L. with Potential to Be Grown as an Organic Crop in Nayarit, Mexico

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Pineapple is an important crop in Mexico. Fourteen thousand hectares are grown with the Smooth Cayenne cultivar mainly in Veracruz and Oaxaca states. However, there is a high potential for this crop all along the Pacific coast, from Sinaloa to Chiapas states. In Nayarit, two types of pineapple are grown: 'Smooth Cayenne' and a land race. The first one is cultivated in about 300 hectares in Compostela county while the land race one is grown in about 700 hectares in Ruiz and Santiago Ixcuintla counties. The land race is grown as a perennial crop under shadow of leguminous trees with almost no pesticide applications. The agroecological conditions where this land race pineapple is grown are shallow soils with a pH from acid to neutral. They have irregular topography with slopes of 10-25%. Also these soils have light textures and are well drained. The annual rain average is 1,800 mm with a mean temperature of 24-26ºC. This area is free of hail and frozen days. The altitude is 100-400 m above sea level. All these conditions make possible to grow this land race pineapple as an organic crop; however, there are still some restrictions. Growers must be better organized to get the certification for an organically grown crop. Also, they must access to research and technical assistance to increase the yield, quality and productivity of this land race pineapple.

Effects of Rotation with Tropical Legumes on Productivity and Stability of Pineapple *Ananas comosus* (L.) Merr. and Intercrops, In Tabasco, Mexico

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Agroecosystems established in tropical regions have a limited productivity when compared to the original ecosystem. However, transgressive overyielding has been reported for mix cropping systems, for certain crops combinations. Pineapple around the world is produced mostly as monocrop. To define the possibility of transgressive overyielding in rotations of legumes followed by pineapple, either alone or intercropped, an experiment was established in Huimanguillo, Tab., Mexico. An split plots design was used, with four replicates, where the large plots (24 X 20 m) were rotation to *Mucuna deeringiana*, to *Canavalia ensiformis* or without rotation. The small plots were planted to either corn alone or associated with beans, and Habanero hot pepper in the middle of pineapple rows. Legumes were planted in May; pineapple was planted in Sept., and the intercrops were planted in Dec. 2000. Vigor parameters (plant height, stem diameter, and yield - except for pineapple-) were evaluated for all crops. Root weight and soil attached to the roots of pineapple samples were also evaluated. Some soil physical and chemical properties were evaluated. Also, a comparative cost/benefit analysis for the tested systems was performed. Yields of intercrops were surprisingly high only after legumes rotation, because without rotation there was no yields of intercrops. After *Mucuna*, yield of corn alone was 3750 k ha^{-1}; for corn associated with beans, the yield was 3875 k ha^{-1} . Beans yield was 634 k ha^{-1} and for Habanero pepper yield was 7551.78 k/ha^{-1}. Therefore, the highest productivity is obtained with the legumes rotation and the apparent stability is achieved with a rather brief time of rotation. The rotation-multicrop systems with pineapple, particularly when *Mucuna* is used, represent a technically viable and economically profitable strategy.

Handling and Transport of Pineapple Planting Materials. The Malaysian Experience

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Almost all activities related to the production and sale of pineapple (*Ananas comosus* {L.} Merr.) planting materials, especially for the new cultivars are carried out in the Peninsular Malaysia. The potential of growing the new cultivar of Josapine in the East Malaysia, particularly Sarawak is very great since it has the largest peat soil areas suitable for its cultivation. However, the South China Sea Ocean separates the East Malaysia from the Peninsular. Therefore, exportation of pineapple planting materials from the Peninsular to the East Malaysia has to be carried out by air or sea shipment. The limited space and high cost are two important factors that discourage exportation by air though it offers faster arrival. Transportation by sea usually takes between 10-14 days period. This paper reports the experiences by the Malaysian Agricultural Research and Development Institute (MARDI) in the handling and transportation of pineapple planting materials cv. Josapine from Johore, Peninsular Malaysia to Kuching, Sarawak in the East Malaysia. The planting materials were produced by quartering technique and raised in the peat soil nursery for 7 months before harvested. They were then subjected to specific treatments as required by the Plant Quarantine Division of Sarawak Department of Agriculture before loading into the reefer container, set at 15 degree Celsius. The qualities of planting materials did not change upon arrival at the port as well as at the farm site. The prospects and problem of the whole handling and transportation system are discussed, including the cost involved and the future needs of the related research and development.

Fruit Yield and Quality of Three Pineapple Genotypes at Three Planting Densities

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An experiment was carried out to determine the best fruit yield and quality of three pineapple cultivars at three planting densities, in southern Veracruz, Mexico in an Aw_0 climate and Dystric Cambisol soil. The trial was laid out in a randomized complete blocks design with treatments arranged in split-plots with

four replications. The large plots were planting densities of 30,000, 45,000 and 60,000 plants ha^{-1} and small plots were the pineapple cultivars: Champaka, Oro and Smoth Cayenne. Variables measured were: fruit weight and its relation to foliar area and fruitlet number, total soluble solids and titratable acidity for three fruit lengthwise sections, fruit diameter and the rate between top and basal section diameter. For 30,00 plants ha^{-1}, 'Smooth Cayenne' (2.74 kg) fruits resulted significantly heavier, than 'Champaka' and 'Oro' by 10 and 35% respectively; whereas at 45,000 and 60,000 plants ha^{-1} 'Champaka' was similar to 'Cayena Lisa' and they both had heavier fruits than 'Oro' by 28%. The lower planting density produced fruits of 2.44 kg, 8.5 and 16% heavier than at 45,000 and 60,000 plants ha^{-1} respectively, but at the higher planting density, fruit yield increased by 72%, that is 126 ton ha^{-1}. 'Cayena Lisa' and 'Champaka' had a heavier fruit per foliar area and higher planting densities required a greater foliar area per kg of fruit. The best fit for fruit weight and fruitlet number was linear (r= 0.6552, 0.7521 and 0.7996 for 'Oro', 'Champaka' and 'Smooth Cayenne' respectively). 'Champaka' and 'Oro' had higher ° Brix than 'Smooth Cayenne' and there were no significant differences for acidity between cultivars, nevertheless the higher the density, the higher resulted fruit acidity. 'Oro' did not show conical shaped fruits whereas 'Smooth Cayenne' showed more at 30,000 plants ha^{-1}. 'Smooth Cayenne' is a better option for domestic fresh market at 30,000 plants ha^{-1}, whereas 'Champaka' is for fresh export market at 60,000 plants ha^{-1} and 'Oro' showed potential for both market types.

Planting Densities and Plastic Mulching for 'Smooth Cayenne' Pineapple Grown in an Aw_2 Climate and Fluvisol Soil in Veracruz, México

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The agroecological conditions prevailing in Southern Veracruz indicate this area has an excellent potential for pineapple production. To exploit such potential new production technologies are needed to assure pineapple growers with sustentability of their production systems. The objective of this research was to evaluate the effect of planting densities with and without plastic mulching on pineapple fruit weight and quality. The experiment was carried out at FISPA-UV, from June 2000 to June 2001 in an Aw_2 climate and a fluvisol soil. Treatments were 30,50 and 70 thousand plants ha^{-1} with and without plastic mulching in each density. Experimental design used was a randomized complete blocks in split-plots. Variables evaluated were: percentage of natural flowering, fruit weight, length, equatorial diameter, heart diameter, ° Brix, acidity and external and internal color, crown length and weight. Plastic mulching resulted significantly better than no plastic mulching for: fruit weight (1.9 vs. 1.8 kg), fruit + crown weight (2.2 vs. 2.1 kg), ° Brix (11.1 vs. 10.8), lower acidity (0.345 vs. 0.329) and fruit equatorial diameter (12.7 vs. 12.5 cm). In regard to planting densities, the best one resulted to be 30 thousand plants ha^{-1} because it showed: fruit weight (2.169 kg), fruit + crown weight (2.419 kg), and ° Brix (11.169). For variables determining fruit shape (fruit diameter and length), all three planting densities produced fruits that meet domestic market requirements. It is concluded that plastic mulching with planting density of 30 thousand plants ha^{-1} showed the best results for fruit weight and some of the fruit quality components.

Short Cycle Crops Interplanted to Pineapple: an Option to Increase Productivity

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The human population overgrowth and environmental deterioration are two reasons why pineapple growers are forced to use in a better way their resources in order to satisfy their food demand and also to produce in excess for the market. By doing this they attempt to increase their production diversity and their economic profitability. Because of the long cycle of pineapple crop a certain group of growers –mainly those with scarce resources- foresee the opportunity to get cash income in a shorter period of time by growing short cycle crops interplanted to pineapple. With the purpose to improve these intercropping systems, INIFAP carried out several trials in: hot "jalapeño" pepper (*Capsicum annum* L.), dry beans (*Phaseolus vulgaris* L.), corn (*Zea mays* L.), and tomato (*Lycopersicon esculentum* Mill.) intercropped to pineapple. For each crop species some of the following components were evaluated: varieties, planting densities, topologic arrangement, fertilizer rates, chemical weed control, and profitability. Pineapple planting density was 35,000 plants ha^{-1}. Results showed that intercropping should be done by the 30th day after planting the pineapple. Varieties of the intercropped species did not affect pineapple, so the most productive ones already evaluated in this region should be used. Planting density and topologic arrangement vary according to crop species, but excess of pineapple shadowing should be avoided: hot "jalapeño" pepper, two rows along the wide stripe only; for tomato and corn, only a row along the wide stripe; and for dry beans a row each for both the wide and narrow stripes. Fertilizer rates are: 150-100-60 kg ha^{-1} of N, P and K for either hot pepper or tomato; 120-46-30 for corn and 46-46-30 for dry beans. The more efficient herbicides are: Metribuzin 0.4 kg ha^{-1} for tomato, Linuron 1.5 kg ha^{-1} for dry beans and Atrazine 3.0 L ha^{-1} for corn. The benefit/cost ratio was best for intercrops than when they were alone. It is concluded that with a good crop management a good fruit production and quality of pineapple is obtained; furthermore, intercropping benefits the short cycle crops, since pineapple protects them from heavy and intense rain and wind, and also some management practices and some inputs are shared by both crops so reducing costs.

Slip Production of Md-2 Hybrid Pineapple by Using Three Methods: Gaulling, Leaf Pruning and a Growth Regulator

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MD-2 hybrid pineapple is being highly demanded for the fresh export market, this allows it to get higher prices and better sale opportunities than those for Smooth Cayenne. Nevertheless, this material is still very scarce in Mexico, and that is why pineapple growers have shown an increasing interest for the multiplication of this hybrid. The objective of this study was to evaluate three methods of enhancing slip production: gaullin, leaf pruning and growth regulators. The levels tested for each method were: gaullin vs non gaullin; for leaf pruning: a) slight lateral leaf pruning, b) severe leaf pruning plus half of the stem (down to soil surface), and c) no leaf pruning; growth regulator levels were: Ethephon + Ciclanilida application at rates 0, 3.0 and 6.0 L ha^{-1}. The experiment was carried out at "Campo Experimental Papaloapan". MD-2 hybrid pineapple plants with an average weight of 400 g were chosen and set at a planting density of 140 thousand plants ha^{-1}. Experimental design was a randomized complete blocks in split-split-plots. Variables evaluated were: number of days to bud break, number, size and weight of slips. Slips were excised at 60, 90, 120 and 150 days after treatment application. Up to this date only partial results are available. It however, can be concluded that at 150 (DATA) gaullin of MD-2 hybrid plants was the best treatment by 86 % against the untreated plants. Regarding leaf pruning, the severe one caused the death of 35 % of the plants; growth regulator at 3.0 L ha^{-1} gave better results than either the higher rate or untreated plants. The interaction between gaullin x no leaf pruning x growth regulator at 3.0 L ha^{-1} was the best treatment with 2.5 slips/plant vs. 0.4 slips of those treatments where plants were not submitted to gaullin.
Ed note: It was confirmed that gaullin is a mistranslation. The correct term in gouging.

8. Postharvest Technology

Effect of Antioxidants on Postharvest Quality Attributes of Fresh-cut Pineapple

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Treatments to control colour changes, microbial spoilage and other quality attribute of fresh-cut pineapple were evaluated. Pineapple slices were dipped in solutions containing ascorbic acid (AA), 4-hexylresorcinol (4-HR) and ascorbic acid + 4-hexylresorcinol (AA+4-HR); packed in a modified atmosphere (MAP) and stored at 10 C. Samples were evaluated for colour changes, microbial spoilage, total soluble solids, total titratable acidity, total sugars, reducing sugars, firmness, carbon dioxide and ethylene concentrations. While separate treatments with AA or 4-HR controlled browning and maintained quality of fresh-cut pineapples slices in conjunction with MAP for 2 days at 10C, the combined treatment of 300 ppm AA+ 200 ppm 4-HR proved most effective in browning inhibition and microbial spoilage over the longer storage period.

Fruit Calcium Concentration and Chilling Injury During Low Temperature Storage of Pineapple

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Overall calcium levels in fruit and calcium distribution in different parts within fruit were recorded in the Queen type Mauritius variety and the Caynne type Kew variety of pineapples. Calcium was measured before and after storage where

fruits were held at 10°C for 17 days followed by 2 days at ambient (28±2°C). Total overall calcium concentrations were significantly ($p<0.05$) higher in Kew pineapple compared with Mauritius. This difference corresponded to a significantly ($p<0.05$) lower incidence of chilling injury in the former. Calcium within fruits at harvest was significantly ($p<0.05$) higher in the shell region for both varieties. Browning symptoms associated with chilling injury were observed in the core and flesh regions adjacent to core, where lower concentrations of calcium were recorded. Chilling injury was minimum in flesh near the shell, where calcium concentrations were significantly ($p<0.05$) higher. Following storage, calcium concentration in the core and flesh regions had decreased while significant ($p<0.05$) increase in concentrations were recorded in the shell region of the susceptible Mauritius variety. Pre-harvest calcium treatments were then tested on the chill sensitive Mauritius variety pineapples to increase fruit calcium concentration and thereby control chilling injury. Calcium chloride spray treatment of 1.3g and 2g per fruit applied in three split doses was effective in reducing chilling injury to commercially acceptable levels. Post storage calcium concentration in core and flesh regions of these fruits was significantly higher ($p<0.05$) than in untreated fruits. Soil side dressings of CaO and $CaSO_4$ at 10 and 15g per plant applied to the soil 6 weeks after planting were observed to be less effective in controlling the disorder. Calcium concentration in such fruits was significantly ($p<0.05$) less than in fruits subjected to the $CaCl_2$ spray treatment.

Utilization of Waxing and Periodic Rewarming on Chilling Injury of Pineapples During Cold Storage *Ananas comosus* cv Cayena Lisa

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Periodic rewarming of tropical fruits has been used to reduce the physiological stress of the products during cold handling. In this study pineapple fruits (*Ananas comosus* cv Cayena lisa) with a ripening grade of 1:2 and 1.3-1.7 Kg weight were separated into two lots, one waxed (Bayleton wax, 500 mg/L) and one unwaxed control. Sub-lots of these fruits were stored, and at 25°C, the latter as a ripening control. Half of the fruits stored at 6 and 12°C were warmed for one day each week at 25°C, and then returned to cold storage. After 5 weeks of storage, weight losses were car. 1% less for fruits treated by wax coating and periodic rewarming than for control fruits. Wax coating did not have a significant effect on soluble solids or pH of the fruits. However, waxing retarded the loss in tissue integrity (electrolyte leakage) in both fruits stored at constant temperature as well as those subjected to periodic rewarming. Ascorbic acid was lost to a greater extent in unwaxed fruits than in waxed ones. After cold storage, pineapples were allowed to ripen at 25°C and symptoms of chilling injury were evaluated. Fruits stored at 6°C showed less chilling injury than those held at 12°C. Both wax coating and rewarming treatments extended the shelf life of cold stored pineapple by reducing the incidence of chilling injury. Rewarmed, wax-coated fruits kept at 6°C ripened normally after 36 days storage, compared to untreated fruits at 12°C which displayed the dark heart defect after 22 days.

1-mcp Controls Chilling Injury of Pineapple

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"Queen" pineapple were treated with 1-methylcyclopropene (1-MC), to examine its effect of chilling injury and fruit quality. Internal Browning (IB) is an important physiological disorder caused by cold storage. Following our discovery that 1-MCP at 100 ppb effectively controls IB in pineapple at 10°C, we have now extended our work to determine the conditions required for MC P treatment. Thus we found that MCP is equally effective when applied at 10°C and 20°C; 10 ppb is as effective as 100 ppb; but 1 ppb gives only 60-80% of the control of IB shown by higher concentrations. The effectiveness of 1 ppb 1-MCP is raised by increasing the temperature of treatment. 1-MCP is potentially a powerful tool in pineapple post-harvest management.

Physical and Mechanical Parameters Evaluated on R*ed Spanish* Pineapple Fruit to Determine its Susceptibility to Mechanical Injuries

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Mechanical and physical properties of *Red Spanish* pineapple variety were evaluated in order to determine the relationship between those properties and the mechanical injuries caused to fresh fruit during harvesting and handling. The research was performed on the area of piña Enterprise in the province of Ciego de Avila during two years. Fresh fruit samples at two maturity stages were used for evaluation purposes. The following parameters were measured: weight, equatorial diameter, height, flesh firmness strength and maximum height from which fruits were let to drop onto three different surfaces. Analysis of correlation and main components for the main parameters were carried out.

Influence of Ethephon (2-choloroethyl Phosphonic Acid) Plus K_2so_4 on the Process of Ripening and Reducing of Internal Browning of Pineapple *Ananas comosus* (L) Merr Cv. Mauritius Under Cold Storage Conditions

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Effects of preharvest treatments during 1- 4 weeks before estimated harvest with 5% K_2SO_4, 5% K_2SO_4 + ethephon (10ppm), and Etherphon (50ppm and 100ppm) sprays on ripening and internal browning, were studied in "Mauritius" pineapple. At five percent level of K_2SO_4 + Ethephon(100ppm) sprays, 4 weeks before harvest increased the fruit quality such as TSS, K content, flavour and shortened the harvest period by 5-7 days. Time of application influenced on the fruit maturity by spraying with K plus ethephon (50-100ppm) 4 week before harvest. Thus, interaction between time of application and the levels of concentration of K_2SO_4 + Ethephon influenced on TSS, internal browning and harvest period. At 5% K_2SO_4 + Ethephon (10 ppm) spray 4 weeks before harvest did not influence on fruit size, yield, and pH. However, titratable acidity (TA), total soluble solids (TSS) and TSS/TA ratio increased by applying with Ethephon (100 ppm) spray 4 week before harvest.

Effects of Pre-harvest Treatments of Potassium, Post-harvest Treatments of Calcium, Hormones and Light on Reducing Internal Browning (Ib) in Pineapple (Ananas comosus cv Mauritius) under Cold-storage

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Laboratory investigations were carried out to test the hypothesis that internal browning and accumulation of malic acid in pineapple result from activation of Crassulacian acid metabolism (CAM) in crown leaves and in bracts of the fruit-peel during the dark cold storage. Accumulation of malic acid in the fruit after harvest was decreased or minimized by spraying with 5% Ca(OH)2 plus 10ppm abscisic acid under the light condition. The treatments arranged in a split plot design, consisted of pre-harvest treatment of 5% K2SO4 sprays in combination with post-harvest treatments of 5% Ca(OH)2 sprays, 10ppm Abscisic Acid plus wax sprays under the exposure of fruits to the light (2000 lux) 20°Cfor 24 hours. Pineapples were stored in corrugated paper cartons for 1-4 wks periods in a cold room (at 10°C and 80-85% RH), to reduce fruit core tissue deterioration and internal browning (IB). Malic acid in the crown leaves was significantly reduced with pre-harvest application of 5% K2SO4 and with post-harvest application of 5% Ca(OH)2 in combination with 10ppm Abscicic Acid (ABA) plus commercial wax sprays (10ml) onto the whole fruit (crown + fruit) before storage. Significant reduction of malic acid content, fruit-core tissue deterioration and IB were achieved by exposing the whole fruit to the light for 24 hours at 20°C before cold storage. These results indicate that K2SO4 significantly increased the flesh firmness while Ca(OH)2 plus ABA and wax sprays decreased the moisture loss and malic acid content in the crown leaves and in the fruit.

Effects of Post-harvest Treatments of Malic Hydrazide Plus Paraffin-polyethylene Wax and Exposure to the Light on Reducing Internal Browning (Ib), and Malic Acid Accumulation in Pineapple *Ananas comosus* (L.) Merrill Cv. Mauritius During Cold-storage

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Laboratory investigations were carried out to test the hypothesis that Internal Browning and accumulation of malic acid in pineapple result from activation of C*rassulacean acid metabolism* (CAM) and deficiency of K in the fruit and the crown during cold storage. Accumulation of malic acid in the fruit after harvest was inhibited spraying with *malic hydrazide* before exposing of fruits to the light for 24 hours at 2000 lux at 20°C. The treatments arranged in a randomized complete block design, consisted of the pre-harvest spraying with 5% K_2SO_4 followed by the post-harvest sprays with 5% $Ca(OH)_2$ in combination with 10ppm *malic hydrazide* plus wax sprays. Fruits were then exposed to the light for 24 hours and stored in corrugated cardboard cartons for 1-4 weeks in a cold room at 10°C and 80-85% R.H to reduce fruit core tissue deterioration and internal browning (IB). Fifty to sixty percent of malic acid contents in the crown leaves and the flesh were significantly reduced by applying with 5% $Ca(OH)_2$ plus 10ppm malic hydrazide before storage. Thirty to forty percent of malic acid contents in the fruit and the crown has decreased with the application of commercial wax sprays in combination with exposing of fruits to the light for 24 hours at 20°C. Significant changes in total soluble solids (TSS), K^+ contents, fruit-core tissue deterioration, firmness, taste, flavour and shelf-life of pineapple fruits were observed during cold-storage from 1 to 4 weeks. These results indicate that applications of *Malic Hydrazide* plus wax sprays have significantly reduced the moisture loss and malic acid accumulation in the crown leaves and the fruit.

Concentrations and Application Methods of Ethephon on the Control of Rind Color and Quality of 'Pérola' Pineapple Fruits Directed to Domestic Markets

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In most Brazilian production regions 'Pérola' pineapple fruits are harvested at the green-ripe stage (green rind, shallow and pale green colored fruitlets at the base), but many buyers have demanded fruits with a more yellow rind, that is more attractive to the consumers. To obtain a yellow colored fruit without affecting its general quality, was the main objective of this study carried out at a commercial pineapple orchard in the semi-arid region of Itaberaba, Bahia, Brazil, and at the laboratories of Embrapa Cassava & Fruits at the beginning of year 2001. Using a completely randomized experimental design, were studied 5 concentrations of ethephon (0, 500, 1000, 2000 and 4000 mg/L) and 3 application methods of the aqueous solution of this plant regulator, one at the pre-harvest stage (A – narrow jet directed to one fruit side, applied 4 days before harvest by using a plastic bottle with a fine hole on its cap) and two right after picking the fruits (B – spraying over the fruits picked up and placed into a harvest basket ; C – fruit dipping into the ethephon solutions for 10 seconds without touching the crowns). The fruits were stored under ambient conditions (25 ± 2°C) and evaluated with respect to physical, chemical and physical-chemical variables for a period of 10 days. The dipping treatment resulted in a faster and more uniform yellowing of the fruit rind. At 1000 mg/L or more of ethephon, fruits stored under ambient conditions of high temperatures typical for the Brazilian summer season, presented a yellow color on more than 75% of their rind area within 4 to 5 days after harvest and conserved their characteristics appropriate for fresh consumption during a minimum period of 9 days.

Control of the Apparent Maturation and Fruit Quality of 'Pérola' Pineapple under Different Storage Conditions

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The 'Pérola' pineapple fruit is highly consumed in Brazil due to its great eating qualities, but its export volumes have been rather low. A more yellow and less green color of its rind and the conservation of its quality during the transport and commercialization period, basic demands for increasing its competitiveness in the international market, were the objectives of this work. Fruits harvested in the semi-arid region of Itaberaba, Bahia, in the main production season (October/November 2000) and taken to the laboratories of Embrapa Cassava & Fruits, Cruz das Almas, Bahia, Brazil, were dipped for 5 minutes into water solutions of ethephon at 0, 500, 1000, 2000 and 4000 mg/L and stored under ambient conditions (CA) (25 ± 2 °C), in a refrigerated room (CR) at (10 to 12 °C, RU > 80%) (experiment I), as well as in a refrigerated room at 21 °C followed by their transfer to CA (experiment II). Fruits were evaluated weekly during 35 days, at the moment of removal from the refrigerated rooms and also 7 days after their transfer to CA, with respect to physical, chemical and physical-chemical variables and visual aspects. The fruits, treated or not with ethephon, did not change to a yellow rind under CR (10 to 12 °C). Under CR at 21 °C the yellowing was slow (8 days for ethephon at 4000 mg/L and >13 days for the control), whereas under CA this occurred within 4 to 5 days and 10 days, respectively. Fruits under CA kept their appropriate consumption quality for a maximum period of 7 to 10 days after harvest and the ethephon treatment, whereas under CR (10 to 12 °C) the quality conservation was good for 28 days, independently of the ethephon concentration used. Fruits transferred from CR to CA followed about the same pattern of changes of rind color and other quality aspects observed for the fruits not refrigerated.

The Use of the Flottweg Belt Press for Increased Yield and Quality of Pineapple Juices

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Very few changes or advances have been made in pineapple juice production methods in the last 50 years. This is in stark contrast with other fruit juice industries such as apple juice production which has fully modernised in the last 10 years. Even though pineapple juices (beverage juice, mill juice, etc) can make considerable money for canneries, they are generally seen as a low priority and consequently, antiquated, high cost, low yielding processing equipment and methods are still commonly used in their production. Over the last 5 years, Flottweg has developed new and novel applications using her belt presses in the pineapple industry and has subsequently installed belt presses in many pineapple canneries in Asia, Africa and Hawaii. In most cases, Flottweg belt presses have been installed in existing pineapple canneries to get extra juice out of waste materials (centrifuge & decanter sludges, wet cakes and skins) and or to improve quality (eg; higher quality mill juice) – in all cases with very fast investment paybacks. In some new pineapple canneries, Flottweg belt presses have been installed in completely novel processes that are cheaper, simpler and higher yielding than traditional pineapple juice extraction systems. This paper will outline the way our pineapple cannery clients have improved yields and changed their processes and factories using Flottweg separation technology and thus modernised their plants and enhanced their own profitability.

Preservation Of Pineapple Fresh-cut

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The present work was required by Ciego de Avila pineapple Enterprise. The purpose of the present work was to evaluate different products for pineapple fresh-cut preservation. 40-42 sizes of fresh pineapple fruits, which are normally rejected by the canning industry and the fresh fruit consumer, were used. The best results were obtained when the preserved pineapple slices were treated with Calcium Chloride, Sodium Bicarbonate and Sodium Metabisulfite, packed in plastic containers. With this process the preserved pineapple fresh-cut had a shelf life longer than 15 days.

Establishment of a Quality Certification Procedure for the Pineapple Industry of Martinique

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Food safety, environmental protection, "follow up" of products and quality improvement are facts that civil society recognizes to individuals actively engaged in the pineapple industry of Martinique. A deep modification of the crop production systems and the pineapple processing factory is under implementation to accomplish consumer demands. "Reasonable" agriculture will allow a drastic reduction of pesticide use. New pineapple varieties better adapted to the new process (aseptic crush and chunks) will allow improving and making unique the production for the international market. "Agriconfidence" certification for production and ISO certification of the processing factory guarantee the "follow up" of products and food safety. The PRAM (Cirad-Flhor) and the Martinique Agriculture Bureau actively support the modifications of the pineapple industry by developing specific research programs and for professional assistance. Development of new varieties and hybrids, "clean" crop production technology, harvest forecasting and quality analysis are fields where researchers and technicians are daily required to provide professional assistance in Martinique and the Caribbean region.

9. Simulation Models

Mechanized Pineapple Production

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The worldwide information was sourced to get a comprehensive list of field machinery used in the production of fresh pineapples. The machinery component for every field operation was weighed for their relevance and purchase was made for those that were needed. A test plot was acquired where the performance testing and adjustment-modification-evaluation of the machines were made. Descriptions and pictorial presentatons on the farm layout, machines and the results of the tests are presented for information sharing.

Determination of the Variables to Use in the Predict of the Pineapple Production to Cultivate Cayena Lisa

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In the pineapple enterprise of Ciego de Avila. A series of experiments in the cultivar pine Cayena Lisa was realized during the years 99-2001. The final objective being to identify the part of the plant which can beutilized for the establishment of prediction methods for the final weight of fruits and possible lost of production. There were also studies on the vegetative and reproductive component. The diameter and height of the inflorescence and peduncule were fundamental elements of the plant better relationed with the final weight of fruits and can be used in de estimation method in the some way they should be used as variable in the regression method. The final weight of fruits , together with the population, effectively of inclusion on the lost of the fruit , allows for a precise prediction in the production of an area, with results economically and operatively more feasible, along with the use of simple equation.◆

Notices

Web Sites of Possible Interest

1. The Malaysian (MARDI) website can be seen at http://www.mardi.my. Working being done in horticulture at

MARDI can be seen by following the Horticultural Crop Research link.
2. Grant Joyce has an interesting website of his farm and surrounding area in Antigua, W.I. at http://www.claremontfarms.com..◆

Commercial Services

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

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

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