Pineapple News

Newsletter of the Workgroup Pineapple, International Society for Horticultural Science
Issue No. 23, July, 2016

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Pineapple Working Group News

From the Editor

Dear Colleagues:

IX International Pineapple Symposium will not be held in Costa Rica

See below details about the cancelation from Workgroup Pineapple Chair Domingo Haroldo Reinhardt.

Thanks

I wish to extend my thanks to all who continue to contribute to and support Pineapple News. As a result of the many interesting contributions provided by "Pineapple People" throughout the tropics over many years Pineapple News celebrates its 23rd year of helping to keep readers informed about the many issues related to pineapple. With the continued support of all those "People", we will meet again in about a year.

Pineapple taxonomy & cultivar naming

The taxonomy of pineapple was greatly simplified in 2003 (Coppens d'Eeckenbrugge and Leal, 2003) and a recent tweak has made it possible for Coppens d'Eeckenbrugge to declare below in **News from France** that it is *The Last Revision of Pineapple Nomenclature*. While the taxonomy of pineapple appears to have been clarified and solidified, the naming of pineapple cultivars remains a serious problem. Many of the problems are encountered in research papers on pineapple published in English by authors who identify experimental material by local or trade names rather than by the cultivar name.

Technically a cultivar has only one correct name and it is the cultivar name that joins new research results to the body of literature that includes all relevant publications about a pineapple clone or cultivar. I don't have the expertise to declare this to be a unique problem with pineapple. However, it is certainly unique when compared with temperate fruit crops and I speculate that the problem with pineapple is partly related to its discovery and its wide distribution in the early years after discovery. The three main cultivars, 'Queen', 'Smooth Cayenne' and 'Spanish', lost whatever names they might have had when early explorers took them from their country of origin. Using 'Smooth Cayenne' as an example, it acquired new names as it was dispersed throughout the tropics and brought to Europe and Great Britian (Collins, 1950). It was first named Cayenne Lisse in France, became 'Smooth Cayenne' (the English translation) in Great Britian, Kew when the English took it to India and Sarawak when it was taken to Malaysia. More recently papers published by researchers from Thailand show it has acquired new names in that country. In addition, there are multiple named clones for each of the three cultivars mentioned above that are often treated as cultivars even though no formal description was published to support the new name.

The first article below was written to identify some of the recent problems with cultivar naming and provide recommendations that, if followed, will provide a strategy to reduce the problem of misnamed cultivars. The proper naming of a cultivar allows research on it to be linked to all other research on the cultivar while incorrect naming relegates such research to some obscure corner where it may or may not be found.

The second article below highlights what has been done to date to publish the names of new pineapple cultivars, introduces a plan to involve the ISHS Workgroup Pineapple in supporting a cultivar naming effort and introduces a list, by country, of pineapple cultivar names and at least some of their synonyms. It is hoped that Workgroup Pineapple members will support these two efforts to assure that pineapple cultivar descriptions are publicly available ant that there is easy access to synonym names in hopes that both efforts will insure that cultivars are properly named in research papers.

Pineapple News also now available without a log in at Univ. of Hawaii Scholar Space

https://scholarspace.manoa.hawaii.edu/handle/10125/41067

Duane P. Bartholomew

Reference

Collins, J.L., 1951. Notes on the origin, history, and genetic nature of the Cayenne pineapple. Pacific Sci 5:3-17.

Proceedings of the 8th International Pineapple Symposium

Acta Horticulturae 1111 (http://www.ishs.org/pineapple) lists the papers, including abstracts, that were presented at the VIII International Pineapple Symposium. Because the 8th International Pineapple Symposium was part of the XXIX Horticultural Congress held in Brisbane, Australia in 2015, the Acta volume that contains all of the papers on pineapple that were submitted for the proceedings also contains the papers on guava and mango. The above page also provides a link to all back issues of Pineapple News under the heading THIS WORKGROUPS PAGES.

Proper Naming of Pineapple Cultivars: Problems and Recommendations for Improvement

D.P. Bartholomew

As a referee of papers on pineapple submitted for publication in technical journals and as an editor of papers and proceedings of the various international pineapple symposiums I have become concerned about the lack of standardization in the naming of pineapple cultivars. Clones of a known cultivar and local names based on geographic location or to attract consumers are not cultivar names and should not be used in published research papers unless they are accompanied by the cultivar name.

Using the correction name of a cultivar connects new research to the body of published literature, which allows others interested in the cultivar to easily locate all of the published research on the cultivar. See below that proper identification of pineapple cultivars is also a concern of others.

> Coppens d'Eeckenbrugge (2014). A widely accepted plant nomenclature, based on precise identifications and descriptions, is essential in defining properly the objects of our scientific and economic activities and making it possible to understand each other and compare results.
>
> Zhou et al. (2015). However, the exchange of vegetative planting materials has also resulted in problems for conservators of pineapple germplasm because records and labels of the cultivars have not always followed the same naming conventions, and accessions have limited information about their correct identity. Therefore, homonyms and synonyms are common among the names of pineapple cultivars and that restricts the sharing of information and materials among pineapple researchers and hampers the use of pineapple germplasm in breeding. Another major challenge for pineapple cultivar identification is that the protracted vegetative propagation has led to the accumulation of somatic mutations. Some mutations caused noticeable phenotypic effects and created intra-cultivar variation, which became the target of clonal selection. While these selected mutants are important in horticultural production, it is necessary to identify them so that breeders and genebank curators can efficiently conserve and use these genetic materials.

In some cases the solution to the problems are obvious. In all cases using the correct cultivar name is the responsibility of the author(s). The proliferation of scientific journals in the current era of rapid review and publication on the World Wide Web makes it nearly impossible for reviewers and editors to focus on the proper identification of a cultivar. Improvement can only come if there is an organized effort to bring order out of the chaos of names.

Examples of cultivar identification problems

Use of local or clone names to identify a cultivar:

- 'Pérola', 'Queen' and 'Smooth Cayenne' have been given various synonyms in multiple countries. The greatest proliferation of such names is relatively recent and mainly in Asia and Africa.

- Sugarloaf and assorted variations of it (Sugar Loaf, sugarloaf), probably in most cases 'Pérola', have been used in the Caribbean for generations. Collins (1960) stated that Sugar Loaf does not refer to a specific variety and Johnson (1935) lists eight varieties that have Sugar Loaf as a synonym. Sugar Loaf, or its French translation, Pain de Sucre, is used in research papers by authors from Benin, Ghana and Malaysia.
- 'Smooth Cayenne' (first mentioned as 'Cayenne lisse' in 1820; as Smooth Cayenne in 1886), also known as 'Kew' in India (first published reference in 1942) and 'Sarawak' (first published reference in 1937) in Malaysia, also has several named clones that are treated by some authors as cultivars. In publications from Thailand synonyms treated as cultivars include the local names Lakata, Pattavia, perhaps Bathavia, Singkapropattavia, Petburi No. 2 and Nanglae (said to be regional sub-variety of Pattavia. In some cases what are listed by authors as cultivars may be varied spellings of the same Thai name.

Inconsistent naming of cultivars

- See above regarding inconsistent naming of what probably are 'Smooth Cayenne' clones in Thailand.
- Even minor name changes can be confusing and limit access to publications. For example, Pérola and Pearl (the latter the English translation of the name) and Fantástico and Fantastic have been used in papers published by authors from Brazil. Fortunately, database searces for Pérola and Perola return the same 217 references while that isn't the case for Pérola and Pearl.
- 'Victoria' and 'Queen Victoria', not to be confused with'Vitória'(also called 'Victoria' in a paper from Brazil), a cultivar developed by Embrapa (Brazil), from a cross between 'Primavera' and 'Smooth Cayenne' (Bartholomew et al., 2010), are used interchangeably in references originating in Mauritius, Reunion and South Africa. Based on the publication history, they are the same 'Queen' clone, first referred to as 'Queen Victoria' in Mauritius in 1972, referred to as Victoria there in 2001, named Victoria and described in Reunion in 1976 and varyingly referred to thereafter as 'Victoria' and 'Queen Victoria' in Reunion and South Africa. To add to the confusion, a Queen Victoria RE43 was reported in Côte d'Ivoire in a 2013 publication.

Naming cultivars developed in countries that do not use the Roman alphabet, e.g., Taiwan

- Tainung cultivars. These hybrids were developed in Taiwan. They have been identified as TN followed by the number and 'Tainon No. etc.' by Taiwanese authors and as 'Tainong No. etc.' in papers by Chinese authors. Minor variations in spelling of the Tainung cultivars can cause confusion and inconsistent search results. The problem is in the translation from the Chinese because when using https://translate.google.com/, Tainung and Tainong result in the same character (logogram) set.

Typographical error/misspelling

- Moris ('Queen') In a few instances the clone is misspelled as Morris.
- 'Josapine' (a name remembering the parents of this Malaysian hybrid: 'JOhor' x 'SArawak'). Josephine was used in an abstract and in a recent paper.

General recommendations:

1. Papers reporting the results of research on pineapple in a language using the Roman alphabet that do not correctly identify the cultivar must be returned to the author(s) for correction.
2. Authors should use the earliest correct name of a cultivar because it takes precedence and avoids confusion. A complete clone and cultivar list is being prepared as a guide (see *A New Source of Pineapple Cultivar Names and Descriptions* below).
3. For countries that use the Roman alphabet, the correct cultivar name is the name in the language of the country, e.g., Pérola, not Pearl.
4. Standardize the translation of cultivars developed in the Asian countries that use characters (logograms) instead of the Roman alphabet.
5. When referring to a local name or a clone of a known cultivar, authors should follow the practice described by Coppens d'Eeckenbrugge et al. (1997), which is to provide the local or clone name along with the cultivar name, for example, Victoria ('Queen'), Sugar Loaf ('Pérola'), Champaka F-153 ('Smooth

Cayenne'). No "cv" prefix or single quotation marks are used around the clone or local names because they are not cultivars.

Acknowledgement: Thanks are due to G. Coppens d'Eeckenbrugge and G. Sanewski for their helpful editing and suggestions.

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Johnson, M.O., 1935. The Pineapple. Paradise of the Pacific Press, Honolulu.

Zhou, L., Matsumoto, T., Tan, H., Meinhardt, L.W., Mischke, S., Wang, B., and Zhang, D., 2015. Developing single nucleotide polymorphism markers for the identification of pineapple (Ananas comosus) germplasm. Horticulture Research 2:(25 November 2015).

New Sources for Pineapple Cultivar Names and Descriptions: Contributions from "Pineapple People" Invited

D. P. Bartholomew, G. Coppens d'Eeckenbrugge and G. M. Sanewski

The American Society for Horticulture Science (ASHS) has quite a long history of publishing cultivar names and descriptions of fruits and nuts in the journal HortScience (Cummins, 1994). Brooks and Olmo (1997) published a compendium of fruit and nut varieties that included the descriptions of the pineapple cultivars CO-2, Smooth Cayenne and Spanish Jewel. The description of Smooth Cayenne included Pineapple Research Institute of Hawaii hybrids '53-116' and '59-656' that should have been listed under their own headings.

No recent compendiums of fruit and nut varieties have appeared since 1997. However, HortScience continues to publish Fruit and Nut variety descriptions every two years. Pineapple has not been well represented in the HortScience Register until recently. In 2009 a list of 17 cultivar descriptions were included in Register of New Fruit and Nut Cultivar List 45 (Bartholomew et al., 2010; see list at http://hortsci.ashspublications.org/content/45/5/716.short). No pineapple cultivar descriptions were contributed to Lists 46 and 47 but an additional 10 cultivar descriptions were contributed to Register of New Fruit and Nut Cultivar List 48 (Bartholomew et al., 2016; see list at http://hortsci.ashspublications.org/content/51/6/620.full.pdf+html). While the HortScience lists are freely available, we are hoping to develop a complete alphabetical list, including photographs, which would provide a more efficient way to access pineapple cultivar descriptions.

Searchable List of Pineapple Cultivar Descriptions

If the "Pineapple People" (Butcher and Gouda, 2014), i.e. the Pineapple Working Group of ISHS (http://www.ishs.org/pineapple), can promote and sustain an effort to publish cultivar information in HortScience, we should soon have a relatively complete list of pineapple cultivars of some commercial importance on national and international markets. Our objective is to create an on-line searchable list of the commercially important cultivars and clones as well as those that are considered to be valuable parents in a pineapple breeding program.

Factsheet to Guide Preparation of Pineapple Cultivar Descriptions

We also plan to develop a cultivar factsheet that can be used to submit information about new cultivars that should be added to the HortScience Register of Fruits and Nuts. Once the factsheet has been developed it will share with readers by email to the Pineapple News mailing list.

Inventory of Diverse Pre-Columbian Pineapple Materials

We also propose to find collaborators who will be willing to help develop an inventory of the highly diverse pre-Columbian materials, marketed at small scales in tropical Latin America. This is expected to require considerable time and be difficult as they are most often mentioned only in the grey literature so accurate descriptions likely would need to be developed. The Factsheet referred to above will be developed with this objective in mind.

Development of an On-line List, by Country, of Pineapple Cultivars.

In support of the above efforts, D.P. Bartholomew searched through the pineapple reference database, now containing over 10,000 references, by country and cultivar and collected a large number of cultivar and synonym names. The names, by country, have been accumulated in a spreadsheet that was reviewed by the co-authors and their additions and corrections have been included in the list. The list can be viewed at: https://docs.google.com/spreadsheets/d/1NDr9v3FSZLP8W3m9rYhScErrxed8vEc7f8meDyLXEmg/pubhtml and contains the following information:

1. Names of cultivars and hybrids found in the published literature from that country.
2. Parents of hybrids where known.
3. Synonyms, clones, local names used for the cultivar in the country.
4. The earliest reference that named the cultivar or contained information about it.

What Can Readers Do

1. Help keep the published list of pineapple cultivars current. G. M. Sanewski (garth.sanewski@daff.qld.gov.au) has agreed to lead and coordinate this effort. He will develop a Factsheet to be used in developing pineapple cultivar descriptions that conform to the guidelines of HortScience. If you or someone you know is developing new pineapple cultivars to please contact G. M. Sanewski.
2. Help develop an inventory of Pre-Columbian pineapple materials currently being grown in Central and South America. Please contact G. Coppens d'Eeckenbrugge (geo.coppens@cirad.fr) if you can help with this project.
3. Help maintain a current by-country database of pineapple cultivars and their synonyms. The final objective for the list would be to have it contain the names of all cultivars that are considered to be important commercially or as parents in breeding programs. Please contact D.P Bartholomew (duaneb@hawaii.edu) with additions and corrections to the spreadsheet.

References

Bartholomew, D.P., G. Coppens d'Eeckenbrugge, G., and C.C. Chen. 2010. Register of New Fruit and Nut Cultivar List 45 (Pineapple, pp. 740-742). HortScience 45:716-756.

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News from Brazil

IX International Pineapple Symposium – Plans for Costa Rica Canceled

Domingo Haroldo Reinhardt, Chair, ISHS Workgroup Pineapple

Contacts done by the ISHS Workgroup Pineapple (WGP; http://www.ishs.org/pineapple) after the last IPS held in Brisbane, Australia, in late 2014 led to the identification of the convener (Dr. Luis Pocasangre) and the institution (University Earth) to coordinate the organization of the IX IPS in Costa Rica, one of the largest producers and the leading exporter of fresh pineapple in the world. Until very recently everything seemed to be all right and the agreement with ISHS was underway. However, on July 19 WGP received a letter from Dr. Pocasangre communicating that he and Earth University are canceling theit intention to organize the event in Costa Rica due to the risk of introduction of the Tropical race 4 strain of *Fusarium oxysporum f. sp. cubense (FOC)*, pathogen of Panamá wilt, which is known to be the most devastating disease of banana plantations in Asia , has recently shown up in Africa, but has not yet been detected in the Americas. Pineapple production in Costa Rica is found in the same region where the main banana production occurs and the big players are mostly the same companies.

PWG has started contacts to define a new site for the event. The preference would be for a country in the American continent, but international concerns about FOC may favor the event location to be focused in a country where that disease is already present or where banana is not an important industry.

Any news on this will be communicated to the WPG and Pineapple News mailing lists. Any useful contribution is welcome and should be sent to Prof. Duane Bartholomew (duaneb@hawaii.edu) and Domingo Haroldo Reinhardt (domingo.reinhardt@embrapa.br).

VI Brazilian Pineapple Symposium

Stella de Castro Santos Machado, Geraldo Chaser Tavares, Aristoteles Pires de Matos, Domingo Haroldo Reinhardt

The VI Brazilian Pineapple Symposium was held under the theme "strengthening the pineapple industry with social and environmental responsibility", in Conceição do Araguaia, Pará, North Brazil, from 11 to 13 November 2015. That is a region where more than 450 thousand metric tons of pineapples are being produced every year by more than a thousand growers mainly under conditions of family agriculture.

There were 700 participants, mostly farmers, researchers, rural extension specialists, teachers and students, all with great interest in recycling and updating their knowledge on pineapple. The participants came from 74 pineapple producing municipalities of eight Brazilian states (Acre, Pará and Tocantins in the North, Bahia, Maranhão and Paraíba in the Northeast, Mato Grosso in the Center-West and São Paulo in the Southeast).

The main themes addressed at the symposium were mechanization, integrated management of pests, climatic changes and their impacts, organic farming, harvest and post-harvest handling. Several interesting round table debates were carried out focusing on the improvement of public policies in support of the pineapple industry, from production to marketing. On the evenings participants and local inhabitants could taste typical regional music and pineapple-based food.

The event was closed with a Field Day carried out at 'Pérola' pineapple fields of a typical small farmer's settlement with demonstrations on sprinkler irrigation systems, mechanized planting and pest control procedures with emphasis on fusariosis. The organizing committee formed by a partnership between Embrapa, Federal Institute of Pará (IFPA), Technical Assistance and Rural Extension Corporation of Pará (EMATER-PA), Agricultural Protection Agency of Pará (ADEPARÁ), the Brazilian Support Service for Micro and Small Enterprises (Sebrae), the State Department of Agriculture and Fisheries Development (SEDAP) and the Municipalities of Conceição do Araguaia and Floresta do Araguaia.

The next Brazilian Pineapple Symposium will be held in the state of Maranhão in 2016 or 2017.

Embrapa Held First Course on Cryopreservation of Plants with Emphasis on Pineapple

Domingo Haroldo Reinhardt.

Thirteen participants from different parts of Brazil took part in the 1st Course on Cryopreservation of Plants held at Embrapa Cassava & Fruits in Cruz das Almas, Bahia, Brazil, from July 11 to July 15, 2016. The event was led by Fernanda Vidigal Duarte Souza, research scientist in tissue culture and genetic resources at Embrapa, and Maria lena González-Benito, professor at the Polytechnic University of Madri, Spain, one of the main international specialist on cryopreservation.

Vegetal cryopreservation is a long term conservation of plants based upon deep freezing conditions in liquid nitrogen at -196 °C. This course was focused on the application of this technique on seeds and plant tissues, especially on pineapple, banana and sugarcane, with a strong theoretical basis and large segments with hands-on practicing, a reason for the limited number of participants. In 2012, Fernanda Souza earned a post-doc period focused on this technique at the National Center for Genetic Resources and Preservation, Fort Collins, Colorado, USA, and is on the way to establish a cryobank for pineapple germplasm at Embrapa, a rather efficient alternative for long term conservation of valuable genotypes.

Organic Pineapple Production System for the Region of Lençóis, Chapada Diamantina, Bahia, Brazil

Tullio Raphael Pereira de Pádua, Aristoteles Pires de Matos, Ronielli Cardoso Reis, Eliseth Souza Viana, Raul Castro Cariello Rosa, Francisco Alisson da Silva Xavier and Domingo Haroldo Reinhardt
Embrapa Mandioca e Fruticultura, Cruz das Almas, Bahia, Brazil

In partnership with the company Bioenergia Orgânicos, Embrapa Mandioca e Fruticultura has been carrying out studies towards the establishment of organic production systems for several fruits, including pineapple. In the first stage, the focus has been on fertilization, planting density and weed control for the new ‘BRS Imperial’ pineapple and the traditional ‘Pérola’. These are aspects related to the important role played by soil components in organic farming. There is always a need to improve the physical, chemical and biological properties of the soil to this environment, aiming to assure adequate plant and fruit development. In addition, planting density is a variable with strong impacts on yield, fruit size and fruit quality to meet the requirements for fresh fruit markets and industrial processing.

The studies have been carried out in the municipality of Lençóis, Chapada Diamantina, Bahia, a region with a sub-humid climate, a rainy season from November to April, when the temperature ranges from 20 °C to 30 °C, and a dry season from May to October with temperatures between 17 °C and 26 °C.

Five fertilization doses, 10, 20, 30, 40 and 50 t/ha, of cattle manure and organic Bokashi compost have been studied, as well as five planting densities (26,315; 31,250; 35,714; 47,620 and 51,282 plants/ha) corresponding to the spacings of 1.5 m x 0.4 m x 0.4 m; 1.2 m x 0.4 m x 0.4 m; 1.0 m x 0.4 m x 0.4 m; 1.0 m x 0.4 m x 0.3 m and 0.9 x 0.4 x 0.3 m, respectively. In addition were studied treatments focusing on the improvement of soil properties before planting the pineapple, using *Crotalaria juncea*, sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum glaucum*), velvet bean (*Mucuna aterrima*), jack bean (*Canavalia ensiformis*), velvet bean + jack bean and spontaneous vegetation. Irrigation was by microsprinkler.

Before planting of pineapple cultivars and after correction of soil acidity by liming, soil preparation was done by sowing a cocktail of cover crops composed of a mixture of grasses (millet and sorghum) and legumes (velvet bean and jack bean) (Figure 1). Seeds were scattered by hand over the soil surface. As a complement of soil fertilization 250 kg/ha of natural phosphate was also applied. The shoot biomass produced by cover crops was mowed 80 days after sowing and kept on the soil surface for natural degradation (Figure 2). Fifteen days later the two pineapple cultivars were planted and 350 g of cattle manure and 250 g of powder-rock (calcosilicataded pyroxenite) were applied per plant.

Figure 1. Sowing and growth of soil cover crops (cocktail) in pre-planting of Pineapple. Lençóis, Bahia, Brazil. (Photos by Padua, T.R.P.)

Figure 2. Mowing of the cover crop biomass 80 days after sowing followed by the planting of pineapple cvs. BRS Imperial and Pérola. (Photos by Padua, T.R.P.)

Pineapples were harvested in August, during the dry season. Average fruit weight increased with increase of the organic fertilization doses up to 40 t/ha, reaching 1.05 kg for BRS Imperial (Figure 3) and 2.0 kg for the Pérola pineapple (Figure 4), both grown in the spacing of 1.20 m x 0.40 m x 0.40 m. The lower fruit weight obtained for the BRS Imperial cultivar was expected. In spite of its smaller fruits, BRS Imperial earned much higher fruit prices in the São Paulo market, probably due to its excellent taste and high total soluble solids (°Brix) content (Figure 5). In comparison to the Pérola cultivar, there is also the advantage of reducing production costs and increasing number of fruits harvested due to its resistance to the fusariosis disease.

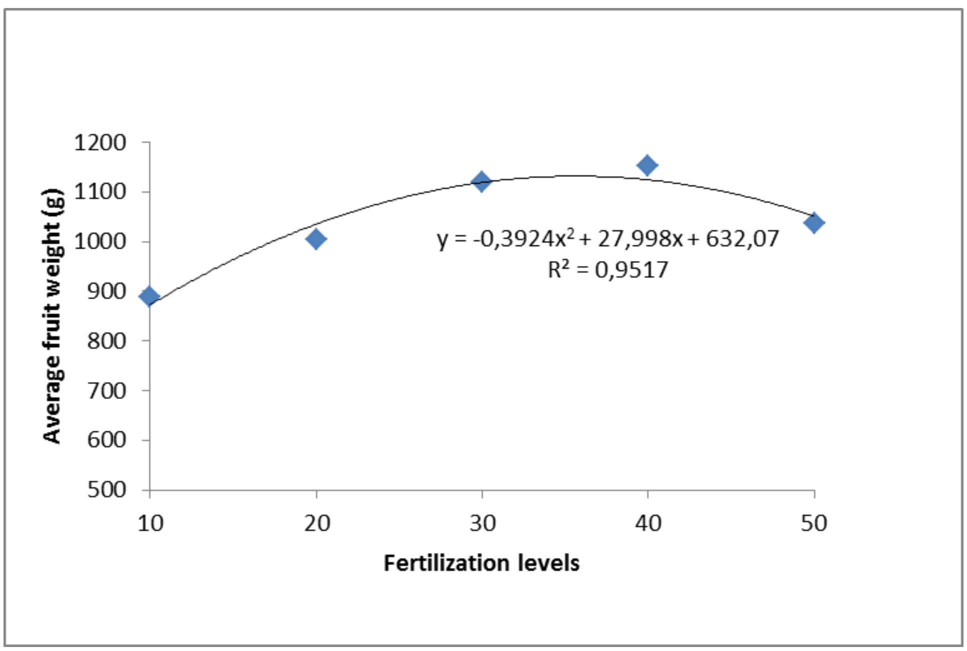

Figure 3. Average fruit weight (kg) of BRS Imperial pineapple grown in an organic production system, in response to five levels of organic fertilization (t/ha). Lençóis, Bahia, Brazil, 2015.

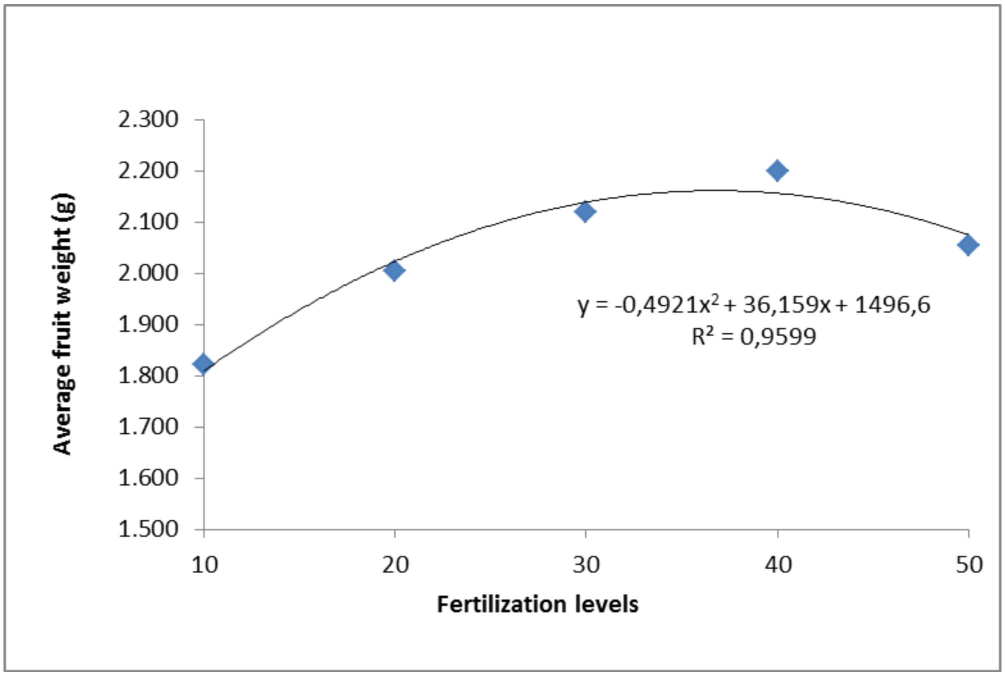

Figure 4. Average fruit weight (kg) of Pérola pineapple grown in an organic production system, in response to five levels of organic fertilization (t/ha). Lençóis, Bahia, Brazil, 2015.

The total soluble solids content (°Brix) of BRS Imperial pineapples (Figure 5) decreased with increasing level of fertilization, but was always superior to the minimum standard required for pineapple marketing in Brazil which is 12.0 °Brix.

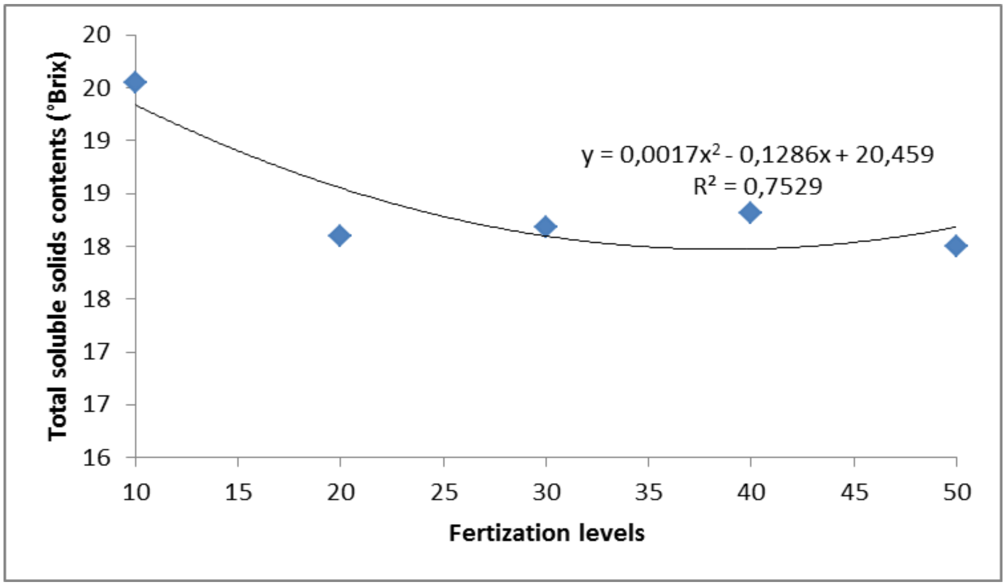

Figure 5. Total soluble solids contents (ºBrix) of BRS Imperial pineapple grown under different fertilization doses in an organic production system. Lençóis, Bahia, Brazil, 2015.

There was no significant effect of fertilization levels on the vitamin C content, titratable acidity (TA) and °Brix:TA ratio of BRS Imperial fruits (Table 1). The results indicate a moderate acidity, lower than that of Smooth Cayenne pineapples, and high ratio which is higher than in Pérola fruits.

Table 1 – Means of the physicochemical evaluations of Imperial pineapples grown under different fertilization doses in an organic production system. Lençóis, Bahia, Brazil, 2015.

Doses (t/ha)	Vitamin C (mg/100g)	Titratable Acidity (% citric acid)	Ratio
10	24.39a	0.55a	38.15a
20	27.33a	0.66a	28.35a
30	26.30a	0.54a	38.15a
40	25.64a	0.57a	35.06a
50	23.90a	0.36a	50.60a
Average	$25.51^{n.s}$	$0.54^{n.s.}$	$38.06^{n.s.}$

Values followed by same letters don’t differ by the Tukey test at 5%

For Pérola pineapples, there was no significant dose effect on soluble solids or TA (Table 2) and the values were considered adequate for this cultivar.

Table 2 – Means of the physicochemical evaluations of Pérola pineapples grown under different fertilization doses in an organic production system. Lençóis, Bahia, Brazil, 2015.

Doses	Vitamin C (mg/100g)	Soluble Solids (ºBrix)	Titratable acidity (% citric acid)
10	29.85	15.13	0.52
20	28.71	15.57	0.58
30	29.01	14.58	0.62
40	30.85	14.93	0.66
50	30.33	15.61	0.59
Average	$29.75^{n.s.}$	$15.16^{n.s.}$	$0.59^{n.s.}$

Values followed by same letters don’t differ by the Tukey test at 5%

Planting density treatments did not significantly affect the fruit weight of BRS Imperial pineapples. Pérola, however, produced higher average fruit weights in the densities of 31,250 and 35,710 plants/ha (Table 3).

Table 3. Fruit weights (kg) of pineapple cvs. BRS Imperial and Pérola in response to different planting densities, grown in an organic production system. Lençóis, Bahia, Brazil, 2015.

Planting densities (plants/ha)	Pérola	BRS Imperial
26,315	1.70 b	0.96 a
31,250	1.92 a	0.95 a
35,714	1.96 a	0.93 a
47,620	1.81 ab	0.95 a
51,282	1.84 ab	0.89 a
Mean	1.85	0.94
CV (%)	18.67	5.48

Values followed by same letters don’t differ by the Tukey test at 5%

There was no influence of planting density on TA or soluble solids content of Pérola pineapple, with an acidity considered moderate for the pineapple crop (0.53%) and a °Brix of 15.0 considered high for this cultivar (Table 4).

Table 4. Means of the physicochemical evaluations of Pérola pineapples grown under different planting densities in an organic production system. Lençóis, Bahia, Brazil, 2015.

Planting density (plants/ha)	Titratable acidity (% citric acid)	Soluble Solids (%)	Ratio	pH
26,315	0.56	15.1	28	3.69
31,250	0.50	15.6	31	3.69
35,714	0.53	14.8	29	3.74
47,620	0.52	15.2	30	3.74
51,282	0.56	14.7	27	3.71
Mean	0.53 ^{ns}	15.0 ^{ns}	29.0 ^{ns}	3.71 ^{ns}
CV (%)	8.94	3.98	7.91	1.44

There was no significant effect of planting density on the physicochemical characteristics of BRS Imperial pineapples (Table 5). Under the local cropping conditions the fruits of this cultivar had much higher average soluble solids content than did Pérola pineapple.

Table 5 - Means of the physicochemical evaluations of BRS Imperial pineapples grown under different planting densities in an organic production system. Lençóis, Bahia, Brazil, 2015.

Planting density (plants/ha)	Titrabale acidity (% citric acid)	pH	Soluble solids (°Brix)	Ratio	Vitamin C (%)
26,315	0.49	4.11	20.00	42.70a	24.65ab
31,250	0.57	4.02	19.17	34.24ab	23.87ab
35,714	0.48	4.09	18.98	40.17ab	24.87a
47,620	0.48	4.23	19.89	44.54a	19.47c
51,282	0.62	4.07	19.87	32.18b	21.53bc
Means	0.53 ^{ns}	4.10 ^{ns}	19.58 ^{ns}	38.77	22.88
CV(%)	15.65	3.48	4.05	13.77	7.10

Regarding the management of soil cover plants done before planting the pineapple cultivars, the results indicate differences in the stock of nutrients in the biomass of these plants. Millet had the largest amount of phosphorus (P) and potassium (K) in the biomass, with more than 12 kg/ha P and 80 kg/ha K. Noteworthy is the potential for soil calcium extraction by the jack bean, above 140 kg/ha (Figure 6).

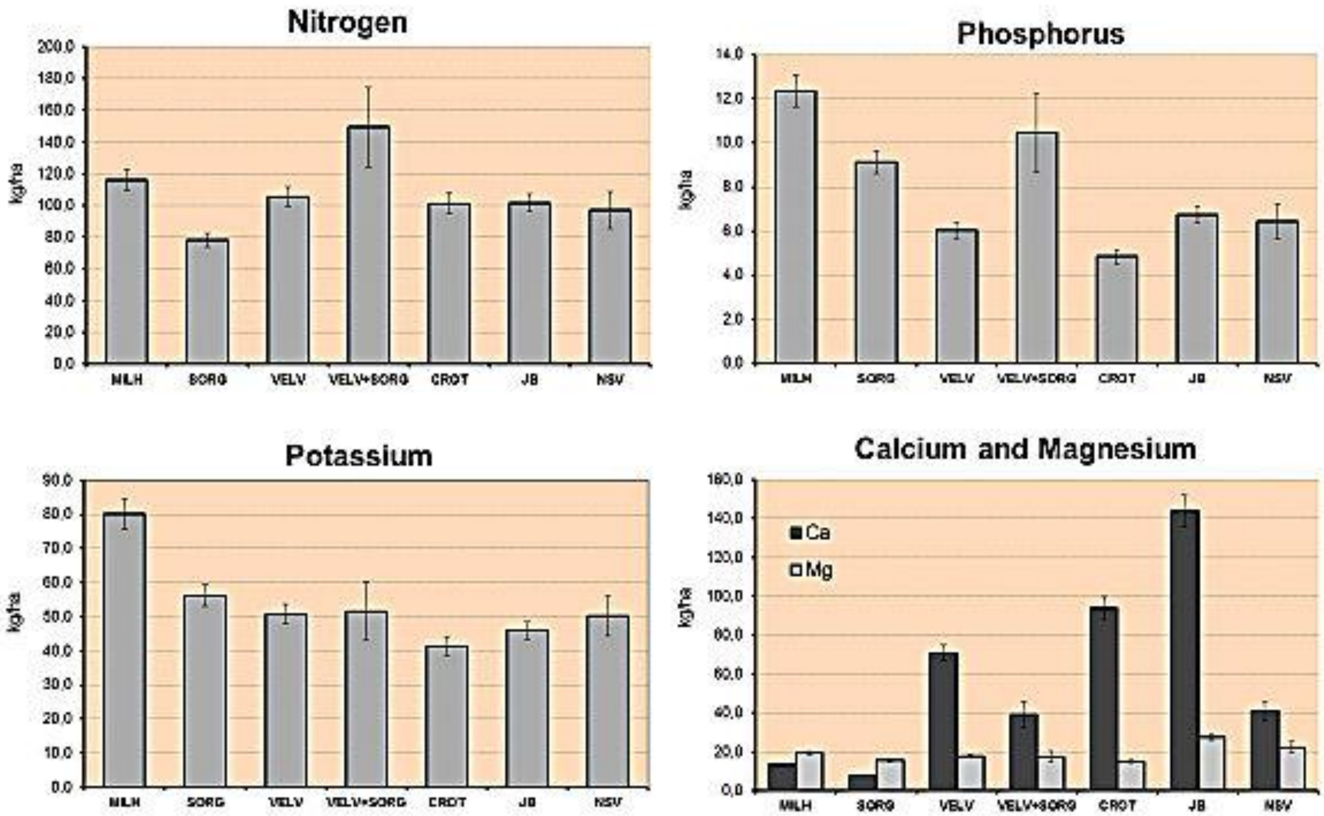

Figure 6. Macronutrient stocks in the biomass of different soil cover crops used as a pre-cultivation in organic production of pineapple. MILH, millet; SORG, sorghum; VELV, velvet bean; VELV + SORG, 1:1 blend of VELV & SORG; CROT: *Crotalaria juncea*; JB, Jack bean; NSV, spontaneous native vegetation. Horizontal bars indicate the standard error of the mean.

When analyzing the average weight of the pineapple fruits due to cover crops cultivation in pre-planting pineapple (Figure 7), results indicated higher production for Pérola pineapple cultivated in the spacing of 1.20 m x 0.40 m x 0.40 m, when combining velvet bean + sorghum which resulted in fruit weights above 2.3 kg. For all soil cover crop treatments the average fruit weight was more than 1.5 kg, which is the parameter for fruits of first quality in Brazil.

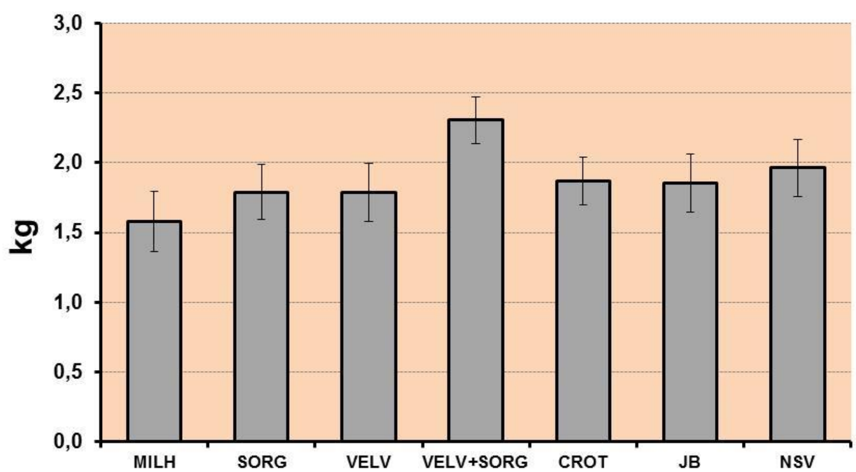

Figure 7. Average fruit weight of 'Pérola' pineapples in response to different soil cover plants used as pre-planting cultivation in an organic production system of pineapple. MILH, millet; SORG, sorghum; VELV, velvet bean; VELV + SORG, 1:1 blend of VELV & SORG, CROT, *Crotalaria juncea*; JB, Jack bean; NSV, spontaneous native vegetation.

Based on the above results, the main recommendations for the cultivation of BRS Imperial and Pérola pineapples in an organic production system in Lençóis, Bahia, Brazil are presented in Table 9.

Table 9. Recommendations for the cultivation of pineapple in an organic system for ‘BRS Imperial’ and ‘Pérola’ in the region of Lençóis, Bahia, Brazil.

Aspects of production and fruit characteristics	Cultivar	
	BRS Imperial	Pérola
Soil preparation	Minimum Movement, planting of cover crops (blend of grasses and legumes)	Minimum Movement, planting of cover crops (blend of grasses and legumes)
Planting density in double rows system (plants/ha and spacing)	35,714 to 47,617 (1.00m x 0.40m, 0.40m; 1.00m x 0.40m x 0.30m)	35,714 to 51,282 (1.00m x 0.40m x 0.40m; 0.90m x 0.40m x 0.30m)
Fertilization at planting date and the first one on soil surface after planting (g/plant)	Cattle manure, 300g + rock powder, 150g	Cattle manure, 300g + rock powder, 150g
Other post-planting fertilizations (5º, 7º, 10º months after planting; g/plant)*	Bokashi, 280 to 320g	Bokashi, 260 to 312g
Average fruit weight (kg)	1.05	2.00
Titratabale acidity (% citric acid)	0.54	0.59
Total soluble solids (ºBrix)	19.00 to 20.00	15.00
Ratio (soluble solids/acidity)	38 to 44	29
Vitamin C content (mg/100g)	25	29.75

*Corresponding to 35 to 40 tons of fertilizer/ha for the ‘BRS Imperial’ and 25 to 30 tons of fertilizer/ha for ‘Pérola’.

Cultivation of Pineapple in Organic System – Recommendations Based on Studies in the Semiarid Region of the Chapada Diamantina, Bahia, Brazil

Tullio Raphael Pereira de Pádua, Aristóteles Pires de Matos, Ronielli Cardoso Reis, Eliseth Souza Viana, Raul Castro Cariello Rosa, Francisco Alisson da Silva Xavier, Embrapa Cassava & Fruits, Cruz das Almas, Bahia, Brazil

Pineapple cultivation in an organic production system is still a little explored activity and with little technical information available. In this cultivation system, the use of inputs is controlled by legislation and the farm must be certified by a control body. The use of conservation practices, products for biological control and minimal soil disturbance in crop management of this system results over time in an increase of biodiversity, reduction of losses by erosion and leaching of topsoil and an improvement of its physical and chemical characteristics.

A good planning for organic production is essential and the following aspects should be taken into account:

- Survey of potential markets for organic pineapple to be focused;
- Definition of the cultivar, planting system and planting time
- Choice of the planting area
- Physical and chemical analyses of the soil
- Definition of soil conservation and management practices in line with the principles of organic farming
- Maintenance and improvement of the physical, chemical and biological soil characteristics
- Identification of weeds in the area to be cultivated and of pests present in nearby pineapple crops
- Acquisition and selection of good quality planting material
- Monitoring and control of pests and natural enemies of those pests present in the area
- Number and dates of fertilizer applications after planting
- Planning the date for floral induction treatment and fruit harvest
- Adequate fruit packaging and transport to the markets

The use of varieties with resistance to the main diseases of the crop is always a great help when looking for an organic production system, as it eliminates the need of other control measures and reduces economic and environmental costs. However, it is not always possible to rely on resistant varieties depending on the market demand and there is always a chance to get adequate yields for cultivars susceptible to important pests. In the case of pineapple in Brazil, if a cultivar susceptible to *Fusarium* must be used, a strategy should be established for the control of this fungus, including practices such as monitoring and rouging, the use of *Fusarium* free plantlets obtained in nurseries from stem sections and an adequate planning of the floral induction to get flowering during a period with environmental conditions less favorable to the fungus.

With respect to soil management, conservation practices must be carried out focused on the improvement of its physical, chemical and biological properties. Among other practices that should be used are minimum tillage, cover crops and mostly flat areas. The area should initially be cultivated with a cocktail of soil quality enhancer plants including grasses and legumes (Table 1). Among the benefits of this practice are improvements in soil structure, nutrient cycling from the lower to the upper soil layers, an increased biodiversity and an increase in the organic matter and nutrient contents in the upper soil layer? The area should be prepared by a light weeding to facilitate sowing and broadcast fertilization of the soil quality enhancer plants. About 90 to 120 days after sowing, and before flowering, the plants should be mowed and the biomass kept on the soil surface.

Table 1. Composition of the cocktail to be used for soil preparation at pre-planting of pineapple in an organic production system in Northeast Brazil.

Species	% of the mixture	Seed amount (kg/ha)
Pork bean (*Canavalia ensiformis*)	25	30.0
Velvet bean (*Mucuna aterrima*)	25	22.5
Pearl millet (*Pennisetum glaucum*)	25	3.8
Sorghum (*Sorghum bicolor*)	25	7.5

The biomass should be allowed to dry over a 15-day period. Thereafter a light disking can be done in order to cut and incorporate the remaining crop residues or, if possible, pineapple may be planted directly into holes or grooves opened through the dried biomass.

The strict selection of the planting material is essential to prevent the entry of pests and for the success of the enterprise. Plantlets, slips or suckers at sizes of at least 30 cm must be obtained and selected from areas with no or low incidence of fusariosis. If possible, plantlets should be produced from pineapple stem sections (Figure 1), a system that assures clean planting material if correctly used.

Figure 1. Production of plantlets by stem sectioning of pineapple cultivars BRS Imperial and Pérola. (Photos by Pádua, T.R.P.)

After the initial growth and establishment of the pineapple crop, pests should be monitored monthly. Plants with symptoms of fusariosis should be removed and buried or burned to control the disease by reduction of the inoculum in the field. In the case of incidence of mealybugs, the transmitter of the pineapple wilt virus, soap syrup (Table 2) should be applied to the lower part of the plant. One week later should be observed if the treatment was efficient and, if necessary, another application should be done.

Table 2. A mixture of ingredients for the control of mealybugs. The mixture is to be diluted in water at a concentration of 0.5% to 3%.

Ingredients	Amount
Vegetal oil	3.7 liters
Ethanol	3.8 liters
Caustic soda	800 grams
Water	1.7 liters
Total	10 liters

During planting, each hole or groove should be fertilized with 350 grams of manure (nitrogen source) and 150 grams of powdered rock per plant (phosphorus source). After planting, topdressings with an organic fertilizer, split into 3 to 5 applications according to availability of material and skilled labor, should be placed at the base of the plant (Figure 2). In the case of three applications, the first topdressing should be done between months 2 and

3, the second between months 4 and 5, and the third between 9 and 10 months after planting. Potassium as potassium sulphate, which is in alignment with the present rules for organic production, should be applied along with organic compost or manure at dosages of 4.6, 6.2 and 7.0 g of potassium sulphate per plant.

Figure 2. Area of production of organic fertilizers type Bokashi and fertilization after planting directed to the lower part of the drip irrigated plants (Photos by Pádua, T.R.P.)

For weed control, cuttings should be done as often as necessary to avoid competition for nutrients, light and water between weeds and the pineapple plants, especially in the first six months of cultivation when the plant is more vulnerable and plant development may be affected and time span until harvest increased. Weed control in the organic system can be done via manual weeding with hoes or by using a power mower and through the use of plastic mulching.

Figure 3. Weed control by a coastal mower or by using plastic mulch. (Photos by Pádua, T.R.P.)

Floral induction in an organic pineapple production system can be done using calcium carbide as there is a permission for that by the certification body. Its application should occur in the late afternoon of less hot and preferably cloudy days. It is recommended to repeat the application 48 hours later, especially for the BRS Imperial pineapple. Calcium carbide should be diluted at a dosage of 400 g of calcium carbide in 100 liters of water, or if costal sprayers of 20 liters capacity are used, 50 to 60 g of calcium carbide should be placed into 12 liters of water leaving some space in the sprayer for the expansion of the acetylene gas released. 50 ml of the solution is applied directly into the central part of the leaf rosette of each plant. As fruit size is to a large extent related to plant size at forcing, this treatment should be done when 'D' leaves of plants present minimum fresh weights of 80 g and 60 g and minimum lengths of 100 cm for Pérola and 80 cm for BRS Imperial, respectively.

After the appearance of the first flowers the inflorescence should be covered using paper bags for protection against sunburn. This practice may also be a protection against *Fusarium* and the fruit borer when placed as soon as possible. Fruit harvesting should be done keeping about 2 cm of the flower stalk below the fruit base in order to reduce the risk of rotting (Figure 4). Protection of the cut surface of the stalk by application of Bordeaux mixture is also recommended.

Figure 4. Aspects of a BRS Imperial pineapple field, its fruits and the presence of a short piece of the stalk at the fruit basis. (Photos by Pádua, T.R.P. (A e B) and Junghans, D.T. (C))

Fruits produced in an organic system usually have higher value in large markets, attending commercial niches that pay more depending on the quality of the product. To serve these markets, after harvest fruits should be packed into cardboard boxes that increase protection and reduce the risk of fruit losses during transport from the production area to the consumer center ensuring adequate fruit quality (Figure 5).

Figure 5. BRS Imperial and Pérola pineapples in cardboard boxes for long distance transport to consumer centers (Photos: Pádua, T.R.P. (A, B) and Matos, A.P.de (C))

Use of Baits for Integrated Pest Management (IPM) of Ants, Pineapple Mealybugs, and Mealybug Wilt Disease of Pineapple in Espírito Santo, Brazil

M.P. Culik, D. dos S. Martins, and J.A. Ventura
Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural CRDR-CN, Linhares, Espírito Santo, Brazil

Keywords: *Dysmicoccus brevipes* (Hemiptera: Pseudococcidae), abamectin, Formicidae

Abstract

Research is being conducted in Espírito Santo, Brazil to evaluate the use of baits containing insecticides for control of ants associated with mealybugs infesting pineapple to reduce mealybug populations and mealybug wilt disease of pineapple. Initial results indicate that baits containing abamectin may be useful for control of ants and thus may help reduce mealybug populations and mealybug wilt incidence.

INTRODUCTION

As a vector of pineapple mealybug wilt-associated virus (PMWaV) and co-factor in development of mealybug wilt disease, the pineapple mealybug (*Dysmicoccus brevipes*) is a major pest of pineapple throughout the world including Brazil. Research in various regions indicates that use of baits containing insecticides to control of ants symbiotically associated with mealybug pests in pineapple and other crops may be effective in reducing ant and associated mealybug pest populations (Taniguchi et al., 2005; Daane et al., 2008). Therefore, we are currently conducting research to evaluate effects of baits for control of ants and associated mealybugs on pineapple and several other crops in Espírito Santo, Brazil, as part of continued development of integrated pest management (IPM) in this region

MATERIALS AND METHODS

Preliminary tests

Preliminary experiments to evaluate the effectiveness of baits containing the insecticides abamectin, boric acid, and spinosad for control of ants in pineapple fields and other crops (coffee and cocoa) have been established at the Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural (Incaper) Experiment Farm in Sooretama, and in Linhares, Espírito Santo.

The study sites consist of established fields. Twelve plants, separated from each other by at least 15 m were identified, and four plants in three blocks were randomly selected for each test treatment (Abamectin, Boric acid, Spinosad, and Untreated control). Granular baits for the tests were prepared with active ingredients (AI): abamectin (0.01%), boric acid (1%), or spinosad (0.015%). At the start of the test, for each bait treatment, bait (35 g) containing the AI was placed in a bait station (perimeter patrol) located at the base of each test plant (for boric acid treatments in pineapple and coffee an additional 35 g of the boric acid bait was added on the day following the initial application). Additional bait (35 g) was added for all treatments after 2 weeks.

To evaluate the effects of the baits on ants, ant activity was monitored at the start of the test and 2 and 4 weeks following bait application as follows: an open 50 ml plastic centrifuge tube with untreated bait (5 ml) was placed at the at the base of each test plant and after approximately one hour the tubes, with ants attracted to the bait inside, were closed and collected for transport to the laboratory for examination. The ants captured in the tubes were subsequently counted and preserved for identification and reference.

RESULTS AND DISCUSSION, CONCLUSIONS

Since this research has only recently begun results are limited at present. However based on our initial observations abamectin appeared to be most effective in reducing ant populations in the crops studied (Figure 1).

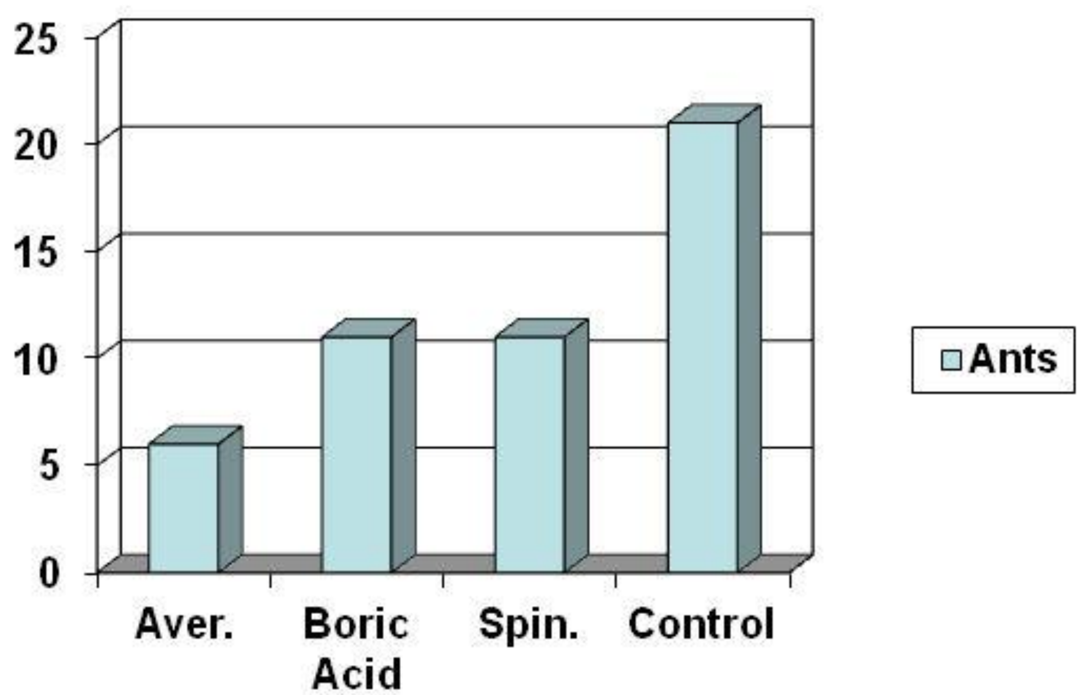

Figure 1. Effect of bait treatments containing abamectin (Aver.), boric acid, spinosad (Spin.) and untreated control on ants (mean number of ants/monitoring tube, 2 and 4 weeks after bait application) in cocoa, coffee, and pineapple crops, Espírito Santo, Brazil (Test 1, 2016).

Field experiments

Based on results of initial tests we plan to evaluate at least one active ingredient in baits in larger field trials for several crop seasons. We will compare pineapple plots with and without baits (10X10 m plots separated from each other by at least 10 m, with 3 replications) with bait stations placed on each side of treated plots, with ant activity recorded as described for the preliminary tests, and additional variables such as ant trailing activity, ant and mealybug infestation levels, and natural enemy activity also monitored.

ACKNOWLEDGEMENTS

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Influence of Washing and Plastic Packaging on Post-harvest Quality of Ornamental Pineapple Stalks

Davi Silva Costa Júnior[1], Everto Hilo de Souza[2], Márcio Eduardo Canto Pereira[2], Maria Angélica Pereira de Carvalho Costa[1] and Fernanda Vidigal Duarte Souza[2*]

[1] Universidade Federal do Recôncavo da Bahia, 44380-000, Cruz das Almas, Bahia, Brazil
[2]Embrapa Cassava & Fruits, 44380-000 Cruz das Almas, Bahia, Brazil
* Corresponding author: fernanda.souza@embrapa.br

Introduction

Ornamental pineapple is a promising alternative in the segment of floriculture, as it can be marketed as cut flowers, potted plant, in landscaping, as a hedge or as ornamental minifruits (Souza et al., 2012). Ornamental pineapple floral stalks (crown, developing inflorescence or syncarp, peduncle and any bracts or leaves attached to it) are already produced and marketed in Brazil, mainly in the states of Ceará and Rio Grande do Norte (Brainer and Oliveira, 2007). For marketing they need to pass through standardization and post-harvest procedures, including the removal of flower debris, sprouts and leaves at the base of the peduncle and washing with high pressure water for the removal of scale-like trichomes, which are popularly and wrongly called wax.

The post-harvest management is one of the main problems faced by floriculture, where losses on the way between production and consumers can reach 50% (Teixeira, 2002). So the proper handling of the products is essential in order to keep quality, increase shelf life and reduce losses of inflorescences after cutting.

The floral stalks of ornamental pineapples are covered by trichomes with a powdery appearance, overshadowing much of its beauty, expressed mainly by its colors. However, the removal of these trichomes by pressure washing significantly increases the final cost of the product (Costa Júnior et al., 2011a). In the case of exporting companies, this procedure represents one of the main production costs. This process also tends to damage the most sensitive plant tissues, especially the bracts located under the syncarp, the crown and the bracts of the fruitlets, which in hybrids derived from *Ananas comosus* var . *bracteatus* are large and present pronounced colors (Costa Júnior et al., 2011b).

According to Chitarra and Chitarra (2005) methods to reduce postharvest losses include the application of modified atmosphere, which can be generated by the use of plastic films or edible coatings that induce changes in the atmosphere around the product by increasing the concentration of CO_2 and decreasing that of O_2 due to respiration of the product. However, the selective permeability of the film must be suitable for the input of O_2 and the output of CO_2 to avoid anaerobic conditions.

The objective of this study was to evaluate the post-harvest life of flower stalks of an ornamental pineapple hybrid developed by Embrapa Cassava and Fruits under different conditions of packaging.

Methodology

Floral stalks of the ornamental pineapple hybrid PL04 were used. This hybrid was originated from a cross between *A. comosus* var. *erectifolius* and *A. comosus* var. *bracteatus*. Stalks having a length of 35 cm were cut at their base after closure of the last flower, but not older than three days after that time. Buds at the base of the syncarp as well as leaves present at the base of the peduncle were removed. Trichomes on the stalks were removed by an electric high pressure washer to achieve commercial standard for the export market. Water jet length was kept at 20 cm distance from the stalk surface. Thereafter the stalks were dried in the shade at room temperature and randomly divided into groups for treatment application.

In order to determine the effect of washing and low density polyethylene (LDPE) packaging on post-harvest quality of the floral stalks the following treatments were studied:

T1) Stalk without washing (control)
T2) Washed stalk
T3) Stalk not washed + full packaging with 4 uM LDPE
T4) Stalk not washed + full packaging with 8 μm LDPE
T5) Stalk not washed + partial packaging with 8 μm LDPE

T6) Washed stalk + full packaging with 4µm LDPE
T7) Washed stalk + full packaging with 8 µm LDPE
T8) Washed stalk + partial packaging with 8 µm LDPE

The LDPE plastic bags were 10 cm wide and 15 cm long and 4 µm or 8 µm thick. In the full packaging treatments two bags were used, one placed from the top of the crown downward and the other from the peduncle base upward warranting a full covering of crown, syncarp and peducncle. In the partial packaging treatments one bag was used covering only crown and syncarp (Figure 1). After application of the treatments the stalks were arranged in floral sponges and stored at room temperature.

Figure 1. Ornamental pineapple stalks fully or partially packed with 8 µm low density polyethylene (LDPE).

The overall appearance of the floral stalks and the specific appearance of each part (crown, syncarp, peduncle) were evaluated individually every two days during the storing period of 24 days, using the following scale: 4 = Excellent: vivid color, shiny and absence of dryness; 3 = Very good: lightly faded color or lightly yellowed and some early drying at the extremities; 2 = Good: more faded and yellowed color and drying affecting about 1/3 of the surface; 1 = Bad: partially degraded colors and drying of about 2/3 of the surface; and 0 = Very bad: Very degraded color (colorless or brown) and completely dry.

The average grade equal to 3 (very good) for appearance of the different parts of the floral stalk was defined as the limit of shelf life for marketing. The experimental design was a completely randomized one using eight treatments with eight replications. Data were submitted to analysis of variance and means were compared by the Scott-Knott test at 5% probability using the SAS statistical software (SAS Institute, 2010).

Results and Discussion

There was significant difference between treatments for the four variables studied. The best overall result was obtained by using a full packaging of 8 µm thickness, with or without washing (treatments 4 and 7), which extended stalk shelf life by four days (Table 1). The unwashed and not packed (control) stalks were evaluated with grade 3 (very good) for a shelf life of up to 10 days, while the washed ones (T2) were in good shape for only six days, showing a negative effect of washing accelerating color fading and overall drying.

The 8 µm LDPE (T4, T7 – see bold characters) significantly increased shelf life by 8 days compared to the 4 µm LDPE (T3, T6) treatment. Packaging, with or without washing, improved overall general performance of all floral parts. These results show that although washing is a procedure that may cause tissue damage, the use of packaging protecting the entire stalk, reducimg water loss due to the microclimate established inside the bags. Crowns achieved longer shelf life when compared to the appearance of peduncle and syncarp. Despite some additional costs which may affect the final price of the product, a shelf life extension by a few days as observed in this study may be a valuable advantage making the investment worth for exporters.

Table 1. Evolution of post-harvest shelf life of floral stalks of the ornamental pineapple hybrid PL04 (*Ananas comosus* var. *erectifolius* X *A. comosus* var. *bracteatus*) in response to washing and LDPE packaging treatments.

Treat[†]		Postharvest evaluation period (days)												Sig[‡]
	0	2	4	6	8	10	12	14	16	18	20	22	24	
		Floral stalk overall appearance												
T1	4	4	3	3	3	3	2	2	2	1	1	1	0	C
T2	4	4	3	3	2	2	2	1	1	1	1	0	0	C
T3	4	4	3	3	2	2	2	2	2	2	1	1	0	D
T4	4	4	3	3	3	3	3	**3**	2	2	1	1	0	**A**
T5	4	4	3	3	3	3	3	2	2	1	1	1	1	B
T6	4	4	3	3	2	2	2	2	2	2	1	1	0	D
T7	4	4	3	3	3	3	3	**3**	2	2	1	1	0	**A**
T8	4	4	3	3	3	3	3	2	2	1	1	1	0	B
CV %														5.32
		Peduncle appearance												
T1	4	4	4	3	3	3	2	2	1	1	1	0	0	C
T2	4	4	4	3	3	3	2	1	1	1	1	0	0	C
T3	4	4	4	3	3	3	2	2	2	1	1	0	0	C
T4	4	4	4	4	3	3	3	**3**	2	2	1	0	0	**A**
T5	4	4	4	4	3	3	3	2	2	1	1	0	0	B
T6	4	4	4	3	3	3	2	2	2	1	1	0	0	C
T7	4	4	4	4	3	3	3	**3**	2	2	1	0	0	**A**
T8	4	4	4	4	3	3	2	2	2	1	1	0	0	C
CV %														8.32
		Syncarp appearance												
T1	4	4	4	3	3	2	2	2	1	1	1	1	0	C
T2	4	4	3	3	2	2	1	1	1	0	0	0	0	C
T3	4	4	4	3	3	2	2	2	2	1	1	1	0	C
T4	4	4	4	4	3	3	**3**	2	2	2	1	1	0	**A**
T5	4	4	4	4	3	3	3	**3**	2	2	1	1	0	**A**
T6	4	4	4	3	3	2	2	2	1	1	1	1	0	C
T7	4	4	4	3	3	3	**3**	2	2	1	1	1	0	**A**
T8	4	4	4	4	3	3	2	2	2	1	1	1	0	B
CV %														8.21
		Crown appearance												
T1	4	4	4	4	4	3	3	3	3	3	2	2	1	C
T2	4	4	4	4	3	3	3	3	3	2	1	1	1	D
T3	4	4	4	4	3	3	3	3	3	2	2	2	1	D
T4	4	4	4	4	4	4	4	4	4	4	4	**3**	2	**A**
T5	4	4	4	4	4	4	4	4	4	4	3	2	2	B
T6	4	4	4	4	3	3	3	3	3	2	2	1	1	D
T7	4	4	4	4	4	4	4	4	4	4	4	3	**3**	**A**
T8	4	4	4	4	4	4	4	4	4	4	3	**3**	2	**A**
CV %														6.21

[†]Treatments are T1, Control; T2, washed; T3, not washed + full 4 µm LDPE packaging; T4, not washed + full 8 µm LDPE packaging; T5, not washed + partial 8 µm LDPE packaging; T6, washed + full 4µm LDPE packaging; T7, washed + full 8 µm LDPE packaging; T8, washed + partial 8 µm LDPE packaging. Scale used: 4 = Excellent; 3 = Very good; 2 = Good; 1 = Bad; 0 = Very bad.

[‡]Treatments followed by the same letters within a category are not significantly different by Scott-Knott test at 5 %.

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News from Costa Rica

Burndown of Pineapple Plants in Costa Rica

Jhonny Vásquez Jiménez . San Carlos, Costa Rica. E-mail: jvasquez@proagrocr.com

Herbicide burndown of pineapple plantation fields is an agricultural practice for eradicating plants that have completed their growing cycle. It is done in order to start preparing the soil for planting a new crop. It is considered a good result when a burndown of 80% of the plant material is achieved (Garita, 2014). Currently, the practice is performed relatively successfully with the use of 6 to 9 L ha^{-1} (commercial product) of paraquat herbicide (recommendation of some paraquat 20 SL label's). Despite the success achieved by Costa Rica companies employing this practice, they have been challenged on the use of paraquat for more than 5 years. Therefore, there is a need to replace this herbicide by others that are not questioned by buyers in fruit markets.

Burndown substitute herbicide characteristics

The desirable characteristics of a burndown herbicide are:

- Desiccate pineapple plants as quickly as possible, depending on weather conditions (the standard of paraquat is 30 days after application), Garcia and Rodriguez (2009).
- The foliage and the mother stem must be killed because buds growing on the stem of pineapple plants will result in undesirable volunteer suckers in the new planting.
- The kill must be rapid enough so that it does not support the reproduction of the stable fly (*Stomoxys calcitrans*), since pineapple crop residues are suitable for stable fly reproduction (Pitta,2011).
- The quantity of active ingredient per hectare needs to be less than that for paraquat, i.e., less than 1.2 - 1.8 kg ha^{-1} a.i.

The 30 days criteria for plant desiccation may be undesirable for some producers with short inter-cycles, but would not be a problem for companies that follow best practices of soil conservation. For such companies, it could be considered a technical advantage because the soil would be covered with stubble while the residue of the last crop was drying.

Since 2012 we have been evaluating the biological efficacy of pineapple burndown by herbicides containing imazamox as the active ingredient. The first tests were carried out on plantations of northern Costa Rica, where several active ingredients were tested, all at the highest dose according to the label. The objective was to assess whether any of the active ingredients tested had the characteristics of a burndown herbicide for use on pineapple. We found that imazamox had interesting behavior, but it was necessary to work in many other doses.

In the following years specific tests were run to determine the dose of active ingredient able to get the desired burndown of the pineapple crop in scenarios consistent with the cultivation practices in Costa Rica. Our results to date with imazamox are summarized below.

We obtained 80% burndown between 45 and 60 days after application of imazamox to pineapple depending on the area (North Zone 45 days and Atlantic Zone 60 days; Figure 1A and 1B).

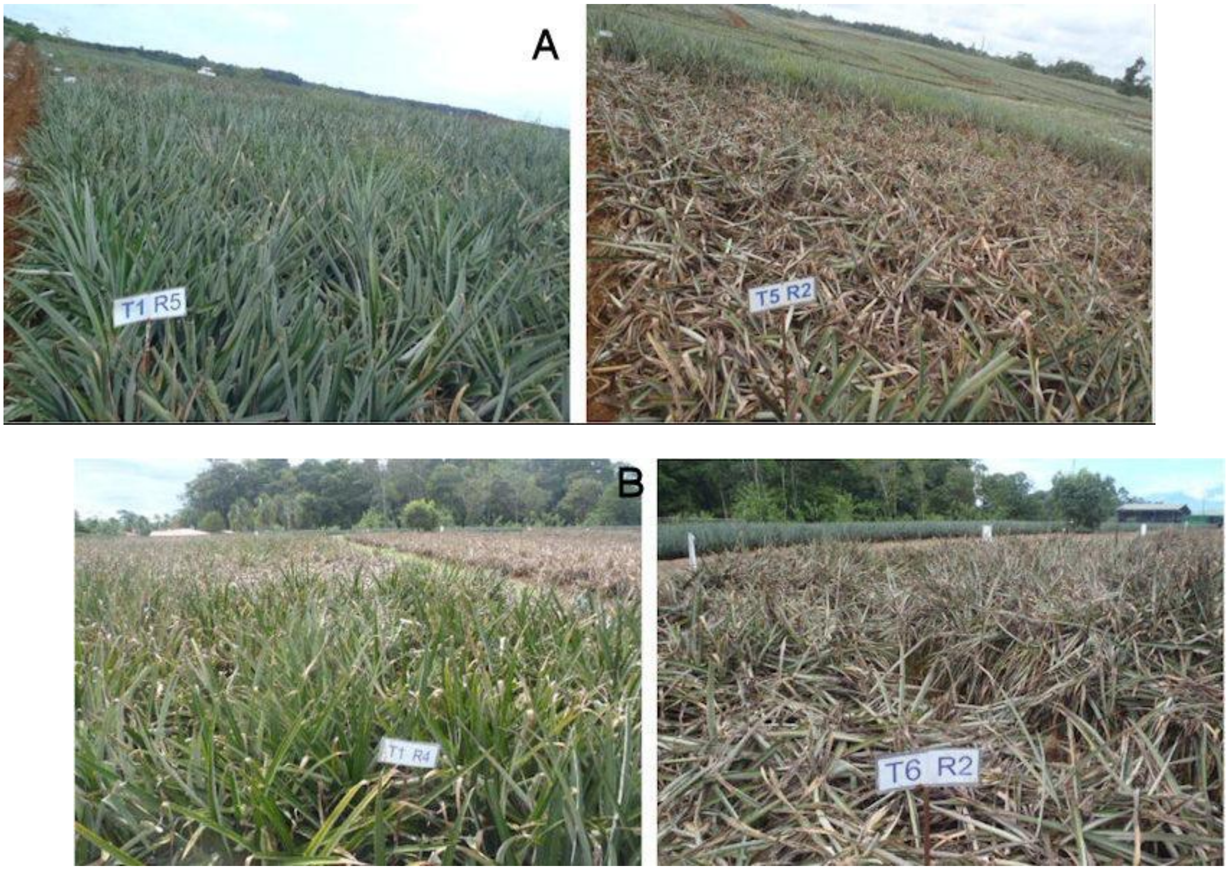

Figure 1A & B. Effects of imazamox herbicide on a pineapple field designated for burndown. Photo A (upper) shows the test in the Atlantic zone at 60 days after application. Photo B (lower) shows the test in the North zone at 45 days after application. The photoes on the left are of untreated fields while the field plots on the right were sprayed with a solution containing 0.35 g · L^{-1} imazamox.

The biological efficacy of the active ingredient is achieved at a minimum concentration of 0.35 g L^{-1} a.i. when the average green biomass per plant is 1.5 kg (Figure 2). However, when the amount of green biomass present is 3.5 kg per plant or higher, a greater spray volume of 4000 L ha^{-1} must be used (Figure 3). All imazamox sprays included 20 kg ha^{-1} urea and 0.3% DASH® adjuvant.

Figure 2. Effect of low biomass (less than 1.5 kg of green matter per mother plant and suckers) on burndown. Left (T1, R3) is the control, center shows the condition of T1 prior to spraying. At right is the burndown at 45 days after the application of 500 L ha^{-1} L of spray containing 0.35 g L-1 a.i. of imazamox. Only 0.175 kg ·ha-1 a.i. of the herbicide was applied.

Figure 3. Effect of imazamox on burndown when the average green plant biomass was >3.5 kg (mother plant and suckers). At left is the untreated control, at center a mother plant and suckers and at right is the burndown achieved 60 days after applying the equivalent of 4000 L ha-1 of a spray containing 0.35 g L-1 a.i. of imazamox. (equivalent of 1.4 kg ha-1 a.i.).

At 15 to 30 days after application of imazamox there was progressive phytotoxic injury in the white basal tissue (leaf rosette), the leaves fold at this level and slowly begin to lose turgor until completely dried. This biocidal effect takes approximately 45 days in the North zone and about 60 days in the Atlantic zone, with the difference being due primarily to differences in the amount of biomass present in the two regions.

Figure 4. Progressive drying of pineapple plants after application of imazamox at, from left, 15, 30 and 45 days.

When evaluations of burndown were carried out over time (Figure 5), at 90 days after application, we found areas of bare soil present in the treatments with the recommended doses.

Figure 5. Advance of burndown in a pineapple field treated with 1.4 kg ha-1 a.i. imazamox in 4000 L of water. The photos above from left to right show the burndown at 25, 35, and 45 days after application (DAA) and similarly below at 60, 75 and 90 DAA.

When the recommended doses (concentration of active ingredient and volume of water) were used there was no evidence of regrowth even 90 days after application (Figure 6). However, if less water was used in areas with high biomass present, some buds were observed on the stems of mother plants.

Figure 6. Photos of plants at 90 days after spraying imazamox in a field where the average green biomass per plant was 3.5 kg. The left photo shows the absence of suckers at 90 days after spraying 1.4 kg h-1 a.i. of imazamox in 4000 L of water. The right photo is a plant from a plot in the same field sprayed with only 0.175 kg ha-1 a.i. of imazamox in 500 L of water (Note succulent leaves and presence of a developing bud (circled)).

Preliminary observations indicated there was a lower incidence of stable fly (*Stomoxys calcitrans*) in the burndown with imazamox, which was associated with fewer infection foci (Figure 7). When paraquat is used to burndown plant residue it creates "macerating" or watery tissues that attract flies. However, with imazamox we found only macerated stems of suckers present after imazamox was applied, but no fly larvae were found in the stem of the parent plant or in leaf tissue.

Figure 7. Changes in pineapple plants from 0 to 90 days after spraying 1.4 kg ha-1 imazamox in 4000 L of water. The average green plant biomass was 3.5 kg and at and after 45 days after application the leaf rosette and upper portions of the stem had begun to decay and produce odors that made the plants susceptible to invasion by the stable fly (Stomoxys calcitrans) (see arrows); however, no evidence was found of insect colonization.

Based on these investigations the process of registering Imazamox began in February 2016 (as an extension of uses "in the label" to include post-harvest burndown of pineapple) in Costa Rica by the "Servicio Fitosanitario del Estado" . Resolution document: DOR-UBSI-PEB-026-2016.

Finally, it is appropriate to comment that some producers with particular conditions (specific targets and at specific times in the annual planting) have chosen methods of nonchemical break down, such as the use of effective microorganisms (EM's) to promote plant decomposition. They have achieved significant success in both the control of stable fly and the incorporation of stubble on the ground.

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News from Cuba

Hardening of 'MD-2' Micropropagated Pineapple Plants by Drought to Improve the Acclimatization-field Transition

René C. Rodríguez-Escriba[1*], Gustavo Y. Lorente[1], Ibraín D. Rodríguez-Cartaya[2], Dariel López[1], Roberto E. Izquierdo[1], Lucía S. Pérez-Borroto[1], Pedro Guerrero Posada[3], Carlos E. Aragón[1], Camilo Bonet[3], Yolanda Garza-García[4], Romelio Rodríguez[1], Florencio E. Podestá[5] and Justo L. González-Olmedo[1].

[1]Laboratorio de Agrobiología. Centro de Bioplantas. Universidad de Ciego de Ávila. Ciego de Ávila, Cuba. [2]Facultad de Biología de la Universidad de La Habana. La Habana, Cuba. [3]Instituto de investigaciones de Ingeniería Agrícola. La Habana, Cuba. [4]Departamento de Biotecnología, Universidad Autónoma de Coahuila. Coahuila, México. [5]Centro de Estudios Fotosintéticos y Bioquímicos, Universidad Nacional de Rosario. Rosario, Argentina.

* To whom correspondence should be addressed: e-mail: renecarlos@bioplantas.cu

Abstract

Current technology of pineapple micropropagation in Cuba has problems with the plant transition from acclimatization stage to the field. These problems are associated with the abrupt environmental changes between the two growth conditions. This work describes the study of crassulacean acid metabolism (CAM) response of 'MD-2' micropropagated pineapple plants under water stress. Plants acclimated to high light intensity were exposed to drought (droughted) for 30 days, after which the plants were fully watered from day 30 to day 45. Control plants were well watered for the entire 45 day period. Droughted plants had a higher succulence index (SI), water use efficiency (WUE), CO_2 uptake ratio and superoxide dismutase (SOD; EC 1.15.1.1) activity and lower chlorophyll (Chl.) than control plants. Both plant groups showed a typical CAM performance, but this was stronger in droughted plants. However, at 15 days after droughted plants were fully watered Chl. increased and SI, WUE, CO_2 uptake ratio and SOD activity decreased. The quick recovery of the droughted plants shows a high metabolic plasticity to water stress and a better response to the acclimatization-field transition after 30 days of drought as long as they were watered during or after their planting in the field.

INTRODUCTION

After bananas and mangoes the pineapple is the third most important tropical fruit produced in the world {FAOSTAT, 2013 #468} and the most important CAM plant {Borland, 2009 #244}. Traditionally the pineapple is propagated using crowns, slips, shoots or suckers, but these planting materials have limitations such as less uniformity, transmission of diseases, and inadequacy for commercial production {Bartholomew, 2009 #765}. *In vitro* propagation is a crucial technique for the rapid production of disease-free pineapple plantlets {Escalona, 2003 #1567}. However, *in vitro*-cultured plants are very sensitive to abrupt environmental changes, mainly when they are removed from *in vitro*-culture containers and placed under *ex vitro* conditions, and later from vessels to field plantation. Therefore, it is often necessary to adapt the plantlets to the harsher and uncontrolled *ex vitro* environment of a greenhouse or the field. This transitional phase of plant development is often called acclimatization or hardening {Rodriguez, 2008 #1564}. Plant hardening can be achieved through management of container size, substrates, and fertilizers, in addition to the control of light intensity, temperature and irrigation. Management of these issues can elicit metabolic responses after vegetative developments that are indispensable for their successful field transition.

Pineapple is a CAM (Crassulacean Acid Metabolism) plant {Bartholomew, 2003 #104}. CAM may operate in different modes which depends mainly of their CO_2 exchange pattern and nocturnal acid accumulation, and they are classified according to the response of both variables {Herrera, 2009 #88;Lüttge, 2004 #216}. Macro-propagated pineapple plants in the field or in their natural habitat are classified as "Strong constitutive CAM plants" {Bartholomew, 2003 #104;Nelson, 2008 #201;Lüttge, 2010 #113;Prigge, 2014 #135}. However, micropropagated pineapple plants have a high metabolic plasticity, responding as C3 plants in *in vitro*-culture conditions and in the first weeks of *ex vitro* acclimatization. Their response can be switched to CAM through stress signaling.

Pineapple plantlets grown under *in vitro* conditions show CAM activity when grown in an alternating warm day-cool night temperature regime {Nievola, 2005 #98} and also by nitric oxide and water deficit applications {Freschi, 2009 #442}. Pineapple plantlets also can be conditioned to function as C3 or CAM plantlets during the first weeks of *ex vitro* growth by low relative humidity, high temperatures and high light intensity {Aragón, 2012 #60;Aragón, 2013 #137}. For these reasons we conjecture that micropropagated pineapple plants as presently grown *in vitro* do not have the magnitude of CAM expression or the defensive mechanisms against oxidative stress required to survive their transition to the field. Two key aspects of acclimatization-technology are easy and practical handling and the low cost production. Rodríguez-Escriba *et al*. (2015) improved the plant acclimatization-field transition process by exposing plantlets to direct sunlight for 30 days. Pineapple plant transition to the field could also be improved by controlled drought, which could induce the plants defensive mechanisms against water stress. The aim of this work was to evaluate the CAM response of micropropagated pineapple plants under water deficit for 30 days, and their subsequent recovery after fifteen days with irrigation.

MATERIAL AND METHODS

Plant material and growth conditions

Plant material (*Ananas comosus* (L.) Merr. 'MD-2') was micropropagated and acclimatized as described by Rodriguez-Escriba et al. (2015). After five months in acclimatization stage plants with 11-12 leaves, 12-13 roots and a FW of 34-36 g were selected in September, 2014 and acclimated to direct sunlight (Figure 1 A-D), 700±60 µmol $m^{-2}s^{-1}$ at 12:00 h, for 30 days {Rodríguez-Escriba, 2015 #1568} until November. Relative humidity and temperature were 56±2 % and 36±3 ºC at midday and 79±4 % and 26±3 ºC at midnight. Irrigation treatments, which were done with a watering can, are described in Table 1.

Figure 1. Micropropagated pineapple plants in aclimatization stage inside the greenhouse (A and B) and acclimated to high light intensity under direct sunlight (C and D).

Table 1. Growth conditions of micropropagated pineapple plants.

Treatments	Until 0 days	Between 0-30 days	After 30 days
Control plants	Well-watered (1)	Well-watered	Fully-watered (3)
Droughted plants	Well-watered	Non-watered (2)	Fully-watered

(1) 120 mL per plants each two days at 9:00 h; (2) Drought; (3) 480 mL per plants every day at 9:00 h

Morphological measurements

Thirty plants were taken for the measurement of leaf number and D-leaf length and width. The D-leaf was the tallest leaf on plants (Figure 2) {Bartholomew, 2003 #104}. Fresh and dry weight (FW and DW respectively) were determined on discs cut from the middle part of four D-leaves taken at 15:00 h. The dry weight was obtained after drying the discs to a constant weight at 70 ºC. D-leaf water content was calculated as the difference between fresh and dry weight. Results were expressed as g cm^{-2}.

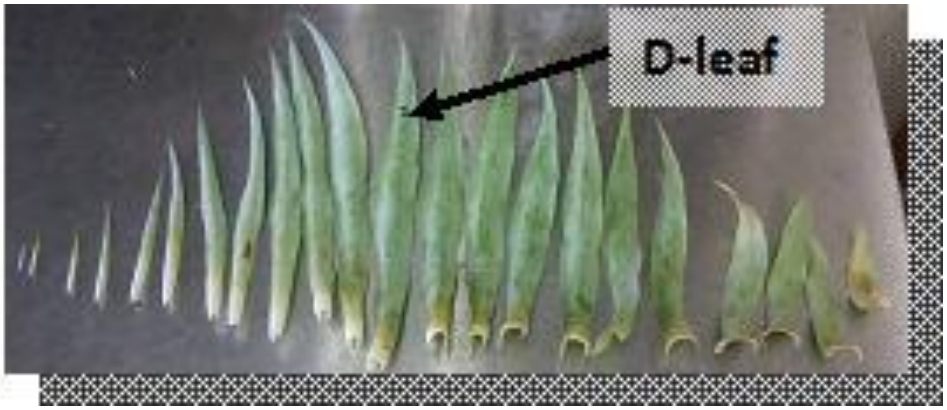

Figure 2. Leaf distribution according to their physiological age with the younger leaves on the left.

Gas Exchange measurement

Gas exchange was done using a Portable Photosynthesis System (PP Systems CIRAS-2). Measurements were done on the middle part of four D-leaves which were enclosed in a rice leaf chamber (1.7 cm^2). Data were collected from measures done each three hours during a whole day according to Rodríguez-Escriba et al. (2015). CO_2 uptake ratio was calculated as the ratio net CO_2 uptake between 00:00 h and 06:00 h: net CO_2 uptake during the whole day (24 h). Water-use efficiency (WUE) was calculated as the ratio net CO_2 uptake day^{-1}: transpiration (T) day^{-1}, µmol $mmol^{-1}$.

Organic acid levels

Samples (1 g) from the middle of the D-leaf were stored under liquid nitrogen until determinations were made. Samples of four plants were added into a test tube containing 50% ethanol and were boiled at 80 ºC for 20 min. The samples were titrated using NaOH [20 mM] and phenolphthalein as indicator. Organic acid levels (OA levels) were expressed as µeq. g^{-1} FW.

Chlorophyll analyses and succulence index

Discs were cut on the middle part of three D-leaves taken at 15:00 h. Samples were stored under liquid nitrogen until determinations were made. Extraction and quantification was done as described by Rodríguez-Escriba et al. (2015) and results were expressed as µg cm^{-2}. Succulence index (SI, water mass: $Chl.^{-1}$, g mg^{-1}) was calculated according to Kluge and Ting (1978).

Extraction and quantification of protein and superoxide dismutase assay

Four D-leaves were collected at 15:00 h and were stored under liquid nitrogen until each determination was made. Protein extraction and quantification and superoxide dismutase (SOD) assay were done according to Rodríguez-Escriba et al. (2015).

Data analysis

Data were analyzed using the statistical software package Statistica v. 8.0 (Statsoft Inc., Tulsa, OK, USA). Before carrying out statistical tests normality of the data was checked by means of the Kolmogorov–Smirnoff statistic ($P > 0.05$) and variances homogeneity by means of Levene's test ($P > 0.05$). Means was compared by ANOVA factorial and Tukey's test ($p \leq 0.05$).

RESULTS AND DISCUSSION

Morphological response

After 30 days the droughted plants had fewer leaves, shorter D-leaf length and a slightly greater width than control plants (Table 2). The D-leaf water content of droughted plants was 2.2 times lower than that of control plants. However, 15 days after droughted plants were irrigated (45 days), D-leaf length had increased and water content was comparable to that of control plants. There were small increases in leaf number and D-leaf width. The slightly greater D-leaf width could be the characteristic morphological response of micropropagated pineapple plants to stress signalling (Table 2). Micropropagated pineapple plants without previous treatments to improve field transition had an increase of the D-leaf width from 2.5 to 3.5 cm after 90 days of planting in the field {Rodríguez, 2013 #121}.

Table 2. Morphological response of micropropagated pineapple plants to water deficit.

Treatments	Leaf number		D-leaf length (cm)		D-leaf width (cm)		Water content of D-leaf discs (g cm^{-2})	
	30 days	45 days	30 days	45 days	30 days	45 days	30 days	45 days
Control plants	16.03^{ab}	16.52^{a}	24.69^{b}	26.62^{a}	3.35^{c}	3.45^{bc}	1.44^{b}	1.64^{a}
Droughted plants	14.86^{c}	15.52^{bc}	23.02^{c}	24.48^{b}	3.53^{ab}	3.56^{a}	0.65^{c}	1.62^{a}
SE	0.92*		0.90*		0.02*		0.01*	

Different letters and the symbol * indicates significant differences among the four means within a category. Data were compared using ANOVA factorial followed by Tukey's test ($p \leq 0.05$) n=30 plants for leaf number and D-leaf length and width, n=4 plants for water content measurements.

Gas exchange response

After 30 days of drought, D-leaf CO_2 exchange and transpiration rates of the droughted plants between 00:00 and 06:00 h had values 3.4 and 5 times, respectively, lower than values for control plants (Table 3). However, leaves of droughted plants had the highest values of water-use efficiency (WUE) and CO_2 uptake ratio. The CO_2 uptake ratio between 00:00 and 06:00 h for droughted plants at 30 days was 99% of CO_2 uptake during the whole day.

Table 3. Gas exchange response of micropropagated pineapple plants to water deficit between 00:00 and 06:00 h.

Treatments	CO_2 exchange rate (A) (µmol CO_2 $m^{-2}s^{-1}$)		Transpiration rate (T) (mmol H_2O $m^{-2}s^{-1}$)		WUE (A/T) (µmol $mmol^{-1}$)		CO_2 uptake ratio respect to the whole day	
	30 days	45 days	30 days	45 days	30 days	45 days	30 days	45 days
Control plants	6.92^{b}	7.31^{ab}	1.50^{c}	1.91^{a}	4.73^{b}	3.85^{c}	0.80^{b}	0.77^{c}
Droughted plants	2.03^{c}	7.98^{a}	0.31^{d}	1.71^{b}	6.60^{a}	4.74^{b}	0.99^{a}	0.79^{bc}
SE	0.03*		0.01*		0.08*		0.01*	

Different letters and the symbol * indicates significant differences among the four means within a category. Data were compared using ANOVA factorial followed by Tukey's test ($p \leq 0.05$). Analyses were done to n=4 plants. Data are means of measures done each three hours between 0:00 and 6:00 h except to CO_2 uptake ratio which is the result of the mean of these hours respect to the mean of the whole day.

When fully watered for 15 days, droughted plants recovered rapidly and had a normal CO_2 exchange rate while the transpiration rate was still significantly less than for leaves of control plants. As a result, WUE was higher for droughted than for control leaves while the CO_2 uptake ratios were quite similar.

Magnitude of CAM expression

At 30 days, droughted plants had OA levels and total chlorophyll contents 1.3 and 3.2 times, respectively, lower than control plants (Table 4), however, SI and SOD activity were significantly higher than those for control plants. The higher SOD activity of droughted plants could be related to a higher production of superoxide radicals in response to the increasing magnitude of CAM expression, also could explain their lower leaf chlorophyll content.

In CAM plants such as pineapple, OA levels are closely related with malic acid levels (Chen et al., 2004). The lower OA levels of droughted plants at 6:00 h were likely to be the result of their low CO_2 uptake during night. The reduced chlorophyll content could be the activation of degradation. An increase in the SI has been related to increased succulence (Herrera, 2009). The increase in SI as a result of drought indicates that leaf total chlorophyll decreased more rapidly than did leaf water content.

Table 4. Behaviour of variables related with CAM magnitude in micropropagated pineapple plants under water deficit.

Treatments	Organic acid levels at 06:00 h (μeq. g^{-1} FW)		Total chlorophyll content at 15:00 h (μg cm^{-2})		Succulence index at 15:00 h (g mg^{-1})		Superoxide dismutase activity at 15:00 h (U mg^{-1} Prot.)	
	30 days	45 days	30 days	45 days	30 days	45 days	30 days	45 days
Control plants	133.28[a]	122.60[b]	39.32[b]	46.55[a]	9.65[c]	9.42[c]	0.021[b]	0.015[c]
Droughted plants	104.17[c]	124.81[b]	12.14[d]	33.54[c]	15.11[a]	12.89[b]	0.053[a]	0.024[b]
SE	3.06*		1.77*		0.25*		0.002*	

Different letters and the symbol * indicates significant differences among the four means within a category. Data were compared using ANOVA factorial followed by Tukey's test ($p \leq 0.05$). Analyses were done to n=4 plants, for SOD activity analyses were done to n=3 plants.

The Droughted plants recovered quite rapidly such that after 15 days of being fully watered the OA level was slightly but significantly higher than that of control plants. Total chlorophyll content also recovered and was only about 28% below the level in control plants at 45 days. The SI recovered somewhat but remained higher in droughted plants than in control plants after 45 days because leaf chlorophyll content had recovered relatively more than leaf water content. The SOD activity also recovered, but as with chlorophyll content, it was slower to recover than OA. Elevated SOD activity has been associated with exposure of micropropagated pineapple plants to drought stress during their four first weeks in the acclimatization stage resulted (Aragón et al., 2013), and also was observed when five-month-old micropropagated pineapple plants were exposed to high light intensity at the end of this stage (Rodríguez-Escriba et al., 2015). SOD is one of the primary enzymatic components of the antioxidant system, which converts superoxide into H_2O_2 and oxygen, it acts like the first defensive response of enzymatic and non-enzymatic mechanisms into cell to remove reactive oxygen species (ROS) (Borland et al., 2006). It is hypothesized that drought-induced SOD activity and other associated physiological changes conditioned plants to better withstand the transition from the acclimatization stage to the field.

CONCLUSION

Micropropagated pineapple plants of six month old had a stronger CAM performance than did control plants when they were drougthed for 30 days. Their recovery after being fully-watered for 15 days was fast, therefore they can be placed under direct sunlight (high light intensity) for 30 days for their acclimation to this condition and later can be droughted during the same time for induction of defensive mechanism against oxidative stress and excessive water losses. On this way by means of drought after their acclimation to direct sunlight the micropropagated pineapple plants can be hardened to acclimatization-field transition.

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Response of 'MD-2' Pineapple Plantlets (*Ananas comosus* var. *comosus*) to a Controlled Release Fertilizer During the Acclimatization Stage

Gustavo Y. Lorente González, René C. Rodríguez-Escriba, Roberto E. Izquierdo Martínez, Lucía S. Pérez Borroto, Yuniesky Lobaina Domínguez, Romelio Rodríguez Sánchez, Justo L. González-Olmedo.
Agrobiology Laboratory, Bioplants Center. University of Ciego de Avila. Cuba.

Summary

The pineapple (*Ananas comosus* var. *comosus*) is the second tropical crop of global importance. The variety 'MD-2' is the most commercial and demanded in the United States and Europe. This variety has high yields and good fruit quality, but production of propagules is low, so it takes a long time to get enough plant material when the crop starts. Micro-propagation protocols can produce a large amount of high-quality propagules, but there are still difficulties with the methodology established for acclimatization, especially in the time required for the plants to reach commercial size. The aim of this study was to evaluate the controlled release fertilizer Multicote®, produced by Haifa Chemicals Ltd, to increase the quality of plantlets of pineapple in the acclimatization stage. Two concentrations of Multicote® (0.2 and 0.8 g / plant) and a control were evaluated to determine their effect on morpho-physiological variables. Fertilizer application in mixture with the substrate during the start of the acclimatization stage significantly increased the growth of pineapple plantlets, including significant increases in D-leaf width and length. The CO_2 exchange rate increased with increasing quantity of fertilizer while transpiration decreased with increasing fertilizer. As a result, water use efficiency was much higher in the fertilizer treatments and increased as the amount of fertilizer was increased. It is assumed that higher wáter use efficiency would improve propagule acclimitization.

INTRODUCTION

Pineapple is one of the most important fruits in the world and is important for processing and fresh fruit for internal consumption and for exportation (Bartholomew et al., 2003). It is also the most important of CAM plants (Borland et al., 2009). In the last decade the world pineapple production has grown at an average annual rate of 1.9% despite the occurrence of adverse economic and climatic phenomena (FAOSTAT, 2013).

In Cuba the 'MD-2' hybrid was introduced to production scale by Agroindustrial Ceballos Enterprise in 2009 and it is well adapted to the soil and climate conditions of the Ciego de Avila province, so that the production of this commercial variety is rising (Rodriguez et al., 2013). The development of micro-propagation techniques has made the rapid spread of various species of economically important plants possible and pineapple is one of the most studied species. However, despite the advances obtained by micro-propagation, there are still limitations in acclimatization protocols, especially with respect to plant development and the reduction of dwell time of the plantlets (González-Olmedo et al., 2005). At Bioplantas Center the time in the acclimatization stage of Smooth Cayenne pineapple "Serrana" was reduced with the use of weekly foliar fertilization (Yanes et al. (2000), but the production costs increased significantly.

It is therefore necessary to know if the application of the controlled release fertilizer Multicote® during the acclimatization stage of 'MD-2' pineapple plantlets improves their quality and reduces their cost.

MATERIALS AND METHODS

This research was conducted in specialized laboratories and acclimatization areas of Bioplants Center at the University of Ciego de Avila "Maximo Gomez Baez" (41° 53'N, 78° 41'W, 45 m asl) between December and May. The test material was micro-propagated 'MD-2' pineapple plantlets (*Ananas comosus* var. *comosus*) produced using the protocol by {Daquinta, 1997 #45@@author-year}.

Effect of Multicote® on the morphology of plantlets during acclimatization

Plantlets selected from plastic culture vessels were about 4.0 cm tall, 7.0 to 8.0 g fresh weight (FW), and had 5 or 6 leaves (Escalona et al., 2003). Plants were dipped in 3.0 ml L−1 of Previcur Energy® (Bayer Crop Science) for 5 min and planted in 250 cm3 plastic containers filled with a 1:1 (v:v) mixture of red ferralytic soil and sugarcane bagasse filter cake (Villalobos et al., 2012). Plants were acclimated into a greenhouse during five months under 80% ± 3% relative humidity, 25.5˚C ± 2˚C temperature and 250 ± 25 µmol m−2s−1 photosynthetic photon flux (PPF). Sprinkler irrigation was done for 30 min at 9:00 am daily. The fertilization treatments were made as follows: Control (foliar application of fertilization every 7 days with COMBI II (5 mL L-1) produced by CARISOMRA SA (Yanes et al., 2000); Multicote® at 0.2 or 0.8 g in 80 cm3 of substrate (5 or 20 granules per well). The dose used was based on recommendations by the manufacturer for use on other crops. After 90 days data on number of leaves, number of roots, plant height (cm), "D" leaf length and width (cm) and plant fresh and dry weight (g) were collected.

Effect of Multicote® on physiological variables of pineapple plantlets.

Gas exchange was measured on the middle of the "D" leaves of three plants with a PP Systems, CIRAS-2 Portable Photosynthesis System and PLC6 cuvette (with an analysis area of 1.7 cm^2). The CO_2 exchange (µmol CO_2 $m^{-2}s^{-1}$) and transpiration rates (mmol H_2O $m^{-2}s^{-1}$) were measured between 9:00 and 10:00 h at 90 days after treatments were imposed. The equipment was automatically calibrated before each measurement. Instantaneous water use efficiency (WUE) was calculated as transpiration rate (mmol H_2O $m^{-2}s^{-1}$) divided by CO_2 assimilation rate (µmol CO_2 $m^{-2}s^{-1}$).

RESULTS AND DISCUSSION

Plantlet fresh weights were significantly greater in the Multicote® treatments than in the control, but there was no significant difference between Multicote® doses (Figure 1). There were no significant differences in the dry weights of plantlets of the three treatments, indicating that the difference in fresh mass could be related to a higher content of water in the tissues of plants in the Multicote® treatments.

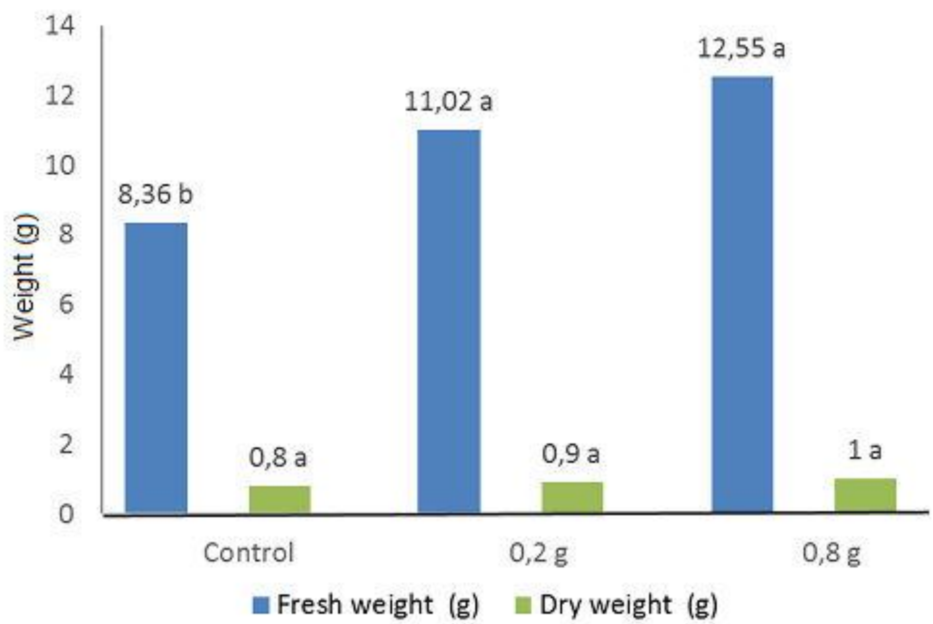

Figure 1. Effect of applying Multicote® on fresh and dry weight of pineapple plantlets during the acclimatization stage. Means with different letters indicate significance by one way ANOVA and the Tukey multiple range test, p <0.05). Each data point represents the mean for n=20.

The increase in fresh mass in the Multicote® treatments resulted in significant increases over the control in all morphological variables (Table 1). The lengths and widths of the D leaves increased significantly as the amount of Multicote® was increased. The use of Multicote® clearly increased growth relative to weekly foliar fertilization.

Table 1. Effect of Multicote ® on morphological variables in pineapple during acclimation.

Treatment	Leaves number	Roots number	Plant height	D-Leaf length (cm)	D Leaf width (cm)	Length / width of D Leaf
Control	11.8 b†	9.0 b	10.8 b	7.5 c	1.7 c	4.4 b
0.2 g	13.0 a	11.0 a	12.5 a	10.4 b	1.9 b	5.4 a
0.8 g	13.3 a	10.8 a	14.6 a	11.5 a	2.1 a	5.4 a
SE ($\bar{X}$)	0.32	0.62	0.68	0, 2	0.09	0.11

†Data within a column followed by the same letter are not significantly different from each other based on one way ANOVA and the Tukey multiple range test ($p < 0.05$). Each data point represents the mean for $n = 20$.

Leaf CO_2 exchange rate was lowest in the control and increased as the dose of Multicote® increased (Table 2). On the other hand plants fertilized with 0.8 g of Multicote® transpired less, indicative of improved water control and much greater water use efficiency, presumably because of improved stomatal functionality.

Table 2. Effect of Multicote® on the photosynthetic activity,' transpiration and efficiency in water use of 'MD-2' pineapple plantlets.

Teatments	CO_2 exchange rate. (µmol CO_2 m^2s^{-1})	Transpiration rate (mmol (H_2O) m^2s^{-1})	Water Use Efficiency (µmol CO_2/mmol H_2O)
Control	2.86 c	0.31	9,22 c
0.2 g	3.20 b	0.23 b	13.91 b
0.8 g	4.95 a	0.15 c	33,00 a

It has been observed that transpiration and CO_2 assimilation rate in pineapple plantlets grown in a greenhouse are very sensitive to light intensity and relativity humidity {Rodríguez-Escriba, #43;Rodríguez-Escriba, 2015 #1568}. The greater water use efficiency (WUE) obtained with the highest dose of Multicote® fertilizer would indicate that the use of a controlled release fertilizer could improve the acclimatization of plantlets.

CONCLUSIONS

Doses of 0.2 and 0.8 g of Multicote® fertilizer mixed with the substrate from the start of the acclimatization stage stimulated all morpho-physiological variables evaluated in pineapple plantlets and this enhanced their commercial quality. The greatest response was to 0.8 g per plant of Multicote® fertilizer. That treatment stimulated the CO_2 exchange rate and reduced seedling transpiration, which greatly increased water use efficiency, which relative to other treatments is assumed to improve adaptation at this development stage.

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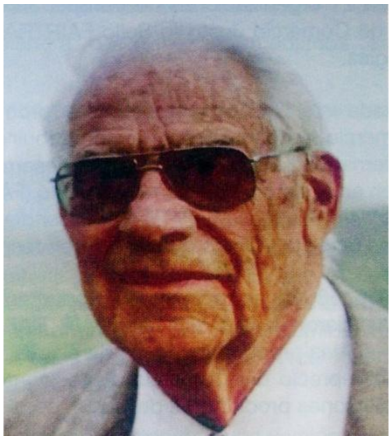
News from France

Claude Py, in Memorium

Jean Marchal and Claude Teisson, CIRAD (retired)



Dr. Claude Py

Claude Py was born in 1923 in north-eastern France, he passed away on July 29, 2015. He was a pioneer and a world-renowned researcher in the agronomy of pineapple, to which he devoted his entire caeer. He made major contributions to the knowledge and cultivation of this species.

After graduating as an agronomist at Grignon Agronomical Engineering School (France), he specialized in tropical agronomy and genetics at ORSTOM (Office of Scientific and Technical Research Overseas, which later became the IRD (French Research Institute for Development). Subsequently, he spent his entire career with the IFAC (French Fruit and Citrus Institute), which was established in 1976 at CIRAD (French Centre for International Cooperation in Agricultural Research for Development).

His energy, enthusiasm, humor, optimism and tolerance were personality traits that were appreciated by everyone who knew him, friends and colleagues alike. They were probably influenced by the ordeal of his deportation to Dachau concentration camp in Germany (1944-1945) and his almost miraculous survival.

After a fact-finding mission on pineapple in the United States and in the West Indies, in 1950, he was assigned to the IFAC research center in Conakry, Guinea ,then to the French West Indies, and ended his career in Mainland France. He retired in 1985, but maintained his interest in pineapple research and continued to play an active role in community life in Montpellier.

Throughout his career and as program director at IFAC and CIRAD, he surrounded himself with an experienced team in each of the different fields of research and development in which he was involved.
He worked for international organizations including the World Bank, the FAO, the European Community, as well as for State enterprises and private firms as a consultant and as an expert on the quality of research, and on opportunities for the further development of pineapple. As such, he visited and gave advice in the majority of pineapple producing countries or regions with pineapple production potential.

He helped to establish relationships and set up joint work programs with a number of scientific organizations including the University of Hawaii, Embrapa and the University of Campinas in Brazil, the Ministry of Research and Agronomic Institute in Cuba and many official bodies in Asia, America and especially in Africa to which he was particularly attached.

C. Py published a great number scientific articles, many in the scientific journal Fruits. He also wrote articles for the general public, expert reports, and provided advice and recommendations for contracting agencies as well as writing internal documents outlining ongoing research and research results.

His first book "Pineapple"(C. Py and MA. Tisseau) was published in 1965. His second book "Pineapple, its cultivation, its products" (C. Py, J-J. Lacoeuilhe, C. Teisson) was published in 1984. An updated English version "The pineapple, cultivation and uses" was published in 1987. This is still the most comprehensive reference work on the crop published to date. The book has been out-of-print for many years; however, some new and used copies can still be found for sale at Amazon.com.

His human qualities made him a great team leader, a true "master" in the old sense of the word, transmitting not only scientific knowledge but human values.

A Tribute from EMBRAPA

Dr. Claude Py gave great contributions to the pineapple research program at Embrapa Cassava & Fruits, Cruz das Almas, Bahia, Brazil, set up in the late seventies and early eighties. His large experience and easy communication allowed Embrapa's pineapple research team to learn a lot during his visits to Brazil, as well as during training activities carried out at the laboratories in Montpellier and Cirad experimental fields in some African countries, especially Côte d'Ivoire, which was one of the main pineapple exporters at that time. For a long time his books have been our main consultation tool on pineapple cultivation. The partnership Cirad – Embrapa, constructed under his leadership, has been continued for decades based upon excellent scientific interactions on all aspects of pineapple research. In the name of all Embrapa colleagues that have had the satisfaction and the benefits of this overseas alliance we express our gratefulness and admiration.

Domingo Haroldo Reinhardt and Aristoteles Pires de Matos
Embrapa Cassava & Fruits, Cruz das Almas, Bahia, Brazil

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(Paste titles in French into https://translate.google.com/ for a translation.)

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The Last Revision of Pineapple Nomenclature

Geo Coppens d'Eeckenbrugge
CIRAD, UMR AGAP, Avenue Agropolis, 34398 Montpellier Cedex 5

The revision of synonymies in pineapple taxonomy, announced in the last issue of our newsletter (Coppens d'Eeckenbrugge, 2015), has been completed and published (Coppens d'Eeckenbrugge and Govaerts, 2015). This publication does not alter the current classification (Coppens d'Eeckenbrugge and Leal, 2003), except for one name. Thus, for those researching any aspect of pineapple cultivated for its fruit the name of the plant is *Ananas comosus* var. *comosus*. If the author name is required, as for example in the title of a scientific article, it should be written *Ananas comosus* (L.) Mill. var. *comosus*.

From a taxonomic point of view, the first practical consequence of this formal work is the restoration of *Ananas comosus* var. *microstachys* (Mez) Smith instead of *Ananas comosus* var. *ananassoides* (Baker) Coppens & F.Leal. A second consequence is that our classification, and the associated synonymies, is now fully recognized in the World Checklist of Selected Plant Families (WCSP) (http://apps.kew.org/wcsp/qsearch.do), which should widen its acceptance well beyond the circle of plant breeders and germplasm curators.

A search on the WCSP website currently yields as many as 88 synonyms for our two species and five botanical varieties. Most of them are anecdotal, and after revision we can bury them back in our memory, as their interpretation does not interfere appreciably with the modern classification. Others correspond to more important steps in the evolution of pineapple nomenclature. Below are listed the most important synonyms recognized by Coppens d'Eeckenbrugge and Leal (2003) and Coppens d'Eeckenbrugge and Govaert (2015).

***Ananas macrodontes* Morren** (1878) (modern)
This is the *yvira*, a wild tetraploid pineapple without crown, propagated vegetatively by stolons instead of suckers. Key synonyms: *Pseudananas macrodontes* (Morren) Harms (1930), *Pseudananas sagenarius* (Arruda da Câmara) Camargo (1939).

***Ananas comosus* (L.) Merrill** (1917) (modern, as are the botanical varieties listed below)
This diploid species includes the following five botanical varieties (1 – 5 below), three of which are domesticates.

(1) *Ananas comosus* var. *comosus* (the edible pineapple)

This is the edible pineapple, known as *Ananas comosus* from 1917 to 2003, then classified more precisely as a botanical variety, to accommodate four other, wild and cultivated, forms at the same rank in the same species.

Key synonyms: *Ananas sativus* Schultes & Schultes (1830; spiny cultivars), *Ananas semiserratus* (Willd.) Schultes & Schultes (1830; cultivars with spines at leaf apex), *Ananas lucidus* (Aiton) Schultes & Schultes (1830; smooth-leaved cultivars), *Ananas debilis* (Lindley) Schultes & Schultes (1830; a lost wave-leaved cultivar), *Ananas comosus* f. *sativus* (Schult. & Schult.f.) Mez (1934), *Ananas comosus* f. *lucidus* Mez (1934).

(2) *Ananas comosus* var. microstachys (Mez) Smith (1934)

This is the most common wild pineapple, with long and narrow leaves and a small fruit, from which the edible pineapple was domesticated. It is distributed in neotropical areas east of the Andes, under conditions of climatic and/or edaphic drought (rocks and sandy soils).

Key synonyms: *Acanthostachys ananassoides* Baker (1889), *Ananas microstachys* Lindman (1891), *Ananas sativus* Schult. & Schult.f. var. *microstachys* Mez (1892), *Ananas ananassoides* (Baker) Smith (1939), *Ananas comosus* var. *ananassoides* (Baker) Coppens & F.Leal (2003), *Ananas ananassoides* Baker var. *nanus* Smith (1939), *Ananas microstachys* var. *nanus* (L.B.Sm.) Camargo (1942), *Ananas nanus* (L.B.Sm.) Smith (1962).

(3) *Ananas comosus* var. *parguazensis* (Camargo & L.B.Sm.) Coppens & Leal (2003)

Another wild botanical variety of pineapple, with wider leaves and some retrorse spines, mostly found in the basins of Rio Orinoco (south-eastern Colombia and southern Venezuela) and Rio Negro (north-western Brazil), and more rarely in the Guianas, together with *Ananas comosus* var. *microstachys*, and forms that appear intermediate between the two wild botanical varieties.

Key synonym: *Ananas parguazensis* Camargo & Smith (1968)

(4) *Ananas comosus* var. *erectifolius* (L.B.Smith) Coppens & Leal (2003)

This is the *curagua*, a small-fruited pineapple**,** cultivated only for fiber (Leal & Amaya, 1991), north of the Amazon River (Guianas and Venezuela). This cultigen (known in cultivation only) evolved from *Ananas comosus* var. *microstachys* through multiple domestication events (Duval et al. 2003), which determined its most characteristic features: erect leaves, related to selection for a high fiber content, and absence of marginal spines, related to a dominant mutation (Collins 1960).

Key synonym: *Ananas erectifolius* Smith (1939). The synonymy with *Ananas lucidus* Miller, a large-fruited and smooth-leaved cultivar, proposed by Smith and Downs (1979) is not founded.

(5) *Ananas comosus* var. *bracteatus* (Lindley) Coppens & Leal (2003)

This cultivated botanical variety is particular in resulting from the introgression of *A. macrodontes* genes into *A. comosus*. It includes two forms that have been propagated vegetatively, which explains their very low genetic diversity. The very rare form, corresponding to *A. fritzmuelleri* Camargo, shares nuclear and cytoplasmic genes with *A. macrodontes*, as well as more morphological traits (longer bracts, retrorse spines). The second form, quite common as an ornamental in tropical gardens, has been given the specific epithets or botanical variety names *bracteatus* (referring to its long bracts) and *sagenaria* (from the Latin word for net, referring to its ancient use as a fiber plant). It appears to share a lesser proportion of nuclear genes and no cytoplasmic genes with *A. macrodontes* (Duval et al. 2001, 2003).

Key synonyms: *Bromelia sagenaria* Arruda da Câmara (1810). *Ananas sagenaria* (Arruda da Câmara) Schultes & Schultes (1830). *Bromelia silvestris* Vellozo (1829). *Ananas silvestris* Müller (1896). *Ananas fritzmuelleri* Camargo (1943), *Ananassa bracteata* Lindley (1827). *Ananas bracteatus* (Lindley) Schultes & Schultes (1830), *Ananas sativus* var. *bracteatus* (Lindley) Mez (1892).

For readers interested in understanding better the history of these synonyms and the evolution of pineapple taxonomy, I present hereafter a summary inspired from the paper of Leal et al. (1998).

Pineapple taxonomy long focused on the description of variation among clones cultivated for the fruit. Indeed, from the late 18th century, pineapple was mostly known from cultivation in European glasshouses, and most cultivars of *A. comosus* var. *comosus* were first given Latin names, generating much confusion with the Latin binomials used for species in the Linnaean system. Botanical knowledge of wild forms was very limited. Beer (1856) examined a herbarium specimen of a small-fruited wild type ("a botanical rarity") and concluded that the differences with the cultivated pineapples (hypertrophy of the syncarp) were only the result of cultivation. Further in the same document, he gave more importance to smaller differences observed among groups of cultivars, raising some of them to the species rank. In 1879, when Morren described a second species of pineapple, *Ananas macrodontes*, from glasshouse plants, he ignored its ecology. Finally, Baker (1889) was the first to give a species rank to a wild pineapple. However, he classified it in the genus *Acantostachys* (*A. ananassoides*), an error which was half-corrected by Lindman in 1891, when the latter classified it as *Ananas microstachys* (in fact, he should have maintained the epithet and named it *Ananas ananassoides*).

Mez (1892) proposed a first simplification, downgrading the common cultivar groups to botanical varieties of a unique species, *Ananas sativus*, and considered the wild pineapple as another botanical variety, *A. sativus* var. *microstachys*. Mez (1892) included *A. macrodontes* within *A. sativus* var. *bracteatus*, because he supposed that the absence of a crown in Morren's description was only the result of observing a juvenile inflorescence. In 1919, two years after Merrill established the binomial *Ananas comosus*, Bertoni (1919) took an opposite direction and divided *Ananas* into five species with many botanical varieties, producing a very confused classification that was never used later. In 1930, Harms created a new, monotypic genus, raising again Morren's *A. macrodontes* to the species rank, under the binomial *Pseudananas macrodontes*.

In 1934, Mez maintained his parsimonious vision, with one genus and only three species. Within *A. comosus*, he included cultivated pineapples as simple "forms" (not botanical varieties), based on leaf spininess and shape. In addition, he recognized *A. macrodontes*, and retained *A. sagenaria* instead of his *A. sativus* var. *bracteatus* of 1892. Surprisingly, he retained no particular status for the wild representatives of *A. comosus*. However, their botanical variety rank was restored by Smith (1934), who proposed *Ananas comosus* var. *microstachys*.

After Mez, pineapple classification returned to a more complex system, as Smith (1939, 1961, 1962, 1971), together with Camargo (1939, 1942, 1943; Camargo and Smith, 1968), multiplied species and botanical varieties without describing significant new variation (except for the re-discovery of the curagua). Many varieties were raised to the species rank, and the genus *Pseudananas* was restored, a process which culminated in a list of two genera and eight species (Smith and Downs, 1979).

The classification of Coppens d'Eeckenbrugge and Leal (2003) may be compared with the parsimonious views of Mez. Although Mez's treatment varied from 1892 to 1934, he mostly considered differences among wild and cultivated crowned pineapples, selected or maintained for distinct purposes (fruit, fiber, ornamental), at the infraspecific level. The similitude is clearer when one compares the synonymies given by Mez and those given in Coppens d'Eeckenbrugge and Leal (2003) and Coppens d'Eeckenbrugge and Govaert (2015). Mez lacked our modern knowledge based on direct observations in the wild, in living collections, and in the field, as well as more data from reproductive biology and molecular genetics, but his acute and critical reading of all the literature then available allowed him to comprehend the essence of pineapple diversity.

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News from the USA (Hawaii)

Solar Injury Causes Crown Deformities of 'CO-2' Fruits

Duane P. Bartholomew and Glenn Taniguchi
duaneb@hawaii.edu; gtani@hawaii.edu

Various crown abnormalities have been observed in Australia, Hawaii and South Africa (Collins, 1950; Newett and Rigden, 2015; Py et al., 1987) and Bartholomew et al (2003) concluded that the principle cause was heat injury to crown apical tissues. Newett and Rigden (2015) state that the incidence of crown injury is greatest when air temperature exceeds 30 °C and there is little or no wind. Py et al. (1987) report that the incidence of crown injury was higher when floral initiation occurred during a dry, sunny period and irrigation, method not specified but assumed to be overhead, reduced the number of affected fruits. The incidence of crown injury is higher in low than in high density plantings, higher on field edges and higher on west than on east sides of affected fields (Collins, 1950; Gowing, 1962; Newett and Rigden. 2015; Py et al., 1987). No data were found on the extent of fruit losses associated with crown injury, but Collins (1950) reported the incidence in different fields ranged from 1.0 to 22.0%.

Maturing pineapple fruits are highly susceptible to solar injury (SI; sunburn) and several methods are used to reduce or prevent such injury and associated losses (Bartholomew, 2008; Chavarria and Ramirez, 2008; Newett and Rigden, 2015; Phillips and Bell, 2008). However, no references were found on losses of fruits due to SI injury to crowns and few formal reports of research on the subject were found. No information was found on the period when crowns are most susceptible, what the lethal tissue temperature is or how to control the problem.

Crown injury surely is a greater problem for the fresh fruit industry than for the fruit processing industry because crowns are part of formal marketing and quality standards (UNECE; USDA). When the inflorescence apical tissue is destroyed by SI before crown leaf tissues are fully developed the result is fruits without crowns (Newett and Rigden, 2015). When crown apical meristem tissues are killed later during crown development one or more buds in crown leaf axils are released resulting in a variety of crown abnormalities, including fruit with multiple crowns (Figure 1; Newett and Rigden, 2015). Severe abnormalities, including multiple crowns that can't be trimmed to meet marketing standards or that result in misshapen fruits, cause fruits to be unmarketable..

The above review was developed to help understand why approximately 30 ha of Oahu, Hawaii fields of 'CO-2' (a.k.a. 73-50) pineapple had a high incidence of crown abnormalities. The blocks were forced with ethephon in late May and early to mid June and harvested in late November and early to mid December 2015. In some blocks up to 25% of the fruits had crown abnormalities so severe they were unmarketable. As a result 8,450 boxes of pineapples did not meet marketing standards (Y. Rosa, personal communication). The problem, and especially its magnitude, had not previously been encountered in fields of pineapple grown on Oahu. Fruits that do not meet marketing standards can only be used for fresh cut fruit or juiced and both products are of lower value or have a limited market, or both.

The crown apical meristem had been killed on fruits that had crown abnormalities (Figure 1B, C, D) so it was initially thought to be the result of a spray application error. However, spray errors were quickly ruled out because the size of the affected area was so large that the highly experienced spray crew would have to have made multiple application errors, which was just not possible. More significantly, no sprays containing phytotoxic compounds had been applied to the affected area and the pattern of injury was asymmetrical with the greatest incidence of multiple crowns on the west side of affected blocks.

Examination of fruits in the affected fields indicated that crown SI occurred before, during or relatively soon after anthesis (flower opening), or all of the foregoing. The most severely affected blocks were oriented northwest – southeast and the injury was most severe on the western sides of such blocks (Figure 2). Those blocks had been forced in late May through mid June, but no data had been collected on the date of emergence of the inflorescence in the leaf whorl so it was not possible to associate weather events with the incidence of SI.

There was some evidence that SI was cultivar specific. Some blocks planted to an 'MD-2' clone located at a lower elevation had been forced on June 8 and June 15, 2015 and fruits in one block were scheduled for harvest during the second week of December, 2015. Blocks in the field were oriented northeast-southwest so it was expected that abnormal crowns would be most prevalent at the ends rather than the sides of the block. None of the fruits on the eastern end of the block had abnormal crowns and only six abnormal crowns were found on a similar number of fruits on the westerly end of the block. We concluded that the greater exposure of 'CO-2' fruits, in part because of their much longer peduncle (Figure 3), accounted for much of the difference between the two cultivars. However, the extensive foliage in the ratoon field of 'MD-2' plants also provided shade for fruits of that cultivar.

Presently there is no known control for crown SI that would be suitable for large farms. However, if SI incidence is high enough to justify some research, it may be that kaolin reflectants such as Surround® WP will provide some protection. It remains to be seen whether the protectant will be washed or weathered off by harvest time so the fruit will appearance will not be affected.

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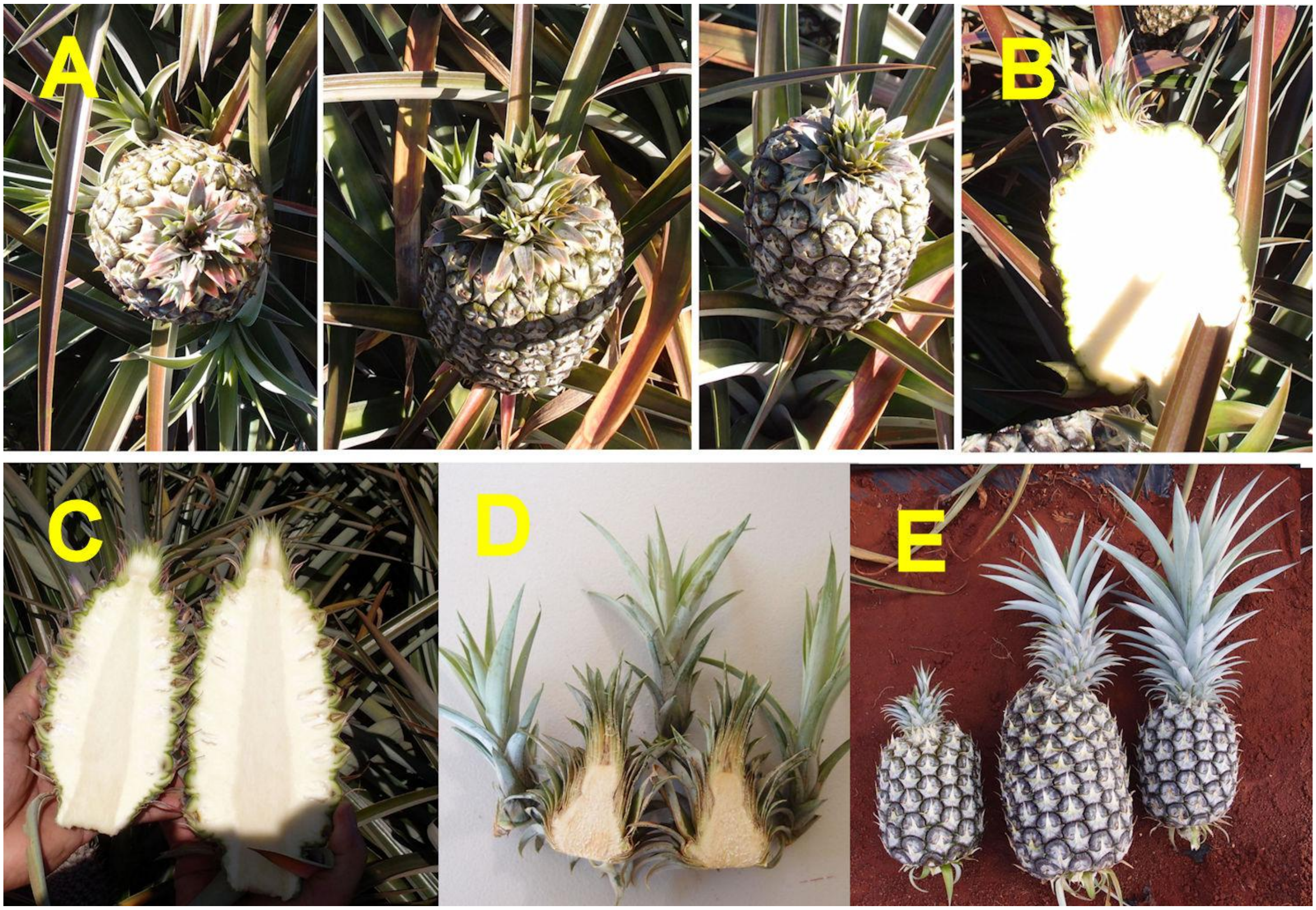

Figure 1. A. Examples of crown abnormalities on fruits of 'CO-2' after the crown stem apex was killed by heat. B. Cross section of crown on fruit near flat eye stage. C. Younger fruits with uninjured crown apex on left and heat killed apex on right. D. Triple crown formed after heat killed the apex of the crown stem. E. At the left is a fruit with a small crown after the original crown stem apex killed by heat; middle, a fruit with a single offset crown that developed after the original crown apex was killed; the fruit probably meets most market standards; at right a fruit with a normal crown.

Figure 2. On December 12, 2015 there were 8 abnormal crowns in 208 fruits (3.8%) on the east side of block B8 – 34 and 25 abnormal crowns on 225 fruits (11.1%) on the west side of the block.

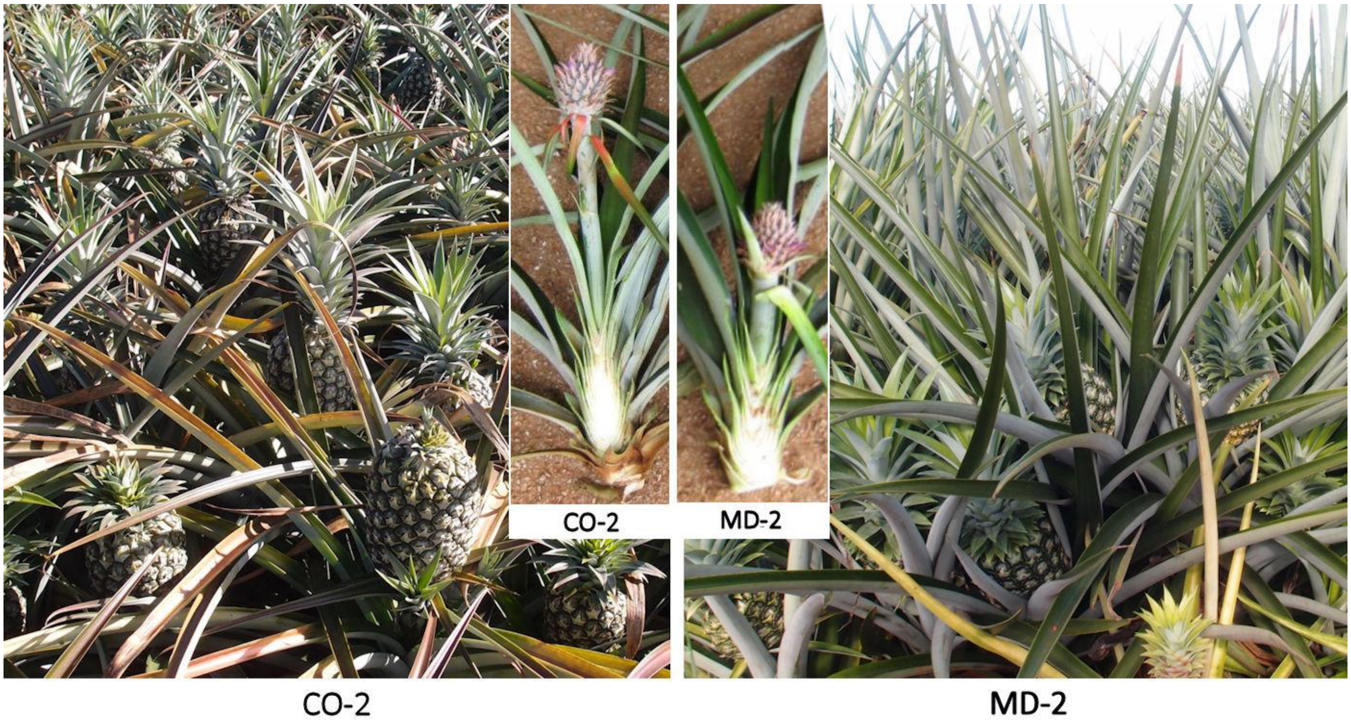

Figure 3. Fruit exposure and peduncle length of a mother plant crop of 'CO-2' and a vigorous ratoon crop of 'MD-2'.Much of the difference in fruit exposure is due to the much longer peduncle supporting fruits of 'CO-2'.

Services

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

Commercial Services

Maintain CF 125 continues to be available for use in pineapple plant propagation anywhere in the world. Supplies can be obtained from N. Bhushan Mandava, Repar Corporation, 8070 Georgia Ave., Suite 209, Silver Spring, MD 20910. Tel: (301) 562 – 7330; Fax: (202) 223 – 0141; On the web at www.reparcorp.com; E-Mail: mandava@compuserve.com.

Professional Services

Dr. Mark Paul Culik. INCAPER, Rua Alfonso Sarlo 160, CEP 29052-010, Vitoria, ES, Brazil; Tel: 27-3636-9817; Email: markculik3@yahoo.com. Experience: PhD in Plant and Soil Sciences with more than 25 years of agricultural pest management experience in crops ranging from apples to papaya and pineapple, identification of pests and beneficial arthropods ranging from mites to fruit flies, and current work on scale insects, including pineapple mealybugs. Areas of specialization: Entomology, Insect and Pest Identification, Integrated Pest Management.

Dr. Herve Fleisch. Interested in consulting on most agronomic and managerial aspects of production operations. See online profile at http://www.linkedin.com/pub/herve-fleisch/28/536/21a

Mr. Rob Moss. E-mail: robmoss@bioteq-ouest.com. I have 30 years experience as a tropical agronomist, have worked with pineapple since 2004 and am now helping Ghana pineapple export companies improve yields and production efficiency. I authored articles in Pineapple News No. 17, pp. 23 (Pineapple and carbon emissions); 20, pp. 57 – 65 (Greenhouse gas emissions of pineapple); and 21, pp. 40-45 (Integrated approach to disease control & soil sertility management for 'MD-2' pineapple) and am an expert on microbiological crop amendments. I am currently testing their potential to increase yields of MD-2 pineapples.

Ing. Jhonny Vasquez Jimenez, MSc. San Carlos, Costa Rica. E-mail: jvasquez@proagrocr.com, Phone: (506) 89103878, (506) 24756795. Advice on the agricultural management of pineapple crop. Analysis and improvement of pineapple crop systems for producer companies (environment and productive potential, nutrition, control pathology, crop management). For Agrochemical Companies, designing and conducting researches for new production technologies in the area of nutrition, plant pathology, weeds and other disorders.

Book Reviews and Web Sites

Book Reviews

No reviews were provided for this issue.

Web Sites of Possible Interest

New References on Pineapple

The list below includes papers related to various aspects of pineapple culture, physiology, processing, preservation or byproducts that were published or located for the period since the last issue up to about March 31, 2013. Some papers may seem relatively unrelated to pineapple but the list follows the principle of inclusion to provide the widest possible content. Often, abstracts of the papers listed below can be found on-line. I suggest searching using the paper title. Of course all abstracts of papers published in Acta Horticulturae are available from info@ishs.org. For a larger view, adjust the magnification in Adobe Reader.

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Send contributions and inquiries to: D.P. Bartholomew, Dept. of TPSS, Univ. of Hawaii, 3190 Maile Way, Honolulu, HI 96822 U.S.A. (Phone (808) 956-7568; Fax (808) 956-6539; E-mail: duaneb@hawaii.edu.

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