Pineapple News

Newsletter of the Pineapple Working Group, International Society for Horticultural Science
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Pineapple Working Group News

From the Editor

Dear Colleagues:

Welcome to new and old readers to issue number 22 of Pineapple News. There have been three scientific meetings in the recent past that have explored various aspects of pineapple science, a rather surprising number. You all will know that the 8th International Pineapple Symposium was held in Brisbane, Australia last August in conjunction with the International Horticulture Congress. A report of that meeting and the abstracts the papers presented at the meeting were provided by Garth Sanewski and can be found under the heading **News from Australia**. Surprisingly, two other international meetings that included pineapple were also held recently.

I learned from Jhonny Vásquez Jiménez, regular contributor to Pineapple News, that the **Primer Simposio Internacional sobre Cambio Climático y sus efectos sobre el Cultivo de Piña** (First International Symposium on Climate Change and its Effects on Cultivation of Pineapple) was held November 24 to 26, 2014 at EARTH University, Guanacaste, Costa Rica. No web site or other announcements of the meeting were found. Several of the speakers were from Costa Rica, but Daniel Uriza, an old friend of the Pineapple Working Group and one of the organizers of the 4th International Pineapple Symposium in Veracruz, Mexico, was among the presenters. See the paper titles and names of the presenters in the section **News from Costa Rica**.

The third meeting, with the clever title **2015 International Symposium on GA3 Tropical Fruit** (GA3 representing the four main fruit crops, guava, sugar apple, pine apple and wax apple grown in Taiwan) was held in Kaohsiung County, Taiwan from April 8 – 11, 2015. See details of the meeting and abstracts of the papers on pineapple presented there under the heading **News from Taiwan**.

Arun Mandel provides a long but colorful and very personal history of pineapple production in North Bengal, India (**News from India**). I deleted several of the photos because of poor quality and to keep the file to a manageable size.

9th International Pineapple Symposium

The 9th International Pineapple Symposium will be held at EARTH University (http://www.earth.ac.cr/), Guácimo, Limón, Costa Rica, from 2 – 8 October, 2017. Prof. Luis Ernesto Pocasangre Enamorado is leading the organizing effort for this next Symposium in beautiful Costa Rica.

Silicon in Pineapple

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This note was prompted by an inquiry from a reader of Pineapple News about information on silica (Si) in pineapple. Since that inquiry, I received information that some pineapple growers in Mexico and Central America were applying a material that contained silica as well as other macro and micro nutrients to their pineapples with no data on yields but with reports of visible responses. The main purpose of this note is to highlight the near complete lack of actual data on the benefits, if any, of Si for pineapple.

Summary

1. Fewer than ten papers published between 1896 and 1949 contained information about Si in pineapple. No studies of the effects of Si on pineapple growth were found in that time period.
2. Data from an experiment on the effects of Si on the growth of 'Smooth Cayenne' pineapple in pots (Thiagalingam, 1971; Thiagalingam et al., 1977) showed a significant increase in growth in Kapaa soil, but not in Paaloa soil. Si in D leaf basal white tissue ranging from 0.10 to 0.16% was designated as low while levels between 0.30 and 0.60% were designated as adequate. Detailed data as well as some limitations of the experiment design and other possible problems with the study are discussed below.
3. Silica is reported to be mainly a defense element (Epstein, 2009) that is reported to protect plants from diseases, predators and stresses. Since pineapple is very tolerant of high levels of soluble aluminum (Al)

and manganese (Mn) and is very drought tolerant, detecting specific benefits of Si in pineapple likely would be difficult. Among the major problems that might be influenced by adequate levels of plant Si are increased resistance to *Phytophthora* spp., bacterial rots and feeding by insects, e.g. *Thecla*, nematodes, symphylids and grubs that feed on roots. Such benefits were not tested for and likely would not have been observed in the research of Thiagalingam (1971) because oven-dried soil was used.

4. It is not likely that pineapple would benefit from applications of Si when grown on soils with adequate amounts of soluble Si. Unfortunately few data on Si in soils in which pineapples are grown were found.
5. To help growers determine the value, if any, of Si application, data on the plant available Si in soils in which pineapple is grown are needed. Also, the critical tissue levels of Si in pineapple reported by Thiagalingam (1971) must confirmed. Data must be generated that show that adequate levels of Si in pineapple tissues provide sufficient benefits to justify product costs.
6. Calcium silicate is an excellent, though probably expensive, liming material and potassium silicate also provides the essential mineral element potassium. Therefor, the potential benefits of these added elements on soil chemistry and plant nutrition cannot be ignored. Mixtures that contain Si as well as other plant macro or micro, or both, nutrients cannot be used to test for the specific benefits of Si.

Introduction

Silicon (Si, SiO_2) is a major component of most soils and most crop plants contain some silica. Research in the 1960s showed that large increases in Si in plant tissue and in yields of sugarcane were obtained when highly weathered mineral soils low in Si were amended with calcium silicate (Fox et al., 1967) and the results were confirmed by Meyere and Keeping (2000). Significant increases in rice and sugarcane yields were also obtained when calcium silicate slag was applied to organic soils in Florida (Anderson et al., 1986). Since then World conferences on Si have been held and the benefits of Si as a soil amendment have been demonstrated on a number of crops (Heckman, 2013) and Heckman and Wolf (2011) present recommendations for testing soils for plant available Si.

Pineapple is not among the crops known to benefit from applications of Si. However, silica bodies are found in the epidermis of pineapple leaves and it was discovered accidentally that the size of the silica body was reduced when plants were grown in a nutrient solution lacking silica (Krauss, 1949). Early reports on the composition of plant ash from pineapple plants showed Si in the ash (tissue not specified, but presumably leaves) ranged from 4.02% of total ash in Jamaica to about 9.4% in Hawaii (Bowrey, 1896; Stewart et al., 1927; Wilcox and Kelly, 1912). These data, and others (Bonewitz, 1908; Flack, 1912; Horner, 1930; Stewart et al., 1927) confirmed the presence of Si in pineapple tissues. However, they provide no insight into how tissue levels are affected by soil Si or whether pineapple growth and development benefits in any way from Si amendments. The only data on the effects of different amounts of applied Si on pineapple growth and mineral element composition can be found in an obscure paper (Thiagalingam et al., 1977) that showed a 6% increase in vegetative yield of 'Smooth Cayenne' plants grown in pots in a Humic Ferruginous Latosol amended with 8.8 t ha^{-1} of calcium silicate. Of the 22 species included in the study, the yield increase reported for pineapple was the smallest of all crops examined. Because the paper reported results for 22 species, information on the methods of the study were sparse.

The limited results reported by Thiagalingam et al. (1977) provided a justification for exploring for more information. The study was part of Dr. Thiagalingam's Ph.D. dissertation, which was available in the University of Hawaii Library. Below are additional details on the materials and methods and the data for pineapple collected in the study. The interpretation of the results provided below are based on my many years of experience in growing pineapples in pots and in the field.

Summary of K. Thiagalingam's study of the effects of calcium silicate amendments to two soils on the growth and mineral uptake of pineapple

Methods

Crowns of Smooth Cayenne pineapples were planted in 3.78 L containers lined with a plastic bag. The treatments, replicated twice, consisted of two soils that were amended to pH 6.0 ± 0.2 with $CaCO_3$ and further amended with 1120 kg ha^{-1} P and the equivalent of 0, 0.56, 2.2 or 8.8 kg ha^{-1} of Si sourced from calcium silicate slag which was thoroughly mixed throughout the soil. The effects of Ca were also minimized by supplying a

quantity of Ca that was considered adequate even at the lowest Ca level (570 ppm Ca). The differing amounts of slag created a calcium differential among the treatments. Plants were sprayed with insecticide and iron chelate every week and a blanket application of N and K were applied every two weeks.

The soils used in the research were Paaloa (Oxisol, annual rainfall of 1780 – 2500 mm, clay fraction includes kaolin, illite, iron oxides and gibbsite; pH 5.3; extractable Si, in ppm, by water, 0.53 and by modified Truog, 15; P by modified Truog, 126 ppm) and Kapaa (Oxisol, about 1250 mm rainfall, clay fraction includes crystalline alumina as gibbsite and concretions of Fe and Ti oxides, low in bases and silica and has a high phosphate fixing capacity; pH of 4.8; extractable Si, in ppm, by water, 0.42 and by modified Truog, 21; P by modified Truog, 9 ppm). The plants were watered twice daily with rain water and the leachate was returned to the pot. The plants were grown for 420 days and at harvest were divided into stem, leaves, peduncle, fruit and crown. Some pineapple plants did not fruit so values reported were averages of the two or three plants that did fruit.

Results and Discussion

The results provide the only data found on the effects of soil type and Si amendments on pineapple growth and composition. The dry weights of plants grown in Paaloa soils (Table 1) were consistently greater than those grown in Kapaa soil. Sugarcane was one of the 22 crops examined in the experiment and the yield of sugarcane in the Paaloa soil was approximately double that obtained in Kapaa soil. No explanation for the growth difference was provided. Growth of pineapple plants in both soils almost certainly was greatly restricted by the small pot environment because the dry mass attained after 420 days (Table 1) was about one-fourth that found for rain-fed, field-grown Smooth Cayenne plants at 430 days after planting (Pineapple Research Institute of Hawaii, unpublished data). The low transpiration rate of pineapple coupled with twice daily watering could induce an anaerobic environment in the soil, which also could suppress plant growth.

There was a statistically significant difference in plant weights among treatments in the Kapaa soil but the response to Si was not consistent. The statistical differences could be do to random error due to insufficient replication or inadequate control of slip size at the time of planting. Silica in a tissue, type not spedified, increased with increasing Si applied to the soil. The decrease in P in tissue with increasing Si applied is consistent in both soils. Among the 22 species represented in the study, there was no consistent relationship between P in tissue and Si applied. Presumably differences in soils, or Ca levels within soils, account for the large increase in Ca in the tissue with increasing Si for plants grown in Paaloa soil. Levels of Mn in plant tissue were reduced at the higher levels of applied Si in both soils; however, such levels are not a concern for pineapple as long as iron sprays are provided.

Table 1. Effect of soil type and silica applied as calcium silicate slag on plant dry mass and mineral composition of pineapple grown in 3.78 L pots in a greenhouse for 420 days. Data from Thiagalingam (1971) tables 4, 5, 6, 7, 8, 9, 11, and 12 are means of two replications.

Kapaa		Element values, %					Values in ppm		
MT Si/ha	Dry wt., g	Si	P	Ca	Mg	K	Mn	Al	Fe
0	149 b	0.05	0.14	0.94	0.18	0.76	84	73	nd[†]
0.56	116 a	0.08	0.14	0.92	0.18	1.06	115	96	nd
2.2	139 b	0.12	0.13	0.91	0.17	1.13	119	67	nd
8.8	158 b	0.23	0.11	0.97	0.14	1.08	83	62	nd
Paaloa									
0	152	0.06	0.15	0.52	0.18	2.7	231	137	221
0.56	174	0.11	0.12	0.5	0.14	2.09	158	125	256
2.2	160	0.14	0.13	0.69	0.16	2.35	150	134	211
8.8	190	0.34	0.11	1.08	0.15	1.96	74	131	219

[†]nd, no data provided.

The effect of applied Si on the distribution of plant nutrients in the plants (Table 2) is provided as a service to researchers or readers with the expertise in soils and plant nutrition to interpret them. Perhaps they will

be of value to any who begin to explore the intricacies of Si in the nutrition of pineapple in the variety of soils in which it is grown.

Table 2. Effects of applied silica on the concentration of macro and micro nutrients in Smooth Cayenne pineapple tissues after 420 days of growth in 3.78 L pots in the indicated soil. The data of Thiagalingam (1971) were rearranged to allow for direct comparison of composition in the various tissues in each of the soils.

	Kapaa soil									Paaloa soil							
Tissue	MT Si/ha	Si	P	Ca	Mg	K	Mn	Al	Fe	Si	P	Ca	Mg	K	Mn	Al	Fe
Crown	0	0.03	0.20	0.75	0.18	1.21	64	8		0.02	0.20						
	0.56	0.05	0.21	0.8	0.18	1.10	55	7		0.03	0.20						
	2.2	0.10	0.21	0.77	0.16	1.18	46	13		0.05	0.20						
	8.8	0.13	0.19	0.81	0.17	1.26	42	15		0.18	0.22						
Fruit	0	0.04	0.20	1.09	0.26	0.84	134	77		0.03	0.21	0.91	0.25	2.78	419	64	242
	0.56	0.07	0.20	1.03	0.25	1.10	165	82		0.05	0.2	0.66	0.19	2.81	186	64	203
	2.2	0.12	0.19	1.09	0.25	1.19	164	58		0.09	0.19	0.98	0.25	3.06	224	62	178
	8.8	0.18	0.18	1.29	0.25	1.1	127	60		0.21	0.18	0.98	0.16	2.4	68	51	190
Peduncle	0	0.04	0.16	0.36	0.13	1.33	31	23		0.03	0.20	0.31	0.31	1.69	107	35	127
	0.56	0.04	0.16	0.31	0.12	1.32	31	8		0.03	0.13	0.27	0.18	2.10	74	34	96
	2.2	0.09	0.16	0.36	0.13	1.18	42	21		0.06	0.16	0.41	0.16	2.19	60	57	96
	8.8	0.16	0.11	0.38	0.11	1.09	31	9		0.24	0.10	0.46	0.08	2.15	20	59	78
Leaves	0	0.05	0.12	0.8	0.16	0.79	87	85	150	0.06	0.12	0.30	0.15	2.33	204	143	255
	0.56	0.08	0.13	0.76	0.18	1.14	124	104	141	0.12	0.12	0.38	0.14	2.06	179	162	315
	2.2	0.14	0.11	0.77	0.16	1.21	126	78	82	0.19	0.12	0.54	0.15	2.40	165	175	252
	8.8	0.26	0.09	0.84	0.14	1.19	99	75	79	0.42	0.09	0.80	0.17	1.98	90	176	265
Stem	0	0.01	0.21	1.99	0.12	0.4	34	11	51	0.01	0.29	0.87	0.13	1.81	45	32	125
	0.56	0.02	0.23	2.25	0.13	0.48	58	27	80	0.02	0.24	1.14	0.12	1.81	42	37	128
	2.2	0.03	0.20	1.84	0.12	0.47	53	29	67	0.03	0.22	1.26	0.10	1.43	17	34	116
	8.8	0.10	0.14	1.74	0.08	0.36	25	18	52	0.16	0.14	1.65	0.07	0.99	6	42	127

Conclusions of K. Thiagalingam (1971).

Yields of 22 species on Kapaa soil and 19 species on Paaloa soil were higher with applications of calcium silicate than without. In 10 of the 22 species yield increases were statistically significant on Kapaa soil whereas the yield increase of only one species was significant on Paaloa soil. Yields at 2.2 T Si/ha were 85% or more of maximum in 17 of the 22 species on Kapaa soil and indicates this rate should produce yields at lower cost than 8.8 T Si/ha. In both soils yields of many species decreased at the 8.8 T Si/ha level and in some species the decrease was statistically significant. Thus high calcium silicate levels may be toxic to some species.

Yield increases from calcium silicate applications were generally greater on Kapaa than on Paaloa soil. Although water and modified Truog extractable Si in both soils were lower than critical levels set by Fox, et al. (1967), Si availability was apparently higher in the Paaloa than in the Kapaa soil. Plant Si levels in the zero Si treatment of the Paaloa soil were generally higher because of the low pH in this soil. Extractable soil P was much higher in the Paaloa (126 ppm) than in Kapaa soil (9 ppm) where it was below the critical level set for P. These combinations of Si and P availability may have accounted for the differential responses obtained on these two soils.

Calcium silicate applications significantly increased Si concentrations in all species, but Si concentrations varied in the different groups and decreased in the following order: Grains > Grasses >Vegetables and Fruits > Legumes, except the two Desmodiums which were similar to grasses. Although P concentrations increased with Si applications in 13 and 14 species on Kapaa and Paaloa soils, respectively, significantly higher yields were obtained only on Kapaa soil. Calcium concentrations in plants grown on both soils generally increased whereas Mg concentrations decreased with few exceptions with applications of calcium silicate. Plant Mn, Al and Fe concentrations were reduced by applications of calcium silicate in both soils.

Calcium silicate exhibited continued availability of Si for as many as four successive crops in which 2.2 T Si/ha produced near maximum yields in all species tested. Silicon and P concentrations generally increased with successive harvests except in a few species. Plant Ca levels decreased with successive harvests in Kapaa soil but

increased in Paaloa soil. Concentrations of Mn and Al increased slightly with successive harvests in both soils, possibly because residual Si was not sufficiently soluble to reduce Mn and Al activity.

Silicon distribution in papaya, sugarcane and pineapple was studied and it appeared that leaves accumulated the highest amounts of Si in papaya and pineapple while sugarcane sheaths had maximum Si concentrations. In pineapple and papaya Si distribution may be related to transpiration. Plant P concentrations were generally lower in leaves suggesting that P distribution is not related to transpiration.

Of the three silicate materials studied, TVA and HCC $CaSiO_3$ produced maximum Kikuyu grass yields in the first harvest with 2 T material/A whereas TG $CaSiO_3$ produced maximum yield with 4 T material/A in Kapaa soil. In subsequent harvests maximum yields were obtained with 16 T Si/A of TVA and TG $CaSiO_3$ while only 4 T material/A were needed for HCC $CaSiO_3$. However HCC maximum yields were lower than those of TVA or TG and in addition, high rates of HCC depressed Kikuyu grass yields on Kapaa soil. Lettuce yields did not show the same depression with HCC $CaSiO_3$ on this soil and the yield responses were generally larger than those of Kikuyu grass. These materials did not produce significant Kikuyu grass yield responses in the first harvest in Paaloa soil, but in successive harvests, higher yields were obtained with HCC and TVA $CaSiO_3$ than with TG $CaSiO_3$. Maximum yields were obtained with the 16 T treatment of all materials. Lettuce yields were increased by all three silicate materials in all harvests on Paaloa soil, but effects were greater for HCC and TVA $CaSiO_3$ than the TG material. Maximum yields were produced with 8 or 16 T levels of all materials. Plant Si levels were generally higher in HCC and TG $CaSiO_3$ than TVA $CaSiO_3$ indicating greater Si solubility of these two materials. Concentrations of Mn were significantly reduced by both HCC and TVA materials while they remained slightly higher with TG $CaSiO_3$.

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New Patented Pineapple Cultivars

Del Monte Fresh Produce Co. Inc. applied for a permit to import a genetically engineered pineapple into the United States. The letter from Del Monte Fresh Produce to Mr. Michael C. Grégoire, Deputy Administrator,Biotechnology Regulatory Services, Animal and Plant Health Inspection Service, United States Department of Agriculture, is dated July 31, 2012 and can be found on the internet at http://www.aphis.usda.gov/biotechnology/downloads/reg_loi/del_monte_inquiry_letter.pdf. In the letter Del Monte Fresh Produce requests permission to import Del Monte Rosé pineapple that was genetically modified to increase lycopene in edible fruit tissues and to reduce natural inducton of reproductive development by suppressing the production of ethylene. Transfomration of pineapple plants to increase fruit lycopene content is covered by U.S. Patent 7,663,021, dated Feb. 16, 2010. The letter, which with appendices is seven pages, provides interesting details of the genetic elements for increased lycopene and flowering control in the development of a new pineapple cultivar. The letter contains information on the steps followed to increase lycopene content and reduce ethylene biosynthesis.

Dole Food Company, Inc. obtained United States Plant Patent US PP20,885 P3 on March 23, 2010 for a pineapple named Dole 14. The cultivar was produced by conventional breeding and resulted from a cross between Dole's 'MG-03', which is genetically similar to 'MD-2', and Dole's patented cultivar 'P-1972', a cross between 64-337, from the breeder number likely a Pineapple Research Institute of Hawaii (PRI) selection, and 59-443, a PRI selection and a parent of 'MD-2'. The new cultivar has a higher carotenoid content, medium acidity, low fiber and has high tolerance to natural induction. That tolerance is a major weakness of 'MD-2'. Both 'P-1972' and 'Dole 14' were granted Plant Variety Protection Rights in Indonesia on August 13, 2013 (http://www.ambadar.com/news/the-certificates-of-pvp-of-p-1972-and-dole-14-pineapples-have-been-issued).

Hawaii does not import fresh pineapples so there is no local information about the commercial success of these new pineapple cultivars and nothing found by an internet search indicates they currently have presence in U.S. mainland markets.

News from Australia

Report of the 8th International Pineapple Symposium

G. Sanewski, Department of Agriculture & Fisheries, Maroochy Research Station, Qld. Australia.

The 8th International Pineapple Symposium was the first of the series to be held in Australia in its 22 year history and for the first time it was also part of the larger International Horticultural Congress (IHC2014). This made it a very different symposium from those held previously. In addition, the challenges of attracting registrants and speakers to Australia during the latter stages of the global financial crisis were obvious. The symposium covered 2 days of presentations with an additional farm tour. There were 24 oral papers and 7 poster papers presented. The pineapple sessions were well attended despite the large number of interesting talks being presented in other symposia at any one time. The number of pineapple papers finally submitted by presenters was few in comparison to previous symposia but the quality of all, especially those of the keynote speakers was very good.

The field tour was well supported with almost 50 people joining the tour to the Sunshine Coast production region. The tour travelled north from Brisbane to the greater Sunshine Coast region and covered a distance of about 180 km on the round trip return to Brisbane. It included three stops to showcase production of pineapples. The 3 farms were:

Pinata Farms Pty Ltd (www.pinata.com.au/)

The Scurr family have farmed pineapple since the 1960's. In 1992, brothers Gavin and Stephen Scurr formed an integrated growing and marketing company that has evolved into Pinata Farms Pty Ltd. Based at Wamuran in South East Queensland (SEQ), the company has an Australia wide focused supply chain for pineapples, mangoes and strawberries. Pinata's own farms plant 5 million pineapple plants per year. They grow MD-2, 73-50 and Smooth Cayenne.

Fullerton Farms Pty Ltd

Established in 1914, Fullerton Farms are celebrating 100 years of farming this year. Fullerton Farms has been the largest supplier of Smooth Cayenne pineapple to the Golden Circle/Heinz cannery for a number of years but recently the business focus has shifted to include the fresh market. Currently they are planting 2.25–2.5 million plants annually, split evenly between Smooth Cayenne and 73-50.

Sandy Creek Pineapple Company

Situated at Glasshouse Mountains on the Sunshine Coast hinterland, Sandy Creek Pineapple Company, operated by Murray and Karen Pike and their son Sam (third and fourth generation on the home farm), covers 45 ha of land on which 1 million plants are planted annually. The farm produces for the fresh fruit market and is dominated by the hybrid 73-50 with a small annual production of Smooth Cayenne.

The papers for the 8th International Pineapple Symposium will be published in a combined Acta 28 "XXIX International Horticultural Congress (IHC2014): International Symposia on Pineapple, Mango and Papaya." I hope this Acta Horticulturae series becomes a good future reference.

Abstracts of Papers Presented at the 8th International Pineapple Symposium

All of the abstracts below will be included in full papers in the combined Acta Horticulturae 28 of the 29th International Horticulture Congress.

Pineapple is a Super Fruit, but How Much Can it be Consumed?

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Abstract

Pineapple can be regarded as a super fruit with profound ethnopharmacological effects. Bromelain is an important compound in pineapple, which has been scientifically proven to have enormous health benefits. Pineapple is served as fresh fruit or juice, but how much to consume to gain its health benefit is not definitive. This is a technical paper aimed to answer why we need to consume pineapple on a regular basis and to establish any limitations. Juice from fruit pulp, fruit core and stem parts of cultivar Gandul was extracted and the bromelain in the juice was quantified. The juices were then tested *in vitro* for their potential to inhibit cancer cells, in particular A2780 (breast) and HT29 (colon). The study found that the extracted pineapple juice was able to inhibit cancer cell growth. The juice from the pulp was most effective with IC_{50} of 280.54 µg/ml after 24 hours and 104.95 µg/ml after 48 hours for A2780 and HT29, respectively. Bromelain in juice was subjected to stomach digestion tests to assess how much bromelain could pass through the stomach and enter the blood stream. Our study also found that the pulp from the Malaysian commercial pineapple cultivar Gandul possesses four to eight times higher bromelain content compared to other cultivars. We recommend that a 250ml glass of pineapple juice provides enough bromelain for daily general health maintenance.

Bioprotection of Pineapple in Ecological Cropping Systems

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Abstract

Monoculture and intensive use of pesticides have reduced the biodiversity of agrosystems and increased the imbalance between pathogenic and beneficial organisms. In the past, pineapple pests were generally controlled by pesticides, but today very few pesticides are authorized. In fragile environments like in the French Antilles, there is a growing public demand for the prevention of environmental risk. Agricultural research is responding by designing new cropping systems based on the ecological intensification of farming practices and alternative ways of managing pests. In Martinique, our strategy is based on agrosystems with increased biodiversity, restored ecosystem functions, enhanced bioregulation and beneficial interactions between plants and microorganisms, including natural defenses (systemic resistance). The aim of our current work is to answer two needs and to confirm several hypotheses: 1) reduce pathogenic inoculum by using non-host rotation plants selected for their functional traits (non-host status, biomass production, balanced rhizosphere microflora); 2) select crop varieties that are able to develop systemic resistance AND to adapt their metabolism to environmental changes: we

hypothesize a relationship between plant adaptability to biotic (defense genes) and abiotic stresses (genes for cysteine-proteases and their inhibitors, phytocystatins); 3) The reliability of systemic resistance at field level depends on a plant's ability to tolerate pathogens despite abiotic stresses, since such stresses may interfere; 4) Pineapple root system naturally bear diazotrophic bacteria (endophytic) that are potential inducers of systemic resistance. Finally, we aim to design cropping systems that reduce soil borne pests before the pineapple crop is planted, and to create an environment that subsequently both enables bioregulation and reduces re-infestation of pineapple by the parasite.

Genetic Resistance to the Root Rot Pathogen *Phytophthora cinnamomi* in *Ananas*

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Abstract

The Australian pineapple industry is expanding as market demand for new high quality fresh fruit products increases. The major fresh fruit varieties, 'MD-2' and '73-50' are more suited to the fresh market than 'Smooth Cayenne', because of their superior eating quality however they also have greater production problems. Both varieties are considered more susceptible than 'Smooth Cayenne' to the root pathogen *Phytophthora cinnamomi*. Root rot is the most serious disease of pineapple in Australia. While the disease can be controlled using chemicals, costs associated with this solution are high and control is incomplete where fields are ratooned. Partial control of the pathogen results in poor yields and disruption of harvest schedules through increased natural flower initiation. Considerable variation in genetic susceptibility to root rot is known to exist within the *Ananas* genus but a reliable screening system is not yet described. In this project a reliable screening method utilising an aeroponics system was developed to evaluate genetic resistance to root rot in a broad range of pineapple genotypes. Roots were inoculated with a motile zoospore suspension in the laboratory before placing the plants back into the aeroponics system for disease expression over 7 days. The plant response ranged from highly resistant in most wild varieties to highly susceptible in the fresh market cultivar 'MD-2'.

Development of Novel SSR Markers from the Genome Sequence of Pineapple

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Abstract

Molecular markers combined with high-density genetic linkage maps are useful for fundamental and applied genetic research and for breeding programs. Simple sequence repeat (SSR) markers provide a reliable method for genetic map construction and evaluation of genetic diversity because of their co-dominant inheritance and the abundance of alleles per locus. However, very few SSR markers have been developed in pineapple. In this study, we performed random shotgun sequencing to obtain the pineapple genome sequence, and then identified candidate SSR sequences. We analyzed the genomic DNA of pineapple cultivar 'N67-10' by using the Roche 454 GS FLX+ platform and used RepeatMasker software to identify repeated sequences, which included long terminal repeat (LTR) elements, short and long interspersed elements (SINE and LINE), DNA transposons, small RNAs and simple repeats; together, these accounted for 8.84% of the total sequence length. We performed *de novo* assembly and found SSRs in the obtained contigs and singletons by using MIcroSAtellite search tool analysis. A total of 55,621 SSRs were found with di-, tri-, tetra-, penta-, or hexanucleotide motifs. SSR markers designed from the newly obtained genome sequence was evaluated for alleles per locus and genetic diversity, and used to

construct a genetic linkage map in pineapple. This information will help us to develop genome-wide markers and to perform marker-assisted selection in pineapple breeding programs.

Evaluation of New Clones of 'Josapine X 53-116' On Malaysian Peat and Mineral Soil

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Abstract

Pineapple [*Ananas comosus* L. (Merr.)] is one of the most important fruit industries in Malaysia with 96,957 metric tons production in 2011 valued at RM 37.2 million. However, the pineapple production areas in Malaysia have reduced steadily over the past 30 years (10,436 ha to 4,062 ha) due to production problems such as deteriorating in yield of the old canning cultivars, inconsistent production of planting materials and susceptibility to diseases such as bacterial heart rot (BHR). To boost this flagging industry, a more vigorous variety with desirable agronomic characteristic, better fruit quality with higher yield per hectare and resistance to prevailing diseases are required. Thus, through MARDI's continuous research and development of breeding programme had initiated a hybridization of Josapine and a hybrid 53-116 pineapple obtained through a germplasm exchange with The Department of Agriculture, Fisheries and Forestry, Australia. The population generated were subjected to a stepwise culling process until eight final lines remain and subsequently the clones were tested on research plots with peat and mineral soil type in order to obtain plant and fruit data. Among the information collected from the eight lines, reveals a significant and promising aspects of the clone Jo x 53-116 (6) in terms of fruit size (kg), sugar content (TSS %), acid content (TTA %), flower response to ethephon as well as the number of slips on the plant. As a result Jo x 53-116 (6) clone will be proposed as a new alternative sweet pineapple clone for the current fresh consumption market in Malaysia.

Leadership Training and Regular Communication Identified as Key Strategies for the Development of the Australian Pineapple Industry

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Abstract

Changes in the circumstances of the Australian pineapple industry left growers with a leadership vacuum, limited technical support and no funds for conducting research and marketing. Inspirational leadership training together with regular district farm meetings were used to assist the Australian pineapple industry to successfully adapt to these challenges. All growers were assigned to one of a number of regional grower study groups and regular on-farm meetings commenced to facilitate communication between growers, transfer of technology, awareness of industry affairs and an opportunity to become involved in industry business. A leader was appointed within each study group and these leaders attended a leadership course consisting of three, three-day modules. These original course graduates formed the nucleus of a new grower representative group which subsequently instigated levies to fund research and marketing. Two more courses have since been conducted to provide the depth of leadership to satisfy the growers' desire to rotate industry leadership on a regular basis.

Evaluation of the Efficacy of Eclipse® in reducing Sunburn in Queen Pineapple of South Africa

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Abstract

Sunburn on Queen pineapples in South Africa can occur any time of the year but is more prominent during the summer months, peaking often during January and February. Temperatures >32°C and no breeze to cool the fruit are often experienced in cases of severe sunburn damage while other factors such as growing

conditions (plants/fruit are "soft"), plant characteristics (ex. long peduncle and translucent fruit), nutritional status of the plant (ex. too much nitrogen) and the surrounding area where fields are planted (surrounding bush prevents air flow), also play a role. Crop losses can be as high as 25%, while in extreme cases damages can reach 70%. Eclipse®, a calcium carbonate and boron colloidal liquid sun shield film, was applied to a number of fields in trials during January/February 2013 and 2014 to prevent sunburn. Application took place at 4 and 2 weeks before harvest at 18 L/ha and 9 L/ha respectively during the first season (2013), while 5 different treatments were applied from 6 weeks to 1 week before harvest during the second season (2014). External sunburn damage was rated according to the degree of severity, namely 1 (slightly damaged – fruitlets show browning; fruit is still marketable), 2 (moderately damaged - fruitlets show more severe browning, sunken skin and often cracking between fruitlets – fruit will be rejected) and 3 (severely damaged - fruitlets show severe browning and cracking between fruitlets, flesh underneath the skin is whitish in colour and often extends to the core of fruit – fruit will be rejected). Severe symptoms provide easy access for diseases. Sunburn in these trials varied between 2% and 27% and the application of Eclipse reduced sunburn to between 0% and 14.4%. Eclipse® especially reduced moderate and severe sunburn damage.

Understanding the Effects of Slip Pruning on Pineapple Fruit Quality

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Abstract

Pineapple fruit quality is important especially when fruits are exported to international markets. Fruits should meet minimum requirements such as a weight of at least 0.7 kg, a ratio between the crown length and infructescence (fruit without the crown) length ranging from 0.5 to 1.5, and a ºBrix of at least 12. Most pineapple producers in Benin face difficulties in meeting these requirements and thus a very low fraction of the produce is exported. Pruning of pineapple slips has been explored as a means to improve fruit quality but no consistent effects were found. In this study slips were pruned from plants with small and large infructescences and the effects on fruit characteristics were determined. Two on-farm experiments were conducted in commercial fields in Benin using a cultivar locally known as Sugarloaf. Split-plot experiments were used with main plots pruned two or three months after inflorescence emergence and split plots having all slips or no slips pruned. The length of the infructescence on the day of pruning was used to characterise plants as least or most advanced. Fruit attributes measured at harvest were fruit (infructescence + crown) weight and length, and total soluble solids. Fruit and infructescence lengths and weights at harvest were positively related to the length of the infructescence at pruning (IL), and the ratio crown: infructescence length at harvest was negatively related to the IL. Pruning of slips, however, did not increase fruit and infructescence weight and length, nor the total soluble solids, in any of the treatments. Therefore, slip pruning is not an option to increase pineapple fruit and infructescence lengths and weights or the percentage of marketable fruits in Benin.

Measuring Nitrous Oxide Emissions from Conventional and Controlled Release Fertilisers in South-east Queensland Pineapple Production

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Abstract

Nitrous oxide (N_2O) is a potent greenhouse gas with a global warming potential 298 times higher than carbon dioxide. Soils are a natural source of N_2O, contributing 65% of global emissions. This paper is the first in Australia to measure and compare N_2O emissions from pre-plant controlled release (CR) and conventional granular (CV) fertilisers in pineapple production using static PVC chambers to capture N_2O emissions. Farm 1 cumulative emissions from the CR fertiliser were 3.22kg ha^{-1} compared to 6.09kg ha^{-1} produced by the CV. At

farm 2 the CV blend emitted 2.36kg ha^{-1} in comparison to the CR blend of 2.92kg ha^{-1}. Daily N_2O flux rates showed a relationship of direct response to rainfall and soil moisture availability. High emissions were observed for wheel tracks where increased N_2O emissions may be linked to soil compaction and waterlogging that creates anaerobic conditions after rain events. Emission measurements over three months highlighted the inconsistencies found in other studies relative to reducing emissions through controlled release nitrogen. More investigations are required to verify the benefits associated with controlled release fertiliser use in pineapples, placement and seasonal timing to address N_2O emissions in pineapples.

Effect of Wheat Gluten-Based Edible Coating and Irradiation on Quality of Fresh-Cut Pineapple

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Abstract

The aim of this research was to study the effect of calcium chloride ($CaCl_2$), wheat gluten-based edible coating and irradiation on the quality of 'Perola' fresh-cut pineapple. Slices of pineapple were treated and packed in rigid polyethylene terephthalate (PET) trays. The packages were irradiated with 2.3 kGy/h and the samples were stored at 5 ± 1 ºC. Analyses were carried out every two days for 12 days. The $CaCl_2$ + 2.3 kGy treatment had the lowest activity of polyphenoloxidase (PPO: 19.3 U/g/min) and peroxidase (PDO: 36.6 U/g/min). The highest respiratory activity and ethylene production was observed for samples treated with $CaCl_2$ + gluten + 2.3 kGy. Browning occurred for all treatments over the storage period of 12 days, with $CaCl_2$ + gluten + 2.3 kGy showing the darkest colour (lightness: 59.7, chroma: 14.4, hue angle: 98.2). However, these same samples showed the lowest psychrotrophic (3.59 log CFU/g - Colony Forming Units per gram), mesophiles (4.32 log CFU/g), and molds and yeasts (4.04 log CFU/g) counts. *Salmonella* and total and fecal coliforms were not found in this experiment for any treatment. $CaCl_2$ + 2.3 kGy and $CaCl_2$ + gluten + 2.3 kGy treatments were effective in maintaining the physicochemical and microbiological quality, respectively.

Physicochemical and Microbiological Changes in Fresh-Cut Pineapple Coated with Wheat Gluten and Alginate

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Abstract

The aim of this study was to compare the effect of wheat gluten and alginate-base edible coating on fresh-cut ´Perola` pineapple shelf-life. Fruit slices were treated with: (i) 1% calcium chloride + vital wheat gluten solution; (ii) 1% calcium chloride + 1% alginate solution; and (iii) 1% calcium chloride, i.e. control. They were packed, stored at 5 ± 1 ºC and evaluated every other day for 12 days. Titratable acidity and pH values showed slight variations but were similar among the treatments. There was a decrease in ascorbic acid values in all treatments. Although the values among the treatments were similar, the pineapple treated with wheat gluten showed firmer texture and less juice leakage. Samples coated with wheat gluten also had lower counts of psychrotrophs and mesophiles, molds and yeasts. No *Salmonella*, *Escherichia coli* and total coliform were detected.

Pineapple Production on Dole Farms in Latin America

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Abstract

Dole distributes and markets DOLE® fresh fruits and vegetables, and packaged food products, including processed pineapple, canned pineapple juices and pineapple juice blend beverages, among other products. Fresh pineapples destined for the North American and Western European markets are grown by Dole Latin America on Dole-owned plantations in Costa Rica, Ecuador and Honduras and sourced from independent producers, primarily in Costa Rica and Guatemala. These products are sold primarily to retail chains and wholesalers, which in turn resell or distribute them to retail food stores. Dole contributes 20% of the total volume produced in Latin America for the export market. Approximately 75% of its fruit is sold in North America, mostly in the Eastern coast and central markets; and 25% goes to Europe. For the past 25 years Dole has been committed to continuously improving the quality of its products by thoroughly revising all farm practices and associated activities. Today Dole has meritoriously earned a number of certifications in important areas such as: food and worker safety, agricultural practices, environmental protection, and social responsibilities. There are a number of challenges still to be faced in pineapple production, and Dole is investing resources to solving the most relevant issues: reduce soil erosion, limit and/or eliminate pesticides usage, implement alternative strategies for pest control, rational use of fertilizers, and diminish the impact of natural flowering differentiation (NDF).

The Application of DArTseq Technology to Pineapple

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Abstract

DArTseq technology is potentially the most appropriate system to discover hundreds of polymorphic genomic loci, scoring thousands of unique genomic-wide DNA fragments in one single experiment, without requiring existing DNA sequence information. The DArT complexity reduction approach in combination with Illumina short read sequencing (Hiseq2000) was applied. To test the application of DArTseq technology in pineapple, a reference population of 13 *Ananas* genotypes from primitive wild accessions to modern cultivars was used. In a comparison of 3 systems, the combination of restriction enzymes PstI and MseI performed the best producing 18,900 DArT markers and close to 20,000 SNPs. Based on these markers genetic relationships between the samples were identified and a dendrogram was generated. The topography of the tree corresponds with our understanding of the genetic relationships between the genotypes. Importantly, the replicated samples of all genotypes have a dissimilarity of close to 0.0 and occupy the same positions on the tree, confirming high reproducibility of the markers detected. Eventually it is planned that molecular markers will be identified that are associated with resistance to *Phytophthora cinnamomi* (*Pc*), the most economically important pathogen of pineapple in Australia, as genetic resistance is known to exist within the *Ananas*. Marker assisted selection can then be utilized in a pineapple breeding program to develop cultivars resistant to *Pc*.

Pineapple Plantation Information System – Application of Geo-Informatics and Unmanned Aerial Sensing Technology for Efficient Land Use Management

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Abstract

Large scale pineapple production faces a multitude of challenges to maintain and improve plant health and productivity. The agronomic performance of a plantation depends on the inter-relationships between biotic and abiotic factors as well as management practices. Several governing factors to ensure long-term farm viability include: arresting excessive depletion of nutrient-rich top soil through erosion, the use of tailor-fit fertilization programs and ultimately, maintenance of soil structure and biology. This paper describes the development of a land use management system for a pineapple plantation in the Philippines, utilizing Unmanned Aerial Sensing (UAS) technology and Geo-Informatics to bring soil erosion to an acceptable limit and to maximize fertilization

efficiency. The overall project was divided into three phases. Phase one includes the development of a central Geo-Information System (GIS) to capture data and provide a tool for research use. During phase two, an UAS system was introduced to map the plantation area with up to 10 cm ground resolution. The images provide a wealth of information about crop condition and erosivity of the field. Phase three includes the generation of recommendations and the implementation of these recommendations by research and production teams in the field. The work presented is part of a multi-year project and is ongoing. The presentation focuses on recently available results.

'D' Leaf and Fruit Characteristics in BRS Imperial Pineapple Cultivar

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Abstract

The Brazilian pineapple industry is based on the cultivar Pérola, very demanded by consumers due to its organoleptic characteristics, but highly susceptible to fusariosis, caused by *Fusarium guttiforme*, the main constraint of that crop in Brazil. Since 1984 Embrapa Cassava and Fruits is conducting a pineapple breeding program aiming at developing fusariosis resistant cultivars. In this regard, BRS Imperial was the first pineapple cultivar released in Brazil in 2003. Aside its excellent physicochemical characteristics, many yield factors must be studied for grower's acceptance. Four 'D' leaf parameters at forcing stage and five fruit characteristics were compared at four distinct sites in the State of Bahia, Brazil, using about 500 plants and fruits. The following variables were evaluated: length, width, fresh and dry weight of 'D' leaf and fruit weight with and without crown, fruit length, total soluble solids and titratable acidity. Highly positive and significant correlations were found between fresh 'D' leaf weight and fruit weight without (r = 0.74) and with (r = 0.72) crown. A moderate and positive correlation was found between 'D' leaf length and fruit weight without (r = 0.65) and with (r = 0.65) crown. Moderate negative correlations were found between 'D' leaf length and fruit titratable acidity (r = -0.58) and between 'D' leaf fresh weight and fruit titratable acidity (r = -0.55).

Vegetative Growth Stages of Irrigated 'Pérola' Pineapple

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Abstract

The objective of the study was to determine the 'Pérola' pineapple vegetative growth stages. A randomized block design was used, with four replicates. The fresh and dry matter of all plant components was measured at 1, 173, 248, 291, 354, 424, 488 and 642 days after planting. Vegetative growth of 'Pérola' pineapple was divided into five stages based on "D" leaf growth and the corresponding vegetative biomass production (VB)up to the date of floral induction treatment (FIT). In stage V1, the "D" leaf fresh mass averaged 29 g and corresponded to the production of an average of 20% of VB. In stage V2, the "D" leaf fresh mass averaged 43 g, corresponding to the production of 40% of the total VB. The third phenological stage (V3) was characterized by a "D" leaf fresh mass averaging 54 g and VB reached 60% of total production. Stage V4 had a "D" leaf fresh mass of averaging 62 g and VB reached 80% of the total. In stage V5 the "D" leaf fresh mass averaged 68 g, with the VB at flower induction defined as 100%. D-leaf fresh matter can be use to estimate the vegetative biomass of 'Pérola' pineapple and the vegetative growth can be divided into five well-defined phenological stages.

'Pérola' Pineapple Growth Under Semi-arid Climate Conditions

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Abstract

The aim of this study was to evaluate the vegetative growth and the production of irrigated 'Pérola' pineapple. The experimental design was in randomized blocks with four replications and sampling times at 1, 173, 248, 291, 354, 424, 488, 642, 703, 764, 858 days after planting. Evaluations were made of plant height, stem diameter, D-leaf length, fresh and dry matter of leaves, stem, root, fruit, crown and slips, vegetative biomass, total biomass, maximum accumulation rate, relative growth rate and crop growth rate. The results were submitted to analysis of variance and regression. The production of 'Pérola' pineapple fresh fruit is 66.41 t ha^{-1} and an average weight of 1.39 kg per fruit. The 'Pérola' pineapple at the end of the cycle produces 134.34 and 61.90 t ha^{-1} of total and vegetative fresh matter, respectively.

News from Benin

Effect of Physical Damage and Storage of Pineapple Fruits on their Suitability for Juice Production

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Summary of PhD thesis, Wageningen University, The Netherlands

This study is a result of the multidisciplinary project Co-Innovation for Quality in African Food Chains (CoQA). The objective of the research was to improve the quality of pasteurised pineapple juice taking the characteristics of the Beninese pineapple marketing system into account. To achieve this goal, a combination of marketing and food technology research has been used to capture the functioning of the system, to evaluate the market possibilities that can improve the system's performance and to improve the pasteurisation technology. The specific objectives were to: (i) evaluate the adaptation of Beninese pineapple marketing systems to the introduction of the pasteurized pineapple juice business; (ii) assess the extent to which pineapples with physical damage (i.e., of potential less quality) can be used for pineapple juice production; (iii) review the present state-of-the-art on the effect of processing on pineapple juice quality and (iv) evaluate the effect of pasteurisation on the microbiological, physicochemical and nutritional quality of pineapple juice.

Chapter 2 of this thesis describes the adaptation of the Beninese pineapple marketing system to the pasteurized pineapple juice business. A conjoint experiment was designed and implemented to assess the preferences of pineapple wholesalers, pineapple consumer-merchants and pineapple juice manufacturers. The study measured and compared the preferences of these actors and investigated whether the preferences of the juice manufacturers have been taken into account by the wholesalers in their everyday business.

Our findings revealed that wholesalers are the main suppliers to both consumer-merchants and juice manufacturers. However, juice manufacturers' preferences are different from those of consumer-merchants. More specifically, juice manufacturers prefer large pineapples from 'Kona Sugarloaf' variety and believe that pineapples with physical damage can be used to produce pasteurized pineapple juice. This offers wholesalers the opportunity to sell pineapples that are not demanded by consumer-merchants, but it was found that wholesalers are not engaged in any specific sorting and grading activities to fulfill the wants of the pineapple juice manufacturers.

The marketing system approach used in this chapter goes beyond the transaction costs, a perspective that is frequently used in the development literature, in that it considers other factors such as cognition, and cultural norms and habits, that influence the perception of market opportunities and the willingness and ability to seize opportunities. Based on that approach, we learned that the reason for the lack of adaptation of the system is caused by the lack of responsiveness of wholesalers due to such factors. The results imply that, in the development context, the adaptation of the marketing system to a development intervention needs to be managed and the effects of interventions need to be considered beyond the primary target group. In other words, complementary marketing interventions should focus on the other actors of the marketing system.

As juice manufacturers considered pineapples with physical damage as a possible raw material for pineapple juice production, the possibility of using pineapples with physical damage for pineapple juice production was investigated in chapter 3. Experiments were designed to simulate different types of physical damage (cuts and bruises) and the damaged pineapples were stored for up to 9 days. Physically damaged pineapples stored for up to 9 days at 20 °C showed no adverse effects on the physicochemical characteristics (pH, total soluble solids, sugars) and vitamin C content of fresh pineapple juice (Chapter 3). This suggests that pineapples with those characteristics are suitable for the production of pasteurized juice and that the preference of juice manufacturers for pineapples with physical damage to produce pasteurized pineapple juice is justified. However, the storage temperature should be taken into account. In the specific context of Benin, with an average temperature of 30 °C, pineapples with physical damage would not last longer than 3-4 days. In addition to this main finding, it was shown that storage of pineapples at 20 °C contributed to a substantial increase of fructose and glucose at day 9 through an inversion of sucrose. This would probably improve the taste through enhanced sweetness, but the increase of glucose and fructose will also enhance the Maillard reaction during and after pasteurisation.

Pasteurisation is widely used in juice production. Yet, few studies have investigated the effect of pasteurisation on the quality of pineapple juice (Chapter 4). In literature, large variations in the composition of pineapple juice are described. For instance, the variation in vitamin C is reported to range from 9 mg/100 mL to 94 mg/100 mL. As far as heat treatment is concerned, high temperatures in the range of 90 °C for 3 min to 99 °C for 17 min caused a loss of vitamin C from 38 to 94 %, respectively. To date, only one study investigated the effect of pasteurisation on the nonenzymatic browning (Maillard reaction) of pineapple juice. Because the technique (spectrophotometric method) applied to measure hydroxymethylfurfural (HMF) in the pasteurized pineapple juice is not the most accurate one, the determination of HMF in the pasteurized pineapple juice has been investigated in chapter 5. In addition, due to insufficient proof that pasteurisation has a negative effect on the pineapple juice quality as demonstrated in other juices (Chapter 4), the effect of pasteurisation on the microbiological (mainly yeasts), physicochemical (pH, degree Brix, organic acids, sugars content) and nutritional (vitamin C) quality was investigated in the range of 55 °C to 95 °C. It was found that yeast inactivation in pineapple juice could be described by the Weibull model. The desired 6 log reduction was achieved at 65 °C for 2 min. This result proved that pineapple juice does not need to be pasteurized at a high temperature (85 °C - 20 min) as it is generally applied in Benin and other countries to ensure juice safety. While not expected, vitamin C, the most important nutritional compound in pineapple juice, proved to be stable under the heat treatments investigated in this research. Actually, the degradation rate of vitamin C was below 20 %. Because of this stability, it was not possible to do a kinetic analysis. The physicochemical attributes of pineapple juice, such as pH, degree Brix, organic acid content, were not affected by the pasteurisation treatment. However, at 95 °C, a decrease of sucrose and a simultaneous increase of fructose and glucose contents was noticed, which will probably increase the sweetness of the juice but at the same time favour the Maillard reaction. The fact that HMF was detected in pineapple juice after 30 min at 95 °C, illustrates that the Maillard reaction can affect pineapple juice quality at higher temperatures and longer heat treatments (Chapter 5). Ultimately, pineapple juice should be pasteurized at for 2 min at 65 °C to preserve its nutritional (vitamin C) and sensorial quality (colour, taste).

Finally, all findings were integrated in chapter 6 and were discussed from an integrative perspective. The integration of food technology and marketing research in one thesis was highlighted. The thesis has implications for further developing the industry. Currently, the pineapple juice industry is segmented because juice manufacturers differ in many ways. They are living in different locations, have different financial capabilities, different knowledge about juice processing techniques and as a result, they produce pasteurized pineapple juice that is variable in quality. In order to improve their pineapple juice quality and to increase their market access, juice manufacturers can be trained on better pineapple sourcing and pasteurisation techniques. Working more closely together, they can produce products at comparable quality levels using their own equipment. This pineapple juice can be branded under the same name and be sold to different markets. Juice manufacturers who are not willing to collaborate in such a manner can continue to produce and improve their pineapple juice quality by taking the recommendations from this thesis into account.

Using Agronomic Tools to Improve Pineapple Quality and its Uniformity in Benin

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Summary of PhD thesis, Wageningen University, The Netherlands

Poor average quality of agri-foods and heterogeneity in quality are important issues especially in less developed countries producing tropical fruits. This is also the case for pineapple in Benin where less than 2% of produced pineapple is exported to international markets. The remaining pineapple is delivered to local and regional markets with lower average quality standards; nevertheless, the bulk of this pineapple loses its quality before being consumed. At the onset of this study, it was unknown how the fresh pineapple supply chains were organised, how the pineapple was grown and how cultural practices affected quality and its uniformity. Therefore the first objective of this study was to understand how fresh pineapple supply chains were organised. The second objective was to increase the knowledge on the agronomic tools used by pineapple producers. Next, the agronomic factors affecting the pineapple quality were studied and trade-offs between different cultural practices were analysed.

In *Chapter 2*, the fresh pineapple supply chains were analysed and the bottlenecks for delivering high pineapple quality to different markets were highlighted. First, 54 semi-structured interviews were held with key informants to obtain an overview of the actor groups in the chains, their activities, the information and product flow between actors and the most important quality attributes. Based on the results of the semi-structured interviews and from literature studies, a framework was designed and adapted to the study. Second, 173 structured interviews using in-depth questionnaires were held with different supply chain actors. The questions in the in-depth questionnaires were constructed based on the framework selected.

Results indicated that pineapples were sold to three markets: the local, regional (neighbouring countries) and European markets. Six actor groups prevailed in the fresh pineapple chains: primary producers, exporters, wholesalers (those selling at local markets and those selling at regional markets), processors, retailers, and middlemen. Two pineapple cultivars were grown: Sugarloaf and Smooth Cayenne, with Sugarloaf being dominant in local and regional markets. Cv. Smooth Cayenne is mainly sold to European markets. Cv. Sugarloaf was produced by 97% of the growers and cv. Smooth Cayenne by 30%. Results indicated that two types of fresh pineapple supply chains prevailed to reach the local and regional markets: (1) chains where primary producers directly deliver their pineapples to retailers, wholesalers, and processors, and (2) chains where pineapples are delivered to these groups through middlemen. For the European markets, the exporters sent their own pineapples to importers, but incidentally bought pineapples from other primary producers (non-exporters) to meet demand.

When analysing these fresh pineapple supply chains, several constraints were found. First, storage and transport conditions were not appropriate to maintain pineapple quality. Thirty-two per cent of the wholesalers and 70% of the processors stored the pineapple in piles in sunlight without covering them. There were no storage facilities with temperature control at the airport for export pineapple. The pineapples were stacked side by side during the transport by trucks without temperature control. Second, there was poor information exchange between producers and other actor groups since 30% of the primary producers producing Sugarloaf and 33% of the primary producers producing Smooth Cayenne had no selling agreement with customers at the time of harvesting of the fruits. Third, more than 50% of primary producers agreed on not receiving training on pineapple cultural practices. Fourth, exporters indicated that there were no boxes for export in the country and that they were obliged to go to neighbouring countries to get them. Fifth, there were no standard quality attributes defined for the local and regional markets; quality attributes were those set by the actor groups except the middlemen whose role was to serve as an intermediate between primary producers and other actor groups in the chains. Quality attributes for the European market were those set by the Codex Alimentarius (2005), requiring minimum levels for fruit weight, the ratio crown: infructescence height, and total soluble solids (TSS), and low heterogeneity within each quality attribute. Sixth, there was a mismatch in the most important quality attributes across actor groups in the chains (except between primary producers and wholesalers in regional markets for cv. Sugarloaf). In addition, there was a mismatch between the quality supplied and the preferred quality criteria within each quality attribute across actor groups in the local and regional markets. For instance, the study showed that wholesalers preferred heavier pineapples than retailers regardless the cultivar sold. So, in the chains where wholesalers supplied the retailers with fresh pineapple, the wholesalers will always fail to meet the retailers' requirement. In addition, exporters faced difficulties to meet the pineapple quality export criteria. Actor groups also indicated the heterogeneity in pineapple quality to be high and problematic and wholesalers indicated reducing the price of the pineapple in case of poor average quality.

The findings emphasized the need to analyse the pineapple production systems to assess which practices contributed to this high heterogeneity in pineapple quality and the reduced overall pineapple fruit quality. This was done in Chapter 3 through interviews with pineapple farmers, and in Chapters 4, 5 and 6 by means of experiments on commercial pineapple fields.

In *Chapter 3*, the pineapple production systems of cvs Sugarloaf and Smooth Cayenne were described based on interviews with 100 pineapple producers. The results were analysed and constraints reducing the quality of pineapple produced were identified. In cv. Smooth Cayenne cultivation, hapas and suckers were used as planting material while in cv. Sugarloaf, slips were the dominant planting material used. Slips, hapas and suckers are side shoots, originating from different parts of the plants. The slips, hapas, and suckers were all collected from plants on the fields from which the fruits had already been harvested. At planting, most pineapple farmers arranged the plants in beds of two rows at an average density of 8.6 ± 0.35 plants/m^2 (range 4-17 plants/m^2) in cv. Sugarloaf and 5.2 ± 0.40 plants/m^2 (4-11 plants/m^2) in cv. Smooth Cayenne. Eighty nine percent of pineapple producers intercropped pineapple with maize (*Zea mays*), tomato (*Solanum lycopersicum*) or chili pepper

(*Capsicum annuum*). Fertilisers were generally applied at 3-4 months after planting and at 2 or 3 weeks before artificial flowering induction. Artificial flowering induction was carried out in both cultivars between 9-13 months after planting by applying carbide of calcium (CaC_2) at the centre of the leaf rosette to induce all plants, synchronise flowering and make the harvest moment synchronous and predictable. Within 34 days after artificial flowering induction K_2SO_4 was applied by 60% of Smooth Cayenne producers and 32% of Sugarloaf producers. Fruit maturity was often induced artificially by the growers in cv. Smooth Cayenne by applying Ethephon at 143 days after flowering induction. The role of Ethephon is to accelerate the change of the skin colour of the fruit from green to yellow. In cv. Sugarloaf, natural maturity induction was common practice. Fruits were hand harvested. Within each cultivar, the production systems were very diverse with regards to planting density, fertiliser application time and type, and timing of artificial flowering induction.

The constraints indicated by pineapple producers reducing the quality of the pineapple were unavailability of appropriate planting material, unavailability and high cost of fertilisers, and heterogeneity in planting material weight. In addition, when analysing the cultural practices, the artificial flowering and maturity inductions practices were regarded as constraints since plants differ in development stage at flowering induction time and fruits differ in development stage at maturity induction time. These practices of artificial flowering and maturity inductions were investigated in Chapters 4 and 5.

In *Chapter 4*, four experiments (two per pineapple cultivar) were carried out in commercial pineapple fields to assess if heterogeneity in vigour of individual plants within a field at the time of artificial induction was associated with heterogeneity in fruit quality at harvest. The number of functional leaves (NL), the D-leaf length (the length of the longest leaf) (DL) and the cross product of number of functional leaves × the D-leaf length (NL × DL) were used to express the plant vigour at artificial flowering induction time. Fruit quality measured at harvesting time included external and internal quality attributes. Results showed that the heterogeneity in fruit weight, infructescence weight and height, number of fruitlets, and ratio crown height: infructescence height in pineapple crops were a direct consequence of the heterogeneity in plant vigour at the time of artificial flowering induction of these crops. Higher plant vigour was associated with higher fruit and infructescence weights, higher infructescence height, more fruitlets and lower ratio crown: infructescence height. The cross product NL × DL was found to be the vigour variate explaining the largest proportion of variance in these quality attributes. Plant vigour at flowering induction was weakly and not consistently associated with TSS, juice pH and the proportion of translucent flesh. These results imply that cultural practices reducing the variation in the vigour of the plant (NL × DL) at flowering induction may yield fruits with lower variation in infructescence and fruit weights, infructescence and fruit height and ratio crown: infructescence height, and number of fruitlets. The results of the study in Chapter 4 also revealed that in cv. Sugarloaf the slip weight also was (weakly) associated with the variation in fruit weight, infructescence weight and fruit height in addition to the plant vigour variate NL × DL.

In *Chapter 5*, trade-offs between flowering and maturity induction for pineapple quality were investigated using the same four experiments as in Chapter 4. In these experiments, eight treatments were derived from the combination of two flowering induction practices (artificial and natural), two maturity induction practices (artificial and natural) and two harvesting practices (farmer's harvesting practice and optimum harvesting practice). Under the natural flowering induction treatments, plants were let to flower by themselves. Under the natural maturity induction treatments, fruits were let to mature by themselves. The farmer's harvesting time was defined as the moment when 25% of the fruits in a plot had changed their skin colour from green to yellow; all fruits in the plot were harvested. The optimum harvesting time was the moment when 25% of the skin of an individual fruit had changed from green to yellow. Each treatment was applied to 240 plants split into plots of 60 plants each. Results indicated that most natural flowering inductions occurred during the coldest months (August and December) in cv. Sugarloaf and the wettest (reduction of the hours of solar radiation) month (June) in cv. Smooth Cayenne. Furthermore, plants exposed to artificial flowering induction gave fruits with (1) lower infructescence weight and height, (2) heavier and longer crown, and (3) a higher ratio crown: infructescence height than the natural flowering-induced plants. Consequently, the percentage of fruits exportable to Europe from artificially-induced plants was lower than that of fruits from naturally induced-plants. Moreover, artificial flowering induction increased the variation in infructescence and fruit weights and in infructescence height in cv. Sugarloaf.

The results also showed that fruits exposed to artificial maturity induction had a lower TSS concentration than fruits with natural maturity induction; artificial maturity induction reduced significantly the percentage of fruits meeting the export criteria to Europe in two out of the four experiments. Natural maturity induced fruits

harvested at optimum harvesting time gave fruits with higher TSS than those harvested at farmers harvesting time.

The results from Chapter 5 also revealed that the reason why a high percentage of fruits was not exportable to Europe when artificial flowering induction was carried out was a ratio crown: infructescence height higher than 1.5 in cv. Sugarloaf; in cv. Smooth Cayenne both the ratio crown: infructescence being higher than 1.5 and a TSS less than 12 ˚Brix reduced the proportion of fruits exportable to Europe. When natural flowering would be viewed as an option to improve the pineapple quality, the costs to obtain naturally flowering-induced fruits were a prolonged vegetative phase by at least 200 days in cv. Sugarloaf and 150 days in cv. Smooth Cayenne; an increase in the number of harvesting of the fruits up to 20 times and a decrease in the proportion of plants producing fruits when compared to artificial flowering-induced plants. The trade-offs of obtaining the sweeter fruits from the natural maturity induction was that the period from flowering induction until harvest was at least 1 day longer in cv. Sugarloaf (where natural maturity induction is already a common practice as found in Chapter 3) and 11 days longer in cv. Smooth Cayenne. So, to improve the TSS, natural maturity induction could be an option. Natural flowering induction cannot be an improvement option for the other quality attributes, given the listed trade-offs. This implies that other improvement options needed to be investigated. These improvement options were studied in Chapters 6 and 7.

In *Chapter 6*, the effects of weight and type of planting material on the average fruit quality and variation in fruit quality were studied. Two experiments were conducted (one per cultivar). Planting material was collected from farmer's fields, and sorted in three weight classes: light, mixture of weights, and heavy. In cv. Smooth Cayenne where hapas and suckers are used as planting material, the effect of the type of the planting material was also studied. Hapas and suckers were mixed following farmers' practice. Flowering induction was carried out following farmers' practice at 12 months after planting or at an optimum induction time determined from data collected from the experiments in Chapter 4. For NL × DL higher than 1235 leaf.cm for cv. Sugarloaf and 2300 leaf.cm for cv. Smooth Cayenne there was a high chance to obtain high volume of fruits falling within the range of fruit weights suitable for exportation to European markets. These values of plant vigour were used to define the optimum flowering induction time and the plants were induced when 75% of the plants under the optimum flowering induction treatments showed a plant vigour equal to or higher than 1235 leaf.cm for cv. Sugarloaf and 2300 for cv. Smooth Cayenne.

Results revealed that, when flowering was induced 12 months after planting, the weight of planting material affected the fruit quality at harvesting time. The use of heavy planting material in the two cultivars gave fruits with heavier infructescence and fruit weights, longer infructescence height, but a shorter crown height and smaller ratio crown: infructescence height than fruits from light planting material. Heavy planting material gave fruits with lower variation in infructescence height than other planting material weights classes, and increased also the proportion of fruits exportable fruits to Europe compared to other weight classes in cv. Sugarloaf. Using heavy slips for cv. Sugarloaf could be an improvement option to reduce the ratio crown: infructescence height indicated as a limiting quality criterion for export in Chapter 5. In cv. Smooth Cayenne the type of planting material had no effect on average fruit quality attributes except that hapas gave fruits with shorter crown than suckers. Flowering induction at optimum flowering induction highly improved average fruit quality in fruits from light and mixed slip weights, hence the proportion of exportable fruits to Europe in fruits from these planting materials increased. Flowering induction at optimum time also increased the proportion of fruits exportable to Europe in fruits from a mixture of heavy hapas plus suckers.

In *Chapter 7*, it was studied if selective slip pruning in cv. Sugarloaf could reduce the heterogeneity in pineapple quality and improve the overall quality level. Two experiments were conducted on commercial fields with cv. Sugarloaf. Four treatments were applied: (1) no plants pruned (control); (2) slips pruned on the one-third least developed plants; (3) slips pruned on the two-thirds least developed plants; (4) slips pruned on all plants. The height of the developing infructescence at the moment of pruning was used as the criterion to identify the least developed plants. The four treatments were applied at 2 or 3 months after inflorescence emergence. Inflorescence emergence is the moment when the inflorescence can be seen at the heart of the leaf rosette. It was found that slip pruning had no consistent effects on the average pineapple quality and also no consistent effects on the variation in fruit quality attributes. This suggests that slip pruning is not an improvement option for the average pineapple quality and the heterogeneity in quality.

Chapter 8 discusses the findings of the present study and proposes options to improve the average pineapple quality and its uniformity at the pineapple production systems level as well as at the supply chain level. At the production systems level, the unavailability of planting material at planting would reduce the capacity of

the producers to increase the volume of their production, so, there is a need to establish planting material production sites that will provide producers with heavy planting material. Artificial flowering induction practice reduced the average fruit quality and the proportion fruits exportable to Europe, but Sugarloaf plants from heavy planting material can be induced at 12 months after planting without quality loss. In cv. Smooth Cayenne, natural maturity induction would help improve the TSS and consequently the proportion of fruits exportable to Europe, but, since natural maturity induction occurs progressively and not uniformly, maturity induction at the moment when natural maturity starts would be an option to both increase the TSS and improve the uniformity in fruit skin colour. In addition, producers should be regularly trained on best pineapple cultural practices so that the diversity in the production systems would be reduced.

At the supply chain level, the improvement of the transport and storage facilities would help to keep the quality of produced pineapple. It is advised to put the pineapple in stackable crates during the transport in the trucks and to implement a cold pineapple chain i.e. a chain where the temperature is controlled and set at 8 ˚C from harvesting until airport. There is also a need to implement cold storage facilities at the airport to maintain pineapple quality. Unavailability of boxes for export reduces capacity of exporters to increase volume of exported pineapple. So, the government should provide boxes in the country or encourage the private sector to invest in their production. Being member of a producer's organisation has many advantages such as reduction of transaction cost, improvement of market access, etc. Producers including exporters should be encouraged by the CARDER (Regional Agricultural Centre for Rural Development) to be part of a producer organisation. There is also a need to establish a platform where all actor groups in the chains can meet and discuss issues related to market access and share quality attributes and criteria. Such a platform would help to reduce the mismatch between the quality supplied and the preferred quality.

This thesis has contributed to identifying bottlenecks for production of uniform pineapples of high quality in Benin. It suggests improvement options that can be used to increase the fruit quality attributes for the markets and also the proportion of fruits exportable to Europe.

News from Costa Rica

Phytotoxicity Resulting from Spraying Different Salt Concentrations on 'MD-2' Pineapple

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Due to frequent experiences with pineapple producers having problems with *Phythopthora* sp and *Erwinia* sp, even with high level plant protection practices against these pathogens, field observations and analysis of records applications indicated grower use of high concentrations of salts in nutrition programs on the affected farms.

It is well known that sprays must be carefully calculated to avoid concentrations of fertilizer in spray solutions that burn the plants (Bartholomew et al., 2002). Those authors mentioned three forms to apply fertilizer at the crop depending on the volume of spray:

- Low-volume sprays of 250–500 liters/ha are directed to the green portion of the leaves, allowing little or no rundown into leaf axils. Nutrient uptake is through green leaf tissue. Salt concentration may be as high as 20 per- cent by weight.
- Medium-volume sprays of 500–2500 liters/ha are directed to the green portion of the leaves, with run-down into leaf axils but with little or no runoff into the soil. Uptake is through green tissue, basal white tissue at leaf bases, and axillary roots near the base of the stem. Maximum salt concentration is 5 percent.
- High-volume sprays greater than 2500 liters/ha are similar to medium-volume sprays except there is runoff of fertilizer solution into the soil at the base of the plant.

It, is also very important to understand how to apply foliar nutrient sprays as the pineapple crop develops. Py et al. (1987) indicated that spraying can be carried out either at regular intervals using increasing quantities, or the same quantities can be applied with increasing frequency.

Returning to the first issue, greater dilution of the nutrients involves larger volumes of water per hectare and therefore reduced machine performance (spray boom and tractors) per hectare per day. To obtain maximum equipment efficiency without danger of injury to the crop, it is crucial to know the maximum salt concentration a crop can tolerate without producing foliar injury that provides openings for pathogens to enter. To evaluate the salinity-toxicity relationship, greenhouse-grown pineapple plants were fertilized every 14 days with 30 cc per plant of fertilizer solutions containing salt concentrations, in percent, of 5, 7, 9, 11, 13 and 15. The solutions were applied over a period of 85 days (6 cycles in total) and photographs of treated plants were taken every 7 days.

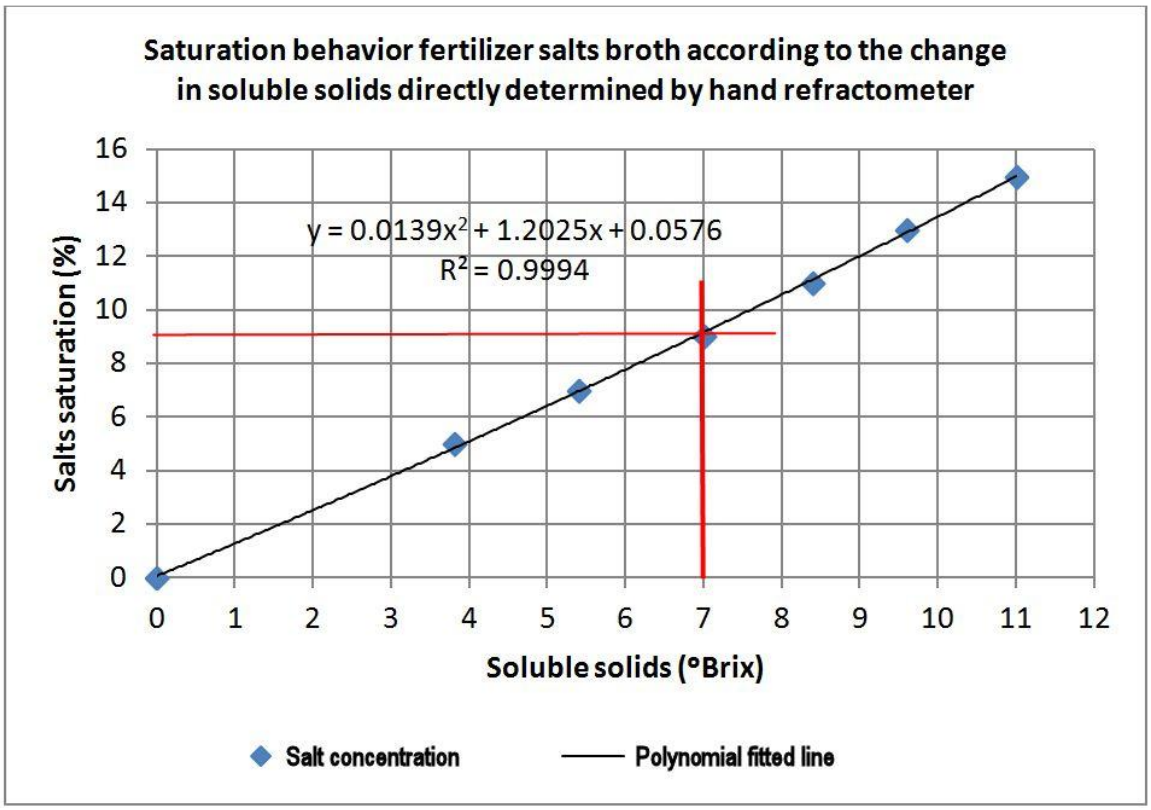
The results showed that the maximum concentration that could be used without injury for the nutrition of 'MD-2' pineapple was 9%. The use of higher concentrations produced leaf tissue injury that would promote infection by pathogens such as *Erwinia* sp and *Phythopthora* sp, *Erwinia* sp being the most dominant disease resulting from a technical error that results in injury due to excessive fertilizer salt concentration.

Figure 1. The left photo shows the results of 6 fertilizer5 sprays containing 9% salts applied at 14 day intervals (similar results were presented with 5% and 7% salts).The photo on the right shows the results o 6 sprays using a solution containing 11% salts (like results were obtained with loadings of 13% and 15%). Similar injury symptoms can occur as a result of a urea overdose (Broadley, et al., 1993).

The photos below provide evidence that the above problem can also be seen in the field.

Freshly planted seed and malnourished seed, especially when it has leaves that have a "constriction" at the stem level (no new growth present), are less susceptible to burning than are growing plants (this is evidence of a “neck” within the last 15 cm of the leaves). The reason these plants are less susceptible to salt levels > 9% is because they do not accumulate spray in the leaf axils so most of the spray goes to the soil. Well established plants (over 3 months) and other well nourished plants are much more susceptible to salt injury, and also to infection by *Phythopthora* sp and *Erwinia* sp.if injury occurs, because the leaves are wider and more spray solution can accumulate in the leaf axils.

We propose using a refractometer (the same that is used to measure the °Brix of fruit juice) as a practical and fast way to check if the salt concentration is correct (Figure 1). Spray solution from a nozzle of the spray boom during fertilization is placed in the refractometer and a reading taken. If the measurement is higher than 7 °Brix, the salt level may be high enough to be phytotoxic to the crop. Phytotoxic concentrations may occur at higher or lower salt levels, and also can depend on the type of fertilizer used. However, the tool is practical and affordable so producers could use the method to easily establish their own parameters.



The above test was performed with the following fertilizers and subsequent equivalent doses per hectare.

	Technical Data	Equivalent dose kg·ha^{-1}
Urea	46% N	50
Ammonium Nitrate	33.5% N	45
Potassium chloride	62 % K_2O	50
Magnesium sulfate	16.4% MgO y 13% S	25
Iron sulfate	20% Fe y 11% S	6,25
Zinc sulfate	35.5% Zn y 11% S	6,25
Boric Acid	17% B	6,25

$^{-1}$ Equivalent dose Kg·ha^{-1} as reference of the 9% treatment salts concentration.

So, according to Bartholomew et al (2002) in their classification of leaf sprays, when applying sprays at medium volume, the salt concentration of foliar sprays should not exceed 9%. This is very important to remember if the grower has a nutrition program where sprays are applied at constant volume at regular intervals but with increasing concentrations of salts as plants grow. There is more potential for mistakes with such a system than there is where sprays of the same salt concentration (the tank formulation is always the same) are applied with increasing frequency as plants grow. There is also greater possibility of a calculation error that results in an excessive salt concentration when less than full tanks are mixed, as would be the case when spraying a small block or when some Blocks need a fraction of a tank to complete the area to be sprayed. Such situations are easily prevented if a refractometer measurement is made before the spray is applied.

It is important to consider that the phytotoxic effects are only beginning to become evident at 25 days after application, while the maximum phytotoxic effect occurs at 60 days. However, pathogens can enter within the first 20 days since tissue injury occurs before symptoms of phytotoxicity become obvious, which often takes about 28 days for the leaf to grow to the point where injury can be seen. The injury may become obvious sooner if the leaf becomes infected with a pathogen.

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Pineapple Culture in Colombia: An Opportunity for Agrochemical Companies and a Need for Exporting Producers

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Over the past five years Colombia has been dabbling in the production of 'MD-2' pineapple. There are several companies with more than 200 net hectares in crop and some pineapples have already been exported to Europe and the United States. Costa Rican professionals are accountable for the areas of production; however because of important differences in climate and soil, in particular the climate is warmer and more tropical than is the case in Costa Rica, the main competitor in the región. As a result, producers have been forced to develop their own culture system. Certainly a different technology should be developed to account for the agro-ecological differences that exist between the two areas.

The above difficulties are compounded by the lack of a portfolio of agricultural inputs that satisfies the basic technology package of pineapple production. However, this shortage is "bureaucratic or political," mainly due to the recent introduction of 'MD-2' in the country, hence it has little commercial importance. The phytosanitary molecules needed are in the market, but most do not indicate its use for pineapple on the label. That precludes its use in the management program for certification issues, this despite the fact that these molecules are approved for use in terms of tolerances (MRLs) in Europe, the United States, Costa Rica and other countries.

This places Colombia in an additional disadvantage, for this reason it is considered important that the main pineapple producers and the agrochemical companies collaborate, with the aim of making a formal appeal of the need for plant protection for fruit destined for export. It is important that the collaboration include the ICA (Colombian Agricultural Institute) as the lead agency in seeking to add pineapple to the list of approved uses of molecules for protection of this new and growing industry.

Undoubtedly, the above is essential for the exporting producers and a great opportunity to agrochemical companies.

Primer Simposio Internacional sobre Cambio Climático y sus efectos sobre el Cultivo de Piña (First International Symposium on climate change and its effects on cultivation of pineapple*)

This symposium was organized by EARTH University Director Carlos G. Murillo and held at the University campus at Libera, Guanacaste, Costa Rica from 24 to 26 November, 2014. No archive of the presentations was found.†

Hora (Hour)	Actividad (Activity)	Expositores (Speaker)

	November 24, 2014	
8:00 am – 8:30	Inauguración	Carlos G. Murillo, EARTH, Ing. Néstor Ramirez
8:30 - 10:00	Variables hidrológicas y modelación de procesos para la toma de decisionesm (Hydrological variables and modeling of processes for making decisiones)	Dr. Ignacio Cohen
10:00 - 11:30	Uso de la microbiología y su impacto en sistemas de producción agrícola (Use of Microbiology and its impact on ecosystems in agricultural production).	Ing. Walter Nuñez wnunez@eurofertil.net; www.eurofertil.net.
12:00 - 13:30	Cuidados en el manejo de hormonas en épocas de estrés hídrico y alta radiación (Hormonal control in pineapple cultivation under stress)	M.Sc. Mauricio Navarro, E-mail: mnavarrogar@hotmail.com
15:00 a 16:30	Desafíos del Mercado de Exportación (Presentation by CANAPEP on the realities and current events of the pinapple sector of Costa Rica)	Ing. Christian Herrera León, CANAPEP
16:30 - 18:00	Dinámica de plagas y enfermedades de la piña en un ambiente de cambio climatic (Dynamics of pests and diseases of the pineapple in an environment of climate change)	Ing. Carlos Rivera
	November 25, 2014	
8:00 – 9:30	Efectos de la temperatura de campo en la calidad y comportamiento post-cosecha de la piña (Effects of the field temperature on post-harvest quality and behavior of pineapple)	M.Sc. Carlos Demerutis, EARTH. E-mail: cdemerut@earth.ac.cr
9:30 – 11:00	Producción Intensiva de PIÑA en ambiente protegido, en México (Intensive pineapple production in protected environment in Mexico)	Ing. Daniel Uriza; E-mail: cepap2@yahoo.com.mx
11:30 – 1:00	Diseño en sistemas de riego sostenible en zonas con baja disponibilidad de agua (Design sustainable irrigation systems for areas with low water availability)	Dr. Javier Ramírez
14:30 - 15:30	Retos claves de la nutrición efectiva (Key challenges of effective nutrition)	Ing. Adrián Ortega
15:30-16:30	La perspectiva climática y sus efectos en la agricultura (The climate perspective and its effects on agriculture)	Carlos G. Murillo, EARTH
	November 26, 2014	
08:00-12:00	Gira de Campo a Fincas Productoras de Piña del Pacífico (Field tour to Pineapple Farms near the Pacific Ocean)	EARTH
14:00 – 15:00	Cierre del evento y Entrega de certificados (Closure of the event and handing out of certificates)	Carlos G. Murillo, EARTH

*Translations from the Spanish were produced by http://www.spanishdict.com/translation.

†Special thanks to Ing. Agr. Jhonny Vásquez Jiménez , San Carlos, Costa Rica for making the above information available to readers of Pineapple News.

News from France

A Short Update on the Pineapple Taxonomy Debate

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In the 2014 Pineapple News issue (n°21), Butcher and Gouda (2014) presented their views on pineapple taxonomy, considering that most pineapples are cultivars and that only three taxa, described from wild materials, should be recognized: *Ananas ananassoides*, *A. parguazensis*, and *A. sagenaria* (syn. *A. macrodontes*). Ananas 'Bracteatus', 'Comosus', and 'Erectifolius' would be considered cultivars.

In my answer to Butcher and Gouda, I refuted their proposal to discard cultivated pineapples from the botanical classification and summarized the main historical problems that have affected pineapple taxonomy (Coppens d'Eeckenbrugge, 2014). This answer was naturally targeted at the 'Pineapple People' (I sincerely enjoyed how Butcher and Gouda created this expression for our tribe). At a wider scale, a more general and formal answer was needed to get rid of the confusions that hamper non-specialists from understanding our classification and comparing it with previous ones. With the help of a recognized expert in formal taxonomy, I undertook a revision of the synonyms for *Ananas macrodontes* Morren, *A. comosus* (L.) Merr., and its five botanical varieties, with detailed explanations on past confusions and errors. The resulting paper has been submitted to a specialized journal and has gone through the first phase of review. I would have been happy to announce here its publication, however editorial delays have been longer than anticipated.

When this work is published, what will be its practical impact for the Pineapple People? In fact, the classification will not be modified in essence. The only change will be strictly nomenclatural, as the most common wild pineapple that was designated as '*A. comosus* var. *ananassoides* (Baker) Coppens & Leal' will then be designated '*A. comosus* var. *microstachys* (Mez) L.B. Smith', following priority rules for names of botanical varieties. In any case, the adjective 'microstachys', meaning "very small spike", was an excellent proposal from Mez (1892) to describe very concisely this wild form.

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News from India

History of Introduction and Development of Pineapples in North Bengal: as Viewed by a Grower

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The Seven Districts of the Northern part of West Bengal (Alipurduar, Coochbehar, Darjeeling, Jalpaiguri, Uttar Dinajpur, Dakkhin Dinajpur and Malda) is popularly known as North Bengal. This vast area requires no identity of its own, except to remain as a part of our beloved West Bengal. Siliguri, a city of tea, timber, tourism and pineapple, has grown up as the 2nd largest city of W.B. North Bengal became the only area producing such a large volume of pineapple and we are producing here one third volume of pineapple of our country. It influenced the economy of our state at large by earning of foreign money also. So the pineapples of North Bengal added a new feather in the crown of our Siliguri City, the informal capital of North Bengal. Bidhan Nagar area in Darjeeling district; 40 km away from Siliguri is the heart of pineapple growing area of this state and we may call it as the "Capital of Pineapple".

This vast area requires no identity of its own, except to remain as a part of our beloved West Bengal. Unfortunately such demand is now rising by some separatist groups of activists. Some demand *Gorkha Land* in the hill region of Darjeeling District, others demand an independent area comprised of Tribal habitants. Keeping this all aside, a prominent shouting is in vogue to attain independent *Kamatapur State* comprising the Districts of North Bengal with an added area within the territory of the Province of Assam, bordering with the District of Coochbehar. Such demands and counter demands, activities and counter activities, turned into a collapsing condition in the Trade & Commerce sector of this so called North Bengal area.

But the cultivation sector, pineapples, manages to bypass the effects of the trouble. Pineapple cultivation attained its expansion over an area of 20,070 ha of uneven and rugged land that is being utilized by 17,500 cultivators now. These cultivators have embraced about one million people, directly or indirectly, in this cultivation system. It reveals from statistical survey that about 543,000 thousand MT of pineapples were produced in 2012 AD in lieu of 30 cores of suckers. Market value of that volume of product as estimated was about 5.5 billion Rupees. Such an amount of financial turnover carries a significant role in the economy of our so called North Bengal.

In the usual course of cultivation— from 50 to 85 MT/ha of such fruit can be on uneven rugged land, where no other traditional crops can be cultivated. Such a huge area of land used to be kept fallow before introduction of pineapple here. We are proud to say that the introduction of pineapple has changed the whole scenario.

Nowadays, *'Kew', 'Mauritius' and 'Queen'* pineapples produced in North Bengal have grabbed market share in Delhi, Punjab, U.P, Orissa, Maharashtra, Bihar, Jharkhand, Gujarat, Jammu, Kashmir and out of country in Nepal and Bhutan. Such trading had been conducted in India and abroad by wholesale merchants like Misters Prankrishna Paul, Biplab Sen, Khokan Ghosh, Dulal Mallik, Ujjal Sarkar, Sajal Ghosh, Suman Kar, Indrajit Roy (@Barka), Anil Paul, Sudhir Das, Nirmal Majumdar, Abani Dev Barman, Bakul Mandal, Nirmal Chandra Majumder, Dulal Ghosh, Goutam Majumder, Mohammad Tamiz, Taranath Sharma, Mohammad Matu Sheikh, Mohammad Asharaful Sheikh, Rajkumar Sha, Harduar Singh, Dulal Sarkar, Binay Das etc.

In addition to the above, 85 warehouse owners of Siliguri and Bidhannagar had also involved themselves in such trading. More over about 350 middlemen are purchasing pineapples directly from the original growers and selling those to the wholesalers.

We are proud to say that the introduction of pineapple has changed the whole scenario. Sale of pineapples used to sellout in two forms— ripens are sold in piece rate and greens are sold in weight. In the last year, 66 million ripe pineapples were sold in piece rate and truck-loads of 152.5 million pieces of pineapples were sold in weight rate, as reported by the wholesellers, from the markets in Siliguri and Bidhannagar.

In the last year, ripe pineapples were able to get its wholesale market price @ Rs. 18.94/- per piece, the greens got @ Rs. 12.30/- per kg. In the current year ripe and green pineapples are being sold @ Rs. 13.00/- per piece and @ Rs. 8.15/- per kg in its wholesale market.

There is no pineapple cultivable land in our Province of West Bengal, except in North Bengal, due to the peculiar characteristics of land it require for pineapple plantation. It is mentioned in a foregone paragraph that during the pre-pineapple days, owners kept such peculiar lands fallow. Then what is the story behind the curtain that made such lands cultivable for such a tasty fruit? We tried our best to find the answer by interviewing the old residents of Bidhannagar and Siliguri, who once were in touch with pineapple and we are happy to find out the answer, as far as they could recollect from memory and simultaneously we screened those by other circumstantial evidences to get a factual story.

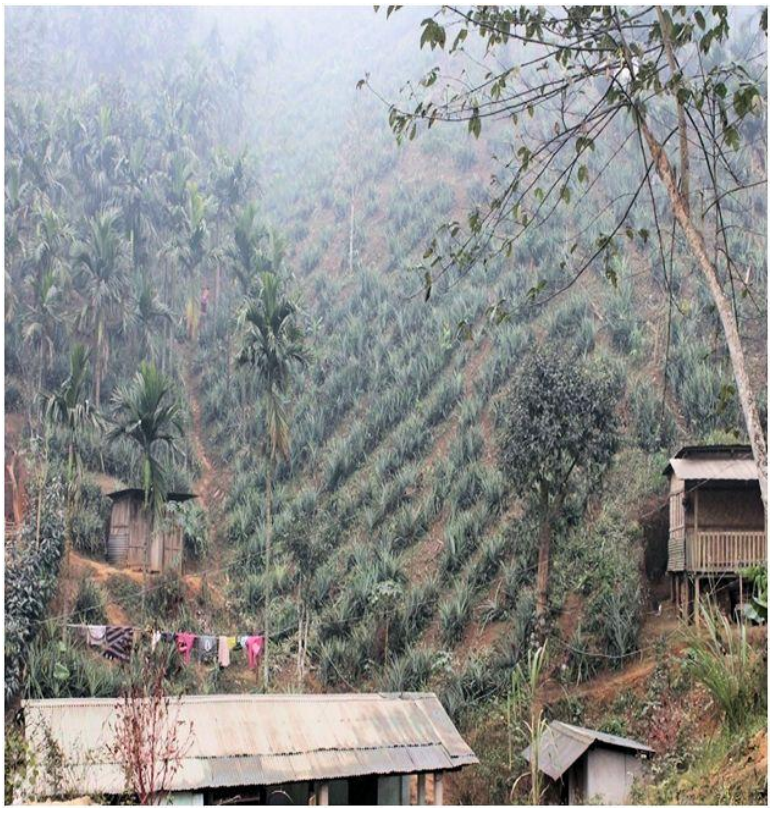
Pineapple Production in West Bengal

Year	Area (ha)	Production, MT	Rate per pineapple or piece
1953	1.6		
1957			3/4 Anna
1971	22,000	243,000	
1974			40 Paisa
1982			70 Paisa
1986			Rs 1.00
1987	33,000-35,000	320,000	
1990			Rs 1.30
1991			Rs 2.00
1992	25,000-30,000	285,000	
1993			40 Paisa
1994	10,000		
2000			Rs 4.50
2005	19,000		Rs 6.00
2009-2010	18969	409,000	Rs 7.10
2010-2011	19513	506,700	
2011-2012	20,070	543,450	
2013			Rs 18.69
2014			Rs 12.64

District wise area and production report in West Bengal

District	Year	Area (ha)	Production (mt)
Darjeeling	2009-10	12,350	262,794
	2010-11	12,740	324,357
	2011-12	13,175	350,000
Uttar Dinajpur	2009-10	3,710	79,615
	2010-11	3,807	114,192
	2011-12	3,875	120,000
Jalpaiguri	2009-10	2,850	65,550
	2010-11	2,905	66,600
	2011-12	2,925	70,000
Coochbehar	2009-10	52	936
	2010–11	70	1326
	2011-12	85 `	3000
Maldah	2009-10	7	105
	2010-11	9	225
	2011-12	10	450

It was said that in the beginning of 5th decade, Mr. Jatin Biswas, the then Manager of *Putinbari Tea Estate,* traveled to the hill area of Halflong in Assam. He was accompanied by three of his friends— Manmatha Biswas, Moni Mitra and Binay Mukherjee. They became amused with the nature's beauty of Haflong. They could not imagine how much of amusing element was waiting for them. They found beautiful scenery— steps on the valley of Haflong hills were covered with well arranged rows of a fruit-like cultivation. What were those? What to do with those? Ultimately they came to know that those were called Pineapple and much pleasant to eat.



The four friends did not hesitate to enjoy the taste of pineapple on the very 1st opportunity in their life. They were charged not only by enjoying the taste, but they were amazed with the beauty of the pineapple plants in rows. Each of the friends was fond of gardening. So they did not missed to carry a few sucker with each of them on the way to back. They planted those in their respective flower gardens. In course of time the suckers turned into plants and added an unforeseen beauty in the gardens. Gradually the plants developed into fruitier and started yielding pineapples in series. But how much of those could be used for family consumption! The four friends tested its commercial viability by placing those in the famous weekly village market Matigara in the district of Darjeeling. Astonishingly the four friends passed the test with a grand success. Pineapple was then introduced as hill-fruit. Mr. Jatin Biswas, on being fully charged with such a grand success, brought 30 thousand suckers from Assam and planted those in four acres of suitable land beside NH-31 in Matigara in 1953. That was a joint partnership venture of the four friends. Production was satisfactory, but Mr. Moni Mitra left the venture and settled with his already existing business. Mr. Binay Mukherjee was a political activist; he also left it in the interest of his political course of activities. But Mr. Jotin Biswas accompanied by Mr, Manmatha Biswas

continued it and started a new technique of plantation called as '*Raton'* on their own land along both the sides of road in village Khaprail in Matigara.

The above is the untold story of introduction of pineapple cultivation in a tiny part our North Bengal. Practically, it was a great discovery by Mr. Jotin Biswas and his friends to add potentiality in the Economy of this part of West Bengal. In jeneral, No discovery can be limited it within itself. The same was in the case of cultivation of pineapple on the uneven, rugged and barren high lands of our North Bengal. So the process once started, continued to proceed with the succeeding cultivators.

Cultivation of pineapples in the form of a commercial crop got its shape with the initiative of Mr. Arjun Chandra Paul, the then factory-staff of Gungaram Tea Estate. He purchased a plot of land in Hansqua near Bagdogra with the financial support of his father Mr. Girish Chandra Paul in the year of 1954 AD. He started to cultivate traditional crops like Paddy, Jute, Sugar-cane and planted pineapples along with those simultaneously to get a commercial profit making comparison. The whole process of such thing was under personal supervision of his father Mr. Girish Chandra Paul. The rate of profit-earning figure from pineapples pushed back the rest of their traditional crops. They were stricken with a great amazement with such a result of practical study!

On attaining success in Hansqua, Mr. Arjun Chandra Paul decided to utilize this barren area for pineapple cultivation. He left his job of factory-staff of Gungaram Tea Estate in the year of 1957 AD and purchased an area of land in village Lacchuvita and Choudhuriyagachh near Bidhannagar/Ghoshpukur area and started to go with pineapple cultivation. In the days of that underdevelopment, there was no scheduled public conveyance from Siliguri to Lacchuvita and Choudhuriyagachh. So Mr. Arjun Chandra Paul had to cover the whole of the 30 Km distance from his residence at Siliguri to Lacchuvita and Choudhuriyagachh on riding bicycle! He started to sale his pineapples through the traders Md. Rajjak Mian and Sri Sudhanya Roy of Bidhan Market of Siliguri.

In those days, pineapples were sold @3/4 Anna per piece. The relatives of Mr. Arjun Chandra Paul had also immigrated to settle here at the end of 5th decade of 20th Century. Mr. Dayal Chandra Paul purchased land at Mooni near Bagdogra. He built his residence there and started a grocery shop. The shop was running very well with the huge customers from workers of Tea gardens surrounding the area. At the same time he started pineapple cultivation. In the mean time Mr. Arjun Chandra Paul started his own trading business of pineapple in Siliguri in the year of 1959 AD and left cultivation activities in favour of his Six sons— Salil krishna, Sunil krishna, Debabrata, Bijay krishna, Anil krishna and Prashanta. The immigration was followed by some other relatives to settle here during the 7th decade. They were Mr. Nilu Paul, Mr. Prabhat Paul, Nagen Paul and many others.

Pineapples of Mr. Arjun Chandra Paul had reached in the market of Kolkata at this first phase of his trading. The hawkers started to sell well-dressed pineapples in the compartments of passenger trains. Pineapples achieved its own identity to public in general in the list of their tasty fruits and in the vast market of India as a promising commercial crop.

In the process of such phenomenal development, pineapple cultivation acquired its stable base in Bidhannagar and adjoining area. In this perspective, the inhabitants of Bidhannagar felt potentiality in self-employment and commercial opportunity there. This immense potentiality attracted peoples from elsewhere to settle there. Even the victims of anti Bengali riots in Assam, people emigrated from there and some others also emigrated from different districts of West Bengal. As a result of such influx by a flow of continuing immigration, Bidhannagar had grownup as a habitation of mixed population of Refugees from the then East Pakistan and other emigrants with aboriginal Rajbanshi & Tribal people. The then Bidhannagar was not in a position to accommodate such a sudden influx. The role of late Dhirendra Nath Sarkar cannot be skipped in this discussion. He also emigrated here with some of his relatives and close mates from the district of Rangpur of East Pakistan via Coochbihar in the year of 1955 AD and settled there. He along with some of his followers negotiated with the *Ryots* (owners of land with legal right and title) to allow those people on their land as habitation.

Dhirendra Nath Sarkar grew up as a leader of the then Communist Party of India. Though he was a district level leader of his party, he confined the focus of his activities with infrastructural development of Bidhannagar. Subsequently his initiative acquired a momentum with posting of Mr. Surya Mandal at Siliguri as

District Agriculture Officer from Kolkata. Mr. Mandal, a man much serious to achieve goal of his department entrusted to him. He used his dynamic personality to attain his goal by mass contact at the grass root level.

As per records maintained in the settlement department of the Governmentt, the name of Bidhannagar is 'Kalachandgachh' till date. Subsequently it was popularly renamed in memory of Dr. Bidhan Chandra Roy, the then Chief Minister of West Bengal, at the initiative of late Dhirendra nath Sarkar. Now the said Kalachandgachh has gone out of currency with the rise of the greater Bidhannagar area.

Once in 1962 AD, a team consisting of Mr. Dhirendra nath Sarkar, Surya Shil sharma, Fulchand Kediya and the DAO Mr. Mandal met with Mr. Subodh Chandra Ghosh, a contractor under Indian Railways. Mr. Ghosh was a resident of Siliguri. The members of the team managed to convince and encourage Mr. Ghosh to contribute a part of his endeavour in pineapple cultivation. Mr. Ghosh purchased vast area of land in the village Sarkar kumartuli in Bidhannagar and started cultivation of pineapple there. Also he started Poultry, Piggery and Dairy farm there. Mr. Subodh Ghosh also had fallen in the love of Bidhannagar and setup a High School there named after his demised mother 'Santoshini'. The School was recognized by the West Bengal Board of Secondary Education with financial aid from Government fund. In course of time, two giants Mr. Mohonlal Sahewala and Fulchand Kediya also paid a close attention in pineapple cultivation. The DAO Mr. Surya Mandal invited his brother Mr. Narayan Mandal to examine the commercial potentiality of pineapple cultivation in Bidhannagar. He became encouraged and purchased a suitable land in the village Droupadi Dangi in Bidhannagar by resigning from his permanent service in the then Post & Telegraph department. He also started piggery and Dairy along with cultivation of pineapple there. Such flow of pineapple cultivation became enriched by embracing many more personalities like Mr. Narayan Aich, Nitai Datta, Khokon Datta and so on. There was no more land suitable for this cultivation in Bidhannagar. But the number of people attracted in this cultivation was ever increasing. The cultivation of pineapple rapidly spread over the neighboring districts of the then Pashchim Dinajpur and Jalpaiguri, even it spread over a part of the District of Coochbihar also.

In the mean time, Mr. Arjun Chandra Paul sent one of his sons Mr. Anil Krishna Paul to Lucknow, in the year of 1964 AD, to get formal Training & Education on fruit processing with emphasis on pineapple processing. On completion of his course of study, Mr. Anil Krishna Paul returned back with full of energy to materialize the dream of his father. He started a fruit processing unit in their residence. At the same time, Mr. Kanu Biswas, the son of Mr. Jatin Biswas started a pineapple processing training centre in his own house. Unemployed ladies were the trainees there. He achieved local market's support to sell Jam, Jelly, Slice and other Tit-bits produced from pineapples. Such products from "Paul Fruit products" owned by Mr. Anil Krishna Paul got its market in other Provinces of India like Lacknow, Banaras, Delhi, Kanpur, Karimganj, Katihar, Kishanganj etc. Also trading of pineapple business of Misters Dayal Paul, Laxmi Paul, Narayan Paul, Shankar Paul, Harekrishna Paul, Suren Paul, Bimal Bhawal, Khokan Datta, Narayan Datta and Shankar Das had spread over the whole India. With a simultaneous effect, 'SIliguri fruits', 'Dooars pineapples' and 'Bina fruits' had been established as popular pineapple trading centers.

Movements in East Pakistan, with a goal to achieve an independent state, 'Bangladesh', free from the military regime of West Pakistan, became violent in the year of 1970. Ultimately the movement turned into warfare against colonial occupation of Pakistani military. Lakhs (thousands) of people were evacuated and came under shelter in the adjoining districts of India in the year of 1970/1971 AD. Our family also along with others chosen the same as refugee and got settled here in Bidhannagar. The then Government of India became sympathetic to the refugees who intended to settle in India like us by offering Citizenship. Many of them like my father Sri Dinesh Chandra Mandal, Sri Fakir Chand Mandal, Sri Jugal Sarkar chosen pineapple cultivation for survival of their families.

Hence, cultivation of pineapples arrived at such a situation that its volume of production seriously surpassed its demand. Pineapple growers faced severe trouble in marketing of their products. A big question mark stood before the growers & traders— how to get relief of this depressive condition? The answer came in two forms— 1st: Consumption of pineapples in its raw state had to be popularized much more. 2nd: More avenues of pineapple processing to get various forms of products and byproducts had to be opened.

Follow-up of the 1st answer— Sri Dhiren Sarkar, Ranjit Sarkar, Benay Das and their followers had started supply of dressed pineapples to the truck drivers at rest in line hotels beside the NH-31 to offer an instant taste of this wild fruits. Even the drivers and their assistants were supplied with pineapples for their family consumption with payment of no price. On the next phase— Sri Ramesh Sarkar, Naresh Chandra Bhowmik, Jatin Prasad Kurmi and others started sale of pineapple standing on footpath. They could sell @ 80 Paisa to One Rupee per pair of pineapple. Sale of pineapple standing on footpath got its strong footings by erecting thatched shops by Maran Sarkar, Moti Mandal, Sadhu Sarkar, Lalit Sarkar, Abhimonyu Sarkar etc. It was a significant development towards marketing of pineapples with the passersby. Busses on long route also stopped in front of those pineapple-shops. Sri Sudhir Ghosh, Moni Sen, Dhiren Bhowal etc became attracted to the success of such local selling outlets and also joined this local marketing system. They also erected 'Goomti', a better type of pineapple stalls to sell their respective own products. The traders who purchased pineapples from their nearby wholesalers, initiated to come to these 'Goomties' to purchase 'directly from the growers'. And thus Bidhannagar, the pineapple growers' area, turned itself into a whole sell market area better acceptable to the traders.

In the year of 1975 Mr. Aloke Ghosh, Mr. Basudeb Choudhury, Mr. Ranjit Ghosh and some others proposed to Mr. Ramesh Sarkar to sell their garden-product on commission basis. Mr. Ramesh Sarkar agreed with the proposal sale of pineapple on commission from his depot (commonly called as *'Arat'*) for the first time in Bidhannagar. This instance was followed by Mr. Sudhir Ghosh, Mr. Khokon Datta, Mr.Moni Sen, Mr. Anath Das, Mr Krishan Lal Dogor, Mr. Kartik Dey and etc. Any Hotel/Lodge facility was not there in the then Bidhannagar. So the depot owners like Mr. Ramesh Sarkar and Mr. Sudhir Ghosh arranged lodging of the wholesale buyers in their own houses. That was the final touch to follow-up the 1st answer.

Follow-up of the 2nd answer— a team of pineapple growers headed by Sri Dhiren Sarkar and Sri Surya Shilsharma met Mr Abdus Sattar, the then Minister-in-charge of agriculture, Govt. of W. B. The Honourable Minister agreed with the proposal of the delegation and sent a team of expert Govt. personnel to enquire into the viability of setting up a project for fruit processing somewhere in Siliguri subdivision. The Govt. team inspected every aspect of the proposal and published their valuable report in the form of a Book. The report revealed that the pineapple cultivating area had increased to 22 thousand ha producing 23 thousand MT of pineapple and 2 lacks (200,000) of working people were involved in the system-network from production to marketing. But 30% of these fruits spoiled due to want of processing units or a cold storage preservation system!

This panicky picture led the then S.D.O, Siliguri Mr. S.S. Ahuja to convene a general meeting of pineapple growers. A Cooperative society constituted from the meeting with its name "Darjeeling fruits and Vegitable Cooperative Society Limited". This was renamed as 'Kanchan' afterwards. Four hundred pineapple growers purchased share of this society which includes Sri Surya Shil Sharma, Birendra Kumar Nandy, Sudhir Kumar Sarkar, Alak Ghosh, Jamini Kumar Das, Bishnupada Mallik, Subodh Chandra Ghosh, Amulya Ratan Ghosh, Fulchand Kediya, Sunil Chandra Pal and Khetranath Biswas. Then the 'Kanchan' started its production first to meet the demand of Indian Army and then its products spread over the whole of India. During this period of depression Mr. Arjun Chandra Paul sent his son Prashanta to Mysore to train up in fruit-processing. Thus the 2nd answer had been continuing to be followed-up.

The period of 1972 to 1977 AD appeared with a great displeasure among the people of India against the regime of Mrs. Indira Gandhi. Ultimately, a state of emergency was promulgated by withdrawing some fundamental democratic rights. National level leaders protesting such act of Mrs. Indira Gandhi were thrown into Jail under Detention of Preventative Act and Defense of India Rules. Repressive activities of the Govt. by police and Para-military atrocity turned the situation into a grave condition. The General Election for Parliament and state Assemblies were held in the year of 1977. The awaited result of the elections dethroned the Congress rulers of both the center and provinces. The Left front government headed by the mass-based C.P.I (M) Mr. Jyoti Basu. This new government offered the taste of new, Governance to the masses of West Bengal at grass root level. This government brought about some significant changes in its basic 'Economic policy'. Its 'Commerce and industry

policy' was also framed to favoure the beneficiaries at grass root level. The 'Cottage and small scale industries' and 'Fruit process industry' department in the government also re-framed its policy keeping eyes to the benefit of the people involved directly in the system. Chief Minister of the Left front government in W. B. announced determination of their Government not to rule from Writers Buildings in Kolkata, but promised that the government shall arrive at the doorstep of the people as a principle and practice. Accordingly the long pending elections of Municipality and Panchayat bodies were hold in the year of 1978 AD. The newly elected bodies were empowered by much more financial strength and also empowered them to select priority on developmental activities as required by the practical need of the area to be implemented by them.

In such a changed perspective, Mr. Birendra Kumar Nandy was elected as the *Prodhan* of Bidhannagar Grampanchayat body at Gram level and Mr. Amar Saha was elected as *Sabhapati* of Khoribari-Phansidewa Panchayat Samity at Block level. Both of them were from the ruling force of the then Government of W. B. Mr. Nandy was a bright man in touch with the pineapple soil. He took a special initiative for development of local Infrastructure for whole sell pineapple market in Bidhannagar. He also arranged to mobilize all sorts of advisory and technical help from Panchayat Samity through the administrative skill of Mr. Amar Saha.

It requires a special note here that the L.F. Government had undertook a fundamental task towards Land-reforms. Necessary Act & Rules was there since long, but none of the predecessor governments bothered to proceed for Land-reforms. Big *Zaminders & Joteders* were allowed occupancy on large areas of land above permissible limit. Those were in direct defiance of land reforms act by both of the occupants and the respective governments.

The L. F. government started to confiscate such impermissible and anonymous land to distribute among the landless cultivators with their every right and title. Such steps of the government extended a far reaching effect on gradual rise in agricultural production of West Bengal. That was because of land started to be used by the real cultivators cultivating for themselves, not for the *Jotedars*. Another reason was the *Jotedars* were either not so much attentive to product beyond their consuming requirements, or they were not properly equipped with necessary amenities and capital to utilize the whole of land under their unlawful or anonymous possession.

The landless cultivators worked hard for earning profit to their landlords till they were provided with land to cultivate for their own earning. But from where they shall get a minimum capital and other implements for cultivation? Shall they borrow personal loan from the professional money-lenders to bear an unbelievable rate of interest? The government came forward to achieve their mission and extend agricultural loan through Bankers. The government stood as guarantor on recommendation from the panchayat bodies. In such a way the government really arrived at the doorstep of the people. Such extensive implementation of the noble task 'land to the tillers' with capital and implements favoured increase in volume of production of pineapple in general.

It has become folklore that once a wholesaler sold pineapples in Sahebganj of the then Bihar (now in Jharkhand). The purchasers did not know how to dress such wild fruit to eat. They ate those normally and started sufferings from unusual painful sore in mouth with bleeding. The purchasers came back showed their wounds and beat the wholesaler. In another occasion, Mr. Binay Das went to Patna to sell pineapples. His loaded truck when was in front of Patna college, some students intended to eat pineapples. He had the lesson from the so-called folklore and so at the first opportunity he taught them how to dress pineapples to eat and thereafter fed them free of cost. Mr. Ramdulali Yadav from Gorokhpur of UP was a bulk purchaser of pineapples. The wholesalers from Bidhannagar were used to wait in Siliguri Rail station for long hours, till his train arrived. They were in belief that arrival of Mr. Ramdulali Yadav in market shall favour them in increasing the market price.

Production of pineapples was increasing day after day, enhancement and widening of a greater market was felt by the owners of fruit processing units, growers and traders. Hence, in 1982 AD, Mr. Debaprosad Roy, an all India leader of the then youth congress, cooperated with a team of delegation comprised of Mr. Sunil Kumar

Paul, Mr. Kanu Biswas, Mr. Purojit Baxi Gupta and Mr. Jyoti Ghosh to meet Mr. Pranab Mukherjee, the then Honourable Minister-in-charge, Department of Commerce in the Government of India. The team was able to convince the honourable Minister to arrange for foreign export having a good response. A team of delegates from the then USSR (USSR) came to inspect on the points of viability of importing pineapples to feed their people. The team talked to Mr. Sudhir Ghosh, Mr. Paresh Sarkar, Mr. Dayal Paul, Mr. Suren Das, Mr. Bimal Bhawal, Mr. Narayan Datta, Mr. Anil Krishna Paul, Surya Shil Sharma, Mr. Benay Das and some others. We express our gratitude to Mr. Harisadhan Ghosh of Siliguri, the then stalwart of C.P.I, for doing his best to introduce the USSR team of delegates with the growers and also for his role as an interpreter. They felt a positive sign and arranged to follow-up. A treaty among the importing agencies of USSR and exporting agencies of India was signed for execution. The exporting agencies were S.T. Corporation, Ratan export, Shriram export, Usha intercontinental and M.J. exporter. With these long efforts, the pineapple of North Bengal sailed for USSR in 1983 AD. At that time, 19 canning factories were setup in our province and the number was above 50 in whole of India.

Mr. Dayal Paul, Mr. Amar Nath and Mr. Ananda Biswas became encouraged with this new development and they also established their respective own processing units in different places at their opportunity. Mr. Kanu Biswas started to make threads and Mr. Binay Das made pasteboards from pineapple leaves. Sale of pineapples hiked @ 70 paisa to Re. 1 per kilogram. Pineapples were sold at piece rate before capturing foreign market. The name of Mr. Sudhir Ghosh became a bright star in the Bidhan Nagar market for pineapple trading. Mr. Surya Shil Sharma was maintaining liaison with foreign market along with the market of Mumbai. The name of Mr. Hari Sarkar became noteworthy in the market of Delhi. Mr. Hari Sarkar attained fame in Bidhannagar as 'Delhi's Hari'. And thus the golden days started for the yellowish-green fruits.

It was on the 31st October-1984, the Prime Minister of India Mrs. Indira Gandhi was assassinated by one of her personal security personnel. Co-incidentally the said assassinator belonged to Punjabi community. Our country faced a horrible reaction which went against trade and commerce of the country for a couple of days. 'Sarderjees' (persons belonging to Punjabi communities are popularly called ''Sarderjees') were bitten, shops & trucks belonging to or conducting by that community were burnt by miscreants. 250 number of pineapple loaded trucks were burnt by the miscreants throughout the country following the shocking assassination.

The devastating flood of 1987 came as terror in the livelihood of pineapple cultivators. The Bridge over river Nagar at Raiganj on NH-34 had failed its load bearing capacity. The Bridge on NH-31 over river Mahanda in Bihar broke down. All of the roadways from North Bengal remained closed for long. The growers and traders failed to encounter such calamity and pineapples spoiled in the field.

Pineapple cultivation during that period covered 33 to 35 thousand hectares of land, 5 lacks (500,000) of people got involved in this field to maintain their livelihood. As victims of nature, a considerable number of growers became hostile to pineapples and chose other alternative to survive. The remaining growers continued to maintain their existence with pineapples depending on the markets in Nepal, Bhutan, USSR, and Delhi.

In the mean time, pineapple producing countries like Thailand, Philippines etc entered in the market of USSR. We had to face a severe competition. We failed to sustain. Our processed products were returned back from USSR. Sufferings came on the pineapple processing units here. As an ultimate result there was no way, but to shut down the processing units.

It was in the year of 1989 AD when order for fresh pineapples came from Spain. Pineapples twice were sailed for Spain under technical supervision of one well acknowledged specialist in such matters. The first sailing was with ripening fruits. Those were decomposed in the ship on the way to Spain. The second sailing was with too green fruits in the fear of decomposing. Since then the people of Spain closed eyes to the Indian pineapples. Some persons known to have formal specialization in this field invited a great harm to export of our pineapples. They even did not pay heed to alarming voice raised from practical experience of Mr. Swapan Dey and Mr. Digen Sarkar. We do not name those demised alive technical specialists for the sake of courtesy only.

On the other side, the cultivators and local traders, engaged in the field of cultivation and marketing since inception, grownup with huge capital to reinvest elsewhere. It appeared to them that, — pineapple plantation for

once yields fruits for a few couple of years, soon thereafter those had to be uprooted for anew plantation, the new plants had to be nourished with a further amount of capital investment. It was in their readymade experience that— once tea is planted, the yield is guaranteed for decades. They had experienced that the class of land required for pineapple plantations is suitable for tea plantations also. Though it requires an initial investment appeared to be too much for common. These capital-enriched people started to convert their lands from pineapple to tea. But this caused a landslide fall in volume of land under pineapple cultivation. During those golden days, pineapple orchards used to be consisting of not less than 100 acres (1 acre=4840 sq. yards) of land. Orchards consisting of 250/350 acres were usual picture in those days. Obviously those new capital-enriched giants shifted from pineapple to tea. That phenomenon made a gradual process to squeeze pineapple land.

This requires a special note here that, uneven, rugged and highland is ideal for pineapple cultivation. But that category of land became scanty due to massive cultivation for commercial crops. So, the new entrants evolved a way to make change the character of normal plain land into dry land where water logging would not be possible. They made very deep drains by digging the soil in and around the land and thus the land turned into a highland suitable for pineapple cultivation.

Thanks goes to Mr. Rajkumar Sha and Mr. Binod Bihari Roy for their hardworking efforts for furthur widening the market in our neighboring countries— Nepal and Bhutan. Mr. Binay Das was supplying to 'Mohan makings'. In course of time, the 'Mohan makings' started production of wine from pineapples. It is a process of fermentation and so the growers felt a little free from fear of non-lasting the ripe pineapples. Only the 'Mohan makings' owned by Mr. A. K. Nayar used to take supply of 270 tones of pineapples in every season. The trading of pineapples continued to be with a sound health up to 10th decade with export and home market by earning of dollars from exports. Mr. A. K. Nayar died in the year of 1990 AD. After his demise, none turned up for 'Mohan makings'.

In September— October- 1990 AD, Mr. L. K. Adbani conducted a 'Rathayatra' (Hindu festival) towards touring India raising voice to demolish the Ramamandir in Ayoddhya. Such voice provoked Hindu fundamentalism and counter fundamentalism became active. That appeared as a great danger against our communal harmony and national integrity. The charriot was barricaded in the entry point to Bihar and roadway transport throughout the country was severely disturbed. Naturally pineapple traders suffered by spoiling fruits in the trucks. Mr. Sudhir Ghosh returned back with his loaded trucks and barricaded the NH-31 in protest against that disorderly situation in the country, which caused spoilage of pineapple loaded in 65 of trucks.

Again a further depression started with downfall of USSR in 1992 AD. The 'United States of Soviet Republic' faced splitting into separate states. Each state followed their separate policies to combat the new situation. Hence we deprived of the exporting facility from the Russian states. The mid-level growers like Mr. S. P. Sarkar, Mr. Suren Das, Mr. Bimal Bhowal, Mr. Moni Ghosh, Mr. Dhananjay Choudhury, Mr. Hemen Choudhury, Mr. Dinesh Chandra Mandal, Mr. Nitai Dutta, Mr. Manik Das etc closed their pineapple cultivation. The fruit processing units like 'Hima vally', 'Kanchan', and 'Paul fruit-products were also closed as its resulting effect. Further more such processing units of Mr. Dayal Chandra Paul, Mr. Amar Nath also had to keep closed. Lands in pineapple also were reduced from 25 to 30 thousand hectares to the bottom of about 10 thousand hectares. Then the golden days came down to face the irony of fate!

The clouds of hard times failed to discourage growers like Mr. Swapan Dey, Mr. Sudhir Sarkar, Mr. Narayan Ach Mr. Asim Ghosh, and Mr. Digen Sarkar. They brought about change in the pattern of cultivation and that was a new technique of pineapple cultivation evolved by Mr. Swapan Dey! They planted 12 thousand of suckers instead of practice of planting 6 thousand. So density of plants doubled, fertilization was tripled from twice to six times in a season, started using wrapper of thin jute-thread instead of paddy-straw to protect from sun-burn and reduced expenses in labour component by changing other traditional practices. They were in nourishing the

plants like the baby of their wombs during the growing period of sucker. Some of their mates thrown taunts to them saying "are these orchard or flower garden!" At the time of harvesting, they took fruits for once instead of four times. Side by side, they uprooted those plants and planted anew. It is obvious that fruit collected for the first time from a plant will be better in juiciness, larger in size and heavier in weight and shall be much more earning generator in commercial market. It indicates that harvesting and afresh plantation should be in a chain on rotation. But where shall they get land for such new plantation? There remains some land owners who are in unfavorable condition to run traditional crops. Absentee peasants with such condition are offered to provide their land on lease-agreement. Now this has become a normal practice to cultivate on absentee peasant's land even with verbal lease agreement only.

So by the law of nature pushed forward some other people to fill up the vacuum created in course of transfer of capital from pineapple to tea. Small land holders involved locally in pineapple trading chosen to play the role of pineapple growers having 1 acre to 5-6 acres of land. So the number of growers increased at large and also the volume of pineapple land also compensated the decrease. Even total volume of pineapple cultivating area is now on the way to cross the earlier figure of 25/30 thousand hectares. So the saying— "Drops of waters make the ocean" came in reality by replenishing the vacuum of pineapple cultivating area.

After completion of the stage of my formal education, I returned back to residence at Bidhannagar in the year of 2001 AD. I was in search of engaging myself for earnings. My father Sri Dinesh Chandra Mandal already started tea plantations leaving pineapple. No more land was there to be utilized by me. I also had chosen the direction towards which Mr. Swapan Dey and his fellows were moving with success. I also managed to get some land on lease. I discussed on all about the tidbits of pineapples with some of my fellows already in the field of this cultivation. I started to realize my dream through such a medium to which I was accustomed passively since my childhood. The discussion with my fellows enriched me on all about the possibilities as well as limitations of the pineapple growing and marketing in its practical field. My goal was to proceed with advancement of pineapple cultivation and also attain a bright future for the pineapple growers.

I also had a discussion with the educated unemployed young friends of me like Narajit Sarkar, Ranjan Ghosh and Badal Sarkar. At the same time Sri Umesh Sarkar, Sri Shib Kumar Ghosh, Sri Gobinchan Mandal, Sri Krishanu Bhattacharchaya, Sri Bishu Sarkar, Sri Abinash Sarkar and Sri Narayan Chandra Paul expressed willingness to join us. With such an initiative we could constitute our North Bengal Pineapple Growers' Association (ACHAS> **A**naras **Ch**ashi **S**angathan) with formal registration from the Govt. of W.B. in the year of 2004 AD. The Association gained its strength with joining of Shrikanta Thakur, Md. Nazir Alam, Sri Bipul Sen, Sri Ramprosad Mandal, Md. Jalal and Md. Ainul Haque. The ACHAS started functioning with an Executive Committee consisting of 17 members democratically elected from among the general members. Out of the 17 E. C members— 1) Sri Umesh Sarkar- President, Sri Badal Sarkar- Vice-president, 3) Sri Arun Mandal- Secretary, 4) Sri Shib Kumar Ghosh- Joint Secretary, 5) Sri Ranjan Ghosh- Assistant Secretary 6) Sri Narajit Sarkar- Treasurer were elected to the respective portfolios. In addition to those, an advisory board was formed with Sri Abinash Sarkar, Shrikanta Thakur, Sri Narayan Chandra Paul and Sri Bishu Sarkar. Sri Abinash Sarkar was entrusted with the responsibility of the Honourable Chief Advisor.

A significant slogan for the Govt. of W.B. was raised by the then Honourable Chief Minister Mr. Buddhadeb Bhattacharya in the year of 2003— "We shall advance towards Industry basing on the strong foundation of Agriculture". The slogan favoured our goal in both way— our mission was also to establish pineapple cultivation on its strong footings and then to proceed towards pineapple-based Industry. A fruit processing unit named 'Dabar' was setup in Karotoa of Jalpaiguri. Setup of a big fruit processing unit 'Calypso' in Bidhannagar and setup of another unit 'Rainbow' in Kantivita, Phansidewa was possible with tireless initiative

of Sri Birendra Kumar Nandy a well known social worker in the District of Darjeeling. The 'Dabar' were purchasing pineapples @ Rs. 2.90 per Kg with crown and @ Rs. 4.65 per Kg without crown. The rate was irrespective of any weight limit. The 'Calypso' purchased fruits on piece basis matching with a detailed specification. The specification was as under:—

A) Dia: 130mm— 140mm & Length: 120mm & above equivalent to 1.75 kg; Rs. 8/- per Piece.
B) Dia: 110mm— 130mm & Length: 120mm & above equivalent to 1.50 kg; Rs. 6/- per Piece.
C) Dia: 90mm— 110mm: Rs. 2/- per Piece.
D) Dia: 75mm— 90mm: Re. 1/- per Piece.

The 'Calypso' authority notified that the supplying growers shall get Rs. 2/- per peace on delivery and remaining amount as per 'Bill' made by them shall be paid after 30 days from the date of delivery. Purchasing & production started.

I along with Sri Umesh Sarkar and Sri Badal Sarkar met with Honourable Minister-in-charge of Fruit processing Industries & Horticulture Department in the Govt. of W.B Mr. Shailen Sarkar. We submitted a charter of demand with 17 point demands seeking Government's assistance for advancement of pineapple cultivation and industry based on pineapples. During this period National Horticulture Mission (NHM) was started by the central government and it was implemented by the Dept. of Food Processing Industries and Horticulture, Govt. of West Bengal. State government realize the importance of location of Siliguri areas of Darjeeling and declared Darjeeling district as NHM focused district. Subsequently, office of Horticulture was created at Siliguri during 2006 and Mr. Nilesh Bhowmick was posted as first horticulture officer for this region. Several small and large farmers received subsidy for cultivation of pineapple during the tireless efforts of government official during this period. Honourable Minister gave a patient hearing to each of our demands. Thereafter the Honourable Minister started to take proper steps to setup 'Bidhannagar Pineapple development center'. We in cooperation of 'Bidhannagar pineapple merchants association', 'Bidhannagar merchants association', 'Bidhannagar Grampanchayat-1' and 'Bidhannagar Grampanchayat-2' identified a land in 'Bara paikepara' and 'Mandilajhar' of Bidhannagar for the project. We formally intimated of this to the Honourable Minister. The Honourable Minister along with the Principal Secretary of the department Mr. S.S. Ahuja came to visit the offered land soon after the intimation and talked to the growers. With this event our organization ACHAS spread with joining of the growers of Uttar Dinajpur, Jalpaiguri, Coochbihar and Malda.

We had a long pending desire to express our love and reverence to the world acclaimed Statesman Mr. Jyoti Basu. We were able to fulfill such long awaited desire on prior appointment. The 8th Jun 2005 was his 92nd Birthday and incidentally we missed it. So we had to meet him on 11th Jun 2005. We got a cordial reception and offered our reverence to him with a token of 92 pineapples following his 92nd Birthday. Then he was not in the Chair of Chief Minister and was in a free and cheerful mood. He passed 40 minute with a pleasant chat. Each and every word of the chat shall remain stored in our memory for the rest of our lives. It was a glorious meet for us seeking no other form of return.

The Bridge of Domohana near Dalkhola of the Uttar Dinajpur District was collapsed by the flood of 2006 AD. The loss to the pineapple trader was of Rs. 13 cores as estimated by the then Mr. P.T. Sherpa, SDO, Siliguri. But in the same year a Pineapple Festival was held for two days in the 'Vidyasagar Mancha' of Bidhannagar. That was a grand success with massive participation of pineapple growers from districts. Pineapple-products like 'Pastry', 'Morobba', 'Rasamalai', 'Rasagolla', 'Chatni' even 'Biriyani' got a great response from the visitors. The festival was inaugurated by the then Honourable Minister-in-charge of the department Mr. Mahanta Chatterjee. Many of the Govt. Officials came forward to reach our goal. We could avail keen cooperation of the department's Principal Secretary Mr. S. S. Ahuja, Mrs. Pritha Sarkar, Deputy Director of the department, Mr. Udayan Chakraborty, Joint Director of the department, Mrs. Nilan Mina IAS, Mr. Jagdish Prosad Mina IAS, Mr Godala

Kiran Kumar IAS, Goutam Roy, Coordinator, Agri Export Zone for Pineaples, Nilesh Bhowmick, Md Khursed Alam, District Horticulture officer, and so on. In this way we proceeded towards our goal and to achieve our mission to develop pineapple culture. During this time Mr. Nilesh Bhowmick resigned from his job and joined as Assistant Professor in Uttar Banga Krishi Viswavidyalaya at 2007.

We wrote to the then chief minister Mr. Buddhadeb Bhattachrya, on 28th September, 2008, narrating the anti-grower role of 'Calypso'. In the letter we criticized the Govt. for wrong selection of the beneficiary company allowing going with the project. Soon after that both of 'Calypso' and 'Dabar' gradually wound up their respective project.

We were invited to Malaysia for participation of our ACHAS in the 7th International pineapple Symposium in the year of 2010 AD. We wrote to the N.H.B, APEDA, fruit processing department in the Govt. of W.B. and to Siliguri-Jalpaiguri Development Authority seeking financial help to join the Symposium. None responded to help us. Ultimately, in spite of our financial stringency, we took part in the Symposium to know and learn the pineapple-culture at international level taking personal loan from our friends. The members of our team to Malaysia were— Sri Arun Mandal, Dr. C.P. Suresh, Dr. D. Mathew and Pratap Subba (researcher, UBKV). We had the opportunity to exchange of our views with 400 Delegates from 60 countries. We had the opportunity to visit the research centers and processing units. We astonishingly found manufacture of Chips, Chocolates, Body-lotion, Shampoo, Cream, and Cloths made out of fine threads as extract from pineapple leafs. We were impressed a much visiting an endless variety of pineapples like MD-2, MTS, T3, Nanas, Queen, Josapine, Smooth Cayenne and so on.

In the mean time, our earlier proposal seeking infrastructural support from the Govt. of W.B turned into reality— with a sincere initiative of the then Minister-in-charge of Municipal & Urban development, Govt. of W.B as well as the Chairman of SJDA, Mr. Ashok Narayan Bhattarya, extended an infrastructural support at the first phase— by constructing 96 no. of whole sell hub, a multipurpose cold storage having capacity of two thousand MT, an administrative building, truck parking space, pack house and necessary roadways with expenditure of 12 Cores (120 million) 67 Lakhs (126,700,000) of Rupees. Necessary space were also kept for a further infrastructural development by construction of Pineapple research center, Training center, processing unit and much more number of whole sell hub etc.

After that a new Government came in power under the leadership of Mrs. Mamata Banerjee by the verdict of people in May, 2011 AD, Dr. Rudranath Bhattarcharya, MLA- Siliguri, Chaired the office of the SJDA. We were able to make him to think over— how much he could contribute to our mission as a follow-up work of his predecessor. He made a Documentary with our activities and progress in this field. In accordance of our suggestion he took initiative to observe Pineapple Festival in the year of 2012 AD. It turned into an International Festival. He proposed to evolve the way of Pineapple-tourism. He handed over the Keys of Pineapple wholesale hub to the cultivators and traders of pineapple. In accordance with our proposal through N.H.B, he expressed his noble wish to send a team of representatives

of ACHAS to the motherland of pineapples Brazil. On other side, he planned to build up the proposed pineapple-research center to be in a position of National level research center. The SJDA prepared a DPR with the cooperation of Mr. Nilesh Bhowmick.

Our formal proposal to send us to Brazil was approved by the N.H.B. But that was turned down by the concerned authority in the Govt. of W.B. Dr. Rudranath Bhattarcharya, Mr. Kajal Ghosh and Sri Ranjan Shil Sharma tried at their level best to send us to Brazil but failed. In the mean time Dr. Rudranath Bhattarcharya was removed from his Chair.

Mr. Nilesh Bhowmick, Assistant Professor of Uttar Banga Krsihi Viswavidyalaya made contact with Dr. P. P. Joy of Kerala Agricultural University for a trip and subsequently we went to Vazhakulam in Kerala to join the pineapple festival in response to their cordial invitation. Our team members to Vazhakulam were Sri Arun mandal, Sri Rajib Purakayastha, Sri Anadi Singha and Mr. Sourabh Pradhan (researcher, UBKV). A National Meet was held there. The Meet resolved to constitute a Pineapple Board. This was resolved with a view to assemble all of the pineapple producers of India under a same umbrella. Its aim was to popularize Indian pineapples in World Market. That was opportunities for dreaming with proceed further in the field of pineapple culture. We did our best to mobilize Government agencies to promote pineapple in respect to its cultivation, pineapple oriented industrialization, foreign export of the products and byproducts. We were able to achieve a level of success. But our experience says— change in governance appears as hindrance against further steps to proceed. So I decided to go at my own avoiding callousness of red tapism. We returned back with full of new energy to do something more with pineapple cultivation. After our return-back we came to know that the verities like 'Haricharanvita' and 'Baruipur' were added variety made by the growers of Coochbihar and 24 Pargana districts. I brought suckers from Kerala with me, also imported suckers from Tripura and Thailand, started my very much efforts to proceed with pineapples commercially with consultation of Mr. Nilesh Bhowmick. I have started with Queen, Mauritius and later on with MD-2, MTS, T3, Amrutha and Nanas. We were able to achieve a level of success. For this inspiration, I take my daughter name '**AMRUTHA**'I faced a loss of about Rs. 2 lakhs 52 thousand (252,000), but I am happy with the outturn of different varieties at this first attempt in this current year. We believe that, we shall be able to create multi-colored diversity in pineapple like that of the Mangoes of Malda. We are determined to organize a green revolution with pineapples. The pineapples has suffered a loss of about Rs. 100 cores (1,000,000,000). In 2012 a devastating hailstorm damaged the Pineapple of about 225 hectares at Chopra Block of Uttar Dinajpur. In the 1st week of Jun 2013 the scorching heat of the Sun completely damaged 2 Cores 10 lacks (21,000,000) pineapples of Siliguri sub-division. But that will not restrain us to proceed. We have started a process to capture markets in England and in Arabian countries. For the 1st time in India we produced "PINEAPPLE HONEY" by rearing Honeybee at a Pineapple garden at Chowdhurygachh in Bidhan Nagar.

A team of researchers from the North Bengal Agricultural University collected samples of Mouritous, Kew and Queen varieties of pineapples from us to test their taste in respect of sugar content. They found total soluble solids for Mouritous, 12.69 for Kew, 15.20 and for Queen, 15.56. This test-result shows that the pineapples grown by us were much delicious in taste.

We will be ambitious to move with aspiration and to proceed with pineapple culture!

News from Taiwan

2015 International Symposium on GA3 Tropical Fruit

The Symposium Convener was Dr. Chung-Ruey Yen, Nat'l Pingtung University, Science and Technology, Dept. of Plant Industry, Neipu, Ping Tung 91207, Chinese Taipei. The Symposium was co-sponsored by ISHS and all publications produced from this symposium will appear in a volume of Acta Horticulturae.

The Symposium was held from 8 to 11 April, 2015 in Kaohsiung County, Taiwan, ROC.
Dr. Wen-Li, Lee

Special thanks to Dr. Wen-Li Lee, Head of Tropical Fruit Tree Dept., Taiwan Agricultural Research Institute and Prof. Chin-Ho Lin, National Chung Hsing University for making this information about the Sympsoium available to readers of Pineapple News.

Letter from convener

Welcome to Taiwan and enjoy your stay! An island nation located at the intersection of tropical and subtropical climate zones, Taiwan is well suited for tropical fruit production, which has accounted for 37% its overall agricultural production in the past decade.

Tropical fruits have been cultivated in Taiwan for 400 years, but have seen considerable growth in agriculture market share beginning in the 1950's. Significant improvements in Taiwan's tropical fruit breeding and management practices have also been transferred to China and a number of Southeast Asian countries. One outstanding example of technology transfer is "forcing culture for season regulation". Advanced orchard management techniques including bagging, fruit-thinning, pruning, and fertilizer application have also led to considerable improvements in fruit quality.

In pursuit of continuous improvements in tropical fruit agriculture, this symposium has been organized to home in on four main crops (GA3: guava, sugar apple, pine apple and wax apple), which are considered minor when compared with banana, mango and coconut palm. However, it is recognized that the success of many crops has been due to the prolonged dedication towards development in breeding and management techniques – and this process has involved the collaborative efforts of government, researchers and producers. To encourage excellence in fruit product development, at GA3 we hope to share past experiences and knowledge with all the participants in attendance, coming from each of their respective countries.

The GA3 initiative has involved hard work and coordination efforts of many actors, and thus I would like to convey my sincerest gratitude to the International Society for Horticultural Science and Taiwan Society for Horticultural Science. Without their assistance and support, we would not be able to conduct and prepare for the hosting of the symposium with such success. Furthermore, I would like to thank the sponsors, the Council of Agriculture, the Agricultural Research Institute and Fengshan Tropical Horticultural Experiment Station. I would also like to express my appreciation for the ongoing assistance of all the staff members, researchers and colleagues dedicated to fruit crops from various research stations at the Council of Agriculture. We trust that the GA3 Symposium will offer you the chance to experience the excellence of Taiwan's tropical fruit and that you will have a fruitful visit to the city of Kaohsiung. Please enjoy the experience which will be both personally and professionally memorable to you.

Chung-Ruey Yen, PhD

The complete Agenda and Program Overview is provided below as a convenience to readers, many of whom research or grow more than one of the crops represented in the Symposium. The abstracts of the papers on pineapple follow the Program section.

Program.
8 April: Visit Fengshan Branch, TARI, Guava and Sugar Apple Orchard
9 April: Visit National Pingtung University of Science and Technology, Pineapple and Wax Apple Orchard

10 April: Opening Ceremony; Scientific Program

0910: Keynote speech (R.A. Drew). International Society for Horticultural Science
The Global Horticulture Initiative, World Poverty and the Importance of Tropical Fruits

1020: Keynote speech (S.K. Mitra) Crop Regulation for Round-the-Year Harvesting of Guava

1100: Keynote speech (R.E. Paull) Production and Postharvest Handling of Low Acid Hybrid Pineapple

1140-1700 Oral Session 1:Genetics, Breeding and Biotechnology. S. Mitra, Moderator

1140: Invited speech (Wen-Li Lee) Recent Developments in the Variety Breeding and Cultivation Techniques of GA3 Fruit Crops in Taiwan

1330: Invited speech (G. Sanewski) The Australian Fresh Market Pineapple Breeding Program

1400 OS1-01: Field evaluation of micropropagated pineapple (*Ananas comosus*) plants. R. A. Drew and J. Moisander Presenter: Roderick A. Drew

1415 OS1-02: The draft genome of pineapple (*Ananas comosus* L.). R. Ming*, R. VanBuren, C. M. Wai, J. Zhang, H. Tang, M. C. Schatz, R. Guyot, R. E. Paull, and Q. Yu.

1430 OS1-03: Anatomical studies on Myrtaceae roots. A. Tuladhar* and N. Nii.

1445 OS1-04 : 'Jen-Ju Bar' Guava exhibited a non-climacteric ripening behavior resulting from a defect in the expression of system II ACC Synthase PgACS1. K. E. Chen, T. C. Liu, Y. C. Liu, and C. T. Wu*.

1500 OS1-05: Triploid breeding in guava – An implication from a triploid guava line. Y. K. Chen*, T. C. Shen, L. F. O. Chen, and M. C. Chung.

1545 Invited speech (C-C. Huang) Innovation of wax apple industry in Taiwan

1615 OS1-06: Ethnobotanical study of guava in Taiwanese aboriginal people. H-F. Yen*

1630 OS1-07: Characteristics evaluation of transgenic delay-flowering pineapple (*Ananas comosus* L. Merr.) Y.K. Tu*, H.W.,Chen and M.T. Wu.

1645 OS1-08: Selection inspiring way of innovation in tropical fruits. A Case in guava. M. Gaikwad*.

1700-1800: Oral Session 2: Biotic and abiotic stresses and protected cultivation. Chair: R.E. Paull.

1730 OS2-01: Effects of net house culture on the plant growth and fruit development of 'Jen-Ju-Bar' guava (*Psidium guajava* cv. 'Jen-Ju'). C H. Wu*, J. J. Xu, I. C. Tsai, W. P. Yeh, and H. L. Lin.

1745 OS2-02: The influence of the population dynamics of spider mites on *Annona* spp. under pesticides stress. S. J Tsai* and Y. T. Hsu.

11 April: Scientific Program; Farewell Dinner

0830-1220: Oral Session 3: Physiology and cultural practices. Chair:. G. Sanewski

0830: Invited speech (N.V. Hoa) Review on guava, wax apple, pineapple research and production in Vietnam

0900 OS3-01: Effect of brassinosteroids and NAA on fruit quality of pineapple (*Ananas comosus* (L.) Merr. cv. Pattawia) J. Chumpookam*, T. Aumkhruea, and S. Teankum.

0915 OS3-02: Effect of uv-c radiation on the quality and antioxidant capacity of fresh cut 'Phulae' pineapple. T. Maithong, A. Safitri, and S. Setha*.

0930 OS3-03: Effects of pruning and defoliating timing on the harvesting time, yield and quality of custard apple cv. African Pride. J. Pan*, G.Huang, F. Li, and X. He.

0945 OS3-04: Effect of low temperature on flowering and fruit development of 'Tainung No.17' pineapple. I. P. Julius*, H-H. Tseng, and H-L. Lin.

1000 OS3-05: Using chlorophyll fluorescence to detect and evaluate heat stress tolerance in guava (*Psidium guajava* L.) Y. C. Chen*, M. C. Ho, Y. C. Wang, and H. L. Lin.

1035: Invited speech (C. Thanarut)

1105 OS3-06: Techniques for year-round organic production of wax apple under structure. J. C. Shih*, J. Z. Yu, S. P. Chen, H. D. Shih, and T. F. Hsieh.

1120 OS3-07: Restoration of Soil Fertility and plant growth for flooded *Annona squamosa* orchard. C.C. Chang*, C. Y Liao, W. Y. Huang, P. S. Lu, and C. H. Wang.

1135 OS3-08: A Year-round Production Strategy for the wax apple industry in Taiwan. S. J. Chen*, Z.H. Shu, K.T. Li, D.M. Yeh. Presenter: Szu-Ju Chen

1150 OS3-09: The temperature growth models of guava (*Psidium guajava* L.). P. A. Chen,*, M. Y. Huang, S. Y. Lin, S. F. Roan, and I. Z. Chen.

1205 OS3-10: Cultivation technique for improving pineapple production in Mekong Delta Region. N. Trinh N. Hang* and N.M. Chau.
1330-1630: Oral Session 4: Postharvest handling and processing. Chair: N.V. Hoa.
1330 Invited speech (S. Yuliati). The tropical fruits production in Indonesia: Development and management of guava, wax apple, sugar apple and pineapple.
1400 OS4-01: Effect of acidic electrolyzed water combined with packaging on quality and storage life of fresh-cut 'Phulae' pineapple. J. Raiputta, S. Setha, K. Wangchai, and P. Suthiluk*.
1415 OS4-02: Effect of bagging colour on fruit quality of 'Thabthimchan' wax apple (*Syzygium samarangense* (Blume) Merr.& Perry). N. Mothina and C. Yapwattanaphun*.
1430 OS4-03: Fruit quality and C/N ratio in sugar apples (*Annona squamosa* L.) under dehydration condition. L. Kowitcharoen*, C. Wongs-Aree, S. Setha, R. Komkhuntod, V. Srilaong, and S. Kondo.
1445 OS4-04: Design and development of a motorized pineapple juice extractor. J. R. C. Dizon*, G. S. Robles, RA Lomeda Dizon, J. E. Lacayanga, E. L. Atienza, D. M. Ruba, D. T. Alba, J. H. Banzon, W. L. Barata, R. R. B. Dela Rosa, C. A. B. Gomez, and B. M. Cunanan.
1530 OS4-05: Effects of different bagging materials on the quality of in-season fruits of custard apple cv. African Pride. G. Huang*, J. Pan, X. He, and F. Li.
1545 OS4-06: Effects of withering and extraction methods on the content of phenolic compounds extracted from guava succulent shoots Y. H. Hung*, S. F. Roan, and I. Z. Chen.
1600 OS4-07: Bagging management and breeding strategy for red sugar apple (*Annona squamosa* L.) H. H. Fang* and Y. S. Liang
1615 OS4-08: Evaluation of oil components of *Annona Squamosa* (Gishta) seeds and antioxidant activity of Their methanolic extracts. S. Elkheir* .
*Indicates presenter.

GA3 Tropical Fruit Abstracts of Presentations on Pineapple

The Australian Fresh Market Pineapple Breeding Program

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Abstract
The Australian fresh market pineapple breeding program commenced in 1991 with the objective of developing clones more suited to fresh consumption than the industry standard clone, Smooth Cayenne. Parent combinations initially included Smooth Cayenne, Queen and the Hawaiian Pineapple Research Institute (PRI) clones 53-116 and 59-656. The Hawaiian fresh market clone 73-50 was first used as a parent on a small scale in 1992 but due to its superior qualities it eventually became the predominant parent. The Hawaiian clone 71-92 was included in 1993 and eventually also became a frequent parent. These early crosses developed approximately 60,000 seedlings from which the 2 varieties Aus-Jubilee and Aus-Festival have been commercialised. Plant Breeders' Rights are used to protect intellectual property. A second program which commenced in 2010 has utilised selections from the first program as parents to produce a segregating population of 20,000 seedlings. This second program includes many half-sib and backcross combinations to concentrate the frequency of desirable genes quicker. Current breeding objectives include sweet, low acid and low fibre, aromatic eating qualities with a low susceptibility to translucency and internal fruit disorders. A good level of resistance to Phytophthora root rot and natural flower initiation is also sought.

Production and Postharvest Handling of Low Acid Hybrid Pineapple

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Abstract
The development of pineapple cultivars more suited for fresh fruit consumption has led to new hybrids that have been widely introduced in Hawaii, Australia, Malaysia and Taiwan. These low acid types have become the preferred types and have expanded rapidly to supply the fresh fruit markets of the USA, Japan and Europe. The newer cultivars present new challenges for producers trying to ensure consistent production and quality. In Hawaii, natural flowering, translucency and too low acid levels are quality issues all tied to production practices. Production practices and experience gained over decades with the older canning types does not always readily apply to these low acid hybrids. Postharvest chilling injury appears to be less of a problem in these hybrids, though shell scuffing is an issue with some clones. Natural flowering increases harvest costs and production losses, and disrupt the marketing of a consistent supply of high quality fruit. This event is a serious problem for the new low acid hybrids. The problem is more severe in regions with a cool season having temperatures below 20℃ and shorter daylengths. Aviglycine (Retain©), an ethylene biosynthesis inhibitor, and methylcyclopropene (1-MCP), an ethylene receptor inhibitor, can control natural flowering. However, both are very costly and further studies are needed to reduce costs while maintaining efficacy. Alternatively, plants have been genetically engineered to be less sensitive to natural flowering conditions. All approaches have been tried in Hawaii. Fruit with flesh translucency increases the fruit's susceptibility to mechanical injury, fermentation and nonpathogenic fungal growth on the broken peduncle, all are of concern with packers, marketers and consumers. Translucency is possibly due to high photosynthate levels in the fruit during the later part of fruit growth. Other possible factors include insufficient calcium uptake during early fruit growth and higher fruit temperatures in the field. Another issue in the inconsistency in fruit quality throughout the year due to variation in the sugar to acid balance, the major fruit flavor component. In the warm season, Hawaii's fruit have high sugars and too low acids. A more desirable balance of acids and sugars occurs in the cool season. The low acid hybrids accumulate high levels of titratable acidity during fruit growth. This acidity peaks at a higher level than in the older canning varieties and declines rapidly as the fruit approach maturity and ripens. Field management, such as fertilization, irrigation practices and harvest scheduling developed for the canning varieties may not be the most appropriate for the production of low acid hybrids' fresh fruit. This difference in varietal responses highlights the need for new field and handling approaches to meet the consumer desire for a consistent supply of high quality fruit.

Characteristics evaluation of transgenic delay-flowering pineapple (*Ananas comosus* L. Merr.)

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Abstract
Pineapple (Ananas comosus) is an important economic crop in Taiwan; however, shortening day length and low temperature in winter can promote endogenous ethylene production which leads to flower naturally. A key enzyme involving in ethylene biosynthesis, 1-aminocyclopropane 1-carboxylate deaminase deaminase (ACCD), was cloned and introduced into popular pineapple cultivar 'Tainung 17' through particle bombardment method. Materials of the transgenic pineapple were kindly provided by Prof. Chin-Ho Lin of National Chung Hsing University. Two copies of ACCD transgene were detected in the transgenic 'Tainung 17' genome by Southern blot analysis. In vitro seedling wound assay showed that ethylene production by the ACCD transgenic line was significantly lower than non-transgenic 'Tainung 17' for the first week. Furthermore, significantly lower ethylene concentrations were detected both in vegetative and in reproductive periods of ACCD transgenic line when compared with 'Tainung 17'. Flowering characteristics of ACCD transgenic line was investigated in-field of central Taiwan for two years. Flowering time records revealed obviously delay-flowering characteristics for ACCD pineapple compared with Tainung 17. The present study demonstrates that introducing a foreign gene, ACCD, into pineapple apparently altered the flowering nature.

Field Evaluation of Micropropagated Pineapple (*Ananas comosus*) Plants

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Abstract
Pineapple (*Ananas comosus*) is a major tropical fruit crop that is consumed as a fresh fruit and used for processing. Pineapples are prone to production of genetic off-types, and the process of micropropagation has been known to exacerbate this problem in other species. A field planting of both in vitro micropropagated pineapple plants and conventionally propagated plants was studied to assess genetic stability. Pineapple plants were produced via micropropagation from bud explants from both slips and crowns of smooth leafed cayenne pineapples. Micropropagated plants from these two sources were compared to conventional slips and crowns in the field trial. The planting was in a randomized block design. Each of the 7 blocks contained 8 plots (2 plots of each of the 4 planting materials) of size 10 m and 2 m. Each plot contained 20 plants in double rows on a raised bed. Plants were evaluated in terms of days from planting to harvest, number of tops, percent plants with spiny leaves, fruit shape, fruit weight, fruit diameter, fruit length, fruit core diameter at top and base of fruit, top weight, percent of fan shaped tops and number of suckers and slips. The ratoon crop was evaluated to determine any traits that were carried through to the next generation. The effects of tissue culture propagation on production of off-types (spiny leaves and fan shaped tops) were assessed. Results including main effects and correlations will be presented for the above data sets and implications for in vitro culture will be discussed.

The Draft Genome of Pineapple (*Ananas comosus* L.)

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Abstract
Pineapple is the third most cultivated tropical fruit in the world behind banana and citrus. The available genetic and genomic resources and a large collection of pineapple germplasm make pineapple an excellent model for studying obligate CAM photosynthesis and it serves as an important outgroup for comparative genomics in the well-studied panicoid grasses. The pineapple genome was sequenced using an integrative whole genome shotgun and BAC based approach using Illumina, 454, Moleculo, and PacBio sequencing technologies. The draft genome has a contig N50 of 131 kb and a scaffold N50 of 644 kb, and covers about 382 Mb of the estimated 525 Mb genome. The pineapple draft genome contains 43% repetitive sequences, and was annotated to have 24,515 genes using Maker and RNAseq data. We identified genes in the CAM pathway based on homology to C4/C3 orthologs in maize, sorghum, and rice, and discovered that the pineapple genome contains fewer CAM/C4 pathway and photosynthesis genes than other monocot genomes. The pineapple genome serves as a framework for dissecting the gene network and regulation of CAM pathway.

Effect of Brassinosteroids and NAA on Fruit Quality of Pineapple [*Ananas comosus* (L.) Merr. cv. Pattawia]

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Abstract
A study was conducted in 17 inches-black plastic pots, at Department of Horticulture, Faculty of Agriculture, Kasetsart University, Thailand during December 2013 to June 2014. The objective of the study was to determine an effect of brassinosteroids (BAs) and 1-Naphthaleneacetic acid (NAA) on fruit quality of pineapple [Ananas comosus (L.) Merr.] cv. Pattawia. Experiment was completely randomized design (CRD) by 4 treatments, 1) 200 mg L^{-1} BAs, 2) 200 mg L^{-1} NAA, 3) 200 mg L^{-1} BAs + 200 mg L^{-1} NAA, and 4) control as water spray in four replications. Pineapple plants were sprayed with treatments at days 14 and 21 respectively after flowering. Results showed that the combination of 200 mg L^{-1} BAs + 200 mg L^{-1} NAA applied to pineapple plant gave the highest crown weight (376.80 g), fruit weight (1.22 kg), fruit diameter (10.82 cm), fruit length (13 cm), peel thickness (5.55 mm), TSS (12.93 °Brix), and TSS/TA (13.62), respectively. Moreover, the maximum of crown width (33.41 cm), stalk length (35.50 cm), and fruit firmness (33.12 N), respectively, were obtained with 200 mg L^{-1} NAA. Whereas, the crown length, stalk width, core size, pH, and %TA were not significant difference. This result suggests that the application of 200 mg L^{-1} BAs + 200 mg L^{-1} NAA can be useful to improve the quality of 'Pattawia' pineapple fruit.

Effect of UV-C Radiation on the Quality and Antioxidant Capacity of Fresh Cut 'Phulae' Pineapple

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Abstract
The effect of ultraviolet (UV-C) on quality and antioxidant capacity of fresh cut 'Phulae' pineapple (Ananas comosus L. Merr) was investigated. The fresh cut pineapple was exposed to UV-C for 60, 90 or 120 seconds. After exposure they were placed in plastic trays, packed in polypropylene (PP) bags and stored at 5℃ for up to 14 days. Microbial counts and the changes of the fruit color, titratable acidity (TA), total soluble solids (TSS), vitamin C, total phenolic content (TPC), antioxidant activities measured by 2, 2-diphenyl-1-picrylhydrazyl (DPPH), and ferric reducing antioxidant power (FRAP) assays were observed during storage. UV-C radiations for 120 seconds significantly reduced microbial population and maintained higher antioxidant capacity than the other treatments by DPPH and FRAP assays. However, there was no statistically significant difference among treatments in TPC and vitamin C content. The changes in color, TSS and TA in fresh cut pineapple were also not significantly different among treatments. UV-C treatment prolonged the shelf-life of fresh-cut pineapple which associated to better flavour and overall appearance if compared with untreated ones. UV-C treatment was demonstrated to be a high potential novel technology to maintain the quality and antioxidant capacity of fresh cut pineapple.

Effect of Low Temperature on Flowering and Fruit Development of 'Tainung No.17' Pineapple

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Abstract
Calcium carbide is a chemical that is widely used to force flowering in pineapple. However, its effect on flower forcing was unstable in the winter season. Therefore, the purpose of this research was to find out the chilling sensitive stage of flower development after flower forcing in pineapple cultivar 'Tainung No.17' by applying artificial cold treatment (12℃ 8 h / 3℃ 16 h for 3-5 days). The results showed that cold treatment at 6, 12, 17, or 22 days after flower forcing resulted in low flowering rate, malformation on fruit and its crown, low starch content, titratable acidity and total soluble sugar. On the other hand, plants received cold treatment at the 33rd day and the 50th day after flower forcing showed no significant difference with control in terms of fruit shape and its crown, starch content, titratable acidity and total soluble sugar. The overall results of this study indicated that chilling sensitive stage was within 22 days after flower forcing and cold treatments during this stage caused low flowering rate and poor fruit development and qualities.

Cultivation Technique for Improving Pineapple Production in Mekong Delta Region

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Abstract
Pineapple is an important tropical fruit of Vietnam as it has a high local demand and potential for the export markets as processed products. In Vietnam, the cultivation of pineapple has been a commercial practice for many years with a total area of about 47,400 ha and production of 472,900 Mg (ton). The 'Queen' pineapple has been cultivated for long time in the acid sulfate soils of Mekong Delta where the area and production are approximately of 22,400 ha and 261,320 Mg, respectively. Four promising 'Queen' clones CDD-11.55.01, CDD-12.55.02, CDD-33.55.03, and CDD-27.55.04 were selected by the Southern Fruit Research Institute (SOFRI) that were developed through clonal selection for higher vigor and yield in the acid sulfate soils of the Mekong Delta. The traditional yield of pineapple is about 30 Mg ha-1. However, application of new cultivation techniques such as high density planting (50.000-60.000 plant ha-1), balance of fertilizer, and uniform induction flowering, etc., the yield has increased 15-20% when compared to the control. Application of the VietGAP standard by a group of small household farms has successful earned a VietGAP certification.

Design and Development of a Motorized Pineapple Juice Extractor

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Abstract
Long-term dietary supplementation with fresh pineapple juice has been reported to decrease the incidence of inflammatory-associated diseases and reduce pain and swelling in acute soft tissue injuries due to the high concentration of enzyme known as bromelain. Commercially available pineapple juice is processed with intensive pasteurization or with minimal heat treatment that degrades the quality of active bromelain and other enzymes found in pineapple juice. In the Philippines and in most parts of the world, pineapple juice in the fresh form has not been commercially available for consumption. In this study, the researchers aim to design and fabricate a small scale motorized pineapple juice extractor that would be convenient for small-medium scale food establishments. The small scale motorized pineapple juice extractor was designed and fabricated using locally-available construction materials. The extractor provides a mechanism for peeling, slicing, chopping, coring, crushing, and extracting pineapple juice. The components of the machine include: a set-of blades for peeling, chopping and coring; a rotating blade inside the hopper for crushing; and a screw press for extracting and separating the juice from the pulp. Other essential parts include a pulley and belt assembly, main frame, juice outlet and pulp chute. The developed pineapple juice extractor is simple and can be easily operated by low-skilled operators. The extractor uses a 1.5 hp motor, and the machine has a capacity of 12 pineapples per hour. The average efficiency of the machine is 81%. While the initial cost of the machine is near 600 USD.

A New Variety of Pineapple (*Ananas comosus* (L.) Merr.) 'Tainung No.22 (Honey Fragrance)'

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Abstract
'Tainung No.22 (TNG22)', also known as 'Honey Fragrance', was a newly released pineapple cultivar by the Chiayi Agricultural Experiment Station, Taiwan Agricultural Research Institute on February 2012. The fruit of TNG22 is large in size (1.76 kg on average) with cylindrical shape, yellow flesh, and orange-red peel at ripe stage. The texture of pulp is medium, close, juicy, yellow to golden-yellow colour, and intermediate acidity with

high sugar content (1.76ºBrix on average). This cultivar is free from the problems of stem-end splitting, pineapple core rupture, and cracking peel. Fruit can be harvested from May through October annually.

Production of Pineapple Mealybug Wilt-associated Virus-free Young Plants by Crown Tip Culture and In Vitro Chemotherapy

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Abstract
Pineapple mealybug wilt-associated virus (PMWaV) is one of the most destructive diseases of pineapple in Taiwan and decreases plant growth vigor and the quality of fruit. Currently ‘Tainung No.16’, ‘Tainung No.17’ and ‘Tainung No.20’ 21’ ’are the most prevailing cultivars, accounting for more than 90% of pineapples planted. With these plants as the experimental materials, this study used crown tip culture (＜2.0 mm length) plus chemotherapy technique to obtain virus-free young plants and to compare the virus elimination rates by using two chemical treatments, ribavirin (RBV) and 5-Azacytidine (AZA). The effectiveness of virus detection by enzyme-linked immunosorbent assay (ELISA) and real-time polymerase chain reaction (RT-PCR) assay was evaluated. Results of the chemotherapy undertaken with RBV or AZA showed that RBV(60 mg L^{-1}) had the highest rates of virus eradication, obtained 63.5, 65.4, and 57.5% virus-free young plants in ‘Tainung No.16, ‘Tainung No.17’, and ‘Tainung No.21’, respectively. Accordingly, it indicated that combination of crown tip meristem culture and chemotherapy could effectively eliminate the virus and be further developed a fast and efficient micropropagation technique for virus-free mother stocks of these three pineapple cultivars.

Molecular Detection of Pineapple Mealybug Wilt-associated Virus-1”

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Abstract
The Pineapple mealybug wilt-associated virus-1 (PMWaV-1) is a major causative agent for pineapple disease. In spite of there being an improvement in PMWaVs detection, antibodies-based techniques showed limitations mostly concerned with sensitivity of assay and time-consuming for the development of high quality monoclonal antibodies. A real-time, one-step reverse transcription (RT) polymerase chain reaction (PCR) assay was developed for the detection of PMWaV-1 in combination with a plant mRNA specific internal control derived from mitochondrial NADH dehydrogenase gene, which can be used as an indicator of the effectiveness of the extraction and real-time RT-PCR. The specificity results revealed that the real-time RT-PCR with designed PMWaV-1 primer set and probe, which targets at heat shock protein 70 homolog (hsp70h), showed high specificity and was capable of distinguishing PMWaV-1 from PMWaV-2 or PMWaV-3, the two virus species in infected pineapple plants. This allows co-amplification of hsp70h and internal quality marker and co-detection of TAMRA or FAM labeled probes, respectively. In addition, the sensitivity was enhanced by 100-1000 fold compared to conventional one-step RT-PCR when using PMWaV-1 transcript RNA as reference samples. This real-time RT-PCR assay is rapid, specific, and highly sensitive, and can be used for PMWaV-1 surveillance as well as diagnosis.

News from the USA (Hawaii)

The role of Pineapple Mealybug Wilt Associated Viruses Encoded RNA Silencing Suppressors in the Etiology of Mealybug Wilt of Pineapple

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Among the many viral diseases of economic importance, mealybug wilt of pineapple (MWP) is one of the most complex viral diseases of plants for which the etiology is still not completely understood (Gambley et al., 2008). To help prevent the mealybug wilt disease completely, an in-depth knowledge of the virus infection cycle, the virus distribution, vector transmissibility and other aspects of the disease are required. One important piece of knowledge to be gained is to characterize the viruses at the molecular level. Knowing the functions of various gene products of the viruses is important in the management of the disease. Until now, most of the research has been focused on epidemiology and the development of detection techniques (Dey et al., 2012). However, the recent completion of genome sequencing of Pineapple Mealybug Wilt associated viruses (PMWaV-1, -2, and -3); (Melzer et al., 2001; Melzer et al., 2008; Sether et al., 2009) provides an excellent platform from which to understand the disease etiology at a molecular level, and will enable sound management practices to be devised.

In recent years, RNA silencing in plants has been intensively studied and been shown to be the major anti-viral-defense mechanism in plants (Baulcombe, 2004). The simultaneous discovery that viruses employ RNA silencing suppressors as a counter defense strategy to overcome host defense mechanisms has advanced our understanding of the host-pathogen interaction. Members of the family *Closteroviridae*, to which PMWaV belongs, have large genomes. A characteristic of these viruses is that their infection cycles are relatively long (Dolja, Kreuze, and Valkonen, 2006). Because of their relatively slow replication, these large genomes must employ some multi-component and/or multi-level counter-defense mechanisms to protect them from attack by host RNA-silencing machinery (Dolja et al., 2006). One such strategy is the early synthesis of sub genomic RNAs that encode RNA-silencing suppressors to counteract host RNA silencing (Dolja et al., 2006). Studying viral suppressor proteins has not only revealed the intricate defense pathways involved in viral host pathogen integrations, but also the involvement of other components of host gene regulations. Although research on the molecular aspects of PMWaVs is lagging far behind similar research on other plant diseases, the recent demonstration that PMWaV-2 and PMWaV-1 produce multiple suppressors of RNA silencing (Dey, 2014) sheds new light on this complex disease and offers possible explanation of molecular mechanism of the virus-host interaction.

Post transcriptional gene silencing (PTGS)

Post Transcriptional Gene Silencing (PTGS) describes an RNA-based eukaryotic (higher plant) defense system that was first recognized as an antiviral defense mechanism in plants (Meister and Tuschl, 2004; Ratcliff, Harrison, and Baulcombe, 1997; Vance and Vaucheret, 2001). The discovery was in fact a spin off from various studies on either viral transgene expression in plants or from observations of plants gaining immunity to the same virus in a subsequent infection. It was first noticed in *Petunia* while experimenting to produce dark purple color in flower petals, but instead produced colorless flowers (Jorgensen et al., 1996; Napoli, Lemieux, and Jorgensen, 1990; Van der Krol et al., 1990). The underlying molecular mechanism of RNA silencing was implicated much later on. The earliest observation by S.A Wingard in 1928 (Wingard, 1928) that the upper leaves of tobacco plants infected with *Tobacco ring spot virus* became resistant to successive infection with the same virus was actually RNA silencing was not known during that time. Later it was found that plant immunity to one or more viruses could be produced when viral genes incorporating snippets of genetic sequences from those viruses were used as transgenes. As a result plants acquired immunity against the same virus or related viruses (Baulcombe and English, 1996). This phenomenon was attributed to the mechanism of post-transcriptional gene silencing (PTGS) (Baulcombe and English, 1996).This form of resistance in which the plant's ability to target specific introduced genes was exploited for making plants resistant to many plant viruses is known as pathogen-derived resistance (PDR) (Ratcliff et al., 1997;Vance and Vaucheret, 2001).

RNA silencing operates in two major ways in surpressing viral infections. The first is to limit the virus in the locally infected cells, also known as local silencing. The second is to cause the RNA silencing to spread to distant tissues of the plant to prevent spread of the virus, also known as systemic silencing (Kalantidis et al., 2008). In a virus-plant interaction, systemic silencing is the basic mechanism a plant employs in its fight against viruses. The initial idea that systemic silencing is in fact the major form of RNA silencing came from two observations. The first is the recovery phenomenon exhibited by plants. In many viral diseases, including MWP, the newer leaves from the diseased plants become asymptomatic and free of virus accumulations (Hu and Sether, 1999). It is now well established that such recovery is via systemic silencing (Ratcliff et al., 1997).The second idea stemmed from observations that infection by a single virus caused mild disease while the presence of other viruses in the systemically infected leaves of the same plants often caused severe disease. Such viral synergism is the result of silencing suppression by one virus to the advantage of the second virus (Anandalakshmi et al., 1998), which often results in increased symptom severity and higher accumulations of the viruses in doubly infected leaves (Bance, 1991; Pruss et al., 1997; Rochow and Ross, 1955). The observation of increased symptom severity as a result of insertion of two encoded proteins from PMWaV-2 into Potato virus X (PVX) and causing infection in an experimental non-host, *Nicotina benthamiana* (Dey et al., 2015*)* indicates that similar mechanism might be in operation in the host pineapple plant.

Suppression of PTGS

After their entry into the plant cell most viruses encode suppressor proteins to counteract PTGS (Ding and Voinnet, 2007; Voinnet, Pinto, and Baulcombe, 1999). After the initial establishment in the infected cells, a virus moves to adjacent cells and from there through the vasculature to distant tissues and organs. In response, the host plant initiates a mobile silencing signal against the virus, which moves in the same route the virus takes (Voinnet and Baulcombe, 1997). As a counter-defence strategy the virus encodes suppressors that block the systemic silencing signal. In fact, of the two forms of RNA silencing, many viruses encodes the systemic silencing suppressors (e.g., Qu and Morris, 2005; and (Dey(2014) and Dey et al.(2015)showed that PMWaVs encodes multiple systemic suppressor proteins.

Role of RNA silencing suppressors in the etiology of Mealybug wilt of Pineapple (MWP)

Mealybug wilt of pineapple is arguably the most important viral disease of pineapple. The complex etiology of the disease involving virus, mealybugs and ants has severely hampered advances in research on the disease. In general, research with members of *Ampelovirus* lags far behind that of the viral members of genera *Closterovirus* and *Crinivirus*, family Closteroviruses, in terms of their molecular biology, replication strategies, virus assembly, gene expression, movement of virus and identification of different RNA silencing suppressors (Chiba et al., 2006; Gowda et al., 2000; Lu et al., 2004; Satyanarayana et al., 1999).

In Hawaii, PMWaV-2 infection, together with mealybug feeding is consistently associated with the disease symptoms and neither factor alone can cause the symptoms, whereas infections by PMWaV-1 or -3 alone, with or without mealybug feeding, do not contribute to disease (Sether and Hu, 2002). PMWaV-2 has a larger genome than PMWaV-1 or -3 and is genetically very different from either PMWaV-1 or -3 (Figure 1). These genetic differences include several open reading frames (ORFs) at the 3'-end of the PMWaV-2 RNA that have no homology to other viral proteins of the *Ampeloviruses*. This suggests that these ORFs encode proteins, which might be involved in either suppression of RNA silencing, or pathogenicity, or both. The availability of the complete sequence of PMWaV-1 and the nearly complete sequence of PMWaV-2 allowed further molecular comparisons of both viruses for such suppressors of RNA silencing. The comparative and systemic analyses for suppressors of RNA silencing in the genome of PMWaV-2, enabled us recently to identify two weak local suppressors, CP and p20, and the proteins CPd, CP, p22 and p20, which have systemic suppressor function. Further analyses of the local suppressors have identified p20 and p22 of PMWaV-2 to be determinants of pathogenicity factors or virulence factors. PMWaV-1 encodes only one protein, p61, with systemic silencing suppressor activity (Dey, 2014) (Figure 1). Many other viral encoded proteins that were initially identified as determinants of pathogenicity or virulence factors were identified later as suppressors of RNA silencing (Brigneti et al., 1998; Cui et al., 2005)

The fact that PMWaV-2 is involved in MWP symptom induction, but not PMWaV-1, in the etiology of MWP (Sether and Hu, 2002) might be due to the local suppressor and pathogenicity factors identified in PMWaV-2 that are absent in PMWaV-1. The different silencing suppressors present in the genomes of PMWaV-2 and PMWaV-1 might also explain how viruses of perennial crops such as pineapple are susceptible to persistent viral infections that are not lethal to the host, whereas many viruses that encode strong suppressors and infect herbaceous hosts are often lethal. The absence of any local suppressor activity in PMWaV-1, which only encodes a single protein with systemic suppressor activity, further supports our hypothesis that viruses encoding only weak systemic silencing suppressors might be favored in persistent infections that do not lead to plant disease.

The identification of suppressors of RNA silencing in the genomes of PMWaV-1 and PMWaV-2 have contributed new knowledge that could be further explored to gain deeper insights into the role of viral gene products in mealybug wilt of pineapple. One promising technique, which enables the direct testing of the role of viral gene products in the host, is by creating an artificial clone of the virus, also known as infectious clone. By systematically knocking out targeted viral genes would make it possible to reveal their functions in the host plant. To confirm the involvements of the identified suppressors and pathogenicity factors in MWP, development of an infectious clone of PMWaV has been initiated (Dey, 2014; Kishore et al., 2015). This research might eventually pin point the role of PMWaV in the complex etiology of MWP

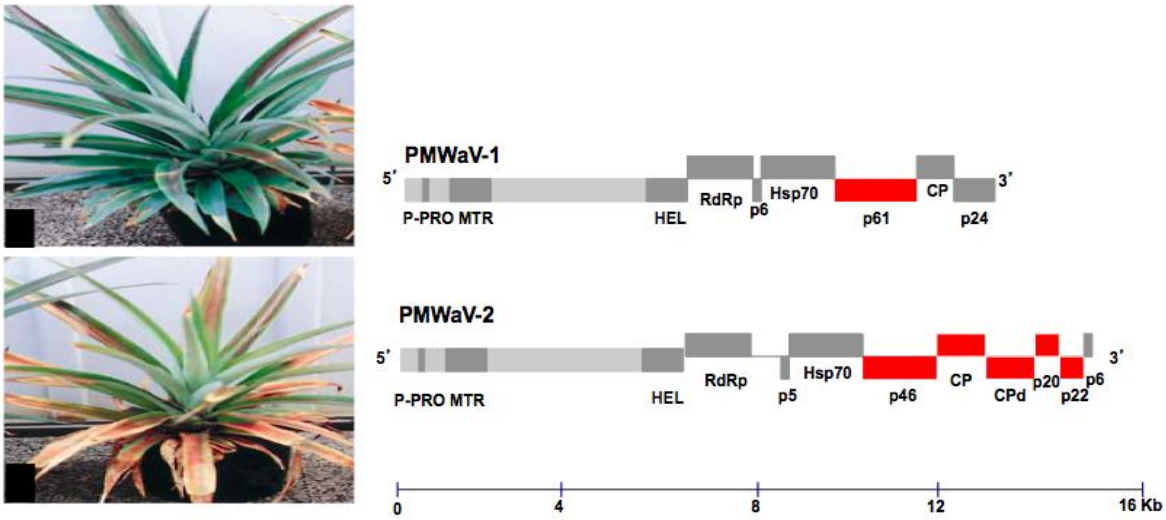

Figure 2: The genome organization of PMWaV-1 and PMWaV-2.

Top, a symptomless pineapple plant infected by PMWaV-1 and it's associated genome organization. Below a symptomatic pineapple plant infected by PMWaV-2 exhibiting typical wilting symptoms and its genome organizations. In the genome organization, boxes represent open reading frames (ORFs) while homologous genes or domains are shown with the same pattern for both viruses. Red boxes represent ORFs that were identified as PTGS suppressors.

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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 obtaine 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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Readers of Pineapple News are invited to contribute articles to this newsletter. The scope of contributions includes:

- Timely news about research on issues related to culture, processing, storage, and marketing of pineapple.
- New, interesting, or unique problems encountered by growers.
- Country or status reports on the local pineapple industry.
- For articles not included in the above, please contact the editor.

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Tables and graphs: Submit tables in Word format or as spreadsheet files. When submitting graphs, provide the original file or submit as a graphics file (jpg, png or other format).

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