Conclusion

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

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Forcing in Pineapples: What is New ?

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Introduction

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

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

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

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

Material and Methods

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

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

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

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

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

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

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

Results

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

The two key points of the system are:

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

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

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

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

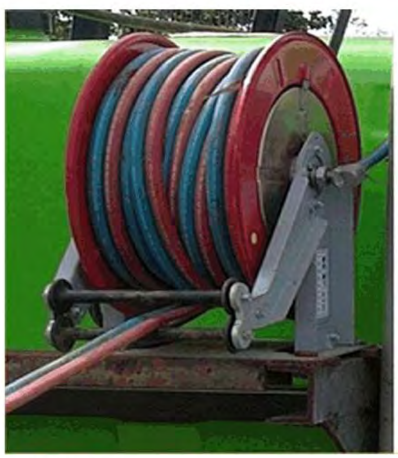

Figure 2 (left). Reel with double hose.
Figure 3 (right). Ethylene injector (Air Liquide).

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

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

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

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

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

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

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

Discussion

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

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

Conclusion

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

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

Acknowledgements

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News From Indonesia

Pineapple Root Health Problem in Indonesia

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

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

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

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