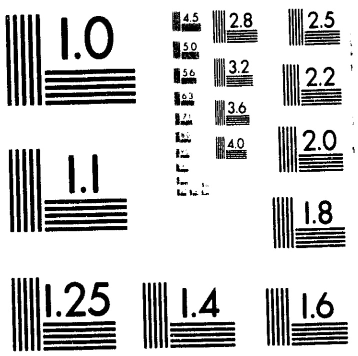
1.0
1.1
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1 of 1

MEDIA STEAM PASTEURIZATION USING GEOTHERMAL FLUID AT NELHA, NOI'I O PUNA LABORATORY

Final Report
Submitted to the
Community Geothermal Technology Program

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NOTICE

PREFACE

This is a report of work performed for the Community Geothermal Technology Program, a small grant program administered jointly by the Hawaii Natural Energy Institute and the State of Hawaii Department of Business, Economic Development and Tourism.

This project was one of five funded under the second phase of the program, which was awarded in 1988. Funds for this phase were provided by the U.S. Department of Energy, the County of Hawaii, and donations from private businesses.

The opinions expressed in this report are those of the author, and are not necessarily shared by the program administrators, funding agencies, or others involved in the program. Responsibility for the accuracy of the data provided in this report lies with the author.

The enthusiasm, talents, and efforts of the grantees are much appreciated, and I look forward to continuing to work with them and with future users of geothermal heat and by-products.

Andrea Gill Beck, Administrator
Community Geothermal Technology Program

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INTRODUCTION

D'Anna B'Nana is a wholesale certified plant export nursery located at Pahoa Agricultural Park. Its primary business is the production of coconut seed products, i.e., husked coconuts and sprouted coconuts for the export market. The nursery also stocks five varieties of *Pritchardia* palms (native Hawaiian fan palm) for the landscaping market.

D'Anna B'Nana was awarded a grant of $15,000 to conduct a research project at the Natural Energy Laboratory of Hawaii Authority (NELHA) Noi'i O Puna laboratory on May 31, 1988. The primary objective was to design and construct a facility to use untreated geothermal fluid as a steam source to pasteurize a growing medium. The second objective was to derive a method of shredding the coconut husk to use as a growing medium. The third objective was to test the resulting media by chemical analysis and field trials.

The underlying reason for the project was a desire to explore the potential of locally available materials as replacements for imported growing media, such as peat moss. In Hawaii, nurseries certified for plant export must use growing media that are free of agricultural pests. One method of guaranteeing the quality of the media is to employ steam for pasteurization or sterilization. The availability of very hot, pressurized geothermal fluids at the state-operated Noi'i O Puna laboratory raised the possibility of using this natural resource, which was potentially available in sufficient quantities and at competitive costs for this purpose. If locally available media could be treated locally with minimal expense, nursery operations could benefit by reducing their importation of expensive potting materials.

After researching soil steam pasteurization, the steam treatment facility was designed with two chambers (Figure 1). The first one was used to flash the fluid, allowing the brine to separate. The steam was ducted overhead to a second chamber and then down through pots sitting on a perforated floor over an exhaust plenum. Temperature probes installed at the flash chamber, in the steam chamber, and inside several media containers allowed for monitoring the temperature range, and the amount of heat could be controlled with a ball valve throttle. It was exciting to harness the raw power of the fluid for useful and productive work.

CONCLUSION

The project was successful in confirming the suitability of shredded coconut husks in potting mix and the acceptability of untreated geothermal steam to pasteurize the mix.

Test plantings using the steamed mixture of coconut husk and cinder show no detrimental effects on palm growth. The first field trials consisted of planting two sets of *Pritchardia*: the experimental group in ten-gallon pots that were steam treated next to a control set of palms planted in media that was not treated. After nine months the plantings showed no discernible difference in growth; both appeared equally robust. The geo-heated media appears to be suitable for raising palms and does not adversely affect plant growth.

The coconut media mix was subjected to routine State Department of Agriculture tests for nursery certification and showed no signs of nematode infestation. Twice a year Department of Agriculture specialists visit certified nurseries such as D'Anna B'Nana and take samples from each raised bench of potted plants. One sample is taken from the actual media, and one sample is taken from the root tips of the palms growing in the media. The samples are scrutinized with a microscope by the agriculture specialist to determine if nematodes are present.

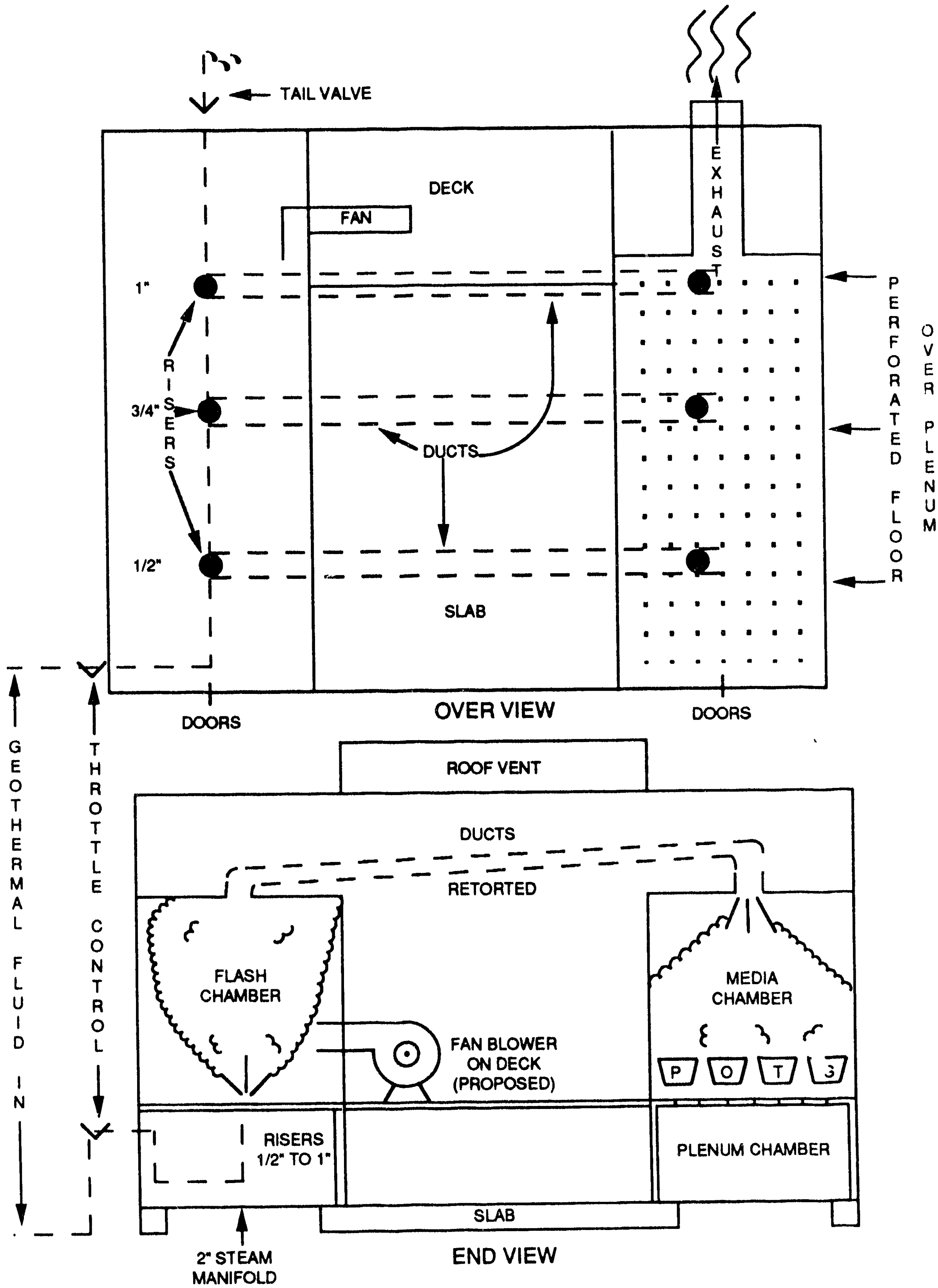

Fig. 1. Sketch of Geothermal Steam Pasteurization Facility

This recertification test has been performed several times on about one dozen benches of palms growing in steamed coconut media mix and also on three benches of palms growing in unsteamed coconut media mix. Nematodes have not been identified in any of the samples.

The results of the analyses of the media varied, but generally the media did not become excessively salted, although the geothermal brine itself is quite salty. This is attributed to the separation of the brine in the flash chamber and to the steaming process taking less than one hour. In the final test the optimum temperature (160° F) was reached in less than 20 minutes and maintained by throttling the steam flow to a trickle.

The pH level of the media elevated only slightly (from 6.8 to 7.4) after steaming. After the media was exposed to the rain, which is normally slightly acidic, the pH level dropped back to 6.5, well within the range compatible to palm growth. Slightly acidic media are actually preferred over neutral or alkaline readings.

DESCRIPTION OF WORK

After the required insurance was obtained and the grant agreement signed, the project research and development began. Dr. Paul Nelson of the University of Pennsylvania, a prominent researcher in this field, suggested looking into the "steam aeration" process for controlling the temperature of the media, using the concept of pasteurization as opposed to sterilization. One main benefit of using a steam/air mixture at 140° to 180° F for "pasteurization" rather than at 220° F for "sterilization" would be the survival of a major portion of beneficial organisms that would provide competition for the harmful organisms. Also, it has been determined that higher temperatures can lead to chemical changes in manganese and soluble salts. The level of salts and trace metals in the geothermal fluids was a possible concern. The University of Hawaii at Hilo library provided written materials about the "steam aeration" process.

The main body of research done since 1954 centered on the production of mushroom compost growing media developed at Pennsylvania State University. Numerous publications were received and reviewed (see Bibliography).

With the information and specifications in hand, the design for the facility at the Noi'i O Puna laboratory could be refined. Meetings were held with the operations manager at the laboratory to discuss the site layout, suitable containers, and materials. It was determined that used shipping containers would make ideal steam vaults, and a trip to Oahu was made to locate some from shipping companies. Damaged aluminum-lined refrigerator units from Matson were selected because the aluminium could resist corrosion when exposed to geothermal steam.

The area designated for the building at Noi'i O Puna was uneven and had several piles of rocks, gravel, and lumber left on it from construction at the laboratory unrelated to this experiment. The contractor allowed the materials to be moved to clear the site.

On-site construction work began on August 8, 1988, with the first pile of rocks being cleared to make a base for the project. Additional loads of rough cinders were brought in to level the area, and a layer of base course gravel was spread and tamped with a rented mechanical tamper. Forms were set up, and rebar and wire were installed for reinforcing the footings. Concrete was placed and finished on August 31, and forms were stripped the next day. Lumber was delivered on September 3, and the sub-floor frames were erected by September 6. The Matson containers arrived the next day, were unloaded, and were set on platforms with a rented crane. The roof frame was completed and painted, with roof iron installed on the top and sides on September 14, marking the completion of the facility enclosure.

One Matson container was used to flash the brine fluid into steam, which was directed into the second container via flexible aluminum ducting. Calculations showed that three six-inch ducts would handle the volume of steam needed to treat the potted media in the second container. A plywood plenum chamber was built under the second container, and 400 half-inch holes were drilled to connect the container with the plenum. After heating the pots, the steam and condensate would collect in the plenum for disposal.

After working with the laboratory's operations manager, calculations showed that a two-inch main pipe for the hot brine would provide more than enough steam. Two stainless steel ball valves were used, one as the throttle control and the other at the "tail" end to provide a drain. That way the fluid could run through the pipe until all the cooler fluid was exhausted and the hot fluid was flashing out the tail pipe. Then, by shutting the tail valve, the superheated fluid would be forced up through the manifold to flash in the first chamber. It was also a good way to drain the cooled fluid at the end of the treatment cycle. However, after all the pipes were in place, the temporary closing of Noi'i O Puna for construction and expansion caused an additional wait for the fluid to be available.

Meanwhile, the coconut shredding process began. To produce a uniform half-inch sieve material for potting mix, a two-horsepower electric shredder/chipper was selected and set up on a concrete slab at the Pahoa Agricultural Park lot. A screen rack was fabricated to sift the chopped materials, and several batches were made. Two discoveries were, first, the husks had to be dry for the machine to shred them and, second, the long fibers tended to clog the shredding chamber. Husks could be fed through the chipping chute but needed to be poked down with a stick or coconut midrib. A two-stage process was developed. The husks were cut across the grain with a bandsaw to make 1.5-inch-wide chunks and then were run through the shredder. Much more production was gained by pre-cutting on the bandsaw in this fashion. The machines were positioned against a hollow tile wall with the sieve screen set up next to them.

Using two workers, enough coconut fiber was processed to fill 24 ten-gallon containers in about eight hours. A total of 200 ten-gallon pots were filled for the initial test batches. This fiber was then mixed with 6,000 gallons of screened black cinder to make the potting mix. A mixture of 20 percent peat moss and 80 percent cinders has been used for the palms for four years with good results, and it was expected that this coconut fiber mix would also be suitable. It was decided to steam the mixture directly in the pots rather than in boxes or bags to simplify the transport of the material to and from the laboratory and to avoid the extra steps involved in filling the boxes or bags with potting mix prior to steaming, and then filling pots with steamed mixture from the boxes or bags after treatment. The manufacturer's specifications for the pots confirmed that the plastic could withstand the boiling point of water (212° F) without melting or deforming. Again, the temperature range was designed to stay below 180° F, so no problems were anticipated.

The operations manager at Noi'i O Puna said that the steam pasteurization facility would be connected to the brine resource about November 1, 1989. During the week of October 23 the final pipes and valves were connected, the finish touched up with paint, and the temperature probes installed.

The first test batch was completed on November 9, 1989. The temperature was raised to 180° F in 30 minutes. Batches of 70 pots were transported to the laboratory, steamed, cooled, and taken back to the nursery. Six batches, for a total of 420 pots, were completed before the geothermal well was shut down on December 11, 1989.

DISCUSSION OF PROBLEMS ENCOUNTERED

A variety of problems were encountered during the project, but none were serious enough to change the plan of work significantly. Some were "learning experiences," which may impact the design of a commercial-scale system, if one is built. Others dealt with the resources at the laboratory and would need to be addressed to support future projects.

Shredder Clogging

To prevent clogging the shredder with long coconut fibers, the husk pieces were hand-cut with a bandsaw prior to feeding them into the shredder. However, this laborious hand-cutting will certainly be too expensive for a commercial venture and is also potentially hazardous. Possibly a special shredder would need to be designed to handle the particular characteristics of coconut husks.

Weather

D'Anna B'Nana's coconut husks are stored in open-air piles, exposed to the rain. In wet weather the husks are particularly difficult to shred. Some protection from rainfall should be considered for a longer-term, larger-scale operation.

Shipping Containers

Although the used shipping containers were convenient, relatively inexpensive, and appropriately sized for the flash and steaming chambers, they had several drawbacks. In the container used to steam the potting mix, foam insulation in the walls and floor expanded during the experimental steaming. The yellow foam actually extruded from holes drilled through one wall for thermometer access and partially clogged holes drilled through the floor to the plenum. At times this expansion was audible, as the inflating foam put pressure on the aluminum lining of the container walls. Due to the short duration of the experiment, the expansion of the foam insulation was not a serious problem. Interestingly, the container used for the flashing chamber did not exhibit insulation expansion. Closer attention should be paid to the construction of the shipping containers if they are to be used again for this purpose.

Also, the shipping containers proved not to be water tight. The condensate in the flashing chamber leaked out beneath the container doors and at several places through the floor during the experiment. Assuming that the disposal of the condensate would be of concern in a commercial plant, water tightness should be addressed.

Disposal of Fluids

As alluded to above, the small volumes of condensate resulting from the short-term experiments were handled by surface disposal, as was the rest of the brine from the geothermal well. In addition, steam from the plenum beneath the steaming chamber was allowed to evacuate into the air. Under the operating permits governing the laboratory at the time, this was acceptable. However, alternative means of fluid disposal may be required in the future.

Lack of 220-Volt Electrical Connection

The original proposal for this steam pasteurization project included the installation of a 220 V fan on the platform between the two chambers. The fan would blow into the flash chamber, helping to move steam from the flash chamber into the steam chamber and, at the same time, mix ambient air with the geothermal steam to control the temperature. It would also help exhaust the steam from the entire system, accelerating the cooling of the pots in the second chamber. This would have allowed the pots to be removed promptly and a new set of pots set inside the chamber for steaming on the same day. As it was, the steamed pots of coconut husk/cinder mix were left overnight and removed the following day.

The lack of the fan did not seriously hamper the project since the steam moved between chambers without it. However, the fan would probably have improved the entire process, especially by allowing more than one batch of pots to be steamed in a day. The 220 V connection was probably not provided by NELHA because of the pending closure of the HGP-A geothermal well and the resulting closure of the Noi'i O Puna laboratory. Even the 110 V electricity from the laboratory building to the steam experiment was made with a temporary connection due to the anticipated closure.

Unavailability of Laboratory and Geothermal Heat

The major problem facing any new project is the closure of the HGP-A well and, as a result, the Noi'i O Puna laboratory in December 1989. Obviously there can be no further experimentation or commercial use of geothermal heat until the fluid is restored. The interruption of the fluid flow affected the experiment, not only shortening the experiment period, but also delaying the final hookup of the system when the Noi'i O Puna laboratory expansion was under construction. In fairness to NELHA, however, it should be noted that there were earlier delays in the project, unrelated to the laboratory, which also significantly affected the experiment's timetable; if the original timetable had been followed, the closure of the laboratory would not have affected the experiment.

DISCUSSION OF DATA

Pots of growing media were successfully pasteurized by exposing them to untreated steam and maintaining an average media temperature of 160° F for 30 minutes (Data Sheet 1, Appendix).

The pH level is slightly elevated in the virgin media. Soluble salts and sodium levels are moderately high. The calcium to magnesium ratio is inverted at 1:5; this ratio is usually recommended to be 2:1 for plant growth (Data Sheet 2, Appendix).

The pH levels rose only slightly (less than 0.5) after steaming. Salt levels doubled but still remained at safe levels. As expected, magnesium solubility did increase after heating, but not to toxic levels (Data Sheet 3, Appendix).

The test plantings showed no significant differences after eight months, leading to the conclusion that the use of untreated geothermal steam had not adversely affected plant growth, and thus that locally available materials such as coconut fiber can be readily pasteurized and used to replace imported potting materials such as peat moss.

FUTURE PLANS

If the steam source becomes available again, the experiment could continue by raising different test plants in different test media, and the steam-pasteurized media could be test marketed. A test planting in a peat/cinder mix is currently underway to compare with a planting in a coconut husk/cinder mix. Results should be available by June 1991.

The chipping operation would need refinement, as discussed above. A larger capacity chipper, a soil mixer, conveyers, and other equipment would be needed for the commercial operation. An appropriate capacity for the specialized chipper would be 100 cubic feet per week.

The economics of a commercial-scale system are closely related to the chipping operation. If a specialized chipper is not developed to overcome the clogging problem, pre-cutting the husks by hand will still be necessary. To make the production of coconut husk potting mix financially viable, the laborer doing the hand-cutting could be paid no more than minimum wage.

In the experiment, labor for chipping the husks cost about $4 per cubic foot of chipped material. The cost of peat moss is also about $4 per cubic foot. To make the locally-produced coconut husk mix competitive with the imported peat moss, the unprocessed husks would have to be free, and it should cost only around $2 per cubic foot to chop and sieve to one-half inch size. Assuming that the material could be steamed for about $1 per cubic foot, the coconut husk mix could be marketed at a price competitive with peat moss.

The supply of coconut husks from D'Anna B'Nana's related agricultural ventures appears to be sufficient for a small commercial enterprise. It is estimated that about 9,000 cubic feet of husks are now stockpiled, and an additional 40 cubic feet per week are generated as coconuts are husked for the tourist market. D'Anna B'Nana currently purchases about 200 cubic feet of peat moss per year for its operations, so the available husks would be sufficient to supply the nursery operations and perhaps several other small nursery ventures as well. If the chipper did have a capacity of 100 cubic feet per week, and if all the steamed material was either used by D'Anna B'Nana or sold, the existing supply of husks would last about two years.

It is unlikely that steamed coconut husks from the current supply would make a significant dent in the state's imports of peat moss, given the large scale of many of the other nursery operations on the island. No other sources of husks are presently known. The long-term viability of a local potting mix pasteurization enterprise would depend on the availability of other suitable raw materials. There are certainly additional markets that could be addressed; in addition to nursery operations that use potting mix, orchid growers may be interested in a substitute for orchid bark, for instance. There is no reason to believe that the steaming procedure would not be just as effective for other materials as it is for the coconut/cinder mix used during this experiment.

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APPENDIX

DATA SHEET 1

GEOTHERMAL SOIL PASTEURIZATION
TEST NO. 6, DECEMBER 11, 1989

Time	Flash Chamber Temp (°F)	Steam Chamber Temp (°F)	Media Temp (°F)	Throttle Valve
11:50 a.m.	0	0	72	1/2 open
11:55 a.m.	212	184	85	1/2 open
12:00 p.m.	220	200	111	1/2 open
12:05 p.m.	222	212	140	1/2 open
12:10 p.m.	222	215	160	1/2 open
12:15 p.m.	220	215	162	1/4 open
12:20 p.m.	220	215	171	1/4 open
12:25 p.m.	220	200	170	1/4 open
12:30 p.m.	218	190	162	closed
12:35 p.m.	218	182	162	closed
12:40 p.m.	215	178	158	closed
12:45 p.m.	210	174	154	closed

DATA SHEET 2

MEDIA ANALYSES – UNTREATED (100% COCONUT HUSK)

	Tissue University of Hawaii	Water Soluble WR Grace Co.
pH	6.5	6.7
Salinity	1.88 mmho	1.35 mmho
N	0.25%	2.55 ppm
P	0.11%	29.7 ppm
K	0.34%	117 ppm
Ca	0.37%	5.93 ppm
Mg	0.41%	32.5 ppm
Na	0.28%	116 ppm
S	0.11%	—
Si	0.11%	—
Mn	36 ppm	0.05 ppm
Fe	2,360 ppm	0.036 ppm
Cu	14 ppm	<0
Zn	105 ppm	0.078 ppm
B	6 ppm	0.066 ppm
Al	345 ppm	<0

mmho = millimho/cm; a measure of electrical conductivity
ppm = parts per million

DATA SHEET 3

COMPARISON OF STEAMED, UNSTEAMED, AND PEAT MEDIA
UNIVERSITY OF HAWAII AT MANOA LABORATORY

	A	B	C	D	COMMENTS
pH	7.2	7.0	5.6 (Acid)	7.4	7 = Neutral
Salts	0.29	0.11	0.11	0.20	Safe Levels
P	<25	<25	<25	<25	Very Low
K	80	60	<40	60	Low
Ca	750	750	750	750	Low
Mg	1,500	750 (Low)	1,500	1,000	Moderate

KEY:

A – Geo Steamed	Coconut/Cinder 1:3 Top of Container
B – Untreated	Coconut/Cinder 1:3
C – Untreated	Peat moss/Cinder 1:3
D – Geo Steamed	Coconut/Cinder 1:3 Middle of Container

Salts = Soluble Salts, Millimhos/cm

P = Phosphorus   Ca = Calcium
K = Potassium   Mg = Magnesium

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3/23/94

END