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FY 2014 HAWAII STATE PLAN

Final Report

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Buying Local for the USDA Fresh Fruit and Vegetable Program

Final Report

The Kohala Center
http://kohalacenter.org/

Project Summary

The School Food Services Branch (SFSB) of the Hawaii Department of Education has considerable purchasing power but has faced significant barriers to procuring Hawaii-grown fruits and vegetables for school meals due to a procurement approach that has focused on obtaining a single vendor to supply fresh produce to all 255 public schools in the Hawaii's single statewide school district. In Hawaii, no single farm could consistently supply enough of a single crop for the entire school district nor could local food distributors consistently aggregate a sufficient quantity of local crops to supply the entire district.

The USDA Fresh Fruit and Vegetable Program (FFVP), which provides federal funds to elementary schools to purchase fresh fruits and vegetables to serve as snacks, offers a more immediate way of increasing the amount of local produce served in Hawaii's schools and a pathway to SFSB procuring local produce for school lunches statewide. In Hawaii, individual schools procure for FFVP, creating order sizes and procurement rules that are much easier for local farmers to meet. Thus, The Kohala Center's (TKC) project aimed to encourage FFVP schools to buy local specialty crops, specifically fresh fruits and vegetables, and to facilitate local farmers' participation in the FFVP.

This project was extremely timely, as it coincided with increased governmental interest in the procurement of Hawaii grown produce for child nutrition programs, including the FFVP. In 2015 Hawaii's Lt. Governor spearheaded the Hawaii Farm to School Advisory Group, with TKC as a key partner. Conducting the work under this grant while participating on the Advisory Group allowed TKC to work with the Hawaii Department of Education on creating new procurement approaches to encourage the procurement of local specialty crops not just for the FFVP, but also for all child nutrition programs in Hawaii. The Advisory Group led to the launch of the statewide Hawaii Farm to School Initiative in November 2016 through which the Hawaii DOE is working closely with TKC to pilot new localized menus for their child nutrition programs, including the FFVP, concentrating on procuring more fresh local specialty crops.

Project Approach

The project approach included the following activities to educate Hawaii specialty crop farmers and distributors about the FFVP and to encourage schools to buy local for the FFVP:
Link to attachments:
http://www.kohalacenter.org/docs/reports/FFVP_Local_Buying_Guide_full.pdf.

1. Created the **USDA FFVP Hawaii Local Produce Buying Guide** (http://www.kohalacenter.org/docs/reports/FFVP_Local_Buying_Guide.pdf) for farmers, distributors and schools, and distributed the guide to all the FFVP schools in Hawaii, all major distributors in Hawaii, and farmers throughout the state. The guide included: (a) guidance for schools on building relationships with local farmers and distributors; (b) a list of all FFVP schools in Hawaii, along with each school's enrollment numbers; (c) estimated annual pounds of produce required to meet FFVP demand on each Hawaiian island; (d) a list of the most desired fruits and vegetables for the FFVP created by HIDOE; (e) a list of distributors on each island, along with their contact information; and (f) a list of farms that have expressed interest in supplying to the FFVP, along with contact information.

2. Created the **Hawaii FFVP Resources Webpage** on TKC's website (http://kohalacenter.org/business/ffvp), which contains the following resources on how to procure Hawaii-grown fruits and vegetables for the FFVP: (1) the FFVP Hawai'i Local Produce Buying Guide referenced above; (2) Hawai'i Seasonality Chart; (3) USDA Food Buying Guide for Produce; (4) TKC's FFVP Report: *Implementing the USDA Fresh Fruit and Vegetable Program in Hawai'i*; and (5) links to the USDA's FFVP page and the Hawaii Child Nutrition Programs' (HCNP) FFVP page.

3. Created the **FFVP Brochure for Farmers** (http://www.kohalacenter.org/docs/resources/rcbds/FFVP_Brochure.pdf) that provides an overview of the FFVP, lists the most desired fruits and vegetables for the FFVP, and includes the web address for the Hawaii FFVP Local Produce Buying Guide, TKC's Hawaii FFVP Resources Webpage, HCNP's FFVP webpage, and the USDA FFVP webpage.

4. Hosted the following **FFVP Supplier Workshops** for Hawaii fruit and vegetable growers, at which TKC presented on the process of supplying to the FFVP and moderated Q&A between specialty crop farmers and FFVP buyers, including the DOE, produce wholesalers, and charter schools.

    a. On March 13 and 20, 2015, TKC held two FFVP Procurement Meetings, one on Hawaii Island and one on Oahu, with the Hawaii Department of Education, charter schools, and produce distributors, to discuss procurement for the FFVP. Jennifer Dang, FFVP & Special Projects Coordinator with the Hawaii Department of Education's Child Nutrition Programs (HCNP), presented on procurement for the program, and TKC led a discussion on increasing local procurement for the FFVP. Three produce vendors attended the Hawaii Island meeting, along with the Hawaii

Department of Education and five charter schools. Four produce vendors attended the Oahu meeting, along with the Hawaii Department of Education.

b. On April 29 and May 21, 2015, TKC presented on the FFVP to farmers from the Hawaiʻi Farmers Union United Kona Chapter (Hawaiʻi Island) and Mauna Kahalawai Chapter (Maui). Kona Pacific Public Charter School (KPPCS) and Adaptations, Inc. Food Hub attended the Kona meeting to meet local farmers and discuss KPPCS's successful farm to school program that is sourcing 100% local for its FFVP through Adaptations. Over 20 farmers attended the Maui meeting, and 16 farmers attended the Kona meeting.

c. On June 30, 2015, TKC presented on the FFVP to 14 farmers, six public charter schools, and three produce distributors at the Hawaii Island FFVP Workshop/Trade Show, described below.

5. Conducted the following **Hawaii FFVP School Workshop/Trade Shows**.

a. On June 30, 2015, TKC hosted the **Hawaii Island FFVP Workshop/Trade Show** to connect charter schools, farmers, and distributors on Hawaii Island; educate schools on procuring Hawaii-grown fruits/vegetables for the FFVP and meeting the nutrition education requirements of the FFVP; and educate farmers on selling produce to schools for the FFVP and other child nutrition programs. Ten FFVP buyers (including six public charter schools, the Hawaii Department of Education, and three produce distributors) attended the event, joined by 14 produce farms. The DOE, distributors, and charter schools presented to farmers on sourcing local produce for the FFVP. The DOE and Hawaii Child Nutrition Programs presented to schools on FFVP requirements and buying local.

b. On April 27, 2016, TKC co-hosted the second Hawaii FFVP School Workshop/Trade Show – the **Oahu Farm to School Information Session and Mixer** to educate farmers on supplying produce for Hawaii Department of Education child nutrition programs, including the FFVP, and to connect farmers to distributors and the DOE's School Food Services Branch, which procures food for all 255 regular public schools in Hawaii. In addition to the Hawaii DOE and the Hawaii Department of Agriculture, six produce distributors and 12 farms attended the event. The Hawaii Department of Agriculture Farm to School Coordinator presented to farmers and distributors on contracting with the state to provide fresh produce for the FFVP and other federal child nutrition programs.

6. Conducted an **FFVP Local Buying Study** to explore ways of facilitating and stimulating increases in local produce production and local produce sales to FFVP schools. The study resulted in the publication of the following two reports. The findings in the second report could benefit non-specialty crop growers, however, the writing of that report was partially funded by a USDA Farm to School Grant. Funds from this grant were used solely to support specialty crop growers in Hawaii.

    a. *Implementing the USDA Fresh Fruit and Vegetable Program in Hawai'i: A report on implementation challenges and tips for success* (http://kohalacenter.org/docs/reports/2015_FFVP_Hawaii.pdf)

    b. *Local Foods in Hawai'i's Schools: A report on the challenges to local food procurement in Hawai'i and the opportunities to advance beyond them* (http://kohalacenter.org/docs/reports/2015_LocalFoodHawaiiSchools.pdf

Goals and Outcomes Achieved

Goal #1: Increase in farmers' awareness of how to participate in the FFVP and increases in schools' and distributors' awareness of farmers that are interested in growing for and supplying to the FFVP.

Outcomes Achieved

TKC built farmer awareness through six workshops (attended by 62 farms) and two new FFVP resources (the Local Buying Guide and the Brochure) and two reports described above and available online and distributed at project events, through The Kohala Center's Agricultural Resources Bulletin (750+ subscribers), through the Hawaii Farm to School and School Garden Hui, Hawaii Farmers Union United, and Hawaii Farm Bureau.

TKC built school and distributor awareness through six workshops (attended by DOE School Food Services Branch, which procures food for all 255 public schools in Hawaii, six charter schools; and 16 produce distributors); two FFVP resources and two reports described above (distributed to schools via the HCNP office (which administers the FFVP in Hawaii) and at TKC events referenced above.

TKC worked with HCNP to add TKC resources to their FFVP webpage (http://hcnp.hawaii.gov/overview/ffvp/).

In addition to these anticipated outcomes, through this grant TKC deepened relationships with the DOE, HCNP, and numerous charter schools. As a result, the Hawaii DOE launched in 2016 the statewide Hawaii Farm to School Initiative, which is focused on increasing the amount of local produce procured for child nutrition programs in Hawaii, including the FFVP. The Initiative is the first program of its kind in Hawaii, and is a public-private partnership between the Hawaii Lieutenant Governor, the Hawaii DOE, HDOA, State Procurement Office, and TKC. Project staff have met with five major produce distributors and over 20 farms to discuss supplying local produce for

DOE schools, including for the FFVP. TKC is working closely with the DOE to develop procurement specifications to support the sourcing of local produce for DOE schools statewide. See http://ltgov.hawaii.gov/farm-to-school-initiative/ for more information.

TKC has also worked closely with a group of four charter schools on Hawaii Island to form a joint buying group to increase their procurement of local produce for their child nutrition programs, including the FFVP. TKC helped facilitate meetings between the charter schools, HCNP, USDA, HDOA, and the Hawaii Department of the Attorney General to develop procurement specifications and joint buying agreements that support buying local produce. The group is on track to launch joint procurement operations in 2017.

Goal #2: At least 10% of FFVP buyers are tracking data on the percentage of FFVP dollars spent on Hawaii-grown specialty crops, and there is a 10% increase in the amount of FFVP dollars spent on Hawaii-grown specialty crops at these schools.

Outcomes Achieved

The project target sample size was at least 10% of the 64 schools in Hawaii participating in the FFVP during the 2014-15 school year. In December 2014, TKC identified 13 schools to participate in the data-tracking project. For December 2014, produce grown in Hawaii comprised 20% of these schools' FFVP orders. Thus, **20% local** was the project baseline. TKC continued to collect FFVP order data from January 2015 – April 2016 from the following schools:

1. Haaheo Elementary*
2. Hawaii Academy of Arts & Science*
3. Honaunau Elementary*
4. Honokaa Elementary*
5. Ka Umeke Kaeo PCS*
6. Kau High & Pahala Elementary*
7. Kaumana Elementary*
8. Ke Kula O Nawahiokalaniopuu*
9. Keaau Elementary*
10. Maunaloa Elementary
11. Mountain View Elementary*
12. Naalehu Elementary*
13. Paauilo Elementary & Intermediate*
14. St. Joseph School of Hilo*
15. Volcano School of Arts & Sciences
16. Waiakeawaene

**Schools with an asterisk are included in the baseline data. The other schools did not place FFVP orders in December. TKC also collected data from Kona Pacific Public Charter School and Laupahoehoe Community Public Charter School. However, because these schools source 100% local for the FFVP, TKC has excluded their data from the analysis. For the 2015-2016 school year, school data was mostly obtained via Hilo Products; thus, orders from other vendors are generally not included.*

From January 2015 through April 2016, the above-listed schools placed, in the aggregate, $290,168 in FFVP orders, of which **24%** ($68,940) was for produce grown in Hawaii. Hawaii schools did not start the FFVP for the 2016-2017 school year until February 2017. As such, TKC does not have data for August – December 2016.

Local procurement increased by 4% during the grant period. Thus, TKC did not see the anticipated 10% increase in local procurement for the FFVP. Project staff believes this was in part due to schools with a strong commitment to buying local for the FFVP no longer participating in the program, as well as the Hawaii DOE not commencing the FFVP for the 2016-17 school year until February 2017.

However, through the work on the Hawaii Farm to School Advisory Group and Initiative, the Hawaii DOE has agreed to conduct an island-by-island solicitation for the FFVP for the 2017-18 school year to include allowable buy local provisions. TKC expects this solicitation to more strongly support local produce procurement for the FFVP, as the program will no longer depend on the individual orders of each school, but will instead set a DOE policy through which the DOE will procure island-by-island for the FFVP with a focus on Hawaiian specialty crops. In addition, during the first three months of the Hawaii Farm to School Initiative, local produce procurement increased by **13%** at the three schools included in the initial pilot. TKC expects that number to increase significantly as the program expands during the 2017-2018 school year.

Goal #3: TKC completes an FFVP Local Buying Study and writes a report that reviews the feasibility of at least two strategies to stimulate increases in Hawaii-grown specialty crop production and Hawaii-grown specialty crop sales to Hawaii's FFVP.

Outcomes Achieved

TKC published the two reports referenced above, posted these reports online, distributed the reports at events and via email to school, farmers, distributors, and other farm to school stakeholders.

The reports identified a farm to school pilot project to develop more localized procurement strategies as a key tool for increasing the procurement of local produce for the FFVP and other child nutrition programs. As mentioned above, the DOE launched this pilot project in November 2016.

The reports also identified building farm to school procurement programs at charter schools as a key tool for increasing the procurement of local produce for the FFVP and other child nutrition programs.

As mentioned above, four Hawaii Island charter schools are developing a joint procurement group for the purpose of procuring local produce for the FFVP and other child nutrition programs.

Beneficiaries

The beneficiaries of the project included:

- Over 100 specialty crop farmers that received information on selling local produce to schools for the FFVP and other child nutrition programs in Hawaii.
- Over 200 schools that received information on buying local produce for their FFVP programs.
- Sixteen specialty crop distributors that received information on sourcing local produce for the FFVP and other child nutrition programs in Hawaii, and made connections to both local farmers and schools.

Lessons Learned

TKC greatly enjoyed implementing this project. Through the project the project staff developed and deepened relationships with numerous farmers, distributors, and schools, which allowed TKC to create more opportunities to increase the amount of local specialty crops purchased by the Hawaii DOE and charter schools for the FFVP and other child nutrition programs. This grant allowed TKC to build from years of foundational work, and proved to be a catalyst for taking this work to the next level. As a result, Hawaii is poised for a school food revolution that will greatly benefit specialty crop farmers to the tune of millions of dollars as the Hawaii DOE and charter schools refine their current procurement strategies to support buying specialty crops.

Contact Information

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Additional Information

Link to documents referenced in this report:
http://www.kohalacenter.org/docs/reports/FFVP_Local_Buying_Guide_full.pdf.

Statewide Trials of Promising New Varieties of Taro

Final Report

University of Hawaii, Office of Research Services
http://www.ors.hawaii.edu/
http://www.ctahr.hawaii.edu/site/

Project Summary

The purpose of the project was to enhance the competitiveness of the specialty crop taro by: a) developing new and improved varieties of taro that are resistant to Taro Leaf Blight (TLB),and b) increasing food self-sufficiency in the Hawaiian Islands by increasing taro yields while maintaining quality. Specifically, this project conducted field trials of 10 of the most promising new varieties across the state of Hawaii.

Project Approach

Project Impact and Findings:

Nine promising taro varieties were multiplied in tissue-culture, acclimated in the greenhouse, and then approximately 24 potted plants were shipped to each coPI on five different Islands in Hawaii. At each experiment station, taro plants were grown in the field to multiply sufficient propagating materials to plant in replicated field trials (30 plant plots). Table 1 shows a summary of progress in evaluating these new taro varieties on each island.

Table 1. Summary of new taro varieties in process of being evaluated on each Island. Number of replicated blocks follow field trials in parentheses.

Variety	Hawaii[+]	Kauai	Maui	Molokai	Oahu
1003-03	1st Rep. trial (3)	Prelim. Trial (1)	Rep. trial (2)	Rep. trial	1st Rep. trial (3)
1005-35	1st Rep. trial (3)	Prelim. Trial (1)	Rep. trial (2)	Rep. trial	1st Rep. trial (3)
1005-66	1st Rep. trial (3)	Prelim. Trial (1)	Rep. trial (2)	Rep. trial	1st Rep. trial (3)
1005-84	Removed	Prelim. Trial (1)	Rep. trial (2)	Multiplying	1st Rep. trial (3)
1003-13	2nd Rep. trial (3)	Multiplying	Multiplying	Multiplying	2nd Rep. trial (4)
1010-16	2nd Rep. trial (3)	Multiplying	Multiplying	Multiplying	2nd Rep. trial (4)
1016-03	2nd Rep. trial (3)	Multiplying	Multiplying	Multiplying	2nd Rep. trial (4)
1024-209	2nd Rep. trial (3)	Multiplying	Multiplying	Multiplying	2nd Rep. trial (4)
1024-299	2nd Rep. trial (3)	Multiplying	Multiplying	Multiplying	2nd Rep. trial (4)

[+]On Hawaii Island, variety 1005-84 was removed due to production of runners.

Table 2. Summary of fresh weight corm yield results (pounds per acre, lbs/ac) of replicated field trials of three to four new varieties of taro on each Island. Yields of new varieties were divided by yield of Maui Lehua or Lehua Maoli (on Molokai) and fractions follow yields in parentheses.

Variety	Hawaii	Kauai	Maui	Molokai[++]	Oahu
1003-03	23,280 (1.4)	12,780 (0.9)	14,860 (2.1)	16,470ab (1.5)	5,240 (1.5)
1005-35	22,040 (1.3)	18,300 (1.3)	13,390 (1.9)	13,720bc (1.2)	4,170 (1.2)
1005-66	10,790 (0.6)	7,840 (0.6)	6,760 (1.0)	10,370c (0.9)	2,380 (0.7)
1005-84[+]	NA	12,200 (0.9)	14,390 (2.1)	NA	7,430 (2.2)
Maui Lehua/ Lehua Maoli	17,050 (1.0)	14,230 (1.0)	7,000 (1.0)	11,330c (1.0)	3,430 (1.0)

[+]On Hawaii Island, variety 1005-84 was removed due to production of runners. On Molokai, there were insufficient vegetative propagules ('huli') of variety 1005-84 to include it in the first trial.
[++]Significant differences were found among varieties in the first trial on Molokai; means followed by the same letter did not differ at the 95% probability level.

Summary of Results:
Fresh weight corm yields of new taro varieties varied between islands (Table 2). Either Maui Lehua or Lehua Maoli were planted in each replicated trial as a control variety. Variety 1003-03 ranged from 10% lower yield on Kauai to a doubling of yield on Maui in comparison to the control variety. Variety 1005-35 ranged from 20% greater yield on Molokai to 90% greater yield on Maui compared to the control variety. Variety 1005-84 ranged from 10% lower yield on Kauai to a doubling of yield on Maui and Oahu in comparison to the control variety. The other five new taro varieties are either being multiplied for inclusion in a replicated trial or are currently in a replicated trial. Variety 1005-66 had significantly greater percentage rot at both Kula Agricultural Park (on Maui) and Waimanalo Research station (on Oahu) and should be discarded.

Activities Performed:
Objectives: Help taro growers increase production through evaluation of new taro varieties with improved resistance to Taro Leaf Blight, increased yields, and good consumer acceptance. These new varieties of taro will be grown experimentally in various agro-environments across the state of Hawai`i.

Accomplishments: Summary of results are presented in above section. Results for each island of yield, resistance to Taro leaf blight, and evaluation of consumer acceptance of new taro varieties are presented below.

<u>Island of Hawaii:</u>
On 10 March 2016, four taro varieties (1003-03, 1005-35, 1005-66, and Maui Lehua) were planted in three blocks in a randomized complete block design at Pepeekeo, Hawaii. Spacing of plants were 1x5 ft. in plots containing three rows of 10 plants. Due to wet weather during fall 2016, the project staff found an epidemic of Taro Leaf Blight (TLB) and ratings were taken at eight months of growth in November 2016 (Figure 1). Taro corms were harvested in January 2017 after 10 months of growth and

yields of each variety were regressed against incidence of disease (Figure 2). A consumer acceptance test (16 participants) were conducted on poi made from these five taro varieties (Figure 3).

Results. Variety 1003-3 had the lowest incidence of disease (averaged across three leaf blades) and Maui Lehua had the greatest (Table 3). Regression of corm yields of each variety against incidence of disease of each variety showed that the disease-resistant varieties had higher yields than disease-susceptible varieties (Figure 2).
A consumer acceptance test of poi made from these varieties showed that Maui Lehua was the highest rated variety (3.5 out of 5.0; where 5=excellent and 1=not good). Next highest rated was variety 1005-35 (3.0). (Figure 3)

Figure 1. Symptoms of TLB caused by the pathogen *Phytophthora colocasiae* in varieties (left to right), 1003-3, 1005-35, 1005-66, and Maui Lehua.

Table 3. Percent incidence of TLB was averaged over three leaf blades for each taro variety grown at Pepeekeo field in November 2016 (8 months of growth). Means followed by the same letter are not significantly different from each other at the 95% probability level.

Variety	% Disease Incidence
1003-3	23.5c
1005-35	32.6bc
1005-66	44.3ab
Maui Lehua	54.0a

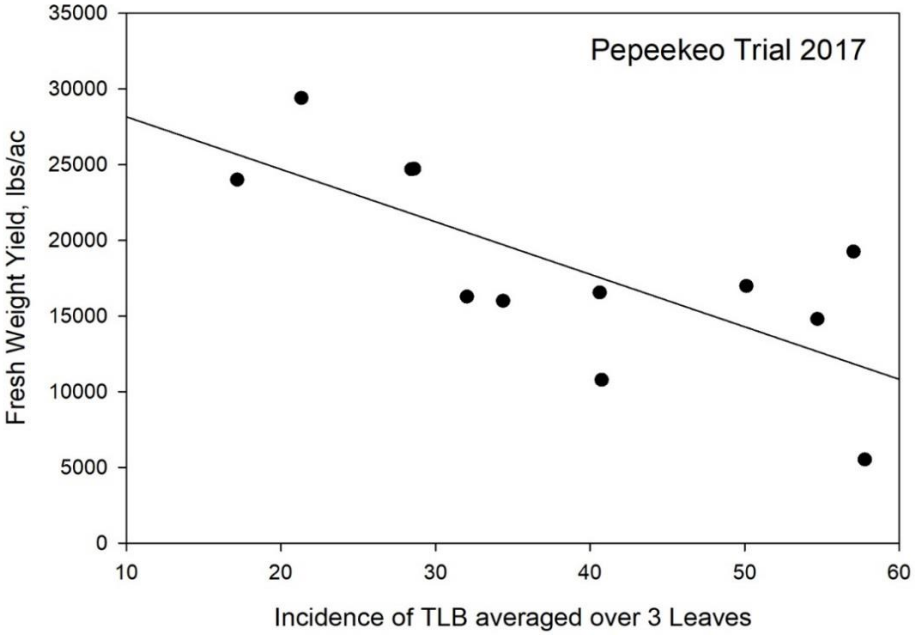

Figure 2. Relationship of fresh weight of corms (lbs/ac) of each taro variety with incidence of TLB (averaged over three leaf blades) for each variety.

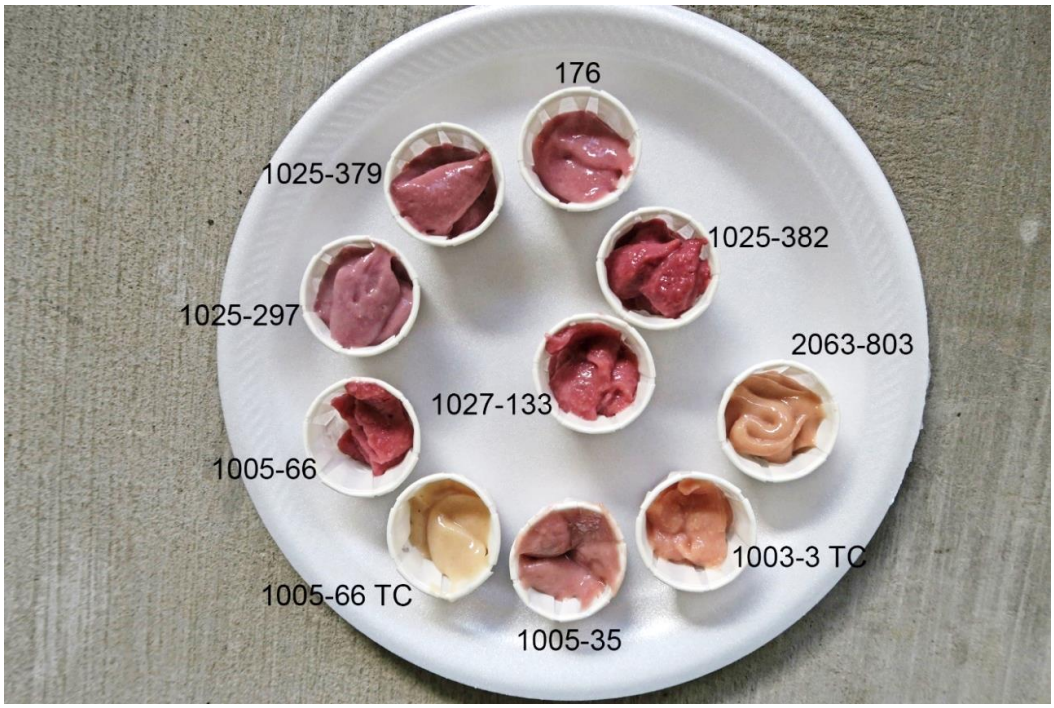

Figure 3. Consumer acceptance taste test of promising taro varieties [1003-03 tissue-cultured (TC), 1005-35, 1005-66 TC, 1005-66, and 176=Maui Lehua] and three other varieties.

Island of Kauai:

A preliminary field trial was planted at Wailua Agricultural Research Center on Kauai in March 2016 with four corms of five varieties (1003-3, 1005-35, 1005-66, 1005-84, and Maui Lehua). Spacing of plants were 1.5 x 5 ft. in plots containing three rows of 10 plants. Corms were harvested in December 2016 (9 months of growth) and weighed. Additionally, the corms were cooked and served at a blind taste test to 13 participants who rated them on a 1-5 scale (1=Best, 5=Worst).

Results. In the preliminary field trial, the new varieties produced corms that ranged between two to three pounds except for 1005-66 (Figure 4). In the blind taste test, the 1005-66 variety was rated the best, with participants primarily liking its flavor (Table 4).

Table 4. Average scores of a blind taste for five taro varieties (n=15) grown on Kauai.

	Taro Variety Preference (1=Best, 5=Worst)				
Variety	1003-03	1005-35	1005-66	1005-84	Maui Lehua
Average Score	3.4	2.9	2.1	3.3	3.1

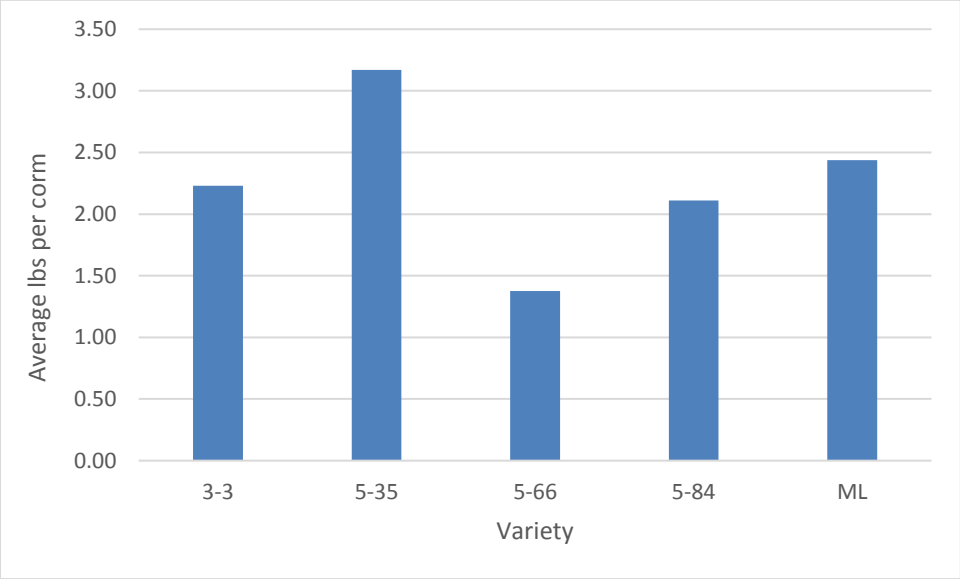

Figure 4. Average taro corm weights of five varieties grown in a preliminary field trial at Wailua, Kauai.

Methods. On 6 October 2016, one block in a randomized complete block design was planted at the Wailua Agricultural Research Center on Kauai with three new taro varieties (1003-3, 1005-35, 1005-84) and a control variety Maui Lehua. Spacing of plants were 1.5 x 5 ft. in plots containing three rows of 10 plants. On the same day, five 'huli' from these same varieties were planted at two cooperating farmers' wetland taro fields.

Results. Taro leaf blight (TLB) damage was assessed on 20 March 2017. No damage from TLB was observed on varieties planted at the Wailua Agricultural Research Center. At the 1st cooperator's field (reported to experience warmer conditions), Maui Lehua exhibited the highest damage due to TLB

(Table 5), and growth also appeared to be smaller than the other varieties (Figure 5). Varieties 1003-3, 1005-35, and 1005-84 were damaged less by TLB, but did not differ significantly from each other. At the 2nd cooperator's field, very little TLB damage was observed.

Table 5. Average Incidence of Taro leaf blight (TLB, %) for four taro varieties grown at wetland field of 1st Cooperator on Kauai and measured on 20 March 2017.

Cooperator	Variety	Incidence of TLB, %	+
1	1003-3	16.0	b
1	1005-35	16.0	b
1	1005-84	5.1	b
1	Maui Lehua	40.0	a

+Means followed by the same letter do not differ significantly at the 95% probability level.

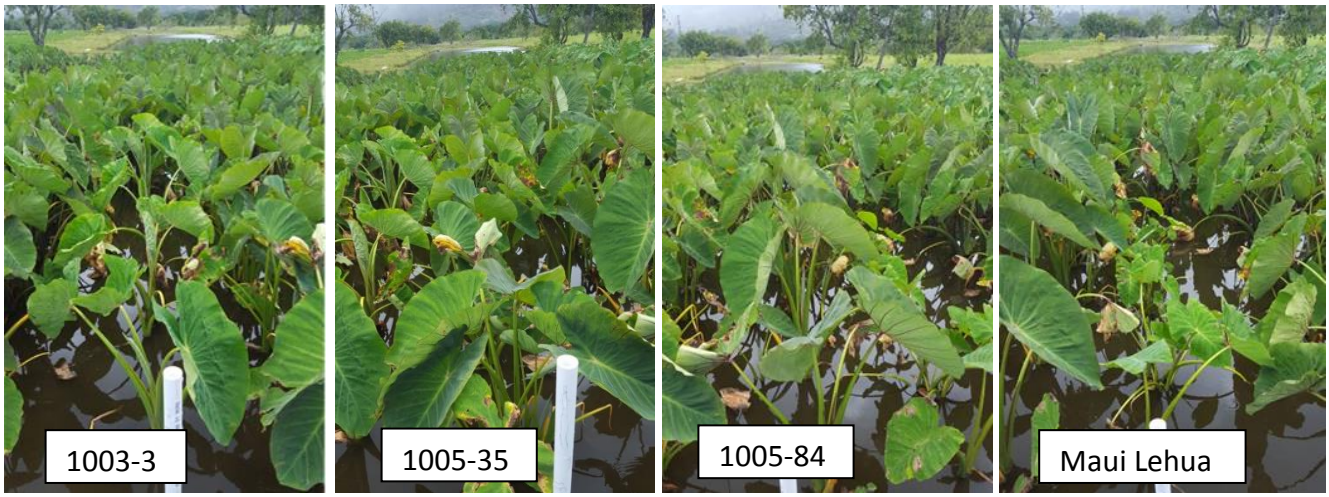

Figure 5. Taro varieties (left to right: 1003-3, 1005-35, 1005-84, and Maui Lehua) planted at 1st cooperator's field on Kauai and exhibiting Taro leaf blight. Note that growth of Maui Lehua appeared to be less vigorous than other varieties.

Island of Maui:

At the Kula Agricultural Park, four new taro varieties (1005-3, 1005-35, 1005-66, and 1005-84) plus control variety Maui lehua were planted in two blocks on 17-20 June 2016 (Figure 6) and harvested almost ten months later on 4 April 2017. The Kula Agricultural Park is in a dry environment and TLB did not occur. Statistical analysis of variance was conducted on fresh weight corm yields (pounds per acre), percent dry matter, and percent rot.

Results. No significant differences were found in fresh weight corm yields among the five taro varieties, probably due to high variability among plants in only two blocks (Table 6). No significant differences were found among the five varieties in percent dry matter or percent of corm rot among the five varieties, probably due to high variability in plants among only two blocks.

Table 6. Fresh weight (FW) yield (pounds per acre, lb/ac), dry matter (% DM), and corm rot (%) of five taro varieties harvested in Kula Agricultural Park, Maui Island on 4 April 2017.

Variety	FW Yield, lb/ac	SE	% DM	SE	% Rot	SE
1003-3	14,858	7,865	28.3	0.8	8	8
1005-35	13,387	647	25.2	3.7	0	0
1005-66	6,761	120	24.7	2.5	46	18.6
1005-84	14,386	1,840	25.7	0.8	0	0
Maui Lehua	7,001	104	20.2	4.2	10.8	10.8

Figure 6. Agent Robin Shimabuku in a plot at Kula Agricultural Park containing 30 plants of taro variety 1003-03 at approximately three months after planting.

Island of Molokai:

On 17 December 2015, a taro trial was installed with three taro varieties (1003-3, 1005-35, and 1005-66; Figure 7) and two control varieties (Bun Long and Lehua Maoli) in three blocks. Vegetative propagules ('huli') were planted at a spacing of 2 x 5 ft. in plots containing 30 plants. There were an insufficient number of 'huli' to include variety 1005-84. No TLB was observed. The trial was harvested in November 2016.

Figure 7. Taro varieties (left to right): 1003-3, 1005-35, 1005-66, and 1005-84.

Results. Fresh weight corm yield was greatest for control variety Bun Long, followed by taro variety 1003-03 that did not differ from the greatest (Table 7). Fresh weight corm yield was lowest for variety 1005-66 followed by the second lowest yield for control variety Lehua Maoli; these two varieties did not differ from each other in yield. Results of soil nematode counts from one plot of each variety showed large differences among plots (Table 8). Statistical analysis was not conducted, since only one plot of each variety was analyzed.

Table 7. Fresh weight corm yields in pounds (lbs) of three new taro varieties (1003-03, 1005-35, 1005-66) and two control varieties (Bun Long and Lehua Maoli) grown on Molokai.

Variety	Mean Corm Wt., lbs	+
Bun Long	4.27	a
1003-03	3.78	ab
1005-35	3.15	bc
Lehua Maoli	2.60	c
1005-66	2.38	c

+Means followed by the same letter do not differ statistically at 95% probability level.

Table 8. Post-harvest soil nematode count (spiral, lesion, root-knot, and reniform) of plots containing three new taro varieties (1003-3, 1005-35, 1005-66) and two control varieties (Bun Long and Lehua Maoli) grown in Molokai.

Variety	Spiral	Lesion	Root-knot	Reniform
1003-03	85	66	85	208
1005-35	132	123	161	1239
1005-66	57	27	38	388
1005-84	9	27	66	397

Lehua Maoli	0	0	9	19
Bun Long	19	47	9	558

Island of Oahu:

On 19 January 2016, six taro varieties (1003-3, 1005-35, 1005-66, 1005-84, Maui Lehua, and Bun Long) were planted in three blocks in a randomized complete block design at Waimanalo Research Station. Spacing of plants were 2 x 2.5 ft. in plots containing 30 plants. Taro leaf blight was not a major problem and no ratings of TLB were taken. Weeds were a major factor reducing yield in this trial. On 2 November 2016, after almost 10 months, corms were harvested (Figure 8), fresh weights determined, corm rots removed and weighed, and a subsample taken for percent dry matter determination.

Results. Variety 1005-66 had the greatest incidence of corm rots (71%) and 1005-84 had the lowest incidence of corm rots (3.1%). No significant differences among varieties were found for fresh weight corm yields, with an overall average of 4,690 pounds per acre.

Figure 8. Corms harvested from one block at Waimanalo Experiment station on 2 November 2016, from left to right: Maui lehua, Bun Long, 1005-84, 1005-66, 1005-35, and 1003-03.

On 20 October 2016, a replicated field trial was installed with all nine promising taro hybrids and the control variety Maui Lehua in three blocks. However, plants did not grow well in this area, perhaps due to lack of pre-plant liming. On 9 June 2017, seven taro hybrids (1003-3, 1003-13, 1005-35, 1010-16, 1024-209, and 1025-299) and the control variety Maui Lehua were planted in four blocks in a new area (Figure 9).

Figure 9. Farm manager Roger Corrales in front of a trial of seven promising taro hybrids planted on 9 June 2017 at the Waimanalo Experiment Station on Oahu.

Goals and Outcomes Achieved

Summary of Results:
Fresh weight corm yields of new taro varieties varied between islands (Table 2). Either Maui Lehua or Lehua Maoli were planted in each replicated trial as a control variety. Variety 1003-03 ranged from 10% lower yield on Kauai to a doubling of yield on Maui in comparison to the control variety. Variety 1005-35 ranged from 20% greater yield on Molokai to 90% greater yield on Maui compared to the control variety. Variety 1005-84 ranged from 10% lower yield on Kauai to a doubling of yield on Maui and Oahu in comparison to the control variety. The other five new taro varieties are either being multiplied for inclusion in a replicated trial or are currently in a replicated trial. Variety 1005-66 had significantly greater percentage rot at both Kula Agricultural Park (on Maui) and Waimanalo Research station (on Oahu) and should be discarded.

Data has been obtained on evaluation of three to four new taro varieties across the major Hawaiian Islands. Taro varieties 1003-03, 1005-35, and 1005-84 appear to be promising. Taro variety 1005-66 appears to be susceptible to corm rots on the Islands of Oahu and Molokai, and should be removed from future trials.

Beneficiaries

On-farm trials are one of the best ways to disseminate information. On Kauai, two taro growers cooperated to evaluate four taro varieties under wetland conditions. On Maui, two growers cooperated to evaluate four taro varieties; one grows taro under wetland conditions and one grows

taro under dryland conditions. On Maui, members of the public were allowed to taste four new varieties (see PDF of poster in Additional Information) at the Maui AgFest in April 2017.

Continuation and Dissemination of Results:
This project succeeded in developing a team of extension agents and University of Hawaii farm managers across the state with experience in growing and evaluating new taro varieties for yield, corm rots, resistance to Taro Leaf Blight, and consumer acceptance. Promising taro varieties were distributed to four cooperating farmers to evaluate these new varieties. The public at Maui AgFest were invited to taste these new taro varieties.

Lessons Learned

Only nine new taro varieties were multiplied in tissue-culture, due to problems of contamination. Of these nine taro varieties, only three to four promising ones were evaluated in replicated field trials across all the major Hawaiian Islands during the period of this project. Taro is a to 13-month crop, and it takes time to multiply sufficient vegetative propagating materials for a replicated field trial on each island. On the Islands of Hawaii, Oahu, Maui, and Molokai, field trials of three to four new varieties were established with two to three replicated blocks. This number of blocks were too small to demonstrate statistically significant results, except on Molokai. On the Islands of Hawaii and Oahu, field trials with three to four blocks have been established with almost all the new taro varieties. On the other islands, more vegetative propagules of taro need to be multiplied to establish field trials with a greater number of blocks.

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Additional Information

Promising, New Disease-Resistant Taro Varieties

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University of Hawaii at Manoa, Dept. Tropical Plant & Soil Sciences, Dept. Plant & Environmental Protection Sciences

Maui lehua Bun long 1005-84 1005-66 1005-35 1003-3

State-wide trials of promising new disease-resistant taro varieties are being conducted.

Funding provided by the U.S.D.A. Specialty Crop Research Initiative through the Hawaii Department of Agriculture.

Variety	Yield, lbs/ac.	% Corm rot
1005-84	7,425	3
Bun long	5,195	19
1003-3	5,245	5
1005-35	4,165	10
Maui lehua	3,427	8
1005-66	2,377	71

Table 1. Yield (pounds per acre) and incidence of corm rot (%) of six taro varieties grown at Waimanalo, Hawaii during 2016 (low incidence of TLB). Yields did not differ significantly, although 1005-84 had the highest fresh weight of corms. Incidence of corm rots was greatest for 1005-66 compared to all others, indicating that this variety is susceptible to soil-borne diseases.

1005-84

1003-3 1005-35 Maui Lehua

Table 1. Percent (%) incidence of Taro Leaf Blight (TLB) in first three leaf blades of four taro varieties grown at Pepeekeo, Hawaii during 2016.
1003-3 had the lowest incidence of TLB, indicating resistance to this disease.

Variety	% TLB
1003-3	24
1005-35	33
1005-66	44
Maui lehua	54

Statewide Hawaii-Grown Cacao Month Initiative to Provide Outreach, Public Awareness, Farmer Assistance and Education Resources

Final Report

Hawaii Chocolate Association*
https://hawaiichocolate.org/
*The Hawaii Chocolate Association is in the process of renaming the non-profit as the Hawaii Chocolate and Cacao Association as shown on the website.

Project Summary

The Statewide Hawaii-Grown Cacao Month provided outreach, farmer resources and educational opportunities to cacao specialty crop beneficiaries and increased public awareness of this highly valued commodity. The project solely enhanced the competitiveness of cacao with the goal of stimulating an increase in acres of cacao planted, providing guidance for growing cacao and generating sales for Hawaii-grown cacao.

The program was timely as it provided outreach and resources for farmers and potential farmer that would not have otherwise happened. The project provided the Hawaii-grown cacao industry a way to increase interest through the cacao network to gain and share information and resources as the cacao community grows. The project provided a platform to focus public awareness on the crop, supported the efforts of the farmers and showcased cacao, specifically promoting the Hawaii-grown cacao to encourage sales of the value-added products.

The project has the economic potential to parallel the success of the coffee industry through the branding of the unique Hawaii-grown product. The project was timely as indicators alert of a chocolate shortage in the future and Hawaii-grown chocolate needs to position the industry now by getting acres in the ground. (https://www.theguardian.com/lifeandstyle/2014/nov/21/cocoa-crisis-world-chocolate-stash-melting-away) Project staff worked to build and grow a community of farmers to support the demand for local cacao as the industry simultaneously promoted and cultivated Hawaii-grown cacao as a high-quality brand. This required creating a network of farmers who understood how to grow and process a consistently high quality cacao crop. It was imperative that the Hawaii cacao industry maintain a high profile for the crop, as many may not know it is a viable crop and therefore will not even consider planting or have the resources to be successful in doing so. This project built upon previously funded programs by complementing and enhancing the previous work by proving the creation of information pieces and collateral materials. It was a driving force and continuity to grow the nascent industry as it struggles to gain a foothold.

Project Approach

The project spanned six islands and targeted growers and potential growers and consumers of Hawaii grown cacao by providing educational outreach events to stimulate the cacao industry in Hawaii. Specific critical educational materials were created in conjunction with industry stakeholders and provided to the public at large and specific target groups. At each venue the project provided only

Hawaii-grown nib, bean and chocolate sampling, pod and tree displays. There were displays and distribution of literature about the cacao crop, including contact information for industry professionals for guidance in planting/growing new and additional acreage as well as educate the public about this high quality specialty crop.

In early 2016, awareness of the current status of the industry was shared with the stakeholders. The industry reported that in 2014 the statewide harvest was 38,600 lbs. dry beans. The 2015 statewide harvest was 32,000 lbs. dry beans. Two likely reasons for the decline: Dieback from strong south west winds in February and March that defoliate trees during the harvest and black pod disease in East Hawaii Issues like weather and disease make it even more important to reach out and tie the current and potential cacao stakeholders more closely exemplifying the need to continue projects like this one that share information.

The project manager concluded that without this project, the industry would see much slower growth with a significant loss of public awareness. It is recommended that support of this type of campaign continue as the farmers alone cannot allocate their time or do not have the ability to facilitate such programs and need a catalyst to oversee and keep the industry efforts on track. Project staff ensured that the funds were specifically used to solely enhance the cacao crop by keeping the activities strictly to the activities of Cacao Month.

The University of Hawaii`s College of Tropical Agriculture and Human Resources (CTAHR) collaborated with the project manager to create and verify the accuracy of information for the project prior to printing collateral materials. In addition, Derek Lanter of Waialua Estate Chocolate on Oahu and President of the statewide cacao trade association also contributed by providing directives as to what materials would be the most meaningful to the industry.

Other supportive roles included project partners on Kauai - Hanapepe Economic Alliance provided workshop venues and display opportunities at the Kauai Chocolate and Coffee Festival. On Maui - Maunawai Estate Chocolate conducted tours and tastings. In Hilo - Hilo Shark's Chocolate conducted cacao tours and demonstrations. On Oahu - Manoa Chocolates conducted tours and demonstrations.

The Hawaii Restaurant Association had a change of leadership during the project time period and did less than hoped however several of their key chefs one from Mac 24/7 demonstrated and promoted Hawaii grown cacao and featured the chocolate recipes made with Hawaii-grown cacao in his restaurant for the month. Chef Ronnie from Tiki's Grill and Bar also created specific dishes featuring locally grown cacao. The success story however was that the chefs developed relationships with the farmers bring local cacao from bean-to-bar and are now sourcing locally grown chocolate for their menus.

Goals and Outcomes Achieved

The project accomplished the goals : 1) Achieving a presence on each island among potential and existing cacao farmers; 2) Creating a catalyst to contact and catalog potential and current farmers; 3)

Generating media focus, exposure and coverage; 4) Solidifying industry focus on the need to develop better communication tools to help move toward industry sustainability; and 5) Resulting in the production of materials and procedures to entice, engage and groom potential cacao farmers and educate the public.

Goal: *To raise awareness of the cacao industry among the Hawaii Chocolate Association members and industry stakeholders during the project period.* **Performance Measure:** Project staff will conduct pre and post month questionnaires of at least 30 known industry entities and request their responses to cacao related questions. **Benchmark:** The information obtained in advance will be used as the benchmark and measured against post results. **Target:** at least one-third of the participating stakeholders will report improved industry awareness as a result of the project.

Project staff distributed the questionnaires, however, the goal to conduct the pre- and post-October surveys as not met as the staff were not successful in collecting the results. Industry stakeholders verbally confirmed their improved awareness and attendance at the activities exceeded 13,000 statewide, which can be a measure of increasing awareness of Hawaii-grown cacao during the project period. The activities that were completed in order to achieve the performance goals included conducting coordinating and/or executing activities at the following locations with attendees noted in parentheses. The Statewide Hawaii Grown Cacao Month confirmed existing farm tours to be included in the calendar and coordinated booths at the farmer's markets and public and ticketed events specifically promoting the specialty crop of cacao.

County (Island)	Event(s)	Date 2015	Participants
Maui (Maui)	Maui Mall Farmers Market	October 9	175
	Maunawili Farm Tours	October	63
Maui (Lanai)	Dole Park Open Market	October 31	60
	Fifth Friday Lanai	October 30	150
	Alberta's Farm and Cacao Presentation	October 31	3
Maui (Molokai)	Molokai Saturday Market	October 10	75
	Mawae Farm Site Inspection and Tour	October 11	5
Kauai	Kauai Chocolate and Coffee Festival	October 23 & 24	1265
	Steelgrass Farm Tours	October	38
	Industry Conference	October	67
Oahu	Hawaii Chocolate Festival	October 16, 17 & 18	1365
	Food and New Products Show	October 17	9823
	Manoa Chocolates Factory Tour	October	71
Hawaii Island	Hilo Farmers Market	October 3	500
	Hilo Sharks Farm Tours	October	41
	Home Tours Hawaii – Cacao Farm	October	33

The project promoted Hawaii-grown cacao and chocolate via publicity and advertising that added to the overall results. According to Dateline Media Tracking report media coverage provided 615,482 impressions with ad value of $51,635.26 and publicity value of $154,905.78.
Goal: *To raise awareness among youth (12 - 18 years old) about the cacao industry*; **Performance Measure:** Project staff will conduct a pre-and post-evaluation of participating youth at the point of activity to determine an increase in knowledge. **Benchmark:** The information obtained in the pre-evaluation will be used as the benchmark and measured against post results. **Target:** It is expected that at least one-half of the participating youth will gain a 25% increased knowledge about the industry.

Project staff noted that the goal to have least 50% of the participants increase their knowledge of the crop by at least 25% was achieved. Staff noted that it was probably closer to an increase of knowledge by 50% as most had never seen the pods, trees or beans before and had no idea that the crop grew in Hawaii. Evidence that this was accomplished was that staff, at each location, provided information sheets for take home (approximately 2,000 distributed) and also engaged with youth participants verbally asking a variety of leading questions to determine their knowledge level to determine a baseline which was noted and then following up with the correct answers as well as provided information sheets for take home. Project staff also provided educational coloring sheets for younger children to work on during these engagements and for take home.

Goal: *To provide growers with information and support for their cacao related business.* **Performance Measure:** Project staff will measure the number of participants in the workshops/seminars conducted. **Benchmark:** The number growers invited as a benchmark. **Target:** It will be expected that at least one-third of the invited participants will attend the workshops/seminars conducted.

This was accomplished by the many public events and further supported with the results of the media tracking service. Potential and existing cacao farmers were invited to participate via direct mail, email, promotion and advertising. The project manager has determined that 100% of the known local cacao growers were contacted and were aware of the opportunities to learn and grow their business as they were invited to participate. This outcome is based on efforts to contact every grower on a list provided by a vast group of resources including: the University of Hawaii College of Tropical Agriculture and Human Resources, information found on the internet and phone book, existing membership lists, and via referrals from industry leaders.

The project staff achieved the goal to one-third of the 86 of the known active industry stakeholders were specifically invited to attend the industry conference with 64 guests attending workshops that covered a variety of issues including how to start a cacao orchard, how to combat common pests such as rose beetle for example. As a result of the project informational materials have been created for the industry in conjunction with the HDOA showing the HDOA logo in support of the industry. These informational materials are accessible to all through the trade industry. This project was the catalyst to creating materials in the form of frequently asked questions, guide to making chocolate, information on why to support Hawaii grown cacao and discussion on how to creating a best practices guide to

further the industry. Thousands of industry supports and potential cacao farmers were exposed to the benefits of the crop.

Educational workshops were also held at the Kauai Chocolate and Coffee Festival featuring cacao expert guest speakers Tony Steelgrass from Steelgrass Farm and Skip Bittenbender from CTAHR who addressed the audience to share their industry experience with potential growers as well as doing comparison chocolate tastings of locally grown cacao among the islands to showcase the range of flavors and quality. More than 50 potential and existing cacao farmers participated at each workshop. Additionally, five chocolate companies featuring Hawaii grown cacao participated by providing free samples of Hawaii grown chocolate including Waialua Estates, Manoa Chocolate, Aloha Chocolate Company, Moloa`a Chocolate, Isola Chocolate. Funding for their travels was privately financed.

Among the outstanding results in increased sales was reported from Manoa Chocolate at that they sold more chocolate at the Kauai Chocolate and Coffee Festival than they did when they travelled to the Southwest Chocolate Festival in Seattle where 20,000 people attend. These kinds of stellar results were reported by most participants and further confirmed by their confirmed participation for the 2016 event.

Tracking results for the activities above were a combination of methods including visual tracking through observation and guest counts conducted. In the case of farmers markets these were estimated impressions, as there were no official guest counts.

Beneficiaries

The project provided support to the small farmers and businesses that may not have the marketing expertise to garner necessary exposure or create meaningful programs. This project allowed them to specialize on what they do best, growing, processing and/or manufacturing cacao and provided them with professional assistance to support the industry allowing them to grow their individual businesses.

Additionally, many of the cacao farmers and potential farmers exposed were located in Congressional District 2, which is considered rural, as there is significant acreage there. The project provided information for beginning farmers regarding the cultivation of cacao and information and resources for current farmers regarding processing and promoting.

Growth of the industry can have a huge economic impact on job creation, exports, tax revenue and more. According to an October 11, 2012 article in the *Huffington Post* "it is estimated that the demand for cacao will outstrip supply by one million metric tons by 2020." If Hawaii-grown cacao, through this project, can capture even a small portion of this business, it will be significant.

Direct beneficiaries of the project activities were the 86 members of the Hawaii Cacao and Chocolate Association that include farmers who participated as well as producers and friends of the industry as they benefit from the increased interest and exposure from the events promoting Hawaii-grown cacao from which local chocolate is made.

On each island project staff secured contact information from at least one potential new farmer that will consider growing cacao as a new crop or expanding their existing cacao production. Project staff also facilitated and conducted site inspections on each island for potential growers or farmers looking to expand their crops of cacao. Several industry participants noted that they were encouraged by the activities presented by the project which provided more confidence that cacao products will have a market if current acres are expanded or new acres planted.

These efforts provided an opportunity to engage consumers and educate them on the benefits of growing, supporting and buying locally grown cacao verses other foreign chocolates and why it may cost more is because of the quality and benefits of this local specialty crop.

Potential growers will benefit from the increased awareness of Hawaii-grown cacao. According to CTAHR Survey, in 2014, acres of cacao planted by island were; 12 Maui; 17 Kauai; 33 Oahu and 34 Hawaii Island. The industry reported in 2015; 22 Maui; 27 Kauai; 38 Oahu and 55 Hawaii Island.

Other beneficiaries were consumers, who gained knowledge about this emerging industry and had the opportunity to meet the chocolatiers of Hawaii-grown cacao, learn how chocolate is made from Hawaii-grown cacao and also taste the superior quality.

Lessons Learned

One unexpected result was that the commitment provided by the Hawaii Restaurant Association was less than anticipated due to a change of leadership resulting in less exposure at the restaurant level than hoped. In the future project staff would ask to work with a committee within the organization rather than just a single contact point. Although the project did not have as broad of exposure in the restaurant industry, the project had representation and achieved results as noted.

Overall, the program was executed as planned. The only deviation from the projected timeline was the additional time necessary to calculate the results and generate the report since the time the actual project was completed was near the end of the contract period.

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Rooting of Papaya Cuttings

Final Report

Hawaii Agriculture Research Center (HARC)
http://www.harc-hspa.com/

Project Summary

Hermaphrodite papayas are the major commercial type grown in Hawaii because they self-pollinate, form full columns of 1.5-pound fruit, and are pyriform, a shape that fills packing boxes with the least waste of space. Seeds or seedlings are the major source of planting materials on the 120 papaya farms. The process of thinning to obtain hermaphrodite papaya trees consumes time and resources. It is possible to micropropagate hermaphrodite papayas, but it is costly and a laboratory or clean room with special equipment is required. In field tests, clonally propagated hermaphrodite plants, micropropagated and rooted cuttings of 'Rainbow,' were about 30% higher yielding and one to three months earlier bearing in the first-year harvest cycle (Fitch et al., 2005a, b). Therefore, this project proposed to increase the output of hermaphrodite rooted cuttings by improving growth of hermaphrodite stock plants and improving survival and rooting percentage of field clones with the use of drier soil and careful monitoring under fluorescent lights in a controlled environment. While rooting of hermaphrodite cuttings using shade-house grown, clean plants had an 80 to 90% rooting rate, despite multiple attempts, only a low percentage, five to 10% of rooted field cuttings, was obtained, and rooting of field cuttings as a major source of propagation material was abandoned. Rooted field cuttings were added to micropropagation-derived stock plants in a shade-house and all stocks were used as clean cuttings to root. This procedure resulted in sales of 650 (2015) and 1150 (2016) rooted plants to growers and homeowners compared to 100 rooted plants in the two previous years (M. Fitch, unpublished results). The procedure was shared at the annual Hawaii Papaya Industry Association meeting in Hilo on 23 September 2016 (see attachment, ~30 growers and associated business people in attendance), will be available on the HARC website, and will be taught at workshops at HARC on 27 January 2017 and in Hilo in March 2017.

Project Approach

The objective of this proposal was to improve the survival rate and rooting percentage of field-grown hermaphrodite cuttings in order to propagate sufficient numbers of plants for several acres of papayas and to develop a salable product that plant nurseries, by implementing the procedure, could use to increase revenues.

Initially a growth area at HARC equipped with fluorescent light racks was used to maintain hermaphrodite 'Rainbow' and 'Laie Gold' stock plants for making rooted cuttings. Cuttings made from the clean stocks were dipped in commercial rooting hormones (Hormodin 3), firmly potted in a peat/perlite mixture(Sunshine4 mixture), and grown sealed in Ziploc bags under cool white fluorescent lights with a 16 hr light/8 hr dark photoperiod. In 2012 when demand for hermaphrodite plants increased and the size of stock plants grew, the stock population was increased. The stocks were

moved to a greenhouse shared with other researchers at HARC where pests from various plants became a problem to control. Therefore in January 2015, at the initiation of this specialty crop block grant project, a shade-house dedicated to papayas was adopted where pest control (Admire Pro systemic insecticide/miticide every three to six months) and irrigation (twice daily for five minutes in summer, four minutes in winter) were more easily controlled. Fertilization with Osmocote 13-13-13 was every three months.

Cuttings made from the stock plants were dipped in the rooting powder, potted in the peat/perlite mixture, and grown sealed in Ziploc bags under fluorescent lights for about one month when pots were examined for roots emerging from drainage holes. Ziploc bags were opened, fertilizer applied, and the bags were place under the lights for about one to two more weeks or until full canopies of leaves were observed. When canopies were large and robust, the plants were removed from the bags and were moved to the shade-house until they were sold or repotted and used as additional stock plants. In the past, stock plants were maintained under fluorescent lights as well, but large numbers of rooted cuttings could not be made because sufficient numbers of stock plants were difficult to maintain under lights. The fluorescent light racks used to maintain stock plants and hermaphrodite rooted cuttings worked well for rooting a small number of plants, for example, experimental plants, but for the large number of commercial plants required by growers, a large population of stock plants is more easily maintained in a dedicated shade-house with automatic-timed irrigation, routine pest control, and fertilization.

Goals and Outcomes Achieved

Goal: Root field- and greenhouse-grown cuttings of hermaphrodite 'Rainbow' and 'Laie Gold' lines, to produce more plants to expand the technology and conduct at least one workshop on Oahu and on Hawaii Island.
Performance Measure: Root a minimum of 2,000 cuttings in the two-year project period.
Benchmark: The protocol has not been tested. Seed and seedlings will always represent the major planting material for most growers because seeds are now plentiful and the techniques are well-practiced. The clonal material, even if it is successfully propagated, will be a niche for very small growers and for growers who wish to make their own rooted cuttings to fill gaps resulting from female seedling removal. So far, no benchmarks have been established.
Target: To serve growers and nursery businesses in Hawaii with robust hermaphrodite papaya cuttings by using the dedicated shade house at HARC to be able to provide sunlight to the stock hermaphrodite plants for more vigorous growth and share the growing protocol with interested parties.

The performance measure, to root a minimum of 2,000 cuttings in the two-year project period was achieved. One thousand eight hundred (1800) rooted cuttings were sold to growers and homeowners, with the income reinvested into the project. Another 600 rooted plants make up the stocks and cuttings that await pickup by homeowners and growers in early 2017. A number of the plants will be used for the scheduled hands-on workshops on Oahu and Hawaii Island.

The rooted cuttings protocol has now been tested. Seed and seedlings will always represent the major planting material for most growers because seeds are plentiful and the techniques are well-practiced. The clonal material, even if it is successfully propagated, will be a niche for very small growers and for growers who wish to make their own rooted cuttings to fill gaps resulting from female seedling removal.

Since 'Rainbow' and 'Laie Gold' are genetically modified (GM) plants, agreements will be established with the University of Hawaii for the nurseries businesses to be able to sell the plants.

The goals have been achieved or will be in early 2017 when the workshops to train growers and nursery owners in the protocols will be conducted. Measurable short-term outcomes are/will be the number of farmers and nursery owners who attend the workshops to learn the procedures to root hermaphrodite papaya cuttings and to manage plants in a greenhouse until ready for planting/sale. The techniques that are the focus of this project and that will be shared at workshops and on the HARC website include the maintenance of healthy stocks in a papaya dedicated shade-house, making, potting, and rooting of cuttings. The long-term goal is to have private businesses, papaya growers and nursery owners, adopt the protocol to grow their agriculture businesses.

A first-time event, the Parade of Farms (see ATTACHED informational documents), was based at HARC on May 14, 2016. Visitors signed up for tours of the HARC fields, other agricultural endeavors like the rum factory, an aquaponics business, and the irradiator. At HARC, the researchers put on various displays and demonstrations of their projects. The papaya group that carries out the rooted cuttings project did hands-on demonstrations with visitors, let them cut and pot the shoots, placed the cuttings under the lab fluorescent lights, and were informed that hermaphrodite 'Rainbow' rooted cuttings were available for purchase. Sample fruit of 'Rainbow' and 'Laie Gold' were donated by the irradiator facility and growers for the visitors to purchase. Two large bowls of 'Laie Gold' fruit were prepared from donated ripe fruit and served as fresh chunks for sampling that day. About 30 rooted 'Rainbow' hermaphrodites were purchased by visitors.

An all-day workshop is being planned for March 2017 in Hilo. Ms. Jari Sugano, CTAHR extension agent on Oahu, is coordinating the workshop at HARC on 27 January 2017. Papaya growers and nursery people will be invited to participate. The workshop will commence at 9 a.m. with hands-on cuttings training, potting, and tour of the facility. Lunch will be provided. A tour of the HARC Kunia fields will conclude the workshop. At a later date, Mr. Clyde Fukuyama, Kahuku Brands, will host a field tour of the 500 rooted 'Laie Gold' cuttings that they purchased and planted in Kahuku. The first fruit were ready for sale in December 2016.

Beneficiaries

The members of the Hawaii Papaya Industry Association benefited from this project. The procedure was shared at the annual Hawaii Papaya Industry Association meeting in Hilo on September 23, 2016, where approximately 30 growers and associated business people attended. Two hermaphrodite

Rainbow plants were awarded during the meeting. Several growers expressed interest in the project and asked questions. A part-time nursery grower also expressed interest in undertaking the project in Hilo.

The procedure will be available on the HARC website, and will be taught at workshops at HARC on January 27, 2017 and in Hilo in March 2017, providing additional opportunities for the industry to benefit from the project.

An additional outcome is student/community agriculture education using this project. HARC serves the agricultural community with educational events throughout the year, for example, students attend an annual agriculture boot camp for a week during the summer. About 10 to 20 high school students have participated in this event every year for the past five years. The rooted cuttings protocol was demonstrated in hands-on sessions with the students before 2015 and in 2016. The first time the protocol was taught students left their cuttings at HARC and picked them up about two months later if they rooted. In 2016, the students made cuttings for HARC that were grown and sold to farmers and homeowners.

Lessons Learned

In the first year of the grant, 2015, survival and rooting percentage of field-grown cuttings from a cooperating grower were not improved by use of drier soil and careful monitoring of cuttings. Although more than 500 cuttings were potted in three different batches, the procedure still resulted in low survival and rooting, about five to 10%. Therefore, plans to continue field cuttings experiments were terminated and rooted cuttings from shade-house grown clean stocks were in turn made into stock plants. The field-grown rooted clones, selections made from the original field test in 1998 in Laie, performed well in replicated field tests in Laie, Kahuku, and Kahaluu (M. Fitch, unpublished results). Therefore eight of the original 11 clones are now maintained in the greenhouse and laboratory. Micropropagated plants from other experiments were added to the stocks in the dedicated shade-house. Problems with other crops' pests and pathogens were solved by having a papaya-dedicated shade-house. Hibiscus mealy bugs, white peach scale, and red spider mites became problems on the stocks that had been pest-free when maintained under fluorescent lights in a laboratory growth room. A routine three to six month pesticide treatment protocol was implemented with Admire Pro (imidochloprid) that controlled the pests. A few stocks contracted the scale insect and were successfully spot-treated with ethanol and dishwashing soap sprays followed by spraying and drenching with Admire to prevent spread of the infestation to healthy plants.

Overhead irrigation was decreased during the cooler, wetter late autumn and winter months because stocks and rooted cuttings were rotting from over-watering. Daily irrigation was switched from two times per day for five minutes each during the hot and dry summer months to four minutes each during the cooler, wet months. Stocks that were cut with no remaining leafy branches to utilize water were placed farther away from irrigation until new shoots emerged because they were rotting from over-watering.

Once cuttings were made survival was close to 100% unless shoots had hidden pests (scale) or were not vigorous then cuttings rotted. Roots formed in one to two months. A problem that surfaced was that plants were not sufficiently well-rooted with strong root systems for transfer to the shade-house where they dried or rotted, thus, only vigorous plants with leafy canopies were transferred to the shade-house. Weaker plants under fluorescent lights eventually became vigorous and survived well in the shade-house.

Hawaii Island growers have not yet requested the clonally propagated plants although they have been informed of HARC's project. The interest in 'Rainbow' on Oahu is not as great as in 'Laie Gold,' therefore 'Laie Gold' rooted cutting stock plants are being increased from about 120. Fewer 'Rainbow' stocks are maintained, about 70, but for the Hilo workshop in March, these plants are being increased to provide plants to growers for making cuttings during the hands-on demonstrations.

Contact Information

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Additional Information

Scans of the Parade of Farms flyer, HPIA meeting schedule, list of attendees to meeting from sign-in sheet, dates of educational outreach/student visits, dates of Seeds-4-Tomorrow science boot camp, description of activities.

2015-2016 Educational outreach at HARC

10 March 2015 LCC and WCC classes visited the lab. I did talks on transgenic papayas including rooted cuttings & displayed rooted cutting samples.

13 November 2015 gave a presentation to Dr. Heather McCafferty's LCC students on transgenic papayas including rooted cuttings & displayed rooted cutting samples.

22 January 2016 40 St. Francis High School sophomores came to HARC to learn about the project work. TKC staff gave a half hour presentation on the transgenic papaya and rooted cuttings work and other aspects of the research, showed them the rooted hermaphrodite plants, and let them taste Rainbow hybrid fruit from the educational garden.

18 February 2016 20 LCC students came to HARC to learn about the project work. I gave a half hour presentation on the transgenic papaya and rooted cuttings work and other aspects of the research, showed them the rooted hermaphrodite plants, and let them taste Rainbow hybrid fruit from the educational garden.

3 March 2016 gave a talk to St. Andrew's 7th grade students and their teachers on transgenic papaya, rooted cuttings and had some transgenic papaya for them to sample.

20 April 2016 Dr. Heather McCafferty's UH tissue culture class visited. I gave a talk on papaya transformation, on the rooted cuttings, and the group's other projects at HARC. Project staff served them some transgenic papaya fruit.

14 May 2016 HARC's Parade of Farms. The papaya group, comprised of three growers and researchers, gave talks on rooted papaya cuttings, transgenic papayas, and other projects with displays and photos of the projects to the HARC visitors during the Parade of Farms. Two large bowlsful of Laie Gold (LG) papaya were cut up for visitors to sample. The growers also donated 11 cases of LG for HARC to sell at $1 and 2/$1 at Parade. Supporters donated one case of Rainbow and 30 Rainbow rooted cuttings and some of the funds were put into this and other papaya projects. The funds from papaya sales were used to give $50 each to four volunteers who helped all day at Parade.

20 July 2016 Seeds 4 Tomorrow high school student 1-week summer agriculture camp at HARC: The group did a rooted cuttings/hands-on workshop with the 12 students to teach them propagation skills. Project staff organized the demonstration, got materials ready, and carried out the demonstration and training of the students during one of the five-day events.

9 August 2016 HARC Kunia Village blessing/lanai area lunchtime display. Project staff displayed photos and samples of *Papaya Ringspot Virus* infected trees, genetically engineered papayas, hermaphrodite and female papayas, and rooted cuttings for the visitors with placards to explain the photos and plant materials.

23 September 2016 Annual meeting of the Hawaii Papaya Industry Association gave talks on three areas of project work including rooted cuttings method.

Workshops are being scheduled for early 2017 to complete the scope of services. Ms. Jari Sugano is coordinating the workshop on Oahu, planned for 27 January at HARC. Mr. Ross Sibucao is coordinating the Hawaii Island workshop in Hilo, possibly March 2017. Invitees are papaya growers and nursery business people.

PARADE
Of FARMS
• CULTIVATING •
• COMMUNITY •
2016 Parade of Farms
Family Friendly Activities
and Tours
Saturday May 14, 2016
9:00 am to 6:00 pm
Hawaii Agricultural Research
Center - Research Facilities
94-340 Kunia Road, Kunia, Oahu
for more information:
www.oahurcd.org/parade-of-farms/
Presented by:

2016 HAWAII PAPAYA INDUSTRY ASSOCIATION CONFERENCE

09:00-09:30A **REGISTRATION**

09:30-09:40A **WELCOME**
-MR. KEN OGAWA
-HPIA CONFERENCE COMMITTEE CHAIRPERSON

09:40-09:55A **"UPDATE FROM THE COUNTY OF HAWAII"**
-MR. GLENN SAKO
-COUNTY OF HAWAII R&D AGRICULTURE SPECIALIST

09:55-10:10A **"HAWAII FARM BUREAU ASSOCIATION MEMBERSHIP"**
-MR. BRIAN MIYAMOTO
-HAWAII FARM BUREAU EXECUTIVE DIRECTOR

10:10-10:15A **"UHM-CTAHR COOPERATIVE EXTENSION"**
-DR. TED FEITSHANS
-HAWAII COUNTY ADMINISTRATOR

10:15-10:35A **20 MIN BREAK**-PLEASE VISIT WITH VENDORS & EDUCATIONAL BOOTHS

10:35-11:05A **"PAPAYA CUTTINGS DEMONSTRATION"**
-DR. MAUREEN FITCH
-HAWAII AGRICULTURE RESEARCH CENTER

11:05-11:20A **"JAPAN TRADE UPDATE"**
-MR. TOSHI AOKI
-HAWAIIAN FRESH PRODUCTS INC.

11:20-11:35A **"MARKET ACCESS TO CHINA"**
-DR. MARISA WALL
-USDA, ARS, DANIEL K. INOUYE, PACIFIC BASIN AGRICULTURE RESEARCH CENTER

11:35-12:45P **LUNCH BREAK & PAPAYA CONTEST**
-EMILIO DELARE 2015 WINNER OF LARGEST SOLO PAPAYA
-LORETO VALLENTE 2015 OF LARGEST RAINBOW PAPAYA

12:45-01:00P **"PAPAYA ZERO WASTE PROJECT"**
-DR. ANA HEURUX
-USDA, ARS, DANIEL K. INOUYE, PACIFIC BASIN AGRICULTURE RESEARCH CENTER

01:00-01:15P **"PAPAYA GERMINATION STUDY"**
-DR. ALYSSA CHO
-UNIVERSITY OF HAWAII MANOA-CTAHR

01:15-01:30P **FOOD SAFETY MODERNIZATION ACT-PRODUCE RULE**
-MS. SHARON MOTOMURA-WAGES
-UNIVERSITY OF HAWAII MANOA-CTAHR

01:30-01:45P **"AGRICULTURAL OPPORTUNITIES"**
-W.H. SHIPMAN LIMITED

01:45-02:00P **"LEGAL & SOCIAL ADVOCACY"**
-MS. LORIE FARRELL
-HAWAII FARMERS & RANCHERS UNITED

02:00-02:20P **20 MIN BREAK**-PLEASE VISIT WITH VENDORS & EDUCATIONAL BOOTHS

02:20-02:35P **"HAWAII'S AGRICULTURAL CONCERNS"**
-REP. CLIFTON TSUJI
-HAWAII STATE REPRESENTATIVE (DISTRICT 2)

02:35-02:50P **"REMOTE MONITORING & MANAGEMENT SOLUTIONS"**
-MR. RICK ABORDO
-VERIZON BUSINESS ACCOUNTS

02:50-03:00P **CLOSING**
-KEN OGAWA

03:00-03:30P **GENERAL MEETING**

04:00-06:30P **PAU HANA-SOCIAL HOUR**

MAHALO TO OUR HPIA 2016 CONFERENCE SPONSORS:

YOUNG BROTHERS

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The Hawaii Papaya Industry Association Growers' Conference 2016

Friday, September 23, 2016
9:00AM-6:30PM
Nani Mau Gardens & Restaurant
Hilo, Hawaii

Who we are

Our Seeds 4 Tomorrow program is a joint effort between local food producers, entrepreneurs, engineers, scientists, and the culinary arts communities. Our group of experienced agricultural professionals engage students in a fun, hands-on learning experience that exposes them to the wide variety of agricultural job opportunities available for them here in Hawaii.

Our Mission

At Seeds 4 Tomorrow we are training the next generation of farmers, researchers, conservationists, and agricultural entrepreneurs – or as we call them - Agriprenuers. We recognize the need for locally grown food and agricultural products to support a sustainable and viable agricultural future for Hawaii.

Contact Us!

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808.621.1361

HARC

Location of Hawaii Agriculture Research Center

SEEDS FOR TOMORROW

Seeds 4 TOMORROW

Cultivating the Next Generation of

Agriprenuers

Hawaii Agriculture Research Center
July 18 - July 23, 2016

Day 1

Sustainable Agriculture and Conservation

We will kick off our camp with an introduction to the fundamentals of sustainable agriculture. Students will learn about their ahupua'a (watershed) and how we can care for the ecosystem services they provide.

Day 2

Research, Cultivation and Agroforestry

Students will get their hands dirty as they delve into the botanical and biological world. They will engage in plant and insect identification and anatomy through hands-on activities around the farm.

Day 3

Crop Improvement and Propagation

Agricultural professionals will teach students common propagation techniques used in agriculture such as cuttings, grafting, and tissue culture. Students will use genetic markers to differentiate DNA between plant cultivars which might have differences in flavor, yield and disease resistance.

DATES

JULY 18 - JULY 23, 2016

TIMES

M – F 8:00 AM - 2:00 PM
SATURDAY 8:00 AM - 10:00 AM

LOCATION

HAWAII AGRICULTURE RESEARCH CENTER
94-340 KUNIA ROAD, WAIPAHU

COST

$50 PER STUDENT
SCHOLARSHIPS AVAILABLE!

WHO CAN APPLY?

OPEN TO ALL STUDENTS IN GRADES 7TH TO 11TH IN HOMESCHOOL, CHARTER, PUBLIC AND PRIVATE SCHOOLS.

APPLICATION DEADLINE:

JUNE 27, 2016

Day 4

Plants to Products

Many of the products we use each day are derived from plants! We will have a chance to take raw plant materials and process them into various products such as coffee, chocolate, biofuel, and fabrics.

Day 5

Young Agriprenuer Day

The next generation of agriculturalists in Hawaii will be producing food and products through innovation and rapidly changing technology. On this day we will introduce students to agricultural business entrepreneurship, and support them as they develop their own business and products using the tools they have learned throughout the week.

Day 6

Business Competition

The culmination of our week. Our Saturday event is sure to be the most exciting day of the camp as our students become young "Agriprenuers" and present their focused businesses to their peers, parents and other farmers! We highly encourage students to invite their friends and family to this fun event!

Phase II of Tea Propagation Initiative – Strategic Propagation for Tea Hubs

Final Report

The Tea Chest
http://www.teachest.com/

Project Summary

This project continued work done in Phase I to increase tea plantings around the state and test the crop on different islands. Small niche growers prefer the crop diversity from seedling propagation. Growers with commercial capacity prefer plant material propagated from cuttings. However, a nursery system to root cuttings did not exist prior to this project.

This specialty crop is now growing on five of the main Hawaiian Islands because of this project. This project added to plantings on Oahu, Maui, Kauai and Hawaii Island in addition to the plantings in Phase I on Molokai.

This project helped spur the formation of Tea Hubs, cooperative groups of growers that can work together to produce a larger aggregate volume of tea.

Numerous sustainable and organic methods continue to be used to grow to the crop statewide.

Project Approach

Four farms from Phase I agreed to act as nurseries to propagate rooted cutting for other growers in the project. These farms were located on Oahu, Maui, Molokai and Hawaii island.

Having a nursery to feed plants to growers on their respective islands eliminated logistical costs and reduced the carbon footprint of the project in comparison to shipping plants from a nursery on one island to growers on other islands. That was the model in Phase I.

Localizing nurseries in each growing region eliminated the transference of invasive species and diseases from one island to another when plants were shipped interisland.

Climatic conditions varied island to island. Therefore, propagating on-island allows the plants to better acclimate to their respective growing conditions.

Potential Tea Hubs were identified around the state. These hubs would be comprised of growers in geographic proximity to each other with the intent to assist each other to achieve semi-automated and fully automated production which would require larger investments but also help to achieve greater efficiencies and higher output volumes.

Areas identified as potential hubs consisted of one in upcountry Maui, one in leeward Oahu, and one central Molokai. Two hubs were identified on Hawaii Island in Kona and another in the Mountain View-Volcano area. Workshops and meetings were arranged so growers got to know each other better and learn from each other.

A goal of this project was to foster relationships among the growers with the intent that they will assist each other and collaborate with one another other to move the crop forward. Growers were encouraged to contact one another outside organized project activities. The culture of the project was to be willing to help one another. Growers not willing to collaborate were not selected for the project.

This project sought to diversify the scope of how tea is grown in Hawaii and provided opportunity for communities on multiple islands to expand their working knowledge of tea. This project encouraged the use of a variety of farming techniques including conventional, organic, biodynamic and understory cropping. And, because of this project, tea is now growing in a variety of places with compelling stories that potentially lift their market values and the brand equity of tea from Hawaii. For example, Kona is well-known for its coffee production which tea from the region might be able to capitalize upon.

Another example is Haleakala is a well-known mountain. High elevation is a valued asset for tea. This project increased the number of plants being grown on the slopes of Haleakala between 4300-4700 feet above sea level.

Goals and Outcomes Achieved

Goals (met, nearly met or not met)	Outcomes Achieved
1. Four nurseries established - not met	Three failed by end of Year 1
2. Establish 28,800 new tea plants - nearly met	25,830 plant starts statewide 6,000 plants for Oahu 8,830 plants for Hawaii island 8,500 plants for Maui 1,500 plants for Molokai 1,000 plants for Kauai
3. Establish 4.5 acres of new tea - nearly met	4.3 acres of new crop statewide
4. Educate, support and foster community among growers - met	Propagation workshops on Oahu and Maui Grower meetings on Maui, Oahu and Hawaii Farm tours on Maui and Oahu

1. Establish four nurseries
This goal was not met for three reasons.

- By the end of Year 1, nurseries on Molokai, Oahu, Maui, and Hawaii island were struggling. The crop on Molokai was challenged by Chinese Rose Beetles eating the plants. Elevation and alternative plants to eat have proven the most successful way to overcome rose beetle infestation. Unfortunately, neither of these alternatives materialized on Molokai.

- A fungus was detected on the plants on Oahu. It was tested and treated with help from the staff at University of Hawaii's Poamoho Research Station but the fungus damaged the size of the plants. The disease slowed the rate of propagation.

- The nursery in Kona (Hawaii island) lost its plant material due to extremely hot and dry conditions linked to El Nino.
- The Maui site was hit by hurricane force winds which toppled their propagation shed and benches.

2. Establish 28,800 new tea plants
This goal was nearly met. 28,830 plant starts were achieved by this grant despite early setbacks. 1000 new plants were established on Kauai, an island that originally did not have an active grower in the project. The crop is now being grown on commercial farms on five islands because of this project.

3. Establish 4.5 acres of new tea
This goal was nearly met. A total of 4.3 acres of new crop plantings will be achieved by the time the last cuttings reach adequate size to be transferred to field. This is based on 6,000 plants per acre.

4. Educate, support and foster community among growers
This goal was met. Growers met on Oahu to attend propagation workshops at the University of Hawaii's Poamoho Agriculture Research Station. Farm tours were held on Oahu and on Maui at two project sites. This provided valuable sharing and learning to take place between growers.

A first-of-its- kind strategic planning meeting was held on Maui to map the formation of a working group with the goal of bringing finished tea to market.

Tea tastings and product demonstrations were held at The Tea Chest as growers came to/through Honolulu. The goal of these tastings was to familiarize and educate farmers on how tea is evaluated as a product assigning market value to characteristics such as color, taste and aroma.

Beneficiaries

32 – Existing tea growers in the state
10 – Farms in the project
5 – Islands in Hawaii now growing tea

Growers:

ISLAND Name	**Farm Name**
Hawaii	
Louis Britos	Hawaii Mountain Farm
Manny Ochoa	Budda's Sanctuary
Eliah Halpenny	Big Island Tea
Bill Dwyer	Kona Mountain Coffee

Oahu	
Lyle Roe	Fat Law Farms
Maui	
Alex de Roode	Maui Tea Farm
Diana Crow	Ulupalakua Ranch
Molokai	
Mark House	Pu'u O Hoku Ranch
Patty McCartney	Pualani o Molokai
Kauai	
Aaron Moeller	Naikela LLC

Lessons Learned

Select experienced and interested farmers. Growers in this project had much farming expertise and passion for the crop. Three growers faced personnel challenges during the project which could have severely jeopardized the outcomes. A grower who spearheaded the nursery on Molokai passed away unexpected. A grower on Oahu pulled back because of they did not have enough farm labor. One grower on the Big Island had a heart attack which curtailed his activity for six months.

The outcomes of this grant were achieved because of the willingness of the growers to learn new techniques and to take on more responsibility. There continues to be a steep learning curve for the crop. Growers must continue to learn how to propagate, cultivate and scale the crop in their given climate and location.

Attrition of active growers from Phase I to the completion of Phase II was 60%. There are a variety of reasons for drop-off. The crop failed in some locations for various reasons including climate, disease and pests. Some farmers chose not to continue because scaling the crop proved to take more resources than expected or that they were willing to commit.

Lessons from Outcomes 1, 2 and 3.

The change from central nurseries to a decentralized propagation model proved beneficial. The model increased hands-on learning by project growers which in turn increased each island's knowledge base for the crop. For example, one grower on Oahu established a nursery of mother plants from Phase I and continued to successfully propagate cuttings from those plants for this project. He had never done this type of propagation with his other crops.

Research was done on tissue propagation with the Hawaii Agriculture Research Center (HARC) as a solution to overcome early setbacks at the nurseries and to speed up propagation of plant material. However, it was concluded not to go in this direction because the $2.50 cost per plant was beyond the project's budget. Consensus amongst project growers was that tissue propagated plants would not be as strong compared to seedlings or rooted cuttings.

The project shifted away from the centralized nursery model and directed propagation to the individual farms. New propagation techniques developed by Jari Sugano and Jensen Uyeda at the University of Hawaii (UH) made it easier for the growers to produce their own plant material. This method proved faster because multiple nodes could be taken from one shoot to make cuttings. This method was more cost effective because less labor and materials were required. The system consisted of hormone dip, large pots and a misting system. It did not require construction of a hoop house and misting system as previously devised by UH.

Propagating on other islands other than Hawaii island was achieved for the first time. This allowed the crop to better acclimate to the specific growing conditions of each island. The decentralized model eliminated logistical costs to ship plants from one island to another. The one exception was with the introduction of the crop on an organic farm on Kauai.

Lesson from Outcome 4.
Emphasis from day one of the project on the willingness to work with other growers to move the industry forward is paying off in the formation of the Tea Hubs.

Decentralized propagation also provided more opportunity for the growers to network and grow in relationship with each other. This dynamic helped support the Tea Hub model.

One driver for Tea Hub formation is synergy. For example, one grower has expertise or a resource and is willing to share said expertise or resource with the group. The output of the collective then becomes easier to produce and/or greater in total than if each grower worked independently. This was the case on Maui where by one grower felt they could help the group as a processor while the other grower wanted to focus on propagation and growing.

Tea hubs are also more likely to form when growers in the group have mutually shared values, risks and goals. A relationship is forming between a grower on Oahu and a grower on Hawaii island because they mutually want to learn from each other about the other crops each farm is growing.

Project growers at this stage want to learn about how to come to market with finished tea. Two growers proved the crop can start producing finished tea within three years of propagation. These two growers crudely dried samples of tea to taste. It now has been proven that the varietal selected for this project can produce finished tea with some good attributes in color, taste and aroma.

Another way to incentivize the formation of a tea hub is to spur product development which the project staff hope to do in the next phase. Growers are willing to invest in tea because they want to continue to earn a living as a farmer. They want to maintain their lifestyle “rooted” in agriculture. They view tea as a new revenue generating crop. Growers share in the common goal of developing mutually beneficial finished product to sell.

The group on Maui see the opportunity and want to work together to make tea grown on Maui a successful product. They share the common goal that being successful with tea is a way to maintain the agricultural community on the island.

The tea hub on Maui leads the way in the development of the tea hubs because the relationship between growers on that island has developed more quickly ahead of the other groups. Tea is a more complex crop to bring to market compared to a crop that is simply picked, washed and shipped. It helped the Maui group that one grower has a history with value-added production and food manufacturing and shared their experience with the group.

A first meeting was held on Maui to present an overview of steps to value-added production, operations of a processing center, equipment needs and strategic investments. This was a very preliminary yet very important first meeting with the intent to form a working group. Growers were educated with the steps to bring the crop to market through a presentation by the Project Manager.

Next steps for would be to reach a working agreement outlining the roles and responsibilities to take the crop from farm to processor to market. Growers can also work with the Project Manager to educate growers on other islands to gain more insight to the value-added production of tea.

The crop must go through significant value-added processing compared to the crude taste tests that have been done up to this point. However, it is promising to know that the crop can produce finished products such as drinking tea, nutritional additives, cooking ingredients and nutritional supplements just to name a few.

The project remains attractive to growers as in the addition of a new grower on Kauai and inquiries from Hawaii island. Therefore, growers could be added to the tea hubs in the future or new tea hubs can be formed.

Increase production of the crop with 1) strategic propagation and 2) product development.

Continued propagation for the tea hubs on Oahu, Kona and Maui will increase supply chain capability. Product development will help to increase demand for the crop by increasing access to the marketplace.

Contact Information

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The Tea Chest
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Honolulu, HI 96819

Additional Information

UH propagation method (Oahu)

New plant starts (Big Island)

Cuttings in tree pots ready for the field (Maui)

1 year old plants (Kona)

1 year old plants (Oahu)

1 year old plants (Maui)

Nursery of mother plants
(Oahu)

Field planting at 4000'
(Maui)

Tea and koa trees at 4700'
(Maui)

Tasting and evaluations
(Oahu)

Packaged tea by project
(Volcano)

Maintaining an Established Breadfruit (Ulu) Orchard

Final Report

Mililani Agricultural Park, LLC (MAP)

Project Summary

This project was the second phase of the project titled, "Establishing a Breadfruit (Ulu) Orchard Incubator", that began with funding from the SCBGP FY12 program. The FY2012 project propagated and planted 10 acres of breadfruit, collected agronomic and economic data which was provided to growers to help them establish a breadfruit orchard. The data from that project was compiled into a guidebook and a field day workshop was conducted for the growers, who were invited to the farm to hear from the researchers involved in the project, see the breadfruit orchard and learn from the trials conducted.

Due to a replacement of the lead researcher during the middle of the project, the project was delayed by six months, however, project staff were able to obtain the data needed to update the grower guidebook. The main goal of this FY14 project was the continued data collection on the maintenance of the breadfruit orchard for distribution to the potential growers throughout Hawaii.

The second phase of the project culminated with the field day workshop on May 20, 2016. This workshop was a continuation of the first phase and was titled, "Establishing a Breadfruit (Ulu) Orchard" for consistency, but included the information regarding maintaining the established breadfruit orchard. The field day was an opportunity for growers, industry professionals, and the community to learn from the studies conducted over the past years of the project regarding the techniques and lessons learned and how to properly start and maintain a breadfruit orchard. The workshop included a detailed guidebook (Attachment 1 Breadfruit Production Guidebook) including information on pruning management, irrigation recommendations, cover cropping, as well as cost of production financial information. The workshop was attended by over 54 participants with talks given by of Southern Turf, the grower, Matt Johnson of Sustain Pro Management, the project manager, Jayme Barton of Hawaii Ag Research Center (HARC), the project's lead researcher, and Erik Shimizu of the Agribusiness Incubator Program (AIP), the feasibility study researcher for the project.

The project was timely due to a renewed interest in breadfruit throughout Hawaii, the US Mainland and the world as another source of plant-based carbohydrates. Breadfruit is a staple crop for Hawaiian and other Polynesian communities and has been gaining interest as a gluten-free food that can be eaten as is or converted into other products such as flour.

Project Approach

At the start of the project, the project team determined that the most significant and useful information needed by growers to properly maintain a breadfruit orchard would be: pruning, irrigation, tissue analysis, weed management, and cost of production modeling.

The research was divided between two groups:

- HARC was contracted to conduct the on farm agronomic trials including the pruning, irrigation, tissue analysis and weed management
- The AIP was contracted to complete the cost of production modeling and feasibility analysis for breadfruit and its value-added potential.

The information gathered by HARC and AIP was compiled and added to the "Breadfruit Production Guidebook" that was created by the SCBGP FY12 program, adding even more information to be used by producers interested in growing breadfruit.

To disseminate the information, a grower's workshop was conducted on May 20, 2016 at Mililani Agricultural Park, the breadfruit research site, and was attended by over 50 participants. Each participant was given a copy of the updated breadfruit guidebook and had an opportunity to hear from the project team members and see the breadfruit orchard. Breadfruit trees produced by the project were distributed to the participants.

Work Plan:

- **Pruning Management:** January, March, April, June, August, October 2015
  The trees were maintained at a manageable height for fruit harvest, with lateral branches, and open middles, allowing for more effective cultural management. Trees about one-year old were lightly thinned. Some trees had developed two trunks, and in these cases, a single trunk was selected and the other removed. Trees two-three years old (from a previous planting) were pruned back to about 6' tall in order to begin training. This amounted to pruning the central leader and a few of the more vertical branches out, until the canopy level of more lateral branches was reached. Other trees were allowed to continue their upward growth for several more years with little training. Techniques and results were reported in the Breadfruit Production Manual.

Pruning to control height growth began in November 2015 and continued through January 2016. Work was delayed due to trees not growing as quickly as expected. A preliminary pruning trial outside of this project cut back about 100 three-year-old trees which were about 12+ feet tall, and reduced their height to about eight to nine feet tall. These trees were not part of the project, but have allowed project staff to see trees that are older, and test pruning ideas. This looked promising for maintaining the height in a more easily harvestable reach.

- **Irrigation Management:** April-August 2015
  Observation of two-year old trees in the ground at the MAP showed that trees which received less irrigation have grown at a reduced rate compared to those trees which received more water. Available lease lands on Oahu sometimes come with irrigation available, and sometimes there is not irrigation available. At least two rows of recently planted breadfruit were put under no irrigation treatments in order to determine the effect on tree growth and at what age

the trees finally are mature enough to produce fruit. Techniques and results were reported in the Breadfruit Production Manual.

During the months of April-August, irrigation was significantly reduced or eliminated in areas with negative effects on trees, such as yellowing of leaves and reduced tree health and vigor. This is primarily due to damage which has occurred to the poly-tubing and the irrigation system, and it is primarily in two of the four blocks of trees. This was unintentional, and sometimes happens when ground crew is busy with multiple projects. Repairs are scheduled for the irrigation systems by December 2015. In the meantime, two of the four blocks have had stable irrigation. In December 2015, two rows of trees in these two blocks will have the irrigation turned off intentionally allowing staff to test again the effects of no irrigation.

- **Tissue Nutrient Recommendations:** February-May 2015
  Most common tropical fruit tree crops such as mango, avocado, lychee, longan, all have tissue nutrition recommendations for N, P, K, Ca, Mg, S, B, Fe, Mn, etc. which indicate what percent or ppm levels are required to be found in a leaf sample in that indicates healthy plants. Frequently disease symptoms which are observed can be traced to nutrient deficiencies which require proper fertilization to correct. Usually annual testing of leaf tissue samples and soil samples are made in order to update the orchard nutrient management plan. In the case of breadfruit, there were no existing nutrient recommendations. Project staff selected approximately 15 to 20 trees to receive a treatment of no fertilizer to determine if staff could find tissue nutrient deficiency symptoms or differences in tree growth and health, in order to develop recommended tissue levels. Techniques and results were reported in the Breadfruit Production Manual. Supplies -- Ground Cover, Herbicide, Liquid Fertilizer, Composted Mulch will be applied at this time as needed.

Collaboration with Peter Bunn of Crop Nutrient Solutions in developing fertigation recommendations began in fall of 2015. Tissue analysis was assessed for the healthiest trees, and the least healthy trees, in order to determine approximate recommendations for tree health in ideal horticultural conditions.

- **Cover Crop Trial:** January – September 2015
  Different varieties of cover crop were tested with breadfruit to determine how it integrates with the cash crop with both weed management and nutrient.

Current owners of the breadfruit orchards are interested in legume cover crops. Cover crops will be selected with the current land manager and will be decided upon to enhance their preferred management practices.

- **Cost of Production Modeling:** October – December 2015
  Comprehensive data on costs for breadfruit plants, nursery development, land clearing, fertilizing, irrigation setup, water costs, land lease, orchard establishment, mulching, and startup labor costs were compiled. These are critical pieces of information for new growers.

When production of fruit began, the economic modeling analysis for cost of orchard establishment, levels of fruit production in a young orchard, and profits were researched and included in the Breadfruit Feasibility Study.

Cost of production modeling information were collected during the during January – May 2016.

Goals and Outcomes Achieved

The main goal of the FY14 project was the continued data collection on the maintenance of the breadfruit orchard for distribution to the potential growers throughout Hawaii. This was achieved through the grower workshop and the updated Breadfruit Production Guidebook that was provided to growers throughout the State to encourage more breadfruit production. The Breadfruit Feasibility Study produced by the project is included as Attachment 2.

GOAL: To gain more understanding of best management practices for maintaining a breadfruit orchard and to disseminate the information to Hawaii growers. This will be completed through facilitating a field day at the end of the project where lessons learned will be presented. It is anticipated that 75% of the attendees will increase their understanding of breadfruit production and 50% will implement this knowledge after the field day (**TARGET**).

The field day attracted 54 attendees whose survey responses indicated that 89% increased their understanding of breadfruit and how it is grown. Ninety-six percent of the attendees stated that the information presented at the field day would be helpful to them as a grower to implement a successful planting.

Maintained Breadfruit Orchard in Mililani, Hawaii

Beneficiaries

The growers and other interested community members (54) that attended the workshop benefited from this project as they were able to see a successful, large scale breadfruit planting early in production, and to learn how this was achieved. Field day attendees were also provided with written planting guidelines that gave instructions on how to achieve the same results.

Other beneficiaries include value-added processors, who will be able to utilize additional breadfruit for various processed items, also markets who currently experience difficulty obtaining fresh breadfruit, and consumers for whom breadfruit is a traditional part of the diet. Breadfruit production on a small scale will provide a nutritious staple for subsistence farmers. Large scale production will help to offset the seasonal harvest, which can make processing difficult if not enough varieties are producing at the same time or if all are available simultaneously. Also larger scale production allows for some loss which is inevitable given the challenges to handling breadfruit at harvest.

Economically, increasing breadfruit production in the State of Hawaii may provide a substantial boost if the right value-added product is chosen. For example, breadfruit can be used to produce gluten free flour, and the demand for gluten free products is rising rapidly. Estimates in 2012 showed that US consumers could spend as much as 3.31 billion dollars in gluten free food and beverage items; in 2016 that projection is expected to rise to 15 billion dollars in sales (UH Pacific Business Center Program briefing paper on Pacific Gluten Free Breadfruit Flour Regional Industry Development Initiative). Even capturing a third of the value added gluten free product projection would bring a boost of several billion dollars to Hawaii. With the retail price of fresh breadfruit close to $2/pound, there is potential for growers to tap into this market that includes over 100,000 Pacific Islanders in the State that consider breadfruit a staple to their diet. Using conservative numbers, if half of the Pacific Islanders in the State were to consume two pounds of breadfruit every other month at a price of $2/pound that would result in creating a $1.2M industry.

Immature breadfruit (left)

Example of a well-maintained breadfruit tree (right)

Lessons Learned

The lesson learned was to have a wide circle of researchers to tap for assistance in the unlikely event that the lead consultant for the production trials might leave the project. It is always challenging to manage staff within a project, however for this project, there was a knowledgeable backup with HARC who was able to finish the work required.

Contact Person

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Additional Information

Attachment 1 – Breadfruit Production Guidebook
Attachment 2 - Breadfruit Feasibility Study

Increasing the Supply of Specialty Crop Fruit Trees for Growers in Hawaii

Final Report

Hawaii Tropical Fruit Growers (HTFG)
http://www.hawaiitropicalfruitgrowers.org/

Project Summary

The purpose of the project was to establish four fruit tree repositories on three Hawaiian Islands to:
1. Provide plant material at low/no cost to HTFG members and other fruit growers.
2. Offer more exotic, unusual varieties of tropical fruit tree planting material to members that encouraged them to expand and diversify the fruit trees in their orchards.

Grafted fruit trees in Hawaii average $65 per tree, which reflects some of the highest prices in the world. HTFG members agreed this cost was prohibitive to expansion and/or to adding new varieties to their orchards to increase production. The same variety of trees in Japan were priced at $7.00, in the Philippines, $3.00, and in India, often under $1.00. This project has made farm expansion more reasonable by providing repositories of tropical fruit trees that HTFG members can graft from or purchase at prices from $10 - $30 apiece. The repositories are now flush with many trees that have and will continue to bring prices for tropical fruit trees in Hawaii down to a reasonable level.

Project Approach

Activity	Completed by	Timeline
Confirmed partnerships for land use on each island.	Ken Love	January / February 2015 Completed February 2015
Developed Advisory Committee	Ken Love	January / February 2015 Completed February 2015
Polled members, chefs and wholesalers as to what fruits they most desired	Ken Love	January – March 2015 Completed February 2015, research/ survey work continues for County of Hawaii
Asked members to start propagation of their personal trees	Ken Love	January – March 2015 Completed February 2015
Secured cuttings, from USDA Germplasm repositories in Davis, CA. of Figs and Pomegranates.	Ken Love	January – May 2015 Completed May 2015
Secured plant material such as seedlings and cuttings from HTFG members based on results of polling customers.	Ken Love	January / February and April / May 2015 Completed May 2015, ongoing to increase plant materials at each site

Placed progress report on Hawaiifruit.net and htfg.org	Ken Love HTFG Webmaster	January / February 2015 August/September 2015 Completed January 2016
Obtained permission from the University of Hawaii to take plant material for propagation from statewide experiment stations. Collected material.	Ken Love	January / February 2015 Completed February 2015
Obtained permission from and collected material from botanic gardens and private collections around the state.	Ken Love	January / February 2015 Completed February 2015
Scouted and photographed locations on Molokai, Kauai, Hilo and Kona	Ken Love	March / April 2015 Completed April 2015
Developed orchard design group.	Ken Love Brian Lievens HTFG West Hawaii Chapter Officers Scott Sloan HTFG Board and NTBG Director	March / April 2015 Completed September 2015
Prepared land and plant trees at each location.	Ken Love HTFG members	March to August 2015 Completed January 2016
Procured propagation materials (pots, soils, fertilizers) for each location.	Ken Love	March / April 2015 Completed April 2015
Monitored all new planted trees to insure health	Ken Love Local HTFG members	May - December 2015 Ongoing with weekly checks
Distributed 50 cuttings or seedlings at each location – Molokai, Kauai, Hilo, Kona	Ken Love Local HTFG members	October 2015 Completed by July 2015
Developed guides for each site and other outreach materials	Ken Love	October 2015 / February 2016 Completed March 2016
Updated websites	Ken Love HTFG Webmaster	November 2015 / February 2016 Began September 2015; ongoing
Prepared Final Report	Ken Love	December 2015 / February 2016 Completed March 2016

This project was completed as proposed despite a few setbacks caused by two separate theft incidences of planted trees at the Kona location. All four of the repositories are completed each with some extra space where HTFG partners have planned on adding additional trees as they become available from members and other growers who heard about the project. Plant material was obtained from growers and nurseries in the state as well as India, Japan, California and Florida, according to USDA regulations. More than 500 trees were donated both for planting and for the distribution towards the end of the project. This exceeded the estimated number of trees that would be produced by the project.

There are over 100 tropical fruit trees planted at each of the four repositories. An additional 150 trees are waiting for planting once they gain size and harden off in full sun.

A fifth repository was created in Kona as a back-up for the other locations. This site continues to flourish while functioning as a nursery and plant quarantine area.

More than 200 volunteers at four locations helped to clear land, dig holes for planting, run irrigation and plant trees. Additional volunteer days in Kona, Molokai, Hilo and Kauai have also taken place. The Kauai location at the National Tropical Botanical Garden will be expanded to include visitor information and signage. HTFG partnership with the park is considered by both groups to be very beneficial.

Plant distributions have taken place at all four locations with original estimates being exceeded. Over 250 trees have need distributed at many functions. HTFG members at each location continue to manage and improve sites as well as solicit supplemental funding for additional weed mat and water. A new project will add 12 rare durian species and trees to each of the four repository locations.

Goals and Outcomes Achieved

Proposed	Achieved	Outcomes and Future Plans
Goal: The goal of this project was to increase the numbers of fruit trees in production in the state of Hawaii.	A minimum of 50 trees were planted at each of four repository locations with space left for additional unusual fruit trees as they become available from local HTFG members managing the sites. The trees selected adapted to market demands; finger limes and other citrus were added.	Members continue to build the repository sites by adding trees for future propagation and offering other trees as work trade or for sale at various events. Networking at each of the four repository locations continues monthly.
Performance Measure: The project maintained records of the distributed trees; HTFG members and other volunteers propagated and distributed as many as 50 trees the first year at each location on Kauai, Kona, Hilo and Molokai. In the second year, 100 trees per site were distributed. Up to 500 trees will be distributed by year five. This includes grafted trees, cuttings and air layered plants.	A total of 504 trees were distributed the first year, exceeding the planned 200 trees. These were rooted trees rather than cuttings.	Two distributions in 2016 demonstrated that the project is on track to meet the goal. Distribution is planned to continue as plants become available.

Benchmark: Working with a core group of 10 volunteers on each island, members will be asked to insure 50 trees are planted on each island the first year. As the amount of material is available the number of trees will increase to 100 per year per location and 500 per year per location by year five.	HTFG members embraced this project much more than anticipated resulting in the planting of twice the number of trees required and added seed and scion exchanges in order to further promote the project mission of increasing the number if specialty crop fruit trees in Hawaii.	HTFG members and others in the community planted an average of 126 trees per location. Many who purchased trees will share other species that they have at future repository events.
Target: Currently there are no trees being distributed outside of commercial nurseries. These nurseries have asked HTFG for assistance in obtaining the more unusual varieties and species asked for by growers. The target was to obtain and plant at least 50 trees in central locations where HTFG members can clone and distribute cuttings, air layered plants and other material for propagation. HTFG's target is to distribute 50 trees the first year at each location.	A total of 286 trees have been planted at the four repository locations with space for an additional 100 trees, depending on the type of tree.	HTFG continued to improve each of the four repository locations and continues to seek additional funding so HTFG can add revenues from agricultural tourism that would allow interested growers to visit the repositories, with the income to be reinvested into the repositories. A new project will make 12 varieties of durian available at each location as well as a number of other specialty crops.

Beneficiaries

The primary beneficiaries of this project are the 600 members of Hawaii Tropical Fruit Growers, whose farms and incomes are enhanced by access to the trees produced from this project, at reasonable prices. The comradery created at the 14 work parties and tree sales that attracted more than 700 people and 36 new members to the group has continued with further events planned to both network and to enhance the four repository sites.

With six tree sales (two each on Kauai and Molokai) plus four other events where tree distribution of project material has taken place, a total of 542 trees have been distributed. This exceeds first year expectation by 342. Some trees distributed at the beginning of the project have already started to flower and will bring a growing economic benefit to growers.

Lessons Learned

Provide security for the plants: There were two issues of theft and damage reported to the police where a total of 20 trees were stolen. In these cases, the trees were pulled from the ground and removed from the area. Attempts were made to pull other trees out of the ground, which resulted in a break at the graft, which, essentially killed the tree. A few of the stolen trees, such as Cepeda mamey sapote and Eugenia mulchi, were rare. Fortunately, these have been replaced with other Cepeda and Eugenia. Other "holes" where trees were removed have been filled with additional varieties such as tropical Apricot, and more jackfruit and durian. Each project site as space for additional trees and when old enough and well established, clones from the mother trees will be replanted at the site.

Seek funding for projects that motivate HTFG Members: Response to the project has been phenomenal. Members have "taken ownership" of the repository locations and have plans to expand the sites and plant additional trees as they become available from the Project Manager and/or from the original ("mother") plants and/or from the University of Hawaii air layered plants. Members think of the plants at the four repository sites as an part of an ongoing, multi-year project that will continue to evolve. Each repository has planned for space for expansion. The Project Manager and HTFG members continue to collect unusual trees for the repository project. A new chapter president in Hilo has voluntarily taken on additional responsibilities for the Honomu repository.

Contact Information

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Additional Information

Hilo

Property belonging to HTFG Chapter President -- Approximately two acres

Preparing the property to serve as the Hilo repository

Molokai

Marshall Joy's farm before and after planting.

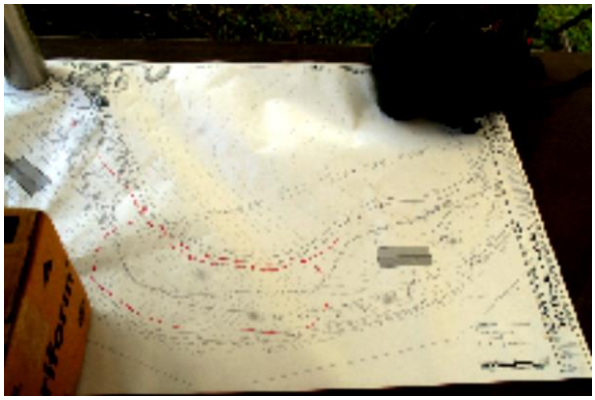
Preparing the property to serve as the Molokai repository

Kona

The repository is on land owned by Kamehameha Schools Bishop Estate (KSBE) and leased to an educational project. HTFG has full access. The partnership with KSBE has helped to increase HTFG membership from West Hawaii.

Kauai

National Tropical Botanical Garden



Kauai Day 3

Tree Sales: Kona, Oct. 18

Eighty-one trees were sold and over 30 given to volunteers.

Germplasm Selection and Management to Optimize Vegetable Quality and Yield in Tropical, Organic Production Systems

Final Report

University of Hawaii, Office of Research Services
http://www.ors.hawaii.edu/
http://www.ctahr.hawaii.edu/site/

Project Summary

The production and availability of seed and plant material for organic production is an important component of the state's effort in working towards food sustainability. Although Hawaii does produce significant amounts of some of the commercially grown vegetables consumed, more than 80% of Hawaii's total food is imported. As more crops/varieties of good performing, insect and disease resistant varieties become available and accessible to farmers in Hawaii, there will be increased potential to produce local organic vegetables. This project focused on selection and production of organic seeds and propagules of vegetable crops and varieties for commercial organic production. The second part of the project focused on data collection, data analyses, evaluation of the results, and dissemination of the project findings to stakeholders. Twelve crops were identified by University of Hawaii researchers and extension agents. Seeds were obtained through the University of Hawaii Seed Program (UH SEED), and the selected crops were planted at two sites (Waimanalo and Poamoho Research Stations on Oahu). Seeding and propagation of plant materials was implemented between Mar. 2016 and December 31, 2016 with successful varieties now available at UH SEED. Work is ongoing with select varieties that were found to be especially promising and desirable. Surveys were administered to local farmers at field day events and through email networks. Survey results indicated a strong response to increasing the number of crops and varieties offered through UH SEED and confirmed that the varieties selected by the UH researchers and extension agents were in fact some of the most desirable varieties.

Project Approach

1. The following 12 crops were selected by researchers and extension agents to be grown: Koba green onion, Anahu tomato, Manoa lettuce, Hirayama kai choy, Hawaiian chili pepper, Nitta x Waimanalo eggplant, papaya(Sunrise and Waimanalo X-77), taro, sweet potato, moringa, fig, and breadfruit ('Ulu)
2. Surveys were administered to local farmers in paper format and online by Survey Monkey. Data from surveys was analyzed and results were summarized in the Appendix. Important findings from the survey include that many growers are using organic seed, currently buy seed from UH SEED, and showed an interest in having more organic seeds available at UH SEED.
3. A field day was conducted at Waimanalo Research Station on November 9, 2016.

4. Seed germplasm was saved from the following crops/varieties and available at UH SEED: Koba green onion, Sunrise papaya, Waimanalo X-77 papaya, Hamasaki eggplant, Manoa lettuce, moringa
5. Vegetative propagules are now available from four of the crops: Sweet potato (16 varieties), taro (45 varieties), fig (10) varieties, ‘ulu (7 varieties)
    a) Sweet Potato Varieties: Jarieleele, Piko, Papaa, Mohihi WG, Mohihilyons, Rapoza, Kahanu purple, Ogasawara, Yama, Diane, Hale Tuahine, Hui 17, Nancy Hall, Hoolehua, Lanai, and Melemele
    b) Taro Varieties: Lehua, PikoUaua, PikoKeokeo, Kai Ala, Kai KBS, Lauloa Palakea Papamu, Lauloa Palakea Eleele, Ulaula Moana, Ulaula Poni, Lehua Maoli, Ohe, Kalalau, Papapueo, Haokea, Pololu, Piko Ulaula, Kai Kea, Lauloa Eleele Ula, Ulaula Kumu, Manini Opelu, Kauai Lehua, Red Moi, PikoLehuapii, Kai Uliuli, LauloaEleeleOmao, Nawao, Nihopuu, LehuaPalaii, Haokea, ManaKeokeo, Manapiko, Moana, KumuEleele, Manini Kea, White Moi, Eleelemakoko, Manalauloa, Uahiapele, Paakai, ManiniOwali, ManiniUliuli, ManaOkoa, Lehuapalaii, ManaUlaula, Elepaio, Pialii, EleleNaioea, Oopukai, ManaEleele, Kai ala, ManaOpelu, PikoEleele, Apu, EleeleMakoko, Maea, Lihilihi Molina, PikoLehuapii, ManaUlu, PikoUliuli, Apuwai, LauloaKekeo, Kuoho, Hapuu, ManaIauloa
    c) Fig Varieties:White Genoa, White Kadota, Brown Turkey, LSU Purple, Conadria, Excel, Early Violet, Black Mission, Violette de Bordeaux, Flanders
    d) ‘UluVarieties: Otea, ‘UluFiti, Maafala, ‘Ulu Hawaii, Piipiia, Puaa

Goals and Outcomes Achieved

The proposed objectives/goals have been achieved within the project duration through different activities (field trials, seeds production, survey data, field days/workshops, and publications). Please see project approach section for detailed activities.

1. Produce organic seed from CTAHR crops/varieties of papaya, onion, mustard and lettuce for sale through the University of Hawaii Seed Program.
2. Identify crops/varieties to be recommended for organic production in Hawaii based on surveys and questionnaires collected from local organic farmers to gauge preference.
3. Disseminate program results via field days, traditional print media and on-line research and extension venues.

Beneficiaries

1. Organic seeds of five crops are currently available from UH Seed Lab from the seeds produced by this project. Koba green onion was among the top popular variety requested by local growers. Also, there’s an increase interest for 'Hamasaki' eggplant as a promising organic seed variety for Hawaii. Further work in being done on screening for disease resistance of this variety. The UH Seed Lab benefited from the project as well as the farmers who receive the seeds from the Lab.
2. Six Field days/Workshops events educated ~ 300 local farmers and stakeholders learned about opportunities and challenges of using locally produced organic seed and plant materials.

3. Survey from approximately 200 participants were collected resulting in an additional five crops been determined and selected for future funding opportunities.

Lessons Learned

Future work needs to include improving management of seed drying, storage, and germination testing. Keeping the website updated is important to notify consumers of the latest seed supply availability. https://www.ctahr.hawaii.edu/seed/

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Additional Information

Public Presentations

- Organic Germplasm Production, November 9, 2016, Waimanalo Research Station
- Plant and Seed Exchange, Pearl City Urban Garden Center, May 20, 2017

APPENDIX: Survey results from the 2016 Organic UH Seed Program Survey

- Participants: 27
- 100% of respondents were aware that UH had a seed lab
- 89% of respondents have purchased seed at the UH Seed Lab before
- 65% of respondents are organic growers
- 80% of respondents already purchase organic seeds
- 100% of respondents would be interested in purchasing organic seed from the UH seed lab
- 60% of respondents indicated they would buy Home Gardener packets while 40% of people would buy in bulk

There was interest in all varieties the project staff listed on the survey. The most popular varieties were Koba Green Onion, Manoa Lettuce, X-77 papaya, Komohana tomato, and Hawaiian Chili pepper. Respondents also indicated interest in these crops/varieties:
Arugula, beets, yellow bean, French bean, other varieties of tomato, sunflower, jalapeño, pickling cucumbers, Heirloom tomato varieties (beefsteak size), basil, Russian kale, curly kale, Italian kale, swiss chard, pak choy, bok choy, lettuce mixes (for baby greens), perennial seeds of poha, asparagus, rambutan, pulsan, pili tree nut, kale, tomato, cabbage, spinach, carrots, pumpkin, bitter melon, dry bean/pulse, fresh green bean, bulb onion, shallot, fennel, okra, Chinese cabbage (Napa), more lettuce varieties, bush beans, poha berry, Sweet peas, Head cabbage, okra, banana tree, kalo, pakchoi, radish, high protein cover crops, cool fruit trees, rice, eggplant, lettuce, bush beans, carrots, tomatoes, kale,

cauliflower, lettuce, eggplant, green onion, kale, pepper sweet and hot, spinach, soybean, kale, lettuce, beets, tomato, sweet and hot peppers, cucumbers, Asian greens

Other comments:

- Project staff noted that the respondents have preferred varieties, but more important than that to the FARMERS is consistency. The farmers need to minimize their risk and want to know if they are going to expend their limited funds to invest in their business, that the seeds they purchase are acclimatized, disease resistant, nematode free and available year-round without shortages. Quality seeds worth purchasing should have reliable germination rates. Also, farmers would like more open communication with the seed developers, maybe a quarterly newsletter? That way the community can give input to what the farmers actually want to grow.
- Concerns regarding responsible genetics.

When asked what quantity of seed would you want to buy annually, the project survey received 18 responses indicating that they would buy:

• 5 pounds each • One packet of each • ~5 lbs of each annually • 4-5 packets depending on size • 50-100 g • Home gardener packet • Less than one ounce per variety • Small producer so packet size is good • 10 pounds; bought some pole beans and snow peas by the pound	• 1-2 pounds • 2-5 pounds • 10 pound bags • 10 fruit seeds • 80% germination rate • Enough for 500 feet/year • Small batch • I do a lot of variety in my planting • Try to stay away from monoculture

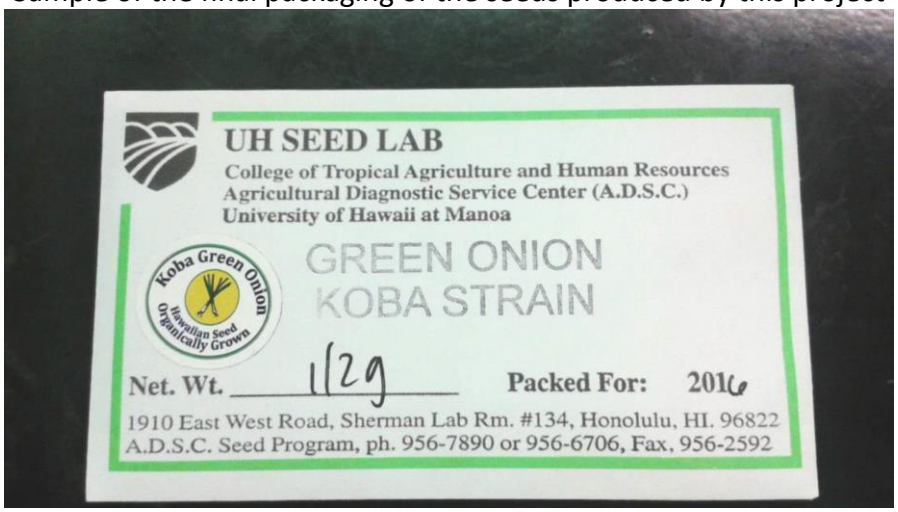
Other comments:

- We spend $1200-$1500 per year on Johnny's seed company;
- We buy organic kale, Swiss chard, beets, provider beans, pumpkins, eggplants and tomatoes;
- We would love to support a local company instead that can show that level of care in breeding and selecting seeds;
- We have supported UH seeds in the past but found germination rates to be low, unpredictable and the seeds were less hardy compared to mainland seed companies. You got the feeling they weren't harvesting the best plant seeds, but just trying to put out product because they were in a shortage most of the year. Feedback from fellow farmers noted similar findings.

Photos

The images below show the crops in production at Waimanalo and Poamoho Research Stations, seed cleaning, and a sample of the final packaging.

Sample of the final packaging of the seeds produced by this project



Germplasm in grow-out trays

Sweet potato varieties

Taro in the field

Green onion in the field

Project staff preparing seeds from this project for distribution

Development of New and Improved Anthurium Cultivars for Hawaii

Final Report

USDA Agricultural Research Service, Pacific Basin Agricultural Research Center (PBARC)
http://www.ars.usda.gov/main/site_main.htm?modecode=53-20-03-00

Project Summary

In Hawaii, prior to the discovery of bacterial blight in commercial anthurium farms, the anthurium industry produced a record high of 30 million flowers sold in 1980. Many farms and cultivars were destroyed by the bacterial blight and the anthurium industry has still not fully recovered (NASS reported 2.9 million flowers sold in 2016). Methods to control the blight have been developed but have added significant cost to production. The research conducted through this project established a key collaboration between the University of Hawaii at Manoa, College of Tropical Agriculture and Human Resources (CTAHR) and USDA ARS DKI PBARC to collect and preserve anthurium accessions that will be important germplasm for conventional breeding and biotechnology efforts. Anthurium accessions were placed into *in vitro* culture, indexed to ensure disease free material are maintained and backed-up at both locations in case of catastrophic events at either location. The plants in culture are available to the anthurium industry for further propagation of clean material. Heritage and commercial varieties with important horticultural attributes are being used as a foundation for commercial breeding and biotechnology development. In addition, anthurium species have been used to investigate molecular pathways for floral improvement.

Project Approach

Researchers on this project met with floriculture and ornamental growers on multiple occasions to further develop the breeding goals and objectives. In addition, floral designers play increasingly important roles in the advancement of the flower industry. The growing niches for floristry are weddings and special events. Currently, floral designers and the (do it yourself) DIY event designers are buying more of the floral products directly from the growers instead of traditional wholesalers, therefore driving the consumer demand for floral products. Dr. Tessie Amore, Dr. Jon Suzuki and Dr. Tracie Matsumoto attended a Floral Workshop at Green Point Nurseries with floral designers Hitomi Gilliam and Lois Hiranaga on July 19, 2016. From this activity, the researchers were able to get a different perspective on breeding objectives. In addition to the traditional breeding objectives historically based on shipping traits (i.e. straight and long stems), the breeding program now also takes into account novel inflorescence size and shape, transition colors in the spathe and spadix, stem length, curvature and turgidity. Floral designers were also able to give their feedback on early selections of new anthurium cultivars being produced by the UHM breeding program to streamline the release of new varieties for these markets.

Survey growers and breeders for available anthurium cultivars. On October 6, 2016, Dr. Tessie Amore from UHM, Dr. Jon Suzuki and Dr. Tracie Matsumoto, gave presentations on the “Anthurium Variety Development: Past, Present and Future” (Amore), “The Road to Anthurium Cultivar Improvement

through Basic Molecular-Genetic Research" (Suzuki), and "Acquisition of Anthurium Germplasm for Preservation and Development of New Cultivars" (Matsumoto) at the Hawaii Floriculture and Nursery Association Special Occasion 16 Import Replacement Educational Growers' Seminar. At the seminar, the growers were presented with a survey to find out: 1) what anthurium cultivars should be preserved, 2) what anthurium cultivars are considered to be their top priority to be available through tissue culture, 3) who could be contacted to find Anthurium species or cultivars. All presentations were taped and will be available to the HFNA member unable to personally attend the conference. In addition, the survey was sent to all the growers. From this survey, the majority of the anthurium varieties identified were already in the respective collections at UHM CTAHR or DKI PBARC. One novel variety was identified by growers as being desirable, however the contact person listed on the survey did not have the variety listed and this variety is being sought by researchers. Researchers presented the summary of this research project at the HFNA Grower's Import Replacement Educational Research Seminar, topics include Anthuriums and Orchids to Increase Hawaii's Agricultural Production (Amore), Development of a Germplasm Bank of Anthurium Species & Heirloom Cultivars (Matsumoto) and Spurring Development of Cultivars with New Ornamental Traits for Anthurium (Suzuki).

Collect plants and/or shoots from growers and other sources. From the survey, project staff identified potential growers for the collection of new anthurium cultivars. In addition, project staff have found heirloom cultivars and anthurium species that were lost in the current collections and other varieties that may have been forgotten by the industry. These materials have been collected from local growers and breeders as well as botanical gardens and collectors throughout the U.S. The materials collected by the researchers were grown in the greenhouse to photographically document the flower, plant shape and size and were initiated into tissue culture by callus culture (UHM) or axillary bud culture (PBARC). The plants are maintained in aseptic culture and triple indexed to ensure plants are free from latent bacterial contamination (ie. bacterial blight). Plants established at UHM are utilized for conventional breeding program and others at PBARC are used for plant transformations. Once plants were established and multiplied, a subset of plants was sent to the other institution as a back-up in case of natural disasters, facility failures or pest or disease outbreaks.

Goals and Outcomes Achieved

The goals of this research project were to 1) Increase varieties or traits available for anthurium improvement for the floriculture and ornamental industry, and 2) Preserve and back-up acquired germplasm in in vitro culture at the University of Hawaii CTAHR and USDA, ARS, DKI US PBARC that would be available to the floriculture and ornamental industry.

Goal 1 Target: At the end of 2017, the project will increase the number of crosses to include 25 to 50% more accessions and species for conventional breeding and an increase of 200% for an additional four varieties for transformation which will result in more novel and unique anthurium varieties available to the floriculture and ornamental industry.

Outcome: Project staff have effectively increased the number of anthurium species and cultivars available for breeding by 50% from five to eight and for transformation by over 200% from two to 10 commercial or heirloom varieties. The varieties and location of the varieties are in Table 1.

Table 1. Accessions maintained in the USDA-PBARC location (P) or UH locations (O=Oahu or H=Hawaii).

Accession	**Greenhouse**	***Tissueculture***
Species		
Anthurium andraeanum	P	
Anthurium amnicola Dressler	H, P	P
Anthurium antioquiense Engl. *Anthurium armeniense (need to confirm)*	O, H	O O
Anthurium bakeri	H, O, P	H, O
Anthurium formosum	O, P	P
Anthurium clidemioides spp. clidemioides	P	
Anthurium clidemioides ssp. pacificum	P	
Anthurium corallinum	P	
Anthurium coriaceum	P	P
Anthurium fragrantissimum	P	
Anthurium hoffmannii	P	
Anthurium lindenianum	O, P	P
Anthurium nymphaeifolium	P	O
Anthurium peltigerum	P	
Anthurium radicans	P	
Anthurium recavum	P	
Anthurium reflexinervium		
Anthurium scandens ssp. *scandens*	P	
Anthurium scandens ssp. *pusillum*	P	
Anthurium vanderknaapii	P	
Anthurium veitchii	P	
Anthurium warocqueanum		
Anthurium wendlingeri *Anthurium xferriense*	P	 O
Anthurium sp. nov. Panama	P	
Heriloom/Commercial cultivars		
‘Aiko’	P	O, P
‘Anastacia’	P	
‘Anuenue’	O, H, P	O
‘Asahi’	H	O
‘Black Queen’	P	

‘Charlie Brown’		O
‘Dusty Pink’		O
‘Ellison Onizuka’	P	O
‘Flamingo’	H	O
‘Hawaiian Butterfly’		
‘Hokuloa’	O, H	O,P
‘Kalapana’	H, P	O,P
‘Kanda Pink’	O	O
‘Kansako’		O
‘Kaumana’	O, H	O
‘Kozohara’	O, H	O
‘Leiahi’	P	O, P
‘Leilani’		O
‘Magalion Salmon’		O
‘Marian Seefurth’	O, H, P	O, P
‘Mauna Kea’	P	
‘Mickey Mouse’		O
‘Midori’	O, H, P	O, P
‘Miura Pink Obake’		O
‘Miss June Purple’	P	
‘Momohara’	O, H	O
‘New Pahoa Red’	O, H, P	O,P
‘New Pahoa Red/Green Obake’	P	P
‘New Pahoa Orange Obake’	P	
‘New Pahoa White’	O, P	O,P
‘New Pahoa Salmon’	P	P
‘Nitta’	O, H, P	O, P
‘Oshiro Red’	O, H	O
‘Oshiro White’	O	O
‘Ozaki’	H, O, P	O, P
‘Ozaki Pink’	O	O
‘Pele’	O, H, P	O
‘Puanani’	P	
‘Purple Passion’	P	
‘Real Purple’	P	
‘Regina’	P	
‘Rudolph’	P	O, P
‘Shibori’	P	O
‘Splash’		O
‘Takahiro Splash’		O

'Tatsuta Pink Obake' 'Tropic Fire'	O, H, P	O, P P

Goal 2 Target: By 2017, increase the available anthurium cultivars by 50% to 80 cultivars.

Outcome: Although project staff were not able to increase the number of disease indexed cultivars from 50 to 80, over the course of this research project, staff did successfully collect over 30 more new cultivars that are in the pipeline to be disease indexed and available to the breeding programs and growers. As cultivars are multiplied, they will be sent to the respective institutions for back-up. Table 2 summarizes the varieties that have been triple indexed and backed-up at each institution.

Table 2: Heirloom or commercial cultivars that have been triple indexed at UHM CTAHR (UHM) or PBARC and a backup is maintained at each location.

Cultivar	Triple indexed	Backup
Aiko	UHM	Yes
Asahi	UHM	
Flamingo	UHM	
Fujii Light Pink	UHM	
Kanda Pink	UHM	
Kaumana	UHM	
Kalapana	PBARC	
Kozohara	UHM	
Lavender Lady	UHM	
Leiahi	UHM	Yes
Marian Seefurth	UHM, PBARC	Yes
Midori	UHM, PBARC	Yes
Momohara	UHM	
New Pahoa Orange	UHM	
New Pahoa Red	UHM, PBARC	Yes
New Pahoa Salmon	PBARC	
New Pahoa White	UHM	
Nitta	UHM, PBARC	Yes
NPR Obake	UHM	
Oshiro Red	UHM	
Oshiro White	UHM	
Ozaki	UHM	
Pele	UHM	
Rudolph	UHM	Yes
Tatsuta Pink Obake	UHM	Yes

Toyama Peach	UHM	
Tropic Fire	PBARC	

Beneficiaries

The direct beneficiaries of this research project are the 15 anthurium growers (2014 NASS publication) in the state of Hawaii. Cultivars generated by this project may also be used as potted plants and are anticipated to improve export sales, thus benefitting the cut flower and florist greens, potted flowering plants and foliage nurseries. The availability of disease-indexed anthurium cultures will facilitate the rapid increase in propagation material for local plant tissue culture laboratories which would be indirect beneficiaries of this proposed work. In addition, backyard growers and farmers that market and sell anthurium plants or flowers at local farmers' markets, which may not be reflected in the USDA NASS surveys will also benefit from the developed cultivars. As a direct result from this research, floral designers and consumers will see new novel anthurium cultivars that are more feasible for trendy designs for weddings and other floral events.

Lessons Learned

Breeding objectives for anthurium flowers in the past were based upon qualities for shipping products to the U.S. and abroad. After meeting with floral designers, the breeding objectives were updated to include a new market based on traits for floristry in weddings and special events.

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A Potential New Crop for Hawaii: Garbanzo Beans (chickpeas)

Final Report

The Hawaii Department of Agriculture (HDOA)
University of Hawaii, College of Tropical Agriculture (CTAHR)
http://www.ctahr.hawaii.edu/site/

Project Summary

Increasing agriculture production and crop diversity in Hawaii was/is essential for the continuity and sustainability of people living on the Islands. Also, value-added products with "Grown & Made in Hawaii" labeling increases the net benefit to local farmers and industry and benefits the state economy. Producing chickpeas in the United States is increasing annually, and this has increased the production of value-added products, which generates additional revenue for the farmers. Chickpea protein can be a good protein replacement especially for a vegetarian diet, which improved the well-being of Hawaii's people. Eleven varieties and 25 genotypes of chickpea were evaluated for growth and yield at six locations in year-one, and three locations in year two, on different islands during the growing seasons of 2016 and 2017. The chickpea varieties were planted on five sowing dates in year-one and two sowing dates in year two. Chickpea genotypes were planted on two locations due to the limited amount of seeds provided by agency partners. Chickpea yield and quality were evaluated and varieties/genotypes were selected for different locations and sowing dates. Chickpea hay was evaluated for its nutritional value at animal feed, which has a potential for off-state animal feed replacement. Four field days/workshops were conducted (Oahu/Maui Islands in year-one and Hawaii/Molokai in year two). Extension bulletins were published to increase awareness among local farmers and community about the chickpea project and call out to farmers to participate in growing chickpea in Hawaii. Value-added products were produced for the project and presented during the field days/workshops events. Startup seeds were provided for five farmers in year one and 25 farmers in year two of the project. Connection was established with Pacific Biodiesel Co. to grow chickpea on five acres in the 2018 growing season. ChicNaturals (http://www.chicnaturals.com/) , Maui Tempeh (https://mauitempeh.co/), and Zen Island Kitchen (http://www.zenislandkitchen.com/) (local businesses) owners expressed needs to purchase locally produced chickpea.

Project Approach

Obtaining seeds:

Throughout the project's two years duration, The Project Manager and staff were successful to obtain:

- 11 most common chickpea varieties on the US Mainlands
- 25 genotypes from the National Plant Germplasm System (NPGS), and
- 20 genotypes from the International Crop Research Institute in the Semi-Arid Tropics (ICRISAT) headquarter in India, from both chickpea types (Desi and Kabuli).

Islands/locations covered:

Six locations/Five Islands were covered: Poamoho on Oahu, Hoolehua on Molokai, Kahului and Kula Ag park on Maui, Kapaa on Kauai, and Waimea on the Big Island.

Activities in year-1 (Oct. 1, 2015 to Sept. 30, 2016):

- Eight varieties were planted at six locations on five Islands (a location on Oahu, Big Island, Molokai, and Kauai, and two locations on Maui Island).
- Chickpea was planted on five locations for four sowing dates (January, February, March, and May). However, on Kauai and due to high rainfall and humidity, project staff decided to delay the planting and evaluated three sowing dates (March, April, and May) only.
- Chickpea 25 genotypes (from NPGS) + 20 genotypes from ICRISAT-India were planted on two locations (Poamoho on Oahu and Kula Ag Park on Maui) due to the small amount of seeds (20-30 seeds) given by both agencies.
- Two field days were conducted (Oahu and Maui Islands) to present the chickpea results to local farmers and the public community.
- Chickpea value-added products (snacks, hummus, chips, and brownies) were produced by the ChicNaturals Company for the field days activities.
- An extension publication was produced to describe the project, its results, and call for local farmers to participate in the project by planting chickpea.
- The project provided startup chickpea seeds for five farmers on different islands to encourage them to try growing chickpea.

Activities in year-2 (Oct. 1, 2016 to Sept. 30, 2017):

- Twenty-two varieties (selected top varieties from year one and new genotypes from NPGS and ICRISAT) were planted at three locations on three Islands (Maui, Big Island, and Molokai).
- Chickpea was planted on three locations for two sowing dates (February and March on Maui and Molokai, and March and April on the Big Island). Dry cold condition on the Big Island allowed to delay the sowing date compared to Maui and Molokai early sowing date.
- Two field days were conducted (Big Island and Molokai) to present the chickpea results to local farmers and the public community.
- Chickpea value-added products (snacks, hummus, chips, and brownies) were produced by the ChicNaturals Company for the field days activities.
- An extension publication was produced to describe the project, its results, and a call for local farmers to participate in the project by planting chickpea.
- The project provided startup chickpea seeds for five farmers on different islands to encourage them to try growing chickpea.
- Preliminary field trial for chickpea mechanical harvest was conducted on Molokai Island in collaboration with the Plant Materials Center of the NRCS in Hoolehua.

Goals and Outcomes Achieved

Objective # 1: Evaluate chickpea suitability to grow at different locations (Oahu, Maui, and Big Island) and sowing dates in Hawaii.

Suitability of chickpea types (Desi and Kabuli) were evaluated for different climates (location, soil, weather, and sowing date) in Hawaii (Fig 1-4). The results showed that four out of six locations were suitable to grow chickpea and February/March sowing dates are the most yielding compared to other sowing dates. Selection of varieties suitable for different locations is on-going.
Objective met.

Objective # 2: Determine yield, seeds quality, and cost of production for the two major types of chickpea (desi and kabuli).
Chickpea yield, seed quality, hay nutritional content (for animal feed) were evaluated (on-going manuscript development for publication in a peer-reviewed scientific journal) for each variety/genotype (Fig. 5-7). Some germination problems were faced in year one of the project. Pre-seeding treatments with fungicide (registered for chickpea) was used to deal with that issue.
Objective met.

Objective # 3: Produce chickpea value-added products (hummus, roasted chickpeas, and others) for "Hawaii-grown-made" labeling.
The ChicNaturals Co. was very active and involved in project activities (field days, workshops, and other events that target to present the chickpea project data). ChicNaturals Co. produced different value-added products for the project, including: Chickpea snacks, hummus, chips, and brownies) for Grown & Made in Hawaii" labeling.
Objective met.

Objective # 4: Disseminate project results to 300-500 local growers, agriculture professionals, and industry members.
Four field days/workshops were conducted (Oahu/Maui Islands in year one and Hawaii /Molokai Islands in year two) to present the project results among local farmers and public community, show chickpea plants, varieties/genotypes, and give presentations about the projects purpose, chickpea types, growth requirement, crop management, diseases/control, value-added products, and expected yield. Included in this objective was to increase adoption among local farmers to grow chickpea. By the end of year one, the project staff had five farmers interested to grow chickpea. By the end of year two, the project team received requests for seeds from 25 farmers on different islands.
Project results were disseminated to over 500 local growers, agriculture professionals and industry members through the field days/workshops, Zoom live video of the Oahu workshop, print coverage in two local newspapers and the University of Hawaii Extension Bulletin.
Objective met.

Beneficiaries

- Three local businesses (ChicNaturals, Maui Tempeh & Zen Island Kitchen) benefited from the potential for locally produced chickpea on the Hawaiian Islands and expected to increase value-added products from chickpea for local consumption of healthy vegetarian chickpea protein.
- About 250 pounds of chickpea has been provided for the local 25 farmers interested in growing chickpea in Hawaii within the project duration and growing season of 2017.

- Four field days and ~100 participants attended the workshops.
- So far, 25 local farmers contacted the project staff for startup seeds.
- Chickpea seeds from certain varieties were provided to Colorado Department of Agriculture as part of expanding the collaboration within the states for future projects.

Lessons Learned

Kauai may not be suitable for Chickpea production: Project staff were not able to harvest chickpea from Kauai due to high rainfall and humidity. The project team is looking for other locations on Kauai Island. Some communications for additional locations are on-going.

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Additional Information

This project was publicized in two local news publications and the University of Hawaii newsletter.
Hawaii Magazine: http://www.hawaiimagazine.com/content/growing-chickpeas-hawaii
The Maui News: http://www.mauinews.com/news/local-news/2017/09/company-to-begin-growing-chickpeas-on-maui/

Extension Bulletin published at HanaiAi (The Sustainable & Organic Farming Program) website:
https://gms.ctahr.hawaii.edu/gs/handler/getmedia.ashx?moid=2334&dt=3&g=12

Photos:

Fig. 1: Chickpea growth at Kula ag park on Maui.

Fig 2: Chickpea growth at Poamoho research station on Oahu.

Fig. 3: Chickpea growth at Kahului on Maui

Fig. 4: Chickpea harvest at Hoolehua research farm on Molokai.

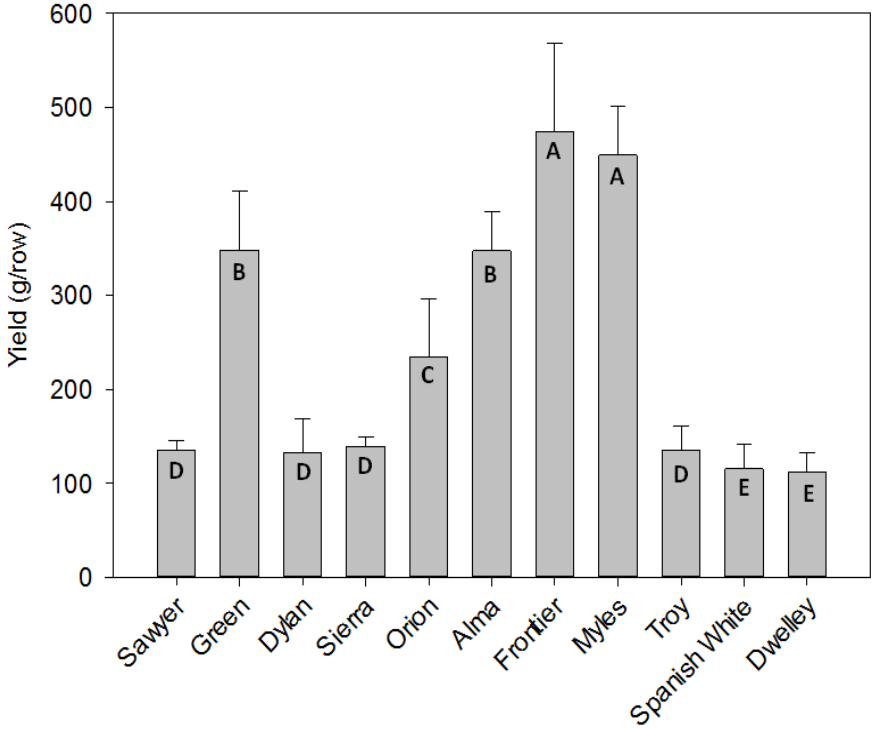

Fig. 5: Average yield of 11 chickpea variety (all locations - Feb. planting).

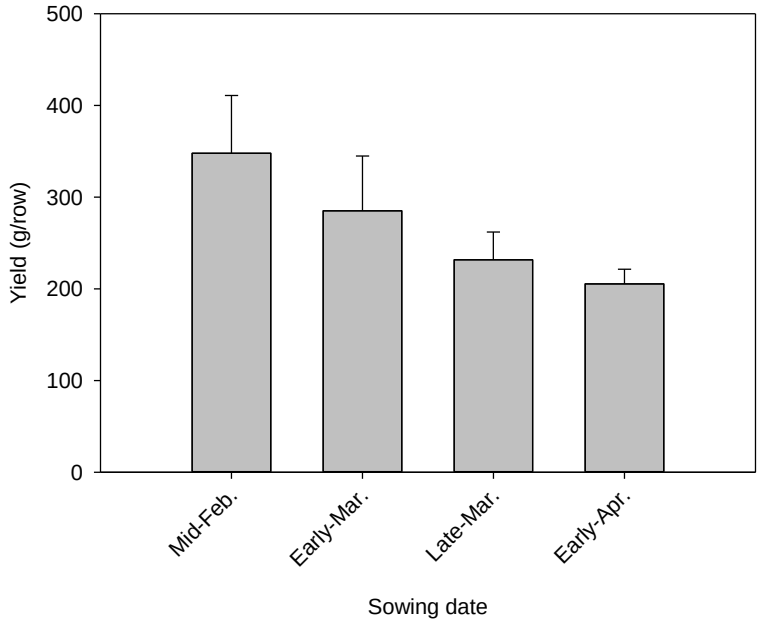

Fig . 6: Effect of sowing date on green chickpea yield (mean of all locations).

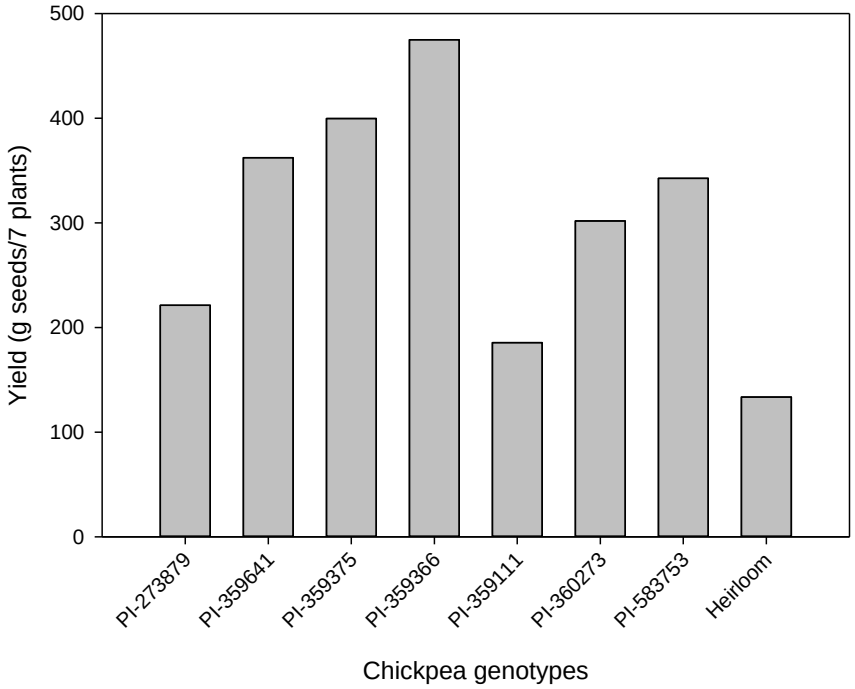

Fig. 7: Chickpea genotypes yield (g/7-plant), February planting on Maui and Oahu locations.

Enhancing the Competitiveness of Basil Production in Hawaii

Final Report

University of Hawaii, Office of Research Services
http://www.ors.hawaii.edu/
http://www.ctahr.hawaii.edu/site/

Project Summary

This project tested new OMRI-approved materials and fungicides to control downy mildew and *Stemphylium* infections in the field. Irradiation treatments used by conventional growers and were tested to determine if irradiation can reduce infection within the leaves. This is especially valuable for the farmers with the *Stemphylium* problem. A strong effort was made to test SAR compounds. These are chemicals that stimulate the defense system of the host and are known as Systemic Activated Resistance. These evaluations were needed immediately because of the huge losses caused by these diseases. The only crop that was tested was basil and the aim for this project was to increase the self-sufficiency of basil growers by enhancing production. The project intended to improve production practices for organic growers, and have useful information for other organic growers on the continent. To some degree this project also assisted in the distribution of basil and develop temperature and shipping conditions for good transport to the U.S. mainland and Canada and development of "Good Agricultural Practices" in Hawaii for basil.

Project Approach September 1, 2015 to May 5, 2016

1. Collect Disease Samples: Diseased basil samples were collected from twelve commercial basil farms: nine from the island of Oahu, two from Maui, and one from Lanai. All samples had either downy mildew, Stemphylium, or both. Additional samples were collected from nine community gardens (eight from Oahu and one from Lanai), three commercial nurseries (two from Oahu and one from Maui), two University of Hawaii Research Stations on Oahu, two restaurants on Oahu that grew their own basil, and three private residences (two from Oahu and one from Lanai). All samples were infected with either downy mildew, Stemphylium, or both. Only two samples, one from a private residence on Oahu, and one from a commercial nursery on Maui, did not have either pathogen.

2. Isolate and Identify Disease: Stemphylium, Alternaria, and Pseudocercospora were isolated from spots on basil leaves. Downy mildew was also observed on almost all of the disease samples taken from farms and gardens.

3. Travel to Maui to Collect Samples: Collected samples from a commercial farm in Kula growing basil for local consumption, a nursery that is providing small potted plants for local lawn and garden shops, and from a botanical garden catering to locals and visitors. Met with owners and to find out what their concerns were regarding management of downy mildew. Gave them information on additional approved fungicides and provided them with information on pesticide rotations schedules that minimize the risk of the pathogen developing resistance.

4. Propagate Basil and Install Greenhouse Test: Over two hundred clean basil plants were propagated by sterilizing seeds in hypoclorite solution, then plating them in petri dishes on water agar. After five days, seeds germinated and clean seedlings were planted individually in Sunshine Blend potting mix in small plastic pots. Seedlings that were contaminated with fungus were not planted. Six weeks later, plants were ready for testing. Plants were sprayed with fungicides, allowed to dry for 24 hours, then inoculated with downy mildew seven days later. Fungicides tested were: Actinovate (*Streptomyces lydicus*), Camelot O (Copper octanoate), and Double Nickel (*Bacillus amyloliquefaciens*) and another is a highly effective conventional fungicide Revus (Mandipropamid). Inoculated plants were maintained on a bench outside the glass covered greenhouse at the UHM Magoon Greenhouse facility in Manoa. This was done to minimize the chances of infecting stock basil plants that were being propagated inside the greenhouse for pathogencity and fungicide efficacy testing. Conditions outside the greenhouse varied with the predominating weather conditions. In the first efficacy test, prolonged wet weather provided optimum conditions for the downy mildew to infect the test plants. Revus was effective in preventing infection up to fourteen days after inoculation and twenty-one days after treatment with fungicide. The other three compounds did not prevent downy mildew infection, and infection levels were similar to the inoculated control group. Only one application of fungicides was made. Data on disease levels were taken seven and 14 days post inoculation. The test was repeated three more times, with each trial ending with low levels of infection on the inoculated control and inconclusive results of efficacy for the four fungicides. This was due to dry conditions and decrease in the levels of infection of the downy mildew on the host plants.

5. Install Field Test: The field test of Actinovate (*Streptomyces lydicus*), Camelot O (Copper octanoate), Double Nickel (*Bacillus amyloliquefaciens*) and Revus (Mandipropamid) was installed on a large commercial basil farm in Kunia, on the island of Oahu. Part of a field with mature plants that was producing harvestable leaves was set aside for the field test. The test section was not sprayed by the farmer for several weeks to allow the downy mildew to increase on plants in the section. When the test was started, all plants in the test plot were severely infected with over 50% of leaves showing signs of infection. The plants were approximately two feet tall, planted in plastic covered rows of approximately 150 plants, with 24 inches between plants, and 36 inches between rows. Twenty plants in a row were sprayed with Actinovate and of those, ten plants were rated for disease development. This constituted a rep for the treatment group. Each row of plants contained a rep for each fungicide and the non-treated control group. Four rows were used so that there were four reps for each treatment group.

A special three nozzle backpack sprayer was fabricated to apply the fungicides to the test plants. In order to deliver the specified amount of product to the test plot for each fungicide, calculations were made to account for the amount of liquid delivered at the specified pressure, walking speed, over a specific time to spray the test plot. The three OMRI approved fungicides: Actinovate, Camelot O, and Double Nickel were applied to test plots on a weekly basis for four weeks. Revus was applied twice, at two week intervals. Disease ratings based on infection levels (on a scale of 0 to 5), on ten test plants within each replicate group were taken weekly from test start date until two weeks after the last fungicide application (Fig. 1).

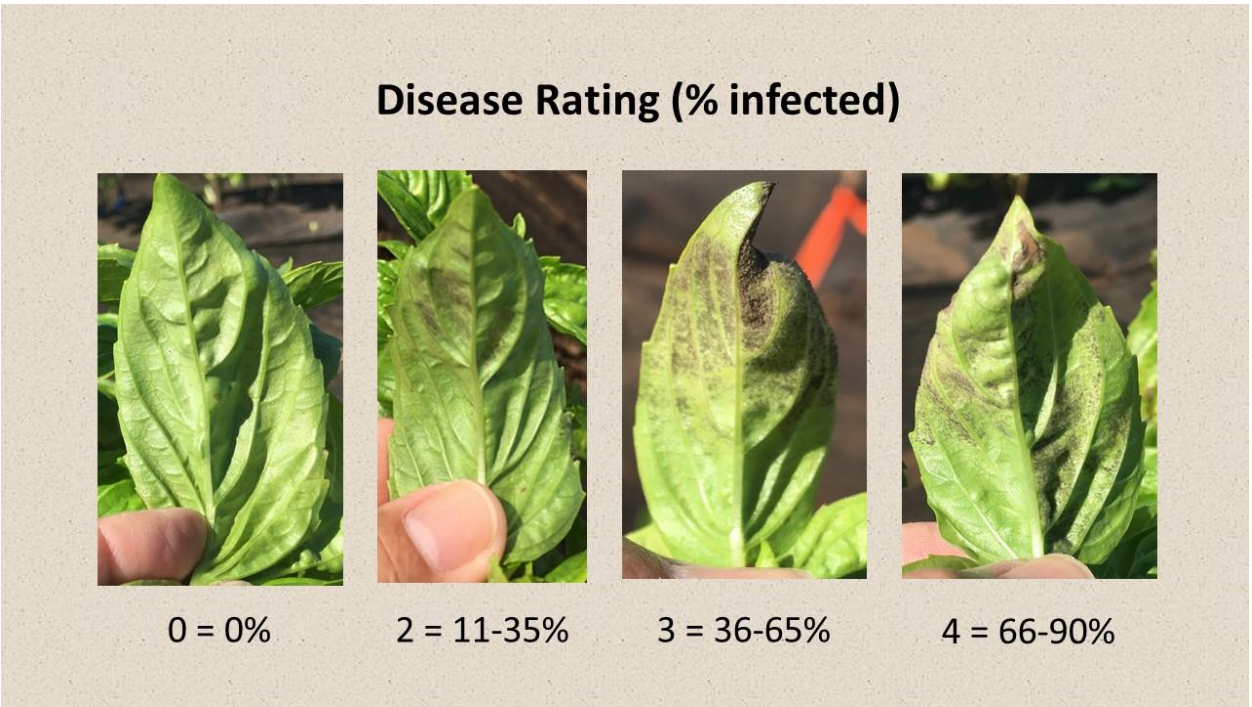

Fig. 1. Field Test of Fungicides for downy mildew control. Disease rating scale.

6, 7, 8 Collect data, analyze, and present results to farmers through workshops: see Goals and Outcomes Achieved below.

Goals and Outcomes Achieved

Fungicide Efficacy Field Test.
Results of the fungicide field test indicate that Revus provides the best disease suppression, followed by Camelot O which provided some benefit, while Actinovate and Double Nickel do not provide any protection from downy mildew infection (Fig. 2). Camelot O did provide some disease reduction, an improvement from 65% infection down to 35% infection after four weeks (Fig. 3). Roughly a 46% reduction in disease levels. At the time the test was run, Camelot O was not approved for use on basil. It has since been approved by HDOA, and is now licensed for use on basil in Hawaii. Although not the best for disease suppression, farmers can still use Camelot O (an OMRI compound) in an integrated spray program, in rotation with Revus and other fungicides from different chemical classes, to control downy mildew, and at the same time, reduce the build-up of resistance in the field.

Fig. 2 Field Test of Fungicides for downy mildew control. Disease levels on representative plants from each group, twenty days after start of test.

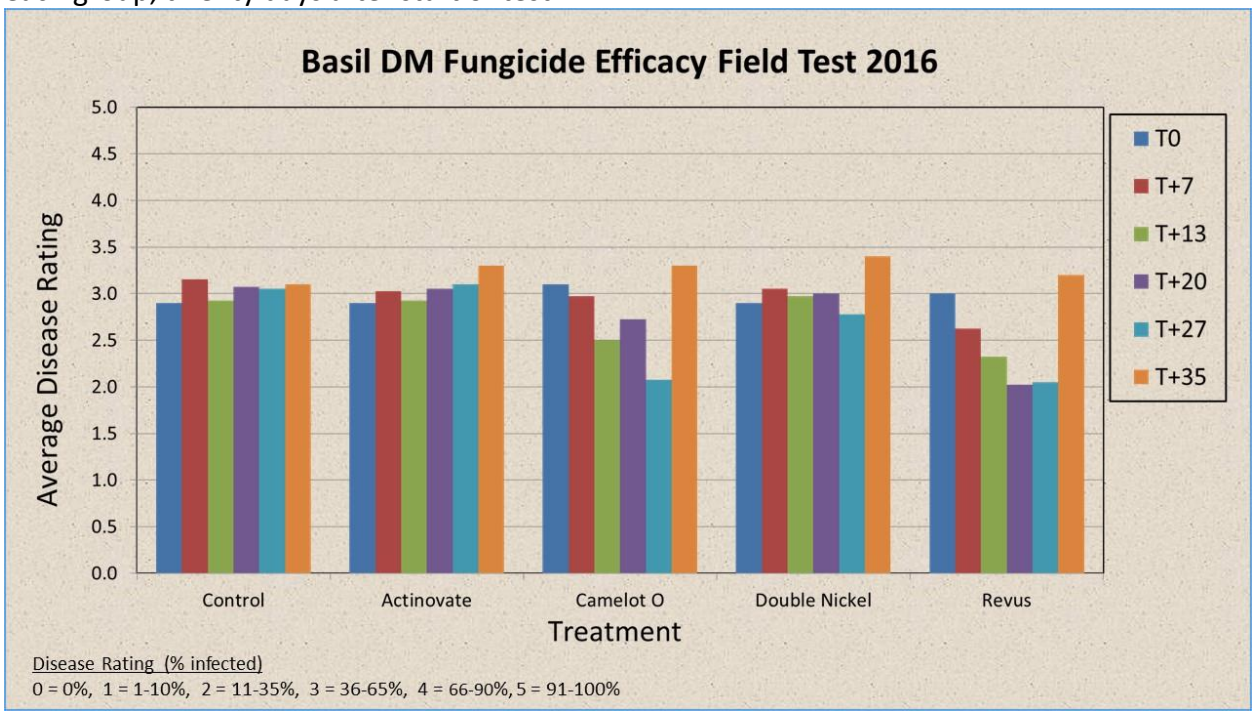

Fig. 3 Field Test of Fungicides for downy mildew control. Fungicide Efficacy Summary

Fungicide Efficacy Greenhouse Test. Actinovate, Camelot O, Revus, and Double Nickel were tested for downy mildew and Stemphylium control. Greenhouse tests for downy mildew were conducted five times, and confirm that Revus provides good protection from downy mildew infection, (Figs. 4 & 5). However, unlike the field test, where Camelot O provided some protection from downy mildew infection, no benefit was seen in the greenhouse tests. The reason for the difference is because the greenhouse tests involved only a single application of fungicides prior to inoculation. The effectiveness of Camelot O was not seen as was the case in the field test, where multiple applications of the fungicide were made over the course of several weeks. In efficacy screening for protection from infection by Stemphylium, a single application of Camelot O provided some degree of protection from Stemphylium infection.

Fig. 4 Greenhouse Test of Fungicides for downy mildew control

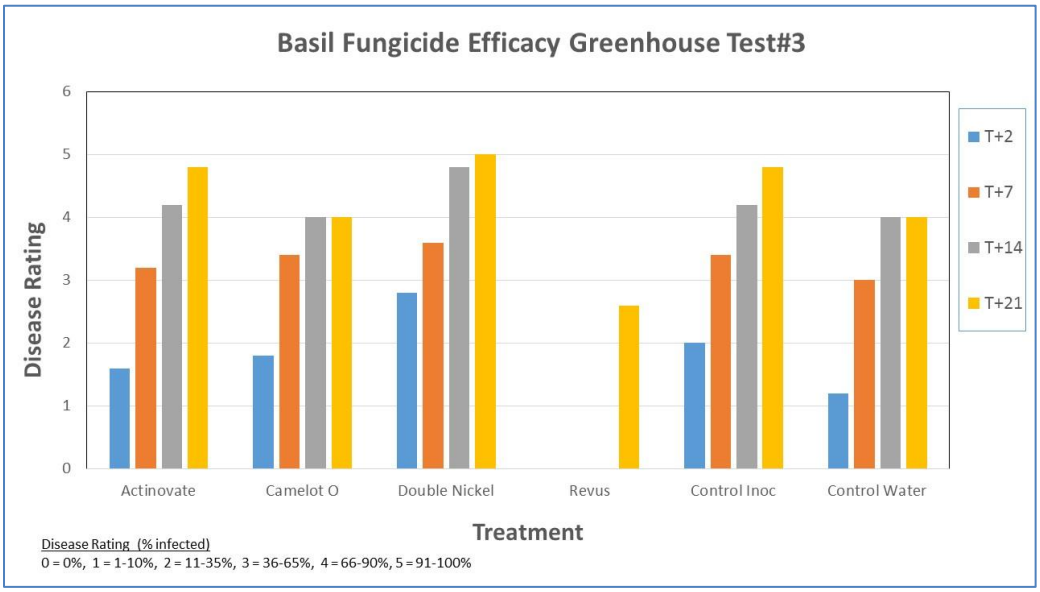

Fig. 5 Fungicide Efficacy Greenhouse Test.

Post-harvest test of cut basil stems. Growers had been told by their buyers that after receiving refrigerated shipments of basil from Hawaii and opening the boxes, spots formed on the leaves and the basil was not usable when the product warmed to room temperature. To replicate this phenomenon, and to test for possible control measures, basil plants were treated with Actinovate, Camelot O, Revus, and Double Nickel, then inoculated with Stemphylium seven days later and maintained in the greenhouse to allow for infection. After 18 days, some small spots had formed, but most of the leaves were asymptomatic. Stems were cut, photographed, then stored at 4°C in boxes for three to four days to simulate shipment to the mainland. After the cool treatment, boxes were removed and stems allowed to warm for 15 minutes to simulate use at a destination market or restaurant. All of the treated groups had brown leaves due to cold storage in the dark. None of the fungicides provided protection from infection (Fig. 6).

Basil treated with fungicide, inoculated with Stemphylium seven days later, maintained in greenhouse for 18 days, then cut and put into bags then into 4°C in boxes for three to four days to simulate shipment to the mainland

Fig. 6 Before going into 4°C in boxes After three days in 4°C in boxes

Irradiation studies. Irradiation studies were conducted with infected basil stems. Stems were packed in plastic bags and then put into boxes and irradiated at 400 grays to determine if irradiation can be used to kill pathogens (downy mildew and Stemphylium) and still retain a salable crop. Boxes were stored in 4°C, and after two days, leaves were examined. Results show that irradiation at 400 grays does not control Stemphylium. The mycelium remains viable and severe tissue damage occured on basil leave, with dark black spots forming on infected areas. Separately, in-vitro tests show that Stemphylium spores remain viable even when exposed to a treatment of 10,000 grays. Downy mildew spores remained viable when exposed to 400 kilograys. Downy mildew spores collected from leaves treated at 400 grays are still able to infect clean basil plants. Thus irradiation does not control downy mildew either.

Research results and information were passed on to Oahu and Maui farmers through the county extension agents, and through direct contact from UH researchers to farmers. Results of the fungicide efficacy field and greenhouse tests were presented at a mini conference on Edible Crop Production coordinated by the Oahu County Extension Agent, on May 24th. The conference was attended by over a hundred farmers, industry professionals, vendors, University researchers, and agricultural stakeholders.

Beneficiaries

Local commercial basil farmers, nursery owners who provide small potted basil plants to garden centers and big box stores, homeowners and backyard gardeners. Government and industry professionals including University researchers, county extension agents, agricultural products supply companies, agricultural professionals from county, state, and federal agencies.

Lessons Learned

At the end of the fungicide field test, basil samples were harvested and brought back to the lab to determine salable amounts for each group. After separating groups and removing symptomatic leaves, only the farmers' current practice had usable samples. The other treatment groups had small amounts

of clean leaves, but the leaves were so young and small that they were not of saleable quality and not something farmers would be able to sell on a commercial basis. The fungicide field test proved that application of a single compound on a weekly basis cannot prevent downy mildew infection and produce salable product. In order to suppress disease development on the leaves, and produce basil of salable quality, multiple fungicides of different classes must be used, and applied more frequently than weekly.

In the fungicide efficacy tests conducted in the greenhouse, stock plants became infected with downy mildew. During the winter months, downy mildew becomes prevalent in the environment and basil plants in almost all locations are susceptible to infection. Although the greenhouse where the stock basil plants were propagated has a solid covered roof, the sides of the building has screens for ventilation. In close proximity (approximately 60 feet) was a small field plot used by another faculty that was testing organic methods for vegetable crop production. One of the test crops planted in the plot was basil. As a result, all of those plants became infected with downy mildew prior to the plants being moved into the adjacent glass greenhouse. The basil plants on the outside of the glass house produced inoculum that made its way into the glasshouse and some stock plants that were being grown for fungicide efficacy testing became infected and not usable. Cool wet weather during the winter was conducive to disease development and the first fungicide test had good results. Drier weather during the spring led to inconsistent results in repeat tests, due to low disease levels on inoculated control plants.

Irradiation studies show that irradiating infected basil leaves at 400 grays, does not control Stemphylium or downy mildew infection. The standard treatment level for commercial produce at the irradiation facility is 400 grays. However, at that level, Stemphylium and downy mildew infection is not controlled by irradiation. Although basil can withstand higher treatment levels, it is not practical or economically feasible for farmers to pay for higher dosages for their produce, thus no further irradiation studies were conducted.

The practice of placing cut basil in plastic bag in boxes, then storing and shipping the boxes under refrigerated conditions, keeps the basil fresh, but it also accelerates disease progression in the box if the leaves are infected with Stemphylium. Fungicide pretreatments do not prevent the progression of the fungal infection, and the basil is unusable when warmed to room temperature. Farmers must strive to prevent infection from occurring prior to harvest, since the shipping process is so conducive to disease development.

Although access to field plots was easier during the summer months, the downy mildew was not present in the fields in sufficient amounts to the start of the fungicide efficacy test. Thus the fungicide efficacy field test had to be delayed until winter, when downy mildew levels in the field were high, and a good assessment of the effectiveness of the fungicides could be made.

Dealing with the highly competitive nature of basil growers, their reluctance to share information, and the language barrier, proved to be significant challenges to the progress of the project.

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Insectary Plants Distribution for Crops Supported in the FY14 Hawaii State Plan

Final Report

University of Hawaii, College of Tropical Agriculture and Human Resources
https://cms.ctahr.hawaii.edu/home.aspx

Project Summary

Previous research by project staff has shown that the planting of insectary plants can be effective in reducing pest pressure. Two field days/workshops were presented to farmers to provide information and resources to encourage "Farm Scaping with Insectary Plants" in their cropping practices. This project specifically demonstrated and educated farmers on how to integrate insectary plants that would be beneficial for specialty crops in Hawaii including basil, taro, garbanzo beans, citrus, tea, mamaki, coffee, cacao, and taro. A total of three videos related to installing insectary plants or insectary settings were shared with interested audiences and one YouTube video was made during an insectary field day. An "Insectary Plants for Hawaii" booklet was published and distributed during the field day at Poamoho. Various insectary plant mixes were shared with farmers.

Project Approach

The first field day organized for this project took place during "GoFarm Hawaii at Waimanalo. Local Seed for Local Needs Field Day" at the University of Hawaii Waimanalo Experiment Station on September 23, 2017. Project staff collaborated with GoFarm Hawaii New Farmers training program where seed packages containing insectary plants to farmers mostly from windward side of Oahu were distributed at no charge.

A second field day with more interactive activities was hosted by the Project Manager and Oahu County Extension Agents and other CTAHR personnel on Oct 28, 2017, at the University of Hawaii, Poamoho Experiment Station, in Waialua. The field day announcement and agenda can be found in Appendix I and II. The field day demonstrated insectary plants that would be beneficial for specialty crops in Hawaii including basil, taro, garbanzo beans, citrus, tea, mamaki, coffee, cacao, and taro. The field day events were video recorded and made into a short clip available at https://youtu.be/lNW6Bmo__Qs.

Videos to demonstrate specific insectary plants for targeted insect pests or natural enemies of interest were shared with the farmers and posted at the Project Manager's website (https://cms.ctahr.hawaii.edu/wangkh/ResearchandExtension/InsectaryPlants.aspx).
https://youtu.be/BsN_3lC35wg
https://youtu.be/1stOru5I-a0
https://www.youtube.com/watch?v=kCleYZ_zwpM

A booklet with pictures and information on insectary plants, beneficial insects and their targeted pests was printed. Sample pages are shown in Appendix III.

Insectary plant seed mixes prepared by UH Sustainable Pest Management Lab and Rincon-Vitova Insectaries, Inc. were distributed to participants. Koolau Seed and Supply also gave away more than 12 species of cover crop seeds. Demonstration plots with these insectary mixes grown at lower elevation in Hawaii were shown during this event.

A representative of the National Resource Conservation Service, was invited to the field day to inform farmers about different government subsidies for farmers planting insectary plants or cover crops.

Goals and Outcomes Achieved

The goal of this project was to demonstrate to farmers the benefits of the use of flowering plants to assist in attracting beneficial insects (pollinators as well as predators) to agroecosystems of the specialty crops listed. The purpose was to help farmers reduce pesticide use and reduce pest pressure, and thus reduce their production costs.

Results from a survey conducted at the end of the field day:

Questions	Average
1. Presentations are very informative for insectary plants for fruits and vegetable crop production.	4.63
2. You are willing to utilize insectary plants for your farm.	4.87
3. You are likely to adopt integrated pest management strategies using insectary plants.	4.88
4. You are happy to see research on non-chemical based pest management strategies.	5.00

Rating scale of 1-5 (1=disagree, 5 = Strongly agree).

Comments from participants were mostly positive and encouraged the project staff to conduct more field days with similar objectives in the future targeting on other specialty crops or cropping systems. In general, participants found the field days informative with helpful information and demonstrations. They especially liked the free “Insectary plants for Hawaii” booklets, wasps nesting block, rose beetle light traps, and insectary plant mixes.

Beneficiaries

Farmers (edible crops, organic crops)
New farmers enrolled in GoFarm Hawaii New Farmers’ Training program
Farm Coaches of GoFarm Hawaii
Extension Agents (agents from neighbor islands are requesting similar workshops in their location after watching the YouTube video of the field day posted online)
Natural Resources and Conservation Service scientists and agents (soil conservationists, soil health promoters)
College students from College of Tropical Agriculture and Human Resources (CTAHR) – both graduate and undergraduate students.

Lessons Learned

There is great interest from the farm community on farm scaping using insectary plants.

Contact Information

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Campus Affiliation	University of Hawaii at Manoa

Additional Information

Pictures from Insectary Field Day at Poamoho

Buckwheat as an insectary border crop

Farmers talking to NRCS/SWCD representative about government subsidiary for planting hedge rows

Hands on demo on constructing rose beetle traps

Rose beetle light traps

Insectary plants' seed distribution

Specialty insectary plant mixes

Native Hawaiian plants for insectary

Appendix I

Insectary Plants for Fruits and Vegetable Crops Field Day

CRATE

Poamoho Experiment Station
65-602 Kaukonahua Rd., Waialua
Oct 28, 2017 (Saturday) 9:00 -11:30 am

Fruit and vegetable crops' farmers are tasked to control insect pests in the most effective and economical methods. This field day introduced and demonstrated different insectary plants or settings that can attract, feed, and shelter insect parasites/parasitoids and predators to enhance natural biological pest control on specialty crops such as basil, garbanzo beans, citrus, tea, papaya, taro, coffee and cacao. In this workshop, farmers learned about using insectary plants as Companion plants, Living mulch, Hedgerows, Trap crops, or for Farm scaping.

Free insectary seeds and insectary settings were given out at first come first serve basis.

State of Hawaii [Department of Agriculture]

LIFE Local & Immigrant Farmer Education
University of Hawai'i at Mānoa
College of Tropical Agriculture & Human Resources

Sustainable & Organic Agriculture Program
University of Hawaii at Manoa

CTAHR
COOPERATIVE EXTENSION
University of Hawaii at Manoa

Appendix II

Insectary Plants for Fruits & Vegetable Crops Field Day
Poamoho Experiment Station
65-602 Kaukonahua Rd., Waialua
Oct 28, 2017 (Saturday) 9:00 -11:30 am

Agenda

8:30 – 9:00 am Sign in (Terrace 2) pick up Insectary booklet.
9:00 – 9:20 am Introduction (Acknowledge HDOA Specialty Crop Block Grant)
- What is insectary plant?
- Benefits of insectary plants - Subsidies for hedge row/cover crop (NRCS/SWCD)

9:20 – 9:30 am Screenhouse with insectary borders
9:30 – 10:10 am How to integrate insectary plants into cropping systems

- Farm scaping (Insectary plant corridors, biological highway, hedgerow, insectary borders, living mulch, ground cover, strip-till cover cropping, trap crop)
- ✓ Basil
- ✓ Taro
- ✓ Garbanzo bean/Chickpea
- ✓ Coffee (mulch and EPN)
- ✓ Rincon-Vitova seed mix
- ✓ Oil radish/mustard (HIPV – Herbivores induced plant volatile attract predatory insects)
- ✓ Lettuce/kai choi

10:10 – 10:20 am Light traps and wasp nesting blocks

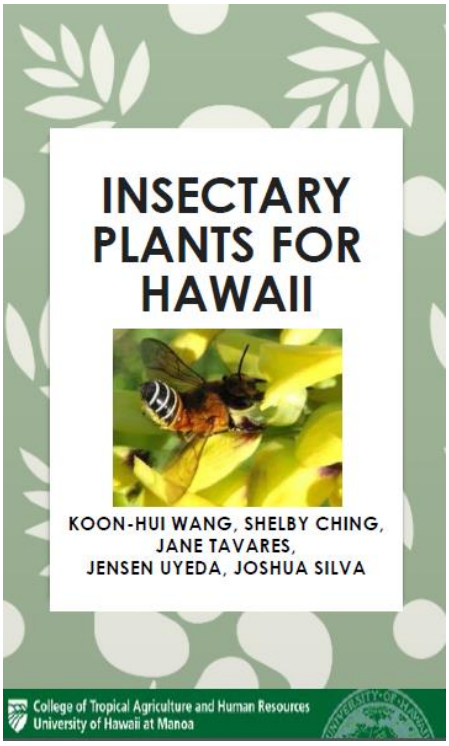
10:20 – 10:40 am Insectary plants for orchard crops

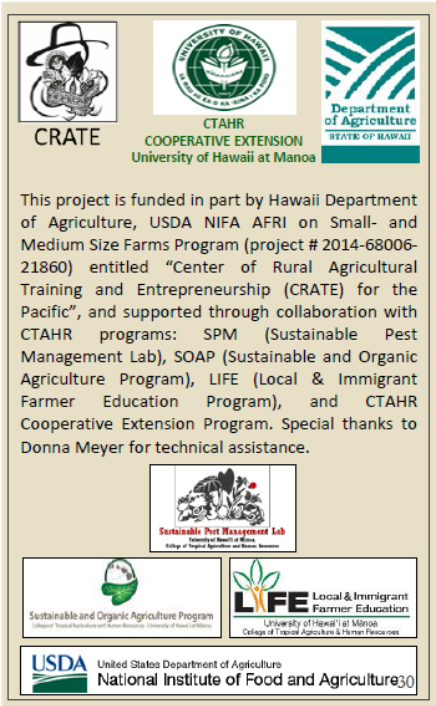
- ✓ Citrus
- ✓ Cacao
- ✓ Tea and Mamaki – minute pirate bugs, Kamehameha butterfly, Sethorus lady beetle

10:40 – 11:00 am Prize giveaways (light traps and wasp nesting blocks) and collection of evaluation sheets, Meet Koolau Seed and Supply; insectary seeds pick up.

Appendix III

Sample pages of "Insectary Plants for Hawaii" booklet





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ESTABLISHING A BREADFRUIT (`Ulu) Orchard

FIELD DAY-- `ULU PRODUCTION & MARKETS

What do you need to know to successfully grow Breadfruit (`Ulu) in Hawaii? To find out, please attend a FREE Field Day at Mililani Ag Park. You will learn about propagation techniques, nutrient needs, irrigation requirements, field prep & spacing, sources for nursery stock, and pruning. A take home planting guide will be provided. Please RSVP to Matt Johnson @ matt.johnson@sustainpromgmt.com. Refreshments will be provided by Mililani Ag Park. H2 North(from H1)
Exit 5B (Mililani Town) Meheula Parkway to the end.
Driveway to Mililani Ag Park is directly across Lanikuhana Ave. proceed to guard gate to check in. Tell security guard you are going to Ulu Workshop.

May 20th, 2016 9:00am-12:00pm

Topics We Will Cover:

- Soil Testing, Nutrients, Amendments
- Planting, Spacing, Fertilization
- Irrigation
- Maintenance, Pruning
- Weed Management
- Markets for Ulu

Speakers:

Danny Green – Southern Turf
Jayme Barton - HARC
Erik Shimizu – Ag Incubator Program

Starter Plants will be Provided as Supplies Last

Breadfruit is a versatile fruit that has long been a staple food for Pacific Islanders. It can be cooked and eaten at almost any stage in its development. It has tremendous potential as a traditional crop and as a crop with many value added possibilities.
But how do you successfully grow breadfruit? What do you need to know to raise strong nursery stock? How do you best prepare a field for breadfruit plantings? How do you maintain your plants after they have been planted?
Join us for the second workshop and find out the answers to these questions, see a breadfruit orchard, and join the conversation about developing a viable market.

Department of Agriculture
STATE OF HAWAII

PRODUCED WITH FUNDS FROM THE STATE OF HAWAII DEPARTMENT OF AGRICULTURE SPECIALTY CROP BLOCK GRANT.

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Breadfruit (`Ulu) Planting Guidelines for Hawai`i

(report can be found online at http://www.oahufresh.com/ag-development-projects/**)**

The purpose of this planting guide is to introduce the grower to breadfruit (`Ulu) and provide guidelines for planting and growing. The practices outlined in this planting guide are based on an in-field, ongoing planting project funded by Hawai`i Department of Agriculture Specialty Crop Block Grant program. Planting conditions and practices may vary for individual producers; this guide is intended to provide suggested practices only.

Breadfruit, commonly referred to as `Ulu in the Pacific Islands, is a staple crop in many Pacific Island cultures. It is a fruit that can be eaten at many stages in its maturity and lends itself to many value added products as well. Breadfruit is a member of the fig family, Moraceae, and it's Latin name Artocarpus altilis is a Greek derivation based on the starchy texture and fragrance, when roasted, of freshly baked bread.

Breadfruit trees can grow up to 80' in height, and typically have a dense canopy. Both male and female flowers emerge on a single tree although yield and productivity vary due to conditions and cultivars. Soil pH preferences seem to be neutral to basic (alkaline) in the range of 6.1-7.4. Breadfruit is able to grow in either sand, sandy loam, loam or sandy clay but has been known to grow in coral sand and somewhat saline soils also.

Sourcing Plant Materials

Tissue culture breadfruit plugs* arrive in a single box of 144 plants (2 flats of 72) at approximately $10 per plant ($1,440 per box). Options for planting up include one gallon pots, dibble tubes, forestry liners, etc. Using Promix or other sterile media is recommended, as some composts may carry pathogens which could be dangerous to the plants at this stage.

Ulu Plant Plugs

One gallon pots which fit about 60 on an 8’ x 4’ bench, forestry liners at 10” depth and 14” depth.

Propagation Methods

Tissue cultured plants were utilized in this project, because the process can be very efficient and is a sure way to obtain true to type varieties. Although it can be difficult to ship root material internationally, tissue cultured plants more easily meet quarantine regulations.

It can be difficult and risky to plant breadfruit tree seeds, because the plant does not develop true to type. Additionally some types are seedless, so vegetative propagation is necessary. This can be accomplished using root shoots or root cuttings, air layering, or grafting.

Propagation by root cutting is taking sections of root and placing them in a media that will encourage additional root growth-sterile compost mixed with peat or perlite is one option. Root cuttings work best with herbaceous plants but can be used to propagate woody plants as well.

Root shoots are small sprouts that grow upward from tree root systems. Root shoots have their own roots resulting in a simple and fast method of propagation. Removing the root shoot and transplanting it produces a tree.

Air layering is a method where the layered plant grows its own set of roots while still attached to the mother plant. The layered plant can later be potted or planted by cutting the layer off from the parent plant below the roots.

Grafting is a similar concept to air layering. Grafting is joining two closely related plants so that they grow from one plant. Grafted plants typically grow a taproot down to the ground; the scion (upper part) of the stem of the grafted plant is attached to the rootstock of the host plant. Grafting can be particularly beneficial for changing cultivars in an orchard setting, providing cross pollination opportunities on a single tree, and cloning in a situation where root cutting success is low.

Nursery Techniques for Seedlings

Roots of the tissue cultured plants in one gallon pots form a nice webbed mat of feeder roots if kept in the pots for 6 months or less. Avoid keeping in pots any longer than 6 months or roots become pot bound. If plants are well maintained and fertilized they may be ready for planting in the ground well before this. Forestry liners have added benefit of encouraging downward growth of roots due to grooved lines running down the sides, and open air bottom holes encouraging air pruning of the roots. However, maintaining these pots upright is awkward due to the not flat shape on bottom and tapered shape from top to bottom. Therefore special crates or self-improvised support structures become necessary. When foliage grows thick in the forestry containers, due to their proximity to each other, it can be difficult to water so special attention to hand watering, or else an improvised ebb and flow system is necessary for irrigation. However, if you will be planting in deep soil, encouraging plants with a downward growing root architecture could be useful.

`

Nutrient Needs

It is of course important to test soils of planting sites to determine that aluminum toxicity, soil compaction, or other issues will not interfere with your root growth. If these issues are present, remedy these situations before planting.

Pre-plant preparations: It is recommended to collect soil samples from each area you will be planting to assess your soil's characteristics and nutrient deficiencies. With trees, it is often very important to add certain nutrients, such as Ca and P, and incorporate them into the soil **BEFORE PLANTING** because after tree roots become established, further incorporation into the soil profile can damage existing root systems.

For directions about how to properly collect soil and tissue samples for fertilizer recommendations please see: http://www.ctahr.hawaii.edu/tropicalfruit/extension.htm

Your soil samples can be submitted to private industry consultants such as Peter Bunn-Crop Nutrient Solutions, BEI, or through your local Cooperative Extension Service.

Cultivars

Currently, three cultivars are available via tissue culture. 'Ma`afala' was the first cultivar released commercially via tissue culture by the Breadfruit Institute and its cooperators. The plants are propagated in a laboratory in Eustis, Florida. This is the main cultivar we are planting at the Mililani Agricultural Park (MAP) for this project. Although there will be one block planted to the other two cultivars for comparison.

Ma`afala was carefully selected due to its production of fruit more consistently throughout the year, producing some fruit nearly year-round, its nutritional characteristics are high, and the fruit size is approximately 1.4 – 2.3 pounds (Breadfruit Institute, National Tropical Botanical Garden, www.breadfruit.org), which is somewhat smaller than some cultivars, and perhaps more marketable in the modern world.

Additional varieties planted at MAP are Pua`a and PiiPiia. Both of these varieties are believed to have originated in French Polynesia. Pua`a has a short harvest window of September to November, and PiiPiia has two main harvests, with another brief harvest in mid summer.

Field Prep

Apply a broad spectrum systemic herbicide labeled for use in Hawai`i and for the broadleaves and grasses present in advance, then follow by disking several times before planting. In this case, Roundup was applied.

Spacing

Currently plantings in the field are split between 15' spacing and 30' spacing. 50% of the plantings are at 15' on center and the other 50% are at 30' apart. All of the rows are 30 feet apart and run north to south. The 15' on center plantings are all located on the east side of the blocks.

As tissue cultured Ma`afala trees tend to be shorter and more compact than trees propagated by air layering, root cuttings, or root shoots, an approximate spacing of 20' x 25' seems to most be appropriate. With trees propagated by traditional methods, after a few years the trees may become very large, and even a 40-50' spacing may be necessary. It is possible to start with a close spacing, and thin trees out at a later date.

One year old 'Ma`afala' tissue culture plant (L) compared to an air layered 'Ma`afala' seven or more years old on 40' spacing (R), tree canopies nearly touching.

Transplanting:

In this project holes were dug using an auger and `ulu plants were placed by hand into the holes. Soil was replaced using a shovel and mulch was applied for moisture retention and to reduce weed pressure.

Irrigation Requirements:

Ulu is reported to need about 60-100inches of water per year, either by rainfall or through an irrigation system. In irrigated situations farmers commonly use drip tape or micro-sprinklers. Typically drip tape is the most water efficient method of water application, but they aren't

always the best option for trees as they can limit the trees root system expansion. Sprinklers with a wider wetting patters can help prevent this, or placement of drip tape on either side if the trees spaced about 1-2 ft apart once the trees are established. If micro-sprinklers are used, try to avoid hitting the lower leaves and branches as this can increase the chance of disease and fungal issues. These sprinklers, as well as drip tape are ideal for applying liquid fertilizers. In areas of high rainfall irrigation may only be necessary for initial tree establishment. Alternative fertilizer programs may also be used that incorporate slow release materials, or small but frequent applications in areas that are not irrigated.

Polytubing irrigation/fertigation with emitters visible.

Pruning

Pruning is important for ulu orchard management. Unmanaged trees can grow 60ft or taller and pose challenges to harvest. It is important to begin the pruning process before trees grow too tall so the pruning will be less severe and trees can recover quickly. Trees in Mililani were pruned first in March 2015 at around 2 years of age at around 7 feet tall. The apical meristem was pruned, primary trunks were selected and secondary trunks were removed. Pruning has primarily been done for canopy development at this point.

A second pruning started in early 2016 and the lowest branches were removed to about 2 feet up the trunk. As the trees get taller the braches will become higher up, so the pruning is just enough to clear the ground and be able to get a mower underneath at this point. Tops were also pruned if taller than about 7-8 feet, as well as top branches that were sweeping upwards. Additional

pruning can also be done after large harvests, and followed up by fertilization to support the plants recovery. Trimmings from the trees may be mulched as used for weed management.

Weed management

Weed management in ulu orchards varies by climate in Hawaii, but in general keeping the area around the base of the plant mostly free of weeds prevents competition and disease.

In wet climates weeds can be controlled by mulching the area around the plant, but be aware that some nutrients from applied fertilizers may get tied up by the mulch. This can be avoided by preventing contact between the fertilizer and mulch. Another option is to use herbicide around the base of the plant, being careful not to spray the branches or trunk of the tree. Wetter climates tend to have some form of ground cover growing naturally, whether established deliberately or existing weedy growth. This can be managed by regularly cutting back the ground cover. Some farmers may choose to establish a selected ground cover before establishing their orchard, carefully removing really invasive vines that may complicate orchard management later.

In dry climates weeds may be less of an issue, but are equally important to control. Mulching and herbicide can be used in the same manner described above. To prevent weedy growth in inter-rows in dry climates many potential cover crop species can be used. These generally compete with unwanted weeds while also keeping the soil covered to prevent erosion from wind and rain. Legumes can also be used to add some nitrogen back to the soil and when used in a mixed species establishment can also aid soil health and microbial activity, which in turn is beneficial to trees.

Various cover crop species can be used, and again these will vary by climate and soil type. There are several legumes which grow well in neutral to basic soils, but may have trouble establishing or not grow at all in acidic soils. Most cover crops can be established with about 1-2 weeks of rainfall or irrigation. After that time they don't need much care or maintenance for about 2 months. Some cover crops can be cut back and regrow, whereas others must be seeded each time. Ultimately the less maintenance is done the more cost effective the cover crop option.

Oats

Perennial Peanut

Oats & Sunn Hemp

Alfalfa

Oats are often a popular choice as they establish quickly and can outcompete weeds. They don't grow very tall and can be cut back 1-2 times before they need to be replanted. They typically need to be cut between 2-3 months, and will need water both for establishment and for regrowth.

They tend to dry out and can die off in dry climates if not irrigated on occasion, especially in the summer.

Perennial Peanut

Perennial peanut is a good option for long term cover. It is a low growing legume which fixes nitrogen and responds well to mowing. It needs full or at least partial sun to establish well, and establishment can take a long time. One drawback to the slow establishment time is the constant need for diligent weed control. This can be very labor intensive for farmers opting not to use herbicide, and for those who do there are very limited options for herbicides that can be used. One possible solution to this is planting mixed species cover crops using perennial peanut along with something like oats. Establish the oats, then clear a small area and plant peanut plugs into the area. This will give the peanut some time to establish while the oats continue to keep back the weeds. Both plants can be mowed. The peanut will need more regular watering to establish.

Alfalfa

Alfalfa is being looked at as a value added cover crop in orchards. It has many benefits including its use for animal feed, and its ability to be cut many times before needing to be replanted. Alfalfa can add value to an orchard as it can be cut and sold as animal feed, which is currently imported from the mainland and very expensive for Hawaii farmers to buy. Alfalfa can be cut many times at and at various intervals, but typically has the highest protein content at around 4-6 weeks. One drawback to this crop is that it does not compete well with weeds, and establishment can be a challenge if the farmer is not diligent about weed control. Alfalfa tends to require more water than other cover crops, so regular watering may be a limiting factor if water costs are high.

Oats & Sunn Hemp

Mixed species cover crops are being evaluated on farms across the country for their benefits to soil health. Species with roots that reach varying depths can help soil microorganisms flourish, break up compaction, and add organic matter at different depths. Mixed species also create diversity above the ground in terms of attracting various beneficial insects like bees and other pollinators. Oats and sunn hemp are two of the most widely used cover crop species in Hawaii. The oats are great at helping out compete weeds and adding organic matter, and the sunn hemp is a nitrogen fixing legume that can add more nutrition to your soil. One thing to be aware of is that sunn hemp can grow very tall when planted in the late spring and summer. It is best used in late summer through early spring.

Yield:

Breadfruit bears seasonally, with most varieties producing one or two crops per year. The main crop typically occurs during the hot, rainy, summer months followed by a smaller crop 3-4 months later. Trees grown from seed begin flowering and producing fruit in 6-10 years. Vegetatively propagated trees start fruiting in 3-6 years which is the case with the trees planted at Mililani.

On the 10 acre test orchard at Mililani Agriculture Park tree spacing was divided into two different configurations for experimental flexibility. As a result, half contain 73 trees per acre and half contain 97 trees per acre. To be conservative, for purposes of any financial projections used in this feasibility study, we will assume 70 trees per acre. Average yields are 150-200 fruits (350-1100 lb) per tree per year in intensive cultivation. According to the Breadfruit Production Guide by Elevitch, Ragone and Cole, the typical Hawaiian ‘Ulu fruit has an average weight of 4.4 lb and an edible portion (Peel and core removed) of 3.8 lbs.

Producing value-added products will require the use of a commercial kitchen. As the cost of building and outfitting a commercial kitchen may be prohibitive for small to mid-size growers and may not be cost-effective considering the seasonal nature of the crop, we are including the cost of renting a commercial kitchen for production in our financial projections. The projected equipment and expected costs needed to produce these value-added products have been included should the grower elect to investigate building kitchen facilities. However, construction, permitting, regulatory, and other requirements to do this are not within the scope of this study and have not been researched.

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Feasibility Study for Breadfruit Related Value-Added Products

May 2016

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Description of the Project

Current Business Scenario

In 2013 Mililani Agricultural Park (MAP) planted 10 acres of breadfruit, creating the largest productive breadfruit orchard in the State. MAP currently manages 75 producing breadfruit trees and proposes to expand upon that production as the additional acres of trees begin to fruit while at the same time documenting their practices and educating other growers to propagate breadfruit throughout the State.

In addition to raw breadfruit, there is a considerable market for processed breadfruit as well. According to Gluten Free Foods and Beverages, in the U.S. the demand for gluten-free food and beverage products has increased dramatically since 2008, going from $1.54 billion to an estimated $3.31 billion in 2012 to an estimated $16 billion market by 2016. Increasing breadfruit production in Hawaii gives local farmers and processors an opportunity to tap into this demand.

This document will explore the:

- Feasibility of breadfruit flour and other value–added products;
- Feasibility of a centralized flour processing facility; and
- Analyze the cost of production and market options for individual farmers who are adding breadfruit production to their farm.

Significant information referenced in this feasibility study is based on the previous research of Craig Elevitch, Diane Ragone, and Ian Cole.

Description of the Project

Breadfruit's seasonal nature makes profitable processing difficult. Food processing operations must operate extremely efficiently because competition keeps profit margins low[1]. For purposes of this feasibility study we will be analyzing the following value added products:

- Packaged sliced or shredded steamed/boiled fruit
- Breadfruit flour
- Breadfruit chips

A 10 acre breadfruit orchard has been established at Mililani Agriculture Park. Tree spacing was divided into two different configurations for experimental flexibility. As a result, half contain 73 trees per acre and half contain 97 trees per acre. The first significant harvests are expected in the summer of 2016. Due to the fact that yield and cost of production data specific to Hawaii and this location are still being collected, we will utilize data obtained from breadfruit operations in the Pacific and Caribbean Islands with selected adjustments when necessary.

[1] Ragone, D. 2011 (revised). Farm and Forestry Production and Marketing Profile for Breadfruit (Artocarpus altilis). In: Elevitch, C.R. (ed.). Specialty Crops for Pacific Island Agroforestry.Permanent Agriculture Resources (PAR), Holualoa, Hawaii. http://agroforestry.net/scps

Market Feasibility

Breadfruit Description[2]

Breadfruit has been an important staple crop and component of traditional agroforestry systems in the Pacific for more than 3,000 years. This species originated in the South Pacific and was spread throughout Oceania by intrepid islanders settling the numerous islands of Melanesia, Micronesia, and Polynesia. Due to the efforts of Captain Bligh and French voyagers, a few seedless varieties from Polynesia were introduced to the Caribbean in the late 1700s. These gradually spread to other tropical regions. Breadfruit is now grown in close to 90 countries.

The fruit (10-30 cm long × 9-20 cm wide) vary in shape, size, and skin texture. They are usually round, oval or oblong weighing 0.25-6 kg. Skin texture ranges from smooth to rough to spiny. The color is light green, yellowish-green or yellow when mature, although one unusual variety ('Afara' from French Polynesia) has pinkish or orange-brown skin. The flesh is creamy white to pale yellow. Fruit are typically mature and ready to cook and eat as a starchy staple in 15-19 weeks. Ripe fruit have yellow or yellow-brown skin and soft, sweet, creamy flesh that can be eaten raw or cooked.

Breadfruit is a versatile crop and the fruit can be cooked and eaten at all stages of maturity. It is an important staple food in the Pacific region, parts of the Caribbean and other tropical regions where it is mainly grown as a subsistence crop in home gardens or small farms. It is an excellent dietary staple and compares favorably with other starchy staple crops commonly eaten in the tropics, such as taro, plantain, cassava, sweet potato and white rice. Breadfruit is rich in vitamins and minerals and provides a gluten-free source with high amounts of carbohydrates and protein.

Breadfruit Industry in Hawaii

The breadfruit tree, known throughout the Hawaiian archipelago as ʻulu, occupied an important niche in ancient Hawaiian culture. Breadfruit figured prominently in Hawaiian spiritual life, was employed in a range of material applications, and served as a ready source of food and medicine.

Breadfruit can easily be grown and managed as a backyard tree as they require little attention or care and produce an abundance of food with minimal input of labor or materials[3].

The farm-gate value of Hawaii's specialty fruits industry more than doubled between 2003 and 2007, from $2.128 million to $4.485 million. Total production during this period increased by 97.6 percent and reached 2.28 million pounds of fresh fruit. Rambutan, longan, lychee, and mango were the principal crops, accounting for 87.8 percent of specialty fruit production and contributing 90.3 percent of the farm-gate value of the industry[4]. Breadfruit is considered a specialty fruit and was included in the analysis. However, specific information for breadfruit was not provided due to low production of the crop.

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[2] National Tropical Botanical Garden Breadfruit Institute website, http://ntbg.org/breadfruit/breadfruit/

[3] Elevitch, C.,D. Rangone, and I. Cole. 2014. Breadfruit Production Guide: Recommended practices for growing, harvesting, and handling (2nd Edition). Breadfruit Institute of the National Tropical Botanical Garden, Kalaheo, Hawaii and Hawaii Honegrown Food Network, Holualoa, Hawaii. www.breadfruit.org and www.breadfruit.info.

[4] M. Nagao. Jan. 2009. Industry Analysis: Identifying Research and Extension Priorities for Hawaii's Avocado, Banana, Citrus, and Specialty Fruits. University of Hawaiʻi at Mānoa, College of Tropical Agriculture and Human Resources (CTAHR). Economic Issues no. 17.

For purposes of this study, we are using a market price of $1.25 per pound for raw breadfruit based on current observed prices. However we are not analyzing the viability of this this price point as it is not within the scope of this study.

Specialty Foods using Breadfruit

Breadfruit is well suited as a base for a range of consumer products because of its high starch content, pale color, and mild flavor. The wide range of corn, rice, and potato products available could be made with breadfruit. Development of breadfruit products is still limited. Chips are a popular item and available on a small scale in local markets in the Pacific and Caribbean Islands, the Seychelles, and Malaysia. Canned breadfruit chunks are produced in Jamaica and available in stores in the USA, Canada and Fiji. Boiled breadnut seeds are also canned in the Caribbean. Raw and cooked seeds can be ground into meal. Breadfruit can also be dehydrated, freeze-dried, or frozen. Dried breadfruit is ground into flour which can substitute a portion of wheat or other flours used in making bread and baked goods. One market advantage of breadfruit is that it is gluten free. Starch can be extracted from firm, mature fruit. The starch and flour are used to make breakfast foods, porridges, crackers, and snack foods[5].

For purposes of this feasibility study we will be focusing on the following breadfruit related value added products:

- Packaged sliced or shredded steamed/boiled fruit
- Breadfruit flour
- Breadfruit chips

While fresh breadfruit is readily available in small quantities from smaller producers and “backyard” growers, the local market currently lacks a commercial supply of the fruit from any large producer or consolidator. The National Tropical Botanical Garden's Breadfruit Institute has developed an initiative to encourage people to eat and grow more breadfruit. As part of this initiative they have enlisted chefs and restaurants to promote the fruit. They are also working with the Hawaii Homegrown Food Network on the Ho'oulu ka 'Ulu project which seeks to revitalize breadfruit as an attractive, delicious, nutritious, abundant, affordable, and culturally appropriate food. Other local initiatives are planned or are underway.

The majority of commercial, value-added breadfruit products found in the market are imported and use breadfruit from the Pacific and Caribbean Islands. Value-added breadfruit products have the opportunity to take advantage of the growing trend of gluten free products in the market. Sales of gluten free products posted an annual growth rate of 34 percent over the five-year period ending in 2014 when market sales reached $973 million, with sales expected to exceed $2 billion in 2019, according to market research publisher Packaged Facts in the recently released report Gluten-Free Foods in the U.S., 5th Edition.

Due to the limited numbers of breadfruit products available on the market we were not able to obtain a wide variety of products for price comparison. As an alternative we have included comparable products in the gluten free market.

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[5] http://ntbg.org/breadfruit/uses/food1.php

Product	Manufacturer	Price	Volume	Price per unit
Breadfruit Flour	Maiden South Pacific Ltd	$ 12.00	1.1 lbs	$ 10.91
Breadfruit Powder	Pilialoha Farms	$ 12.50	1 lbs	$ 12.50
Gluten Free Artisan Flour Blend	Pamela's Products	$ 13.29	4 lbs	$ 3.32
Gluten Free Flour	Cup4Cup	$ 15.80	3 lbs	$ 5.27
Gluten Free All Purpose Baking Flour	Bob's Red Mill	$ 39.80	25 lbs	$ 1.59
Gluten Free Flour	King Arthur Flour	$ 7.95	1.5 lbs	$ 5.30
Ulu Chips	Taro Ko Chips	$ 5.00	4 oz	$ 1.25
Purple Sweet Potato Chips	Atebara	$ 5.00	4 oz	$ 1.25
Taro Chips	Atebara	$ 6.00	4 oz	$ 1.50

Industry Competitiveness

Commercial production of breadfruit is still in its infancy stages as organizations like the Hawaii Homegrown Food Network and the National Tropical Botanical Garden's Breadfruit Institute try to educate growers and consumers of the viability of the crop. Breadfruit's primary competition comes from other local and imported carbohydrate staples it seeks to supplant.

In addition, as the trees require little maintenance there are an abundance of backyard gardens that are producing fruit and most likely providing it to neighbors at little to no cost. Therefore, the key to developing a commercial demand for the fruit is in the development of viable value-added products beyond the raw product itself.

Retail/Wholesale Market

The wholesale market is appears to be a limited option for the individual growers. In order to make this venture profitable, the individual growers need to get the best price they can and that indicates sales directly to consumers in the retail market or through wholesalers with lower margin requirements. Production volumes at the levels we are projecting for the individual growers may not be high enough (due to the projected labor and processing times) to support multiple large wholesale customers (i.e. supermarkets, convenience stores, etc.) on a weekly/semi-weekly basis.

A centralized processing facility would also need to maximize prices due to the high fixed costs related to running a brick and mortar operation. A centralized facility should be able to produce at volumes necessary to support larger wholesale customers while also utilizing its physical location as a retail outlet for sales direct to the consumer. An entirely wholesale customer base does not appear to be a viable sales strategy based on our financial projections.

Market Potential

The term "superfruit" was first used in the industry in 2004. In recent years, products such as goji berry, hempseed, and wheatgrass have been marketed as "superfoods" because of their supposed extraordinary health benefits even though such claims are not scientifically proven. Breadfruit has been garnering significant attention in the media as the next "superfood" due to the high amounts of vitamins, minerals, carbohydrates and protein it possess and because it is a gluten-free food source.

Celiac disease is an autoimmune disorder affecting primarily the small intestine and is caused by a reaction to gluten. Approximately 1 in 100 people suffer from this affliction, the only known effective treatment for which is a strict gluten-free diet. While the disease seems to have come out of nowhere over the past several years, research suggest it has steadily been on the rise and is four times more

common today than it was in the 1950s. The relatively recent awareness of the affliction as well as the perception that "gluten free" is healthier has resulted in the extensive branding of "gluten free" products and the development of "gluten free" alternative food sources.

Executives from Mondelez, for example, spoke about their recent acquisition of healthy lifestyle brand Enjoy Life Foods (which includes products for consumers who have allergies or want gluten-free and non-GMO fare), citing 30% growth of the US allergen-free segment. General Mills GIS +0.24% executives are betting on gluten-free, too: They cite the category as a bright spot with an estimated $8.8 billion in US retail sales in 2014 with predicted growth of $10.6 billion in 2015[6].

In dollars and cents, sales of gluten-free products were expected to total $10.5 billion last year, according to Mintel, a market research company, which estimates the category will produce more than $15 billion in annual sales in 2016[7].

Technical Feasibility

Breadfruit Producer

General Needs

This study assumes the grower and/or their employees have learned the appropriate techniques for cultivating and harvesting breadfruit. For purposes of this study we will assume that the grower will be adding breadfruit to an existing farming operation. Therefore, for purposes of our financial projections we are using only .5 to 1 acre of production. In addition, we are assuming the planting area would require minimal prep work and as it is a relatively low maintenance crop, additional employees would not need to be added during the growing period as the trees could be cared for by the current maintenance crew. Additional employees will most likely be necessary during the harvesting periods and for the value-added production operations.

Production Needs

Breadfruit bears seasonally, with most varieties producing one or two crops per year. The main crop typically occurs during the hot, rainy, summer months followed by a smaller crop 3-4 months later. Trees grown from seed begin flowering and producing fruit in 6-10 years. Vegetatively propagated trees start fruiting in 3-6 years.

On the 10 acre test orchard at Mililani Agriculture Park tree spacing was divided into two different configurations for experimental flexibility. As a result, half contain 73 trees per acre and half contain 97 trees per acre. To be conservative, for purposes of any financial projections used in this feasibility study, we will assume 70 trees per acre. Average yields are 150-200 fruits (350-1100 lb) per tree per year in intensive cultivation. According to the Breadfruit Production Guide by Elevitch, Ragone and Cole, the typical Hawaiian 'Ulu fruit has an average weight of 4.4 lb and an edible portion (Peel and core removed) of 3.8 lbs. Little information is available about managing breadfruit for commercial production. It is a relatively low maintenance crop and can be fertilized once or twice a year (at the beginning and end of

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[6] http://www.forbes.com/sites/nancygagliardi/2015/02/18/consumers-want-healthy-foods-and-will-pay-more-for-them/#2187fb31144f

[7] http://www.nytimes.com/2014/02/18/business/food-industry-wagers-big-on-gluten-free.html?_r=0

the fruiting seasons) with a balanced fertilizer. Pruning should be limited to the removal of dead branches, but trees are often topped to make it easier to harvest fruits[8].

Producing value-added products will require the use of a commercial kitchen. As the cost of building and outfitting a commercial kitchen may be prohibitive for small to mid-size growers and may not be cost-effective considering the seasonal nature of the crop, we are including the cost of renting a commercial kitchen for production in our financial projections. The projected equipment and expected costs needed to produce these value-added products have been included should the grower elect to investigate building kitchen facilities. However, construction, permitting, regulatory, and other requirements to do this are not within the scope of this study and have not been researched.

Breadfruit Flour

Processing fresh breadfruit into flour takes several steps. The fruit must be picked at the right stage, peeled/cleaned, shredded, dried and ground. The Trees That Feed Foundation has developed a prototype hybrid solar dryer that they are currently testing in Jamaica and Haiti. The construction materials include mainly plywood (preferably pressure treated or otherwise waterproofed), galvanized metal sheets, and clear plastic sheets (preferably UV stabilized) with a total cost of construction falling around $1,700 (including 30 hours of labor at $20 per hour). Design calculations indicate a drying capacity of 100 pounds of fresh shredded breadfruit in approximately 24 hours. Assuming an 80% weight loss due to moisture this equates to approximately 20 pounds of dried breadfruit per batch. The published research paper can be found on the Trees That Feed Foundation website[9].

Assuming the half acre of production in our model, the dehydrator described in the previous paragraph would require approximately 10 days to dehydrate the projected yield of 23,100 lbs of breadfruit. Additional equipment would include a commercial slicer and a burr style mill for grinding (see the Breadfruit Institute "How to Dry & Grind Breadfruit Into Flour" brochure located on their website at http://ntbg.org/breadfruit/resources/cms_uploads/BFI_UBC_Flour_Brochure_color.pdf). Projected capital equipment costs for an individual producer would be approximately $2,800 as detailed below:

Equipment	Cost
Dehydrator	$ 1,700
Grinder	$ 800
Slicer	$ 300

Breadfruit chips

Processing fresh breadfruit into chips is a simpler process. As with breadfruit flour, the fruit must be picked at the right stage, peeled/cleaned and then sliced and fried. A 35-50 lb. fat capacity

[8] Ragone, D. 2006 Artocarpus altilis (Breadfruit), ver. 2.1. In: Elevitch, C.R. (ed.). Species Profiles for Pacific Island Agroforestry.Permanent Agriculture Resources (PAR), Holualoa, Hawaii. http://www.traditionaltree.org

[9] http://www.treesthatfeed.org/wp-content/uploads/2016/03/A-Hybrid-Solar-Dryer-for-Processing-Breadfruit-August-2015.pdf

commercial fryer can be purchased for approximately $700. Generally, a quality fryer can produce a volume (per hour) equal to 1.5 to 2 times the weight of oil it can hold. Assuming the half acre of production in our model, a 35-50 lb. fryer would require 58 hours to process the projected 4,620 lbs. of breadfruit. The fryer, with the added cost of a commercial slicer would result in projected capital equipment costs of $1,000.

Packaged sliced or shredded steamed/boiled fruit

Processing the fresh breadfruit by cleaning, slicing or shredding, boiling or steaming and then vacuum packaging adds value for home cooks and restaurant chefs by eliminating time-consuming processes. Combi-steamers are relatively expensive and can range from $4,000 for home models to over $10,000 for commercial equipment. Commercial kettle boilers are also in the high price range and can fall anywhere from $4,000 for a 6-gallon tilting kettle to $11,000 for a 10-gallon table top gas tilt kettle. Vacuum sealers are more commonplace and range in prices from around $200 to $2,000 and up depending on the seal size and package size.

Raw Materials

In addition to the breadfruit, the value added products may require additional raw materials to add flavor, prolong shelf life, etc. that can be easily sourced from local wholesalers. Other than the labor for harvesting and processing the product, packaging is the next significant expense and can contribute to cash flow issues. In order to take advantage of shipping discounts, it is financially advantageous to order packaging in large quantities. However, payment is required at the time of order and cannot be recovered until product sales are made, in many cases months after the original packaging purchase.

Marketing and Sales Needs

Individual growers should focus on retail consumers and market their products as local, gluten free, specialty food items coming directly from the farm. Packaging and product labeling should support this positioning. At lower volumes of sales, the individual grower will have a higher level of direct interaction with the customer and will have opportunities to educate them directly on the benefits and versatility of the fruit.

Centralized Processing Facility

General Needs

Breadfruit's seasonal nature makes profitable centralized processing difficult. Food processing operations must operate extremely efficiently because competition keeps profit margins low. Idle time during processing is highly unprofitable because fixed costs accrue and production of finished products for sale diminishes. This seasonal supply difficulty can be mitigated by: 1) Bulk preservation (i.e. drying/freezing raw material at the height of the season); 2) dovetailing breadfruit processing with other products with different seasonal glut; and, 3) planting varieties with sequential seasons[10].

[10] Ragone, D. 2011 (revised). Farm and Forestry Production and Marketing Profile for Breadfruit (Artocarpus altilis). In: Elevitch, C.R. (ed.). Specialty Crops for Pacific Island Agroforestry.Permanent Agriculture Resources (PAR), Holualoa, Hawaii. http://agroforestry.net/scps

Production Needs

A centralized processing facility would purchase fruit directly from the grower and clean, process and package the various value added products. We are including the cost of leasing and outfitting a commercial kitchen space for production in our financial projections. Our projections assume, at the minimum, a 1,000 sq. ft. facility. For our financial projections we are estimating a cost of $2.00 per sq. ft. per month for a monthly lease/rent expense of $2,000. The facility would be segregated into separate areas to support receiving, processing, storage and retail sales activities. Along with adequate storage and refrigerator/freezer space, a centralized processing facility would require larger volume versions of all the equipment described earlier plus several other pieces of equipment to facilitate other value added processes. The projected equipment and anticipated costs needed to produce value added products have been researched on a preliminary basis and are described in the table below (Total estimated cost of $56,800). However, detailed construction, permitting, regulatory, and other requirements (such as electrical load, floor maps, etc.) are not within the scope of this study and have not been researched.

Item	Specifications	Est. Price Range
Reach-in Refrigerator/Freezer	20.41 Cu.Ft. Freezer Capacity; 43.81 Cu. Ft. Refrig. Capacity	$ 7,000
Walk-in Freezer	Walk-In Outdoor Freezer 6 X 10 X 7'7" w/ Floor	$ 8,000
Commercial Range	60in 6 Burner w 24in Raised Griddle, 2 Convection Ovens	$ 8,500
Dehydrator	Stainless Steel 148 Sq.Ft. Drying Capacity	$ 13,000
Pallet Jack/Lift	5500 Lb. capacity	$ 1,000
Pallet Rack	Steel Shelving (Various weight capacities)	$ 500
Commercial Sink	Three Compartment Sink With Faucets/Plumbing	$ 800
Commercial Mixer	20 - 30 Qt. Variable Speed Mixers	$ 2,000
Commercial Fryer	Deep Fryer 63lb Gas Floor Fyer - 119,000 BTU	$ 6,000
Commercial Steamer	Counter Top 5 Pan Steamer	$ 10,000

Raw Materials

As stated earlier, breadfruit's seasonal nature makes profitable centralized processing difficult. In order to avoid idle time, this seasonal supply difficulty can be mitigated by: 1) Bulk preservation (i.e. drying/freezing raw material at the height of the season); 2) dovetailing breadfruit processing with other products with different seasonal glut; and, 3) planting varieties with sequential seasons. In this case, the centralized processor should source breadfruit from producers in different regions with different harvest periods to minimize idle time. In addition, they should seek other products for the offseason months.

As we stated for the individual grower, in addition to the breadfruit, the value added products may require additional raw materials to add flavor, prolong shelf life, etc. that can be easily sourced from local wholesalers. A significant expense for a centralized processing facility is labor as the facility would require a manager, operators and a sales marketing staff at the very least. Also, as the facility might be producing several different value added products, packaging would be another significant expense and can create the cash flow issues we described earlier.

Marketing and Sales Needs

To support the volume of production and sales needed to operate a centralized facility, a significant effort must be made on the marketing end to educate the consumer and increase acceptance of breadfruit and breadfruit value added products. Over the past few years there has been an increasing awareness of breadfruit which has been reflected in the media:

“Is this the new wonder food? Breadfruit is high in protein and has the potential to feed the world, experts say” – Daily Mail (UK)

“The wonder food you’ve probably never heard of” – www.newscientist.com

“Celebrating and savoring breadfruit in Hana, Hawaii” – LA Times

“A Solution To World Hunger? Breadfruit, Gluten-Free 'New Superfood,' Is High In Carbs and Protein” – www.medicaldaily.com

In addition, there have been a number of federal and state grant related projects and non-profit interests relating to research of breadfruit as a potential commercial food crop.

Financial Feasibility

Assumptions Used in Financial Feasibility Analysis

70 trees per acre

150 fruit per tree annually

Average weight of 4.4 lbs. per fruit (3.8 lbs. peeled and cored)

80% weight loss due to moisture lost during the dehydration process

Labor wage rate of $15/hr

Employee benefits and taxes calculated at 30% of salaries/wages

Centralized facility monthly rent of $2.00 per sq. ft. for a 1000 sq. ft. property on Oahu

Wholesale cost per lb. for raw fruit of $1.25/lb.

Retail price for 4 oz. bag of chips $5.00

Retail price for 1 lb. bag of flour $10.00

Wholesale price for 1 lb. vacuum sealed bag of sliced and cooked fruit $4.00

Packaging/labeling cost of $0.15 per unit

Annual maintenance cost of 10% of capital machinery costs

Fuel costs of $200 per month

Marketing/Advertising costs of $200 per month for individual grower; $100 per month for centralized facility (lower due to wholesale sales and dedicated salesperson reflected in labor costs)

Utilities costs of $400 per month

Financial Projections - Breadfruit Producer

Startup requirements for the individual growers vary depending on the numbers of trees, types of products they plan to produce, etc. As noted earlier, potential equipment costs could include:

Equipment	Cost
Dehydrator	$ 1,700
Grinder	$ 800
Slicer	$ 300
Comm. Fryer	$ 700
Comm. Kettle Boiler	$ 4,000
Combi-Steamer	$ 4,000
Vacuum Sealer	$ 200

In lieu of purchasing equipment, the grower could rent commercial kitchen space. However, capital would still be needed for:

- Growing and Harvesting Fruit
- Labor Expenses

- Product Development
- Commercial Kitchen Rent
- Product Packaging: ingredients and packaging.
- Marketing: brochures, product photos, website, product launch, product display, signage etc.
- Miscellaneous Supplies

The following summarizes projected revenues and expenses for the three value added product lines in this study:

	Individual Grower		
	Sliced/Dried		Sliced/Cooked
	Chips	Flour	
No. of Acres	1	1	1
Processed Yield Lbs	7,980	7,980	39,900
Yield in Oz.	127,680	N/A	N/A
Retail price per unit	$ 5.00	$ 10.00	$ 4.00
Wholesale price per unit	$ 3.00	$ 6.00	$ 2.40
Sales Revenue (100% Retail)	$ 159,600	$ 79,800	$ 159,600
Sales Revenue (100% Wholesale)	$ 95,760	$ 47,880	$ 95,760
Sales Revenue (50% Retail/50% Wholesale)	$ 127,680	$ 63,840	$ 127,680
Packaging	$ 4,788	$ 1,197	$ 5,985
Raw Breadfruit	$ -	$ -	$ -
Field Labor	$ 31,200	$ 31,200	$ 31,200
Production Labor	$ 31,200	$ 31,200	$ 31,200
Employee Benefits and Taxes	$ 18,720	$ 18,720	$ 18,720
Commercial Kitchen Rental	$ 6,000	$ 6,000	$ 6,000
Rent	$ -	$ -	$ -
Gen. Liability Insurance	$ 650	$ 650	$ 650
Maintenance	$ -	$ -	$ -
Fuel	$ 2,400	$ 2,400	$ 2,400
Marketing/Advertising	$ 2,400	$ 2,400	$ 2,400
Utilities	$ 4,800	$ 4,800	$ 4,800
Projected Costs	102,158	98,567	103,355
Projected Profit/Loss (100% Retail)	$ 57,442	$ (18,767)	$ 56,245
Projected Profit/Loss (100% Wholesale)	$ (6,398)	$ (50,687)	$ (7,595)
Projected Profit/Loss (50% Retail/%50 Wholesale)	$ 25,522	$ (34,727)	$ 24,325

Financial Projections - Centralized Processing Facility

Startup requirements for a centralized processing facility would vary depending on the volume of fruit they could obtain, types of products they plan to produce, etc. As noted earlier, potential equipment costs could include:

Item	Specifications	Est. Price Range
Reach-in Refrigerator/Freezer	20.41 Cu.Ft. Freezer Capacity; 43.81 Cu. Ft. Refrig. Capacity	$ 7,000
Walk-in Freezer	Walk-In Outdoor Freezer 6 X 10 X 7'7" w/ Floor	$ 8,000
Commercial Range	60in 6 Burner w 24in Raised Griddle, 2 Convection Ovens	$ 8,500
Dehydrator	Stainless Steel 148 Sq.Ft. Drying Capacity	$ 13,000
Pallet Jack/Lift	5500 Lb. capacity	$ 1,000
Pallet Rack	Steel Shelving (Various weight capacities)	$ 500
Commercial Sink	Three Compartment Sink With Faucets/Plumbing	$ 800
Commercial Mixer	20 - 30 Qt. Variable Speed Mixers	$ 2,000
Commercial Fryer	Deep Fryer 63lb Gas Floor Fyer - 119,000 BTU	$ 6,000
Commercial Steamer	Counter Top 5 Pan Steamer	$ 10,000

Additional capital would still be needed for:

- Purchasing Fruit From Growers
- Labor Expenses
- Product Development
- Commercial Kitchen Lease Fees
- Product Packaging: ingredients and packaging.
- Marketing: brochures, product photos, website, product launch, product display, signage etc.

The following summarizes projected revenues and expenses for the three value added product lines in this study:

	Centralized Facility		
	Sliced/Dried		Sliced/Cooked
	Chips	Flour	
No. of Acres	5	5	5
Processed Yield Lbs	39,900	39,900	199,500
Yield in Oz.	638,400	N/A	N/A
Retail price per unit	$ 5.00	$ 10.00	$ 4.00
Wholesale price per unit	$ 3.00	$ 6.00	$ 2.40
Sales Revenue (100% Retail)	$ 798,000	$ 399,000	$ 798,000
Sales Revenue (100% Wholesale)	$ 478,800	$ 239,400	$ 478,800
Sales Revenue (50% Retail/50% Wholesale)	$ 638,400	$ 319,200	$ 638,400
Packaging	$ 23,940	$ 5,985	$ 29,925
Raw Breadfruit	$ 288,750	$ 288,750	$ 288,750
Field Labor	$ -	$ -	$ -
Production Labor	$ 124,800	$ 124,800	$ 124,800
Employee Benefits and Taxes	$ 37,440	$ 37,440	$ 37,440
Commercial Kitchen Rental	$ -	$ -	$ -
Rent	$ 24,000	$ 24,000	$ 24,000
Gen. Liability Insurance	$ 650	$ 650	$ 650
Maintenance	$ 5,680	$ 5,680	$ 5,680
Fuel	$ 2,400	$ 2,400	$ 2,400
Marketing/Advertising	$ 1,200	$ 1,200	$ 1,200
Utilities	$ 4,800	$ 4,800	$ 4,800
Projected Costs	513,660	495,705	519,645
Projected Profit/Loss (100% Retail)	$ 284,340	$ (96,705)	$ 278,355
Projected Profit/Loss (100% Wholesale)	$ (34,860)	$ (256,305)	$ (40,845)
Projected Profit/Loss (50% Retail/%50 Wholesale)	$ 124,740	$ (176,505)	$ 118,755

Study Conclusions

Based on our analysis, we noted the following:

Breadfruit is clearly gaining traction as a potential commercial food crop. Over the past few years there has been an increasing awareness of breadfruit which has been reflected in the media through articles online and in various publications and in the number of federal and state grant related projects and non-profit interests relating to research of the crop. A key component in the economic viability of this crop in the US market will be in marketing and educating the consumer on the benefits of the fruit and their eventual acceptance of breadfruit related products.

Regarding the products analyzed in this study, breadfruit flour does not appear to be a viable value added product for the individual grower or the centralized facility due to the fact that the projected direct and indirect costs are larger than the potential revenues generated by the product in all scenarios (100% retail sales, 100% wholesale sales and 50%/50% between retail and wholesale). Specifically, for the centralized facility, the cost of buying the raw breadfruit combined with the weight lost from peeling/coring and dehydrating results in a high per unit cost of production that appears to be an insurmountable obstacle to profitable operations. There may be potential for an individual grower if they can be efficient in managing expenses and have retail channels that can maximize sales. Otherwise there does not appear to be a scenario where potential revenues surpass expenses.

On the other hand, packaged sliced or shredded steamed/boiled fruit and breadfruit chips appear to be viable products provided the individual grower or the centralized facility can find retail channels or a mix of retail and wholesale channels that can maximize sales. The wholesale price point does not appear to be viable as the only sales outlet unless operational efficiencies can be found to minimize expenses below those in our projections. Sufficient market interest appears to be present as local chefs are open to incorporating the fruit into their menus, evidenced by their participation in events such as the Breadfruit Festival and the Ho'oulu ka 'Ulu project of the Hawaii Homegrown Food Network and the Breadfruit Institute of the National Tropical Botanical Gardens which posts recipes, instructional videos and publications online to revitalize breadfruit use in Hawaii.