Louisiana Specialty Crop Program
Final Performance Report
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## CONTACTS


Program Administration: Michelle Estay, Director of Commodity Promotion & Research
Louisiana Department of Agriculture & Forestry
47076 N. Morrison Blvd.
Hammond, LA 70401-7308

Financial Officer: Dane Morgan, Assistant Commissioner
Office of Management & Finance
Louisiana Department of Agriculture & Forestry
P.O. Box 3481
Baton Rouge, LA 70821-3481


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## PROGRAM OVERVIEW

The Louisiana Department of Agriculture & Forestry (LDAF) applied for a Specialty Crop Block Grant (SCBG) from the USDA Agriculture Marketing Service (AMS) under the authorization of Section 101 of the Specialty Crops Competitiveness Act of 2004 (7 U.S.C. 1621). That application was approved by AMS at which time the LDAF and AMS entered into a cooperative agreement September 2015. The award was in the amount of $358,364.91.

Louisiana's projects focused on programs working to inform consumers of the availability of Louisiana grown specialty crops, seasonal availability and where they can be purchased for increased sales and consumption. Projects also focused on specific specialty crop research to improve management, growth development and yield, the study of new science based processing to reduce food safety risk, and educational training and outreach through schools on specialty crop growing and consumption.

These projects were chosen for their importance to Louisiana's specialty crop industries. LDAF projects were designed to improve the competitiveness of Louisiana's specialty crops and educate the consumer.

LDAF staff monitored each project by requiring quarterly activity reports and maintaining periodic phone calls, site visits and email update discussions. All invoicing and grant fund payments were completed prior to this report.

LDAF submitted Change in Budget Requests as needed and they were approved by the USDA.

## PROJECT ONE TITLE- GRAFTING TOMATO TO MANAGE BACTERIAL WILT CAUSED BY RALSTONIA SOLANACEARUM

### SUB-GRANTEE: LOUISIANA STATE UNIVERSITY AGRICULTURAL CENTER

## Project Summary:

### Background Information

Bacterial wilt, caused by the soilborne bacterium *Ralstonia Solanacearum* (Bacteria wilt), results in major losses to tomato, pepper and eggplant growers who have infested soils due to the genetic diversity and complex biology of the pathogen and the lack of effective management strategies. Bacteria wilt infects tomato and eggplant roots through natural openings or wounds and then colonizes and clogs the vascular system, preventing the movement of water up through the plant. Depending on the cultivar, Bacteria wilt infestation levels in the soil and the presence of root knot nematodes, plants can wilt and

collapse in 2-5 days. These bacteria are easily dispersed and can move to non-infested fields through water, soil, mechanical means, and infected plant material. Bacterial wilt causes severe yield and economic losses to growers in Louisiana (LA) and other southeastern states and often results in growers abandoning infested fields for tomato, pepper and eggplant production.

*Ralstonia solanacearum* is genetically and metabolically diverse on a regional and global scale and is considered a species complex. The world population of *R. solanacearum* is divided into four biovars, three races and several phylotypes and sequevars. In the southeastern United States (US) (Florida and North Carolina), race 1, biovars I and II, and phylotype II are predominant. Strains of *R. solanacearum* have not been characterized in LA but are assumed to be race 1 biovar 1.

Management of bacterial wilt is challenging, particularly for LA tomato growers who produce on small acreages and have limited capacity to rotate out of tomato or other host crops for multiple years, which is the recommended practice. Soil fumigants are not effective and the vertical movement of *R. solanacearum* allows the bacterium to reinfest fumigated soil. Host resistance, which is the backbone of most disease management programs, is minimally effective because bacterial wilt resistance is quantitative and strongly influenced by soil temperature, pH and moisture. Resistance is also strain specific, which has resulted in the development of resistant lines that are not durable over diverse geographic regions. In addition, many of the resistant varieties being developed produce small fruits that are not desirable to the consumer. Grafting cultivars with desirable traits to rootstocks with strain-specific resistance is one possible way to overcome these challenges.

**Timeliness of Project**

Grafting has been successfully utilize to manage bacterial wilt of eggplant in Asia but has not been widely accepted in the US, due in part to the perceived cost of producing or purchasing grafted plants and the non-availability of resistant hybrid lines. However, a recent study out of Florida and Virginia identified seven hybrid tomato rootstocks with varying levels of resistance to endemic strains of *R. solanacearum*. In addition to these seven varieties there is resistance available in cultivars ‘Hawaii 7996’, ‘Hawaii 7997’, and ‘Hawaii 7998’ but again these varieties do not produce desirable fruit and thus are better suited for the breeding of market desirable cultivars. In 2011, Lebeau et al. identified 11 tomato and 10 eggplant and pepper lines with host resistance to bacterial wilt, referred to as Core-TEP. These lines are currently being evaluated in Florida and North Carolina for resistance against *R. solanacearum* strains isolated from these states. Melanie Ivey, past pathologist at the LSU AgCenter received these CORE TEP lines to evaluate against *R. solanacearum* strains in Louisiana soil. Grafting could be a valuable tool for tomato growers in LA to manage bacterial wilt if resistant rootstocks can be identified. Finding an alternative method to control or reduce bacterial wilt populations is important as there are several growers in Louisiana that depend on tomato sales to keep the farm successfully running that now have infestations of bacterial wilt on their farms. A 5 year crop rotation out of tomatoes and anything related (i.e. potato, pepper, and

eggplant) is the current recommendation to reducing bacterial wilt populations as fungicides and bactericides are not effective. The goal of this project was to identify and evaluate sources of bacterial wilt resistance to strains of *R. solanacearum* present in Louisiana soils, and this goal was met.

Previous Funding

This project was not previously funded with SCBGP or SCBGP-FB funds.

## Project Approach and Goals and Outcomes Achieved:

Goal 1 of this project was to collect data to support the selection of three bacterial wilt resistant root stock lines. This study looked at thirty-one resistant tomato, pepper and eggplant lines. Of the 31 lines, only one pepper (cv. PM702) and one eggplant (cv. MM152) variety were highly resistant to all of the bacterial wilt strains collected in Louisiana. None of the CORE TEP tomato varieties were found to be resistant to all identified strains. We would have loved to have identified a resistant tomato rootstock however, with none of them resistant to all strains of bacterial wilt identified in Louisiana; we cannot recommend any partial resistant lines to commercial producers. However, Tomato 'Hawaii 7996' is known to have resistance to bacteria wilt strains so we also used this as a rootstock. See below for details on how GOAL 1 was designed and implemented.

Goal 1 was completed by Alejandra Jimenez, the graduate student assigned to this project. Alejandra began this objective with collecting soil samples from varying Louisiana bacterial wilt contaminated fields. She identified strains or races of the bacterial wilt in each sample, narrowing individually identified strains down to 7 strains. The 7 strains were identified:

- MLI69-15
- MLI71-15
- MLI75-15
- MLI85-15
- MLI86-15
- MLI-87-15
- WLS-2

These 7 *R. Solanacearum* strains from LA were classified as Race 1 and were split between two phylotypes –I and II, and at least two Sequevars and two Biovars 1 and 3. Based on the fingerprinting pattern, there is a high diversity of *R. Solanacearum*(Rs) strains in LA. Because there are so many strains it is important that any rootstocks selected for resistance to bacterial wilt be resistant to all of the strains identified in Louisiana, so that a producer anywhere in the state could successfully use the rootstock to protect his plants against any strain found in his/ her soil. A. Jimenez's full thesis (attached to this report) provides detailed information on identification of the bacterial wilt strains commonly found here in Louisiana.

Alejandra then grew out 5 replicates of CORE- TEP seed lines (a group of tomato, eggplant and pepper plants found to be resistant to some strains of bacterial wilt and being evaluated in Florida and North Carolina for resistance to local strains of bacterial wilt). She placed the seedlings in soil and inoculated each seedling with the 7 strains of bacterial wilt commonly found in Louisiana. Seedlings were produced under controlled conditions in a greenhouse inspected by APHIS located on the LSU Baton Rouge campus. Average daytime temperatures were 30 °C and average relative humidity was 80%. All seedlings at the 2 to 4 true-leaf stage, within a single 72-cell flat, were inoculated with a single strain of Rs by wounding the roots with a sterilized blade and drenching 10 ml of inoculum near the soil-seedling crown line. One single 72-cell flat that contained five plants of each variety was mock inoculated with tap water and served as a non-inoculated control. Flats were arranged in a randomized complete block design by strain. The seedlings were evaluated for symptoms of bacterial wilt. Out of the 11 tomato, 10 eggplant and 10 pepper CORE-TEP varieties evaluated, only one pepper named 'PM702' and one eggplant named 'MM152' were rated as highly resistant to the bacterial strains commonly found in Louisiana.

This is excellent information because now we can use these two CORE-TEP lines plus 'Hawaii 7996' (a tomato variety known to be resistant to bacterial wilt strains but producing poor quality tomatoes) as rootstock for grafting more desirable, however not resistant tomatoes.

**Measurable 1: Data collected will be used to support the selection of three bacterial wilt resistant root stock lines.**

**Resistant Rootstocks Specific to Louisiana's Strains of Bacterial Wilt Included:**

- Pepper 'PM702'
- Eggplant 'MM152'
- Tomato 'Hawaii 7996'

The measurable outcome of Goal 2 was to collect data to support the selection of four combinations of grafted plants using the bacterial wilt resistant varieties selected in Goal 1. In order to collect this data and fulfil Goal 2, prior to plants being tested in a greenhouse or field, scion wood of commercially viable tomatoes (yet not resistant to bacterial wilt) were grafted onto the CORE-TEP lines selected in GOAL 1 and 'Hawaii 7996'.

- Three tomato varieties (cultivars (cvs.) Celebrity, BHN602 and Florida 91) were grafted onto pepper PM702,
- Three tomato varieties (cvs. Celebrity, BHN602 and Florida 91) were grafted onto eggplant MM152.
- Three tomato varieties (cvs. Celebrity, BHN602 and Florida 91) were grafted onto tomato Hawaii 7696.

All grafts were completed using the Japanese tube style grafting method (see A. Jimenez full thesis for details). Ninety-three of the percent of the self-grafted 'BHN602' seedlings survived the grafting process. Of the tomato varieties grafted to 'Hawaii 7996', 60% of those grafted to 'Florida 91' or 'BHN 602' survived and all (100%) of the plants grafted to

Celebrity survived. Twenty-seven percent, 13% and 56% of 'Florida 91', 'Celebrity' and 'BHN602' seedlings survived being grafted onto cv. 'MM152' eggplant rootstocks. None of the grafted 'PM 702' pepper seedlings survived the grafting process as shown in (Table 1).

**Table 1. Survival of grafted seedlings of susceptible tomato cultivars grafted onto resistant rootstock cultivars** (TABLE from A. Jimenez thesis – see attached document for full thesis).

| Treatment Rootstock/Scion | Rootstock Cultivar | Scion Cultivar | Percent Germination of Rootstock | Total Number of Plants Grafted | Percent Graft Success[1] |
|---|---|---|---|---|---|
| **Tomato/Tomato** | BHN 602 | BHN 602 | 100 | 15 | 93 |
| | Hawaii 7996 | Florida 91 | 100 | 15 | 60 |
| | Hawaii 7996 | Celebrity | 100 | 15 | 100 |
| | Hawaii 7996 | BHN 602 | 100 | 15 | 60 |
| **Tomato/Eggplant** | MM 152 | Florida 91 | 100 | 15 | 27 |
| | MM 152 | Celebrity | 100 | 15 | 13 |
| | MM 152 | BHN 602 | 60 | 9 | 56 |
| **Tomato/Pepper** | PM 702 | Florida 91 | 53 | 8 | 0 |
| | PM 702 | Celebrity | 53 | 8 | 0 |
| | PM 702 | BHN 602 | 53 | 8 | 0 |

1 Percent of plants that survived the grafting process seven days post-grafting.

Significant differences in median wilt severity scores were observed between the tomato varieties grafted into 'Hawaii 7996' and no differences were observed between the self-grafted and non-grafted plants (Table 2). Self-grafted and non-grafted plants along with the tomato Celebrity grafted to 'Hawaii 7996' had higher severity scores than the tomato 'BHN602' and 'Florida 91' grafted to 'Hawaii 7996' ($p=0.005$) (Table 2). The CORE-TEP pepper and eggplant were grafted to three tomato varieties Florida 91, Celebrity and BHN 602. The pepper variety PM702 was incompatible with all tomato varieties when using the Japanese Tube grafting method. All three tomato varieties were successfully grafted to the eggplant rootstock variety MM152. No bacterial wilt symptoms were observed on any of the eggplant grafted plants up to 23 days after inoculation.

The first part of our Target 2 for GOAL 2 was to identify four grafted combinations of commercially viable tomatoes onto bacterial resistant rootstocks that displayed less than 20% wilt and 5% incidence to bacterial wilt. **We identified 6 grafted combinations with less than 20% wilt and were resistant to bacterial wilt. They included:**

1. Florida 91 tomato grafted onto Hawaii 7996
2. Celebrity tomato grafted onto Hawaii 7996
3. BHN 602 tomato grafted onto Hawaii 7996
4. Florida 91 tomato grafted onto eggplant MM152
5. Celebrity tomato grafted onto eggplant MM152
6. BHN 602 tomato grafted onto eggplant MM152

As shown in Table 2, of the 6 combinations successfully grafted above, **all combinations grafted onto eggplant rootstock MM152 had less than 5% wilt severity, the second part of target 2 goal 2. The tomatoes grafted onto eggplant had no wilt symptoms whereas self-grafted and non-grafted had wilt symptoms.**

**Table 2. Wilt severity and AUDPC for three tomato varieties grafted to eggplant or tomato rootstocks with resistance to *Ralstonia Solanacearum* strains** (Table from A. Jimenez thesis see attached document for more information).

| **Grafted Plants** | **Median Wilt Severity Score** | **AUDPC** |
|---|---|---|
| **Tomato rootstock-Hawaii7996** | | |
| BHN602 | 3.0 a | 3.2 a |
| Florida91 | 3.0 a | 2.8 a |
| Celebrity | 4.0 b | 3.6 b |
| **Eggplant rootstock-MM152** | | |
| BHN602 | 0.0 a | 0.0 a* |
| Florida91 | 0.0 a | 0.0 a* |
| Celebrity | 0.0 a | 0.0 a* |
| **Self-grafted-BHN602** | 4.0 b | 5.1 b |
| **Non-grafted-BHN602** | 3.5 b | 3.8 b |
| **p-value** | 0.005 | 0.001 |

**Wilt severity was scored on a scale of 0 to 4 where 0=no wilted plants, 1=one leaf wilted, 2=two to three leaves wilted, 3=all leaves except the top two wilted and, 4=all leaves wilted or a dead plant.**

One pepper (cv. PM702) and one Eggplant (cv. MM152) cultivar were highly resistant to **all of the strains** collected in LA. However, because the pepper variety was unable to successfully graft to commercially desirable tomatoes, only the CORE –TEP eggplant rootstock MM152 and tomato rootstock Hawaii 7996 are viable rootstock selections for any of the three scion varieties BHN 602, Florida 91 and Celebrity giving us 6 combinations for commercial growers to evaluate in their fields if they are infected with bacterial wilt. **The remaining portion of Target 2 of Goal 2 was to determine if we could use the resistant scion/ rootstock combinations to increase yields by 50% (lb./A) compared to non-grafted or self-grafted plants, which have no resistance.**

The original expectation of GOAL 2 was to evaluate grafted combinations in a field that was highly infected with bacterial wilt. But because of severe Louisiana flooding, the cooperative farmer was not back in business by the end of this grant period. Therefore we evaluated the grafted combinations in non-infected fields at the LSU AgCenter Botanical Gardens at Burden located in Baton Rouge, LA to determine if a 50% increase in yield was found as compared to self-grafted plants.

In order to accomplish the last portion of Target 2 Goal 2, seeds were sown in late December 2016 and were grafted in early February 2017. Grafted plants were planted into a field at the LSU AgCenter Botanic Gardens mid-March 2017. Grafted field

tomatoes were managed by Kathryn Fontenot. Commercial traits such as average fruit size, total yields, and marketable yield were rated.

**Six tomato grafted combinations were evaluated in the field. The six grafted combinations included:**

- BHN 602 scion grafted onto BHN 602 rootstock (self-graft)
- BHN 602 scion grafted onto Tomato Hawaii 7996 rootstock
- Roma scion grafted onto Tomato Hawaii 7996 rootstock
- BHN 602 scion grafted onto Eggplant MM152 rootstock
- Florida 91 scion grafted onto Eggplant MM152 rootstock
- Celebrity scion grafted onto Eggplant MM152 rootstock

Eggplant MM152 was the only CORE TEP variety found to be both resistant to bacterial wilt strains identified in Louisiana and also compatible with tomatoes using the Japanese tube style grafting procedure. Although pepper PM702 was resistant to Louisiana strains of Bacterial Wilt, it was not compatible for grafting tomatoes, therefore we did not trial it in the field. Tomato Hawaii 7996 is known for being resistant to certain strains of Bacterial Wilt. However its fruit have not been found favorable by commercial producers. BHN 602 was grafted onto itself simply as a check. We would not typically recommend it as a rootstock.

The grafted plants performed well in the field. Table 3 displays field yield data. Bacterial wilt was not present in our field. We chose not to inoculate this field, as doing so would render the space at the botanical gardens unusable for tomato production for the next 5 years. Our cooperator farmer in Livingston parish was still recovering from flood damage, and was unable to allow us to use his contaminated field for this demonstration.

**Table 3. Field Characteristics of Grafted Tomato Plants Spring 2016 LSU Plots**

| Scion Wood/ Rootstock Combination | Total Harvested (Number) | Marketable Harvested (Number) | Total Harvest (lbs.) | Marketable Harvest (lbs.) | Individual Fruit Weight (oz.) |
|---|---|---|---|---|---|
| | **Expected yields per 100 ft. row** | | | | |
| **BHN 602 onto BHN 602** | **1232** | **462** | **474** | **157** | **6.2 oz.** |
| **BHN 602 onto Tomato Hawaii 7996** | 836 | 726 | 376 | 324 | 7.2 oz. |
| **BHN 602 onto Eggplant MM152** | 1408 | 528 | 691 | 215 | 7.8 oz. |
| **Roma Tomato onto Hawaii 7996** | 4224 | 2618 | 1029 | 928 | 3.9 oz. |
| **Florida 91** | 770 | 462 | 295 | 185 | 6.1oz. |

| | | | | | |
|---|---|---|---|---|---|
| **onto Eggplant MM152** | | | | | |
| **Celebrity onto Eggplant MM152** | 1298 | 286 | 467 | 124 | 5.8 oz. |

**Averages based off of plot work conducted at the LSU AgCenter Botanical Gardens. Data extrapolated to reflect a single 100ft row assuming the row is 48 inch wide, plants single drilled on 18 inch centers, totaling 66 plants per 100ft row.**

As expected there are differences in average fruit size for the varying scion (top portion of the graft) varieties. This was expected as these tomatoes are different from one another regardless of being grafted or not grafted. What is interesting are the slight differences among the BHN 602 tomatoes grafted onto different rootstocks. BHN 602 grafted onto BHN 602 (itself, the self graft), yielded an ounce per fruit lighter in weight as compared to when it was grafted onto Eggplant MM152 and Tomato Hawaii 7996. However the percent marketable number of fruit was exactly the same between BHN 602 on itself and BHN 602 on Eggplant MM152, with 38% total number marketable tomatoes harvested. BHN 602 tomato grafted onto Tomato Hawaii 7996 yielded 86% marketable fruit. But can we determine that this was because of superior graft compatibility? **At this point, no**. Marketable fruit is dependent on insect, disease and environmental stressors that affect the quality of fruit. What we can determine is that that grafted plants were all grown in the same field under the same conditions and **100% of the grafted in the field survived**. Roma tomatoes had 61% marketable fruit (in terms of number of fruit harvested). Again a lot of the unmarketable fruit damage was caused by insect injury. The Roma tomatoes performed quite well under field conditions and produced a good amount of fruit. Celebrity tomatoes grafted onto Eggplant MM152 also produced a good amount of fruit. The marketability was not exceptional, but again this was due to insect injury not graft incompatibility. **If this field was artificially inoculated we would most likely have seen the hypothesized 50% increase in fruit produced on plants grafted onto eggplant MM152 and Tomato 'Hawaii 7996' as compared to BHN 602 grafted onto itself, because BHN602 is not resistant to *R. Solanacearum* (bacterial wilt). The self grafted plants most likely would not have survived until the end of harvest season.** Had we been able to get into the originally intended and naturally infected field in Livingston parish this result would be apparent. While we did not gain a 50% yield increase in grafted plants onto resistant rootstocks, we can confirm suspicions of Target 2 of Goal 2 by stating BHN 602 tomato grafted onto Eggplant MM152, Roma tomato grafted onto Hawaii 7996 and Celebrity Tomato Grafted onto Eggplant MM152 all had higher total number of fruit harvested than BHN 602 grafted onto itself. Also Roma tomatoes grafted onto Hawaii 7996 and BHN 602 tomatoes grafted onto Eggplant MM152 had higher total yields than BHN 602 grafted onto itself. Celebrity tomato grafted onto eggplant MM152 had very similar yields as BHN 602 grafted onto itself. **Overall, if a commercial or home vegetable producer was affected by *R. Solanacearum*, we would recommend growing grafted plants, especially grafted onto rootstocks eggplant MM152 and Hawaii 7996. This is a viable option for tomatoes that otherwise could not be planted in affected fields.** Tomatoes are a drawing crop. Customers often visit a farm stand because they have tomatoes and then buy other crops

while they are there. If a farmer did not have tomatoes, he or she would lose on sales of others crops, because they would be passed over at the market for the producer who has a wider selection of vegetable crops available for sale.

LSU AgCenter recommends pairing grafted plants with best management practices in the field. A good spray regimen of both insecticides and fungicides is needed to produce grafted tomato plants. This is because of the host of other diseases that still affect grafted plants and the wide range of insects that thrive in Louisiana's hot humid climate. Additionally, grafted plants must be treated differently than non-grafted in the field. Plastic mulch is essential to avoid soil splashing above the grafted line and entering the plant at injury points. Injury point may come from environmental, insect, or disease damage. Injury points may also come from mechanical damage such as pruning lower branches. We recommend all suckers be pruned to avoid contact of lower limbs with the soil. Suckering must be completed when sucker diameters are small less than the size of a pencil to avoid excessive injury. We also recommend producers stake each plant with a rebar or a wood stake versus using the typical Florida weave staking method. This is to prevent the lower trunk from leaning on top the soil surface, sending out aerial roots from above the graft union that would compromise the resistance of the grafted plant.

**Goal 3.** ***Increase growers' knowledge of grafted tomato plants to manage bacterial wilt by disseminating the new knowledge obtained from the proposed studies in the form of extension presentations to growers, on-line extension factsheets and the publication of research results in peer reviewed journals.***

Goal 3 was completed by presenting the information we gathered in this project to various commercial producers, hobby gardeners and county agents. See the bulleted list below for a list of presentations made regarding this project.

**Extension Presentations**

- The grafted tomato field was toured by 84 Louisiana fruit and vegetable producers and county agents on May 10, 2017 at the LSU AgCenter/ LFVGA Fruit and Vegetable Field Day. There, Alejandra Madrid (graduate student in this project), gave a detailed presentation in the field on how to graft tomatoes. She first demonstrated the Japanese tube method of grafting, and then allowed attending farmers to replicate the grafts she made. Afterwards, they entered the field where Kathryn Fontenot discussed managing grafted plants in the field. Proper staking methods, and planting methods to reduce soil contact with the scion portion of the grafted plant were specifically addressed. Planting grafted plants properly ensures that the scion wood does not come in contact with the soil. If soil is contaminated with Bacterial Wilt and the scion wood contacts it, the grafted plant would not survive. Therefore proper planting and staking methods are crucial to success. Raj Singh and Dennis Ring discussed disease and insect management of grafted plants in field settings. During this field day, farmers rotated between several field stations, we placed a heavy emphasis on the grafting station allowing most growers to spend at least 45 minutes in this field station.

  - Informally at this field day we polled the 84 attendees to see if they experienced Bacterial wilt problems in their fields. Only 6 attendees had experienced bacterial wilt problems that they could accurately say was diagnosed. Zero growers were currently using grafted plants at the time of the field day. **86% (72 of the 84 participants) raised their hands yes, when asked "if you encountered bacterial wilt in your fields, would you consider using grafted plants as a management strategy to offset losses from bacterial wilt?"**

- Kathryn Fontenot presented a how to lesson and presentation on tomato grafting at the Spring Garden Show March 17, 2017 in St. Tammany Parish. Master Gardeners and home gardeners attended. They were extremely interested in this information as many have experienced produce damage in their personal gardens from Bacterial wilt. After the presentation, the audience was welcomed to try to graft tomatoes with us so that they not only heard how to graft but had an opportunity to graft. A copy of the PowerPoint presentation given to the Master Gardeners is submitted with this report as a separate file.
- Kathryn Fontenot presented a how to lesson and presentation on tomato grafting at the LSU AgCenter Annual Conference to 50 horticulture county agents and horticultural specialists in December 2017 in Baton Rouge, La. Since that date two county agents have used the same presentation and presented it to growers and homeowners in their respective parishes. All county agents now have the knowledge on how to grow and graft tomato plants. They can all present this information to growers and home gardeners in their parishes.
- Mary Sexton (vegetable Extension Associate) presented the how to lesson and presentation on tomato grafting at the Louisiana State Horticulture Society Annual Meeting in January 2018. Thirty hobby and professional gardeners learned the same technique to graft tomatoes and care for them after planting as described in the presentations above. Mary Sexton has been working with Kathryn Fontenot on this grafting project.
- Kathryn Fontenot will present a tomato grafting demonstration and lecture to home gardeners and commercial growers at the 2018 Les Reeves Lecture Series hosted by Stephen F. Austin University. This will take place after the grant project has concluded. However, we felt the need to mention it because this work is very valuable and important to our industry therefore we will continue to work with grafted tomato plants even after the conclusion of this funded project.

**Target 3 of Objective 3 of this study was that 15% of current Louisiana tomato growers, who are also members of the Louisiana Fruit and Vegetable Growers' Association (LFVGA), would plant grafted tomato plants with bacterial wilt resistance. While 15% are not currently growing grafting plants as projected, we know 86% of growers attending the last LFVGA field day are willing after seeing how to graft learning what companies graft plants, and seeing grafted plants growing in a field, are willing to use grafted plants if they encounter bacterial wilt in their fields.** Fortunately this disease is spreading slowly throughout Louisiana. See the

grower survey below for more information on how Louisiana Fruit and Vegetable growers perceive grafted plants for disease management.

**Grower Survey**

A component of this project and Alejandra's thesis was to survey Louisiana producers to determine if they would use grafting as a disease management strategy. Three hundred and two surveys were mailed to Louisiana vegetable producers. Forty-two surveys were returned for a final response rate of 13.9%. Of the returned surveys, 39 participants answered 90% of the questions and 3 participants answered 30% of the questions. Fifty-eight percent of the respondents had encountered bacterial wilt on their farm in the past 5 years. Twenty-nine percent had never encountered this disease. Thirteen percent of respondents were unable to accurately recognize bacterial wilt and therefore did not feel confident in the presence of the disease on their farm. Growers were then asked upon finding bacterial wilt, how they managed the disease. Producers could select one or more management strategies. Sixty-eight percent of producers removed the infected plants from the fields; 50% treated the plants with a fungicide; 9% used a bio control; 27% left the plants in the ground and 22% indicated that they also used "other" management strategies. The next question asked would you be interested in learning how to graft tomatoes plants to manage bacterial wilt. **A little over half of the responding producers (57%) were willing to graft while 7% were a firm no towards using this disease management strategy.** What was interesting was 35% of the respondents answered that they may be interested in learning how to graft. To determine why there was interest but not a firm commitment, the survey asked this question: "What factors impeded you from using grafted plants to manage bacterial wilt?" Thirty-two percent of responders indicated unease with using grafted plants because of a lack of training to grow these plants, 18% responded that cost was a factor in the decision to use grafted plants, 17% had a lack of facilities to grow the grafted plants. An additional 17% of respondents indicated that they simply did not know where to purchase grafted plants. Interestingly enough 8% of respondents said bacterial wilt was not of economic concern, therefore grafting wasn't a high priority for them. This may be the case in growers who are just starting to see this disease on their farm, because over time bacterial wilt will reduce yields to zero, making this a great economic concern for a tomato producer. Seven percent of growers were concerned with the extra time it takes to graft plant and a small 1% of respondents indicated that they did not trust that the grafting supplier would deliver the plants in time for planting. When producers were asked if the costs of grafting were less than the potential costs associated with yield losses from bacterial wilt, would you consider using grafted tomato plants 60% responded yes and only 2.5% responded no. An additional 37.5% of the respondents were chose "maybe," indicating a hesitation to use grafted plants. When asked how much growers were willing to pay for a single grafted tomato plant, answers ranged from less than a dollar to $7 per plant, with the majority of respondents indicating $1 was the most they would pay per grafted plant. The responses from this survey definitely let us know this project is worthwhile.
The main concerns of Louisiana tomato growers regarding using grafting as a management tool for bacterial wilt include 1) the lack of training on grafting and 2) hesitation in the thought that grafting can really help resolve yield loss. However, we feel

confident with the hands on training growers received at the 2017 spring field day and the availability of the new tomato grafting publication/ factsheet and video, growers will not be hesitant to use grafted plants because of their lack of knowledge about the grafting procedure.

**Online and Printed grafting Information**

- A factsheet covering reasons to graft, how to graft and how to manage grafted plants was produced as a result of this grant. The factsheet can be found online at the following web link. http://www.lsuagcenter.com/profiles/bneely/articles/page1506716432464 . This publication was also printed. Copies were mailed to each of Louisiana's 64 parish offices for distribution to local hobby and commercial tomato producers. Additional copies are in store at the LSU AgCenter publication warehouse for future use at trainings and will be provided to commercial growers and hobby gardeners as requested.

- A short You-Tube style video was also prepared to demonstrate how to graft a tomato plant using the Japanese tube style method. The video shows the actual grafting procedure and care for the grafted plant until the union between the scion wood and rootstock are healed. This task was not originally planned in the proposal for this project. However we felt creating this video was necessary as many people seek short how to videos for information before they will read an article. This video can be found at the following web link. https://www.youtube.com/watch?v=RdpS-GuD5tI . The video was produced by Craig Gautreaux a communication specialist with the LSU AgCenter. Alejandra Jimenez and Mary Sexton are featured in the video. The video script was prepared by Kathryn Fontenot.

**Publication of Research Results**

Alejandra Jimenez, the graduate student working on this project, has completed her defense and graduated in the Spring 2017 semester. Her thesis funded by this grant project is titled "Characterization and Management of *Ralstonia Solanacearum* in Louisiana." It was published on Louisiana State University's electronic thesis and dissertation database one year from her graduation date May 2017. Withholding public viewing is a common practice for those graduate students who have not yet published their work. However, a pdf version of the thesis is included in this final report. Additionally, Ms. Jimenez has written and submitted a journal article titled "Diversity of *Ralstonia Solanacearum* strains causing bacterial wilt of tomato throughout Louisiana" to the peer-reviewed journal titled Plant Disease Journal. She is also writing two additional articles titled, "Evaluation of sources of disease resistance to bacterial wilt in Louisiana", and "Perceptions of growers towards the adaption of grafting tomatoes as a management strategy for bacterial wilt". The second two articles will be submitted to APS publications Phytopathology and Plant Disease. All extension papers, presentation,

publications and videos were completed in this grant project. Articles in scientific peer reviewed publications are still in the submission/ review process.

## Beneficiaries:

Members of the Louisiana Fruit and Vegetable Growers Association (LFVGA) clearly benefited from this project. They attended a field day saw grafted plants growing in the field, learned about managing those plants and all members had the opportunity to graft plants at the field day.

It is this group and all commercial tomato producers who benefit most from this project as we now know grafting tomatoes onto eggplant MM152 does not wilt when subjected to bacterial wilt inoculation. This will help keep producers in tomato production rather than having to rotate out of this important and valuable crop for 5 years.

Hobby gardeners are extremely interested in grafting. We presented a how to, why to and how to manage grafted plants presentation to Master Gardeners, hobby gardeners and county agents throughout the state. All participants were able to actually graft tomatoes during the presentation. Now these participants have learned how to but actually have experience before going back to their home, farm or consulting with a grower on this process.

In order to reach an audience who were unable to attend our live presentations, we created an online factsheet and video on how to graft so they can learn about this process in their homes via the internet. For those gardeners without internet services that are interested in grafting, we also used grant funds to print the online factsheet. These fact sheets can be delivered in person or by US mail services to the homes of hobby and professional tomato producers throughout the state.

The 2016 value of the tomato industry in Louisiana was projected at $6.2 million Gross Farm Value. An estimated 249 producers on 237 acres were planting tomatoes (LSU AgSummary, 2016). This is too valuable a crop to Louisiana vegetable producers to not research alternative methods of controlling diseases.

## Lessons Learned:

We learned many lessons during this project.

- Grafting plants using the Japanese tube style method is extremely easy. However, the grafting environmental conditions must be exact. Producers who are interested in doing this for themselves must manage environmental conditions. The optimum temperature range for healing the grafted plant is 70-80F and humidity should range between 80-95%.
- The CORE TEP varieties were specifically given to Dr. Melanie Ivey. We will need to determine how we can receive more of the CORE –TEP eggplant MM152 line seed which was resistant to Louisiana strains of bacterial wilt. We as researchers will also need to find a seed supplier who can keep enough of the

seed available for our local growers. Doing so would mean to continually grow this eggplant away from other cultivars to avoid crossing lines to keep resistance high.

- We learned that growers were very willing to try grafting but are still somewhat hesitant to purchase grafted plants. It seems as though many growers were willing to try to graft their own plants. We will need to continue training county agents on grafting techniques so if and when this disease becomes a larger threat we are capable to using alternative methods to controlling it on Louisiana vegetable farms.

☐ Provide unexpected outcomes or results that were an effect of implementing this project.

- We did not expect so many strains (7) of *Ralstonia Solanacearum* (Bacteria wilt) would be present in Louisiana soils. This really made finding a resistant rootstock line more difficult because instead of one type of disease we had many versions of this disease in which we had to find resistance. (We often explained it to our audience as being similar to the flu. You may receive a shot, but it's only effective if it is the same strain of flu as that which is spreading that season. In order to effectively manage bacterial wilt, the resistant rootstock you choose must be resistant to all strains of bacterial wilt found in your soil. )
- We really expected higher compatibility of the commercially favored tomato lines onto the resistant CORE TEP pepper line. However, the incompatibility did not prevent us from still testing the resistant eggplant line as a rootstock.

☐ If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

- We learned that flooding although uncontrollable, has significant impact on our farmers. Because our field of choice (a severely infected bacterial wilt field) was rendered unusable for a long period of time, we were unable to really test our hypothesis of field survival and wilt percent in an inoculated field setting. We did test it under greenhouse conditions, which was second best. Other researcher attempting to test resistant varieties under actual infected field conditions should have at least 1-3 backup fields to use for field studies.

## Contact Person:

Dr. Kathyrn Fontenot, PhD
LSU AgCenter, School of Plant,
Environmental and Soil Sciences
225-578-2417
kkfontenot@agcenter.lsu.edu

## Additional Information:

A copy of the publication "Grafting Tomatoes to Improve Plant Health" can be found at this web link.
http://www.lsuagcenter.com/profiles/bneely/articles/page1506716432464

The grafting video developed as a result of this grant project can be found at this web link https://www.youtube.com/watch?v=RdpS-GuD5tI

The PDF version of a presentation that was made several times during the course of this project is attached as a separate file.

A copy of Alejandra Jimenez's thesis is attached as a separate file. This thesis was made available to the public in May 2018 on LSU's electronic thesis and dissertation webpage.

**PROJECT TWO TITLE- LOUISIANA SPECIALITY CROP SCHOOL GARDEN PROGRAM**

**LOUISIANA DEPARTMENT OF AGRICULTURE AND FORESTRY**

## Project Summary:

The purpose of this program stemmed from realization of the high percentage of Louisiana children living in households that lacked the means to access nutritious fresh fruits and vegetables. The project aimed to plant and sustain fruit, vegetable and/or flower gardens in a total of thirty Louisiana schools (15 schools per year); while increasing the knowledge and consumption of Louisiana specialty crops amongst school-aged children grades K-12. By allowing schools to be reimbursed for allowable expenses for the implementation of a school garden, it was hypothesized that there would be a greater participation in the program. This component was very crucial; especially with the economic hardships our schools are facing with the lack of critical funding for programs, in helping to decrease the stress of funding to implement a program that would connect children with the food they eat and Louisiana specialty crops.

## Project Approach:

For this project, the Louisiana Department of Agriculture and Forestry partnered with the Louisiana Department of Education to notify all K-12 Louisiana schools of the Louisiana School Garden Reimbursement Grant Program. All schools were given an equal opportunity to apply for inclusion in the program. Each school that participated in the project agreed to implement a new school garden or expand an existing garden at their school. A garden coordinator was assigned by each school that was in charge of all activities of the garden program. School garden coordinators or school staff administered

pre and post surveys, formulated by the Louisiana Department of Agriculture and Forestry (LDAF) project staff, to the students. The surveys were used to measure the knowledge and consumption of Louisiana specialty crops.

Schools submitted paid invoices and/or receipts for approved allowable garden expenses for reimbursement. Monitoring activities involved random site visits by LDAF project staff and/or photographic documentation of school gardens. Some schools even hosted cooking demonstrations for the students which provided a hands-on approach to specialty crop gardening and to tasting the foods produced in the gardens.

## Goals and Outcomes Achieved:

This project was projected to directly reach 900 kids and indirectly reach 4,500 by exposing them to fruits, vegetables and/or flowers by actively participating in the school gardens; giving children the opportunity to learn where their specialty crop food comes from and the importance of good nutrition while promoting the Louisiana's specialty crop industry. The Louisiana School Garden Reimbursement Grant Program reached its targeted thirty schools and surpassed its target of directly reaching 900 children by nearly 100%.

There were several measurable outcomes that the project pre-identified to determine the goals and outcomes achieved by the program. The main activities that were necessary to achieve the performance goals and measurable outcomes for the project were the following: Active participation of schools in the implementation of school gardens and active student involvement during the program. Each student involved in the program completed a pre and post survey that was used as a tool to measure the knowledge obtained from the implementation of the school garden cost reimbursement program and schools documented the implementation of their garden program photographically. Partner schools were provided pre and post surveys by LDAF project staff. The goals and outcomes are further summarized by the analysis of the pre and post surveys over the two year project which may be found below. Photographic documentation of the school garden implemented by the schools is also attached below to measure the involvement of students in the program.

**Expected Measurable Outcomes and Results-**

| Goals | Performance Measures | Benchmarks | Targets | Outcomes |
|---|---|---|---|---|

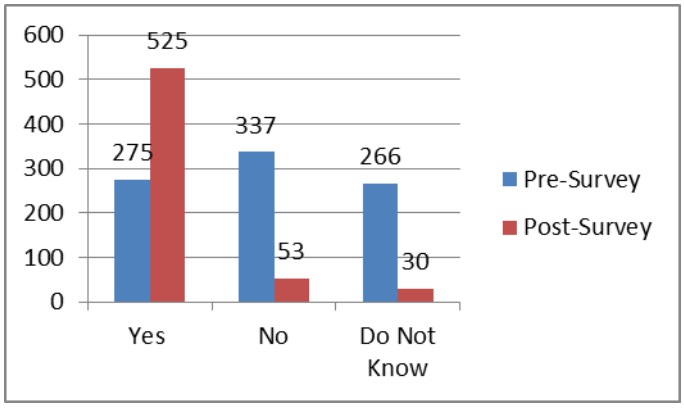
| | | | | |
|---|---|---|---|---|
| 1. To show a positive attitude towards the consumption of fruits and vegetables. | Surveys taken before and after the project which show the amount of fruit and vegetables students reported consuming before, and after the project. | The results of the pre-project survey of students. (Questions 3 and 4) | 50% increase in positive attitude towards the consumption of fruit and vegetable by students. | 76.6% of students surveyed showed a positive attitude towards the consumption of fruits and vegetables. |
| Promote the purchase of local specialty crops by Louisiana households. | Surveys taken after the project which show the number of households with an increase in purchases of fruits and vegetables. | The results of the post-project survey of students. (Question 6) | 15% increase in purchases of Louisiana specialty crops by households. | 75.1% of households responded yes to buying more fruits and vegetables. |
| 3. To show the knowledge of Louisiana specialty crops. | Surveys taken before and after the project which show the awareness level of students about LA specialty crops. | The results of the pre-project survey of students. (Questions 1, 2 and 5) | 50% increase in the knowledge and awareness of Louisiana specialty crops by students. | 85.6% showed an increase in knowledge of Louisiana specialty crops. |

***Year 1- Analysis of Pre and Post Survey Data for:***

**Question 1:**

Do you know what a specialty crop is?

| | Yes | No | Do Not Know |
|---|---|---|---|
| **Pre-Survey** | 275 | 337 | 266 |
| **Post-Survey** | 525 | 53 | 30 |



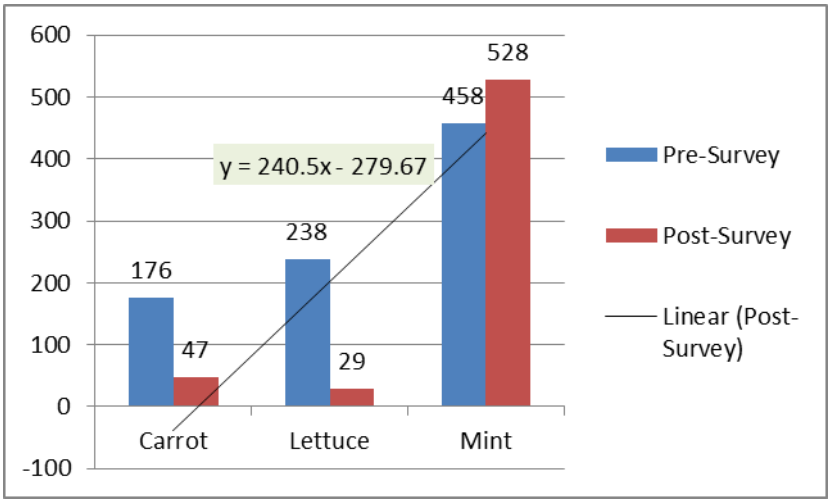

The pre-survey showed the importance of this program being implemented to support one of the key purposes of the program for increasing the knowledge of Louisiana specialty crops among school-aged children grades K-12. The data showed that of 878 children surveyed, 68.7 % or 603 students answered either no to the question of if they knew what a specialty crop was or either responded as did not know. Only 31.3% or 275 students answered yes to this question.

The post-survey data proved that this program was highly effective in increasing the knowledge of what a specialty crop was amongst children grades K-12. The data showed that there was a 55% increase in the post-survey as compared to the pre-survey in children responding to yes to this question. 86.3% students answered yes to this question while only 8.7% answered no and 5% responding do not know. This decline in the no and do not know responses was crucial in showing that the implementation of programs such as these are very important and play a key component in increasing the knowledge and exposure to Louisiana specialty crops.

**Question 2:**

Which of these is an herb?

| | Carrot | Lettuce | Mint |
|---|---|---|---|
| **Pre-Survey** | 176 | 238 | 458 |
| **Post-Survey** | 47 | 29 | 528 |



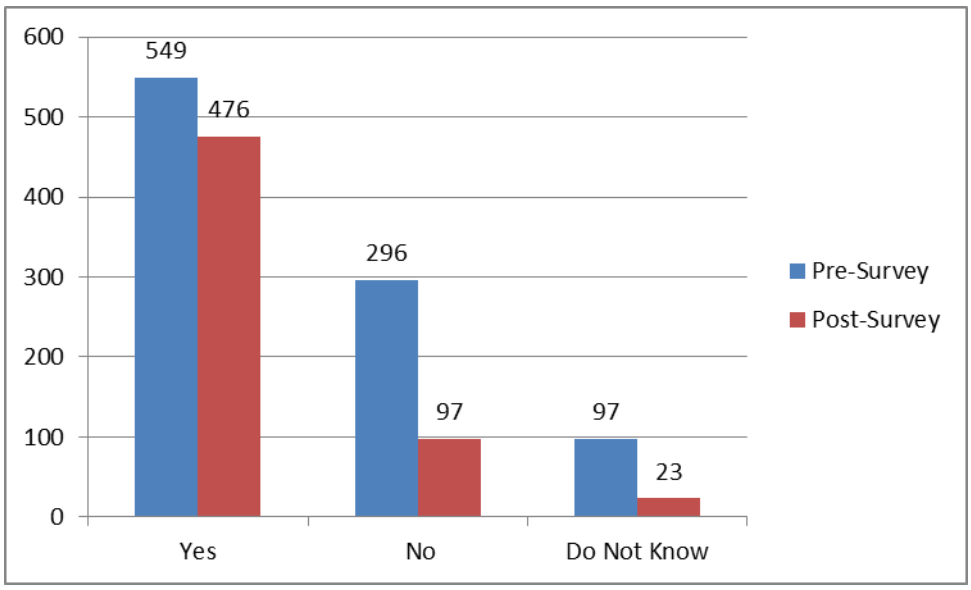

The pre-survey showed that only 20.2% of students surveyed knew that mint was an herb; while 79.8% thought that either a carrot or lettuce was an herb. There were a total of 872 students who participated in the response to this question.

The post-survey analysis of the data for the same question proved that the program increased the accuracy and knowledge of which produce was an herb. 87.4% of students responded that mint was an herb in the post-survey which was a 67.2% increase from the data collected in the pre-survey. The post surveyed also supported that there was a significant decline in students responding that carrot and lettuce were herbs. In the post survey data, only 7.8% of students surveyed chose carrot while the other 4.8% chose lettuce. The data also showed that the trend line between the pre and post surveys supports the notion that knowledge increased of students knowing that mint is an herb with the trend line being (y= 240.5x – 279.67).

**Question 3:**

Do you eat vegetables daily?
Do you eat more fruits and vegetables daily now than before the program was implemented?

| | Yes | No | Do Not Know |
|---|---|---|---|
| **Pre-Survey** | 549 | 296 | 97 |
| **Post-Survey** | 476 | 97 | 23 |



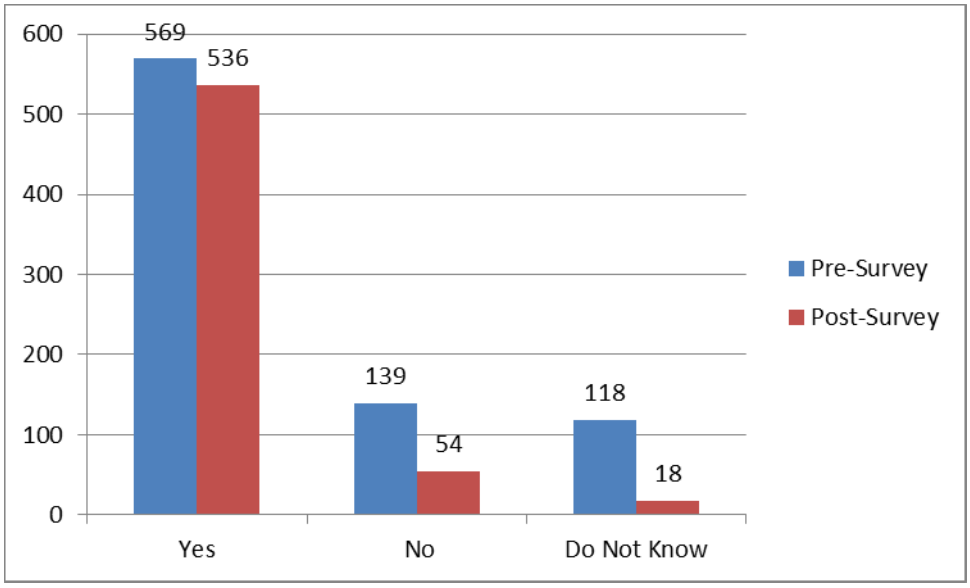

When asked if the student ate vegetables daily, the pre-survey showed that only 58.3% of students surveyed responded yes; while the remaining 41.7% did not consume fruit and/or vegetables daily or did not know if they did. There were a total of 942 students who participated in the response to this question.

Analysis of the post-survey data showed that as a result of the implementation of the school garden reimbursement program, there was an increase by 21.6% of students responding yes to consuming more vegetables and/or fruit. The total percentage of participants responding yes to this question was 79.9%; while only 16.3 % responding no to eating more fruit and vegetables as a result of the implementation of the program and 3.8% responded they did not know.

**Question 4:**

Do you eat fruits and vegetables at least three times a week?

| | Yes | No | Do Not Know |
|---|---|---|---|
| **Pre-Survey** | 569 | 139 | 118 |
| **Post-Survey** | 536 | 54 | 18 |



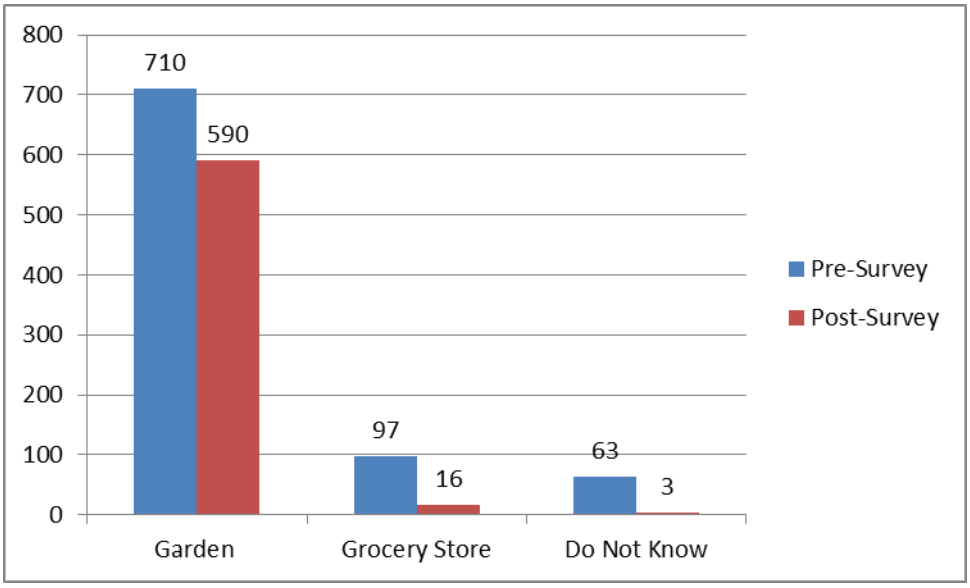

When asked if you ate fruit and vegetables at least three times a week, analysis of the pre-survey showed that 68.9% of students surveyed responded yes. This was a surprising percentage considering the statistical rates of children not having access to nutritious foods on a daily basis. 16.8% responded no and 14.3% responded did not know.

The post survey analysis did however show a 19.3% increase in students eating fruit and vegetables at least three times a week. This data supported the fact that this program was needed and showed benefits of students being exposed to specialty crop gardens. The number of students responding no decreased from 16.8% to 8.9% while the number of students responding did not know decreased from 14.3% to 2.9%. We expected the numbers to show a stronger decrease, but some of the post-surveys were lost due to the flood. As a result only 608 post-surveys were counted as compared to 826 pre-surveys.

**Question 5:**

Are vegetables and fruits grown in a grocery store or garden?

| | Garden | Grocery Store | Do Not Know |
|---|---|---|---|
| **Pre-Survey** | 710 | 97 | 63 |
| **Post-Survey** | 590 | 16 | 3 |



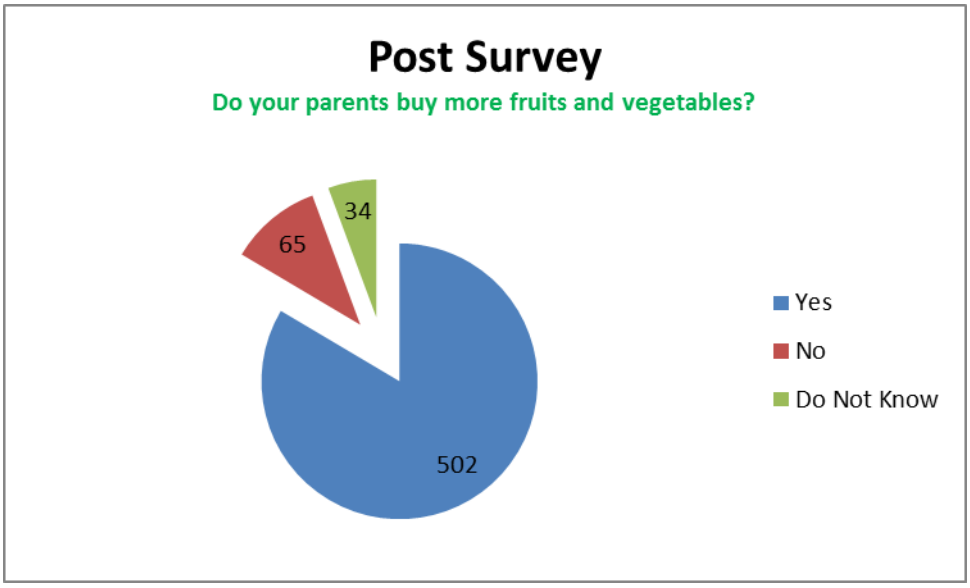

This was a surprisingly good question that showed that most children were knowledgeable as to where fruit and vegetables were grown. The pre-survey analysis showed that 81.6% or 710 students out of 870 surveyed, responded that fruits and vegetables came from the garden, while 11.2% thought they came from the grocery store and 7.2% did not know.

The post-survey data still showed an increase in the response of where fruit and vegetables came from with 96.9% of students responding yes. The post-survey also showed that the responses to the grocery store decreased to 2.6% and that students responding, did not know, decreased to 0.5%.

**Question 6 (Post-Survey Only):**

Do your parents buy more fruits and vegetables?

| Pre-Survey | Yes | No | Do Not Know |
|---|---|---|---|
| **Post Survey** | 502 | 65 | 34 |



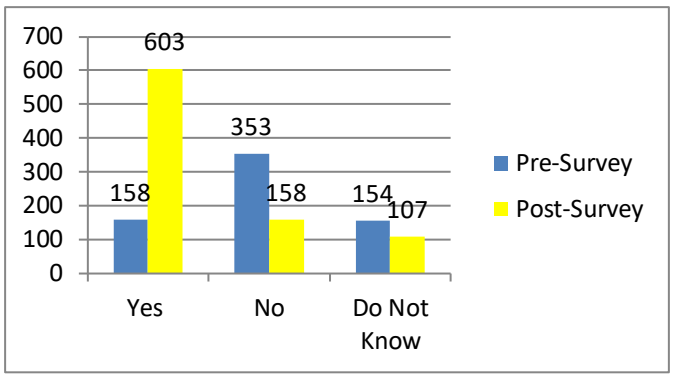

We felt that it was imperative to add an additional question to the post-survey asking students if their parents bought more fruits and vegetables as a result of the students demanding more locally grown fresh fruits and vegetables. The post-survey showed that 83.5% responded yes, 10.8% responded no and 5.7% responded they did not know. The analysis from this question was enough to support that by the implementation of the program with just the few schools that participated, Louisiana's specialty crop industry should see an increase in the consumption of fruits and vegetables. There was definitely an increase in the knowledge of the industry and what specialty crops are by the students and teachers.

***Year 2-Analysis of Pre and Post Survey Data for:***

**Question 1:**

Do you know what a specialty crop is?

| | Yes | No | Do Not Know |
|---|---|---|---|
| **Pre-Survey** | 158 | 353 | 154 |
| **Post-Survey** | 603 | 158 | 107 |



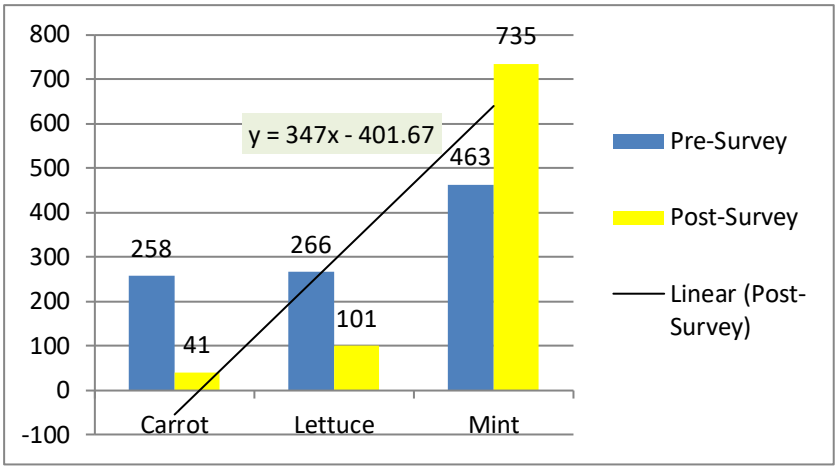

For year two, we thought it would be beneficial to see how students compared to those who participated in year one of the program. The pre-survey for year two showed the importance of this program being implemented. The data also was similar to that of year one. Year two data for this question supported the key purpose of the program for increasing the knowledge of Louisiana specialty crops amongst school-aged children grades K-12. The data showed that of 668 children surveyed, 76% of students answered either no to the question of if they knew what a specialty crop was or either responded as did not know. Only 24% of the students surveyed answered yes to this question.

The post-survey data for year two proved that this program was highly effective in increasing the knowledge of what a specialty crops was amongst children grades K-12. The data showed that 69.4% of students who took the post-survey responded yes to knowing what a specialty crop was. Only 18.2% answered no and 12.4% responded do not know. This decline in the no and do not know responses was crucial in showing that the implementation of this project for year two played a key component in increasing the knowledge and exposure to Louisiana children to specialty crops.

**Question 2:**

Which of these is an herb?

| | Carrot | Lettuce | Mint |
|---|---|---|---|
| **Pre-Survey** | 258 | 266 | 463 |
| **Post-Survey** | 41 | 101 | 735 |



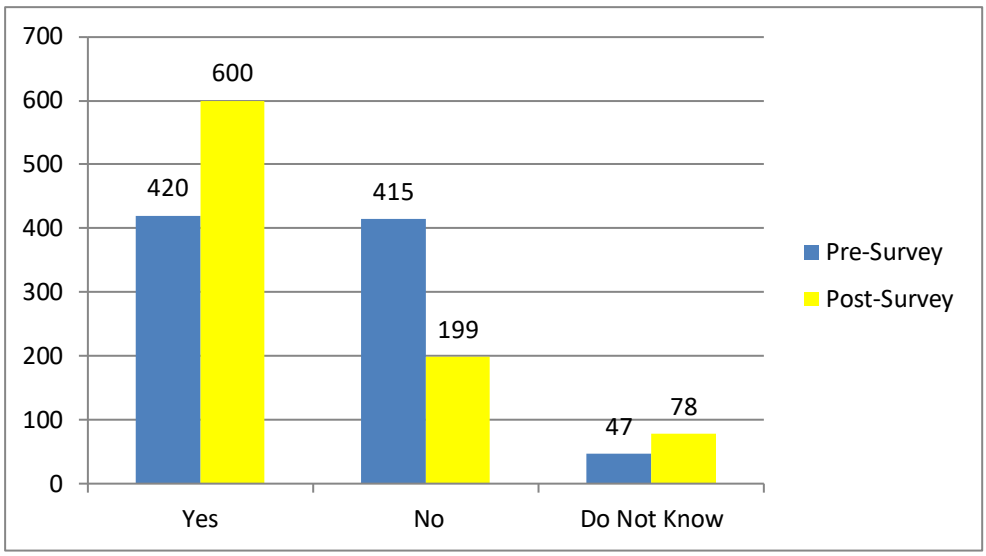

The pre-survey for year two showed that only 46.9% of students surveyed knew that mint was an herb; while 53.1% thought that either a carrot or lettuce was an herb. There were a total of 987 students who participated in the response to this question.

The post-survey analysis of the data for the same question proved that the program increased the accuracy and knowledge of which produce was an herb. 83.8% of students responded that mint was an herb in the post-survey which was a 36.9% increase from the data collected in the pre-survey. The post survey also supported that there was a significant decline in students responding that carrot and lettuce were herbs. In the post survey data, only 4.7% of students surveyed chose carrot while the other 11.5% chose lettuce. The data also showed that the trend line between the pre and post surveys supports the notion that knowledge increased of students knowing that mint is an herb with the trend line being (y=347x-401.67).

**Question 3:**

Do you eat vegetables daily?
Do you eat more fruits and vegetables daily now than before the program was implemented?

| | Yes | No | Do Not Know |
|---|---|---|---|
| **Pre-Survey** | 420 | 415 | 47 |
| **Post-Survey** | 600 | 199 | 78 |



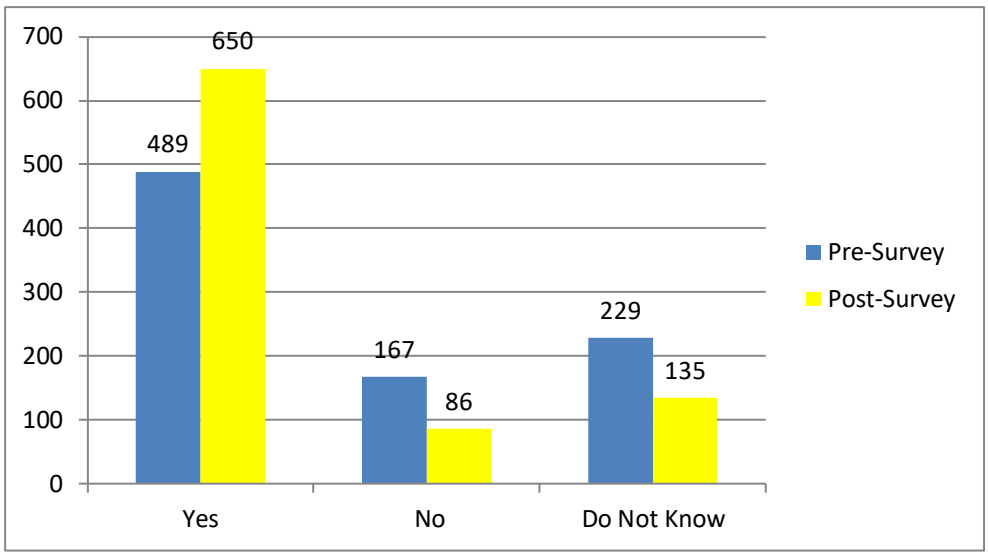

Students who participated in the program in year two, when asked if they ate vegetables daily, the pre-survey showed that only 47.6% of students surveyed responded yes; while the remaining 52.4% did not consume fruits and/or vegetables daily or did not know if they did. There were a total of 882 students who participated in the response to this question.

Analysis of the post-survey data for year two, showed that as a result of the implementation of the school garden reimbursement program, there was an increase by 20.8% of students responding yes to consuming more vegetables and/or fruits as to the pre-survey response to this question. The total percentage of participants responding yes to this question was 68.4%; while only 22.7 % responding no to eating more fruits and vegetables as a result of the implementation of the program and 8.9% responded they did not know.

**Question 4:**

Do you eat fruits and vegetables at least three times a week?

| | Yes | No | Do Not Know |
|---|---|---|---|
| **Pre-Survey** | 489 | 167 | 229 |
| **Post-Survey** | 650 | 86 | 135 |



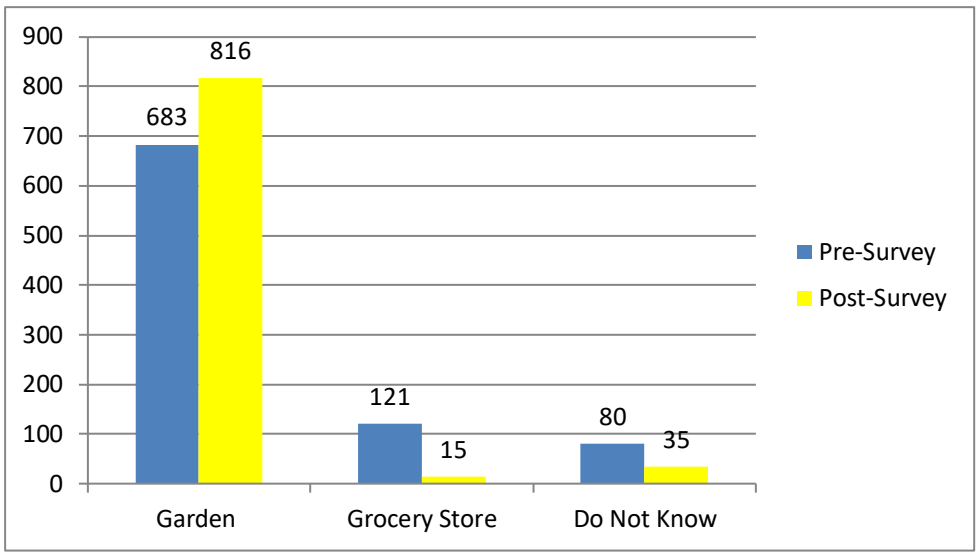

For year two this data was similar to that analyzed from year one. When asked if you ate fruits and vegetables at least three times a week, analysis of the pre-survey showed that 55.3% of students surveyed responded yes, 18.9% responded no and 25.8% responded did not know.

The post survey analysis for year two resulted in the same increase from data from year one, a 19.3% increase in students eating fruit and vegetables at least three times a week. This data supported the fact that this program was needed and showed benefits of students being exposed to gardens.

**Question 5:**

Are vegetables and fruits grown in a grocery store or garden?

| | Garden | Grocery Store | Do Not Know |
|---|---|---|---|
| **Pre-Survey** | 683 | 121 | 80 |
| **Post-Survey** | 816 | 15 | 35 |

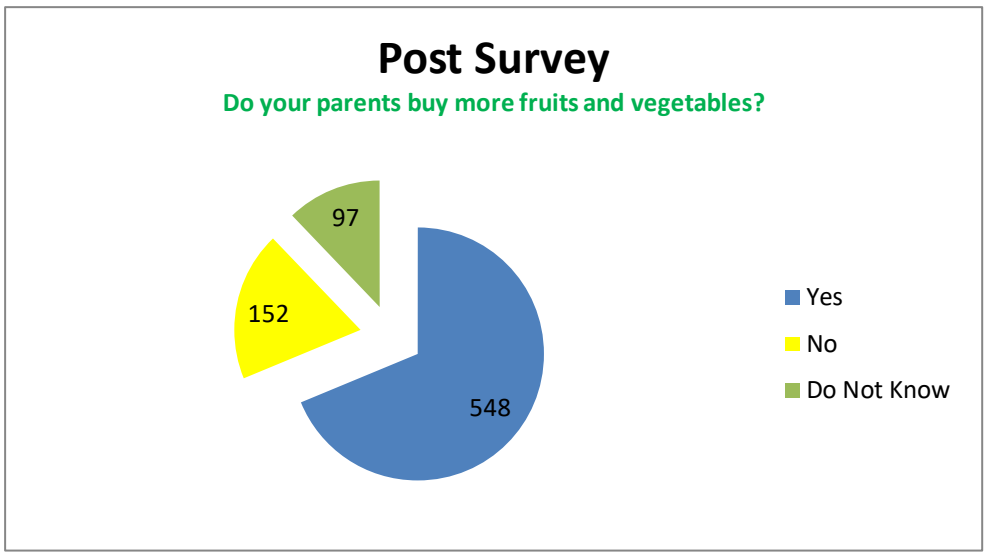



Data results from year two compared similar to that data collected in year one of the program for this answer. This question showed that most children were knowledgeable as to where fruits and vegetables were grown. The pre-survey analysis showed that 77.3% of students responded that fruit and vegetables came from the garden, while 13.7% thought they came from the grocery store and 9% did not know.

The post-survey data results for year two showed an increase in the response of where fruits and vegetables came from with 94.2% of students responding yes. The post-survey also showed that the responses to the grocery store decreased by 12% and students responding did not know decreased by 5%.

**Question 6 (Post-Survey Only):**

| Do your parents buy more fruits and vegetables? | | | |
|---|---|---|---|
| | **Yes** | **No** | **Do Not Know** |
| **Post Survey** | 548 | 152 | 97 |

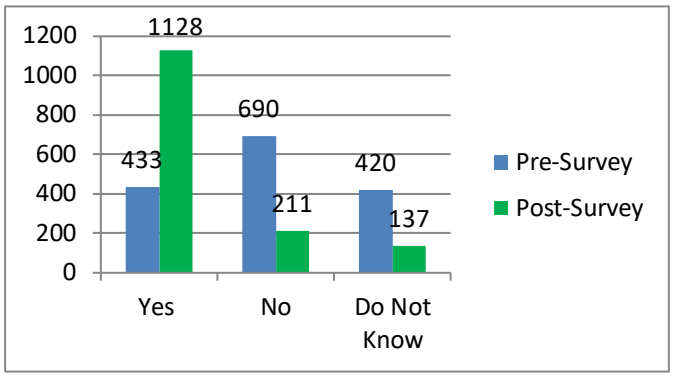



We felt that it was imperative to add an additional question to the post-survey asking students if their parents bought more fruits and vegetables as a result of the students demanding more locally grown fresh fruits and vegetables. 68.8% of students' households responded yes to buying more fruits and vegetables as a result of participating in this program in year two. The analysis further supports the hypothesis that by the implementation of the program from school participation, Louisiana's specialty crop industry should see an increase in the consumption of fruits and vegetables. There was definitely an increase in the knowledge of the industry and what specialty crops are by the students and teachers.

***Analysis of Data for Overall Program:***

**Question 1:**

| Do you know what a specialty crop is? | | | |
|---|---|---|---|
| | **Yes** | **No** | **Do Not Know** |
| **Pre-Survey** | 433 | 690 | 420 |
| **Post-Survey** | 1128 | 211 | 137 |



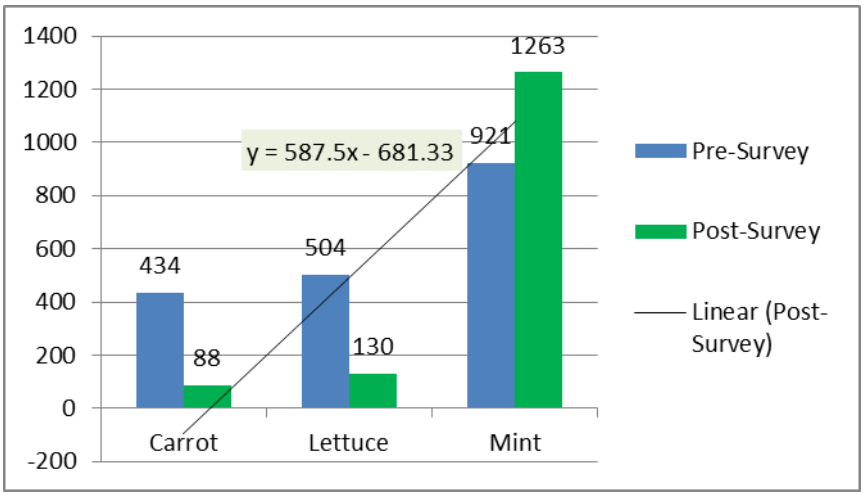

Overall data for this project shows from the pre-survey results that this program was needed to serve as a tool for increasing the knowledge of Louisiana specialty crops amongst school-aged children within the state. The data showed that of 1,543 children surveyed, 72% of students answered either no to the question of if they knew what a specialty crop was or either responded as did not know. Only 28% of the students surveyed answered yes to this question.

The post-survey data for the overall project proved that this program was highly effective in increasing the knowledge of what a specialty crops was amongst children grades K-12. The data showed that 76.4% of students who took the post-survey responded yes to knowing what a specialty crop was. Only 14.3% answered no and 9.3% responded do not know. This decline in the no and do not know responses was crucial in showing that the implementation of this project played a key component in increasing the knowledge and exposure to Louisiana children to specialty crops.

**Question 2:**

Which of these is an herb?

| | Carrot | Lettuce | Mint |
|---|---|---|---|
| **Pre-Survey** | 434 | 504 | 921 |
| **Post-Survey** | 88 | 130 | 1263 |



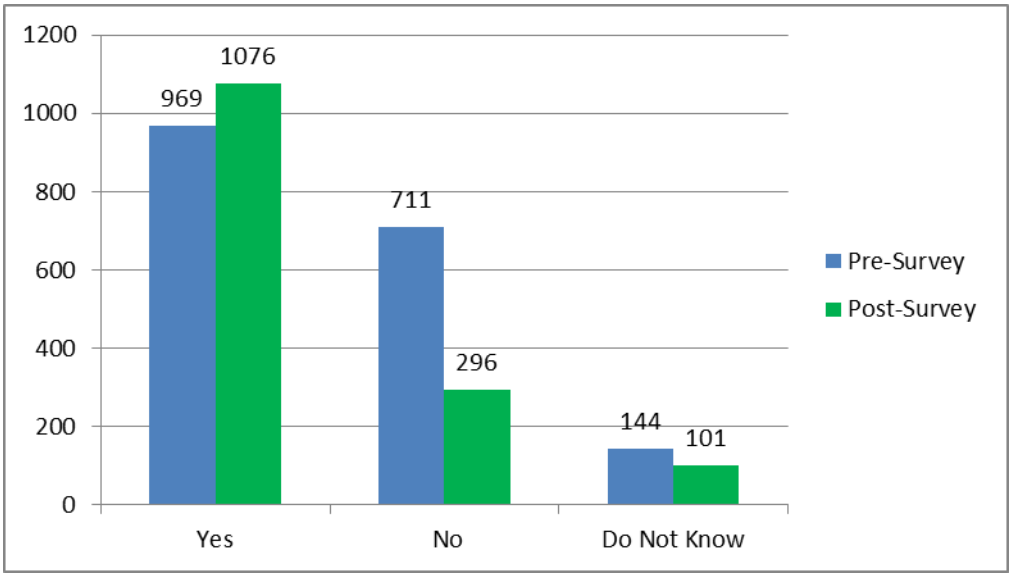

The overall project pre-survey showed that 49.5% of students surveyed knew that mint was an herb; while 50.5% thought that either a carrot or lettuce was an herb. There were a total of 1,859 students who participated in the response to this question.

The post-survey analysis of the data for the same question proved that the program increased the accuracy and knowledge of which produce was an herb. 85.3% of students responded that mint was an herb in the post-survey which was a 35.8% increase from the data collected in the pre-survey. The post surveyed also supported that there was a significant decline in students responding that carrot and lettuce were herbs. In the post survey data, only 5.9% of students surveyed chose carrot while the other 8.8% chose lettuce. The data also showed that the trend line between the pre and post surveys supports the notion that knowledge increased of students knowing that mint is an herb with the trend line being (y=587.5x-681.33).

**Question 3:**

Do you eat vegetables daily?
Do you eat more fruits and vegetables daily now than before the program was implemented?

| | Yes | No | Do Not Know |
|---|---|---|---|
| **Pre-Survey** | 969 | 711 | 144 |
| **Post-Survey** | 1076 | 296 | 101 |



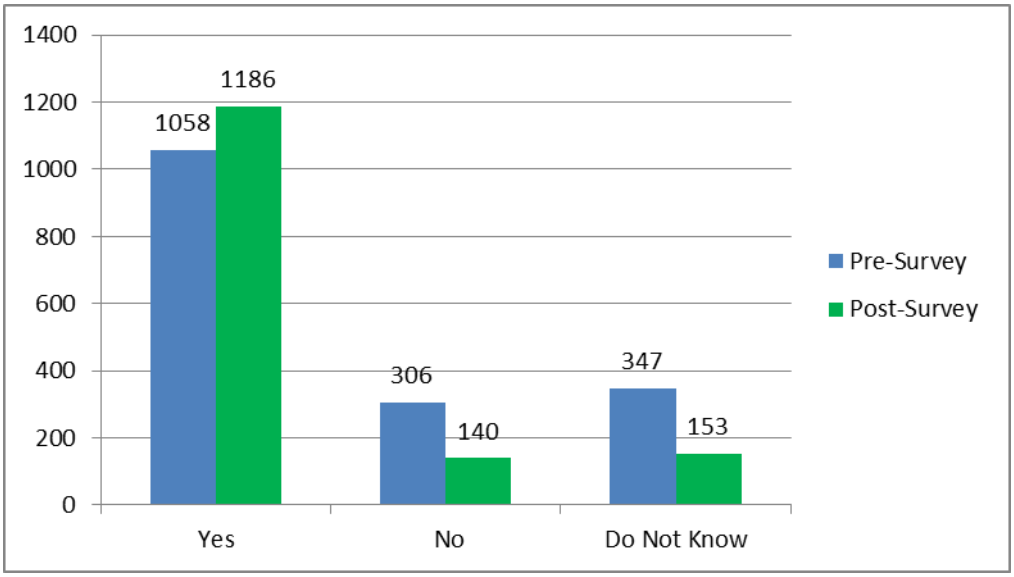

Overall data collected from this project for asking student if they ate vegetables daily showed from the pre-survey that only 53% of students surveyed responded yes; while the remaining 47% did not consume fruits and/or vegetables daily or did not know if they did. There were a total of 1,842 students who participated in the response to this question during the project implementation.

The post survey data for the overall project showed that as a result of the implementation of the school garden reimbursement program, there was an increase by 20% of students responding yes to consuming more vegetables and/or fruits as to the pre-survey response to this question. The total percentage of participants responding yes to this question was 73%; while only 20 % responding no to eating more fruits and vegetables as a result of the implementation of the program and 7% responded they did not know.

**Question 4:**

Do you eat fruits and vegetables at least three times a week?

| | Yes | No | Do Not Know |
|---|---|---|---|
| **Pre-Survey** | 1058 | 306 | 347 |
| **Post-Survey** | 1186 | 140 | 153 |



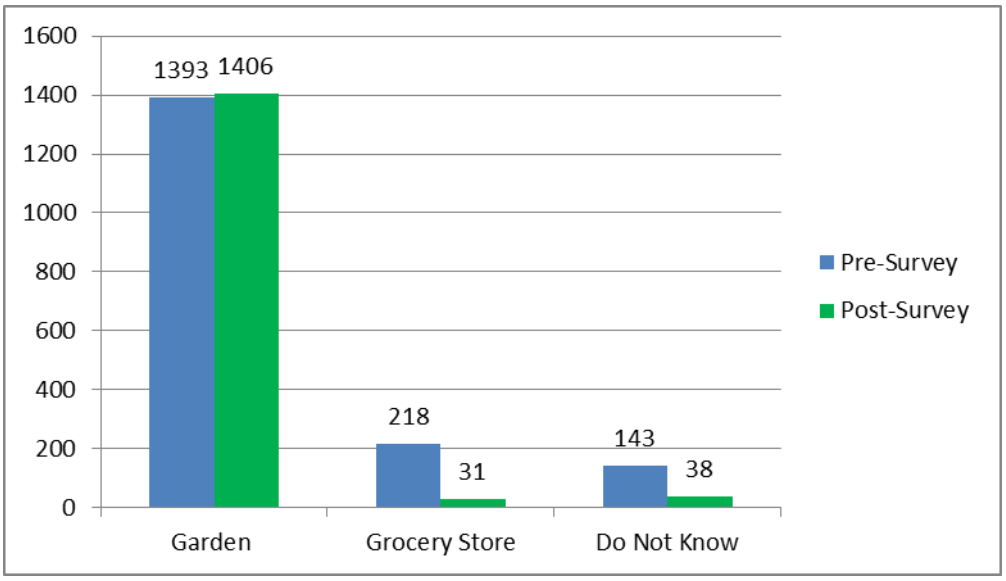

When asked if you ate fruits and vegetables at least three times a week, analysis of the pre-survey showed that 62% of students surveyed responded yes, 18% responded no and 20% responded did not know.

The post survey analysis showed an 18.2% increase in students eating fruits and vegetables at least three times a week. This data supported the fact that this program was needed and showed benefits of students being exposed to gardens.

**Question 5:**

Are vegetables and fruits grown in a grocery store or garden?

| | Garden | Grocery Store | Do Not Know |
|---|---|---|---|
| **Pre-Survey** | 1393 | 218 | 143 |
| **Post-Survey** | 1406 | 31 | 38 |

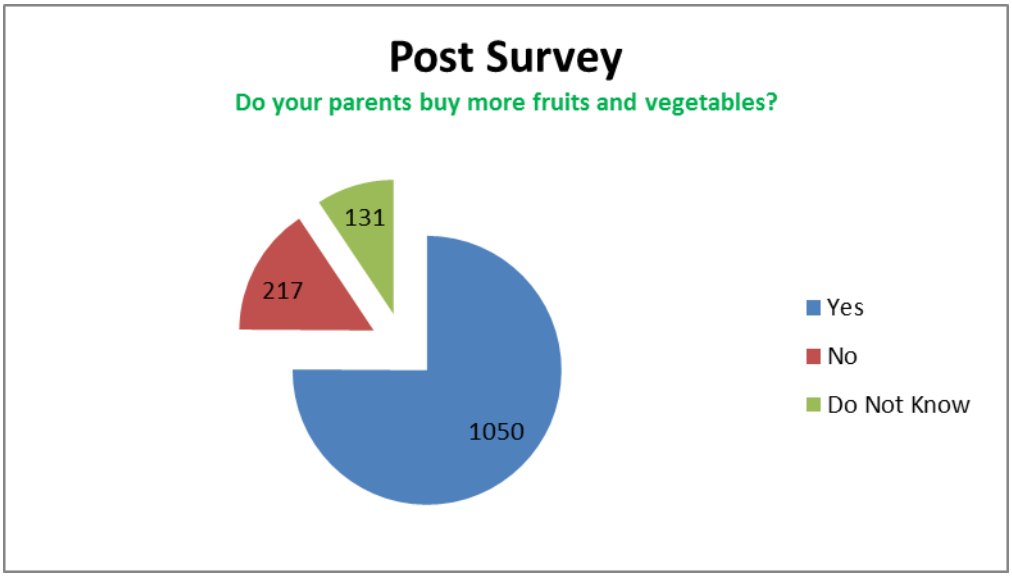



This question showed that most children were knowledgeable as to where fruits and vegetables were grown. The pre-survey analysis showed that 79.4% of students responded that fruits and vegetables came from the garden, while 12.4% thought they came from the grocery store and 8.2% did not know. Data results for this pre-survey question was unexpected, considering we had a lot of schools participate from urban areas.

The post-survey data results still showed an increase in the response of where fruits and vegetables came from with 95.3% of students responding yes. The post-survey also showed that the responses to the grocery store decreased by 10.3% and students responding did not know decreased by 5.6%.

**Question 6 (Post-Survey Only):**

| Do your parents buy more fruits and vegetables? | | | |
|---|---|---|---|
| | **Yes** | **No** | **Do Not Know** |
| **Post Survey** | 1050 | 217 | 131 |




As mentioned in the Analysis for years one and two, we felt that it was imperative to add an additional question to the post-survey asking students if their parents bought more fruits and vegetables as a result of the students demanding more locally grown fresh fruits and vegetables.

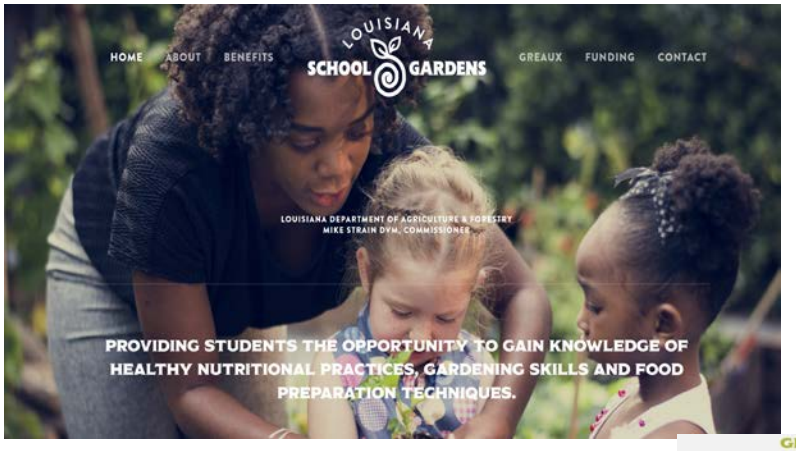
One of the goals set for the project was to promote the purchase of local specialty crops by Louisiana households. The project had a target of achieving a 15% increase in purchases of Louisiana specialty crops by households. 75.1% of students' households responded yes to buying more fruits and vegetables as a result of participating in this program. The analysis further supports the hypothesis that by the implementation of the program from school participation, Louisiana's specialty crop industry should see an increase in the consumption of fruits and vegetables. There was definitely an increase in the knowledge of the industry and what specialty crops are by the students and teachers.

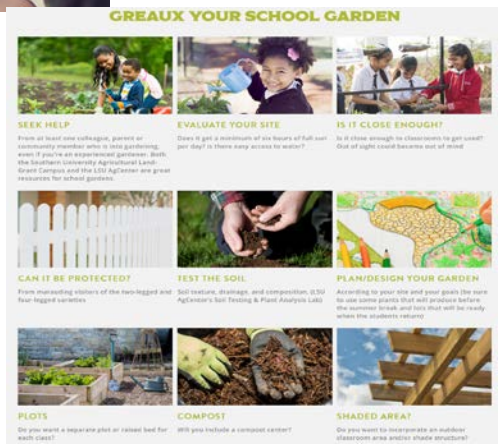
**Website and Logo:**

Forty-eight million Americans, including thirteen million children in the United States, live in households that lack the means to get enough nutritious food on a regular basis. Nearly one in six children in America lives in households that struggle with food insecurities. The Louisiana Department of Agriculture and Forestry's goal, through the help of the USDA's Specialty Crop Block Grant, was to increase the knowledge of, access to and consumption of Louisiana specialty crops in school-aged children across the state. A Louisiana school garden website was established through this program to serve as an educational component to provide schools the opportunity to be able to obtain information on specialty crop gardening and the Louisiana Specialty crop industry.

The Louisiana School Gardens website was designed to move people from awareness to action. It provided a ”GREAUX Your School Garden” component that allowed schools to see that although gardening was hard work, it was still achievable; especially when implementing gardens that focused solely on bringing awareness to the Louisiana specialty crop industry.

https://louisianaschoolgardens.com/




## Beneficiaries:

The beneficiaries of this project are Louisiana specialty crop growers, Louisiana school children, school administrators and teachers, parents, food service workers and fresh fruit and vegetable consumers. Through this program we have provided the opportunity for schools to establish and sustain school gardens; while incorporating them into their curriculum. The first year we had over thirty-six schools show interest in participating in the program.

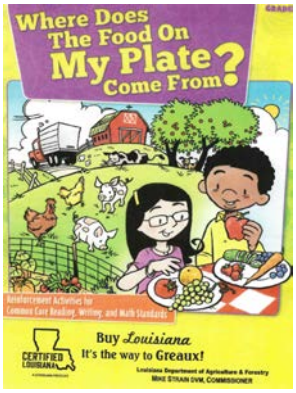
Through the implementation of school gardens across the state of Louisiana, school districts are benefiting from the program. These gardens have helped to bring awareness of local fresh fruits and vegetables that could be served in schools while supporting the Louisiana specialty crop industry.

Implementing the Louisiana School Garden Program directly impacted 1842 students that participated in garden activities and survey activities at thirty Louisiana schools. This project indirectly reached more than 5000 by exposing an average of three student's family members to the educational information by word of mouth of the student and take home educational materials. Additional students were also reached in numerous other schools in the districts where nutritional staff partnered with participating schools to bring their students to visit schools in the program to see their garden progress and learn about specialty crops. It is an aim to have those schools showing interest, to start their own gardens at their schools and continue to educate and expose future students to specialty crops and the benefits of their consumption. Project schools under this grant project are listed below.

1. BELLE CHASSE ELEMENTARY/PRIMARY SCHOOL
2. BISHOP NOLAND EPISCOPAL DAY SCHOOL
3. CROWLEY KINDERGARTEN
4. IMPACT CHARTER ELEMENTARY ACADEMY
5. NORTHEAST ELEMENTARY SCHOOL
6. OAKDALE SCHOOL-BASED HEALTH CENTER
7. OUACHITA PARISH HIGH SCHOOL- OUACHITA FFA
8. TALLULAH CHARTER SCHOOL
9. TANGLEWOOD ELEMENTARY SCHOOL
10. MARIGNY ELEMENTARY SCHOOL
11. WESTDALE HEIGHTS ACADEMIC MAGNET
12. ACADIA SCHOOLS/ CROWLEY
13. WILDWOOD ELEMENTARY SCHOOL
14. WEATHERFORD ACADEMY
15. IMMACULATE CONCEPTION SCHOOL
16. SCOTLANDVILLE PRE-EGINEERING MAGNET ACADEMY
17. PARK FOREST MIDDLE SCHOOL
18. OUR LADY OF THE LAKE SCHOOL
19. DOLORES T. AARON ACADEMY
20. ACADEMY OF OUR LADY
21. AMI KIDS OF BATON ROUGE
22. NORTHWOOD HIGH SCHOOL
23. ST. MARK'S CATHEDRAL SCHOOL
24. FOUNTAINBLEU HIGH SCHOOL
25. MARIGNY SCHOOL/ ST. TAMMANY
26. JESUS THE GOOD SHEPARD CATHOLIC SCHOOL
27. WOODLAKE ELEMENTARY SCHOOL
28. ST. JOSEPH CATHOLIC SCHOOL
29. THRIVE ACADEMY
30. MADISON HIGH/ MIDDLE SCHOOL

Through specialty crop education and the distribution of educational materials in the form of an activity book entitled "Where Does the Food on My Plate Come From?" used by

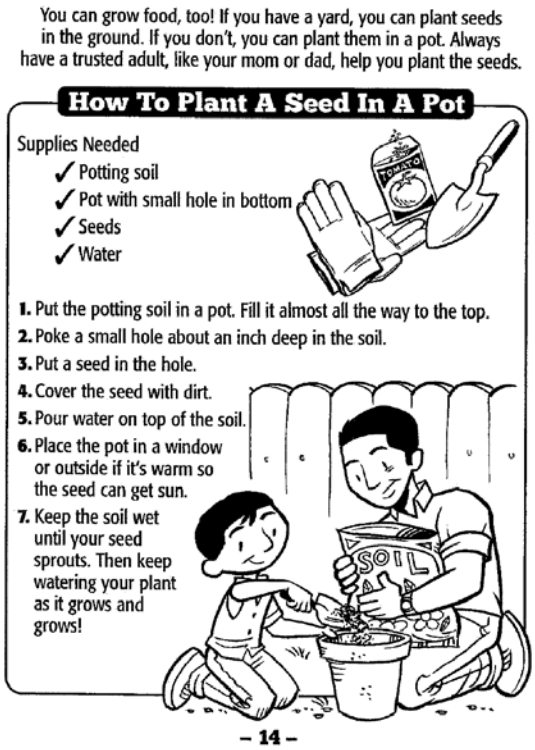
staff to focus on specialty crop food choices, students and school districts benefited from the knowledge acquired from the participation in the lessons.




Lesson 1: Explore the mystery of where food comes from.

Lesson 3- Discover what plants need in order to grow and how to plant a seed in a pot.

Lesson 4: Find out which kinds of plants fruits and vegetables grow on.



You can grow food, too! If you have a yard, you can plant seeds in the ground. If you don't, you can plant them in a pot. Always have a trusted adult, like your mom or dad, help you plant the seeds.

**How To Plant A Seed In A Pot**

Supplies Needed
- ✓ Potting soil
- ✓ Pot with small hole in bottom
- ✓ Seeds
- ✓ Water

1. Put the potting soil in a pot. Fill it almost all the way to the top.
2. Poke a small hole about an inch deep in the soil.
3. Put a seed in the hole.
4. Cover the seed with dirt.
5. Pour water on top of the soil.
6. Place the pot in a window or outside if it's warm so the seed can get sun.
7. Keep the soil wet until your seed sprouts. Then keep watering your plant as it grows and grows!

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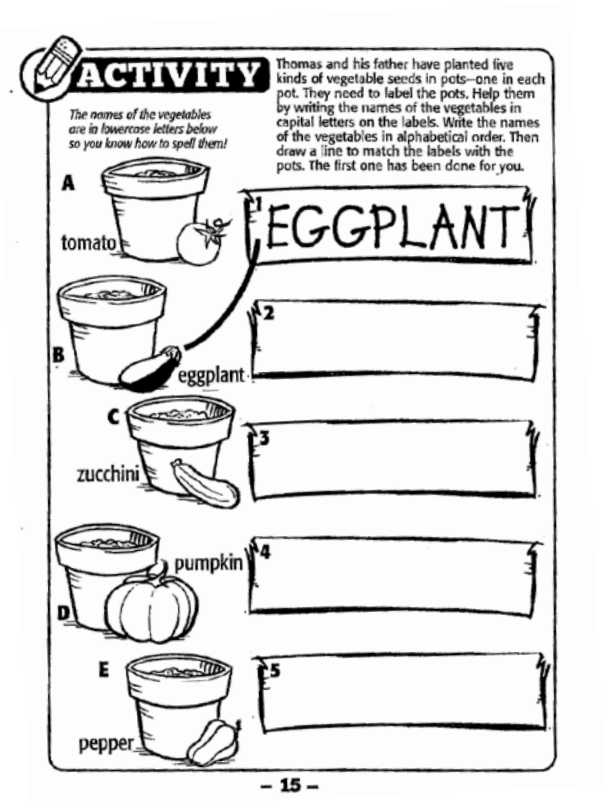


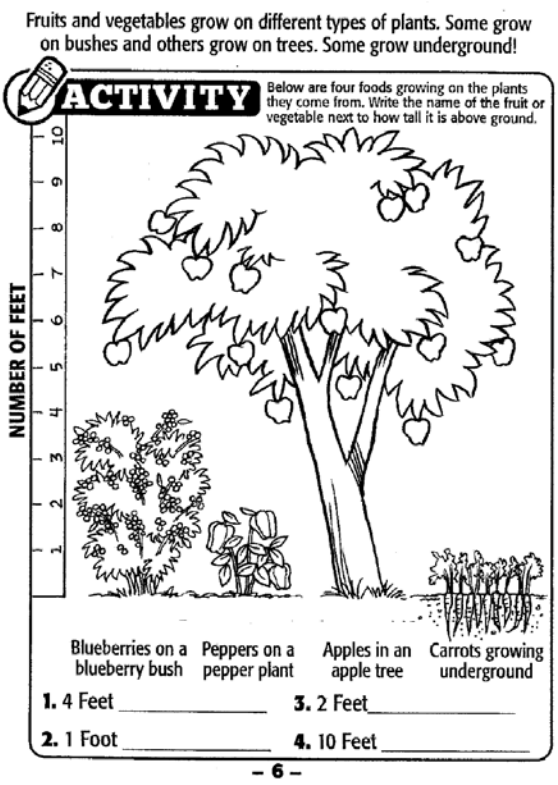
**ACTIVITY**

Thomas and his father have planted five kinds of vegetable seeds in pots—one in each pot. They need to label the pots. Help them by writing the names of the vegetables in capital letters on the labels. Write the names of the vegetables in alphabetical order. Then draw a line to match the labels with the pots. The first one has been done for you.

*The names of the vegetables are in lowercase letters below so you know how to spell them!*

A tomato — 1 EGGPLANT
B eggplant — 2
C zucchini — 3
D pumpkin — 4
E pepper — 5

– 15 –


Fruits and vegetables grow on different types of plants. Some grow on bushes and others grow on trees. Some grow underground!

ACTIVITY

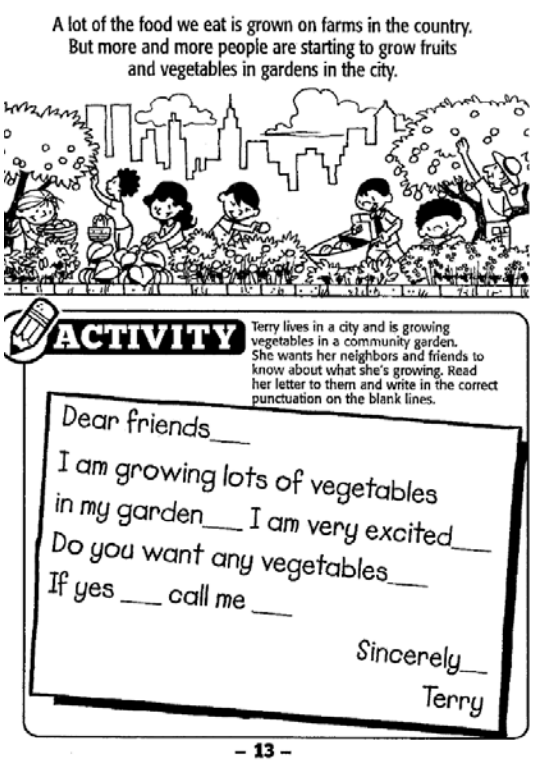
Below are four foods growing on the plants they come from. Write the name of the fruit or vegetable next to how tall it is above ground.

NUMBER OF FEET

Blueberries on a blueberry bush | Peppers on a pepper plant | Apples in an apple tree | Carrots growing underground

1. 4 Feet _____
2. 1 Foot _____
3. 2 Feet _____
4. 10 Feet _____

– 6 –


A lot of the food we eat is grown on farms in the country. But more and more people are starting to grow fruits and vegetables in gardens in the city.

ACTIVITY

Terry lives in a city and is growing vegetables in a community garden. She wants her neighbors and friends to know about what she's growing. Read her letter to them and write in the correct punctuation on the blank lines.

Dear friends___
I am growing lots of vegetables
in my garden___ I am very excited___
Do you want any vegetables___
If yes ___ call me ___

Sincerely__
Terry

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## Lessons Learned:

Through this program there were several lessons learned and unexpected outcomes. The first lesson learned was that school districts are very different in the level of dedication devoted to school gardening activities and expendable personnel to be assigned to specialty crop gardening efforts. If the grant was repeated in the future, it would be important to meet with school personnel and administrators to pre-identify committed personnel. Another lesson learned is that gardening activities are better implemented in the fall, to allow for students to be exposed to the garden for a full school year. Through this project we also learned that Mother Nature is unpredictable and time needs to be allotted for natural disasters and unpredictable weather events.

One of the biggest lessons learned is that offering paper surveys to be collected manually instead of digitally was very difficult when it came to comprising the data. If this project is done in the future, an online data collection process will probably be the best method for collecting the data into a centralized simple system such as Survey Monkey. The Louisiana School Garden website would be utilized to house the link for the pre and post survey data process.

A major lesson learned through this project was how important partnerships and collaborations were in contributing to the overall success of the project. The Louisiana Department of Agriculture and Forestry partnered with the Louisiana Department of

Education to notify all of the K-12 schools in the state of Louisiana about the program and its benefits. Through this project, there were unexpected collaborations with the LSU AgCenter and the Southern University Agricultural Land-Grant Campus to offer technical assistance to the schools. The project director has developed great communication with key team members of both universities.

The development of cooking demonstrations from school participation in this program was highly unexpected. Many schools not only allowed students to have a hands on upfront educational experience about learning what Louisiana specialty crops were, but they incorporated cooking components which enhanced children's preference for the food in which they grew. This concept proved to help with the success of the Louisiana School Garden Program.

**Contact Persons:**

Jeremy Hendrix, MBA
Louisiana Department of Agriculture and Forestry
225-952-8155
jhendrix@ldaf.state.la.us

Deana Erdey
Louisiana Department of Agriculture & Forestry
225-922-2903
derdey@ldaf.state.la.us

**Additional Information:**

**Monitoring Activities**

LDAF Program Co-Administrator Deana Erdey conducting sight visits of a school garden that participated in the program. School garden coordinator Eric Scott, shows Erdey how well the cantaloupe bed produced from the implementation of raised beds.

## School Garden Design

The images show just how creative a school can be with their specialty crop garden layout and design. This garden was very impressive. This was the first time the school had a garden and the first time the garden coordinator ever had any specialty crop garden exposure. The school partnered with a local specialty crop farmer who helped the students with weed control methods and plant production.

Vertical and Container Gardens for limited space

## Student Involvement

## Tasting Healthy, Nutritious and Fresh Vegetables

**PROJECT THREE TITLE_ - DEVELOP SCIENCE BASED PROCESSING TECHNOLOGY TO REDUCE FOOD SAFETY RISK AND ENHANCE ECONOMIC COMPETITIVENESS OF LOUISIANA PRODUCED PECANS**

**SUBGRANTEE: LOUISIANA ST**ATE UNIVERSITY AGRICULTURAL CENTER

## Project Summary:

Pecans are one of the most desired tree nuts in the United States. In the past few years, there have been several recalls due to potential bacterial contamination. This study was performed to investigate feasibility of using hot water treatment as a kill-step for food-borne pathogens during pecan shelling. The time-temperature treatments to achieve a 5-log reduction of *Salmonella enterica*, *Escherichia coli* O157:H7, *Listeria monocytogenes*, and non-pathogenic *Enterococcus faecium* were determined.. *monocytogenes* was most susceptible to heat treatment and were reduced by 4.6±0.35 log CFU/g at 70°C for 5 min, while 3 to 5 min at 80 and 90ºC treatments was required to achieve a similar reduction level for *S. enterica*, *E. coli* O157:H7, and *E. faecium*. *S.* e*nterica* were most resistant and required 4 min treatment time to achieve a 5-log reduction at 80 and 90°C. Hot water treatment, alone, and subsequent roasting had minimal effect on pecans' physicochemical properties. Consumers liked colour and aroma of treated pecans. Hot water treatment showed promise as a post-harvest microbial intervention strategy without affecting the eating quality and consumer acceptability. Results were distributed through LSU AgCenter extension outreach programs, presentation during pecan growers' association meetings, scientific conferences, peer reviewed and extension publications.

Pecans are native to the lower Midwest and South-central United States. They grow naturally in bottom lands with good alluvial soils and moisture. Crop production requirements of pecan trees include adequate space, water, nitrogen, and zinc. (Call et al. 2006). On average, pecan production adds about $17.4 million to the Louisiana economy each year (LSU AgCenter's 2014 Ag Summary).

In native pecan areas, there is a long standing tradition of "double cropping" the land by allowing cattle to graze in pecan groves. This pecan grove floor management philosophy provides a second source of income from the same parcel of land (pecans + beef) and a significant reduction in orchard mowing costs. However, cattle manure is the main source of food borne pathogens such as *E. coli* O157:H7, *Salmonella* spp. and *Listeria monocytogenes*. (Alam and Zurek, 2006; Pell, 1997). Research shows that pathogens in raw manure can survive up to several months (Nicholson et al., 2005) indicating the risk of pathogen contamination to pecans after they fall off from the tree. Marcus and Amling, (1973) found that *E. coli* population of the samples collected from orchards grazed with cattle is six-fold higher than that of samples collected from non-grazed orchards.

With the enactment of the Food Safety Modernization Act (FSMA) produce safety rule, producers who grow crops that are consumed raw will be required to take preventive control measures to reduce the risk of foodborne diseases (US-FDA 2014). Since most of

the tree nuts are consumed raw, they should meet the FSMA proposed produce safety rule requirements. FDA had originally proposed to require a nine-month interval between applications and harvest if the soil amendment is untreated and if there is chance that the amendment will come into contact with covered produce after application (FSMA, 2013). In the re-proposed rule, FDA has significantly modified this approach and suggested that growers follow the USDA's National Organic Program (NOP) standards for raw manure application. The USDA's NOP call for a 120-day interval between the application of raw manure for crops in contact with the soil and 90 days for crops not in contact with soil.

The food safety risk associated with the pre-harvest conditions of pecan production has increased concerns among the pecan processors and food manufactures. Concerns are higher with consumer and among manufactures that incorporate pecans without processing treatments which would be lethal to microorganisms. There is a provision in the proposed FSMA produce safety rule that a farm will be exempted from the produce safety rule coverage if the produce from the farm is processed with a kill step. FDA recommends a treatment process must achieve a 5 log reduction of microbial populations to be regarded as a kill step. Attempts to use sanitizers (chlorinated water, lactic acid, levulinic acid and peroxy acid) for pathogen reduction from in-shell pecans were moderately successful, but the maximum reduction of *Salmonella* levels was only 3.7 log CFU/g (Beuchat et al., 2012). Food products processed with a kill step will insure food safety in the final products. Thus, identifying a kill step in pecan processing is vital for reducing the food safety risk associated with pecans grown in orchards that use cattle grazing as part of their management scheme.

Thermal treatment is an effective method to eliminating the risk; however longer treatment times may cause adverse effects on the quality and shelf life of food. Processing with higher temperature treatment, may significantly reduce the treatment time. Because of the hard surface of the pecans, higher temperature and short time treatment may be a suitable alternative for disinfecting common foodborne pathogens.

Our **long term goal** is to contribute to the assessment of food safety risk of Louisiana produced specialty crops and to develop control strategies to mitigate food safety risks during pre/post-harvest processing. The **goal** of this project was to develop research based processing technology to reduce food safety risk associated with pecan and increase economic competitiveness of Louisiana pecan processors. This project is **important** because critical knowledge gaps exist regarding the fate of pathogens and effect on quality of pecans after hot water treatments. This project is **timely** as the FDA FSMA requires specialty crop growers to meet certain food safety requirements depending on the risk associated with their farming activities. The objectives to meet this goal were:

1) Identify the time and temperature parameters for hot water and steam treatment during pecan processing that can be regarded as a kill step
2) Scale up the hot water or steam treatment to a pilot scale with surrogate microorganisms to mimic actual pecan processing conditions
3) Conduct educational outreach program to disseminate the findings

## Project Activities:

A master student from the School of Nutrition and Food Sciences was supported from this project. The graduate student conducted this research as a part of her thesis, working at least 20 hours a week on this research and present the outcome of research as poster and oral presentations at scientific conferences and commodity group meetings and prepared manuscripts to submit to peer-reviewed journals. A project planning meeting with project partners was held before the start of the laboratory works. Laboratory works were divided into three parts such as 1) Pecan hot water treatment laboratory scale evaluations 2) Pecan steam treatment laboratory scale evaluations and 3) Sensory evaluation test with the new process parameters. After optimizing the treatments in the lab a scale-up to a pilot scale test mimicking actual processing conditions was performed in the LSU AgCenter food incubator. Results of the study were distributed through LSU AgCenter extension outreach programs, presentation during pecan growers' association meetings, scientific conferences, peer reviewed and extension publications.

Pecan hot water study was performed to investigate feasibility of using hot water treatment as a kill-step for food-borne pathogens during pecan shelling. In-shell pecans were subjected to hot water at 70, 80 or 90°C for 1, 2, 3, 4 or 5 minutes. The time-temperature treatments to achieve a 5-log reduction of *Salmonella enterica*, *Escherichia coli* O157:H7, *Listeria monocytogenes,* and non-pathogenic *Enterococcus faecium* were determined. Thermal death values were determined for each tested condition. *L. monocytogenes* was most susceptible to heat treatment and were reduced by 4.6±0.35 log CFU/g at 70°C for 5 min, while 3 to 5 min at 80 and 90ºC treatments was required to achieve a similar reduction level for *S. enterica*, *E. coli* O157:H7, and *E. faecium*. *S. enterica* were most resistant and required 4 min treatment time to achieve a 5-log reduction at 80 and 90°C. The D-values ranged from 1.15 to 1.72, 0.83 to 1.19, and 0.41 to 0.92 min at 70, 80 and 90˚C, respectively. *E. faecium* had the highest D-value (1.72 min at 70˚C), indicating a potential surrogate for process validation for pecan industries. Utilizing proper hot water and steam treatment during pecan shelling could reduce food safety risk.

After optimizing the pre-treatment conditions the effect of pre-treatment of in-shell pecans on physicochemical properties, consumer acceptance and purchase intent of dehulled and roasted kernels was evaluated. In-shell pecans were first subjected to hot water at 70, 80 and 90ºC for 8.6, 6.6 and 4.6 min, respectively and kernels were later dry roasted at $160^0$C for 10 min. The physicochemical properties of hot water treated and untreated nuts, before and after roasting were determined. Furthermore, consumer acceptance and purchase intent of the roasted kernels were determined. Hot water treatment, alone, and subsequent roasting had minimal effect on pecans' physicochemical properties. Consumers liked ($P<0.05$) colour and aroma of treated pecans. No effect ($P>0.05$) of pre-treatment was observed on acceptability of other sensory attributes. Safety claim increased treated pecans' overall liking; however, it decreased purchase intent. Hot water treatment showed promise as a post-harvest microbial intervention strategy without affecting the eating quality and consumer acceptability.

Results were distributed through LSU AgCenter extension outreach programs, presentation during pecan growers' association meetings, scientific conferences during the International Association of Food Protection annual conference in Salk Lake City, Utah and Institute of Food Technologists Annual Conference, Chicago, and peer reviewed and extension publications.

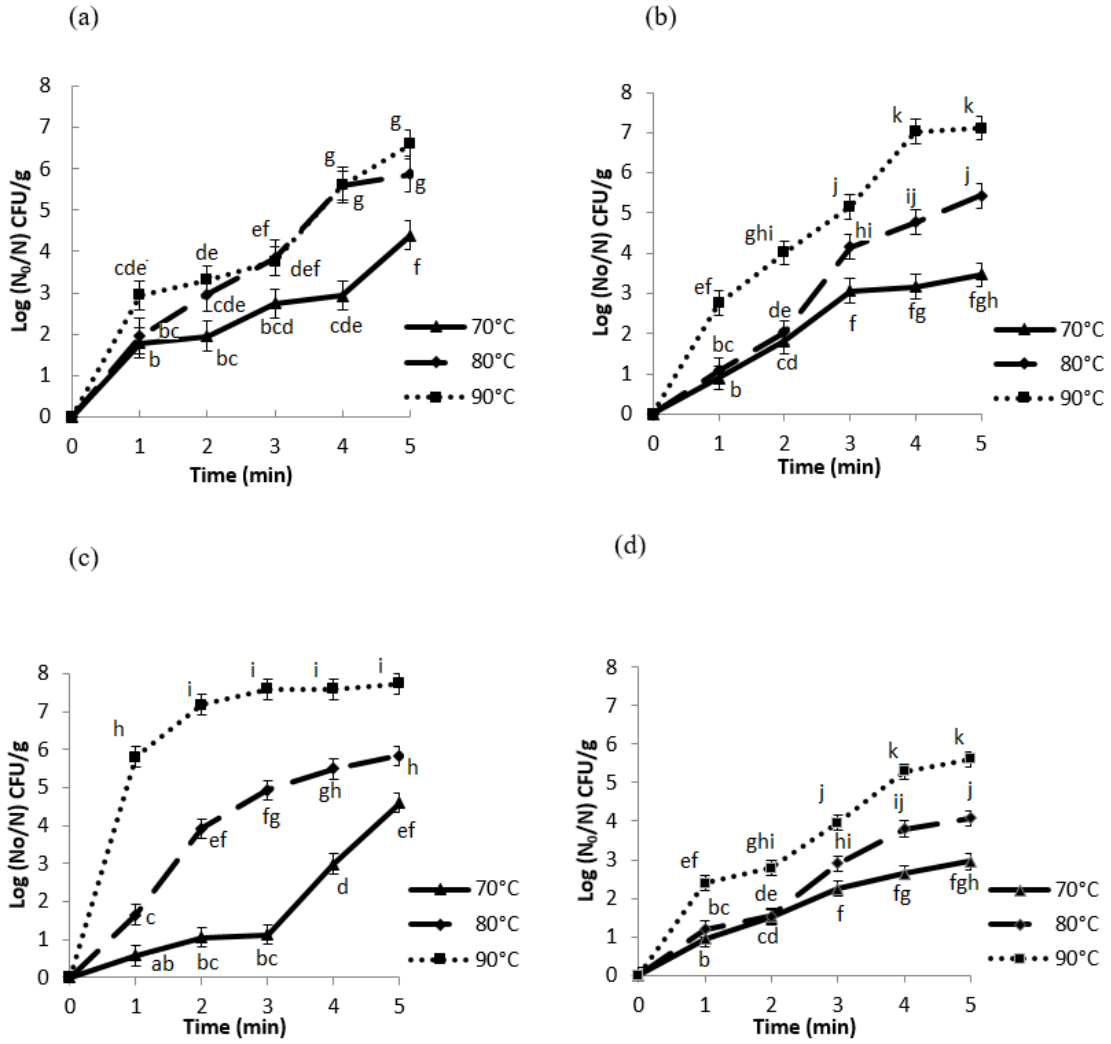



**Fig. 1.** Reduction (log CFU/g) of (a) *S. enterica*, (b) *E. coli* O157:H7, (c) *L. monocytogenes*, and (d) *E. faecium* observed in in-shell pecans when treated with hot water at 70, 80 and 90°C for 5 minutes. Mean values with different letters in each figure represent significant difference ($P<0.05$).

Table 1. Physicochemical properties of heat treated pecans

| Parameters | Control | | Hot water treated Pecans | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 70°C | | 80°C | | 90°C | |
| | Before Roasting | After Roasting | Before Roasting | After Roasting | Before Roasting | After Roasting | Before Roasting | After Roasting |
| **Moisture (%)** | 6.45±0.65$^{a}$ | 2.06±0.24$^{b}$ | 6.48±0.22$^{a}$ | 2.94±0.34$^{b}$ | 6.09±0.40$^{a}$ | 2.84±0.09$^{b}$ | 6.97±0.83$^{a}$ | 2.39±0.1$^{b}$ |
| **$a_w$** | 0.81±0.00$^{b}$ | 0.35±0.01$^{d}$ | 0.82±0.01$^{b}$ | 0.44±0.02$^{c}$ | 0.83±0.00$^{ab}$ | 0.44±0.00$^{c}$ | 0.85±0.02$^{a}$ | 0.44±0.01$^{c}$ |
| **Color** | | | | | | | | |
| **L*** | 47.09±0.28$^{a}$ | 47.18±0.30$^{a}$ | 45.74±0.28$^{ab}$ | 44.76±0.07$^{b}$ | 45.81±0.30$^{ab}$ | 44.69±1.08$^{b}$ | 47.05±0.48$^{a}$ | 41.87±0.69$^{c}$ |
| **a*** | 13.06±0.38$^{ab}$ | 11.03±0.22$^{b}$ | 13.13±0.13$^{a}$ | 13.87±0.09$^{a}$ | 13.30±0.98$^{a}$ | 12.16±1.20$^{ab}$ | 13.75±0.32$^{a}$ | 13.01±0.33$^{ab}$ |
| **b*** | 25.83±0.93$^{ab}$ | 20.97±0.18$^{c}$ | 27.03±0.72$^{a}$ | 26.29±0.20$^{ab}$ | 27.56±0.66$^{a}$ | 23.99±2.53$^{abc}$ | 27.43±1.72$^{a}$ | 22.61±2.91$^{bc}$ |
| **Chroma** | 28.95±0.66$^{abc}$ | 23.69±0.26$^{d}$ | 30.5±0.59$^{ab}$ | 29.72±0.22$^{abc}$ | 30.60±1.02$^{ab}$ | 26.93±2.28$^{bcd}$ | 30.69±1.39$^{a}$ | 26.12±2.49$^{cd}$ |
| **Hue (°)** | 63.16±1.51$^{a}$ | 62.25±0.26$^{a}$ | 64.08±0.82$^{a}$ | 62.19±0.03$^{a}$ | 64.26±1.11$^{a}$ | 63.01±3.42$^{a}$ | 63.34±1.97$^{a}$ | 59.88±3.31$^{a}$ |
| **Texture - Hardness (N)** | 45.70±13.60$^{a}$ | 35.66±7.16$^{b}$ | 40.75±9.83$^{ab}$ | 40.15±13.05$^{ab}$ | 40.86±6.21$^{ab}$ | 38.86±5.69$^{ab}$ | 43.05±9.42$^{ab}$ | 36.14±7.82$^{b}$ |

Mean Values in the same row by different letters are significantly different ($P$<0.05).

Table 2. Consumer acceptability scores$^{\beta}$ and purchase intent before and after of heat treated pecans

| Treatment | Appearance/ Color | Aroma | Texture | Flavor | OLb | OLa | PIb$^{\mu}$ (%) | PIa$^{\mu}$ (%) |
|---|---|---|---|---|---|---|---|---|
| **Control** | 5.2±1.73$^{b}$ | 5.79±1.77$^{b}$ | 6.63±1.52$^{a}$ | 6.29±1.8$^{a}$ | 6.31±1.75$^{a}$ | 6.21±1.8$^{a}$ | 37.50 | 43.75 |
| **70°C** | 6.46±1.45$^{a}$ | 6.32±1.47$^{a}$ | 6.64±1.57$^{a}$ | 6.42±1.7$^{a}$ | 6.42±1.58$^{a}$ | 6.53±1.5$^{a}$ | 33.04 | 30.36 |
| **80°C** | 6.70±1.56$^{a}$ | 6.37±1.51$^{a}$ | 6.49±1.61$^{a}$ | 6.17±1.8$^{a}$ | 6.29±1.71$^{a}$ | 6.43±1.7$^{a}$ | 35.71 | 35.71 |
| **90°C** | 6.79±1.39$^{a}$ | 6.42±1.66$^{a}$ | 6.58±1.69$^{a}$ | 6.21±1.7$^{a}$ | 6.46±1.62$^{a}$ | 6.52±1.6$^{a}$ | **39.29** | **33.04** |

β Mean and standard deviation from 112 consumer responses based on 9-point hedonic scale. Mean values in the same column by different letters are significantly different ($P$<0.05).

μStatistically significant p-values in bold print ($P$<0.05) based on McNemar Exact Probability

Posters from scientific conferences:

## Efficacy of Hot Water Treatment of In-Shell Pecans as a Postharvest Intervention Strategy to Destroy Food-borne Pathogens

Karuna Kharel[1], Namrata Karki[1], Charles J. Graham[2], Achyut Adhikari[1]
[1]School of Nutrition and Food Sciences, LSU AgCenter, Baton Rouge, LA
[2]Pecan Research/Extension Station, LSU AgCenter, Shreveport, LA

### INTRODUCTION

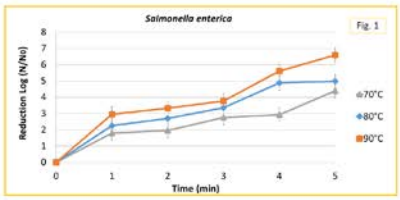
Pecans are harvested from the ground which increases the risk of microbial contamination. Cattle grazing in the pecan orchards is still prevalent in some parts of the U.S. as a second source of income and also to reduce the mowing cost. However, these practices may pose risk of cross-contamination of pecans with pathogenic microorganisms such as *Salmonella*, *E. coli* O157:H7 and *Listeria monocytogenes*. This necessitates development of efficient post-harvest treatment strategies to help ensure microbiological safety of pecans.

### OBJECTIVES

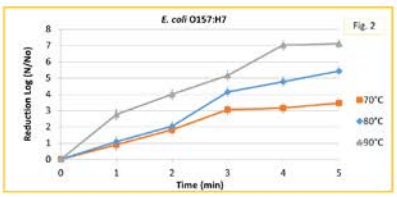
- To develop a post-harvest hot water treatment intervention as a kill step to destroy foodborne pathogens on in-shell pecans
- To calculate D and Z-vales of test bacteria subjected to hot water treatments.

### MATERIALS AND METHODS

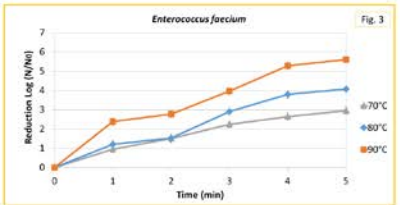

### RESULTS




❖ Treatment for 5 min at 80°C or 4 min at 90°C reduced *Salmonella enterica* by 5 log CFU/g




❖ Treatment for 5 min at 80°C or for 3 min at 90°C reduced *E. coli* O157:H7 by 5 log CFU/g




❖ *Enterococcus faecium* was reduced by 5 log CFU/g when pecans were treated at 90°C until 4 mins

**Figs 1-3. Effect of hot water treatment of in-shell pecans on *S. enterica*, *E. coli* O157:H7 and *E. faecium***

**Table 1. Calculated D and Z-values of different organisms**

| Type of organisms | D-values (min) | | | Z-value (°C) |
|---|---|---|---|---|
| | 70°C | 80°C | 90°C | |
| *Enterococcus faecium* | 1.71 | 1.19 | 0.92 | 7.50 |
| *Salmonella enterica* | 1.34 | 1.05 | 0.85 | 10.01 |
| *E. coli* O157:H7 | 1.38 | 0.87 | 0.71 | 6.89 |

- Among the tested pathogens, *Salmonella* was found to be the most resistive towards heat treatment with higher D-values and z-values.
- When compared to *Salmonella*, non-pathogenic *Enterococcus faecium* took longer time to get reduced by 90%. This shows that *Enterococcus faecium* can be used as an alternative to *Salmonella* for process validations.
- Among the three organisms, Enterococcus faecium has the highest D value. This shows that *Enterococcus faecium* can be used as a surrogate for *Salmonella* and *E. coli* O157:H7 for process validations.

### CONCLUSIONS

- Hot water treatment of in-shell pecans for a minimum of 5 minutes at 80°C is found to be optimum to obtain a 5 log reduction of *E.coli* O 157: H7 and *Salmonella enterica*, respectively
- Non-pathogenic *Enterococcus faecium* (ATCC 8459) can be used as a surrogate organism for process and equipment validation by pecan industry
- Sensory evaluation studies of the heat treated pecans need to be conducted to determine optimum treatment conditions for better end-product quality, consumer acceptability and microbiological safety.

### ACKNOWLEDGEMENTS

This research is supported by Louisiana Department of Agriculture and Forestry- Speciality Crop Grant under the award number CFMS# 2000177976. Sincere thanks goes to Dr. Michelle Danyluk, University of Florida for providing the bacterial strains of pathogens used in the study and to Dr. V. Kranti Yemireddy for the technical help and encouragement throughout.

## Effect of Extraction Method and Variety on Antioxidant and Antimicrobial Properties of Pecan Shell Extracts

Cameron Cason[1], Veerachandra Yemmireddy[1], Charles Graham[2], and Achyut Adhikari[1]
[1]School of Nutrition and Food Sciences, LSU AgCenter, Baton Rouge, LA; [2]Pecan Research and extension Station, LSU AgCenter, Shreveport, LA

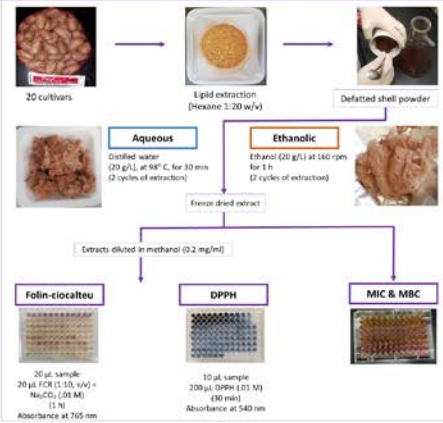
### INTRODUCTION

Pecan (*Carya illinoensis*) nuts are highly valued crop with great market value. However, the shells of pecans are underutilized. Approximately 270 million pounds of pecans are produced annually in the United States[1]; shells account for roughly 50% of the harvested mass.[2] Pecan nut shells are rich source of various phenolic compounds with potential antioxidant and antimicrobial properties. Increasingly, consumers are demanding minimally processed food products that are formulated with non-synthetic, functional ingredients. As a result, plant bioactive compounds have received more attention for use in various food applications. However, as per our knowledge the effect of variety on the phenolic and antioxidant properties of native varieties of southeastern USA grown pecans is not well known. In addition, the effect of extraction processes on the recovery of bioactive compounds and their potential antimicrobial activity on foodborne pathogens needs further investigation. Thus, in this study we evaluated 20 different pecan varieties using two different extraction methods.

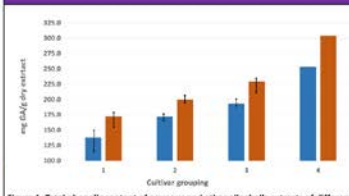
### OBJECTIVES

1. To determine the effect of extraction method and cultivar on phenolic content and antioxidant activity of pecan shell extracts.
2. To evaluate the *in vitro* antimicrobial affects of pecan shell extracts against common foodborne bacterial pathogens

### MATERIALS AND METHODS




### RESULTS




| Grouping → | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Aqueous extractions | Gloria Grande Jackson Melrose Elliot Cape Fear Creek Moreland | Cherokee Desirable Success Kiowa Nacono | Summer Oconee Caddo Maramec P-cou Schley Pawnee | Curtis |
| Ethanolic extractions | Cherokee Success Nacono | Kiowa Schley Pawnee Summer Creek Cape Fear Curtis Desirable | Caddo Moreland Melrose Jackson Gloria Grande Elliot | P-cou |

**Figure 1. Total phenolic content of aqueous and ethanolic shells extracts of different pecan cultivars (Grouped together as shown in the adjacent table)**

**Table 1. Estimated antioxidant activity (mg TE/g) of pecan shell extracts**

| Sl.No | Cultivar | Aqueous | Ethanolic |
|---|---|---|---|
| 1 | Curtis | 934.9$^{a}$ | 820.4$^{ab}$ |
| 2 | Moreland | 718.6$^{cd}$ | 630.8$^{defgh}$ |
| 3 | Desirable | 690.6$^{de}$ | 611.9$^{efgh}$ |
| 4 | Schley | 667.4$^{de}$ | 542.5$^{ij}$ |
| 5 | Pawnee | 666.5$^{de}$ | 608.4$^{efgh}$ |
| 6 | Kiowa | 656.8$^{e}$ | 581.7$^{ghij}$ |
| 7 | Creek | 638.7$^{f}$ | 650.5$^{defgh}$ |
| 8 | Gloria Grande | 630.47$^{fg}$ | 733.0$^{bcdefg}$ |
| 9 | Cherokee | 630.2$^{fg}$ | 652.9$^{defgh}$ |
| 10 | P-Cou 2 | 612.6$^{g}$ | 796.1$^{abcd}$ |
| 11 | Success | 606.3$^{g}$ | 542.5$^{j}$ |
| 12 | Cape Fear | 606.35$^{g}$ | 526.7$^{j}$ |
| 13 | Caddo | 600.55$^{g}$ | 680.4$^{defgh}$ |
| 14 | Oconee | 599.65$^{g}$ | 571.1$^{hij}$ |
| 15 | Nacono | 574.15$^{g}$ | 580.2$^{ghij}$ |
| 16 | Summer | 569.6$^{g}$ | 544.3$^{ij}$ |
| 17 | Jackson | 538.1$^{g}$ | 710.5$^{defgh}$ |
| 18 | Maramec | 522.55$^{g}$ | 840.6$^{a}$ |
| 19 | Melrose | 495.3$^{g}$ | 668.4$^{defgh}$ |
| 20 | Elliot | 468.3$^{g}$ | 768.2$^{abcde}$ |

**Table 2. MIC and MBC's (mg/ml) of pecan shell extracts against various strains of *E. coli* O157:H7**

| Strain | Source | Aqueous | | Ethanolic | |
|---|---|---|---|---|---|
| | | MIC | MBC | MIC | MBC |
| H1730 | Lettuce | 5 | ≥5 | ≥5 | ≥5 |
| 658 | Cantaloupe | 5 | ≥5 | ≥5 | ≥5 |
| Pecan field | Pecan field | 5 | ≥5 | ≥5 | ≥5 |
| Cock-tail | | 5 | ≥5 | ≥5 | ≥5 |

- Estimated phenolic content of pecan shell ethanolic extracts ranged from **104.2 (*P-cou 7*)** to **153.5 (*Cherokee*) mg GAE/g** and aqueous extracts ranged from **253. 8 (*Curtis*)** to **114.6 (*Jackson*) mg GAE/g**
- Antioxidant activity of ethanolic extracts ranged from **840.6 (*Jackson*)** to **526.7 (*Desirable*) mg TE/g** and aqueous extracts ranged from **934.9 (Curtis)** to **468.3 (*Elliot*) mg TE/g**
- Minimum concentration of pecan shell ethanolic and aqueous extract to inhibit growth of *E. coli* O157:H7 was **5 mg/ml**
- Minimum concentration of pecan shell ethanolic and aqueous extract to kill *E. coli* O157:H7 was **≥ 5 mg/ml**

### CONCLUSIONS

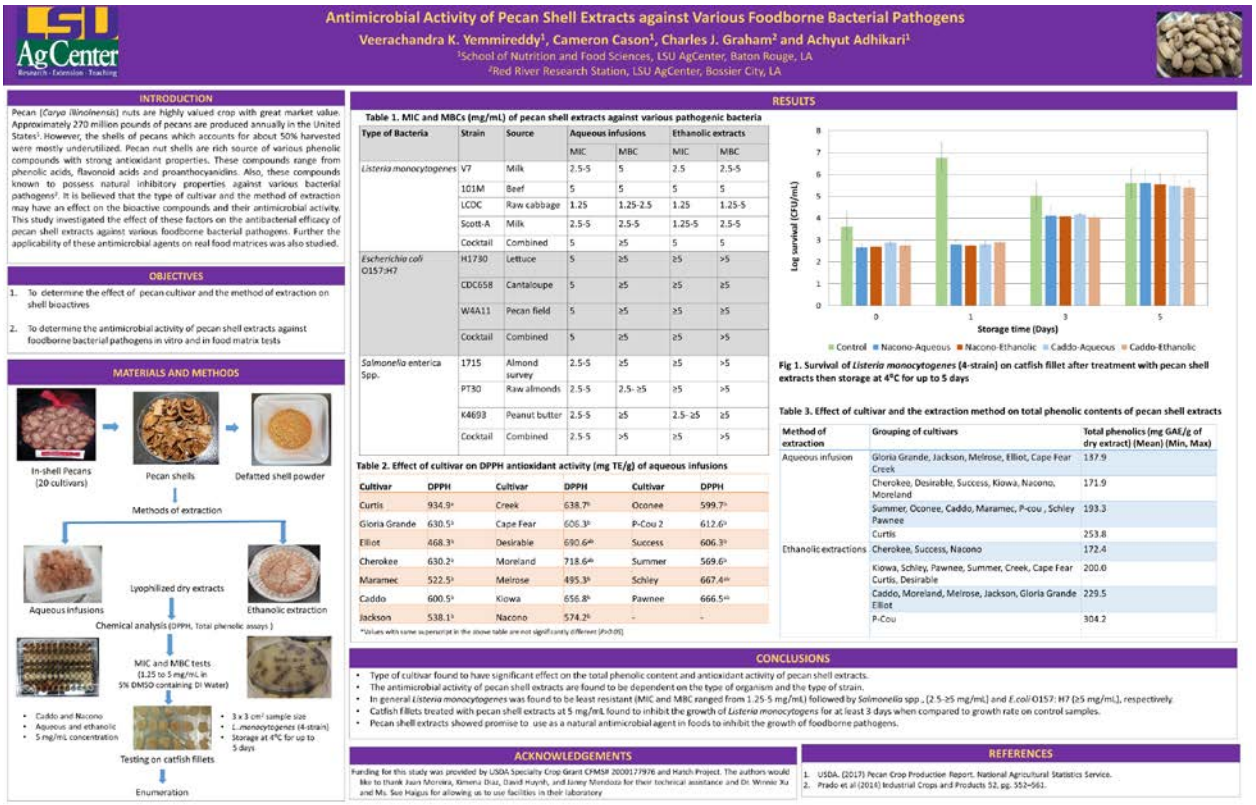
- Method of extraction did not significantly ($\alpha = 0.05$) affect the phenolic content and antioxidant activity of aqueous and ethanolic pecan shell extracts.
- Pecan cultivar has a significant affect ($\alpha = 0.05$) on the total phenolic content and antioxidant activity of aqueous and ethanolic pecan shell extracts.
- Pecan shell aqueous and ethanolic extracts (5 mg/ml) inhibited the growth of *E. coli* O157:H7 *in vitro*.
- The findings of this study show promise to utilize pecan shells as an alternative source of natural antioxidants and antimicrobial agents for use in various food applications.

### REFERENCES

1. USDA. (2017) Pecan Crop Production Report. National Agricultural Statistics Service.
2. Worley. R. E. (1994) Pecan physiology and composition. In: Santerre C. R. (eds) Pecan Technology.

### ACKNOWLEDGEMENTS

Funding for this study was provided by USDA Specialty Crop Grant CFMS# 2000177976 and Hatch Project



Antimicrobial Activity of Pecan Shell Extracts against Various Foodborne Bacterial Pathogens

Veerachandra K. Yemmireddy[1], Cameron Cason[1], Charles J. Graham[2] and Achyut Adhikari[1]

[1]School of Nutrition and Food Sciences, LSU AgCenter, Baton Rouge, LA

[2]Red River Research Station, LSU AgCenter, Bossier City, LA

INTRODUCTION

Pecan (*Carya illinoinensis*) nuts are highly valued crop with great market value. Approximately 270 million pounds of pecans are produced annually in the United States[1]. However, the shells of pecans which accounts for about 50% harvested were mostly underutilized. Pecan nut shells are rich source of various phenolic compounds with strong antioxidant properties. These compounds range from phenolic acids, flavonoid acids and proanthocyanidins. Also, these compounds known to possess natural inhibitory properties against various bacterial pathogens[2]. It is believed that the type of cultivar and the method of extraction may have an effect on the bioactive compounds and their antimicrobial activity. This study investigated the effect of these factors on the antibacterial efficacy of pecan shell extracts against various foodborne bacterial pathogens. Further the applicability of these antimicrobial agents on real food matrices was also studied.

OBJECTIVES

1. To determine the effect of pecan cultivar and the method of extraction on shell bioactives
2. To determine the antimicrobial activity of pecan shell extracts against foodborne bacterial pathogens in vitro and in food matrix tests

MATERIALS AND METHODS



RESULTS

Table 1. MIC and MBCs (mg/mL) of pecan shell extracts against various pathogenic bacteria

| Type of Bacteria | Strain | Source | Aqueous infusions | | Ethanolic extracts | |
|---|---|---|---|---|---|---|
| | | | MIC | MBC | MIC | MBC |
| *Listeria monocytogenes* | V7 | Milk | 2.5-5 | 5 | 2.5 | 2.5-5 |
| | 101M | Beef | 5 | 5 | 5 | 5 |
| | LCDC | Raw cabbage | 1.25 | 1.25-2.5 | 1.25 | 1.25-5 |
| | Scott-A | Milk | 2.5-5 | 2.5-5 | 1.25-5 | 2.5-5 |
| | Cocktail | Combined | 5 | ≥5 | 5 | 5 |
| *Escherichia coli* O157:H7 | H1730 | Lettuce | 5 | ≥5 | ≥5 | >5 |
| | CDC658 | Cantaloupe | 5 | ≥5 | ≥5 | ≥5 |
| | W4A11 | Pecan field | 5 | ≥5 | ≥5 | ≥5 |
| | Cocktail | Combined | 5 | ≥5 | ≥5 | >5 |
| *Salmonella enterica* Spp. | 1715 | Almond survey | 2.5-5 | ≥5 | ≥5 | >5 |
| | PT30 | Raw almonds | 2.5-5 | 2.5- ≥5 | ≥5 | >5 |
| | K4693 | Peanut butter | 2.5-5 | ≥5 | 2.5- ≥5 | ≥5 |
| | Cocktail | Combined | 2.5-5 | >5 | ≥5 | >5 |

Table 2. Effect of cultivar on DPPH antioxidant activity (mg TE/g) of aqueous infusions

| Cultivar | DPPH | Cultivar | DPPH | Cultivar | DPPH |
|---|---|---|---|---|---|
| Curtis | 934.9[a] | Creek | 638.7[h] | Oconee | 599.7[h] |
| Gloria Grande | 630.5[a] | Cape Fear | 606.3[h] | P-Cou 2 | 612.6[h] |
| Elliot | 468.3[b] | Desirable | 690.6[gh] | Success | 606.3[h] |
| Cherokee | 630.2[a] | Moreland | 718.6[gh] | Summer | 569.6[h] |
| Maramec | 522.5[b] | Melrose | 495.3[h] | Schley | 667.4[gh] |
| Caddo | 600.5[a] | Kiowa | 656.8[h] | Pawnee | 666.5[gh] |
| Jackson | 538.1[b] | Nacono | 574.2[h] | - | - |

*Values with same superscript in the above table are not significantly different (P>0.05)




Fig 1. Survival of *Listeria monocytogenes* (4-strain) on catfish fillet after treatment with pecan shell extracts then storage at 4°C for up to 5 days

Table 3. Effect of cultivar and the extraction method on total phenolic contents of pecan shell extracts

| Method of extraction | Grouping of cultivars | Total phenolics (mg GAE/g of dry extract) (Mean) (Min, Max) |
|---|---|---|
| Aqueous infusion | Gloria Grande, Jackson, Melrose, Elliot, Cape Fear Creek | 187.9 |
| | Cherokee, Desirable, Success, Kiowa, Nacono, Moreland | 171.9 |
| | Summer, Oconee, Caddo, Maramec, P-cou , Schley Pawnee | 193.3 |
| | Curtis | 253.8 |
| Ethanolic extractions | Cherokee, Success, Nacono | 172.4 |
| | Kiowa, Schley, Pawnee, Summer, Creek, Cape Fear Curtis, Desirable | 200.0 |
| | Caddo, Moreland, Melrose, Jackson, Gloria Grande Elliot | 229.5 |
| | P-Cou | 304.2 |

CONCLUSIONS

- Type of cultivar found to have significant effect on the total phenolic content and antioxidant activity of pecan shell extracts.
- The antimicrobial activity of pecan shell extracts are found to be dependent on the type of organism and the type of strain.
- In general *Listeria monocytogenes* was found to be least resistant (MIC and MBC ranged from 1.25-5 mg/mL) followed by *Salmonella* spp., (2.5-≥5 mg/mL) and *E.coli* O157: H7 (≥5 mg/mL), respectively.
- Catfish fillets treated with pecan shell extracts at 5 mg/mL found to inhibit the growth of *Listeria monocytogenes* for at least 3 days when compared to growth rate on control samples.
- Pecan shell extracts showed promise to use as a natural antimicrobial agent in foods to inhibit the growth of foodborne pathogens.

ACKNOWLEDGEMENTS

Funding for this study was provided by USDA Specialty Crop Grant CPMS# 2020017976 and Hatch Project. The authors would like to thank Juan Moreira, Ximena Diaz, David Huynh, and Janey Mendoza for their technical assistance and Dr. Winnie Xu and Ms. Sue Haigus for allowing us to use facilities in their laboratory

REFERENCES

1. USDA. (2017) Pecan Crop Production Report. National Agricultural Statistics Service.
2. Prado et al (2014) Industrial Crops and Products 52, pg. 552-561.

## Goals and Outcomes Achieved:

This study optimized the hot water and steam treatment parameters to reduce the microbial food safety risk associated with pecans without affecting the sensory properties of pecan nuts. The results from this study were presented during the scientific conferences such as International Association of Food Protection annual conference in Salk Lake City, Utah and Institute of Food Technologists Annual Conference, Chicago, IL. In our proposal we were expecting to share the results to around 200 pecan producers but we ended up sharing the results directly to more than 300 pecan producers and processors from Louisiana, Mississippi and Arkansas through tri-state pecan growers meeting, LA pecan growers meeting and through Dr. Adhikari food safety workshops and trainings program. Through publications in scientific journal and pecan magazine and fat sheets the results were shared indirectly to more than 1000 producers. The results of the study increased Louisiana pecan growers' knowledge pertaining to the efficacy, usability and economic feasibility of implementing improved processing technology for food safety risk reductions associated with pecan. This improved processing technology and increase knowledge on food safety risk reduction associated with pecan will increase economic competitiveness of Louisiana pecan processors.

**This study resulted in three posters, two peer reviewed manuscript in a very high rating international Journal (LWT Food Science and technology and International**

**Journal of Food Science and Technology), one magazine article and one fact sheet was published from this study.**

Examining a kill step of inshell pecans: Pecan South Magazine. Available at: https://pecansouthmagazine.com/magazine/article/examining-a-kill-step-for-inshell-pecans/

Hot water treatment as a kill-step to inactivate Escherichia coli O157:H7, Salmonella enterica, Listeria monocytogenes and Enterococcus faecium on in-shell pecans. LWT Food Science and Technology: Available at: https://www.sciencedirect.com/science/article/pii/S0023643818306315

Pecan Safety: Hot water conditioning to mitigate microbial hazards: https://www.lsuagcenter.com/profiles/bneely/articles/page1536078114504

A survey of pecan producers and processor were performed during the LA pecan growers meeting. The survey indicated that 50% of the respondents were currently using sanitizers to treat pecan. 15% mentioned that they use random hot water treatment parameters but the pecan turned dark and not good looking. After presenting the results from this study, 80% agreed that they will evaluate the microbial food safety risks associated with their pecan production and processing practices. About 75% of the growers were willing to adopt this technology within next 2-3 years.

## Beneficiaries:

More than 300 pecan producers and processors directly benefited from this project through the research findings presented through pecan growers meetings and through Dr. Adhikari's food safety workshops and trainings program. An additional 250 pecan growers, that weren't able to attend the events, will also benefit from the project through publication of the study and continued outreach. Through publications in scientific journal and pecan magazine and fact sheets the results were shared indirectly to more than 1000 producers. The results of the study increased Louisiana pecan growers' knowledge pertaining to the efficacy, usability and economic feasibility of implementing improved processing technology for food safety risk reductions associated with pecan. This improved processing technology and increase knowledge on food safety risk reduction associated with pecans will increase economic competitiveness of Louisiana pecan processors.

## Lessons Learned:

We took longer duration to finish this project than expected. One of our project activities required a pilot scale steam treatment equipment to scale-up the laboratory scale evaluations to mimic actual processing conditions. The steam treatment equipment was not available in the market until summer 2017 and it was slower than anticipated for

delivery of the steam boiler. We received the steam boiler the first week of November, 2017 but it took another several months for fabricating a steam treatment chamber and receiving permit to run the equipment. Also, pecan samples were only available during the harvesting season later in the fall so we have to wait several months to run some of the laboratory and sensory studies. This taught us that we should store enough samples for unexpected repetitive works and some modification of protocol during the course of the study.

## Contact Person:

Dr. Achyut Adhikari, Asst. Professor & Food Safety Specialist
LSU AgCenter, School of Nutrition and Food Science
225-578-2529
acadhikari@agcenter.lsu.edu

## Additional Information:

Graduate student Ms. Karuna Kharel presenting her resesrach work at the IFT 2018 conference in Chicago.


Graduate students presenting their research during the tri-state pecan growers meeting


Dr. Adhikari's lab group attending pecan growers meeting

# PECAN SAFETY
## Hot Water Conditioning to Mitigate Microbial Hazards

LSU AgCenter
Research · Extension · Teaching

### What are the potential food safety risks associated with pecans?

Pecans have not been associated with any foodborne disease outbreaks, but orchard conditions before and after the harvest indicate there are potential food safety risks. Contamination on in-shell pecans and nutmeats can occur preharvest, at harvest and during postharvest handling and processing. During rainfall, the shucks surrounding pecans get wet along with the nut. The nutrient-rich shucks provide a suitable environment for microbial growth. *Salmonella* can survive for several weeks, making it one of the favored routes for contamination.

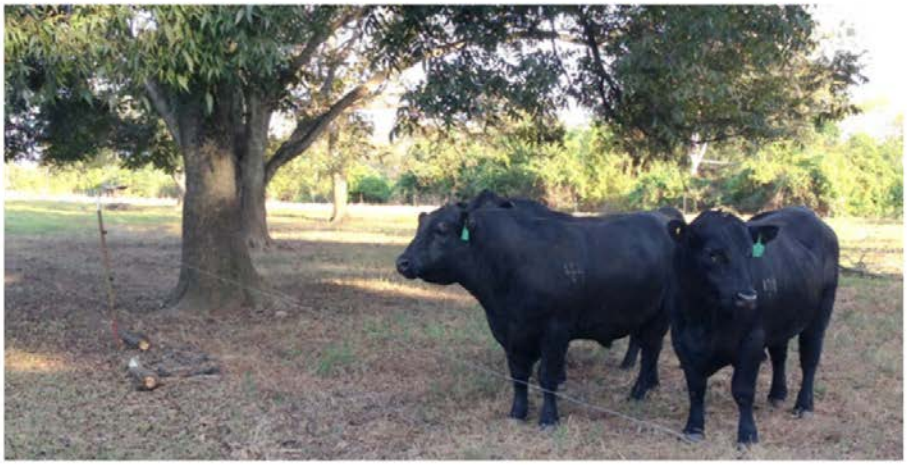
During harvesting, pecan tree nuts are shaken off, or the nuts are naturally allowed to drop on the ground. They can remain there for several days until collected. The nut absorbs moisture from soil that can be potentially contaminated with bacteria from wild and domestic animal feces, inadequately composted manure, irrigation or runoff water from land grazed by livestock. Additionally, worker health and hygiene in orchards and processing areas also play an important role in maintaining the safety of pecans.

### How can cattle grazing on the orchards affect pecan safety?

Cattle grazing is practiced in several orchards in Louisiana. It is one of the most common forms of ground cover management in native pecan groves. Cattle grazing in orchards provides a second source of income from the same parcel of land. It also results in a significant reduction in orchard mowing costs. However, cattle manure has been found to be the main source of health-hazardous bacteria that can survive up to several months and may increase the risk of contamination.

### How to mitigate the potential risk?

Conditioning prior to cracking is an essential step in pecan processing to reduce kernel breakage and improve shelling efficiency. However, it can also eliminate microorganisms that may be on the shell. Following scientifically validated practices during pecan shelling will help pecan growers produce safe, high-quality pecans.



*Cattle grazing in a pecan orchard.*

LSU Agcenter's Fact sheet on pecan safety

**PROJECT FOUR TITLE: STATEWIDE LOUISIANA GROWN MARKETING CAMPAIGN TO CONTINUE CONSUMER AWARENESS AND INCREASE SALES EFFORTS OF LOUISIANA SPECIALTY CROPS**

**LOUISIANA DEPARTMENT OF AGRICULTURE AND FORESTRY**

## Project Summary:

The purpose of this project was to conduct a statewide consumer awareness marketing campaign of Louisiana specialty crops to increase consumer awareness through point of sale, social media and advertising efforts to increase sales. This statewide promotion effort expanded on past activities began under the 2010 SCBGP to increase consumer awareness that local produce is available and identify Louisiana producers and locations where direct purchasing can be conducted. Utilizing funding in the past, Louisiana was able to assist specialty crop farmers with limited point of sale signage for their use at farmers' markets and roadside stands, commodity sales during growing seasons and media commercials in limited broadcast presence.

With this grant funding, this statewide campaign was able to enhance assistance for additional Louisiana grown specialty crop producers with one recognizable messaging effort on a larger scale by developing additional signage, banners, and educational and food preparation materials. New broadcast markets were able to be utilized to promote specialty crops as well as adding billboard media visibility to reach consumers throughout the state. Website design that was created previously was enhanced with technological enhancements to add interactive mapping directions to specialty crop producers, update and add additional producers and make the site more user friendly. A social media page was established to reach consumers through modern advertising venues. Point of sale cooking demonstrations were added to enhance consumer education of specialty crops on their nutritional value, how easy it is to prepare them and how delicious they are to eat. Increasing child and adult nutrition knowledge is an important issue. Louisiana's overall health rank, based on America's Health Rankings, is 50$^{th}$ (United Health Foundation 2015). This includes a rank of 47$^{th}$ for obesity, 39$^{th}$ for diabetes and 46$^{th}$ for cardiovascular deaths. Increasing consumer consumption of healthy, fresh specialty crops can help improve these numbers. The purpose of all the project activities was to increase awareness of the availability of specialty crops and ultimately increase sales for specialty crop producers, and this project was successful.

## Project Approach:

The interest for locally produced fruits and vegetables and other specialty crops has seen an increase nationally in recent years, but many Louisiana farms still find it extremely hard to connect to consumers and retailers with their products due to the extreme cost of advertising. This project gave the local producer the ability to capitalize on the demand for local produce through statewide promotional efforts and advertising. Many consumers cannot always locate their local farmers or are unaware of the retail outlets that focus on locally produced specialty crops and nursery products. Through this project, LDAF conducted additional promotion activities and purchased additional advertising to develop a concerted advertising consumer awareness campaign designed to grow demand and sales of local specialty crop products in farmers' markets, roadside stands and retail stores.

The first objective of the project was to reach out to Louisiana specialty crop producers, farmers' markets, roadside stands and retail stores, making them aware of the advertising

campaign and have them become actively involved in promotion efforts and the utilization of the messaging and signage for their products at their sales locations.

The second objective was to promote Louisiana grown fruits and vegetables and other specialty crops through timely advertising and promotion efforts so that the consumer was more aware when and where local specialty crops were available and request it when it was not in their retail locations.

LDAF grant administrator worked with LDAF staff to secure the assistance of an ad agency to assist in the advertising development and placement of the advertising campaign to promote Louisiana grown specialty crops. The development and establishment of a focused point of sale, direct sales and consumer awareness promotion plan was completed.

LDAF grant administrator worked with a digital design company to update the Louisiana Grown Specialty Crop website to include new information and add interactive mapping and surveying technology. Design and establishment of a social media Facebook page for promotion presence was also completed.

LDAF grant administrator along with additional LDAF staff worked to inform Louisiana specialty crop producers of the statewide marketing campaign program activities, input additional producers' information to the website and encourage them to become actively involved in promotion efforts. Point of sale educational and promotional materials were designed, purchased and distributed to specialty crop producers to be used at farmers' markets, roadside stands, schools, regional events and in retail stores where Louisiana specialty crop producers provide inventory.

Television commercials were placed on 13 different broadcasting stations throughout Louisiana, blanketing the state from Shreveport, New Orleans, Lafayette, Baton Rouge, Monroe to Alexandria. More than 974 commercials ran during the peak harvesting season in Louisiana in spring/summer of 2017 and 2018 to inform the consumer that fresh specialty crops were now available and to increase demand and consumption while specialty crops were readily available, increasing sales. Print media was developed and placed during the fall specialty crop season of 2017.

LDAF grant administrator worked with the ad agency to develop messaging to catch the eye of the consumer that was placed on billboards throughout the state in high travel corridors where they would reach the most consumers in cities and rural areas. Six billboards were covered with specialty crop messaging with a reach of two million travelers a week during peak harvesting season in 2018. Billboards were placed in Bossier, Baton Rouge, Denham Springs, New Orleans, Prairieville, and Lafayette during May and June. Several of these billboards stayed up visible through July at no cost to the project with one still up in November, reaching the consuming public through fall.

The commercials and billboards also provided information to lead consumers to additional information provided on the website, and surveying was conducted on the site to measure traffic to the site as a result of the campaign or by other means.

LDAF grant administrator worked with seven point of sale locations to conduct educational and cooking demonstration events to show shopping consumers how to easily prepare tasty specialty crops. These demonstrations were very successful and showed an increase in sales at those locations as a result of the project's activities. Forty-one specialty crop producers reported that they had seen an increase in sales due to project activities ranging from 5% to 50% sales increase resulting in an average total of 19% sales increase. One event reported that all their specialty crop producers completely sold out. This was a very successful project activity.

LDAF reached out to several schools and provided specialty crop information and educational materials to increase knowledge of specialty crops and encourage kids to taste and add specialty crops to their diets. Tasty recipes were provided for the kids to take home to their parents to aid in reinforcing specialty crop consumption. LDAF also attended several events such as the Monroe Ag Expo, Louisiana Fruit and Vegetable Growers Field Day, Farm Bureau Conventions, and the Louisiana Food Service and Hospitality Expo in New Orleans in 2016, 2017, and 2018. This event helped to connect with buyers and restaurants to promote our specialty crop producers for direct sales opportunities.

LDAF staff conducted surveys of Louisiana specialty crop producers at the end of the project activities to determine measurable results of the project. Producers were personally called to take a survey of how they thought the project went, if they saw increased demand during their harvesting time when the advertising was being conducted and if the point of sale signage and educational materials assisted in their sales efforts. The survey results were greater than expected in our project goals.

## Goals and Outcomes Achieved:

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| Goal 1: | Conduct outreach to inform and recruit a minimum of 50 specialty crop farmers to sign up for presence as a specialty crop producer/provider of Louisiana specialty crops. |
| Performance measure: | Registration records |
| Benchmark: | 76 specialty crop producers. |
| Target: | 50 additional producers. This target was reached and surpassed with a total of 155 at the end of the grant period. |

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| Goal 2: | Conduct promotional activities and purchase advertising to increase consumer awareness of the availability of Louisiana grown specialty crop products and increase demand of Louisiana grown products in retail stores, thereby increasing sales. |
| Performance measure: | Staff will track Louisiana grown members' sales by conducting a survey of members' sales volume at the end of the project. |
| Benchmark: | There was no current data. Farmers are extremely reluctant to provide a detailed number of their actual sales. We learned that they will, however, provide a percentage account of sales increased or decreased in a given year compared to the prior sales. |
| Target: | Increase in sales from pre-campaign efforts to those post-campaign efforts by 5%. This target was reached and surpassed. Specialty crop farmers were contacted by phone in November of 2018, giving them time to assess their sales. A sampling of 50 producers was called with 42 responding to the survey. All 42 responded that the website and social media was informative and a good resource for consumers, they felt the campaign promotional mediums were effective forms of advertising to reach the public, the developed point of sale items were a positive way to promote the specialty crop industry and they felt additional efforts in this manner would continue to benefit the specialty crop industry. Five producers experienced hardships and didn't plant during the last couple of growing seasons, and three producers stated that their sales were good, but the same with no significant sales increase. Thirty-four producers of the sampling survey reported great selling records since the start of the statewide specialty crop campaign compared to sales from prior years. The increases ranged from 5 percent to 60 percent. After calculating the responses, the data showed an 18% increase in sales post project activities to prior activities. This surpassed the project target. |
| Goal 3: | Increased consumer awareness of the availability of Louisiana grown specialty crops and the increased purchasing behavior of the consumer. |

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| Performance measure: | We established a survey on the Louisiana Grown website that asked the consumer if they were led there by an advertisement or a promotional effort. There were additional questions to determine if the consumer intended to purchase Louisiana grown specialty crops, increase consumption of such, and/or try new crops and preparation ideas. |
| Benchmark: | There is no current data for this measure. In the previous project, we monitored hits to the website. In an effort to better assess the success of advertising efforts, this method, we feel, more accurately tracked the visits to the site due to advertising compared to normal random site visits. Surveying provided a better monitoring mechanism. A survey was developed and posted to the website to co-inside with the beginning of the campaign and was monitored throughout the project. |
| Target: | We expected at least 50% of those completing the online survey, during the project activities timeframe, to answer that their visit to the site was due to seeing an advertisement or attending a promotional event effort. The target was reached and surpassed. The survey results showed that 91% stated that they were driven to the site as a direct result of the project's campaign. The results showed that 82% stated that they were very/extremely likely to increase their specialty crop consumption after seeing the commercials and viewing the web information and 77% reported they were very/extremely likely to add new specialty crops they had never tried before to their diets as a result of the information and recipes provided. |

## Beneficiaries:

Direct beneficiaries were the 155 specialty crop producers registered as specialty crop farmers under this project's web promotion page who received point of sale support materials and benefited from the statewide marketing campaign. Additionally, indirectly all Louisiana specialty crop producers benefited from the messaging and promotional efforts of the mass marketing campaign of broadcast, billboard and print media. Louisiana consumers young and old benefited from an increase in knowledge of specialty crop nutrition and availability and where to purchase fresh Louisiana specialty crops in season.

## Lessons Learned:

A lesson learned is that small specialty crop producers are in need of projects to help them reach retail buyers. Many expressed the ability to plant and produce more specialty crops that would help them financially and add to the economy, but getting into retail locations or school sales is extremely difficult for small farmers. They believe that with the promotional efforts and more people looking for fresh specialty crops, they need to expand. Projects that address food safety and assistance with paperwork would be good projects to pursue to help specialty crop farmers. We also learned that they are still very private individuals. It is extremely difficult to get them to answer detailed questions about their business financially. I don't believe we will be able to continue marketing projects in the future under the new measureable of providing actual monetary increases instead of percentages.

## Contact Person:

Michelle Estay, Director
La Department of Ag and Forestry
985-345-9483
estay@ldaf.la.gov

**Additional Information**:


Specialty Crop Signs


Specialty Crop Banners

Specialty Crop Cooking Demo

Specialty Crop Print Ad

Specialty Crop Billboards


Specialty Crop Educational Materials