FINAL REPORT

Project title: A new approach for successful organic peach production in the Southeast

1. Project Summary

The production of organic peaches is extremely difficult under the humid conditions of the Southeast due to high pest and disease pressures, and the lack of effective, organically approved pesticides. Consequently, only very few growers have taken the risk and transitioned into organic peach farming. This project aimed to provide growers in the Southeast with a new tool to reduce the risk of transitioning to organic production of peaches. This strategy consisted of the use of paper bags to physically protect the fruit from pests and diseases to reduce reliance on spray applications. Bagged fruit was compared with non-bagged fruit (control) in a 4-acre orchard in an organic farm. Results showed that there was an increased in marketable yield in the bagged treatment. Bagged fruit had same size and weight, and same soluble solid content as non-bagged fruit, and were less acidic than control fruit. Labor costs were estimated. Farms using conventional methods could benefit from selling the "grown-in-bag" fruits at a premium. Organic farms could use bags as a technique to control pest and diseases which can help to increase the yield of the farm

2. Introduction to Topic

Provide an introduction to the organic farming issues being addressed by this project and what led to the development of this project.

Pest and disease pressure is generally high in commercial peach orchards of the southeastern U.S., and conventional growers rely on weekly applications of insecticides and fungicides to produce high-quality fruit. The most important pests affecting fruit and/or trees are plum curculio, borers, scale, and beetles. The major diseases affecting skin quality and/or pre-harvest and postharvest decay are brown rot, peach scab, bacterial spot, and anthracnose. Managing these pests and diseases is especially challenging for organic growers: for instance, the only efficacious control method for plum curculio in organic orchards is the application of crop protectants derived from kaolin clay that work as a deterrent (Ames, 2012). Organic growers spray multiple layers of kaolin clay as the fruit matures and grows but its effect on plum curculio is limited and can only be used to reduce plum curculio injury to fruit (Wise et al., 2017). For organic growers, high rates of sulfur is the only control option for diseases but this fungicide is marginal against scab and extremely weak against brown rot. Because of this, production of organic peaches is extremely difficult under the humid conditions of the Southeast and consequently, very few growers are risking the organic transition and taking this chance.

Still, peaches experienced the largest production growth in organic fruit in the U.S. between 2008 and 2011, with a 49% increase in acreage, with 21,372 tons being produced in 2011 (Perez and Plattner, 2013). Nevertheless, most of this growth in organic peach production occurred in California, where 18,024 tons were produced in 2011; this is because organic peach production is much easier than in other peach producing states due to low pest and disease pressures as a consequence of their semiarid climate. South Carolina and Georgia are the second and third peach producing states in the U.S. after California, with 65,700 and 35,500 acres respectively. As of now, there is only one certified organic peach producer in South Carolina, and none in

Georgia (only one farm in transition to organic production). This producer in South Carolina reports a higher number of applications for pest and disease control than conventional peach producers. His strategy is to tighten application intervals to offset weak efficacy of products. This is a huge expense considering the high rates of sulfur and kaolin applied. And still, when disease and pest pressure is high during wet spring and early summer, he is losing large portions of his crop to pests and diseases. Thus, pest and disease control remains his main challenge. For these reasons, additional tools to reduce risk and increase the production of high-quality organic peaches must be developed.

A strategy that is being used in other parts of the world to protect the fruit from pests and diseases, and to produce a high quality peach is the use of paper bags. Fruits are individually bagged by hand at early stages of fruit development, and paper bags protect the fruit during the rest of the season from diseases, insects, and sunburn. Paper bags are physical barriers between the fruit and the pests and diseases and thus the fruit cannot be attacked (exclusion principle). Our hypothesis is that this technique may not only be used as an additional tool to reduce production risk, but it may also allow for a significant reduction of organic pesticide applications.

During 2015, Dr. Juan Carlos Melgar and Dr. Guido Schnabel (Clemson University) collected preliminary data from two proof-of-concept experiments funded by the Southern IPM grant program. These experiments were performed in two organic orchards with enormous blossom blight and brown rot pressure typically only seen in unsprayed blocks. Our preliminary data suggested that the increase in yield due to disease suppression alone would cover the labor cost of bagging individual fruit: bags increased the percentage of marketable fruit, we found no insect damage in fruit grown in bags, and we recorded significantly less brown rot development at harvest and postharvest. Nevertheless, one year of results based on single tree replicates (there were bagged fruit and non-bagged fruit on the same tree) was not enough to make solid conclusions, and we requested funds to expand experiments and study fruit bagging when every single peach in two acres of peach trees is bagged.

3. Objectives Statement

The goal of this project was to provide growers in the Southeast with a new tool to reduce the risk organic production of high-quality peaches. The objectives of this research project were:

1. To produce high-quality, organic peaches in bags that follow commercial standards of size and color.
2. To determine if bagging peaches increases marketable yield due to improved pest and disease control.
3. To investigate consumer acceptance and economics (costs vs. benefits) of fruit bagging

4. Materials and Methods

Experimental setup

This research was carried out in 2016 in a commercial organic farm: Watsonia Farms, located in Monetta, SC (33°52’09” N, 81°35’36” W). Watsonia has earned GAP and GHP Food Safety Certifications through USDA and Primus, and also Organic Certification from the Clemson University Department of Plant Industry and USDA National Organic Program.

A 4-acre orchard of mature trees of the mid-season cultivar ‘Sweet Dream’ grafted onto Guardian™ peach seedling rootstock was selected. Planting density was 140 trees per acre. Trees were pruned and thinned following grower standards. After thinning, two treatments were established: control and bagged fruit.

Fruit paper bags were obtained from Shijiazhuang City Yishun Package Product Co. Ltd. Hebei province, People’s Republic of China. The bags were customized, 15 x 18 cm in size with integrated rod and notch to fit the branch. Before bagging, organic trees were treated with sulfur and pyrethroids. Bags did not degrade during production season. At harvest the fruit of 10 trees were collected and separated by treatments. Data was recorded on the number of marketable (with no or minimal blemishes) and rotten/damaged fruit in both treatments.

Fruit Quality

Fruit size (diameter, mm) and weight (g) were measured using a Fruit Texture Analyzer (FTA; GÜSS, Strand, South Africa) from a subsample of five fruit per treatment, per tree. Afterwards, fruit juice was squeezed from a composite sample comprised of two slices from each of the five fruit and subsequently used for measurement of solid soluble content (SSC) and titratable acidity (TA). The SSC was measured with a temperature-compensated refractometer (model ATC-1, Atago Co., Tokyo, Japan), and data were given as °Brix. The pH and TA were determined by autotitration with 0.1 N NaOH to pH 8.2 (Titrosampler, Metrohm Riverview, FL, USA) and data were given as % malic acid per 100 g of fresh weight (FW).

Post-Harvest

Thirty fruit per tree were set aside for a post-harvest disease assessment. The fruit were stored in a room kept at 20 °C, and were evaluated three and seven days later to determine the incidence of brown rot.

Statistical Analysis

Data were subjected to analysis of variance (ANOVA). When a significant F-test was observed, means were separated using Tukey’s test ($P \leq 0.05$).

5. Project Results

Fruit size and mass of bagged fruit were similar to those of control (non-bagged) fruit (Figures 1 and 2). Soluble solid contents in bagged fruit and control were also similar (Table 1). However, bagged fruit were significantly less acidic than non-bagged fruit (Table 1). We observed a similar trend in a previous preliminary study carried out on ten trees with bagged and non-bagged fruit being on the same trees. That experiment was carried out over two years, and bagged fruit had bigger and heavier fruit, and lower acidity than non-bagged fruit only in one of the years. In this experiment funded by OFRF, close to 300 trees were bagged

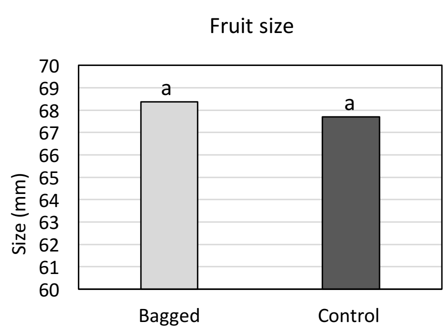

Fig. 1: Size (mm) of bagged and control fruit. Means with the same letters were not significantly different with each other.

so the sample size was much bigger and representative, and consequently we can confirm that fruit quality of bagged fruit is either the same or better than that of non-bagged fruit. Color is a very important fruit quality parameter for growers and consumers. We did not measure it numerically but we did field observations at harvest and saw that bagged fruit uniformly developed a red blush, although they had a slightly reduced intensity compared to non-bagged fruit (Figure 3).

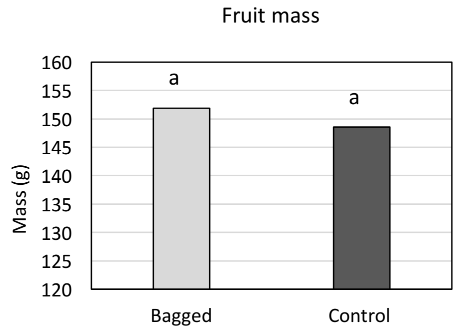

Fig. 2: Fruit mass (g) of bagged and control fruit. Means with the same letters were not significantly different with each other.

Bagging significantly increased marketable yield (11%). The increase was a consequence of having less fruit damaged by diseases such as brown rot or insects such as plum curculio in bagged fruit compared to control fruit. Postharvest assessment showed that bagged fruit has a shorter shelf life than control fruit: three days after harvest (no refrigeration, peaches were in a room at 20 °C), 52% of the bagged fruit showed some damage versus 40% of control fruit. Seven days after harvest, 88% of the bagged fruit was damaged versus 42% of control fruit. This is a consequence of fruit not receiving any chemical sprays while being bagged (non-bagged fruit received repeated sulfur applications). In any case, consumer surveys previous to this study already showed us that this is a desirable trait for many consumers: fruit without residues of pesticides.

Table 1. Soluble solid content (SSC, measured as °Brix), titratable acidity (TA, %), brix/acidity ratio

	SSC (Brix)	TA (%)	Brix/Acidity
Bagged	13.4 a	0.32 b	41.9 a
Control	13.9 a	0.38 a	36.9 a
Significance	P=0.5538	P=0.0474	P=0.0755

Figure 3: Fruit color of bagged fruit (left bin) was less intense than that of non-bagged fruit (right bin). Nevertheless, bagged peaches developed a uniform red blush that is very attractive for growers and consumers.

Bagging time and labor cost is one of the most repeated questions that growers have. With this experiment, we were able to estimate labor costs more precisely than with the preliminary study we did in the past because here we bagged two acres of a peach orchard, this is approximately 280 trees. A crew of 27 people took 10 hours bagging these two acres, thus, approximately one hour per tree per person. These trees are mature trees that can hold about 400 fruit per tree. Another common question was: "how do we know when the fruit is ready to pick if we can't see it inside the bag?". We needed to check several times before harvest to be sure the fruit was at commercial ripening; the way we found more effective was to rip the bags open (just the bottom of the bag) at the first pick, which is based on the expected harvest date, and to pick only the fruit that is ready then, and leave the rest until they are ready and come back in a few days. We do not believe there was increased damaged because of this since the bag is only open at the bottom and it is only for a few days.

During this experiment there were some other observations that were not part of the objectives but that are very valuable and worth mentioning. We learned that, although bagging protected peaches from some of the main pests and diseases that affect organic growers, there was no protection against all of them. For instance, San Jose scale was noticed in both bagged and unbagged fruit indicating that the bags do not offer protection against this insect pest. Also, when the fruit were harvested, there was bacterial spot on both the bagged and control peaches but with one distinct difference: the control fruit had deep craters, indicating an early season infection along with small, newly formed craters indicating a later infection that had not fully developed. On the bagged peach fruit, only the deep craters were observed indicating it might not be effective in preventing early infections of bacterial spot (between shuck-off stage and before bags were placed), but could reduce bacterial spot infections later in the season.

Bagging gave us clues on some peach skin disorders that we are currently investigating. For instance, streaking is a peach skin disorder where the peach fruit have distinctive lines of discolored skin. During the bagging experiments some fruit were unbagged 10 days before harvest to see how the red blush was being affected. When the fruit were harvested we noticed that the unbagged fruit had streaking as well as the control (non-bagged) fruit, while the bagged fruit did not. The observation provided clues to the timing of streaking along with indicating this disorder might be environmentally influenced. On the other hand, peach fruit was not protected from another skin disorder called bronzing, which occurs on a small sections of the peach fruit skin which become discolored and bronzed, causing it to become unmarketable because of cosmetic damage. Observing bronzing on both control and bagged peaches provided clues that the cause of bronzing might be physiological instead of environmental. As a consequence of these results, we are developing some new research lines on these two topics.

6. Conclusions and Discussion

Bagging peaches in the southeastern United States can be a valuable practice under certain conditions. In a commercial setting, fruit quality was comparable to that of non-bagged fruit but marketable yield was increased and spray applications were reduced. Furthermore, we believe that growers may benefit from increased profits if bag peaches are sold in the right market. From consumers surveys we learned that consumers viewed "grown in bags" peaches in a positive light and were willing to pay a premium. This premium averaged at $0.38/lb more than the current price, with certain consumers (for instance those at a farmer's market) saying that they would pay up to $1more per pound. This increase in price would offset the cost of the bags and the extra labor involved, and provide benefits to the growers. For instance, if a farmer harvests an average of 250 pounds of fruit per tree, which is approximately what a mature tree with 400 fruit can yield, and sells them at a price increase of $0.38 then the potential profit per tree would be $95. Since it costs about one hour for one worker to bag an entire tree (this is $12/hour) and about $4-5 to pay for the bags needed for one tree, this makes the cost of bagging all the fruit of one tree is less than $20. We want to perform a more detailed economic analysis with an economist but we believe this increase in profits maybe worth for organic farms that are struggling to find efficacious control methods against brown rot and plum curculio, as far as they have the personnel to bag the fruit and the proper marketing channels to sell this fruit at markets where consumers are looking for this type of product.

The growers we have worked with were very excited about using bagging in their orchards. Their main concern is the availability of workers: they think they can only bag a very limited acreage because of this. As a consequence of this grant, other small peach producers in Georgia (in transition to organics) and in Florida, one in New Jersey, some small apple producers in North Carolina, and one Asian pear producer in British Columbia have showed interest in using paper bags. Thus, we think this can be a viable option for small growers and that, with time, some marketing channels can grow for this type of product.

There are several other factors that we would like to investigate in further studies, for instance: 1) bags cannot be reused but can think they can be composted; 2) how do pest population and disease incidence in an organic orchard change over time if the same area of several acres is bagged year after year, will populations in an organic orchard decrease?; and 3) detailed economic analysis of the cost/benefit and marketing options for this type of fruit.

7. Outreach

One graduate student (Jaine Allran) have been working for this project and has defended her M.S. thesis at Clemson University in July 2017. Two researchers and two farmers have been directly involved in this project.

Results have been presented in oral presentations at the following events:

- The Southeast Fruit Professional Workers Conference in Gainesville, FL, and the Cumberland-Shenandoah Fruit Workers Conference in Winchester, VA. The typical audience of these two meetings are researchers, students, and extension agents (50-80 total).
- The Organic Agriculture Research Symposium, in Lexington, KY. There were about 200 attendees, and they were mostly organic growers.
- The American Society for Horticultural Science Annual Conference in Atlanta, GA. There were about 40 attendees in the room for this presentation, mostly researchers and graduate students.
- The Southeastern Branch of the Entomological Society of America Annual Meeting in Memphis, TN. There were about 30 attendees and they were mostly researchers and graduate students.
- The Musser Farm Field Day, at Clemson University's Musser Fruit Research Farm, in Seneca, SC. There were about 70 attendees at this field day, mostly growers, backyard growers, extension agents, and students.
- Clemson University Three Minute Thesis, at Clemson SC. There were about 30 students.

8. Financial accounting

The line item breakdown for how the money was spent includes the following expenditures:

Graduate student salary:

Budgeted: $8,400.00; Expended: $8,387.57

Fringe benefits for graduate student:

Budgeted: $689.00; Expended: $701.43

Other costs (transferred to category 'Travel', see details below):

Budgeted: $5,869.00; Expended: $2,154.82; Balance: $3,714.18

Since we needed to bag the fruit before the agreement between OFRF and Clemson University was signed, we requested that the funds that were originally budgeted for supplies (bags) could be used for travel for disseminating results in conferences, which we had not budgeted in the original project. This was approved by OFRF through Budget Revision 247-2011455, requested on November 16, 2016 and approved on February 7, 2017.

Comment [JO1]: Do we want then to provide exact accounting with dollar amounts?

9. Leveraged resources

The investigators have secured funds from an USDA-NIFA-OREI grant to continue studying the use of paper bags for the production of organic peaches in the Southeastern U.S. Researchers from Clemson University, the University of Georgia, and the University of Florida, and peach growers from South Carolina, Georgia, and Florida are participating in this $1M grant.

10. References

Ames, G. K. (2012). Peaches: Organic and low-spray production. NCAT. ATTRA Publication IP047.

Perez, A., and Plattner, K. (2013). Fruit and tree nuts outlook: Commodity highlight organic fruit and berries. USDA Economic Research Service.

Wise, J. (2017). *Effectively controlling plum curculio in stone and pome fruits.* (Extension Publication). Michigan State University.

11. Photos and other addenda

‘Sweet Dream’ peach trees bagged at Watsonia Farms, SC.

Bagging peaches

Streaking in non-bagged fruit

Links to articles and press releases:
http://www.foxcarolina.com/story/32277330/clemson-makes-breakthrough-in-organic-peach-growth
http://newsstand.clemson.edu/mediarelations/clemson-organic-peach-research-bags-1-million-grant/
http://southeasternpeachgrowers.com/tag/clemson-university/

Thesis:
Allran, Jaine. 2017. Investigation of peach fruit bagging to produce high quality fruit and to manage pests and diseases. Clemson University.