Figure 10. Roots being recured by placing under curing conditions

- **150-day inoculations**

These were performed between 14th February – 26th February 2021. This time, roots were washed with tap water (Figure 13) one week prior to inoculations and treatment application, then air dried and kept on baskets under storage conditions until inoculation time. Due to limited root availability, only the bruise wound was used (Figure 14). Additionally, while 10 roots were used per cultivar for each replication within a given treatment for cultivars Beauregard, Covington and Bellevue, Bayou Belle had up to 7 roots in some cases and Orleans had up to 8 roots. The root size was also more variable since there were not many roots to choose from to obtain uniform roots.

Figure 12. Sweetpotato roots with RSR (right) and the presence of whiskers (black fuzzy growth on wounded area)

Figure 13. Washing of sweetpotato roots

7-day-old cultures of *R. stolonifer* were used to prepare a spore suspension for inoculations as described above. The final spore concentration was adjusted to 10^6 sporangiospores/ml based on hematocytometer counts. A total volume of 704.5ml was prepared to inoculate approximately 1050 sweetpotato roots. Wounding, inoculation, and application of treatments was performed as described above, except that only the rubber band impelled wooden dowel was used to wound the roots (bruise wound). Additionally, deeper containers were purchased for dip treatments (Figure 15). All roots were incubated under storage conditions (60º F) and evaluated for RSR incidence at 14 days after inoculation, by counting how many roots out of the total had soft rot.

Figure 14. Wounding roots

Figure 15. Containers used for dip treatments

- **Experimental design and statistical analysis**

The roots were arranged on baskets in a completely randomized design with 3 replications. The total number of sweetpotato roots with RSR was recorded at 14 days, for both sampling times. The root counts were converted to percent, by dividing the roots with RSR by the total roots inoculated. The data were analyzed for each sampling time as full models for main effects treatment and cultivar using generalized linear mixed models (PROC GLIMMIX) due to the binary nature of the outcome (rot or no rot). While only the treatment main effect was significant at 130 days, both main effects (treatment and cultivar) were highly significant at 150 days after harvest. The mean percent rot was determined for each treatment and for each cultivar using PROC UNIVARIATE, and these were used to generate bar graphs to show differences among treatments. Mean separation among treatments was based on Fisher's least significant differences (LSD) among the odds of RSR, at a critical level of $P < 0.05$. All analysis was performed in SAS 9.4 (SAS Institute, Cary, NC).

Literature cited

Edmunds, B.A. and Holmes, G.J., 2009. Evaluation of alternative decay control products for control of postharvest Rhizopus soft rot of sweetpotatoes. Plant Health Progress, 10, p.26.

Holmes, G.J. and Stange, R.R., 2002. Influence of wound type and storage duration on susceptibility of sweetpotatoes to Rhizopus soft rot. Plant disease, 86, pp.345-348.

Sweany, R.R., Picha, D.H. and Clark, C.A., 2020. Hot-water baths, biologicals and re-curing effects on Rhizopus soft rot during sweetpotato packing. Plant Pathology, 69, pp.284-293.

Number of Farmers participated in research

None.

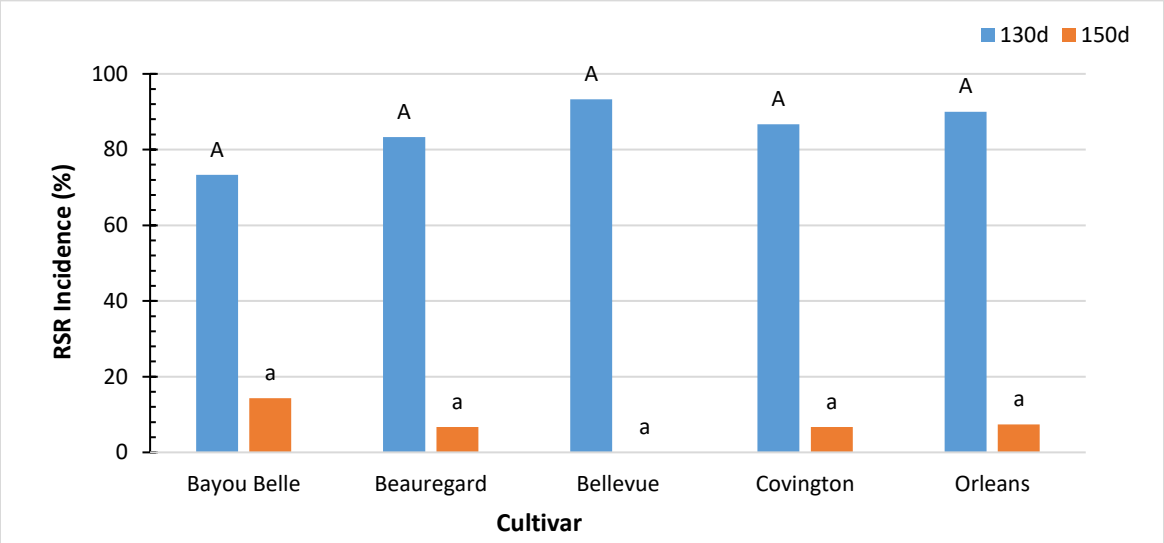
Results and Discussion (What results did you achieve and how were they measured? For production projects, include yields, field analysis, and related data. How do these compare with conventional systems used previously?)

With the exception of one Bayou Belle root, there was no rot on all roots wounded with the potato peeler (scrape wound) and so the data will only show the incidence of RSR associated with roots wounded with the rubber-band impelled wooden dowel (bruise wound).To show the effectiveness of each treatment at each sampling time, bar graphs were generated that demonstrated the effects of a particular treatment on all five cultivars at both 130 and 150 days after harvest. The results will be presented in the same order as the objectives and will end with a look at dicloran and the non-treated control.

- **Bio-Save 10LP (*P. syringae* strain ESC-10) applied as a dip**

The Bio-Save applied as a dip was not effective at 130 days based on the high incidence of RSR observed for all cultivars (>73%). At the second sampling however, there was a drastic improvement with 85% control for Bayou Belle and up to 100 % control on cultivar Bellevue (Figure 16). At 150 days, the Bio-Save effectively controlled the RSR in all cultivars, with no significant differences in the RSR incidence among the cultivars.

Figure 16. Effect of Bio-Save applied as dip on RSR incidence. Bars labelled with the same capital letter at 130 days or the same small letter at 150 days are not significantly different based on Fisher's LSD among odds at P < 0.05.

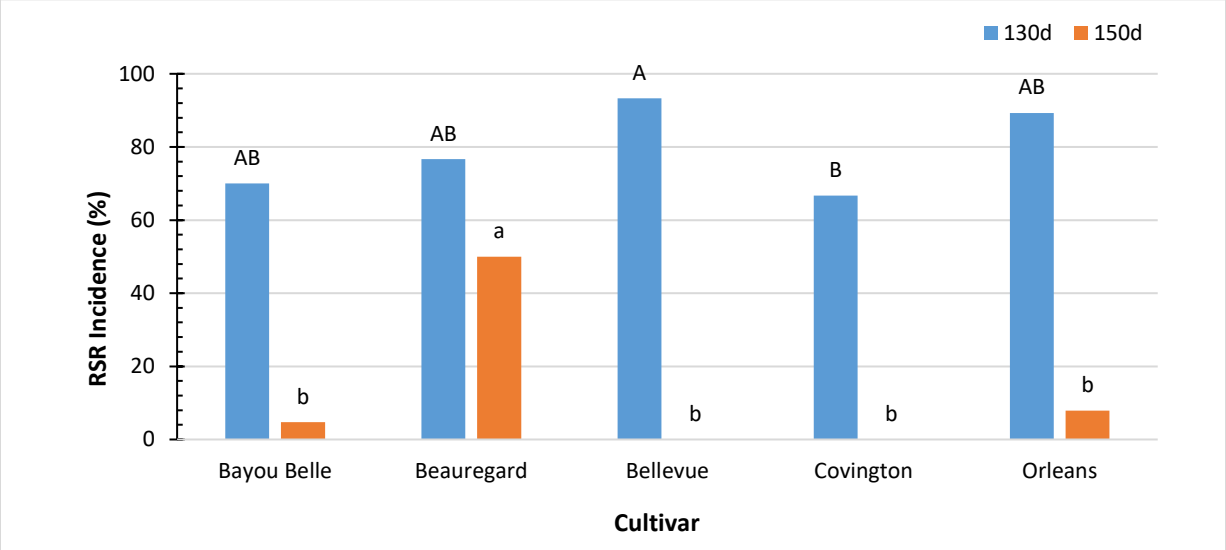


- **Bio-Save 10LP (*P. syringae* strain ESC-10) applied as a spray**

When applied as a spray, the Bio-Save was also not effective at 130 days, even though there were slight variations among cultivars (Figure 17). At 150 days, the Bio-Save resulted in up to 100% control in the cultivars Bellevue and Covington, which were not significantly different from Bayou Belle and Orleans that had less than 10% RSR. The only exception at 150 days was cultivar

Beauregard which had 50% RSR, the highest among all cultivars, but less than that observed at 130 days.

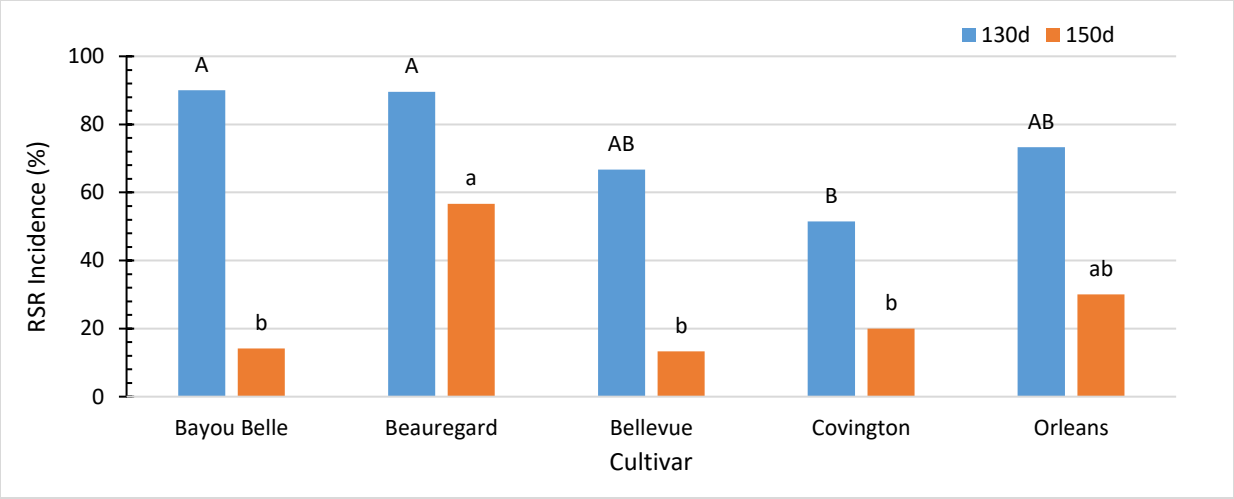
Figure 17. Effect of Bio-Save applied as spray on RSR incidence. Bars labelled with the same capital letter at 130 days or the same small letter at 150 days are not significantly different based on Fisher's LSD among odds at P < 0.05.



- **Re-curing for 24 hours**

The effects of re-curing were variable among the sweetpotato cultivars and at each sampling time. (Figure 18). Overall, there was a significant decline in RSR incidence for all cultivars between the two sampling times. At 130 days after harvest, re-curing resulted in the least RSR incidence for Covington which had 51.5 % RSR. At 150 days, in addition to the overall reduction for all cultivars, the re-curing was more effective for most cultivars with the lowest RSR incidence observed in Bayou Belle, Bellevue and Covington which all had <20% RSR. Even though the Beauregard had a reduction in RSR incidence from the first to the second sampling, it had the highest incidence (56.7%) at the second sampling. The low RSR incidence observed especially at the second sampling suggest that re-curing could have potential, but different cultivars may require different re-curing periods based on the variability in responses.

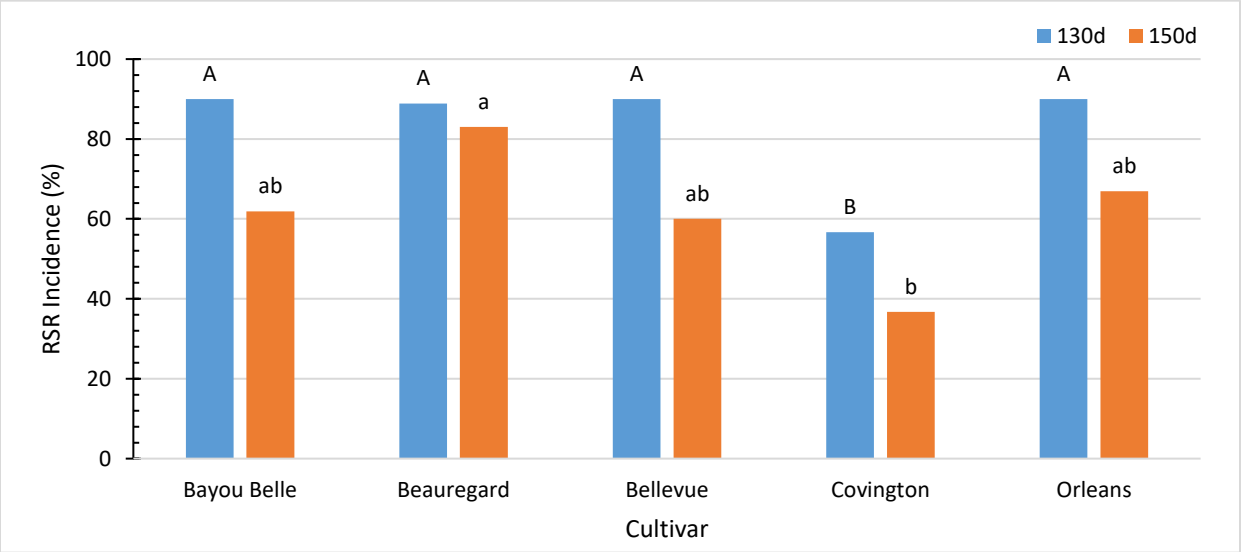
Figure 18. Effect of re-curing for 24 hours on RSR incidence. Bars labelled with the same capital letter at 130 days or the same small letter at 150 days are not significantly different based on Fisher's LSD among odds at P < 0.05.



- **Bio-Save dip combined with re-curing 24 hours**

When the roots were dipped in Bio-Save and then re-cured, the RSR ranged from 56.7%-90% among all cultivars at 130 days, and 36.7-83% at 150 days. At 130 days, all cultivars except for Covington had >89% of the roots rotting (Figure 19). Even though there was a reduction in RSR for all cultivars at 150 days, RSR incidence was still quite high (>60%) for the cultivars Bayou Belle, Beauregard, Bellevue, and Orleans. The re-curing seemed to have caused a greater incidence of RSR compared to when the Bio-Save was used on its own, so the combination of treatments was not effective.

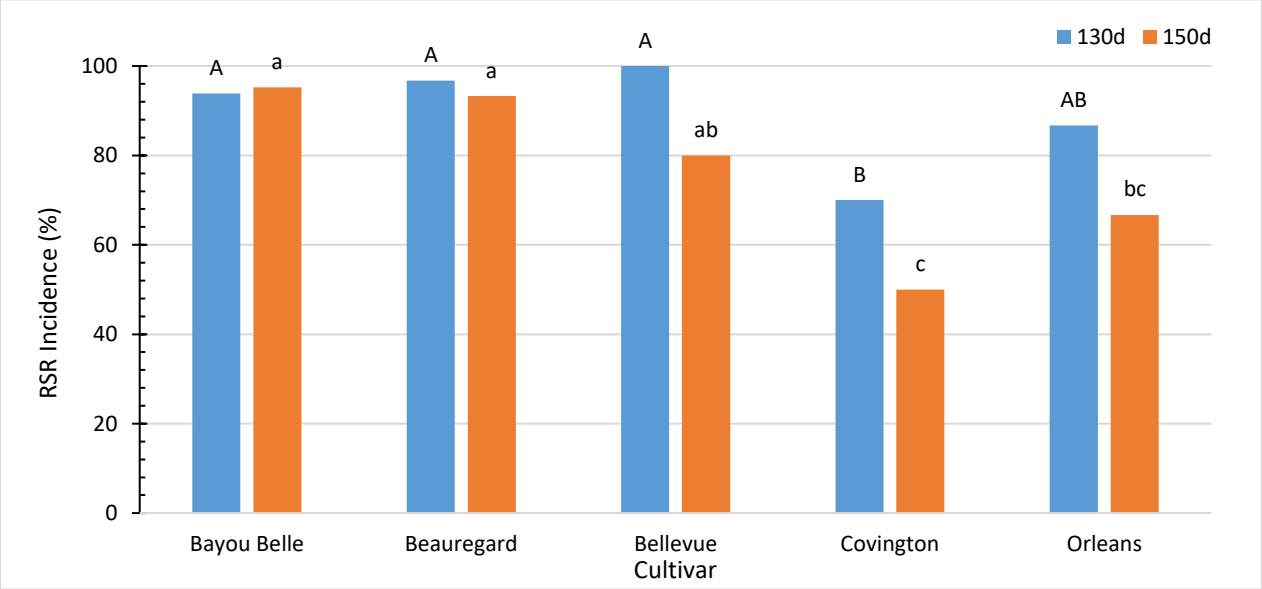
Figure 19. Effect of Bio-Save applied as dip combined with re-curing on RSR incidence. Bars labelled with the same capital letter at 130 days or the same small letter at 150 days are not significantly different based on Fisher's LSD among odds at $P < 0.05$.



- **Bio-Save spray combined with re-curing 24 hours**

Similar to the Bio-Save applied as dip, RSR incidence at 130 days was quite high with all cultivars except Covington having greater than 87% (Figure 20). Except for Bayou Belle which had a slight increase in RSR incidence at 150 days, there was a small reduction in RSR incidence for all other cultivars. At 150 days, the RSR incidence ranged from 50% in Covington to 95% in Bayou Belle, thus the Bio-Save spray combined with re-curing was also not effective in the second year. In fact, the RSR incidence was even greater when treatments were combined compared to when the Bio-Save applied as a spray was used alone. The Bio-Save was applied the same way at both sampling times, just by different individuals, so the slight reduction is probably age related as has been shown by previous authors.

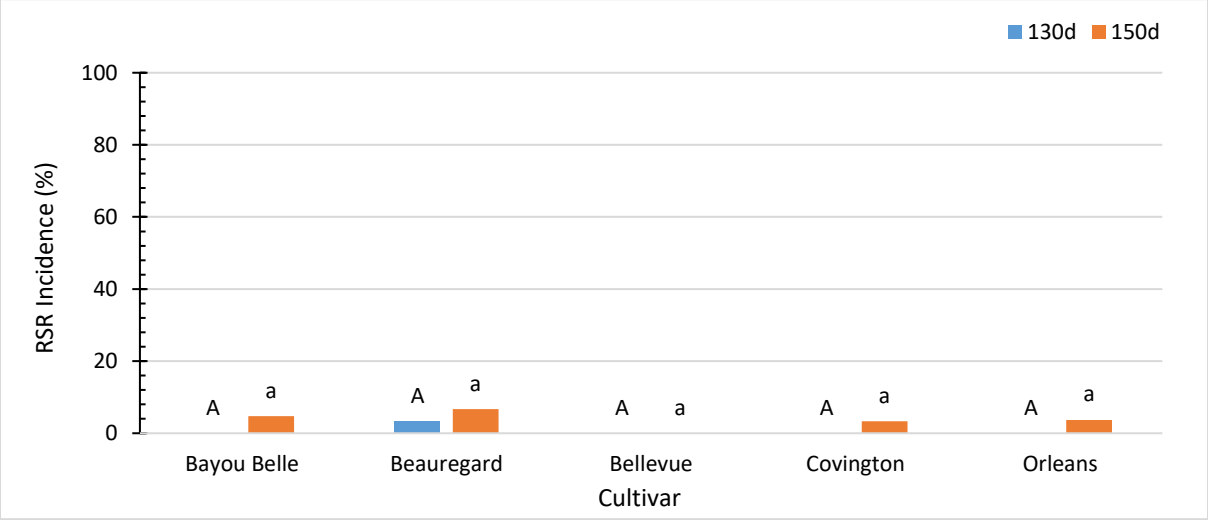
Figure 20. Effect of Bio-Save applied as spray combined with re-curing on RSR incidence. Bars labelled with the same capital letter at 130 days or the same small letter at 150 days are not significantly different based on Fisher's LSD among odds at P < 0.05.



- **Dicloran (the industry standard)**

As expected, the fungicide dicloran provided at least 97% and 93% control at 130 days and 150 days, respectively (Figure 21). The same level of efficacy was provided regardless of cultivar, with some cultivars like Bellevue having no RSR completely, hence no significant differences among cultivars at each sampling time. At 150 days, apart from Bellevue, the overall RSR incidence was slightly higher than that at 130 days, an opposite trend as that observed for all other treatments.

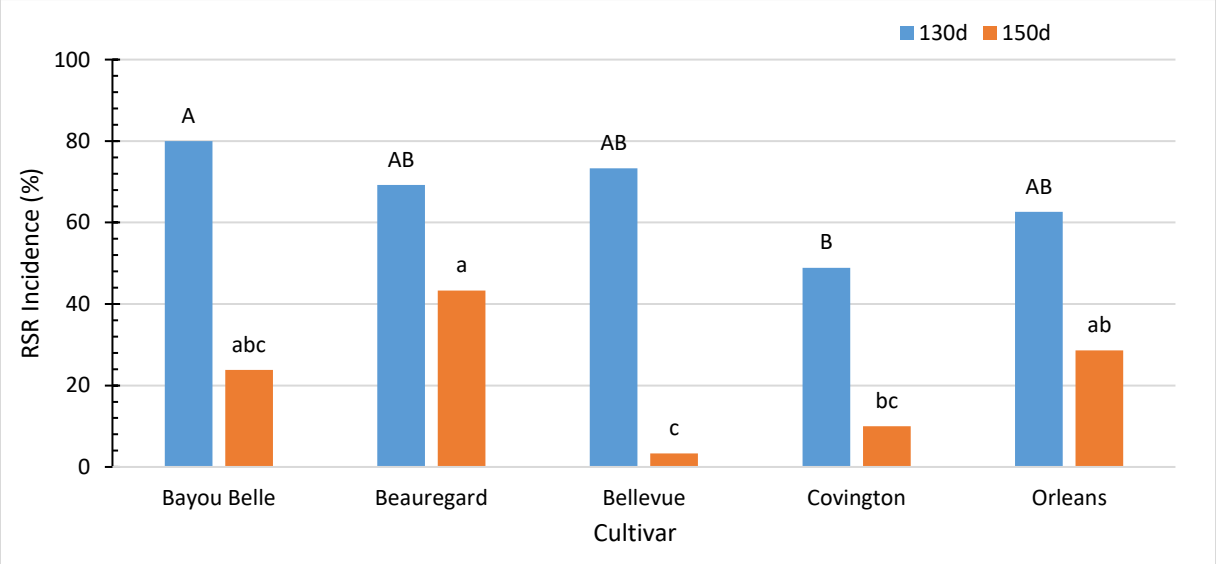
Figure 21. Effect of Dicloran applied as dip on RSR incidence. Bars labelled with the same capital letter at 130 days or the same small letter at 150 days are not significantly different based on Fisher's LSD among odds at P < 0.05.



- **Non-treated control**

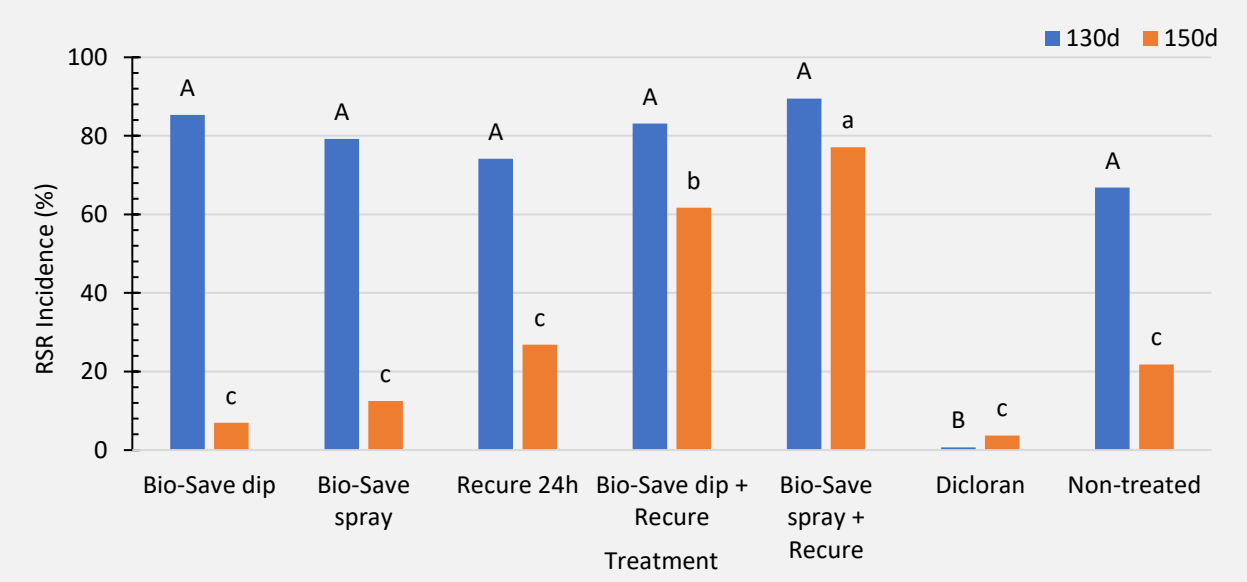
The non-treated roots had among the highest RSR incidence at 130 days, ranging from 48.9%-80% (Figure 22). Covington had the lowest RSR incidence, with Bayou Belle having the highest and the other three cultivars in between. At 150 days, there was a significant reduction for all cultivars with Bellevue only having 3.3% of its roots rotting indicating the influence of storage time on RSR.

Figure 22. Effect of not treating roots on RSR incidence. Bars labelled with the same capital letter at 130 days or the same small letter at 150 days are not significantly different based on Fisher's LSD among odds at P < 0.05.



When the results are combined across cultivars to show the treatment efficacy at each sampling time (Figure 23), the fungicide dicloran offered the greatest control at 130 days (99.3%), with no significant differences among the other treatments which ranged from 74.2-89.5%. The different source of roots used in the second year as well as the extra day in the curing room at 130 days are two possible explanations for the differences observed from the first year's results, and the generally higher incidence at 130days. At 150 days, the RSR incidence was lower across all treatments, and treatment differences were noticeable with the lowest number of roots rotting on roots treated with the fungicide dicloran (3.7%). The Bio-Save applied as dip and spray provided 93 and 87.5% control, respectively. When combined with re-curing, the efficacy of the dip and spray dropped to 38.3% and 22.9%, respectively indicating that combination of the treatments was not effective option. Interestingly, the non-treated roots had lower RSR incidence than the biological and re-cure treatments both alone and combined in both years (66.8% in year 1 and 21.8% in year 2) suggesting that some treatments may have increased the susceptibility of the roots to RSR. Re-curing when pooled across cultivars was not bad indicating it has some potential, thus there might be a need to investigate the ideal times and conditions for the different cultivars.

Figure 23. Mean RSR Incidence for each treatment at 130 and 150 days. The total rot per treatment is pooled across cultivars. Bars labelled with the same capital letter at 130 days or the same small letter at 150 days are not significantly different based on Fisher's LSD among odds at $P < 0.05$.



The results showed the variations in response that can exist amongst cultivars even to the same treatment. Regardless, the biological product Bio-Save regardless of application method and provided good control for the most part, especially at the second sampling time where it was second to dicloran. The fungicide dicloran performed as expected, with the best control at both sampling times for all cultivars. This time around however, the Bio-Save was only effective on its own and not when combined with re-curing, which seemed to increase the RSR incidence and negatively impact the efficacy of Bio-Save observed on its own.

Educational and Outreach activities (Enter or update the total numbers of different types of educational resources created and the total numbers of different types of activities conducted by the project team, to date.)

- **Activities**

Consultations - 0
Curricula, factsheets or educational tools - 0
Journal articles - 0
On-farm demonstrations - 0
Online trainings - 0
Published press articles, newsletters - 0
Tours - 0
Webinars, talks, presentations – 1 (Oral presentation at the 2021 Southern Division APS annual meeting)
Workshop/Field day – 1 (2021 virtual sweetpotato field day)
Other educational activities – 0

- **Participants**

Number of farmers/ranchers who participated in education and outreach activities – 0
Number of agricultural professionals who participated in educational activities - 0

- **Education and Outreach description (**Describe the activities indicated above as well as outreach in progress (e.g. newsletter, journal articles, upcoming presentations, etc.).

So far, an oral presentation entitled "Evaluating Options for the Control of Rhizopus Soft Rot on Sweetpotato" was given at the 98th American Phytopathological Society Southern Division 2020 virtual meeting. Since this was a scientific meeting, the audience was primarily comprised of graduate students, faculty, and industry representatives. This year, the results obtained from both years and other similar research will be shared as a video during the virtual sweetpotato field day in August. The virtual sweetpotato field day targets various sweetpotato stakeholders including growers and packers who would benefit greatly from the research. Since the project was extended, plans are to have a workshop with sweetpotato growers, packers, and agriculture professionals later in the Fall. Black Gold farms, are a possible host for the workshop if it would take place in-person. During the workshop, results from both years would be shared, and hopefully this would be an interactive session to learn and get feedback from the attendees. The last planned outreach would be to give an oral presentation at the National Sweetpotato Collaborators group meeting if it takes place, since it was not held this year. The results will eventually be published in the Horticulture journal for the scientific community and extension publications shared with various extension personnel in various states.

Project Outcomes

Number of farmers/ranchers who report changes in knowledge, attitude, skills and/or awareness, if applicable – 0

Number of farmers/ranchers who changed or adopted a practice, if applicable – 0

Number of grants received that built upon this project - 0

Number of new working collaborations - 0

Knowledge gained (During the course of this project, how did you and your advisor's knowledge, attitude, skills and/or awareness about sustainable agriculture change?)

It has both been a learning experience as well an eye opener to some research aspects that could be looked at in the future. During the project, one thing that came out was the fact that many other variables that could be overlooked influence the control efficacy of the various treatments. A wholistic approach would therefore be valuable if feasible.

Project Outcomes (Describe and assess how your project has affected agricultural sustainability or will contribute to future sustainability. Include economic, environmental, and social benefits for farmers.)

Based on the results obtained from both years, the biological product Bio-Save provided good control, though this was dependent on what point in storage the roots were, the treatment combination, and the cultivars suggesting the need for cultivar and time-specific control options. Overall, applied as a dip, it was more effective and, in some cases, comparable to the dicloran thus could potentially be used by growers/packers to manage RSR. The re-curing treatment both alone and in combination with Bio-Save was not effective for all cultivars in both years, thus cannot be recommended at this point. Having another alternative comparable to dicloran would result in reduced fungicide use, improved environmental stewardship and better quality of produce for the various markets.

Recommendations (Indicate any recommendations for future study or comments you'd like to share with SARE (optional))

Based on the experiences during the entire project, the first recommendation would be to develop RSR management recommendations specific to the time in storage and cultivar because different responses were observed. Secondly, it would be good to test the products used in this study at an actual packing facility before making recommendations to growers to get an idea of what it would be like in real life. Additionally, it would be good to perform a cost benefits analysis with growers incorporated into the study, using Bio-Save which showed the most potential in comparison to the standard used fungicides. Based on the variability observed related to root source it would be good to use roots from various locations representing various growing conditions so that recommendations would be specific to certain areas. Collaborating with sweetpotato growers would be a good strategy to have increased root numbers for evaluations since this was one limitation in both years.