

# FINAL REPORT

## FINAL PROJECT REPORT TEMPLATE

### PROJECT INFORMATION

<b>Project Title</b>	Controlling nematodes in potatoes by enhancing a suicide hatch in the absence of a host		
<b>Recipient Organization Name:</b>	University of Idaho		
<b>Period of Performance:</b>	<b>Start Date:</b>	10/1/2019	<b>End Date:</b> 6/30/2022
<b>Recipient's Project Contact</b>			
<b>Name:</b>	[REDACTED]		
<b>Phone:</b>	[REDACTED]		
<b>Email:</b>	[REDACTED]		

### PERFORMANCE NARRATIVE

#### PROJECT BACKGROUND

*Provide enough information for the reader to understand the importance or context of the project. This section may draw from the background and justification contained in the approved project proposal.*

The presence of *G. pallida* in Idaho has been viewed with alarm by other states and countries that import Idaho potatoes. Prior to implementation of the current quarantine measures, import of Idaho fresh potato products and nursery stock was banned in Canada, Mexico, and Japan. Consequently, eradication of *G. pallida* is a top priority for the Idaho potato industry including the Idaho Potato Commission, the Idaho State Department of Agriculture, and USDA-APHIS. Millions of dollars have been spent in Idaho on eradication efforts. A critical component of this work has been fumigation of infested fields with MeBr. However, APHIS voluntarily discontinued MeBr use in 2014 due to Br- contamination issues and in 2016, the registrant pulled their supplemental Idaho label. Because some viable *G. pallida* cysts can persist even after repeated fumigations, new strategies are needed in eradication efforts and to manage potential new infestations.

#### ACTIVITIES PERFORMED

*Address the below sections as they relate to the entire project's period of performance.*

#### OBJECTIVES

*Provide the approved project's objectives.*

#	Objective	Completed?	
		Yes	No*
1	Objective 1. Pilot plant methods will be developed for extraction and concentration of the hatch-enhancing compound.	Yes	
2	Objective 2. Co-products will be evaluated to ensure overall economic viability of the extraction/concentration process.	Yes	
3	Objective 3. Tests of hatch enhancement of <i>G. pallida</i> with the formulated product will be performed to demonstrate efficacy.	Yes	
4	Objective 4. Collaborations with potential commercial partners will be developed to scale-up the extraction/concentration technology.	Yes	

\*If no is selected for any of the listed objectives, you must expand upon this in the challenges and lessons learned sections.

## ACCOMPLISHMENTS

List your accomplishments for the project's period of performance, including the impact they had on the project's beneficiaries, and indicate how these accomplishments assist in the fulfillment of your project's objective(s), outcome(s), and/or indicator(s).

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	A pilot plant spray-drying unit for concentration of the hatch-enhancing compound from mustard meal extract were evaluated.	Objective 1. Pilot plant methods will be developed for extraction and concentration of the hatch-enhancing compound.
2	Mustard meal extract filtration was optimized to reduce the bulk of the product and to facilitate the drying of the final product. Filtration was evaluated for different batches and varieties of mustard meal feedstock that would be commonly used.	Objective 1. Pilot plant methods will be developed for extraction and concentration of the hatch-enhancing compound.
3	Methods for quality control and analysis for co-products, sinapine and myrosinase from mustard meal were evaluated. The availability of such a method will not only allow for the value-added products development, but also provide a control methods for the active ingredient efficiency.	Objective 2. Co-products will be evaluated to ensure overall economic viability of the extraction/concentration process.
4	The optimal conditions for co-extraction of value-added products from mustard meal extract were evaluated. The logistics of co-extraction of all potential biologically active components provide an opportunity for the improved formulation and economic sustainability of the overall process.	Objective 2. Co-products will be evaluated to ensure overall economic viability of the extraction/concentration process.
5	The effect of 4-hydroxybenzyl alcohol on the hatch of <i>G. pallida</i> eggs was demonstrated to be significantly higher than the control hatch. This suggests the potential of using this naturally derived compound or a synthetic analog for promoting <i>G. pallida</i> egg hatch.	Objective 3. Tests of hatch enhancement of <i>G. pallida</i> with the formulated product will be performed to demonstrate efficacy.
6	Mustard seed meal extracts containing equivalent concentrations of 4-hydroxybenzyl alcohol were shown to be as efficient as the pure compound indicating the potential of mustard seed meal extract formulation for enhancing a suicidal hatch of <i>G. pallida</i> eggs in the absence of a host. This indicates that even crude extracts of mustard meal can be used for <i>G. pallida</i> control with no reduction in efficiency while providing an economic benefit of reduced sample preparation.	Objective 3. Tests of hatch enhancement of <i>G. pallida</i> with the formulated product will be performed to demonstrate efficacy.
7	Working relationships were established with with a commercial partner Farm Fuel (Watsonville, CA). Farm Fuel works with a diverse base of customers thus providing useful feedback for our products as well as communicating customers needs and preferences to us for product development guidance.	Objective 4. Collaborations with potential commercial partners will be developed to scale-up the extraction/concentration technology.

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
8	Working relationships with the potential commercial partner MustGrow Biologics Inc. company has been developed. Commercial partner product developed based on our technology was tested and analyzed for active ingredient concentrations, release, and efficacy.	Objective 4. Collaborations with potential commercial partners will be developed to scale-up the extraction/concentration technology.

## CHALLENGES AND DEVELOPMENTS

*Provide any challenges to the completion of your project or any positive developments outside of the project's original intent that you experienced during this project. Also, provide the corrective actions you took to address these issues. If you did not attain an approved objectives, outcome(s), and/or indicator(s), provide an explanation in the Corrective Actions column.*

#	Challenge or Development	Corrective Action or Project Change
1	The progress of the project has been affected significantly by COVID pandemic. The staffing issue was the most pressing issue encountered during the period.	To resolve staffing issues multiple scientists, have to be hired for a varied amount of time to assure the successful completion. While the personnel turnover was higher than anticipated, this corrective action assured the completion of the project in a timely manner.
2	Several categories of consumables and supplies for conducting experiments were backlogged or unavailable due to the supply chain breaks.	Alternative strategies have been used to continue with the experiments. For example, filters and tubing from alternative vendors and materials were used for preparation of mustard extracts. Complete validation and compatibility tests were performed prior to any substitutions to assure the continuity of data.
3	Another issue encountered was California wildfires during Summer 2021. We source our seed meal from FarmFuel located in Watsonville, CA that was affected by wildfires, that consequently put a strength on obtaining mustard seed meal for extraction and pilot plant optimization.	We temporary scaled down the extraction set up to accommodate the available mustard meal amount while continuing the progress of the project.
4		

## LESSONS LEARNED

*Provide recommendations or advice that others may use to improve their performance in implementing similar projects.*

During the project, several lessons were learnt. We learnt the limitations associated with EPA label development and the pathway to commercialization. This led us to the development of stronger relationships with our stakeholders and potential commercial partners. The flexibility and communication were two key components that helped us advance in this area.

## CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

*Describe your plans for continuing the project (sustainability; capacity building) and/or disseminating the project results.*

The effort for natural compounds from mustard extract commercialization will be continues to assure the availability of the technology for producers. We are motivated to keep the working relationships with our commercial partners to assure the sustainability of the project and advance in technology transfer. The research on the improvement of extract production flow will be continued under the scope of the recently

funded National Institute of Food and Agriculture Methyl Bromide Transition Program proposal. Additional funding will be sought to assure the continuity of the product development. Dissemination of project results has been accomplished through the presentation at the science meeting. Currently a peer-review publication is in the preparation to highlight the project findings.

## BENEFICIARIES

**Number of project beneficiaries:**.....600

## OUTCOME(S) AND INDICATOR(S)/SUB-INDICATOR(S)

*Provide the results of the project outcome(s) and indicator(s) as approved in your application and project proposal. The results of the outcome(s) and indicator(s) will be used to evaluate the performance of the Program on a national level.*

### OUTCOME MEASURE(S)

*Select the Outcome Measure(s) that were approved for your project.*

- Outcome 1:** Enhance the competitiveness of specialty crops through increased sales
- Outcome 2:** Enhance the competitiveness of specialty crops through increased consumption
- Outcome 3:** Enhance the competitiveness of specialty crops through increased access
- Outcome 4:** Enhance the competitiveness of specialty crops through greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- Outcome 5:** Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- Outcome 6:** Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- Outcome 7:** Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources
- Outcome 8:** Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

### OUTCOME INDICATOR(S)

*Provide the indicator approved for your project and the related quantifiable result. If you have multiple outcomes and/or indicators, repeat this for each outcome/indicator (add more rows as needed).*

#	Outcome and Indicator	Quantifiable Results
1	Outcome 4 Indicator 2a: Number of growers/producers indicating adoption of recommended practices – 2.	Technology not yet commercially available. Product application and efficacy studies in progress.
2	Outcome 5 Indicator 1: Number of new or improved innovation models (biological, economic, business, management, etc.), technologies, networks, products, processes, etc. developed for specialty crop entities including producers, processors, distributors, etc. – 1.	A procedure for extraction of nematode hatch enhancer was developed.
3		
4		

### DATA COLLECTION

*Explain what data was collected, how it was collected, the evaluation methods used, and how the data was analyzed to derive the quantifiable indicator.*

Experimental data generated during the project consisted of engineering drawing and diagrams, chromatographic data, proteins/enzymes, nematode hatching, and viability results, staining and nematode rearing results, experimental result tables, plots, images, as well as photographs as needed. Data were collected using manual documentation (e.g., extraction settings, pilot plant plumbing set up, physical characteristics of produced extracts, nematode hatching count, greenhouse and field performance of the product) and software generated files (e.g., chromatographic chromatograms, mass spectra). Evaluation methods included quantitative and qualitative methods, technology indicators, internal peer-review of procedures and tasks performed, and analysis of relevant scientific and gray literature. Obtained data were analyzed quantitatively using statistical analysis to identify the significance and interactions of different treatments and parameter changes. Qualitative analysis was performed by evaluating obtained data and datasets for constructing new variable, analyses, and procedures.

## FEDERAL PROJECT EXPENDITURES

### EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
<b>Personnel</b>	96,000	71,227.38
<b>Fringe Benefits</b>	3,648	26,344.95
<b>Travel</b>	4,000	4,178.29
<b>Equipment</b>		
<b>Supplies</b>	20,000	17,269.97
<b>Contractual</b>		
<b>Other</b>		
<b>Direct Costs Sub-Total</b>	123,648	119,020.59
<b>Indirect Costs</b>		
<b>Total Federal Costs</b>	123,648	119,020.59

### PROGRAM INCOME (IF APPLICABLE)

Source/Nature (i.e., registration fees)	Amount Approved in Budget	Actual Amount Earned
1.		
2.		
3.		
<b>Total Program Income Earned</b>		

#### Use of Program Income

*Describe how the earned program income was used to further the objectives of this project.*

## ADDITIONAL INFORMATION

*Provide additional information available (i.e., publications, websites, photographs) that is not applicable to any of the prior sections.*

Randall, J., Popova, I.E. 2021, "Fate of Brassicaceae meal derived biopesticides in soil", National Meeting of the American Chemical Society, virtual.

Randall, J. 2022, "Bioassays for assessing the fate of Brassicaceae-derived biopesticides in soil and an analysis of the kinetics of myrosinase isoenzymes from select Brassicaceae species"  
" Master thesis.