

Western IPM Center Project Report Form

How to submit: Please submit this completed form electronically, as an attached Microsoft Word file, to Frank Zalom at fgzalom@ucdavis.edu. **Content:** Complete each section below, and include responses to as many of the questions listed in Attachment A as are relevant to your project. *These are guidelines.* Provide your readers with enough detail that someone who is not familiar with your project can understand what you were trying to achieve, how you went about it, and what you accomplished, but please keep it concise.

A. Report Data

Date: 10/05/2009

Reporting Period: 09/01/2008-08/30/2009

Report Type (please check one):

Progress Report Final Report

B. Grant Data

- Grant Agreement #: USDA-CSREES 2008-34103-19091
- Title: Non-chemical Postharvest Insect Control in Lentils Using Radio Frequency Energy
- Grant Type: Research
- Lead investigator:
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 - Title: Assistant Research Professor
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- Team members (name, title, institution): Juming Tang, Professor, WSU; Judy Johnson, Research Entomologist, USDA-ARS, Parlier, CA
- State(s) involved: WA and CA

C. Nontechnical Summary. An overview of the project, briefly outlining the problem(s), how your project addresses them, and your results, *written to a lay audience*. (500 words)

Chickpea, lentil, and pea are three important rotational pulse crops in the western United States. A major problem in the production, storage and marketing of those crops is infestation by insect pests. Of particular economic importance are three bruchids, cowpea weevil, bean weevil, and pea weevil, and the pyralid, Indianmeal moth. Increased use of integrated pest management (IPM) practices in the field and in storage has not completely controlled pest populations. It is critical to develop successful postharvest treatments to augment existing IPM. Infested pulse crops are not easily detected by external inspection. Regulatory agencies and importers in many countries have established requirements for phytosanitary quarantine treatments intended to prevent the introduction of exotic pests. Currently, the pulse industry relies on fumigation with methyl bromide (MeBr) for postharvest insect control. In accordance with the Montreal Protocol, most phytosanitary uses of MeBr were phased out by 2005, although yearly exemptions may be granted until alternatives become available. There is an urgent need to develop effective and environmentally sound phytosanitary and quarantine treatments for the pulse industry to replace fumigation and maintain competitiveness for U.S. agriculture in international markets. In this project, radio frequency (RF) energy is used to develop postharvest disinfestation methods for pulse crops. RF energy directly interacts with commodities to raise the temperature of the whole volume of a treated sample and can significantly reduce treatment times when compared to conventional heating methods. RF heat treatments are relatively easy to apply and leave no chemical residues. Dielectric properties of the commodities govern their interaction with RF energy to generate thermal energy and in part determine heating uniformity. Over the past year, dielectric properties of four legumes (chickpea, green pea, lentil, and soybean) at four different moisture contents were measured by using an open-ended coaxial probe and impedance analyzer at frequencies of 10 to 1800 MHz and temperatures of 20 to 90°C. At 27 MHz, a commonly used frequency in industrial RF units, RF energy was found to penetrate all the legumes to a depth that is suitable for large-scale industrial RF treatments of bulk legumes for postharvest insect control with acceptable heating uniformity and throughputs. Comparison of the dielectric properties of the legumes with that of cowpea weevils indicated that the weevils heat faster than the legumes, which should improve efficacy. Heating block studies showed that pupae were the most tolerant cowpea weevil stage, and are more heat tolerant than Indianmeal moth. In addition, a pilot-scale 27 MHz, 6 kW RF unit was used to investigate RF heating in chickpea, green pea, and lentil samples. Only 5-7 min was needed to raise the central temperature of legumes to 60°C using RF energy, compared to more than 275 min when using forced hot air at 60°C. RF heating uniformity in product samples was improved by adding forced hot air and conveyor belt movement. Legume quality was unaffected by RF treatments capable of controlling insect pests, thus RF treatments have potential as an alternative to chemical fumigants.

D. Objectives and Progress. List your objectives and describe your progress for each objective.

- 1) Determine the dielectric properties of insects and pulse crops as a function of moisture content and temperature;
Completed.
- 2) Study the RF heating uniformity in pulse crops;
Partially completed; research is continuing
- 3) Conduct efficacy tests to determine the effective temperature-time combination using pilot-scale RF systems;
Thermal death kinetics of the targeted insect is being determined and the efficacy tests will be conducted next year.
- 4) Evaluate the thermal responses of pulse crops to RF heating.
Research is ongoing, some preliminary results are available.

E. Outputs. List your project's outputs, which might include publications, information, data, meetings held, attendance at meetings held, etc.

Refereed journal publications:

Guo, W., Tiwari, G., Tang, J., Wang, S., 2008. Frequency, moisture and temperature dependent dielectric properties of chickpea. *Biosystems Engineering*, 101(2): 217-224.

Guo, W., Wang, S., Tiwari, G., Johnson, J.A., Tang, J., 2009. Temperature and moisture dependent dielectric properties of legume flours associated with dielectric heating. *LWT - Food Science and Technology*, in press.

Conference presentations:

Johnson, J.A., Wang, S., Tang, J., 2009. Radio frequency heat treatments to disinfest dried pulses of cowpea weevil. Proceedings of 2009 Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reduction, San Diego, CA, November 14-16, 2009.

Tiwari, G., Wang, S., Tang, J., 2009. Computer simulation of radio frequency heating of dry products. In: Proceeding of 43rd Annual Microwave Symposium-presented by International Microwave Power Institute, July 8-10, 2009, Washington DC, USA.

Tiwari, G., Wang, S., Tang, J., 2009. Mathematical modeling of radio frequency heating of a low loss food material. In: IFT Meeting, June 6-10, 2009, Anaheim, CA, USA.

Wang, S., Guo, W., Tiwari, G., Johnson, J.A., Tang, J., 2009. Temperature and moisture dependent dielectric properties of legume flours associated with dielectric heating. In: 2009 ASABE Annual International Meeting – June 21-24, 2009 – Reno, Nevada. Paper No. 095910. ASABE, St. Joseph, MI, USA. 10p.

F. Impacts and Potential Impacts. The “impacts” and “potential impacts” sections of your report will help the Western IPM Center highlight the value of IPM research and education by detailing the real-world impacts of Center-funded projects. We will use the information in news articles, reports, and informational brochures to showcase the impacts of projects that our program supports. *See Attachment A at end of form for questions to assist you in describing the impacts of your project.*

1. Impacts. Describe any impacts of your work. *Impacts* are specific changes in condition for those affected by your work. Impacts include adoption of technology, creation of jobs, reduced cost to the consumer, less pesticide exposure to farmers, access to more nutritious food, and a cleaner environment and healthier communities.

The dielectric property measurements from the current research have been used to select the optimum treatment frequency and bed depth for industrial RF applications. The heating uniformity of RF treated legumes determined by the study also demonstrates the feasibility of RF treatments for legumes as a non-chemical disinfestation method.

2. Potential impacts. Describe your project's potential impacts. *Potential impacts* are the ways that your project's outputs could directly lead to changes in condition that will unfold in the future.

As a result of this study, should a practical treatment for legumes using RF energy be developed and adopted, industry will no longer need chemical fumigants for disinfestation. This would alleviate both the environmental problems, including ozone depletion, air quality degradation and global warming, and worker safety issues often associated with fumigants. These environmental benefits would be obtained while satisfying the demand for insect-free product and maintaining export markets, thereby preserving the economic health of the legume industry.

G. Appendices

1. With your report, please attach *at least two (2) photographs* that illustrate your project. Please describe the photo and indicate the name and institution of the person who took the photo. (If you submit more than two photographs, please include those additional descriptions and photo credits under "H. Additional Information," below.)

Photo #1 description:

Dielectric properties are important to understand the interaction between electromagnetic field and samples. Photo 1 shows an open-ended coaxial probe technique with an impedance analyzer (model 4291B, Innovative Measurement Solutions, Inc., Santa Clara, Cal.). The sample was confined in a stainless steel cell to allow the coaxial probe to fit into the cell and to be in close contact with the sample. The sample temperature was controlled by circulating water (15 L min⁻¹) from a water bath (model 1157, VWR Scientific Products, Niles, Ill.) into the jacket of the test cell. A type-T thermocouple (0.8 mm diameter and 0.8 s response time) was used to monitor the sample temperature.

Photo #1 credit (photographer's name and institution):

Shaojin Wang, WSU

Photo #2 description:

Photo 2 shows a 6 kW, 27 MHz pilot-scale RF system (COMBI 6-S, Strayfield International, Wokingham, U.K.) used for heating chickpea, green pea and lentil samples. The gap between the two parallel electrodes (75 cm x 55 cm) was adjusted to change RF power coupled to the samples. A conveyor belt moved samples between electrodes during RF heating to simulate continuous processes.

Photo #2 credit (photographer's name and institution):

Shaojin Wang, WSU

Photo #3 description:

Photo 3 shows mung beans infested with cowpea weevil about to be subjected to high temperatures using a heating block developed by Washington State University engineers. The data obtained with these studies are used to determine the temperatures and exposures needed to obtain control of insect pests.

Photo #3 credit (photographer's name and institution):

Judy Johnson, USDA-ARS

2. Also attach any printed fact sheets or other publications resulting from your work that will enhance our understanding of your project and its impacts. Please provide a description of each attached publication below.

Document #1 description:

Guo, W., Tiwari, G., Tang, J., Wang, S., 2008. Frequency, moisture and temperature dependent dielectric properties of chickpea. *Biosystems Engineering*, 101(2): 217-224.

Document #2 description:

Guo, W., Wang, S., Tiwari, G., Johnson, J.A., Tang, J., 2009. Temperature and moisture dependent dielectric properties of legume flours associated with dielectric heating. LWT - Food Science and Technology, in press.

Document #3 description:

H. Additional Information

Credit: Some of the language about impacts and potential impacts was adapted from a PowerPoint presentation by H. Michael Harrington, Executive Director, Western Association of Agricultural Experiment Station Directors, Colorado State University.

Attachment A

Questions to Help in Reporting Impacts and Potential Impacts

Below are some questions that will guide you in assessing and then describing the impacts and potential impacts of your project. The relevance of each question may vary depending on whether yours is a research or extension project. Please answer as many as you can to the best of your ability, and feel free to describe any additional types of impacts not mentioned below. Remember to identify any potential impacts.

1. Innovations in IPM:

Are there new IPM practices that have been (impacts) or could be (potential impacts) adopted as a direct result of your project? What is the total number of acres (or homes, schools, greenhouses, nurseries) on which these practices could realistically be implemented?

2. Safeguarding human health and the environment:

- a. Has the project reduced risk (or could it potentially do so) by changing the use of pesticides on farms, in homes, in schools, etc.? For example, could it result in fewer sprays per season or a switch to lower-risk pesticides? If possible, quantify the changes in condition. (Since there is no unanimous definition of *high* and *low risk*, investigators selecting this indicator are asked to categorize the pesticides they are reporting on as *high* or *low risk* according to the particular situation [e.g., lower risk to natural enemies]).
- b. Are there any other impacts or potential impacts on human health or the environment as a result of your project?

3. Economic benefits:

- a. What is (or could be) the economic benefit (e.g., dollars saved) for clientele who adopt IPM strategies and systems you studied? Do you envision potential commercialization or mass production of these systems?
- b. How many clients are satisfied with IPM results (such as improved yield, improved quality of yield, reduced pest populations, more effective pest control, greater preservation of nonpest species)?
- c. Are there other financial benefits that might be realized (potential impact) as a result of your project?

4. Implementation of IPM:

- a. How many IPM strategies and systems have been validated through this project (e.g., through on-farm trials, large plot tests, or other methods used to confirm efficacy)?
 - b. How many educational materials were delivered? To whom? And what are the impacts or potential impacts?
 - c. What is the number of growers/personnel trained? And what are the impacts or potential impacts?
 - d. For a Web site, what volume of traffic and type of use has the site experienced? (For example, number of visitors per day or month; number of page views; number of unique user sessions; change in volume during growing season; average viewing time.) And what are the impacts or potential impacts?
 - e. How many more people adopted IPM practices as a direct result of your project, or how many people adopted new IPM practices?
 - f. Are there other ways in which your work will result in improved use or increased implementation of IPM strategies in your region or across the West?
5. Has your project or study increased collaboration among stakeholders interested in the development and implementation of improved IPM strategies and systems?