Irradiating insect pests

Dr Peter A Follett discusses his pioneering work on the development of phytosanitary irradiation as an effective postharvest quarantine treatment when exporting agricultural products

Melon fly on papaya.

Could you begin by introducing your main research aims and activities?

Along with my colleagues at the US Department of Agriculture-Agricultural Research Service, I work to develop new or improved postharvest quarantine treatments so that Hawaiian farmers can safely export high-quality, fresh agricultural products to the US mainland and other countries. Due to its mild climate, diverse tropical and subtropical agricultural crops and habitats, reliance on imported fresh produce, and popularity as a travel destination, Hawaii has acquired a wide variety of invasive insect pests from around the Pacific Rim. Many of these pests, such as the Mediterranean fruit fly, are not established in mainland US, and therefore quarantine treatments are required by law to prevent their spread in host commodities (fruit, vegetable or ornamental crops) exported to the continental US or elsewhere. Postharvest treatment of fresh commodities with heat, cold, chemical fumigants or irradiation aims to kill any insect pests or hitchhikers and prevent their spread to new areas. It's estimated that new invasive pests cost American farmers $120 billion annually, and are a major threat to agriculture, as well as urban and natural ecosystems.

In what ways does phytosanitary irradiation differ from other types of food irradiation?

Food may be irradiated for several reasons: to reduce food-borne pathogens such as *Escherichia coli*, *Listeria* and *Salmonella*; to inhibit sprouting in tuber and bulb crops such as potatoes, onions and garlic; to extend shelf life by deactivating spoilage organisms; and to control quarantine insect pests in fresh commodities or stored products to reduce contamination and losses.

I mostly work in the latter area, developing postharvest, phytosanitary treatments to control insects in fresh and durable commodities. Irradiation is an alternative technology to fumigation, particularly to methyl bromide fumigation. This is the most common method of disinfesting commodities, but has been shown to damage the stratospheric ozone layer.

How widespread is the current use of phytosanitary irradiation?

Hawaii has been a leader in the use of irradiation to export fresh fruits and vegetables, having conducted pilot studies in the 1990s and opened two commercial irradiators in 2000 and 2013. These are designed specifically to treat fresh agricultural products like fruit, vegetables, herbs and flowers. Currently, Hawaii is shipping 10 types of fresh fruit and vegetables to the US mainland using irradiation to control quarantine pests, and the state has approvals for 15 more.

Interest from foreign countries in exporting irradiated fresh produce took off in 2006 after the approval of the first ever generic irradiation treatments. During the past eight years, India, Mexico, Pakistan, South Africa, Thailand and Vietnam have all established bilateral agreements with the US for the use of phytosanitary irradiation, and are exporting increasing volumes of fruit (13.6 million kg in 2014) using generic radiation treatments. Other parts of the world are following suit. Australia is exporting an increasing number of fruits and vegetables to New Zealand and Malaysia using irradiation quarantine treatment.

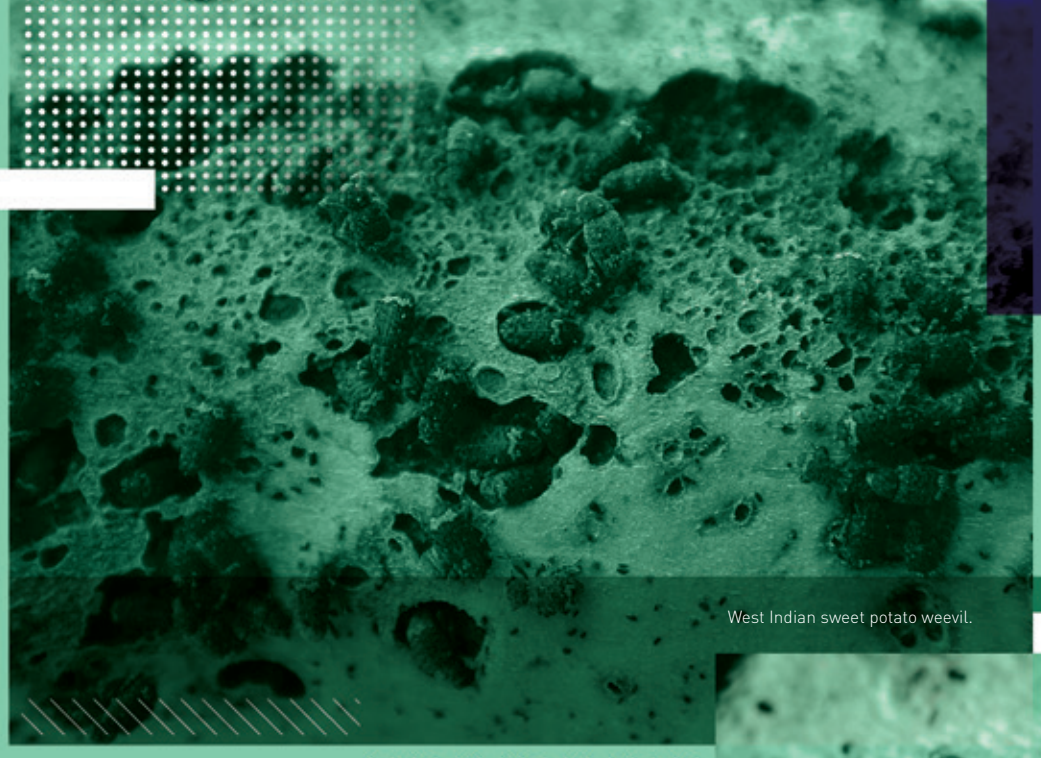
What are the negative effects, if any, of phytosanitary irradiation?

Technically speaking, there are no shortcomings. All insect pests can be controlled by irradiation, and most fresh horticultural commodities can tolerate irradiation treatment without injury at the low doses required to control insects. For this reason, irradiation is superior to other postharvest quarantine treatment technologies.

Furthermore, irradiation is probably the most thoroughly studied food processing technology, with hundreds of nutritional and toxicological studies during the past 60 years on a variety of foods. Numerous major health and science organisations have reviewed the literature and endorsed, approved or supported the safety and benefits of food irradiation. Irradiation is approved in more than 60 countries around the world for a wide variety of food products.

Can you share your hopes for the future of phytosanitary irradiation?

For countries that have already approved use of phytosanitary irradiation, fresh produce exports should steadily increase. Consumers should see a wider variety of produce available in the marketplace as countries such as India, South Africa, Thailand, Mexico and Vietnam export increasing volumes of irradiated tropical fruits – including mango, rambutan, guava and dragon fruit – to major markets and gain market penetration. Other countries should come aboard soon given recent successes. The sky's the limit!



West Indian sweet potato weevil.

A phytosanitary solution

Cutting-edge research underway at the **US Department of Agriculture-Agricultural Research Service** aims to advance irradiation on the world stage as a means of reducing insect pests present in fresh produce

BEING ABLE TO control the presence of insect pests in agricultural products is essential if growers are to export foodstuffs internationally without facilitating the movement of these pests across borders. Although postharvest insect control can be achieved through fumigation, this is not a fail-safe solution; for example, the fumigant methyl bromide is considered an ozone-depleting chemical and, if used inappropriately, is toxic to humans. One alternative that is growing in popularity is phytosanitary irradiation, which employs electron beam, gamma ray and X-ray radiation to either kill or sterilise insect pests commonly found in fresh fruits and vegetables – a method that can prevent their global spread through trade.

IRRADIATION RESEARCH

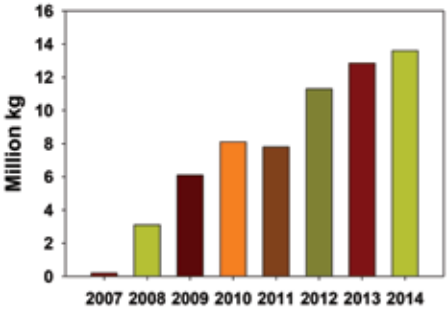
At the US Department of Agriculture-Agricultural Research Service (USDA-ARS) in Hawaii, Dr Peter A Follett and his colleagues are working to advance phytosanitary irradiation. Phytosanitary irradiation has been used in Hawaii since the 1990s as a means to prevent the invasive insect pests found in the state from reaching the US mainland, and it is often the simplest, fastest and most cost-effective approach. To date, its safety and benefits have been confirmed by organisations including the American Medical Association, Mayo Clinic, US Centers for Disease Control and Prevention, Food and Agriculture Organization of the UN (FAO), Scientific Committee of the European Union, and World Health Organization.

Follett's first project with the USDA was the development of an irradiation quarantine treatment against mango seed weevil, and the export protocols that emerged from this research were so successful that they have since been employed in Hawaii, India and Pakistan. Following on from this, Follett turned his attention to the expansion of Hawaii's first commercial X-ray irradiation facility, which was opened in 2000. His aim has been to create new treatments against quarantine pests that are capable of meeting regulatory requirements. "This collaboration turned out to be a great researcher-industry-regulator partnership and, over the past 15 years, we have developed effective radiation doses to control more than 20 key insect pests on two dozen fresh fruits and vegetables for export," he asserts.

Notable outputs to have emerged from this collaborative partnership include novel irradiation treatments for sweet potato and mango; first-ever treatments for scale insects and hitchhiker ants; and the modification of existing treatments for bananas, papayas and several other fruits commonly produced in Hawaii for exportation.

AN ALL-PURPOSE ANSWER

One of Follett's most significant successes to date has been his work on the establishment of generic treatments, which can be employed against a broad group of pests and for a wide



Growth in US irradiated fruit imports.

range of commodities without adverse effects. Until recently, quarantine treatments were developed for one specific pest and commodity at a time – an R&D approach that was both lengthy and costly. Follett's studies on radiation tolerance in oriental fruit fly, Mediterranean fruit fly and melon fly, however, paved the way for the approval of a generic radiation dose of 150 gray (Gy) for the quarantine treatment of tephritid fruit flies (the most important group of quarantine pests worldwide), and of 400 Gy for all other insects except pupae and adult Lepidoptera (moths and butterflies). "This means that if a pest risk assessment demonstrates that no pupae or adult Lepidoptera are associated with a commodity, export approval can be forthcoming with no further research," Follett explains.

The US, Australia and International Plant Protection Convention have already approved these generic doses, and the Codex Alimentarius Commission and FAO have also published guidelines relevant to their use. Follett is confident that the availability of these prescribed amounts will contribute to their wider acceptance and use on an international level: "Generic dose treatments make irradiation an attractive option compared with other quarantine treatments because, in most cases, export protocols for new pests can be developed immediately without further research on efficacy," he elucidates. "Also, if a new pest becomes a quarantine concern, trade will not be interrupted because the generic treatments are already approved and available."

At present, Follett and his collaborators are working to advance technology in this area; current research activities include the development of specific doses for the quarantine Lepidoptera not covered by generic dose treatments, and the establishment of generic doses below 400 Gy for economically important groups of quarantine arthropods other than fruit flies.

ADVANCING THE TREATMENT

In addition to their generic dose research, Follett and his collaborators are furthering phytosanitary irradiation from several different angles. The team is seeking to reduce dose levels and, consequently, required treatment times for specific pests and commodities. The researchers also aim to: improve commodity tolerance and extend shelf-life; contribute to the design of small-scale in-line cabinet X-ray machines; develop irradiation combination treatments involving plant essential oils; and advance modified atmosphere packaging (MAP) beyond current limitations. At present, regulators worry that MAP's low-oxygen environment can increase insect radiation tolerance, and thus may compromise insect quarantine treatments.

Phytosanitary irradiation employs electron beam, gamma ray and X-ray radiation to either kill or sterilise insect pests commonly found in fresh fruit and vegetables


Mango seed weevi.

In terms of future research, Follett is keen to explore a number of avenues. One is overcoming the 1 kilogray limit – a restriction imposed by the US Food and Drug Administration back in 1986. "The limit is a hindrance to application of the 400 Gy (0.4 kGy) generic dose owing to the high-dose uniformity ratio, which can reach 3:1 during treatment at high-energy, multi-purpose irradiation facilities," Follett explains. "In a perfect world, the limit would be raised or eliminated to allow for more efficient commercial treatment, but changing the rule is a complicated and lengthy regulatory process. Alternatively, lowering the generic dose for insects would also solve the problem."

Another challenge that Follett aims to overcome relates to the appropriate labelling of foodstuffs that have been treated using irradiation. In the US, irradiated fresh food products must be labelled as such, despite the fact that no similar restrictions are applied to products that have undergone any other insect disinfestation processes. "Labelling can be an impediment to the marketing of irradiated fresh produce – retailers can be reluctant to carry irradiated fruits and vegetables because the label implies a warning," Follett states. "If labelling remains a requirement for irradiated fresh commodities, more flexible and accurate labelling options might improve marketability and acceptance."

In the meantime, Follett and his team will continue to conduct cutting-edge research with the ultimate aim of supporting the universal acceptance of phytosanitary irradiation. By working to advance the available treatments and promote their benefits both within the US and further afield, their work is already beginning to pay dividends.

INSECT DISINFESTATION OF AGRICULTURAL COMMODITIES FOR MARKET ACCESS AND IMPROVED QUALITY

OBJECTIVES

- Develop new or improved postharvest treatments or approaches to control quarantine pests and facilitate export of fruits, vegetables and ornamentals to domestic and foreign markets
- Increase agricultural commodity quality, marketability and safety, while reducing pest treatment costs
- Develop holistic approaches to quarantine security that result in realistic pest-risk analyses and reduced treatment severity

KEY COLLABORATORS

Dr Monique Lacroix, INRS-Institut Armand-Frappier, Quebec, Canada

Dr Dominique Cloetta, Comet AG, Switzerland

Dr Ron Haff, US Department of Agriculture-Agricultural Research Service (USDA-ARS), California, USA

Dr Marisa Wall, USDA-ARS, Hawaii, USA

Dr Luis Calcaterra, FuEDEI, Buenos Aires, Argentina

Randol Kirk, Applied Energy Devices, New Mexico, USA

Yves Henon, International Atomic Energy Agency (IAEA), Austria

PARTNERS

CW Hawaii Pride, USA

Pa'ina Hawaii, USA

USDA Animal Plant Health Inspection Service, USA

University of Hawaii at Manoa, USA

Kasetsart University, Thailand

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USDA Foreign Agriculture Service

California Cherry Industry

CONTACT

Dr Peter A Follett
Research Entomologist

USDA-ARS
US Pacific Basin Agricultural Research Center
64 Nowelo Street
Hilo, Hawaii 96720
USA

T +1 808 959 4303
E peter.follett@ars.usda.gov

http://bit.ly/USDA-Follett

DR PETER A FOLLETT joined the USDA-ARS in 1997. Since then, he has been conducting research to develop improved pest management methods and postharvest treatments for tropical fruits and vegetables to control quarantine pests that restrict exports. He earned his BS in Plant and Soil Science from the University of Vermont, his MS in Entomology from Oregon State University and a PhD in Entomology from North Carolina State University.