Irradiation to Control Quarantine Insects in Exported Fresh Commodities: Pioneering Generic Doses

Peter A. Follett

USDA-ARS, U.S. Pacific Basin Agricultural Research Center, PO Box 4459, Hilo, Hawaii 96720
e-mail: peter.follett@ars.usda.gov

INTRODUCTION

World trade in agricultural commodities continues to grow. As agricultural trade expands, it increases the risk of introducing exotic insects into new areas where they may become plant pests. The establishment of new pests can be costly due to increased crop damage, control programs, and quarantine restrictions on trade. Quarantine or phytosanitary treatments such as cold, fumigation, heat, and irradiation disinfest host commodities of insect pests before they are exported to areas where the pests do not occur.

LOW-DOSE RADIATION TREATMENTS

The United States Food and Drug Administration has approved radiation doses up to 1000 Gy (1 kGy) for preservation and disinfestation of fresh fruits and vegetables [1]. Ionizing radiation breaks chemical bonds within DNA and other biomolecules, thereby disrupting normal cellular function in the infesting insect [2, 3]. Radiotolerance can vary among the life stages of an insect [4], and between taxonomic groups of insects. Unlike other disinfestation techniques, irradiation does not need to kill the pest immediately to provide quarantine security, and therefore live (but sterile or not viable) insects may occur with the exported commodity [5]. The goal of a quarantine treatment is to prevent reproduction, and therefore the required response for a radiation treatment may be prevention of adult emergence [6] induction of adult sterility [7], or F_1 sterility [8, 9].

GENERIC RADIATION DOSES

In 2006, USDA-APHIS published a pioneering rule providing generic low-dose radiation quarantine treatments to control insects. A generic treatment is a single treatment that controls a broad group of pests without adversely affecting the quality of a wide range of commodities. The rule approved radiation doses of 150 Gy for any tephritid fruit fly and 400 Gy for all other insects except the pupa and adult stages of Lepidoptera (moths and butterflies) [10]. The generic radiation treatments apply to all fresh horticultural commodities. Therefore, 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. The logic behind generic doses is that information on radiotolerance for a subset of species in a group can be extrapolated to related species to arrive at an effective generic dose. Traditionally, quarantine treatments are developed for one pest and commodity at a time, and research could take years to complete, so this first-ever approval of a generic treatment was a huge leap forward.

Generic treatments are the culmination of decades of research but not an end point [11]. Future research will focus on development of specific doses for quarantine Lepidoptera not covered by the generic treatments [e.g. 12]; reduction of dose levels for specific pests and commodities to shorten treatment time [e.g. 7]; development of generic doses below 400 Gy for important groups of quarantine arthropods other than fruit flies [11]; and development of information on commodity tolerance and novel methods to reduce injury and extend shelf-life [13, 14, 15].

RESEARCH TO LOWER DOSES

Most fresh commodities traded between countries will initially make use of the 400 Gy generic dose due to the diversity of insect pests and the absence of information on radiotolerance for specific pests. If lowering the dose for a quarantine pest or group of pests allows lowering of the dose for the commodity of interest, the cost of treatment will be reduced, any quality problems will be minimized, and the capacity of the treatment facility may be increased owing to shorter treatment time [11].

Development of generic doses for groups of common plant pests other than fruit flies (e.g. mealybugs, mites) would be beneficial. A generic radiation dose is recommended after information has accumulated on effective quarantine radiation doses for a wide range of insects within the group or for the important economic species within the group [16].

The approved generic radiation treatment of 400 Gy excludes the pupa and adult stages of Lepidoptera [10]. Typically, exported fresh commodities that may contain pupae or adults of actionable lepidopteran pests must be inspected and found free of the pest before export is permitted, and their presence could result in rejection. Development of a radiation dose to control the lepidopteran pest would reduce inspections and prevent potential rejections.

The radiation dose for a pest may also be lowered using a combination treatment. For example, Mediterranean fruit fly is controlled in clementine mandarins with a radiation dose of 30 Gy and subsequent exposure to 1^{o}C for 2 d [17], which is a significant reduction from both the approved generic radiation dose of 150 Gy and the standard cold quarantine treatments of

1.1-2.2°C for 14-18 d. Cold is a convenient combination treatment with irradiation for commodities that are shipped with refrigeration.

TRADE FACILITATION

Generic treatments will facilitate safe trade between countries that have approved the use of irradiation as a phytosanitary treatment. Hawaii has been shipping papaya, sweet potato, longan, banana and other tropical fruits to the U.S. mainland using irradiation for 10 years [5]. During the past few years, India Thailand, Vietnam, and Mexico have gotten approvals to export fruits to the U.S using generic radiation treatments. In 2009, the International Plant Protection Commission approved the generic radiation dose of 150 Gy for tephritid fruit flies, which will facilitate worldwide adoption [18]. The availability of generic dose treatments makes irradiation an attractive option compared with other quarantine treatments.

REFERENCES

[1] FOOD AND DRUG ADMINISTRATION (FDA). "Irradiation in the Production, Processing, and Handling of Food". Federal Register 51 (75): 13376, April 18, 1986. Rules and Regulations. (1986)

[2] DUCOFF, H. S. "Causes of Cell Death in Irradiated Adult Insects". Biol. Rev. 47: 211. (1972)

[3] KOVAL, T. M. "Intrinsic Stress Resistance of Cultured Lepidopteran Cells", pp. 157-185. *In* K. Marmarorosh and A. McIntosh [eds.] Insect Cell Biotechnology CRC Press, Boca Raton, Florida, USA. (1994)

[4] FOLLETT, P. A., and R. LOWER. "Irradiation to Ensure Quarantine Security for *Cryptophlebia* spp. (Lepidoptera: Tortricidae) in Sapindaceous Fruits from Hawaii". J. Econ. Entomol. 93: 1848. (2000)

[5] FOLLETT, P. A., and R. GRIFFIN. "Irradiation as a Phytosanitary Treatment for Fresh Horticultural Commodities: Research and Regulations", pp. 143-168. *In* Sommers, C. H., and X. Fan [eds.] Food Irradiation Research and Technology. Blackwell (2006)

[6] FOLLETT, P. A., and J. W. ARMSTRONG. "Revised Irradiation Doses to Control Melon Fly, Mediterranean Fruit Fly and Oriental Fruit Fly (Diptera: Tephritidae) and a Generic Dose for Tephritid Fruit Flies". J. Econ. Entomol. 97: 1254. (2004)

[7] FOLLETT, P. A. "Irradiation as a Methyl Bromide Alternative for Postharvest Control of *Omphisa anastomosalis* (Lepidoptera: Pyralidae) and *Euscepes postfasciatus* and *Cylas formicarius elegantulus* (Coleoptera: Curculionidae) in Sweet Potatoes". J. Econ. Entomol. 99: 32. (2006)

[8] FOLLETT, P. A. "Irradiation as a Phytosanitary Treatment for *Aspidiotus destructor* (Homoptera: Diaspididae)". J. Econ. Entomol. 99 (6): 1138. (2006)

[9] FOLLETT, P. A. "Irradiation as a Phytosanitary Treatment for White Peach Scale (Homoptera: Diaspididae)". J. Econ. Entomol. 99 (6): 1974. (2006)

[10] USDA-APHIS. "Treatments for Fruits and Vegetables". Federal Register 71 (18): 4451., June 27, 2006. Rules and Regulations. (2006)

[11] FOLLETT, P.A. "Generic Radiation Quarantine Treatments: The Next Steps". J. Econ. Entomol. 102: 1399. (2009)

[12] HOLLINGSWORTH, R. G., and P. A. FOLLETT. "Ionizing Radiation for Quarantine Control of *Opogona sacchari* (Bojer) (Lepidoptera: Tineidae)". J. Econ. Entomol. 100: 1519. (2007)

[13] MORRIS, S. C. and A. J. JESSUP. "Irradiation", p. 163-190, *In* R. E. Paull and J. W. Armstrong [eds.] Insect Pests and Fresh Horticultural Products: Treatments and Responses. CAB International, Wallingford, UK. (1994)

[14] WALL, M. M. "Quality of Postharvest Horticultural Crops after Irradiation Treatment". Stewart Postharvest Review 4 (2):1, online at www.stewartpostharvest.com (2008)

[15] FOLLETT, P. A., and E. WEINERT. "Comparative Radiation Dose Mapping of Single Fruit Type and Mixed-Fruit Boxes for Export from Hawaii". J. Food Process. Preserv. 33: 231. (2009)

[16] FOLLETT, P.A. and L.G. NEVEN. Current Trends in Quarantine Entomology. Annu Rev. Entomol. 51:359. (2006)

[17] PALOU, L., M. A. DEL RIO, A. MARCILLA, M. ALONSO, and J. A. JACAS. "Combined Postharvest X-ray and Cold Quarantine Treatments Against the Mediterranean Fruit Fly in 'Clemenules' Mandarins". Span. J. Agric. Res. 5: 569. (2007)

[18] INTERNATIONAL PLANT PROTECTION CONVENTION (IPPC). "International Standards for Phytosanitary Measures (ISPM) No. 28, Phytosanitary Treatments for Regulated Pests". Irradiation treatments annexed 2009. FAO, Rome. (2007)