

IRRADIATION DISINFESTATION OF DIAPREPES ROOT WEEVIL (COLEOPTERA: CURCULIONIDAE) AND PAPAYA FRUIT FLY (DIPTERA: TEPHRITIDAE)

WALTER P. GOULD¹ AND GUY J. HALLMAN^{1,2}

¹USDA-APHIS-PPQ, 4700 River Road, Unit 147, Riverdale, MD 20737

²Subtropical Agricultural Research Center, USDA-ARS, 2413 E. Highway 83, Weslaco, TX 78596

Ionizing irradiation has become a viable disinfestation technique to overcome biological barriers to export of agricultural commodities produced in Florida. During the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), outbreaks of 1997-98, some boxes of mangoes were irradiated at a minimum absorbed dose of 225 Gy so they could be moved out of quarantined areas. Since 1999, about 80 metric tons per year of guavas have been irradiated with 150 Gy against Caribbean fruit fly, *Anastrepha suspensa* (Loew), and shipped to Texas and California. Beginning in 2000, an increasing amount of 'boniato' sweetpotatoes (now >200 metric tons annually) has been irradiated with 165 Gy against sweetpotato weevil, *Cylas formicarius elegantulus* (Summers) and shipped to California (Hallman 2001a). Greater potential lies ahead; in August of 2003, California accepted irradiation at 150 Gy as a quarantine treatment for any fruit from Florida where Caribbean fruit fly is the only quarantined insect. That dose may be reduced in the future; Gould & von Windeguth (1991) found that 50 Gy would suffice.

To be able to use this promising treatment on a wider variety of commodities, doses for other quarantined insects in Florida are needed. The root weevil *Diaprepes abbreviatus* (L.) has been in Florida since at least 1964 (Woodruff 1968) and is associated with about 270 plant species, including sugarcane, citrus, and many ornamentals (Simpson et al. 1996). Although it would not be advisable to use irradiation disinfestation on plant propagative materials, such as nursery stock, because it would be detrimental to their growth, some agricultural commodities, such as sugarcane pieces and root crops, may be infested with *D. abbreviatus* and, thus, be amenable to radiodisinfestation. Invariably, radiotolerance increases positively with insect development (Hallman 2001b). Although adult *D. abbreviatus* are not normally found in host commodities that may be disinfested via irradiation, it is possible, and a quarantine treatment must be effective against the most radiotolerant stage that may be present in a shipped commodity regardless of its frequency of occurrence.

Papaya is the only commodity that the papaya fruit fly, *Toxotrypana curvicauda* Gerstaecker, normally infests. The fly is found in Florida (introduced about 1905), Central and South America, and the Caribbean. As such, shipment of papayas

from these areas to other areas where papayas are grown is prohibited. No disinfestation treatment is available. Irradiation at 150 Gy has been proposed as a generic treatment for all tephritid fruit flies infesting all fruits (Hallman & Loaharanu 2002). The measure of efficacy of irradiation disinfestation against tephritids is prevention of emergence of adults capable of flight when late third instars are irradiated inside fruit. Papaya fruit fly is considerably larger and otherwise morphologically distinct from all other tephritids studied with irradiation. It would lend more confidence to the proposal of a generic dose of 150 Gy if that dose could be shown to control papaya fruit fly.

The objectives of this research were to investigate a dose that could disinfest commodities of *D. abbreviatus* and determine if 150 Gy is sufficient to prevent adult emergence from irradiated third instar papaya fruit fly.

Diaprepes abbreviatus. Adults were field collected near Homestead, FL, and separated according to sex. Twenty females were irradiated (Gammacell model 220, Atomic Energy of Canada, Ltd., dose rate about 50 Gy/min) in 0.5-liter plastic containers at the following doses: 0 (control), 10, 20, 30, 40, or 50 Gy. Each female was placed separately without males in the containers with sugar water for food and small bundles of waxed paper in which to oviposit. There were 11 replicates. Egg numbers were counted for 6 days, and the eggs held to observe eclosion rates. Eclosion data were subjected to regression (Prism 4.0, GraphPad Software, San Diego, CA) and probit analysis (SAS 1986).

The mean number (\pm SEM) of egg masses and eggs laid per replicate of 20 females during the 6-day period was 24.3 (\pm 0.68) and 1,354 (\pm 50), respectively, and the slopes were not significantly non-zero in the dose range studied (for number of egg masses, F statistic for test of non-zero slope was 0.38; $df = 1, 64$; $P = 0.54$. For number of eggs, $F = 0.19$; $df = 1, 64$; $P = 0.67$). The mean number (\pm SEM) of females per replicate that oviposited during the 6-day period was 14.0 (\pm 0.19), and the slope was not significantly non-zero ($F = 0.50$; $df = 1, 64$; $P = 0.48$). Egg hatch was significantly affected by dose and fit the normal probability density function ($n = 88,372$; slope + SE = 0.093 + 0.0029; ED(effective dose)₉₉ = 20.0 Gy; 95% CL = 19.5-20.6 Gy; $\chi^2 = 0.32$).

Irradiation up to 50 Gy did not affect the number of eggs nor masses laid or the proportion of females ovipositing. It did reduce eclosion, with one egg of 15,730 hatching at 40 Gy and none of 13,835 hatching at 50 Gy. Therefore, *D. abbreviatus* is quite radiosusceptible. Other adult curculionids are prevented from reproducing at doses between 80-165 Gy (Hallman 2001b). Because the adults were not observed until they died and 30% of the females did not oviposit during the 6-day observation period, it is probable that the dose to confidently prevent reproduction by irradiated *D. abbreviatus* adults is somewhat >50 Gy. Plum curculio, *Conotrachelus nenuphar* (Herbst) (Coleoptera: Curculionidae), adults lived up to 25 days after they were irradiated at a dose (80 Gy) that prevented reproduction; after 25 days only 13% of non-irradiated controls had died (Hallman 2003). In any case, this research shows that commodity disinfection of *D. abbreviatus* could probably be accomplished by low dose irradiation, which is tolerated by a great many commodities.

Papaya fruit fly. Over the course of 3 replicates, 1,180 papayas (560 kg) naturally infested with papaya fruit fly were harvested at the U.S. Dept. Agr., Agric. Research Service Subtropical Horticulture Research Station, Miami, Florida, and divided into 2 groups of 590 each. One group was irradiated at 150 Gy, and the other was held as a control. Most of the papaya fruit flies inside the papayas were third instars. After treatment, the papayas were placed on perforated plastic seedling trays at 24°C, which allowed for emerging larvae to fall into sand in fiberglass bins under the trays. Larvae and puparia were sifted from the sand with flour sifters, collected, and counted. After larvae stopped emerging from the fruit, the remains of the papayas were examined for any additional larvae and puparia. Puparia were held for at least a month to observe adult emergence.

A total of 1,640 larvae emerged from the irradiated papayas, 1,131 (69%) pupariated, but no adults emerged, not even partially. A total of 2,098 larvae emerged from the control papayas, 1,918 pupariated (91%), and 1,093 (52%) emerged as adults. Fifty five percent of the adults were females. Although the numbers studied fall far short of the numbers usually required to confirm a quarantine treatment against fruit flies (about

30,000), this research demonstrates that papaya fruit fly is not considerably more radiotolerant than other tephritids and lends support to a generic dose of 150 Gy for all tephritids.

Wayne Montgomery, USDA-ARS, Miami, Florida, is acknowledged for his technical help.

SUMMARY

Irradiation disinfection is being used in Florida and elsewhere to overcome biological barriers to trade. More potential exists. This research examined radiosusceptibility of two pests in Florida, the root weevil *Diaprepes abbreviatus* and the papaya fruit fly, *Toxotrypana curvicauda*. The root weevil was found to be quite susceptible to radiosterility; 50 Gy prevented eclosion of eggs laid by irradiated adults. A dose of 150 Gy prevented adult emergence from mostly third instar papaya fruit flies naturally infesting papaya fruit; lower doses were not tried.

REFERENCES CITED

- GOULD, W. P., AND D. L. VON WINDEGUTH. 1991. Gamma irradiation as a quarantine treatment for carambolas infested with Caribbean fruit flies. Florida Entomol. 74: 297-300.
- HALLMAN, G. J. 2001a. Ionizing irradiation quarantine treatment against sweetpotato weevil (Coleoptera: Curculionidae). Florida Entomol. 84: 415-417.
- HALLMAN, G. J. 2001b. Irradiation as a quarantine treatment, pp. 113-130 In R. A. Molins [ed.], Food Irradiation: Principles and Applications. John Wiley & Sons, New York.
- HALLMAN, G. J. 2003. Ionizing irradiation quarantine treatment against plum curculio (Coleoptera: Curculionidae). J. Econ. Entomol. 96: 1399-1404.
- HALLMAN, G. J., AND P. LOAHARANU. 2002. Generic ionizing radiation quarantine treatments against fruit flies (Diptera: Tephritidae) proposed. J. Econ. Entomol. 95: 893-901.
- SIMPSON, S. E., H. N. NIGG, N. C. COILE, AND R. A. ADAIR. 1996. *Diaprepes abbreviatus* (Coleoptera: Curculionidae): Host plant associations. Environ. Entomol. 25: 333-349.
- WOODRUFF, R. E. 1968. The present status of a West Indian weevil (*Diaprepes abbreviata* (L.)) in Florida (Coleoptera: Curculionidae). Florida Dept. Agric., Div. Plant Industry Entomology Circ. No. 77.