GAMMA IRRADIATION AS AN ALTERNATIVE QUARANTINE TREATMENT FOR METHYL BROMIDE TO DISINFEST SWEET POTATO OF WEEVILS

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The importation of commodities infested with sweetpotato weevil, Cylas formicarius elegantulus (Summers) (SPW), into the United States is prohibited unless the roots have been disinfested (Nilakhe 1991). Fumigation with methyl bromide is the current postharvest quarantine treatment used to kill SPW in sweet potato roots (APHIS 1994). The treatment causes severe tissue necrosis and fungal decay (Brown 1985). Irradiation is a potential treatment that was evaluated as an alternative to methyl bromide fumigation.

Cobalt 60 doses from a Gammacell 220 were tested to disinfest roots and to produce adult sterility. Dose rates in gray (Gy) in the center of the chamber at the start of tests were 1.61 Gy per second on January 1992 and 1.53 Gy per second on June 1993 when tests were ended.

Roots purchased from local markets were presented to a laboratory colony of SPW for 8 days and then irradiated to treat eggs. Roots were presented to SPW for 8 days and then held for 12-14, 17-19, and 20-22 days to obtain first, second, and third instars, respectively for irradiation. Also, roots were exposed for 8 days to SPW and held for 29-32 and 35-40 days to obtain pupae and adults for irradiation. Instars were confirmed by measuring head capsule width (Sherman and Tamashiro 1954, Jayaramaiah 1975). Pupae and adults were confirmed visually.

Eggs in 80 roots (16 roots per dose) were irradiated at 5 doses from 15 to 30 Gy. First instars in 133 roots (19 roots per dose) were irradiated at 7 doses from 10 to 45 Gy. Second instars in 125 roots (25 roots per dose) were irradiated at 5 doses from 10 to 30 Gy. Third instars in 200 roots (50 roots per dose) were irradiated at four doses from 10 to 25 Gy. Pupae in 190 roots (38 roots per dose) were irradiated at 5 doses from 100 to 1,000 Gy. Adults in 140 roots (20 roots per dose) were irradiated at 7 doses from 200 to 1,000 Gy. An equal number of roots infested with the same stage served as controls to estimate the number of irradiated stages. After irradiation, all infested roots sorted by stage and dose rate were placed into separate opaque plastic storage cans (16.3 cm diameter by 17.8 cm high) with mesh covers for aeration. The number of emerged SPW was recorded daily from each container for each irradiation test. After 45 days, all roots were opened, and the number of remaining adults was recorded.

The irradiation dose needed for 99.9968% mortality was based on the number of adults recovered from roots, which was subjected to the PROBIT procedure (SAS Institute 1988). Logistic, Gompertz, and normal probit probability density functions (PDF) were used with and without log 10 conversion of dose. Equations from Finney (1971) were used to compute an estimate of probit 9 (99.9968%) mortality at the 95% fiducial limits (FL).

For adult sterility tests, 32 petri dishes each with 150 virgin males and 32 petri dishes each with 150 virgin females were prepared. Two petri dishes with males and two petri dishes with females were irradiated at 100 Gy. Then 150 irradiated males were combined with 150 irradiated females; 150 unirradiated females were combined with 150 irradiated males; 150 unirradiated males were combined with 150 irradiated females; and 150 unirradiated males were combined with 150 unirradiated females (control). The same procedures were followed for each irradiation dose at 150, 180, 190, and 200 Gy. Tests were repeated 9 times at each dose. Paired sexes of each treatment were kept in mesh covered opaque cans with two roots and allowed to mate. Fresh roots were replaced every 2 days for 15 days. Two pairing tests were done at 240, 270, and 300 Gy to confirm female sterility. At 240 Gy, 1,050 unirradiated males were combined with 1,050 irradiated females, and 105 unirradiated males were combined with 105 unirradiated females (control). At 270 Gy, 825 unirradiated males were combined with 1,650 irradiated females, and 75 unirradiated males were combined with 165 unirradiated females (control); and at 300 Gy, 2,185 unirradiated males were combined with 4,480 irradiated females, and 219 unirradiated males were combined with 448 unirradiated females (control). Tests were repeated three times at each dose. Paired sexes of each treatment were kept in mesh covered opaque plastic cans and allowed to mate. Two fresh roots were presented to each group of paired SPW for food and oviposition every 2 days for 15 days. Then infested roots were transferred to similar cans and held until weevils emerged. Roots were kept at 26-27 C, 58-60% RH, and under a photoperiod of 14:10 hours light:dark. All roots were held for 40-45 days to allow the weevils to develop to adults. The number of emerged adults was recorded daily. All roots were opened after 40-45 days, and the number of weevils was recorded.

RESULTS AND DISCUSSION

Egg totals of 3,532, 2,416, 2,698, 2,465, and 3,325 were irradiated at 10, 15, 20, 25, and 30 Gy, respectively. No adult SPW were recovered from eggs treated at 30 Gy or more. Gompertz PDF analysis without log 10 conversion gave a reasonable estimate (and FL) of 37 Gy (35-42 Gy) needed for probit 9 egg mortality. Dawes et al. (1985) reported that no adult weevils emerged from eggs treated at 50 Gy or more.

At 10, 15, 20, 25, 30, 35, and 45 Gy, 3,942, 2,307, 2,357, 3,348, 1,842, 4,249, and 6,491 first instars in roots were irradiated, respectively. No adults were recovered when first instars were treated at 45 Gy or more. Gompertz PDF analysis with log 10 conversion gave a reasonable estimate of 73 Gy (53-132 Gy) needed for first instar probit 9 mortality.

At 10, 15, 20, 25, 30, and 35 Gy, 4,379, 4,233, 2,619, 4,519, 2,254, and 4,027 second instars in roots were irradiated, respectively. Gompertz PDF analysis with log 10 conversion gave a reasonable estimate of 38 Gy (31-55 Gy) needed for second instar probit 9 mortality.

At 10, 15, 20, 25, 30, and 35 Gy, 6,649, 5,448, 6,720, 8,260, 7,185, and 4,752 third instars in roots were irradiated, respectively. Gompertz PDF analysis without log 10 conversion gave a reasonable probit 9 estimate of 28 Gy (23-45 Gy).

Pupae irradiated with 800 Gy or more produced no adults. Gompertz PDF analysis with log 10 conversion gave an estimate of 1,497 Gy (963-2,929 Gy) needed for probit 9 mortality.

Adult SPW (15,674) irradiated with 200-1,000 Gy did not die immediately, but died within 40 days after exposure. This is similar to the results of Dawes et al. (1987).

Irradiating males with 150 Gy produced sterility when the treated males were paired with unirradiated females, and 300 Gy produced sterility among females when the irradiated females were paired with unirradiated males. The results are similar to those of Walker (1966) and Dawes et al. (1987).

Roots containing feeding larvae are not suitable for consumption or sale, although irradiation kills the larvae and meets quarantine requirements. As larvae feed in the roots they grow and produce tunnels that fill with frass. The feeding induces terpenoid production in the roots and makes them unpalatable (Akazawa et al. 1960). The United States Food and Drug Administration approved doses up to 1,000 Gy to disinfest the roots (Anonymous 1986). The dose has been reported to increase the sugar content in the roots and produce other changes (Hayashi and Kawashima 1982, Lu et al. 1987). Roots that had been irradiated with several doses up to 1,000 Gy and baked for 45 minutes exhibited darker orange medullar tissue compared with irradiated roots that were not baked (McGuire and Sharp 1994).

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