SHORT, NON-REFEREED PAPER

PARENTAL AND F_1 STERILITY OF *ELDANA SACCHARINA* WALKER (LEPIDOPTERA: PYRALIDAE)

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Abstract

To assess suitability of Sterile Insect Technique (SIT) as a pest management strategy against *Eldana saccharina,* laboratory reared adult males and females were exposed to increasing doses of radiation and crossed with non-irradiated counterparts or irradiated counterparts at the same radiation dose. Radiation treated males mated with untreated females, and radiation treated females mated with untreated males, were exposed to radiation doses of 100, 150, 200, 250, 300 and 350 Gray (Gy). Treated females mated with treated males were exposed to the same radiation doses except 350 Gy (no offspring survival). To assess F_1 sterility, the surviving progeny from all three crosses were mated with non-irradiated laboratory counterparts or F_1 adults of the opposite sex from each radiation dose. Fertility declined significantly at increasing doses of radiation in the parental and F_1 progeny crosses of treated males. Treated females mated with laboratory males and those mated with treated males were more sensitive to radiation and were sterile at 200 Gy, while treated males mated with laboratory females still had a residual fertility of 0.19% when exposed to 350 Gy. F_1 male and female progeny of treated males mated with non-irradiated counterparts were sterile at 250 Gy, while their male parents' fertility was 0.82%. These radiation doses are consistent with those used in already established SIT programmes against citrus and deciduous fruit damaging Lepidoptera.

Keywords: Sterile Insect Technique, *Eldana saccharina*, Lepidoptera, Pyralidae, F_1 sterility

Introduction

The use of Sterile Insect Technique (SIT) as a component of Area Wide Integrated Pest Management (AW-IPM) targets an entire pest population, irrespective of farm or political boundaries (Vreysen *et al.*, 2006; Conlong and Rutherford, 2009). The approach involves mass rearing target insects, then irradiating and releasing them into the crop environment to mate with their wild counterparts. This induces sterility in the wild population (Klassen, 2005). The advantage of SIT is that it is species specific, environmentally friendly and easily integrated with biological control (Carpenter *et al.*, 2005; Vreysen *et al.*, 2006). Ionizing radiation is the primary method used to induce sterility in insects (Bakri *et al.*, 2005). Compared to Diptera, Hymenoptera and Coleoptera, Lepidoptera are resistant to radiation. They require higher radiation doses to induce full parental sterility (Carpenter *et al.*, 2005; Robinson, 2005). These high radiation doses induce unfavourable physiological and behavioural changes, resulting in released insects not being competitive with their wild counterparts for mates. Lepidoptera that receive sub-sterilising doses of radiation commonly produce progeny that are male biased with very low fertility. This is known as F_1 sterility (North, 1975; Carpenter *et al.*, 2005). Other factors common to F_1 sterility include longer development time of immature stages and F_1 progeny are more sterile than their parents (North, 1975; Carpenter *et al.*, 2005). A lower dose of radiation used to induce F_1 sterility is preferred because it ensures that the quality and competitiveness of released insects are not compromised (Bloem *et al.*, 2001). Proverbs (1970, cited by Carpenter *et al.* 2005) found that the release of partially sterile insects offered greater suppressive control than the release of fully sterile insects. Fertility of parent adult *Eldana saccharina* Walker (Lepidoptera: Pyralidae), a major pest in South African sugarcane, and their progeny (F_1) was assessed following exposure to increasing doses of radiation, to determine its suitability as a candidate for SIT.

Materials and Methods

Virgin adults of the same sex <24 hours old were placed in groups of 10 and exposed to increasing doses of Gamma radiation of 100, 150, 200, 250, 300 and 350 Gray (Gy). Five males (♂) from each irradiated group and five females (♀) from each irradiated group (T) were mated with adults of the opposite sex that did not receive radiation (N). The remaining five males from each irradiated group were mated with the remaining females that were irradiated at the same radiation dose. Crosses were therefore made as follows at each radiation dose: T♂xN♀; T♀xN♂; T♀xT♂. At 350 Gy, the T♀xT♂ cross was not made because previous unpublished data showed that no progeny emerged from this cross. Five pairs of untreated adults were crossed as a control (N♀xN♂).

Pairs were then placed individually into a 500 ml paper cup, with a pleated cardboard oviposition substrate (50x10 mm when pleated five times) and a 10 mm cotton dental wick soaked with water for the adults to drink from. Oviposition substrates were changed daily until the female died or was five days old, after which the females were killed by freezing and dissected to assess the presence of a spermatophore. Removed oviposition substrates were placed in labelled sealable plastic bags. To assess % fertility, neonate larvae emerging from the eggs were counted and divided by total number of eggs laid per female. The emerged neonate larvae from each of the parental crosses were placed onto artificial diet to complete development for F_1 fertility assessments. Virgin emerged adults (<24 hours old) from the progeny of each of the parental crosses above at each radiation dose tested were mated with normal adults of the opposite sex as follows: F_1 male x normal female (F_1♂xN♀); F_1 female x normal male (F_1♀xN♂) and F_1 female x F_1 male (F_1♀xF_1♂). Pairs were placed individually into paper cups for mating and oviposition (as described above). A maximum of 10 adults were paired for each cross. However, 10 repetitions were not obtained at the higher radiation doses due to poor survival. Fertility % was assessed as previously described.

Statistical analysis

Genstat 12.1© (2009) was used for Residual Maximum Likelihood (REML) variance component analysis because the data were unbalanced as not all pairs mated. Sigmaplot 9.0© (2004) was used for regression analysis. Where data did not conform to the normal distribution, data were transformed before analysis.

Results

Parental fertility

There was a significant interaction of dose and type of cross on fertility (χ^2=25.92, df=9, P=0.006) as treated females were more sensitive to radiation than treated males. In the Treated male x Normal female cross, fertility declined significantly (y=7.41-0.019x; F=60.97; df=34, P<0.001, R^2=0.65) at increasing radiation doses, from 31.32% at 100 Gy to 3.11% at 350 Gy compared to the control (65.35%). In the Treated female x Normal male cross, fertility declined significantly at increasing doses of radiation (from 16.43% at 100Gy to 0.16% at 200 Gy and 0.04% at 300 Gy compared to the control (65.35%) ($y=8.055-0.0611x+0.00112x^2$, F=195.27, df=31, P<0.001, R^2=0.93). Treated females laid even fewer fertile eggs than normal females mated with treated males. In the Treated female x Treated male cross, fertility was significantly reduced at increasing doses of radiation (from 0.23% at 100 Gy and 0% at 200 Gy compared to the control (65.35%) ($y=7.698-0.0826x+0.000202x^2$, F=192.336, df=26, P<0.001, R^2=0.94) and was lower than the Treated female x Normal male cross.

F_1 fertility

There was a significant dose by cross interaction on fertility of F_1 offspring from the parental Treated male x Normal female cross (χ^2=18.65; df=9, P=0.039). F_1 males were sterile at 150 Gy, but 5.95% fertile at 200 Gy and 2.14% fertile at 250 Gy. There was an increase in F_1 male and F_1 female fertility comparable to the controls at the higher radiation doses of 300 and 350 Gy, but these results were considered erroneous. The experiment was repeated at radiation doses of 200 to 350Gy for the Treated male x Normal female cross and 200 Gy for the Treated female x Normal male cross.

Parental and F_1 fertility of adults irradiated at 200-350 Gy

Increasing doses of radiation applied to the parent males had a significant effect on F_1 male and F_1 female fertility (χ^2=44.69, df=2, P=0.001). There was no survival of Treated male progeny at 300 Gy and 350 Gy therefore F_1 crosses could not be made. F_1 males were 14.57% fertile when their male parents were exposed to 200Gy. At 250Gy F_1 males and F_1 females were sterile while their male parents were 0.82% fertile. Figure 1 compares F_1 sterility of Treated male progeny from the first and second experiments respectively. Treated females exposed to 200 Gy and mated with normal males were sterile.

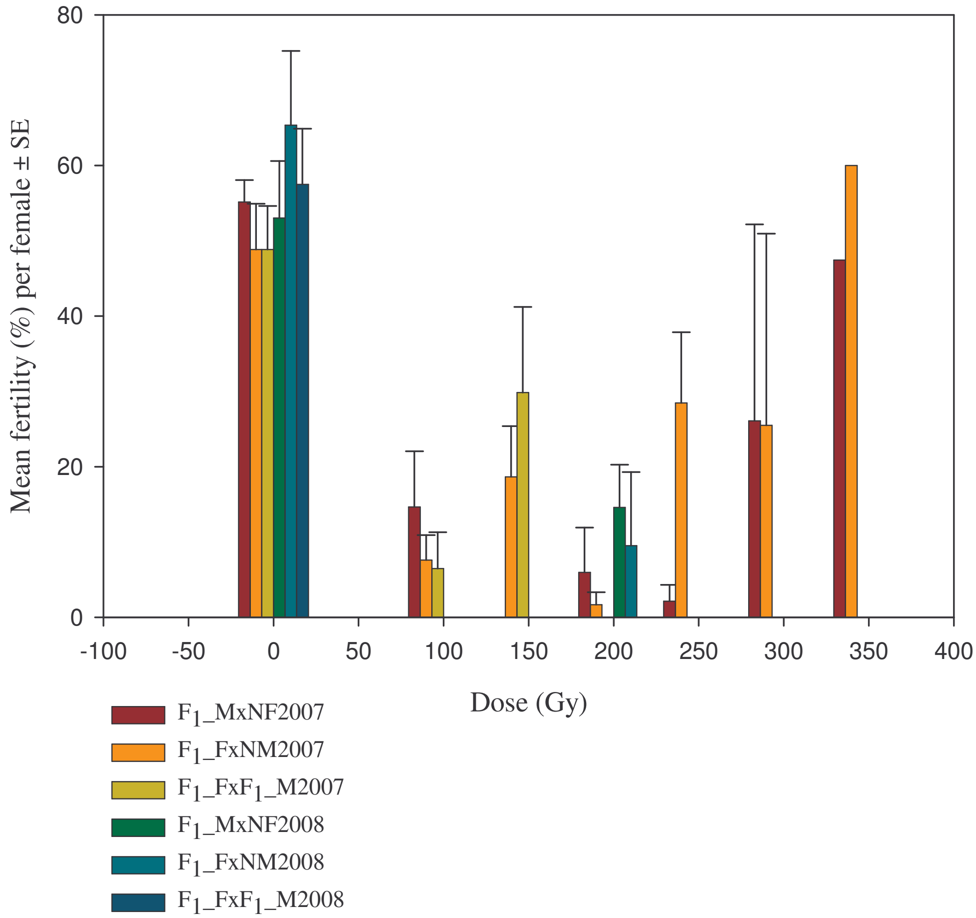

Figure 1. Comparison of mean fertility per *Eldana saccharina* female from F_1 crosses made from treated parent males in 2007 and repeated in 2008 at radiation doses 200-350 Gy (F_1= offspring from irradiated parent; N= Normal; M= Male; F= Female).

Discussion

A linear decline in parental fertility and F_1 fertility has been reported in many Lepidoptera following exposure to radiation (Ashcraft *et al.*, 1972; LaChance *et al.*, 1973; North, 1975; Sanford, 1976; 1977; Brower, 1979; Nabors and Pless, 1981; Henneberry and Clayton, 1988; Bloem *et al.*, 1999; Marec *et al.*, 1999; Carpenter *et al.*, 2001; Seth and Sharma, 2001; Bloem *et al.*, 2003; Carpenter *et al.*, 2005), and *E. saccharina* was no exception. It responded similarly to SIT as did important South African citrus and deciduous fruit pests such as the codling moth *Cydia pomonella* L. (Lepidoptera: Tortricidae) (Bloem *et al.*, 1999; Blomefield *et al.*, 2010) and the false codling moth (FCM) *Thaumototibia leucotreta* Meyrick (Lepidoptera: Torticidae) (Bloem *et al.*, 2003) as well as the cactus moth *Cactoblastis cactorum* Berg (Lepidoptera: Pyralidae) (Carpenter *et al.*, 2001). Females were more sensitive to increasing doses of radiation than males, which is common in Lepidoptera (North, 1975; Carpenter *et al.*, 2005).

Conclusion

Radiation doses inducing sterility in treated females and treated male F_1 progeny of *E. saccharina* are similar to those used in a SIT programme targeting FCM in South Africa. A similar SIT programme is likely to be successful for *E. saccharina* in the South African sugar industry.

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