Management of cigarette beetle (*Lasioderma serricorne* Fabricius) in turmeric (*Curcuma longa* Linnaeus) by using of gamma radiation

K Ravi Kumar, C Narendra Reddy, K Vijaya Lakshmi, K Rameash, K Keshavulu and B Rajeswari

Abstract

An experiment was conducted to study the management of cigarette beetle by exposing to different doses of gamma radiation of 200 Gy, 400 Gy, 600 Gy, 800 Gy, 1000 Gy and 1200 Gy along with untreated check treatments showed that increase in the dose of gamma radiation resulted in the increase of mortality percentage and decrease in the fecundity and adult emergence. Among all the treatments, the dose of 1200 Gy showed superior performance over other treatments and was adjudged as the best treatment which resulted in complete mortality in short time (8 days) and prevented the subsequent development of the pest.

Keywords: Turmeric, cigarette beetle and nanoparticles

Introduction

Turmeric is a rhizomatous herbaceous perennial plant belonging to the ginger family (Zingiberaceae), botanically known as *Curcuma longa* Linnaeus, originated from Tropical south Asia (India) (Ravindran et al., 2007) [31]. It is one of the oldest spices and an important spice bowl of India which had been used since ages. The world production of turmeric stands at around 800,000 tons in which India hold a share of approximately 75 to 80 per cent. India consumes around 80 per cent of its own production (INDIABIST.COM- 2015) [21]. In India the total area under cultivation is 184.4 thousand hectares with production of 830.40 thousand metric tonnes and productivity of 4.50 MT Ha⁻¹ (INDIABIST.COM- 2015) [21]. Among all the states, Telangana state stands first in area with 43.50 thousand hectares and production of 216.30 thousand metric tonnes while Himachal Pradesh stands first in productivity with 17.90 MT Ha⁻¹ (INDIABIST.COM- 2015) [21]. Various insects have been recorded on dry turmeric, which belong to the order coleoptera, include cigarette beetle (*Lasioderma serricorne* Fab.), drugstore beetle (*Tribolium castaneum* Herbst), lesser grain borer (*Rhyzopertha dominica* Fab.), saw toothed grain beetle (*Oryzaephilus surinamensis* L.) and coffee bean weevil (*Araecerus fasciculatus* DeG.) (Ravindran et al., 2007) [31]. Among all these insects, the cigarette beetle (*Lasioderma serricorne* Fab.) is serious. The damage loss by cigarette beetle in turmeric in terms of quantitative weight loss at three and six months after storage was recorded as 7.15 and 22.75 per cent in turmeric (Vidya and Awaknavar, 1994) [36].

Fumigants and other insecticides are widely used to control stored grain pests but residues and development of resistance in certain species have been of some concern (Champ and Dyte, 1976) [31]. Furthermore, fumigation is being increasingly restricted for environmental reasons. Methyl bromide was phased out and phosphine has less application which makes unsuitable for many disinfection requirements. As options become more limited, countries can be expected to increasingly turn to irradiation as an alternative treatment (Pszczola, 1997) [30]. Moreover, the residue-free advantages of irradiation disinfection over chemical fumigation have been demonstrated repeatedly (Tuncbilek, 1995) [35]. The use of ionizing radiation has been recommended not only as a possible alternative but also as a supplement to other control methods (Cornwell 1966, Watters 1968) [12, 37]. Irradiation, unlike chemicals, leaves no residues in treated food. Several works had been done on the use of radiation to control stored product pests (Brower and Tilton, 1983, Hasan, 1999, Azelmat et al., 2005 Boshra and Mikhail, 2006) [9, 19, 7, 8].

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Gamma irradiation treatments have been used for the sterilization of various stored product pests and disinfestation in the quarantine (Hallman, 2000, Fields and White, 2002, Follett and Neven, 2006) [18, 14, 13]. Irradiation is an approved method for the direct control of stored product insects in wheat and flour in many countries and probably would be approved for all grain, grain products and other dry food commodities (Brower and Tilton, 1983). The advantages of irradiation as a pest control measure include the absence of undesirable residues in the foods treated, no resistance development by pest insects (Ahmed, 2001, Lapido et al., 1991) [15, 24].

Gamma chamber
Gamma chamber 5000 was used for giving radiation treatments. It is compact shelf shielded Cobalt60 gamma irradiator providing an irradiation volume of approximately 5000cc. The material for irradiation was placed in an irradiation chamber located in vertical drawer inside the lead. This drawer can be moved up and down with the help of a system of motorized drive, which enables precise positioning of the irradiation chamber at the center of the irradiation field. Radiation field was provided with service sleeves for grasses, thermocouple, etc. mechanism for rotating / stirring samples during irradiation was also incorporated. The Lead shield provided around the source was adequate to keep the external radiation field well within permissible limits.

The quantity absorbed dose (kGy) can be defined as the amount of energy absorbed per unit mass of the matter at a point of interest.
1 Gy = 100 rads
1 kGy = 1000 Gy
Since the spice is being widely used for consumption, there is a need to test use of biorational approaches for management of L. serricorne is need of hour.

In view of serious losses in storing the turmeric from the infestation and a search for the possible biorational, the present investigation was taken up.

Materials and Methods
Management of cigarette beetle by using the gamma radiation was carried out at Quality control lab, EEI premises, Rajendranagar, Hyderabad and at laboratory of Department of entomology, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad, Telangana During 2014-16.

Experimental setup
Preparation of insect culture:
The parental culture of L. serricorne was procured from the local farmers having the infestation on stored cured turmeric rhizomes. For maintaining the culture, about twenty pairs of adult beetles were released into glass jars (20 X 15 cm) containing 500 g of disinfested turmeric powder and the mouth of the jar was covered with muslin cloth and tied with rubber bands. Fifty of such jars were maintained for mass culturing of test insect. The jars were kept undisturbed under laboratory conditions (28 ± 2 °C temperature and 70 per cent relative humidity) till the emergence of F1 adults. The pest was mass cultured in the laboratory for 4-5 generations and the freshly emerged adults were used in the experimental study. The males and females were identified by careful observation of the external genitalia and the size of the insects. The females are bigger in size than males.

Results and Discussion
Effect of gamma radiation on adult mortality of L. serricorne
The adult mortality of L. serricorne exposed to different doses of gamma radiation indicated that low doses of gamma radiation i.e., 200, 400 and 600 Gy did not shown any effect on adult mortality at two days after treatment and even at twelve days after treatment also the mortality reached to 9.33, 34.67 and 58.67 per cent, respectively (Table 2). Higher doses of 800 and 1000 Gy also recorded low mortality (17.33 and 22.67 per cent, respectively), at two days after treatment and it increased to 73.33 and 94.67 per cent, respectively at twelve days after treatment. Among all the doses, 1200 Gy dose was proved to be significantly superior to other treatments and untreated control, where 29.33 per cent adult mortality was observed at one day, 34.67 per cent of adult mortality at two days after treatment and all the adults exposed to 1200 Gy dose of gamma radiation died at eight days after treatment.

The overall mean adult mortality (Fig.1) results obtained from different gamma radiation treatments showed superior performance of 1200 Gy over other treatments and was adjudged as the best treatment which resulted in complete mortality in short time.

The results were in agreement with the findings of Titima et al. (2003) [34] who reported that there was complete mortality of Lasioderma serricorne when exposed to dose of 1200 Gy. The results were also in agreement with the findings of Titima et al. (1966) [31], Burov (1973) [10], Padwal Desai et al. (1987) [27], Abdelsabki (1996) [3], Ignatowicz (2004) [20], Osae et al. (2006) [28], Amanda et al. (2007) [6], Juliana (2007) [23], Juliana and Marcos (2008) [22], El-Naggar and Mikhail (2011) [13] who reported that the higher dose of gamma radiation was detrimental to cigarette beetle, L. serricorne and resulted in increased adult mortality.
with increase in the dose of gamma radiation in different stored products. Similar findings were also reported by Richard and Patrick (2014) against S. zeamais and C. maculatus in maize and cow pea, respectively, Saad and Kabbashi (2014) against T. castaneum in Composite flour (80 per cent wheat and 20 per cent sorghum) and Ahmadi et al. (2013) against T. castaneum and Prabhakumary et al. (2011) against T. castaneum in cashew kernels.

Table 2: Effect of gamma radiation on adult mortality of L. serricorne

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dosage</th>
<th>Per cent adult mortality Days after treatment (DAT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>200 Gy</td>
<td>0.00 (0.00) 0.00 (0.00) 0.00 (0.00) 0.00 (0.00) 0.00 (0.00) 2.67 (7.68) 4.00 (11.53) 6.67 (14.79) 8.00 (16.42) 9.33 (17.70)</td>
</tr>
<tr>
<td>T2</td>
<td>400 Gy</td>
<td>0.00 (0.00) 0.00 (0.00) 5.33 (13.16) 8.00 (16.07) 13.33 (21.36) 16.00 (23.46) 18.67 (25.55) 22.67 (28.40) 29.33 (32.76) 34.67 (36.04)</td>
</tr>
<tr>
<td>T3</td>
<td>600 Gy</td>
<td>0.00 (0.00) 9.33 (17.70) 21.33 (27.47) 25.33 (30.19) 30.67 (33.60) 38.67 (38.42) 45.33 (42.30) 49.33 (44.60) 54.67 (47.66) 58.67 (49.97)</td>
</tr>
<tr>
<td>T4</td>
<td>800 Gy</td>
<td>0.00 (0.00) 17.33 (24.56) 20.00 (26.48) 26.67 (31.06) 33.33 (35.24) 38.67 (38.42) 42.67 (40.76) 49.33 (44.60) 57.33 (49.20) 62.67 (52.32) 68.00 (58.90)</td>
</tr>
<tr>
<td>T5</td>
<td>1000 Gy</td>
<td>0.00 (0.00) 22.67 (28.40) 30.67 (33.60) 37.33 (35.24) 44.00 (41.53) 50.67 (45.36) 56.87 (49.97) 65.33 (53.91) 78.67 (62.48) 86.67 (68.60) 90.67 (72.26) 94.67 (76.80)</td>
</tr>
<tr>
<td>T6</td>
<td>1200 Gy</td>
<td>29.33 (32.76) 34.67 (36.04) 49.33 (44.60) 62.67 (52.32) 74.67 (59.77) 82.67 (65.40) 90.67 (72.26) 100 (90.00) 100 (90.00) 100 (90.00)</td>
</tr>
<tr>
<td>T7</td>
<td>0 Gy (Control)</td>
<td>0.00 (0.00) 0.00 (0.00) 0.00 (0.00) 0.00 (0.00) 0.00 (0.00) 0.00 (0.00) 0.00 (0.00) 0.00 (0.00)</td>
</tr>
<tr>
<td>CD</td>
<td>0.96 1.82 2.75 2.66 2.99 3.53 2.52 5.16 2.01 2.81 2.57 2.90</td>
<td></td>
</tr>
<tr>
<td>SE(m)</td>
<td>0.31 0.59 0.90 0.87 0.97 1.15 0.82 1.68 0.65 0.92 0.84 0.94</td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td>11.65 8.12 8.91 7.30 6.69 7.16 4.57 7.92 2.83 3.73 3.23 3.49</td>
<td></td>
</tr>
</tbody>
</table>

Figures in parentheses are angular transformed values

The fecundity and adult emergence studies indicated the superior performance of 1200 Gy dose treatment over other gamma radiation treatments (Table 3). Since the higher dose of gamma radiation (1200 Gy) resulted in complete mortality of adults at eight days after treatment, the egg laying was low (3.67) and there was no adult emergence. The lower doses of gamma radiation (200, 400 and 600 Gy) resulted in higher oviposition of 66.67, 54.67 and 37.33 eggs, respectively. In the next higher dose of gamma radiation viz., 800 and 1000 Gy treatments the fecundity recorded were 24.67 and 10.33, respectively. The number of adults emerged in the lower doses of gamma radiation (200, 400 and 600 Gy) varied from 58.33 to 21.67 showing the least efficacy of 200 Gy dose over the other treatments. The higher doses of gamma radiation i.e., 800 and 1000 Gy recorded the adult emergence of 12.33 and 1.67. In case of 1200 Gy, the few eggs laid by the insect...
did not develop into adults, indicating the superior performance of 1200 Gy dose treatment over other treatments. The results were in accordance with the findings of Titima (2003) [34] who reported that dose of 1000 Gy completely prevented the emergence of adults in *Lasioderma serricorne*. Juliana and Marcos (2008) [22] reported that there was 100 per cent mortality and failure in the emergence of adults at dose of more than 1.00 kGy for cigarette beetle, *Lasioderma serricorne*, while Amanda et al. (2007) [6] reported that the lethal dose of gamma radiation required for disinfestation of *Lasioderma serricorne* was 1.75 kGy. Padwal-Desai et al. (1987) found no emergence of adults of *O. surinamensis* treated with gamma radiation at dose of more than 1000 Gy. Peter et al. (2013) [28] reported that there was decrease in the number of adult emergence of *Sitophilus oryzae* with increase in the dose of gamma radiation. Abbas and Nouraddin (2011) [1] reported that the high dose of gamma radiation above 700 Gy have controlled population growth and prevented adult emergence of *Tribolium castaneum*. Boshra and Mikhail (2006) [8] indicated that a dose of 1000 Gy killed all date moth, *Ephestia calidella* stages and also prevented the emergence of adults. The increase in the dose of gamma radiation thus resulted in the increase of mortality percentage decrease in the fecundity and adult emergence. The results were in conformity with the findings of Osae et al., 2006 [26], Abbas et al., 2010 [3], Prabhakumary et al. (2011) [29], Mamta et al. (2003) [25] and Tuncbilek (1995) [40].

**Table 3:** Effect of gamma radiation on fecundity and adult emergence of *L. serricorne*

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dosage</th>
<th>Fecundity</th>
<th>Number of adults emerged</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>200 Gy</td>
<td>66.67</td>
<td>58.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(8.22)</td>
<td>(7.70)</td>
</tr>
<tr>
<td>T2</td>
<td>400 Gy</td>
<td>54.67</td>
<td>43.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(7.46)</td>
<td>(6.68)</td>
</tr>
<tr>
<td>T3</td>
<td>600 Gy</td>
<td>37.33</td>
<td>21.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6.19)</td>
<td>(4.75)</td>
</tr>
<tr>
<td>T4</td>
<td>800 Gy</td>
<td>24.67</td>
<td>12.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5.06)</td>
<td>(3.64)</td>
</tr>
<tr>
<td>T5</td>
<td>1000 Gy</td>
<td>10.33</td>
<td>1.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.36)</td>
<td>(1.57)</td>
</tr>
<tr>
<td>T6</td>
<td>1200 Gy</td>
<td>3.67</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.13)</td>
<td>(1.00)</td>
</tr>
<tr>
<td>T7</td>
<td>0 Gy</td>
<td>93.33</td>
<td>90.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(9.71)</td>
<td>(9.53)</td>
</tr>
<tr>
<td>C.D. (P=0.05)</td>
<td>0.33</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>SE(m)</td>
<td>0.10</td>
<td>0.13</td>
<td></td>
</tr>
</tbody>
</table>

*Figures in parentheses are square root transformed values*

Irradiation, whether by isotopes or machine sources (e-beam or X-ray), has the same mode of action: the gamma rays, X-rays, or electrons knock electrons out of their orbits, creating ions and radicals. The free electrons collide with further electrons resulting in an electron shower. The ions and radicals cause further damage to large organic molecules such as DNA stopping development of irradiated organisms. Indeed, the secondary damage caused by ions and radicals produced by the electron shower may cause more damage to organic molecules than the primary radiation itself. In organisms, irradiation most easily affects sites of ongoing cell division, which in the adult insect include the gonads and midgut. At minimal doses they stop the functions of these organs insects will not reproduce and will cease feeding because the midgut cannot process food (Hallman, 2013) [17]. Ghogum (1991) [16] and Prabhakumary et al. (2011) [29] reported that the irradiation will affect the reproductive ability of adult females and progeny by causing sterility and inhibition of sexual ability.

**Conclusions**

Gamma radiation at dose of 1200 Gy was adjudged as the best treatment which resulted in complete mortality in short time (8 days) and prevented the subsequent development of the *L. serricorne*.

**Acknowledgement**

At the very outset, I submit the commodious and indefinite thanks to my family members, friends and teachers for successful accomplishment of three years in this college and to present this diminutive piece of work. I am grateful to Professor Jayashankar Telangana state agricultural University and Government of Telangana for the financial help in the form of stipend during my study period which can’t be forgettable.

**References**


