Australian Journal of Agricultural Engineering AJAE

AJAE 1(4):132-135 (2010) ISSN:1836-9448

Effects of UV irradiation on the survival of the red cotton bug, *Dysdercus koenigii* (Heteroptera: Pyrrhocoridae)

Snigdha Mohan and Dinesh Kumar*

Department of Zoology, Centre of Advanced Study, Banaras Hindu University, Varanasi-221005, India

***Corresponding author: dines1953@yahoo.com**

Abstract

The effects of UV irradiation on the survival of *D. koenigii* were investigated. Nymphs were irradiated with UV rays (254nm) for 10, 15 and 20 min durations. UV-irradiated nymphs exhibited a significant decrease in survival with increasing exposure time. They showed delayed moulting into adults, which also showed significantly decreased survival. A significant increase in morphological deformities was also recorded in the nymphs as well as their resultant adults. These results show that UV irradiation appears to be a promising agent for controlling the population of cotton stainers.

Keywords*:* UV irradiation; survival; cotton stainer; *Dysdercus koenigii*.

Introduction

Several species of cotton stainer have been found to exist in various countries (Central America, India and West Indies). Cotton stainers are one of the most destructive cotton pests. Most of the nymphal stages as well as the adults feed on the seeds within the developing cotton bolls (Sprenkel, 2000), leaving a stain on lint. Thus, feeding by puncturing flower buds or young cotton bolls usually causes reduction in size; or the fruiting body may abort and drop to the ground. Cotton stainers are also severe pests of oranges. By puncturing an orange, a cotton stainer often inserts its proboscis full length with no visible wound. Thus, single puncture may cause the orange to drop in a few hours from the tree leading decay in one or two days (Hubbard, 1885). Cotton stainers are also sap sucking insect pests of okra. It does not significantly reduce the yield, but it lowers the quality of the fruits by inflicting a rusty appearance on the surface (Tomas and Gajete, 2008). Further, cotton stainers are also severe pest of some other economically important plants such as legumes, red gram (Singh and Singh, 1971; Singh and Singh, 1978) and portia tree (Peter and Sivasothi, 1999). Thus these pests are highly harmful for economically important crops. Hence to have good yields of these plants, pest's population needs to be controlled.

It is well known that insecticides have created a wide ranging negative impact on the beneficial insects (Michaud et al., 2003; Chauzat et al., 2006), economically important plants (EI-Daly and Khalil, 2008), humans' health (Taylor, 2003; Hydbom et al., 2004; Hampton, 2005) and the several important components of the ecosystem. These existing problems and their concomitant impact on environment have necessitated exploration of alternative non-toxic pest control methods.

Radiation studies on insects have suggested the use of UV rays as one of the potential agents for controlling insect pests in stored grains and their products (Calderon et al., 1985; Sharma and Dwivedi, 1997; Parween et al., 2004; Faruki et al., 2005, 2007). UV rays of 254nm wavelength have been reported to have a germicidal effect on the microorganisms in food, air and water (Pszczola, 1977; Brickner et al., 2003; Michael and Antignus, 2004; Pan et al., 2004). UV rays have also been reported for the control of some other insects such as *Periplaneta americana* (Gingrich et al., 1977; Hwang and Chen, 2004), *Aedes albopictus* (Jayachandran and Fallon, 2002) and *Bactrocera tryoni* (Collins et al., 2008). However, effects of UV irradiation on cotton stainers have not been studied. Keeping above in view, effects of UV rays on the survival of *D. koenigii* were investigated in order to establish UV irradiation as a possible insect pest control measure vice insecticides.

Materials and methods

Dysdercus koenigii were collected from the field having okra (Lady's finger) plants in the Banaras Hindu University campus and agricultural fields abounding Varanasi city. In laboratory, insects were maintained in a biochemical oxygen demand (BOD) incubator (Narang Scientific, NSW 152) on wet cotton seeds (pre-soaked in water for 24 h) under long day (16L:8D) photoperiod at 25 $\pm$ 2°C and relative humidity of 70%-80% (Venugopal et al., 1994). Freshly moulted fifth-instar nymphs were used for UV irradiation experiments.

A 15-W germicidal lamp (Philips, GE15 T8), measuring 45 × 4 cm was used as the source of 254nm UV radiation. The lamp was fixed inside a desk-type wooden container. Experiments with 2, 4, 6 and 8 min dose: 1.098 ± 0.01097 SE mW/cm^2 irradiation were performed, but no significant results were obtained. Therefore, higher exposure time of 10,

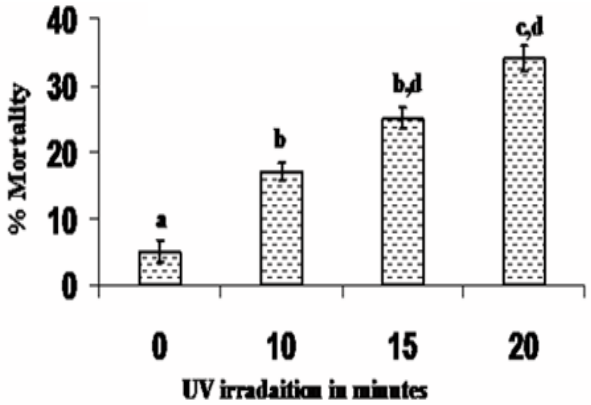

Fig 1. Comparison of mortality of fifth-instar nymphs of *D. koenigii* irradiated for different durations with constant UV dose and of control group. Data are expressed as mean ± SE and were analyzed by one-way ANOVA ($p < 0.001$) followed by Tukey test ($p < 0.05$). The bars superscripted with different letters are significantly different from each other and bars superscripted with same letters are not significantly different from each other. 0 min: control (non-UV-irradiated group)

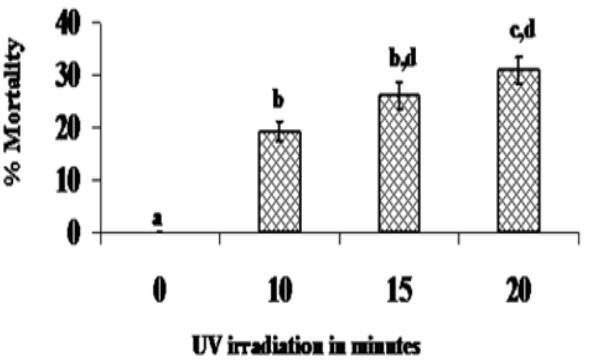

Fig 2. Comparison of mortality of resultant adults obtained from fifth-instar nymphs of *D. koenigii* irradiated for different durations with constant UV dose and of control group. Data are expressed as mean ± SE and were analyzed by one-way ANOVA ($p < 0.001$) followed by Tukey test ($p < 0.05$). The bars superscripted with different letters are significantly different from each other and bars superscripted with same letters are not significantly different from each other. 0 min: control (non-UV-irradiated group)

15 and 20 min each was given and the number of nymphs was 20 for each exposure. The control group (non-UV-irradiated nymphs) received normal light. Before irradiation, the test nymphs were placed under mild ether anaesthesia and placed in Petri dishes (3.5 cm diameter) at a distance of 5 cm from the lamp. After UV irradiation, these nymphs were put in the BOD incubator for 25 days to study their further development. The intensity of UV rays was measured by a UV-C radiometer (Lutron, Q 273797).

The number of dead nymphs as well as dead resultant adults in the UV-irradiated and control groups were counted daily. After UV irradiation, the numbers of deformed insects (nymphs as well as adults) were also recorded daily for both the groups separately. The experiments were repeated five times. These numbers were compared by analysis of variance (one-way ANOVA) and means separated using Tukey test. All data were analysed by using the procedure of sigma statistics (Sigma Stat 2.0, Jindal Corporation).

Results and discussion

The results of the effect of UV rays on the survival of fifth instar nymphs of *D. koenigii* are shown in Fig. 1. UV irradiation significantly decreased the survival of fifth instar nymphs in comparison to the control group. It was found that as the exposure period increased the survival of nymphs decreased. There was significant difference in the survival of nymphs at each exposure time ($p < 0.05$ Tukey test). UV irradiation studies on the survival and development of other insects have been extensively carried out (Gingrich et al., 1977; Calderon et al., 1985; Sharma and Dwivedi, 1997; Jayachandran and Fallon, 2002; Hwang and Chen, 2004; Parween et al., 2004; Faruki et al., 2005, 2007; Collins et al., 2008). UV irradiation for 2, 4, 8, and 16 min on the larvae of *Alphitobius diaperinus* has been reported to affect their survival. However; in the present study UV irradiation for 10, 15 and 20 min on nymphs induced highest mortality. This reveals that the UV irradiation sensitivity varies according to species, strain, and individual and even at different developmental stages of the individual (Tazima, 1978). All the UV-irradiated nymphs moulted into adults showed morphological deformities and significantly decreased survival (Fig. 2). Moulting of nymphs into adults became delayed as the exposure period increased. It was found that as the exposure period increased the survival of resultant adults decreased in comparison to the control group (Fig. 2). There was further significant difference in the survival of resultant adults at each exposure time ($p < 0.05$ Tukey test). UV irradiation for 8, 16 and 24 min on *A. diaperinus* (Faruki et al., 2005; Parween et al., 2004) and *Tribolium castaneum*, *T. confusum* and *Cadra cautella* (Faruki et al., 2007) have also been found to arrest the survival and moulting of larvae and resultant adults. Adverse effects of other radiations such as gamma irradiation on the survival and morphological deformities of *T. castaneum*, *Plodia interpunctella* and *Oryzaephilus surinamensis* (Tilton et al., 1974), arthropods (Tilton and Brower, 1983), *Sitophilus oryzae* (Tuncbilek, 1995), *S. granarius*, *T. confusum* and *Ephestia kuehniella* (Warchalewski et al., 2000), and *T. castaneum* (Banu et al., 2006), X-ray irradiation on *T. confusum* (Ducoff and Bosma, 1966) and silk worms (Mathavan, 1982), and UV-laser irradiation on *Bombyx* and *Drosophila* (Myohara, 1995) and *Bombyx mori* (Manjunatha et al., 2006) have also been reported.

The number of deformed insects with several morphological deformities was significantly high in the UV-irradiated nymphs as well as in the resultant adults (Fig. 3). Number of deformed insects increased as the exposure period increased in comparison to the control group. These findings are in agreement with the report of Ducoff et al., (1966) who has reported that UV irradiation induces morphological abnormalities in the pupae of *T. confusum*. These results are also in consonance with the results obtained by Gingrich et al., (1977) and Hwang and Chen (2004), who observed increased deformities with reduced viability in the irradiated nymphs of *Periplaneta Americana*.

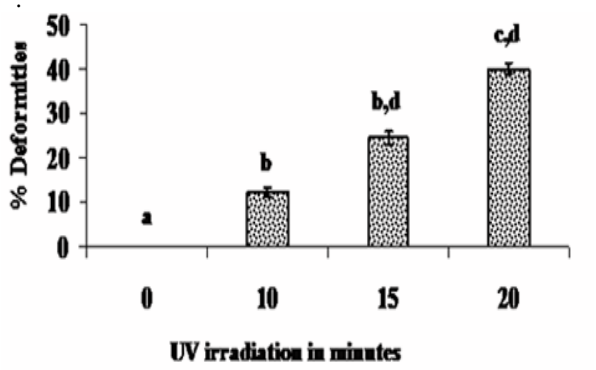

Fig 3. Number of deformed insects formed after treatment of fifth-instar nymphs for different durations with constant UV dose. Data are expressed as mean ± SE and were analyzed by one-way ANOVA ($p < 0.001$) followed by Tukey test ($p < 0.05$). The bars superscripted with different letters are significantly different from each other and bars superscripted with same letters are not significantly different from each other. 0 min: control (non-UV-irradiated group)

In conclusion, the results of the present investigations clearly demonstrate the adverse effects of UV irradiation on the survival of *D. koenigii*. The significantly reduced nymphal survival, delayed moulting into adults and severe morphological deformities caused by UV irradiation in this pest is promising from pest management point of view. Therefore, we suggest that by releasing the irradiated-nymphs from the laboratory into the affected field can control the population of cotton stainers. We presume that UV rays might serve as effective, acceptable and cheap approach for controlling cotton stainers and related insects.

Acknowledgements

This study was supported by the University Grants Commission, New Delhi, India as a part of project number 01/553 2008. Authors are thankful to the Commission.

References

Banu PA, Ali IA, Salam MA (2006) Effects of gamma radiation on the reproductive organs in the red flour beetle *Tribolium castaneum* (Herbst). Univ J Zool Rajshahi Univ 25:11-14.

Brickner PW, Richard L, First M, Nardell E, Murray M, Kaufman W (2003) The application of ultraviolet germicidal irradiation to control transmission of airborne disease: Bioterrorism countermeasure. Public Health Rep 118:99-114.

Calderon M, Bruce WA, Leecsh LG (1985) Effect of UV radiation on eggs of *Tribolium castaneum*. Phytoparasitica 13:179-244.

Chauzat MP, Faucon JP, Martel AC, Lachaize J, Cougoule N, Aubert M (2006) A survey of pesticide residues in pollen loads collected by honey bees in France. J Econ Entomol 99:253-262.

Collins SR, Weldon CW, Banos C, Taylor PW (2008) Effects of irradiation dose rate on quality and sterility of queensland fruit flies, *Bactrocera tryoni* (Froggatt) Appl Entomol 132:398-405.

Ducoff HS, Bosma GC (1966) The influence of pupal age on sensitivity to radiation. Biol Bull 130:151-153.

El-Daly FA, Khalil MS (2008) Biochemical influence of cyanophos insecticide on radish plant I. changes in some enzymatic activities exposed to various concentrations during the growth period. Aust J Basic Appl Sci 2:323-330.

Faruki SI, Das DR, Khatun S (2005) Effects of UV-radiation on the larvae of the lesser mealworm, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae) and their progeny. J Biosci 5:444-448.

Faruki SI, Das DR, Khan AR, Khatun M (2007) Effects of ultraviolet (254nm) irradiation on egg hatching and adult emergence of the flour beetles, *Tribolium castaneum*, *T. confusum* and the almond moth, *Cadra cautella*. J Insect Sci 7:1-6.

Gingrich JB, Pratt JR JJ, Mandels GR (1977) Potential of ultra violet radiation for control of American cockroach populations. Entomol Exp Appl 21:112-120.

Hampton T (2005) Health effects of insecticides. J Am Med Assoc 293:2992.

Hubbard HG (1885) Orange Insects, Department of Agriculture Division of Entomology, U.S. 165-168.

Hwang SY, Chen LM (2004) Effects of four physical treatments of oothecae of *Periplaneta americana* on parasitism and development of parasitic wasp *Evania appendigaster*. Environ Entomol 33:1321-1326.

Hydbom AR, Rylander L, Giwercman A, Jonsson BA, Ehle PN, Hagma L (2004) Exposure to CB-153 and p,p'-DDE and male reproductive function. Human Repro 19:2066–2075.

Jayachandran G, Fallon AM (2002) Ultraviolet light sensitivity, unscheduled DNA synthesis and DNA repair in C7-10 *Aedes albopictus* mosquito cells. J Insect Sci 48:133-141.

Manjunatha HB, Hosagoudar SR, Inamdar SR (2006) Biochemical changes and somatic mutation induced by UV laser irradiation at embryonic stages of *Bombyx mori*. Int J Radiat Biol 82:648-657.

Mathavan S (1982) Effect of X-ray irradiation on developing eggs of the silkworm. Experientia 39:1037-1039.

Michael R, Antignus Y (2004) UV radiation effects on pathogens and insect pests of greenhouse grown crops. Photochem Photobiol 79:219-226.

Michaud JP, Grant AK (2003) IPM-Compatibility of foliar insecticides for citrus: Indices derived from toxicity to beneficial insects from four orders. J Insect Sci 3:1-10.

Myohara M (1995) Reponses to localized UV-laser irradiation are different between *Bombyx* and *Drosophila* eggs. Dev Growth Differ 37:93-98.

Pan J, Vicente AR, Martinez GA, Chaves AR, Civello PM (2004) Combined use of UV-C irradiation and heat treatment to improve postharvest life of strawberry fruit. J Sci Food Agric 84:1831-1838.

Parween S, Faruki SI, Akther R (2004) Growth and development of *Alphitobius diaperinus* (Panzer) (Coleoptera: Tembrionidae) developing from pupae irradiated with ultra-violet rays. Univ J Zool Rajshahi Univ 23:23-26.

Peter KLN, Sivasothi N (1999) Animal diversity. A guide to the mangroves of Singapore, 2nd edn. Singapore Science Centre, Singapore.

Pszczola DE (1997) 20 ways to market the concept of food irradiation. Food Technol 51:46-48.

Sharma MK, Dwivedi SC (1997) Investigation on the effects of ultraviolet and infrared light on the life c *Callosobruchus chinensis* Linn. J Adv Zool 18:27-

Singh HK, Singh HN (1991) Some major pest incid certain late cultivators of pigeon pea, *Cajanus cajan* (L.) during half pod formation stage. Indian J Entomol 53:298-303.

Singh RN, Singh KM (1978) Influence of intercropping of succession and population build up of insect-pests in early variety of red gram, *Cajanus cajan* (L.) Millsp. Indian J Entomol 40:361-375.

Sprenkel RK (2000) Cotton plant and pest monitoring manual for Florida, Florida.

Taylor M (2003) Voices for pesticide reform, the stories of those who have been harmed by pesticides. Pesticides and you, Beyond pesticides, National coalition against the misuse of pesticides, Washington, DC 23:18-20.

Tazima Y (1978) Radiation mutagenesis of the silkworm. In: Tazima Y (ed), The silkworm an important Laboratory tool, Kodensha Limited, Tokiyo Japan.

Tilton EW, Brower JH, Cogburn RR (1974) Insect control in wheat flour with gamma irradiation. Int J Appl Radiat Isotopes 25:301-305.

Tilton EW, Brower JH (1983) Radiation effects on arthropods. In: Josephson ES, Peterson MS (ed) Preservation of food by ionizing radiation. CRE Press, Florida.

Tomas D, Gajete (2008) Okra Production. Open Academy for Philippine Agriculture.

Tuncbilek AS (1995) Effect of ^{60}Co gamma radiation on the rice weevil, *Sitophilus oryzae* (L.). Anz Schadlingskd Pfl Umwel 68:37-38.

Venugopal KJ, Kumar D, Singh AK (1994) Developmental studies on proteins from haemolymph, fat body and ovary of a phytophagus bug, *Dysdercus koenigii* (Heteroptera: Pyrrhocoridae). Biochem Arch 10:297-302.

Warchalewski JR, Pradzynska A, Gralik J, Nawrot J (2000) The effect of gamma and microwave irradiation of wheat grain on development parameters of some grain pests. Mol Nutr Food Res 44:411-414