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Irradiation Control of *Plodia interpunctella* L. (Lepidoptera: Pyralidae) in Dehydrated Ginseng (*Panax ginseng*)

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Abstract.- Mortality of the stored-product insect Indian meal moth *(Plodia interpunctella)* was evaluated at different growth stages by gamma irradiation. *P. interpunctella* reared on Korean ginseng *(Panax ginseng)* was exposed to ^{60}Co-gamma rays at low doses (0.05~0.5 kGy) as well as high doses (1 ~5 kGy) at ambient temperature and then subjected to the corresponding study during storage for 21 days to investigate the effect of irradiation on Indian meal moth disinfestation. Adult mortality rate was 74.44% just after irradiation at 0.05 kGy, which increased to 93.33% at 21-day of storage. Mortality of pupae was 78.89% after irradiation that reached 95.55% on 21st day after storage irradiated at 0.05 kGy. Both adult and pupa achieved 100% mortality at 0.5 kGy irradiation dose but larvae were more resistant to the same irradiation level. However, no larvae survived at 1 kGy, 21days after treatment. So, Ginseng can be successfully, disinfested from Indian meal moth at an irradiation dose of just 1 kGy and 100% mortality can be achieved at higher dose of 2, 3, and 4 kGy just five, three and one day after treatment, respectively.

Key words: Ginseng, *Plodia interpunctella*, irradiation

INTRODUCTION

Ever since Korean ginseng was recognized to be superior in biological efficacy, the demand for ginseng products has increased over the year. New Korean ginseng herbal medicine and natural health food attracted many health conscious consumers. As a consequence, hygienic processing and manufacturing of high quality ginseng products are recognized as an important prerequisite to gain the wider acceptance of consumers. Although dehydrated ginseng products are usually processed to reduce moisture content as low as possible, and biological deterioration has been reported with stored products, which were poorly dehydrated and processed (Kwon, 1991; Lee, 1989).

The Indian meal moth, *Plodia interpunctella,* has been the most important pest of stored products. It is a cosmopolitan pest that not only attacks a wide range of stored cereal products (LeCato, 1976; Mbata, 1990; Madrid and Sinha, 1982) but also other food products including dried vegetables (Na and Ryoo, 2000), groundnuts (Mbata, 1987), dried fruits and almonds (Cox and Bell, 1991), Pistachios and walnuts (Johnson *et al*., 1992), raisins and prunes (Johnson *et al*., 1995), processed foods (Simmons and Nelson, 1975), and white ginseng (Kwon *et al*., 2000).

Ginseng infested with Indian meal moth may be disinfested with chemicals such as methyl bromide (MeBr) and hydrogen phosphide (PH3). Despite low residues, fumigation with MeBr and hydrogen phosphide may not be desirable from the viewpoint of human health. More importantly, MeBr can deplete the ozone layer and on this basis it will be phased out for most uses by the year 2005 in developed countries (Marcotte, 1998). Applications of extreme temperatures offer potential as an alternative method for protecting and disinfesting stored commodities. Cold disinfestation often require long exposure periods, measured in days, and are of more use for preservation of products than as a means of disinfestations (Evans, 1986). Other studies have shown that heat treatment for 3 hours at 45°C completely controlled *P.*

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interpunctella pupae (Arbogast, 1981). But heat treatment can affect the quality of host commodities.

Development of an alternative treatment is urgently needed. Ionizing radiation, either from isotope or machine generated sources has been suggested as an alternative to methyl bromide. The PPQ Treatment Manual currently listed irradiation as acceptable non-chemical treatment that meet - quarantine standards (USDA, 2002). Irradiation treatment is a process to expose infested commodities to ionizing radiation so as to sterilize, kill, or prevent emergence of insect pests by damaging their DNA (Morrison, 1989). The objective of using irradiation, as with any quarantine treatment is to prevent the establishment of exotic pests.

The purpose of this study was to determine the applicability of irradiation for treatment of different developmental stages of Indian meal moth in ginseng.

MATERIALS AND METHODS

Larvae of *P. interpunctella* L. (Lepidoptera: Pyralidae) from 2-6 instars were collected from the laboratory rearing culture and were reared on commercial ginseng purchased from local market in Korea. The larvae were released on ginseng in a transparent plastic box (27cm x 18cm x Bcm) with mesh screen on top for ventilation. The infested ginseng was held for various period of time to permit the eggs to develop, hatch and to allow for larval development. The ginseng infested with different developmental stages *viz.* larvae, pupae and adults of *P. interpunctella* were exposed to cobaIt-60 gamma rays at room temperature at KAERI (Korean Atomic Energy Research Institute, Daejon, Korea) with irradiation dose of low intensity (0.05,0.1,0.25, 0.5kGy) and high intensity (1, 2, 3, 4, 5 kGy). For each treatment there were three replications, each of about 30 live larvae, pupae and adults. After treatments of irradiation all the individuals in boxes were placed in a dark room maintained at 28±2°C and 60% humidity. The data of mortality from all treatments were recorded by counting the dead individuals from each box 1, 3, 7, 14 and 21 days after treatments. The data were subjected to analysis of variance. Significant ($P < 0.05$) treatment means were separated by Duncan's (1955) multiple range test.

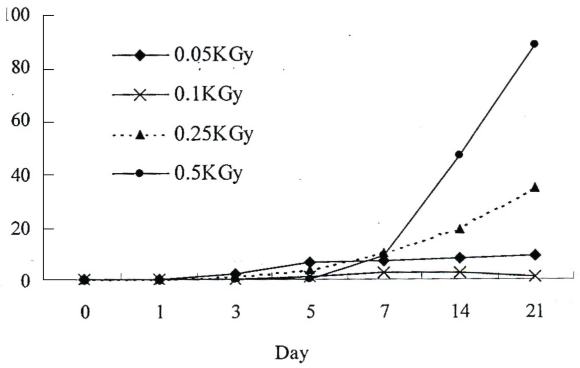
RESULTS

Results of *P. interpunctella* larval mortality suggested that lower (0.05 to 0.5 kGy) irradiation doses have very poor effect up to 7 days after treatment (Fig. 1). The maximum larval mortality was observed 41.11a and 87.77a% (cdl= 14.03 and 11.01, df=2,4) at 0.5 kGy, 14 and 21 days after treatment respectively. At lower treatment of irradiation pupal mortality showed comparatively better results. Data revealed that as the irradiation frequency increased, the pupal mortality was also increased, respectively. Data showed that 100a% pupal mortality was achieved (Fig. 1) one day after treatment at 0.5 kGy irradiation, which was dominantly higher than 0.05 (78.88c%) and 0.1 kGy (83.33bc%) mortality of pupae (cdl= 12.42, df= 2, 4). The pupal mortality at 0.5 kGy was statistically at par with 0.25 kGy irradiation followed by the mortality at 0.1 kGy. Results showed that there was non-significant difference in all lower treatments of irradiation (0.05 to 0.5 kGy) and were equally effective showing 100% pupal mortality, 21 days after treatment.

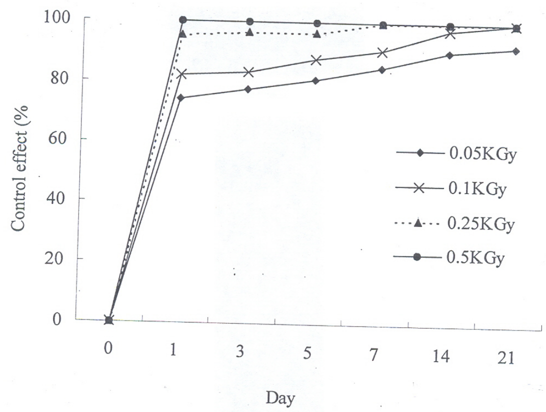
Same trend of adult mortality was also observed with the treatment from 0.05 to 0.5 kGy irradiations. Results showed that one-day after 0.5 kGy treatment, 100a% mortality of adults can be achieved which was significantly parallel to the mortality (95.55a%) at 0.25 kGy but statistically higher than the mortality observed at 0.05 kGy (74.44b%) and 0.1 kGy (82.22b%) (cdl= 8.88, df= 2,4). Same trend of adult mortality was observed for 7 days after treatment. Where as no significant difference in adult mortality was observed from 0.05 to 0.5 kGy treatments showing 93.33 to 100% mortality at 21 days after treatment. It is concluded that lower doses of irradiation were effective for the control of *P. interpunctella* pupae and adults with in minimum days. Where as for larval mortality higher dose than 0.5 kGy is required to get good results.

Adults, pupae and larvae were also exposed to higher irradiation doses from 1 to 5 kGy. There were significant differences among all doses of irradiation at 1, 3, 5, 7, 14 and 21 days after treatments. Results showed 100% mortality at 4 and 5 kGy on day 1 after treatment (P<0.001), which was dominant as compared with the treatment of 1, 2 and 3 kGy.

Larvae



Pupae



Adults

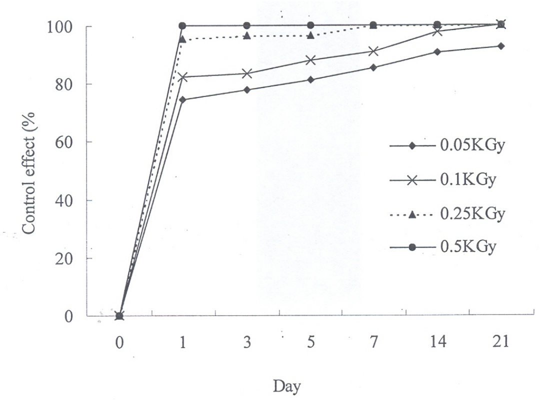


Fig. 1. Effect of low intensity gamma irradiation on mortality (%) of larvae, pupae and adults of *P. interpunctella*.

which showed no larval mortality at all (Fig. 2). On the 3rd and 5th day after treatment, 2 kGy showed 84.43 and 100% larval mortality (P<0.001). All higher irradiation from 1 to 5 kGy showed 100% larval mortality 21 days after treatment. In the same way all treatments of high doses of irradiation proved equally good for the control of pupae and adults with mortality ranging from 83.33 to 100%.

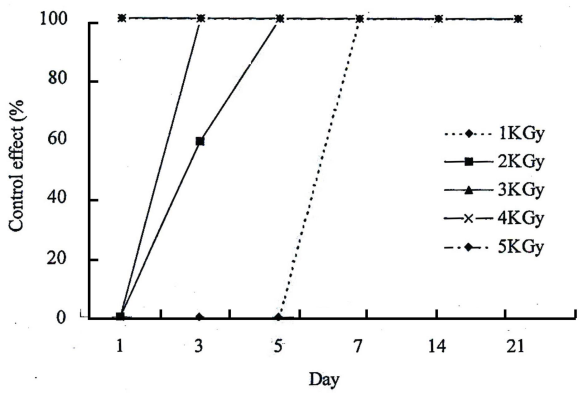


Fig. 2. Effect of high intensity gamma irradiation on the mortality (%) of *Plodia interpunctella* larva by low intensity gamma irradiation.

DISCUSSION

Korean ginseng *(Panax ginseng)* was exposed to cobalt-60 gamma rays at low doses (0.05~0.5 kGy) as well as high doses (1~5 kGy) to study the irradiation effect on different stages of Indian meal moth.

At low dose intensity, no adult survived after irradiation. Their mortality started after one day of storage and reached to 92.59% on 21st day. Irradiation dose of 0.25 kGy achieved 100% mortality after 7 days, whereas dose of 0.5 kGy achieved this on first day of irradiation (Fig. 1). Tilton and Burditt (1983) summarized the sterilizing radiation of stored product insects. According to them, 0.60 and 0.50 kGy are effective to control *P. interpunctella.* They also indicated that the lepidopteran insects were more resistant to radiation sterilization than other groups of insects. In the present study response of pupal mortality was similar to the adult and showed 100% mortality after irradiation at 0.5 kGy (Fig.1) that coincided the results of Johnson and Vail (1988), who reported 100% mortality of pupae at 0.149 to 0.627 kGys treatment. On the other hand, 0.319 and 0.269 kGy) had little or no effect on the adult emergence from irradiated pupae (Jhonson and Patrick, 1987), whereas 0.50 kGy greatly reduced the number of adults (Brower, 1975). Larvae of *P. interpunctella* were more resistant to irradiation than the pupae and adults (Fig. 1). Larvae treated at 58-98 Gy showed non-significant difference in mortality (Burditt *et al*., 1989). There was no larval mortality after 5 days of irradiation at a dose of 0.5 kGy. After 21 days storage, this mortality increased to 87.64%. Jhonson and Patrick (1987) have reported that 0.45 kGy is not effective to cause 100% mortality of *P. interpunctella* larvae and the present study results also prove the same.

At high intensity irradiation trials, doses of 1, 2, 3, 4 and 5 kGy showed 100% mortality of adults and pupae at all doses one day after treatment. As larvae are resistant to irradiation compared to adult and pupae, they achieved 100% mortality 7 days after irradiation treatment (Fig. 2). Larvae survived after exposing to 2kGy also, but 58.89% died on 3rd day and all died on 5th day of irradiation. The results of present study are in agreement with Johnson and Vail (1988) who reported that higher radiation doses decreased the time required for 100% larval mortality.

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