IRRADIATION OF AGRICULTURAL PRODUCTS FOR MITE /Acarina: Acaroidea/ DISINFESTATION

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Abstract

The purpose of this guideline is to present information for the use of ionizing radiation in treating agricultural products to disinfest them of mites /Acarina: Acaroidea/. The ionizing radiation which may be employed in irradiating stored products is limited to gamma rays from Co-60 or Cs-137, X-rays at or below an energy level of 5 MeV, and electrons at or below energy level of 10 MeV. An electron beam and gamma rays from radioactive cobalt were found to be equally effective in preventing the reproduction of mites when the dose of absorbed radiation from both sources was equal.

Control of mite pests of stored products by ionizing radiation may employ either high doses of radiation to produce mortality or lower levels to produce sterility in mites. For immediate mortality of mites, doses higher than 2 kGy /2-3 kGy/ of ionizing radiation are required. Doses in the range of 1.3-1.5 kGy would be sufficient if lethality within a few weeks is the goal. A dose of 0.25-0.3 kGy would be effective if the goal is sterility of living mites.

If commodities are infested not only with mites, but also with beetles and moths, a dose of 0.5 kGy will control even the most resistant beetle species and immature stages of moths.

INTRODUCTION

Pest infestation of post-harvest agricultural products is largely confined to the activities of acarid mites /Acarina: Acaroidea/. The acarid mites do harm by contaminating agricultural products with excrements, by eating, warming and dumpening, and also by infesting them with saprophytic microorganisms such

bacteria and fungi'/Boczek, 1980/.

Of acarid mites, the following species are the most common in the stored products: the grain mite /Acarus siro L./, the mold mite /Tyrophagus putrescentiae /Schrank//, the furniture mite /Glycyphagus domesticus Deg./, the bulb mite /Rhizoglyphus echinopus /F. et R.//, and the dried fruit mite /Carpoglyphus lactis L./. These pests are often found in grain, mill products, seeds of various plants, on cheese, in medical herbs, dry fruits, vegetables and mushrooms, fish meal, powdered eggs and milk, dry meat, yeast and other products /Boczek, 1980/.

Until now, fumigation with chemicals is the most effective method for disinfestation of stored products infested by mites. However, the fumigation has many limitations /Moy, 1988/. Therefore, there is a need for alternatives for chemical methods of disinfestation.

Irradiation may be used to disinfest agricultural products of mite pests present. Such treatment may accomplish the following useful effects:

/a/ prevention of mite damage to the food;

/b/ prevention of the transfer of mites from one locality to another, as might occur in the shipment of infested products /Ignatowicz, 1988; Ignatowicz and Brzostek, 1990/.

The purpose of this paper is to present information for the use of ionizing radiation in treating agricultural products to disinfest them of the acarid mites.

1. Pre-irradiation treatment of agricultural products infested with the acarid mites

In general, there are no special requirements for treatment or handling of the agricultural commodities before irradiation but that the products to be irradiated be obtained from producers who use good agronomic practices and that the products to be of good over-all quality.

To minimize pest contamination, agricultural commodities should be stored in clean, pest-free store-houses. Before the irradiation treatment the products should be dried to the required low moisture content and kept at low temperature and

low humidity. The acarid mites feed and reproduce in the stored products with 12.8-13.0% or more humidity. The development and reproduction of most mites is possible at 8°C and higher temperatures /Boczek, 1980/.

Agricultural commodities may be irradiated as bulk products, without any form of packaging, or they may be packed. Where possible, packaging should be done prior to irradiation to prevent post-irradiation re-infestation. Packaging materials that the insects and mites cannot penetrate /pest-proof packages/ or treatment with a penetration inhibitor are suggested /Highland, 1989/.

2. Irradiation of agricultural products infested with the acarid mites

A/ Irradiation facility

The ionizing radiation which may be employed in irradiating agricultural products infested with the acarid mites is limited to /a/ gamma rays from ^{60}Co or ^{137}Cs, /b/ X-rays generated from machine sources operated at or below an energy level of 5 MeV, and /c/ accelerated electrons /electron beam/ generated from machine sources operated at or below an energy level of 10 MeV.

The radiation must penetrate the depth of the product at sufficient level. Gamma rays and X-rays penetrate the treated products easily, but electron radiation penetrability is much lower, depending on the electron energy employed. For products irradiated in containers such as bags, boxes, etc., conventional batch irradiator producing gamma rays or X-rays may be used in accord with usual practices. A single-purpose irradiator generating electron radiation is suggested for irradiation of bulk products such as cereal grains. The methods usually suggested for irradiating grain by an electron beam involve moving the grain through the beam in an air stream at high spead /Tilton and Stuart, 1984/. The treatment should be done while products are being moved /flowed/ for another purpose, such as loading or unloading a ship /Port of Odessa, USSR/. It

will reduce the cost of handling and provide the minimalization of post-irradiation infestation.

It is not possible to distinguish irradiated from unirradiated product by inspection, therefore physical bariers should be used for keeping the irradiated and non-irradiated products separate.

Conditions usually employed for irradiation various materials at ambient temperatures may be employed. However, the irradiation area should be well-ventilated to minimize ozone build-up. Ozone can be phytotoxic to some agricultural products, e.g. fruits.

B/ Dose of ionizing radiation for mite disinfestation of agricultural products

Of the irradiation process parameters, the most important is the amount of ionizing energy absorbed by the target material. This absorbed dose should be the minimum dosage required to accomplish the desired disinfestation.

Control of mite pests of stored products by ionizing radiation may employ either high doses of radiation to produce mortality or lower doses to produce sterility.

Small to moderate doses /up to 0.25 kGy/ of ionizing radiation may prolong the lifespan of adults of the acarid mites. Increases of longevity are usually greater in females than in males. At 0.25-0.35 kGy doses, the longevity of irradiated and untreated mites is similar. At the higher absorbed doses, the irradiated mites of both sexes live shorter than unirradiated adults /Ignatowicz, 1988/.

The longevity of these mites is usually inversely related to the size of the radiation dose. However, the long period between irradiation and death of mites is characteristic at dosages up to 1 kGy. At 1.3-1.5 kGy complete mortality occurs within 1 to 3 weeks, depending on the susceptibility of the species to ionizing radiation /Fig. 1 and 2/.

Lethal effects of radiation are not as pronounced as those achieved with chemical insecticides or fumigants that kill mites rapidly. Although, equivallent effects are obtained by very high doses of ionizing radiation. An absorbed dose in the

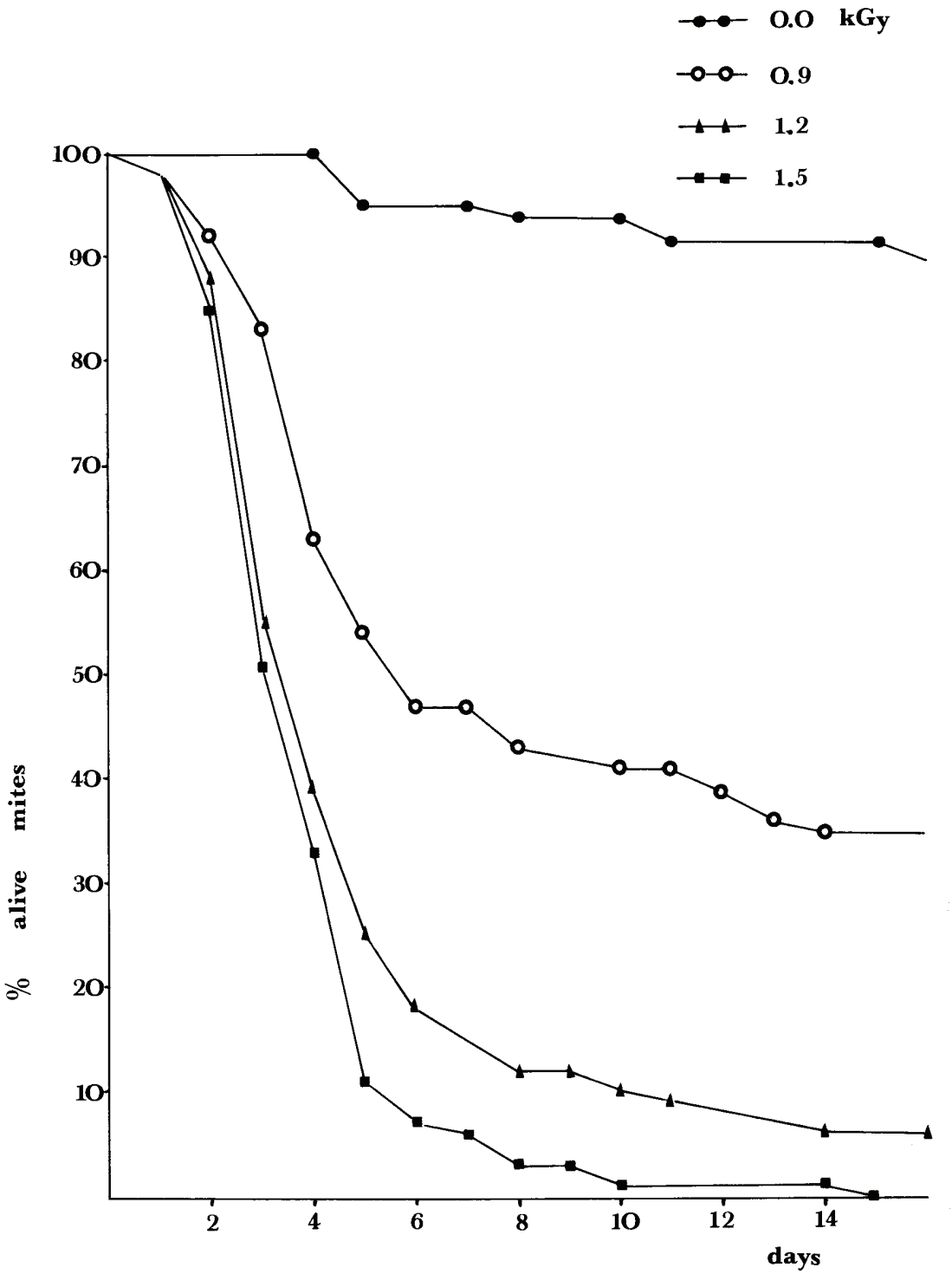

Fig. 1. Effect of gamma radiation on longevity of the bulb mites, R. echinopus, irradiated with 0.9-1.5 kGy.

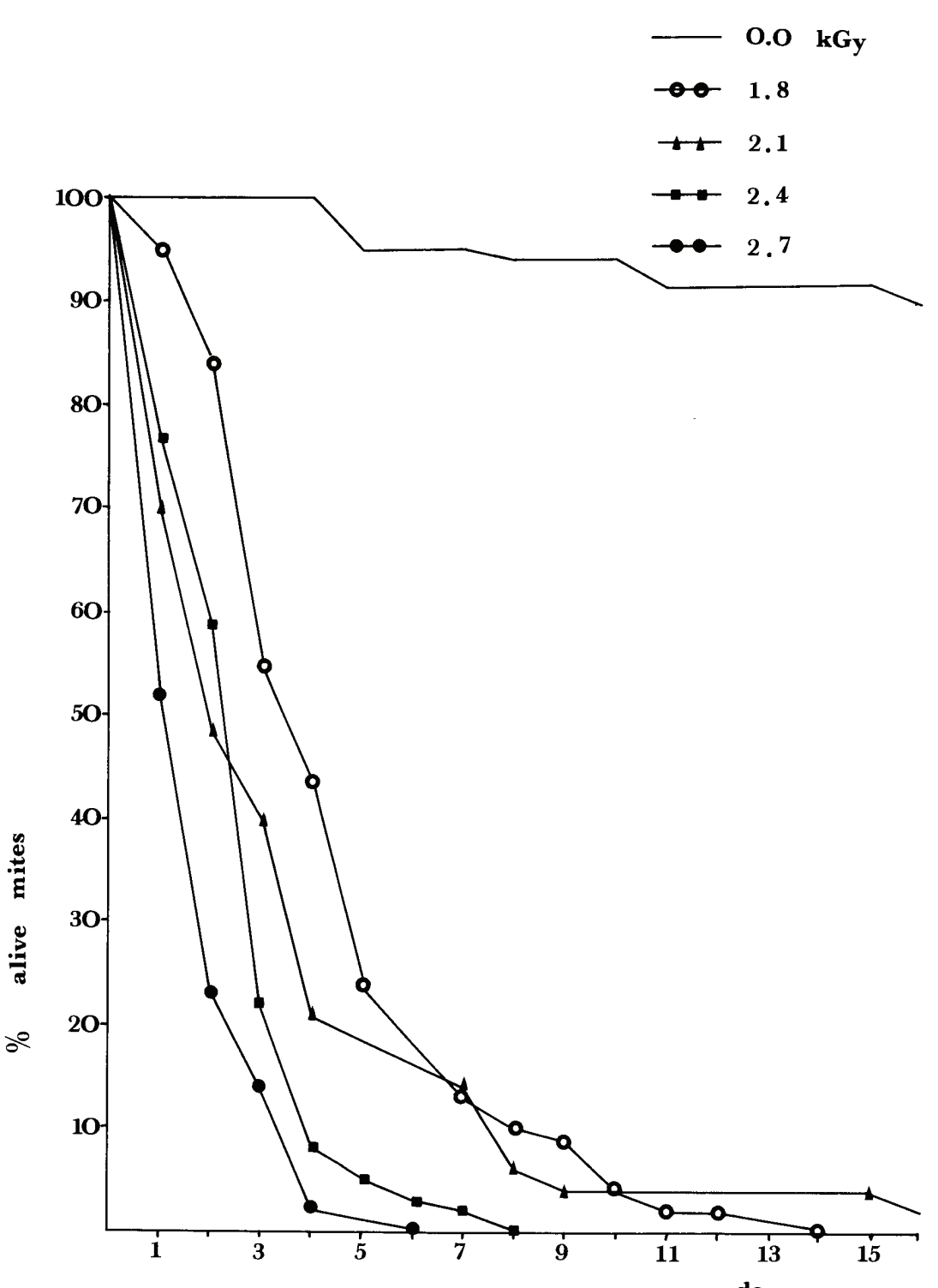

Fig. 2. Effect of gamma radiation on longevity of the bulb mites, R. echinopus, irradiated with 1.8-2.7 kGy.

Table 1. Fecundity and viability of eggs produced by adults of the acarid mites treated with gamma radiation

Dose /kGy/	T. putrescentiae		T. neiswanderi		R. echinopus	
	Fecundity /no.eggs/♀/	Viability of eggs/%/	Fecundity /no.eggs/♀/	Viability of eggs/%/	Fecundity /no.eggs/♀/	Viability of eggs/%/
0.0	415.0±24.0	96.0	201.7±19.1	86.5	335.6±25.9	99.2
0.1	189.9±28.6	73.8	195.4±25.3	41.2	261.0±23.3	30.6
0.2	-	-	112.4±19.1	13.7	104.8±5.4	0.4
0.25	15.4±2.4	0.0	53.5±8.0	11.7	43.6±3.4	0.2
0.3	-	-	48.6±5.2	8.3	30.5±2.2	0.0
0.35	8.9±1.2	0.0	37.5±3.5	0.8	-	-
0.4	-	-	22.7±2.6	1.6	65.6±2.6	0.0
0.5	9.5±1.1	0.0	10.0±1.3	0.0	59.7±2.4	0.0

[a]/ Mean number of eggs per fecund female ± standard error.

range 2-3 kGy is needed to produce complete mortality of mites within 1-3 days /Ignatowicz and Brzostek, 1990/.

Sterility in the mites is achieved following irradiation of adults with much lower doses than needed to kill the mites. An absorbed dose of 0.25-0.3 kGy was found to be sterilizing or nearly sterilizing dose for the most acarid mites /Ignatowicz, 1988; Ignatowicz and Wróblicka-Sysiak, 1989; Ignatowicz and Naedee, in press/. Sterility effects produced by radiation are immediate and at doses above the sterility threshold appear to be permanent /Ignatowicz and Łagowska, 1982/.

Radiotolerance of the acarid mites increases during development, and adults are the most resistant stage to ionizing ra radiation. Sterile adults may develop from eggs, larvae or nymphs treated with lower doses than needed for sterilization of mature mites /Ignatowicz, 1988/.

Control of mite infestation in agricultural products may be considered in the following general terms. For immediate lethality of mites, doses higher than 2 kGy /2-3 kGy/ of ionizing radiation are required. Doses in the range of 1.3 to 1.5 kGy would be sufficient if lethality within a few weeks is the goal. A dose of 0.25-0.3 kGy would be effective if the goal is sterility of living mites. At these dosages, however, live mites will be present in a product for several days, and some of the adults might remain fertile, but the few progeny they produce would be sterile because of genetic damage.

If commodities are infested not only with mites, but also with beetles and/or moths, an absorbed dose of 0.5 kGy will control even the most resistant beetles and immature stages of moths /Tilton and Brower, 1973/.

3. Post-irradiation maintenance of agricultural products

Irradiated products should be stored in dry and cool conditions to avoid growth of moulds. Also, appropriate measures to prevent re-infestation are necessary since irradiation results in no lasting protection against subsequent insect infestation.

In a cese of re-infestation, the subsequent irradiation of the same product is possible because radiation doses for mite

disinfestation are low. The total absorbed dose of two treatments shall not exceed the maximum dose permitted, above which radiation produce impairment of functional properties of the product. However, irradiation of such products more than once is generally not recommended.

After the treatment of packaged products, each unit should be labelled by a paper sticker or equivallent. Labelling should not only identify the food as irradiated, but also serve to inform the purchaser as to the purpose and benefits of the treatment.

Bulk products cannot be labelled, therefore documents with a protocol of irradiation treatment should accompany the commercial movement of each lot or unit of such products /ICGFI, in prep./.

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L'IRRADIATION DES PRODUITS AGRICOLES DANS LA DESINFESTATION DES ACARIENS (ACARI : ACAROIDEA)

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RESUME

Ce guide a pour but d'apporter des informations sur l'utilisation des radiations ionisantes dans la désinfestation des stocks agricoles parasités par les acariens (Acari : Acaroidea).

Les stocks agricoles peuvent se présenter en vrac ou emballés en conteneurs tels que sacs ou boîtes en carton. Un tel emballage doit être fait avant d'irradier avec, si possible, des matériaux imperméables aux déprédateurs.

On a proposé deux méthodes d'élimination par radiations ionisantes : l'irradiation à dose élevée des produits infestés pour tuer les acariens et l'irradiation à faible dose pour les stériliser. La seconde méthode semble préférable, la première exigeant une plus grande protection et étant donc plus onéreuse.

Le cadre général de lutte contre les acariens des produits agricoles est le suivant : pour obtenir la mort immédiate, il faut des doses supérieures à 2 kGy. Pour obtenir la mort en quelques semaines, il faut des doses allant de 1,3 à 1,5 kGy. Pour obtenir la stérilité, il faut des doses allant de 0,25 à 0,26 kGy.

On peut utiliser l'irradiation selon les conditions habituelles à température ambiante. Le stockage après irradiation ne demande aucune attention particulière.