MARDI Res. J. 18(1) 1990: 95–98

Radiographic technique for assessing postharvest grain losses

(Teknik radiografi untuk menilai kerosakan bijian selepas tuai)

M. A. Rahim*

Key words: X-ray, insects, losses, grains

Abstrak

Teknik radiografi yang menggunakan pancaran sinaran-X lembut dapat mempercepat penilaian kerosakan bahagian dalaman bijian akibat serangan serangga perosak. Kaedah ini boleh juga digunakan untuk menganggarkan kerosakan lain seperti hampa, retak dan belum matang. Adalah dianggarkan bahawa kerosakan padi selepas tuai akibat serangan serangga utama ialah 4.6%, hampa 5.4%, retak 0.6% dan belum matang 2.6%.

Abstract

With the radiographic technique using soft X-ray, it is possible to conduct quick detection and assessment of grain losses due to internal insect infestation. This technique can also be used to estimate other types of losses such as empty, cracked and immature kernels. It was estimated that losses of padi after harvest was 4.6% due to damage by primary insects, 5.4% empty kernels, 0.6% cracked kernels and 2.6% immature kernels.

Introduction

The radiographic or X-ray technique is widely used in laboratory experimental work and by commercial cereal grain industry for detection of internal insect development in biological studies and estimation of infestation damages in grain cereals (Milner et al. 1950; Pederson and Brown 1960; Sharifi and Mills 1971; Dobie 1973). The most damaging insect species in grains and fruits are those whose life-cycle developed within the produces which subsequently either greatly reduced the qualitative value or entirely destroyed the produce. For cereal and vegetable seeds, radiographic films can also reveal other damages to the grain. These include cracked kernel, empty kernel and immature kernel. As such, this technique can be used in breeding experiments for quick evaluation of varietal characteristics and growth performance of new varieties by examining the radiographs of the harvested seeds. For entomological studies, the X-ray technique, though expensive, provide a reliable alternative for estimation of losses attributed to internal primary insect infestation in grains, which otherwise depended on comparison of weight loss of the grain and relative insect population differences. Loss assessments by grain weight differences often do not reflect the actual loss due to moisture movements between the grain and atmosphere. Similarly, quantifying losses based on insect population does not always reflect the quantitative losses on the stored produce.

*Food Technology Division, MARDI, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia
Author's full name: Ab. Rahim Muda

The main objective of this experiment was to evaluate post-production padi losses using X-ray technique. Specifically, this study was directed to assess losses attributable to:

- insect infestation at harvest and during storage
- cracked, immature and empty kernels during harvest

Materials and methods

The X-ray technique was employed in a survey of postharvest losses of padi stored by farmers at Tanjong Karang, Selangor. Samples were taken at monthly intervals for six consecutive months. Besides insect related damage, the magnitude of other losses related to preharvest and postharvest practices was assessed from each radiographed sample for empty kernel, cracked and immature grains. The 30 kg padi sample withdrawn from each of the 23 farmers' padi storage bin were subsequently reduced by successive coning and quartering to working samples of approximately 1 000 grains each. This procedure conforms to the standard set by International Organization for Standardization (I.S.O. Recommendation R 1162) for testing cereals and pulses for infestation by X-ray examination. Radiographs were made with a Faxitron^{R} X-ray unit generating soft X-rays and operating at 20 kV at 5 mA and 6 min exposure. Kodak type SR-5 Industrial X-ray film was used and the padi grains were placed on top of it, 50 cm below the X-ray source. The X-ray passed differentially through the grain and through the paper envelope containing the film to form an image on the film. Trials were carried out earlier to investigate the correct voltage and exposure time settings in order to obtain good contrast on the film. The above settings afforded the best pictures. All films were developed in Kodak Dental X-ray Developer for 10 min. To facilitate the counting of damaged kernels, a cardboard frame designed to subdivide the grains into four lots was placed beneath the grains spread in a single layer on the 10 cm x 12 cm film. Readings were made directly from the padi image without further magnification.

Results and discussion

The quantum of the various types of grain damage, assessed monthly over a 6-month padi storage period, are shown in *Table 1.* The insect damage data was earlier reported (Rahim et al. 1983) which showed gradual increment of losses from initial 1.5% to 6.7% after 3 months of storage. The insect related damage is characterized by partially damaged kernels *[Plate 1 (a)]* due to the insect larva's feeding habit from within the grain. Subsequently the adult emerges from the kernel, resulting in partial degradation of the kernel. Only three insects from at least 20 species associated with stored padi are insidious in nature, namely; the beetles *Sitophilus oryzae* (L.); *Rhizopertha dominica* (F.) and the

Table 1. Postharvest padi losses assessed by radiographic technique

Storage period (months)	Infested kernel (%)	Empty kernel (%)	Cracked kernel (%)	Immature kernel (%)	Total loss (%)
Prestorage	1.5	3.4	1.0	1.5	7.4
1	5.7	5.2	0.9	2.8	14.6
2	5.5	7.3	0.4	3.3	16.5
3	6.7	5.9	0.6	2.3	15.5
5	4.8	6.1	0.5	2.6	14.0
6	3.8	5.0	0.4	3.1	12.3
Mean	4.6	5.4	0.6	2.6	13.2

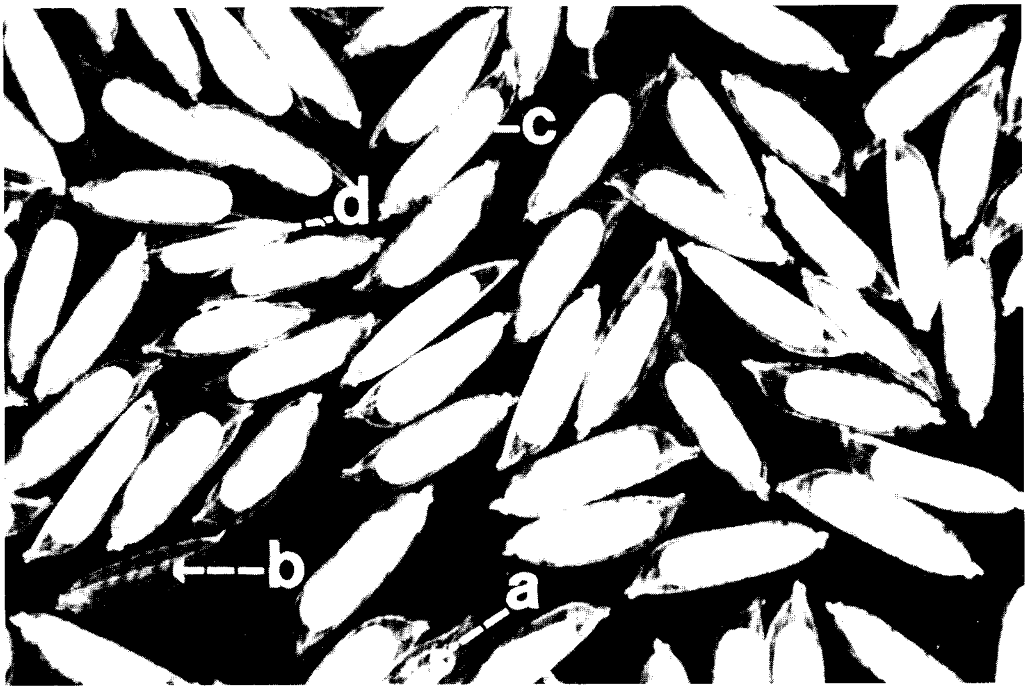

Plate 1. Radiograph showing various stored padi damages: Kernel damaged by insect (a); empty kernel (b); cracked grain (c); and immature grain (d)

moth *Sitotroga cerealella* (Ol.). Others are surface feeders and are therefore less damaging.

Empty kernels are easily detected by radiograph pictures *[Plate 1 (b)]* which clearly show the absence of the kernel. Assessments showed that 3.4–7.3% (by count) of the harvested padi are without kernels. Occurrence of empty husks is related to growth characteristics of the padi plant; the magnitude varies among different padi varieties, soil type, environmental conditions, and crop management.

Cracked grains are depicted by the sharp line through the midsection of the kernel *[Plate 1 (c)]*. These grains subsequently break up during milling. The cracked grains amounts to less than 1% of the harvested grains. Its occurrence is often associated with mechanical injuries due to manual threshing and overdried padi.

Immature kernels are characterised in the radiograph by the smaller, uneven-shaped kernel *[Plate 1 (d)]*. From the padi harvested, 1.5–3.3% are immature, which normally occur in grain harvest due to the uneven growth rate of the plant.

The above studies on the mass detection of various types of padi damages by radiographic technique showed that 7.4% padi losses during padi harvest are in the form of insect damage, cracks, immature grains and empty kernels. The losses increased to an average of 13.2% (ranging from 7.4% to 16.5%) during storage, the increase being mainly due to insect infestation. The proportion of infested kernels increased from 1.5% at the beginning of storage to 6.7% after 3 months, but declined after this period. This sigmoid nature in grain damage-time relationship is a typical phenomena in small grain storages and is related to insect activities. Insect population normally perpetuate rapidly for a time period. However, corresponding increase in grain temperature due to increase respiratory activities of the insects, microorganisms and the grains which gradually spread over the grain mass would invariably have adverse effect on their number. In addition to that, continuous removal of the padi for domestic consumption or for sales gradually reduced the available food for the insects in the stored padi (0.8 t to 1.0 t) at Tanjong Karang.

Changes in the proportion of empty, cracked and immature kernels were unrelated to insect infestations and storage conditions. Variation in the percentage of these seed damages and deformities was probably due to variation of the grain origin such as production areas and pre-production factors.

Besides affording a quick estimation of grain losses, the radiographic technique is more often used to study the life-cycle of internally developing insects. The gradual development of various stages and the pupae of beetles in stored padi can be easily detected with the exposure times and dosages applied in this and earlier studies. It is conceivable that similar detailed studies can be carried out on the damage characteristics and losses incurred by internally infesting insect pests of other grains and perishable produce such as fruits and vegetables. The importance of making qualitative and quantitative assessments of losses caused by pests on crops has long been recognised as the means of establishing the economic status of a specific pest. Thus, it is possible to determine the extent of infestation to justify its control, and to estimate the correct time to apply insecticide for effective pest control.

References

Dobie, P. (1973). An investigation into the use of an X-ray technique in the study of pre-emergant stages of *Sitophilus oryzae* (L.) developing in Manitoba Wheat. *J. stored Prod. res.* ***9***: 7–12

Milner, M., Milford, L. and Katz, R. (1950). Application of X-ray technique to the detection of internal insect infestation of grain. *J. econ. Ent.* ***43(6)***: 933–95

Pederson, J. R. and Brown, R. A. (1960). X-ray microscope to study behaviour of internal-infesting grain insects. *J. econ. Ent.* ***53(4)***: 677–9

Rahim, M., Masdek, N., Tee, S. P., Ab. Shukor, A. R. and Rohani, M. Y. (1983). Farm level grain storage in Malaysia: Pest infestation and fungi infection. *Proc. 6th Annual workshop on grain post-harvest technology*, 3–6th May 1983. Bogor, Indonesia. (Teter, M. C., Semple, R. L. and Frio, A. S., ed.) p. 266–83

Sharifi, S. and Mills, R. B. (1971). Radiographic studies of *Sitophilus zeamais* (Mots.) in wheat kernels. *J. stored Prod. Res.* **7**: 195–206

Accepted for publication on 14 March, 1989