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How to Sample Grain for Insects[1]

David Hagstrum, USDA-ARS, U.S. Grain Marketing Research Laboratory
Paul Flinn, USDA-ARS, U.S. Grain Marketing Research Laboratory
Scott Fargo, Oklahoma State University

Introduction

Throughout the marketing system, sampling for insects often has been limited to counting the number of adult insects in the grain samples that are taken for the purpose of grain grading. Samples from several locations in the grain mass are combined into a composite sample and a subsample is examined to determine grade factors (USDA 1983, 1988).

Special care is taken in deciding where to take samples and in designing equipment used to subdivide samples to ensure that the subsample will be representative of a lot of grain. The grain trier (Figure 1) was developed to remove enough grain to provide a representative sample of grade factors.

Grain grading involves removing several kilogram samples of grain to determine physical characteristics of the grain-test weight, moisture, class, shrunken and broken kernels, fines, and foreign material. However, most of these grade factors are more evenly distributed in grain than insects. Thus, these samples cannot provide a representative sample of insect populations.

A greater proportion of the grain needs to be sampled by taking more or larger grain samples to estimate insect population size. Insect populations can increase rapidly and change more quickly than other grade factors. Therefore, grain must be sampled more frequently to ensure that infestations have not reached damaging levels. Models predicting insect population growth can be used to reduce the frequency of sampling. However, improvement of insect pest management will require new sampling programs better suited to estimating insect population size.

Sampling Devices

A variety of devices have been developed for taking grain samples and separating insects from grain. The devices most commonly used are the grain trier[2] and the pelican sampler[2] (Figure 1). The grain trier generally is used to take samples from grain being stored in bins ortransported in trucks and railcars, while the pelican sampler is used to take samples from a moving grain stream as grain is loaded or unloaded. The pelican sampler often is automated so that samples are taken at regular intervals from the grain stream, then pneumatically conveyed to the grain inspection laboratory.

The vacuum probe[2] is another sampling device that was developed to more easily take larger samples from deep within the grain mass. The vacuum probe pulls air,

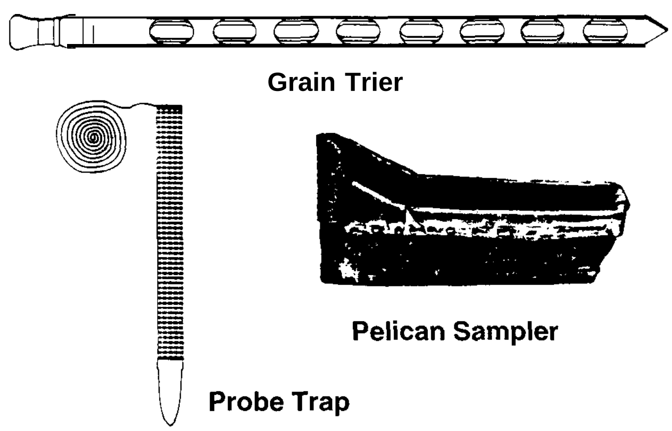

Figure 1. Sampling devices.

[1] Mention of a proprietary product in this paper does not constitute an endorsement of this product by the U.S. Department of Agriculture or Oklahoma State University.

[2] Equipment available from Seedburo Equipment Company, 1022 West Jackson Blvd., Chicago, Illinois 60607.

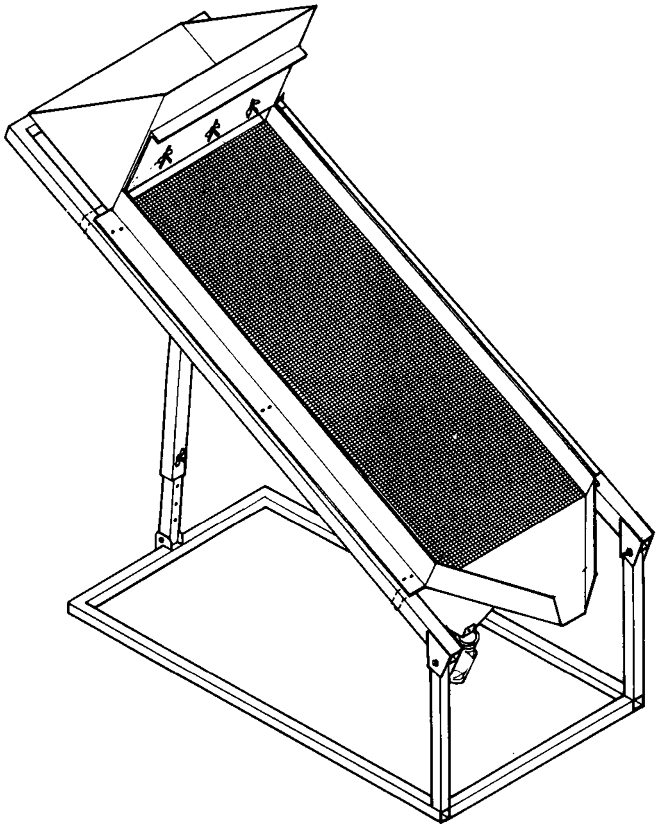

Figure 2. Inclined sieve.

carrying the grain up through an inner tube. Replacement air passes down between this tube and an outertube. The air with grain then passes into a cyclone collector which allows the grain to fall out.

Insects are usually separated from small grain samples with a hand sieve[2] or from large grain samples with an inclined sieve[3] (Figure 2). Insects will be easier to remove if the layer of grain on the sieve is no more than one-half inch thick. Shaking the hand sieve 20 to 30 times, or three passes over the inclined sieve, will remove the majority of insects.

Insect traps specifically designed for sampling grain insects, such as probe traps[4] (Figure 1), are also available. The probe trap is a perforated tube which is pushed vertically into the grain. Insects moving through the grain are trapped in a collection vial when they fall through the holes in the tube. A new method of acoustical detection[3] under development uses insect sounds to automatically monitor both internal and external feeding insects. This diversity of sampling equipment can provide many options for improving insect detection and for monitoring changes in population size.

Number of Samples

With the small portion of grain inspected for insects, it is often possible to detect the presence of insects, but to inaccurately estimate insect densities (Hagstrum et al. 1985). More samples are needed to accurately estimate insect population size. Management decisions often are based on detection alone and assume that the probability of detection is directly related to insect density.

The number of one-kilogram samples of grain required for 95 percent certainty of detection decreases rapidly as insect density in the grain increases (Table 1). The probability of detection also increases as more samples are taken. For instance, if only one sample is taken, the probability of detecting a mean density of two insects per kilogram of grain is only 76 percent. When 10 samples are taken, there is a 100 percent probability that an insect infestation with a density of two insects per kilogram will be detected.

Increasing the number of samples also increases the accuracy of the estimates (i.e., the probability of estimates being close to the actual mean insect density) (Figure 3). With only one sample, estimates of a population with an actual mean density of two insects per kilogram can vary from 0 to 4.3. Increasing the number of samples narrows the range of estimates of insect population density. With fewer samples, a manager could either underestimate populations and not apply control when it is needed, or

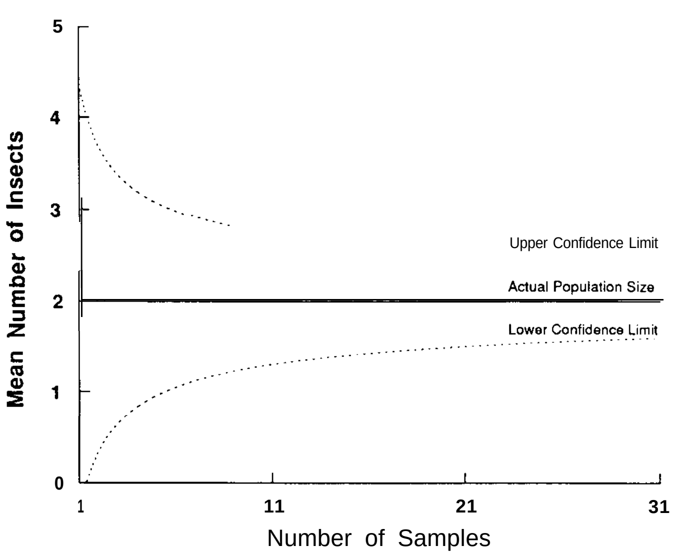

Figure 3. Variation in population estimates in relation to number of samples.

[3] Equipment not commercially available.

[4] Traps available from Trece Incorporated, P.O. Box 6278, Salinas, California 93912.

Table 1. Probability of detection[a] for insects in stored grain in relation to the number of samples and insect density.

Number of Kg Grain Samples per 1000 Bushels	Mean Number of Insects per Kilogram of Grain					
	0.02	0.06	0.2	0.6	2.0	6.0
1	0.02	0.06	0.19	0.43	0.76	0.95
2	0.04	0.12	0.34	0.67	0.94	1.00
5	0.10	0.28	0.64	0.94	0.99	1.00
10	0.19	0.48	0.87	1.00	1.00	1.00
25	0.42	0.80	0.99	1.00	1.00	1.00
100	0.89	1.00	1.00	1.00	1.00	1.00

[a] Calculated at the 95 percent level.

Table 2. 95 percent confidence intervals for insects in stored grain in relation to the number of samples and insect density.

Number of Kg Grain Samples per 1000 Bushels	Mean Number of Insects per Kilogram of Grain					
	0.02	0.06	0.2	0.6	2.0	6.0
1	+ 0.07	+ 0.15	+ 0.33	+ 0.67	+ 1.49	+ 3.07
2	+ 0.05	+ 0.10	+ 0.23	+ 0.47	+ 1.05	+ 2.17
5	+ 0.03	+ 0.07	+ 0.15	+ 0.30	+ 0.66	+ 1.37
10	+ 0.02	+ 0.04	+ 0.10	+ 0.21	+ 0.47	+ 0.97
25	+ 0.01	+ 0.03	+ 0.07	+ 0.13	+ 0.30	+ 0.61
100	+ 0.01	+ 0.01	+ 0.03	+ 0.07	+ 0.15	+ 0.31

overestimate insect population density and treat the grain unnecessarily. Thus, the confidence intervals for estimates are important in determining whether enough samples have been taken to make a correct management decision.

The number of samples needed to estimate populations within plus or minus the value of the mean decreases from 10 to 1 as the mean insect density increases from 0.02 to 0.6 insects per kilogram of grain (Table 2). Tables 1 and 2 allow us to determine the minimum number of samples needed to detect the lowest density of insects that is of interest, or to estimate densities of insects with the desired accuracy. These tables are generally based on fewer samples being required for uniformly distributed populations than aggregated populations, because the variation among samples decreases as the population becomes more uniform.

The distribution of insects among samples has been shown to be similar for most common species of stored-product insects in a number of diverse situations (Hagstrum et al. 1988). This similarity suggests that these tables may be applicable to many situations. A sufficient number of samples needs to be taken to accurately estimate insect populations at low densities, and thus make correct management decisions. Decisions need to be made while insect densities are low and there is still time to implement management action before damaging levels are reached.

Probe Traps vs. Grain Trier Samples

Probe traps exploit insect behavior to detect insect populations with less effort than grain sampling methods, such as grain triers, that determine the number of insects per volume of grain (Lippert and Hagstrum 1987). However, this exploitation of behavior results in a larger variation in trap catch. Much of this variation in trap catch is attributable to variation in trap efficiency (Hagstrum et al. 1990).

Table 3. Effects of sampling method and duration of trapping on probability of detecting a density of 0.2 rusty grain beetles per kilogram of grain.

Number of Probe Traps	Duration[a] of Trapping	Number of Trier Samples	Probability of Detection
1	1	1	0.19
1	5	5	0.64
2	1	2	0.34
2	5	10	0.87
5	1	5	0.64
5	5	25	0.99

[a]In days.

This variation often is due to environmental factors affecting insect behavior rather than actual changes in population density. Also, probe traps cannot be used when immediate estimates of insect density are required, such as when grain is arriving at an elevator.

Because insects move around in the grain mass, increasing the time that traps are in the grain is equivalent to increasing the amount of grain that is sampled (Fargo et al. 1989, Cuperus et al. 1990) (Figure 4). Clearly, traps capture rusty grain beetles more readily than lesser grain borers. This difference is a result of the greater mobility of the rusty grain beetle. Table 3 compares traps and grain triers as insect detection devices. Better estimates of insect population size also can be achieved by adjusting the capture rate of probe traps for the duration of time the traps are present in the grain.

Sampling Program

Monitoring insect populations is a fundamental part of managing stored grain. In designing a sampling program, stored-grain managers must consider the number of samples, the choice of sampling device, the locations at which samples will be taken, and the frequency of grain sampling. Decisions about these factors are not independent. If large numbers of samples are taken, managers can sample less frequently and still be confident that insect populations will not grow to unacceptable levels before they sample again.

The number of samples needed is determined largely by the distribution of insects in the grain. When insect densities are high, the sample-to-sample variation is low and fewer samples are needed to obtain the same accuracy (Table 2). However, more than the recommended number of samples may need to be taken to be sure that insects are detected throughout the grain bulk. At leastfive grain samples or probe traps should be used for sampling 1,000 or less bushels of grain.

For on-farm storage, five grain samples or probe traps may be used in bins of up to 5,000 bushels. With newly harvested grain stored in clean bins, the majority of insects tend to be located in the top 1,000 bushels of grain (Hagstrum 1989). Thus, there is a definite advantage to taking samples in this top three feet of grain.

A typical sampling plan might involve placing one probe trap three inches below the grain surface in the center of the bin, and four other traps equally spaced halfway between thecenter and the bin wall. Interpretation of trap catch will be more accurate if traps are left in the grain a week or less.

If a grain trier is used instead of traps, samples would be taken at these same locations. Sampling should be repeated at 30-day intervals until grain cools below 20% in the fall. Pelican samplers generally are more easily used to sample grain arriving at or leaving an elevator. The samples should be evenly spaced through the loading or unloading period.

Role of Sampling in IPM Decisions

The cost-effectiveness of management decisions is directly related to the quality of the sampling program. To minimize the cost of pest management, control decisions

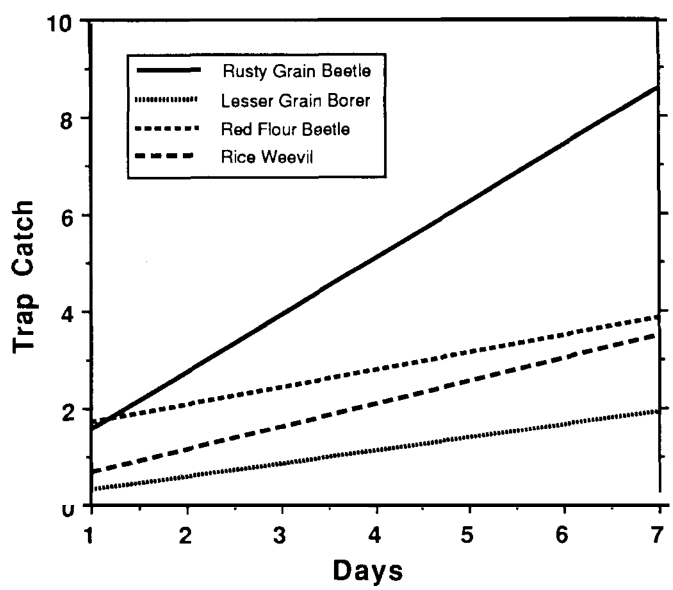

Figure 4. Increase in trap catch in relation to duration of trapping.

must avoid both unnecessary treatments and unacceptable insect population levels. Imprecise estimates of insect density can lead to incorrect management decisions and unnecessary expense. Accurate estimates of insect populations while densities are still low can increase the number of insect control options available.

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