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John T. Linehan
Patuxent Wildlife Research Center, Newark, Delaware

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JOHN T. LINEHAN, Bureau of Sport Fisheries and Wildlife, Patuxent Wildlife Research Center Sub-Station, Newark, Delaware

INTRODUCTION

When corn is damaged by birds, kernels are eaten or "milked" and the affected ears are left with fewer intact kernels. The resulting damage, or loss, can be expressed in terms of the number, weight, volume, or value of the kernels that were removed or pecked. Assessment of loss thus frequently entails measuring, counting, or estimating from evidence of kernels lost.

Estimates of loss resulting from the activity of birds should express the difference in value between a crop grown under the conditions that prevail and the value under the hypothetical condition of no adverse bird activity. To offset the effect of subsequent storm loss or failure to harvest a given crop, we found it expedient to assume that 96 percent of a standing crop one month prior to harvest will complete development, be harvested, and ultimately be utilized. The volume of destroyed corn further varies from the value of the eventual loss according to the response of the growing corn to bird damage: an animal nutritionist (George Haenlein, per comm.) indicated that in some corn varieties light damage to the tip of an ear early in the maturation will result in little or no reduction in the eventual total nutrient yield of the ear.

MEASUREMENT CRITERIA

The damage to a single ear resulting from birds pecking some of the kernels can be measured in the following ways: a) counting the remains of pecked kernels; b) counting pecked kernels and the remaining kernels, then calculating the proportion of the two (might be expressed as a percent); c) in the case of ears being picked and then subjected to bird attack, weighing an ear both before and after bird attack, then subtracting from this weight-loss, the weight-loss in a similarly treated ear that was not subject to bird attack; d) measuring the distance down the ear that the damage extends, or the distance down each row of kernels that the damage extends; e) measuring the total length of the ear and the damaged part (as in d) and calculating the ratio; f) estimating the percent of the surface of the ear that has been pecked; g) weighing the damaged ear after it has been dried to a given moisture content and expressing the loss as percent of weight of a comparable size ear without bird damage; h) estimating the number of pecked kernels or the distance down the ear that the damage extends (the information is expressed as percent of the whole and is taken in broad categories or classes); i) designating the ear as "damaged" when there are but two classes of ears: damaged and undamaged.

The method selected depends largely on the number of ears to be examined in relation to the effort available and the precision required. When great care and effort have gone into a small scale experiment, the use of one or more of the time-consuming damage measurement methods is warranted. In contrast, when a general area survey is undertaken, or when experimental treatments are applied over large areas involving thousands of ears, precise measurement should be sacrificed for increased sampling. Before selecting the method of assessing damage on the ear, one should determine: a) the number of damaged ears that must be examined, b) the uniformity of the corn population, c) the degree of damage that must be detected to fulfill the objective of the test. When the progress of damage on an ear is being measured (as when treatments are being applied intermittently a few days apart) a method must be selected that does not involve picking or altering the ears, as in f), h), or i) above

Examples of Use

The several methods of measuring damage on an ear of corn, plus numerous variations of the methods, have been used by investigators in different parts of the country:

a. The validity of using the number of damaged vs. undamaqed ears is well covered by Hayne (1946) based on work in Michigan; however, there is evidence that under the non-uniform conditions of corn production in the Delaware Valley, a simple count of damaged ears cannot satisfactorily reflect the amount of damage sustained in a planting of corn.

b. Glitz (1965) in Ohio assessed damage on ears by measuring the distance down the ear from the tip that the damage extends. This measurement is expressed either directly in inches or as a fraction of the total length of the ear (normally in tenths of the total length). A similar method was previously used in New Jersey, but Granett (1966) is currently estimating percent of kernels destroyed, utilizing five broad categories of damage. The areas of damage on the ear, and even the volume of damage, are often fairly approximated by these methods, given uniform conditions of time of damage, type of damage, and type and maturity of the corn.

c. DeGrazio (1963) at Sand Lake, South Dakota, used a method similar to that used in Ohio, but with the additional refinement of selecting samples of several sizes of ears, drying the ears, and then determining the amount of grain associated with each 1/2 inch of kernels removed. From a table based on these data, one can estimate directly the grain loss when he knows the total length of an ear and the distance down an ear that the damaqe extends. No effort was made to adjust for various shaped ears or differing kernel depth associated with different strains and hybrids.

CALCULATING LOSS

The damage measurement data are used in various ways to calculate loss. The number or percent of kernels, the length or area of damage on the ear, or the percent of the ear affected is translated into either absolute loss (weight or bushels per acre) or percent of the crop destroyed. When absolute loss is figured directly, the yield information must be gathered concurrently with damage data; loss expressed as percent of the crop requires no gathering or calculation of yield information. (Complete yield data can usually be obtained separately at harvest or through one of the agricultural crop reporting agencies.) The ratio for converting raw damage measurement data to loss is not fixed, and it must be based on prior work under comparable test conditions. Direct conversion of percent of ear or percent of kernels is seldom satisfactory because ears vary greatly. For example, the top 1/3 of an ear was found to have, on the average, only 10 percent of the volume of grain in one variety but over 20 percent in another variety.

RATE OF SAMPLING

The number of ears to be examined is sometimes set by the nature of the test. In one series of tests where great effort was expended on relatively few ears, careful measurements on the moisture, maturity, weight loss and sugar content (all related to damage) took 40 minutes per ear. In another test, where the trend of damage throughout a two-county area was being sought in relation to bird populations, damage measurements were made in less than 2 seconds per ear.

The objective of the test or survey should be considered in detail to determine the type and the rate of sampling; possible different use of the damage data by others also should be considered.

One should initially consider just the number of ears to be examined, without reference to samples, fields or location. Ideally, the ears would be independently selected (as 5,000 ears in a county, each ear randomly selected without reference to township, fields or samples within fields). However, since 50 or 100 ears can be examined in little more time than it takes to select and examine one ear (by certain of the assessment methods), and since additional samples within a field can be taken much faster than the same number of samples taken from several fields, independently selected individual ears are seldom used. A sample of many ears instead of a single ear provides an improved estimate of the sample; however, the use of many ears in a sample is not the same as additional sampling.

An investigator should avoid sampling the whole field on which his test is being conducted unless the objective is to obtain results applicable only to that specific field or other comparable fields. Each field has a whole set of peculiarities influencing bird damage; hence fields vary greatly and whole-field tests usually have very limited application. In addition, satisfactory tests are much easier to perform when the objective is directed toward restrictively defined corn (plots that are located a given distance from the treatment area within a field, have the same physiographic and cultural conditions, etc.). A series of such tests can cover most of the important conditions under which corn is produced, and thus the results have general application.

In exploratory or initial testing of an hypothesis, it is usually desirable to restrict the assessment to a single set of conditions. For example, evaluate the treatment effect on corn that is: a) a given distance from marsh, b) of a given hybrid, c) a given distance from field edge, d) uniform in respect to ear size, husk coverage and height of ears above ground. An investigator who has thus controlled these test conditions has assurance that differences in damage that he detects are related to the treatment effect, and not to the compared corn plots being a different distance from marsh-land, of different hybrids, etc.

PLANNING CONSIDERATIONS

The decisions leading to an appropriate test design must be based on prior information on the distribution and nature of damage to be expected. Much damage information has been collected and arranged in a form that should be useful to one who is designing a test and is faced with the questions: What measurement method should be used? What sampling intensity and sample size are necessary?

Distribution of Damage

The single key to the proper design of all tests and surveys is an understanding of how damage is distributed: how it is distributed spatially (in respect to hydroqraphic and topographic features, roosting areas, flightlines, etc.); how it is distributed temporally (the amount of damage that occurs during each of several stages of maturity of the corn crop, and the amount of damage in respect to advancement of the season independent of crop maturity); how it is distributed among ears (the tendency for damage to be equally distributed among most ears vs the tendency for damage to be concentrated on relatively few ears). Figure 1 depicts the distribution of damage among a series of samples within a grouping of low damage areas and another series from a grouping of high damage areas; 43 percent of the samples in both series had less than 5 percent of the grain destroyed. The data were taken during a survey study of field corn damage in the Mid-Atlantic States, 1959 to 1965.

Variation in Measurement

In addition to knowledge of the damage distribution to be expected, the research planner must also know how reliably the damage that has occurred will be measured. To gain some understanding of consistency of damage assessment information, damage has been measured under various sets of conditions of testing that embodied: 1) four methods of measuring damage; 2) three different sample sizes; 3) two intensities of damage (light or under *5%* of the grain destroyed, and heavy or over 8%); 4*)* different numbers of observers (one to four observers measuring damage on the same samples); and 5) different methods of indicating the samples (samples with each ear marked, and samples with just the sample area indicated).

CONCLUSION

The underlying doubts as to the validity of findings that assail many workers in the field of blackbird depredations stem from an inability to judge what damage is to be expected under various normal conditions. When the conditions under which damage occurs are carefully isolated and the changes in damage that are associated with changes in degree or setting of each condition are determined, then tests, field evaluations, and surveys can be judged with confidence.

CITATIONS

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Figure 1. Distribution of bird damage among samples of corn in the Delaware Valley, 1959 to) 965. The x's represent 288 samples from high damage areas (mean grain destroyed: 24 percent), and the o's represent 288 samples from low damage areas (mean grain destroyed: 6 percent). The 247 samples with less than 5 percent grain destroyed are combined and shown in detail in the insert.