'Crop Loss' Correct Term When Meaning Understood

In his editorial "Use of the Term 'Crop Loss'" (PLANT DISEASE, Vol. 69, No. 2, p. 95), R. James Cook continues the discussion on crop losses presented so ably by C. E. Main and others in *Challenging Problems in Plant Health* (1) and *Crop Loss Assessment* (2). Dr. Cook proposes that in most cases the usage of the term "crop loss" is incorrect. Surely, "crop loss" is merely an abridged form of "potential crop loss" or "theoretical crop loss," meaning the difference between attainable and actual yield. Thus understood, its usage is entirely correct. Conceptually, one can have a potential yield early in the season, then lose it before harvest time comes.

I agree with Dr. Cook that losses claimed for weeds, insects, pathogens, and nematodes usually should not be combined additively. It would be interesting to attempt to determine the accuracy achievable by combining these potential crop losses in a very simple multiplicative way. To do this, one needs precise yield data from a factorial experiment, such as a test of a fungicide and an insecticide or herbicide. With over $10 billion per annum spent on pesticides, there must be many agronomists who have done such work under the aegis of integrated pest management, in tank mixes, or simply during the course of checking whether the extension advice given to our farmers is really cost-effective. A check in the library and with a dozen or so colleagues in protection research, extension, and economics has failed to turn up a single paper with which to test the multiplicative hypothesis, so I would be grateful to hear from any readers who have published such data.

Often, the issue of how to deal with multiple causes of loss is largely avoided by conducting experiments on a single pathogen under conditions relatively free from weeds, insects, and nematodes.

Using "crop loss" is much to be applauded because the term highlights the reality and urgency of such losses, despite the fact they are not as tangible as, for example, the trail of a leaking grain truck I saw yesterday. The change in thinking that is required is not a change in semantics, but rather a greater emphasis on thorough study of the disease-yield relation and integrated crop management. In particular, editors should encourage authors to include economic analyses with their data. These analyses should include sufficient information to enable the reader to substitute a different pricing structure and recalculate the analyses if desired.

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A recent editorial by R. James Cook (PLANT DISEASE, Vol. 69, No. 2, p. 95) addressed the value and usage of the term "crop loss." He suggested that usage of the term "in most cases is incorrect" and implies that the term has no clear definition and hence is of limited usefulness.

We believe the term has utility when addressing the impact of pests and pathogens upon crop growth and yield. Dr. Cook states that with few exceptions, diseases "do not cause 'crop loss,' nor can they 'reduce yields.'" An analogy involving tax laws and acceptable deductions is offered to demonstrate the case. We find this analogy somewhat misleading. Tax laws are rather arbitrary constructs designed to procure revenue for the government in a fair and expeditious fashion. The tax laws certainly do not allow for specific types of claims involving capital gains because 1) it is not in the government's interest to do so and 2) the innumerable problems associated with verification of claims prohibits leeway in this regard. We thereby discount arguments that include analogies involving the IRS and taxation laws.

As to the term "crop loss," we submit that it is commonly defined as Dr. Cook believes it should be (and seems to believe is not) as: an assessment of the influence of pests and pathogens in modifying the growth and yield of crop plants as compared with their potential growth and yield under specific soil, climate, and agronomic conditions. The concepts involved have been excellently reviewed by Zadoks and Schein (1). Typically, "crop loss" studies are conducted under controlled laboratory, greenhouse, and field experiments. They are designed to test, via specific statistical analyses, differences in plant growth and yield relative to appropriate "reference standards"—control treatments. The control treatments do not necessarily represent totally controlled, pestfree environments, and appropriately account for the multivariate nature of yield-determining factors. These types of experiments seek information on the relative performance of crop plants under specified biotic stresses. Experiments may address a specific pest, pathogen, or suite of pests and pathogens. Ideally, the experiments would involve those "key pests" that appear to most influence plant growth and yield. Two questions arise: 1) How realistic are the experiments and can the results be extended to other situations? 2) Is "crop loss" a term that can be used to describe the impact of the pests and pathogens upon crop growth and yield?

The first question deals with the philosophy of science and the justification of our claim to a "scientific understanding" of any specific biological phenomenon. The hypothetico-deductive scientific method involves the generation of hypotheses, testing of hypotheses, and subsequent acceptance, rejection, or modification of hypotheses in an iterative process.

The hypothesis that the total impact of a suite of pests and pathogens can be obtained by summing estimates of relative growth and yield from disparate studies is rejected on this basis—it does not stand a comparison with the observed results. Dr. Cook suggests that accepting usage of the term "crop loss" implies concurrent acceptance of such a hypothesis. This suggestion is not realistic, and crop loss assessment is not based on such a hypothesis. Understanding complex biological phenomenon is typically accomplished via reductionist, discipline-oriented research, and the problems of such approaches are many and manifold. The philosophy of integrated pest management has been advanced partially because of the shortcomings of the classic reductionist, hypothetico-deductive approach.

The second question has been answered in the negative by Dr. Cook, as "one cannot lose that which never existed." On the surface this statement seems true, but is it?

A growing crop plant is actively incorporating radiant energy into biomass and conforms to the laws of thermodynamics. The energy budget of the plant can be quantified. Therefore, a growing crop plant (under specific conditions) can be reasonably expected to "perform" in a specific manner; a potential for growth exists (assuming for the sake of argument that abiotic factors are not limiting). This potential is contained in the genome of the plant, and as it grows, this potential is expressed. Pests and pathogens may directly consume plant biomass and convert that biomass to pest or pathogen biomass, thus altering the trajectory of expression

of potential plant growth and yield. The plant is losing something that it did have—an investment of energy. The summation of incremental losses of energy and biomass over time represents a portion of crop loss. The argument concerning "losing what you never had" collapses upon examination.

We recognize that the impact of a parasite or pathogen upon plant physiological processes is also important in determining plant growth and yield. A strong analogy may be drawn between the accepted definition of "loss" in an electrical circuit and "loss" in plant growth rate due to pests or pathogens. In an electrical circuit a loss may be defined as a reduction of current (a rate) due to resistance. This is analogous to a "loss" in the growth rate of a plant due to the imposed resistance of pest or pathogen.

The concept of crop loss is also couched in terms of economics. From the economic standpoint, profit-motivated growers generally adopt crop management practices based on expected returns on investment. Due to the impact of pest or pathogens, the crop never attains its full growth or yield potential. If the impact on the crop is severe, the grower may elect to forego the additional production costs associated with harvesting the crop. To the grower, this clearly and irrefutably represents an economic loss—a loss of a crop that "never was." This scenario, even though extreme, can be extended to intermediate levels of pest or pathogen infestation. To the grower experiencing the economic impact of pests or pathogens, the difference between realized yield and expected yield represents a loss. This is in total agreement with published definitions of the term "loss." The quantification of differences between expected and realized yields forms the economic rationale for crop management.

We believe the concept of "crop loss" is a useful construct. We do not deny that it is susceptible to misuse; however, this does not invalidate proper use of the term. The problems associated with assessing relative yield are significant, and researchers interested in assessing crop losses due to the activities of specific pests and pathogens should recognize such potential problems and try to conduct research within a sound statistical framework. We hope that criticisms of crop loss assessment will spur further participation of plant pathologists in integrated crop management programs.

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