Economic Nematology

edited by J. M. Webster

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Preface

The aim of this book is to satisfy the needs of agriculturalists, nematologists, researchers and students for a reference text to the important nematode pests of the world's major crops. It was believed there was an urgent need to produce such a textbook to complement the taxonomic and physiological nematology texts. Information on the cultural practices used in the production of each of the crops was essential to show how these practices could influence the presence and development of the specific nematode pests of the crops. One of the major concerns of the book was to emphasize not only the nematode pests of crops and how they are controlled, but also to give some estimate of the economic loss currently caused by nematode pests.

This breadth of coverage meant that no one person could write authoritatively on such diverse crops and so twenty-two experts have contributed the various chapters of this book. Although the coverage is wide it is inevitable that many crops are included only briefly or not at all. In choosing crops for inclusion, cognizance was taken of the volume and value of the world production of the crop as well as any special growing conditions. It is nevertheless regrettable that separate chapters could not be devoted to such crops as pineapple, maize, grapes or hops, but space was at a premium.

One of the possible hazards of several authors writing on a common theme is the chance of considerable overlap of chapter content. This has been kept to a minimum, and as each chapter probably will be read as a self-contained unit such overlap as occurs should afford completion and emphasis of the topic rather than cause confusion.

Except for the first, the penultimate and the final chapters, which themselves serve to draw together and place new perspective on the content of the seventeen "crop chapters", the general format for each chapter follows the same pattern: namely, introduction to the crop and its production, nematode pests, cultural and environmental influences on the nematode pests, control and, finally, economics of the nematode pest problems. It is this last section in each chapter which really is the *raison d'être* for the book. Hence, the reason, also, for the first chapter on the economics of crop diseases. I venture to suggest that the completed text indicates that we are still unable, for many crops, to make dependable predictions on crop losses. Therefore, as well as serving as a

useful reference work on nematode pests this book should also encourage researchers to consider in economic terms some of the data that current investigations provide.

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January, 1972 JOHN M. WEBSTER

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Economic Aspects of Crop Losses and Disease Control

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I. Introduction

Plant diseases and the consequent crop losses are as much a subject of concern to the economist as they are to the plant pathologist, the nematologist, the entomologist, the agronomist and the rest. The economic consequences of crop losses due to diseases are many and varied.* First, there is the loss of revenue or the increased cost of production to the farm producer because of the reduction in crop yield or the loss in quality of the marketable produce. In addition, there is the factor of uncertainty which the farmer must face. Second, there is the loss to the consumer, household and industry, either through the price increase or through the deterioration in quality of the consumable product or a combination of these two. Third, there is the loss to the society, of which the producer and consumer are a part, in the form of wasted

* For this study, crop diseases include those which are caused by the attacks of insect pests, fungi, viruses, nematodes and weeds.

resources which have direct and implicit costs. Finally, there is the loss sustained by the world community, especially in those parts of the world that are struggling against food and raw material shortages, population growth and slow development. These losses are not confined to food crops. They affect also the cash crops which form a major source of revenue to the farmers and to the industry.

There is yet another dimension to this problem: the economic aspects of disease control. If controls are technically feasible and effective, they normally involve additional costs which have to be compared with the revenue saved or the benefits derived. It may be that the costs of control exceed their benefits. If that is so, the economic problem is clear and a decision must be made as to whether to control the pest or to shift the given crop resources to some other use. In other words, resource reallocation may be considered.

Current literature on crop diseases and their control, while it is voluminous and impressive in the field of biology, is scarce and incomplete in that of economic analysis, as can be seen from Cramer (1967), Anon. (1967), and a recent study published by Anon. (1971). There seem to be many reasons for this and they need no restatement here. In this study, those deficiencies of analysis which have economic foundation will be examined. This examination will take the following form:

1. An attempt will be made to discuss available data on the extent and type of crop losses, in quantity and value, caused by diseases.
2. The economic principle will be defined and its relevance to the subject of crop diseases and their control analysed.
3. The economic aspects of crop losses due to diseases will be examined.
4. The economic aspects of disease control will be analysed.
5. A research proposal on the methods of economic evaluation of crop diseases and their control will be presented.

II. The Extent and Type of Crop Losses due to Diseases

It is well recognized that there is a paucity of information about the extent and type of crop losses due to various diseases. Even in those few countries where statistics are collected and published, they are often incomplete and inaccurate. There are several reasons for this. First, in the majority of cases, there are conceptual problems arising from the definition of losses. Second, there are the problems of estimation of losses. Third, in many parts of the world there is no system of record collection, in which case sound interpretation of the available data is almost impossible.

Notwithstanding the above reservations, one recent study of the extent and type of crop losses due to plant diseases is quite comprehensive (Cramer, 1967). With some changes in the arrangement of data, the annual world crop losses in quantity and value are reproduced in Tables I and II.

TABLE I. Annual world crop losses (in million tons; 1 ton = 1·02 metric tons)

Commodity	Actual production	Potential production	Crop losses due to: Insect pests	Diseases	Weeds	Total
Cereals	961·1	1467·5	203·7	135·3	167·4	506·4
Potatoes	270·8	400·0	23·8	88·9	16·5	129·2
Sugar-beet and Sugar-cane	694·6	1330·4	228·4	232·3	175·1	635·8
Vegetables	201·7	279·9	23·4	31·3	23·7	78·2
Fruits	141·7	197·2	11·3	32·6	11·6	55·5
Stimulants	10·2	16·5	1·9	2·6	1·8	6·3
Oils	94·7	137·0	14·5	13·5	14·3	42·3
Fibres	16·0	23·2	3·0	2·6	1·6	7·2
Natural Rubber	2·3	3·0	0·1	0·5	0·1	0·7
All Crops	2393·1	3854·7	510·1	539·6	412·1	1461·6

After Cramer (1967).

TABLE II. Annual world crop losses (in 1000 million U.S. dollars)

Commodity	Actual value	Potential value	Crop losses due to: Insect pests	Diseases	Weeds	Total
Cereals	63·9	98·0	14·4	8·7	11·0	34·1
Potatoes	10·6	15·6	1·0	3·4	0·6	5·0
Sugar-beet and Sugar-cane	7·6	13·9	2·3	2·3	1·7	6·3
Vegetables	16·7	23·1	2·0	2·3	2·0	6·3
Fruits	14·3	20·1	1·2	3·3	1·2	5·7
Stimulants	7·2	11·4	1·3	1·7	1·2	4·2
Oils	10·6	15·7	1·8	1·6	1·7	5·1
Fibres and Rubber	8·6	12·7	1·8	1·5	0·8	4·1
All Crops	139·7	210·5	25·8	24·8	20·2	70·8

After Cramer (1967).

As Cramer (1967) admits in his study, the estimates given in Tables I and II are no more than the dimension of magnitudes they represent. Yet these approximations emphasize the enormity of the problem in that about 33% of the potential agricultural value is lost annually. These are, however, not the only losses which result from crop diseases. Virtually no data are available on the value of losses to the consumer and to the society. Assuming that such losses occur, the total loss due to crop diseases must exceed the figures given in the studies by Cramer (1967), Anon. (1965) and Anon. (1971).*

III. The Economic Principle

Economic science deals with a particular relationship between ends and means. Ends or objectives may deal with physical production, consumption or profits. Means or resources are concerned with physical resources, funds or organizations which can be used in achieving the objectives. However, this relationship between ends and means is not *per se* an economic problem. It is an economic problem only if there are *many* ends that need satisfying, and that the means to achieve these ends are *limited*. Given this condition, the central problem in economics is the problem of choice between alternatives. To resolve the problem of choosing between alternatives, economics deals with the maximizing and minimizing conditions. The maximizing condition deals with the maximization of ends, like physical output, consumer satisfaction and resource allocation. The minimizing condition involves the minimization of means, like the use of land, labour, capital and organization. Economics, therefore, deals with either the maximization of ends with the given means or the minimization of the use of means for the given ends.

Since at the heart of economics lies the problem of choice, it seems appropriate to demonstrate this problem of choice. Suppose that a farmer has one unit of resources which can be used in the production of crop A or B. His goal is profit maximization. Specifying the production conditions of crops A and B, that one unit of resources will yield 20 bushels of crop A or 50 bushels of crop B, should he grow A or B? His choice principle is given by the crop price ratios. If the price of crop A is $2.00 per bushel and that of crop B is $1.00 per bushel, the choice ratio of A to B is 2 : 1. Given this, the farmer should obviously select B and not A. But if this ratio changes in favour of A, because either the price of A goes up and the price of B remains unchanged or

* This study by a committee chaired by Dr J. Feldmesser provides extensive data, perhaps for the first time, on crop losses due to nematodes in agriculture in the U.S.A.

the price of A remains unchanged and the price of B goes down, he must select A rather than B.

Of course, in practice the problem of choice is not as simple as stated above, but this example does illustrate the choice principle clearly. The choice indicator may be different, depending on the objective(s) selected, but the principle remains intact. The economist has come to rely more and more on mathematics as a tool of developing these choice indicators.

Having so defined the economic principle, its relevance to the problems of crop protection becomes at once obvious. This principle is equally applicable to the farmer, the consumer and the society. To the farmer, its relevance lies in the fact that, at any given moment, he has limited resources which he can use in different farm enterprises. Crop losses due to diseases, whether they affect the crop yield or the price because of the deterioration in the quality of the product or the residual effect on land, give rise to either losses in revenue or increases in the cost of production. To the consumer, the adverse effects of crop losses result in price increases which reduce his real income or through the loss in quality of the product they affect his total satisfaction. To the society, these losses result in the non-optimum use of national resources. It is obvious that in all these cases the maximizing and minimizing conditions are being violated. Using the economic principle, the economist can demonstrate more accurately the consequences of crop losses. It seems quite appropriate to pause and look at some of these consequences through the economist's eye.

A. The Consequences to the Farmer

Crop losses due to plant diseases appear in different forms on the farm. The more common of these forms would be the loss in yield of the product and the deterioration in the quality of the product. Both of these are likely to affect the price and total revenue—total revenue being the product of the price per unit multiplied by the quantity sold. The yield and quality losses also increase the cost of production per unit of resources. There may be yet another type of loss that the farmer faces if the disease is of a persistent character, in the sense that it leaves residual effects in soil or seed, which will affect farm planning for several seasons or years. This could force the farmer to reallocate his resources. In addition, if the farmer undertakes disease control, his cost of production might increase to the extent that, on per unit basis, the additional cost is greater than the additional revenue. In almost every case, controls add to the current or variable costs (like labour) of production. If these additional costs, while kept to a minimum, cannot save much additional value or return, these controls cannot be regarded as

profitable. In fact, the farmer may find it more profitable to invest his resources in another crop or farm enterprise. The discussion on the economic consequences of controls will be postponed until a later section.

Returning to the price and revenue effects, assume that there are no effective controls available and that the yield and quality of the crop are adversely affected in one season only. The initial effect is that there is a decrease in marketable supply. This reduction in supply, if it occurs only on one farm and if the affected producer is not an influential supplier (i.e. he is only one among many), is most likely to reduce the total revenue of this producer because he cannot determine the price of the product by himself. But if the disease affects the majority of the suppliers in a market, the economic scene changes. As for the price and revenue effects on the farmers, much will depend on the nature of demand for the product so affected. This can be demonstrated by a simple example.

Assume that there are only two crops, wheat and apples. Also assume that the supply conditions for these two are similar. On the demand side, assume that it is dissimilar for these crops. The conditions of demand may differ for several reasons. First, wheat and apples occupy different positions in the consumer's budget and preference scale. Wheat is a staple crop, while apples are not. Second, apples are likely to have more close substitutes than wheat has. Following these assumptions of supply and demand, it can be shown that the decrease in the supply of the two crops caused by disease will have different results.

In Figs 1 and 2 the familiar demand and supply conditions for wheat and apples are depicted. The demand line, DD, shows the combinations of various quantities that the consumers would be willing to buy and the price levels at which these quantities will be bought. The supply line, SS, indicates the combination of various quantities that the producers or suppliers would be willing to sell and the price levels at which these quantities will be sold. The demand lines or curves for wheat and apples have different slopes, which reflects the fact that the two products occupy different places in the consumer's basket. The demand line for wheat has a steeper slope. In the economist's jargon, wheat has a relatively "less elastic" demand and apples have a relatively "more elastic" demand.

The concept of "elasticity" has a specific meaning in economics. The ratio of the percentage change in quantity to the percentage change in price, when the price change is small, gives the elasticity of demand for a particular product. If, in response to a percentage change in the price of a product, the percentage change in the quantity demand is greater, the demand is said to be relatively more elastic. Conversely,

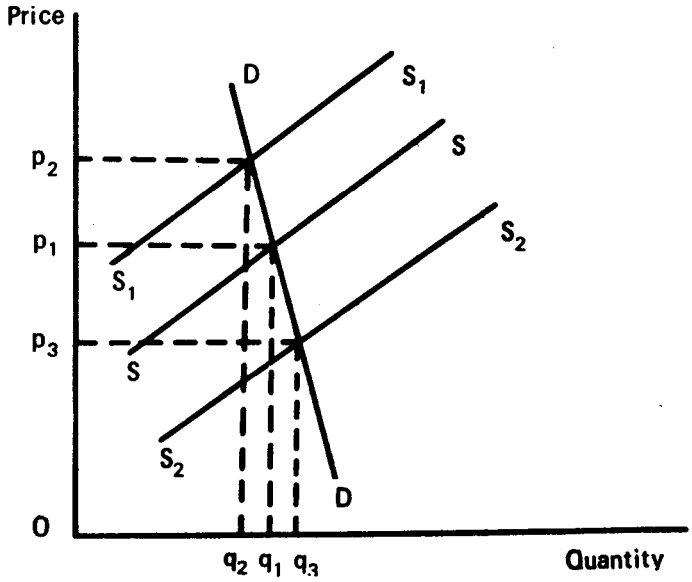

FIG. 1. Wheat: price and quantity effects.

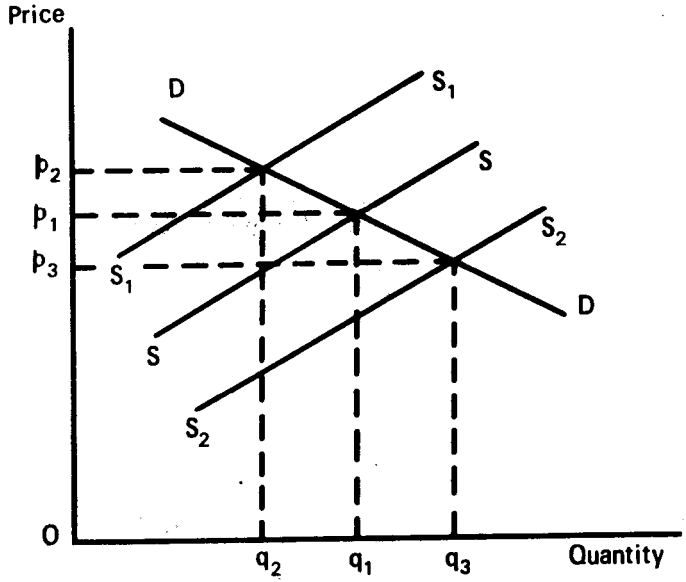

FIG. 2. Apples: price and quantity effects.

if the percentage change in the quantity demanded in response to a percentage change in the price is smaller, the demand is said to be relatively less elastic. In the example used here, the demand for wheat is relatively less elastic and for apples it is relatively more elastic. Buyers of wheat are, in other words, less responsive in terms of the change in quantity than to a change in the price. In the example of apples, buyers are more responsive.

Returning to Figs. 1 and 2, say the original positions of supply and demand are shown by SS and DD lines. The prices and quantities which are agreeable to the buyers and sellers are at the point of intersection of supply and demand curves. These are labelled as p_1 and q_1 for wheat and apples. Assume now that owing to diseases on both wheat and apples, the supply at each given price is reduced: less of these two products is offered for the same price. This means that the supply curves shift upward to the left, from SS to S_1S_1. Also assume that the demand conditions remain unchanged. The result is obvious: that the prices of wheat and apples will increase and the quantities bought and sold will decrease, p_1 to p_2 and q_1 to q_2. The changes in the price and quantity of wheat are likely to increase the total revenue and decrease the costs. However, for apples, these changes will reduce the total revenue and perhaps will increase the costs. While the price and quantity changes are similar in both instances, in one instance the farmers stand to gain and in the other they may lose.

In reality it is not as simple as that. The reduction in supply may also mean that farm resources have not been used optimally or at the lowest cost per unit of output. First, in instances where additional revenue has accrued through price increases that may not equal the cost that the waste in resources imply. Second, the wasted resources could have been used optimally had they been put to some other crops. Finally, to a single farmer, who may be the only one affected adversely by crop losses due to diseases, the total loss may even be greater.

Modifying the foregoing example, assume now that the farmers have been growing wheat and apples under disease conditions but they now find controls which save the yield and the quality of products to be marketed. What will this increased supply do to the farmers? Going back to Figs 1 and 2, the immediate effect is that the supply curves shift outward to the right from SS to S_2S_2: more is supplied at each given price. The price received will decrease, from p_1 to p_3, but the quantity sold will increase, from q_1 to q_3. In the case of wheat, the decrease in price is likely to result in a loss of total revenue to the farmers, while for apples, this may increase the total revenue. So it is not always true that disease control will increase the farmers' total revenue. Further,