Man-Made Plant Diseases

Some agricultural operations necessary for efficient crop production favor many plant diseases and create new ones.

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Driven by the need for more food and the desire to produce it for less and less cost, men have developed agricultural practices which have been spectacularly successful in attaining both of these goals. Yet these same activities have favored the incidence and development of plant diseases. Part of the impact of man's activities on losses from plant diseases is obvious and dramatic. More subtle effects are apparent only as a result of comparing disease development under natural ecological conditions with that resulting from specific treatments.

Nearly all major crop plants originated before the dawn of history (*1*), and their major pathogens are probably also prehistoric. Yet the number of recognized diseases is increasing. Between 1926 and 1960 the number of recorded diseases of our principal crops increased about threefold (*2*). Some of this apparent increase is undoubtedly due to recognition of diseases which had been previously overlooked. Some of the increase in this period, as well as prior and subsequent to it, is due to the activities of man in increasing the numbers, prevalence, and destructiveness of diseases.

The principal mechanisms by which man has been and still is increasing disease are by plant introduction and commerce, vegetative propagation, monoculture, tillage, harvesting, storage, fertilization, irrigation, use of herbicides, plant breeding, site location, and release of disease-producing chemicals. All of these procedures are necessary or desirable for highly productive agriculture, or are an accidental result of man's activities. Each will be further documented.

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Plant Introduction and Commerce

Most crops are grown in areas other than where the species evolved (*3*). This introduction of crops has been highly desirable in that it has given wheat and soybean to North America, and potatoes and corn to Europe, to cite only four of many examples. But crop introduction by man has introduced many pathogens to areas which were previously free of them. This has been especially true where planting stock such as seedlings or vegetative parts have been moved. Examples are white pine blister rust from Europe to North America and potato late blight from South America to Europe.

The pathogen may also be effectively introduced by man on seed, lumber, packing material, soil, dried plant specimens, or pure cultures. The disastrous Dutch elm disease was apparently introduced to America in cut logs (*4*). A crop may be introduced to an area where it is attacked by an inconspicuous or unknown pathogen of the native flora. Fire blight of pears caused by *Erwinia amylovora* (*5*) and yellow bud mosaic of peaches caused by tomato ringspot virus (*6*) are examples. Quarantines are designed to prevent the introduction of pests by man, but there is no logical way to anticipate and prevent diseases such as fire blight and yellow bud mosaic.

Vegetative Propagation

Vegetative propagation is an efficient method of man to reproduce desirable clones of crop plants such as potatoes, peaches, and bananas. But it is also a major method of dissemination of many pathogens which are carried in vegetative parts of plants but not in seeds (*7*). Examples are psorosis of citrus, leaf roll virus of potatoes, and fan leaf of grape. Certification of planting stock, propagation from seeds, heat therapy, and tip culture are designed to control this type of infection.

Monoculture

Pure stands of species are rare in nature. Monoculture is the almost universal practice in agriculture of growing the individual plants of a given crop close together to the exclusion of other species. This makes for efficient agricultural operations, but it favors many diseases (*8*). Logically and experimentally, the chance of dissemination of a pathogen from an infected plant to a healthy one varies inversely with the distance between them (*9*). One method of controlling such diseases is by genetic diversity (*10*), but this has obvious limitations.

Tillage

Tillage is the mechanical cultivation of soil before planting a crop or the interrow treatment during crop growth or both. Tillage was perhaps the most decisive feature in the change of civilization from food gathering to permanent agriculture. It has been estimated that food production per unit area of land increased about 6000-fold (*11*) as a result of this change. Most, if not all, diseases occur without tillage, but tillage greatly increases the incidence of many of them (*12*). Because agricultural crops were selected in prehistory to produce well with tillage, the best examples of disease increase due to tillage are naturally with nonagricultural plants. In my experience (*12*), the greatest increase in disease due to tillage has been with powdery mildew on coyote brush (*Erysiphe cichoracearum* on *Baccharis pilularis*) and canker on buckeye (*Phoma paviae* on *Aesculus californica*), where cultivated plants were heavily infected and noncultivated plants were practically free. Of 21 fungal pathogens and one virus observed in this study, 12 fungi were more severe on cultivated than on noncultivated plants, eight were about equally severe on cultivated and noncultivated plants, and only one (*Botrytis cinerea* on *Vicia faba*) was apparently reduced by cultivation. In these cases

the increased disease was clearly associated with the increased growth and succulence of the tilled plants. Such diseases can be reduced by reducing tillage, but the loss in crop production due to reduced tillage would be greater than the loss in crop due to disease.

Tillage may increase disease by redistribution of the pathogen as with tobacco mosaic of tobacco (*13*) and with southern blight of peanuts (*14*). Many of the wounds through which pathogens enter their hosts are produced by tillage, as with *Fusarium* on beans (*15*) and crown gall on stone fruits (*16*). Usually wounding and inoculation occur simultaneously.

Diseases favored by tillage can be reduced by substituting chemical weed killers (*17*) or plastic covers (*18*) for tillage, but these treatments have limitations.

Harvesting and Storage

Harvesting and storage are necessary for the maintenance of food supplies for long periods after crop maturity. Harvesting practices, especially modern high-speed methods, favor disease by distribution of the pathogen as with stinking smut of wheat (*19*), and by causing wounds to the harvested product as with *Rhizopus* rot of sweet potatoes (*20*).

A disease-favoring aspect of storage is the crowding together of the harvested units. This favors disease in the same way as monoculture. In addition, the storage environment, especially temperature and humidity, may determine the development of pathogens already present. Storage diseases are controlled by individual wrapping of fruits, by maintenance of low temperature and humidity, by fungicidal gases, and by ventilation.

Fertilization

Fertilization with mineral nutrients (nitrogen, phosphorus, and potassium), more than any other agricultural operation, is responsible for the increased crop yields in the United States in the past 40 years. Increases in disease due to fertilization are also common (*21*). Control of such diseases by reduced fertilization is impractical because the increased yield due to fertilization is usually much greater than the loss due to disease (*22*).

Irrigation

Irrigation is necessary for profitable agriculture in many areas of the world, especially in the arid western United States. The addition of water which favors the crop also favors many diseases. Furrow or flood irrigation favors pathogens requiring high soil moisture such as *Pythium*. Sprinkling irrigation favors diseases spread by splashing rain such as bacterial blight and anthracnose of bean (*23*). Control of diseases favored by flood irrigation may sometimes be accomplished by reduced watering, by fungicidal treatment of the soil, or by crop rotation. Control of diseases favored by sprinkling irrigation may be accomplished by change to flood irrigation, or by timing irrigation so plants remain dry at night.

Herbicides

Use of herbicides to control weeds is the most recent of the widespread application of chemicals to agriculture. They may decrease disease as in the substitution of herbicides for tillage (*17*), or they increase disease as in selectively favoring a host which carries a pathogen or carries a vector of a pathogen (*24*).

Plant Breeding

Most annual crops are under continued breeding programs to produce better cultivars. Selection in the absence of a particular pathogen may unwittingly result in selection for susceptibility to that pathogen. The development of Victoria-type oats for resistance to rust unconsciously resulted in selection of varieties susceptible to *Helminthosporium victoriae*, a pathogen previously unknown (*25*). In general, the succulent, fast growing commercial varieties of crops are more susceptible to pathogens than their wild ancestors. The crossing of susceptible commercial varieties with resistant wild species is a standard method of breeding for disease resistance.

Site

The incidence of disease is determined in large part by environment and by proximity to sources of infection. Sites which are favorable for a specific crop may be disastrously favorable for a disease of that crop. Over a period of many years hop production in California became concentrated in bottom lands along the Russian, American, and Consumnus rivers. These sites proved especially favorable for hop downy mildew caused by *Pseudoperonospora humuli*, which was accidentally introduced in 1934. Although fungicidal control for this disease was developed, this control was so expensive that this industry has moved to the drier interior valleys of Oregon, Washington, and Idaho.

On a smaller scale, head lettuce and tomatoes cannot be grown profitably in proximity to nurseries where ornamentals are grown, because many ornamentals are an important source of infection for spotted wilt virus, which may be severe on lettuce and tomatoes.

Man-Made Diseases

Several nonparasitic diseases are caused entirely by man. The smog which eliminated such crops as Romaine lettuce from certain areas near Los Angeles (*26*) was produced largely by automobiles and industry. The killing of vegetation near smelting plants has been largely due to sulfur dioxide (*27*). The injury to roadside trees in the northeastern states is largely due to sodium chloride applied to speed the removal of winter snows (*28*). Control of these diseases lies in reduction of release of these toxic chemicals or removal of agricultural operations from these sites.

Discussion

Agricultural operations have contributed more to upsetting the balance of nature than any other acts of man. Many, if not most, of these operations are necessary to support the present population, or even to maintain the present affluence of a much smaller population. Some of these operations contaminate the environment directly by the dissemination of fungicidal chemicals, increasing smog, favoring dust storms, increasing erosion, silting of reservoirs and lakes, and speeding the eutrophication of inland bodies of water, and indirectly by increasing plant diseases, as well as in other ways. It seems likely that aggravation of pollu-

tion and plant disease by agricultural operations will continue, as no easy solution is in sight.

According to a recent estimate (*27*), annual losses to world crops as a result of disease are about $25 billion, in spite of present control practices. Some of this loss results from man's activities directed at producing these crops. Modification of these activities to reduce disease would usually decrease production or at least increase the cost of production. Most of disease control in the near future, as in the past, must likely be directed at the pathogen by such treatments as exclusion, eradication, protection, immunization, and therapy. But efforts must be expanded to secure control by methods which do not contaminate the environment.

Summary

Some of the increases in plant diseases are due to intensive agricultural and industrial operations such as plant introduction and commerce, vegetative propagation, monoculture, tillage, harvesting and storage, fertilization, irrigation, use of herbicides, plant breeding, site location, and release of industrial fumes. In many cases the gain in crop production due to these operations is greater than the loss due to disease, and therefore control of such man-favored plant diseases will be difficult.

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Tax-Exempt Foundations: Their Effects on National Policy

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The large tax-exempt foundation is a child of private enterprise. Foundations have acquired a unique role which is not readily describable in terms of "public" or "private" sector. The purpose of this article is to examine the impact of tax-exempt foundations upon public policy in the United States and to show that their "third-sector" character makes its difficult for them to secure acceptance of their activities or an economic base for charting new directions.

The term *foundations* designates organizations that have grown during the 20th century (most often in the form of corporations or trusts) and that have broadly defined charitable purposes, substantial capital assets, and income derived from gifts, bequests, and capital investments. They are granted tax-exempt status by section 501-c-3 of the Internal Revenue Code. The Code also allows income, gift, and estate tax deductions for contributions to foundations. Organizations supported by government funds are not foundations, nor are formal educational or church institutions, organizations testing and experimenting on behalf of the public interest, or certain non-tax-exempt trusts which set aside some funds for charity (*1*).

Longitudinal Profile of Foundations and Government

Big foundations became rooted in the United States at the beginning of this century and are a unique product of affluent industrialism. Organizations of such scale could hardly exist without the vast surplus of wealth which was accumulated in the United States during the 20th century. However, they did grow out of charitable organizations which flourished in earlier American history (*2*). These were endorsed, to an extent unparalleled anywhere else, by cultural influences which strongly favored "charity" as a mode of ameliorating social problems.

1) A dominant Protestantism propagated the idea that men achieved salvation by "good works" rather than religious rituals. Money could be spent to accomplish good works; individuals with sufficient funds used them in this way to assure themselves a life in the hereafter and, more especially, to give the pursuit of profit a higher status and meaning.

2) As a young nation the United States was basically a loose collection of dispersed and diverse communities relying more on ethical bonds than on a strong national government as a source of unity. Charitable donation was a means of strengthening the moral

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