at the world's fairs at New York and San Francisco will be made by internes in training at the Buffalo Museum of Science under Carlos E. Cummings, director, in cooperation with Robert P. Shaw, director of the New York Museum of Science and Industry. The internes will make an analysis of each exhibit, covering such items as the use of light and color, sound effects, labels, leaflets and folders, attendants and visitor participation and flow. An endeavor will be made also to list exhibits that might be suitable for museum use after the fairs. The Rockefeller Foundation has made a grant for preparing a report. The American Museum of Health, New York, has received a grant from the Carnegie Corporation of New York for a study of the reaction of visitors to the museum's medical and public health exhibit at the New York fair. The study will be directed by Dr. Mayhew Derryberry, of the U. S. Public Health Service.

DISCUSSION

DISEASE, DAMAGE AND POLLINATION TYPES IN "GRAINS"

AMERICAN students of plant diseases for over half a century have been more concerned with the organisms causing disease, especially fungi, than with the host plants. No doubt the present interest in plant breeding will tend to readjust the balance. But even to-day interest in virus diseases centers rather on the nature of the viruses than on their effects. In particular, any attempt to generalize as to the disease relations of groups of plants has been almost wholly lacking from our literature. Hartley's[1] discussion of the disease hazards incident to planting clonal varieties of trees is a conspicuous exception. He notes that "The expectation that genetic uniformity will favor the building up of specialized strains of parasites is supported by practical experience with such clonal cultures as Lombardy poplar avenues, rubber plantations, fruit trees, roses, potatoes, bananas, sugar cane and the creeping-bent golf-green grasses." The present paper is an attempt to examine some of the available evidence in order to determine whether such a relation is observable among major crop plants.

That numerous biological strains of many parasitic fungi exist in nature and that they vary continually through crossing and otherwise has been abundantly demonstrated in recent literature. Some of our crop plants, on the other hand, because of the method used in propagation or their own floral characteristics, have very much less natural opportunity for variation and adaptation than others. It seems probable that in their long-continued mutual association, parasites might well obtain a relatively greater advantage over those host plants which themselves had the least capacity for variation and adjustment. This might express itself in greater disease losses over a period of years or, in the case of parasites particularly favored by special environmental conditions, it might express itself in epidemics in the relatively weaker groups of host plants.

As to the capacity of the host to vary and adjust itself, vegetatively propagated plants would be less efficient than those produced from seed. Among plants grown from seed there would be a gradation in this respect from plants largely self-pollinated, to plants with perfect flowers which are usually cross-pollinated, then monoecious and finally dioecious or heterostylous plants. Of course, no such complete series exists among comparable crop plants, but those commercially classed as "grains" offer some interesting contrasts.

In an attempt to evaluate disease losses in the United States as a whole, one naturally turns first to the estimates of diseases losses compiled by the Plant Disease Survey. These have, however, been systematically collected for only twenty years and suffer, to some extent, from the lack of regular reports from many states. In fact, there are no subjects on which present-day plant pathologists are more reluctant to express an opinion than the extent of crop losses from disease and the economic importance of plant diseases. These are obviously not the same thing. Economic importance, while difficult to measure, must be in some way a function of the value of the crop concerned, the loss caused by disease and the fluctuations in loss. This last is a very important consideration. Other things being equal, even the average losses over a period of years, that disease is the most important which fluctuates most. Secretary Wallace has said, "Fluctuations in yields cause as much embarrassment as unbalanced acreage."[2]

In searching for some means of measuring the relative importance of diseases of economic plants, it dawned upon me that volume of publication must, in some degree at least and for the more important crops, express the opinion of plant pathologists and others interested as to the importance of diseases.

I have accordingly tabulated the total pages regarding the diseases of various important crops in the publications of the U. S. Department of Agriculture up to January, 1925, of the Experiment Stations up to December 1, 1927, and in *Phytopathology* up to January, 1927. This covers, for the experiment stations, a period of 40 years and, in the case of the

[1] Carl Hartley, *Phytopathology*, 29: 9, 1939.

[2] *New Republic*, December 2, 1936.

Federal Government, goes back even before the Department of Agriculture was organized and includes some publications of the Commissioner of Patents. My reason for stopping at a point over a decade ago is that these are the dates of the excellent bibliographies compiled by Miss Jessie Allen, librarian of the Bureau of Plant Industry. In the introduction to one of these, Miss Allen states that, "Some appraisement has been made for subjects upon which there are many contributions, the brief and less important ones being omitted. For subjects on which there are few publications all have been included." Thus any error in the figures is in increasing their size for the less important crops or diseases.

Obviously such a means of measuring the importance of plant diseases can have no validity in the case of many small and highly specialized crops where the publications of a small group of enthusiastic workers or even one investigator—or for that matter a single paper—easily assume undue importance. Nor could we expect to compare too closely, succulent vegetables with grains. But it may be possible to obtain a measure of the apparent relative economic importance of diseases in the culture of crops which have a not too widely different value per acre, are marketed in somewhat the same way, and produced by more or less comparable groups.

Such a unit is apparently found in the crops classed together as "grain crops" for statistical purposes in the publications of the U. S. Department of Agriculture. For such crops this means of measurement must have real significance, unless there has been something radically wrong with the administration of plant disease work in this country over a period of half a century. Most of this work has been tax-supported and the obligation to see that most of the money was spent where most needed must have been generally recognized. Indeed, it would probably have been enforced by popular pressure.

If such figures are to be used as a means of evaluating the relative importance of diseases in different crops, some adjustment must be made for the value of the crop; the most obvious method seems to be to divide the number of pages published by the value of the crop concerned in millions of dollars. This has been done, using the average value of the crop for the ten-year period 1910–1919 as a basis of computation. Several other periods were tried with no difference in the order of the various crops. Some of the results of this summary are given in Table 1.

For comparison with these crops, it may be noted that the disease indices computed on the same basis for grapes and the important tree fruits—all vegetatively propagated—are over 30 and that for potatoes over 20.

TABLE 1

RELATIVE ECONOMIC IMPORTANCE OF DISEASE IN VARIOUS "GRAINS" AS INDICATED BY VOLUME OF PUBLICATION IN U. S. A.

	Total pages	Disease index (corrected by value of crop)
Flax	426	14.2
Rice	205	4.9
Barley	526	3.5
Wheat	3526	3.4
Sorghum	305	2.3
Oats	1178	1.8
Rye	94	1.5
Corn	1941	0.8
Buckwheat	0	0

Whatever may be one's opinion of the validity of this method of appraising the importance of diseases in the culture of a crop, there are probably few who will take exception to the fruits being placed far above the grains in this respect or to the order of most of the "grain" crops in the table.

In this it is at least worthy of comment that the highest six are largely self-pollinated under natural conditions, rye and corn chiefly cross-pollinated, and buckwheat heterostylous and thus always cross-pollinated.

There can be no point in emphasizing too much the fact that at least up to 1927 no single page had been devoted to diseases of buckwheat in the literature reviewed. Indeed, the only reference to the subject found so far is the statement in Robbins and Ramaley's text,[3] "It is singularly free from insect pests and fungous diseases." To be sure, buckwheat is not a major crop, nor on the other hand is it negligible. Its average farm value per year for the period 1910 to 1919 was over 16 million dollars, and in 1920 the farm value of the crop in New York State was over 6 million. Serious epidemics of disease in crops valued at 6 millions have not gone unnoticed in New York State during the past 25 years.

Any one who is unwilling to accept the significance of a correlation between the striking freedom from disease and the fact that the plant can reproduce only by crossing (a condition comparable to that in all the higher animals) should at least advance some other hypothesis.

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ARTIFACTS IN CANADIAN RIVER TERRACES

ARCHEOLOGY frequently yields finds tantalizing in their incompleteness and implications, which do little more than point the way for future work. It is in this class that we must place the few rough artifacts found this past summer in the terraces of the North Saskatchewan and Peace rivers, in Alberta.

[3] "Plants Useful to Man," p. 184.