

THE EXPERIMENTAL APPROACH IN ASSESSING DISEASE LOSSES IN CEREALS: RUSTS AND SMUTS

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Smuts

The smuts were the main diseases of cereal crops in Western Canada at the turn of the century. According to Johnson (8), A. Mackay, superintendent of the Indian Head Experimental Farm, reported that in 1891 one in three bushels of wheat delivered to an elevator was damaged by smut; and in 1895, S. A. Bedford, superintendent of the Brandon Experimental Farm, reported that from 10 to 25% of the oat and barley crops was destroyed by loose smut. Bedford also reported finding fields of oats with 75% of the heads smutted. Bunt was the main disease and yield reductions of 30 to 40% were not uncommon. Losses were so severe that seed treatment with blue stone was a widely used control measure by 1892, only 13 years after the railway reached Winnipeg. The amount of smut decreased sharply as seed treatment became a common practice, but Güssow (7) estimated that the average annual loss from smut from 1920 to 1923 was 1.2, 3.0, and 3.4% for wheat, barley, and oats, respectively. The average annual monetary loss was estimated to be about 11 million dollars. Smut losses have declined steadily since that time, but reports in the Canadian Plant Disease Survey show that occasional fields of wheat and barley in Western Canada have 5 to 10% smut.

Estimates of smut losses probably have been reasonably accurate. They have been based on field counts of smutted heads, and there is evidence (1, 4, 11, 12) that 1% smutted heads cause about 1% loss in yield. The relationship may vary under abnormal conditions: for example artificial inoculation caused a yield decrease of 11.3% for each 1.13% bunt in the resistant variety 'Ridit' (4). This large decrease was attributed mainly to the deforming effect of smut infection on plants that did not produce smutted heads.

A reasonably good estimate of smut losses can be obtained by means of well-organized surveys and good sampling techniques. The main source of error is the non-random selection of fields for sampling. Smut infections are heaviest in isolated areas where farmers do not use the best cultural methods and continue to use homegrown grain for seed. Loss estimates might be more informative if they were determined for each crop zone rather than for a province.

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The Board of Grain Commissioners' records of carlots graded "smutty" provide a fairly reliable indication of losses from decreases in quality.

Rusts

Rust losses, as estimated by various methods, have been enormous. Losses from the wheat rusts in some important epidemics have been estimated at 100 million bushels in 1916; 90 million in 1927; 87 million in 1935; and 150 million in 1954. The average annual loss in Manitoba and Saskatchewan from 1925 to 1935 was 35,518,000 bushels and for Manitoba alone 15,092,000 bushels. The use of resistant varieties reduced the average annual loss in Manitoba from 1953 to 1962 to 3,741,600 bushels, and most of this loss occurred between 1953 and 1956, before susceptible varieties were replaced by 'Selkirk'. In oats the average annual loss from stem rust from 1929 to 1934 was estimated at 8,334,000 bushels; and from 1953 to 1962 the use of resistant varieties reduced the average annual loss from crown rust and stem rust to 2,008,800 bushels (2, 6, 9, 10).

The potential of the rusts to cause losses has not diminished. Data from various tests frequently indicate what could have happened if resistant varieties had not been grown. In a test by A. B. Campbell at Winnipeg in 1964, 'Marquis' yielded 2.6 bu/acre; 'Selkirk', 20.6; and 'Manitou', 29.3. On the basis of these yields and estimating costs at \$20.00/acre, a farmer growing 'Marquis' would have lost \$15.67/acre. However a farmer growing 'Manitou' would have made \$32.62/acre. In recent years 'Selkirk' and 'Pembina' have been damaged by leaf rust. In 1965, D. J. Samborski found that plants of 'Selkirk' when protected by a fungicide yielded 55.0 bu/acre in plots at Winnipeg, whereas unprotected plants of 'Selkirk' yielded 44.3 bu/acre - a loss of nearly 20%. Similar losses from oat crown rust were demonstrated by Fleischmann (3) in 1964.

The estimation of rust losses over large areas involves the effects of many variables. The methods used to obtain data for an estimate of loss should take these variables into account if the estimate is to be reasonably accurate. Four requirements seem to be necessary to obtain data that are reasonably complete and reliable. The first is frequent and thorough plant disease surveys. It is difficult to understand how loss estimates can be regarded as reasonably accurate if they are not supported by a sound knowledge of disease development in farm fields. The second requirement is experimental

evidence of the amount of yield reduction caused by natural rust infection on the widely grown varieties. The third is an accurate and reliable method of determining the loss from reduced quality of the product. The fourth is a method of applying experimental and survey data to an area as large as Western Canada in a manner that will accurately indicate rust losses.

The fourth requirement presents the most difficulties. Obviously, the results of one experiment and limited survey data are inadequate for an accurate estimation of rust losses in Western Canada. If reasonably complete data are to be obtained, experimental work with the main varieties of each crop will be needed at many locations. The experimental data should be supplemented by thorough rust surveys and by efforts to determine the losses from reductions in grade. It might be argued that the expense of such a programme could be reduced by restricting it to the traditional rust area of Manitoba and southeastern Saskatchewan, but serious losses to wheat in this region have been limited in most recent years to the small acreage sown to susceptible varieties. Much of the loss in recent years has occurred farther west, where 'Thatcher' has been attacked by leaf rust and occasionally by stem rust, and in western Saskatchewan and Alberta, where susceptible varieties of common and durum wheat are occasionally damaged by leaf rust and stem rust. Investigations on rust losses in oats could be restricted to Manitoba and southeastern Saskatchewan, since stem rust and crown rust of oats rarely spread outside this area.

Some of the better methods for estimating rust losses have been developed in Western Canada. In the early days of rust research, F. J. Greaney (5) developed a method that "had the merit of being based on the results of controlled experiments, but is still subject to certain sources of error." He dusted plots of wheat and oats with sulfur at different rates and frequencies and controlled stem rust at different levels of infection. He then calculated the yield reduction for each 10% of rust. The total rust loss was calculated from these figures and from survey reports on the amount of stem rust in different parts of Western Canada. W. C. McDonald (9) compared the average yields in test plots of varieties with different rust reactions and computed the losses caused by each rust from the acreages sown to the different varieties.

A very good estimate of rust losses was made for the rust epidemics of 1953, 1954, and 1955 by B. Peterson (10). In Manitoba and eastern Saskatchewan in 1953, he compared the yields of 57 matching fields of rust resistant 'Selkirk' and a susceptible variety. In 1954 in Manitoba the yields of 165 fields of 'Selkirk' were compared with the yields of 168 fields of the more susceptible varieties 'Red-

man', 'Thatcher', and 'Lee'; and in Saskatchewan the yields of 169 fields of 'Selkirk' were compared with the yields of 169 fields of 'Thatcher'. The large number of comparisons he made in a wide variety of locations gives one confidence in his estimate despite the fact that the data were obtained from questionnaires returned by farmers rather than from controlled experiments.

We should not overlook the rapidity with which the rust situation changes. The reactions of the widely grown varieties can change dramatically in a short time. In the next year or two we expect that 'Manitou' will reduce rust losses in wheat to negligible amounts. Little would be gained by devoting time to estimating losses while its resistance is effective. On the other hand, our oat varieties are now susceptible to stem rust and crown rust. These circumstances do not seem to justify an expensive program to determine rust losses, but there is a need to obtain better information than we have had in the past.

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DISCUSSION OF THE PAPER BY G. J. GREEN, J. J. NIELSEN,
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M. L. Kaufman: We have heard considerable discussion about making accurate estimates of loss, in this case from rust and smut diseases. I wonder if it is necessary, bearing in mind the long history of these diseases, to prove that we suffer large losses. Unless our programs are being hampered because people are not aware of this fact, I do not see the need for detailed and accurate estimates. I believe sufficient evidence was presented here to show that programs are not hampered.

G. J. Green: Certainly for most of us in agricultural research we do not have to prove again and again the destructiveness of plant diseases. We must, however, have data for the public. We may say that there is a moderately-severe infection of leaf rust on Selkirk wheat in Manitoba and eastern Saskatchewan, but few people comprehend this. Most persons want to know how much is the loss. This then requires experimental data, observation within the area, information on when the rust came in, and at what stage of plant development. When asked how great a loss there is, "no comment" would constitute an unacceptable reply. Without staff and facilities to be on top of the problem continuously, sometimes one must hazard a guess as to losses.

W. E. Sackston: I think too there are other aspects to be considered. Some of us will recall that just prior to the outbreak of the 15B race of stem rust, serious consideration was given to phasing out the breeding for rust resistance at the Winnipeg Laboratory. There seemed little justification to continue the breeding program since the rust problem had been overcome! Survey and loss information as to what was happening in the rust race picture was very pertinent and helped prevent an action which, if carried out, might have had very serious consequences. We can also recall the interest by industry in chemicals to combat rusts. Industry needs to know what the potentials for a product are before it embarks on a serious program in development.

D. J. Samborski: It's relatively easy to show losses from stem rust since the disease is very des-

tructive. The last several years we have been predicting losses from leaf rust in Saskatchewan, and there have been substantial losses. Bumper crops, however, have been highlighted, and since leaf rust exacts only a moderate toll, our estimates receive little credence generally.

W. E. Sackston: Well, I think that this is an excellent argument for the need for accurate survey and experimentation. Mr. Creelman cited Large's work on potato blight and this, I believe, documents the case that in the years most favorable for the development of the disease, there is also a tendency to get the highest crop yields. The same conditions that favor the crop simultaneously favor the disease. This is obviously the case with leaf rust. If we had adequate documentation on the effect of disease on yields in years of optimum production we would have a better idea of the maximum potential. This, of course, is one of the objectives of assessing plant disease losses.

D. J. Samborski: There is difficulty in educating the public, because losses from diseases like leaf rust occur primarily in the best crop years. When conditions are poor, for example, very dry, there seldom is much leaf rust.

W. E. Sackston: Yes. On a disease survey in a favorable year a farmer expelled me from his field saying "Sonny, we don't want to know how to grow more wheat, we want to know how to sell it."

P. K. Isaac: With reference Dr. Samborski's comment, the attitude of the public is quite understandable. How can one lose something that you never had?

G. J. Green: A methodical way of determining losses annually would be very good. It would require additional staff and facilities. I do think that there was a considerable loss from leaf rust in northern Saskatchewan last year. Some figures I have seen would place the loss at about 6 bu/acre.

A. J. Skolko: Additional staff and funds for survey and disease loss determinations might be com-

mendable. However, the assignment of additional support to solving our present problems may be even more meritorious.

W. E. Sackston: One of the comments by LeClerc in the A. P. S. symposium was on why it was important to have as accurate as possible determinations of crop losses. It was to ensure the most efficient use of research effort and funds. Another was to establish the need for the control of certain diseases. A disease accepted as a minor one today may upon documented evidence turn out to be a major one. Documenta-

tion of losses is important and deserves emphasis.

D. W. Creelman: It is likely that the diseases that are considered serious in Canada today and that are subjects of research were shown to be important through plant disease surveys. We are fortunate in Canada in having a plant disease survey. Some countries do not have one. A colleague from New Zealand was commenting on this recently. Where survey is lacking, research may be subject to pressure groups.