# WHEAT LOSSES DUE TO COMMON ROOT ROT IN THE PRAIRIE PROVINCES OF CANADA, 1969-71[1]

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## Abstract

A survey was conducted, 1969-71, to estimate losses due to common root rot of wheat on the Canadian Prairies. The estimated average annual loss over the entire area for the 3 years was 5.7% or 30 million bushels. Diseased plants suffered a reduction in number of heads per plant, in kernel weight, and in size of heads as compared to healthy plants. Protein content of the grain was little affected by root rot. A formula is presented for conversion of percentage diseased plants in a field to loss in yield.

## Introduction

The last comprehensive survey to estimate losses due to common root rot in wheat caused by Cochliobolus sativus (Ito & Kurib.) Drechsl. ex Dastur, condial state Helminthosporium sativum Pamm., King & Bakke., syn. Bipolaris sorokiniana (Sacc. in Sorok.) Shoem., and by Fusarium spp., on the Canadian Prairies was carried out in 1939-41 by Machacek (10). This study showed losses of 8, 16, and 12% respectively for the 3 years. Since then, there has been a considerable change-over in varieties used and a radical change in cultural procedures; competition by broad-leaved weeds has been largely eliminated through the use of herbicides and the land has been under cultivation an additional 30 years.

Wheat and barley are the important crops subject to common root rot. They so dominate prairie agriculture that rotations that free the land from one or other of these crops for more than a year or two at a time are not practical. Thus wheat seldom is planted on land with an inoculum potential low enough to significantly limit disease development (8). Cultural procedures have shifted to almost universal adoption of surface tillage implements in contrast to the widespread use of the mold-board plow at the time of Machacek's survey (10). Consequently, more of the inoculum of the causal organisms is retained near the soil surface. Retention of crop debris on the soil surface perhaps allows spore production from infected tissues over a longer period than was the case when the plow was used. Furthermore, conidia probably survive longer on or near the soil surface than they do when buried in the soil (9). Nevertheless, "old" fields do not appear to be problem fields as far as common root rot is concerned and spore population or inoculum potential is not the sole consideration in manifestation of the disease.

Creelman (3), LeClerg (7) and McDonald et al. (12, 13) and others have adequately outlined the purpose and detailed the desirability of estimates of losses from crop diseases. This report presents the results of a cooperative survey covering Alberta, Manitoba, and Saskatchewan for the crop years 1969-70-71, designed to estimate the yield reductions in wheat attributable to common root rot.

## Materials and methods

Survey routes in each province were chosen at the discretion of the cooperating individuals and were such as to cover most Cxop Districts (CD) in Manitoba and Saskatchewan and Agricultural Reporting Areas (ARA) in Alberta. Fields were chosen at random, except as noted below, along the survey routes. Time, weather, and resources occasioned some curtailment of plans or omissions of crop districts. The surveys were conducted during the short period when the wheat crop was ripening and only fields in the firm dough stage were sampled. Shallowly planted fields with many plants lacking a subcrown internode were rejected. Field margins were avoided.

In 1969 and 1970 each field was sampled by selecting two 1-yd² quadrats 15-20 yards

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apart. All the plants from each quadrat were pulled carefully, bagged, labelled, and transported to headquarters for processing.

In 1971 a single diaqonal traverse of 100 paces was made in each field, starting 25 paces from the field margin. A small handful of about 8 to 10 plants was pulled at 4–pace intervals along the traverse, givinq a sample of over 200 plants.

In the laboratory each plant within a sample was assigned to one of four disease classes, clean, slight, moderate, and severe (Figure 1), based on extent and severity of lesions on the subcrown internode. Plants lacking an appreciable length of subcrown internode on which an assessment could be made were placed in a fifth group, unclassified. For each class the number of plants and heads and the weight of grain were recorded. The data from the two quadrats in each field, taken in 1969 and 1970, were bulked. In Alberta in 1969 and 1970, paired samples were taken from 45 and 56 fields respectively, and in 1971 single samples were taken from 55 fields. In Manitoba paired samples were taken from 25 and 20 fields in the first 2 years and single samples from 29 fields in 1971. In Saskatchewan in 1969 and 1970 paired samples were obtained from 53 and 71 fields respectively and in 1971 single samples were taken from 155 fields. In 1969 and 1970, the samples averaged 175 plants per quadrat or 350 per field while in 1971, the average was 275 plants per field.

Protein content was determined on grain from the clean and severely diseased classes of 25 fields in 1970. Thousand kernel weights were taken on some of the material each year. In 1969 and 1970, the heads of all samples in Saskatchewan were examined in an effort to identify the variety.

Losses for each field were calculated using the formula derived by Machacek (10):

$$\text{percent loss in yield} = 100 - \left(\frac{W}{W_1 \times N} \times 100\right),$$

where W is the total weight of grain from a sample, and $W_1$ the average weight of grain per plant from the clean plants of the sample, and N the total number of plants in the sample. In other words, the percent loss is the difference between 100 and the actual yield expressed as a percentage of the potential yield.

The percent loss in yield for a CD or ARA was expressed as the mean of the percent losses €or the fields samples in the specified area. This mean was applied to the actual production statistics (1, 4, 11) for the area to calculate potential production. In Alberta and Manitoba where all CD's or ARA's were not sampled, the mean for those areas sampled was applied to the ones not sampled to derive potential production. potential production for the provinces and the entire region was obtained by summation of the values for the CD's or ARA's. Loss in bushels and percentage loss were calculated from the difference between potential and actual production.

The soil zones were superimposed on a crop district map of the prairie provinces (Figures 2–4). Zone 1, in the southern part of Alberta and Saskatchewan, comprises the brown soil area of the prairies. It is characterized by high evaporation; however, it has extensive areas well suited to cereal production. Zone 2 rouqhly parallels Zone 1 on the north. The soil is dark brown and moisture conditions are somewhat more favorable than in Zone 1. In it are many areas of medium and heavy clay soils. Zone 3 is the black soil zone comprising most of the cultivated land in Manitoba and in general the parkland portion of Saskatchewan and Alberta. Moisture conditions are usually favorable. Zone 4 occupies the area between the parkland and boreal forest. Soils are degraded black and gray and moisture is generally good. The average percentage loss for all fields sampled within each soil zone was calculated to give soil zone losses.

While the survey was confined to hard red spring wheat, the results were projected to include durum wheats as well; a breakdown in production between durum and hard red wheats is difficult to obtain. Further, observations and field experiments indicate that the durum wheats are somewhat more susceptible to common root rot than most of the recommended varieties of common wheat. Thus the data presented are for all wheats in the three provinces.

## Results

The locations of the fields sampled in each province during the 3 years of the survey are shown in Figures 2 to 4. The soil zones also are outlined on the maps (Figures 2 to 4) and the average loss within each soil zone in each of the 3 years is shown. For example, the average losses for soil zones 1 to 4 in 1971 were 4.61, 3.8%, 5.2%, and 4.8% respectively (Figure 4).

Percentage loss by CD or ARA for the three provinces for the 3 years is given in Table 1. In Table 2, acreage, yield, total production, percent loss, potential production, loss in bushels, and number of fields involved in the survey are summarized by province and year. The percent losses in 1969, 1970, and 1971 were as follows: 4.4%, 6.31, and 5.5% respectively in Alberta, 6.21, -3.8%, and 5.7% in Manitoba and 5.7%, 10.2%, and 4.0% in Saskatchewan.

In Table 3 are shown the average losses in yield of each disease class and the unclassified group (plants lacking a subcrown internode), relative to the clean class, for the three provinces in each of the 3 years. The mean reduction for the three provinces

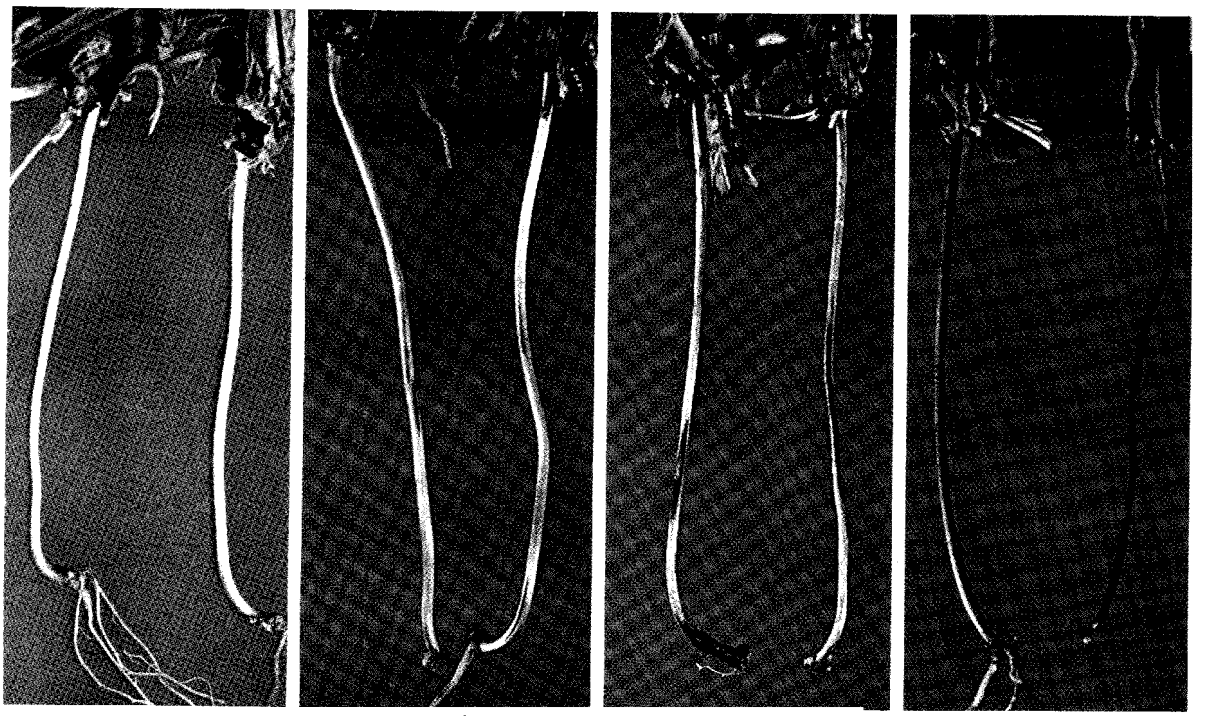

Figure 1. Symptoms of common root rot on subcrown internodes of mature wheat plants; left to right, severity classes clean, slight, moderate, and severe.

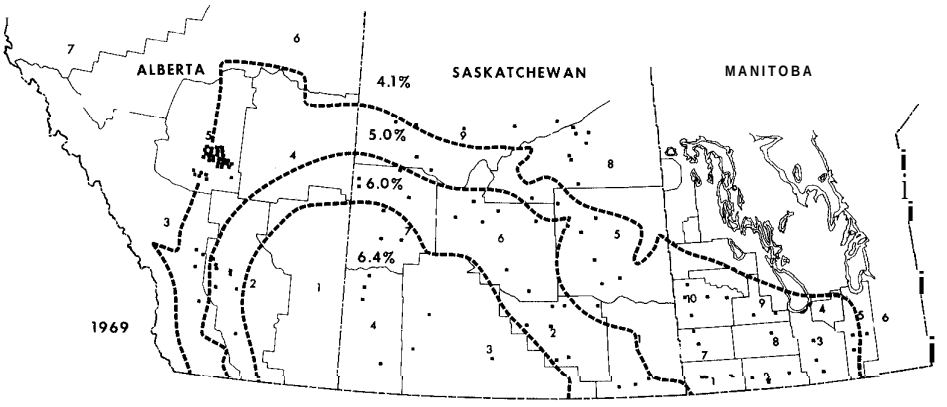


FIG. 2

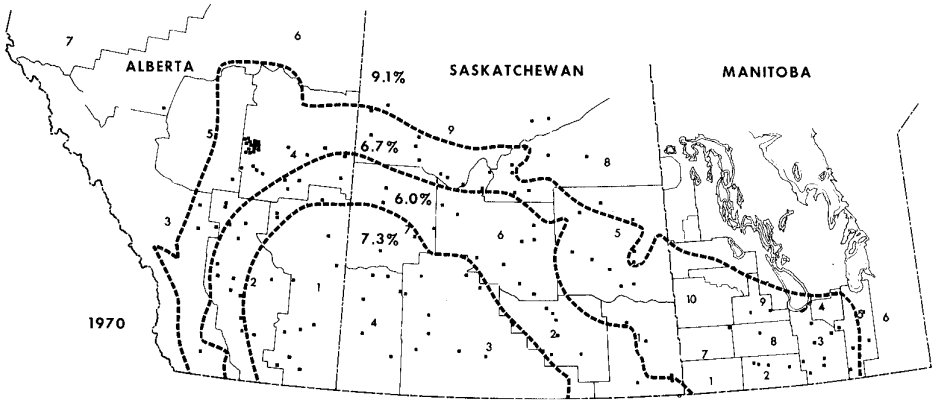


FIG. 3

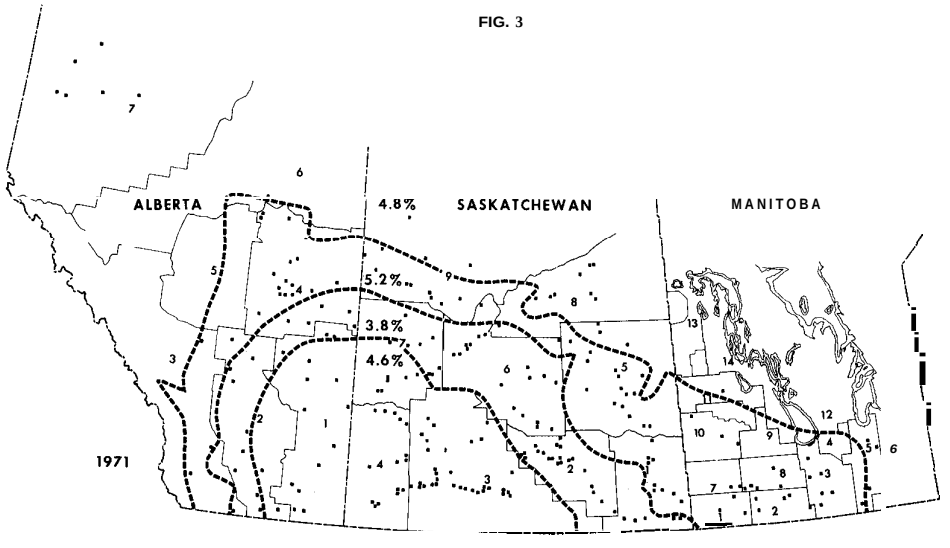


FIG. 4

**Figures 2-4. Location of wheat fields sampled in each of the prairie provinces in 1969, 1970, and 1971. Numbered zones refer to crop districts (in Alberta, agricultural reporting areas); heavy broken lines outline the four major soil zones, and percentages indicate the average loss from common root rot in each soil zone.**

**Table 1. Percent losses from root rot in wheat by Crop Districts or Agricultural Reporting Areas in the prairie provinces, 1969-71**

| | Saskatchewan | | | Manitoba | | | Alberta | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | CD | No. of fields | Loss (%) | CD | No. of fields | Loss (%) | ARA | No. of fields | Loss (%) |
| 1969 | 1 | 3 | 5.5 | 1 | 3 | 8.9 | 2 | 8 | 7.2 |
| | 2 | 7 | 3.8 | 2 | 2 | -2.3 | 3 | 4 | -3.2 |
| | 3 | 3 | 4.8 | 3 | 7 | 5.8 | 5 | 33 | 3.5 |
| | 4 | 4 | 10.4 | 5 | 3 | 3.3 | | | |
| | 5 | 7 | 7.2 | 7 | 2 | 3.7 | | | |
| | 6 | 8 | 5.4 | 8 | 1 | 6.5 | | | |
| | 7 | 7 | 6.7 | 9 | 2 | 28.3 | | | |
| | 8 | 6 | 5.3 | 10 | 5 | 0.3 | | | |
| | 9 | 8 | 6.3 | | | | | | |
| | Mean | | 6.2 | | | 5.2 | | | 2.5 |
| 1970 | 1 | 5 | 14.6 | 2 | 3 | -6.3 | 1 | 11 | 3.7 |
| | 2 | 7 | 7.4 | 3 | 8 | 3.2 | 2 | 15 | 5.4 |
| | 3 | 9 | 8.6 | 5 | 5 | -0.2 | 3 | 4 | 5.1 |
| | 4 | 6 | 10.5 | 7 | 1 | -12.8 | 4 | 24 | 7.6 |
| | 5 | 10 | 8.5 | 8 | 1 | -6.6 | 5 | 1 | 16.9 |
| | 6 | 14 | 8.7 | 9 | 2 | -6.5 | 6 | 1 | 2.2 |
| | 7 | 5 | 6.2 | | | | | | |
| | 8 | 5 | 15.9 | | | | | | |
| | 9 | 10 | 9.1 | | | | | | |
| | Mean | | 9.9 | | | -4.8 | | | 6.8 |
| 1971 | 1 | 13 | 4.1 | 1 | 3 | 9.6 | 1 | 14 | 3.5 |
| | 2 | 21 | 3.9 | 2 | 5 | 5.6 | 2 | 11 | 5.7 |
| | 3 | 33 | 4.4 | 3 | 6 | 3.5 | 3 | 4 | 2.8 |
| | 4 | 15 | 6.8 | 5 | 4 | 5.1 | 4 | 19 | 8.0 |
| | 5 | 18 | 3.2 | 7 | 3 | 3.1 | 6 | 1 | 8.1 |
| | 6 | 20 | 3.4 | 8 | 4 | 4.9 | 7 | 6 | 2.5 |
| | 7 | 13 | 3.2 | 10 | 4 | 8.8 | | | |
| | 8 | 9 | 2.9 | | | | | | |
| | 9 | 12 | 5.7 | | | | | | |
| | Mean | | 4.2 | | | 5.7 | | | 5.1 |

over 3 years was 6.0% for the slight disease category and 12.5% and 28.2% for the moderate and severe categories respectively. The unclassified plants on the average yielded slightly more grain than the clean category. This was particularly true in Saskatchewan, where the increase over the 3 years was 12%.

The average numbers of heads per plant for the disease classes and the unclassified category for the three provinces in each of the 3 years are shown in Table 4. It will be seen that the slight disease class suffered a reduction in heads of 3.7%, the moderate class 8.3%, and the severe class 15.2%. In Saskatchewan head numbers per plant in the unclassified category were appreciably higher than in the clean class each year; the mean 3-year average was 11.3% higher. In Alberta and Manitoba no appreciable differences were observed.

Thousand kernel weights from some representative samples taken in each of the 3 years are shown in Table 5. Kernel weights in the severe class averaged 6.7% lower than those in the clean class.

Table 2. Wheat losses in Alberta, Manitoba, and Saskatchewan due to common root rot 1969, 1970, 1971

| Province and year | | Acreage ('000) | Yield (bu/ac) | Production ('000 bu) | % Loss | Potential production ('000 bu) | LOSS ('000 bu) | No. of fields sampled |
|---|---|---|---|---|---|---|---|---|
| Alta. | 1969 | 5,300 | 26.4 | 140,000 | 4.4 | 146,400 | 6,400 | 45 |
| | 1970 | 2,600 | 27.7 | 72,000 | 6.3 | 76,800 | 4,800 | 56 |
| | 1971 | 3,500 | 26.3 | 92,000 | 5.5 | 97,300 | 5,500 | 55 |
| Man. | 1969 | 2,500 | 25.6 | 64,000 | 6.2 | 67,500 | 4,000 | 25 |
| | 1970 | 1,400 | 21.8 | 30,500 | -3.8 | | | 20 |
| | 1971 | 2,400 | 29.2 | 70,000 | 5.7 | 74,200 | 4,200 | 29 |
| Sask. | 1969 | 16,600 | 27.8 | 461,000 | 5.7 | 488,600 | 27,600 | 53 |
| | 1970 | 8,000 | 26.2 | 210,000 | 10.2 | 233,800 | 23,800 | 71 |
| | 1971 | 12,800 | 26.7 | 342,000 | 4.0 | 356,200 | 14,200 | 155 |

Table 3. Percent loss in yield of wheat in root rot classes derived from a comparison of yields from clean and diseased plants

| Province and year | | Slight | Moderate | Severe | Unclassified |
|---|---|---|---|---|---|
| Alta. | 1969 | 1.5 | 4.9 | 11.5 | -6.9 |
| | 1970 | 7.7 | 4.9 | 27.5 | 2.0 |
| | 1971 | 6.7 | 10.9 | 25.2 | -0.7 |
| Mean | | 5.3 | 6.9 | 21.4 | -1.8 |
| Man. | 1969 | 7.1 | 10.4 | 22.4 | 4.8 |
| | 1970 | -5.8 | 19.6 | 46.8 | -7.5 |
| | 1971 | 7.7 | 17.6 | 27.1 | 11.4 |
| Mean | | 3.0 | 15.8 | 32.1 | 2.9 |
| Sask. | 1969 | 9.6 | 11.3 | 28.0 | -9.9 |
| | 1970 | 12.7 | 19.6 | 39.2 | -12.0 |
| | 1971 | 6.7 | 13.4 | 26.5 | -14.2 |
| Mean | | 9.6 | 14.7 | 31.2 | -12.0 |
| Grand mean | | 6.0 | 12.5 | 28.2 | -3.7 |

Table 4. Average number of heads per wheat plant in different root rot disease classes from Alberta, Manitoba, and Saskatchewan, 1969–71

| Province and year | | Clean | Slight | Moderate | Severe | Unclassified |
|---|---|---|---|---|---|---|
| Alta. | 1969 | 2.1 | 2.0 | 2.0 | 1.9 | 2.0 |
| | 1970 | 2.2 | 2.0 | 2.0 | 1.8 | 2.2 |
| | 1971 | 2.1 | 2.0 | 1.9 | 1.8 | 2.1 |
| Mean | | 2.13 | 2.00 | 1.97 | 1.83 | 2.10 |
| Man. | 1969 | 1.9 | 1.8 | 1.7 | 1.7 | 1.8 |
| | 1970 | 1.6 | 1.8 | 1.5 | 1.2 | 1.8 |
| | 1971 | 1.7 | 1.7 | 1.6 | 1.7 | 1.6 |
| Mean | | 1.73 | 1.76 | 1.60 | 1.53 | 1.73 |
| Sask. | 1969 | 1.9 | 1.8 | 1.8 | 1.6 | 2.1 |
| | 1970 | 2.2 | 2.0 | 1.9 | 1.6 | 2.4 |
| | 1971 | 2.0 | 1.9 | 1.8 | 1.7 | 2.2 |
| Mean | | 2.03 | 1.90 | 1.83 | 1.63 | 2.26 |
| Grand mean in % | | 100 | 96.3 | 91.7 | 84.8 | |

The protein levels of grain from clean and severely diseased samples did not differ much; clean samples averaged 12.258 protein and severely diseased samples 12.47%.

Virtually all of the Saskatchewan fields sampled in 1969-70 proved to be Thatcher or the Thatcher derivatives Canthatch and Manitou, except for a few of the solid stemmed Rescue type. Therefore a comparison of varietal root rot losses was not feasible.

Table 5. Thousand kernel weights of wheat from representative clean and severe root rot classes in Alberta and Saskatchewan

| Year | Province | No. of samples | Clean (g) | Severe (g) | % Shrinkage |
|---|---|---|---|---|---|
| 1969 | Alberta | 24 | 27.55 | 26.13 | 5.16 |
| 1970 | Saskatchewan | 25 | 26.20 | 24.76 | 5.50 |
| 1971 | Alberta | 7 | 28.74 | 25.36 | 11.76 |
| 1971 | Saskatchewan | 50 | 30.20 | 28.85 | 4.47 |
| | Mean | | 28.17 | 26.27 | 6.7 |

Relation of disease rating to yield loss

Some years ago Sallans (1964, unpublished) introduced a simplified method into the root rot survey in Saskatchewan. Instead of separating the plants into four classes, clean, slight, moderate, and severe, he combined the clean and slight, and the moderate and severe into two classes, healthy and diseased respectively. In field practice the percentage of diseased plants in a sample is the disease rating.

In the 4-class system, giving weights of 2, 5, and 10 for the slight, moderate, and severe disease categories, the disease rating Y is derived, on a 100 plant sample, from the formula

$$Y = \frac{2a + 5b + 10c}{10}$$

where a, b, and c are respectively the number of slightly, moderately, and severely diseased plants in the sample. The weights assigned, namely 2, 5, and 10 are roughly proportional to the losses suffered by the slight, moderate, and severe classes, namely 6.0, 12.5, and 28.2 (Table 3). The Saskatchewan samples for the years 1969–71, a total of 270, when assessed by the 2-class and the 4-class method of rating gave mean disease ratings of 18.88 and 18.83 respectively. The coefficient of correlation between ratings for the two methods was 0.985.

Disease ratings calculated in this way do not reflect yield loss directly, nor are they intended to do so. The disease rating must be multiplied by a conversion factor to give an approximation of loss. In earlier studies Sallans (unpublished) derived the factor 0.4 and found this to be realistic. The factor is simply obtained by dividing the calculated percentage loss in a field or group of fields by the observed disease ratings for these fields. In Table 6 the conversion factors for each crop district in Saskatchewan for the 3 years of the study are given to indicate the degree of variability that occurred among years and districts.

**Table 6. Conversion factors and the number of fields involved in determination of each factor for the years 1969–71 in Saskatchewan**

| | Conversion factor | | | No. of fields | | |
|---|---|---|---|---|---|---|
| CD | 1969 | 1970 | 1971 | 1969 | 1970 | 1971 |
| **1** | **0.41** | **0.50** | **0.23** | **3** | 5 | **13** |
| 2 | **0.38** | **0.30** | **0.33** | 7 | 7 | 22 |
| **3** | 0.22 | **0.36** | 0.21 | **3** | 9 | **33** |
| **4** | 0.29 | **0.43** | 0.23 | **4** | **6** | **15** |
| 5 | **0.31** | **0.33** | 0.26 | 7 | **10** | **18** |
| **6** | 0.25 | **0.53** | **0.33** | **8** | **14** | 20 |
| 7 | 0.29 | **0.38** | 0.24 | 7 | **5** | **13** |
| **8** | **0.30** | 0.70 | 0.19 | **6** | 5 | 9 |
| 9 | 0.27 | 0.49 | 0.39 | **8** | 10 | 12 |
| **Mean** | **0.30** | **0.45** | 0.27 | | | |

## Discussion

The 3 years of the study were characterized by better than normal wheat crops in all provinces, reflecting near-adequate moisture. The mean yields for the 3 years were 26.8, 25.5, and 26.9 bu/ac in Alberta, Manitoba and Saskatchewan (15) respectively, compared with a 1940–1969 average of 20.8, 22.0, and 18.5 bu/ac for the three provinces (5,6). It is recognized that common root rot is aggravated by drought, hence one would expect higher losses in dry years.

The sampling was considered minimal; however, in view of the vast area to be surveyed and the time involved in processing a sample, the input was considerable. In Manitoba and Saskatchewan, one person in each province sorted the plants into their disease classes while in Alberta, three workers were responsible. The multiplicity of observers was not considered a serious weakness. Although different people may set slightly different standards, there is not much room for difference in deciding that a plant is free of lesions and therefore belongs in the clean class and it is the mean yield of the clean plants that determines the percent loss estimate. Any individual differences in placing plants in slight, moderate, and severe categories would not appreciably affect the overall loss estimates. They would only have affected the distribution within classes and the losses assigned to the different classes.

The change in sampling procedures in 1971 was made in anticipation that a more representative field sample would result. Comparative data to show that this was indeed the case are lacking; however, there was a saving in time and effort in the single diagonal sampling method as contrasted to the taking of paired square-yard samples and this is reflected in the larger number of fields sampled in 1971.

The percent losses in the different provinces over the 3 years ranged from a high of 10.2% in Saskatchewan in 1970 to a negative loss, or, in other words, an increase in yield due to root rot, of 3.8% in Manitoba the same year. Whether this increased yield may be significant is a moot point that warrants comment. Examination of the data indicates that the higher yield probably is significant. Disease ratings

were low in the 20 Manitoba fields sampled. In these samples, 30% of the plants were clean and 60% were in the sliqht class, while only 8% and 2% were in the moderate and severe classes respectively. This is not the usual distribution. In Manitoba in 1969, for example, the distribution was 53%, 27%, 14%, and 6% for the clean, slight, moderate, and severe classes respectively. In 1970, the plants in the moderate and severe categories showed reductions of 20% and 46% respectively, but there were few plants in these classes. Plants with slight lesions, which were greatly predominant, showed an increase in heads of 12% and a yield increase of 6% over the controls. The overall result as noted was a negative loss of 3.8%. Growing conditions were good and moisture was adequate in the summer and fall of 1970 in Manitoba. It may well be that the observed gain in yield reflects the recovery phenomenon noted by Sallans (14), in which recovery from early infections is followed by enhancement of growth and yield over and above the healthy controls.

It is noteworthy that losses were calculated on an individual field basis and the average of these losses was taken to represent the loss in the unit area. If the data for an area had been bulked and the Machacek formula applied, a single atypical field could adversely affect the results. For example, in one crop district, six samples were collected; individually, each showed a loss due to root rot. However, one field from which square-yard samples were taken had a poor crop, had been very densely seeded, and the plants were nearly all in the clean class. In this field the per plant yield was extremely low. When the data for the crop district were bulked, the excessive number of low yielding plants from this one field depressed the per plant yield of the clean class without a parallel decrease in plant yield of the disease classes because there were so few plants from this sample represented in them. As a result, when the Machacek formula, in which potential yield is projected from the per plant yield of the clean plants, was applied a negative loss for the crop district was indicated.

It is suggested that workers assessing disease loss give consideration to the unit on which the losses are computed. In the study reported here, erroneous results would have been obtained on several occasions had the samples from a CD or ARA been treated in bulk, whereas no problem arose when each field sample was treated as a unit.

The most common machine used for seeding on the prairies is the discer. This seeder more or less broadcasts the seed, and depth placement is not precise. A percentage of seeds are left near the soil surface. Such plants have short internodes and are not amenable to classifying by the method used and they were placed in the unclassified category. They may or may not be invaded by the root rot organisms. Observations indicate that shallow seedinq results generally in low root rot levels. Agronomic recommendations are for seeding as shallow as is in keepinq with the establishment of a good stand. Anderson (2) reported that yields of Manitou, Chinook, and Thatcher wheat were reduced by 23%, 24%, and 33% respectively when seeding depth was increased from 2 inches to 4 inches. If moisture is good, shallow seeding encourages prompt emergence and the plants get off to a quick start. This may be the reason the unclassified category contained more heads and gave higher yields than the healthy.

Plants in the slight, moderate, and severe categories suffered proqressive reduction in tillering as evidenced in numbers of heads produced. The results, covering the entire survey, showed reductions of 3.7%, 8.3%, and 15.2% for the three classes as compared with the healthy. Kernel weight reduction was minimal. Representative data taken each year showed only a 6.7% reduction in kernel weight in the severe class. Data are not available on the intermediate classes. Assuming that three components, number of heads, kernel weight, and size of heads, account for total yield, then the reduction in size of heads was 6.31, which is the difference between the total reduction, 28.2%, and the sum of the reductions in number of heads and kernel weight.

No effort was made to relate soil type to disease levels or losses; however mean losses for the four major soil zones were calculated. In Saskatchewan long-time root rot surveys usually have shown higher disease ratings, and presumably higher losses, under the more droughty conditions often encountered in the brown soil of Zone 1. The rather slight and somewhat variable differences from year to year (Figures 2 to 4) may reflect lower losses due to better than normal rainfall in the short grass zones of the prairies in the years in question. Sallans (14) reported that conditions resulting in yields of less than 16 bu/ac were accompanied by marked increases in common root rot. Such conditions were not experienced during this study.

Protein levels in wheat appear to be little affected by root rot. The sliqht difference in favor of the grain from severely diseased plants is probably not significant.

The validity of the methods used in arriving at losses may be open to criticism on the grounds that some of the observed loss in diseased plants may be compensated for by the reduced competition they afford healthv plants, which then produce more grain than they would if all plants were free of the disease. This aspect is under investigation.

The close correlation between disease ratings obtained using the 4-class system with weights of 2, 5, and 10 applied to the

slight, moderate, and severe disease classes, and the simple 2-class system is of interest and of practical importance. A survey is much simplified if one has only to determine the percentage of plants diseased, i.e. those with moderate or severe lesions. A conversion factor must then be used to convert these to yield losses. This factor has unfortunately been found to be somewhat variable. In Saskatchewan it was **0.30, 0.45,** and **0.27** for **1969, 1970,** and **1971** respectively. It is apparent too (Table **6**) that there was considerable variability among crop districts. It is thought that variability may be a salient feature in loss from a disease such as common root rot. Disease may occur at any time during plant development. Too, plants may tolerate considerable levels of disease without serious loss if moisture is adequate and temperatures moderate during maturation. On the other hand, harsh conditions during maturation may promote extensive losses from low disease levels. The factor 0.4 determined by Sallans some years ago may be slightly high for presently grown varieties. The mean of the factors determined for the 3 years of this study is *0.33*. This figure may be applicable to a simplified survey based on the **2-class** system. An alternative is to do a number of loss determinations each year and annually compute a factor based on the relationship of disease rating to loss and then convert the survey disease ratings to loss using the factor obtained.

The average **30** million bushel loss annually for the three provinces is substantial. However, on a percentage basis it is not as high as Machacek reported in his study.

## Acknowledgments

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