# DISEASES AND OTHER FACTORS AFFECTING AVERAGE YIELDS OF BARLEY IN MANITOBA, 1954-1968[1]

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## Abstract

In 11 of the 15 years under consideration, diseases were responsible for decreasing average yields of barley considerably below those expected under prevailing conditions of management and weather. Epidemics of stem rust occurred in 6 of the 15 years, and in 1954 alone the loss due to stem rust was over $9 million. Significant losses from one or more of the foliage diseases occurred in 10 of the 15 years and the total loss amounted to over $21 million. Virus diseases decreased yields in at least 4 of the 15 years, and the total loss from aster yellows alone was over $8 million. Annual losses from smut have been limited by the use of seed treatment chemicals. Nevertheless losses over the 15-year period exceeded $7 million. The use of varieties developed during this period that are resistant to rust and smut eliminated much of this loss and resulted in a gain of nearly $8 million. Good management practices appeared to be more important than weather or varieties in achieving a high average yield of barley in Manitoba.

## Introduction

The acreage of barley grown in Manitoba decreased by 77% from 1954 to 1962 and many reasons were proposed for farmer disillusionment with this crop. One of the factors believed to be a primary cause of low yields was the effect of diseases. However, although the prevalence of diseases was reported yearly in the Canadian Plant Disease Survey, no estimates of actual losses were made. In this paper losses from diseases and gains from the use of resistant varieties are estimated from an analysis of yield data for the period 1954-1968. The effects of diseases and other factors on the yearly variations in yield are also discussed.

## Methods

Comparative yield data for the three most popular varieties grown in Manitoba from 1954 to 1968, Montcalm, Parkland and Conquest, were obtained from reports on the Western Cooperative Barley Tests. Each variety represented a group of commonly grown varieties with similar yields and disease susceptibility. 'Montcalm', susceptible to all diseases, represented 'OAC 21'; 'Parkland', resistant to stem rust, represented 'Vantage' and 'Herta' (although it is not rust resistant, Herta's yield has been similar to that of 'Parkland' in the rust-free years since it became popular in 1965); and 'Conquest', resistant to stem rust and smut, represented 'Keystone'. The yields are averages of the four test locations in Manitoba: Winnipeg, Portage la Prairie, Morden, and Brandon. Since 'Montcalm' was not included in the cooperative tests after 1964, the yield of 'OAC 21' was substituted from 1965 to 1968.

Data on the Manitoba average yield, total acreage, and price were obtained from the Yearbook of Wanitoba Agriculture 1968 (3), and the percentage of the acreage sown to varieties susceptible to stem rust and smut, to varieties resistant to stem rust, and to varieties resistant to both stem rust and smut was provided by the former Line Elevators Farm Service, Winnipeg. The yields from the cooperative tests were reduced by a conversion factor calculated by summing the products of test yield x acreage of each variety, and dividing that sum by the total Manitoba production. The potential yield of a variety was calculated by multiplying the converted yield by 100 and dividing by 100 minus the percentage loss from all diseases. Total yield losses from disease and gains from resistance were based on the acreage of susceptible or resistant varieties.

The loss from stem rust was assumed to be the difference in yield between 'Montcalm' and the resistant varieties 'Parkland' and 'Conquest', minus an allowance for the inherent advantage in yielding ability of the latter two. The inherent advantage in yield was calculated by comparing the average increase, in rust-free years, of 'Parkland' over 'Montcalm' as a percentage of 'Parkland' yield, and similarly the average increase of 'Conquest' over 'Montcalm' as a percentage of 'Conquest' yield. These calculations showed that 'Montcalm' yielded 8% less than 'Parkland' and 13% less than 'Conquest' in the absence of diseases to which the latter two varieties are resistant.

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The yearly average percentage of smut in barley in Manitoba is recorded in the Proceedings of the Manitoba Agronomists Conference and these figures were used to calculate losses on susceptible varieties. In 1965 the acreage of smut resistant varieties began to increase with a concomitant reduction in the average percentage of smut. Therefore, to assess the losses on susceptible varieties and the gains from resistance an average of the percentages of smut in the previous 11 years was used.

No data are available on the percentage loss caused by foliage or virus diseases in Manitoba during this period but reports on the prevalence and severity of these diseases in epidemic years appear in the Canadian Plant Disease Survey. Results from experiments using fungicidal sprays (1), varietal comparisons (4), or inoculations (2) showed that leaf spot diseases can cause

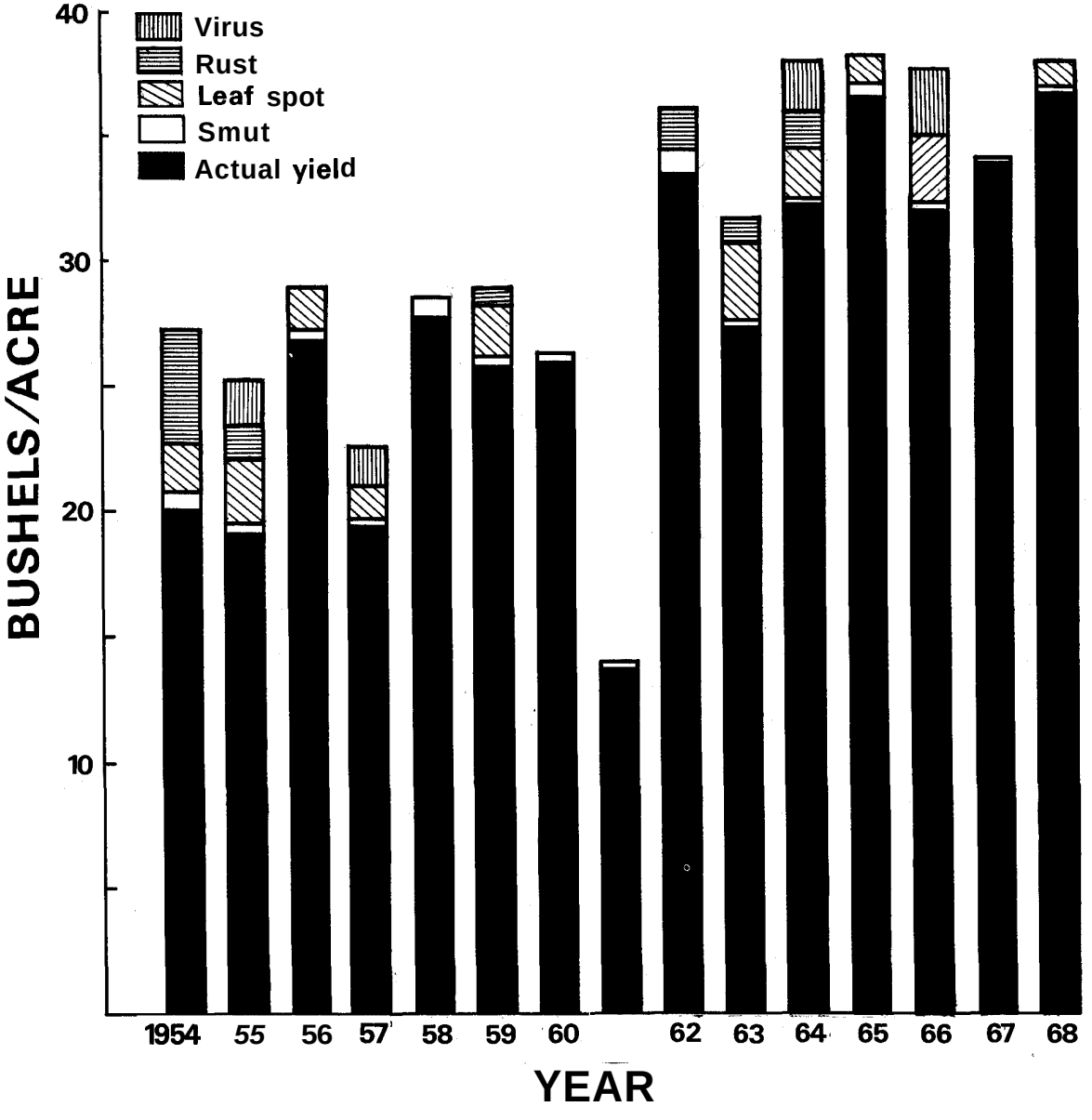


Figure 1. The effect of diseases on barley yields in Manitoba, 1954–68 The solid portion of a bar represents the actual average yield; the area above the solid portion represents the estimated yield loss from diseases. The top of a bar, therefore, represents the estimated potential average yield in the absence of disease.

Table 1. Yield, acreage, and loss from diseases of barley in Manitoba, 1954-68

| | | | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Test yield - | Montcalm | bu/ac | 47.3 | 54.2 | 61.1 | 52.3 | 62.9 | 61.7 | 55.7 | 43.1 | 55.0 | 41.9 | 52.6 | 62.3 | 49.6 | 64.1 | 68.4 |
| | Parkland | bu/ac | 64.1 | 63.5 | 68.7 | 61.9 | 71.4 | 71.1 | 61.7 | 45.5 | 68.0 | 48.8 | 68.6 | 68.0 | 52.4 | 67.7 | 70.5 |
| | Conquest | bu/ac | | | | | | | | | | 55.6 | 77.2 | 72.3 | 56.5 | 69.3 | 77.2 |
| Acreage | Montcalm | % | 93 | 89 | 88 | 83 | 57 | 46 | 45 | 42 | 41 | 34 | 28 | 21 | 12 | 7 | 4 |
| | Parkland | % | 7 | 11 | 12 | 17 | 43 | 54 | 55 | 58 | 59 | 58 | 57 | 54 | 46 | 22 | 23 |
| | Conquest | % | | | | | | | | | | 8 | 15 | 25 | 42 | 71 | 73 |
| Conversion factor | | | 2.424 | 2.891 | 2.305 | 2.780 | 2.394 | 2.578 | 2.261 | 3.248 | 1.876 | 1.715 | 2.031 | 1.855 | 1.681 | 2.017 | 2.046 |
| Manitoba average yield | | bu/ac | 20.0 | 19.1 | 26.9 | 19.4 | 27.8 | 25.9 | 26.1 | 13.7 | 33.4 | 27.4 | 32.2 | 36.6 | 32.0 | 34.0 | 36.8 |
| Converted yield | Montcalm | bu/ac | 19.5 | 18.7 | 26.5 | 18.8 | 26.3 | 23.9 | 24.6 | 13.3 | 29.3 | 24.4 | 25.9 | 33.6 | 29.5 | 31.8 | 33.4 |
| | Parkland | bu/ac | 26.4 | 22.0 | 29.8 | 22.3 | 29.8 | 27.6 | 27.3 | 14.0 | 36.2 | 28.5 | 33.8 | 36.7 | 31.2 | 33.6 | 34.5 |
| | Conquest | bu/ac | | | | | | | | | | 32.4 | 38.0 | 39.0 | 33.6 | 34.4 | 37.7 |
| Disease loss | Montcalm | % | 27.8 | 25.1 | 6.8 | 14.0 | 2.3 | 13.7 | 1.3 | 2.6 | 15.2 | 19.7 | 28.0 | 4.8 | 15.8 | 1.8 | 4.8 |
| | Parkland | % | 9.6 | 18.4 | 6.8 | 14.0 | 2.3 | 8.5 | 1.3 | 2.6 | 3.0 | 10.8 | 10.9 | 4.8 | 15.8 | 1.8 | 4.8 |
| | Conquest | % | | | | | | | | | | 10.0 | 10.0 | 3.0 | 14.0 | 0.0 | 3.0 |
| Potential yield | Montcalm | bu/ac | 27.0 | 25.0 | 28.4 | 21.9 | 26.9 | 27.7 | 24.9 | 13.6 | 34.6 | 30.4 | 36.0 | 35.3 | 35.0 | 32.4 | 35.1 |
| | Parkland | bu/ac | 29.3 | 26.9 | 32.0 | 25.9 | 30.5 | 30.1 | 27.7 | 14.4 | 37.4 | 31.9 | 37.9 | 38.5 | 37.0 | 34.2 | 36.2 |
| | Conquest | bu/ac | | | | | | | | | | 36.0 | 42.2 | 40.2 | 39.1 | 34.4 | 38.9 |
| Average disease loss | | bu/ac | 7.2 | 6.1 | 2.0 | 3.2 | 0.7 | 3.1 | 0.3 | 0.4 | 2.8 | 4.3 | 5.8 | 1.7 | 5.7 | 0.2 | 1.3 |
| Total acreage | | 000ac | 2202 | 2090 | 1548 | 1704 | 1584 | 1270 | 930 | 655 | 629 | 584 | 497 | 601 | 875 | 970 | 1170 |
| Total disease loss | | 000bu | 15,820 | 12,823 | 3,108 | 5,381 | 1,036 | 3,976 | 319 | 239 | 1,770 | 2,525 | 2,886 | 995 | 4,947 | 170 | 1,542 |
| Price | | $/bu | 0.92 | 0.94 | 0.82 | 0.79 | 0.81 | 0.78 | 0.84 | 1.05 | 1.00 | 0.92 | 1.02 | 1.05 | 1.10 | 0.91 | 0.85 |
| Total disease loss | | $000 | 14,555 | 12,054 | 2,549 | 4,251 | 839 | 3,101 | 268 | 251 | 1,770 | 2,322 | 2,944 | 1,045 | 5,442 | 155 | 1,311 |

about 20% loss in yield when severe. On this basis, losses in years when the diseases were widespread in farm fields were conservatively estimated as follows: severe, 10%; moderate to severe, 7%; moderate, 5%; and light to moderate, 3%. Similarly, no data are available on the extent of the damage caused by aster yellows and barley yellow dwarf on barley prior to 1964. However, epidemics of aster yellows on other crops occurred in 1955 and 1957 and it is assumed that barley was affected also. In 1966, a loss of 7% from this disease on barley was estimated by Westdal (5), so this figure was used as an estimate of the loss in the other 2 years.

## Results and discussion

### Effect of disease incidence on average yield

The potential average yield of barley in Manitoba in the absence of major disease epidemics is shown in Fig. 1, and the losses caused by disease are tabulated in Table 1. In 11 of the 15 years, diseases were responsible for decreasing the average yields considerably below those expected under the prevailing conditions of management and weather.

Major epidemics of stem rust (Puccinia graminis Pers.) occurred in 1954, 1962, and 1964, and less severe epidemics in 1955, 1959, and 1963. In 1954, when over 90% of the acreage was sown to susceptible varieties, the total loss was over $9 million and the gain from growing 'Vantage' was over $680,000 (Table 2). By 1964, only 28% of the acreage was sown to susceptible varieties and the loss was $874,000 compared to a gain of $1.7 million (Table 2) from the use of resistant varieties. Although rust does not appear every year, severe losses occur in epidemic years and rust resistance is mandatory for successful barley production in Manitoba.

The annual loss from smut diseases of barley caused by Ustilago nuda (Jens.) Rostr., U. nigra Tapke, and U. hordei (Pers.) Lagerh. varied little from 1954 to 1964 and averaged 1.8%. This comparatively low figure reflects the use of seed treatment chemicals for control, because losses as high as 12% still occur in fields of susceptible varieties grown from untreated seed. Losses over the 15-year period amounted to over $7 million, and with the introduction of smut-resistant varieties the gain has been $1.3 million.

Losses from foliage diseases include those caused by the three main diseases that occur in Manitoba; net blotch (Pyrenophora teres [Died.] Drechsl.), spot blotch (Cochliobolus sativus [Ito & Kurib.] Drechsl.), and septoria leaf blotch (Septoria passerinii Sacc.). Significant losses occurred from one or more of these diseases in 10 of the 15 years, and the total loss amounted to over $21 million.

Virus diseases decreased yields in at least 4 of the 15 years. Total losses from aster yellows were estimated to be over $8 million for the three major epidemics reported in 1955, 1957, and 1966. A loss from barley yellow dwarf was recorded only in

Table 2. Value of resistance to stem rust and to smut in barley varieties grown in Manitoba, 1954-68

| Year | Yield loss on susciptible varieties (%) | Yield of resistant varieties (bu/ac) | Yield increase from resistance (bu/ac) | Acreage of resistant varieties (000 ac) | Increase in production (000 bu) | Price ($/bu) | Value of resistance ($000) |
|---|---|---|---|---|---|---|---|
| Stem rust | | | | | | | |
| 1954 | 18.2 | 26.4 (P)* | 4.8 | 154 | 739.2 | 0.92 | 680.1 |
| 1955 | 6.7 | 22.0 (P) | 1.5 | 230 | 345.0 | 0.94 | 324.3 |
| 1959 | 5.2 | 27.6 (P) | 1.4 | 686 | 987.8 | 0.78 | 770.5 |
| 1962 | 12.2 | 36.2 (P) | 4.4 | 371 | 1639.8 | 1.00 | 1639.8 |
| 1963 | 8.9 | 28.5 (P) | 2.5 | 338 | 858.5 | 0.92 | 789.8 |
| | | 32.4 (C) | 2.9 | 47 | 134.5 | 0.92 | 124.6 |
| 1964 | 17.1 | 33.8 (P) | 5.8 | 283 | 1635.7 | 1.02 | 1668.4 |
| | | 38.0 (C) | 6.5 | 75 | 487.5 | 1.02 | 497.3 |
| | | | | | | Total | 6494.8 |
| Smut | | | | | | | |
| 1963 | 0.8 | 32.4 (C) | 0.3 | 47 | 12.2 | 0.92 | 11.2 |
| 1964 | 0.9 | 38.0 (C) | 0.3 | 75 | 25.5 | 1.02 | 26.0 |
| 1965 | 1.8 | 39.0 (C) | 0.7 | 150 | 105.0 | 1.05 | 110.3 |
| 1966 | 1.8 | 33.6 (C) | 0.6 | 368 | 224.5 | 1.10 | 247.0 |
| 1967 | 1.8 | 34.4 (C) | 0.6 | 685 | 424.7 | 0.91 | 386.5 |
| 1968 | 1.8 | 37.7 (C) | 0.7 | 854 | 580.7 | 0.85 | 493.6 |
| | | | | | | Total | 1274.6 |

* P = Parkland, C = Conquest.

**1964.** Losses from this disease probably occurred in other years but the effects of the disease were not recognized by those surveying for barley diseases prior to **1964.**

## Effect of weather conditions on average yield

Weather conditions varied between extreme drought in **1961** to excessive moisture in **1968** and accounted for sbme of the variations in average yield experienced during this period. Hot, dry weather reduced yields in **1957, 1961, 1963,** and **1967,** whereas cool, wet weather and absence of severe epidemics of disease contributed to near-record average yields in **1965** and **1968.** Although weather conditions affected yearly fluctuations in yield, they are not believed to have contributed to the marked increase in average yield evident during the period after **1961.** The Manitoba average yield for the period **1962** to **1968** was **30%** higher than for the period **1954** to **1960,** but the average yield of 'Parkland' in the cooperative tests was 3% lower. If weather was a factor it should have influenced the yield of 'Parkland', which was grown under uniform, optimum management conditions during the same periods.

## Effect of varieties on average yield

From **1954** to **1960,** varieties susceptible to stem rust and smut were grown on over **45%** of the acreage in Manitoba, and, from **1962** to **1968** the use of higher yielding, disease resistant varieties increased to **96%** of the acreage. The increased yield from these varieties contributed significantly to the higher Manitoba average yields obtained during the latter period but does not account for all of the increase. The average yield of barley in Manitoba from **1962** to **1968** was **30%** higher than in the period **1954-60.** However, the Manitoba average yield and the' yield of 'Montcalm' differed by only **11%** for the period **1962-68.** The yield difference oetween the Manitoba average, which reflects the acreage and yield of new varieties, and 'Montcalm' should have been greater if varietal improvement was mainly responsible for the better performance of barley in recent years.

## Effect of management on average yield

Good management practices such as the use of quality seed of recommended varieties, early seeding, seed treatment where necessary, weed control, soil testing, and the optimum use of fertilizers have been strongly recommended to obtain increased yields of barley. It appears from the analysis of these data that improved management has been the main factor in achieving higher average yields in recent years. The cohversion factor, which relates the yields obtained under optimum management conditions in experimental plots and the Manitoba average yield, was considerably smaller in each of the years **1962** to **1968**

than in any year previous to 1961 (Table 1). As disease, weather, and varieties have no bearing on this figure, it must be concluded that better management of barley has decreased the difference between yields in farm fields and those in experimental tests. The acreage of barley dropped from a peak of 2,365,000 acres in 1953 to 497,000 acres in 1964, the lowest acreage since 1914. Possibly only those farmers who were using the best management practices and obtaining satisfactory yields continued to grow barley, and the higher Manitoba average yield reflects the yields obtained by only the best growers.

## Conclusions

Estimates of losses from diseases and gains from resistance are only as accurate as the data on which they are based. In most studies, as in this one, the lack of data on disease incidence has been the limiting factor. Information is available on the yield losses caused by specific diseases under experimental conditions, but the results of these studies must be correlated with extensive surveys over all of the area involved to determine the prevalence of each disease. Recognizing this limitation, I have been as conservative as possible in extrapolating losses from these data.

Losses were assessed only in years when epidemics of specific diseases were known to occur. Losses in other years or from other diseases such as root rot, seedling blight, ergot, and bacterial blight, for which adequate data on incidence were not available, were not included. Average losses varied from 0.3 bu/ac in 1960 to 7.2 bu/ac in 1954 and the total loss for the 15-year period amounted to $52,846,000. These losses reflect estimates of decreased yield only, and no attempt was made to assess the decrease in value of the crop resulting from the effects of diseases on quality.

It should be emphasized that the total gain of $7,769,400 (Table 2) from the use of resistant varieties does not reflect the total value of these varieties to the economy. This figure only represents the value of their disease resistance and does not include the value of their inherent yield advantage over older varieties. To obtain estimates of their true value, similar studies would have to he made in Saskatchewan and Alberta where 75% of the barley in Western Canada is grown.

The results substantiate conclusions reached previously by those working on barley improvement in Manitoba. Extension services must place greater emphasis on promoting good management practices, and research programs must place greater emphasis on developing high yielding varieties with resistance to foliage diseases as well as to rust and smut, and on developing control measures for virus diseases through varietal resistance or other methods.

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