LOSSES FROM CEREAL DISEASES IN MANITOBA IN 1971[1]

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Introduction

It was pointed out previously by McDonald et al. (8) that data on losses caused by plant diseases have become increasingly important to agencies such as FAO, USDA, and CDA in the setting of priorities in research programs. The objective sought in a three-year study initiated by this station in 1969 was to appraise the degree of reduction of crop yield from various diseases and to place a monetary value on the gains achieved by growing the current resistant varieties. By following similar procedures in successive years in the same territory observations could be made on consistencies and discrepancies. To this end the disease loss study in cereal crops begun by McDonald et al. in 1969 (8) in Manitoba and in 1970 extending also over a part of Saskatchewan (9) was continued in the present study in 1971 in Manitoba only.

Methods

The procedure followed was essentially the same as in 1969 and 1970. Observations were made over the same six survey routes as previously followed in Manitoba. Because the 1971 provincial agricultural census was not available, the 1966 census (3) was again used to ascertain the number of survey sites required in each district, as described previously by McDonald et al. (8), and in general close agreement was achieved (Table 1).

The surveys were made from July 26 until August 10. Crop maturity varied from the heading to the dough stage but the data were adjusted to be equivalent to the milky-ripe stage for the conversion of disease incidence into estimated crop damage. To facilitate comparisons, the results in the 12 crop districts surveyed were grouped into five larger areas as in 1969 and 1970.

The methods of assessing losses from individual diseases were similar to those used previously (8, 9). Field readings of leaf rust of wheat and crown rust of oats, made as a percentage rating based on the modified Cobb scale, were adjusted according to the maturity of the crop. To those made before the milk stage 20% was added; from those made after the milk stage, 20% was subtracted. The adjusted reading was then referred to Chester's Table 4 (1) to find the estimated percentage loss.

The loss from leaf spotting diseases such as infection by bacteria, Septoria spp., Helminthosporium spp., and Rhynchosporium secalis, was derived from the formula

$$\frac{\text{2/3 infection \% flay leaf} + \text{1/2 infection \% 2nd leaf}}{2}$$

This formula was adapted from the work of James et al. (7) with Rhynchosporium secalis infection in barley.

The potential average yield in each area was estimated by use of the formula

$$\frac{100 \times \text{mean yield}}{100 - \text{\% loss from all diseases}}$$

The loss in bushels was calculated by multiplying the mean percentage loss attributable to diseases by the potential yield per acre times the acreage.

The methods of assessing losses from individual diseases and of assessing gains from disease resistance were similar to those used previously (8). In the 1971 Western Wheat Cooperative Tests, the mean yields in cwt/acre from nine stations in the rust area (Glenlea, Morden, Portage la Prairie, Brandon, Indian Head, Melfort, Regina, and Saskatoon) were: 'Manitou', 32.1; 'Thatcher', 32.1; and 'Marquis', 27.7. The mean yields from ten stations in the adjoining rust free area (Edmonton, Evansburq, Beaverlodge, Kindersley, Scott, Acme, Lethbridqe, and Swift Current) were: 'Manitou', 30.1; 'Thatcher', 30.4; and 'Marquis', 28.8. The gain in production from leaf rust resistance was calculated by subtracting the difference between the mean yields of 'Manitou' and 'Thatcher' in the non-rust area from the difference between the mean yields of 'Manitou' and 'Thatcher' in the rust area and expressing this quantity as a Dercentage of the yield of Manitou in the rust area.

A somewhat parallel calculation was made for the gain in production from stem-rust resistance. The difference between the mean yields of 'Thatcher' and 'Marquis' in the

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Table 1. Number of commercial farms in Manitoba with specific crops, number of survey sites in 1971 and percentage of farms surveyed by crop district

Area and crop district	Wheat			Oats			Barley		
	Number of farms*	Farms surveyed (no.)	(%)	Number of farms	Farms surveyed (no.)	(%)	Number of farms	Farms surveyed (no.)	(%)
East									
4	513	7	1.4	605	8	1.3	403	7	1.7
5	1750	14	0.8	1880	5	0.3	843	7	0.8
6	96			189			29		
12	600			728			321		
Total	2959	21	0.7	3402	13	0.3	1596	14	0.9
Central									
3	3723	18	0.5	3204	18	0.6	1649	18	1.1
Southwest									
1	1544	13	0.8	1207	12	0.9	586	5	0.9
2	2335	14	0.6	1913	13	0.7	994	10	1.0
7	1422	11	0.8	1299	10	0.8	632	12	1.9
Total	5301	38	0.7	4419	35	0.8	2212	27	1.2
West-central									
8	1541	13	0.8	1427	12	0.8	571	10	1.8
9	1360	10	0.7	1276	12	0.9	571	8	1.4
10	2543	20	0.8	1852	20	1.1	1465	18	1.2
14	599	4	0.7	630	3	0.5	273	3	1.1
Total	6043	47	0.8	5185	47	0.9	2880	39	1.4
Northwest									
11	1818	2	0.1	1489	4	0.3	810	5	0.6
13	932	7	0.8	656	6	0.9	702	6	0.9
Total	2750	9	0.3	2145	10	0.4	1512	11	0.7

* Based on 1966 farm census.

non-rust area was subtracted from the difference in the mean yields of 'Thatcher' and 'Marquis' in the rust area and this subtracted quantity was expressed as a percentage of the yield of Manitou in the rust area. This percentage was applied to the production of wheat "Manitou predominating) in Manitoba to find the gain in production attributable to the stem rust resistance in 'Manitou'.

For the probable losses that would be caused in susceptible cereals as compared with the resistant varieties sown in Manitoba, the methods of estimatinq used by McDonald et al. (8) were adopted.

Results

Wheat

Yield losses from the diseases of wheat that occurred in Manitoba in 1971 amounted to 6.4 million bushels or 8.8% of the potential yield without disease (Table 2).

Most of the wheat acreage surveyed was sown to varieties that were resistant to stem rust (Puccinia graminis Pers. f. sp. tritici Erikss. & Henn.) and losses from this source were of no significance.

Bacterial black chaff [Xanthomonas translucens f. sp. undulosa (Smith, Jones, & Reddy) Haqborg and X. translucens f. sp. cerealis Hagborg] caked a loss of 2.7 million bu or 3.7% of the potential production. Previously this disease had been included under leaf spots but in 1971 it was recorded separately. The high frequency of mid-season rains probably resulted in more bacterial infection than averaqe. A particularly severe infection, not included in the disease loss survey, was noted in the second half of August in an area north and west of Portage la Prairie. In this district every one of 13 fields examined had bacterial black chaff present. Leaf area destruction ranged from 15% to 100% with a mean value of 65%. Glume discoloration was less destructive but in some fields was recorded on 100% of the heads.

Leaf rust was the second most important single disease, causing losses of 1.1 million bu or 1.6% of the potential production.

Leaf spots caused by Dreschslera tritici-repentis (Died.) Shoem., Bipolaris sorolciniana (Sacc. in Sorok.) Shoem., and Septoria avenae Frank. f. sp. tritici T.

Table 2. Yield losses from diseases in wheat in Manitoba, 1971

Area (crop districts)		Yield losses from: Leaf rust	Bacterial black chaff	Leaf spots	Viruses	Root rot	Total loss	Average yield (bu/ac)	Potential avg yield (bu/ac)	Acres ('000)	Potential production ('000 bu)
East	Range (%)	0–6	0–28	0	0	0					
(4, 5)	Mean (%)	0.8	5.6	0	0	0	6.4	27.4	28.7	357	10,246
	Bu* ('000)	82	574	0	0	0	656				
Central	Range (%)	0–12	0–13	0–35	0	0–1					
(3)	Mean (%)	2.5	1.7	4.9	0	0	9.1	28.9	31.8	499	15,868
	Bu ('000)	397	270	778	0	0	1444				
Southwest	Range (%)	0–8	0–20	1–20	0-tr†	0–6					
(1, 2, 7)	Mean (%)	1.8	4.6	3.7	0	0.3	10.4	29.0	32.4	637	20,639
	Bu ('000)	372	949	764	0	62	2146				
West-central	Range (%)	0–15	0–18	0–20	0	0-tr					
(8, 9, 10)	Mean (%)	1.4	3.0	2.3	0	0	6.7	29.9	32.0	543	17,376
	Bu ('000)	243	521	400	0	0	1164				
Northwest	Range (%)	0–3	0–12	0–20	0	0-tr					
(11, 13, 14)	Mean (%)	0.5	4.0	6.9	0	0	11.4	29.8	33.6	268	9,005
	Bu ('000)	45	360	621	0	0	1027				
Total ('000 bu)		1139	2674	2563	0	62	6437	28.9	31.7	2304	73,134
% of potential production		1.6	3.7	3.5	0	0.1	8.8				

* Bu = bushels

† tr = trace

Johnson, caused losses of 2.6 million bu or 3.5% of the potential production. No losses from smuts and virus diseases were recorded and the losses from root rot were light at 0.1%.

Oats

Losses from diseases in oats were 1.6 million bushels or 2.2% of the potential production for Manitoba. Stem rust was found in trace amounts at only two locations, but crown rust reduced the yield by 0.7 million bu or 0.9% of the potential production (Table 3).

Leaf spots, caused by Drechlera avenacea (Curt. ex Cke.) Shoem., Septoria avenae Frank f. sp. avenae Conners and Pseudomonas coronafaciens (Elliott) Stevens also reduced the yield by 0.7 million by or 0.9% of the potential production. Colletotrichum graminicola (Ces.) G. W. Wilson made an erratic appearance varying from absent to as high as 20% of the leaf area affected. Virus diseases, viz. barley yellow dwarf, oat blue dwarf, and aster yellows, caused an estimated 0.1 million bu loss (0.1%) and blast a 0.2 million bu loss (0.3%). No losses were recorded for smuts.

Table 3. Yield losses from diseases in oats in Manitoba, 1971

Area (crop districts)		Yield losses from: Crown rust	Leaf spot	Viruses	Blast	Total loss	Average yield (bu/ac)	Potential avg yield (bu/ac)	Acres ('000)	Potential production ('000 bu)
East	Range (%)	0–10	0-tr	0-tr	0-tr					
(4, 5)	Mean (%)	1.5	0	0	0	1.5	50.7	51.5	306	15,759
	Bu ('000)	236	0	0	0	236				
Central	Range (%)	0–10	0-tr	0–4	0					
(3)	Mean (%)	1.4	0	0.2	0	1.6	54.9	55.8	274	15,289
	Bu ('000)	214	0	31	0	245				
Southwest	Range (%)	0–3	0–10	0-1	0–5					
(1, 2, 7)	Mean (%)	0.6	0.3	0.2	0.1	1.2	51.6	52.2	337	17,591
	Bu ('000)	106	53	35	18	211				
West-central	Range (%)	0–14	0–10	0-0.7	0-10					
(8, 9, 10)	Mean (%)	0.7	0.5	0	0.3	1.5	50.8	51.6	344	17,750
	Bu ('000)	124	89	0	53	266				
Northwest	Range (%)	0	0–10	0-tr	0–5					
(11, 13, 14)	Mean (%)	0	5.7	0	1.4	7.1	45.7	49.2	197	9,692
	Bu ('000)	0	552	0	136	688				
Total ('000 bu)		680	694	66	207	1646	51.1	52.2	1458	76,081
% of potential production		0.9	0.9	0.1	0.3	2.2				

Table 4. Yield losses from diseases in barley in Manitoba, 1971

Area (crop districts)		Yield losses from: Viruses	Leaf spot	Thrips	Leaf rust	Stem rust	Smut	Root rot	Total yield loss	Average yield (bu/ac)	Potential avg yield (bu/ac)	Acres ('000)	Potential production ('000 bu)
East	Range (%)	0-1	0-13	0-1	0	0	0	0					
(4, 5)	Mean (%)	0.2	3.5	0.1	0	0	0	0	3.8	43.9	45.6	289	13,178
	BU ('000)	26	461	13	0	0	0	0	501				
Central	Range (%)	0-2	0-15	0-1	0-tr	0	0-5	0					
(3)	Mean (%)	0.3	3.3	0.1	0	0	0.3	0	4.0	46.6	48.5	409	19,837
	Bu ('000)	60	655	20	0	0	60	0	793				
Southwest	Range (%)	0-3	0-30	0-5	0-tr	0	0-tr	0					
(1, 2, 7)	Mean (%)	0.3	3.3	0.4	0	0	0	0	4.0	46.7	48.6	585	28,431
	Bu ('000)	85	938	114	0	0	0	0	1137				
West-central	Range (%)	0-0.7	0-30	0-5	0-tr	0	0-13	0					
(8, 9, 10)	Mean (%)	0	2.8	0.4	0	0	0.8	0	4.0	47.3	49.2	482	23.714
	Bu ('000)	0	664	95	0	0	190	0	949				
Northwest	Range (%)	0-tr	0-27	0-tr	0	0	0-10	0-tr					
(11, 13, 14)	Mean (%)	0	9.6	0	0	0	1.4	0	11.0	41.9	47.1	361	17,003
	BU ('000)	0	1632	0	0	0	238	0	1870				
Total ('000 bu)		171	4350	242	0	0	488	0	5250	45.6	48.1	2126	102,163
% of potential production		0.2	4.3	0.2	0	0	0.5	0	5.1				

Barley

Yield losses in barley from disease amounted to 5.3 million bu (5.1%) and from damage by thrips 0.2 million bu (0.2%, Table 4).

Of all diseases, leaf spots incited by Bipolaris sorokiniana, Drechslera teres (Sacc.) Shoem., Septoria passerinii Sacc., Puccinia hordei Otth., Rhynchosporium secalis (Oud.) Davis, and Xanthomonas translucens f. sp. hordei–avenae Hagborg were the most destructive, resulting in a loss of 4.4 million bu (4.3% of the potential yield). Smuts caused a loss of 0.5 million bu (0.5%) and viruses 0.2 million bu (0.2%). The virus disease most prevalent was barley stripe mosaic and in a special survey Chiko (2) found it in 34% of the fields of 2–rowed barley and 4.5% of the fields of 6–rowed barley.

Value of resistance

The resistance to stem rust, leaf rust, and loose smut in the varieties of wheat presently grown combined to make a

Table 5. Value of disease resistance in cereal varieties grown in Manitoba, 1971

Crop	Disease	Loss in* susceptible varieties (%)	Acreage of† resistant varieties (%)	Total** production ('000 bu)	Gain in production ('000 bu)	Price ($/bu)	Value ($000)
common wheat	Stem rust	8.7	100	70,000	6,090	1.40	8,526
	Leaf rust	0.9	90		567		894
	Loose smut	1.3	100		910		1,274
	Total				7,567		10,694
Oats	Smut	1.2	99	80,000	950	0.50	475
Barley	Smut	2.1	60	100,500	478	0.75	358
Total					8,593		11,523

* See McDonald et al. (8) for method of determining loss in susceptible varieties.

† Seed Time and Harvest. Nos. 117, 119, 122. Federal Grain Ltd., Winnipeg, Manitoba.

** Manitoba Agriculture 1971 Yearbook.

substantial gain in wheat production in 1971 worth over $10 million (Table 5) and when this was added to gains from resistance to the smuts of oats and barley a total was reached of more than $11.5 million.

A summary of the losses from disease and the gains from disease resistance in the varieties grown for the 3-yr period is given in Table 6. It will be noted that the annual saving for the three years is estimated at over $11 million.

Table 6. Yield losses from diseases in wheat, oats and barley in Manitoba, 1969-71

Year	Wheat.	Oats	Barley
		bushels	
1969*	3,344,600	5,259,100	4,073,200
1970†	2,837,400	9,906,900	3,992,500
1971	6,437,000	1,646,000	5,250,000
Total	12,619,000	16,812,000	13,315,700
Mean	4,206,333	5,604,000	4,438,567

* Data from McDonald et al. (8).

† Data from McDonald et al. (9).

Discussion

The present paper covers the last phase of a three-year study of disease losses by means of systematic plant disease surveys. Losses from the different diseases, especially the rusts, fluctuated from year to year suggesting that even qreater fluctuations might occur in a longer study. Similarly the savings from resistance probably did not reach a maximum. Thus the yields of Marquis wheat in the Western Wheat Cooperative Tests in the "rust area" during the three years, viz. 18.1, 21.2 and 27.7 cwt/ac, did not suggest that rust was potentially severe in any of these years. The same opinion apparently was held by Green (4,5,6). Two noticeable changes in 1971 were the marked drop in virus diseases in barley and the appreciable loss from bacterial black chaff recorded when this disease was separated from other leaf spot diseases.

Satisfactory observations on ergot could not be made at the time of the general disease loss survey as ergot bodies were not evident at this date.

Two general conclusions appear to be obvious from the study. Losses from all diseases, reaching an annual averaqe of 4.2 million bu of wheat, 5.6 million bu of oats, and 4.4 million bu of barley, are great enough to justify considerable research and extension work in their control; and, secondly, the average annual gain in production as a result of the use of the present disease-resistant varieties (Table 7) has amply justified the federal and provincial expenditures on research and extension in Manitoba thus far.

Table 7. Gain in productivity from the use of disease-resistant wheat, oats and barley varieties in Manitoba, 1969-71

Year	Wheat	Oats	Barley	Total
1969	$16,146,100	$ 411,800	$ 466,000	$17,023,900
1970	4,820,700	314,200	487,600	5,622,500
1971	10,694,000	475,000	358,000	11,523,000
Total	31,660,800	1,201,000	1,311,600	34,169,400
Mean	10,553,600	400,333	437,200	11,389,800

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