LOSSES FROM CEREAL DISEASES AND VALUE OF DISEASE RESISTANCE IN MANITOBA AND EASTERN AND NORTHERN SASKATCHEWAN IN 1970[1]

W.C. McDonald, J.W. Martens, J. Nielsen, G.J. Green, D.J. Samborski, G. Fleischmann, C.C. Gill, A.W.Chiko, and R.J. Baker

Data on the losses caused by specific plant diseases and on gains in productivity from the use of disease control measures are necessary for the efficient management of the limited research resources available to solve disease problems.

Obtaining the data, however desirable they may be, presents many problems. The pathologists must be familiar with many fungal, bacterial, viral, and physiologic diseases on a number of crops; there must be research to establish the losses caused by various levels of infection at different stages of crop development so that field observations can be related to loss; and large areas must be surveyed at a time when the research and development disease nurseries require the most attention.

Until 1969, pathologists in Manitoba relied on limited field surveys and yield trials in experimental plots to assess the importance of the various diseases. This approach was adequate for its time and served to identify the most important diseases which were then given a high priority in cereal breeding programs. However, except for the rusts, very little specific disease data were generated; less obvious diseases received scant attention; and there was inadequate information to redirect or initiate research and control programs.

Similarly, the advantages of new, disease resistant varieties have been so obvious that no need was felt to provide extensive data on their value to growers or to those providing funds for research.

To provide additional much needed information, an extensive survey was done in Manitoba in 1969, estimating the losses caused by the major diseases of wheat, oats, and barley (1). This paper reports a similar survey, extended to include parts of Saskatchewan, conducted in 1970.

Materials and methods

The methods used were similar to those developed in 1969 (1) with sliqht modifications. Eight survey routes were mapped to cover all of the crop districts in Manitoba and four in eastern and northern Saskatchewan. The routes through Manitoba, two for each crop, were designed to pass through the areas in which over 75% of the specific crop was grown; the Saskatchewan routes were intended to cover all cereal crops. The length of specific routes varied from 370 to 1600 miles covering a total of 6000 miles and 689 fields in 41 man days.

The optimum number of survey sites in each crop district was arbitrarily set at 1% of the farms growing the specific crop and this figure was usually achieved or exceeded, except in the case of wheat (Table 1). The number of farms, rather than the number of acres in a district, was used because management practices such as seed treatment, crop rotation, and other disease control measures were assumed to be uniform on a particular farm regardless of the size of fields. The sites were marked on the route maps at 15- to 20-mile intervals and the field closest to each site on the route was surveyed. Although each route was designed to survey a specific crop, some sites for the other two crops were also included. Disease incidence in each field was assessed on 25 plants, one collected every 2 paces along a traverse 50 yards long and 50 yards in from the edge of the field. Disease ratings and information on stage of growth, location, etc. were recorded on crop-specific survey forms.

The surveys were conducted during the period of July 28 to Aug. 12 when most of the crop was in the soft dough stage. For the final analysis of the data the 14 crop districts were grouped into five areas based on previous knowledge of the general distribution of diseases. For Saskatchewan existing crop districts were used.

The range and mean percentage loss for each disease were determined and the potential average yield in each area was found by multiplying the average yield by 100 and dividing by 100 minus the percentage loss

[1] Contribution No. 469, Research Station, Canada Department of Agriculture, Winnipeg 19, Manitoba.

Table 1. Number of farms with specific crops, number of survey sites, and percentage of farms surveyed in Manitoba and in eastern and northern Saskatchewan

Area and Crop District	Wheat			Oats			Barley		
	No. of farms*	Farms surveyed (No.)	(%)	No. of farms*	Farms surveyed (No.)	(%)	No. of farms*	Farms surveyed (No.)	(%)
MANITOBA									
East									
4	513	6		605	15		403	4	
5	1750	12		1880	20		843	16	
6	96			189	3		29		
12	600			728	1		321		
Total	2959	18	0.6	3402	39	1.1	1596	20	1.2
Central									
3	3723	25	0.7	3204	33	1.0	1649	26	
Southwest									
1	1544	14		1207	7		586	6	
2	2335	12		1913	12		994	11	
7	1422	11		1299	8		632	13	
Total	5301	37	0.7	4419	27	0.6	2212	30	1.4
West-central									
8	1541	11		1427	13		571	12	
9	1360	11		1276	15		571	13	
10	2543	15		1852	18		1465	16	
14	599	2		630	2		273		
Total	6043	39	0.6	5185	48	0.9	2880	41	1.4
Northwest									
11	1818	8		1489	8		810	10	
13	932	4		656	4		702	4	
Total	2750	12	0.4	2145	12	0.6	1512	14	0.9
TOTAL		131			159			131	
SASKATCHEWAN									
Southeast (1)		26			20			13	
East-central (5)		37			24			35	
Northeast (8)		19			13			20	
Northwest (9)		26			9			26	
TOTAL		108			66			94	

* Manitoba Agriculture Yearbook, 1969.

from all diseases. The loss in bushels from individual diseases was calculated by multiplying the mean percentage loss from a disease by the potential yield and by the acreage.

The methods of assessing losses from individual diseases were similar to those used the previous year (1). The gain in wheat production from the use of stem- and leaf-rust resistant varieties was obtained by comparing the average yield of 'Manitou' (resistant to stem rust and moderately resistant to leaf rust), 'Thatcher' (susceptible to leaf rust) and 'Marquis' (susceptible to both rusts) in the 1970 Western Wheat Co-operative Tests. The mean yields in cwt/acre from seven stations in the 1970 rust area (Brandon, Portage la Prairie, Morden, Indian Head, Melfort, Regina and Saskatoon) were: 'Manitou', 25.7; 'Thatcher', 23.7; and 'Marquis', 21.2. The mean yields from ten stations in the adjoining rust-free areas of Saskatchewan and Alberta (Cabri, Kindersley, Scott, Swift Current, Acme, Beaverlodge, Edmonton, Evansburg, Lacombe, and Lethbridge) were: 'Manitou', 26.5; 'Thatcher', 25.7; and 'Marquis', 24.2 cwt/acre. The gain in production from leaf rust resistance was calculated from the difference in yield between 'Manitou' and 'Thatcher' as a percentage of the yield of 'Manitou'; and from stem rust resistance, the difference between 'Thatcher' and 'Marquis' yields as a percentage yield advantage of 'Manitou' and 'Thatcher' under rust-free conditions.

Table 2. Yield losses from disease in wheat in Manitoba, 1970

Area (Crop District)		Yield losses from: Leaf rust	Leaf spot	Virus	Root rot	Total	Average yield (bu/ac)	Potential avg yield (bu/ac)	Acres ('000)	Potential production ('000 bu)
East	Range (%)	T –20	0–25	0-T	0-0		18.3	19.8	234	4,633.2
(4, 5, 6, 12)	Mean (%)	2.6	4.7	0	0	7.3				
	Bu† ('000)	120.5	217.8	0	0	338.2				
Central	Range (%)	T–10	0–17	0–3	0-0		19.3	20.7	297	6,147.9
(3)	Mean (%)	0.8	2.0	0.1	0	2.9				
	Bu ('000)	49.2	123.0	6.1	0	178.2				
Southwest	Range (%)	0–35	0–25	0–4	0-1		22.2	23.8	418	9,948.4
(1, 2, 7)	Mean (%)	3.2	3.2	0.1	0.1	6.6				
	Bu ('000)	318.3	318.3	9.9	9.9	656.6				
West-central	Range (%)	T–20	0–15	0-T	0-T		22.8	24.3	307	7,460.1
(8, 9, 10)	Mean (%)	5.1	1.2	0	0	6.3				
	Bu ('000)	380.5	89.5	0	0	470.0				
Northwest	Range (%)	T–35	0–32	0-0	0–10		24.1		144	4,665.6
(11, 13, 14)	Mean (%)	17.4	6.7	0	1.5	25.6		32.4		
	Bu ('000)	811.8	312.6	0	70.0	1,194.4				
Total ('000 bu)		1,680.3	1,061.0	16.0	79.9	2,837.4	21.6	23.5	1,400	32,855.2
% of potential production		5.11	3.23	0.05	0.24	8.64				

* T = trace

† Bu = bushels

Table 3. Yield losses from disease in oats in Manitoba, 1970

Area (Crop District)		Yield losses from: Crown rust	Stem rust	Virus	Leaf spot	Blast	Total	Average yield (bu/ac)	Potential avg yield (bu/ac)	Acres ('000)	Potential production ('000 bu)
East	Range (%)	0–50	0–56	0–14	0–5	0-0					
(4, 5, 6, 12)	Mean (%)	14.8	17.3	0.8	0.3	0	33.2	35.9	53.7	328	17,613.6
	Bu ('000)	2,606.8	3,047.2	140.9	52.8	0	5,847.7				
Central	Range (%)	T–34	0–40	0–8	0–5	0-1		39.2	51.0	203	10,353.0
(3)	Mean (%)	9.8	12.8	0.3	0.2	0	23.1				
	Bu ('000)	1,014.6	1,325.1	31.1	20.7	0	2,391.5				
Southwest	Range (%)	0–16	0–15	0–4	0–8	0–3		43.4	45.4	275	12,485.0
(1, 2, 7)	Mean (%)	2.2	1.6	0.2	0.3	0.1	4.4				
	Bu ('000)	274.7	199.8	25.0	37.5	12.5	549.3				
West-central	Range (%)	0–20	0–15	0–3	0–2	0–5		48.0	50.2	289	14,507.8
	Mean (%)	3:7	0.4	0.1	0.1	0.1	4.4				
	Bu ('000)	536.8	58.0	14.5	14.5	14.5	638.3				
Northwest	Range (%)	0–10	0–2	0–2	0–32	0–5		44.8	47.7	165	7,870.5
(11, 13, 14)	Mean (%)	2.3	0.1	0.3	2.9	0.5	6.1				
	Bu ('000)	181.0	7.9	23.6	228.2	39.3	480.1				
Total ('000 bu)		4,613.9	4,638.0	235.1	353.7	66.3	9,906.9	41.9	49.9	1,260	62,829.9
% of potential production		7.34	7.38	0.37	0.56	0.10	15.76				

Table 4. Yield losses from disease in barley in Manitoba, 1970

Area (Crop District)		Yield losses from: Virus	Leaf spot	Thrips	Leaf rust	Stem rust	smut	Root rot	Total	Average yield (bu/ac)	Potential avg yield (bu/ac)	Acres ('000)	Potential production ('000 bu)
East (4, 5, 6, 12)	Range (%)	0–29	0–17	0–5	0–3	0-0	0-11	0-0	T–42	27.6	32.0	242	7,744.0
	Mean (%)	7.8	4.5	0.2	0.2	0	1.1	0	13.8				
	Bu ('000)	604.0	348.5	15.5	15.5	0	85.2	0	1,068.7				
Central (3)	Range (%)	0–28	0-11	0–5	0–6.4	0–17.5	0–4.0	0-0	0–43.1	29.9	32.4	275	8,910.0
	Mean (%)	3.8	1.3	0.9	0.4	1.2	0.2	0	7.8				
	Bu ('000)	338.6	115.8	80.2	35.6	106.9	17.8	0	694.9				
Southwest (1, 2, 7)	Range (%)	0–15	T–15	0–10	0-4.8	0-0	0–10	0-T	T–30.0	36.1	38.0	399	162.0
	Mean (%)	1.3	1.7	1.5	0.3	0	0.3	0	5.1				
	Bu ('000)	197.1	257.1	227.4	45.5	0	45.5	0	773.3				
West central (8, 9, 10, 14)	Range (%)	0–6	0–20	0–10	0–13.5	0-0	0–5	0-T	0–33.5	39.5	41.6	331	769.6
	Mean (%)	0.2	2.1	1.9	0.7	0	0.1	0	5.0				
	Bu ('000)	27.5	289.2	261.6	96.4	0	13.8	0	688.5				
Northwest (11–13)	Range (%)	0-1.2	T-8.5	0-10	0–7	0-0	0-T	0–12	T–30.6	34.9	37.9	253	588.7
	Mean (%)	0.1	1.9	3.2	1.1	0	0	1.7	8.0				
	Bu ('000)	9.6	182.2	306.8	105.5	0	0	163.0	767.1				
Total ('000 bu)		1,176.8	1,192.8	891.5	298.5	106.9	162.3	163.0	3,992.5	34.1	36.8	1,500	55,174.3
% of potential production		2.13	2.16	1.61	0.54	0.20	0.30	0.30	7.24				

Results

Wheat

Losses from the major diseases of wheat that occurred in Manitoba and eastern and northern Saskatchewan amounted to 2.8 and 4.3 million bu or 8.6 and 8.11, respectively, of the potential yield without disease (Tables 2 and 5). The value of rust and smut resistance for Manitoba was estimated at 3.4 million bu. or $4.8 million (Table 8).

Most of the wheat varieties grown in the area surveyed are resistant to stem rust (Puccinia graminis Pers. f. sp. tritici Eriks. and E. Henn.) and losses were not significant. Leaf rust (Puccinia recondita Rob. ex. Desm.) was the single most important disease in Manitoba, causing losses of 1.7 million bu or 5.1% of the potential production. Saskatchewan losses amounted to 1.9 million bu or 2.6% of the potential production.

All of the common wheat varieties grown in Manitoba are resistant to loose smut caused by Ustilago tritici (Pers.) Rostr.; only trace infections occurred in both common and durum wheats in 1970.

Leaf spot diseases caused by Drechslera tritici-repentis (Died.) Shoem., Bipolaris sorokiniana (Sacc. in Sorok.) Shoem. and Septoria avenae Frank f. sp. triticea T. Johnson caused losses of 1.0 and 2.2 million bu or 3.2 and 4.2% of the potential production for Manitoba and the Saskatchewan area respectively.

Losses caused by virus diseases and root rot were slight in all areas surveyed.

Oats

Losses from diseases in oats amounted to 9.9 and 0.8 million bu or 15.8 and 1.4% of the potential production for Manitoba and the Saskatchewan areas respectively (Tables 3 and 7). Crown rust (Puccinia coronata Cda. f. ap. avenae Eriks.) and stem (Puccinia graminis Pers. f. sp. avenae Eriks. and E. Henn.) were the most destructive diseases of oats in Manitoba, causing losses of $4.6 million. Abundant inoculum combined with a considerable acreage of late-seeded oats resulted in the most severe epidemic and the greatest yield loss since 1955.

Most of the oat varieties grown in the area surveyed are resistant to the prevalent races of smut; only trace infections of loose and covered smut were found in Manitoba and mean levels of up to 0.1% were present in only one district in Saskatchewan. The gain in production form the use of smut resistant varieties in Manitoba amounted to 0.6 million bu or $0.3 million. In the area surveyed, virus diseases and leaf spot diseases caused by Drechslera avenacea (Curt. ex Cke.) Shoem. and Septoria avenae Frank f. sp. avenae caused only slight losses.

Barley

Losses caused by the major diseases and by thrips in barley totalled 4.0 and 6.1 million bu or 7.2 and 7.6% of the potential production for Manitoba and the Saskatchewan area, respectively (Tables 4 and 6).

Thrips were the most important cause of crop damage in the Saskatchewan area, causing losses of 3.5 million bu or 4.3% of potential yield; Manitoba losses from this cause were

Table 5. Yield losses from disease in wheat in eastern and northern Saskatchewan, 1970

Area (Crop District)		Yield losses from: Leaf rust	Leaf spot	Virus	Root rot	Total	Average yield (bu/ac)	Potential avg yield (bu/ac)	Acres ('000)	Potential production ('000 bu)
Southeast (1)	Range (%)	0–3	0–8	0-T	0–5	T–9	21.7	22.1	463	10,232.3
	Mean (%)	1.1	0.4	0	0.3	1.8				
	Bu ('000)	112.6	40.9	0	30.7	184.2				
East–central (5)	Range (%)	0–35	0–27	0-T	0-T	T–42	26.4	29.4	668	19,639.2
	Mean (%)	7.2	2.9	0	0	10.1				
	Bu ('000)	1,414.0	569.5	0	0	1,983.6				
Northeast (8)	Range (%)	0–3	T–25	0-T	0–12	T–29	27.2	29.1	358	10,417.8
	Mean (%)	0.6	4.9	0	1.0	6.5				
	Bu ('000)	62.5	510.5	0	104.2	677.1				
Northwest (9)	Range (%)	0–20	0–38	0–2	0–1	T–50	29.2	33.0	375	12,375.0
	Mean (%)	2.6	8.7	0.1	0.2	11.6				
	Bu ('000)	321.7	1,076.6	12.4	24.8	1,435.5				
Total ('000 bu)		1,910.8	2,197.5	12.4	159.7	4,280.4	25.9	28.3	1,864	52,664.3
% of potential production		3.63	4.17	0.02	0.30	8.13				

Table 6. Yield losses from disease in barley in eastern and northern Saskatchewan, 1970

Area (crop District)		Yield losses from: Virus	Leaf spot	Thrips	Leaf rust	Smut	Root rot	Total	Average yield (bu/ac)	Potential avg yield (bu/ac)	Acres ('000)	Potential production ('000 bu)
Southeast (1)	Range (%)	0-4	T-1.3	0-1.0	0-4	0-3	0-0.2		41.6	42.3	277	11,717.1
	Mean (%)	0.7	0.2	0.1	0.4	0.3	0	1.7				
	Bu ('000)	82.0	23.4	11.7	46.9	35.1	0	199.2				
East–central (5)	Range (%)	0-0.1	T-23.0	0-10	0-0.1	0-3	0-20		42.5	45.4	521	23,653.5
	Mean (%)	0	1.5	4.0	0	0.4	0.6	6.5				
	Bu ('000)	0	354.8	946.1	0	94.6	141.9	1,537.5				
Northeast (8)	Range (%)	0-0.1	T–14	0-10	0-0.1	0-4	0-5		40.4	43.8	406	17,782.8
	Mean (%)	0	2.3	4.8	0	0.4	0.3	7.8				
	Bu ('000)	0	409.0	853.6	0	71.1	53.3	1,387.1				
Northwest (9)	Range (%)	0-10	0-20	0-10	0–0	0-8	0-4		44.2	49.6	556	27,577.6
	Mean (%)	1.3	2.4	6.1	0	0.9	0.2	10.9				
	Bu ('000)	358.5	661.9	1,682.2	0	248.2	55.1	3,005.9				
Total ('000 bu)		440.5	1,449.1	3,493.6	46.9	449.0	250.3	6,129.7	42.4	45.9	1,760	80,730.9
% of potential production		0.54	1.79	4.33	0.06	0.56	0.31	7.59				

0.9 million bu or 1.6% of potential production.

Virus diseases and the foliaqe diseases spot blotch (Cochliobolus sativus [Ito & Kurib.] Drechs. *ex* Dastur, imperfect state Bipolaris sorokiniana [Sacc. in Sorok.] Shoem.); net blotch (Pyrenophora teres (Died.) Drechs., imperfect state Drechslera teres [Sacc.] Shoem.); and septoria leaf blotch (Septoria passerinii Sacc.), combined, caused losses of 2.4 and 1.9 million bu or 4.3 and 2.3% of the potential yield for Manitoba and the Saskatchewan area, respectively.

Most of the six–rowed varieties grown are resistant or moderately resistant to the prevalent races of smut and the value of this resistance was estimated at 0.6 million bu or $0.5 million. Smuts caused by Ustilago nuda (Jens.) Rostr., U. nigra Tapki, and U. hordei (Pers.) Lagerh. occurred mainly on 2-rowed varieties and on a small acreage of susceptible, but not recommended, 6–row varieties. Combined losses for the entire area surveyed were 0.6 million bu or 0.9% of the potential yield.

Table 7. Yield losses from disease in oats in eastern and northern Saskatchewan, 1970

Area (Crop District)		Yield losses from: Crown rust	Virus	Leaf spot	Smut	Blast	Total	Average yield (bu/ac)	Potential avg yield (bu/ac)	Acres ('000)	Potential production ('000 bu)
Southeast (1)	Range (%)	0-T	0-4	0-T	0-0	0-1	0-4	52.7	52.9	200	10,580
	Mean (%)	0	0.2	0.1	0	0	0.3				
	Bu ('000)	0	21.2	10.6	0	0	31.7				
East-central (5)	Range (%)	0-8	0-2	0-T	0-T	0-1	0-8	55.4	56.0	388	21,728.0
	Mean (%)	0.6	0.2	0.1	0	0.1	1.0				
	Bu ('000)	130.4	43.4	21.7	0	21.7	217.3				
Northeast (8)	Range (%)	0-0	0-1	0-T	0-0	0-5	0-5.1	52.3	52.7	175	9,222.5
	Mean (%)	0	0.2	0.1	0	0.5	0.8				
	Bu ('000)		18.4	9.2	0	46.1	73.8				
Northwest (9)	Range (%)	0-0	0-8	0-1	0-1	0-0	0-8	59.3	60.9	329	20,036.1
	Mean (%)	0	2.4	0.2	0.1	0	2.7				
	Bu ('000)	0	480.9	40.0	20.0	0	541.0				
Total ('000 bu)		130.4	563.9	81.5	20.0	67.8	863.8	55.6	56.4	1,092	61,566.6
% of potential production		0.21	0.92	0.13	0.03	0.11	1.40				

Table 8. Value of disease resistance in cereal varieties grown in Manitoba in 1970

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	4.0	100	30,223.7	1,208.9	1.40	1,706.5
	Leaf rust	7.8	77.7		1,831.5	1.40	2,564.1
	Loose smut	1.3	100		392.9	1.40	550.1
	Total				3,433.3		4,820.7
Oats	Smut	1.2	99.0	52,805.4	628.4	0.50	314.2
Barley	Smut	2.1	60.4	51,195.8	650.2	0.75	487.6
Total					4,711.9 bu		$5,622.5

Discussion

The estimates of disease loss and the value of resistance calculated for 1970 are probably conservative. The assessment did not take into account actual and potential losses in quality of the crop.

The methods used for this survey are, of course, open to criticism; more fields, more samples per field, or simply more resource imput would have been desirable. However, we believe a survey of this nature to be adequate for the purposes intended; the economic reality of plant disease losses and the justification for control research are clearly indicated. Research resources should not be diverted to large scale precise determination of disease losses when they could be used to control the losses.

Acknowledgments

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Literature cited

1. McDonald, W. C., J. W. Martens, G. J. Green, D. J. Samborski, G. Fleischmann, and C. C. Gill. 1969. Losses from cereal diseases and value of disease resistance in Manitoba in 1969. Can. Plant Dis. Surv. 49:114-121.