AIR-BORNE RUST INOCULUM OVER WESTERN CANADA IN 1967'

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In these studies, urediospores of the cereal' rusts are trapped mainly to learn the time of arrival and the relative amount of primary inoculum brought into Western Canada from wheat-growing areas to south. Knowledge of spore concentrations in the air during the growing season also helps in the evaluation of the seriousness of a rust threat. The date of the first appearance of rust is important because the growing season in Western Canada is short. Wheat seeded about the end of May may be ripe by mid-August and not subject to rust damage after early August. In most years rust has about 2 months in which to develop; therefore, rust appearing in early June is more apt to increase to destructive amounts in the fallowing 8 weeks than rust appearing early in July. The amount of primary inoculum is important also because it usually determines the amount of secondary inoculum produced. The arrival of spores from the south later in the season may also increase the rate of rust development.

In 1967 spore traps were operated at Winnipeg, Mordcn, and Brandon in Manitoba, and at Indian Head and Regina in Saskatchewan The vaseline-coated slides exposed at these stations were forwarded to Winnipeg for examination. Spore concentrations were similarly determined at the Canada Department of Agriculture Research Station, Saskatoon The slides were exposed for 48-hour periods at an angle of 45" from the vertical in sheet-metal spore traps, which were oriented by a wind-vane so that the vaseline-coated surface faced into the wind After exposure, the area under a 22 x 50-mm cover slip was examined microscopically and the number of spore.; per square inch determined

Spore counts were the lowest since 1961 (Table 1) and were indicative of the scarcity of rusl in Western Canada in 1967 Although few spores were present in the air during May and June, a fairly large number of leaf rust spores were caught at Winnipeg on June 10 and 11 (Table 2) This spore shower probably was responsible for the appearance of leaf rust on susceptible winter wheal in experimental plots at Winnipeg on June 26 However, spore deposition seems lo have been mainly in the

Table 1. Total number* of urediospores of stem rust and leaf rust caught in spore traps in Western Canada from 1960 to 1967

	Winnipeg		Morden		Brandon		Indian Head		Regina		Saskatoon	
Year	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust
1960	1,719	1,295	677	1,708	223	546	49	2,087	49	3,674	0	10,277
1961	88	153	109	212	24	80	27	71	37	101	8	246
1962	782	1,563	2,236	6,282	1,640	2,972	789	1,874	3,000	4,840	198	2,498
1963	2,544	13.685	2,477	26,612	1,722	15,210	1,597	39,785	2,008	69,681	5,571	80,657
1964	12,872	15,041	18,578	14,780	16,439	12,797	3,798	6,918	8,632	42,129	132	531
1965	4,943	9,811	5,362	25,978	2,698	16,091	10,559	66,730	31,035	227,576	1,927	77,502
1966	3,830	7,356	1,843	14,805	737	5,019	469	17,339	724	86,525	526	37,989
1967	2,498	8,997	918	6,974	72	1,107	34	454	70	473	117	344

* Expressed as spores per square inch except the data for Saskatoon for the years 1960 to 1964, where the numbers represent spores per slide.

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Winnipeg area because no leaf rust appeared in farm fields until July 13.

Spore showers during May have little practical significance since most of the crop in Western Canada is usually planted in the latter half of the month. Spore showers in mid-June are most important, because crops usually emerge early in June and are growing rapidly by mid-month. Spore showers occurring about mid-June or earlier can cause infections that produce pustules in about 14 days. In 1967, seedling was general in Western Canada by May 20 and was nearly completed by the end of the month. According to the Telegraphic Crop Report of the Dominion Bureau of Statistics on June 21, crops were in the 2- to 5-leaf stage in Manitoba. Leaf rust found on spring wheat in farm fields on July 13 developed slowly until the crop began to mature early in August. Stem rust was first found on susceptible winter wheat varieties in experimental plots on July 11, but it was not found during the season on the resistant varieties grown by farmers in the rust area. Readily observable amounts of stem rust did not appear on susceptible wild barley (Hordeum jubatum L.) until August 3.

Because of the scarcity of rust, especially stem rust, in farm fields in Western Canada in 1967, conclusions may be drawn concerning the origin of the spores caught. It is evident that insignificant numbers of spores of leaf rust were produced in Western Canada before mid-July and of stem rust before early August. The spores caught on the slides during May, June and early July, therefore, were carried into Western Canada by air movements from the south. The influx of spores from the south continued during the latter part of July, probably until July 28, and was complemented by locally produced leaf rust spores which became more abundant during this period. During August, spores on slider

Table 2. Number of urediospores of stem rust and leaf rust per square inch caught on vaseline-coated slides rxposed for 48-hour periods at three locations in Manitoba and threr locations in Saskatchewan in 1967

	Winnipeg		Morden		Brandon		Indian Head		Regina		Saskatoon	
Date	Stem rust	Leaf rust	Stem rust	Loaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust	Stem rust	Leaf rust
May 15-16	0	0	0	0	0	0	0	0	0	0	0	0
17-18	0	0	0	0	0	0	0	0	0	0	0	0
19-20	0	0	0	0	0	0	0	0	0	0	0	0
21-22	0	0	0	0	0	0	0	0	0	0	0	0
23-24	0	0	0	0	0	0	0	2	0	0	0	0
25-26	1	3	0	1	0	0	0	0	0	0	0	0
27-28	n	0	0	0	0	1	0	1	0	1	0	0
29-30	n	0			0	0	0	0	0	0	0	0
May Total	1	0	2	1	0	1	0	3	0	1	0	0
May 31-June 1	0	0	0	0	0	0	0	0	0	1	0	0
2-3	0	3	0	0	0	1	0	0	0	0	0	0
4-5	0	0	0	0	0	0	0	0	0	0	0	0
6-7	0	0	0	0	0	0	0	0	0	0	0	0
8-9	4	1	4	0	3	1	0	0	0	0	0	0
10-11	2	55	0	1	1	2	0	0	0	0	0	0
12-13	0	0	0	0	0	0	0	0	0	0	0	0
14-15	0	4	0	0	0	0	0	0	0	0	0	0
16-17	0	9	0	6	0	1	0	5	0	2	0	0
18-19	0	4	0	0	0	0	0	2	0	1	0	0
20-21	2	7	0	3	0	7	0	4	0	2	0	0
22-23	0	0	0	0	0	0	0	1	0	1	0	0
24-25	0	0	0	0	0	0	0	0	0	0	0	0
26-27	0	1	0	4	0	0	0	0	0	1	0	4
28-29	0	0			0	0	0	3	0	2	0	5
June Total	8	84	4	14	4	12	0	15	0	10	0	9

Table 2 (Concluded)

Date	Winnipeg Stem rust	Winnipeg Leaf rust	Morden Stem rust	Morden Leaf rust	Brandon Stem rust	Brandon Leaf rust	Indian Head Stem rust	Indian Head Leaf rust	Regina Stem rust	Regina Leaf rust	Saskatoon Stem rust	Saskatoon Leaf rust
June 30 - July 1	0	1	0	1	0	1	0	2	0	2	0	0
2-3	0	2	0	2	0	2	0	3	0	3	0	4
4-5			4	29	3	22	0	4	1	6	0	5
6-7	0	4	1	8	0	6	1	8	1	6	0	11
8-9	2	5	2	1 2	2	9	1	6	2	14	0	13
10-11	13	5	1	6	1	4	1	4	2	16	0	16
12-13			0	6	0	7	0	2	0	5	0	14
14-15	0	2	18	195	0	8	0	13	0	12	0	71
16-17	1	13	0	20	0	6	I	16	33	39	0	22
18-19	2	23	5	131	2	18	0	22	1	14	0	26
20-21	11	43	4	56	0	12	0	1	0	5	0	16
22-23			0	16	0	7	0	6	0	9	0	8
24-25	0	18	1	53	0	3	1	4	0	6	0	31
26-27	0	3	0	26	0	8	0	0	0	1	0	6
28-29	8	66	1	41	0	7	0	4	2	9	0	14
30-31	11	74	14	791	2	41	0	20	0	21	0	15
July Total	48	259	51	1393	10	161	5	115	42	168	0	272
Aug. 1-2	2	229	5	94	0	41	2	24	0	13	0	3
3-4	0	43	11	240	2	60	0	9	0	16	0	0
5-6	40	355	5	79	0	22	0	5	0	8	0	3
7-8	11	132	5	209	0	6	0	2	1	4	0	2
9-10	2	29	4	80	0	8	0	8	6	17	0	2
11-12	21	277	41	539	7	18	1	11	2	27	0	1
13-14	50	293	16	180	1	47	0	5	0	9	0	1
15-16	75	553	33	309	2	38	0	7	0	5	0	1
17-18	73	630	18	312	5	220	0	8	0	18	0	2
19-20	223	1164	76	451	4	66	0	70	0	16	0	11
21-22	94	366	113	481	12	66	11	64	12	56	104	6
23-24	516	1906	147	789	8	113	12	47	2	49	0	0
25-26	774	406	115	499	9	67	1	12	0	8	0	4
27-28	445	1894	159	863	5	100	0	34	2	29	9	22
29-30	115	374	115	441	3	61	2	15	3	19	4	5
Aug. Total	2441	8651	863	5566	58	933	29	321	28	294	117	63
TOTAL	2498	8997	918	6974	72	1107	34	454	70	473	117	344

were probably from both sources, but the proportions from either source cannot be determined. Appreciable numbers of the stem rust spores caught were probably brought in from the south since the only local source of inoculum was lightly infected wild barley.

Because of the unusual conditions that existed in the 1967 growing season, an attempt was made to correlate the spore trapping results with weather conditions. The climatologist of the Meteorology Branch, Canada Department of Transport, Winnipeg, provided a report (Appendix) on air movements during periods of high spore counts. It was assumed that spores brought into Western Canada originated mainly in the winter-wheat-producing areas of Kansas and Nebraska. A homogenous air mass was present from Kansas and Nebraska to Manitoba and eastern Saskatchewan during many of the selected periods. In each period, air from the south moved into Western Canada and, without exception, the air masses present were unstable. It is also evident that during the selected periods there were convection currents that could carry spores to high altitudes and bring them down again. Once aloft, the spores could be transported rapidly in the upper air currents (40-60 nautical mph.). The report further indicates that there is great opportunity for spores to become distributed more or less uniformly over large areas. This would be especially true late in

season when many spores are air-borne. It is clear from the absence of rust in Western Canada early in the season and from the reports on air movements that many of the spores caught in Western Canada during the 1967 season originated in the winter wheat area of the United States and that this influx of spores continued during the growing season.

It is interesting to consider the climatologist's report for the period May 23-26 in relation to the light spore shower that was detected by the traps. In Western Canada seeding was in progress and no spores were being produced. In the winter wheat area to the south, stem rust infections were very light. Southerly winds arrived in eastern Saskatchewan about midnight of May 22 and spread eastward into Manitoba during the next morning, Two leaf rust spores were caught at Indian Head in eastern Saskatchewan during May 23-24. Strong southerly winds blew from Kansas into Manitoba on May 24 and 25 and a few spores of stem rust and leaf rust were caughtat Winnipeg and Morden on May 25 and 26. Despite northerly winds that commenced on May 26 and spread arctic air into the eastern prairies, single leaf rust spores were caught at Brandon, Indian Head, and Regina during May 27-28. Evidently the flow of arctic air did not immediately remove all air-borne rust spores from the area, No spores were caught on May 29 and 30, and only one was trapped, at Regina, during the period May 31-June 1.

Acknowledgments

The cooperation of personnel of the Canada Department of Agriculture at the spore trap locations made this project possible.

Appendix

THE SYNOPTIC WEATHER SITUATIONS DURING SPORE SHOWERS, 1967[3]

May 23 - May 26

On the evening of May 22 a low-pressure system passed to the south of Winnipeg and a light northerly to northwesterly flow of air was established over the eastern prairies. A second disturbance appeared over western Montana at midnight and in advance of it southerlies developed in eastern Saskatchewan and spread as far east as Winnipeg by morning. At that time the trajectory of the wind affecting Saskatchewan and Manitoba would have been from an origin in the western Dakotas northward to the eastern prairies (assuming airmass homogeneity*). On the evening of the 23rd, a Maritime tropical airmass spread over Montana, Wyoming, the western Dakotas and gradually spread eastward to encompass most of the remainder of these states by the evening of the 24th. This airmass overran the cooler polar air over the southern prairies causing showery precipitation from Regina to Winnipeg on the 24th and over Manitoba on the 25th. The circulation on the night of the 24th and the 25th saw strong southerlies develop from Kansas into Manitoba, although winds had begun to shift in Saskatchewan into a westerly as they moved into a Maritime Arctic airmass which spread into the Winnipeg area by the evening of the 25th, ending the woutherly circulation. By the morning of the 26th, north winds and arctic air had spread into all of the eastern prairies.

The Maritime tropical airmass referred to above was very unstable therefore strong convective currents would be present in it, which would carry particulate matter aloft to considerable heights.

Precipitation fell on 24th and 25th from an unstable airmass which had passed through the Kansas, Nebraska area. Had spores been available in these areas they would readily have been transported aloft into the airmass by strong convective currents and deposited in Saskatchewan in precipitation and in Manitoba by precipitation or by moderate south winds blowing from southern regions on the night of the 24th and on the 25th. An upper air sounding made at Bismark, North Dakota was representative of this airmass and showed possible convective currents to 33,000 feet during the afternoons.

June 2 - 3

The airmass was homogenous from Kansas and Colorado-Utah to eastern Saskatchewan-Manitoba. Strong southerly to south-southwesterly winds persisted in these areas until the passage of a cold front shifted the winds to strong northwest in Saskatchewan, the western Dakotas and northwestern Nebraska during the late morning and early afternoon of the 3rd and over Manitoba during the late afternoon.

The airmass south of Saskatchewan was quite unstable on June 2 and 3 but Nebraska-North Dakota soundings indicated that convection would be cut off at about 5,000 ft on June 2. On the 3rd, however, these soundings had warmed to the extent that very strong convection currents would be present.

Conditions were ideal for transfer of spores Saskatchewan on the 2nd and early morning of the 3rd. and into Manitoba on the 3rd.

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[3] Contributed by P. J. Pender, Climatologist, Meteorology Branch, Canada Department of Transport, Winnipeg, Manitoba.

* Homogeneity of airmass here implies the same airmass over the eastern prairies as over the Kansas - Nebraska areas.

June 8 - 11

In this period the airmass was again generally homogeneous. There was a light easterly circulation, which became a little south of east on the 11th in eastern Saskatchewan and Manitoba. A weak cold front changed the winds to west at Regina early on the morning of the 11th, but it did not advance much further eastward that day.

The Bismarck sounding was chosen as representative of the airmass. Instability was present on June 8, 9, and 10, with maximum convective currents to 23,000 on the afternoon of the 9th. By the afternoon of the 11th it had become quite stable.

June 14 - 20

From June 14 to 17, winds on the eastern prairies were northerly to easterly as disturbances moving from Kansas to the Upper Great Lakes avoided this area. On the 17th a new storm track became established south of the eastern prairies from west to east through the Dakotas. Winds continued easterly to northeasterly until a major system moving into western Saskatchewan on the afternoon of the 17th initiated south to southeast winds in eastern Saskatchewan, the Dakotas, Nebraska and Kansas. Strong southerlies developed in Manitoba by mid-morning on the 18th and swept up from the Nebraska-Kansas areas. At the same time, they had begun to shift into the northwest at Regina and by evening all of Saskatchewan had northwest winds. By evening on the 19th the wind shift had spread to Winnipeg and northwesterlies prevailed across the eastern prairies.

Bismarck and Shilo soundings on the 18th indicated convection to 30,000 feet during the period of strong southerly winds.

June 26 - 27

Conditions were almost identical to those on June 2 - 3 except that winds were not as strong. Considerable convection indicated by cumulus cloud and thundershowers scattered throughout the airmass.

July 10 - 21

This period began with strong northwest winds over the area following the passage of a cold front. A high-pressure system then pushed down from the Northwest Territories and maintained north winds at Regina until the evening of the 12th when they became light easterly. As the high turned eastward, winds shifted behind it into the east and finally into the south. Moderate southerlies had developed at Regina by the evening of the 13th. Weak southerlies reached as far east as Winnipeg by morning of the 14th and freshened by afternoon. However, a second cold front had now moved through Saskatchewan and here winds were back to the north. By noon on the 15th, northwest winds had returned to Winnipeg as the cold front continued eastward. Another high followed. Southerlies developed in Saskatchewan on the morning of the 17th as a weak low moved into western sections of that province and spread to Manitoba during the afternoon. The disturbance then turned northward into northern Manitoba, maintaining southerlies at Regina till the morning of the 19th when another weak cold front moved through the areas and reached Winnipeg late in the evening on the 20th. A light west to northwest circulation was then established.

In each of the above cases convection occurred during southerly circulations, and the southerly circulation extended far enough south to include the Kansas - Nebraska area. The southerlies were not particularly strong at any time except on July 17 over Eastern Saskatchewan.