SOME DISEASES OF PLANTS

COMMON TO IOWA CEREALS.

BY L. H. PAMMEL.

I have received numerous queries about certain diseases of plants that it may not be out of place at this time to briefly describe a few and make some suggestions as to their probable cause, and prevention.

The season has been an unusual one both in regard to precipitation and temperature, and this perhaps accounts for the severity of some diseases. The subject of fungus diseases of plants is no doubt closely connected with certain conditions of soil and atmosphere, but it is very evident that these are not the only causes at work. Practical farmers have long learned by experience that warm, sultry weather accompanied by rain is conducive to the production of rust.

In order to study this question from an intelligent basis I have added tables of temperature and precipitation made by Mr. Dickinson under the direction of Prof. Franklin. These are for the periods of May, June and July. To these I have added another table showing the temperature at the surface of the earth, using a minimum thermometer, and taking the temperature at 9 a. m., 12 m. and 5 p. m.

From these meterological data it will be seen that the weather was cloudy, accompanied by frequent rains. The temperature when the rust forming period began was quite uniform. It should also be noted that heavy dews during this period were frequent. Comparing Mr. Dickinson's observations with those in the shade of Bachelor's Button and oats, we notice a uniformly lower temperature. To this should be added the fact that the leaves contained considerable moisture during the greater part of the morning.

METEOROGICAL RECORD FOR MAY.—AMES, IOWA.

Date.	TEMPERATURE.			PRECIPITATION.			WIND.						CLOUDS (Tenths.)			WEATHER FOR DAY.
	$\frac{7+2+9+9}{4}$ MEAN.	MAX.	MIN.	TIME OF— BEGINNING.	TIME OF— ENDING.	Rain Fall.	7 A. M. DIR. FROM.	7 A. M. FORCE 0–10.	2 P. M. DIR. FROM.	2 P. M. FORCE 0–10.	9 P. M. DIR. FROM.	9 P. M. FORCE 0–10.	7 A. M. 0–10.	2 P. M. 0–10.	9 P. M. 0–10.	
1	55.3	68	46	R. Night.	Night.	.85	0	0	N. W.	1	0	0	10	10	10	Cloudy.
2	56.3	65	50	R. 6:30 P. M.	Night.	.54	N.	1	0	0	0	0	10	10	10	Cloudy.
3	51.3	62	49	.....	.....	....	N. W.	1	N. W.	1	N. W.	1	10	10	10	Cloudy.
4	49	62	38	R. 4 P. M.	.....	....	0	0	E.	1	S. E.	1	5	8	10	Cloudy.
5	59 6	57	42	....	12 M.	1.67	0	0	S. W	1	N. W.	1	10	8	0	Part cloudy.
6	47.6	73	41	.....	.....	....	N. W.	1	N. W.	2	N. W.	1	5	0	0	Cloudless.
7	50	57	36	.....	.....	..	0	0	0	0	N. E.	1	0	0	6	Cloudless.
8	45.6	58	38	R. 3 P. M.	Night.	.83	E.	1	E.	2	E.	2	10	10	10	Cloudy.
9	45	50	39	R. 1 P. M.	Night.	.68	S. E.	2	S. E.	2	S. E.	1	10	10	10	Cloudy.
10	46.3	47	43	.....	.....	....	S. W.	1	N. W.	2	N. W.	2	10	10	10	Cloudy.
11	44.3	48	40	.....	.....	....	N. W.	1	N. W.	1	N W.	1	10	10	10	Cloudy.
12	51	49	32	.....	.....	....	0	0	S. E.	1	0	0	0	8	10	Hazy.
13	50.6	49	40	R. night.	Night.	.70	S. E.	1	0	0	0	0	10	10	10	Cloudy.
14	56.6	59	39	.....	.....	....	S E.	1	S. E.	1	N. W	1	10	10	10	Cloudy.
15	58	65	48	.....	.....	....	0	0	W,	1	0	0	10	5	0	Part cloudy.
16	64.3	66	48	R. night.	Trace.	....	S.	1	S.	2	S. E.	1	8	2	5	Part cloudy.
17	69.6	74	48	R. 5:30 P. M.	.....	....	S. E.	1	S. E.	1	S. E.	1	10	5	10	Cloudy.
18	54	77	52	.....	Night.	1.79	S. W.	2	N. W.	3	N. W.	2	10	10	10	Cloudy.
19	54	77	47	.....	.....	....	N. W.	2	N. W.	2	N. W.	2	5	5	1	Part cloudy.
20	38.6	62	30	6 A. M. S. Trace.	R. 10 A. M.	.04	N. W.	2	N. W.	2	N W.	1	10	10	10	Cloudy.
21	52	.....	35	.....	.....	....	0	0	0	0	N. W.	1	10	5	0	Part cloudy
22	58.3	59	35	.....	.....	....	N. W.	2	N.	1	0	0	0	5	5	Part cloudy.
23	62	65	58	.....	.....	....	S. W.	1	S. W.	1	S.	1	0	2	0	Cloudless.
24	64.3	69	52	.....	.....	....	S. E.	1	S. W.	1	N. W.	1	10	10	0	Part cloudy,
25	62	76	49	.....	.....	....	0	0	N. W.	1	0	0	8	5	0	Part cloudy.

METEOROLOGICAL RECORD FOR MAY.—CONTINUED.

Date.	TEMPERATURE. 7+2+9+9 / 4 MEAN.	MAX.	MIN.	PRECIPITATION. TIME OF— BEGINNING.	ENDING.	Rain-fall.	WIND. 7 A. M. DIR. FROM.	7 A. M. FORCE 0–10.	2 P. M. DIR. FROM.	2 P. M. FORCE 0–10.	9 P. M. DIR. FROM.	9 P. M. FORCE 0–10.	CLOUDS (Tenths.) 7 A. M. 0–10.	2 P. M. 0–10.	9 P. M. 0–10.	WEATHER FOR DAY.
26	58.3	72	52	.....	.....	....	N. W.	1	N. W	1	N. W.	1	5	2	0	Cloudless.
27	63	66	38	.....	.....	....	0	0	S.	1	S. E.	1	0	0	0	Cloudless.
28	61	68	38	R. night.	2:30 P. M.	.81	S. E.	1	S. W.	1	N. W.	1	10	10	0	Part cloudy.
29	60	71	52	R. 11 A. M.	12 M.	trace.	0	0	0	0	0	0	10	10	0	Part cloudy.
30	67	72	51	.....	.....	....	0	0	N.	1	0	0	0	2	8	Part cloudy.
31	52	72	52	R. 7 A. M.	Night.	.60	N.	1	N.	1	0	0	10	10	10	Cloudy.
Sum.	1706.9	.....	.....	.....	.....	8.66	Latitude 42°, Longitude 93.35. Height above sea 1000 feet.									
Mean.	55	.....	.....	.....	.....	2.86										

METEOROLOGICAL RECORD FOR JUNE.

1	49.3	55	47	R. 7. A. M.	Night.	.60	N.	1	N.	1	N.	1	10	10	10	Cloudy.
2	55.6	51.5	46	....	.....	....	N.	1	N.	1	0	0	8	10	10	Cloudy.
3	57	61	55	.....	.....	....	0	0	0	0	0	0	10	10	10	Cloudy.
4	61	64	53	....	.....	....	E.	1	S. W.	1	0	0	10	10	10	Cloudy.
5	72	70	52	.....	.....	....	S. W.	1	S. W.	1	S.	1	5	5	2	Part cloudy.
6	72	80	61	R. 6 P. M.	7:30 P. M.	.03	S.	1	S.	1	W.	1	0	0	5	Cloudless.
7	62.6	77	52	R. 1 P. M.	Night.	.12	S. W.	1	W.	1	0	0	5	5	2	Part cloudy.
8	70.6	72	52	.....	.....	....	N. W.	1	0	0	0	0	2	0	0	Cloudless.
9	75.3	82	62	.....	.....	....	S. W.	1	S. W.	1	0	0	0	0	5	Cloudless.
10	77	84	66	.....	.....	....	S W.	1	S. W.	1	S. W.	2	2	0	0	Cloudless.
11	81	84	68	.....	.....	....	S. W.	1	S.	1	S. W.	1	0	0	0	Cloudless.
12	83.6	90	70	.....	.....	....	S.	2	S.	2	S.	2	2	0	1	Cloudless.

				6 A. M.	10 A. M.	1.06										
13	64.0	90	62	R. 1 P. M.	3 P. M.	1.61	N.	1	S. W.	1	0	0	10	8	5	Cloudy.
14	71.3	90	55	.....	.....	....	N. W.	1	0	0	0	0	0	0	0	Cloudless.
15	77	79	59	.....	.....	....	S. E.	1	S.	1	S. W.	1	2	7	0	Part cloudy.
16	80	88	60	.....	.....	....	S.	1	S. W.	1	0	0	2	0	6	Part cloudy.
17	69.3	86	66	.....	.....	....	N. W.	1	0	0	0	0	7	10	2	Part cloudy.
18	69.6	77	58	.....	.....	....	0	0	0	0	0	0	5	5	2	Part cloudy.
19	73.3	79	62	R 3 P. M.	Night.	.08	0	0	S.	1	S. E.	1	10	10	10	Hazy.
20	77.6	88	58	.....	.....	....	0	0	S. W.	1	S.	1	0	0	8	Cloudless.
21	68.6	87•	63	.....	.....	....	0	0	0	0	0	0	10	10	2	Cloudy.
22	77.6	76	62	R. night.	Night.	.06	S. E.	1	S. W.	1	N.	1	10	10	10	Hazy.
23	66.6	90	65	.....	.....	....	0	0	0	0	0	0	10	10	8	Cloudy.
24	62.6	76	59	R. night.	Night.	.02	N. W.	1	N. W.	2	N. W.	1	5	0	0	Cloudless.
25	70.3	76	54	.....	.....	....	0	0	0	0	0	0	0	4	2	Cloudless.
26	66.6	79	55	R. 5 P. M.	7. P. M.	.02	0	0	S. W.	1	N. W.	1	10	0	0	Part cloudy.
27	62.3	80	52	.....	.....	....	N.	1	N. W.	2	0	1	0	0	0	Cloudless.
28	69.3	80	52	.....	.....	....	0	0	N. W.	2	0	0	0	0	0	Cloudless.
29	67.6	77	52	R. night.	Night.	.14	S.	1	N. W.	1	N. W.	1	0	0	0	Cloudless.
30	61.3	78	48	.....	.....	....	N. W.	1	N. W.	1	0	0	0	0	0	Cloudless.
Sum..	2061.9	.....	.....	.....	.....	3.74										
Mean.	68.7	.....	.....	.....	.....	.124										

METEOROGICAL RECORD FOR JULY.

1	66	72	44	8 P. M.	Night.	1.87	S.	1	S. E.	1	S. E.	1	2	5	10	Part cloudy.
2	71.7	79.5	57	8.30 P. M.	Night.	.03	S. W.	1	W.	1	N. W.	1	10	8	1	Part cloudy.
3	70.2	78	56	.....	.....	....	N. W.	1	0	0	0	0	1	2	1	Cloudless.
4	73	81	54	.....	.....	....	S. W.	1	S. W.	1	S. W.	1	0	3	4	Cloudless.
5	73.3	81	52	.....	.....	....	0	0	E.	1	S. E.	1	1	3	0	Cloudless.
6	71.8	78.4	52	.....	.....	....	S. E.	1	S. E.	2	S. E.	1	1	1	1	Cloudless.
7	73	81	49	.....	.....	....	S. E.	1	S. E.	1	0	0	1	1	1	Cloudless.
8	72.7	82	52	.....	.....	....	0	0	N. E.	1	E.	1	1	5	0	Cloudless.
9	72	78	65	9 A. M.	.....	trace.	E.	1	S. E.	1	0	0	10	9	8	Cloudy.
10	72.2	78	66	Night.	.....	trace.	S. E.	1	S. E.	1	S. E.	1	10	9	2	Part cloudy.

Date.	TEMPERATURE. 7 2+9 9 / 4 MEAN.	MIN.	MIN.	PRECIPITATION. TIME OF— BEGINNING.	ENDING.	Rain Fall.	WIND. 7 A. M. DIR. FROM.	FORCE 0–10.	2 P. M. DIR. FROM.	FORCE 0–10.	9 P. M. DIR. FROM.	FORCE 0–10.	CLOUDS (Tenths.) 7 A. M. 0–10.	2 P. M. 0–10.	9 P. M. 0–10.	WEATHER FOR DAY.
11	77.6	87	60	.....	.....	....	0	0	S.	1	S. E.	1	0	5	1	Cloudless.
12	80.8	91.5	62	.....	.....	....	S. W.	1	S. W.	1	N. W.	1	7	3	0	Part cloudy
13	77.8	86	63	.....	.....	....	N.	1	0	0	0	0	4	6	1	Part cloudy.
14	78.8	89.5	61	Night.	.....	trace.	S. E.	1	S. E.	1	S. E.	1	10	6	9	Cloudy.
15	71.8	78	64.5	Night.	.....	.84	N. W.	2	N. W.	2	N. W.	1	2	3	0	Cloudless.
16	70.2	79	55	.....	.....	....	S. E.	1	0	0	S. E.	1	6	8	4	Part cloudy.
17	70.7	78	55	.....	.....	....	S. E.	1	S. E.	1	S. E.	1	0	0	1	Cloudless.
18	77.3	88.5	63	6 A. M.	10 A. M.	1.39	S.	1	S.	1	S.	1	10	7	0	Part cloudy.
19	72.7	92	67	Night.	.....	.02	S. E.	1	S. E.	1	0	0	10	0	8	Part cloudy.
20	83.2	81	69	7 A. M.	10 A. M.	.53	N.	3	S. E.	1	S. E.	1	10	7	0	Part cloudy.
21	77.8	92	64	5 A. M	6.30 A. M.	.30	S. E.	1	S.	1	E.	1	8	0	5	Part cloudy.
22	79.8	88	70	.....	.....	trace.	0	0	S. E	1	S. E.	1	9	2	8	Part cloudy.
23	83.2	94.6	72	.....	.....	trace.	S.	1	S.	1	0	0	5	4	1	Part cloudy.
24	83.7	92.5	69	.....	.....	....	N. E.	1	S.	2	S.	2	1	0	0	Cloudless.
25	83.7	89.4	74	.....	.....	....	S.	1	S. E.	1	0	0	1	1	1	Cloudless.
26	84.6	91.5	71	.....	.....	....	S.	1	S.	2	S.	1	0	0	0	Cloudless.
27	84.1	94	77	.....	.....	....	S.	2	S.	2	S.	1	0	1	5	Cloudless.
28	94	70	57	Night.	3 P. M.	2.02	0	0	N.	2	N.	1	10	10	9	Cloudy.
29	66.6	76.6	52.5	.....	.....	....	N.	1	N.	2	0	0	0	1	1	Cloudless.
30	71.7	80.2	51	.....	.....	....	E.	1	E.	1	0	0	0	2	0	Cloudless.
31	72	85	52	4 A. M.	7 A. M.	.06	0	0	S. W.	1	N. W.	1	2	2	10	Part cloudy.
Sum ..	2328	2593	1876	.....	.....	7.06										
Mean.	75.1	83.7	60.5	.....	.....	....										

RADIATION THERMOMETER IN OATS.

DATE		TIME. 9 A. M.	12 M.	5 P. M.	Minimum.	Mean.	Precipitat'n	Irregular.
May	12	.....	62	56	28	48.6	.....	
"	13	47	50	51	45	48.2	.08	
"	14	54	57	*60	49	55	.65	*4 P. M.
"	15	.....	64	66	46	58.6	.15	
"	16	*67	74	72	43	64	.....	*10 A. M.
"	17	70	79	.....	55	68	.13	
"	18	50	51	51	50	50.5	1.54	
"	19	55	*63	63	41	55.5	.02	*10 A. M.
"	20	41	*39	38	31	37.2	.01	*10 A. M.
"	21	45	58	57	24.5	47 3	.04	
"	22				} 36*			* For 22
"	23	67	67	73		60.7	.....	and 23.
"	24	74	65	73	47	64.7	.....	
"	25	76	78	69	41	66	.....	
"	26	65	74	65	45	62.2	.....	
"	27	70	81	57	29	64.2	.....	
"	28	54	60	70	47	57.7	.65	
"	29	67	58	77	43	61.2	.03	
"	30	65	78	70	46	64.7	.....	
"	31	50	49	50	48	49.2	.60	
June	1	47	.....	47	44	44.6	.24	
"	2	66	61	78	44	62.2	.....	
"	3	54	60	*70	48	58	.02	*3 P M.
"	4	64	71	64	50	62.2	.....	
"	5	*80	81	78	54	73.2	.....	*9:30 A M
"	6	75	80	74	55	71	.....	
"	7	61	70	60	52	60.7	.16	
"	8	74	77	82	46	69.7	.....	
"	9	77	88	84	55	73.5	.....	
"	10	75	89	79	60	76	.....	
"	11	80	90	87	63	80	.....	
"	12	75	89	.....	63	75.6	.....	
"	13	60	70	58	57	61.2	1.10	
"	14	65	71	*66	51	63.2	1.60	*6:30 P M
"	15	70	75.5	79	51	68.8	.....	
"	16	75	80	74	63	73	.03	
"	17	65	66	72.5	61.5	66.2	.....	
"	18	62	70	71	50	63.2	.....	
"	19	74	80	70	50	68.5	.09	
"	20	69	80	73	52	68.5	.07	
"	21	63	67	69	59	64.5	.07	
"	22	66	79	79	57	70.2	.07	
"	23	64	66	65	60	63.7	.03	
"	24	62	70	66	54	63	.....	
"	25	66	71.5	.....	50.5	62.6	.....	
"	26	66	67	62	52	61.7	.03	
"	27	61.5	70.5	68	49	62.2	.....	[A. M.
"	28	*75	77	72	52	69	.....	*10:30
"	29	62	73	69	49.5	64.3	.14	
"	30	60	70	64	45	62.2	.....	
July	1	.....	66	62	41	56.3	.....	
"	2	66	63	67	54	62.5	.....	
"	3	60	.....	66	52	59.3	.....	
"	4	67	71	.....	50	62.6	.....	

RADIATION THERMOMETER IN OATS—CONTINUED.

DATE		TIME. 9 P. M.	12 M.	5 P. M.	Minimum.	Mean.	Precipitat'n	Irregular.
July	5	68	73	*63	49	63.5	.....	7:30 P.M.
"	6	68	72	68	49	64.3	.....	
"	7	71	77	76	47	67.7	.....	
"	8	69	73	71	52	66.2	.....	
"	9	64	68	71	62	66.2	.....	
"	10	66	70	72	61	72	.05	
"	11	74	81	76	57	73	.....	
"	12	75	85.5	80	63	75.8	.....	
"	13	72	79	74	60	71.2	.....	
"	14	73	82	79	57	72.7	.89	
"	15	65	71	65.5		68	.....	
"	16*	64.5	68	75.5	50	62.1	.....	
"	17	69	72	71	52	66	.....	
"	18	66	74	75	60	66.2	1.39	
"	19	75	81	83	64	75.7	.....	
"	20	61	68	71	61	65.6	.....	
"	21	71	80	76	60	71.7	.....	
"	22	72	80	75	56	70.7	.....	
"	23	74	80	80	67	75.2	.....	
"	24	74	81	82	65	75.5	.....	
"	25	75	80	81	67	75.7	.....	
"	26	74	84	80	65	75.7	.....	
"	27	80	84	80	64	77	.....	
"	28	64	61	55.5	63	60.8	.....	
"	29	61.5	67	64	49	60.2	.....	
"	30	65	73	65	46	62.2	.....	
"	31	68	74	63	52	64	.....	

* Up to July 16, the radiation thermometer was kept in oats, after that in Bachellor's Button (*Centaurea cyanus*).

The subject may be divided up into the diseases of wheat, oats, and barley.

DISEASES OF WHEAT.

One of the most serious enemies of the wheat crop in Iowa is rust. The damage every year amonnts to millions of dollars. The crop on the college farm, it was thought, would yield 35 bushels to the acre, but from the present appearances. Prof. Curtiss informs me the yield will not be over 12 bushels to the acre in most varieties.

On the college farm the loss, at a low estimate, has been 50 per cent. Generally the loss may be estimated at not far from one-half per cent. According to the Department of Agriculture report for 1891 the wheat crop of Iowa amounted to 27,586,000 bushels. If the loss is one-half per cent the total for the state would amount to 137,930 bushels.

Prof. T. J. Burrill[1] estimates the loss from wheat rnst in Illinois at 375,000 dollars.

Prof. H. L. Bolley[2] says farmers would consider that rust usually takes less than one-hundreth part of the wheat crop. On the basis of the wheat crop of 1880, 512,763,500 bushels at 80 cents per bushel would entail a loss of 4,102,108 dollars.

It is a well known fact that portions of the United States, especially near the Gulf, are wholly unsuited for growing wheat, rust being so bad that a crop cannot be produced. In South Australia[4] the loss from wheat rust in 1890 amounted to over 7,500,000 dollars, while for Australia[4] the loss has been estimated at 10,000,000 dollars.

What is rust? The farmer answers by saying "It is caused by hot sultry weather and rain." The botanist answers by saying that it is a plant of low organization which produces spores or reproductive bodies of a certain kind, and belongs to the order *Uredineæ*. Another feature of rusts is that they are heterocismal, that is plants producing several distinct stages, one of which at least appears on an entirely different plant. Let it be distinctly understood *that rust is a plant*,

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[1] Parasitic Fungi of Illinois, Part I, Uredineae, p. 145.
[2] Bulletin of Agriculture Experiment Station, Indiana, No 26, p. 8.
[3] Report Department of Agriculture, Queensland. Rust in wheat; minutes of proceedings at a conference of delegates, p. 6.
[4] Report of the conference on rust of wheat, legislative assembly, New South Wales, December 14, 1891, p. 2.

and belongs to a great class known as *fungi* which cannot assimilate or make their own food.

Wheat is chiefly attacked by two species of rust. One may be designated as Common Rust (*Puccinia graminis*) and the second as Covered Wheat Rust (*Puccinia rubigo-vera*). Both species manifest themselves by producing red pustules, frequently imparting to the plant a red, rusty appearance. This stage is known as the *uredo* or summer stage. Close observation will show that the red pustules are replaced by those of black or greyish color. This is the winter stage and contains the teleutospores. The two kinds of rust are easily distinguished even by those who are not botanists. *Puccinia graminis* occurs mainly on the stems and sheaths, the long pustules are black in color which is due to the fact that the epidermis (the outer layer of cells of the plant) is separated from the remainder of the tissues of the plant.

Puccinia rubiga-vera occurs on the leaves and sheaths, is gray in color while the epidermis is not broken or but tardily so. The first stage of the former rust occurs on the barberry and produces the Barberry Cluster Cup Fungus; described by older botanists as *Aecidium berberidis*. The first stage of the second species occurs on members of the Borage Family and especially *Onosmodium carolinianum*, but it appears from Prof. Bolley's investigation that this *Aecidium* does not cause the infection of wheat.[5]

As to rust on barberry there is no doubt about its connection as inoculation experiments have shown.[6]

Rust in the latitude of Ames so long as observations have been made has never appeared before the Cluster Cup Fungus on the barberry has been formed. On one occasion rust was found on Blue Grass in May, before the appearance of the Cluster Cup Fungus, but as nothing more than uredo-spores occurred it is difficult to say whether it belongs to rust on wheat or not. This rust on Blue Grass is common at some times.

In 1891 rust occurred on winter wheat as early as June 19. A

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[5]Wheat Rust: Is the infection local or general in origin. Agri. Science, vol. 5, p. 261.
The subject was described and illustrated in Bulletin No. 16, of the Iowa Experiment Station.

[6]DeBary. Morphology of Fungi Mycetozoa and Bacteria, p. 274. Ann. d. s. c. Nat. Ser. 4, xx p. 64.

package of this rust was sent to Prof. H. L. Bolley, of the Agricultural Experiment Station of North Dakota, who was conducting some experiments to determine whether the infection of wheat rust was local or general. He says concerning the material: "The sample was two days in mails, and seven days exposed to outdoor atmosphere, protected only from rain. These spores then germinated freely and were capable of producing infection." This rust in question was *Puccinia rubigo-vera*. Rust was abundant about the first of July, 1892. The first observed on the lower leaves of oats was June 24, on rye June 23. Neither of these, however, belong to the Common Grass Rust. A few days later rust began to appear on the stems of wheat. This may be referred to the Common Grass Rust. From this it appears that grain does not generally rust earlier than the middle and latter part of June, some weeks after the Cluster Cup Fungus on barberry has appeared. In 1891 the cluster cups were observed to open on May 19 and followed by rain on the 26th. Rust could not be found on winter wheat on May 22. It appears from the investigations of Prof. Bolley[7] that the rusts in question are not preserved in the tissues of several wild grasses in North Dakota, he says: "That the uredo-spores are the chief generators of rust in the field, that it is possible for these spores to be carried through a dry atmosphere without loss of vitality and that the general infection of the fields of the country is very probably here accounted for." Several grasses on which *Puccinia rubigo-vera* and *P. graminis* occur were examined on December 1. The plants were clean to the ground on April 15, leaves began to show green. A careful microscopic investigation failed to show any mycelium.

The uredo-stage on Squirrel-tail Grass keeps well into winter. In 1890 they were found during the latter part of December. Some wheat plants taken into the College green house for experimental purposes by Mr. Sirrine in 1890, soon developed so much rust that they succumbed. That fall, uredospores were abundant on both rye and wheat after severe frosts in November. On several occasions during the winter and early spring searches were made for rust but none could be found. Prof. Bolley, however, finds in Indiana that the mycelium

[7] L. C. p. 261.

winters in the tissues of the leaf during cold weather. In March the rust produced spores.[8]

One fact in this connection of general interest is that the destructive wheat pest in the United States appears to be *Puccinia rubigo-vera*. Prof. Arthur in calling attention to this fact, says:[9] "The presence of this species did not, however, seem particularly surprising as it has been known for some time that the early rust in England is this same species, and although occurring every year, is thought to do little damage to the crop. As time passed on, however, the whole wheat crop became thoroughly rusted and practically the one species." The common grass rust doing little damage. When Prof. Arthur was investigating this subject in 1889, I wrote him that *Puccinia rubigo-vera* was the common rust in Iowa on wheat. I have since observed that in 1891 it was the common species in Western Wisconsin and Iowa, but this year *Puccinia graminis* has been very destructive, attacking not only the sheathes and stems, but also the awns and parts of the flower. It appears from the researches of N. A. Cobb that this same species is the troublesome one in New South Wales.[10]

An examination of the eleven plats of wheat on the College Farm showed the following conditions: Velvet chaff rusted badly, spikes, stems, leaves and sheathes covered with the red pustules of rust. The loss has been very great.

Johnson: leaves, stems, sheathes and spikelets covered with rust, spikelets often appearing red. Injury great.

Early Red Clawson: rusted badly like the last variety, the beards also show numerous rust pustules, damage great.

Stewart: considerable rust but not as bad as Velvet Chaff, wheat still green on July 13.

Hybrid Dattel: considerable rust but not as bad as Early Red Clawson.

Hybrid Lamed: leaves and stems rusted as badly as Hybrid Dattel but heads not so bad. On the west side near a row of trees, not rusted as badly as farther in the patch.

Golden Cross: rusted severely, beards, leaves, culms and

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[8]Indiana Experimental Station, L. c., p. 13.
[9]Tenth Annual Meeting Soc. Prom. of Agrl. Science, Toronto Meeting, 1889, pp. 11 and 12.
[10]Agricultural Gazette of New South Wales, Vol. I, pt. 3, pp. 184-214.

spikelets covered with red pustules. Plants near trees not so badly rusted.

James White Fife: badly rusted.

Pool: badly rusted.

Turkish Red: this contained less rust than any other variety on the grounds, although the leaves showed *Puccinia rubigo-vera*, but in ordinary usage would be termed free from rust. This is the hardest wheat grown on the College Farm.

Some few miles from the college I noticed a field of wheat of the variety Velvet Chaff on second bottom land which was rusted no more than the Turkish Red on the college farm. That local conditions and circumstances produce rust, every one will admit. Hon. John Morrison,[11] of Hedrick, in speaking of his crop of winter wheat says: "I have six acres of clean level prairie, tiled, and have just harvested the third wheat crop in succession. First crop 23 bushels per acre; second crop 26 bushels per acre; third crop, just cut, (July 23) but not threshed, is far the heaviest."

It may be of interest to see what botanist have found in regard rust and certain varieties of wheat. Prof. Bolley[12] says, "Certain it is that there is a slight prejudice in favor of red wheats for which, perhaps, there is some ground. The white wheats as a rule produce a softer and more succulent straw which is more favorable for the growth of parasites." He found in Indiana that on some varieties it is apparently difficult for the rust to get a working hold. He mentions especially the varieties, Fulcoster, Egyptian and Dietz Lonbgerry. In this connection it is noteworthy that he fonnd Velvet Chaff badly rusted. According to his testimony it is one of the most susceptible to rust. Mr. M. Hume Black[13] writing about rust in Brisbane says: "Unquestionably some varieties of wheat under like circumstances and conditions suffer much less from rust than others." He mentions the varieties Ward's Prolific, Steinwedel's, and a Mediterranean variety, known as Belatonvka. Sorauer [14] makes the statement that certain, kinds especially Polish Wheat (*Triticum polonicum*) and spelts (*T. spelta*) and an

[11]Iowa State Register, July 28, 1892.
[12]Bulletin of Indiana Agricultural Experiment Station, July, 1889, p. 15.
[13]Department of Agriculture, Queensland, Brisbane, 1880, p. 58.
[14]Pflanzenkrankheiten, Vol. II, p 220.

English wheat, derived from *Triticum turgidum* are less subject to rust. He also states that Werner, Koernicke, and Havenstein, found after several years of observation, that two varieties of winter wheat were little subject to rust. Spaulding's Prolific wheat, though it lodged and grew on rich soil, had little tendency to rust.

It would make this paper to long too quote from various station bulletins as regards rust and different varieties of wheat. It will suffice to quote a few. In 1889 Director R. P. Speer, sowed 2.30 acres of wheat of the varieties, Black Sea, Fife, White Fife, Manitoba Fife, Golden Globe, and Lost Nation. All of these varieties were badly rusted. The yield of the whole was 19 bushels per acre. In March 1.7 acres were sown with Velvet Chaff and Blue Stem. These were slightly rusted and the yield was 48⅔ bushels. The Saskatchewan showed little tendency to rust that year.

On March 26, 27 and 28, 1890, the following varieties of spring wheat were sown: Campbell's Fife, White Chaff, Ladoga, Saxonka, White Russian, Saskatchewan, Wellman Fife, Black Sea, Velvet Chaff, Blue Stem, and French Hybrid. My recollections of the spring wheat on the college grounds in 1890 are that it was all more or less severely injured by rust. Some of the varieties entirely worthless. Director Speer[15] writes that the French Hybrid was healthy. "Last year we recommended the Saskatchewan, this year the former was destroyed by rust and blight and the latter was severely injured."

In the fall of 1889 the following varieties of winter wheat were sown: Turkish Wheat, Golden Cross, Red Fultz, Ontario, New Monarch, Fulcoster, and Deitz Longberry. The only thing to note is that rust appeared about June 28 and that it did but little injury. The Turkish wheat yielded 24 bushels. Bulletin No. 15 of the Iowa Experiment Station has a a record of eight varieties of wheat; Hybrid Lamed, Hybrid Dattel, "found in Golden Cross," Pool and James White Fife. Early Red Clawson was nearly free from rust. Golden Cross not diseased. Turkish Red gave a big yield. From my own observations made it seems that not a single variety was entirely exempt but it was not sufficient to injure

[15] Bulletin No. 10, Iowa Experiment Station, p 393.

the crop seriously. This year some of the same varieties were so badly rnsted that the leaves, stems, spikelets, and awns contained pustules. In going through the different fields my clothes and shoes became covered with the brown spores—every stalk containing thousands of spores. If the rust spores could have been collected and weighed they would have made many pounds. Why such an abundance of rust? The question can fairly be answered;—first, rich soil. Wheat in rich soil has a tendency to produce a great deal of stalk and leaf, also a larger amount of nitrogen which is largely used in the growth of the fungus. Had the year been less moist and the temperature less favorable for the germination of the uredo-spores there would have been less rust. It should be noted that Turkish Red growing at the south end of the same field under the same conditions was less rusted than other varieties. This may have been due to a varietal difference as it has apparently not rusted heretofore to any extent, nor in another part of the farm. It is well known that some varieties harbor rust less than others, but this is sometimes a question of locality, as last year a variety of oats, said to have been "rust-proof." rusted severely; in fact it was the only variety that was badly affected.

It is a well known fact that the hard wheats to which our Turkish Red belongs are much less subject to rust than the soft wheats. Prof. E. M. Shelton,[16] whose opinion is always worthy of consideration, remarks: "In the United States there has been a pretty steady diminution of the damage caused by rust during the past twenty-five years, and that in face of the fact that the area of cultivatied land has been enormously extended, particularly in the western states. In the last twenty years we have changed at least five times, not a change in isolated parts, but a radical change covering a large area of the country in which wheat is grown. We grow now to the exclusion of nearly all others the hardy red varieties. These are the slightly bearded which go under a variety of names: They are known as Russian, Bulgarian, and Turkish or Black Sea wheats, but they are subsiantially one and the same."

[16] Rust in wheat, Department of Agriculture, Queensland, Brisbane, 1890, p. 17.

He adds that from his experience among farmers these are the best rust resisters. There is enough to show that early sowing is advantageous, this is shown in a very striking manner in spring wheats, which are usually rusted more than winter. I do not know as any comparative tests have been made in this direction in the United States as practical experience has taught the farmer that he must get his grain in early, although they have been made elsewhere. Mr. A. N. Pearson[17] says the earliest sown wheat was quite free from rust. "This result is in accordance with the general experience in our colony, that early sown wheats suffer less from rust than late sown ones."

Dr. Cobb[18] has studied the cuticle and leaves of wheat. As regards leaves he finds that the resistant wheats have narrow, stiff, upright foliage—the rust liable varieties have broad, flabby and pendant foliage. He also found that when a vrriety is resistant the cuticle is thick, when not resistant the cuticle is thinner. He also found that the proportion of strength giving tissue is greatest in rust resistant varieties and mentions the Saskatchewan and Fife as good wheats. Saskatchewan on the College Farm rusted badly in 1890.

It would be interesting to consider several other points in this connection, but space will not permit.

In conclusion it may be well to bear the following in mind: Use as far as possible hard wheats, sow early enough to bring the wheat well under way before the latter part of June. It is better to sow wheat thin.

Finally as to spraying wheat for rust. Experiments made on the college grounds in 1891 gave only negative results.[19] Prof. Kellerman,[20] at Manhattan, Kansas, had a similar experience, but Dr. Cobb[18] has found Bordeaux mixture, *eau celeste* and ammonical carbonate of copper and simple solutions of copper sulphate effective.

WHEAT BLIGHT.

Only one other serious enemy can be recorded on wheat known as "Blighted Heads," "Wheat Blight," in Ohio commonly called "Wheat Scab." That this is a serious trouble

[17] Rust in wheat, Legislative Assembly, second session, 1891, p. 10.
[18] Agricultural Gazette, N. S. Wales, Vol. III. part 3, p. 193
[19] Iowa Experiment Station Bulletin 16, p 324.
[20] Bulletin No. 22, Kansas Agricultural Experiment Station.

will be seen from the following estimate in Velvet Chaff Wheat: Out of a total of 125 heads 73 were perfect, 24 blighted one-third, 7 entirely, and 24 less than one-third of the head affected. In the variety John, Mr. Stewart estimated the loss about one-fifth. In Hybrid Dattel out of 120 heads counted, 57 were perfect, 8 entirely, 8 one-half, 15 one-third, and 32 partially. The disease is caused by a fungus known as *Fusarium culmorum*, first described by Worthington G. Smith.[21] Weed has made it the subject of several papers. The charaeters are briefly as follows: The disease appears about the time when the grain begins to turn. The entire head or only parts ripen prematurely and suddenly. If the head is partially destroyed the lower part will be green. Heads or parts of the same affected have a white appearance instead of a golden yellow. The disease usually starts at the upper end although it may begin at the lower end. An examination of the affected head will show a white mycelium spreading over and through the spikelets and head. The spikelets become glued together by a gelatinous substance thrown off by the mycelium of the fungus.

An examination of the kernels shows that it is very much shrunken, in fact nothing remains but the shell. The spikelets as well as the kernels are pink in color and contain the spores of the fungus.

SMUTS.

The ordinary Loose Smut of wheat *Ustilago tritici* was quite common in many varieties. The following table shows the number of smutted heads in stools of the varieties Hybred Dattel and Pool, which may be of interest:

[21] Disease of Field and Garden Crops, p. 208.
Weed Soc. Prom. Agrl. Science, Indianapolis meeting. See also Pammel, Jour. Mycology, Vol. VII, p. 97.

HYBRID DATTEL.			POOL.		
Total number of sta ks.	Not smut-ted.	Smutted.	Total number of stalks.	Not smut-ted.	Smutted.
7	4	3	5	2	3
6	2	4	8	2	6
2	..	2	4	1	3
2	..	2	4	1	3
3	2	1	12	4	8
4	1	3	9	5	4
2	..	2	6	1	5
5	3	2	5	..	5
4	..	4	9	5	4
6	1	5	6	1	5
4	1	3	5	..	5
..	..	..	6	2	4
..	..	..	4	..	4
..	..	..	3	1	2
Total..45	11	31	86	25	61

These counts were made from random selections in the field, and show that usually the greater number of plants in a stool will be smutted.

Prof. Bessey[22] has made similar observations. He records out of 77 stalks in 19 hills, that 55 were smutted and 22 sound.

Bunt: *Tilletia fœtens* was found in the varieties Velvet Chaff. Hybrid Dattel, but it did not injure the varieties to any extent. This fungus differs from Loose Smut in that it occupies the kernel not breaking open till crushed, and when fresh emits a disagreeable odor which becomes very nauseating when soaked in water. If farmers intend sowing winter wheat this fall they should purchase clean seed, and to make sure that bunt will be removed, use the Jensen hot water treatment which consists in destroying the smut spores in hot water. We planned some experiments with this fungus but the winter wheat was sowed too late so that it winter killed, no report can therefore be made. The method of treating is as follows: Provide two large vessels or boilers on a stove. One should contain water from 110-120° Fahrenheit, the second, scalding water at 131° Fahrenheit. Two vessels should be used because it will be hard to keep the proper temprature in one vessel. Prof. Kellerman[23] says in regard to precautions to be used: "1st. Maintain the proper temperature of the watar, (131° Fahrenheit) in no case allowing it to go higher than 135°. Immersion fifteen

[22]Bull. Iowa Agrl. College, Dept. Botany, 1884, pp. 123 and 124.
[23]Bull. No. 21 Kansas Agrl. Experiment Station, Aug. 1891, p. 71. See also Report of Botanical Department for 1889, &c.

minutes will not injure the seed. 2d. See that the volume of scalding water is much greater (at least six or eight times) than that of the seed treated at any one time. 3d. Never fill the basket or sack containing the seed entirely full, but always leave room for the grain to move about freely. 4th. Leave the seed in the second vessel of water fifteen minutes."

Oats: The enemies of oats in the fungus line, observed in Iowa, are rusts and smuts. Two species of rust commonly attack it, Common Grass Rust described under wheat, occuring on the stem, sheaths and glumes. Covered Rust of Oats (*Puccinia coronata*) occuring on the leaves. This fungus also has three stages, the uredo or red-rust stage; the teleuto or winter-spore stage, and the aecidium or first stage. The accidium stage occurs on Buck-thorns (*Rhamnus* and *Frangula*) which has been found in several places in Iowa, but it is certainly not common. In a patch of garden soil of experiment oats, treated for smut, every stalk and leaf was badly rusted. Where oats was rank and thick on the College Farm considerable rust appeared, but in places where the oats were thin rust was not bad. The subject of smut in oats will be considered fully in another bulletin where we will report on the treatment.

Barley: This year we have found *Puccinna graminis* on the stems and sheathes, but it is usually not abundant. A more serious enemy is the Yellow Leaf Disease of Barley, caused by *Helminthosporium graminum.*[24] The history of this fungus is given in Journal of Mycology and need not be repeated in this connection. The disease appears a little before heading time; usually all the plants of a stool are affected. Instead of having a normal green color they are somewhat variegated with yellow and green. In older parts of the leaf blackish masses can be seen; these masses consist of large olive brown spores, which are usually six celled. The mycelium or vegetative part of the fungus lives in the tissues of the plant.

Rye is a little subject to disease. Rust (*Pucinnia rubigovera*) occurs but it is not destructive. Ergot (*Claviceps purpurea*) is abundant every year especially on isolated plants.

[24] Monthly Review of the Iowa Weather and Crop Service Bulletin, 189 , Vol. 2, p. 9. See, also, reprint, separate, p. 27.
L. H. Pammel, New Fungus Diseases of Iowa, Journal of Mycology, Vol. 2, p. 97.