ZINC FERTILIZATION OF CONTINUOUS CORN

West Central Experiment Station - Morris

Samuel D. Evans

In the spring of 1965 an experiment was initiated involving the use of zinc fertilizer on continuous corn. The plots were set up on Forman clay loam and corn grown previously on this soil had not shown zinc deficiency, even though leaf samples indicated the zinc content was below 20 ppm zinc.

Table 1: Yields for 1969 and 1965-69.

Treatment	When applied	Yield in bu./acre at 15.5% moisture 1969	1965-69 aver.
Check	--	54.9	81
5 lbs zinc as zinc sulfate	1965	51.4	79
10 lbs zinc as zinc sulfate	1965	49.3	79
10 lbs zinc as zinc sulfate	yearly	57.3	82
20 lbs zinc as zinc sulfate	1965	50.0	82
0.5 lbs zinc as Zn chel.	yearly	45.1	74
45 lbs P broadcast	yearly	44.9	78
45 lbs P broadcast + 10 lbs zinc as zinc sulfate	yearly 1965	53.6	79

Table 2: Summary of phosphorus and zinc leaf analysis for 1969.

Treatment	When applied	%P	ppm Zinc	P/Zn Ratio
Check	--	.26	12	228
5 lbs zinc as zinc sulfate	1965	.23	14	169
10 lbs zinc as zinc sulfate	1965	.24	16	148
10 lbs zinc as zinc sulfate	yearly	.25	24	102
20 lbs zinc as zinc sulfate	1965	.25	20	128
0.5 lbs zinc as Zn chel.	yearly	.24	15	164
45 lbs P broadcast	yearly	.29	10	301
45 lbs P broadcast + 10 lbs zinc as zinc sulfate	yearly 1965	.26	12	225

1965 Variety-Dekalb XL 304 Date Planted - May 13, 1969

WEATHER SUMMARY - 1969

West Central Experiment Station - Morris

Samuel D. Evans

Month	Period	Precipitation 1969	Precipitation Average 1930-59	Precipitation Deviation from Nor.	Air Temperature 1969	Air Temperature Average 1930-59	Air Temperature Deviation from Nor.	Temp. Soil(10 CM) 1969
January	1-31	2.17	.56	+1.60	0.6	10.1	-9.5	26.6
February	1-28	1.02	.67	+0.35	12.4	14.7	-2.3	27.0
March	1-31	0.68	1.11	-0.43	15.9	27.5	-11.6	28.5
April	1-10	1.77			35.3	37.3	-2.0	34.2
	11-20	.23			49.0	43.5	+5.5	46.4
	21-30	.97			48.2	48.6	-0.4	51.2
Total or Average		2.97	2.05	+0.92	44.2	43.1	+1.1	43.9
May	1-10	2.32			54.6	53.0	+1.6	54.2
	11-20	1.97			53.4	56.3	-2.9	57.0
	21-31	.14			63.0	60.2	+2.8	65.9
Total or Average		4.43	3.07	+1.36	57.2	56.5	+0.7	59.3
June	1-10	.27			58.3	63.6	-5.3	65.1
	11-20	.54			57.6	66.3	-8.7	65.0
	21-30	1.22			61.0	68.4	-7.4	62.8
Total or Average		2.03	3.79	-1.76	59.0	66.1	-7.1	64.3
July	1-10	.86			64.5	70.4	-5.9	68.0
	11-20	.67			75.5	72.0	+3.5	79.0
	21-31	1.99			70.0	72.6	-2.6	76.1
Total or Average		3.52	3.25	+0.27	70.0	71.7	-1.7	74.4
August	1-10	.13			70.9	72.3	-1.4	77.0
	11-20	.04			72.6	70.1	+2.5	79.3
	21-31	.04			72.1	66.7	+5.4	77.1
Total or Average		.21	2.87	-2.66	71.8	69.7	+2.1	77.8
September	1-30	2.81	1.94	+0.87	60.3	59.7	+0.6	63.5
October	1-31	2.83	1.44	+1.39	42.4	48.9	-6.5	44.9
November	1-30	.85	1.09	-0.24	30.5	30.4	+0.1	34.8
December	1-31	1.95	.59	+1.36	17.3	17.0	+0.3	27.2
April 1-Aug. 31		13.16	15.03	-1.87	60.6	61.7	-1.1	64.1
Jan. 1 - Dec. 31		25.47	22.43	+3.04	40.3	43.0	-2.7	47.8

1968 CLIMATIC STUDIES AT THE PARK RAPIDS SULFUR EXPERIMENTAL FIELD

J. B. Swan, A. C. Caldwell, G. W. Rehm, E. Seim, D. G. Baker

Past research at the Park Rapids experimental field has indicated that climatic conditions commonly imposed limitations on yields. The drought limitation has been eliminated by irrigation. However, other climatic limitations remain, including the normally short growing season and low air temperatures as illustrated by only 1766 GDD on the average (base temperature 50°F) for the average warm season period at Park Rapids. Low soil temperatures may also constitute a severe limitation. Measurements in 1967 indicated that in irrigated corn the soil temperatures throughout the growing season were well below the optimum. During 1968, soil temperatures were measured at the 2-and 12-inch depths under widely varying populations of irrigated corn and also under potatoes, bare soil and sod. Daily pan evaporation and maximum and minimum air temperatures were recorded.

Table 1 reports the weekly soil temperature at the 2-and 12-inch depths in the row for irrigated corn at populations of 30,000 and 100,000 plants. Measurements were made by using 4 thermocouples placed in parallel for each treatment. Readings were taken at 8:15 AM CDST ± 90 minutes and 5:10 PM CDST ± 40 minutes to approximate the daily minimum and maximum soil temperatures, respectively. The varieties of corn used were Pioneer PXEI for the 100,000 population and Trojan TX68 for the 30,000 population. The soil temperatures reported are the weekly means of the average daily temperatures.

As in 1967, soil temperatures for irrigated corn were well below

optimum in 1968. Sizeable differences in weekly average maximum 2-inch soil temperature were recorded between populations of 30,000 and 100,000. However, data from a single year must be judged with caution due to wide fluctuations likely to occur between years.

Greatest temperature difference between the two populations for both maximum and average 2-inch soil temperatures occurred during late June and early July and was probably caused by the more dense shading during this period in the 100,000 plant population treatment. Differences in weekly mean afternoon temperatures were as great as 7°F. Figure 1 shows the weekly mean of the average and maximum 2-inch soil temperatures never exceeded 74°F or 81°F for the 100,000 plant or the 30,000 plant population treatments, respectively. Weekly measurements of average 2-inch soil temperatures were lower and did not rise above 71°F for the 100,000 plant population treatment or 73°F for the 30,000 plant population. These temperatures were generally well below the optimum for corn which is of the order of 85°F. Weekly values of the average 2-inch soil temperature exceeded 70°F for only 1 week for the 100,000 plant population treatment and for 2 weeks for the 30,000 plant population treatment.

Figure 2 and Table 2 show the 2-inch soil temperatures measured by maximum-minimum type mercury-in-steel soil thermometers for populations of 20,000, 40,000 and 50,000 plants.

Weekly mean soil temperatures recorded for bare soil and sod at the 2-, 4-and 12-inch depths are reported in Table 3. Soil temperatures measured by the mercury-in-steel type maximum and minimum thermometers at the 4 and 12-inch depths under potatoes and maximum and minimum air temperatures are shown in Table 4.

Measurement of the evaporation from a Class A type pan and the estimated evapotranspiration are listed in Table 5. The ratios of the two evapotranspiration estimates to the measured values of pan evaporation would indicate, for 1968, that pan evaporation in this locality overestimates evapotranspiration by about 15-20%. The potential evapotranspiration estimate by the Penman method for the growing season (defined as period when probability of occurrence of 32°F or less remains less than 50%) is about 16.5 inches of water. The Thornthwaite method estimate amounts to about 17.8 inches per season. Thus, an average of about 17 inches might be assumed.

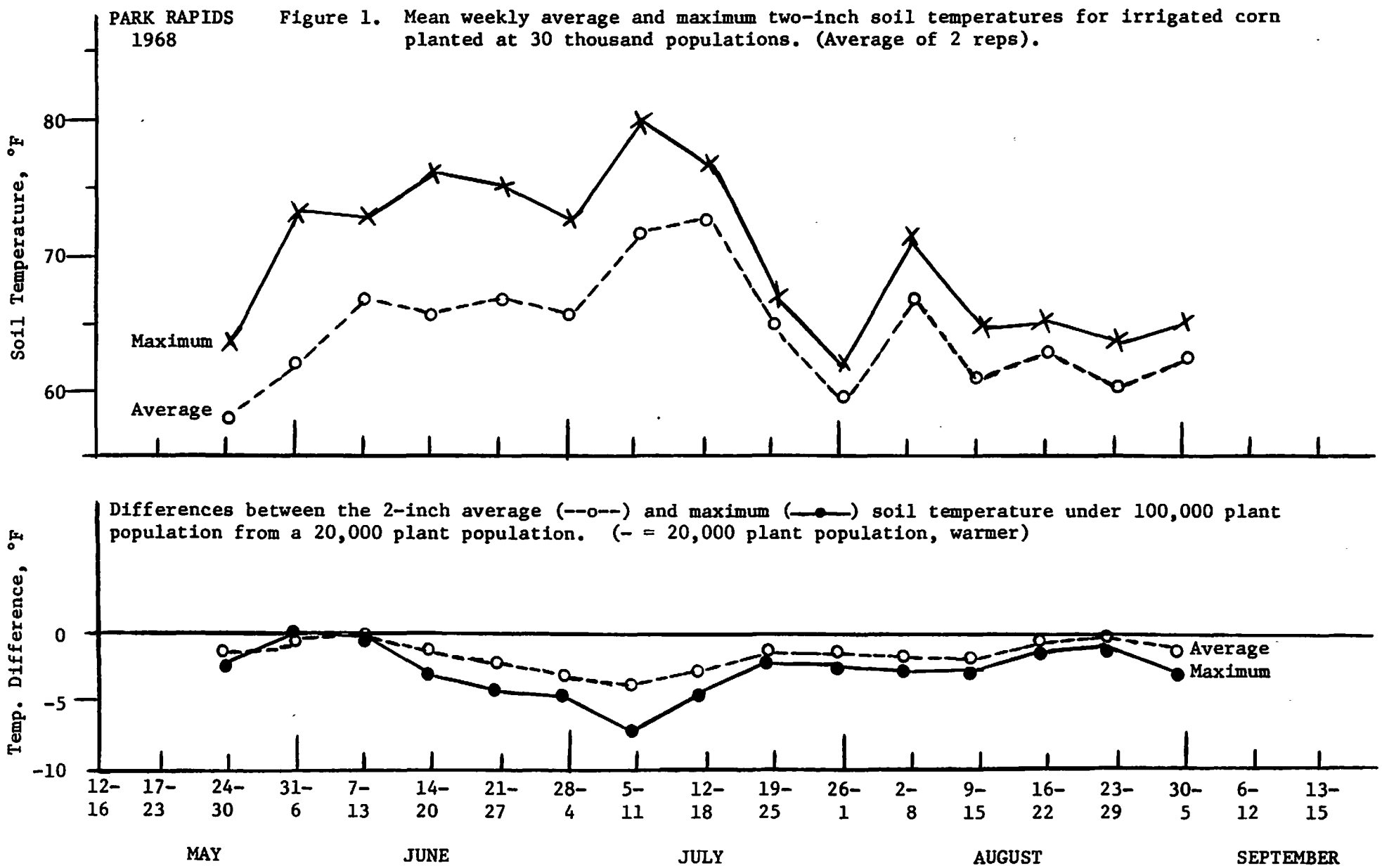

Figure 1. Mean weekly average and maximum two-inch soil temperatures for irrigated corn planted at 30 thousand populations. (Average of 2 reps).

Differences between the 2-inch average (--o--) and maximum (—●—) soil temperature under 100,000 plant population from a 20,000 plant population. (- = 20,000 plant population, warmer)

PARK RAPIDS
1968

Figure 2. Mean weekly average and maximum soil temperature two-inch depth for irrigated corn at 20,000 plant population.

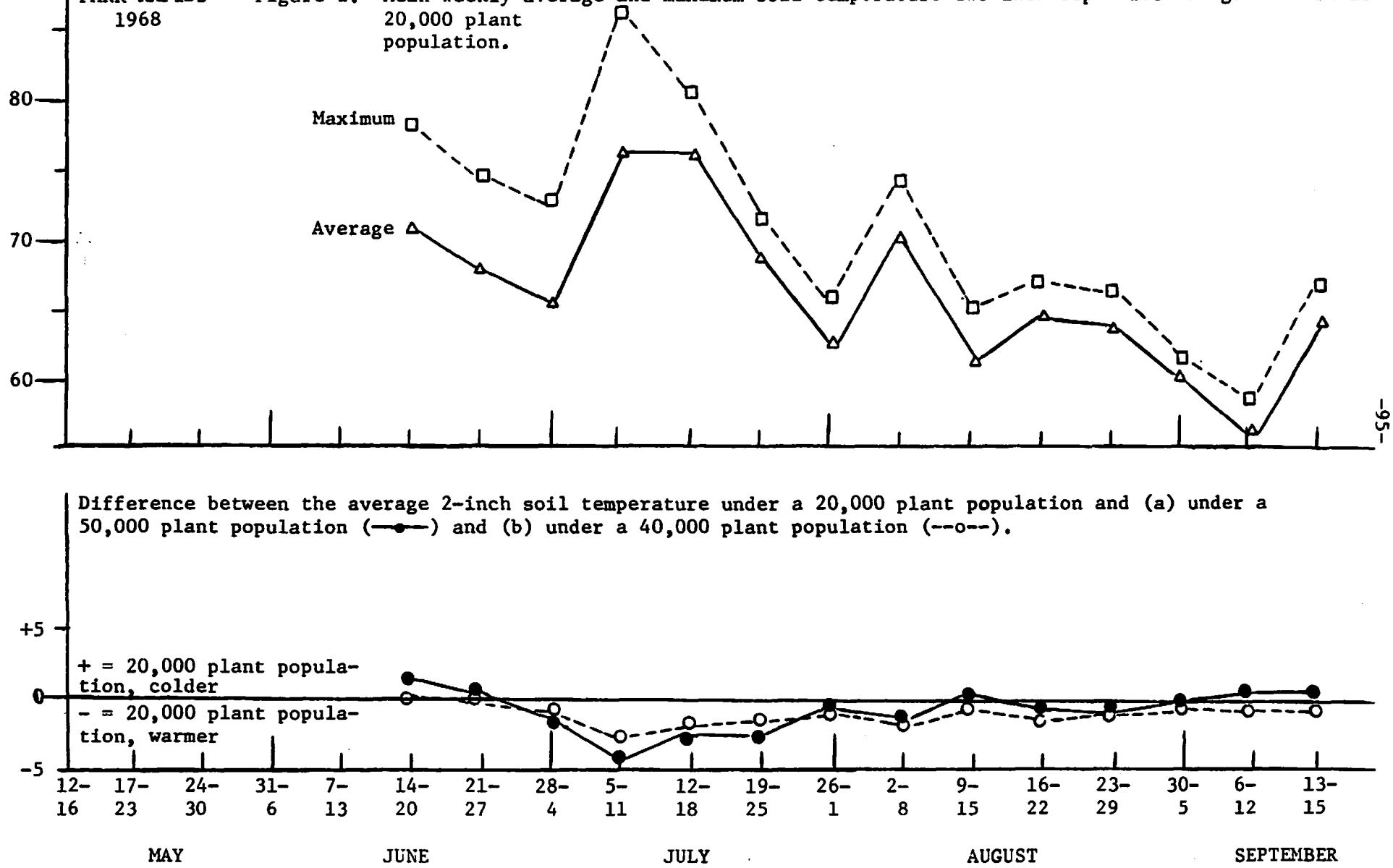

Table 1. Mean Weekly Soil Temperature (°F) at 2 and 12-inch Depths Under Irrigated Corn for Two Populations, Park Rapids, 1968.

Period	Climatological Week Number	100,000 POPULATION-(Plot 5) 2-Inch Depth AM °F	PM °F	AVG. °F	12-Inch Depth AM °F	PM °F	AVG. °F	30,000 POPULATION-(Plot 6) 2-Inch Depth AM °F	PM °F	AVG. °F	12-Inch Depth AM °F	PM °F	AVG, °F	Aug. 2-inch ΔT (30-100) °F
May 24-May 30	13	49.7	62.0	57.2	52.4	52.6	53.4	49.9	64.2	59.4	51.7	53.3	53.4	+2.2
May 31-June 6	14	55.2	71.7	59.3	56.6	57.9	53.8	54.7	71.4	58.8	55.0	57.8	53.7	-0.5
June 7-June 13	15	61.1	72.2	66.7	64.2	64.1	64.2	61.2	73.0	67.1	63.4	63.8	63.7	+0.4
June 14-June 20	16	56.6	74.3	65.5	59.6	60.6	60.1	55.4	76.4	65.9	59.5	61.0	60.3	+0.4
June 21-June 27	17	58.8	72.2	65.4	61.7	61.4	61.5	59.2	74.8	66.7	61.7	61.9	61.8	+1.3
June 28-July 4	18	56.4	68.4	63.0	61.1	60.4	60.3	57.0	72.0	65.9	61.6	61.4	61.2	+2.9
July 5-July 11	19	62.3	74.9	68.7	65.5	64.7	65.3	62.8	78.9	70.8	65.9	66.7	66.7	+2.1
July 12-July 18	20	68.5	73.3	70.5	68.6	68.0	68.7	68.7	75.4	71.8	69.3	69.0	69.0	+1.3
July 19-July 25	21	60.9	65.9	63.4	64.0	63.6	63.9	61.2	67.1	64.3	63.6	65.0	64.3	+0.9
July 26-August 1	22	56.9	60.3	58.5	59.8	59.3	59.8	56.7	62.0	59.3	60.0	60.7	60.5	+1.2
August 2-August 8	23	62.7	69.2	65.6	62.5	62.7	61.9	62.6	70.4	66.5	63.0	63.8	62.3	+0.9
August 9-August 15	24	57.5	63.8	60.6	61.1	60.6	60.8	57.8	65.3	61.6	60.4	60.5	60.5	+1.0
August 16-August 22	25	59.2	64.8	62.3	60.5	60.6	60.7	59.3	64.9	62.3	60.7	59.7	60.6	0
August 23-August 29	26	57.6	63.2	60.4	60.2	60.4	60.5	56.9	64.8	61.1	60.2	59.5	60.2	+0.7
August 30-August 31	27	59.2	64.2	62.2	60.9	62.0	60.9	58.7	66.8	62.7	59.9	61.0	60.8	+0.5

100,000 Population Pioneer PXE-1
30,000 Population Trojan TX68
24 inch row width

Four thermocouples were placed in parallel in the row in each treatment
AM readings taken about 8:15 DST± 90 minutes (approximates daily minimum temp.)
PM readings taken about 5:10 DST± 40 minutes (approximates daily maximum temp.)

Average temperatures were calculated from weekly averages of daily average temperatures. Where either AM or PM readings were missing, these data were not included in the averages.

Table 1 (continued).

Period	Climatological Week Number	100,000 POPULATION-(Plots 22) 2-Inch Depth AM °F	PM °F	AVG. °F	12-Inch Depth AM °F	PM °F	AVG. °F	30,000 POPULATION-(Plot 25) 2-Inch Depth AM °F	PM °F	AVG. °F	12-Inch Depth AM °F	PM °F	AVG. °F	Avg. 2-inch ΔT (30-100) °F
May 24-May 30	13	50.7	61.5	56.6	52.8	51.3	51.2	50.7	63.3	57.3	52.3	51.6	51.9	+ .7
May 31-June 6	14	57.2	74.3	63.8	55.7	57.5	56.1	57.0	75.2	65.5	56.3	58.7	57.2	+1.7
June 7-June 13	15	60.9	72.9	66.9	62.8	63.0	63.0	60.4	72.9	66.7	63.4	63.7	63.6	-0.2
June 14-June 20	16	56.5	72.7	64.6	59.1	60.1	59.6	56.1	76.3	66.3	58.9	60.8	59.9	+1.7
June 21-June 27	17	59.0	70.1	64.4	61.2	61.8	61.4	58.9	75.8	67.2	61.6	62.3	61.9	+2.8
June 28-July 4	18	56.1	68.0	62.8	59.7	60.6	59.6	56.4	73.6	66.2	60.2	61.9	60.6	+3.4
July 5-July 11	19	61.4	71.9	66.7	63.6	62.8	63.3	62.9	82.0	72.5	66.8	66.9	67.0	+5.8
July 12-July 18	20	67.1	71.3	70.0	66.7	67.3	66.9	68.4	78.0	74.0	68.6	69.7	69.0	+4.0
July 19-July 25	21	60.3	64.3	62.4	62.9	62.8	63.0	61.7	67.7	64.8	65.8	65.1	65.5	+2.4
July 26-August 1	22	56.1	60.2	57.9	58.6	58.4	58.8	56.6	63.1	59.8	60.3	60.3	60.5	+1.9
August 2-August 8	23	61.8	67.5	64.4	62.7	62.1	61.9	63.5	72.6	67.8	64.0	64.7	63.8	+3.4
August 9-August 15	24	55.8	60.4	58.1	59.0	59.1	59.0	57.6	65.4	61.5	62.0	61.2	61.6	+3.4
August 16-August 22	25	59.4	63.7	61.8	59.6	58.5	59.1	60.0	66.2	63.3	62.4	61.2	62.0	+1.5
August 23-August 29	26	56.9	62.9	60.0	58.7	58.7	58.8	57.1	63.4	60.1	62.2	59.6	59.8	+0.1
August 30-August 31	27	59.2	60.8	59.5	60.0	60.1	60.0	59.1	64.4	61.7	60.1	61.3	60.6	+2.2

Table 2. Mean Weekly Soil Temperature (°F) at 2-inch Depth Under Irrigated Corn with Populations of 50, 40, and 20 thousand Plants/Acre, Park Rapids, 1968.

Period	Climatological Week Number	50,000 POPULATION 2-Inch Depth (Plot 3)			40,000 POPULATION 12-Inch Depth (Plot 40)			20,000 POPULATION 2-Inch Depth (Plot 41)			Colder or warmer than 2-inch temp. under 20,000 pop.	
		MIN. °F	MAX. °F	AVG. °F	MIN. °F	MAX. °F	AVG. °F	MIN. °F	MAX. °F	AVG. °F	50,000 °F	40,000 °F
June 18-June 20	16	62.7	81.3	72.0	61.3	80.0	70.7	63.0	78.0	70.5	+1.5	+0.2
June 21-June 27	17	60.0	76.0	68.0	60.0	75.1	67.6	60.7	74.4	67.6	+0.4	0.0
June 28-July 4	18	55.3	72.0	63.6	57.7	70.0	63.9	57.7	72.3	65.0	-1.4	-1.1
July 5-July 11	19	64.3	78.4	71.4	64.6	81.6	73.1	65.6	85.9	75.7	-4.3	-2.6
July 12-July 18	20	69.3	77.1	73.2	69.0	78.6	73.8	71.1	80.1	75.6	-2.4	-1.8
July 19-July 25	21	63.1	67.7	65.4	63.9	68.9	66.4	64.0	70.7	68.0	-2.6	-1.6
July 26-August 1	22	59.4	63.0	61.2	59.1	63.1	61.1	58.7	64.9	61.8	-0.6	-0.7
August 2-August 8	23	63.7	71.4	67.6	63.4	71.3	67.4	65.0	73.4	69.2	-1.6	-1.8
August 9-August 15	24	57.7	63.9	60.8	57.3	62.1	59.7	56.7	63.6	60.1	+0.7	-0.4
August 16-August 22	25	60.0	65.6	62.8	60.1	63.4	61.8	60.7	66.1	63.4	-0.6	-1.6
August 23-August 29	26	59.3	64.7	62.0	59.6	64.3	61.9	60.0	65.6	62.8	-0.8	-0.9
August 30-Sept. 5	27	56.9	60.4	58.6	56.9	59.9	58.4	57.3	60.1	58.7	-0.1	-0.3
Sept. 6-Sept. 12	28	51.4	57.7	55.3	51.4	56.7	54.1	52.1	57.3	54.7	+0.6	-0.6
Sept. 13-Sept. 15	29	60.0	67.7	63.8	59.7	65.3	62.5	61.0	65.0	63.0	+0.8	-0.5

Measurements made by Palmer max-min thermometers placed in the row.

24 inch row width

Varieties and population: 50,000 Trojan TX68; 40,000 Pioneer 3985; 20,000 Trojan TX80

Table 3A. Mean Weekly Sod Cover Soil Temperatures (°F) at two-, four-, and twelve-inch depths at Park Rapids, 1968

Period	Climatological Week Number	Weekly Mean Soil Temperature (°F) 2-Inch Depth AM °F	2-Inch Depth PM °F	2-Inch Depth AVG. °F	4-Inch Depth AM °F	4-Inch Depth PM °F	4-Inch Depth AVG. °F	12-Inch Depth AM °F	12-Inch Depth PM °F	12-Inch Depth AVG. °F	Number of Readings per Period AM	PM	AVG.
May 12-May 16	11	50.9	58.0	57.1	52.2	56.5	55.0	53.1	51.0	52.3	4	5	4
May 17-May 23	12	45.6	57.0	51.3	47.0	53.4	50.2	49.3	48.7	49.1	7	6	6
May 24-May 30	13	49.9	56.8	53.8	50.6	53.7	52.5	51.3	50.4	50.9	6	5	4
May 31-June 6	14	55.1	65.1	60.1	54.9	62.3	58.5	55.1	52.7	55.1	6	5	4
June 7-June 13	15	62.7	71.8	67.3	64.1	69.6	66.0	64.7	64.7	64.7	6	6	6
June 14-June 20	16	57.8	70.8	64.3	59.7	68.4	64.1	62.0	61.9	61.9	6	6	6
June 21-June 27	17	61.6	72.1	66.4	62.1	68.4	65.1	62.6	63.8	63.1	7	6	6
June 28-July 4	18	58.2	68.0	63.8	59.3	65.9	63.0	61.4	61.6	61.5	5	6	4
July 5-July 11	19	64.3	77.1	70.6	65.4	73.0	69.3	65.7	66.2	65.9	7	6	6
July 12-July 18	20	69.7	81.4	75.8	70.0	77.3	73.8	70.2	70.2	70.3	5	7	5
July 19-July 25	21	66.1	77.2	71.7	67.5	74.4	71.0	69.5	69.0	69.2	7	7	7
July 26-August 1	22	61.2	74.6	67.7	63.1	70.3	66.7	66.0	65.6	65.9	7	6	6
August 2-August 8	23	66.1	83.1	74.5	67.3	76.6	71.9	68.6	68.8	68.2	5	6	4
August 9-August 15	24	63.2	77.3	70.2	64.5	72.8	68.6	67.9	67.4	67.6	7	7	7
August 16-August 22	25	62.8	74.3	68.6	63.9	70.7	67.4	65.4	66.2	65.7	7	6	6
August 23-August 29	26	61.3	71.8	66.9	61.8	69.8	66.0	66.0	66.1	65.7	6	5	4
August 30-August 31	27	62.9	72.5	67.6	63.2	69.3	66.0	64.8	64.9	65.2	2	1	1

AM readings taken about 8:15 AM DST (± 90 minutes)
PM readings taken about 4:50 PM DST (± 40 minutes)

Temperatures measured by three thermocouples in parallel

Table 3B. Mean Weekly Bare Soil Soil Temperatures (°F) at two-, four-, and twelve-inch depth at Park Rapids, 1968

Period	Climatological Week Number	Weekly Mean Soil Temperature (°F) 2-Inch Depth AM °F	2-Inch Depth PM °F	2-Inch Depth AVG. °F	4-Inch Depth AM °F	4-Inch Depth PM °F	4-Inch Depth AVG. °F	12-Inch Depth AM °F	12-Inch Depth PM °F	12-Inch Depth AVG. °F	Number of Readings per Period AM	PM	AVG.
May 12-May 16	11	49.4	64.9	56.8	50.5	62.1	56.4	51.1	49.1	48.5	4	5	4
May 17-May 23	12	41.4	65.2	53.1	44.0	59.6	51.8	49.3	48.8	49.2	7	6	6
May 24-May 30	13	49.7	65.7	58.9	50.6	61.0	56.8	53.1	52.8	53.0	6	5	4
May 31-June 6	14	56.3	77.3	67.2	56.0	70.3	63.6	57.8	56.4	57.5	6	5	4
June 7-June 13	15	60.8	74.8	67.8	60.9	71.2	66.1	63.6	63.9	63.8	6	6	6
June 14-June 20	16	55.4	76.3	65.9	55.4	71.9	63.7	60.7	61.4	61.1	6	6	6
June 21-June 27	17	59.3	76.6	67.0	59.3	72.4	65.8	62.8	62.3	62.5	7	6	6
June 28-July 4	18	56.0	74.2	66.2	57.2	69.3	63.8	61.8	62.2	61.8	5	6	4
July 5-July 11	19	65.0	85.2	74.1	65.1	79.5	72.2	68.3	67.8	68.0	7	6	6
July 12-July 18	20												
July 19-July 25	21												
July 26-August 1	22												
August 2-August 8	23												
August9-August 15	24												
August 16-August 22	25												
August 26-August 29	26	57.4	80.9	69.0	60.4	76.7	68.1	66.6	65.8	66.0	4	2	2
August 30-August 31	27	61.7	81.9	70.3	62.6	76.6	69.0	65.4	63.6	63.8	2	1	1

Table 4. Mean Weekly Soil Temperature of Irrigated Potatoes at 4 and 12-inch Depth and Mean Weekly Air Temperature, Park Rapids, 1968.

Period	POTATOES 4-Inch Depth Min. °F	Max. °F	Avg. °F	12-Inch Depth Min. °F	Max. °F	Avg. °F	AIR TEMPERATURE Min. °F	Max °F	Avg. °F
May 12-May 16	49.2	53.0	51.1	51.8	53.0	52.4			
May 17-May 23	44.8	53.5	49.2	47.2	50.5	48.8			
May 24-May 30	51.0	57.6	54.3	53.6	55.6	54.6	60.5	44.5	52.5
May 31-June 6	58.4	69.9	64.1	57.4	62.7	60.1	54.5	72.8	63.7
June 7-June 13	62.0	76.9	69.4	63.6	67.9	65.7	54.6	74.3	64.4
June 14-June 20	56.9	72.4	64.6	60.3	65.0	62.6	44.4	70.3	57.4
June 21-June 27	59.9	70.0	64.9	62.1	64.4	63.3	51.3	70.4	60.9
June 28-July 4	58.7	65.9	62.3	60.7	63.7	62.2	47.7	69.6	58.6
July 5-July 11	62.1	72.7	67.4	63.6	66.0	64.8	53.3	80.0	66.6
July 12-July 18	69.0	72.7	70.9	67.7	68.1	67.9	63.6	82.7	73.1
July 19-July 25	64.1	66.6	65.4	65.0	65.9	65.4	53.4	77.6	65.5
July 26-August 1	59.3	61.9	60.6	61.3	62.4	61.9	47.1	72.3	59.7
August 2-August 8	64.1	67.4	65.8	64.1	64.4	64.3	56.6	79.9	68.2
August 9-August 15	59.0	62.7	60.9	59.6	62.7	61.1	47.0	68.6	57.7
August 16-August 22	61.7	64.1	62.9	61.1	62.0	61.6	53.1	74.1	63.6
August 23-August 29	62.1	65.4	63.8	62.0	63.9	62.9	51.3	74.1	62.7
August 30-September 5	58.4	61.7	60.1	59.7	61.4	60.6	47.6	66.6	57.1

Table 4 (continued)

Period	POTATOES						AIR TEMPERATURE		
	4-Inch Depth			12-Inch Depth					
	Min. °F	Max. °F	Avg. °F	Min. °F	Max. °F	Avg. °F	Min. °F	Max. °F	Avg. °F
September 6-September 12	54.1	60.4	57.3	56.7	57.4	57.1	42.6	67.3	54.9
September 13-September 15	63.3	66.7	65.0	59.3	60.7	60.0	56.3	77.0	66.7

Soil temperature measured by Palmer Max-Min thermometer placed on the row.

Table 5. Pan evaporation measurements at Park Rapids, 1968*

Month	Number of Days	Inches Pan Evaporation Per Day	Estimated Potential Evapotranspiration Penman	Estimated Potential Evapotranspiration Thornthwaite	Ratio of Penman PE Estimate / Meas'd. Pan Evaporation	Ratio of Thornthwaite PE Estimate / Meas'd. Pan Evaporation
May	16	0.145	0.12	0.10	0.83	0.69
June	29	0.184	0.15	0.16	0.82	0.87
July	31	0.201	0.16	0.18	0.80	0.90
August	31	0.193	0.13	0.15	0.67	0.78
September	13	0.115	0.09	0.09	0.78	0.78

* Class A Type pan used

Penman Calc from G. R. Blake, E. R. Allred, C. H. M. van Bavel, and F. D. Whistler, Agricultural Drouth and Moisture excess in Minnesota, Technical Bulletin 235, May 1960.

EFFECT OF BORON RATES ON STAND, APPEARANCE AND NUTRIENT COMPOSITION OF CORN AND ALFALFA

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In conducting some field experiments on a sulfur deficient soil in west north central Minnesota it was found that the area was low in available boron. Since it was suspected that many acres of similarly coarse textured soils were also deficient in boron, it was thought desirable to study boron response further. An additional factor favorable to conducting studies on this experimental field was the availability of irrigation water to ensure an adequate supply of this important plant growth factor, particularly in a moisture deficient area and also in an area where there appeared to be considerable promise of future irrigation development.

It was decided therefore to study boron further on these soils and an experiment was set up with the objectives of determining the effects of boron rates on stand, appearance and nutrient composition of corn and alfalfa.

PROCEDURES

The soil on which the experiments were conducted is a Dorset sandy loam, low in sulfur, but also low in boron, containing less than 1 ppm of available B. The soil had been limed to pH 6.5.

Boron rates on corn

Boron rates of 0, 1, 2, 4, and 8 lbs/A of actual B (applied broadcast as Borax), were used in a series of plots randomized and replicated

4 times. Other nutrients (S, P, K, and N) were applied according to soil test. The corn variety was Minhybrid 806, with an 85 day maturity rating. Usual insect and weed control practices were followed. The corn was irrigated every 7 to 10 days depending partly on need. Periodically observations were made on growth and plant appearance. Corn tissue samples were obtained first at thinning time, and about every 2 weeks thereafter until tasseling. In early sampling large mature leaves were taken, but later on when the ear became apparent, the ear leaf was sampled. All told, 6 samples were secured. When corn ears became mature, yields were taken.

Boron on alfalfa

Boron rates of 0, 2, 4, 8, and 16 lbs/A of actual B (applied broadcast as Borax), were applied on randomized and replicated plots for alfalfa. Other nutrients (P, K, and S) were applied as needed. The variety Glacier was planted at the rate of 12 lbs/A. As a measure of possible damage from heavier rates of B, stand counts were made. Alfalfa tissue was taken for analysis when plants were about 10 inches high and when sampled for yield.

Plant analysis

Corn and alfalfa tissues were analyzed for content of chemical elements by spectrographic analysis. Nitrogen and S (which are not determined by spectrographic means) were estimated by accepted procedures.

Soil sampling and analysis

Soils were sampled in the fall at 0-6, 6-12, and 12-18 inch depths by a hydraulic tube method. Soils were analyzed for available B by the hot water soluble method, B being determined colorimetrically as a boron-curcumin complex by the method of Grinstead and Snider.

RESULTS AND DISCUSSION

Boron on corn

It became evident early in the growth of the corn that the 8 pound rate of B was toxic. Plants were shorter than on other plots and were somewhat chlorotic. Later on in the season the damaged plants outgrew these ill effects to some degree, but the yield data (table 1) show that the best treatment was 4 pounds of B per acre, and the lowest yields were obtained when 8 pounds of B were applied.

Table 3 shows the effect of B rates on the B content of corn tissue. The figures all through the season reflect the impact of rates. The heaviest rate induced very high levels of B, especially in the young plants. If the figure for the critical level of B in corn of 10 ppm (Agron. Jour. 61:18), is assumed to be approximately correct, the data show that corn from plots without B were below the critical level and even when 1 and 2 pounds of B were applied the B content of the mature corn was close to a deficiency situation.

The effects of B rates on the S content of corn are shown in table 3. Data for later samplings seem to indicate an enhancement of S uptake with increase in B applications, however these differences though consistent are not great and are of doubtful significance.

Data for the analysis of other chemical constituents in corn tissue are given in tables 4 through 13. An examination of these figures fails to show any consistent pattern of influence of B rates on these essential plant nutrients.

Boron rates on alfalfa

The effects of B rates on the stand and yield of alfalfa are shown in table 14. It was apparent in the field and the stand counts show

that the heaviest B application (16 lbs/A) was toxic to alfalfa. The stand was just about cut in half when this amount of B was used. The yield data reflect the effects of B also, but not to the degree that they should. Growth was not as vigorous as was hoped for and perhaps 1970 yields will be better when plants become better established. However the yields do show that the 2 pound B rate was the best.

Thirty ppm of B is given as the critical level in alfalfa (see citation given above), and without B application (table 15) the amount of B in alfalfa tissue is too low. It can be ssen also that an application of 2 lbs/A is enough to meet the needs of the plant.

The N and S contents of alfalfa seemed to be influenced favorably by B applications, (table 16). As was the case with corn, the S content of mature alfalfa increased progressively with B rates. Since the same phenomenon occurred in both crops this effect could well be real, but it is a little difficult at this point to evaluate the significance of this to plant growth.

The effects of B rates on 10 inch and mature alfalfa are given in tables 17 and 18, respectively. An examination of these data reveals no consistent influence of B on these essential nutrients.

Effect of B rates on available B in the soil

Soils were sampled at 6 inch intervals down to the 18 inch depth on the corn plots. The available B in the samples are shown in table 19. After one season of cropping and irrigation, B is still concentrated in the top 6 inches of soil, but measurable amounts have also moved down to 18 inches when 2 or more lbs/A of B were applied.

SUMMARY

Boron broadcast at 8 pounds of actual B per acre (as Borax) was harmful to corn. The best treatment was 4 pounds of B per acre, this rate giving the highest yield and moving the B level in corn tissue well above the critical point. An increase in B rates brought about progressive increases in S content in corn tissue, but had little effect on other essential macro- and micronutrients. Boron broadcast at 16 pounds actual B per acre (as Borax) damaged the stand of alfalfa, reducing it to about half that of highter treatments or none at all. Two pounds of B was the best treatment, this rate giving the best yield and a sufficiently high B level in the plant. The N and S contents of mature alfalfa increased progressively with increases in rates of B application, but other essential macro- and micronutrients were not affected. All B rates for corn increased the B level in the soil. Applications of 2, 4, and 8 pounds of B per acre affected the available B down to a depth of 18 inches, though the major concentration was in the top 6 inches of soil.

Table 1. Effect of boron rates on yield of corn.

Treatments B, lbs/A	Corn yield bu/A
0	120.1
1	113.6
2	120.5
4	129.9
8	100.2

Table 2. Effect of boron rates on B content of corn tissue.

Treatments	Samplings*					
B, lbs/A	1	2	3	4	5	6
	B in tissue, ppm					
0	8.1	6.8	6.3	5.0	7.8	8.9
1	15.6	13.5	8.7	6.8	10.4	12.0
2	22.7	21.0	13.2	7.5	11.6	14.5
4	43.9	38.7	24.1	13.5	21.3	22.4
8	108.2	80.1	46.6	34.8	50.6	43.3

*Sampling started when corn was a few inches high and continued at about 2 week intervals thereafter.

Table 3. Effect of boron rates on the sulfur content of corn tissue.

Treatments	Samplings					
B, lbs/A	1	2	3	4	5	6
	S in tissue, %					
0	.308	.357	.285	.276	.253	.253
1	.310	.349	.294	.268	.263	.289
2	.256	.358	.292	.290	.266	.284
4	.290	.351	.314	.296	.282	.260
8	.327	.359	.308	.301	.280	.274

Table 4. Effect of boron rates on the nitrogen content of corn tissue.

Treatments	Samplings					
B, lbs/A	1	2	3	4	5	6
	N in tissue, %					
0	3.46	4.28	3.73	3.05	3.06	2.69
1	3.62	4.24	3.54	2.98	3.01	2.71
2	3.36	4.31	3.56	3.08	3.10	2.71
4	3.58	4.26	3.77	3.22	3.02	2.53
8	3.74	4.27	3.80	3.16	3.20	2.55

Table 5. Effect of boron rates on P content of corn.

Treatment	Samplings					
B, lbs/A	1	2	3	4	5	6
	P in tissue, %					
0	.41	.39	.24	.22	.37	.37
1	.42	.40	.25	.23	.39	.35
2	.40	.39	.25	.23	.38	.38
4	.43	.41	.25	.21	.37	.33
8	.45	.41	.25	.24	.37	.33

Table 6. Effect of boron rates on the K content of corn.

Treatment	Sampling					
B, lbs/A	1	2	3	4	5	6
	K in tissue, %					
0	2.35	2.40	2.45	2.07	2.06	1.71
1	2.52	2.39	2.35	1.96	2.01	1.63
2	2.18	2.46	2.41	2.07	2.04	1.74
4	2.47	2.54	2.43	2.04	2.08	1.64
8	2.44	2.48	2.44	2.12	2.09	1.71