Table 9. Effect of varying rates of broadcast phosphorus and starter fertilizers on sugarbeet percentage of phosphorus in petiole, root yields, percentage sugar, impurity index and recoverable sugar on the Wayne Schwitters farm in Chippewa County, Minnesota, 1976.

Phosphorus Treatment[1] lbs/A P_2O_5	Starter Applied[2]	Phosphorus Petiole %	Roots T/A	Sugar %	Impurity Index	Recoverable Sugar T/A
0	yes	.12	14.1	17.2	630	2.17
0	no	.12	14.2	17.4	588	2.55
25	yes	.12	16.2	17.4	613	2.39
25	no	.14	12.4	17.4	589	2.69
50	yes	.12	15.1	17.5	573	2.40
50	no	.12	15.1	17.3	597	2.22
75	yes	.13	17.0	17.1	648	2.67
75	no	.12	13.2	17.7	609	2.43
100	yes	.12	15.0	17.7	557	2.15
100	no	.14	13.9	17.4	564	2.19
Sig.		ns	ns	ns	ns	ns

BLSD (.05)

(1) 5 x 5 Latin square design with a starter - no starter superimposed in a split plot configuration.

(2) All starter plots received 5 gal/A of 7-21-7.

Table 10. Effect of varying rates of fertilizer potassium on sugarbeet root yield, percentage sugar, amino nitrogen, impurity index and recoverable sugar on the Wayne Schwitters farm in Chippewa County, Minnesota, 1976.

Potassium Treatment(1) lbs/A K_2O	Potassium (brei) ppm	Sodium (brei) ppm	Roots T/A	Sugar %	Impurity Index	Recoverable Sugar T/A
0	1775	170	13.4	17.2	647	1.975
100	1510	150	13.2	18.5	498	2.254
200	1663	215	14.1	17.3	650	2.179
300	1980	168	12.7	17.4	685	1.971
400	1923	155	13.1	17.0	668	1.993
Sig.	ns	ns	ns	*	*	ns
BLSD (.05)				-	-	
(.10)				.7	91	

(1) 2 replicates.

WILD RICE FERTILIZATION RESEARCH - 1976

A PROGRESS REPORT
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John Grava and Keith A. Raisanen
Department of Soil Science
University of Minnesota
St. Paul, Minnesota 55108

Research was continued during 1976 on fertilization, nutrient requirement and water quality. Nitrogen rate studies were conducted on mineral soil at Grand Rapids with two varieties in second production year, and with three varieties in first production year. Three fertilization experiments were established on peat with a 2nd year stand in Aitkin county to study NPK rates and to explore effectiveness of foliar fertilization. A strip-trial on peat with potassium was conducted in Clearwater county. Plant samples were collected and analyzed to learn more about nutrient requirement of the plant. Soil temperature, redox potential and quality of paddy water were monitored during growing season to obtain information on the environment in which wild rice grows.

A. NITROGEN RATE AND VARIETY STUDIES ON MINERAL SOIL

Two experiments were conducted on mineral soil at the North Central Experiment Station, Grand Rapids. Experiment 1 was established in spring of 1976 with three varieties: early maturing K2 and M3 and the late maturing "Johnson". Experiment 2 had been established in spring of 1975 with K2 and "Johnson" varieties and was in second production year.

FIRST YEAR STAND

The experimental paddy was in fallow during 1975 and was fumigated with methyl bromide in fall 1975. Four rates of nitrogen were used: 0, 20, 40, 80 lb/acre. Urea (46-0-0) was applied with a 3-foot Gandy spreader on April 28 and incorporated into the soil by rototilling. Phosphorus and potassium were not applied because high availability of these nutrient elements was indicated by soil tests (4/8/76: pH 5.8; P 88; K 245). Three varieties, the early maturing K2 and M3 and late maturing "Johnson" wild rice were grown. Each variety occupied a 48 x 72 ft. area. Varieties were separated by 10 foot wide alleys. "Johnson" variety was placed between the two earlier maturing varieties to minimize cross-pollination. Individual plots were 12 x 12 ft. Each N treatment was replicated 6 times. Wild rice was seeded on April 28 and rototilled into the soil. Water level in the paddy was maintained at about 8-12 inches. Plant population in this experiment was 5-7 plants per square foot. Malathion (1.5 lb/A) was sprayed on May 28 to control midge. Copper sulfate (15 lb/A) was applied to control algae. Dithane and malathion were used to control disease and rice worm. Although the paddy had been covered with netting, blackbirds caused grain losses in some areas. Ten

plants were selected at random from each plot at jointing and 5 plants per plot at late flowering for weight measurements and plant analysis. A 4 x 4 ft. square area from each plot was hand-harvested for yield determination. The K2 and M3 varieties were harvested on August 24 and the "Johnson" on September 1.

Wild rice responded well to nitrogen treatments and exhibited height and color differences, particularly at jointing and boot stages. Plants in N0 plots were short, light green in color with yellow lower leaves. Plants in N40 and N80 plots were taller and had dark green color. At flowering, plants lodged in the N80 plots.

Yield of grain was not affected by different rates of nitrogen (table 1). Nitrogen concentration in second leaf at jointing of the K2 variety was increased from 3.56% in plants from N0 treatment to 4.55% in those from N80 plots (table 2). Nitrogen concentration and uptake in different plant parts are given in tables 3 and 4. These values were affected by N rates in a few instances.

Table 1. Effect of nitrogen application on the yield of three wild rice varieties - 1976,
Grand Rapids, 1st year stand.

Variety	N rate, lb/Acre				Average (variety)
	0	20	40	80	
	Grain yield, lb/Acre				
K2	808[1)]	901	1046	862	904
M3	996	1052	932	766	937
"Johnson"	741	839	782	817	795
Average (rate)	848	931	920	815	

[1)] 7% moisture; 76% ave. Grain recovery
Significance NS (not significant)

Table 2. Effect of Nitrogen application on N concentration in 2nd leaf at jointing,
Grand Rapids - 1976, 1st year stand.

Variety	N Rate, lb/Acre				Significance
	0	20	40	80	
	N% in Dry Matter				
K2	3.56[1)]	3.75	3.76	4.55	+
M3	3.56	3.60	3.95	3.91	NS
"Johnson"	3.04	3.82	3.00	3.75	NS

[1)] Average of 20 plants
+ = Significance at the 10% level.

Table 3. Effect of Nitrogen application on N concentration of different plant parts at late flowering.
Grand Rapids - 1976, 1st year stand.

Variety	N Rate lb/Acre	Panicles	Stems	Leaves
		N% in Dry Matter		
K2	0	1.41[1)]	0.60	1.90
	20	1.63	0.76	1.75
	40	1.47	0.62	2.08
	80	1.96	0.76	2.17
Significance		+	NS	NS
M3	0	1.59	0.72	2.03
	20	1.59	0.70	2.24
	40	1.62	0.76	2.38
	80	1.61	0.74	2.44
Significance		NS	NS	NS
"Johnson"	0	1.50	0.67	1.85
	20	1.51	0.71	1.92
	40	1.40	0.59	1.77
	80	1.58	0.75	1.88
Significance		NS	NS	NS

[1)] Average of 10 plants.

Table 4. Effect of Nitrogen application on total uptake of N by wild rice at late flowering.
Grand Rapids - 1976, 1st year stand.

Variety	N Rate lb/Acre	Panicles	Stems	Leaves	Total
		N in milligrams per plant			
K2	0	43[1)]	60	56	158
	20	59	88	71	218
	40	54	90	94	237
	80	64	88	101	253
Significance		NS	NS	NS	NS
M3	0	63	86	82	230
	20	59	98	101	258
	40	45	74	103	221
	80	64	109	142	315
Significance		NS	NS	*	NS
"Johnson"	0	63	124	106	294
	20	64	122	119	305
	40	71	134	144	348
	80	88	159	145	392
Significance		NS	*	*	NS

[1)] Average of 10 plants.
NS = Not Significant; * = Significant at the 5% level.

SECOND YEAR STAND

The nitrogen rate-variety experiment, established in spring of 1975 was continued. Three rates of nitrogen were used: 0, 40, 80 lb/acre. Urea was applied on April 28 and incorporated into the soil. Straw was disked and rototilled into the soil. A split-plot design was used in this experiment with the varieties, K2 and "Johnson", as main plots and N rates as sub-plots. Individual plots were 10 ft. wide and 12 ft. long. Nitrogen treatments were replicated 6 times with 3-foot wide alleys separating replications. Water level and pest control measures were the same as used in 1st year paddy.

Redox potential (Eh) of flooded paddy soil was determined by placing platinum electrodes into the root zone. Following readings were obtained during the season:

Date	Eh, millivolts
5/21	+ 190
6/02	- 100
7/16	- 190
7/22	- 190
8/04	- 200
8/12	- 205.

During June - August Eh ranged from -100 to -205 mv indicating a strongly reduced condition in the mineral soil.

The stand was not thinned and plant population was 8 - 9 plants per square foot. At jointing and boot stages striking differences in plant height and color were observed. Plants in N0 plots were shorter and lighter in color than those in plots receiving N80 treatment; plants in N40 plots were intermediate in color and height. In August, heavy lodging occurred in the plots receiving 80 lb/acre of N.

Grain yields (at 7% moisture) varied from 659 to 1231 pounds per acre (Table 5). The earlier maturing K2 outyielded the "Johnson" variety by nearly 330 lb/acre. Yield of wild rice was not affected significantly by the rate of nitrogen. It appeared, however, that the 80 pound N rate had a more adverse effect on the "Johnson" variety, probably due to greater vegetative growth (Table 7) and more severe lodging than on the K2 yield. Nitrogen concentration in second leaf at jointing was increased from 3.27 to 3.88 % by the application of 40 lb N/acre (Table 6). At late flowering, a single plant contained from 294 - 367 milligrams of N. Fertilization, generally had little or no effect on N concentration of different plant parts (Table 8) or the N uptake by wild rice at this stage of plant development.

Table 5. Effect of Nitrogen application on the yield of two wild rice varieties.
Grand Rapids - 1976, 2nd year stand.

Variety	N Rate, lb/Acre		
	0	40	80
	Grain Yield, lb/Acre		
K2	989[1)]	1101	1231
"Johnson"	787	892	659

1) 7% moisture; Ave. Grain Recovery 79%

(a)

Variety	Grain Yield, lb/Acre
K2	1107
"Johnson"	779
Significance	*
Blsd (.05)	263

(b)

N Rate, lb/Acre	
0	888
40	997
80	945
Significance	NS

Table 6. Effect of Nitrogen application on N concentration in 2nd leaf of two varieties at jointing,
Grand Rapids - 1976, 2nd year stand.

Variety	N Rate, lb/Acre			Average (Variety)
	0	40	80	
	N % in Dry Matter			
K2	3.24[1)]	4.11	3.71	3.69
"Johnson"	3.30	3.65	3.96	3.63
Average (Rate)	3.27	3.88	3.84	

1) Average of 60 plants
Significance *
BLSD (0.05) 0.44

Table 7. Effect of Nitrogen application on plant weight of two varieties at jointing.
Grand Rapids - 1976, 2nd year stand.

Variety	N Rate 0	N Rate 40	N Rate 80	Average (Variety)
	Dry Matter, grams per plant			
K2	3.87[1)]	3.42	3.73	3.67
"Johnson"	3.75	3.47	4.25	3.82
Average (Rate)	3.81	3.45	3.99	

[1)] Average of 60 plants.
Significance (Rate) *
BLSD (0.05) 0.53

Table 8. Effect of Nitrogen application on N concentration of different plant parts at late flowering,
Grand Rapids - 1976, 2nd year stand.

Variety	N Rate lb/Acre	Panicles	Stems	Leaves
		N % in Dry Matter		
K2	0	1.71[1)]	1.00	2.39
	40	1.98	0.93	2.56
	80	1.74	0.88	2.44
"Johnson"	0	1.88	0.95	2.30
	40	1.88	1.04	2.50
	80	1.72	0.91	2.46
Significance		+	NS	NS

[1)] Average of 30 plants.

Table 9. Effect of Nitrogen application on total uptake of N by wild rice at late flowering, Grand Rapids - 1976, 2nd year stand.

Variety	N Rate lb/Acre	Panicles	Stems	Leaves	Total
		N in milligrams per plant			
K2	0	69[1)]	121	104	294
	40	76	113	121	310
	80	80	140	144	364
"Johnson"	0	79	139	109	327
	40	82	152	133	367
	80	58	114	122	294

[1)] Average of 30 plants.
Significance NS.

B. FERTILIZATION STUDIES ON PEAT

Since the great majority of paddies in Minnesota are on organic soils it is important that soil fertility and fertilization problems are investigated on organic soils. In the past our effort in the soil fertility area has been handicapped by the lack of an experimental site on peat. In fall of 1975 a suitable area of nearly 2 acres in size was located in one of Kosbau Bros. paddies in Aitkin county. A good first year stand of K2 variety was present. Soil samples were collected and depth of peat was measured in October of 1975. Soil characteristics for areas eventually occupied by experiments are given in Table 10.

Experiments were staked out and fertilizer materials were applied by hand on April 3. Fertilizer was not incorporated into the soil. Within a week the area was flooded. Rice was thinned once by airboat on May 26 when plants were in floating leaf-aerial leaf stage. Copper sulfate (20 lb/A) was applied on June 30 to control algae. Plant population, at early tillering stage, was 3 - 4 plants per square foot. Redox potential (Eh) on June 22 was -227 mv. indicating a strongly reduced condition. Paddy was sprayed with chemicals to control blight and rice worm, Helminthosporium was not evident, there was no lodging and no damage caused either by rice worm or blackbirds. By July 14 the paddy had been drained. Experimental areas were harvested on August 18. A 4 x 4 ft. area was hand-harvested from each plot for yield measurement.

Table 10. Depth of peat and soil test values of experimental areas Kosbau Bros., Aitkin County.

Area	Depth of Peat Inches	Soil test results for 0-6 inch depth		
		pH	Extractable P pp2m	Exchangeable K pp2m
Foliar Fertilization 175-225 ft.	7-8	4.6	17	40
NK Experiment 250-350 ft.	8-11	4.6	14	50
NP Experiment 400-500 ft.	18-21-11	4.4	7-15	60

NP RATE TRIAL

The NP experiment was located in an area within the paddy were the peat layer was thickest, ranging from 18-21 inches on north side and decreasing to 11 inches on south side (table 10). Water depth in this portion of paddy was greatest and wild rice yielded more than in the two other experimental areas. Extractable P was 7-15 pp2m indicating low to medium phosphorus level. Three nitrogen rates were used: 0, 40, 80 lb/acre with urea as N source. Concentrated superphosphate (0-46-0) was used to supply phosphorus at three rates: 0, 40, 80 lb P_2O_5/acre. All plots received 60 lb K_2O/acre. Fertilizer treatments were replicated 6 times. Size of individual plot was 12 x 12 ft.

Wild rice yield (table 11) ranged from 1110 to 1171 pounds per acre. Nitrogen and phosphorus treatments had no effect on the grain yield.

Nitrogen concentration in 2nd leaf at jointing ranged from 3.44-4.05% and was increased by application of N in combination of 40 lb P_2O_5 per acre. Total N uptake by the plant at jointing ranged from 82-114 mgm per plant and was increased significantly either by the N80 treatment alone or by N40 treatment in combination with phosphorus. Phosphorus concentration in 2nd leaf at jointing ranged from 0.52-0.58% P but was not affected by applications of either element. Total phosphorus uptake by the plant was not related to fertilizer treatments. A plant, on the average, had taken up 22 mgm P by jointing and 88 mgm by late flowering.

No visual differences in plants related to P treatments were observed during growing season. At the boot to heading-out stages plants in the NO treatment plots were slightly shorter and lighter in color than those receiving N application.

Table 11. Effect of nitrogen and phosphorus application on grain yield of wild rice 1976, Kosbau Bros., Aitkin County.

P rate P_2O_5, lb/acre	N rate, lb/acre 0	40	80	Ave.
	Grain yield, lb/acre			
0	1059[1)]	1061	1171	1097
40	1098	1064	1132	1098
80	1030	1084	1110	1075
Ave.	1062	1070	1138	

[1)] 7% moisture; 79% Ave. Grain recovery
Significance NS

NK RATE TRIAL

Exchangeable potassium in the plot area ranged from 30-70 pp2m considered to be a relatively low level. Depth of peat ranged from 8-11 inches. Nitrogen treatments consisted of 0, 40, 120 lb N/acre. Potassium was applied at rates of 0, 60 and 200 lb K_2O per acre. Urea and muriate of potash (0-0-60) were the fertilizer materials used in this experiment. All plots received 40 lb P_2O_5/acre. Fertilizer was applied by hand on April 3 but was not incorporated into the soil.

Plants, at jointing and boot stages, showed striking response to nitrogen treatments. Plants in NO treatment plots exhibited typical nitrogen deficiency symptoms: plants were slightly shorter and lighter in color than those observed in plots receiving N applications. Lower leaves were yellow with dead tissue at tips; some of these leaves had yellow margins (slightly resembling the marginal scorch observed in K deficient corn leaves). Response of wild rice to K treatments was not detected by visual observation.

Yield of wild rice, in this experiment ranged from 737 to 931 lb/acre (table 12). Nitrogen,applied at a rate of 120 lb/acre, increased the grain yield by 133 pounds per acre. On the other hand, potassium treatments (60 and 200 lb K_2O/acre) had no effect on the yield.

Weight and several chemical characteristics of plants collected at jointing and late flowering were affected by NK treatments. Most effective, however, appeared to be nitrogen treatments, particularly when applied at the high rate (120 lb/acre).

Dry matter at jointing ranged from 4 to 5 grams per plant and the increase was mainly due to N. At late flowering, an average plant weighed from 18 to 26 grams and the increase again was related mainly to N treatments.

At jointing, N concentration of the 2nd leaf was increased from 3.33% to 4.17% by the application of 120 lb N/acre (table 13). Average potassium concentration in 2nd leaf at jointing was 3.80% (table 14). Application of 60 lb K_2O/acre in combination with 40 lb N/acre increased concentration in 2nd leaf from 3.65 to 4.10%.

Total N uptake by wild rice was increased by the use of high rate of N. At jointing, a plant had taken up 100 to 160 milligrams of N. The same relationship between N uptake and nitrogen rate was found at late flowering (table 15). On the average, 237 grams of N had been taken up by wild rice. Total N uptake by plant was increased from 199 to 313 milligrams by the use of 120 lb N/acre.

Total K uptake by the plant also showed significant increases. However, such increases in K uptake resulted more from the increased dry matter production caused by N application than from K treatments. An average plant contained 125 grams of K at jointing and 237 grams at late flowering.

Table 12. Effect of nitrogen and potassium application on grain yield of wild rice - 1976, Kosbau Bros.

K rate K_2O, lb/acre	N rate, lb/acre 0	40	120	Ave.
	Grain yield*, lb/acre			
0	778	801	909	829
60	737	827	931	832
200	795	811	869	825
Ave.	770	813	903	

* 7% moisture; 79 ave. grain recovery
Significance +
BLSD (0.10) 133

Table 13. Effect of NK application on N concentration in 2nd leaf at jointing, Kosbau Bros. - 1976.

K rate K_2O, lb/acre	N rate, lb/acre 0	40	120	Average (K rate)
	N% in dry matter			
0	3.47[1)]	3.49	3.33	3.43
60	3.34	3.43	4.12	3.63
200	3.28	3.65	4.17	3.87
Average (N rate)	3.36	3.52	3.87	

1) Average of 60 plants
Significance *
BLSD (0.05) 0.70

Table 14. Effect of NK application on K concentration in 2nd leaf at jointing, Kosbau Bros. - 1976.

K rate K_2O, lb/acre	N rate, lb/acre 0	40	120	Average (K rate)
	K% in dry matter			
0	3.49[1)]	3.65	3.83	3.66
60	3.77	4.10	3.83	3.90
200	3.79	3.95	3.81	3.85
Average (N rate)	3.68	3.90	3.82	

1) Average of 60 plants
Significance +
BLSD (0.10) 0.37

Table 15. Effect of NK application on N uptake by wild rice at late flowering,
Kosbau Bros. - 1976.

K rate K_2O, lb/acre	N rate, lb/acre 0	40	120	Average (K rate)
	N in milligrams per plant			
0	207[1)]	190	294	230
60	204	205	324	244
200	187	203	322	237
Average (N rate)	199	199	313	

1) Average of 30 plants
Signiicance *
BLSD (0.05) 85

FOLIAR FERTILIZATION

Growers' interest was aroused by the publicity given, last winter, to work by Dr. John Hanway at Iowa State University (J. J. Hanway, Foliar Fertilization of Soybeans, 28th Annual Fertilizer & Ag. Chemicals Dealers Conference, Des Moines, Iowa, 1976). Yields, on some fields, had been increased by 10 to 20 bushels per acre by applying a specially formulated fertilizer solution on foliage during the seed-filling period. The keys to the new technique appeared to be time of application and the ratio of specific nutrients of the solution. Understanding what happens within the soybean plant during its development was helpful in this research.

During the seed filling period, sugars produced in the leaves are moved to the seeds. This normal occurrence shortchanges the root's food supply, then (a) root growth slows down or stops, (b) nodules die, hence a reduced nitrogen supply, (c) nutrient uptake from the soil is reduced, and (d) loss of leaf nutrients as they nourish the seed causes a decline in photosynthesis (sugar manufacture) and further bean growth stops.

Supplying the depleted leaves with the right ratio of nutrients at this strategic time is expected to stop the decline of the soybean plant and can increase yield because it will prevent leaf nutrient depletion and keep leaves and roots active longer. But, excess amounts of fertilizer on the leaves can injure, or "burn" the leaves. So to increase seed yield by use of foliar fertilization, it is essential that the proper kinds and amounts of fertilizer solutions be sprayed on the plants at the proper times.

Numerous soybean leaf spraying trials were conducted in the Midwest during 1976. In some instances yields were increased slightly by foliar fertilization but there were many cases where serious "leaf burn" reduced yields resulting from foliar spraying related either to drought or too high application rate. "Wait and see" is the advice on foliar fertilization of soybeans that most researchers give.

Hanway (Foliar Fertilization of Soybeans, talk given at Soils, Fertilizer and Agricultural Pesticides Shortcourse, Minneapolis, Minn. 12/15/76) feels that there still is much to be learned before foliar fertilization should be generally recommended for farmers. But, he suggests that, because of the potential and the successes that have been obtained research should be continued. Research is needed to determine: (1) The most effective time and rate of application; (2) Forms of nutrients that are effective; (3) The most effective adjuvants; (4) Factors that result in leaf burn; (5) The effects of dew, urease, etc.; (6) Factors that limit yield increase.

Hanway has emphasized that foliar fertilization is in addition to, not a substitute for, for other good crop production and soil fertilization practices. To be successful, foliar treatment should supply all four elements, N. P, K and S, at about the same ratio as found in grain. Spray applications should be made at 2 to 4 times during the seed-filling period and each application should not exceed 20 to 25 lb N/acre.

FORMULATION

An objective of foliar fertilization is to supply four major nutrient elements at a ratio as closely as possible to that found in the seed. The concentrations of NPKS in wild rice grain are:

Nutrient	Green rice	Dehulled rice
	% in dry matter	
N	2.04	2.39
P	0.42	0.44
K	0.40	0.30
S	0.15	

So the desired ratio of the four elements, on elemental basis, is 6: 1: 1: 0.58, or on oxide basis 6: 2.3: 1.2: 0.58. Note: with the available fertilizer materials, the actual formulation was 6 - 2.3 - 3.7 - 0.58. It contained 3 times more K than desired. A fertilizer solution, having this formulation and applied at a rate of 250 pounds per acre (26.4 gallons/acre, since the material has specific weight of 9.4 lb per gallon) would give: 15+6+9+1.3S pounds per acre of plant nutrients at each spraying. Table 16 shows the formulation, materials used and the cost of foliar fertilization.

Table 16. Formulation for a 6-2,3-3.7-0.5S fertilizer solution

Material	Pounds per ton	Cost per pound	Cost per ton	Nutrient element	lb per ton	%
Urea (46-0-0)	260	6¢	$15.60	N	120	6
Potassium polyphosphate (0-26-25)	177	12.4	21.95	P_2O_5	46	2.3
				K_2O	44	3.7
Potassium sulfate (0-0-50-17S)	58	6.4	3.71	K_2O	29	
				S	10	0.5
Water	1505					

Total	2000*	$41.26
Add dealer service charge (25%)		10.32
Approximate cost to grower		$51.58

At 250 lb/acre: 0.125 tons x $51.58	$6.45/acre
Aerial application ($3.00 + 26.4 gal. x 25¢)	9.60/acre
Total cost per application	$16.05/acre
2 applications	$32.10
3 applications	$48.15

*Plus Tween 80 surfactant (adjuvant)

Potassium polyphosphate was supplied by the TVA, and Dr. Harvey Meredith (TVA) provided necessary information for calculating formulation and costs. Soil application of 40+40+60 lb/acre of N, P_2O_5 and K_2O, at 1976 prices, would cost $18.20 per acre.

In spring of 1976, a foliar fertilization trial was established with 2nd year stand of K2 variety on peat, Kosbau Bros. paddies, Aitkin county in an area adjoining the NK and NP experiments. Depth of peat was 7-8 inches. Soil test results (Table 10) indicated medium extractable P and low exchangeable K levels. Soil applications of fertilizer (40+40+60) were made by hand on April 3 but fertilizer materials were not incorporated into the soil. The paddy was flooded on April 4. Rice was thinned once with an airboat at floating leaf-aerial leaf stage. At 2nd aerial leaf stage the plant population was 4 plants per square foot. To control algae, 20 lbs per acre of copper sulfate were applied at boot stage. Pesticides were applied

to control Helminthosporium and rice worm. Fertilizer solution was sprayed on 12 x 12 ft. plots with an electric cordless garden sprayer at a rate of 400 milliliters per plot. Foliar applications were made on the following dates:

1st spraying, 6/30 - at boot stage,
2nd spraying, 7/20 - mid-flowering,
3rd spraying, 8/06 - early grain formation.

No "leaf burn" damage was observed in this trial. Plots were harvested on August 18. Two 4 x 4 ft. areas were hand harvested from each plot. One replication, however, was not harvested because of extremely poor stand and growth due to low water level and weeds.

Table 17. Effect of foliar and soil application of fertilizer on the grain yield of wild rice - 1976, Kosbau Bros., Aitkin County.

Foliar Application					Soil Application		
Number	Total plant nutrients applied lbs/Acre				None	40+40+60	Average (Foliar)
	N	P_2O_5	K_2O	S			
					Grain yield[1], lb/acre		
None	None				658[2]	717	688
1x	15 +	6 +	9 +	1.3	---	734	734
2x	30 +	12 +	18 +	2.6	---	867	867
3x	45 +	18 +	27 +	3.9	781	791	786
Average (soil)					720	777	

[1] 7% moisture; [2] Ave. of 3 replications; Significance NS; C.V. % 16.7

Wild rice yield was increased slightly by foliar fertilization (table 17). The most effective treatment consisted of soil application (40+40+60) and two foliar applications (30+12+18+2.5S) made at boot and early grain formation.

Foliar fertilization of wild rice is not a recommended practice at the present time. With the varieties and production know-how that are available today, nutrient requirements of the plant can be satisfied effectively and economically by conventional soil applications of NPK and N topdressing. But there is potential that should be explored by continued investigation of this new practice. First, the positive trends of wild rice yield obtained in the 1976 trial look promising. Secondly, growers already are applying pesticides and topdress-N by airplane or helicopter. So there is a possibility of combining these operations, thus, making foliar fertilization more economical than it is today.

C. POTASSIUM RATE TRIAL

The role of potassium in wild rice production is subject to frequent inquiry. The possibility that losses caused by lodging or disease may be lessened, as in other crops, by the application of K is most intriguing to growers. Some growers have experimented with different K rates but the results have been inconclusive. In our own experiments, moderately high rates of potassium (200 lb/acre K_2O) have not produced any striking results. In 1974 on peat, plots receiving 200 lb/acre K_2O combined with 0-40 lb/acre N, had healthier plants and less lodging than plots receiving 0 or 40 lb/acre K_2O treatments. This, however, was not true for the 120+40+200 treatment. Since it is possible that rather large amounts of K are required for the nutrient to become beneficial to the crop, it was decided to include in this study some exceptionally high rates. Two trials were established on growers paddies. The cooperators applied fertilizer in 40-60 ft. wide strips in fall of 1974. In 1976 one of these trials was discontinued. The remaining trial was located in paddy No. 2W owned by the Clearwater Rice, Inc. in Clearwater county. The paddy had a good stand of "Johnson" wild rice (1972 seeding). Muriate of potash (0-0-60) was applied in 40x516 ft. strips in fall of 1974 and then rototilled into the soil. A basic application of 35+12+7 was made by airplane on June 29, 1976. Paddy was treated with insecticide against rice worm but Dithane was not used. The stand was thinned with an airboat. There was very little lodging in the paddy and infection with Helminthosporium was not serious. The yield was determined by harvesting two 4 x 4 square areas from each strip.

Grain yield was variable and did not appear to be affected by fertilization with potassium (table 18). At jointing stage, dry matter weight, K% of 2nd leaf and total K uptake by plant were not affected by K treatments (table 19, 20, 22). At the late flowering stage, however, the extremely high rates of potassium, made in fall of 1974, appeared to result in slight increases of total plant weight (table 19), K concentration in stems and leaves (table 21) and total K uptake by the plant (table 22).

Table 23 shows K test results of samples collected from the fertilizer strips (0-6 inch depth) at the end of 1975 and 1976 growing seasons. Exchangeable potassium in the root zone was increased only slightly by the application of 840-1260 lb K_2O/acre. Generally, in this trial, high to extremely high rates of potassium fertilizer had little or no effect on disease resistance, lodging and yield.

Table 18. Residual effect of K application on grain yield of wild rice on peat,
1976 - Clearwater Rice, Inc.

Treatment[1] K_2O, lb/acre	Grain Yield lb/Acre
0	720[2]
42	633
210	543
420	768
630	867
840	753
1050	1032
1260	771

1) All strips received a basic treatment of 35+12+7 applied by plane on June 29.

2) 7% Moisture.

Table 19. Effect of K application on dry matter of wild rice,
1976 - Clearwater Rice, Inc.

Strip No.	Treatment K_2O, lb/Acre	Dry matter	
		At jointing	At late flower
		Grams per plant	
1	0	9[1]	25[2]
2	42	11	22
3	210	13	24
4	420	12	23
5	630	6	23
6	840	9	25
7	1050	13	33
8	1260	8	31

1) Average of 10 plants; 2) Average of 5 plants

Table 20. Effect of K application on K concentration of wild rice tissue at jointing stage - 1976. Clearwater Rice, Inc.

Strip No.	Treatment K_2O, lb/Acre	2nd leaf	Whole plant
		K% in dry matter	
1	0	3.45[1)]	5.00[1)]
2	42	3.79	3.90
3	210	3.97	4.63
4	420	3.37	4.87
5	630	4.29	5.12
6	840	3.97	5.21
7	1050	3.81	4.88
8	1260	3.73	5.96

[1)] Average of 10 plants

Table 21. Effect of K application on K concentration of wild rice tissue at late flowering - 1976. Clearwater Rice, Inc.

Strip No.	Treatment	Stems	Leaves	Flower parts
		K% in dry matter		
1	0	3.36[1)]	2.58	1.47
2	42	3.98	2.84	1.38
3	210	4.15	2.51	1.21
4	420	3.41	2.63	1.44
5	630	4.62	3.52	1.54
6	840	4.81	3.39	1.53
7	1050	4.86	3.18	1.86
8	1260	5.02	3.46	1.73

[1)] Average of 5 plants

Table 22. Effect of K application on K uptake by wild rice, 1976 - Clearwater Rice, Inc.

Strip No.	Treatment K_2O, lb/Acre	Stage of development: Jointing	Stage of development: Late flowering
		— K uptake, milligrams per plant —	
1	0	425[1)]	728[2)]
2	42	440	738
3	210	615	796
4	420	549	665
5	630	324	908
6	840	487	998
7	1050	630	1268
8	1260	486	1274

[1)] Average of 10 plants

[2)] Average of 5 plants

Table 23. Effect of K application to peat on soil test levels, Clearwater Rice, Inc.

Treatment* K_2O, lb/Acre	Sampling date: 9/11/75	Sampling date: 8/31/76
	Exchangeable K, pp2m	
0	60	50
42	50	50
210	30	40
420	30	50
630	50	70
840	110	60
1050	100	90
1260	110	70

* Applied as 0-0-60 in fall 1974 and rototilled into the soil.

D. WEATHER AND PLANT DEVELOPMENT

The growing season of 1976 was an unusally warm and dry one. When compared to the normal (for a period 1931-60) all months from April through August in 1976 were warmer and consequently had a greater number of Growing-Degree-Days (see table 24 and Fig. 1). This warmer weather, coupled with increased solar radiation, allowed wild rice growth and development to advance about 2 weeks ahead of the usual pattern. Air temperature data for the Aitkin and Clearwater (Fosston) areas were taken at the nearest available weather station. These data may differ somewhat from actual temperature conditions in the peat bog area (bogs are usually cooler than upland areas) but they are indicative of the same "warmer than normal" trend.

The temperature and GDD data indicate that April, 1976 was much warmer than usual and started the growing season early. Upon seedling emergence, in mid-May, development was consistently ahead of the usual schedule. When compared to 1974, which had very close to normal temperature, 1976 wild rice development stages were always advanced by 2 weeks or more. The jointing stage occurred in mid-June rather than in mid-July and final harvest was in early September rather than mid-September (see Fig. 2). Regardless of planting date, however, the actual number of days from the floating leaf stage to maturity is rather constant and, at Grand Rapids, may vary from 90 to 110 days.

This early plant development during 1976 was also aided by increased solar radiation. Cloud cover was reduced and consequently radiation was increased by approximately 20%.

All of these factors leading to advanced plant development were beneficial in that they reduced the amount of late season cool weather and eliminated chances of frost injury.

Table 24. Average air temperature as measured at three U.S. weather stations.[1)]

Station, Year	Month					5 Month Average	GDD T_b=40
	April	May	June	July	August		
	average air temperature, °F						
Fosston, Polk Co.							
Normal[2)]	41.0	54.6	63.6	69.4	67.5	59.2	2954.5
1974	41.0	50.5	63.4	71.6	62.8	57.9	2743.9
1975	34.8	55.7	61.9	70.5	64.6	57.5	2851.8
1976	46.6	54.9	66.8	68.8	70.9	61.6	3314.6
Grand Rapids, N.C. School							
Normal	39.9	52.7	62.0	67.4	65.1	57.4	2681.2
1974	41.6	49.4	62.7	70.7	62.8	57.4	2669.5
1975	34.7	57.0	62.2	71.5	65.2	58.1	2950.7
1976	47.1	54.4	66.1	68.2	67.4	60.6	3166.0
Aitkin							
1974	42.9	49.8	63.1	71.1	63.3	58.0	2770.2
1975	39.0M	59.4M	64.4M	72.1	66.2M	60.2	3140.7
1976	47.5	54.8	66.8	69.3M	68.1	61.3	3267.2

1) Source: Climatological Data, Minnesota, Vol. 80, 81, 82 (1974-76), U.S. Dept. of Commerce.

2) Normals for the period 1931-60.

3) M = less than 10 days record missing.

Fig. 1. CUMULATIVE GROWING DEGREE DAYS, GRAND RAPIDS

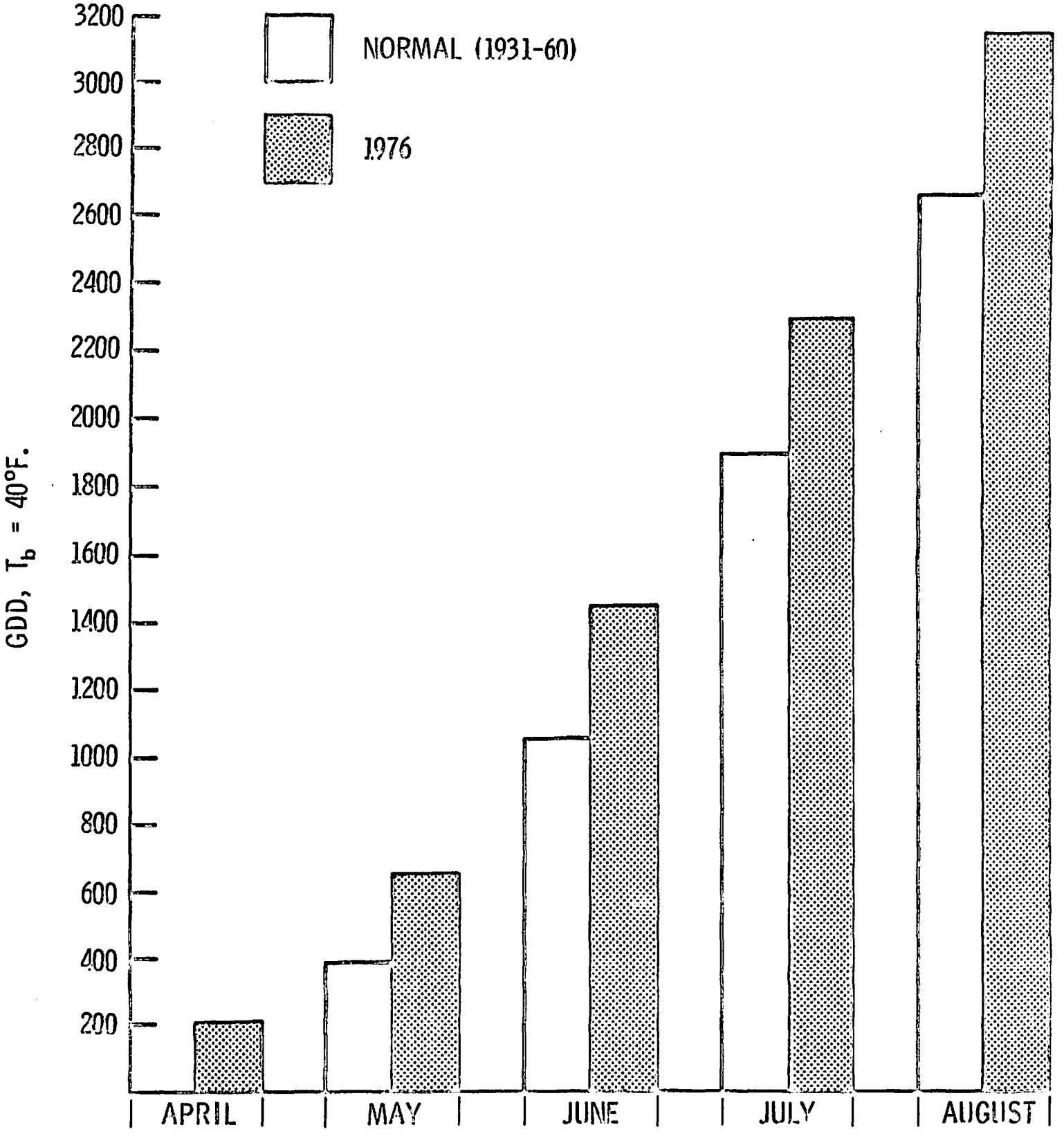


Fig. 2. DEVELOPMENT OF WILD RICE AT GRAND RAPIDS - 1974, 1975, 1976
JOHNSON VARIETY

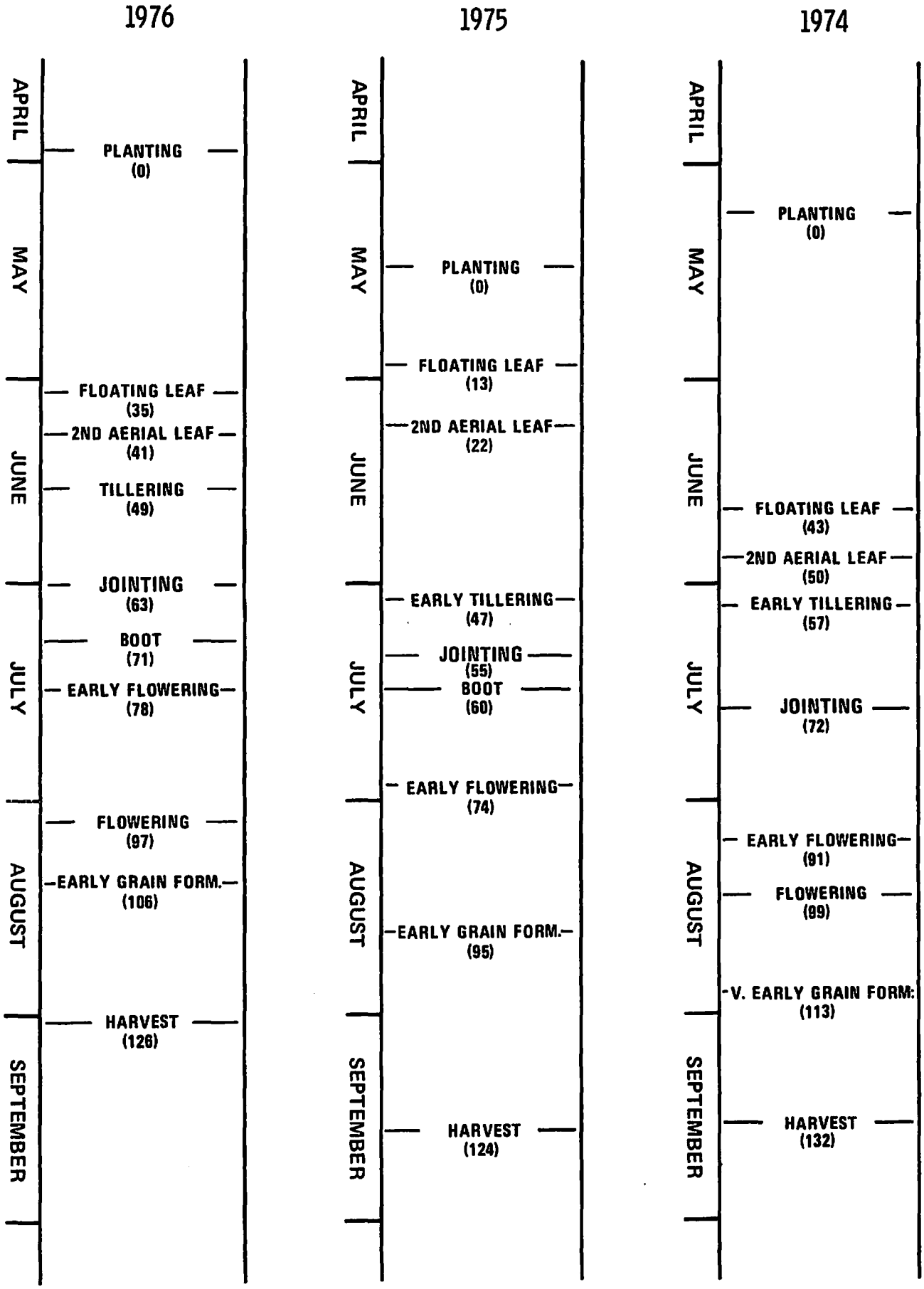
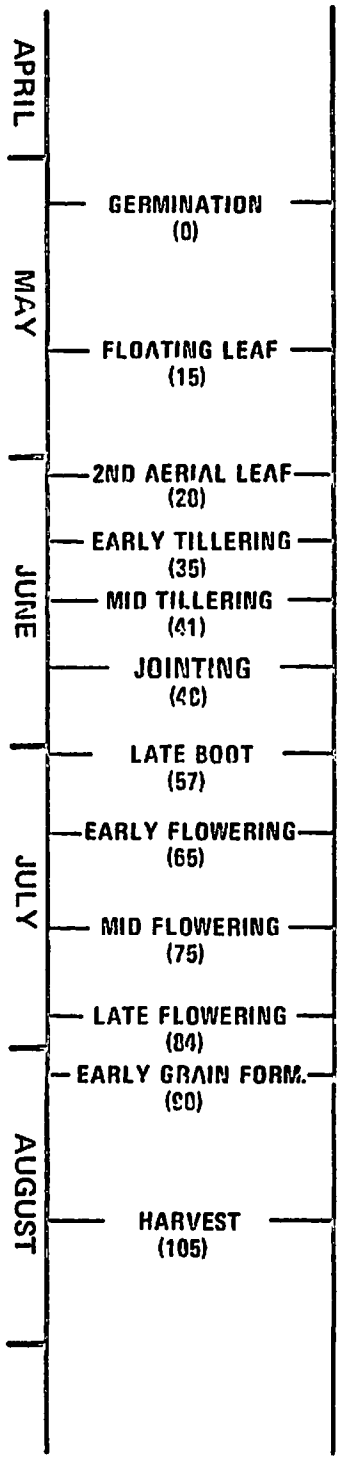


Fig. 3.
WILD RICE DEVELOPMENT
KOSBAU BROS. AITKIN CO.; 1976
K2 VARIETY
(April 3, 1976 - frost @ 3" depth)



TEMPERATURE MEASUREMENTS - 1976

Soil temperatures were taken during the growing season at Grand Rapids and at a commercial grower's paddy in Aitkin county. Air and water temperatures were also measured at the Aitkin county site. The soil temperature at Grand Rapids was measured by a stainless steel probe, inserted horizontally at about the 6 inch depth and connected to a thermometer measuring maximum, minimum and current soil temperatures (in °F.). This thermometer was read and reset daily. The soil, air and water temperatures at the Aitkin county site were measured by a 3 point, automatic sensing and recording thermograph (Weathermaster Corp. #T603). One probe was inserted into the soil at a 6 inch depth, one probe was placed in the water horizontally at a depth 6 inches from the water surface, and one probe was placed 3 feet above the water surface. Selected data for the two sites are reported at 5 day intervals (see Fig. 4-6).

The soil temperature for the Grand Rapids mineral soil (Fig. 4) was found to fluctuate much more than in the peat soil at the Aitkin county site (Fig. 5). The mineral soil temperature often varied by as much as 10°F in a single day, whereas the peat soil never varied by more than 3°F in a single day. However, both soils followed the same general heating and cooling trends. Both soils reached their maximum temperatures during the second week of June with the mineral soil reaching a high of 79°F and the peat soil reaching 70°F. After reaching these peaks both soils fluctuated within 60° and 70°F until harvest, with the peat soil being slightly cooler than the mineral soil.

The air and water temperatures at the Aitkin county site (Fig. 6) showed much greater fluctuations than the soil temperature. The water temperature closely followed the daily air temperature fluctuations. The mean water temperature was always slightly higher than the mean air temperature. The soil temperature was much more stable than air and water temperatures and stayed within the 60° and 70° range after it had reached its maximum.

Fig. 4. SOIL TEMPERATURE, 1976, GRAND RAPIDS - SOILS PADDY

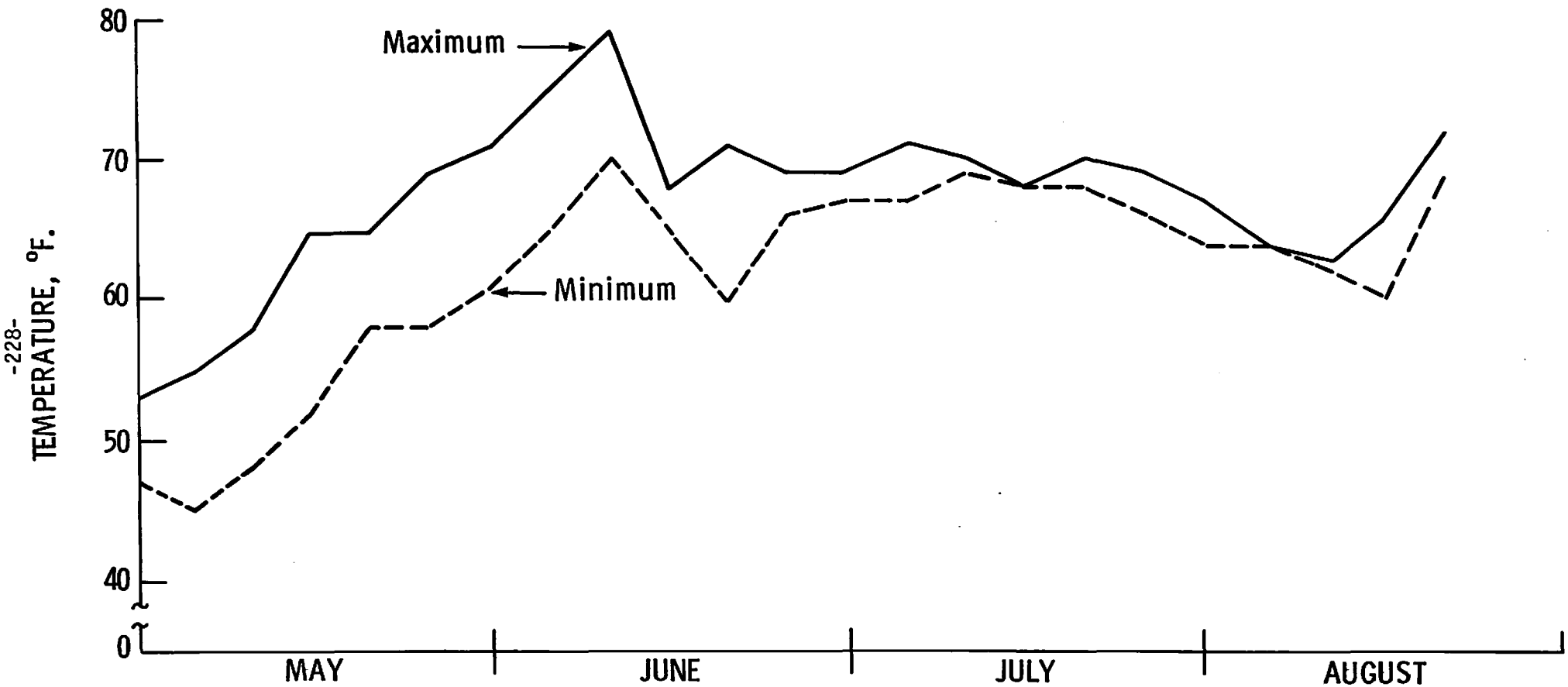


Fig. 5. SOIL TEMPERATURE, 1976, KOSBAU BROS., AITKIN COUNTY

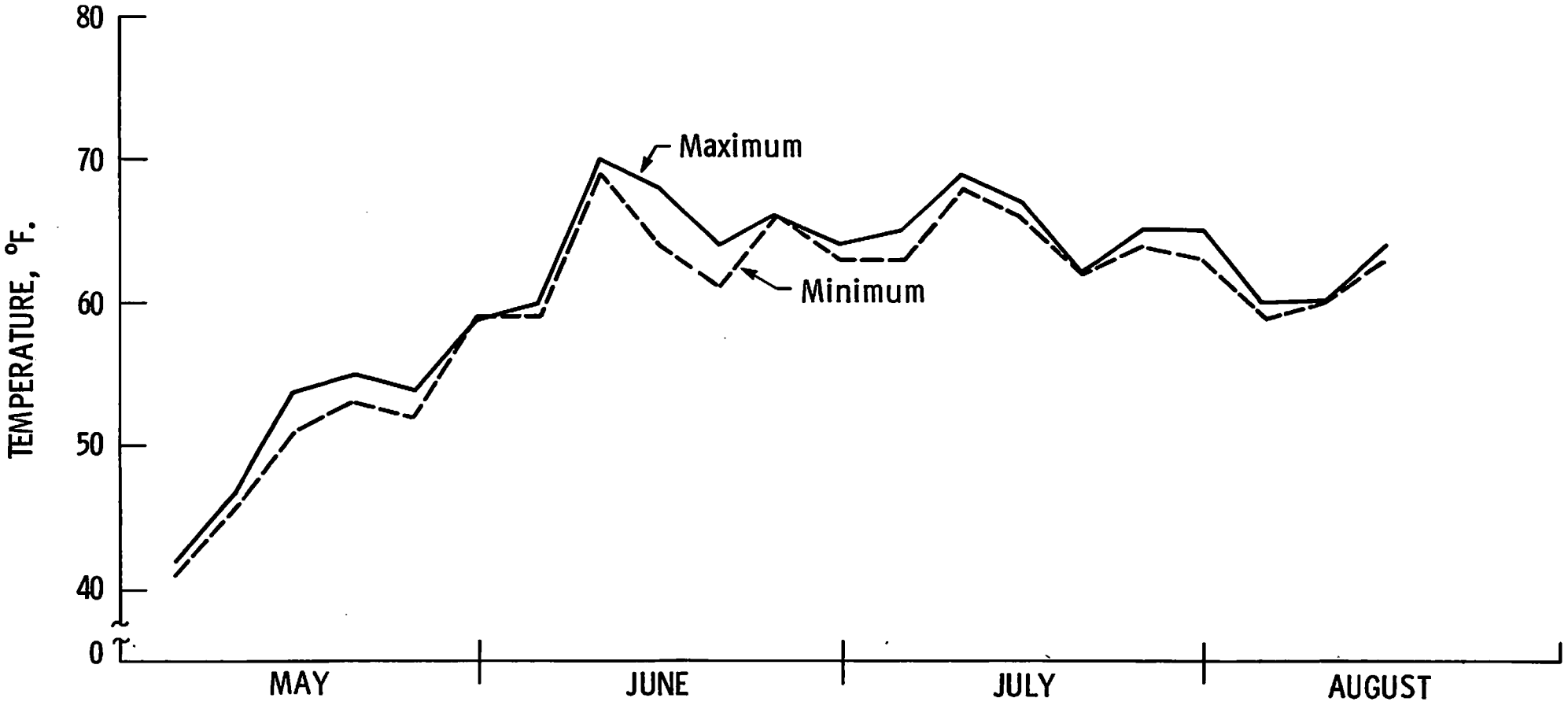
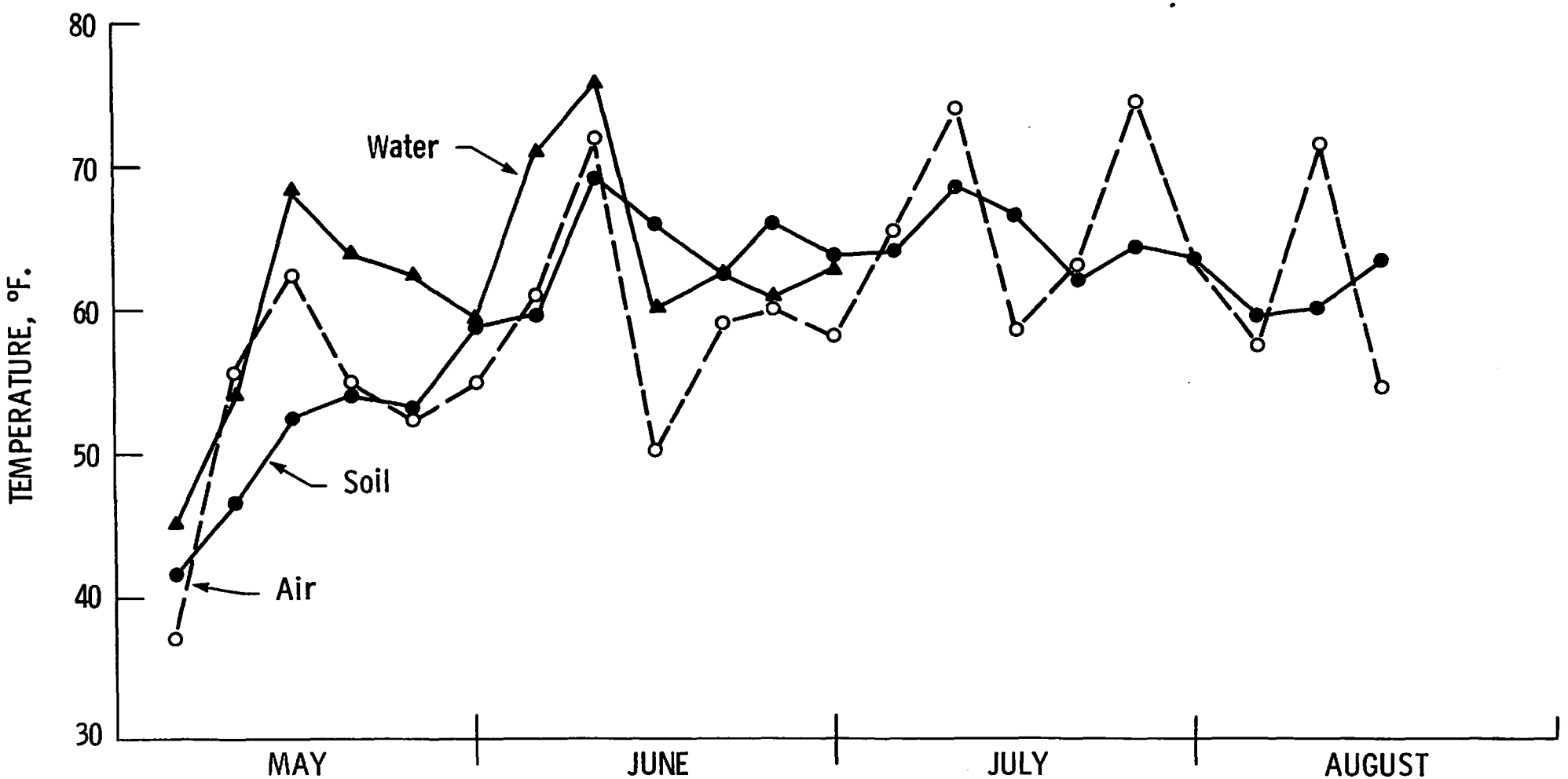


Fig. 6. MEAN AIR, WATER, SOIL TEMPERATURES, KOSBAU BROS., 1976



E. CHEMICAL CHARACTERISTICS OF PADDY WATER

The quality of paddy water is of interest to the grower as well as to state and federal agencies. The grower may be concerned, for example, with the concentration of sulfate in the water. Plant response to fertilization also may be related to nutrient levels found in the water. Public control agencies may want to know the levels of nitrogen and phosphorus present in the water when it is released during draining of paddies.

Water samples were collected from four paddies during 1976 growing season. Two of the paddies located on the Grand Rapids Experiment Station were used for nitrogen rate studies on mineral soil. Source of water is the Prairie River. The third sampling site was a paddy on peat in Aitkin county in which 3 fertilization trials were conducted. Paddies, at this location, derived water from the Little Willow River via a diversion ditch. Water passed through two other production paddies before entering the research paddy. Water level in the paddy dropped from June 15 on due to evaporation and by July 14 the remaining water had been drained off. The fourth paddy on peat in Clearwater county was the site of a potassium rate strip-trial. Water from Clearwater River reaches this paddy via Ruffy Brook. Chemical determinations were made by the Research Analytical Laboratory, University of Minnesota. Information on sampling dates and the chemical composition of water are given in table 25.

The alkalinity of water is its capacity to neutralize acid. The results, in this report, indicate alkalinity obtained by titration with a combination of indicators having an endpoint of pH 5.0. In most natural waters, the alkalinity is practically all produced by dissolved carbonate and bicarbonate ions. Some organic acids also may contribute to titratable alkalinity. The values for alkalinity follow closely to those of hardness. Water samples from the Kosbau paddy showed the lowest alkalinity levels and those from Clearwater the highest with the Grand Rapids paddy water having intermediate values.

The hardness is calculated by mutiplying Ca and Mg concentrations by factors, adding up and is expressed as $CaCO_3$, mg/liter. Water from Clearwater paddy is very hard with values ranging from 201 to 364. Water in Grand Rapids paddies is moderately hard (53-98 mg/L) while the Kosbau paddy has soft water with hardness values ranging from 26 to 62.

Chemical characteristics of water from 1st and 2nd year paddies at Grand Rapids were nearly the same. Total N, generally, did not exceed the 2 ppm level and total P concentration ranged from 0.13 to less than 0.01 ppm. Potassium concentration during most of the growing season was less than 2 ppm. Water contained less than 2 ppm sulfate-S or less than 6 ppm of sulfate (SO_4).

Water from paddy on peat located in Aitkin county, contained about 1.9 ppm total N and 0.73 ppm P at the end of April. Levels of these two chemical elements in water increased as the season progressed due to evaporation and release from the soil. Maximum levels of 4.97 ppm of total N and 2.75 ppm P were reached during June. Potassium levels also were exceptionally high in the water of this paddy. However, the water did not contain appreciable amounts of sulfate.

Water from the paddy on peat in Clearwater county contained 1.88 to 3.55 ppm total N, but the total P concentration was less than 0.7 ppm. May sampling showed 12.1 ppm K but by August the concentration had decreased to 3.3 ppm. Sulfate level in samples from this paddy varied considerably. The highest concentration of 13.6 ppm sulfate-S was measured on May 11, equivalent to 40 ppm of sulfate (SO_4).

ACKNOWLEDGMENTS

Grateful acknowledgments are made to following cooperators and University personnel for their valuable assistance during 1976 in obtaining information reported here: Messrs. Franklin and Harold Kosbau, Aitkin county; Messrs. Donald Barron and Ray Skoe, Clearwater Rice, Inc.; Dr. Wm. Matalamaki and the Staff, North Central Experiment Station, Grand Rapids; Drs. E. A. Oelke and M. F. Kernkamp, Messrs. Owney Koski and Henry Schumer, University of Minnesota; CENEX Co-op Oil Association, Gully.

Table 25. Chemical composition of water collected from wild rice paddies during the 1976 growing season.

Sample No.	Sampling Date	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Ammonium N ppm	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm
Location: Grand Rapids, 1st year paddy												
3.	4/28	50	58	.76	.20	.27	.61	< .01*	< 2.0#	16.5	4.0	1.5
9.	5/21	69	75	1.00	.10	< .01	.08	.02	< 2.0	20.6	5.8	2.0
15.	6/3	78	81	.53	.07	.07	.05	.01	< 2.0	22.5	6.1	2.3
17.	6/9	84	87	1.07	.19	< .01	.08	< .01	< 2.0	24.5	6.3	2.1
24.	6/16	68	73	.73	.10	.05	.05	< .01	< 2.0	20.6	5.3	1.6
28.	6/22	70	73	.58	.04	< .01	.02	< .01	< 2.0	20.0	5.6	1.5
32.	6/30	46	53	.90	.07	< .01	.04	< .01	< 2.0	15.1	3.6	.4
35.	7/8	73	81	1.61	.19	< .01	.13	.05	< 2.0	22.7	5.8	1.4
39.	7/15	78	76	1.60	.21	< .01	.16	.04	< 2.0	20.9	5.7	1.3
43.	7/22	79	77	1.99	.18	< .01	.21	.02	< 2.0	21.4	5.8	1.4
47.	7/27	83	80	1.33	.08	.01	.12	.03	< 2.0	22.7	5.6	1.8
49.	8/3	91	87	1.48	.33	< .01	.10	.04	< 2.0	24.0	6.5	1.5
53.	8/12	104	98	1.70	.26	< .01	.06	.01	< 2.0	25.8	8.1	2.0
Location: Grand Rapids, 2nd year paddy												
4.	4/28	50	57	.84	.10	.19	.37	< .01	< 2.0	16.3	4.0	1.6
10.	5/21	72	77	.96	.07	< .01	.06	.01	< 2.0	21.7	5.6	1.8
16.	6/3	86	86	.62	.08	< .01	.06	.01	< 2.0	24.1	6.2	2.7
18.	6.9	84	81	1.09	.22	< .01	.14	.03	< 2.0	22.1	6.3	2.2
23.	6/16	65	71	.73	.14	.05	.06	< .01	< 2.0	19.7	5.3	1.4
27.	6/22	72	71	1.31	.06	< .01	.13	.13	< 2.0	19.6	5.3	1.4
31.	6/30	48	55	1.00	.08	< .01	.06	.01	< 2.0	15.9	3.8	< .1
36.	7/8	66	75	.93	.07	< .01	.03	.01	< 2.0	21.7	5.0	1.1
40.	7/15	78	72	1.46	.13	< .01	.10	.02	< 2.0	20.1	5.2	2.1
44.	7/22	73	65	2.12	.11	< .01	.17	.05	< 2.0	18.4	4.7	2.6
48.	7/27	71	67	.88	.07	< .01	.06	.02	< 2.0	19.6	4.5	2.0
50.	8/3	78	72	1.77	.32	< .01	.18	.13	< 2.0	20.2	5.2	4.2
54.	8/12	93	81	1.10	.29	< .01	.13	.13	< 2.0	23.3	5.6	6.0

* < = less than; # 2.0 ppm sulfate-S x 3 = 6.0 ppm sulfate (SO_4).

Table 25. Chemical composition of water collected from wild rice paddies during the 1976 growing season (continued).

Sample No.	Sampling Date	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Ammonium N ppm	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm
Location: Kosbau Bros., Aitkin County												
5.	4/29	32	47	1.90	.20	< .01*	.73	.35	< 2.0#	12.3	3.9	15.7
11.	5/20	48	62	1.53	.30	< .01	1.04	1.01	< 2.0	15.6	5.5	17.9
14.	6/2	38	53	4.97	.58	< .01	1.63	1.63	< 2.0	13.0	4.9	21.4
20.	6/9	25	48	2.59	.63	.01	2.75	2.75	< 2.0	9.9	5.7	28.5
22.	6/15	10	28	4.32	.61	< .01	2.31	1.97	< 2.0	4.1	4.2	19.7
26.	6/22	13	26	4.45	.38	< .01	1.45	1.22	< 2.0	2.3	4.8	11.2
30.	6/30	18	29	2.78	.31	< .01	1.08	.86	< 2.0	4.0	4.7	6.6
38.*	7/14	50	52	3.45	.29	< .01	.35	.22	< 2.0	11.4	5.8	5.0
Location: Clearwater Rice, Inc., West 2 paddy												
7.	5/11	192	206	2.05	.08	< .01	.12	.03	13.6	55.1	16.5	12.1
33.	7/8	175	201	1.88	.12	< .01	.67	.63	< 2.0	44.5	21.9	9.6
52.	8/11	333	364	3.55	1.55	< .01	.65	.43	9.1	95.2	30.6	3.3

* < = less than; # 2.0 ppm sulfate-S x 3 = 6.0 ppm sulfate (SO_4).

SOIL WATER RECHARGE EXPERIMENT USING DRAINAGE WATER

Lowell Hanson and Dennis Linden

There were indications in the fall of 1975 that subsoil moisture conditions in south central and southwest Minnesota were quite dry and that without above normal rainfall, drought conditions would develop over wide areas in the 1976 crop season. Since ground water resources are generally inadequate for irrigation in this part of the state, the possibility of using drainage water from ditches was considered. A preliminary study of the use of spring drainage water as a soil water recharge source was conducted.

Arrangements were made with a farmer cooperator, Mr. Archie Forsberg, in Sibley County, for an experiment on corn. The site selected was on an area of Nicollet clay loam of 0-3% slope located near State Highway 19 just west of County Road 53. The water was pumped out of Judicial Ditch No. 2 about 300 feet west of the plot area. The total plot area was 1/2 acre and consisted of six plots, each 90.7 x 40 feet. Three treatments and two replications were used.

Initial Soil Water

A Nicollet soil about one half mile west was sampled (Nov. 17, 1974) and had only 0.37 inches of water in the 60 inch profile. However, a detailed sampling of the experiment site in the spring of 1975 showed that water recharge had occurred during the winter and early spring. Moisture samples were collected the week of April 12 and indicated that the soil contained about 70 percent of field capacity, or 7.6 inches of available water based on the moisture holding characteristics of the SCS sample site previously referred to.

Treatments

The three treatments consisted of two water application methods and a check. One of the application methods was a series of 20 inch deep by 4 inch wide trenches spaced 12 feet apart. The trenches were filled with corn cobs, sphagnum peat moss and surface soil. The purpose of this treatment was to test the feasibility of getting water directly into the subsoil, which was somewhat drier than the surface soil. The second water application method consisted of a sprinkler application at a rate of 50 gallons per minute (.63 inches/hr.) on an area of 7280 square feet. Water applications were made the week of April 21 after fertilizer application rates of 150+50+50 per acre. Corn was planted on May 3 and no additional water was applied. The amount of water applied for both methods of application was 3 inches.

Results

The growing season weather was extremely hot and dry in south central and southwest Minnesota. Baker[1/] reported that the precipitation departure from normal was -9 to -10 inches in Sibley County from April through August, 1976.

The corn was severely damaged by drought. Yields were increased on the water treatment plots, however, the differences were not significant at the 90 percent probability level.

Corn Yield Response to Spring Water Treatments

Treatment	Yields, Bu/Ac
Check (Rain and no additional water)	30.5
Sprinkler, 3" (Rain + 3")	52.3
Trench, 3" (Rain + 3")	48.1

F 1.74 N.S.

Conclusions

In retrospect, it would have been desirable to have added additional water later in the season. Water was available through early June but pumping equipment was not available.

This additional water would have increased yields substantially. The concept of using water stored from fall and spring runoff or from early drainage flow directly from ditches appears to have merit. Dr. Wallace Nelson at Lamberton plans further work on this concept in 1977.

Appreciation is expressed to Ed Clapp, ARS, for making pump and lines available, and to Curt Klint, Tom Malterer, Archie Forsberg and John Peterson for assisting in the experiment.

1/ Baker, Donald G. and Earl L. Kuehnast. 1977. The 1976 Drought in Minnesota. Soil Series 68. Soil Science Department. University of Minnesota.

ESTIMATES OF EVAPOTRANSPIRATION

George R. Blake

The following pages show a summary of evapotranspiration estimates based on formulae of Penman and Thornthwaite, net radiation, pan evaporation and measurements of plant water use at Lamberton.

Table 1 compiled by James Swan and Donald Baker shows a summary of some of these values and a judgemental estimate of potential evapotranspiration.

Table 2 is an estimate by George Blake of evapotranspiration at Minneapolis-St. Paul adapted specifically for grass cover. The Et corrections are as judgemental estimates of open water to grass vegetation using both Penman estimates made for England and the ratios for corn at Lamberton.

Figure 1 shows the Minneapolis-St. Paul precipitation and the Et estimates from Table 2.

Table 3 is reworked from Table 2.

Table 1. Monthly ET and PET Estimates and ET Measurements for the Seven County Metropolitan Area (MSP).

	1	2	3	4		5=6x7	6	7	8	9	10
	PET Mpls. Penman	Mpls. PET Thornth-waite	R_N St. Paul	61-67 Lamberton ET Meas. Corn Mo. Avg.	Mo. Max.	ET Est. Mpls. Plan X Factor	Factor= Lamb. ET Lamb. Pan	St. Paul Pan	PET Lamb. Thorn-thwaite	Range of Est.	PET Best Est. Adapted
Jan.	.15										.15
Feb.	.48										.48
Mar.	1.18										1.18
Apr.	2.58	1.25	2.70	.90	1.50	.72	.38	1.90	1.01	1.25-2.58	1.70
May	3.66	3.19	4.30	3.41	4.34	2.46	.43	5.74	3.05	3.19-3.66	3.50
June	4.47	4.87	4.80	5.10	7.20	4.99	.60	8.31	5.03	4.47-5.00	4.90
July	4.96	5.55	5.27	4.96	6.51	6.41	.75	8.55	6.63	4.96-5.55	5.50
Aug.	4.00	4.81	4.03	4.03	4.96	4.40	.66	6.59	4.68	4.00-4.81	4.60
Sept.	2.58	3.07	2.10	2.40	3.60	2.01	.46	4.37	2.81	2.10-3.07	2.50
Oct.	1.43	1.53	0.62	0.31	0.93	0.22	.22	1.04	1.71	1.43-1.53	1.40
Nov.	.48										.48
Dec.	.15										.15
Total	26.12	24.27									26.54
Source	Tech. Bull. 235 Agr. Drought	Baker letter	72 Blue-Book Soils	68 Bluebook-Soils			71 Blue-book	Baker	67 Blue-Book		

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Table 2. Estimate of Evapotranspiration for Grass Cover.

	Et[1/] Monthly	Et Corr.[2/]	Et Corrected	Et Corr. Begin 1/2 Mo. Period	Et 1/2 Mo. Period	Ppt.[3/] Begin 1/2 Mo. Period	Ppt. 1/2 Mo. Period	Ppt. Minus Et 1/2 Mo. Period
January	0.15	0.4	0.08					
February	0.48	0.4	0.28					
March	1.18	0.5	0.84					
April 1-15	2.58	0.6	2.21	1.50	0.93	1.67	0.88	- .05
April 15-30				2.21	1.30	1.85	1.12	- .18
May 1-15	3.66	0.7	3.66	3.00	1.66	2.62	1.45	- .21
May 15-31				3.66	1.96	3.19	1.75	- .21
June 1-15	4.47	0.75	4.79	4.2	2.25	3.80	1.95	- .30
June 15-30				4.79	2.52	4.00	1.93	- .59
July 1-15	4.96	0.8	5.67	5.4	2.77	3.70	1.74	-1.03
July 15-31				5.67	2.74	3.27	1.63	-1.11
August 1-15	4.0	0.8	4.57	5.3	2.47	3.25	1.61	- .86
August 15-31				4.57	2.02	3.18	1.53	- .49
Sept. 1-15	2.58	0.7	2.58	3.5	1.51	2.92	1.34	- .17
Sept. 15-30				2.58	1.11	2.43	1.06	- .05
Oct. 1-15	1.43	0.6	1.23	1.85	0.77	1.80	0.85	+ .08
Oct. 15-31				1.23		1.59		
November	0.48	0.4	0.28					
December	0.15	0.4	0.28					

1/ Blake, G.R., E.R. Allred, et al. Tech. Bull. 235. 1960. Agric. Drought and Moisture Excesses in Minnesota.
2/ Takes into account Penman's factors plus those by Baker, D.G. Bluebook, March 1971, p. 11.
3/ Baker, D.G., et al. Tech. Bull. 254. 1967. Climate of Minnesota. Part V. Precipitation, Facts, Normals, Extremes. Values in this column are on monthly basis. Monthly precipitation at beginning of April 1-15 period plus monthly precipitation at beginning of April 11-30 period divided by 4 gives the ppt for 1/2 month period shown in next column.

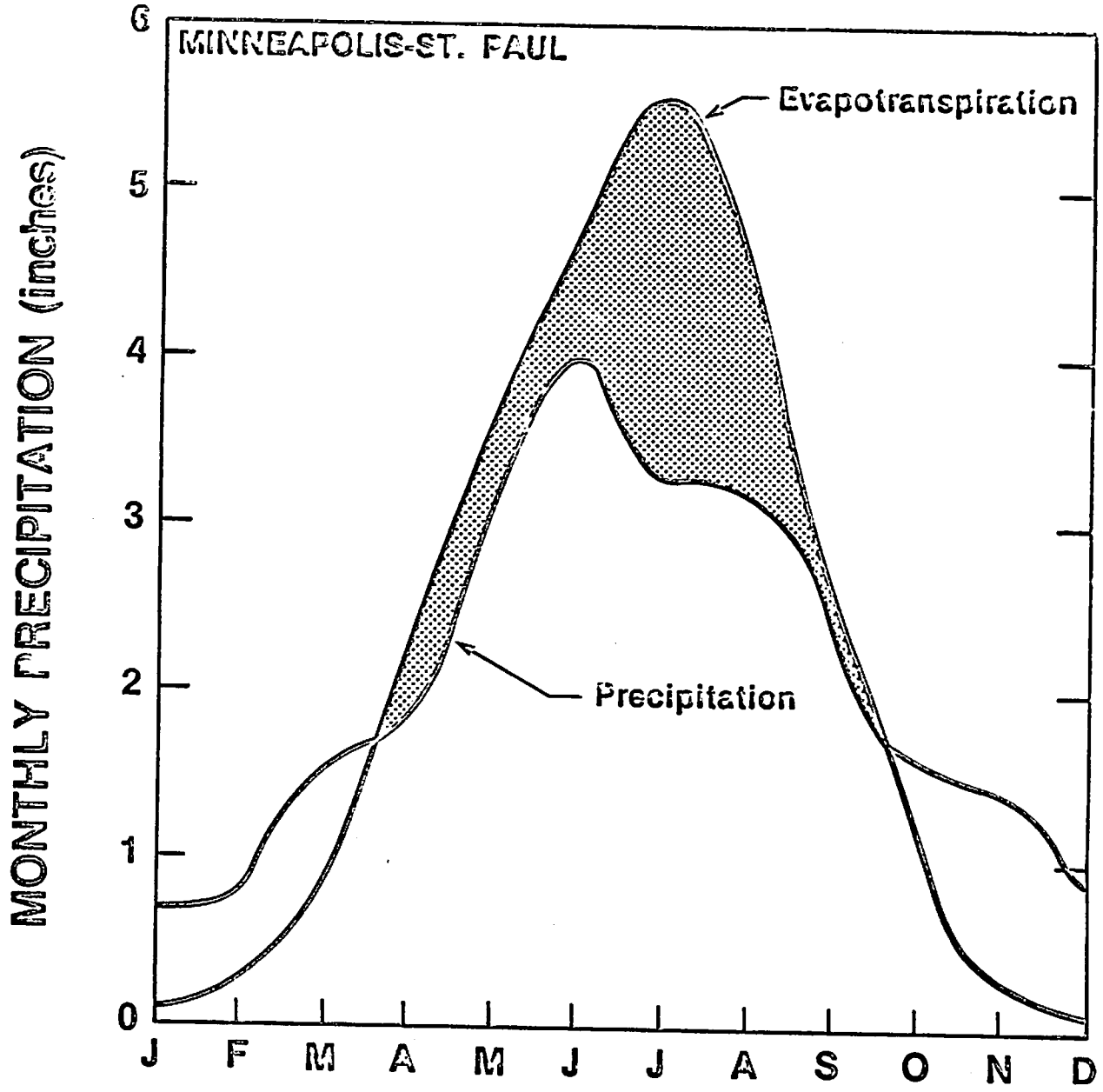
MINNEAPOLIS-ST. PAUL
Evapotranspiration
Precipitation
MONTHLY PRECIPITATION (inches)
0
1
2
3
4
5
6
J
F
M
A
M
J
J
A
S
O
N
D

Table 3. Supplemental Irrigation of Turf

Twin Cities Area

G. R. Blake

Period	Evapo-Transpiration inches	Normal Rainfall inches	Supplemental Water Needed inches
April 1 to 15	0.9	0.9	0
April 15 to 30	1.3	1.1	0.2
May 1 to 15	1.7	1.4	0.3
May 15 to 30	2.0	1.7	0.3
June 1 to 15	2.2	1.9	0.3
June 15 to 30	2.5	1.9	0.6
July 1 to 15	2.8	1.7	1.1
July 15 to 31	2.7	1.6	1.1
August 1 to 15	2.5	1.6	0.9
August 15 to 31	2.0	1.5	0.5
September 1 to 15	1.5	1.3	0.2
September 15 to 30	1.1	1.1	0
October 1 to 15	0.8	0.8	0

EFFECT OF WEX ON CROP YIELDS*

W. E. Fenster, G. W. Randall, W. W. Nelson, and S. D. Evans

The product Wex is a soil additive which is supposed to increase crop yields. Since Wex is not a fertilizer, it is supposed to achieve this by releasing additional amounts of nutrients from the soil and enhance fertilizer efficiency.

With this in mind, experiments were conducted using the soil additive on corn, soybeans and wheat at the Waseca, Lamberton, and Morris Experiment Stations.

Experimental Procedure

Randomized complete block designs were used with six replicates and three treatments at Waseca and Morris and five replicates and three treatments at Lamberton. The treatments consisted of a check, and 8 and 16 oz. of Wex per acre at all locations. The Wex treatments were incorporated with the soil at Lamberton and surface applied at Waseca and Morris. There was a fourth treatment used on the corn experiment at Waseca which was another surfactant, Hydro-wet, applied at 16 oz./A and used for comparison purposes with Wex. The experiments were established on Webster clay loam at Waseca, Nicollet silty clay loam at Lamberton, and Forman clay loam at Morris. In all cases, adequate N, P and K treatments were applied and good weed and insect control were maintained.

Results and Discussion

The yield data for wheat, soybeans, and corn are presented in tables 1-3. There were no significant yield differences among treatments for any of the crops at any of the locations. Yield data are not reported for corn and soybeans at Morris because of crop failure due to drouth.

Table 1. Effect of varying levels of Wex on Era wheat yields in 1976.

Wex Treatment fl. oz/A	Waseca	Lamberton yield (bu/A)	Morris
0	55	25	25
8	54	25	26
16	53	26	26
Sig. (.05)	ns	ns	ns

* Laboratory analyses were paid for by the Conklin Co.

Table 2. Effect of varying levels of Wex on soybean yields in 1976.

Wex Treatment fl. oz/A	Waseca	Lamberton
	yield (bu/A)	
0	36	17
8	37	16
16	37	17
Sig. (.05)	ns	ns

Table 3. Effect of varying levels of Wex on corn yields in 1976.

Treatment Material	Fluid oz/A	Waseca[1/]	Lamberton
		yield (bu/A)	
Control		77	23
Wex	8	70	22
Wex	16	71	25
Hydro-wet	16	77	--

[1/] Moderate rootworm damage was noted at this site.

Various other criteria were also used to help determine if Wex improved plant growth. These included stand counts, early plant growth, silage yields on corn, lodging, whole plant weight, percentage of essential nutrients in the plant at various stages of growth, and percent protein in the wheat grain. In all cases, there were no meaningful significant differences in any of the criteria examined. Soil moistures were also taken post harvest and no differences were noted between treatments.

Based on the data collected in 1976, it would appear that Wex does not improve crop yields. It should be remembered, however, that this conclusion is based on one year's research and that 1976 was a very droughty year.