Minnesota Wild Rice Research 1980

Agricultural Experiment Station
University of Minnesota
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CONTENTS

Most of the research reported here is preliminary, thus the results should be interpreted with caution and should not be used in publications unless arrangements are made with the authors.

The wild rice team wishes to acknowledge the assistance provided by many people. The cooperation of Dr. Rust, Superintendent of the North Central Experiment Station, Grand Rapids, was greatly appreciated. The cooperation of Dr. Wilcox, Superintendent of the Rosemount Experiment Station was also greatly appreciated as was the help of John Lange, Coordinator of the Horticultural Research Center at Excelsior. Also, the help of Drs. Rabas and Boedicker at the North Central Experiment Station, Grand Rapids was highly appreciated. The daily supervision of the research plots at Grand Rapids by Henry Schumer, Research Plot Supervisor, was very valuable and deeply appreciated. We are also extremely grateful to the growers and processors for providing seed, land area and facilities for research. We thank the growers for the funds provided in 1980 to the Agricultural Engineering Department. Some improvements and expansion of research paddy areas were done in 1980. The research paddy area for plant breeding at Rosemount was increased and electricity is now available at Grand Rapids. We appreciate the continued support of the Agricultural Experiment Station for wild rice research.

WILD RICE FERTILIZATION RESEARCH - 1980

A PROGRESS REPORT
December 18, 1980

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Research was continued during 1980 on fertilization, nutrient requirement and water quality. Soil, water and air temperatures, and quality of paddy water were monitored during the growing season to obtain information on the environment in which wild rice grows. Two nitrogen experiments were conducted with the Netum variety on a mineral soil at Grand Rapids. A fertilization trial was conducted with K2 wild rice on peat in Aitkin County. Tissue samples were collected for plant analysis to learn more about nutrient uptake by the plant.

A. WEATHER CONDITIONS AND PLANT DEVELOPMENT

The growing season of 1980 started exceptionally early and higher than normal temperature during April and May advanced plant development ahead of the usual pattern. At Grand Rapids, for example, the average air temperature (Table 1) was 6.2° and 7.2°F above normal during April and May, respectively.

Soil, water and air temperatures were measured at three locations by automatic sensing and recording thermographs (see Fig. 1, 2, 3). Water temperature was not recorded at Gully because of an instrument malfunction.

The air and water temperatures, as expected, fluctuated more than the soil temperature. The mineral soil at Grand Rapids also showed greater temperature fluctuations than the two organic soils. The temperature of both organic soils measured about 45°F during plant emergence on May 2, increased to about 55° by mid-May and remained somewhat constant within the range of 55-65° for the rest of the season.

Plants emerged on May 2 at Grand Rapids and in Aitkin County (Fig. 4, 5). The jointing stage was reached by Netum (2nd year stand) at Grand Rapids on June 12, 41 days after emergence, and by K2 in Aitkin County on June 25, 54 days after emergence. Netum was harvested on July 30, 89 days after emergence. The K2 in Aitkin County was harvested on August 18, 108 days after emergence. During 1979, for comparison, Netum at Grand Rapids emerged on May 11, reached the jointing stage on July 6 and was harvested on August 2, 108 days after emergence. The K2 variety in Aitkin County emerged on May 8, 1979, reached the jointing stage on July 9 and was harvested on August 28, 112 days after emergence.

Table 1. 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	2955
1974	41.0	50.5	63.4	71.6	62.8	57.9	2744
1975	34.8	55.7	61.9	70.5	64.6	57.5	2852
1976	46.6	54.9	66.8	68.8	70.9	61.6	3315
1977	49.1	66.4	64.6	70.3	60.6	62.2	3446
1978	41.7	59.2	63.4	67.8	67.7	60.0	3060
1979	36.0	48.7	63.6	69.6	63.6	56.3	2627
1980	48.9	61.3M	68.5	71.0	64.6	62.9	3466
Grand Rapids, N.C. School							
Normal	39.9	52.7	62.0	67.4	65.1	57.4	2681
1974	41.6	49.4	62.7	70.7	62.8	57.4	2670
1975	34.7	57.0	62.2	71.5	65.2	58.1	2951
1976	47.1	54.4	66.1	68.2	67.4	60.6	3166
1977	48.2	63.8	64.0	69.2	60.2	61.1	3284
1978	41.3	57.9	62.8	66.5	66.0	58.9	2892
1979	37.1	49.5	61.5	68.1	62.6	55.8	2511
1980	46.1	59.9	64.0	69.0	66.4	61.1	3237
Aitkin							
1974	42.9	49.8	63.1	71.1	63.3	58.0	2770
1975	39.0M[3/]	59.4M	64.4M	72.1	66.2M	60.2	3141
1976	47.5	54.8	66.8	69.3M	68.1	61.3	3267
1977	48.3M	64.4M	65.4M	70.3M	61.0	61.9	3446
1978	40.7M	57.5M	64.1M	67.0M	66.9	59.2	2938
1979	37.7	50.6M	62.0	68.1M	63.4	56.4	2585
1980	53.9	58.3	64.0	68.5	66.0	62.1	3394

1/ Source: Climatological Data, Minnesota, Vol. 80-86 (1974-80), U.S. Dept. of Commerce.

2/ Normals for the period 1931-60.

3/ M = less than 10 days record missing.

Figure 1. MEAN AIR, WATER AND SOIL TEMPERATURES GRAND RAPIDS-1980

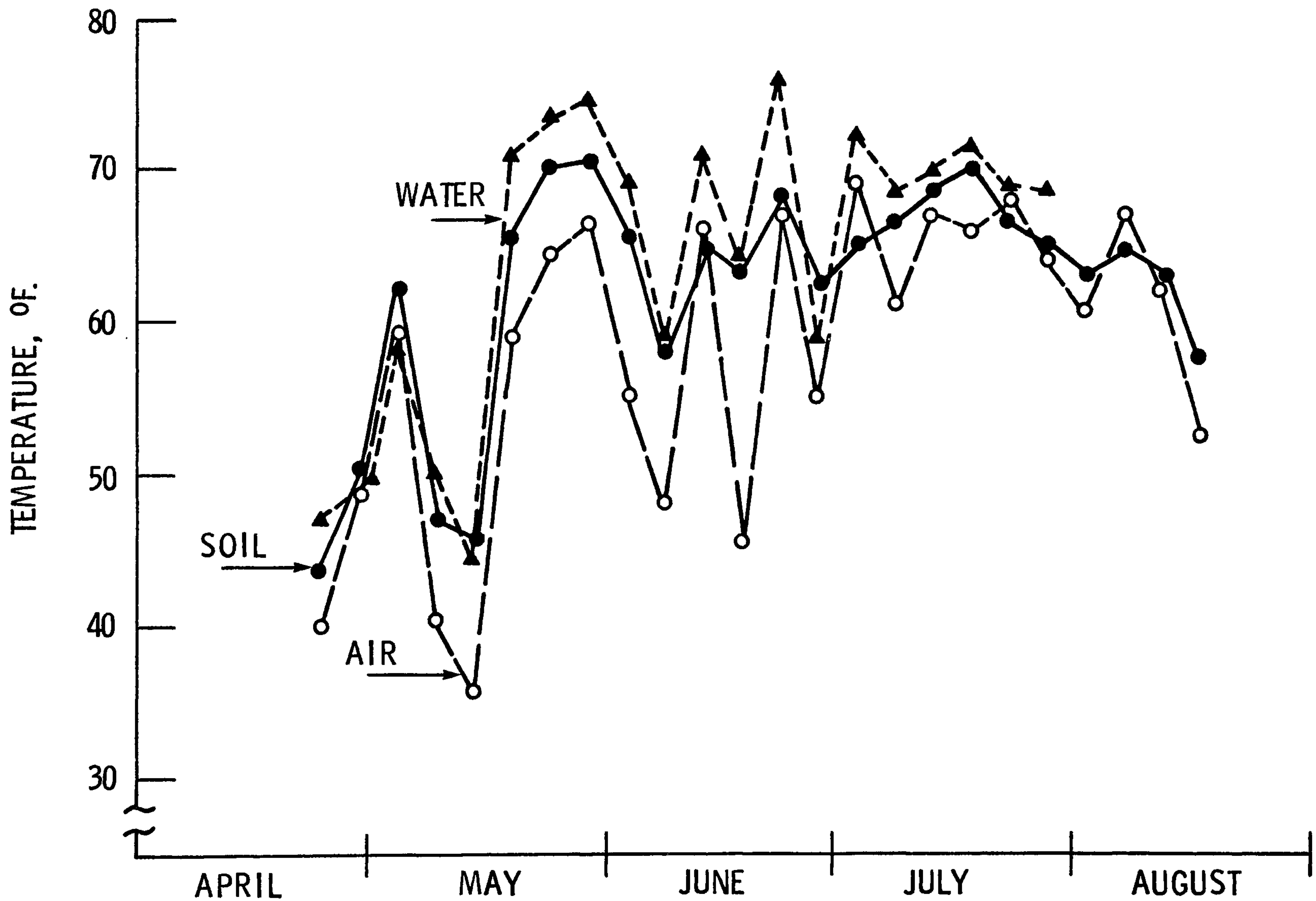


Figure 2.

MEAN AIR, WATER AND SOIL TEMPERATURES
KOSBAU BROS., AITKIN CO.-1980

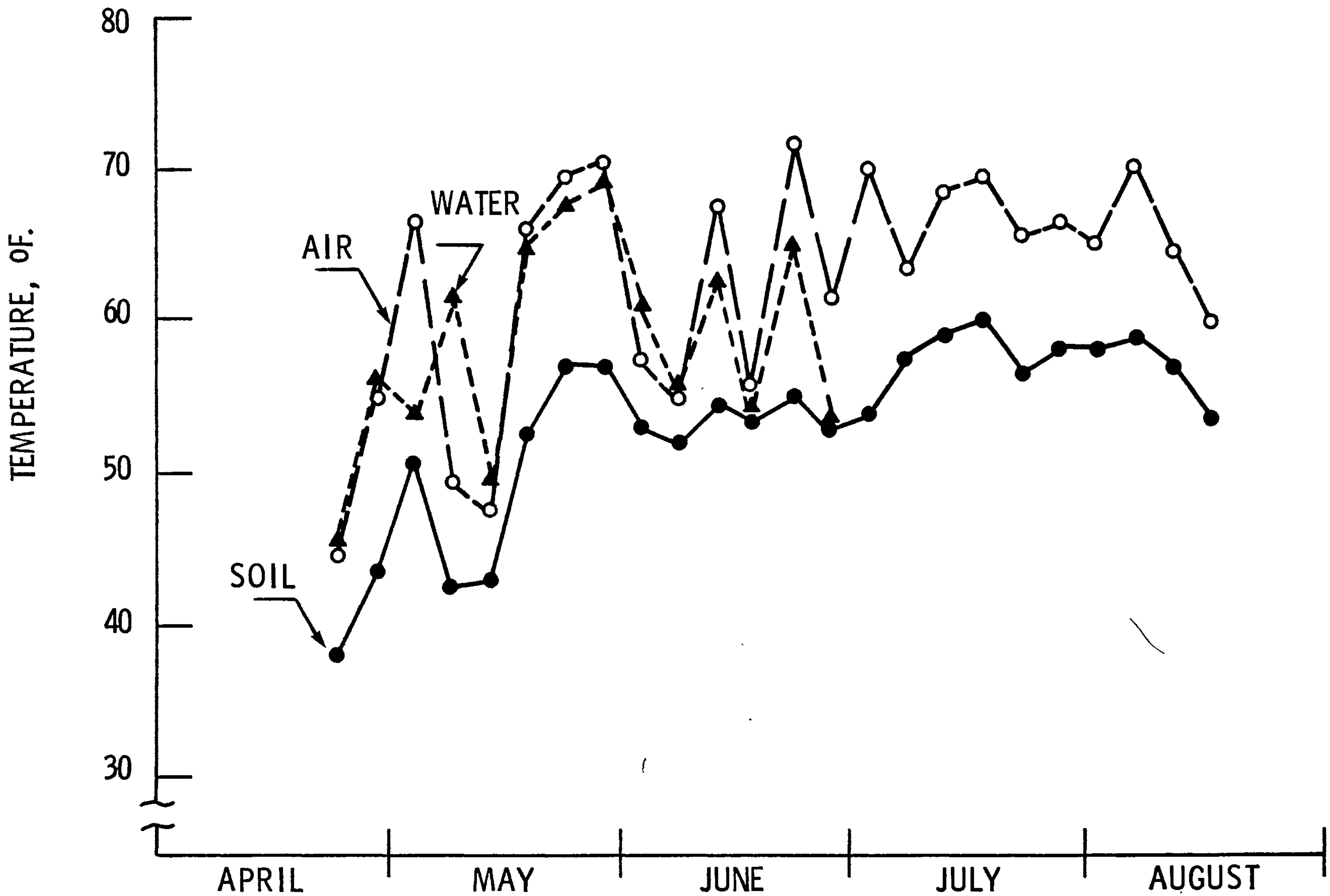


Figure 3. MEAN AIR AND SOIL TEMPERATURES
GULLY-1980

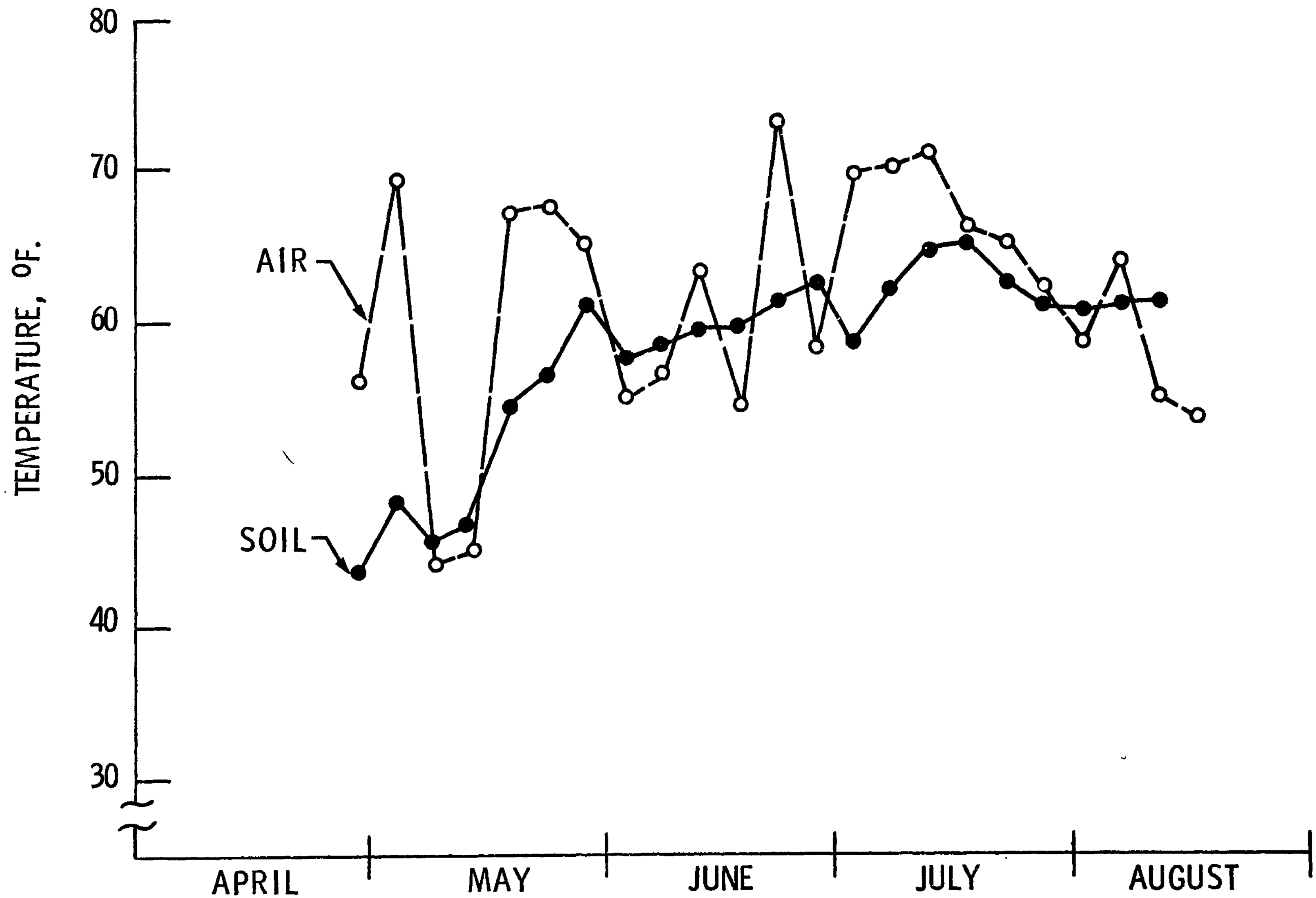
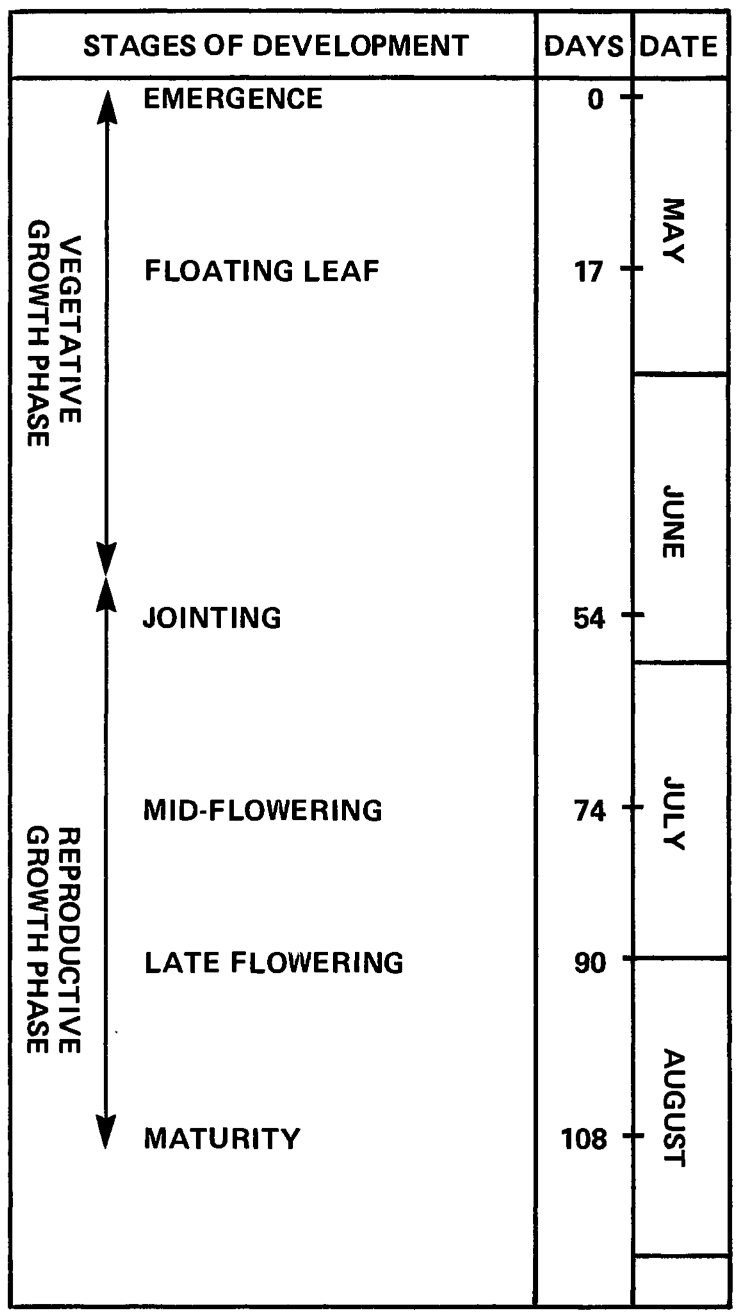


Figure 4. WILD RICE DEVELOPMENT
NETUM VARIETY, 2ND YEAR STAND
GRAND RAPIDS, 1980

	STAGES OF DEVELOPMENT	DAYS	DATE
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY
	FLOATING LEAF	11	MAY
	AERIAL LEAF	21	MAY
	TILLERING	34	JUNE
REPRODUCTIVE GROWTH PHASE	JOINTING	41	JUNE
	BOOT	46	JUNE
	HEADING	51	JUNE
	MID-FLOWERING	62	JULY
	LATE FLOWERING	74	JULY
	MATURITY	89	JULY

Figure 5. **WILD RICE DEVELOPMENT**
K2 VARIETY, KOSBAU BROS., AITKIN CO., 1980



B. CHEMICAL CHARACTERISTICS OF PADDY WATER

Water samples were collected from several sites at three different paddy locations during the 1980 growing season. At Grand Rapids, samples were collected from two experimental paddies used for nitrogen studies on mineral soil, and from the Prairie River which was the source of water. Water was also sampled within an experimental paddy in Aitkin County. Paddies at this site derived water from the Little Willow River via a diversion ditch. The third sampling site was in the Imle and Gunvalson paddies near Gully. These paddies derived water from the Clearwater River.

Water samples were collected and stored in 250 ml polyethylene bottles, with a preservative added (2 ml mercuric chloride solution, made by dissolving 40 mg $HgCl_2$/L, to 250 ml of sample). Chemical analyses were made by the Research Analytical Laboratory, University of Minnesota. Information on location, sampling dates, and chemical composition data of water is given in Table 2.

The electrical conductivity measurement gives an indication of total concentration of salts in the water. The conductivity of samples from Grand Rapids and Aitkin County locations was relatively low ranging from 0.14 to 0.30 mmhos/cm, while that of the water at Gully ranged from 0.58 to 0.78 mmhos/cm. The hardness of water is a measure of dissolved calcium and magnesium, and is expressed as mg $CaCO_3$/ liter. The water from the Clearwater River was very hard (251 mg/L) while water from the Prairie River and Little Willow River was moderately hard (76 and 63 mg/L).

At Grand Rapids, total N, P and K concentrations of paddy water were slightly higher than those of the river water, and increased as the growing season progressed. Total concentrations in the water ranged from 0.6 to 2.4 ppm N, 0.02 to 0.19 ppm P, and 1.5 to 6.3 ppm K.

At Gully, nutrient concentrations of the water ranged from 1.0 to 4.3 ppm N, 0.07 to 0.25 ppm P, and 3.2 to 9.6 ppm K.

Paddy water at the Aitkin County location had considerably higher concentration of total N, P and K than that found in the river water. Total N concentration of paddy water ranged from 3.2 to 10.0 ppm compared to 0.9 to 2.4 ppm found in samples collected from the diversion ditch. Total P concentration in paddy water ranged from 0.81 to 1.84 ppm compared to 0.05 to 0.23 ppm in the water from the diversion ditch. Potassium levels of paddy water ranged from 3 to 10 ppm while the water from the diversion ditch had a concentration of 1 to 4 ppm K.

The sulfate concentration of water is reported in terms of parts per million of sulfate-sulfur. To convert results to the sulfate form, they must be multiplied by 3. For example, 14 ppm sulfate-S x 3 = 42 ppm sulfate (SO_4) in the water.

The water at Grand Rapids and in Aitkin County, generally, contained about 15 ppm of sulfate. The sulfate concentration of the water at Gully, however, was relatively high (131-157 ppm SO_4).

Table 2. Chemical composition of water collected from wild rice paddies during 1980 growing season.

Sample No.	Sampling Date	Location	Conductivity millimhos/cm	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	Na ppm
<u>Location: Grand Rapids</u>															
3.	4/23	EP-E	.19	59.0	62.9	1.5		<0.1	0.07	<0.01	5.0	16.4	4.7	1.7	2.1
4.	4/23	EP-W	.18	60.5	66.9	1.1		0.1	0.07	<0.01	5.1	17.3	5.0	1.5	2.2
5.	4/23	PR	.20	76.0	75.8	1.0		0.1	0.02	<0.01	5.0	20.4	5.5	1.5	2.2
12.	5/22	EP-E	.19			1.6			0.06			19.4	5.3	1.2	2.4
13.	5/22	EP-W	.19			1.0			0.06			19.7	5.2	1.2	2.4
14.	5/22	PR	.22			0.6			0.03			21.4	6.0	1.5	2.4
18.	6/17	EP-E	.17			2.2			0.11			25.1	7.7	3.6	3.6
19.	6/17	EP-W	.18			1.4			0.08			24.9	7.5	2.3	2.8
17.	6/17	PR	.20			0.6			0.04			27.7	7.7	3.3	3.0
26.	7/3	EP-E	.18			0.8			0.10			19.8	6.3	3.7	3.6
27.	7/3	EP-W	.15			0.3			0.05			19.6	6.6	1.6	2.5
28.	7/3	PR	.19			0.8			0.04			26.3	7.1	2.0	2.9
33.	7/23	EP-E	.22			2.4			0.19			25.1	8.2	6.3	4.6
32.	7/23	EP-W	.20			2.1			2.15			27.3	7.8	2.9	3.5
31.	7/23	PR	.20			0.9			0.13			28.2	7.7	4.4	3.3

Abbreviations and description of sampling sites at Grand Rapids: EP-E = Experimental Paddy #1 East; EP-W = Experimental Paddy #1 West; PR = Prairie River.

Table 2 continued.

Sample No.	Sampling Date	Location	Conductivity millimhos/cm	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	Na ppm
Location: Kosbau Bros., Aitkin Co.															
1.	4/23	EP	.14	9.5	33.2	10.0		<0.1	0.94	0.08	14.0	7.7	2.5	9.0	3.4
2.	4/23	DD	.18	62.0	62.6	1.7		<0.1	0.06	0.01	5.1	15.8	5.1	1.3	2.6
8.	5/13	EP	.23			4.4			0.42			18.1	5.9	7.7	4.2
9.	5/13	DD	.22			0.9			0.05			20.9	6.6	1.8	3.2
10.	5/22	EP	.26			3.2			0.65			20.7	6.5	1.6	4.5
11.	5/22	DD	.24			2.4			0.09			24.3	7.7	1.9	3.4
16.	6/12	EP	.24			3.3			1.26			30.7	9.8	10.3	5.6
15.	6/12	DD	.24			1.3			0.07			34.0	10.5	3.7	4.3
22.	6/25	EP	.19			8.2			1.84			31.0	10.2	3.1	4.7
23.	6/25	DD	.26			2.1			0.23			41.6	11.9	0.9	4.3
30.	7/7	EP	.26			3.9			0.81			38.7	12.2	6.1	7.3
29.	7/7	DD	.27			2.1			0.13			39.0	12.2	1.9	5.5
34.	7/31	DD	.30			2.4			0.25			45.0	14.1	1.9	5.9

Abbreviations and description of sampling sites at Kosbau Bros.: EP = Experimental Paddy; DD = Diversion Ditch at bridge near the Little Willow River.

Sample No.	Sampling Date	Location	Conductivity millimhos/cm	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	Na ppm
Location: Imle and Gunvalson, Gully															
6.	4/28	PP	.60	169.5	247.6	4.3		<0.1	0.21	0.02	52.2	63.1	21.3	9.6	5.2
7.	4/28	CR	.60	210.5	251.4	1.1		<0.1	0.07	0.01	43.6	64.6	21.3	4.0	4.7
20.	6/18	PP	.78			2.9			0.25			121.2	44.6	3.2	9.2
21.	6/18	CR	.61			1.1			0.19			88.5	32.9	5.7	8.0
25.	7/1	PP	.58			1.4			0.11			85.1	32.6	3.9	7.8
24.	7/1	CR	.65			1.0			0.13			94.9	34.5	5.2	8.3

Abbreviations and description of sampling sites at Gully: PP = Production Paddy; CR = Clearwater River.

C. NITROGEN STUDIES ON MINERAL SOIL

Two field experiments were conducted with Netum wild rice on a mineral soil at the North Central Experiment Station, Grand Rapids. Soil tests (Table 3) indicated a very high level of extractable phosphorus (60 and 80 pp2m) and medium to high level of exchangeable potassium (164 and 230 pp2m).

N Rate Trial

The nitrogen rate study, initiated in 1979, was continued on paddy No. 1 East with 2nd year stand of Netum. Four rates of nitrogen were used in this experiment: 0, 20, 40, 80 pounds per acre. Urea (46-0-0) was applied by hand and incorporated into the soil by rototilling. A randomized block design was used in this experiment. Each nitrogen treatment was replicated five times. Individual plots occupied a 14 x 16 ft. area and were separated from adjoining plots by 5 ft. wide alleys. To ensure a sufficient stand, 27 pounds per acre of seed was broadcast - applied by hand on October 17 and rototilled into the soil. Plant density, at harvest, was about 8 plants per square foot. Water level was maintained at about 6 to 10 inches. Ten plants were collected at random from each plot at jointing, and five plants at late flowering for weight measurement and plant analysis. The jointing stage was reached on June 12 (Fig. 4). A 32 sq. ft. area from each plot was hand-harvested on July 30 for yield determination.

Netum wild rice produced 543 to 684 pounds of grain per acre (Table 4). The yield, however, was not affected by the application of nitrogen.

The second leaf at jointing contained 2.63 to 3.37% N, considered to be low to medium concentration (Table 5). The total amount of nitrogen accumulated by the plant at jointing and late flowering stages was relatively low and was not affected by the N treatments (Table 6).

Generally, individual Netum plants in this experiment were somewhat shorter and had fewer tillers than observed in previous seasons. Individual plants had accumulated about 3 and 6.5 grams of dry matter at jointing and late flowering, respectively. This may have been partially due to the exceptionally early and warm growing season which hastened plant development, and to the relatively thick stand (8 plants/sq. ft.). Also the grain yield could have been higher if the harvest had been delayed by about one week.

Table 3. Soil test values of experimental paddies, Grand Rapids.[1)]

Location	pH	Extractable P pp2m	Exchangeable K pp2m	NO_3-N lb/A
Paddy No. 1 East	5.8	88	164	18
Paddy No. 1 West	5.7	60	230	18

1) Samples collected from 0-6 inch depth on 10/17/79.

Table 4. Effect of nitrogen application on the yield of Netum wild rice, 2nd year stand, Grand Rapids, 1980.

N Rate lbs/acre	Grain Yield lbs/acre
0	565[1)]
20	543
40	604
80	684
Significance	ns

1) 7% moisture, average of 5 replications

Table 5. Effect of nitrogen application on N concentration in 2nd leaf of Netum wild rice at jointing, 2nd year stand, Grand Rapids, 1980.

N Rate lbs/acre	N % in Dry Matter
0	2.89
20	2.69
40	2.63
80	3.37
Significance	ns

Table 6. Effect of nitrogen application on total uptake of N by the wild rice plant at jointing and late flowering, Netum variety, 2nd year stand, Grand Rapids, 1980.

N Rate	Stage of Development	
lbs/acre	Jointing	Late Flowering
	---N in milligrams per plant---	
0	55	77
20	57	80
40	47	80
80	59	78
Significance	ns	ns

N Rate and Time of Application Trial

This experiment was established in paddy No. 1 West in fall of 1979. The paddy had been in fallow during 1979 and had been fumigated with methyl bromide. Nitrogen treatments consisted of four rates (0, 20, 40, 80 lb N/acre) applied in single (fall) or split-applications (½ fall + ½ jointing, or ½ fall + ½ early flowering). Urea (46-0-0) was the source of nitrogen. Fall-application of urea was made on October 17 and the fertilizer was incorporated into the soil by rototilling. Additional N was topdressed by hand at jointing or early flowering. A randomized block design was used in this experiment. Each treatment was replicated four times. Individual plots occupied a 14 x 16 ft. area and were separated from adjoining plots by 5 ft. wide alleys. Seed of Netum variety was broadcast-applied by hand on October 17 and rototilled into the soil. Plant density, at harvest, ranged from 1 to 2 plants per square foot.

It was extremely difficult to maintain the water level in this paddy at the desired level, particularly during the early stages of plant development. Frequently the surface soil in some areas was not covered with water. This appeared to delay the emergence and development of plants. Generally, the plants of this 1st year stand (Paddy No. 1 West) was from 7 to 10 days behind in development to the 2nd year stand of Netum in Paddy No. 1 East. Jointing stage was reached on June 19. A 16 sq. ft. area from each plot was harvested on August 19 for yield measurement. Harvesting was delayed on purpose to allow the grain to ripen, shatter and thus ensure a sufficient stand of wild rice next season.

Grain yields (7% moisture) ranged from 833 to 1144 lb/acre (Table 7). The yield of wild rice was not affected by any of the nitrogen treatments.

The second leaf at jointing contained 4.33 to 5.05% N, considered to be a relatively high concentration (Table 8). Total nitrogen uptake by the plant at jointing or late flowering was not affected by the N treatments (Table 9).

Generally, the stand in areas that appeared to be most affected by the low water level was sparse, and the plants were shorter and behind in development to normal plants in other areas. The affected plants were light green in color with yellow lower leaves. While these symptoms are generally associated with nitrogen deficiency, they were observed also in plants that had received 40 or 80 lb/acre of nitrogen in the fall. Poor growth of wild rice appeared to be more related to the location within the paddy than to nitrogen treatments.

Table 7. Effect of nitrogen application on the yield of Netum wild rice, 1st year stand, Grand Rapids, 1980.

Treatment No.	N Rate lbs/acre	Time of Application			Grain Yield lbs/acre
		Fall	Jointing	Early Flowering	
		---------N lbs/acre----------			
1	0	-	-	-	1144
2	20	20	-	-	833
3	40	40	-	-	1063
4	40	20	20	-	909
5	40	20	-	20	937
6	80	80	-	-	1141
7	80	40	40	-	960
8	80	40	-	40	1105
Significance					ns

Table 8. Effect of nitrogen application on N concentration in 2nd leaf of Netum wild rice at jointing, 1st year stand, Grand Rapids, 1980.

N Rate lbs/acre	N % in Dry Matter
0	4.56
20[1]	4.88
40[1]	5.05
80[1]	4.33

[1] Fall applied treatments

Table 9. Effect of nitrogen application on total uptake of N by Netum wild rice, 1st year stand, Grand Rapids, 1980.

Treatment No.	N Rate[1] lbs/acre	Stage of Development	
		Jointing	Late Flowering
		---N in milligrams per plant---	
1	0	37	165
2	20	29	106
3	40	47	118
4	40	-	127
5	40	-	131
6	80	48	125
7	80	-	124
8	80	-	143

[1] See Table 7 for time of application

D. FERTILIZATION STUDIES ON PEAT

A fertilizer experiment was conducted with the K2 variety of wild rice on organic soil in a Kosbau Bros. paddy in Aitkin County. Relatively high extractable phosphorus (23 pp2m), and medium/low exchangeable potassium (103 pp2m) levels were indicated by soil tests. The soil pH was 5.6. This was an incomplete factorial experiment with six NPK treatments, replicated six times, arranged in randomized blocks. Individual plots occupied a 14 x 16 ft. area. Fertilizer materials (46-0-0, 0-46-0, 0-0-60) were applied by hand on October 18, 1979 and incorporated into the soil by disking. The stand was thinned once by airboat on May 20. Average plant density, at harvest, was 5 plants per square foot.

Plants reached the jointing stage on June 25. The paddy was drained on June 28. A 16 sq. ft. area from each plot was harvested on August 18 for yield determination. Some grain from the primary panicles had been lost through shattering and some grain in the panicles of tillers had not filled. This may explain why the wild rice in this experiment produced only moderate yield (Table 10). Fertilizer treatments had no effect on the yield.

The concentration of nutrient elements in the 2nd leaf at jointing (see Table 10) was relatively high: 3.85-4.29% N, 0.59-0.65% P, 3.67-4.02% K.

Table 10. Effect of fertilization on grain yield and N concentration in 2nd leaf of K2 wild rice at jointing, Kosbau Bros., 1980.

Treatment			Grain Yield	N%	P%	K%
N	P_2O_5	K_2O		in Dry Matter		
lbs/acre			lbs/acre			
None			528	4.10	0.59	3.74
0 +	40 +	60	584	3.86	0.59	3.78
30 +	40 +	0	535	4.04	0.60	3.67
30 +	0 +	60	505	3.85	0.61	3.82
30 +	40 +	60	452	4.29	0.65	4.02
60 +	40 +	60	467	3.95	0.64	3.86
Significance			ns	ns	ns	ns

ACKNOWLEDGMENTS

Grateful acknowledgments are made to the following cooperators and University personnel for their assistance during 1980 in obtaining the information reported here: Messrs. Franklin and Harold Kosbau, Aitkin County; Messrs. Paul Imle and John Gunvalson, East Polk County; the Staff of the North Central Experiment Station; Dr. E. A. Oelke, Messrs. Alan Juhnke, and Henry Schumer, University of Minnesota.

WILD RICE PRODUCTION AND SEED RESEARCH - 1980

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The areas of emphasis this year were weed control and competition, elimination of volunteer wild rice plants, plant population, simulated hail damage, time of harvest, seed survival, and seed storage. The work was conducted on University plot land in St. Paul and Grand Rapids and in growers' fields near Aitkin and Clearbrook. Some of the work was also conducted in the greenhouse and growth chambers in St. Paul. The 1980 growing season was warm and wild rice matured before freezing temperatures. Some growers had difficulty obtaining sufficient water in the spring to adequately flood all their fields. Yields were similar to 1979.

WEED RESEARCH

Herbicides

The herbicide trials in 1980 again concentrated on the use of 2,4-D amine and MCPA in wild rice for control of waterplantain. The trials were conducted at Grand Rapids, Aitkin and St. Paul. One trial at Grand Rapids was a repeat of a trial conducted last year. The objective of the trial was to see if the varieties, Johnson, Netum and K2, differed in their response to 2,4-D amine. The three varieties were treated with 1/4, 1/2 and 3/4 lb a.i. (active ingredient) per acre of 2,4-D amine. The chemical was applied at late tillering and early boot growth stages of wild rice. Table 1 presents grain yield and moisture for the 3 varieties as influenced by rate and time of application of 2,4-D amine.

Table 1. Yield response of 3 varieties to 2,4-D amine applied at 3 rates on 2 dates - Grand Rapids - 1980.

Date	Rate of 2,4-D amine	Variety					
		Johnson	K2	Netum	Johnson	K2	Netum
	lb/A a.i.	Grain yield*, lb/A			% Grain moisture**		
6/11	0	696	1312	1396	41	42	36
(late	1/4	720	1216	1600	41	33	34
tillering)	1/2	1056	1312	1460	39	35	37
	3/4	844	1240	1244	48	39	37
6/17	0	1128	876	1580	40	40	36
(jointing)	1/4	980	1404	1536	38	37	36
	1/2	1300	1256	1652	37	43	35
	3/4	888	1340	1520	34	42	34

*40% moisture
**At harvest

As was true for last year's trial, there was no difference among varieties in their response to 2,4-D amine since no significant interaction for varieties and rate of 2,4-D amine was obtained (Table 1). However, the yield of the Johnson variety seemed to be more variable than for K2 and Netum. This may have been due to more lodging in this variety rather than 2,4-D amine injury. Some injury was evident and it appeared that K2 was less susceptible to injury than the other 2 varieties, however as indicated, this was not expressed in yield differences. Yield was not influenced by 2,4-D amine rate. Even the high rate of 3/4 lb/A a.i. did not reduce yield. However previous trials have given injury even at 1/2 lb/A a.i. The recommended application time of 2,4-D amine is at the late tillering stage of growth and only at 1/4 lb/A a.i.

Two trials were conducted to ascertain the stage of growth at which waterplantain is the most sensitive to phenoxy herbicides. The trials were conducted in paddies at Grand Rapids and in plastic lined boxes at St. Paul. MCPA and 2,4-D amine at 1/4 and 1/2 lb/A a.i. were applied at several growth stages. Table 2 summarizes the response of waterplantain dry weight and percent control as influenced by the growth stage treated with 2,4-D amine and MCPA.

Table 2. Waterplantain dry weight and percent control as influenced by application time of 2,4-D amine or MCPA - Grand Rapids and St. Paul - 1980.

Growth stage	Grand Rapids		St. Paul	
	Dry wt	Control	Dry wt	Control
	gm/plant	%	gm/plant	%
First aerial leaf	41*	12	--	--
5 aerial leaves	43	12	--	--
Flower stem visible	37	23	19	36
Early flowering (10%)	44	21	30	6
Late flowering (100%)	--	--	31	10
Seeds visible	--	--	28	8
Check	67	--	21	--
LSD .05	8	8	6	5

*Values represent averages for both rates (1/4 and 1/2 lb/A a.i.) of MCPA and 2,4-D amine.

At Grand Rapids, herbicide applications at all growth stages resulted in reduced plant dry weight in comparison to the check. Dry weight was reduced to the greatest extent when herbicides were applied as the flower stem first became visible. Percent control, a visual assessment of injury, was only 12% at the two early growth stages and then exceeded 20% at the two latter growth stages.

At St. Paul, all but the earliest application increased waterplantain dry matter when compared to the check (Table 2). This increase was probably due to the plants in the check starting to decompose as they matured earlier than treated plants, and all plants were older than those weighed in the Grand Rapids experiment. Again waterplantain appears to be most sensitive when the flower stem first becomes visible, as dry matter was reduced to the greatest extent and percent control increased to the greatest extent at this stage.

Table 3. The effect of 2,4-D amine and MCPA on waterplantain dry weight and percent control - 1980.

Chemical	Rate	Grand Rapids Dry wt	Grand Rapids Control	St. Paul Dry wt	St. Paul Control
	lb/A a.i.	gm/plant	%	gm/plant	%
Control	0	67*	0	21	0
2,4-D amine	1/4	54	9	27	9
2,4-D amine	1/2	42	14	21	16
MCPA	1/4	44	12	27	12
MCPA	1/2	26	37	21	24
LSD .05		8	8	6	5

*Values represent averages over all stages of growth treated.

Table 3 summarizes the effect of chemical and rate on waterplantain dry weight and percent control when averaged over all growth stages treated. At Grand Rapids, MCPA consistently reduced waterplantain dry weight to a greater extent than 2,4-D amine. In fact, MCPA at 1/4 lb/A a.i. was nearly as effective as 2,4-D amine at 1/2 lb/A a.i. Maximum dry weight reduction and percent control occurred with MCPA at 1/2 lb/A a.i.

At St. Paul, waterplantain dry weight was similarly reduced with the higher rate of either MCPA or 2,4-D amine (Table 3). Percent control, however, was greater with MCPA than 2,4-D amine at each rate.

Table 4. The effect of 2,4-D amine and MCPA at 2 rates, applied when flower stems first become visible, on waterplantain dry weight and percent control - 1980.

Chemical	Rate	Grand Rapids Dry wt	Grand Rapids Control	St. Paul Dry wt	St. Paul Control
	lb/A a.i.	gm/plant	%	gm/plant	%
Control	0	67	0	21	0
2,4-D amine	1/4	53	2	19	19
2,4-D amine	1/2	35	25	18	37
MCPA	1/4	39	13	20	18
MCPA	1/2	19	51	7	70
LSD .05		18	17	12	9

The effect of chemical and rate on dry weight and percent control of waterplantain when treated as the flower stem first became visible is summarized in Table 4. MCPA was nearly twice as effective as 2,4-D amine in reducing waterplantain dry weight and in increasing percent control. Waterplantain at St. Paul and Grand Rapids responded similarly to treatments although the response was more significant at St. Paul. MCPA at 1/2 lb/A a.i. gave excellent control in St. Paul (70%) and good control at Grand Rapids (51%).

It appears from this work, that MCPA is more effective than 2,4-D amine in waterplantain control. These data also indicate that the growth stage treated can have a significant effect on the response of waterplantain to these chemicals and that waterplantain is probably the most sensitive if treated when the flower stem first becomes visible.

MCPA and 2,4-D amine also were compared for effectiveness of waterplantain control in a grower's field near Aitkin. The chemicals were applied at 1/4 and 1/2 lb/A a.i. when waterplantain was in the aerial leaf, flower stem visible and flowering stages of growth. MCPA generally controlled waterplantain better than 2,4-D amine. Good control was obtained even at the early application date with MCPA. Early applications of MCPA could possibly be used for waterplantain control. More work will be done with MCPA next year.

To further investigate wild rice tolerance to phenoxy herbicides, experiments were conducted to determine if wild rice tolerance is influenced by growth stage, and if tolerant stages in wild rice correspond to sensitive stages in waterplantain. Table 5 summarizes the effect of 2,4-D amine and MCPA on wild rice yield (green weight) when applied at 4 growth stages.

Table 5. The effect of growth stage on wild rice yield when treated with 1/4 or 1/2 lb/A a.i. of either 2,4-D amine or MCPA - 1980.

Growth stage	Harvested yield** Grand Rapids	Harvested yield** St. Paul
	lb/A	lb/A
Floating leaf	716*	1857
2nd aerial leaf	727	1478
Mid-tillering	760	1460
Boot	768	1187
LSD .05	n.s.	240

* Values are averages over all herbicide treatments; 40% moisture.
** Harvested using a small thresher at Grand Rapids and by hand stripping mature seeds from heads at St. Paul.

Harvested yield did not differ among treated growth stages at Grand Rapids. Yield at St. Paul, however, was reduced as applications were delayed. A reduction in yield of 32% occurred when herbicide applications were made to wild rice in the boot stage. It is not clear why the wild rice at St. Paul was more sensitive to herbicide treatments than the wild rice at Grand Rapids. It may have been because of the warmer temperatures or the water was confined for each treatment while at Grand Rapids this was not the case. More uptake of the chemical from the water may have occurred at St. Paul.

The 4 growth stages in this experiment correspond to the first 4 growth stages of waterplantain in the experiment discussed previously. As an example, wild rice was in the mid-tillering stage at the same time waterplantain was in the 'flower stem visible' stage. This means that the most tolerant wild rice stage (floating leaf stage) does not occur concurrent with the most sensitive waterplantain stage (flower stem visible). However, the most sensitive waterplantain stage does occur before the boot stage of wild rice, which appears to be its least tolerant stage. More research with these growth stages will be conducted next year.

Table 6. The effect of 2,4-D amine and MCPA on wild rice yield - 1980.

		Harvested yield**	
Chemical	Rate	Grand Rapids	St. Paul
	lb/A	lb/A	lb/A
Control	0	769*	--
2,4-D amine	1/4	719	1574
2,4-D amine	1/2	754	1504
MCPA	1/4	766	1486
MCPA	1/2	732	1464
LSD .05		n.s.	n.s.

* Values are averages over all growth stages treated; 40% moisture.
** Harvested using a small thresher at Grand Rapids and by hand stripping mature seeds from panicles at St. Paul.

Table 6 summarizes the influence of chemical and rate on wild rice yield. At both locations no significant yield reduction occurred regardless of chemical or rate. Wild rice injury did appear more often with a high rate of MCPA, but this injury apparently did not affect yield.

The rope-wick applicator was tried again for applying herbicides to waterplantain. A concentrated formulation of MCPA was applied to waterplantain in a grower's field near Aitkin. The first application was made on May 21 when most of the waterplantain had 2-3 aerial leaves and wild rice was in the floating leaf stage of growth. Only fair control of waterplantain was obtained at this date because not all the waterplantain plants had aerial leaves. Another application was made 1 week later when nearly all of the waterplantain plants had aerial leaves. Good control was obtained at this date. Two passes over the same area were needed to get the best control. If a commercial applicator could be made using the rope-wick principle for applying MCPA to waterplantain, perhaps this could be a way to control waterplantain in wild rice fields.

Water Depth and Waterplantain Control

Research was initiated to investigate the effect of water depth on waterplantain establishment and growth. Waterplantain seeds and rootstocks were grown in water depths ranging from 0-19 inches at Grand Rapids and 3-16 inches at St. Paul. Table 7 only summarizes the effect of water depth on rootstock waterplantain plants at Grand Rapids because seedling waterplantain plants were present early in the spring but failed to survive the entire growing season at this location. Table 8 shows water depth data from St. Paul, and contains information on both rootstocks and seedlings.

Table 7. The effect of water depth on dry weight, seed weight, and plant height of waterplantain grown from rootstocks at Grand Rapids - 1980.

Water depth	Plant dry wt.	Seed wt.	Plant ht.
in.	gm/plant	gm/plant	in.
0	22 c*	13 b	29 b
3	37 abc	23 a	34 b
7	53 a	28 a	41 a
11	44 ab	22 a	45 a
19	32 bc	13 b	45 a

* Values followed by the same letter do not differ at the 5% probability level using Duncan's Multiple Range test.

Table 8. The effect of water depth on dry weight, seed weight, and plant height of waterplantain grown from rootstocks and seeds at St. Paul - 1980.

Water	Seedlings			Rootstocks		
depth	Plant ht.	Dry wt.	Seed wt.	Plant ht.	Dry wt.	Seed wt.
in.	in.	gm/ 5 plants	gm/ 5 plants	in.	gm/ plant	gm/ plant
3	17 ab	8 ab*	3 a	32 b	12 c	6 bc
8	20 a	12 a	5 a	41 a	35 a	15 a
12	15 b	3 b	0 b	38 a	21 b	7 b
16	20 a	3 b	0 b	38 a	15 bc	4 c

* Values followed by the same letter do not differ at the 5% level using Duncan's Multiple Range test.

At Grand Rapids, rootstock waterplantain plant height increased with increasing water depth (Table 7). Plant dry weight was greatest with 7 inches of water and decreased as water depth increased or decreased. Seed weight responded similarly to plant dry weight.

At St. Paul rootstock waterplantain plant height was maximum at the 8 inch water depth (Table 8). Plant dry weight was also the greatest at 8 inches as was seed weight. Waterplantain seedlings also appear to prefer depths (8 inches) optimum for rootstock waterplantain plant growth. However, depths greater than 8 inches reduced plant dry weight severely. In addition no seed was produced by plants grown in the 12 and 16 inch water depths.

It is important to note that the optimum water depth for wild rice occurs around 10 inches. This means that the optimum water depth for waterplantain parallels closely the optimum for wild rice. However, depths slightly greater than 12 inches may limit the establishment of seedling waterplantain, while still maintaining respectable wild rice growth.

Waterplantain Competition in Wild Rice

Research on the effect of waterplantain density on wild rice yield initiated in 1979 was repeated in 1980. Table 9 summarizes the yield data only for both 1979 and 1980.

Table 9. Wild rice yield in 1979 and 1980 as influenced by densities of common waterplantain plants developed from rootstocks.

Rootstock density	Harvested yield (lb/A)		Processed yield (lb/A)	
Plants/ft^2	1979	1980	1979	1980
0	1241a*	1235a	447a	489a
1/4	—	917b	—	358b
1/2	966b	528c	347b	195c
1	661c	416c	237c	172c
2	517c	387c	184c	147c
4	145d	—	42d	—

* Values within a column followed by the same letter do not differ at the 5% probability level using Duncan's Multiple Range test.

Wild rice yield was significantly reduced by all waterplantain rootstock densities in both 1979 and 1980. Harvested and processed yield responded similarly to competition. The lowest rootstock density (¼/ft^2), which was included only in 1980, reduced yield by 25%. The highest rootstock density (4/ft^2) reduced yield by 90%. These data indicate that waterplantain grown from rootstocks is a serious competitor with wild rice and that care should be taken to avoid its establishment even at very low densities.

The effect of length of competition of waterplantain rootstocks with wild rice was also investigated in 1980. Waterplantain established from rootstocks was removed by hand from wild rice at two week intervals. Table 10 summarizes the results of this experiment for both 1979 and 1980.

Table 10. Wild rice yield as influenced by length of competition with common waterplantain plants developed from rootstocks at a density of 1.5/ft^2.

Length of wild rice - waterplantain competition (wks)	Harvested yield (lb/A)		Processed yield (lb/A)	
	1979	1980	1979	1980
0 (weedfree)	1290a*	1182a	447ab	498a
3	1375a	—	485a	—
5	1209a	888a	381b	375b
7	1210a	988a	434ab	357b
9	696b	568b	256c	204c
11	—	568b	—	210c
All season	521b	363b	166c	120c

* Values within a column followed by the same letter do not differ at the 5% level using Duncan's Multiple Range test.

Waterplantain grown at a density of 1.5 plants/ft^2 did not significantly reduce harvested yield when removed by the 7th week of growth in both 1979 and 1980. After nine weeks of waterplantain - wild rice competition, harvested yield was reduced 46% in 1979 and 52% in 1980. No further yield reduction occurred after 9 weeks. Processed yield responded similarly to harvested yield, though some reduction did occur by 5 weeks of competition in both years. These data suggest that weed removal should occur by 5 weeks after germination if yield reductions are to be avoided.

PLANT POPULATION

Plant Population and Yield of Netum

Previous plant population studies with other varieties indicated that four plants per ft^2 were needed to obtain maximum yield. Yield decreased at lower and higher plant populations. One previous trial with Netum also indicated that four plants per ft^2 were best for maximum yield for this variety. To confirm these results, a plant population trial was conducted at Grand Rapids. Netum was seeded, broadcast onto the soil surface and rotovated into the soil in the fall at 5, 10, 15, 30, 45, 75 and 100 lb per acre of wet seed. Data from the trial are shown in Table 11.

Table 11. Plant characteristics and yield of Netum as influenced by plant population - Grand Rapids - 1980.

Seeding rate	Plants	Stems	Plant height	Grain moisture at harvest	Grain dry wt	Grain weight at 40% moisture
lb/A	/ft^2	/plant	cm	%	lb/A	lb/A
5	0.21	9.6	190	38.7	209	348
10	0.37	8.0	189	33.6	279	465
15	0.39	7.0	182	37.0	299	498
30	0.69	5.5	192	36.6	383	638
45	1.05	4.5	191	37.0	452	753
75	1.12	4.7	195	36.5	569	948
100	1.33	4.4	172	35.8	542	903
LSD .05	0.34	--	NS	NS	101	168

Plant populations ranged from 0.2 to 1.3 plants per ft^2. The highest plant population obtained even with 100 lb per acre of seed was 1.3 plants per ft^2 (Table 11). Based on percent viable seed we should have obtained 13 plants per ft^2. Apparently due to the clay loam soil only one percent of the seeds developed into seedlings. In other plots, where the clay percent of the soil was even higher, poor plant populations were obtained.

As expected, the number of stems per plant decreased as plant population increased (Table 11). Plant height and grain moisture at harvest was not significantly different among the different plant populations. Grain yield increased with increased plant populations. Because of the low plant populations, it is difficult to confirm our previous results that four plants per ft^2 are needed for optimum yield. Yields may have continued to increase with higher plant populations.

SIMULATED HAIL DAMAGE

Leaf Removal and Stem Breakage

To simulate hail damage on wild rice, 33, 67 and 100% of each leaf blade was cut off with a scissors at 5 plant growth stages. The leaf tissue was removed at the floating leaf, aerial leaf, tillering, flowering and early milk stages of plant growth. In addition, 33, 67 and 100% of the stems were broken below the panicle. The stems, however, were not completely broken off. Table 12 gives the data obtained at harvest from the various leaf removal and stem breakage treatments. The trial was conducted at Grand Rapids.

Table 12. Influence of removing 33, 67 and 100% of leaves on wild rice plants at 5 stages of growth plus 33,67 and 100% of stems broken at last 2 stages of growth - Grand Rapids - 1980.

Growth stage	Percent leaf removal	Plant number	Stem number	Plant height	Lodging score*	Flowering date	Panicle number	Straw dry weight	Grain dry weight	Percent grain yield reduction from no leaf removal
		/ft^2	/ft^2	cm	--	July	/plant	lb/A	lb/A	%
Floating leaf	33	2.6	6.9	214	1.7	6	2.6	4770	723	20.1
	67	2.5	7.4	217	7.0	7	3.1	3842	752	16.9
	100	2.0	4.5	195	1.0	11	2.2	2833	345	61.9
Aerial leaf	33	2.6	8.2	210	4.0	5	3.2	5010	752	16.9
	67	2.5	8.4	230	4.3	4	3.5	5714	880	2.8
	100	2.0	8.0	229	6.0	5	3.9	4386	826	8.7
Tillering	33	2.2	8.0	228	6.7	4	3.7	5266	875	3.3
	67	2.8	9.4	224	4.0	4	3.5	4576	933	0.0
	100	2.2	8.5	203	6.0	7	4.1	4146	536	40.8
Flowering	33	2.2	9.4	218	6.0	2	4.6	4528	917	0.0
	67	2.1	8.8	212	3.7	3	4.4	3938	690	23.8
	100	2.2	5.3	183	2.3	7	2.4	2433	178	80.3
Early milk	33	2.2	8.8	222	2.7	3	4.1	5282	875	3.3
	67	2.4	8.5	212	4.3	7	3.7	6514	615	32.0
	100	2.2	7.8	217	4.3	3	3.5	4338	514	43.2
Control	0	2.4	8.6	222	3.7	4	3.6	4984	905	--
LSD .05		NS	1.7	17	NS	-	___	NS	362	

* 1 = no lodging; 10 = completely lodged

The number of plants per ft^2 was not significantly different at harvest for the different treatments (Table 12). However, the number of stems per ft^2 was the lowest when the leaves were removed at the floating leaf stage compared to removal at later growth stages. This resulted in fewer panicles per plant and consequently considerable yield reduction even when only 33% of all leaves was removed at the floating leaf stage. Yield reductions were not as great when removing leaf tissue at the aerial leaf and tillering stages of growth compared to earlier and later removal. Removing 33% of all leaves plus breaking 33% of the stems at flowering and early milk stages of growth did not result in much yield reduction. However, removing 66 and 100% of all leaf blades plus breaking 66 and 100% of the stems caused severe yield reductions. The most yield reduction occurred when 100% of all leaf blades was removed plus breaking all stems at the flowering stage of growth.

The yield reduction caused by leaf removal and stem breakage during flowering and grain filling was expected. Damage to other small grains during this time results in yield losses. However, the yield losses resulting from leaf removal during the floating leaf stage were not expected. An earlier study in 1977 showed some yield loss from leaf removal at the floating leaf stage, but not the substantial losses obtained in this year's trial. Apparently the floating leaves are very important to the wild rice plant for early plant development.

TIME OF HARVEST

<u>Netum Date of Harvest</u>

Netum was harvested 4 times over a period of 21 days to ascertain when to harvest this variety for maximum yield. The trial was conducted at Grand Rapids. Date of harvest, yield and grain moisture at harvest are given in Table 13.

Table 13. Netum yield and grain moisture as influenced by harvest date - Grand Rapids - 1980.

Harvest date	Grain yield	Grain moisture at harvest
	lb/A	%
8-18	2310	41
8-22	1927	39
3-27	1375	37
9-8	990	32

Maximum yield was obtained on the first harvest date when the grain moisture was the highest (Table 13). Grain yield may have been even higher had harvest been started earlier, however previous studies with other nonshattering varieties indicated maximum yield can be obtained by harvesting when the grain has about 40% moisture. Additional harvest studies will be conducted next year with Netum.

Grain Moisture at Harvest and Recovery Percent

Through the courtesy of Robert Schwob of Northern Rice Laboratories, Inc., we obtained the grain moisture percent and recovery percent of 191 wild rice samples submitted to him for analysis. The values were listed without any sample identification. The moisture percent of the grain samples varied from 20 to 51, however most of the values were in the upper 30's and lower 40's. Recovery percents ranged from 25 to 63 with most of the values in the mid 30's to lower 40's. Recovery percent was calculated on a green weight basis. All of the samples were not directly from the combine, thus these samples were not as representative as they should be for combine samples.

A correlation coefficient was calculated for grain moisture percent and recovery percent. The correlation coefficient is a measure of the degree to which grain moisture percent and recovery percent vary together. The correlation obtained for the 191 pairs of numbers was relatively good in this case, but in other cases the relationship has not been as good. More work is planned next year to determine the exact relationship.

If growers could use grain moisture percent as an indicator of when to harvest for optimum yield and/or recovery percent, then it would be desirable to have meters available to test grain moisture. Ordinary grain moisture testers will not accurately test grain with high moisture contents. One possibility would be to use forage moisture testers. We checked three forage testers for wild rice. One was the Koster Crop Tester, Inc., 4716 Warrensville Ctr. Rd, North Randall, Ohio. They ran five tests and found that an accurate moisture content of the grain could be obtained in 25 minutes. This is not a quick test and the tester requires electricity, but the test probably would be quite accurate. In addition, it only requires about 100 grams of seed.

Another moisture tester checked was the Dickey-John forage tester manufactured by the Dickey-John Company, Auburn, Ill. This tester requires a large grain sample (2 lbs) but takes only a few seconds to obtain and does not require any electricity, thus it is very portable. Figure 1 shows the readings obtained on the Dickey-John with the actual moisture percent of the grain obtained by oven drying.

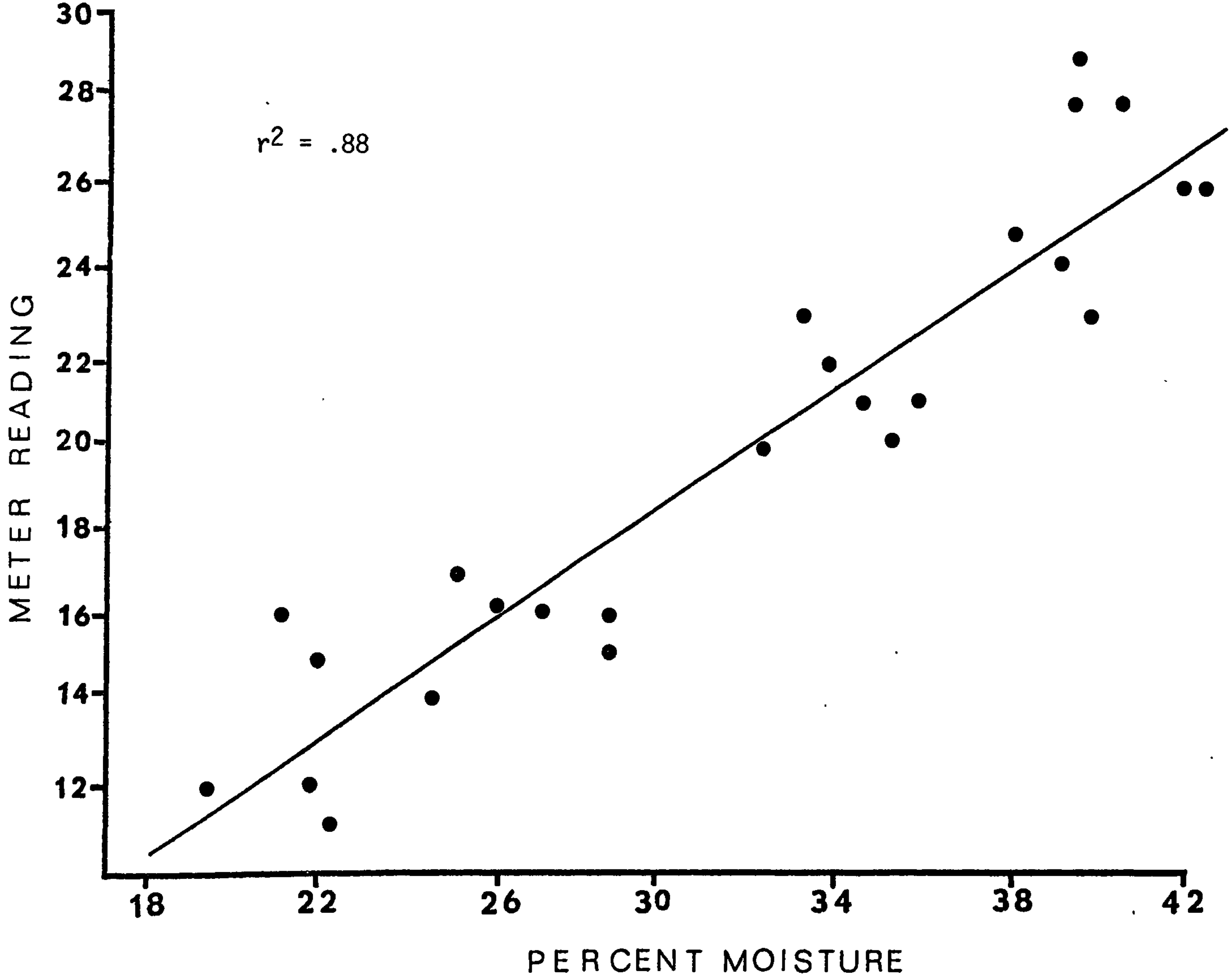

Figure 1. The actual grain moisture percent obtained by oven drying and the Dickey-John meter readings obtained for the grain before drying.

The preliminary test of the Dickey-John moisture tester would indicate some problems with this unit in obtaining a very accurate test. However, with more samples and additional testing a curve might be established for this meter to construct a table of meter readings with corresponding wild rice grain moisture.

The third meter tested was the NF1210 Forage-Silage-Grain Moisture Tester manufactured by the N.J. Froment and Co., Ltd., Stanford, England. The preliminary tests indicate that it may be difficult to obtain accurate readings for wild rice with this moisture tester.

Another meter which was used in cheese makinq at one time and was tested by the University of Wisconsin is the Cenco Moisture Meter. This meter also works on the same principle as the Koster moisture tester. However, it is more expensive than the Koster meter but is somewhat faster. Other moisture meters may be available that could be tried on wild rice. More work will be done with moisture meters next year.

WILD RICE PLANT DEVELOPMENT

Temperature and Daylength Response

Growth chamber experiments were continued in 1980 to investigate wild rice plant response to daylength and temperature. Two varieties, Johnson and a Canadian lake shattering type, were grown at two temperatures and daylengths. Two growth chambers were utilized. First, both varieties were grown in the two chambers with identical temperatures of 66° F during the day (9 hours of full light) and 60°F the remainder of the time. The daylength in each, however, was different. One chamber had 9 hours of full light intensity plus an additional 6 hours of low light intensity to simulate a 15 hour day and a 9 hour night period. The other chamber had 9 hours of full light intensity and 15 hours of darkness to simulate a 9 hour day. The procedure was repeated except for a different temperature regime for the two chambers. The temperatures were 72°F during the day (9 hours of full light) and 66°F at night in both chambers. Table 14 gives information on the response of wild rice to the four temperature - daylength treatments.

The higher temperature regime resulted in much more rapid plant development of both varieties compared to the lower temperature regime (Table 14). This resulted in shorter plants with fewer leaves and tillers. The floret number on the main stem was reduced by over 50% by the warmer temperature. These data confirm our earlier results on temperature and plant development.

Both varieties initiated flowers and flowered earlier under 9 hours compared to 15 hours of light (Table 14). Floret number on the main stem was decreased by the shorter daylength as were leaf and tiller

Table 14. Plant growth measurements made on 2 wild rice varieties grown at 2 different temperatures and 2 daylengths, St. Paul - 1980.

		Day-night temperature, F				Mean			
		66-60		72-66					
Variety	Plant characteristic	Long day*	Short day**	Long day*	Short day**	Long day*	Short day**	Cool temp.	Warm temp.
Canadian lake	Plant ht. (cm)	135.0	92.5	94.7	95.8	114.8	94.2	113.8	95.2
	Leaf no.***	5.3	4.3	2.4	2.7	3.8	3.5	4.8	2.6
	Tiller no.***	2.7	1.8	2.0	1.7	2.4	1.8	2.2	1.8
	Floret no.***	46.0	15.0	17.5	14.5	31.8	14.8	30.5	16.0
	Days to initiation	36.0	29.0	28.0	29.5	32.0	29.2	32.5	28.8
	Days to flowering	57.0	49.0	44.5	44.5	50.8	46.8	53.0	44.5
	Dry plant wt (gm)	7.7	4.4	3.3	2.7	5.5	12.3	6.0	3.0
Johnson	Plant ht. (cm)	132.0	97.0	115.0	96.0	123.5	96.5	114.5	105.5
	Leaf no.***	6.0	4.9	2.9	2.3	4.4	3.6	5.4	2.6
	Tiller no.***	2.8	2.2	2.6	1.7	2.7	2.0	2.5	2.2
	Floret no.***	72.0	24.5	26.7	18.4	49.4	21.4	48.2	22.6
	Days to initiation	42.0	30.0	31.3	30.5	36.6	30.2	36.0	31.4
	Days to flowering	66.0	53.0	55.0	50.5	60.5	51.8	59.5	52.8
	Dry plant wt. (gm)	8.6	5.8	5.1	3.2	6.8	4.5	7.2	4.2

* Long day was obtained by 9 hrs of full light intensity plus 6 hrs of low light intensity giving 15 hrs light and 9 hrs dark.

** Short day was obtained by 9 hrs of full light intensity and 15 hrs dark.

*** Leaf tiller and floret numbers were counted on the main stem at maturity.

number. The response to daylength was not as great when plants were grown in the warmer chamber compared to the cooler one. This was not as evident in our earlier studies when we used longer daylengths for each of the daylengths (14 and 18 hours vs 9 and 15).

It appears from our growth chamber studies that wild rice responds as a short day plant i.e. it will flower earlier under short (14 hours or less) days compared to longer days. Also wild rice development will be accelerated by warm temperatures, thus wild rice probably would yield less under short days and warm temperatures.

SEED STORAGE

Storing Seeds at Above and Below Freezing Temperatures

An experiment was initiated in the fall of 1979 to investigate if seeds could be stored longer using just below freezing temperatures rather than just above freezing. Seeds were stored at -2 and +2°C and at five different conditions at each temperature. The five conditions were 1) mixed with peat in sealed plastic bags, 2) mixed with peat in open paper cups, 3) mixed with peat in paper cups but flooded, 4) placed into sealed plastic bags without soil, and 5) placed into water in paper cups. Seeds were removed after 57, 120, 189, 242, 306 and 386 days of storage at the two different temperatures. Seeds were germinated at room temperature in water. If seeds did not germinate after three weeks, the lemma and palea were removed and the pericarp carefully scraped off above the embryo. The seeds were again placed into water at room temperature and allowed to germinate for three weeks. Table 15 gives the germination percentages after storage for different lengths of time in the above different conditions.

Very little germination occurred without scraping the seeds after they were stored at -2°C (Table 15). Apparently seed dormancy is not broken at temperatures below freezing. It also appears that keeping seeds at -2°C for more than a year is detrimental to germination. The best storage condition for keeping seed 386 days was when the seed was mixed with peat and kept in plastic bags. About 20% of the seeds were still viable but more than 50% of them did not germinate unless the pericarp was removed from above the embryo. Storing the seeds in sealed plastic bags without peat was nearly as good as with peat. When seeds were kept in cups the seed survival was low after 120 days of storage. Part of this may be because some of the seed dried out. Storing the seed in ice was not very good for long term storage.

One set in the -2°C freezer was removed after 198 days and then stored at +2°C for an additional 97 days. About six times as many seeds germinated without scraping after being at room temperature for three weeks then for the treatments stored at -2°C for the same total length of time. Thus it appears that temperatures above freezing are necessary

Table 15. Wild rice seed germination after storage for different lengths of time in 5 different conditions at 2 temperatures - St. Paul - 1980.

Storage conditions*	Days in storage						Days in storage					
	57	120	189	242	306	386	57	120	189	242	306	386
	----- % Germination without scraping -----						-- Total % germination after scraping** ----					
-2°C												
Peat in bags	1	6	4	4	0	9	40	46	34	28	21	22
Peat in cups	3	12	2	4	0	1	40	46	17	10	8	1
Flooded peat	1	1	1	0	0	1	30	29	13	3	0	1
Plastic bags	1	6	4	4	0	10	44	48	36	22	16	10
Water (ice)	1	2	1	1	0	0	45	39	17	7	0	0
+2°C												
Peat in bags	28	54	54	40	27	21	65	66	54	52	32	29
Peat in cups	32	48	31	28	16	21	79	58	31	33	18	29
Flooded peat	10	28	54	51	46	40	62	57	58	52	46	41
Plastic bags	32	28	52	26	11	1	66	35	52	26	11	2
Water	27	56	71	62	52	43	70	66	72	62	52	44

* All seeds were in sealed plastic bags kept at +2°C for 40 days before the experiment was started; Netum variety.

** Scraping means removal of the pericarp from above the embryo.

in order for seeds to break dormancy.

The best long term storage condition for the seeds stored at +2°C was keeping the seeds in flooded peat (Table 15). After 386 days 41% of the seeds were still viable. This was lower than for those stored in water, but included in the 44% viable after 386 days in the water were 34% that had germinated in storage. Very few seeds germinated in storage when they were in flooded peat soil. One of the reasons for better longevity of the seeds in flooded peat was the presence of fewer detrimental molds compared to those in unflooded peat or in plastic bags without peat. Perhaps seeds could be stored at +2°C longer if done under more sterile conditions to prevent seed loss from molds.

SEED SURVIVAL

Seed Survival in the Soil

Samples of seeds which were buried in 1976 at Grand Rapids at three different soil depths in peat and mineral soil under three different flooding regimes were removed on October 3. Nylon mesh bags containing 550 seeds each were retrieved from each burial depth and flooding regime. Table 16 gives the number of seeds which survived after burial in the soil for 4 years.

Table 16. The influence of burial depth, soil type, and flooding regimes on seed survival after 4 years in the soil - Grand Rapids - 1980.

Burial depth	Flooding regime and soil type					
	Continuous flood		Continuous fallow		Winter fallow-summer flood	
	Mineral	Peat	Mineral	Peat	Mineral	Peat
	number of seeds					
0 in.	0	0	0	0	0	0
2 in.	1	0	0	0	5	0
10 in.	12	9	0	0	24	10

No seeds remained viable after 4 years when they were left on the soil surface (Table 16). This was expected since no seeds remained viable after 2 years on the soil surface. Burying the seed 2 inches deep allowed only a very small portion (less than 1%) of the seeds to survive and then this was only when the seeds were kept moist by flooding all or part of the year. After 3 years of burial at this depth nearly 9% of the seeds were still viable. The most seeds remained viable at the 10 inch burial depth but again only about 1%. About 7% remained viable after 3 years. Survival seemed to be slightly better in mineral compared to peat soils.

This seed burial experiment would indicate that a grower could eliminate all of the old seed in a field by keeping it fallow for 4 years. However, the soil should be kept dry enough so the seed would dry down below 28% moisture so it would lose viability. The low lying peat soils are difficult to dry sufficiently for this purpose. Probably the best way to change a field to a new variety would be to germinate as many seeds as possible for 2 years in a row. This could be done by spring flooding, early draining, destroying the small plants by tillage and repeating this operation for 2 years. Some growers indicate they have been successful using this procedure.

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WILD RICE DISEASE RESEARCH - 1980

A PROGRESS REPORT

January 23, 1981

Dr. James A. Percich, Project Leader
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In 1980 the University of Minnesota's plant pathology wild rice research team continued its search for new chemical and non-chemical management stratagies to control brown spot disease of wild rice. Also, increased attention was given to the identification, prevelence, and biology of several bacterial and fungal pathogens that can be found in both natural stands and cultivated wild rice paddies. Major areas of investigation centered on the following:

1) Completion of three years of field testing of several fungicides and adjuvant materials (non-fungicidal carrier materials) for their effectiveness in controlling brown spot caused by *Bipolaris oryzae* (*Helminthosporium oryzae*) and *B. sorokiniana* (*H. sativum*).

2) Crop loss assessment utilizing a defoliation experiment which would, hopefully, simulate the photosynthetic loss that would occur due to infection by the brown spot organisms.

3) Continuation of the investigation of *Helminthosporium sigmoideum*, causal organism of stalk rot of paddy grown wild rice and assessment of its biological and economic importance.

4) Further investigation into the possibility of the development of dithane tolerance in *B. oryzae* and *B. sorokiniana* and the possible resulting changes in their biology.

5) The continued study of the identification and biology of the bacterium that causes bacterial leaf streak of wild rice.

6) Preliminary studies on zonate eyespot of wild rice caused by *Drechslera gigantea*.

7) Screening of plant introductions for possible resistance to brown spot (in cooperation with Dr. R. Stucker, Department of Agronomy and Plant Genetics).

MATERIALS AND METHODS

Chemical Control Studies

Fungicides and Adjuvants. The following materials were field tested at recommended label rates for other grass species for effectiveness in controlling brown spot of wild rice.

* methyl 1 (butylcarbamoyl) - 2 - benzimidazole - carbamate, benlate - 1.1 kg/ha (1 lb/a)

* tetrachloroisophthalonitrile, Chlorothalonil (bravo) - 11.4 kg/ha (10 lb/a)

* coordinate product of zinc ion and manganese ethylene bisdithiocarbamate, dithane M-45 - 2.27 kg/ha (2 lb/a)

* 2,4-dichloro-6-(O-chloroanilino)-s-triazine, anilazine, (dyrene - 2.27 kg/ha (2 lb/a)

* RH-2161, experimental fungicide, Rhom and Haas Company, Philadelphia PA - 0.57 kg/ha (0.5 lb/a) RP-26019, experimental fungicide, Rhone-Poulenc, Freso, CA - 6.05 kg/ha (5.5 lb/a)

* acrylocoat, experimental hard resin adjuvant, Rhom and Haas Company, Philadelphia, PA - 1.25 ml/l (1.0 pt/100 gal)

* di-l-p-methene, nu-film 17-0.55 ml/l (7 oz/a)

* rhoplex B-95, experimental hard resin adjuvant, Rhom and Haas Company, Philadelphia, PA-1.25 ml/l (1 pt/a)

* alkyl aryl polyxethylene glycol, triton AG-98- 1.25 ml/l (1 pt/100 a)

* modified phthalic glycerol alkyl resin, triton B-1956 - 0.62 ml/ l - (0.5 pt/100 gal)

* alkyl aryl polyethoxylate and sodium alkylsulfonated-alkylate, triton CS - 7 - 1.25 ml/l (11 oz/a)

FIELD TRIALS

A randomized split block design with seven replicates was used. Plots consisted of 3 x 3m squares with 200 plants in 1978 and 1979, respectively. A standardized 1.5 x 1.5 m inner square was hand harvested for data determination. The fungicides and adjuvants were applied utilizing a designed backpack CO_2 pressurized sprayer system delivering 300 ml of material at 25 psi per plot, which was equivalent to a rate of 331 l/ha. The initial application of the various chemical materials was made during the late-boot and early flowering stages of plant development, approximately 72 days after emergence. The three additional applications were applied at 10 day intervals. Controls were sprayed with water only.

Inoculation of plants. Wild rice plants, cultivated K-2, were inoculated with 5 different single-spored isolates of both *Bipolaris oryzae* (*Helminthosporium oryzae*) and *B. sorokiniana* (*H. sativum*).

DEFOLIATION STUDY

A section of a wild rice paddy at the North Central Experiment Station at Grand Rapids, Minnesota was planted in 1980 with the cultivated wild rice "variety" designated K-2 in 50 ft. (15 m) rows with each row containing 25 plants at 2 foot (0.6 m) intervals. A defoliation consisting of one-third of every leaf on each test plant was made at the following stage, of plant development:

Defoliation	Date	Stage of Development
A	June 23, 1980	Tillering
B	July 9, 1980	Early Flowering
C	July 30, 1980	Late Flowering
D	August 13, 1980	Grain Filling, Maturity

Each defoliation was replicated in 5 test plots. The control plots were not defoliated but were allowed to grow and mature normally. Leaf material was removed from a randomized sampling of ten treated plants and immediately taken to the laboratory and placed in a computerized instrument which recorded the leaf area of each leaf section. At harvest the seed from each test plot was graded according to seed size with the control plots containing approximately 40% dark seed. All plots were sprayed 2 times with Dithane M-45 plus Triton B-1956 at a rate of 2 lbs per acre in 30 gal of water to control *Bipolaris* spp. infection. Green weights were determined at harvest on August 26, 1980.

STEM ROT OF WILD RICE

A study involving the effect of the fungal pathogen *Helminthosporium sigmoideum* on yield and lodging of wild rice at harvest was conducted at St. Paul in fiberglass tubs. These 3' x 6' tubs were filled with 15" of standard greenhouse soil. A 5" water depth was maintained independently in each tub. The fungus in the overwintering form of sclerotia was introduced on the water surface at varying times of plant development. Each treatment, excluding the control, was inoculated a minimum of six times over a two week period to insure infection.

Green weight yield consisted of three pickings over a two week period. Each was a rapping of the rice head against the side of the container to dislodge ripened kernels. A final harvest (rasp bar threshing) was taken one week after the third picking.

The diameter of dried dehulled seed constituted the measurement for seed quality. The largest diameter of 4 mm is considered the "highest grain quality".

The total number of plants and stems per tub was harvested immediately preceding harvest.

The presence of sclerotia in the stem after harvest was the criteria for stem infection. Lodging notes were taken one week after final harvest.

RESULTS

CHEMICAL CONTROL

Significant control of brown spot of wild rice was observed with all chemicals tested when applied at least twice, except for RP-2619, as compared to the water treated controls (table 1). The control plots had an average disease index rating of 2.8 (46% leaf area covered) on a 0 to 5 scale when observed throughout the growing season. Increasing yields resulted in all fungicide treated plots with additional applications, except those treated with the systemic compounds benomyl and RH-2161 in which case phytotoxicity characterized by a progressive and generalized yellowish chlorosis resulted after the third and fourth applications. However, those plots sprayed only twice with either benomyl or RH-2161, produced the highest significant yields recorded; even-though the plants were inoculated an additional two times with both B. oryzae and B. sorokiniana (table 1).

Both anilazine and RP-26019 at 2 and 3 applications gave good disease control, even though one was not significantly better than the other. But, RP-26019 at 4 applications did produce a significantly greater yield than did anilazine (table 1).

Chlorothalonil and dithane M-45 at 1, 3, and 4 applications resulted in similar, but significant brown spot control. These fungicides produced the highest significant yields at both 3 and 4 applications than any of the compounds tested (table 1).

A comparison of five different adjuvant materials, each separately in combination with dithane M-45 at 1, 2, 3, and 4 applications was investigated (table 2). The previously recommended combination of dithane and triton CS-7 resulted in significant yield increases at 2 and 3 applications, as compared to dithane alone. Two applications of dithane and triton AG-98 produced a non-significant increase in yield when compared with the fungicide in combination with triton CS-7. However, when dithane was in combination with either acrylocoat or nu-film 17, significant yield increases resulted at 2, 3, and 4 applications as similarly compared to the fungicide and triton CS-7 (table 2). Even though acrylocoat and nu-film 17 did not differ from each other at 1,2, or 3 applications; their yields were significantly different from each other at 4 applications resulting in increases of 16 and 35% respectively, over dithane plus triton CS-7. Dithane in combination with either triton CS-7 or triton B-1956 did not result in yields that were significantly different from each other regardless of the number of applications.

DEFOLIATION STUDY

Wild rice plants that were not defoliated and allowed to develop normally yielded 1787 grams on a green weight bases (table 3). However, plants that were defoliated at tillering, early flowering, late flowering, and grain filling had reduced yields of 327, 233, 337, and 127 gms respectively when compared to the non-defoliated controls. Significant yield reductions of 18, 13, and 19% occurred during the tillering, early flowering, and late flowering stages of plant development respectively, when compared to the control (table 3). Defoliation during the grain filling period resulted in a nonsignificant reduction in yield when compared to controls.

Grain diameter as they relate to the time of defoliation were also compared (table 4). Grain diameter of 4 mm or larger are those which had the highest quality and potential economic value. Defoliation had no significant effect, regardless of the stage of plant development, on the ratios of grain size as compared to the untreated control.

STALK ROT OF WILD RICE

Wild rice stems were recovered and examined at tillering, early flowering, and late flowering had 68, 76, 71% lodging, respectively, whereas only 47% of the control plants lodged (table 5).

The percent stem infection was 82, 90, and 88% at tillering, early flowering, and late flowering, respectively (table 5). The stems of uninoculated control plants had only a 20% infection. The presence of infection was probably due to previously infected seed.

The treatment green yields, numbers of stems per plant, and treatment yields on a per acre basis were not significantly affected by *H. sigmoideum* infection regardless of the stage of plant development at the time of inoculation (table 5).

The effect of *H. sigmoideum* infection on seed quality during various seed maturation periods was examined (table 6). Regardless of the infection or harvest dates, no significant reduction in the percentage of "highest quality" seed was observed (table 6).

Therefore, the data indicates that even though wild rice plants may be highly infected with *H. sigmoideum*; the resulting yields or seed quality is not affected significantly. However, increased lodging was observed in plants infected with *H. sigmoideum*. Lodged plants essentially result in zero yield, if mechanical combining is utilized. Investigation of the influence of water depth, time of water removal, fertilization, and possible chemical control to prevent plant infection is presently in progress.

BACTERIAL PATHOGEN STUDIES AND FOLIAGE DISEASE SURVEY

BACTERIAL LEAF STREAK

Bacterial leaf streak (BLS) is characterized by narrow, dark green, water-soaked streaks which expand along the leaf blade for up to 20 centimeters. These lesions turn brown or black giving the leaves a striped appearance.

In the 1975 annual research report it was stated that BLS was caused by a yellow bacterium which was tentatively identified as *Xanthomonas translucens*. In the 1979 annual report the causal agent of BLS reported to be a white bacterium and was identified as *Pseudomonas* sp. This apparent discrepancy was resolved by further work in 1980.

More than 200 isolations from BLS symptoms collected in 23 different locations yielded 151 cultures of *Pseudomonas syringae* and 20 of *Xanthomonas translucens*. Representatives of both species were proved to be pathogenic in greenhouse and field tests and both reproduced BLS symptoms. Symptoms produced by *X. translucens* were almost indistinquished from those produced by *P. syringae*, the only difference being that *X. translucens* lesions often have drops of yellow exudate on the surface. It appears, therefore, that BLS symptoms in the field can be caused by either *P. syringae* or *X. translucens* and that *P. syringae* is much more common.

A survey of 6 natural lake and river stands of wild rice in 1980 found BLS present in 2 sites and at both sites the disease was very rare. Twelve of thirteen commercial growers also had BLS present in their fields. Average severity was less than 1% of the leaf area, but a few fields had 1-5% of the leaf area affected. At this time, the relatively low severity of BLS probably does not warrant the use of control measures.

BACTERIAL BROWN SPOT

A new bacterial disease of wild rice was identified in 1980. The initial symptom is usually a small water-soaked spot or short streak on the leaves. This rapidly develops into a brown, oval to spindle-shaped spot which is 0.3 to 2.0 cm long and 0.2 to 0.5 cm wide. Occasionally spots are irregular in shape or much larger. The original water-soaked spot or streak is often visible as a translucent spot or slit in the center of the lesion. Bacterial brown spot is very similar to brown spot caused by *Bipolaris oryzae* and *B. sorokiniana*, but can often be distinguished by the presence of the central translucent slit or spot.

Isolation from bacterial brown spot symptoms consistenly yielded *Pseudomonas syringae*. These isolates were able to reproduce the brown spot symptom in tests conducted in the greenhouse and in the field and these symptoms were distinctly different from the leaf streak symptom. A comparison of *P. syringae* isolates which produced brown spot and those which produced leaf streak revealed that isolates which produce brown spot also produce a toxin. The leaf streak producers exhibited no toxin production. It therefore seems that P. syringae on wild rice can be divided into two strains, the toxin producers and the nonproducers which cause brown spot and leaf streak symptoms respectively.

Bacterial brown spot was the most important brown spot pathogen in 4 out of 14 fields tested. Severity in one case was apparently in the 5-25% range. Future surveys will be required to determine whether or not control measures are warranted.

FOLIAGE DISEASE SURVEY

On August 4-7, 1980, 6 natural stands and 13 grower's fields were surveyed for foliage diseases and the results are presented in (tables 7 and 8). In natural stands, plants were usually fairly disease-free. Although several diseases were widely distributed, none were significant.

In commercial paddies, brown spot symptoms had the highest average severity and also the highest individual ratings with one field having in excess of 50% of the leaf area destroyed. The second most severe disease was bacterial leaf streak but it reached significant levels (1-5%) in only one grower's fields. The other diseases caused only minor damage in 1980.

Since brown spot is the most important disease and since three different organisms (Bipolaris oryzae, B. sorokiniana, Pseudomonas syringae) are all capable of producing this symptom, isolations were made to determine which of these is most important. The results are given in (table 7).

In commercial paddies, B. oryzae was the most important. In most fields, and especially in fields with severe infection, it was the most commonly isolated brown spot pathogen. The bacteria were dominant in several cases and in one instance, B. sorokiniana was most important.

In natural stands, B. sorokiniana was consistently dominant and B. oryzae was found in only one location. It appears, therefore, that the dominance of B. oryzae and B. sorokiniana are reversed in natural and commercial stands.

Several conclusions can be drawn from this survey data. The first is that brown spot and specifically B. oryzae is the major foliage disease problem on paddy-grown wild rice. Control efforts should be concentrated on this disease. Bacterial brown spot is easily confused with brown spot caused by B. oryzae and may in some cases cause significant damage. In natural stands B. oryzae is apparently not a problem and even B. sorokiniana is present only at low levels.

NEW PATHOGENS

PHAEOSEPTORIA

Phaeoseptoria sp. was isolated from foliar lesions of another new disease. Lesions were yellow to yellowish-brown with a grayish border and contained numerous very small black fruiting bodies in their centers. The lesions were typically found along the leaf margins and were up to a few centimeters long.

Phaeoseptoria sp. can be found in both natural and commercial paddy stands but is always fairly rare. Presenly this fungus is considered to be a weak pathogen of wild rice and control is not necessary.

ZONATE EYESPOT DISEASE (DRECHSLERIA GIGANTEA HEALD & WOLF)

Zonate eyespot disease of wild rice was observed for the first time in farmer's fields in August 1979. The early symptoms were tiny blackish brown lesions on leaves that might be confused with the early symptoms of brown spot disease of wild rice. The lesions will enlarge, become grayish in the center with a well defined blackish brown margin. In the latter stage, secondary lesions might be formed around the primary lesions which proudced a typical zonate eyespot appearance. White coarse strands of mycelia were often formed radiating from the margin of the lesions on the lower surface of the infected leaves.

The disease was caused by Drechslera gigantea Heald & Wolf. The fungus produced two types of conidia on V8 medium, macroconidia and microconidia. However, only macroconidia had been observed on infected leaves so far. The macroconidium was cylindrical, light brown, 173.40 - 479.40 x 11.22 - 20.40 μ in size with 5 - 13 septa. The microconidium washaline to olive, 1 - 2 cells, ellipsod, 9.52 - 23.8 x 3.57 - 7.14 μ in size and produced in chains. Blackish areas were clearly seen at the point of attachment. The microconidia were borne on a conidiophore or from germinating macroconidia. The conidiophore was dark brown, 153 - 469.20 x 8.33 - 14.28 μ in size with 2 - 14 septa. The tip of conidiophore was slightly swollen and the color was much lighter. The base of conidiophore was also often swollen. Some isolates only produced a few amount of macroconidia and microconidia on V8 medium, while the others did not produce any conidia at all. Isolates obtained from single macroconidia or microconidia showed the same cultural appearance and produced both macro and microconidia.

In 1979, the disease was observed in one growers farm in Aitkin county and at the Rosemount Experiment Station. In a survey conducted in August, 1980, the disease was recorded at the Excelsior Experiment Station and three growers farms in Aitkin county, but was never found in natural stands. In most places the disease only produced light infection. Mild infection was only found in two farmer's fields in 1979.

The reaction of three wild rice cultivars at three growth stage to Zonate eye spot disease has been studied ub the greenhouse (table 10). Netum K_2 and Johnson cultivars were also susceptible to D. gigantea (table 10). All these cultivars produced typical Zonate eyespot. The reaction of each cultivar at the seedling stage was the same as the reaction of plants at the tillering and flowering stages. Some plants of Johnson cultivar produced Johnson Brown (JB) lesions similar to the symptoms caused by Bipolaris cryzae on some plants of Johnson cultivar. This JB symptom was consistently observed at the seedling, tillering, and flowering stages. As the reaction of three wild rice cultivars at three growth stages were the same, it might be possible to screen the resistance of wild rice cultivars to Zonate eyespot using seedlings of wild rice plants in the greenhouse.

The host range of D. gigantea had also been studied in the greenhouse (table 11). Fifteen species of crop plants and grasses were inoculated with a suspension of macroconidia and microconidia of D. gigantea and then were kept in a moist chamber for 12 days. Among 15 species of plants tested, well develop sporulating lesions only formed on wild rice (Netum cultivar), brome grass, quack grass, and reed canary grass (table 10). Other plants such as rice, wheat, barley, corn, sorghum, asian wild rice, southern wild rice, foxtail and crab grass only produced tiny, non-sporulating lesions. Oats were even considered to be immune. The data indicated that some grasses might serve as the alternate host of D. gigantea, even though in nature this phenomenon has not been observed.

Preliminary studies of chemical control of D. gigantea indicated that Bravo 500, Dithane M-45 and Ciba Geigy CGA-64250 were effective to control this fungus (table 12). However, further experiments are required to confirm this data, as only light infection was produced on control plants.

SCREENING FOR PLANT DISEASE RESISTANCE TO BROWN SPOT

A METHOD OF SCREENING FOR RESISTANCE TO BIPOLARIS ORYZAE

Growing resistant cultivars is the cheapest and safest method of disease control. However, before we can find and use resistant cultivars, an efficient and reliable screening method must be established.

Up to now, the screening for resistance of wild rice cultivars/lines have always been conducted under field conditions. This technique has some disadvantages, as it requires a large area and a large amount of inoculum to get a severe infection. In addition, it is also difficult to control and maintain favorable environmental conditions for the development of the disease in the fields. The low air temperature and humidity at the growing season often becomes a limiting factor for the occurrence of severe epidemics in the test plots.

A possibility of screening method using seedling plants in the greenhouse have been studied. Using seedling plants has some advantages. Smaller size of plants will only require small areas and make it possible to screen more entries in each experiment. In addition, the period of time required to conduct the experiment is shorter, so that the experiment can be repeated many times. Besides, we only need fewer amounts of inoculum, and the favorable environmental conditions for the development of the disease can be controlled easily. However, a screening method using seedlings might only be possible if the reaction of plants at seedling stage is relevant to the reaction of mature plants.

For this purpose, we compared the reaction of Netum K_2 and Johnson to Bipolaris oryzae at seedling, tillering and flowering stages. Each cultivar was grown in pots; 5 seedlings/pot, 2 tillering stage plants/pot, and 2 flowering stage plants/pot. The plants were fertilized with 0.5 g urea, 0.5 g K and 0.5Pg/ pot. Each cultivar has five replications (1 pot/replication). The water level was maintained low, (± 0.5 cm from the soil surface), so that the seedlings grew faster and had no floating leaf stage. The plants were inoculated with spore suspension of Bipolaris oryzae (Bo 11 Gu, 300,000 spores/cc = 50 cc spore suspension/ 20 pots), and then were kept in a moist chamber for one week. Observations were made one week after inoculation, and the resistance of wild rice plants was evaluated using the following criteria:

	Scoring scale	Reaction
0	Healthy plants	Immune
1	Tiny blackish brown lesion	Resistant
5	Typical brown spot symptoms ellipsord/oval lesion grayish brown in the center with dark brown margins, and yellow halo around the lesion	Susceptible
9	"Johnson Brown" lesion: tan, large lesions. This type of lesions are considered to be more susceptible than the typical brown spot lesion	Very susceptible

The results indicated that Netum K_2 and Johnson were susceptible to Bipolaris oryzae. The reaction of plants at seedling stage was relevant with the reaction of plants at tillering, and flowering stages. "Johnson Brown" lesion type was observed on ± 20% of Johnson cultivar, but not in other cultivars. The occurrence of "Johnson Brown" symptom was observed in seedling, tillering and flowering stages. The data suggested that the screening to resistance to B. oryzae can be done in the greenhouse using seedling plants. However, further works should be done to standardize this screening procedure.

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Table 1. Effect of several different fungicides at 1, 2, 3, and 4 applications for brown spot control of wild rice

Treatment	Treatment wt.[x] Number of Applications 1	2	3	4	Treatment wt. over control Number of Applications 1	2	3	4	% increase over control Number of Applications 1	2	3	4
Benomyl	494 b[y]	863 a	743 a	523 c	9*	405	303	125	2*[z]	88	69	31
Chlorothalonil	505 b	628 b	692 a	707 a	20*	170	252	303	4*	37	57	76
Dithane M-45	493 b	523 bc	763 a	772 a	8*	65	323	374	2*	14	73	94
Anilazine	486 b	541 bc	569 bc	580 c	1*	83	129	182	1*	18	29	46
RH-2161	493 b	789 a	636 ab	523 c	8*	331	196	125	2*	72	45	31
RP-26019	597 a	597 bc	588 bc	688 ab	112*	139	148	290	23*	30	34	73
Control	485 bc	458 c	440 c	398 d								

x = Data are mean seed weights in kg/ha consisting of 14 fooled samples from two separate experiments each having 7 replicates per treatment.

y = Means in each column followed by the same letter are not significantly different at P = 0.05 according to Duncan's multiple range test.

z* = Not significantly different at P = 0.05 from control.

Table 2. Comparison of various adjuvant materials in combination with Dithane M-45 for brown spot control of wild rice

Treatments	Treatment wt.[x] Number of Applications 1	2	3	4	Treatment wt. over Dithane M-45 + Triton CS-7 Number of Applications 1	2	3	4	% increase over Dithane M-45 + Triton CS-7 Number of Applications 1	2	3	4
Dithane M-45 Alone	473[y]	467	676	712								
Dithane M-45 + Triton CS-7	493a	523b	763bc	772c								
Dithane M-45 + Acrylocoat	553a	620a	860a	899b	40a	97a	97b	127b	8a	18a	18a	16b
Nu-film 17	540ab	575a	909a	1066a	47a	52b	146a	294a	10a	10b	19a	38a
Triton AG-98	501a	571a	672d	611de	8c	48b			2b	9b		
Triton B-1956	511a	552ab	803ab	849c	18b	29c	40c	77c	4b	6c	5b	10c

x = Data are mean seed weights in kg/ha each of which consists of 14 pooled samples from 2 different experiments each having 7 replicates per treatment.

y = Means in each column followed by the same letter are not significanly different at P = 0.05 according to Duncan's multiple range test.

Table 3. The Effect of Defoliation of Wild Rice at Four Different Stages of Plant Development

Treatment	Treatment Weight[a]	Weight Loss Compared to Control	% Weight Loss Compared to Control
1. Control (no defoliation)	1787		
2. Tillering	1460	327	18
3. Early Flowering	1554	233	13
4. Late Flowering	1450	337	19
5. Grain Filling	1660[b]	127	7[b]

a = Fresh (Green) weight in GMS.
b = Not significant at 5% level.

Table 4. Relationship Between the Grain Size (Diameter) to the Stage of Plant Development at the Time of Defoliation

Treatment	Percent Grain Diameters in Millimeters		
	$>^a 4$	$<4 \geq^b 3$	$<3 \geq 2$
1. Control (no defoliation)	40	52	8
2. Tillering	39	51	10
3. Early Flowering	38	52	10
4. Late Flowering	39	50	11
5. Grain Filling	35	55	10

a = Greater than

b = Less than or equal to

Table 5. The effect of Helminthosporium sigmoideum infection on wild rice at various plant stages

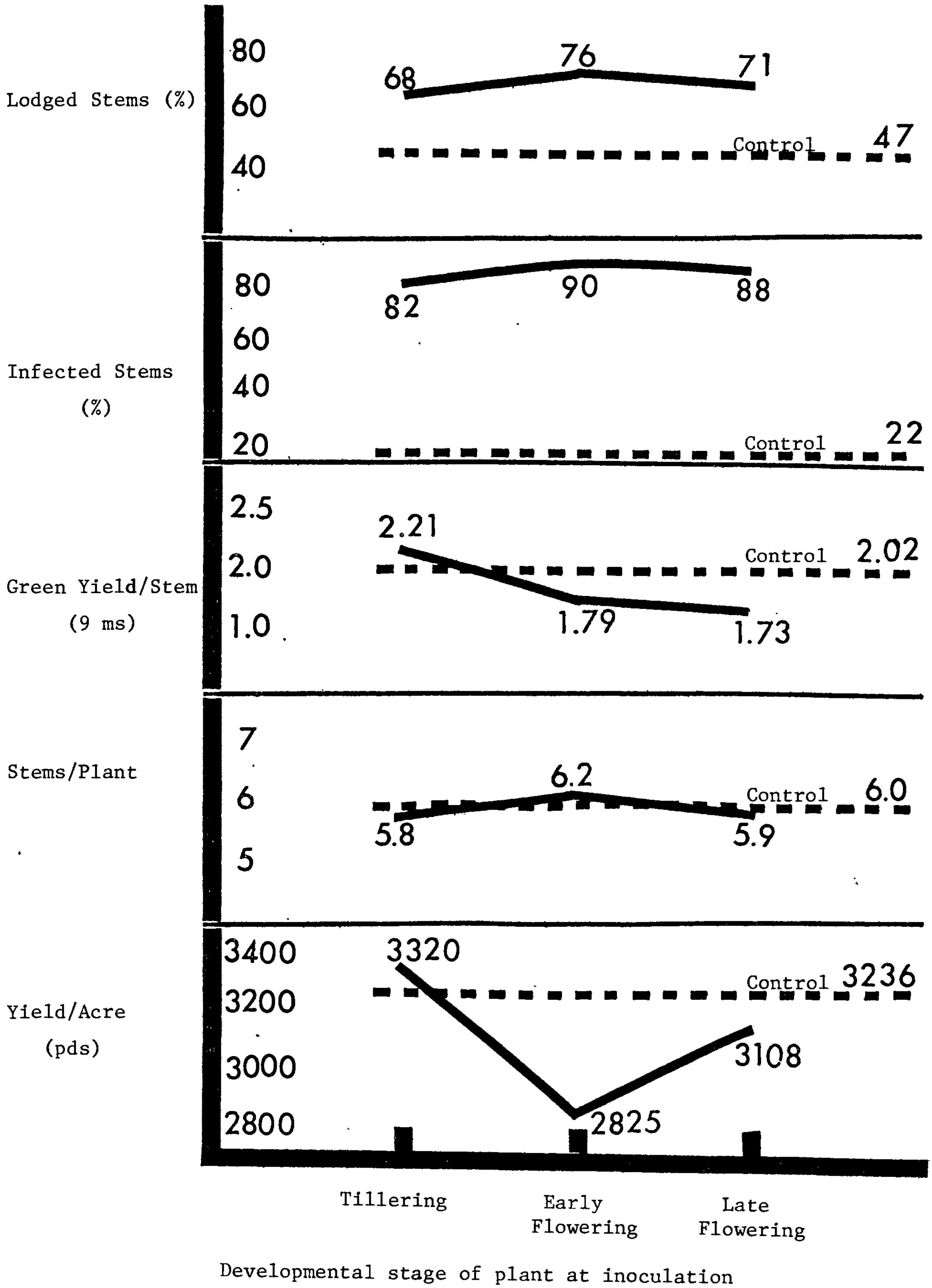
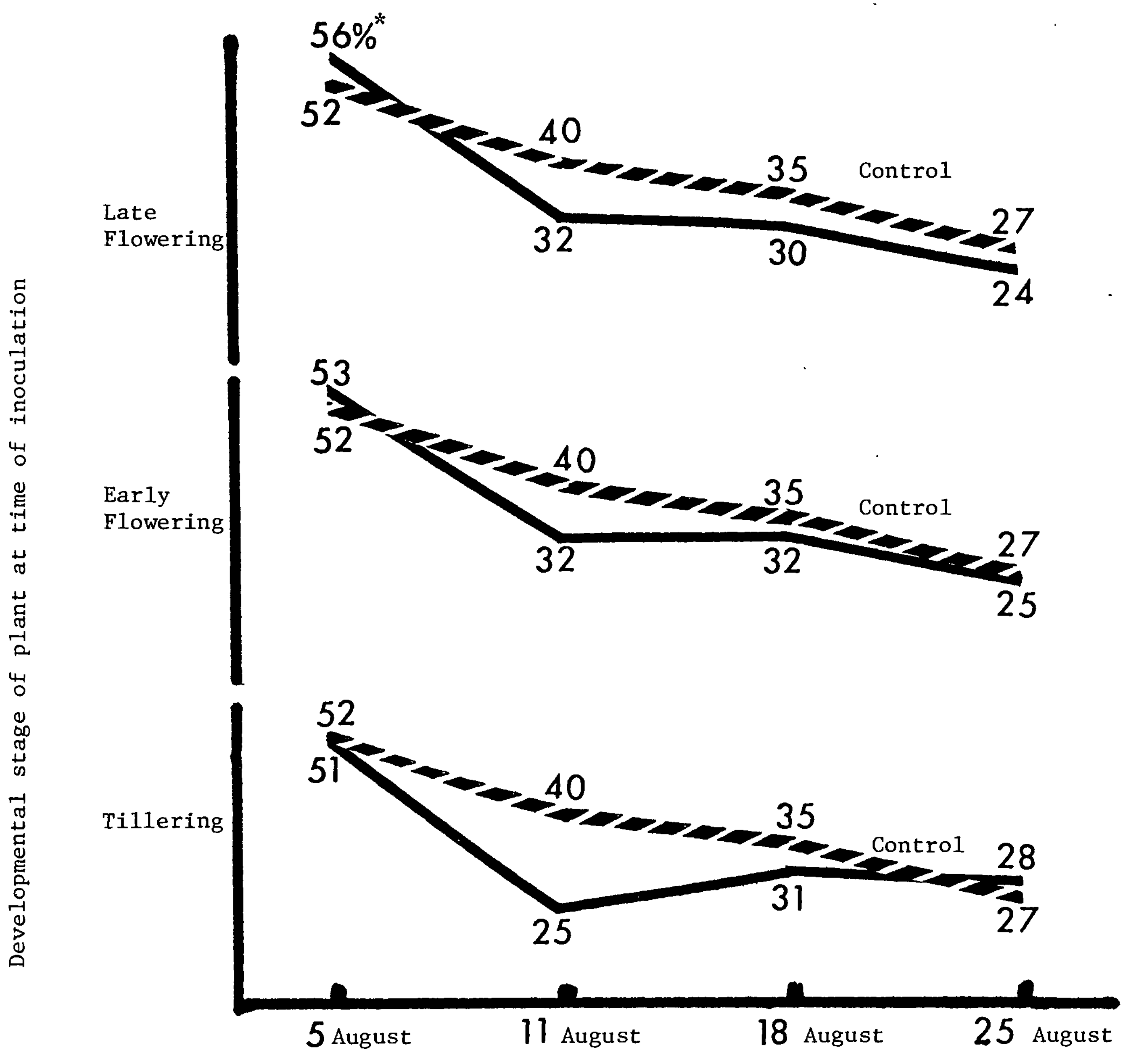


Table 6. The effect of Helminthosporium sigmoideum inoculation time on maturing date of high quality (larger than 4 mm diameter) wild rice grain



*percent of harvest with 4 mm diameter or more

Table 7. Brown Spot Isolations

	location	brown spot severity	% of isolations B.O.	B.S.	P.S.
paddy	1-1	5	50	0	0
	1-2	1	76	5	19
	2-2	7	82	0	24
	3-1	1	54	0	23
	4-1	5	0	0	66
	5-1	1	46	0	54
	6-1	1	71	0	24
	6-2	1	100	0	0
	7-1	3	0	0	100
	8-1	9	86	0	0
	10-1	1	71	0	0
	11-1	1	6	40	0
	11-2	3	15	23	61
	12-1	3	73	0	0
	Sandy River	1	40	50	0
	Mississippi River	1	0	45	9
	Plantaganette Lake	1	0	44	0
	Garfield Lake	1	0	31	6

Notes

1. B.O. = *Bipolaris oryzae* B.S. = *Bipolaris sorokiniana*
   P.S. = *Pseudomonas syringae*

2. Percentages do not necessarily add to 100% because some specimens yielded more than one isolate and some yielded none.

Table 8. Foliage Disease Survey: Commercial Paddies

Foliage Disease Survey: 1980

Commercial Paddies

Field	County	Variety	Brown Spot	Bacterial Leaf Streak	Anthracnose	Zonate Eyespot	Smut	Phaeoseptoria
			Symptom Severity					
1-1	Aitkin	Johnson	5	1	0	0	1	1
1-2	"	"	1	1	1	0	1	0
1-3	"	"	3	1	1	0	1	0
2-1	"	"	5	0	0	0	1	0
2-2	"	K2	7	0	0	0	1	0
3-1	"	"	1	1	1	1	1	0
4-1	"	mixed	5	1	1	1	1	0
5-1	"	K2	1	1	0	0	1	0
5-2	"	"	1	1	1	0	1	0
6-1	"	"	1	3	0	0	1	0
6-2	"	"	1	3	0	0	1	0
6-3	"	"	1	3	1	1	1	0
7-1	"	M1	3	1	1	0	1	0
8-1	Beltrami	K2	9	1	0	0	1	0
8-2	"	"	5	1	1	0	1	0
8-3	"	Johnson	3	1	0	0	1	0
8-4	"	"	3	1	0	0	1	1
9-1	"	"	3	1	0	0	1	0
9-2	"	"	3	1	0	0	1	0
10-1	"	Minnesota	1	1	0	0	1	1
11-1	Clearwater	Netum	1	1	0	0	1	0
11-2	"	Johnson	3	1	0	0	1	0
12-1	"	K2	3	1	0	0	1	0
13-1	Polk	"	1	1	0	0	1	0
13-2	"	"	1	1	0	0	1	0
	AVERAGE		2.8	1.2	0.3	0.1	1.0	0.1

Foliage Disease Survey: 1980

Natural Stands

Location	County	Brown Spot	Bacterial Leaf Streak	Anthracnose	Zonate Eyespot	Smut	Phaeoseptoria
Sandy River	Aitkin	1	1	1	0	1	1
Sandy Lake	Aitkin	1	0	1	0	1	1
Prairie River	Itasca	1	0	1	0	1	0
Mississippi River	Beltrami	1	0	1	0	1	1
Plantagenette Lake	Hubbard	1	1	1	0	1	0
Garfield	Hubbard	1	0	1	0	1	1
AVERAGE		1	0.3	1	0	1	0.7

Scoring system: 0= 0% of leaf area affected; 1= less than 1%, 3= 1-5%; 5= 5-25%; 7= 25-50%; 9= more than 50%.

Table 9. Reaction of Three Wild Rice Cultivars at Three Different Growth Stages to *Bipolaris oryzae*.

Cultivar	1st Exp. Growth Stage Seedling	1st Exp. Growth Stage Tillering	1st Exp. Growth Stage Flowering	2nd Exp. Growth Stage Seedling	2nd Exp. Growth Stage Tillering	2nd Exp. Growth Stage Flowering
Netum	S	S	S	S	S	S
K2	S	S	S	S	S	S
Johnson	S/VS	S/VS	S	S/VS	S/VS	S /VS

TABLE 10. Reaction of three wild rice cultivars at three growing stages to <u>Drechslera gigantea</u>.

Variety	1st Expt. Growth Stage			2nd Expt. Growth Stage		
	Seedling	Tillering	Flowering	Seedling	Tillering	Flowering
Netum	S	S	S	S	S	S
K2	S	S	S	S	S	S
Johnson	S/VS	S/VS	S/VS	S	S/VS	S/VS

Notes:

- Johnson cultivars showed two types of lesion, typical Zonate eye spot and "JB" lesions.
- S: Susceptible reaction: infected plants showed typical zonate eyespot symptoms.
- VS: Very susceptible reaction; infected plants showed large tan "JB" symptoms.

Table 11. Host Range of *Drechslera gigantea*

No.	Scientific Name	Common Name	Cultivar	Reaction
1.	*Triticum aestivum*	wheat	Angus	-
2.	*Avena sativa*	oats	Lodi	i
3.	*Hordeum vulgare*	barley	Morex	-
4.	*Zea mays*	corn	Golden Cross Bantam	-
5.	*Sorghum vulgare*	sorghum	Bugoff	-
6.	*Oryza sativa*	rice	Starbonnet	-
7.	*Zizania aquatica*	wild rice	Netum	+
8.	*Z. latifolia*	Asian wild rice	N/A	-
9.	*Zizaniopsis miliacea*	Southern wild rice	N/A	-
10.	*Phalaris arundinacea*	reed canary grass	Rise	+
11.	*Setaria glauca*	yellow foxtail	N/A	-
12.	*Echinochloa crus-galli*	barnyard grass	N/A	-
13.	*Agropyron repens*	quack grass	N/A	+
14.	*Bromus inermis*	brome grass	N/A	+
15.	*Digitaria* sp.	crab grass	N/A	-

Notes: i = immune, - = tiny non-sporulating lesions, + = well developed and sporulating lesions.

TABLE 12. The efficacy of five fungicides to control *Drechslera gigantea*.

Fungicides	Concentration	Diverse Severity 1st Exp.	2nd Exp.
Kocide 77 wp	2.4 g/1	1.08 *	1.44^{ns}
Benlate 50 wp.	1.2 g/1	1.00 *	3.17^{ns}
CGA - 64250	0.6 ml/1	0.50 *	0.78 *
Bravo 500	3.07 ml/1	0.08 *	0.11 *
Dithane M45	2.4 g/1	1.25 *	0.67 *
Control	-	2.33	2.44

Notes: In the first experiment the plants were sprayed with 10cc/pot fungicide and inoculated with 15cc spore suspension, while in the second experiment the test plants were sprayed with 20cc/pot of a fungicide and inoculated with 25cc/pot spore suspension.

- *significant at 1% level of significance.
- N.S. not significant at 1% level of significance.

Wild Rice Breeding - 1980

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Agronomy and Plant Genetics

Changes in Personnel and Development of Facilities

The breeding project has had two research technicians. This arrangement was very useful during our spring and summer seasons but created a problem of efficiency during the late summer and winter. When one of the technicians resigned last April, I chose to not fill the position but rather combined the funds from that position with some miscellaneous help funds to create two additional Graduate Research positions. Mr. Boze started July 1980 and the third Graduate Research Assistant will arrive in July 1981. The Department believes that this arrangement will result in a better use of research dollars. The graduate students have to replace the labor requirement of the former technician. However, they can additionally conduct useful research problems more or less independently. The net result should be that the breeding program will progress more rapidly in the years to come. Particularly, we should be able to better develop the scientific information on research problems that will eventually permit more rapid and knowledgeable development of varieties.

We completed a new set of paddies at the Rosemount Experiment Station in the Spring of 1980. The paired paddies are each .25 acres in size and will be used alternately as is common with most of our research paddies. The construction bill amounted to some $10,000. and included cost of drilling an irrigation well to supply the water. While most of the money came from funds allotted to the wild rice breeding project, Dr. Clifford Wilcox did underwrite some of the expenses involved and we appreciate his interest in and support of the wild rice breeding program.

We have not netted the new paddies and still need to bury the irrigation pipes, but hope to complete these details by July 1. If funds are available we hope to build a small paddy in isolation from the larger paddies. Our expected development of facilities in the future will consist of developing a series of small (.05 to .1 acres) paddies in isolation. These are necessary to maintain experimental populations and develop necessary quantities of seed for testing. We used the first of the new paddies this year and were well pleased with its quality and the plant growth.

The paddies were designed by the Soil Conservation Service and the construction was supervised by Mr. Howard Moechnig of their Farmington Office. The quality of the paddies, I believe, reflects the careful input of the SCS. If the second paddy functions as well as the first, I believe we will have an excellent facility.

Progress in breeding for early maturity

The second cycle of mass selection for early flowering in K2 and M3 was completed in 1980. Seed from the first cycle of selection in K2 was spring planted at Grand Rapids. The 106 earliest flowering plants were selected out of approximately 2670 plants from cycle 1 selection in 1979 (4% selection). The selected plants were transplanted to an intermating box in isolation from other wild rice. Approximately 4700 seed were harvested to provide the second cycle population. The designations used in testing will be K2E-C1 and K2E-C2 for cycle 1 and cycle 2, respectively.

Seed from M3E-C1 were planted at Excelsior in the Spring of 1980. Stand counts at near flowering indicated approximately 1500 plants flowered. The 91 earliest flowering were selected and transplanted to an intermating box in isolation (6% selection). Approximately 6700 seed were harvested. The number of plants available for the selection experiment were reduced in M3E-C1 compared to K2E-C1 due to a significant number of shattering plants in the cycle 1 intermating box. These plants were discarded and only progeny from non-shattering plants were used for the second cycle of selection.

The first cycle of selection in M3 and K2 was evaluated in the advanced yield tests at Grand Rapids and Excelsior. Grand Rapids plots were fall seeded and Excelsior plots were spring seeded. Notes on flowering date were taken without knowledge of the genotype of the plot to prevent a bias in the decision of when a plot reached heading. We define heading date to be the date when 50% of the plants in a plot have at least the first floret visible in the boot.

Results of the experiment are presented in Table 1. The interesting comparisons are flowering date of K2E-C1 versus K2, M3E-C1 versus M3, and K2E-C1 and M3E-C1 compared to Netum. At both locations, the selected populations were earlier than their parent population. Based on this test, K2E-C1 and M3E-C1 do not equal the flowering date of Netum but we believe that significant progress has been achieved.

We hope that the second cycle of selection will result in populations of K2 and M3 which will equal or be somewhat earlier than Netum. Of course, an extensive evaluation of the selected populations will be required in order to substantiate that flowering date has changed. In addition, we hope that desirable attributes of the parent populations would not be lost during selection. Some information on harvest date and yield will be discussed in the next section.

Advanced yield trials

Advanced yield trials included plots of several experimental populations. These are included to obtain information on one or more traits of interest to us. At this stage of development, only K2 early is considered to be a possible varietal release within the next few years.

Four varieties and six experimental populations were fall seeded at Grand Rapids, October 1979, in 4-row plots with rows spaced 1 foot apart and 10 feet in length. Five replicates were planted. The four varieties and 5 experimental populations were spring seeded at Excelsior, May 1980, in 4-row plots, 12 feet in length. Emergence was slow at Grand Rapids and final stands were lower than we normally attain. At Excelsior the plots were even more variable in stand. Paddies were netted when the varieties neared maturity on the first

Table 1. Results of selection for early flowering in K2 and M3 after 1 cycle. Numbers are days after June 1, 1980.

Grand Rapids	K2	K2E-C1	M3	M3E-C1	Netum
Rep 1	37	25	35	30	25
2	37	26	33	30	22
3	33	25	34	27	23
4	36	26	35	26	24
5	38	25	33	25	22
AVE	36	25	34	28	23
Excelsior					
Rep 1	37	32	37	34	30
2	37	33	37	32	30
3	37	37	40	33	33
4	37	32	39	33	30
5	39	35	37	36	33
AVE	37	34	38	34	31

Averages within Grand Rapids or within Excelsior are significantly different if they exceed 2 days.

mainstems. The very early experimental population was damaged by birds at Excelsior and destroyed at Grand Rapids. The results of measurements of flowering date, harvest date, percent moisture at harvest, yield, and heads per plant, are presented in Tables 2 and 3.

The primary purpose of the trial this year was to start accumulation of data which must be available when and if a release decision is considered for an early version of K2. We are just as interested in an early M3 population, but some additional selection for uniformity of plant type and for shattering resistance will be necessary in M3. We already indicated that we believe the selected populations are earlier in flowering than the parent populations. We attempted to be very conscientious about harvest date this year because that is the important indicator of earliness. The travel problem prevents a careful adherence to a decision of when to harvest at Grand Rapids. If a plot is close to ready and we have to leave town, we will harvest then, rather than waiting another day or two. At Excelsior, we can wait until a plot is ready. Thus, the Excelsior harvest dates are probably slightly superior in uniformity. Those dates are likely to be a very conservative estimate of genetic differences since the spring planting and warmer summer temperatures tend to give more rapid growth and thereby diminish differences among genotypes. Uniformity of stage of harvest can be checked by moisture %.

At Grand Rapids, K2E-Cl was 11 days earlier in flowering than K2 and 8 days earlier in harvest date. The average moisture percent was 1.5% higher in K2E-Cl. Thus, we probably harvested a day or two earlier than we should have. In comparison to Netum, K2E-Cl was 2 days later than Netum at flowering and 3 days later at harvest. The Netum moisture percentage was 4.7% less, so probably the harvest maturity difference between Netum and K2E-Cl is greater than 3 days. For M3E in comparison to M3, flowering date was 6 days earlier but harvest date was only 1 day earlier. The moisture percentage difference was about 1%; thus I suspect that M3E-Cl is a day or two earlier in harvest date.

At Excelsior, K2E-Cl was 3 days earlier in flowering and 3 days earlier in harvest date compared to K2 and the average moisture percent at harvest was in the right direction. M3E-Cl was 4 days earlier at flowering and 2 days earlier at harvest compared to M3. Here the moisture percent difference suggests that the harvest dates are likely to be less than 2 days.

Please keep in mind that the first cycle of selection is only a transient population. We are really interested in the population resulting from the second cycle of selection. Also, we need to test the populations much more extensively than at just 2 locations. Since the seed supply is very limited, the 1981 results will not be definitive either. Nevertheless, we consider this year's results to be encouraging. The yield data on the selected populations is also encouraging. The Excelsior test was not a very good experiment because of highly variable stand densities. None of the entry yield differences show statistical significance. The Grand Rapids results are more in line with the types of difference we expect from our variety tests. At Grand Rapids, K2E-Cl compared to K2 (2103 versus 2135) and M3E-Cl compared to M3 (2359 versus 2447 pounds per acre) do not indicate that maturity selection has resulted in a significant change in

Table 2. 1980 Wild rice advanced yield trial results - Grand Rapids (5 reps)

Entry	Heading[1/] date	Harvest[1/] date	% Moisture	Adjusted[2/] yield (lb/A)	Heads per plant
K2	36	80	35.4	2135	6.7
K2E-C1	25	72	36.9	2103	7.0
Netum	23	69	32.2	1655	6.7
Net x K2E	26	71	36.6	2055	5.6
M3	34	78	38.5	2447	5.3
M3E-C1	28	77	37.6	2359	6.3
Net x M3E	25	77	37.8	2463	7.1
Johnson	37	81	36.6	1336	5.6
Prel. Early	18	59	28.6	1231	4.4
Dwarf[3/]	15	--	----	----	---

[1/] Expressed as days after June 1.

[2/] Expressed as pounds per acre of grain at 40% moisture (LSD (.05) = 475 #/A).

[3/] Destroyed by birds before paddy could be netted.

Table 3. 1980 Wild rice advanced yield trial results - Excelsior (6 reps)

Entry	Heading date[1/]	Harvest date[1/]	% Moisture	Adjusted yield (lb/A)[2/]	Heads per plant	Seed retention (gm)[3/]
K2	37	70	36.7	1319	7.3	144
K2E-C1	34	67	35.6	1373	7.1	134
Netum	31	66	33.8	1419	6.5	110
Net x K2E	34	68	35.2	1326	7.0	89
M3	38	73	31.9	1579	5.8	62
M3E-C1	34	71	34.0	1559	7.3	85
Johnson	42	77	34.3	1319	5.6	85
Prel. Early	25	63	30.1	1153	5.2	133
Dwarf	20	60	23.2	1153	3.7	128

[1/] Expressed as days after June 1.

[2/] Expressed as pounds per acre of grain at 40% moisture (LSD (.05) = 304 #/A). Differences in yield are not significant.

[3/] Measured by tensile strength meter in grams of pull. This should be considered with caution. Some differences are significant statistically (LSD .05 = 40).

yield. Our breeding objective, of course, is to develop an earlier version of K2 which will not be significantly lower in yield.

M3 Early will provide more of a challenge. The early version will be moved into a more detailed breeding procedure in which shattering resistance will be considered and in which we will select for uniformity of plant type. Based on our yield tests over the last four or five years, we believe that M3 is a higher yielding variety than K2. Given a more intensive breeding procedure, we expect to develop a high yielding, early, and reasonably uniform version of M3.

The yield comparisons of the varieties in the Grand Rapids trial follow more or less what we have seen in years past. The mean of the test was considerably higher than we anticipated. Additional nitrogen was applied at about emergence. That coupled with the lower stands probably resulted in increased tillering and thus good to excellent yields. The yield differences at Excelsior were not significant and thus should not be given much consideration.

Breeding for shattering resistance

Our efforts in breeding for shattering resistance have made use of a tensile strength meter to measure how much force is required to pull a seed from the plant. A host of technique problems have been involved and most of those have not been solved. Our present graduate research assistants have been working on the problem. Les Everett is conducting selection experiments for shattering resistance within Netum. A comparison of two methods of selection for reduced shattering was initiated in fall, 1979. The tensile strength meter is used to decide which plants should be selected. Les has now completed two cycles of single plant selection; the first cycle was completed in the greenhouse in the fall of 1979. The best 75 plants out of a population of 750 plants were selected and their seed bulked to form the first cycle population. These were planted in the greenhouse in the fall of 1980, and the best 50 plants out of 500 were selected. Their seed were bulked to form the second cycle population. This population will be grown and evaluated for shattering resistance in comparison to Netum next summer.

In his other procedure, Les evaluated 226 families, each derived from a single Netum plant out of Truman Sandland's 1979 Netum. Tensile strength was measured in our Excelsior paddy in 1980 on 5 seeds of each of 5 plants in each of the families. After the data were complete, he identified the best 26 families. From cold storage of remnant seed of those families, about 20 plants of each family were planted in the greenhouse in the fall of 1980 and they were intermated to form a selected population of Netum. Les obtained a good quantity of seed from these plants. An evaluation experiment will be grown in the summer, 1981, to evaluate shattering resistance in the second cycle of mass selection, the first cycle of half-sib selection, and Netum. From these experiments we expect to decide if we can make progress for shattering resistance using the tensile strength meter, and we should be able to evaluate the relative efficiency of mass selection versus half-sib selection. Mass selection is much easier but it is not as effective as half-sib selection when the character being measured is highly affected by the environment in which a plant is growing.

A major task for us is to show that in fact high tensile strength seed retention is directly related to field shattering resistance. Larry Boze will be working on this problem, or aspects of it, for his research problem. Larry conducted tensile strength measurements on border rows of the plots in our Excelsior advanced yield trial. He measured 5 seed on each of 5 plants in six replications of the nine entries in the test. A subjective evaluation of seed maturity is required to obtain reasonable data, since immature seeds are hard to pull from the plant, and seeds past maturity will fall from the plant when they are touched.

Usable data were obtained from 4 measurements on each of 4 plants in 5 of the six replicates. This is the first set of comparisons of shattering resistance we have obtained on several varieties in one common environment. Analysis indicated that some of the nine varieties differed significantly for mean seed retention. The results of the experiment are given as mean seed retention in grams of pull (Table 3). The data must be regarded as very preliminary. Only 20 plants were used to obtain the means. Nevertheless, the approach is statistically valid and the results are encouraging. They show that the varieties differ for seed retention as measured with the tensile strength meter. K2 had the largest seed retention and M3 the least. Preliminary Early, our Dwarf population and K2E-C1 all are close to K2. Netum is not statistically different from K2 but the difference is large.

The results also show that there is significant variation in seed retention (grams of pull) among plants within each of the entries. Therefore, we should be able to make genetic improvement for shattering resistance by selecting the better plants within a variety. Everett should be able to confirm this with his experiments this summer. K2 shows considerably less variation among plants than does K2E, Netum, our Dwarf population and our population called Preliminary Yield Early.

We need a better measure of shattering resistance than that provided by the tensile strength meter. We will have difficulty evaluating large numbers of plants satisfactorily with the meter. We would like to find a procedure which would quickly measure shattering on a whole plant. A major objective of Larry Boze's research will be to attempt to find a suitable procedure. I would like to see a mechanical device with a mild threshing action which would remove all the seed on a plant which is shattering and remove a considerably lesser amount of seed from a plant which is shattering resistant. Then whole plants could quickly be rated for shattering resistance. We expect to work with Dr. Cletus Schertz in devising an appropriate machine.

Miscellaneous Topics

Netum reselection

Periodically every wild rice variety must be reselected if varietal integrity is to be maintained. We selected some 460 single plants out of Netum grown on a new paddy on the Landreth farms. The resulting families were fall seeded at Rosemount and will undergo selection for maturity, uniformity of plant type and color and possibly shattering resistance and yield in subsequent years. The result may eventually be a new version of Netum.

Evaluation of the Dwarf population

We did not obtain good yield data on the Dwarf population in 1980. It was very early and was destroyed by the birds at Grand Rapids before the paddies were netted. It was damaged some at Excelsior. Another experiment to evaluate the Dwarf population was fall planted at Grand Rapids. Three planting densities were used at two levels of nitrogen. K2 and Netum were included as checks.

The population is very short and early. It flowered June 15 at Grand Rapids and June 20 at Excelsior compared to June 23 and July 1 for Netum at Grand Rapids and Excelsior respectively. It was several days earlier than Netum at harvest date. Both the short stature and the earliness suggest that it will be low yielding. We hope that a high planting density and high nitrogen might result in a useful yield level for an early variety. Our seed supply was limited so the tests may not be conclusive.

We crossed the Dwarf population with Johnson and are interested in attempting to select a medium height plant type that is medium to early in maturity. Two or 3 years of work will be involved before any results will be obtained in this objective.

Variety variance experiments

We evaluated 160 half-sib families of Netum, K2 and M3 at Grand Rapids and Excelsior in 1980. We took notes on family flowering date and collected seed samples from which seed measurements will be obtained. The seed measurements are not complete at this date. An important outcome of these experiments will be to evaluate the usefulness of the Excelsior nursery in breeding for early flowering types which will also be early in the northern rice growing areas.

Disease evaluation

We planted a large disease nursery consisting of some 400 families at Excelsior in 1980; the plots were inoculated by the Plant Pathology Project. A relatively uniform incidence of disease developed after the first inoculation with leaf blight organisms. Secondary infection, and thus an epidemic, did not occur at a level which would permit us to select for resistant or partially resistant plants. The pathologists expect to develop and make operational a misting system which may enhance the epidemic development of disease. Such a system would be very useful to the breeding project for our cooperative disease work with the pathologists.

The Pathology Project now has a workable inoculation system for development of disease in the greenhouse. This system may have merit in screening for disease differences among wild rice plants.

Development of nursery materials

We have been interested in developing populations of plants from which new or interesting plant types might be selected. We collected plants from White Elk Lake, Shovel Lake, Twenty Lake and Mallard Lake and transplanted them to our Excelsior Farm I paddy. Crosses were made with non-shattering plants. Netum was crossed to a source of rice from Big Rice Lake in the greenhouse in 1980, and Henry Schumer made crosses of Netum with plants from our Germplasm Pool population. Mr. David Holmbeck of Grand Rapids gave us seed from some sixteen different lakes in the fall of 1980 and these will be crossed to Netum during the spring of 1981. Progeny from all of these crosses will be grown in our genetic nursery in the summer of '81 and subsequent years. The primary objective, here, is to eventually select for non-shattering plants which have a greater genetic diversity of background than the K2, Netum, M3 and Johnson based materials with which we now work.

Acknowledgements

The cooperation of the Branch Experiment Stations is acknowledged and appreciated. Henry Schumer at Grand Rapids, Dave Sandstrom at Rosemount and Gerald Ochocki at the Fruit Farm at Excelsior have been our primary contacts. Our work would be severely limited without their help.

WILD RICE HARVEST STUDIES-1980

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The harvest studies in wild rice during 1980 were directed to 1) refinement of the combine discharge sample collector, 2) check-out of alternate processes for retrieving the lost grain from the combine discharge samples and 3) collecting and processing of combine discharge samples from two combines. An objective of the combine discharge sample collector is to incur only minimum interference to the harvest operation from which the sample is being collected. An objective of the combine discharge sample processing system is to accomplish the sample processing within a few hours of the time that the sample is collected. Summary observations are that the combine discharge sample collector is functioning satisfactorily. However, the processing of the combine discharge samples is inadequate.

Combine Discharge Sample Collector

The combine discharge sample collector was further refined this year to provide powered actuation of the collector bags (diapers). This was useful in insuring more accurate insertion and retraction of the collector bags at the beginning and ending of the sample distance than was possible with the manual rope control method used previously. The power actuation worked satisfactorily on the combine for which discharge samples were collected at Site I. Because of width limitations with rear wheels on the combine at Site II the previous manual rope control system was used with on-site modification of the width and location of the sticks for holding the sample bags. Also the tracks of the all terrain vehicle carrying the collector bags were modified to prevent the straw plugging and wrapping problem that was encountered in 1979.

Processing of the Combine Discharge Samples

Investigations were made for alternate methods of processing the combine discharge samples to retrieve the lost grain from the discharge samples.

In 1979 the main item used for processing the samples was a parked combine. This combine was used by feeding the samples directly to the cylinder and having a collector tray beneath the cylinder and walkers. Other processing devices were used to further clean the grain passing into the collecting tray. The use of the parked combine was considered more equipment than what was desired for the small samples involved.

The hand sorting of the heads was done, as in previous years, for assessing the threshing loss. However, due to the time involved for this activity, it is considered important that an alternate method be devised. Hand sorting not only is time consuming but is subjective and leads to arbitrary and inconsistent results.

For 1980, alternate on-site processing devices were tried with varying degrees of success. The sequence of devices used on the walker discharge samples was a specially built tumbler, a rotary screen, a fanner and an aspirator. The sieve discharge samples passed through the same devices with the exception of the tumbler because the size of the discharge sample was small enough to go directly to the rotary screen. The ranges of efficiencies of these devices for separating the lost grain from the walker discharge samples were 77 to 95%, 75 to 97%, 78 to 98% and 87 to 98% respectively. These levels of efficiencies are considered unsatisfactory because of the low level and especially because of the wide ranges which suggest inconsistencies.

A forced natural air batch dryer was used to partially dry the samples to facilitate separation of the lost grain from the discharge samples. Even with this partial drying, the efficiencies of these sample processing devices were lower than had been expected.

Observed Combine Performance

Combine discharge samples were collected and processed for two combines. These combines were at two different sites (I and II). The results of these tests are tabulated in Tables 1a, 1b, 2a, and 2b. The combine at Site I was equipped with a spiked tooth cylinder and concave and the combine at Site II was equipped with a raspbar cylinder and concave. This difference in combines is noted only for the accuracy of reporting the results. Care should be taken in attempting to make comparison between the two because of differences in a) location [southern wild rice growing region for Site I and northern wild rice growing region for Site II], b) wild rice variety, c) date of harvest, d) crop, weather and field conditions and e) other parameters of the harvest operation.

Tables 1a and 2a show the data available after the completion of the on-site processing of the discharge samples. The weights reported in these two tables were measured in the condition as coming from the combine and processing equipment. The grain was not dried to normalize the data. The net yield samples were weighed very shortly after harvest so those data are an accurate indicator. However, the weight of the grain in the various combine discharge samples were subject to the extent of drying from the time of collecting, through the time of processing and to the time of weighing. The time of processing did include some drying in the forced natural air batch dryer which was used on most of the samples.

Tables 1b and 2b show the data from final processing of the samples. For final processing of the grain lost in the combine discharge, the samples were dehulled, sorted for size greater than 2 1/2/64 inches diameter, dried to zero moisture, weighed and calculated as the equivalent weight at 7%M wet basis. The data tabulated in Tables 1b and 2b show results of processing for only that wild rice which was retrieved by the on-site processing equipment. There was no correction made to adjust the data for the inefficiencies of the on-site processing equipment.

Some observations from the data of these tables are:

1. The discharge loss levels are very low. As a group these are the lowest that have been measured and reported in wild rice harvest. Data from other years' research show combine discharge losses in the 10 to 30% range to be more typical. Reasons for the low combine discharge loss this year are not clear. The unique characteristics of crop and/or combine(s) for this year are not understood.

2. Changing the speed of travel (runs 103, 4, 5, and 6) had little influence on the discharge losses.

3. Opening the top sieve (run 107-109 and 401-409) reduced the sieve losses.

4. For the combine at Site I the material other than grain (MOG) over the sieve ranged from 10 to 20% of the MOG over the walkers.

5. For the combine at Site II the MOG over the sieves ranged much less than 10% of the MOG over the walkers.

6. Opening the top sieve (runs 107 and 108) decreased sieve loss and decreased recovery percentage by 2.4 percentage points.

7. Opening of the lower sieve (run 108 and 109) decreased walker loss and decreased the recovery percentage only an additional .7 percentage points.

8. Opening the top sieve (run 107 and 108) increased tailings return rate whereas opening the lower sieve (runs 108 and 109) decreased the tailings return rate.

9. Opening the top sieve (runs 404-406 vs 401-403) decreased sieve loss and decreased recovery percentage by 2.6 percentage points.

10. Opening the lower sieve (runs 407-409 vs 401-403) decreased walker losses and decreased recovery percentage points an additional 2.4 percentage points.

11. Data available from on-site processing of samples are indicative of the final result after final processing.

12. On-site quantifying of the data for threshing loss was not attempted except to sort the wild rice heads out of the walker discharge samples to prevent that grain from appearing as walker loss. These samples of wild rice heads are processed at a later time to retrieve the wild rice kernels which is threshing loss.

Because the combine at Site II was equipped with a raspbar cylinder and concave, an evaluation of the damage to the wild rice kernels was of special interest. The results, from processing plant grading of several thousand pounds of wild rice which had come from a combine with raspbar cylinder and concave, showed that 8.4% of the weight of processed rice was graded as broken. The criteria for grading as broken was based on the length being 20/64 (5/16) inch or shorter. It was judged that this is about the average, for percent brokens, for all wild rice the processing plant had processed this past season.

Table 1a Data available at time of completion of on-site processing of samples for Site I.

Run No. 80-	Travel speed MPH	Sieve opening in 1/16 in. Upper Front	Upper Rear	Lower	Tailings Rate lb/min	Mat'l other than grain (MOG) Over Walker lb/min	Over Sieve lb/min	Net Yield Green lb/ac	Discharge losses[a] Walker lb/ac	Sieve lb/ac	Notes
101	2.3	8	8	8	NA	224	28.3	760	14.1	27.4	b
102	2.4	↓	↓	↓	NA	214	42.0	746	13.9	28.7	
103	2.4	8	8	8	3.1	110	22.7	585	3.6	5.6	c
104	2.1	↓	↓	↓	4.2	106	18.4	536	4.2	4.9	
105	1.7				2.8	108	20.2	555	4.3	4.2	
106	2.9				9.6	151	17.5	536	3.5	4.3	
107	2.4	8	8	8	1.7	167	28.7	651	6.1	10.7	d
108	2.4	12	12	8	4.5	213	20.6	667	7.5	5.7	
109	2.4	12	12	12	3.0	218	16.8	700	6.7	5.4	

a) Weight in condition at completion of on-site processing (not dried, not dehulled).

b) Shakedown runs to check out procedure for collecting and processing the samples.

c) Variations in travel speed for adjacent passes with combine.

d) Variations in sieve openings for adjacent passes with combine.

Table 1b. Data from final processing of samples for Site I.

Run No. 80-	Travel Speed MPH	Sieve Opening in 1/16 in. Upper Front	Upper Rear	Lower	Mat'l other than grain (MOG) Over Walker lb/min	Over Sieve lb/min	Net Yield % Moist.	% Rec.	lb @ 7%M wb /ac	Discharge Losses[a] Thresh-ing loss % of net	Walker loss %of Net	Sieve loss % of net	Notes
101	2.3	8	8	8	224	28.3	42	44.9	341	2.7	1.1	2.2	b
102	2.4	↓	↓	↓	214	42.0	41	45.7	341	2.2	1.4	3.0	b
103	2.4	8	8	8	110	22.7	40	47.7	279	1.1	0.4	0.8	c
104	2.1	↓	↓	↓	106	18.4	36	49.0	263	1.0	0.5	0.8	c
105	1.7	↓	↓	↓	108	20.2	40	47.1	262	0.8	0.7	0.6	c
106	2.9	↓	↓	↓	151	17.5	37	50.9	273	1.1	0.6	0.6	c
107	2.4	8	8	8	167	28.7	41	43.3	281	2.0	0.7	1.5	d
108	2.4	12	12	8	213	20.6	43	40.9	273	2.5	1.1	0.8	d
109	2.4	12	12	12	218	16.8	42	40.2	281	2.8	0.8	0.6	d

a) Samples were dehulled, sorted for greater than 2 1/2/64 inch diameter, dried weighed and calculated at 7%Mwb.

b) Shakedown runs to check out procedure for collecting and processing the samples.

c) Variations in travel speed for adjacent passes with combine.

d) Variations in sieve openings for adjacent passes with combine.

Table 2a Data available at time of completion of on-site processing of samples for Site II.

Run No. 80-	Travel Speed MPH	Sieve opening in 1/16 in. Upper Front	Upper Rear	Lower	Tailings Rate lb/min	Mat'l other than grain (MOG) Over Walker lb/min	Over Sieve lb/min	Net Yield Green lb/ac	Discharge Losses [a] Walker lb/ac	Sieve lb/ac	Notes
201	2.2	Not recorded			NA	52	3.8	664		3.0	b
202	2.2	↓	↓	↓	NA	174	15.5	885		90.5	
203	2.3				NA	177	14.8	803		75.7	
401	2.8	11	11	6	NA	162	nil	324	16.0	nil	c1
402	2.0	↓	↓	↓	NA	196	2.1	931	16.5	1.8	
403	2.6				NA	176	4.4	713	9.2	1.1	
404	2.8	8	11	6	NA	247	11.1	407	23.4	14.2	c2
405	1.8	↓	↓	↓	NA	155	5.5	917	10.1	22.5	
406	2.4				NA	199	9.0	849	12.5	20.4	
407	2.2	11	11	12	NA	131	2.5	509	16.2	1.1	c3
408	2.0	↓	↓	↓	NA	201	3.2	781	16.6	3.1	
409	2.0				NA	148	2.1	836	9.8	1.2	

a) Weight in condition at completion of on-site processing (not dried, not dehulled).

b) Shake down runs to check out procedure for collecting and processing the samples.

c1, c2, c3) Replicated runs in each group with indicated variations in sieve openings. Attempted to hold other parameters fixed.
Each group of three were in sequence in a single pass with the combine and spaced a few hundred feet apart. Runs 401, 2 & 3 were adjacent to runs 404, 5 & 6 respectively, which were adjacent to runs 407, 8 & 9 respectively.

Table 2b. Data from final processing of samples for Site II.

Run No. 80-	Travel Speed MPH	Sieve Opening in 1/16 in.			Mat'l other than grain (MOG)		Net Yield			Discharge Losses [a]			Notes
		Upper Front	Upper Rear	Lower	Over Walker lb/min	Over Sieve lb/min	% Moist.	% Rec.	lb @ 7%M wb /ac	Threshing % of Net	Walker % of Net	Sieve % of Net	
201	2.2	Not recorded			52	3.8	38	51.5	342			1.6	b
202	2.2	↓	↓	↓	174	15.5	39	50.4	446			43.7	b
203	2.3	↓	↓	↓	177	14.8	39	51.1	410			37.4	b
401	2.8	11	11	6	162	nil	39	46.3	150	6.4	5.9	nil	c1
402	2.0	↓	↓	↓	196	2.1	40	46.3	431	4.4	1.5	0.2	c1
403	2.6	↓	↓	↓	176	4.4	38	48.6	347	4.0	1.2	0.1	c1
404	2.8	8	11	6	247	11.1	38	49.3	201	4.9	6.6	3.4	c2
405	1.8	↓	↓	↓	155	5.5	38	49.4	453	4.4	1.0	2.5	c2
406	2.4	↓	↓	↓	199	9.0	37	50.5	429	2.5	1.4	2.5	c2
407	2.2	11	11	12	131	2.5	40	43.5	222	3.8	3.9	0.2	c3
408	2.0	↓	↓	↓	201	3.2	39	44.9	351	8.3	2.1	0.4	c3
409	2.0	↓	↓	↓	148	2.1	37	48.9	409	1.8	1.1	0.1	c3

a) Samples were dehulled, sorted for greater than 2 1/2/64 inch diameter, dried, weighed and calculated at 7%Mwb.

b) Shake down runs to check out procedure for collecting and processing the samples.

c1, c2, c3) Replicated runs in each group with indicated variations in sieve openings. Attempted to hold other parameters fixed.
Each group of three were in sequence in a single pass with the combine and spaced a few hundred feet apart. Runs 401, 2 & 3 were adjacent to runs 404, 5 & 6 respectively, which were adjacent to runs 407, 8 & 9 respectively.

PROCESSING STUDIES

John Strait, J. J. Boedicker

Processing studies conducted during 1980 were almost entirely directed toward the development of a new and improved parching system featuring a continuous flow mode of operation and a parching medium consisting of a mixture of heated air and superheated steam.

Research continued with the laboratory scale batch parcher reported on briefly in last year's research report. The parcher was described as using heated air. It is equipped with a rotating drum covered with 12 x 12 mesh woven wire rotating at about 20 revolutions per minutes. The drum is enclosed in what amounts to an air tight chamber. A supply duct with electric heating elements receives air from the fan for passage over the drum. A return duct from the drum chamber to the fan inlet provides a circuit for continuous recirculation of the air. A damper in the return duct can be used to adjust the rate of airflow. A thermostat in the heater circuit regulates the temperature of the air to a preset volume. The drum can be charged with up to five pounds of green wild rice. A small steam generator was added to supply a moderate flow of steam to the return duct. The recirculating parching medium consists of a mixture of air and steam derived from the steam generator and the water evaporated from the wild rice.

Results of tests from the batch parcher described above can be summarized as follows:

1) Hulling efficiency was excellent. Values of about 1% unhulled kernels were typical.

2) Broken kernels for a typical good run would be about 5%.

3) If the finished rice was examined microscopically the same day or the day after parching, 75 to 80% of the finished rice by weight would consist of what we term sound whole kernels. These are kernels not broken and no stress cracks can be found when examined under the microscope. If however, the rice is re-examined a week or two after parching late developing stress cracks will be found in many of the kernels and the percentage of sound whole kernels may have dropped to the range of 40 to 60%.

4) Increasing the temperature and decreasing the flow rate of the parching medium to the drum, adding steam from the steam generator, and steaming the rice prior to parching appeared to have beneficial influences upon the process.

Continuous Flow Parcher

Utilizing the concept of the batch unit as well as the experimental data derived from it, a laboratory scale continuous flow parcher was completed and test runs were started by mid-summer. A review of the data from the batch dryer indicated that some of the best results were obtained when the temperature of the parching medium was 320° leaving the heating elements and the flow rate was approximately 50 cfm. These conditions had resulted in a parching time of about 40 minutes. These values were used as the basis for the design of the continuous flow unit.

The continuous flow parching unit is shown schematically in Figure 1. It has 3 conveyor belts on which the rice is supported in a layer about 1 inch in thickness and through which air can pass. The conveyor pulleys are 3 feet between centers and the conveyors have an effective operating width of about 6 inches. The variable speed conveyor drive is arranged for a nominal drying time of 40 minutes. A feeder mechanism delivers a uniform thickness of green wild rice to the inlet air lock which in turn drops the rice onto the upper conveyor belt. The wild rice is dropped from the upper to the center conveyor and then onto the lower conveyor as it passes through the parcher. The lower conveyor discharges into an outlet air lock which provides a sealed exit from the parcher. A fan operating in cooperation with a supply duct and a return duct provides for continuous recirculation of the parching medium. Paddle type agitators within the parching compartment agitates the parching medium to provide for more uniform exposure of the rice kernels to the parching medium. A steam generator provides a moderate quantity of steam to the return duct in the recirculating system. Thermostatically controlled heating coils in the supply duct downstream from the fan maintains the temperature of the parching medium entering the conveyor compartment to the desired preset value. Once equilibrium has been achieved the parching medium consists primarily of superheated steam.

When the conveyor belts are supplied with a thickness of wild rice of approximately one inch the laboratory parcher has a capacity of about 15 pounds of green wild rice per hour. We have operated the parcher with a one and one-half inch layer and observed no significant change in its performance.

Results of Test Runs

Forty-one test runs have been completed with the continuous flow parcher in the laboratory. Various combinations of parching medium temperature and flow rates have been used in combination with different treatments of the wild rice prior to parching. Table 1 shows the results of some typical test runs with the continuous flow parcher. These runs were selected for inclusion in this report because they cover a range of wild rice varieties and treatments prior to parching. From the test data presented therein and from a study of the remaining test runs some general conclusions regarding trends can be formulated. Higher parching temperatures and resulting lower moisture contents of the finished rice seem to be desirable as was indicated with the batch unit. Hulling efficiency is excellent as indicated from the data and kernel breakage appears to be within acceptable limits. It appears that there may be genetic factors which have an influence upon the processing characteristics of wild rice. All our test data show that the percentage of sound whole kernels for all treatments decreased with lapsed time following parching.

Late Developing Stress Cracks

The occurrence of late developing stress cracks after parching and during storage remains a problem on which we intend to do further research. This is not a phenomenon that is limited to our parching procedures but according to limited data which we have collected is presently occurring with what might be termed conventional processing procedures. We have tried various post-parching treatments on a limited basis which indicates that the occurrence of these late developing stress cracks can be significantly reduced by temperatures common to the ordinary household refrigerator or approximately 35° F. The figures presented in Table 1 with regards to the percentage of sound whole kernels being reduced by late developing stress cracks are a result of microscopic examination on a very critical basis. Kernels are counted as having stress cracks even though a very minor and likely insignificant crack can be detected. It is difficult to predict the significance of these late developing stress cracks. Certainly any stress crack will predispose that kernel to breakage if it is stressed. However, as the data indicates, the rougher processing operations such as hulling and scarifying would normally have been completed before the late developing stress cracks occur and therefore perhaps a relatively small percentage of these stress cracked kernels would ultimately be broken.

Excess Moisture Reduction

Our laboratory studies have shown that a low final moisture content of the finished rice is desirable from the standpoint of reducing broken kernels and increasing hulling efficiency. It is also the best way that we know of at this time to minimize the occurrence of late developing stress cracks by variations in the parching operation. Of course, the major disadvantage of removing moisture in excess of that required for safe keeping of the product is the apparent weight loss involved. We have done some experiments involving the direct addition of water to the wild rice prior to storage and it appears that such a procedure may possibly be feasible. The addition of water to increase the moisture content appears to decrease the percentage of sound whole kernels and tends to reduce kernel strength. These influences seem to be more pronounced at room temperatures of about 70° and are reduced by lower temperature storage.

Plans for a Continuous Flow Prototype Parcher

We are presently proceeding with a design of a prototype of our laboratory continuous flow parcher which we expect to have in operation this fall with the 1981 crop. The parcher will have a design capacity conservatively estimated at 1000 pounds of green rice per hour. It will be basically a scaled-up version of the laboratory parcher. It will have 3 conveyor belts 4 feet in width and 24 feet between the head and tail pulleys. The fan will have a capacity of up to 20,000 cfm but will be equipped with a variable speed drive for experimental work with reduced quantities of the parching medium. There will be a propane fired heat exchanger with an output rating of about 1 million BTUs per hour. The burner will be equipped with a modulating control on the gas supply and the temperature of the parching medium will be thermostatically controlled. A steam generator will not be required since the water evaporated from the wild rice will provide an ample supply of steam. As with the laboratory unit when equilibrium operating conditions are reached, the parching medium will be predominantly superheated steam. Provisions will be made for all systems of the parcher to be varied in their operating characteristics for experimental purposes.

Table 1: Data and results from selected test runs with the continuous flow parcher.

Run #	Wild Rice to Parcher	Treatment	Date Processed	Set Temp, ° F	Moisture Content Initial, %	Moisture Content Final, %	Finished Rice Broken, %	Finished Rice Unhulled, %	Sound Whole Kernels Date	Sound Whole Kernels %
CF26	K-2 1979 unseparated	Frozen	6/27/80	350	44.50	2.54	5.87	1.60	6/28/80 9/19/80	71.62 57.51
CF6	K-2 1979 unseparated	Frozen	8/4/80	275	44.05	4.24	2.49	2.83	8/5/80 9/18/80	78.14 40.70
CF12	Netum 1980 medium	Fresh	8/21/80	295	45.82	2.82	11.15	1.06	8/22/80 9/19/80	79.19 64.38
CF17	K-2 1980 medium	Steamed	8/26/80	295	41.61	3.01	4.42	1.05	8/29/80 9/19/80	77/98 43.53
CF27	K-2 1980 heavy	Fermented	9/10/80	295	40.54	4.10	9.01	.75	9/12/80 9/22/80	77.19 55.60
CF32	Johnson 1980	Fermented	10/23/80	295		3.48	7.32	1.09	10/24/80 11/21/80	88.19 64.55
CF33	Ontario Lake Rice 1980	Fermented	10/23/80	295	49.39	4.51	8.25	.58	10/24/80 11/21/80	87.93 75.30
CF40	K-2 1980 medium	Frozen	12/23/80	295	41.60	4.13	8.32	1.92	12/24/80 1/5/81	76.70 54.27
	Ontario Lake Rice 1980	Fresh	9/11/80	295	34.19	4.69	1.49	.39	9/12/80 12/31/80	96.82 83.28

Figure 1. Schematic of laboratory-scale continuous flow parcher.