Minnesota Wild Rice Research 1978

Agricultural Experiment Station
University of Minnesota
St. Paul, Minnesota 55108
January 17, 1979

CONTENTS

Page

Wild Rice Fertilization Research - J. Grava and O. Koski; Department of Soil Science 1

Wild Rice Production and Seed Research - E. A. Oelke; Department of Agronomy and Plant Genetics. 23

Wild Rice Breeding Research - R. E. Stucker; Department of Agronomy and Plant Genetics. 53

Wild Rice Disease Research - J. A. Percich, L. L. Nickelson, T. J. Arlt, and R. Bowden; Department of Plant Pathology. 63

Summary of Research on Wild Rice Insects - A. G. Peterson and P. Hanson; Department of Entomology, Fisheries, and Wildlife 81

Harvest Studies - Raspbars, Tailings and Stripping - C. E. Schertz, W. Chinsuwan and J. J. Boedicker; Department of Agricultural Engineering 87

Processing Studies - J. Strait, S. Schenk, and J. J. Boedicker; Department of Agricultural Engineering. 93

Much of the research reported here is preliminary, thus the results should be interpreted with caution. Results 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 Drs. Matalamaki (deceased) and Rust, former Superintendent and acting Superintendent of North Central Experiment Station, Grand Rapids, respectively, 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.

WILD RICE FERTILIZATION RESEARCH - 1978

A PROGRESS REPORT
January 4, 1979

John Grava and Owney Koski
Department of Soil Science
University of Minnesota
St. Paul, Minnesota 55108

Research was continued during 1978 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. Nitrogen rate studies were conducted on a mineral soil at Grand Rapids with two varieties in first production year, and with three varieties in third production year. Three fertilization experiments were established on peat with a first year stand in Aitkin County to study N, P, K rates, and the effectiveness of foliar fertilization. Tissue samples were collected for plant analysis to learn more about nutrient uptake by the plant.

A. WEATHER AND PLANT DEVELOPMENT

The average air temperature (table 1) was nearly 5°F above normal in May. During the main part of the growing season, air temperature was nearly normal. Heavy rainfall on August 22-23 made harvesting in the Aitkin area difficult.

Soil, water and air temperatures were measured at two locations by 3-point automatic sensing and recording thermographs (Fig. 1,2). The measurement of soil temperature at the Aitkin County location was discontinued after mid-May because of instrument malfunction. The air and water temperatures fluctuated much more than the soil temperature.

Plants emerged on May 8 in Aitkin County and on May 15 at Grand Rapids (Fig. 3,4,5). The jointing stage was reached by Netum on June 29, 45 days after emergence, and by K2 about a week later, on July 6. Netum was harvested at Grand Rapids on August 23, 100 days after emergence, and the K2 variety was harvested a week later. In Aitkin County, K2 wild rice was ready for harvest 108 days after emergence.

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

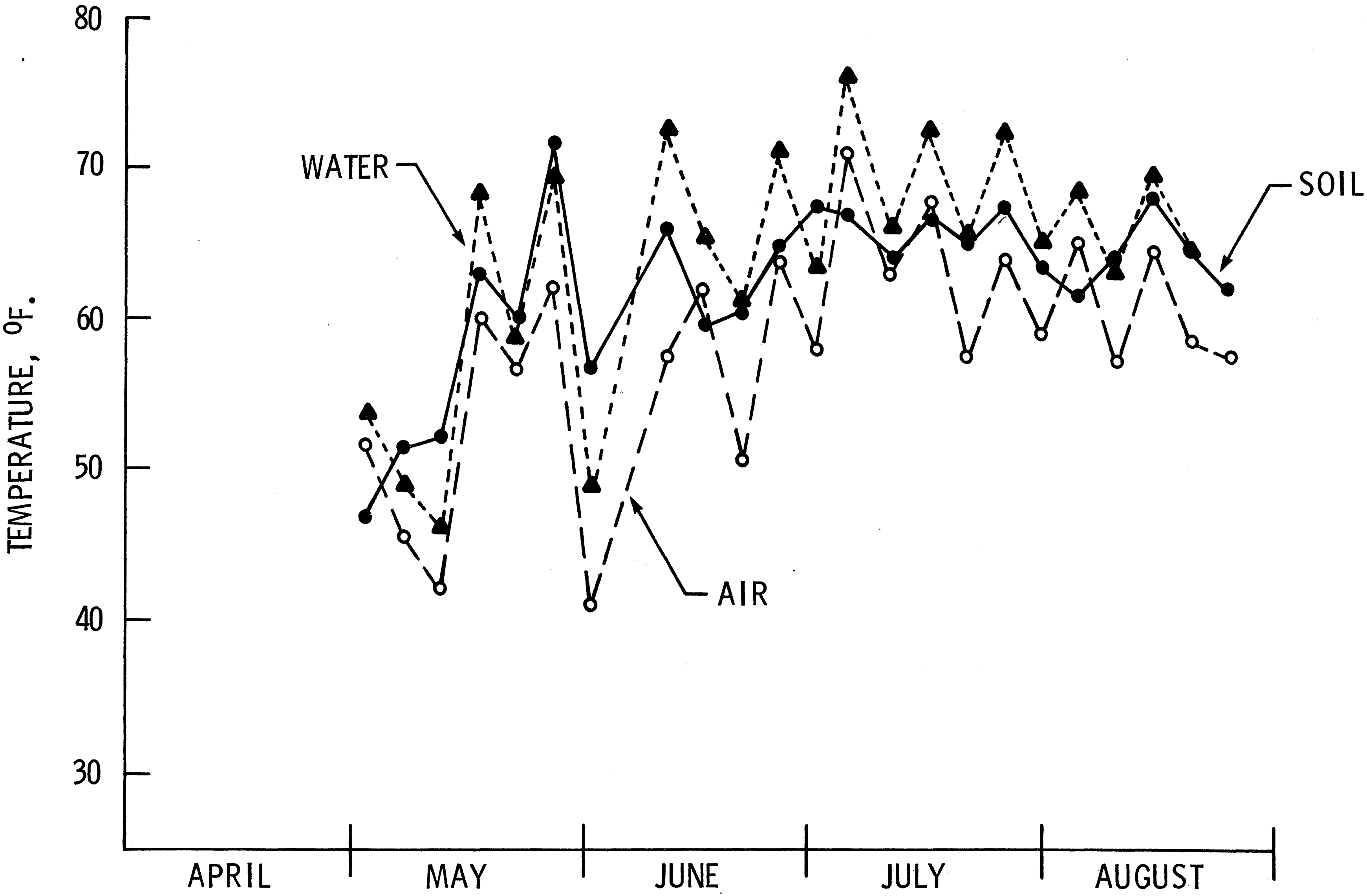
Station Year	April	May	June	July	August	5 Month Average	GDD T_b=40
	Month						
	---------average air temperature, °F---------						
Fosston, Polk Co.							
Normal[2/]	41.0	54.6	63.6	69.4	67.5	59.2	2955
1974	41.0	50.5	63.4	71.6	62.8	57.9	2744
1975	34.8	55.7	61.9	70.5	64.6	57.5	2852
1976	46.6	54.9	66.8	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
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
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

1/ Source: Climatological Data, Minnesota, Vol. 80, 81, 82, 83, 84 (1974-78), U.S. Dept. of Commerce.

2/ Normals for the period 1931-60.

3/ M = less than 10 days record missing.

FIG. 1 MEAN AIR, WATER, AND SOIL TEMPERATURES GRAND RAPIDS - 1978



IG. 2 MEAN AIR, WATER, AND SOIL TEMPERATURES KOSBAU BROS., AITKIN COUNTY - 1978

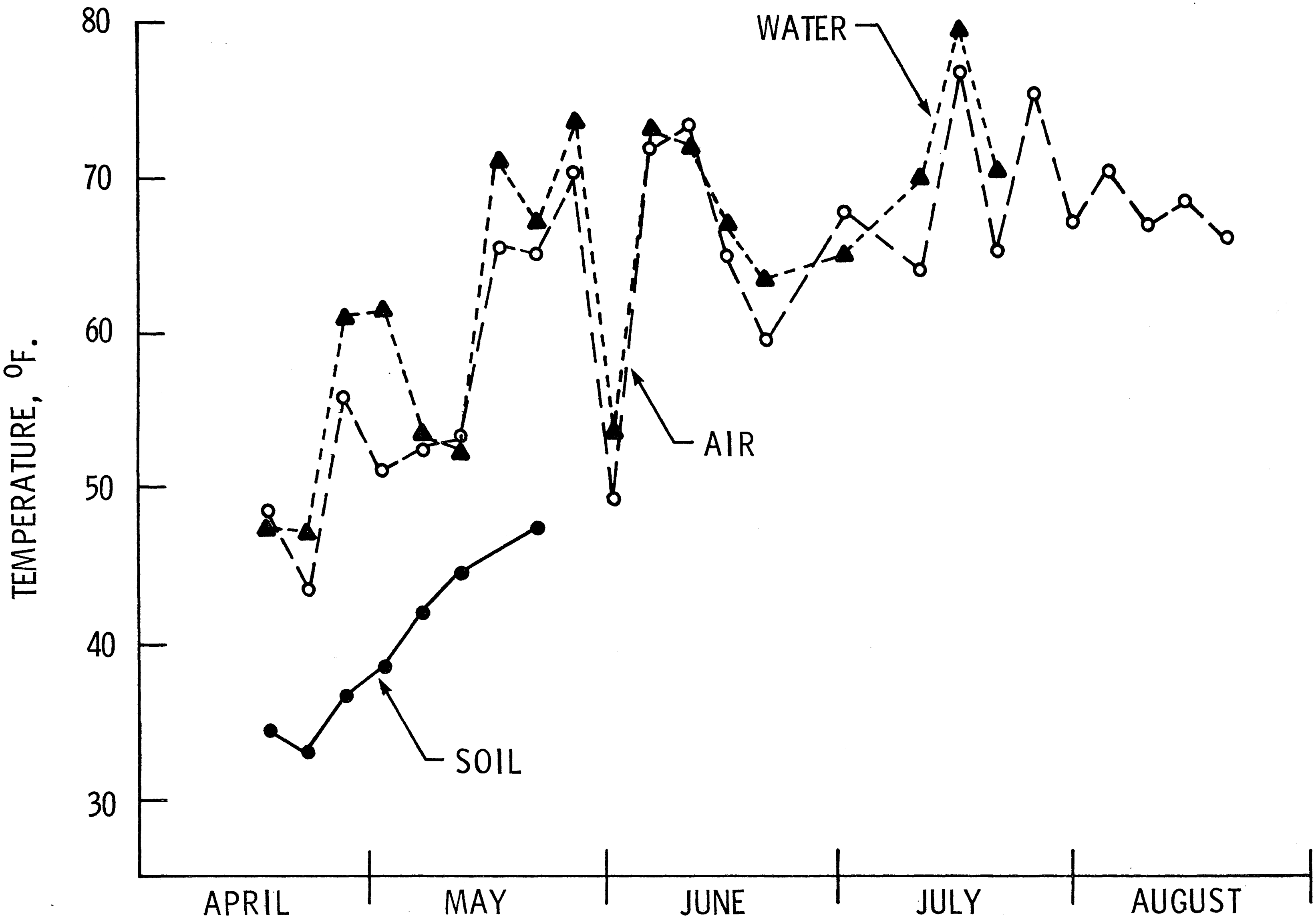


FIG. 3

WILD RICE DEVELOPMENT
NETUM VARIETY, GRAND RAPIDS, 1978

	STAGES OF DEVELOPMENT	DAYS	DATE
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY
	FLOATING LEAF	9	
	2ND AERIAL LEAF	19	JUNE
	EARLY TILLERING	29	
REPRODUCTIVE GROWTH PHASE	JOINTING	45	
	EARLY FLOWERING	64	JULY
	LATE FLOWERING	80	AUGUST
	MATURITY	100	

FIG. 4

WILD RICE DEVELOPMENT
K2 VARIETY, GRAND RAPIDS, 1978

	STAGES OF DEVELOPMENT	DAYS	DATE
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY
	FLOATING LEAF	9	
	2ND AERIAL LEAF	19	JUNE
	EARLY TILLERING	29	
	TILLERING	45	
REPRODUCTIVE GROWTH PHASE	JOINTING	53	JULY
	EARLY FLOWERING	64	
	MID FLOWERING	80	AUGUST
	LATE FLOWERING	86	
	MATURITY	106	

FIG. 5

WILD RICE DEVELOPMENT
K2 VARIETY, KOSBAU BROS., AITKIN CO., 1978

Phase	STAGES OF DEVELOPMENT	DAYS	DATE
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY
	FLOATING LEAF	17	
	2ND AERIAL LEAF	31	JUNE
	EARLY TILLERING	37	
REPRODUCTIVE GROWTH PHASE	JOINTING	55	JULY
	BOOT	63	
	EARLY FLOWERING	71	
	MID FLOWERING	79	
	EARLY GRAIN FORMATION	93	AUGUST
	MATURITY	108	

B. CHEMICAL CHARACTERISTICS OF PADDY WATER

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

Water samples were collected from several sites at three different paddy locations during the 1978 growing season. At Grand Rapids, samples were collected from two experimental paddies used for N rate studies on a mineral soil. Source of water is the Prairie River. Water was also sampled at two sites within Kosbau Bros. paddies in Aitkin County. Paddies at this location derived water from the Little Willow River via a diversion ditch. One sampling site was located at the beginning of the diversion ditch, near the river; the other site was within a paddy in which three fertilization trials were conducted. The third sampling location was in the Gunvalson and Imle paddies near Gully. These paddies derived water from the Clearwater River.

Water samples were collected and stored in 250 ml polyethylene bottles. After the determination of pH and conductivity, a preservative was added (2 ml of 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 of water are given in tables 2, 3, and 4.

Table 2. Chemical composition of water collected from wild rice paddies during 1978 growing season. Location: Grand Rapids

Sample Number	Sampling Date	Location	pH	Cond. milli-mhos/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
6	5/10	PR	6.6	.12	52	52.8	0.7	0.04	<.1	0.11	0.02	<2.0	14.4	4.1	1.9
7	"	EP #1	6.8	.10	42	42.6	0.7	0.08	<.1	0.12	0.02	2.0+	11.3	3.5	1.4
8	"	EP #6	6.7	.11	42	44.9	1.0	0.08	<.1	0.01	0.01	<2.0	11.9	3.7	1.5
13	5/18	EP #1	6.4	.14			1.1			0.12					1.7
14	"	EP #6	6.5	.13			1.1			0.07					1.4
15	"	PR	6.6	.15			0.8			0.05					1.2
20	5/30	PR	6.2	.14			0.2			<0.01					1.3
21	"	EP #1	6.5	.11			0.2			<0.01					1.0
22	"	EP #6	6.6	.13			0.2			<0.01					1.2
26	6/8	EP #1	6.0	.10			0.8			0.16					1.5
27	"	EP #6	6.3	.13			0.7			0.06					1.3
28	"	PR	6.5	.13			0.6			0.04					1.1
31	6/14	EP #1	7.1*	.10			1.7			0.21					1.2
32	"	EP #6	7.3*	.09			0.8			0.06					1.0
33	"	PR	7.1*	.12			0.7			0.04					1.1
38	6/28	EP #1	7.0				2.1			0.05					1.0
39	"	EP #6	7.3				1.9			0.02					1.7
40	"	PR	7.3				1.9			0.07					1.8
45	7/11	EP #1	7.3	.06			0.9			0.11					0.4
46	"	EP #6	7.0	.13			0.9			0.03					1.2
47	"	PR	6.9	.14			1.8			0.03					1.3
52	8/23	EP #1		.12	30	48.3	0.9	<0.1	<0.1	0.08	0.07	1.3	11.50	4.93	2.96
53	"	EP #6		.11	46	47.9	0.7	0.2	<0.1	0.10	0.05	1.8	12.46	3.97	2.96
54	"	PR		.16	70	75.7	0.8	<0.1	<0.1	0.23	0.06	2.8	20.51	5.70	.72

* pH tested in lab - late afternoon 6/14
\+ ppm sulfate-S x 3 = ppm sulfate (SO_4)

Abbreviations and description of sampling sites at Grand Rapids

- PR — Prairie River
- EP #1 — Experimental Paddy #1, 3rd year stand
- EP #6 — Experimental Paddy #6, 1st year stand

Table 3. Chemical composition of water collected from wild rice paddies during 1978 growing season. Location: Kosbau Bros., Aitkin Co.

Sample Number	Sampling Date	Location	pH	Cond. milli-mhos/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
1	4/17	DD	7.3	.12	49	52.9	0.8	0.03	<0.1	<0.01	<0.01	2.2+	13.1	4.9	1.2
2	"	EP	5.4	.08		10.8	3.6	1.92	0.7	2.19	2.19	2.2	2.5	1.1	8.6
4	5/3	DD	7.1	.18	70	79.0	0.9	0.04	<0.1	0.09	0.03	<2.	19.6	7.3	1.1
5	"	EP	4.6	.11		18.7	3.9	0.76	0.2	2.64	2.38	<2.	4.2	2.0	13.8
9	5/10	DD	6.6	.17			1.2			<0.01					0.9
10	"	EP	4.5	.11			3.8			3.08					13.5
16	5/18	DD	6.5	.18			1.3			0.04					0.8
17	"	EP	4.6	.11			3.9			2.68					13.7
23	5/31	DD	6.6	.14			1.4			0.02					1.0
24	"	EP	4.7	.10			4.7			2.68					9.9
25	"	EP	4.9	.10			4.8			2.87					9.9
29	6/8	DD	6.4	.16			1.0			0.06					0.8
30	"	EP	4.4	.10			4.6			3.09					12.6
34	6/14	DD*	6.9	.15			1.0			0.08					0.6
35	"	EP*	4.7	.10			4.4			3.42					11.4
41	6/28	DD	6.5				1.3			0.08					0.7
42	"	EP	4.2				7.7			3.67					19.0
43	7/10	DD	6.1	.15	54	79.0	2.7	<0.1	<0.1	0.09	<0.01	<1.	20.3	6.4	1.1
44	"	EP	4.5	.06		17.4	5.1	0.1	<0.1	2.08	1.84	3.2	2.2	2.1	6.6
48	7/18	EP	5.1	.05		22.0	8.1	0.1	<0.1	2.20	1.66	3.9	3.6	2.1	5.4
49	"	DD	6.4	.20		98.4	3.4	0.1	<0.1	0.37	0.04	1.9	25.3	7.5	1.2

* pH tested in lab - late afternoon 6/14
+ ppm sulfate-S x 3 = ppm sulfate (SO_4)

Abbreviations and description of sampling sites
DD = Diversion ditch at bridge near Little Willow River
EP = Experimental paddy

Table 4. Chemical composition of water collected from wild rice paddies during 1978 growing season. Location: Gunvalson and Imle, Gully

Sample Number	Sampling Date	Location	pH	Cond. milli-mhos/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
3	5/3	PP	7.0	.42	124	172.0	2.3	0.04	<.1	0.36	0.12	20.8+	45.5	14.0	9.8
11	5/17	CR	7.2	.50	228	249.0	0.8	0.06	<.1	0.12	0.01	15.8	64.0	21.6	2.6
12	"	PP	6.9	.52	166	225.0	1.6	0.09	<.1	0.36	0.36	25.0	59.3	18.8	14.3
18	5/24	CR	7.2	.46			0.3			<0.01					2.1
19	"	PP		.57			1.5			0.69					13.1
36	6/26	PP	6.8				2.2			1.51					6.8
37	"	CR	7.1				1.2			0.06					2.7
50*	7/19	PP	6.5	.13	39	45.2	2.0	0.5	0.2	1.18	0.97	4.0	11.1	3.9	10.0
51	"	CR	6.4	.44	204	242.0	1.8	<0.1	<0.1	0.28	0.09	8.7	58.9	22.6	2.4

* Paddy recently drained, almost dry
\+ ppm sulfate-S x 3 = ppm sulfate (SO_4)

Abbreviations and description of sampling sites
PP = Production paddy
CR = Clearwater River

C. NITROGEN RATE AND VARIETY STUDIES ON MINERAL SOIL

Two experiments were conducted on a mineral soil at the North Central Experiment Station, Grand Rapids. Experiment 1 (first year stand) was established in the fall of 1977 with two early maturing varieties: Netum and K2. Experiment 2 (third year stand) had been established in the spring of 1976 with K2, M3 and Johnson varieties.

First Year Stand[1/]

The experimental paddy No. 6 was in fallow during 1977 and was fumigated with methyl bromide in the fall. Four rates of nitrogen were used in this experiment: 0, 20, 40 and 80 pounds per acre. Urea (46-0-0) was applied by hand and incorporated into the soil by rototilling. Phosphorus and potassium were not applied because of relatively high soil tests. Two early maturing varieties, Netum and K2, were grown. A split-plot design was used in this experiment, with the N rates as main plots and varieties as subplots. Each plot, containing one N rate and both varieties, occupied a 12 x 15 ft. area. Each N treatment was replicated five times. The wild rice was planted in rows that were one foot apart on November 8. Plant population, at harvest, was one plant per square foot. Water level was maintained at about 8-12 inches. Ten plants were selected at random from each plot at jointing stage, and five plants at late flowering for weight measurements and plant analysis. The jointing stage was reached by Netum (Fig. 3) on June 29 and by K2 (Fig. 4) by July 6. An 80 sq. ft. area from each plot was hand-harvested for yield determination. Netum was harvested on August 23 and K2 six days later.

The K2 variety outyielded Netum by 143 pounds per acre (table 5). The grain yield of both varieties was increased by nitrogen fertilization. Maximum yields were produced with 40 pounds of N per acre.

Dry matter production was not affected by N fertilization, but K2 plants were slightly heavier than Netum at jointing and late flowering (table 6).

Nitrogen concentration of 2nd leaf at jointing was not affected by N treatments and no varietal differences were detected (table 7). Total uptake of N by the plant was related to the amount of nitrogen applied (table 8).

[1/] This experiment was conducted in cooperation with Mr. Gary Linkert, Department of Agronomy and Plant Genetics.

Table 5. Effect of nitrogen application on the yield of two wild rice varieties, Grand Rapids, 1st year stand, 1978.

Variety	N Rate, lb/Acre 0	20	40	80	Average (variety)
	Grain Yield, lb/Acre				
K2	895[1)]	947	1038	1045	981
Netum	778	767	935	872	838
Average (Rate)	836	857	986	959	

1) 7% moisture

(a)

Variety	Grain yield, lb/Acre
K2	981 b
Netum	838 a
Significance	**
BLSD (0.05)	85

(b)

N Rate, lb/Acre	
0	836 a
20	857 ab
40	986 c
80	959 bc
Significance	*
BLSD (0.05)	118
C.V.	14

Table 6. Effect of nitrogen application on plant weight of two varieties at jointing and late flowering, Grand Rapids, 1st year stand, 1978.

Development stage and variety	N Rate, lb/Acre				Average (variety)
	0	20	40	80	
	Dry matter, grams per plant				
(a) Jointing					
Netum	3.70	3.72	4.43	3.91	3.94
K2	5.09	4.47	4.79	5.20	4.89
Average (rate)	4.40	4.10	4.61	4.56	
(b) Late Flowering					
Netum	15.57	19.13	18.64	20.16	18.38
K2	20.85	18.63	20.97	21.79	20.56
Average (rate)	18.21	18.88	19.81	20.98	

Table 7. Effect of nitrogen application on N concentration in 2nd leaf at jointing, Grand Rapids, 1st year stand, 1978.

Variety	N Rate, lb/Acre 0	20	40	80	Average (variety)
	--------------------N % in dry matter--------------------				
K2	4.44	4.10	4.40	4.32	4.32
Netum	4.23	4.36	4.50	4.32	4.35
Average (rate)	4.34	4.23	4.45	4.32	

Table 8. Effect of nitrogen application on total uptake of N by the wild rice plant at late flowering, Grand Rapids, 1st year stand, 1978.

Variety	N Rate, lb/Acre 0	20	40	80	Average (variety)
	----------------N in milligrams per plant----------------				
K2	237	258	293	321	277
Netum	231	294	300	304	282
Average (rate)	234	276	297	313	

Third Year Stand

The nitrogen-variety experiment, established in the spring of 1976, was continued in 1978. Three wild rice varieties were grown: the relatively early maturing K2 and M3, and the later maturing Johnson. Three N rates were used: 0, 40, 80 pounds per acre. To minimize cross-pollination, the Johnson wild rice was placed between the two earlier maturing varieties and each variety was grown in a 48 x 72 foot area separated from adjoining variety by a 10 ft. wide alley. Individual plots were 12 x 14 ft. in size. Nitrogen treatments were replicated five times. Straw was disked and rototilled into the soil. Urea was applied on May 2 and rototilled into the soil. Phosphorus and potassium were not applied because of relatively high soil test levels (P 72, K 308, pH 6.0; nitrate-N 16 lb/A 0-6 inch depth). The plant density of M3 was excessive and required manual thinning. At early tillering, average plant density of K2 was 4, while M3 and Johnson had six plants per square foot. There was heavy infestation of broadleaf weeds, especially in the K2 area. On July 5, 2,4-D (¼ lb/acre) was sprayed to control weeds.

Fertilization with nitrogen resulted in striking height and color differences. Plants in N0 plots were shorter and lighter in color than those receiving either N40 or N80 treatments. There was moderate lodging in the N80 treatment plots.

Blackbird control was ineffective and heavy yield losses occurred. Nearly 80% of grain was lost, particularly in M3 plots. The yield ranged from 211 - 233 lb/acre for K2, 120 - 190 lb/acre for Johnson, and 152 - 189 lb/acre for M3.

Visual differences in plant height and color, observed during the growing season, also were reflected by weight and plant analysis data (tables 9, 10 and 11). The application of 40 or 80 lb/acre of nitrogen resulted in the production of more dry matter and increased the total N uptake by the plant compared to the control.

Table 9. Effect of nitrogen application on plant weight of three varieties at jointing and late flowering, Grand Rapids, 3rd year stand, 1978.

Development stage and variety	N Rate, lb/Acre 0	40	80	Average (variety)
	----------Dry matter, grams per plant----------			
(a) Jointing				
K2	1.69	2.64	3.12	2.48
Johnson	2.58	3.36	4.38	3.44
M3	2.80	2.93	3.36	3.03
Average (rate)	2.36	2.98	3.62	
(b) Late Flowering				
K2	6.68	9.53	11.75	9.32
Johnson	6.53	6.55	10.66	7.91
M3	9.23	9.29	15.78	11.43
Average (rate)	7.48	8.46	12.73	

Table 10. Effect of nitrogen application on N concentration in 2nd leaf at jointing, Grand Rapids, 3rd year stand, 1978.

N Rate lb/Acre	Variety K2	Variety M3	Variety Johnson	Average (rate)
	N % in dry matter			
0	2.46	2.62	2.29	2.46
40	2.74	2.77	1.94	2.48
80	2.84	2.95	2.39	2.73
Average (variety)	2.68	2.78	2.21	

Table 11. Effect of nitrogen application on total uptake of N by the wild rice plant at late flowering, Grand Rapids, 3rd year stand, 1978.

N Rate lb/Acre	Variety K2	Variety M3	Variety Johnson	Average (rate)
	N in milligrams per plant			
0	68	98	58	75
40	105	123	87	105
80	142	208	112	154
Average (variety)	105	143	86	

D. FERTILIZATION STUDIES ON PEAT

Three fertilizer experiments were conducted in a Kosbau Bros. paddy in Aitkin County. During 1977, rye was grown, receiving 12 + 72 + 72 lb/acre of N, P_2O_5 and K_2O. Fertilizer was applied by hand to 12 x 12 foot plot areas on October 19, 1977. K2 wild rice was seeded, and the seed and fertilizer were incorporated into the soil by rototilling. Wild rice started to emerge on May 8 and by July 2 had reached the jointing stage (Fig. 5). Some lodging occurred throughout the experimental area, and in some areas, the stand was spotty and thin with heavy infestation of cattails. Average plant density was two plants per square foot. The paddy was drained on July 22. A 4 x 4 foot area was hand-harvested from each plot for yield measurement on August 24. No color or height differences were observed during growing season and there was a general lack of response to fertilizer treatments. The grain yield ranged from 300 to 500 lb/acre.

Table 12. Soil test values of experimental areas, Kosbau Bros., Aitkin Co.

Area	Soil Test Results for 0-6 inch Depth			
	pH	Extractable P pp2m	Exchangeable K pp2m	NO_3-N lb/A
NK trial	3.9	18	145	3
NP trial	4.0	19	240	3
Foliar-Fertilization	4.2	21	116	2

Samples collected on 10/19/77.

NK RATE TRIAL

Exchangeable potassium in the experimental area was 145 pp2m, considered to be a medium level (table 12). Nitrogen treatments consisted of the following rates: 0, 20, 60 pounds per acre. Potassium was applied at rates of 0, 60 and 200 pounds of K_2O per acre. All plots received 40 pounds of P_2O_5 per acre. Fertilizer treatments were replicated six times. Urea, muriate of potash and concentrated superphosphate were applied by hand during the fall of 1977 and incorporated into the soil by rototilling.

The yield of wild rice ranged from 349 to 431 pounds per acre (table 13). Neither nitrogen nor potassium treatments had any effect on the yield.

Table 13. Effect of nitrogen and potassium application on grain yield of wild rice, Kosbau Bros., 1978.

K Rate	N rate, lb/acre			Average
K_2O lb/acre	0	20	60	(K rate)
	------------Grain yield, lb/acre------------			
0	342[1)]	358	431	377
60	425	392	365	394
200	369	379	342	363
Average (N rate)	379	376	379	

1) 7% moisture

Significance ns

NP RATE TRIAL

Extractable phosphorus in the experimental area was 19 pp2m, indicating medium relative level (table 12). Nitrogen was applied at rates of 0, 20, 40 lb/acre, and phosphorus treatments included 0, 40 and 80 pounds of P_2O_5 per acre. All plots received 60 lb/acre of K_2O. Fertilizer treatments were replicated six times. Urea, concentrated superphosphate and muriate of potash were applied by hand in the fall and incorporated into the soil by rototilling.

Grain yields ranged from 298 to 494 pounds per acre (table 14). Although the application of phosphorus, combined with either the N0 or the N20 treatments, tended to increase the yield by nearly 100 lb/acre, the differences were not statistically significant.

Table 14. Effect of nitrogen and phosphorus application on grain yield of wild rice, Kosbau Bros., 1978.

P Rate	N rate, lb/acre			Average
P_2O_5 lb/acre	0	20	40	(P rate)
	Grain yield, lb/acre			
0	374[1)]	298	491	388
40	485	467	468	473
80	469	461	494	475
Average (N rate)	443	409	484	

1) 7% moisture

Significance ns

FOLIAR FERTILIZATION TRIAL

Foliar fertilization studies initiated in 1976 were continued. In the fall of 1977, a new experiment was established in an area adjoining NK and NP trials. Soil application of fertilizer (20 + 40 + 60) was made during the fall and incorporated into the soil. Fertilizer solution was sprayed on 12 x 12 foot plot areas with a backpack sprayer at a rate of 26.4 gallons per acre or 250 pounds per acre. Spraying pressure was maintained at 30 psi by using a carbon dioxide cylinder. The formulation, fertilizer materials used and costs were reported, in detail, in the 1976 Wild Rice Research Progress Report. In 1978, foliar fertilizer applications were made on the following dates:

1st spraying, 7/10 - at boot stage,
2nd spraying, 7/26 - mid-flowering,
3rd spraying, 8/9 - early grain formation.

No "leaf burn" damage was observed in this trial.

The grain yield in this experiment ranged from 380 to 492 pounds per acre. Fertilizer, either by soil or foliar application, had no effect on the grain yield (table 15).

Table 15. Effect of foliar and soil application of fertilizer on grain yield of wild rice, Kosbau Bros., 1978.

Foliar Application					Soil Application		
	Total Plant Nutrients Applied, lb/Acre						Average
Number	N	P_2O_5	K_2O	S	None	20+40+60	(Foliar)
					-----Grain yield, lb/Acre-----		
None	none				492[1)]	419	456
1 x	15 +	6 +	9 +	1.3	-	389	389
2 x	30 +	12 +	18 +	2.6	-	389	389
3 x	45 +	18 +	27 +	3.9	380	388	384
Average (soil)					436	396	

1) 7% moisture, average of 6 replications; Significance ns

ACKNOWLEDGMENTS

Grateful acknowledgments are made to the following cooperators and University personnel for their valuable assistance during 1978 in obtaining the information reported here: Messrs. Franklin and Harold Kosbau, Aitkin County; Messrs. John Gunvalson and Paul Imle, East Polk County; the Staff of the North Central Experiment Station; Dr. E. A. Oelke, Messrs. Robert Stassen, Gary Linkert, Loren Nickelson, and Henry Schumer, University of Minnesota.

WILD RICE PRODUCTION AND SEED RESEARCH - 1978

E. A. Oelke

Research was conducted during 1978 on water management, plant population, cultural and chemical weed control, elimination of volunteer wild rice plants, seed survival, and seed dormancy. The research was conducted on University plot land at St. Paul and Grand Rapids and in growers' fields near Aitkin, Clearbrook and Gully. The temperatures during the 1978 growing season were similar to the long term averages except for August which was slightly warmer resulting in some good yields from commercial fields.

WATER MANAGEMENT

Water Depth

The following is a 6 year summary of the water depth experiments conducted at Grand Rapids. The Johnson variety of wild rice was grown for the first 3 years in water depths ranging from 0 (saturated) to 24 in. This range of water depths was obtained by growing the plants on a sloping area. The area was 55 x 80 ft. in size and was seeded each year with 45 lb/A of seed to the Johnson variety. The area was marked off into 3 strips and each strip into 7 sampling areas. Each strip was designated as a replication. Water was added daily or every other day to maintain the proper water level. Plant samples were taken at periodic intervals for measurement from each sampling area. Grain yield was determined by harvesting from 7 designated areas within each strip. The following figures depict data from the first 3 years of the water depth work.

Plant population was the highest in 13 inches of water compared to deeper or shallower depths (Fig. 1). The low wild rice plant population in the 4, 7 and 10 inch water depths probably was caused by competition from weeds such as barnyardgrass, water plantain and arrowhead. The low plant population at the deep end was due to the inability of some plants to emerge through the water.

The floating leaves of wild rice elongate until they reach the top of the water, therefore plant height at the floating leaf stage increased as water depth increased (Fig. 2). At tillering this trend was still evident, however, at maturity, the tallest plants were found at the 13 through 16 inch depths.

The number of tillers per plant was the highest in 7 inches of water when counted at flowering (Fig. 3). The lower tiller number at the 4 inch depth resulted from weed competition while the lower number in the deeper water was due to the inability of some tillers to emerge through deep water. The number of leaves per plant are the same at all water depths early but vary about the same as tiller number at tillering and flowering (Fig. 4).

Internode elongation, which takes place shortly before the panicle emerges from the boot, is an indicator of maturity. Internode separation began the earliest at the 13 inch water depth (Fig. 5). The earlier maturity was also evident by the 7 to 10 day earlier flowering at the 13 inch depth compared to the 23 inch depth.

Plant dry weight was the highest at the intermediate depths at tillering, flowering and maturity (Fig. 6). This was in contrast to the higher tiller number at shallow depths, but not in contrast to plant height. Grain yield was the highest at the 10 inch depth when averaged for the 3 years (Fig. 7), however, this yield was not statistically different from the yield at 7 and 13 inch depths. Weed control was better at the 13 inch depth and the plants matured earlier than at the 10 inch depth, therefore the best water depth to use for the Johnson variety would be about 13 inches. Deeper water caused some lodging after the water was drained before harvest.

Three varieties were grown in the same sloping area for 3 years following the 3 years of the Johnson variety. The area was fumigated, divided into 3 strips and each strip seeded to a different variety. Similar data were collected on the 3 varieties as had been for the Johnson variety alone. The M1 and K2 varieties responded to water depth nearly the same way as the Johnson variety (Table 1). There was no statistical interaction for yield between variety and water depth, which means the same water depths can be used for all varieties.

The conclusion from our 6 years of water depth studies is that wild rice should be grown using water depths ranging from 10 to 16 inches for highest yields and earliest maturity. These depths will control most weeds while lodging occurs in depths greater than 16 inches.

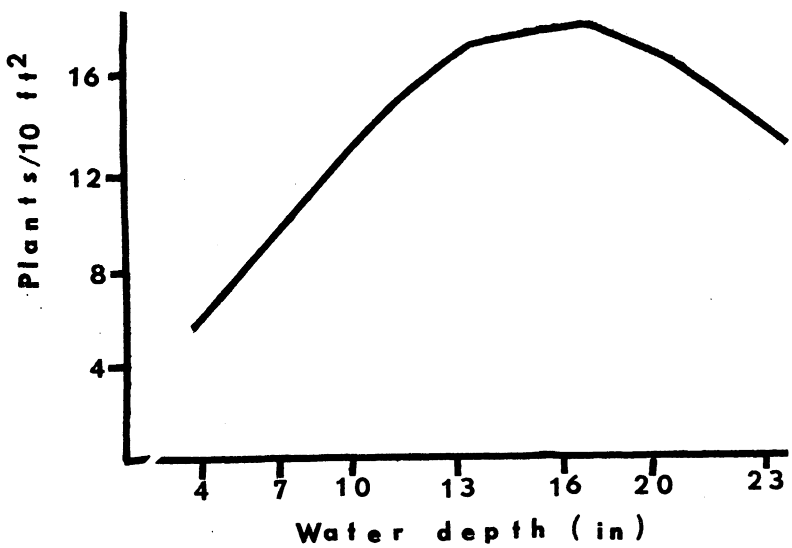


Figure 1. Plant population of wild rice as it varies with water depth. The values represent a 3 year average for the Johnson variety. Numbers significantly different at 5% level for plants/10 ft^2.

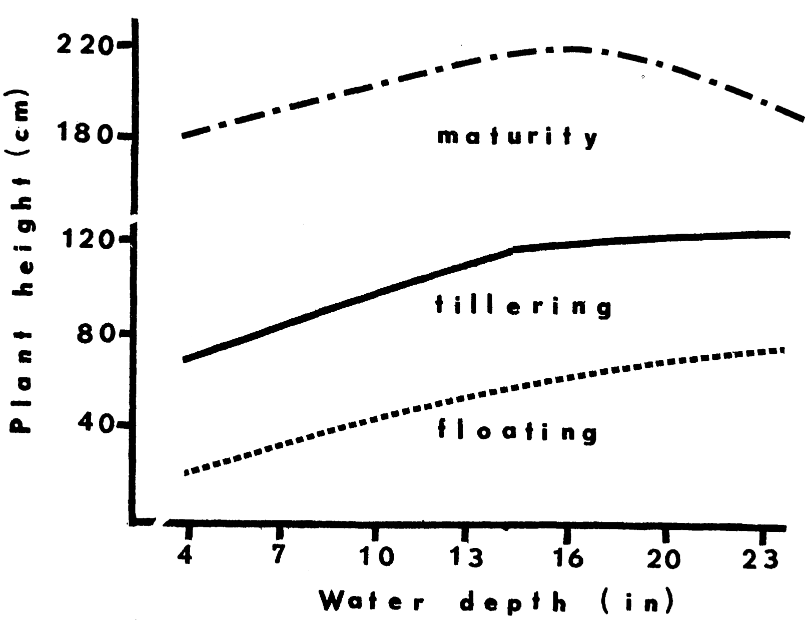


Figure 2. Plant height of wild rice as it varied with water depth. Plants were measured at all depths on the same date when plants in 13 in. of water were in the floating leaf, tillering and mature stages of growth. Plant height among water depths significantly different at the 5% level for all 3 dates.

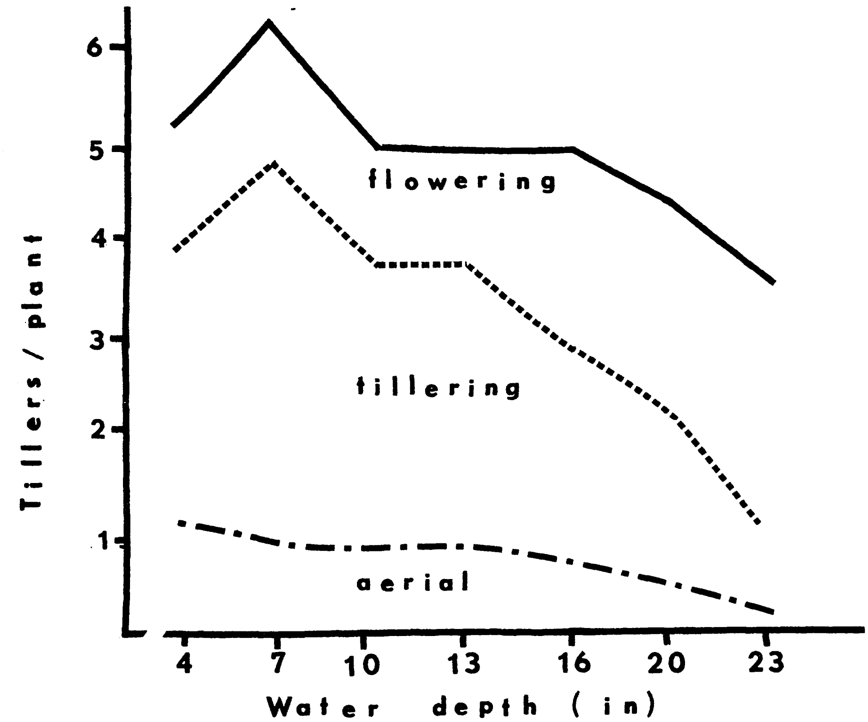


Figure 3. The influence of water depth on tillering of wild rice. Tiller counts were made on the same date for all depths when plants in 13 in. depth were at above growth stages. Tillers/plant among water depths are significantly different at the 5% level for the aerial and tillering date and 10% for the flowering date.

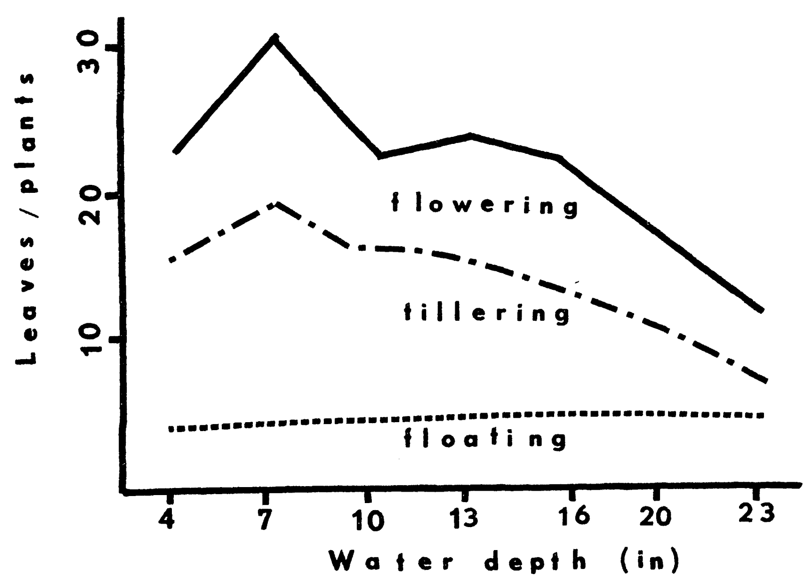


Figure 4. Number of leaves per plant of wild rice as influenced by water depth. The number of leaves were counted on the same date as tillers. Leaves/plant among water depths are significantly different at the 5% level for tillering and flowering date.

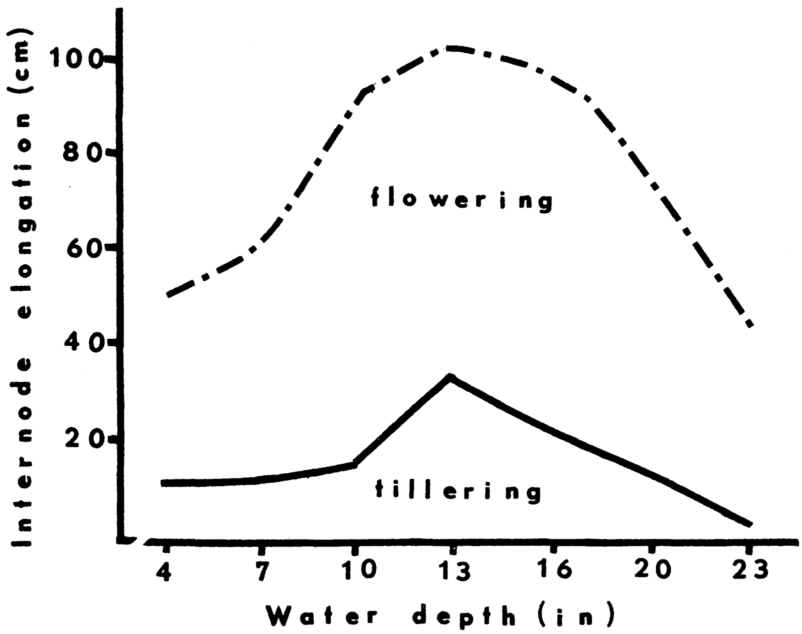


Figure 5. Maturity of wild rice as indicated by internode elongation of main stem, and water depth relationship. Internode separation measured at same date for all depths when plants in 13 in. depth were at above growth stages. Internode elongation among water depths significantly different at 5% level for both dates.

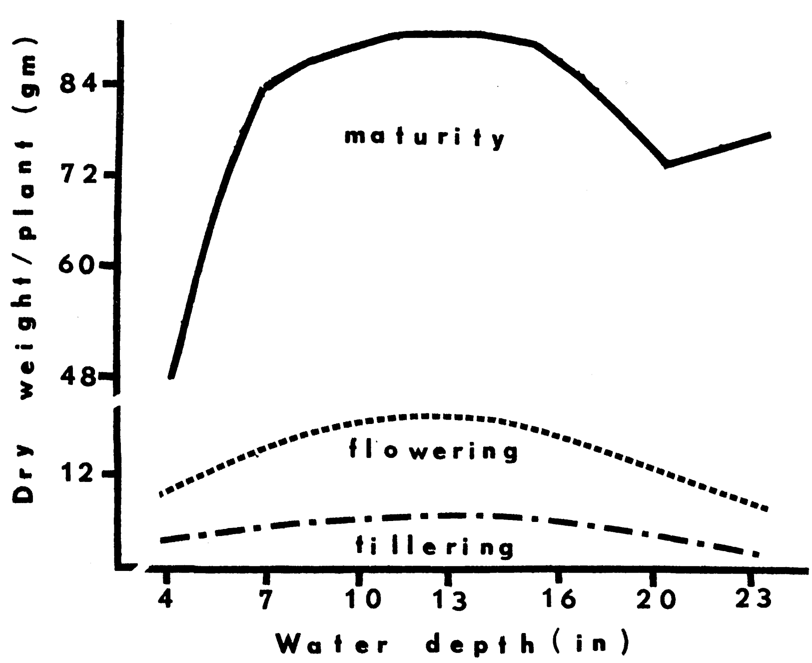


Figure 6. Dry weight per plant of wild rice as influenced by water depth. Dry weights taken on the same date for all depths when plants in 13 in. depth were at above growth stages. Dry weight significantly different at the 5% level for all 3 dates among water depths.

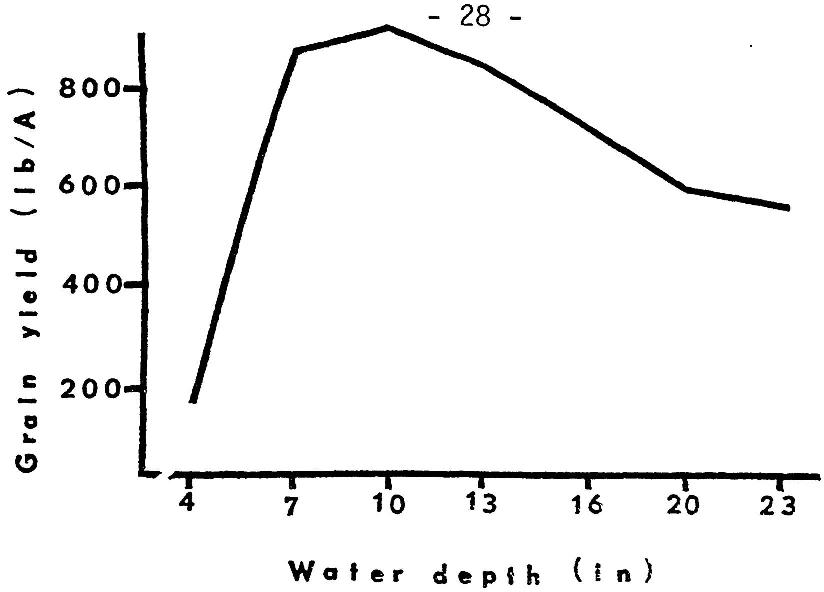


Figure 7. Grain yield at 40% moisture as influenced by water depth. Yield significantly different at 1% level between water depths.

Table 1. The response of 3 varieties to water depth - Grand Rapids - 1976-78

Water depth (in.)		Plants/ ft^2	Grain moisture at harvest (%)	Grain yield lb/A*
			K2 variety	
4		0.1	39.0	136
7		0.4	38.0	243
10		1.3	38.7	1070
13		1.7	38.7	975
16		1.9	39.0	892
20		1.8	38.7	699
23		1.0	40.7	462
	$LSD_{.05}$	1.4		356
			M1 variety	
4		0.1	37.0	127
7		0.4	39.0	331
10		1.3	40.3	735
13		1.6	40.0	671
16		1.9	40.0	798
20		1.4	41.0	716
23		1.3	40.7	576
	$LSD_{.05}$	1.0		199
			Johnson variety	
4		0.1	39.0	109
7		0.1	30.0	84
10		0.6	38.0	365
13		1.9	41.0	785
16		1.6	41.0	682
20		1.7	42.3	757
23		0.8	42.7	362
	$LSD_{.05}$	0.3		275

* 40% moisture

Water Management Systems

The water management system experiment conducted in 1977 was repeated in 1978. The major objective of the experiment was to determine if maintaining a continuous flood during most of the growing season is an efficient water use system for growing wild rice. The systems used for comparison were 1) continuous soil saturation, 2) flood for germination and then keep soil moisture at field capacity, 3) flood to mid-tillering and then keep soil saturated, 4) flood to mid-tillering and then keep moisture at field capacity, 5) flood to 50% flowering and then keep soil saturated, and 6) flood to 50% flowering and then keep soil moisture at field capacity.

Peat soil was put into 4 x 4 ft plastic lined boxes to a depth of 10 inches. Seeds (270) were placed 1 inch below the soil surface in each box. All boxes were flooded to a water depth of 4 inches except the ones which were to remain saturated. Later, at the appropriate date, some boxes were drained to field capacity. Water was added to all boxes as needed to maintain the designated water regime. The amount of water added was recorded and the watering terminated 1 week after the beginning of harvest. The grain was harvested as it matured. Total harvest time was about 4 weeks. The summary of 1977-78 data are given in Tables 2 and 3.

Table 2. Water use as related to water management systems - St. Paul - 1977-78

Water management system	Initial amount water added	Water added during season	Rainfall during season	Total water used
	Acre inches			
Continuous flood	7.8	15.1	14.8	37.7
Continuous saturation	3.8	19.8	14.8	38.4
Flood to germination, then field capacity	7.8	13.3	14.8	35.9
Flood to mid-tillering, then saturated	7.8	24.2	14.8	46.8
Flood to mid-tillering, then field capacity	7.8	16.0	14.8	38.6

Table 2. continued

Water management system	Initial amount water added	Water added during season	Rainfall during season	Total water used
	Acre inches			
Flood to 50% flowering, then saturated	7.8	15.0	14.8	37.6
Flood to 50% flowering, then field capacity	7.8	13.0	14.8	35.6
	$LSD_{.05}$	3.0	-	-

Table 3. Plant growth as related to water management systems - St. Paul - 1977-78

Water management system	Plants $/ft^2$	Tillers /plant	Total stems/16 ft^2	Plant height (cm)	Yield lb/acre*
Continuous flood	6.4	1.85	189	153	1262
Continuous saturation	6.0	2.03	221	155	1290
Flood to germination, then field capacity	4.7	1.94	146	143	911
Flood to mid-tillering, then saturated	5.7	2.16	197	156	1232
Flood to mid-tillering, then field capacity	5.2	1.98	165	148	1071
Flood to 50% flowering, then saturated	6.0	2.08	200	161	1452
Flood to 50% flowering, then field capacity	5.6	1.97	177	158	1060
$LSD_{.05}$	-	-	-	7	170

* At harvested moisture

The continuous flood or continuous flood until 50% flowering and then keeping the soil saturated systems appear to be good water management systems for wild rice. The yields were high and water use was intermediate. (Tables 2 and 3). The two systems which had lower water use did not yield as much. This was partly due to some wilting of the plants, particularly during hot weather, when the soil was kept at field capacity. From the 2 years data, it appears that continuous flooding up to 2-3 weeks before harvest is a good system to use for growing wild rice.

WEED RESEARCH

Herbicides

The herbicide trials this year concentrated on the use of phenoxy herbicides for control of water plantain. Several studies were conducted on time of application, split applications and use of adjuvants to obtain better control of water plantain with low rates. The trials were conducted at St. Paul, Grand Rapids, Clearbrook and Aitkin.

Table 4 gives the injury ratings and yield when phenoxy herbicides were applied to wild rice at the aerial, tillering and early heading stages of growth. The trial was conducted at Grand Rapids.

Table 4. Herbicides applied to wild rice at 3 growth stages - Grand Rapids - 1978

Herbicide	Rate lb/A ai*	Wild rice growth stage				
		Aerial	Tillering	Early heading	Aerial	Tillering
		Injury rating**			Grain yield***	
2,4-D amine	1/8	1.0	1.0	1.3	553	618
(Weedar 64)	1/4	1.0	1.0	1.6	647	586
	1/2	1.0	1.7	3.0	696	706
	3/4	1.0	4.0	4.0	607	561
	1	1.0	3.7	4.3	529	529
	1-1/2	1.0	5.0	8.3	550	300
MCPA amine	1/8	1.0	1.0	1.3	651	367
	1/4	1.0	1.3	2.0	641	693
	1/2	1.0	1.7	4.0	621	382
	3/4	1.3	3.7	8.0	456	330
	1	1.3	4.0	6.7	683	333
	1-1/2	2.3	6.3	9.5	529	264

Table 4. continued

Herbicide	Rate lb/A ai*	Wild rice growth stage: Aerial	Tillering	Early heading	Aerial	Tillering
		Injury rating**			Grain yield***	
MCPA	1/8	1.3	1.0	1.0	526	553
Na salt	1/4	1.0	1.0	1.0	556	564
	1/2	1.0	2.0	2.0	543	475
	3/4	1.0	3.0	3.0	525	462
	1	1.0	4.7	5.0	564	337
	1-1/2	1.3	5.7	9.0	548	426
2,4-D amine	1/4	1.0	1.0	-	538	656
(Formula 40)	1/2	1.0	1.3	-	724	495
	3/4	1.0	2.7	-	845	590
Control	0	1.0	1.0	1.0	778	550
				$LSD_{.05}$	295	246

* Rate based on acid equivalent or acid ingredient; not formulation
** 1 = no injury; 10 = complete kill
*** 40% moisture; yield from early heading application lost due to blackbirds; lbs/A

Injury to wild rice increased as herbicide application was delayed. The two 2,4-D formulations gave less injury than the MCPA formulations (Table 4). The yields were variable because of plant population variability therefore only a few treatments gave yields statistically less than the control. No yield could be obtained from the late application due to feeding by blackbirds. The 1/4 lb/A rate of 2,4-D amine applied before early heading appears to be the highest rate of 2,4-D that can be applied without injurying wild rice and reducing yield.

The same herbicides that were applied to wild rice without any water plantain in the stand at Grand Rapids were applied (6/27) to a wild rice stand in a growers field near Aitkin which was infested with water plantain from rootstocks. Wild rice was in the late tillering stage and water plantain was flowering. Table 5 gives the injury ratings to water plantain and wild rice and the plant height of wild rice. No yield was obtained because of the sparse population of wild rice.

Table 5. Herbicides applied to water plantain from rootstocks which was beginning to flower and wild rice in late tillering stage - Aitkin - 1978

Herbicides	Rate lb/A ai	Water plantain injury rating*	Wild rice injury rating*	Wild rice plant height**
2,4-D amine	1/8	1.3	1.0	150
(Weedar 64)	1/4	1.7	1.0	147
	1/2	4.7	2.3	150
	3/4	7.3	3.7	140
	1	8.7	4.0	137
	1-1/2	9.3	4.3	127
MCPA amine	1/8	2.5	1.0	147
	1/4	2.0	1.0	152
	1/2	6.5	3.5	145
	3/4	7.0	4.5	114
	1	8.5	5.0	107
	1-1/2	8.5	5.5	104
MCPA	1/8	2.5	2.0	152
Na salt	1/4	3.0	2.0	150
	1/2	4.5	2.5	145
	3/4	6.0	3.5	122
	1	7.0	3.5	132
	1-1/2	7.5	3.5	119
2,4-D amine	1/4	2.5	2.0	152
(Formula 40)	1/2	3.5	2.0	130
	3/4	5.0	3.0	145
Control	0	1.0	1.0	150

* 1 = no injury; 10 = complete kill
** Cm

It took at least 1/2 lb/A of 2,4-D to give some control of water plantain and 3/4 lb/A to get nearly complete control (Table 5). However, at these rates wild rice was injured as evidenced by the ratings and height reduction compared to the control. Since this has been the situation in several trials during the past few years, repeat applications of 1/8 lb/A of phenoxy herbicides were tried.

Table 6 shows the injury ratings for water plantain and plant height of wild rice when herbicides were applied on June 5 and June 20. Water plantain and wild rice were both in the aerial leaf stage on June 5 while on June 20 water plantain was beginning to flower and wild rice was at mid-tillering stage of growth.

Table 6. Repeat applications of herbicides to water plantain from rootstocks - Aitkin - 1978

Herbicides	Rate lb/A ai	Water plantain injury rating*	Wild rice plant height**
2,4-D amine	1/8 + 1/8	1.3	142
(Weedar 64)	1/4 + 1/4	4.7	147
	1/2 + 1/2	8.0	140
2,4-D ester	1/8 + 1/8	4.6	145
	1/4 + 1/4	7.0	137
	1/2 + 1/2	8.7	119
Bentazon	1/2 + 1/2	6.0	122
	1 + 1	9.3	125
MCPA amine	1/8 + 1/8	4.3	127
	1/4 + 1/4	5.7	119
	1/2 + 1/2	9.7	130
MCPA	1/8 + 1/8	2.0	127
Na salt	1/4 + 1/4	6.3	132
	1/2 + 1/4	6.7	145
MCPA ester	1/8 + 1/8	1.7	125
	1/4 + 1/4	3.3	122
	1/2 + 1/2	9.3	119
2,4-D amine	1/8 + 1/8	1.3	130
(Formula 40)	1/4 + 1/4	5.0	122
	1/2 + 1/2	6.0	130
Control	0	1.0	139

* 1 = no injury; 10 = complete kill
** Cm

A double application of 1/8 lb/A of 2,4-D amine did not give better control of water plantain from rootstocks than a single later application (Table 6). A double application of 1/4 lb/A however, gave better control than a single later application. Wild rice plant height was not reduced compared to the control with the double application using the Weedar 64 formulation of 2,4-D amine but was reduced using the Formula 40 formulation. The double application of 1/8 lb/A 2,4-D ester gave fair control of water plantain without reducing wild rice plant height.

Double applications of phenoxy herbicides were applied at Grand Rapids to water plantain which grew from seeds. In addition, a sparse population of wild rice was present in the plots. Water plantain had 1-2 aerial leaves with the remainder floating on the first application date (7/6) while most of the plants had 5-6 aerial leaves on the second application date (7/13). Wild rice was in the early tillering stage on the first application date and late tillering on the second date. Table 7 shows injury ratings for water plantain and wild rice.

Table 7. Repeat applications of herbicides to seedling water plantain and wild rice on 7/6 and 7/13 - Grand Rapids - 1978

Herbicide	Rate lb/A ai	Water plantain injury rating*	Wild rice injury rating**
2,4-D amine	1/8 + 1/8	1	1
	1/4 + 1/4	3	2
	1/2 + 1/2	4	1
2,4-D ester	1/8 + 1/8	5	4
	1/4 + 1/4	7	6
	1/2 + 1/2	7	6
Bentazon	1/2 + 1/2	5	7
	1 + 1	7	8
	1-1/2 + 1-1/2	7	9
MCPA amine	1/8 + 1/8	1	5
	1/4 + 1/4	3	7
	1/2 + 1/2	6	8
MCPA Na salt	1/8 + 1/8	6	6
	1/4 + 1/4	5	5
	1/2 + 1/2	5	5
MCPA ester	1/8 + 1/8	1	1
	1/4 + 1/4	2	2
Control	0	1	1

* At time of first application water plantain had 1 to 2 aerial leaves and rest floating; at second application water plantain had 5 to 6 aerial leaves; 1 = no injury, 10 = complete kill

** At time of first application wild rice early tillering; at second application wild rice in late tillering; 1 = no injury, 10 complete kill

Fair control of seedling water plantain was obtained with 2 applications of 1/2 lb/A of 2,4-D amine with little injury to wild rice (Table 7). The rest of the treatments either didn't control water plantain, or if they did, the injury to wild rice was too severe.

A time of application of 2,4-D amine onto seedling water plantain study was conducted at Grand Rapids. Four rates of 2,4-D amine were applied on 6/28, 7/5 and 7/13. Water plantain was in the 2 and 6 aerial leaf stage and budding stage of growth. Table 8 gives the injury ratings on water plantain for the 3 dates and 4 rates.

Table 8. Applications of 2,4-D amine to seedling water plantain at 3 different growth stages - Grand Rapids - 1978

2,4-D rates	Application time to water plantain: 1 to 2 aerial leaves;	5 to 6 aerial leaves; some stems in bud stage	Fully developed all stems budding
	Injury ratings*		
1/4 lb/A ai	3.0	3.7	3.7
1/2	5.7	6.7	7.3
3/4	7.0	7.3	9.3
1	9.0	7.0	10.0
Control	1.0	1.0	1.0

* 1 = no injury, 10 = complete kill

Better water plantain control was obtained the later 2,4-D was applied for all rates except the 1 lb/A rate (Table 8). The 1/2 lb/A rate at the bud stage was required for fair control, but the 3/4 lb/A rate was needed for nearly complete control.

Two trials were conducted to determine if adding oil or spreader to 2,4-D amine would increase the effectiveness of 2,4-D amine in controlling water plantain. Crop oil (SunCo) at the rate of 1 qt/A or spreader (X-77) at the rate of 0.5% of total volume were added to 1/8, 1/4 and 1/2 lb/A of 2,4-D amine/A. The mixtures were applied on 6/6 when water plantain from rootstocks had 5-6 aerial leaves. Table 9 gives the injury ratings for the oil and spreader treatments.

Table 9. The effect of adding oil or spreader to 2,4-D on the control of water plantain - Aitkin - 1978

Adjuvant	2,4-D amine rate, lb/A ai	Injury rating on water plantain*
None	1/8	2.0
	1/4	2.0
	1/2	4.0
Crop oil (1 qt/A)	1/8	2.3
	1/4	2.7
	1/2	7.0

Table 9. continued

Adjuvant	2,4-D amine rate, lb/A ai	Injury rating on water plantain*
Spreader (0.5% of total volume)	1/8	6.0
	1/4	4.0
	1/2	4.7
Control	0	1.0

* 1 = no injury; 10 = complete control

Adding crop oil to 2,4-D amine increased the effectiveness of 2,4-D for controlling water plantain but it still required more than 1/4 lb/A for good control (Table 9). The addition of spreader was more effective than crop oil at the lower rates but not at the high rate of 2,4-D. The 2,4-D amine crop oil or spreader mixtures were also applied to wild rice at 2 dates to see if increased injury would result. The injury ratings to wild rice are given in Table 10.

Table 10. The effect of adding oil or spreader to 2,4-D on phytotoxicity to wild rice - Grand Rapids - 1978

Adjuvant	2,4-D amine rate, lb/A ai	Injury rating on wild rice*	Yield lb/A**
	2,4-D applied at aerial leaf		
None	1/8	1.0	441
	1/4	1.3	311
	1/2	1.0	620
Crop oil (1 qt/A)	1/8	1.0	555
	1/4	1.3	539
	1/2	1.0	592
Spreader (0.5% of total volume)	1/8	1.0	488
	1/4	1.7	386
	1/2	3.3	394
Control	0	1.0	593
	2,4-D applied at mid-tillering		
None	1/8	1.0	384
	1/4	1.0	426
	1/2	2.0	489

Table 10. continued

Adjuvant	2,4-D amine rate, lb/A ai	Injury rating on wild rice*	lb/A**
Crop oil	1/8	1.0	401
(1 qt/A)	1/4	1.0	525
	1/2	3.0	418
Spreader	1/8	2.0	519
(0.5% of total	1/4	2.0	367
volume)	1/2	3.6	376
Control	0	1.0	660

* 1 = no injury; 10 = complete kill
** No significant differences among yields

Both the addition of crop oil or spreader to 2,4-D amine increased the injury to wild rice. The addition of spreader injured wild rice more than the addition of oil. Even though yields were not statistically different from the control the yields from the addition of spreader to 2,4-D generally were lower than when crop oil was added. From this one year's data it appears that adding spreader to 2,4-D amine will increase the effectiveness for control of water plantain, but injury to wild rice is also more severe. Thus adding either oil or spreader to 2,4-D amine may not be feasible.

A weed which has become increasingly more severe in fields is bur-reed (*Sparganium eurycarpum*). It is a perennial and can completely take over a field. Bur-reed has fibrous roots and creeping horizontal rhizomes. The early leaves are upright (2-3 ft tall), long and narrow. The flowering stems (3-4 ft tall) have shorter leaves and flowers scattered on the upper part. The flowering heads become bur-like (1/2 to 1 in. in diameter) and come apart during combining. The individual seeds are obpyramidal () in shape, 6-10 mm long and 4-8 mm broad.

A number of chemical treatments were made on 6/28 in a grower's field near Clearbrook which had an area of bur-reed. At the time of application bur-reed was flowering. Table 11 gives the various chemical treatments and the injury ratings on bur-reed.

Table 11. Herbicides applied on 6/28 to bur-reed when flowering - Clearbrook - 1978

Herbicide and adjuvant	Rate lb/A ai	Injury rating on bur-reed*
2,4-D amine	1/4	3
	1/2	3
	3/4	5
	1	7
	1-1/2	7
	2	5
	3	8
2,4-D amine + crop oil	1/2	3
	1	8
	2	9
2,4-D amine + X77 spreader	1/2	5
	1	9
	2	7
2,4-D amine + B-1956 spreader	1/2	5
	1	9
	2	6
2,4-D ester	1	7
	2	8
	3	8
MCPA ester	1	5
	2	6
	3	7
Glyphosate	1-1/2	6
	3	5
	4-1/2	7
MCPA	3/4	6
MCPA + crop oil	3/4	6
MCPA + X77	3/4	7
MCPA + B-1956	3/4	4

* 1 = no injury; 10 = complete kill; taken on 7/13

It required 3 lb/A of 2,4-D amine without any additives to give complete control of bur-reed. However, the rate could be reduced to 1 lb/A with the addition of 1 qt/A of crop oil. Wild rice with this treatment was also completely killed. The addition of spreaders (X-77 and B-1956) were not as effective as crop oil. 2,4-D ester, MCPA and glyphosate were not as effective as 2,4-D amine + crop oil.

In summary, our chemical weed control work this year substantiated our earlier work that 2,4-D amine at the rate of 1/4 lb/A ai rate can be used to surpress water plantain but won't give complete control. Some wild rice injury can occur even at this low rate therefore caution must be used not to apply more than this rate. It is advisable to treat only the areas with very dense populations of water plantain rather than the whole field.

Cultural Control of Water Plantain

Water plantain rootstocks were collected from a grower's field in the spring and transplanted into soil 0, 2 and 7 inches deep on May 12. The soil was in 4 X 4 ft plastic lined boxes; some boxes were flooded while the soil moisture in others was kept at field capacity. In the nonflooded boxes no water plantain plants developed from the rootstocks planted at different depths. In the flooded boxes, 4 plants developed from the 6 rootstocks left on the soil surface. No plants developed from the rootstocks buried 2 and 7 inches deep. Thus it appears that burying rootstocks by plowing or rototilling will help control water plantain which develops from rootstocks. Some control of water plantain was evident in a grower's field where he was able to rototill in the fall compared to an adjacent strip where he was not able to rototill due to wet conditions. Fall plowing areas which had considerable water plantain during the summer might be desirable if conditions permit. The plowed areas would have to be reseeded with wild rice.

Water plantain rootstocks were again transplanted 1 inch deep and 6 inches apart in a 96 ft row in the water depth plot at Grand Rapids. The water depth ranged from 0 to 24 inches. Observations were made on plant development during the season and shortly before harvest plant numbers were determined at each depth. Water plantain population and plant measurements for the 2 years are given in Table 12.

Table 12. The influence of water depth on water plantain plants originating from rootstocks - Grand Rapids - 1977-78

Water depth (cm)	No. of water plantain plants/ft^2		Seed bearing stems/plant		Plant height (cm)		Dry wt/ plant (gm)
	77	78	77	78	77	78	77
0	.58	.67	2.8	1.3	84	100	21
2	.83	.67	4.5	1.7	78	110	40

Table 12. continued

Water depth (cm)	No. of water plantain plants/ft^2		Seed bearing stems/plant		Plant height (cm)		Dry wt/ plant (gm)
	77	78	77	78	77	78	77
6	.67	.50	4.2	2.0	82	100	52
10	.83	.75	5.6	3.3	80	110	43
14	.67	1.00	4.2	2.7	98	110	60
17	.50	.60	5.6	1.3	100	100	47
20	.33	.50	1.8	1.0	101	90	23
24	.42	.42	2.2	2.0	104	120	27

It appears that nearly 20 inches of water are needed to give some control of water plantain which grows from root stocks (Table 12). However, even at the 24 inch depth, water plantain did develop some seed bearing stems. It may be difficult to completely control water plantain from rootstocks with deep water since wild rice yields are considerably lower in 20-24 inches of water compared to 10-14 inch depths.

Wild Rice Yield Reduction Caused by Water Plantain

Water plantain rootstocks collected from a grower's field were transplanted into wet soil in the spring at Grand Rapids at different densities where wild rice was planted in the spring at 45 lb/A. The plots were flooded immediately after transplanting. The trial was similar to the one conducted in 1977. However, lower densities of water plantain and wild rice were obtained and the grain yield was lost to blackbirds. The data obtained for the 2 years are given in Table 13.

Table 13. Yield reduction of wild rice from water plantain plants originating from rootstocks - Grand Rapids - 1977-78

Water plantain plants/ft^2		Wild Rice							
		Plants/ft^2		Panicles/ft^2		Plant height (cm)		Yield	
77	78	77	78	77	78	77	78	77*	78*
4.0	1.4	1.5	0.3	3.1	0.6	172	101	493	5.6
2.0	0.9	2.2	0.4	5.5	1.2	182	110	1012	9.0
1.0	0.7	2.4	0.6	7.0	2.2	193	128	1627	10.8

Table 13. continued

Water plantain plants/ft^2		Wild Rice							
		Plants/ft^2		Panicles/ft^2		Plant height (cm)		Yield	
77	78	77	78	77	78	77	78	77*	78**
0.5	0.5	2.6	0.8	10.3	4.0	198	139	2075	14.5
0	0	3.0	0.7	11.6	5.1	203	125	2560	23.1
							$LSD_{.05}$	825	7.1

* lb/A grain at 40% moisture
** Dry weight/plant-gm; grain yield lost due to blackbirds

This year's results were not as dramatic as last year, however, the trends were similar to the data obtained in 1977 (Table 13). The number of wild rice plants/ft^2, panicles/plant, plant height and dry weight per plant increased as the number of water plantain plants decreased. Grain yield could not be obtained in 1978 but the dry weight per plant was reduced by 76% compared to the control when 1.4 water plantain plants/ft^2 were present.

VOLUNTEER CONTROL

Chemicals

Our work on chemicals to eliminate volunteer wild rice plants was limited to vapam. An experiment was conducted in the spring at St. Paul where vapam was applied 3 ways to the soil at 3 different rates. Wild rice seeds were placed 0, 1, 3, 6 and 9 inches into the soil to determine if vapam would kill the nondormant seeds. The 3 rates were 25, 75 and 100 gallons per acre of vapam and the 3 methods were 1) sprayed onto the soil surface and then watered into the soil, 2) applied 6 in. below the soil surface and 3) sprayed onto the soil surface and then flooded. After 10 and 30 days, wild rice seeds were removed and checked for germination. Table 14 shows the germination of seeds after removal from the vapam treatments.

Table 14. Vapam applied to soil by different methods and rates for elimination of residual seeds - St. Paul - 1977

Method of application	Rate gal/A	Depth of seed in soil (in.) 0		1		3		6		9	
		10D*	30D**	10D	30D	10D	30D	10D	30D	10D	30D
		% germination									
Soil surface and irrigated into soil	25	0	0	0	0	56	20	60	43	62	65
	75	8	0	0	0	0	0	51	31	59	42
	100	8	0	0	1	0	0	15	48	61	55
6 in. below soil surface	25	0	0	45	4	0	7	0	0	0	0
	75	0	0	15	3	0	0	0	0	0	0
	100	0	0	0	0	0	0	0	0	0	0
Into flood water	25	8	18	0	0	7	0	46	0	60	0
	75	11	5	0	0	1	0	16	3	50	1
	100	4	2	0	0	0	0	28	2	34	0

* Germination counts made 10 days after exposure to treatments
** Germination counts made 30 days after exposure to treatments

The best treatment was applying 100 gal/A 6 inches below the soil surfact without flooding (Table 14). All seeds were killed at all burial depths. Generally, applying vapam 6 in. below the soil surface and not flooding the soil for 30 days gave the best seed kill. Even the low rate of 25 gal/A, after 30 days, only 3-7% of the seeds remained viable. Since applying vapam 6 in. below the soil surface seemed effective in killing seeds, an experiment in cooperation with Dr. Schertz was initiated this fall in a grower's field to determine if vapam would be effective in killing seeds by placing it at the bottom of a plow furrow. A vapam applicator was mounted on a 5-bottom plow and 25, 50 and 100/gal/A applied at the bottom of the furrow. Next spring the number of volunteer plants will be counted.

Plowing

Volunteer plant counts were made this fall in an area in a grower's field that was plowed 6, 9 and 12 inches deep the preceeding fall. Table 15 gives the number of volunteer plants that grew in the plowed area.

Table 15. Number of volunteer wild rice plants in the spring on fall plowed area - Clearbrook - 1978

	Plowing depth (in.)			
	0	6	9	12
Number of volunteer plants/ft^2	13.1	4.0	3.2	1.5

Plowing 12 inches deep reduced the number of volunteer plants by 88% but there were still 1.5 plants/ft^2 that grew. Plowing deeper than 12 inches probably is necessary to obtain complete control of volunteer plants. We will be checking a field for volunteer plants which was plowed by a grower 20 inches deep with a large plow. It appeared that most of the seed was buried at least 10 inches deep. If this procedure works, deep plowing may be an economical way to change a field to a new variety.

PLANT DENSITY

Seeding Rate of Netum

The seeding rate trial conducted in 1977 was repeated in 1978 in a grower's field near Aitkin. Netum was seeded in the fall at 5, 10, 15, 30, 45, 75 and 100 lb/A of wet seed in both years. After seeding the area was flooded. Table 16 gives the average data for the 2 years.

Table 16. The relationship of plant growth and yield of Netum and seeding rate - Aitkin - 1977-78

Seeding rate lb/acre	Plants /ft^2	Plant height cm	Panicles /plant	Moisture at harvest %	Yield lb/acre*
5	.17	133	12.0	40.8	184
10	.31	142	9.1	43.0	241
15	.53	160	7.2	40.6	380
30	.82	161	6.6	41.9	442
45	1.36	162	5.1	39.4	541

Table 16. continued

Seeding rate lb/acre	Plants /ft^2	Plant height cm	Panicles /plant	Moisture at harvest %	Yield lb/acre*
75	1.41	167	5.3	43.0	474
100	1.80	171	4.6	41.5	594

* In 1977 considerable grain was lost by wind the day before harvest and in 1978 considerable grain was lost to blackbirds

Plant population and plant height increased while panicles per plant decreased as the seeding rate increased (Table 16). Maturity was not greatly influenced by plant population as evidence by grain moisture at harvest. Yield tended to increase with plant population but appears to remain relatively constant after the 30 lb/A seeding rate. This 45 lb/A rate gave 1.36 plants per ft^2 which might be adequate for this variety, however higher plant populations will be tested next year.

The plant population and yield of Netum was checked in a first (seeded at 12 lb/A) and second year field of the variety near Waskish. The plant populations and yields are given in Table 17.

Table 17. Plant population and yield of Netum variety - Waskish - 1978

Plant population	Yield - 40% moisture
Plants/ft^2	lb/A
.37	442
2.86	840

The second year field had nearly 3 plants/ft^2 and yielded 840 lb/A of 40% moisture grain, while the first year field with .37 plants/ft^2 yielded about half of the second year field (Table 17).

In cooperation with Dr. Stucker, Netum, K2 and Johnson varieties were seeded in the fall in a grower's field near Gully at 30, 60 and 120 lb/A. The quality of the seed lots varied considerably, therefore the plant population also varied between varieties. The plant population, panicles per plant, panicle length, % recovery and yield are given for the three varieties in Table 18.

Table 18. Yield, panicles per plant, panicle length, % recovery and yield of 3 varieties at different populations - Gonvick 1978

Variety	Plant population	Panicles per plant	Panicle length	Recovery	Yield (40% moisture)
	Plants/ft^2	no.	cm	%	lb/A
Netum	.50	5.2	22.5	38.1	638
	.72	5.4	21.0	43.0	641
	.89	3.9	23.5	42.4	680
K2	.25	7.5	21.0	32.1	666
	.39	6.6	22.3	34.7	868
	1.04	3.8	21.5	35.7	909
Johnson	1.69	2.2	22.0	43.2	925
	1.86	3.4	21.0	33.0	706
	3.32	1.3	22.0	35.4	693

* Yield differences were not significant

The plant population ranged from .5 to 3.3 plants per ft^2 (Table 18). The number of panicles per plant decreased for all varieties as plant population increased. Panicle length was variable. The yield increased with plant population for the Netum and K2 varieties, but decreased with population for the Johnson variety. Generally the recovery percent was higher for the Netum variety because it matured earlier. The highest plantpopulations of the Netum and K2 varieties were still too low, while the high plant population for the Johnson variety was too high for optimum yield. Previous work with the K2, M1 and Johnson varieties has shown that yields are similar for plant populations from 2 to 4 plants per ft^2. From the 3 studies (Tables 16, 17 and 18), it appears that Netum will also yield best at 2 to 4 plants per ft^2.

SEED SURVIVAL AND DORMANCY

Seed Survival in the Soil

Seeds were sampled on October 20 from the seed survival experiment which was started October 26, 1976 in Grand Rapids to determine the length of time seed remains viable when buried at 3 different depths in peat or mineral soil under 3 different flooding regimes. Nylon mesh bags containing 550 seeds each were retrieved from each burial depth and flooding regimes. No germination of any seed occurred without removal of the pericarp from above the embryo. Table 19 shows the germination of the seed after 2 years of burial in the soil.

Table 19. The influence of burial depth, soil type and flooding regimes on seed germination after 2 years in the soil - Grand Rapids - 1978

Burial depth	Flooding regime and soil type: Continuous flood		Continuous fallow		Winter fallow - Summer flood	
	Mineral	Peat	Mineral	Peat	Mineral	Peat
	Germination percent*					
0 in.	0.8	0.2	0	0	0	0
2 in.	7.1	14.4	0.7	0.9	26.0	4.5
10 in.	74.1	67.3	8.6	1.0	82.0	3.2

* Seeds removed 10/20/78; no germination occurred unless pericarp was removed above embryo

The continuous flood treatments allowed the most seed to survive while the continuous fallow treatments allowed the least seed to survive the 2 years in peat soil. This was not the case for the mineral soil. The most seeds survived in the winter fallow - summer flood treatment and the least in the continuous fallow. The continuous fallow system thus appears to be the best way to reduce viable seeds in the soil regardless of soil type. It is difficult to understand why so many seeds survived in the mineral soil in the winter fallow - summer flood regime unless the seeds did not dry out as much in the mineral soil as in the peat soil during the fallow period.

Viable Seeds Found in Wild Rice Fields

Soil samples were taken from several fields in the fall of 1977 to determine the number of viable wild rice seeds which remain in the soil after a field has been followed or planted to other crops for 2 or more years. Each field was sampled 6 inches deep with a golf course plugger. Each soil core had a surface area of 12 in^2. A total of 48 cores were taken at random from each field giving a total of 4 ft^2 of soil surface area. The soil samples were stored outside during the winter and this spring the soil was washed to remove the fine soil. The remaining debris was picked through by hand for seeds. The seeds were put into water at room temperature to check for germination. Those seeds which did not germinate were scraped (pericarp removed over the embryo by a razor blade) to test for additional germination. Table 20 gives the cropping history after wild rice, the number of seeds found and the number of viable seeds.

Table 20. Fields sampled in fall 1977, cropping history, number of seeds found and number of viable seeds

Field	County	Cropping history after wild rice	Seeds found	Viable seeds
			— per 4 ft^2 —	
Diebold, #12	Aitkin	Peat; 2 years in small grains	19	2
Kosbau, A_1	Aitkin	Peat; 2 years in small grains	6	2
B_1	Aitkin	Peat; 2 years in small grains	12	4
C_4	Aitkin	Peat; 2 years in small grains	0	0
Florhaug, Bowe	Beltrami	Clay; 2 years in small grains	0	0
Saum	Beltrami	Peat; 2 years in small grains	11	5
Rennemo, 54	Beltrami	Peat; 2 years in small grains	130	68
Black Gold	E. Polk	Clay; 2 years in wheat and corn	4	0
Peutz, 9 acre	Crow Wing	Peat; 4 years in corn and buckwheat	0	0
Clearwater Rice	Clearwater	Peat; 5 years in grass seed production	42	4
Bowe	Beltrami	Peat; 10 years in pasture	0	0

It appears that predicting the number of viable seeds remaining in the soil on the basis of years out of production is not very reliable. Some fields which were out for 2 years had no seeds while one had 68 viable seeds in a 4 ft^2 area. The one field which was out of production for 5 years still had 4 viable seeds in a 4 ft^2 area.

Abscisic Acid (ABA) In Wild Rice Seeds

Abscisic acid, a known growth inhibitor, has been found in dormant seeds of other plants. Ken Albrecht, who finished his M.S. degree this year, found that treating nondormant seeds with ABA inhibited germination. He then analyzed dormant and nondormant seeds for presence of ABA and found less ABA in nondormant seeds than dormant seeds. He also found that the pericarp and embryo have the highest concentration of ABA. We concluded from his results that high levels of ABA in dormant seeds may be partially responsible for seed dormancy of wild rice. The results are given in fugures 8, 9 and 10.

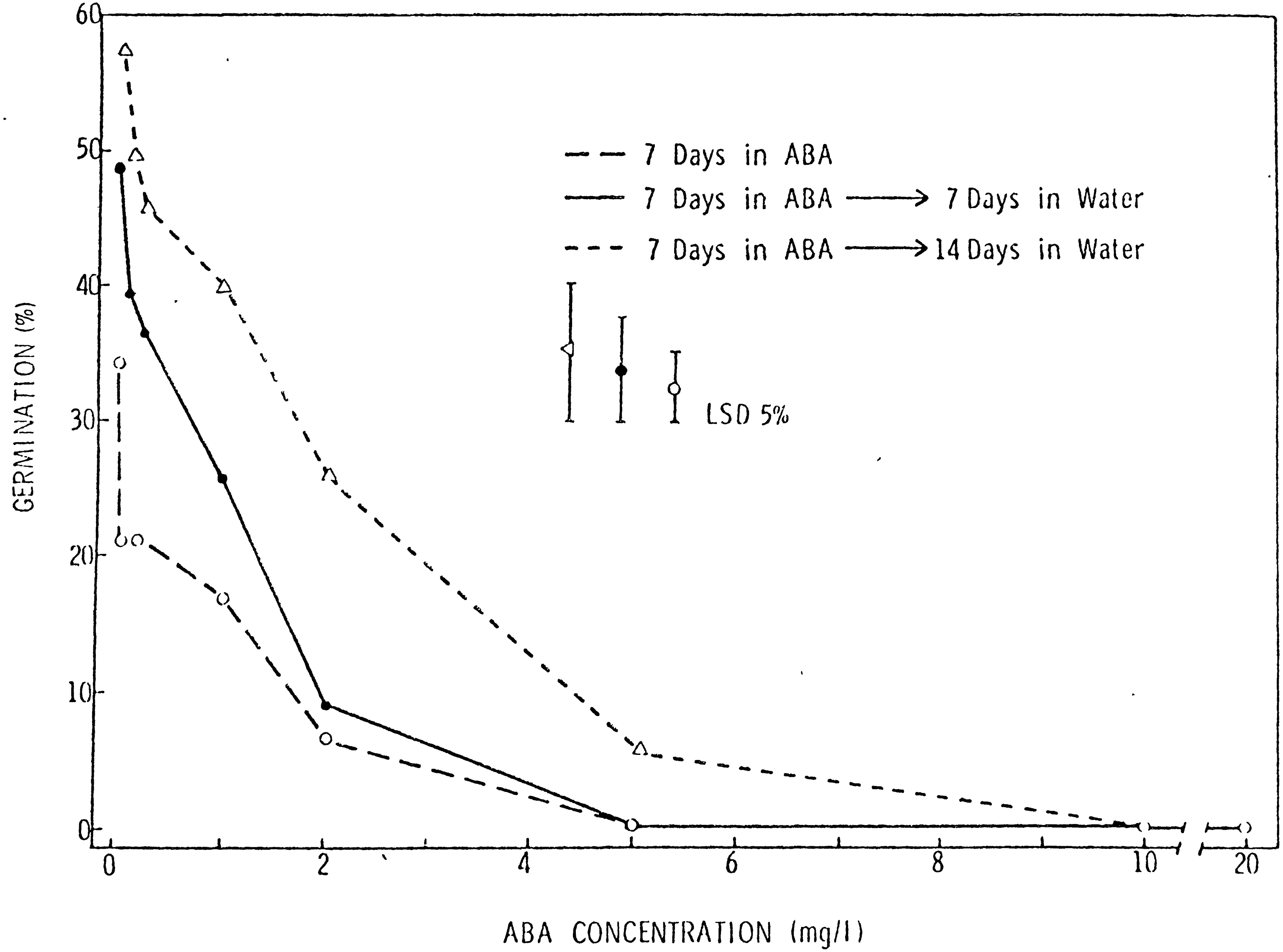


Figure 8. The effect of soaking nondormant seeds in ABA solutions for 7 days on germination

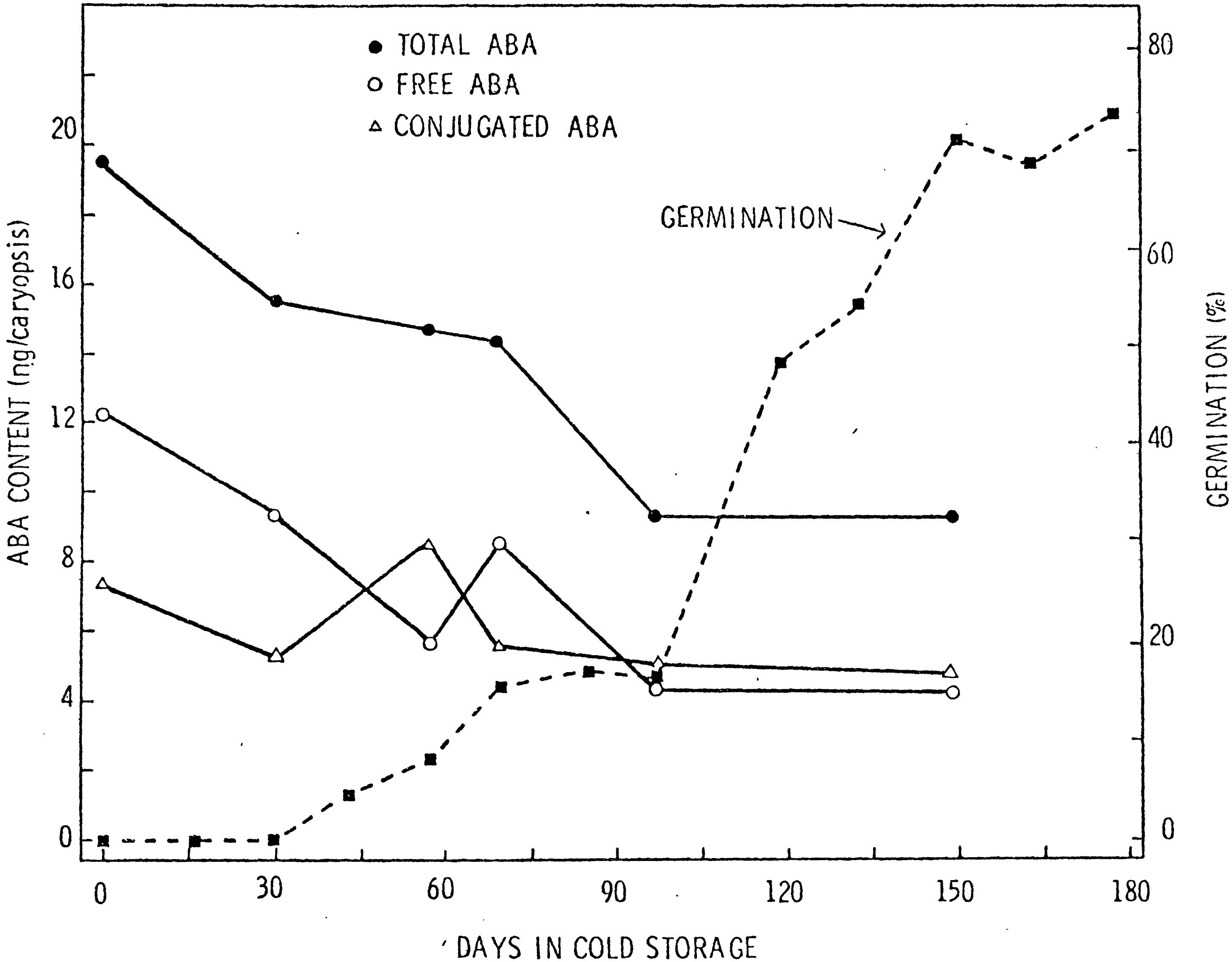


Figure 9. Germination percent and ABA content of wild rice seeds as affected by length of storage in water at 3 C

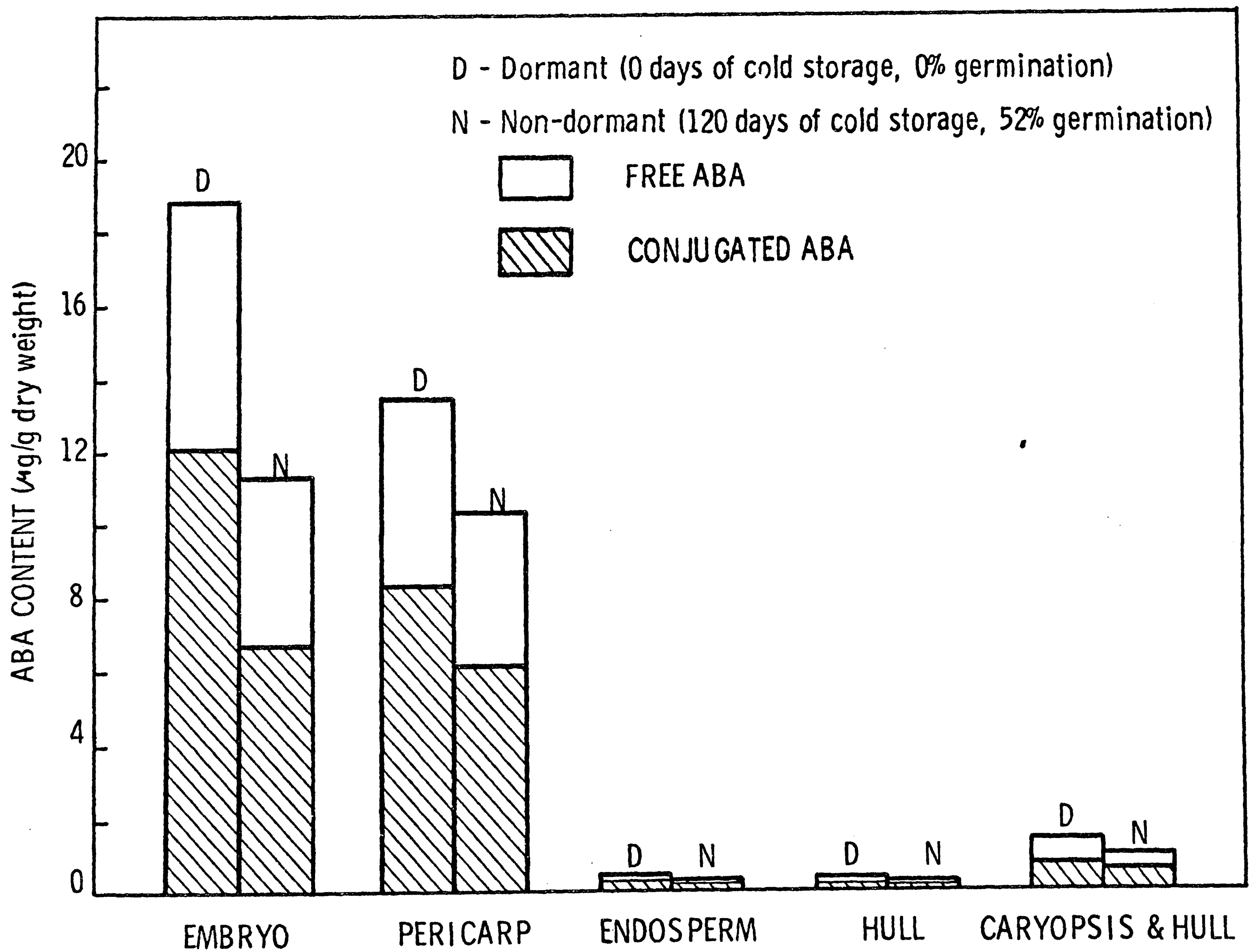


Figure 10. Effect of storage in water at 3 C on levels of ABA recovered per gm dry weight of tissue

ACKNOWLEDGEMENT

The help during the year of Mike McClellan, plot technician, Joel Ransom, graduate student, and Kent Seetin, undergraduate student, was greatly appreciated. Also appreciated was the help of Henry Schumer at Grand Rapids. The cooperation of growers Franklin and Harold Kosbau, Hubert and Leonard Jacobson, David Rued, Ray Skoe, Truman Sandland, Harold Sabo and Pete Olson was valuable and greatly appreciated.

Wild-rice Breeding Research - 1978

R.E. Stucker

Introduction: Dr. Anson Elliott, project leader from 1972 to 1977, resigned as of December, 1977. The research results presented herein are from experiments planned by Dr. Elliott and conducted by the project technicians.

1) Advanced yield tests

Five varieties (Netum, K2, M3, Jns and Jns white flower) and "Experimental 1 short" (a short selection related to Netum) were evaluated at two locations, Grand Rapids and Excelsior in 1978. The six entries were planted in 8-row plots; the 12 feet long rows were spaced at 1 foot intervals. Seeding rate was approximately 180 seeds per row. The entries were replicated six times in a randomized complete block design. Grand Rapids plots were seeded November 7, 1977 and Excelsior plots were seeded May 16, 1978. Entries were harvested at the "40% dark seed" stage, not all at the same date. Ten-foot lengths of the center four rows of each plot were harvested. The results are presented in Tables 1 and 2.

The results confirm observations from prior years that Netum yields significantly less than K2 and likely also M3 when the growing season permits a successful harvest of the latter two varieties. The Johnson's-Netum comparison was not significant and varied between locations. The Grand Rapids data from fall planting confirms also the expected maturity differences of about 6 to 13 days between Netum and the later varieties K2, M3 and Johnson's. The differences between the Grand Rapids results and the Excelsior results may reflect location effects on growth and maturation of wild-rice, but more likely, fall planting versus spring planting affects the comparisons. Additional research is going to be necessary on this point. In the future we need a good appraisal of the validity of southern location results for northern growing areas. Our advanced yield tests need to be fall planted at both locations in order to obtain this information. We will always want to conduct advanced variety tests in northern areas but if varieties respond similarly in southern areas, we can easily supplement testing by using metropolitan testing areas.

Exp. 1 short was derived from the same cross as Netum, but short selections were combined. We would expect it to differ predominantly in height. The Netum vs. Exp. 1 short comparison looks good with respect to plant height -- a mean reduction of approximately 7 inches,-- and for maturity -- little difference or earlier depending on the location involved. The yield data are not quite as encouraging, although the differences are not close to exceeding the amount required for the differences to be significant. We will continue to watch "Exp 1 short" with interest and under more extensive testing.

2) Nitrogen fertilization of Netum and K2 (cooperative with Dr. John Grava - Department of Soil Science)

This experiment was conducted at Grand Rapids for the second year. The fertilizer-variety combinations were evaluated in 8-row plots 12 feet

Table 1. Advanced yield trial results - Grand Rapids location. 1978.

Entry	Heading date	Harvest date	% Moisture	Adjusted yield (lb/A) [1/]	Plants per ft.^{2}	Panicles per ft.^{2}	Height (in)
Netum	6/29	8/16	35	1457	2.2	7.0	71
Exp 1 short	6/28	8/16	33	1255	2.6	6.8	64
K2	7/12	8/22	35	1822	3.4	9.4	74
M3	7/18	8/29	32	1811	2.0	7.4	75
Jns	7/19	8/29	36	1197	2.3	6.5	72
Jns W.F.	7/21	8/28	34	1112	.8	4.8	74
$LSD_{(.05)}$ [2/]	2 days	2 days	(ns)	375	.9	1.7	3

[1/] Adjusted yield is computed as green weight in pounds per acre assuming 40% moisture.

[2/] Difference between 2 varieties is likely to be statistically significant if their means differ by more than the LSD value.

Table 2. Advanced yield trial results - Excelsior location. 1978.

Entry	Heading date	Harvest date	% Moisture	Adjusted yield (lb/A)[1/]	Plants per ft.^{2}	Panicles per ft.^{2}	Height (in)
Netum	7/8	8/18	36	1055	.9	5.0	69
Exp 1 short	7/4	8/11	37	990	1.0	6.7	61
K2	7/13	8/22	39	1485	1.4	8.1	66
M3	7/15	8/25	36	1828	2.0	9.0	70
Jns	7/17	8/25	46	1305	1.7	7.5	73
Jns W.F.	7/7	8/22	36	1393	2.2	8.0	66
$LSD_{(.05)}$[2/]	3 days	4 days	ns	497	1.1	1.5	no estimate

[1/] Adjusted yield is computed as green weight in pounds per acre assuming 40% moisture.

[2/] Difference between 2 varieties is likely to be statistically significant if their means differ by more than the LSD value.

long and spaced 1 foot apart; seeding rate was approximately 180 seeds per row. Each combination was replicated 5 times. At harvest 10-foot lengths of the 4 center rows of each plot were harvested. The 1978 results are reported in Table 3.

Moisture percentage at harvest was not affected by fertilization rates and was 32% for Netum and approximately 35% for K2. Netum yielded significantly less than K2 (1339 lb/A versus 1568) but was harvested 6 days earlier and at slightly lower moisture. It averaged 2" shorter than K2. The N rate of 40 lbs per acre appears optimum for both varieties. The number of plants per square foot was relatively uniform across varieties and treatments but the number of panicles per square foot was significantly less for Netum. Both varieties had an increase in number of panicles per square foot with increasing nitrogen up to 40 lbs per acre. Since the stand was relatively uniform in this experiment, the yield differences appear to be directly related to ability to produce mature tillers.

Plant breeders are always interested in consistency of response of varieties to a cultural practice. We discuss such consistencies or lack thereof under the name "Genotype x Variety interaction". We would like to see varieties respond in the same manner to nitrogen fertilization (in the case of this study). Then, a grower does not have to worry about changing cultural practices from one variety to another. In this experiment Netum and K2 responded similarly to nitrogen for every agronomic trait measured, with the possible exception of % moisture. K2 had a slightly higher moisture percentage at 80 lbs of N per acre than at the lower levels of N. This is an expected response and might have been noted with Netum had it been harvested a few days earlier.

The general results of this test (1978) follow those from last year, despite some hail damage in 1977.

3) <u>Variety - planting rate experiment</u> (cooperative with Dr. Ervin Oelke and Harold Sabo - planted on Sabo paddy at Gonvick). 1978.

Three varieties, Netum, K2 and Johnson's, were fall planted at 3 rates of seeding (30, 60, and 120 lb/A, broadcast) in 6-foot by 12-foot plots. Six replicates were planted and 3 were protected by nets during the growing season. High winds blew down nets and caused some plot damage. Salvageable plots were harvested by hand August 26, 1978. The mean yields and mean number of plants per plot are presented in Table 4. The moisture percent ran around 40% and did not vary much except for Johnson's seeded at 60 and 120 lb/A (up to 48%). Yield differences were not significant. The stand data suggest some serious problems with viable seed planted or numbers of seed planted and the problems are obviously related to varieties and seed numbers. Our advanced yield tests and the fertilizer study - although seeded in rows - were running around 2 plants per square foot. Thus, K2 and Netum seem to have far too few plants for the seeding rate used. Even with fewer plants per square foot, K2 outyielded Netum. The seed source used in this experiment probably caused the anomalous stand problems.

Table 3. Nitrogen fertilization of Netum and K2.

Variety	Fertilizer rate (lb/A)	Adjusted[1/] yield (lb/A)	Plants per ft.^{2}	Panicles per ft.^{2}	Height (in)	Harvest date
Netum	0	1243	2.0	6.7	70	
	20	1227	2.1	6.4	72	
	40	1493	2.2	7.4	74	
	80	1393	2.0	7.1	72	
Mean		1339	2.1	6.9	72	8/23
K2	0	1427	2.3	7.3	73	
	20	1513	2.0	7.4	73	
	40	1658	2.2	7.9	74	
	80	1671	2.4	8.2	75	
Mean		1568	2.2	7.7	74	8/29

[1/] Adjusted to 40% moisture.

	Adjusted yield (lb/A)	Plants per ft.^{2}	Panicles per ft.^{2}	Height (in)
$LSD_{(.05)}$ Netum versus K2	125	ns	.4	1.5
$LSD_{(.05)}$ Fertilizer - variety combinations	250	--	.84	--

Table 4. Results from variety-seeding rate test. Sabo paddy at Gonvick. 1978.

Variety	Seeding rate (lb/Acre)					
	30		60		120	
	Yield[1/]	Plants/plot[2/]	Yield	Plants/plot	Yield	Plants/plot
Netum	638	36	680	64	641	52
K2	666	18	868	28	909	75
Johnson's	925	122	706	134	693	239

1/ Yield is expressed as lbs/Acre at 40% moisture. Differences are not statistically significant.

2/ Note large differences in final stands.

I believe we need to continue variety tests on grower paddies in the future. The bird problem is going to be difficult to handle, however. In order to be manageable for the project, we must test without nets and risk failure because of bird damage. As long as the varieties entered in a test differ in maturity, our likelihood of bird damage on very early or very late entries will be considerable. Obviously, we need to adjust seeding rates to plant comparable numbers of good seed per variety.

4) Preliminary yield trials of "Experimental 3" progenies

An experimental population (designated Exp. 3) was developed by Elliott through 3 cycles of mass selection for shattering resistance from Experimental 1 (Netum) material. (Shattering resistance was measured using a tensile strength meter to record the amount of force required to pull kernels from the panicle.) Outcrossed seed from Experimental 3 lines grown in isolation was harvested in 1977 for testing in preliminary yield trials in 1978.

The progenies were deemed desirable for testing based on the following selection criteria on the Experimental 3 lines:

Superior yield	11 entries	(Elite)
Earliness	8 entries	(Earliest)
Best tensile strength	9 entries	(Tensile)
Reduced plant height	9 entries	(Shortest)

The selected progenies were fall planted at Grand Rapids in two-row plots (one-foot spacing and 10 feet long at 150 seeds per row) with plots replicated two or three times depending on the amount of available seed. The progenies from each selection group were tested in four different experiments with K2 and Netum included as check entries to form a basis for comparison. Some of the data are presented in Table 5.

Table 5. Results of preliminary yield tests of "Experimental 3" derivatives.

Selection group	Adjusted yield1/				Average2/ Height (in)	Harvest date	Panicles per ft.^{2}
	Average	Best entry	K2	Netum			
Elite	1263	1676	1904	lost	62	8/15	7.7
Earliest	971	1208	1760	1208	60	8/13	9.0
Tensile	714	1231	1351	1261	60	8/15	4.6
Shortest	1231	1423	1730	900	62	8/15	7.9

1/ Yield in pounds per acre at 40% moisture.

2/ Average height of K2 and Netum was 69 and 65 inches, respectively.

Preliminary yield test data must always be interpreted with caution since the tests are usually conducted with limited amounts of seed in small plots. Some observations can be made that are of interest to me.

1. Netum itself is not very consistent in performance.
2. The best entry in each group is probably not superior to Netum itself when a good test of Netum is obtained.
3. Comparison of the best entry from each selection should be based on how it compares to K2. To say the best "Elite test" progeny is superior to the best "Earliest" progeny is not appropriate because the materials were not evaluated in the same experiment.
4. The progenies of "Experimental 3" lines selected for shortness were not shorter than those selected for the other characteristics.
5. Earliness selected entries are probably earlier than the other selections.
6. The best progeny among the tensile strength selections is interesting because the mean of that group was low and K2 performance was also down.

Most of this material will be discarded but we might combine the superior progenies from each group if remnant seed is available. We are continuing selection for tensile strength in Experimental 3 with the hope of increasing shattering resistance in the Netum genetic background. The population needs to be field evaluated for shattering in order to assess the amount of progress being made.

5) Preliminary yield trials of bulk selections from Excelsior paddy isolation.

The outcrossed progenies from isolation plots at Excelsior in 1977 were evaluated at Grand Rapids in the same format as the above described preliminary yield trials. The progenies trace to some crosses of Canadian lines and project materials. K2 was included as the check. Three of the entries were not significantly lower yielding than K2 and thus will be of some interest. The outcross progenies had adjusted yields of 1272, 1328, and 1160 compared to 1368 pounds per acre for K2. They flowered a few days earlier than K2 but the two higher yielding selections matured at the same date as K2. One was 6 inches shorter than K2.

6) Disease resistance studies (cooperative with Dr. James Percich, Department of Plant Pathology).

Dr. Elliott had three selection programs for disease resistance. The 1978 season was not favorable for disease development in the breeding plots. The programs were continued by selecting plants on the basis of desirable agronomic appearance when there was no evident disease infection in the plots. We need to have a higher level of infection in the disease nurseries in order to select for disease resistance. Dr. Percich believes that the planting arrangement used by the breeding project does not favor disease build-up. The solid seeding he proposes is not well-suited to single plant selections necessary in Elliott's designs. If we can in fact show solid seeding favors disease development, the selection programs will have to be changed in design. The combined effort of the pathology and breeding projects on disease resistance has been considerable in the last few years. We must make every attempt to achieve better progress from these efforts.

7) Genetic studies have not been given high priority the last year or so. Pollen travel studies important in determining minimum isolation

distances for maintaining varietal purity had to be abandoned when the white flower stocks were discovered to be segregating. We have greenhouse materials planted to clean up the stocks, but we are having trouble getting pollen production in the materials flowering in December-January. We need to develop more genetic marker stocks and will emphasize this area of work.

Acknowledgements: The cooperative efforts of the personnel at Grand Rapids Experiment Station, the Fruit Farm at Excelsior and Rosemount Experiment Station are vital to the success of the breeding project. Growers also contribute through their interest, advice, and direct participation in cooperative tests or seed increase. We appreciate your support and welcome your continued participation, direct or indirect.

Plot technicians carry the burden of the project research. Gary Linkert and Mark Weinberger (resigned in Fall of 1978) continue to do a good job in carrying out the project research. Henry Schumer, technician at Grand Rapids, has provided good support for our Grand Rapids research. Only the past and present project leader can fully appreciate how important these men are to the project's success.

WILD RICE DISEASE RESEARCH - 1978

A PROGRESS REPORT
January 15, 1979

Dr. James Angelo Percich, L. L. Nickelson,
T. J. Arlt, and R. Bowden
Department of Plant Pathology
University of Minnesota
St. Paul, Minnesota 55108

The sixth full year of plant pathology wild rice research was completed during 1978. Research continued to be focused on the development of efficient chemical control procedures and studies into the fungal and bacterial pathogens of wild rice. Major areas of study centered on the following:

1. Continued search and field testing of alternate fungicidal materials.

2. An examination of various stickers and spreaders to increase the efficiency of Dithane M-45.

3. Continued aerial application of Dithane M-45 with two different types of Triton products.

4. A preliminary study of stalk rot caused by *Helminthosporium sigmoidium* and an investigation of seed for the presence of seedborne pathogens.

5. Continued screening of plant introductions for *Helminthosporium* species resistance.

MATERIALS AND METHODS

Screening for Alternative Fungicides

In the spring of 1978 paddies at the North Central Experiment Station at Grand Rapids, Minnesota were planted with a cultivated wild rice "variety" designated K-2 at a rate of 35 lb per acre. Fungicide applications were made utilizing a backpack, CO_2 pressurized sprayer system delivering 300 ml of material at 25 psi which is equivalent to a rate of 35 gallons of spray material per acre. The test plots were 10 ft x 10 ft, with a standardized 5 ft x 5 ft inner square being hand harvested for data determination. Each test plot was replicated 5 times with a completely randomized design being employed.

The following chemicals were utilized at recommended label rates for the control of *Helminthosporium* spp. or the members of the grass family:

Chemical	Rate
Benlate 50-WP	1 lb actual per acre
Bravo-6F	10 lb " " "
Dithane M-45	2 lb " " "
Dyrene 50-WP	2 lb " " "
RH-2161	0.5 lb " " "
RP-26019 50-WP	87 oz " " "

Triton CS-7 was used at a rate of 1 pint per 100 gal for all the above chemicals except for RH-2161 and Bravo-6F, in which case none was used. The first spray application was initiated on July 5, 1978 during the late boot stage of plant development, the 2nd, 3rd, and 4th sprays being applied on July 12, 25, and August 8th, respectively.

On July 6 and July 20 all plots were inoculated with mixed isolates of *Helminthosporium oryzae* and *H. sativum*. On September 6, 1978, the seed was hand harvested, green weights determined, and then dried for 14 days at 95 F, and weighed in grams. All yield data was then converted to pounds per acre. The check plots were sprayed 1, 2, 3, or 4 times with water alone.

Study of Various Stickers and Spreaders With Dithane M-45

In the sticker-spreader study the plot size, numbers of replication, and inoculation times and procedures were the same as the fungicide tests. The stickers and spreaders investigated were added to the recommended rate of Dithane M-45 (2 lb/a) at the following amounts:

Sticker-Spreader	Rate
Triton CS-7	11 oz per acre
Triton AG-98	1 qt per acre
Triton B-1956	2.4 oz per acre
Nu Film-17	7.0 oz per acre
Acrylic	7 qt per acre

The check plots were sprayed with water or Dithane M-45 alone. The same harvesting procedures were utilized as in the fungicide trials.

Airplane Application of Dithane M-45 and Triton CS-7 and Triton B-1956

Tests were done in the summer of 1978 to determine the efficacy of controlling *Helminthosporium* spp. blight of wild rice utilizing large scale airplane application. Dithane M-45 was applied at a rate of 2 lb/a in 5 gal of water plus either 1.6 oz of sticker-spreader Triton CS-7 or .3 oz of Triton B-1956. All the plots were 120 ft wide and ranged in length from 230 to 400 ft depending on location. The aerial applications at Clearbrook and Gully began when the plants were in late boot and early flowering with little or no blight being present in the paddies when the tests were initiated. Applications were made at 7 to 10 day intervals. In each location 1, 2, 3, or 4 applications were made with the last one being at least 26 days before harvest to comply with EPA regulations.

Observations were made on the initiation of blight throughout the growing season. The incidence of disease at the Clearbrook and Gully locations during 1978 was generally quite low.

Yields from the test plots were hand harvested by taking five 10 ft x 10 ft sections randomly (at least 100 yd apart), dried and weighed as previously outlined. The checks consisted of strips not treated with either Dithane M-45 or any sticker-spreader.

RESULTS

Study of Alternative Fungicides

When Dithane M-45, Bravo-6F, Dyrene 50-WP, Benlate 50-WP, RH-2161, and RP26019 were used against plants inoculated with mixed cultures of *Helminthosporium oryzae* and *H. sativum* they all produced significant (at the 5% level) increases in yield when compared to the uninoculated checks (Tables 1-6).

Four applications of Dithane M-45 resulted in a 71% increase in yield over the check plots (Table 1). The plots treated with 3 sprays were lost because of lodging and bird damage.

Bravo-6F also resulted in good yields when compared to the check (Table 2). An increase of 59 and 56% occurred with 3 and 4 sprays, respectively. Those plots which received only two applications resulted in only a 14% increase over the control, due to lodging.

Dyrene, another protective fungicide like Dithane M-45 and Bravo-6F resulted in only a 26% increase in yield when averaging the results of 2, 3, and 4 applications (Table 3). Even though tests with this fungicide in the laboratory against the fungi indicated good fungicidal activity, field tests in 1978 were not very dramatic.

Benlate 50-WP is a systemic fungicide. Its use, especially with only 2 applications resulted in a 94% increase over the non-treated controls (Table 4). Subsequent applications of 3 and 4 sprays resulted in only yields of 34 and 17%, respectively, over the check. Since Benlate is a systemic fungicide and is actively taken up and redistributed in the plant tissues, the yield decline may have been a result of possible plant damage (phytotoxicity) by the chemical. Work with Benlate at different dosages will have to be investigated.

RH-2161, an experimental chemical from Rohm and Haas Company, may be both a protectant and eradicant (chemical taken up locally by the plant) in nature. After 2 and 3 applications yield increases were 77 and

43%, respectively (Table 5). Decreasing yield increases, as in the case of Benlate (Table 4), may have been a result of phytotoxicity.

Rhodia Corporation's experimental systemic chemical, RP-26019, was also examined. Increasing the number of applications resulted in a corresponding increase in yields when compared to the checks (Table 6).

A maximum increase of 55% over the check occurred with 4 applications of RP-26019. One, 2, and 3 applications resulted in increasing yields of 34, 34, and 32%, respectively, over controls (Table 6).

The data comparing the yield increases of Bravo-6F, Dyrene 50-WP, Benlate 50-WP, RH-2161, and RP-26019 to Dithane M-45 is illustrated in Table 7. Bravo-6F and Dyrene 50-WP, the two protective fungicides, at 3 applications resulted in a 72 and 41% increase in yield over Dithane M-45 (Table 7), while Benlate, RH-2161, and RP-26019, the three systemic or eradicant chemicals, at 3 applications resulted in a 46, 55, and 43% increase in yields over Dithane M-45 (Table 7). However, in all cases the test chemicals, after 4 applications, resulted in less yield than Dithane M-45. This was due to bird damage and lodging, as well as possible phytotoxic effects of the systemic chemicals.

Study of Various Stickers and Spreaders With Dithane M-45

Table 8 summarizes the effects of using Triton CS-7, Triton AG-98, Triton B-1956, Nu-Film 17, and Acrylic in combination with Dithane M-45 when compared to Dithane M-45 alone. Applications of 2, 3, and 4 sprays were utilized in this experiment. In all cases, except for Triton AG-98 and Triton B-1956, after 2 and 3 application rates yield increases resulted when compared to Dithane M-45 alone (Table 8). There was no significant increases in yield with Triton AG-98 regardless of the number of applications. Also, Triton AG-98, Triton B-1956, and Nu-Film did not differ significantly from each other or from Triton CS-7 at the 2 and 3 application rates. However, Nu-Film 17, at the 4 application rate, and Acrylic, at all rates of application, did result in a significant yield increase over both Dithane M-45 alone and Dithane M-45 plus Triton CS-7 (Table 8). In all cases possible harmful effects on wild rice by the use of these chemical sticker-spreaders may exist and will have to be investigated further before any recommendation can be made.

Airplane Application of Dithane M-45 With Triton CS-7 or Triton B-1956

Airplane application of Dithane M-45 plus Triton CS-7 was compared to Dithane M-45 plus Triton B-1956 at Clearbrook and Gully, Minnesota during the summer of 1978 (Tables 9 and 10).

At Clearbrook, Minnesota the only significant differences existing in yield over the check with Dithane M-45 plus Triton CS-7 occurred only at the 1 application rate (Table 9) whereas Dithane M-45 plus Triton B-1956 at the 1 and 3 application rates resulted in a 25 and 14% increase in yield, respectively. These values were statistically significant at the 5% level. When comparing the performance of Dithane M-45 plus Triton B-1956 to Dithane M-45 plus Triton CS-7 significant differences did result.

There was a 34 and 35 lb/a difference between the two at the 1 and 3 application rate, respectively. This is an increase of 13 and 15%, respectively, over Dithane M-45 + Triton CS-7 (Table 9).

The aerial application experiment at Gully, Minnesota with Dithane M-45 with either Triton CS-7 or Triton B-1956 did result in significant differences in yields over the check plots at all application rates Table 10). However, when comparing the use of Dithane M-45 with Triton B-1956 to Dithane M-45 plus Triton CS-7 only with the 3 application rate did a significant difference exist. Dithane M-45 in combination with Triton B-1956 resulted in an increase of 209 lb which is equivalent to a 26% increase over Dithane M-45 plus Triton CS-7 (Table 10).

A Preliminary Study of Stalk Rot Caused by Helminthosportium sigmoidium and An Investigation of Seedborne Pathogens.

An apparently increasingly important plant pathogen, Helminthosporium sigmoidium, causal agent for "stalk rot" in wild rice, was investigated at the Kosbau brothers' farm in 1978. All plots were treated with Dithane M-45 plus Triton CS-7. Treatment plots received either 2 sprays of Du-Ter at 4 lb/a or one spray at 2 lb/a during late boot stage of development. Those plots having the one spray application had a yield increase of 5%. Plant damage (phototoxicity) did occur and may have played an important role in experimental results. Du-Ter has been successfully used on white rice in the southern and southeastern rice growing areas of the U.S. for efficient control of H. sigmoidium. The role of this pathogen in yield reduction due to stalk rot and subsequent lodging will be investigated in 1979.

In 1978 two seedborne pathogens, Helminthosporium oryzae, causal organism of Helminthosporium blight and Fusarium roseum Graminearum, causal organism for a seedling blight and stalk rot were found in some wild rice growers' seed. The former was found in 11% of the seed and the latter in 6%. This may be a very serious problem and could explain low seed germination and potential overwintering of the blight organism. A program is now underway to screen growers' seed and test such seed lots with systemic fungicides for eradication of these two pathogens.

Development of Disease Resistant Lines (In Cooperation With Mr. G. Linkert and Dr. W. Anson Elliott)

During the summer of 1978 the Plant Pathology project, in cooperation with Dr. Anson Elliott and his staff, screened wild rice introductions for possible disease resistance to Helminthosporium blight. Over 5,000 plants were inoculated three times at Grand Rapids and Rosemount, Minnesota with isolates of H. oryzae and H. sativum collected throughout the state. The resulting infection was monitored and individual plant reactions were observed and recorded. Disease readings based on lesion size and percent leaf coverage were made on July 13, 25 and August 1 and 18.

The fourth cycle of ear-to-row selection was completed during the summer of 1978. Each of 9 lines selected in 1977 were planted separately in 6 replications. The least diseased individual plant from each of the 54 plots was selected.

Similar disease screening techniques were used to select 4 resistant progeny from the 20 plants selected in 1977 from the general gene pool.

Also, in 1978 over 200 plants were selected from the disease mass selection plots.

CONCLUSION AND SUMMARY OF WORK COMPLETED IN 1978

I believe the past year, my first as the wild rice project leader, has been a turning point in Plant Pathology's involvement in this program and with 1979 promising to be a productive year.

In 1978 I have been able to develop a working laboratory-greenhouse physical plant for mycology and bacteriology research, improved communication with growers and cooperators, and potential research productivity by the addition of two graduate students.

Much needed improvements were made in the laboratory along with the obtaining of suitable greenhouse facilities to allow, for the first time, productive research efforts during the winter months.

In 1978 I was able to gain greater grower involvement and interest in our program through improved visibility, extension writing, and the development of a seed testing program. Additional funding for the control and eradication of seedborne pathogens has been explored. Improvements in communication and research productivity occurred in 1978 with pathology taking an even greater responsibility in the breeding program and, for the first time, involvement with the extension agronomist in a disease control program.

Graduate student training in the project during 1978 has been exciting with the completion of one M.S. student and the addition of two more: Robert Bowden (M.S. candidate who will study the bacterium *Pseudomonas oryzae*, causal organism of bacterial streak, a potentially serious problem in Minnesota) and Kosim Kardin (Ph.D. candidate who will investigate the distribution, taxonomy, and races of *Helminthosporium oryzae*, the most serious pathogen limiting wild rice production). I hope to have an additional student in 1979 to investigate the epidemiology of *H. oryzae*.

Summary of Work Completed in 1978

1) The continued development and testing of a newly designed quantitative inoculator (QI) and a detached leaf bioassay (DLB) for the efficient and accurate screening of plant introductions for resistance to *Helminthosporium* spp. A paper on this technique should be completed during 1979.

2) Grower use and confidence in Dithane M-45 statewide.

3) Chemical research

    a) Screening of 11 protectant and/or systemic fungicides in the laboratory with the best 5 being field tested. All gave significant disease control with Bravo-6F, RH-2161, RP-26019, and perhaps Benlate 50-WP, showing promise as alternate fungicides to Dithane M-45.

b) Screening of several sticker-spreaders in use with Dithane M-45 to potentially reduce the rate and numbers of applications without loss of disease control effectiveness.

A publication is scheduled for late 1979.

4) Establishment of a seed testing research program for seedborne pathogens on a statewide basis.

Acknowledgement

We gratefully acknowledge and appreciate the cooperation of the following people: John Gunvelson, Paul Imle, James Nickelson, Ervin Oelke, Henry Schumer and his staff at the North Central School and Experiment Station, Grand Rapids, Minnesota and to the Minnesota wild rice growers for their continued interest and support of the Plant Pathology Wild Rice Project in 1978.

TABLE 1. EFFECT OF DITHANE M-45 ON HELMINTHOSPORIUM BLIGHT DISEASE CONTROL AT GRAND RAPIDS, MINNESOTA.

	DITHANE M-45		
APPLICATIONS	WEIGHT	TREATMENT WT. OVER CHECK	% INCREASE OVER CHECK
1	434	42	11
2	461	69	17
3	361	-31	
4	672	280	71

CHECK = 392 LB/A

TABLE 2. EFFECT OF BRAVO-6F ON HELMINTHOSPORIUM BLIGHT DISEASE CONTROL AT GRAND RAPIDS, MINNESOTA.

	BRAVO-6F		
APPLICATIONS	WEIGHT	TREATMENT WT. OVER CHECK	% INCREASE OVER CHECK
1	553	161	41
2	445	53	14*
3	622	230	59
4	610	218	56

CHECK = 392 LB/A

* NOT SIGNIFICANT AT THE 5% LEVEL

TABLE 3. EFFECT OF DYRENE 50-WP ON HELMINTHOSPORIUM BLIGHT DISEASE CONTROL AT GRAND RAPIDS, MINNESOTA.

	DYRENE 50-WP		
APPLICATIONS	WEIGHT	TREATMENT WT. OVER CHECK	% INCREASE OVER CHECK
1	384	-8	
2	476	84	21
3	510	118	30
4	499	107	27

CHECK = 392 LB/A

TABLE 4. EFFECT OF BENLATE 50-WP ON HELMINTHOSPORIUM BLIGHT DISEASE CONTROL AT GRAND RAPIDS, MINNESOTA.

	BENLATE 50-WP		
APPLICATIONS	WEIGHT	TREATMENT WT. OVER CHECK	% INCREASE OVER CHECK
1	376	-16	
2	760	368	94
3	526	134	34
4	461	69	17

CHECK = 392 LB/A

Table 5. EFFECT OF RH-2161 ON HELMINTHOSPORIUM BLIGHT DISEASE CONTROL AT GRAND RAPIDS, MINNESOTA.

	RH-2161		
Applications	Weight	Treatment Wt. Over Check	% Increase Over Check
1	434	42	11*
2	695	303	77
3	560	168	43
4	461	69	17

Check = 392 lb/A

* Not significantly different from the check at the 5% level.

TABLE 6. EFFECT OF RP-26019 ON HELMINTHOSPORIUM BLIGHT DISEASE CONTROL AT GRAND RAPIDS, MINNESOTA.

	RP-26019		
APPLICATIONS	WEIGHT	TREATMENT WT. OVER CHECK	% INCREASE OVER CHECK
1	526	134	34
2	526	134	34
3	518	126	32
4	606	214	55

CHECK = 392 LB/A

TABLE 7. COMPARISON OF VARIOUS FUNGICIDES TO DITHANE M-45 FOR THE CONTROL OF HELMINTHOSPORIUM BLIGHT AT GRAND RAPIDS, MINNESOTA.

	Dry Weight In Pounds/Acre No. of Applications				% Increase Over Dithane M-45 No. of Applications			
	1	2	3	4	1	2	3	4
DITHANE M-45	434	461	361	672				
BRAVO-67	553	445	622	610	27	--	72	--
DYRENE 50-WP	384	476	510	499	12*	3*	41	--
BENLATE 50-WP	376	760	526	461	--	65	46	--
RH-2161	434	695	560	461	0	51	55	--
RP-26019	526	526	518	606	21	14	43	--

* Not significant at the 5% level

Table 8. EFFECT OF VARIOUS STICKER-SPREADERS AND DITHANE M-45 COMBINATIONS FOR THE CONTROL OF HELMINTHOSPORIUM BLIGHT ON WILD RICE AT GRAND RAPIDS, MINNESOTA.

Treatment	Treatment Wt.			Treatment Wt. Over Dithane M-45. Alone			% Increase Over Dithane M-45. Alone		
	No. of Applications			No. of Applications			No. of Applications		
	2	3	4	2	3	4	2	3	4
DITHANE M-45-Alone	603	741	652						
DITHANE M-45-Plus									
TRITON CS-7	652	794	729	49	53	77	8*	7*	12
TRITON AG-98	510	714	683	-93	-27	31	--	--	5*
TRITON B-1956	591	629	856	-12	-111	204	--	--	31
NU FILM-17	626	794	814	23	53	162	4*	7*	25
ACRYLIC	745	841	802	142	100	150	23	14	23

Check = 392 lb/A

* Not significant at the 5% level

TABLE 9. POUNDS OF WILD RICE PER ACRE USING DITHANE M-45 IN COMBINATION WITH EITHER TRITON CS-7 OR TRITON B-1956 AT CLEARBROOK, MINNESOTA.

Numbers of Applications	Dithane M-45 CS-7	Dithane M-45 B-1956	Yield Over Check CS-7	Yield Over Check B-1956	% Increase Over Check CS-7	% Increase Over Check B-1956
1	258	292	24	58	10	25*
2	239	237	2	3	1	1
3	231	266	-3	32	--	14*

Check = 234 lb/A

* Significantly different from check at the 5% level

TABLE 10. POUNDS OF WILD RICE PER ACRE USING DITHANE M-45 IN COMBINATION WITH EITHER TRITON CS-7 OR TRITON B-1976 AT GULLY, MINNESOTA.

Numbers of Applications	Dithane M-45		Yield Over Check		% Increase Over Check	
	CS-7	B-1956	CS-7	B-1956	CS-7	B-1956
3	814	1,023	105	285	15*	38*
4	821	801	112	92	16*	13*

Check = 709 lb/A

* Significantly different from check at the 5% level

SUMMARY OF RESEARCH ON WILD RICE INSECTS

A. G. Peterson and Paul Hanson

Observations were continued on first appearance and seasonal abundance of the riceworm (Apamea apamiformis) and the rice stalk borer (Chilo plejadellus) by means of light trap catches and field observations. Riceworm larvae were confined on bagged heads of wild rice at Grand Rapids at rates of 0, 1, and 2 larvae per head in order to investigate further the relationship between numbers of riceworm larvae per head and yields. We counted riceworm eggs and larvae on different varieties in an advanced variety trial at Grand Rapids in order to observe possible differences in varietal resistance to riceworms. Although we planned to compare malathion and methiocarb for control of riceworms again in 1978, we could not find a suitable paddy which had enough riceworms. Observations were continued on the biology of the rice water weevil (Lissorhoptrus oryzophilus).

Seasonal abundance of the riceworm. First adults of the riceworm were collected June 26, 1978, as compared with June 19 in 1977 and June 24 in 1976. The first emergence of adults occurred about the same time as the first appearance of heads of wild rice and first blossoms of common milkweed. As reported previously, adult moths visit flowers of common milkweed for nectar. The flight period of riceworm moths extended from June 26 to August 7. First eggs were laid about July 1, and first hatching was observed July 10. Eggs of the riceworm were less abundant than usual. They ranged from 9 to 20 egg masses per 100 heads at Aitkin and from 11 to 40 egg masses per 100 heads at Grand Rapids during mid-July. Most of the eggs hatched by August 1, but there was still an appreciable number of unhatched eggs on that date, and freshly laid eggs were observed as late as August 10. Larval populations developed slowly in relation to the progress of the season and the development of the crop. On August 18 many riceworms were only half grown (4th instar) at Grand Rapids. Riceworms continued to decline in abundance for the third successive year. Infestations were localized, and use of insecticides to control riceworms was not necessary in many paddies. A surprisingly heavy infestation of riceworms developed late in the season in the wild rice breeding plots at Excelsior. Here there were 48 to 176 egg masses per 100 heads on July 27. Very few of the eggs had hatched on that date, and we found only 1 larva. In general, the relatively small numbers of riceworms and their delayed development resulted in less injury than usual in commercial paddies.

Evaluation of injury by riceworms. For each of the 26 replicates of this experiment we selected 3 heads of wild rice of approximately the same size and stage of development. One head was left without riceworms as a control. One larva of approximately the 4th instar was placed on the second head, and two larvae were placed on the third head. Each head was enclosed in a dacron cloth bag. There were not enough riceworms available for this experiment at either Aitkin or

Grand Rapids this year, and we collected riceworms from a paddy north of Gully on August 8 and placed them on the heads of wild rice at Grand Rapids on August 9. The heads were harvested on September 1 without removing them from the bags and stored in a freezer. During October we counted the numbers of kernels on each head and classified them as plump, unfilled, or damaged by riceworms. The number and growth stage of riceworms on each head were recorded.

Results of the experiment are summarized in Table 1. During the period of the experiment, each larva which developed beyond the 4th instar destroyed an average of 8.7 kernels of wild rice. We calculated an average loss of 10.87% for a population of 100 larvae per 100 heads. This is a lower figure than the 16.3% calculated in 1977. However, we believe the 10.87% to be more realistic because the heads in the 1978 experiment were allowed to mature longer and there was an average of 80 plump kernels per head in 1978 as compared to only 43 plump kernels per head in the 1977 experiment. (Figures used for comparison were plump plus damaged kernels as given in Table 1.)

Results of field and laboratory experiments prior to 1978 led us to recommend that growers control riceworms if the population exceeded 20 larvae per 100 heads with an anticipated yield of 400 lbs. green rice per acre (450 kg./ha.). Results obtained in 1978 do not indicate that any change is needed in our recommendations for control of riceworms. Table 2 gives the calculated losses in dollars per acre due to riceworms as based on (1) 10.87% loss per larva per head, (2) on expected yields, and (3) on a selling price of $1.25 per lb. for green rice. Growers can use the table as a guide in making the decision whether to apply an insecticide to control riceworms or not.

Table 1. Summary of results from confining 0, 1, and 2 riceworm larvae on bagged heads. Grand Rapids.

	1977	1978
Total florets per head	107.3	131.6
Plump undamaged kernels per head	41.7	72.1
Wt. (gms.) per plump kernel	.028	.035
Plump + damaged kernels per head	43.40	80.05
Kernels destroyed per larva	7.09	8.70
Av. instar of larvae at harvest	5.96	5.97
Loss per larva per head	16.34%	10.87%

Table 2. Calculated losses in dollars per acre due to riceworms as based on expected yields, numbers of riceworms per 100 heads, and a selling price of $1.25 per lb. for green rice.

No. worms/	Expected yield in lbs. per acre						
100 heads	100	200	300	400	600	800	1,000
10	$1.36	$2.72	$4.08	$5.44	$8.15	$10.87	$13.59
15	2.04	4.08	6.11	8.15	12.23	16.31	20.38
20	2.72	5.44	8.15	10.87	16.31	21.74	27.18
30	4.08	8.15	12.23	16.31	24.46	32.61	40.76
40	5.44	10.87	16.31	21.74	32.61	43.48	54.35
60	8.15	16.31	24.46	32.61	48.92	65.22	81.53
80	10.87	21.74	32.61	43.48	65.22	86.96	108.70
100	13.59	27.18	40.77	54.35	81.53	108.70	135.88

Use of methiocarb for control of riceworms. We planned to compare malathion and methiocarb for control of riceworms again in 1978, but we could not locate a paddy suitable for the experiment. Riceworms were not abundant at Grand Rapids or in the paddies we surveyed in the Aitkin-Palisade area. We did find a heavy infestation in a paddy north of Gully, but the stand was too thin and uneven for an insecticide experiment. According to our 1977 data, we can expect 75 to 80% control of riceworms by methiocarb when it is applied to prevent damage from blackbirds.

Varietal susceptibility to riceworms. Under conditions of a low infestation, there appeared to be little, if any, difference in numbers of riceworms on Netum and K2 varieties in replicated plots of a fertilizer experiment at Grand Rapids (Table 3). However, in an advanced variety trial including six varieties there was significantly more oviposition in Johnson, Johnson White, and M3 than in the varieties Netum, Netum Short, and K2 (Table 4). After the riceworm eggs had hatched and the larvae had dispersed on their silken threads, there appeared to be a relatively uniform infestation among the different varieties (See count made on August 10, Table 4). Larval dispersal may not have been far, because in this experiment Replicate 2 had the most eggs on August 1 and also the most larvae on August 10. It seems likely that the variety Netum may escape some imjury by riceworms because it is harvested a week or so earlier than the other varieties.

Table 3. Average counts of riceworm eggs and larvae per 25 heads on 4 replications of Netum and K2 varieties in a fertilizer experiment. Grand Rapids, 1978.

		Netum	K2
Florets with eggs	Aug. 1	0	3.0
Riceworm larvae	Aug. 1	1.75	0
Riceworm larvae	Aug. 10	10.25	11.0

Table 4. Counts of riceworm eggs and larvae in an advanced variety trial. Grand Rapids, 1978.

Variety	No. florets with eggs/25 heads[1]	Larvae per 25 heads Aug. 1	Aug. 10
Netum	3.2 bc[2]	1.4	4.3
Netum Short	3.2 bc	0.6	2.3
K2	2.0 c	0.6	3.5
Johnson	6.4 a	0.6	2.3
Johnson White	8.4 a	0.4	3.3
M3	5.4 ab	0.2	3.5

[1]Includes both eggs and eggs which have hatched.

[2]Figures with a letter in common do not differ significantly at the 5% level according to Duncan Multiple Range Test.

Seasonal abundance of the rice stalk borer. The first adults of the rice stalk borer were collected June 11. The flight period continued until July 28. A total of only 24 adults was collected at Grand Rapids during the 83 nights in which the light trap was operated, and only 37 adults were collected at Aitkin during 17 nights of light trap operation. The maximum catch for any one night was 8 as compared to 15 in 1977 and 195 in 1976. These small catches in 1978 indicate a further decline in the abundance of stalk borers. We found a few egg masses of the stalk borer in the Aitkin area during June, but eggs were quite scarce. The few *Chelonus* wasp parasites which we observed seemed to be having a hard time in finding stalk borer eggs in which to oviposit. We recommend that growers continue to destroy weeds along dikes and in areas adjacent to rice paddies in order to eliminate the common overwintering sites of the stalk borer.

Observations on the rice water weevil. The rice water weevil continued to be abundant in the wild rice paddies at the Grand Rapids Experiment Station during 1978, but we did not find a single commercial paddy in which it was abundant enough to cause economic damage. Actually, two species of rice water weevils (*Lissorhoptrus oryzophilus* and *Lissorhoptrus buchanani*) were found to be widely distributed in small numbers in commercial paddies of wild rice. They often occurred together in the same paddy. Our life history studies have been conducted on *L. oryzophilus* which is the more important species, but the life history of *L. buchanani* is probably similar. Adults overwinter primarily in sod along the ditch banks. On May 5, 1978, adult rice water weevils were found up to 8 per sq. ft. in sod along the ditch banks at Grand Rapids. Some of the weevils were feeding to a limited extent on leaves of bluegrass, and some were mating. Dispersal from overwintering sites to wild rice occurred between May 19 and May 27 at Grand Rapids. Adults feed on the floating leaves of wild rice and leave long narrow holes in the leaves. They mate and females deposit their eggs inside the epidermal cells of the submerged leaf sheath. We observed feeding, mating, and oviposition activity all through June and into early July. After the eggs hatch, the young larvae crawl down to the roots and begin to feed. They depend on the roots for both food and oxygen. Larvae were observed on roots of wild rice at Grand Rapids on July 10. Larvae were quite abundant during late July and early August. Although they averaged less than 10 per plant, roots of some plants had from 20 to 47 larvae. Pruning of the roots was evident wherever we found larvae on the roots, but we could not see that it resulted in lodging of plants. Larvae pupated during late July and August. Pupation takes place in a cocoon resembling a tiny ball of mud which is attached to the roots of the plant. New adults began to emerge August 9. These newly emerged adults fed for a time and then migrated to overwintering sites along the ditch banks.

Although the rice water weevil is considered to be one of the most important pests of white rice in the United States, it has not become a major pest of wild rice in Minnesota. There are several possible reasons. In the southern states where white rice is grown the weevil has two generations per year, while in Minnesota it has only one. Commercial paddies of wild rice are usually drained about August 1. At this time most of the rice water weevils are in the larval stage, and they are not able to survive. Drainage of paddies is one of the methods recommended for control of the rice water weevil on white rice. The experimental paddies at Grand Rapids are not usually drained until harvest time or later, and this may explain why the weevil has become more abundant at Grand Rapids than in commercial paddies of wild rice.

HARVEST STUDIES--RASPBARS, TAILINGS AND STRIPPING

by
Cletus Schertz, Winit Chinsuwan and James Boedicker

The harvest research in wild rice has been directed toward means for reducing harvest losses. These studies included: 1) preliminary evaluation of the raspbar cylinder and grate concave system to assess its capability for threshing and separating wild rice, 2) study of the flow rate and makeup of the tailings return material to help gain an understanding of what is happening inside the combine during harvest, and 3) basic studies on the concept of stripping to consider ways to strip kernels from the stalks so as to reduce the amount of straw material going into a harvest machine for separation.

Raspbar Cylinder and Grate Concave

A preliminary study was made on the use of the raspbar cylinder and grate concave. The term "preliminary" should be emphasized because it was exactly that. No conclusions should be drawn from these results. The results point to more unanswered questions than they answer.

A combine equipped with a raspbar cylinder and grate concave was available from another research program. The objective of this study was to assess the harvest performance characteristics of the raspbar system in wild rice.

The harvest performance characteristics were evaluated in terms of net yield and the extent of discharge losses. The abbreviated results are tabulated in Table 1. The net yield measurements were taken from the clean grain elevator during a 100-foot length of combine operation after it had reached steady state conditions. The clean grain collected during 100 feet of travel was weighed and a subsample was taken from which the recovery percentage was determined. The discharge loss samples were collected by use of two catch cloths (one to collect the material from the walkers and one to collect the material from the sieves) inserted beneath the discharge zones of the combine during 30 feet of travel, about midway within the 100-foot distance used for collecting the net yield. After collecting the discharge samples, the wild rice heads were removed from the straw walker discharge before transporting the samples to the laboratory. This removal of the heads was done to isolate the kernels that had not been threshed from the head by the cylinder and to evaluate this as threshing loss. Subsequent to taking the samples to the laboratory, they were air dried and the necessary steps taken to determine the amount of wild rice dry matter in each sample. Then the data was calculated on the basis of 7 percent moisture wet basis.

The data on grain feed quantity per acre points out the variations in crop conditions which were not obvious from cursory observations at time of harvest. This variation in crop condition is also evident from the data on weight per acre of discharged straw. These variations can be reduced by careful control of the field operations before harvest time, increase size of samples and replication of sampling. Because of the extensive time required for processing the samples, the sampling was restricted in size and number.

Table 1. Results of net yield and discharge losses for a combine with raspbar cylinder and grate concave and a combine with spike tooth cylinder.

	Run No.				
	821	822	823	825	826
Type System	raspbar	raspbar	raspbar	spike	spike
Near indicated run No.	826	825	825	822&823	821
COMBINE PARAMETERS					
Travel speed, MPH	1.7	2.3	1.9	2.1	1.9
Cylinder speed, RPM	700	700	1,000	430	430
Concave opening	7/16" front, 5/16" rear			?	?
Fan speed, RPM	1,200	1,200	1,200	1,200	1,200
Air deflector position	ctr	ctr	ctr	ctr	ctr
Sieve openings, in:					
Top front	1/2	1/2	1/2	1/2	1/2
Top rear	3/4	1/2	1/2	1/2	1/2
Bottom	1/4	1/4	1/4	1/4	1/4
Walker wires removed	partial	partial	partial	none	none
RESULTS					
Net yield:					
Green wt. yield, lb/ac	790	650	830	600	460
Percent recovery	39	41	37	37	39
Equivalent lb WR@7% Mwb, lb/ac	310	270	310	220	180
Discharge losses: (equiv. lb WR@7% Mwb) lb/ac					
Threshing loss (walker straw, heads)	6.4	10.2	4.2	21.0	17.7
Walker separation (free kernels)	7.2	10.0	6.0	25.0	33.1
Sieve separation	2.3	2.3	3.0	4.3	1.6
Total	15.9	22.5	13.2	50.3	52.4
Percent Net Yield	5.2	8.4	4.2	22.7	29.3
Grain feed quantity: Total of net yield and discharge losses: (equivalent lb WR@7% Mwb) lb/ac	326	292	323	270	232
Weight of straw discharged, lb/ac	3,940	3,700	4,160	5,900	7,220
Straw feed rate, lb/min	220	280	250	400	440

The data for runs 821, 822, and 823 show the discharge loss averaged 6% of net yield. These three values of discharge loss percentage are well below previous data on discharge losses in wild rice. The data from runs 825 and 826 and visual observation of the kernels contained in the threshing loss sample suggest that the cylinder was not aggressive enough to detach the kernels from the head. Aggressiveness of the cylinder can be increased by increased speed and decreased clearance. It is felt that the cylinder speed of 430 RPM for the two runs was too slow and should be increased to reduce threshing losses.

In all the runs 821, 822, 823, 825, and 826, the data show that the walker separating losses were much greater than the sieve separating losses. It's preferred to have a near balance between these two sources of separation losses. To help balance these for any one machine, the openness of the walkers can be increased in some combines by removal of wires.

A casual observation of the samples of clean grain suggests there are more cracked kernels from the raspbar cylinder than from the spike tooth cylinder. It's uncertain if this is due to the combine or to a variation in sample processing procedure which had been assumed to be noninfluential. The optimum adjustments of cylinder speed and concave clearance and their influence on performance in wild rice have not been determined for either of these two systems.

These two studies relating to raspbar cylinder and grate concave suggest the need for more complete replicated experiments to determine the severity of influence of selected machine adjustments on performance.

Tailings Return Material

The makeup of the tailings return material was studied on 3 machines during harvest of wild rice. This material was studied by determining the flow rate of the tailings return material and also the makeup of this tailings return material. Table 2 provides a brief summary of the results for these studies. No general deductions can be drawn from these results. To have this type of data useful, data should be taken on the tailings return material and correlated with variations in combine adjustments and with combine performance. It's perhaps worthwhile to point out the following: 1) that a higher flow rate of tailings material increases the amount of material from which the combine system must separate the wild rice kernels and 2) a higher percentage of good kernels in the tailings increases the opportunity for the kernels to be carried through the machine as a discharge loss; on the other hand, it also increases the opportunity for the kernels to be directed to the clean grain tank.

A rule of thumb in harvest of small grains is to have the tailing return material be made up of approximately equal parts of threshed grain, unthreshed grain and chaff. No such rules-of-thumb have been developed for wild rice harvest.

The samples of tailings return material were taken by use of a special tube with gate to replace the conventional tube over the auger going to the tailings elevator. For safety reasons it's advised not to sample tailings with the limited access to the tailings that is available on most of the current combines.

Table 2. Tailings return material, flow rate and makeup.

	Combine I	Combine II Avg. of 3 Runs	Combine III Avg. of 2 Runs
Grain feed rate into machine, lb/min (Clean grain + discharge losses)	54*	50	46
Tailings return:			
rate, lb/min	8	28	14
Make up, percentages:			
Good kernels	67	28	15
Non good kernels	26	54	58
Straw and chaff	7	18	27

*Discharge loss not included

Stripping of Kernels From Stalks

The concept of stripping wild rice kernels from the stalks is considered from the standpoint of reducing the amount of straw material taken into the harvest machine. This material-other-than-grain hinders the separation process under present harvest conditions. To evaluate the stripping concept, a test unit, restricted to doing only the stripping action, was developed. This test unit is shown in Figure 1 in schematic and in a photograph. The surfaces of the stator and the rotor were covered with rubber matting with knobs molded in the surface. To use this test stripping unit, the wild rice stalks were cut by hand, clamped in a holder, and fed into the stripper unit at controlled speeds. For evaluation two combinations of stalk orientation and stalk motion were used. One combination is depicted in Figure 1a and the other combination is shown in Figure 1b. The best stripping efficiency (removal of wild rice kernels) was obtained with the combination shown in the photograph of Figure 1b--that of the stalks oriented in planes perpendicular to the axis of the rotor and moved tangential to the rotor surface so that the stalks moved into the stripper and then reversed and pulled out. For this combination, a stripping efficiency of over 99% independent of speed of the stalks was achieved, whereas the other combination of stalks oriented parallel to the axis of the rotor and motion tangential to the rotor surface provided a stripping efficiency of 88 to 95% dependent upon speed of the stalks.

During these tests only a small portion of the stalks was broken free and included with the grain. The results suggest the value of research in developing the design criteria for components from feeding to collection of the stripped grain.

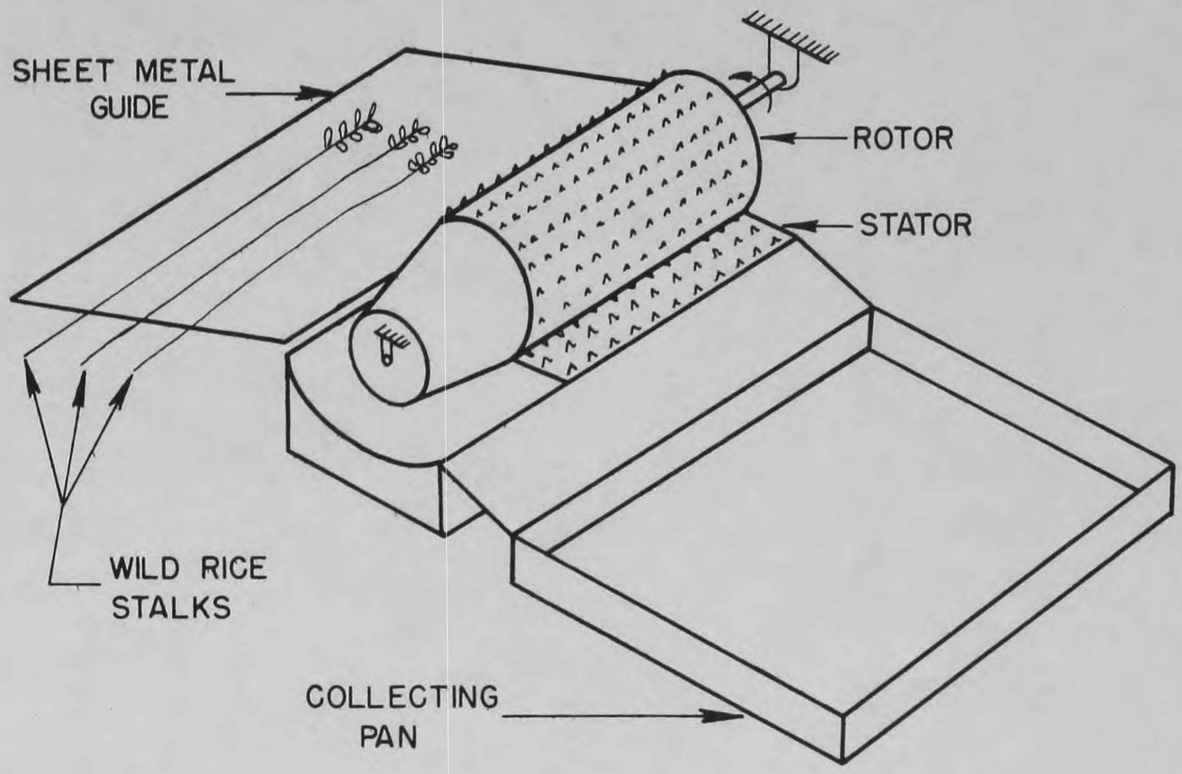


Figure 1a. Isometric sketch of stripper test unit. In this sketch the stalks are oriented parallel to the axis of the rotor and moved tangential to the surface of the rotor.

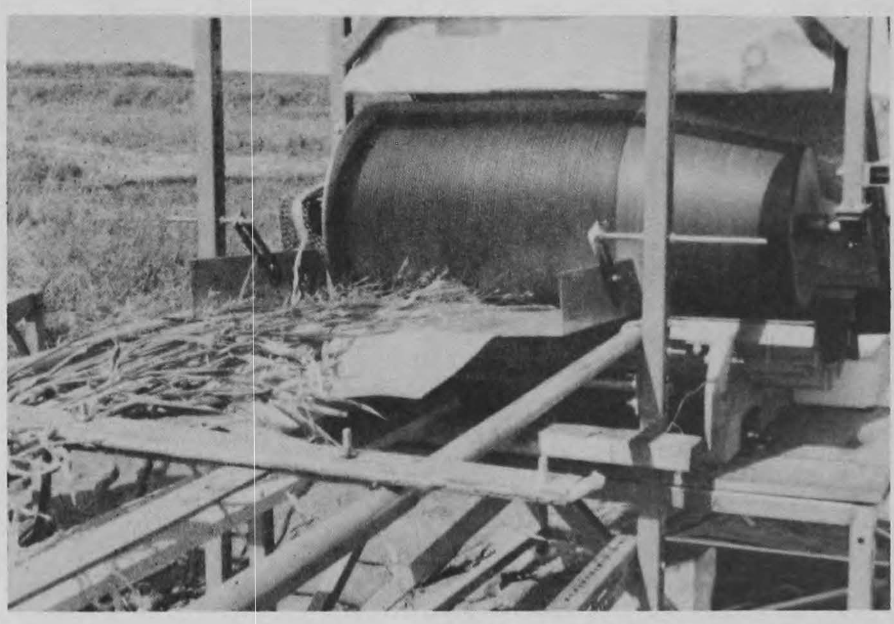


Figure 1b Photograph of stripper test unit. For this photograph the stalks were oriented in planes perpendicular to the axis of the rotor and moved tangential to the surface of the rotor.

PROCESSING STUDIES - 1978

John Strait, Stephen Schenk, J. J. Boedicker

Separation of Immature Kernels

Research on the separator to remove immature kernels from combined wild rice continued during 1978 but at a much reduced level. Continued analysis of samples and data from the 1977 crop showed that the rerun system on the separator gave improved separation of immature kernels. This is a system whereby rice falling at the border between the immature (light) and intermediate maturity (medium) compartments of the collection chamber is returned to the feed table for another pass through the machine. About 7% of the rice fed to the separator is returned.

Table 1 includes data from the 1977 crop which show the overall performance of the separator and more particularly the value of the rerun system. Table 1 shows that on a volume basis, the separator sorted about 32% of the combined rice into the light fraction with the rerun system operative but only about 23% into the light fraction with the rerun system inoperative. The laboratory yield of finished rice was only slightly higher (3.9% compared to 3.6%) for the light fraction with rerun which means that the quantity of immature rice removed was significantly increased with almost no increase in loss of finished rice.

Table 1. Separation data and laboratory-based yield figures averaged for all test runs completed on the 1977 crop.

		As Separated			Finished Rice	
Fraction	Rerun Feature	M. C. Wet Basis %	% by Wt.	% by Vol.	Yield % Green Wt.	% of Total Recovered
Heavy	W/O	37.5	51.0	39.3	50.3	64.9
Medium	W/O	44.0	36.0	37.6	36.9	33.5
Light	W/O	61.4	13.0	23.2	3.6	1.6
Heavy	W	37.0	46.3	33.8	51.4	60.8
Medium	W	44.8	35.4	34.5	41.3	37.4
Light	W	60.0	18.4	31.7	3.9	1.8

The conveyors on the Deerwood separator were rebuilt in an effort to prevent rice from collecting on the conveyor pulleys. We were only moderately successful in this endeavor. The rerun conveyor drive was changed to slow the rate of travel of the conveyor paddles.

Mechanical drawings of all the principal components of the Deerwood separator were completed. The drawings include assembly drawings and detail drawings of individual parts. They should be very helpful in the construction of a separator. The drawings are available at cost from the Agricultural Engineering Department.

Some assistance was provided in the completion of the separator for the Outing processing plant.

Almost all the paddy rice processed at the Deerwood and Outing plants was run through the separators prior to parching. At Deerwood, approximately 95,000 pounds of immature rice was removed from about 800,000 pounds of combined rice. At Outing, about 1,300,000 pounds of combined rice was run through their separator and an estimated 175,000 pounds of immature rice was removed. On a volume basis, the immature rice removed at both plants would represent about 25% of the combined rice separated.

The use of the separators reduce by about 25% the volume of material which had to be run through the parchers with little loss of finished rice. The significance of this is that the operating tine for the plants could be reduced by 25% or alternatively, the annual processing capacity of the plants could be increased by 25%. In addition to the direct savings in operating costs by not processing the immature rice, additional savings accrued by more timely processing of the remainder of the crop. Of course, the cost of separation must be included in an overall economic analysis.

Parching Studies

We are currently working on the development of an improved parching system. Desirable characteristics which we are working to incorporate into the system are as follows:

1. High capacity at reasonable cost.
2. Efficient use of energy and labor.
3. Produce a product of consistent and high quality.

Our working hypothesis is that high kernel strength with a minimum of stress cracks will minimize the problem of broken kernels. Nearly complete gelatinization of the starch and the absence of white and hollow centers would be desirable.

Laboratory studies are in progress to establish design and operating parameters upon which to base the design of the parching system. Laboratory work to date has been concerned with determining the influence of processing variables upon the properties of the finished rice.

Processing variables included in our laboratory studies have included steaming prior to parching, rate of drying, rate of cooling, and methods of drying including hot surface, oven, and hot air. The finished rice is being tested for kernel strength and examined under a microscope for stress cracks. We have been handicapped in determining degree of gelatinization of the starch because of instrumentation problems.

Two devices were constructed to test individual rice kernels for strength. An impact tester consisted of a block to support the rice kernel at two positions near its ends and a pendulum which applied am impact load on the kernel midway between the support points. The energy expended in fracturing the kernel was calculated from the swing of the pendulum past the kernel support block. We also developed a tester which applied a dead load to the kernel midpoint of two supports. The kernel was loaded as a simple beam. The force to fracture the kernel was measured by a strain gage and recorded on a strain gage recorder. Results from the two testers were similar and since the strain gage tester was easier to use, the impact tester was abandoned.

The microscope used to inspect kernels for stress cracks is equipped with a rather powerful light which can be directed upon the kernels from below. Stress cracks are easily visible.

Results

Figure 1 shows results from a single run in which samples of wild rice were removed from the laboratory rotary drum parcher at varying kernel temperatures. The curves show the resulting moisture content, broken kernels and unhulled kernels after one and two passes through the huller. Only kernels remaining unhulled after the first pass were put through the huller again. This test was done in response to a question regarding the possibility of increasing the yield of saleable rice by processing the rice to a higher than usual moisture content. It would appear that hulling problems would be encountered at higher moisture contents. Perhaps increasing the moisture content after normal processing operations would be a better option. More tests will be done on this and the related problem of accurately determining when parching has been completed.

Figure 2 shows the influence of steaming upon strength of wild rice kernels. The wild rice was steamed and then placed in the laboratory oven. The air temperature in the oven for this test was 140° C (285° F). The rice was in a shallow pan so, in reality, the rate of drying would have been relatively slow. After hulling and sorting into size groups, the rice samples were divided and about 70 randomly selected kernels were tested for strength with the results shown. Kernel strength on all graphs is given in terms of pen deflection on the strain gage recorder. Pen deflection is directly proportional to the applied force required to break the kernel. The steamed samples were slightly stronger than the unsteamed sample.

Figure 3 shows the kernel strength of wild rice treated in a similar manner to that described relative to Figure 2 except in this test the rice was parched in our laboratory parcher to a temperature of 285° F. Under these conditions the drying process was relatively fast. Results were erratic, and the influence of steaming was not as pronounced as with the oven-dried material. Kernel strengths were generally much lower than with the similarly treated oven-dried rice. Note the difference in the vertical scale of pen deflection between Figures 2 and 3.

The results shown in Figures 2 and 3 which are typical of other test runs which we have completed suggest that steaming prior to parching is more

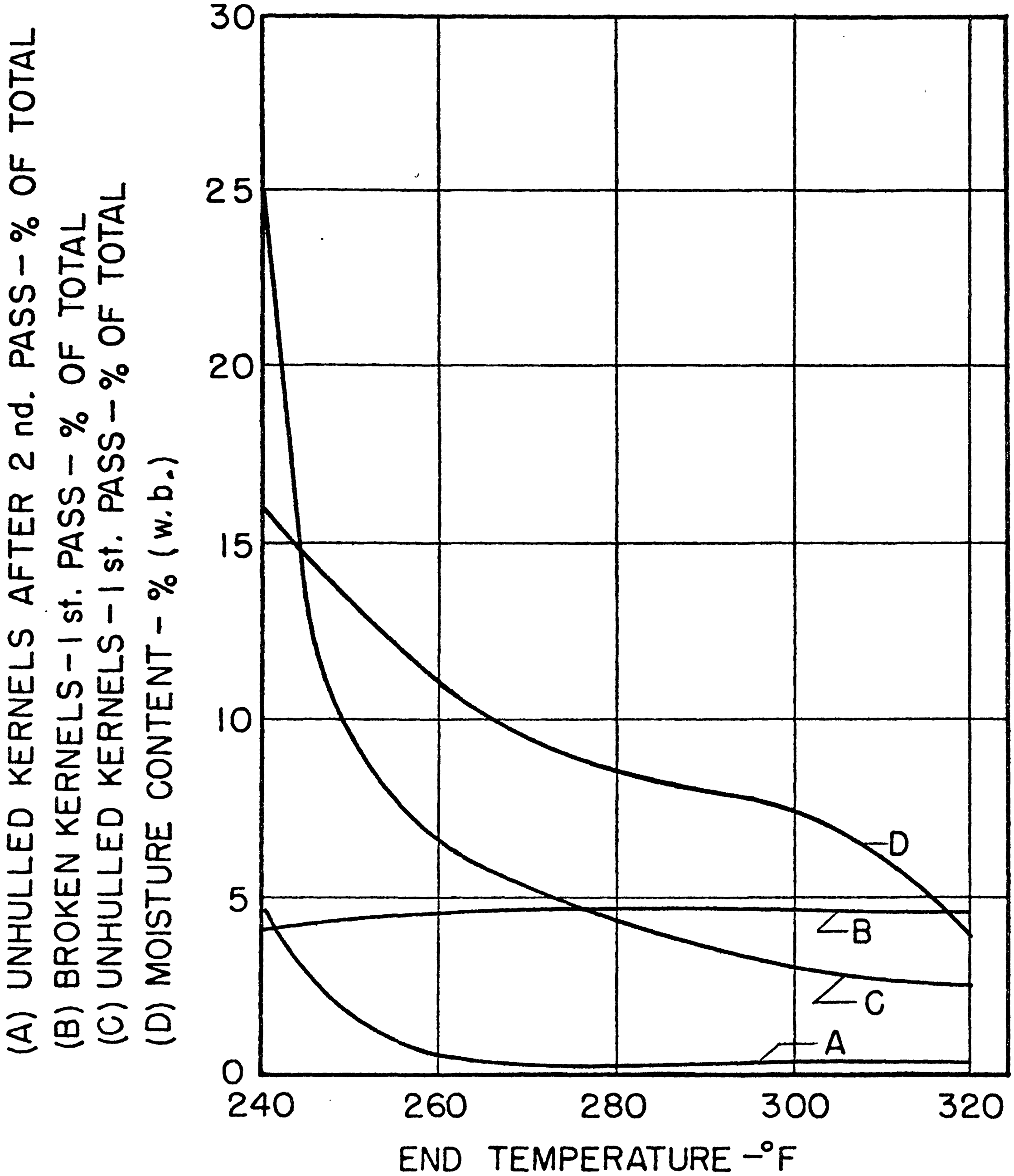
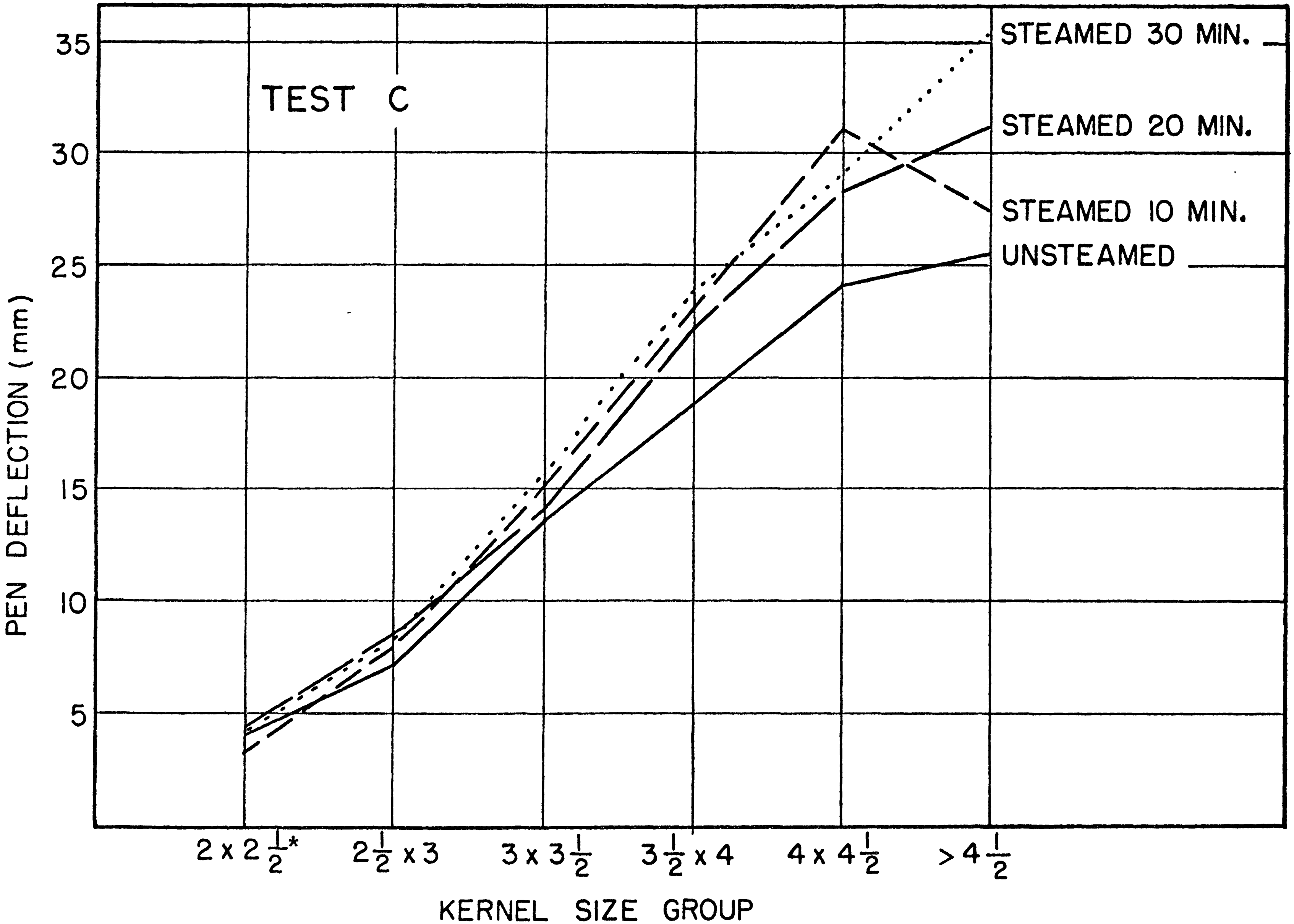


Figure 1. Processing characteristics of wild rice parched to varying kernel temperature in laboratory rotary drum parcher.



*Kernels passed a 2.5/64 slotted sieve and were retained on a 2/64 slotted sieve.

Figure 2. Strength of wild rice kernels oven dried at 285° F.

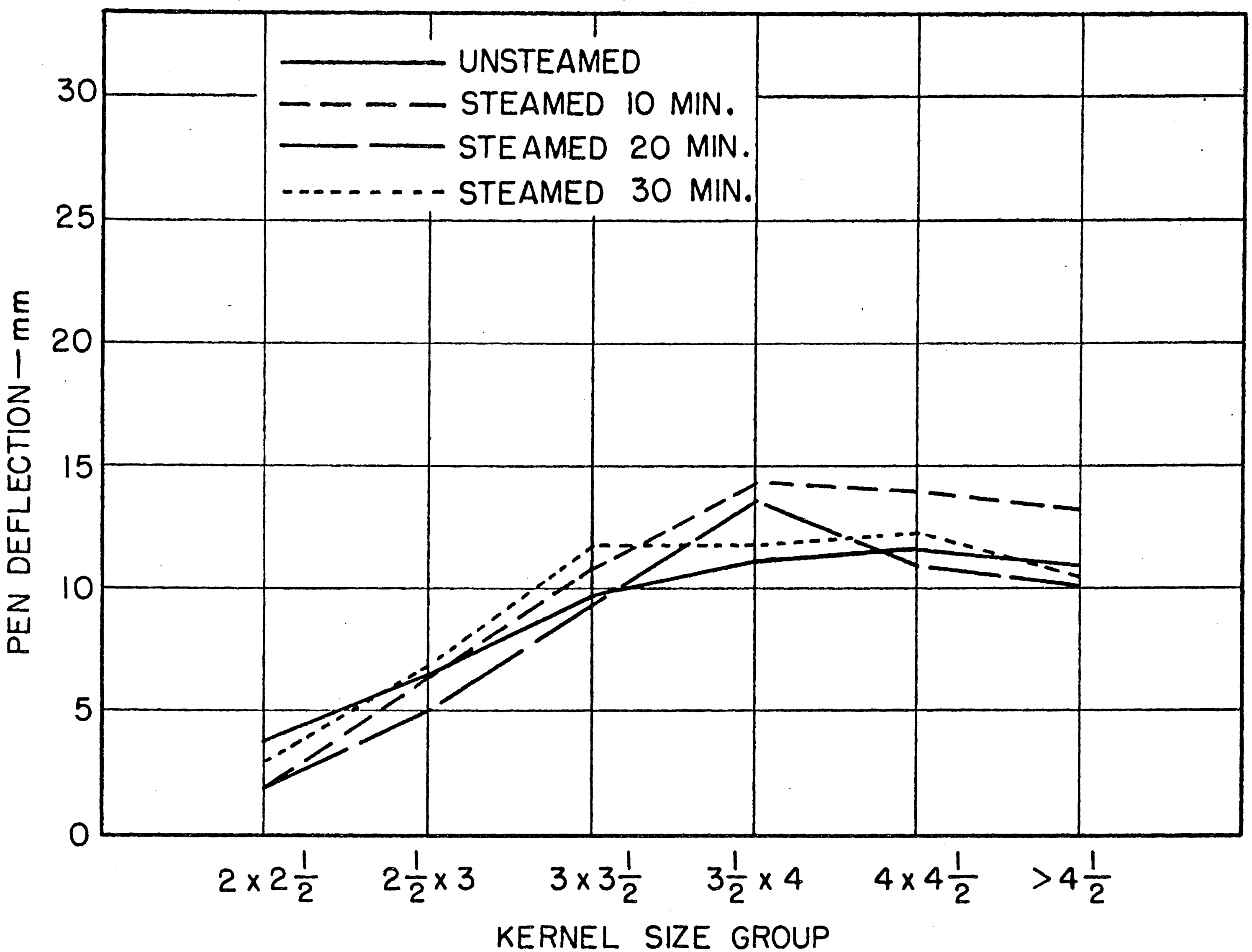


Figure 3. Strength of wild rice kernels. Parched in laboratory parcher to a kernel temperature of 285° F.

beneficial if the rice is air dried as compared to drying in a rotary drum parcher. The results also suggest that kernel strength may be affected by rate of drying.

Figure 4 shows the effects two post-parching treatments upon kernel strength. A batch of wild rice was parched in the laboratory rotary drum parcher. The batch was divided when emptied from the parcher into two test lots. One lot was hulled immediately. The other lot was placed in an insulated box and allowed to cool slowly to room temperature. It was hulled about 24 hours after parching. Results of strength tests for the lot hulled immediately after parching are shown on the curve labeled, hulled hot. The curve marked, hulled cold, gives the average strength of kernels hulled about 24 hours after parching. Approximately 70 randomly-selected whole kernels were tested from each size group of the two lots. The kernels hulled immediately after parching tested relatively weak compared to those hulled cold. Rate of cooling from parching temperature was the only significant difference in the treatment of the two lots.

Representative samples from each size group in each of the two test lots of Figure 4 were examined with the microscope for stress cracks. The results are shown in Table 2.

Table 2. Percent of kernels showing stress cracks.

Kernel Size Group	Kernels with stress cracks, %	
	Hulled Hot	Hulled Cold
Over 4½	95.8	33.3
4 x 4½	85.7	48.5
3½ x 4	80.8	52.2
3 x 3½	46.2	10.3
2½ x 3	33.3	8.0

Table 2 shows that stress cracks were found much more frequently in the kernels from the lot hulled immediately after parching. Also, the larger kernels of both lots were most likely to have stress cracks.

Kernels without stress cracks were selected from each size group of the two lots of Figure 4 and tested for strength. The results are shown in Figure 5. Figure 5 would suggest that except for stress cracks, rate of cooling has no appreciable effect upon kernel strength although the kernels cooled slowly tended to be stronger than those cooled at a relatively fast rate.

Comparing Figures 4 and 5, it is evident that the average strength of kernels in a given size group without stress cracks was clearly greater than that for the same size kernels randomly selected which would include kernels having stress cracks.

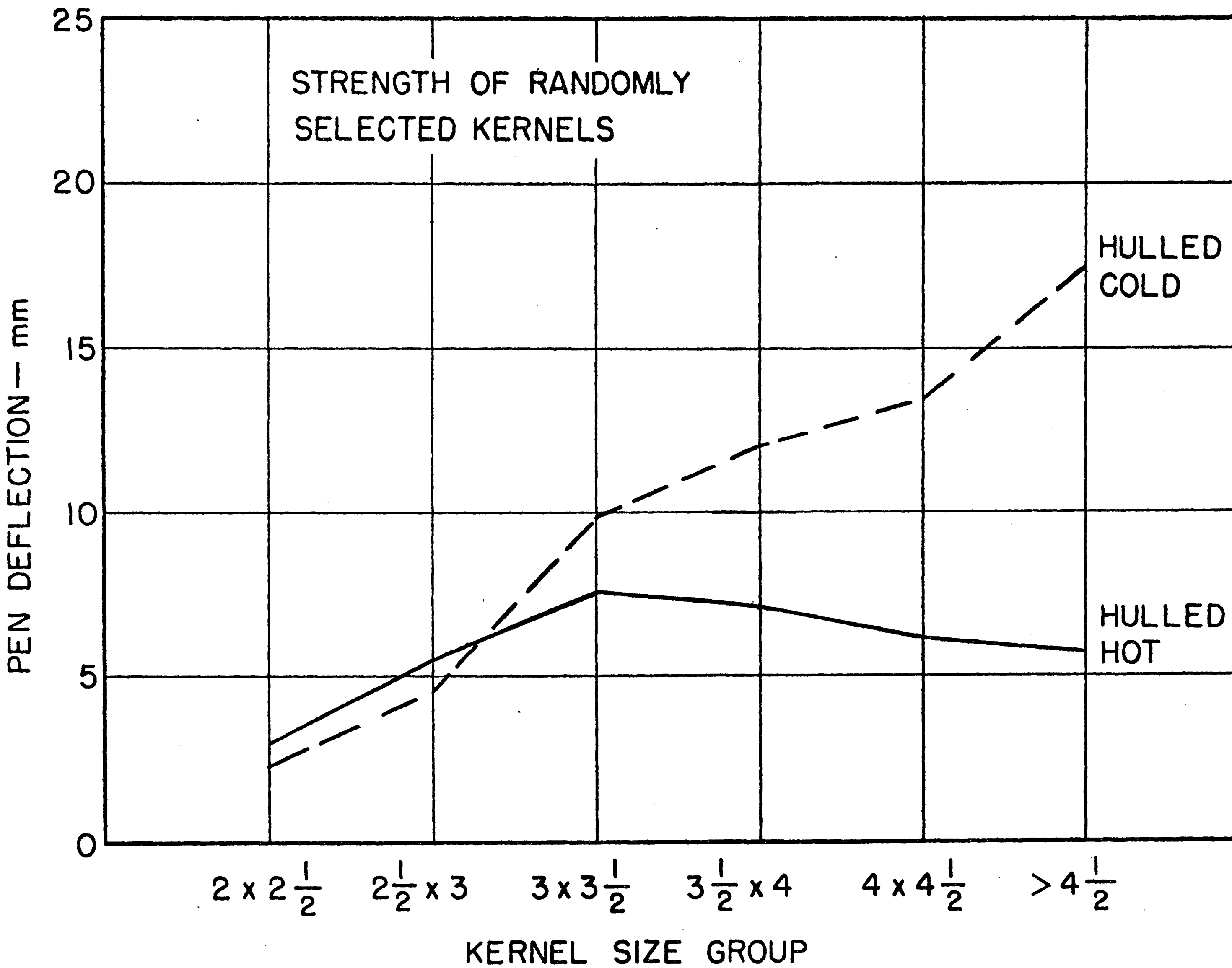


Figure 4. Kernel strength of wild rice subjected to two post parching treatments.

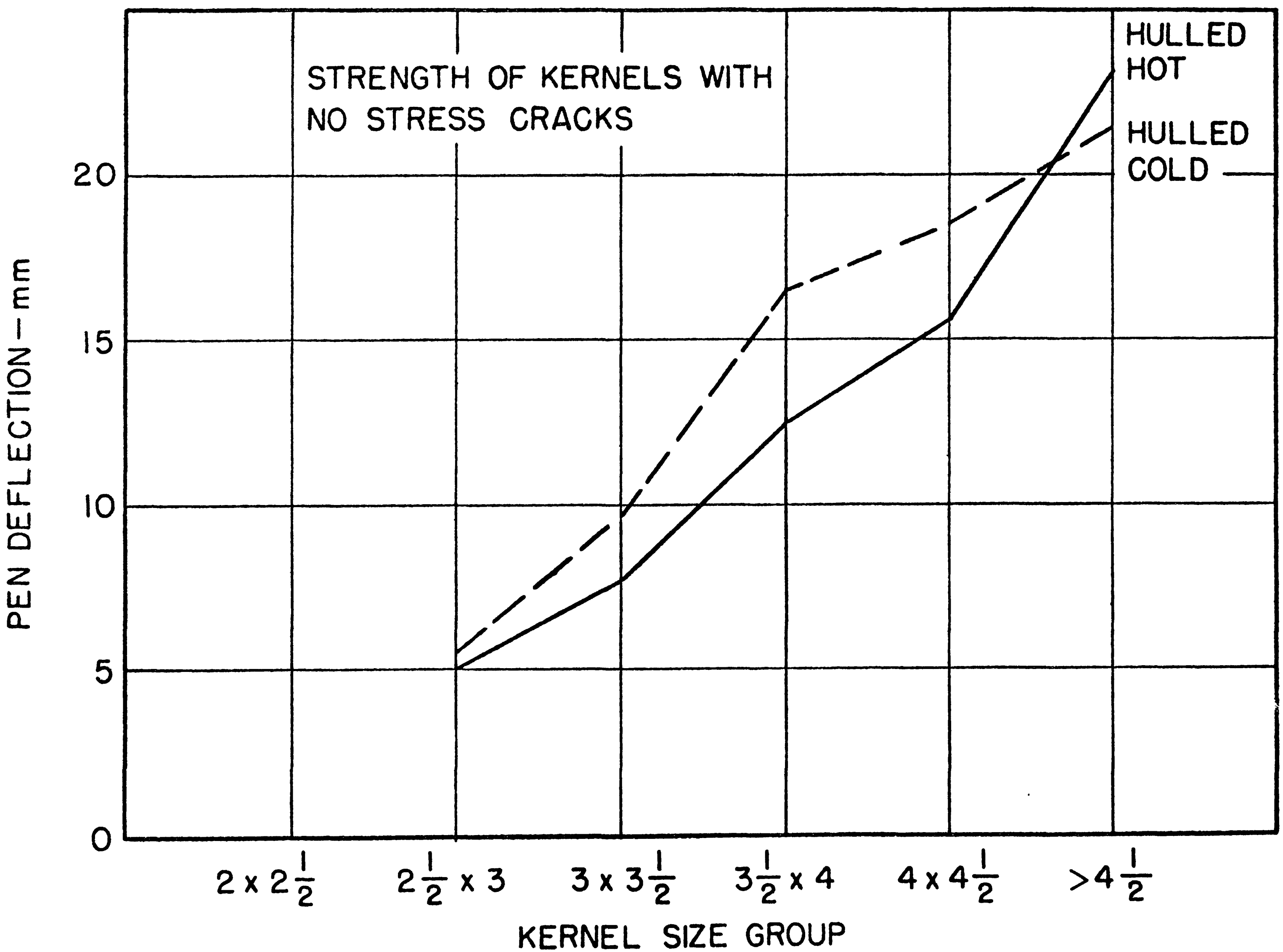


Figure 5. Strength of whole kernels having no visible stress cracks.

A comparison of Figures 2 and 3 would suggest that rate of drying is also a factor in the formation of stress cracks in wild rice kernels during parching.

It seems reasonable to assume that stress cracks developed during parching are a principal cause of broken kernels in finished rice, and to conclude that stress cracking is, to a degree, controllable.

When design and performance parameters are established to a reasonable degree, we will proceed to work on the design of a laboratory-scale parching system. Results of research with the laboratory-scale parching system would be used to design a pilot system for processing plant experiments and use.