Minnesota Wild Rice Research 1982

Agricultural Experiment Station
University of Minnesota
St. Paul, Minnesota 55108
January 20, 1983

CONTENTS

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

The wild rice team wishes to acknowledge the assistance provided by many people. The cooperation of Dr. Rust, Superintendent of the North Central Experiment Station, Grand Rapids and Dr. Wilcox, Superintendent of the Rosemount Experiment Station was greatly appreciated. The use of facilities at the Horticultural Research Center at Excelsior was appreciated. 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 Coordinator was very valuable. We are also extremely grateful to the growers and processors for providing seed, land area and facilities for research. We appreciate the continued support of the Agricultural Experiment Station for wild rice research.

WILD RICE FERTILIZATION RESEARCH - 1982

John Grava
Department of Soil Science

Research was continued during 1982 on fertilization and nutrient requirement of wild rice. Soil, water and air temperatures were monitored during the growing season at Grand Rapids and St. Paul. A nitrogen experiment was conducted with the Netum variety on a mineral soil at Grand Rapids. An NPK fertilization trial with the K2 variety was conducted on peat in Aitkin County.

A. WEATHER CONDITIONS AND PLANT DEVELOPMENT

Average temperatures recorded at three U.S. weather stations were above normal in May and, generally, below normal during April, June, July and August (Table 1).

Soil, water and air temperatures were measured at Grand Rapids within the experimental paddy No. 1 West, and on the St. Paul Campus within an area where experiments in 4 x 4 ft. boxes were conducted (see Fig. 1 and 2).

At Grand Rapids, plants emerged on May 3 (Fig. 3). The jointing stage by Netum wild rice was reached on June 17th, 45 days after emergence. Wild rice was harvested on August 12th, 102 days after emergence. Accumulated Growing Degree Days (GDD) at each stage of plant development was calculated with a base temperature of 40°F. Accumulated GDD's for the 1982 season were 793 at jointing and 2275 at harvest, respectively.

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

Station Year	Month April	May	June	July	August	5 Month Average	GDD T_b=40
	average air temperature, °F						
Fosston, Polk Co.							
Normal[2/]	41.0	54.6	63.6	69.4	67.5	59.2	2955
1974	41.0	50.5	63.4	71.6	62.8	57.9	2744
1975	34.8	55.7	61.9	70.5	64.6	57.5	2852
1976	46.6	54.9	66.8	68.8	70.9	61.6	3315
1977	49.1	66.4	64.6	70.3	60.6	62.2	3446
1978	41.7	59.2	63.4	67.8	67.7	60.0	3060
1979	36.0	48.7	63.6	69.6	63.6	56.3	2627
1980	48.9	61.3M[3/]	68.5	71.0	64.6	62.9	3466
1981	44.4	55.3	60.8	68.1	65.7	58.8	2898
1982	37.0	55.1	55.5	66.8	63.0	55.5	2477
Grand Rapids, N.C. School							
Normal	39.9	52.7	62.0	67.4	65.1	57.4	2681
1974	41.6	49.4	62.7	70.7	62.8	57.4	2670
1975	34.7	57.0	62.2	71.5	65.2	58.1	2951
1976	47.1	54.4	66.1	68.2	67.4	60.6	3166
1977	48.2	63.8	64.0	69.2	60.2	61.1	3284
1978	41.3	57.9	62.8	66.5	66.0	58.9	2892
1979	37.1	49.5	61.5	68.1	62.6	55.8	2511
1980	46.1	59.9	64.0	69.0	66.4	61.1	3237
1981	43.9	54.8	62.0	68.0	67.0	59.1	2941
1982	38.6	57.7	58.5	68.0	64.4	57.6	2753
Aitkin							
1974	42.9	49.8	63.1	71.1	63.3	58.0	2770
1975	39.0M	59.4M	64.4M	72.1	66.2M	60.2	3141
1976	47.5	54.8	66.8	69.3M	68.1	61.3	3267
1977	48.3M	64.4M	65.4M	70.3M	61.0	61.9	3446
1978	40.7M	57.5M	64.1M	67.0M	66.9	59.2	2938
1979	37.7	50.6	62.0	68.1M	63.4	56.4	2585
1980	53.9	58.3	64.0	68.5	66.0	62.1	3394
1981	45.1M	53.8	62.1M	67.5	66.0	58.9	2902
1982	38.3	57.4	57.6	68.6	64.8	57.3	2723
St. Paul, U of M							
1982	43.4	61.3	62.4	73.9	67.3	61.6	3332

1/ Source: Climatological Data, Minnesota, Vol. 80-88 (1974-82), U.S. Dept. of Commerce.
2/ Normals for the period 1931-1960.
3/ M = less than 10 days record missing.

Fig. 1

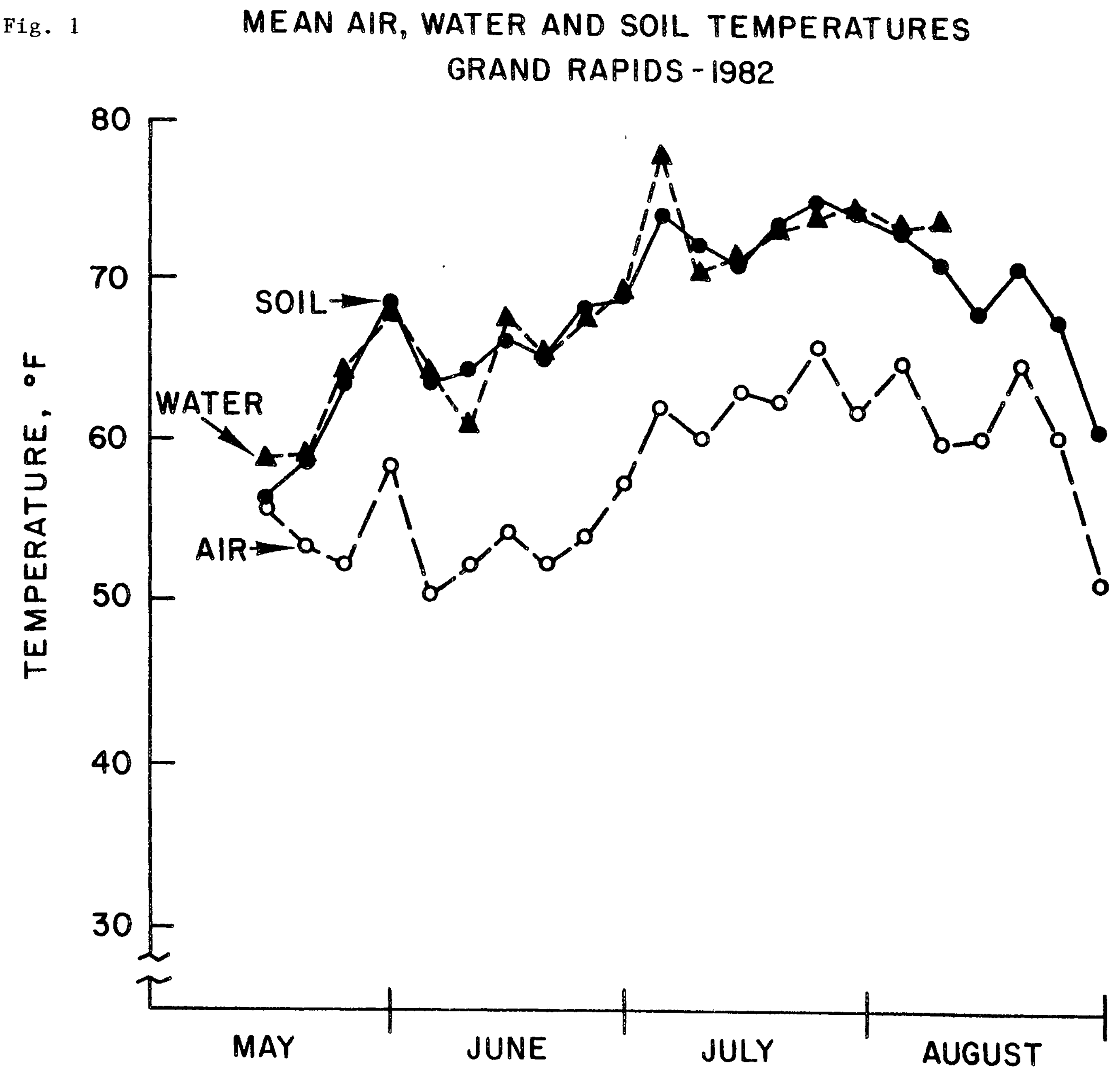
MEAN AIR, WATER AND SOIL TEMPERATURES
GRAND RAPIDS - 1982
TEMPERATURE, °F
80
70
60
50
40
30
SOIL
WATER
AIR
MAY
JUNE
JULY
AUGUST

Fig. 2

MEAN AIR, WATER AND SOIL TEMPERATURES
ST. PAUL CAMPUS - 1982

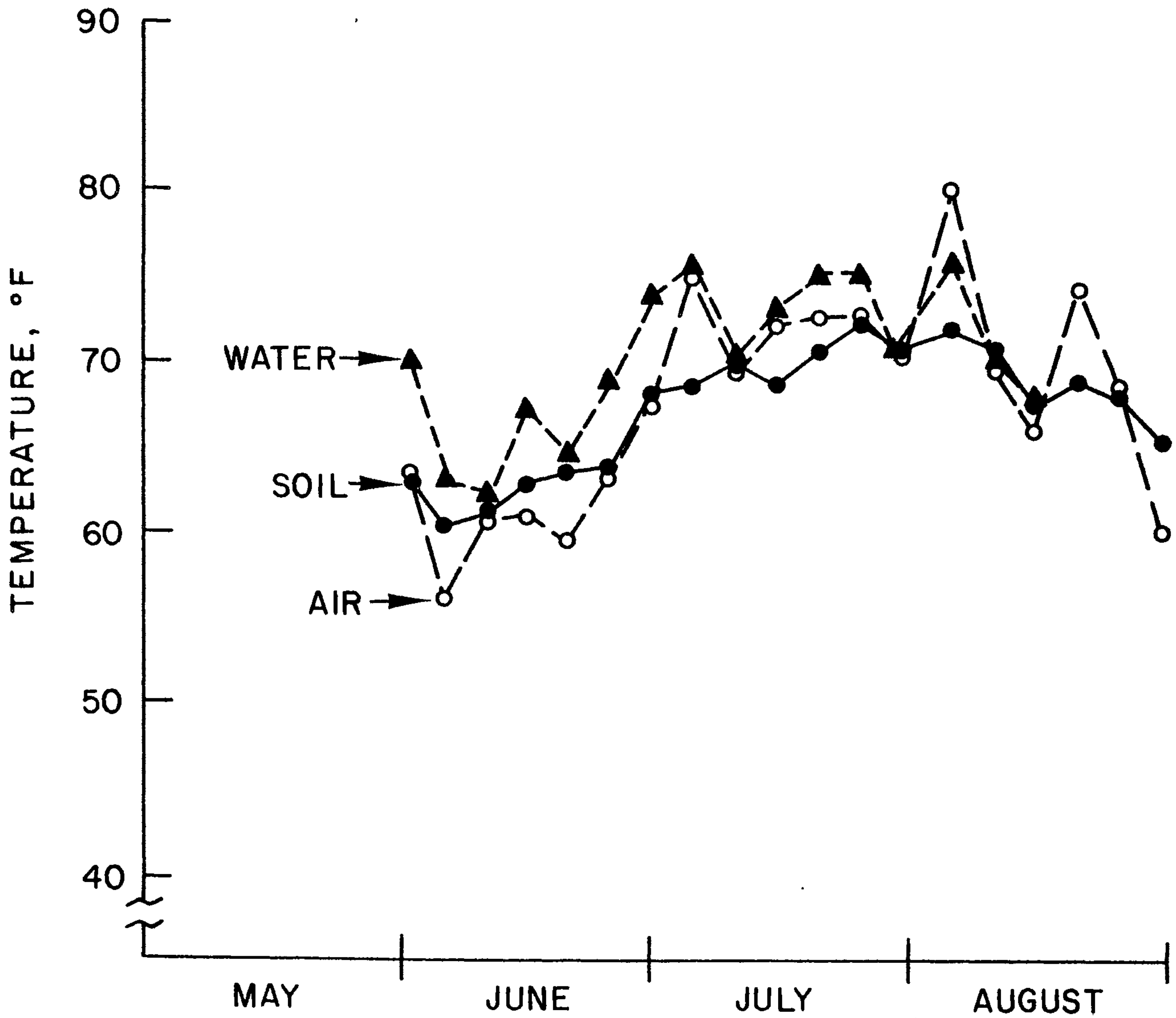

Fig. 3

WILD RICE DEVELOPMENT
NETUM VARIETY, 3RD YEAR STAND
GRAND RAPIDS, 1982

	STAGES OF DEVELOPMENT	DAYS	DATE	GDD 1/
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY	0
	FLOATING LEAF	11	MAY	156
	AERIAL LEAF	24	MAY	400
	TILLERING	38	JUNE	662
REPRODUCTIVE GROWTH PHASE	JOINTING	45	JUNE	793
	BOOT	53	JUNE	943
	HEADING	64	JULY	1220
	EARLY-FLOWERING	67	JULY	1312
	LATE-FLOWERING	89	JULY	1797
	MATURITY	102	AUGUST	2275

1/ - ACCUMULATED GROWING DEGREE DAYS, $T_b = 40°F$

B. NITROGEN STUDIES ON MINERAL SOILS

The nitrogen rate and time of application trial, initiated in the fall of 1979, was continued with 3rd year stand of Netum wild rice in paddy No. 1 West at the North Central Experiment Station, Grand Rapids. The soil is classified as an Indus clay loam (very fine, montmorillonitic, frigid Typic Ochraqualf). Soil tests (Table 2) indicated very high levels of extractable phosphorus (63 pp2m) and exchangeable potassium (300 pp2m). It should be noted that these two plant nutrients have remained at such very high levels since 1974 although no phosphate or potash fertilizers have been applied to this soil. It has been a common practice, however, to incorporate wild rice stubble and straw into the soil. Since nearly 75% of total P and 97% of total K taken up by the wild rice plant remain in stems and leaves, a certain recycling of these nutrients occurs.

Nitrogen treatments consisted of four rates (0, 20, 40, 80 lb N/acre) applied in single (fall) or split-applications (½ fall + ½ jointing or ½ fall + ½ early flowering). Urea (46-0-0) was the source of nitrogen. Fall-application of urea was made on November 5, 1981 and the fertilizer was incorporated into the soil by rototilling. Additional N was topdressed by hand at jointing (on June 23) or early flowering (on July 9). A randomized block design was used in this experiment. Each treatment was replicated four times. Individual plots occupied a 14 x 16 ft. area and were separated from adjoining plots by 5 ft. wide alleys. Water level was maintained at about 6 to 10 inches. Plant density, at harvest, ranged from 7 to 11 plants per square foot. Ten plants were collected at random from each plot at jointing, and five plants at late flowering for weight measurement and plant analysis. The jointing stage was reached on June 17th (Fig. 3). A 16 sq. ft. area from each plot was hand-harvested on August 12th.

The plants in this experimental paddy were very short, spindly and had a "grassy" appearance. One may speculate that poor plant growth on this mineral soil resulted from relatively high density and the age of stand.

Individual plants at jointing had accumulated less than one gram of dry matter and 15 to 20 milligrams of nitrogen (Table 3). The second leaf at jointing contained 2.53 to 2.68% N, considered to be a relatively low concentration. It should be noted that the concentration of leaf nitrogen at jointing ranged from 4.33 to 5.55% during the first year (1980).

Netum grain yield (7% moisture) ranged from 332 to 445 pounds per acre (Table 4). The yield of wild rice was not affected by any of the nitrogen treatments. At late flowering, the plant had accumulated from 1.72 to 3.74 grams of dry matter and 22 to 57 milligrams of nitrogen.

Table 2. Soil test values of experimental paddy No. 1 West, Grand Rapids.[1)]

pH	Extractable P pp2m	Exchangeable K pp2m	Nitrate-N lb/A
6.1[2)]	63	300	7

1) Samples collected from 0-6 inch depth on 11/5/81.
2) Average of two composite samples.

Table 3. Effect of nitrogen application on weight of dry matter, N-concentration in 2nd leaf, and total uptake of N by wild rice plant at jointing, Netum variety, 2nd year stand, Grand Rapids, 1982.

	N Rate lb/acre	Dry Matter grams per plant	N% in dry matter	N in milligrams per plant
	0	0.66[2)]	2.68[2)]	18[2)]
	20[1)]	0.64	2.68	15
	40	0.69	2.67	18
	80	0.91	2.53	20
Significance		ns	ns	ns

1) Applied in fall 1981.
2) Average of four replications.

Table 4. Effect of nitrogen application on the weight of dry matter, total uptake of N, and the yield of Netum wild rice, 3rd year stand, Grand Rapids, 1982.

Treat-ment No.	N Rate lb/acre	Time of Application Fall 11/5/81	Jointing 6/23/82	Early Flowering 7/9/82	Dry Matter at late Flowering g/plant	N Uptake mg/plant	Grain Yield[1)]
1	0	-	-	-	3.69	57	343
2	20	20	-	-	2.29	28	332
3	40	40	-	-	2.14	27	414
4	40	20	20	-	3.74	47	390
5	40	20	-	20	3.21	36	423
6	80	80	-	-	2.68	29	439
7	80	40	40	-	2.48	26	404
8	80	40	-	40	1.72	22	445
Significance					ns	ns	ns
C.V. %					50	58	30

1) At 7% moisture, average of four replications.

C. FERTILIZATION STUDIES ON PEAT

A fertilizer experiment was conducted with the K2 variety of wild rice on an organic soil in a Kosbau Bros. paddy in Aitkin County. A medium level of extractable phosphorus (15 pp2m) and a low level of exchangeable potassium (90 pp2m) were indicated by soil tests (Table 5). The soil pH was 5.8. This was an incomplete factorial experiment with six NPK treatments, replicated six times, and arranged in randomized blocks. Individual plots occupied a 14 x 16 ft. area. Fertilizer materials (46-0-0, 0-46-0, 60-0-0) were applied by hand on October 7, 1981 and incorporated into the soil by disking. Wild rice reached the jointing stage on June 29. A 32 sq. ft. area from each plot was harvested on August 17.

The concentration of nutrient elements in the 2nd leaf at jointing (see Table 6) was relatively high: 2.85 to 3.06% N, 0.44 to 0.48% P, 3.37 to 3.56% K. The grain yield (7% moisture) ranged from 671 to 720 pounds per acre (Table 7). Neither the yield nor the total uptake of N, P and K at late flowering were affected by fertilization.

ACKNOWLEDGEMENTS

Grateful acknowledgements are made to the following cooperators and University personnel for their assistance during 1982 in obtaining the information reported here: Messrs. Franklin and Harold Kosbau, Aitkin County; the Staff of the North Central Experiment Station; Dr. E. A. Oelke, Messrs. Jeffrey Schmidt and Henry Schumer, University of Minnesota.

Table 5. Soil test values of experimental area, Kosbau Bros., Aitkin Co.

pH	Extractable P pp2m	Exchangeable K pp2m	Magnesium pp2m	Copper ppm	Sulfur ppm
5.8	15	90	604	0.9	11

Samples collected from 0-6 inch depth on 10/7/81.

Table 6. Effect of fertilization on N, P, and K concentration in 2nd leaf of K2 wild rice at jointing, Kosbau Bros., 1982.

Treatment (lb/acre) N	P_2O_5	K_2O	N% (in Dry Matter)	P%	K%
none			2.85[1)]	0.44	3.38
0	+ 40	+ 60	2.98	0.44	3.56
30	+ 40	+ 0	2.98	0.47	3.42
30	+ 0	+ 60	3.06	0.47	3.44
30	+ 40	+ 60	2.85	0.46	3.37
60	+ 40	+ 60	2.96	0.48	3.47
Significance			ns	ns	ns

1) Average of six replications.

Table 7. Effect of fertilization on total uptake of N, P and K and the yield of K2 wild rice, Kosbau Bros., Aitkin Co., 1982.

Treatment (lb/acre) N	P_2O_5	K_2O	Total Uptake at Late Flowering N (mg/plant)	P	K	Grain Yield[1)] lb/acre
none			26	7	56	720
0	+ 40	+ 60	34	8	64	690
30	+ 40	+ 0	30	7	59	708
30	+ 0	+ 60	28	7	54	700
30	+ 40	+ 60	27	7	52	671
60	+ 40	+ 60	35	8	66	691
Significance			ns	ns	ns	ns
C.V. %						12

1) At 7% moisture, average of six replications.

Redox Potential Profiles in Flooded Peats

Paul Bloom, John Norman and John Grava
Department of Soil Science, University of Minnesota

Purpose

When soil is flooded, oxygen is depleted and the soil becomes anaerobic. In a mineral soil a surface oxidized layer is formed due to oxygen diffusion from the overlying floodwater to the soil surface (Patrick and Mahapatra, 1968). The depth of the layer depends on the extent of oxygen penetration (related to the rate of diffusion and rate of oxygen consumption). Measurement of the oxidation-reduction (redox) potential, Eh, in a zone shows the intensity of redox conditions there (Bohn, 1968). Making a series of measurements with increasing depth allows construction of a profile of redox potential. The purpose of this experiment is to produce redox potential profiles for peats, as we have no information about a surface oxidized layer and its depth, if present, in peat.

Materials and Method

Two peats were used: an acidic peat, pH 5.4, (Kosbau Wild Rice Co., Aitkin County) and a neutral peat, pH 7.1, (Clearwater Rice Inc., Clearwater County). Duplicate four liter beakers were filled about two-thirds full with shredded peat. Water was added, with stirring, to fill the beakers. The peat was allowed to settle undisturbed for one day, and formed a very flat horizontal surface. Redox electrodes with 2 mm platinum tips were suspended from the lids of the beakers. These electrodes were inserted into the peat in increasing depths by 3 mm increments. Measurements were made using a standard potentiometric reference electrode to complete the circuit. The system was calibrated by the known potential of hydroquinone in a pH 4.01 buffer. Measurements were made at several times over a twenty day period. Figure 1 is a plot of the average Eh at each depth on the twentieth day.

Results

Initially the Eh in each soil dropped rapidly with depth until a certain depth was reached where the potential remained steady as shown in Figure 1. This depth occurred at about 3 mm in the neutral peat and about 21 mm in the acidic peat.

We defined the lower boundary of the oxidized layer as the Eh where ammonium is in equilibrium with nitrate (+363mV) at pH 7. In Figure 1, our measurement of the surface potential of the neutral peat is already well below this value. Before comparison of the acidic peat we must correct the Eh because it is pH dependent: $Eh_{5.4} = Eh_7 + (7-5.4)(0.059V)$. The lower boundary of the oxidized layer in the acidic peat then, is +457 mV. The depth of the oxidized layer is about 4 mm by interpolation in Figure 1 in the acidic peat.

Discussion

In defining the lower boundary potential of the oxidized layer we allowed for the presence of nitrate (the soluble oxidized form of nitrogen) as well as oxygen. Conversion of ammonium to nitrate does occur, but accumulation of nitrate in the oxidized layer is prevented by downward diffusion of the nitrate into the reduced zone followed by rapid denitrification. The nitrification-denitrification pathway is thought to account for major losses of fertilizer N applied to paddy soils (Patrick and Mahapatra, 1968).

The depths of the oxidized layers were small: 4 mm in the acidic peat, and not even resolveable in the neutral peat. Activity of soil microbes is high in peat, due to the high organic matter content. A neutral soil would also be expected to have higher microbial activity than an acidic soil. Thus, in a neutral peat all dissolved oxygen may be consumed at the soil/water interface preventing formation of a measureable oxidized layer.

Flooded peats are currently used in over 12,000 acres of wild rice cultivation in Minnesota (Elder, 1981). Urea-N is usually incorporated into the soil before flooding. However, a second application of urea is "top-dressed" later in the growing season (Grava, 1982). To reach the root zone, the ammonium must diffuse through the oxidized layer, risking large losses by nitrification-denitrification. A better method would utilize "deep placement" of the fertilizer into the reduced zone. Ammonium diffusion would then occur in the root zone before it entered the oxidized layer.

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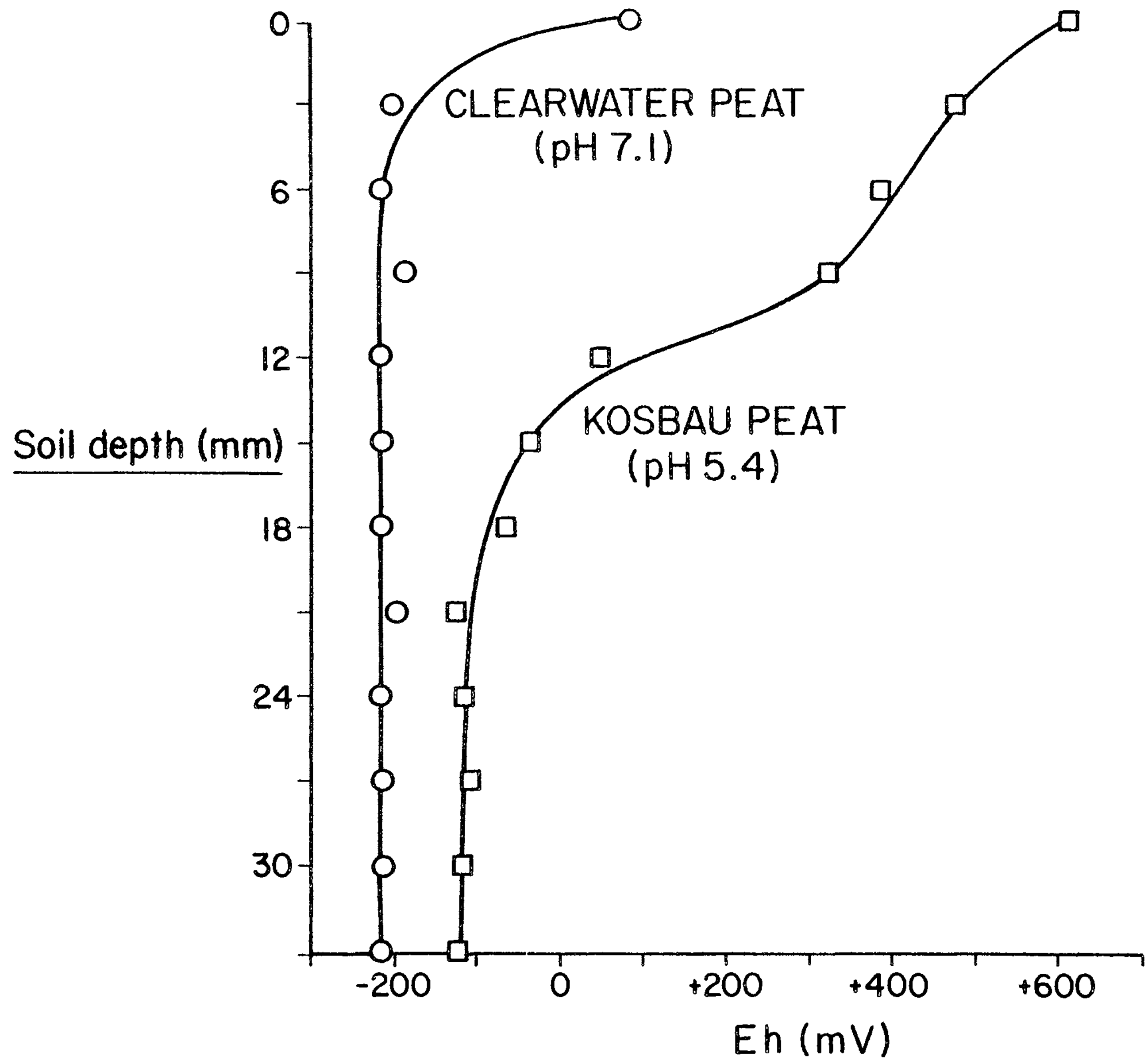
FIG. 1 REDOX POTENTIAL PROFILES OF TWO PEATS SUBMERGED FOR 20 DAYS



Ammonium Status of Wild Rice Paddies Following Fertilization

Paul Bloom, John Norman and John Grava
Department of Soil Science, University of Minnesota

Purpose

This experiment was conducted to monitor ammonium concentrations in the root zone of flooded wild rice paddies. One mineral soil paddy and one organic soil paddy were sampled. Wild rice crops usually receive two applications of N-fertilizer; the second one occurs at the jointing stage of the rice plant. This experiment coincided with the second application and lasted two weeks.

Materials and Method

Soilwater samples were collected from a depth of six inches below the soil surface using porous cup sampling tubes. Floodwater samples were also collected from the paddy water.

Experimental plots at Grand Rapids Experiment Station, Itasca County (mineral soil) received 0, 20 or 40 lbs. urea-N per acre in the fall. Additional urea was topdressed at the same rates on June 29 following floodwater sampling and installation of soilwater samplers (in three plots at each N level). Floodwater was sampled only once at each N level.

Experimental plots located at Kosbau Wild Rice Co., Aitkin County (organic soil) received 0, 30 or 60 lbs. urea-N per acre in the fall but no additional application. Floodwater samples were taken in one plot at each N level on June 29, and soilwater samplers were installed in three plots at each N level. Two additional plots which received no N in the fall were treated with 30 or 60 lbs. urea-N per acre on June 29 after floodwater sampling and installation of soilwater samplers (three in each plot).

Soilwater (in triplicate) and floodwater were sampled for two weeks following fertilization. Determinations of ammonium concentration were performed immediately after sample collection using an ammonia electrode and portable potentiometer.

Results

Floodwater ammonium in the mineral soil plots remained essentially constant within the range of 5-10 micromolar following fertilization. This level was also found in the floodwater of the organic soil plots that were not fertilized. Elevated floodwater ammonium (35 micromolar) was found after one day only in the organic plot fertilized at the higher rate. One week later it was back in the "normal" range, but after two weeks, both fertilized plots showed elevated floodwater ammonium (25-30 micromolar).

Soilwater ammonium was highly variable as shown by the large standard deviations. Soilwater ammonium (13-65 micromolar) was correlated to the fertilization rate one day after application in the mineral soil plots, but after one week fell to the floodwater level (6-7 micromolar). After two weeks time, soilwater ammonium was slightly decreased (4 micromolar). In the organic soil plots, soilwater ammonium was not correlated to either fall or June fertilization rates. Soilwater levels fell from 58-81 micromolar after one day to 23-40 micromolar after one week. After two weeks, soilwater (5-11 micromolar) had fallen to the level of the floodwater.

Discussion

Considerable variation in soilwater ammonium was found at every N level in both the mineral and organic paddies. Greater replication could provide a more accurate average ammonium level for a given N treatment, however, the uneven ammonium distribution would still produce an average of questionable significance.

We found that the soilwater samples were not contaminated (i.e., diluted) by floodwater. Unpublished data for Na^+, K^+, Ca^{2+} and Mg^{2+} in these samples showed that while soilwater had much higher levels of these ions over floodwater, both solutions were essentially homogenous (varied little) throughout the plots.

Variation of soilwater ammonium was also not due to uneven application of the June urea since the greatest variation was found in plots not receiving this application.

The main contribution of this investigation is to show the rate of N-loss from the root zone. Relative to the floodwater level, ammonium N was essentially depleted within one week after the urea application in the mineral soil. In the organic soil, regardless of whether or not the plots received this application, the ammonium N was depleted within two weeks.

Table 1.

Paddy & Water Type	N-Rate (lbs/acre)	Applied	Mean Ammonium Concentrations (micromolar) ± std. dev.			
			6/29	6/30	7/7	7/14
mineral soil, soilwater:	0 + 0	fall + 6/29		13.4 ± 3.2	6.9 ± 1.9	3.9 ± 1.0
	20 + 20	"		39.2 ± 20.6	6.6 ± 1.5	3.5 ± 0.3
	40 + 40	"		65.1 ± 38.7	6.0 ± 1.1	3.7 ± 0.5
mineral soil, floodwater:	0 + 0	fall + 6/29	6.3	6.2	8.4	6.9
	20 + 20	"	6.9	5.3	6.3	4.8
	40 + 40	"	6.3	5.9	6.6	5.6
organic soil, soilwater:	0	fall		58.3 ± 19.9	27.5 ± 28.3	7.9 ± 3.0
	30	"		81.0 ± 61.5	22.7 ± 23.0	5.2 ± 1.0
	60	"		71.2 ± 82.1	38.9 ± 46.3	6.0 ± 1.0
	30	6/29		60.1 ± 34.8	40.4 ± 31.2	11.4 ± 7.3
	60	"		67.0 ± 32.8	25.9 ± 14.8	6.4 ± 1.7
organic soil, floodwater:	0	fall	7.7	4.8	6.7	6.8
	30	"	5.6	4.6	6.1	7.5
	60	"	5.6	10.4	5.3	8.6
	30	6/29	8.7	9.0	6.1	23.8
	60	"	12.5	34.3	6.7	28.9

WILD RICE PRODUCTION RESEARCH - 1982

E.A. Oelke, J.K. Ransom and M.J. McClellan
Department of Agronomy and Plant Genetics

Cultural research in 1982 involved work on weed control, plant population and disease, deep plowing and seed survival. The research was conducted on University plot land in St. Paul and Grand Rapids and in growers' fields near Aitkin and Waskish. A glasshouse and growth chamber at St. Paul were also utilized for some of the work. Temperatures during May were warm resulting in good early plant growth but they were below normal the rest of the summer, however all of the plots were harvested before freezing temperatures occurred.

WEED RESEARCH

Herbicides

The herbicide trials in 1982 continued on the use of 2,4-D amine and MCPA for control of common waterplantain. Trials were conducted on the early application of these compounds using spray or pipewick application methods. Three additional compounds, triclopyr, propanil and bentazon, were also tried on wild rice. Herbicide trials were conducted at Grand Rapids, Aitkin and St. Paul.

Table 1 shows the yield and injury ratings of wild rice when 2,4-D amine and MCPA were applied to wild rice at three stages of growth. The chemicals were applied with a back-pack sprayer at the rate of 1/4, 1/2 and 3/4 lb/A a.i. (active ingredient) when wild rice had 2 or 5 leaves above the water or 2 to 3 tillers per plant. No injury to wild rice or yield reduction was observed by applying the two compounds at the three rates when wild rice had 2 aerial leaves. The 1/4 lb/A rate of both 2,4-D amine and MCPA also did not injure wild rice at the 5 aerial leaf or early tillering stage. However, the 1/2 and 3/4 lb/A rate of both compounds reduced wild rice yield at the last two application dates. MCPA reduced wild rice yield more than 2,4-D amine. These results confirm those from the previous two years. Higher rates (greater than 1/4 lb/A) of 2,4-D amine and MCPA can only be used if applied early before wild rice has a significant amount of leaf area (2 to 3 aerial leaf stage).

MCPA and 2,4-D amine were also applied onto a stand of wild rice infested with common waterplantain in a grower's field near Aitkin. Applications were made at approximately the same date as in the previous trial at Grand Rapids. However, the chemicals were applied at double the rates (1/2, 1 and 1-1/2 lb/A) on the first date, but at the same rates (1/4, 1/2 and 3/4 lb/A) on the last two dates. Table 2 gives the results from this trial.

The best treatments which gave excellent common waterplantain control and slightly higher wild rice yields than the weedy check were 2,4-D amine or MCPA at 1/2 lb/A when wild rice had 1 to 2 aerial leaves and common waterplantain had 2 to 3 aerial leaves. The 1 and 1-1/2 lb/A rates at the early date gave excellent common waterplantain control

Table 1. The influence of applying three rates of 2,4-D amine or MCPA onto wild rice at three stages of growth - Grand Rapids - 1982.

Wild rice growth stage and date	Herbicide	Rate	Injury* ratings	Grain yield	Yield for each growth stage
		lb/A a.i.		--------lb/A**	---------
2 aerial leaves (6/3)	2,4-D amine	1/4	0.0	1,157	
		1/2	0.0	1,099	
		3/4	0.0	1,045	
	MCPA	1/4	0.0	1,061	
		1/2	0.0	1,067	
		3/4	0.0	1,131	1,093
5 aerial leaves (6/14)	2,4-D amine	1/4	0.0	1,024	
		1/2	0.0	896	
		3/4	1.6	773	
	MCPA	1/4	0.0	912	
		1/2	3.3	624	
		3/4	5.0	523	792
Early tillering (6/21)	2,4-D amine	1/4	0.0	976	
		1/2	0.6	933	
		3/4	1.7	965	
	MCPA	1/4	1.0	1,003	
		1/2	2.3	779	
		3/4	5.3	485	857
	Untreated check	0	0.0	1,146	
	LSD .05		---	240	---

* Ratings taken on 7/7; 0 = no injury, 10 = all dead.
** 40% moisture.

but reduced wild rice yield. Generally, 2,4-D amine did not control common waterplantain as well as MCPA but MCPA also reduced wild rice yield more than 2,4-D amine.

Airplane applications of 2,4-D amine and MCPA were made in the same grower's field as the previous trial. The field was infested with three common waterplantain plants per ft. The herbicides were applied in 40 x 300 ft. strips. Two 16 x 130 ft. areas were removed with a combine from each treated and from an adjacent untreated strip. Wild rice and common waterplantain seeds were separated from each harvested sample and the dry weights are given in table 3.

Table 2. The influence of applying 2,4-D amine or MCPA at three dates onto a stand of wild rice infested with common waterplantain - Aitkin - 1982.

Common water-plantain growth stage and date	Herbicide	Rate	Common waterplantain Control*	Common waterplantain Stand	Wild rice Injury*	Wild rice Yield**
		/A a.i.	%	plants/ft^2	rating	lb/A
2-3 aerial leaves (6/2)***	MCPA	1/2	93	0.0	0.0	665
		1	100	0.0	8.5	235
		1-1/2	100	0.1	9.0	95
	2,4-D amine	1/2	93	0.0	2.3	665
		1	98	0.1	0.5	585
		1-1/2	100	0.0	6.5	300
5-6 aerial leaves (6/16)***	MCPA	1/4	78	0.0	1.0	570
		1/2	75	0.2	1.0	435
		3/4	80	0.0	1.5	405
	2,4-D amine	1/4	13	3.0	0.0	565
		1/2	55	0.1	0.0	615
		3/4	70	0.2	0.5	515
Flower bud developing (6/22)***	MCPA	1/4	17	1.9	0.0	590
		1/2	67	0.3	0.5	580
		3/4	57	0.1	1.7	355
	2,4-D amine	1/4	10	3.0	0.0	655
		1/2	37	0.6	1.3	550
		3/4	58	0.3	0.5	515
	Weedy check		0	2.6	0	595
	Hand-weeded check		100	0.0	0	825
	LSD .05					164

* Ratings taken on 7/7; injury on wild rice, 0 = no injury, 10 = all dead.

** 40% moisture.

*** Wild rice on 6/2 had 1 to 2 aerial leaves, on 6/16 it had 5 to 6 aerial leaves and on 6/22 it was in the mid- to late-tillering stage.

Table 3. Airplane applications of 2,4-D amine and MCPA to wild rice infested with three plants per square ft of common waterplantain - Aitkin - 1982.

Herbicide	Rate	Stage of growth: Wild rice	Stage of growth: Waterplantain	Grain moisture at harvest	Weed seeds	Grain yield
	lb/A a.i.			%	----lb/A*---	
2,4-D amine	1/4	5-6 aerial leaves	5-6 aerial leaves	40.1	105	826
	1/2			44.6	48	707
MCPA	1/4	Mid tillering	Flowering	42.6	88	793
	1/2			40.2	44	824
Untreated check	0			46.8	392	601

* Dry weight; 2% moisture.

Wild rice grain yields per acre were higher for all treatments compared to the untreated check. The amount of weed seeds per acre were substantially less for all the treatments compared to the untreated check. Even though complete control of common waterplantain was not obtained, wild rice yields in this trial were increased by aerial applications of 2,4-D amine or MCPA when applied before the nodes in the main stem of wild rice plants began to separate.

Several years of trials with spray applications of 2,4-D amine and MCPA indicate that the two compounds are less injurious to wild rice when applied at the early aerial leaf growth stage compared to later applications. The 1/4 lb/A rate can be used up to stem elongation but the 1/4 lb/A rate should only be used during the 2 to 5 aerial leaf stage of wild rice.

Trials for a third year were conducted with a pipewick applicator as a means of applying herbicides to common waterplantain without contacting the leaves of wild rice. Two chemicals, MCPA and glyphosate, were applied at two dates to common waterplantain in a grower's field near Aitkin. Single and double applications were made at each date. Two gallons of water were mixed with one gallon of MCPA or one gallon of glyphosate and these solutions were put into a 5 ft. hand held pipewick applicator. Both compounds were applied onto 5 x 20 ft. strips. Table 4 shows the results.

The first application was made on June 2 when common waterplantain had 2 to 3 leaves out of the water (3 to 6 inches) and wild rice had a few plants with aerial leaves. The second application was made on June 10 when common waterplantain had 4 to 5 leaves out of the water and 15% of the wild rice plants had aerial leaves. At each date, some plots were treated once with MCPA while others were treated twice. In addition, some plots were treated once with glyphosate and some twice at each date. Good control of common waterplantain was obtained

Table 4. Applications of MCPA and glyphosate with pipewick applicator onto common waterplantain - Aitkin - 1982.

Date and chemical	Rate*	Common waterplantain Plant no.	Control	Wild rice Plant no.	Plant height	Yield
		/16 ft^2	Rating	/16 ft^2	cm	lb/A**
June 2						
MCPA	Single	2.3	10	145	135	765
Glyphosate	Single	2.0	10	153	135	635
MCPA	Double	0.0	10	186	138	735
Glyphosate	Double	4.3	9	134	140	785
June 10						
MCPA	Single	3.3	10	150	137	605
Glyphosate	Single	2.5	8	152	125	645
MCPA	Double	1.3	10	114	128	445
Glyphosate	Double	2.3	9	134	138	590
Hand weeded		0.0	10	118	132	805
Not weeded		81.0	0	137	152	545
LSD .05		---	--	---	---	155

* Single = 1 pass with applicator; Double = 2 passes over same area with applicator.
** 40% moisture.

with all treatments on both dates. However, some of the wild rice plants were injured on the last date particularly when MCPA or glyphosate were applied twice to the same plot. A single application of MCPA with the pipewick when common waterplantain has 2 to 3 leaves out of the water appears to be a good way to control this weed. Glyphosate did not appear to be any more effective than MCPA in controlling common waterplantain with a pipewick applicator. The pipewick applicator shows considerable promise for use in wild rice to control weeds in wild rice that emerge earlier than wild rice from the water.

Previous work with field applications of 2,4-D amine onto common waterplantain which develops from corms has shown that this weed is the most sensitive to control when the flower stalk first becomes visible. Joel Ransom while he was a graduate student on the project in 1982 did some work with radioactive 2,4-D. He treated various plant parts with radioactive 2,4-D and four days after treatment examined the foliage, corm, roots and buds on the corm for radioactivity. Table 5 shows the amounts of 2,4-D found in each plant part when treated at three stages of growth.

The data in table 4 indicate that the increased sensitivity of common waterplantain at the bud visible stage compared to the 5-leaf and early flowering stages is related to increased translocation of 2,4-D to the corm where regrowth initiates. The increased concentration

Table 5. Effect of growth stage on the total amount, and concentration of 2,4-D in various plant parts 4 days after treatment with 1/4 lb/A.

Growth stage	Plant part: Foliage Total	Foliage Concentration	Corm Total	Corm Concentration	Root Total	Root Concentration	Bud Total	Bud Concentration
	(ug/ plant)	(ug/G)	(ug/ plant)	(ug/g)	(ug/ plant)	(ug/g)	(ug/ plant)	(ug/g)
Five-leaf	143c*	96b	20c	40b	11b	8a	1b	12b
Bud-visible	503a	136a	72a	84a	21a	8a	2a	24a
Early flowering	376b	42c	55b	36b	12b	4b	1b	5c

* Means within a column followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

of 2,4-D in the corm at the bud-visible stage compared to the 5-leaf stage is due to an increased proportion of the absorbed 2,4-D being translocated to the corm. The reduced concentration in the corm at the early flowering stage, however, is due to reduced retention, particularly by the leaves, and poor absorption and translocation by the flower. Thus, it appears to be important that enough 2,4-D be translocated to the corm where the buds are located for regrowth in order to get effective common waterplantain control by phenoxy herbicides.

Two herbicides, propanil and bentazon, showed some promise in previous work. They were tested again along with triclopyr which had not been tested for use in wild rice. These compounds were applied to common waterplantain in a grower's field which had very little wild rice in the area where common waterplantain was present and to wild rice at Grand Rapids. Table 6 gives the results. Propanil appears to have the most promise and will be tested more in 1983.

Table 6. The influence of four herbicides at several rates on wild rice yield at Grand Rapids and common waterplantain control at Aitkin - 1982.

Herbicide	Rate	Waterplantain control	Wild rice injury	Grain yield
	lb/A a.i.	%	rating*	lb/A**
Triclopyr	1/4	10	0	880
	1/2	23	0	779
	3/4	77	2	677
	1	73	4	512
	1-1/2	--	5	352
Bentazon	1/4	10	0	923
	1/2	43	0	792
	1	57	0	619
	2	73	3	304
Propanil	1	43	0	827
	2	43	0	907
	3	50	0	827
	4	57	0	683
MCPA	1/4	43	---	---
	1/2	90	---	---
	3/4	100	---	---
Untreated check	0	0		995
	LSD .05	---	---	204

* 0 = no injury; 10 = all plants dead.

** 40% moisture.

Water Management and Weed Control

We reported in 1981 that fall flooding may significantly reduce the viability of common waterplantain corms the following spring. To further investigate the influence of fall flooding corms were placed between 4 inches of peat soil in 1 liter plastic containers. The containers were either flooded or left dry and were placed in growth chambers at either 2 or -2C. The chambers were kept dark. After 2, 4, 8, 12 and 16 weeks, corms were removed and planted in 12 inch plastic pots filled to within 2 inches of the top with greenhouse soil. Pots were flooded and placed in the glasshouse at 25C with 16 hr of light. After 4 weeks the percent survival was determined. Table 7 gives the results from this experiment.

Table 7. Common waterplantain corm viability as influenced by flooding, storage temperature, and length of treatment - St. Paul - 1982.

Length of treatment	Flooded 2C	Flooded -2C	Dry 2C	Dry -2C
weeks	%			
2	100	95	100	100
4	95	95	100	90
8	95	70	95	95
12	100	0	100	70
16	100	0	100	80

LSD .05 (flood x temperature x weeks) = 16%

Corm survival decreased significantly after 8 weeks of treatment in flooded containers at -2C. Moreover, after 12 weeks of this treatment all corms were dead. A maximum of 30% mortality occurred in corms stored at -2C in dry containers. These data along with our 1981 data indicate that flooding that is not accompanied by ice formation or sub-freezing temperatures without sufficient water to allow ice formation will not significantly influence corm viability. Furthermore, a minimum of 8 weeks of ice-encasement is required before mortality of the corm will occur. Fall flooding a field with a severe common waterplantain problem may be one way to effectively reduce the number of viable corms the following spring.

The second year of an experiment was completed where wild rice was grown alone and in combination with common waterplantain from corms at several water depths. Tables 8 and 9 summarize the data collected at Grand Rapids in 1982.

Table 8. The influence of water depth and wild rice competition on growth of common waterplantain grown from corms - Grand Rapids - 1982.*

	Corms grown alone			Corms grown with wild rice		
Water depth	Plant number	Dry wt	Plant height	Plant number	Dry wt	Plant height
in.	/plot	gm/plant	cm	/plot	gm/plant	cm
1	6.0	67	117	5.6	54	112
4	6.0	78	120	6.0	48	113
7	6.0	71	123	6.0	59	118
11	4.6	53	125	4.7	46	112
17	5.7	68	127	5.0	54	132
22	5.7	57	---	5.3	55	---

* Data taken at time of wild rice harvest.

The growth of common waterplantain from corms was best when grown in 4 to 7 inches of water (Table 8). This was true also when they were grown with wild rice but the trend was not as evident based on dry weight per plant. Generally the dry weight per plant of common waterplantain was less at all water depths when wild rice competed with common waterplantain.

Wild rice yield was optimum at the 4 to 7 inch water depth range when wild rice was grown alone (Table 9). Yields were considerably reduced when common waterplantain from corms competed with wild rice. The yield reduction was the greatest at the 4 to 7 inch water depth range. This was similar to the data obtained in 1981.

After several years of experimentation on the influence of water depth on wild rice yield and on control of common waterplantain, optimum yield of wild rice was obtained in 4 to 7 inches of water but water depths of 12 to 14 inches were needed to prevent seedling common waterplantain from producing seeds. Water depths greater than 24 inches were needed to control common waterplantain which develops from corms; however wild rice lodged at this depth and yields were severely reduced. Thus, water depth alone will not control corm common waterplantain in wild rice.

PLANT POPULATION AND BROWN SPOT DISEASE

In cooperation with Dr. Percich, a trial was conducted at Grand Rapids to investigate the relationship of wild rice plant population

Table 9. The influence of water depth and common waterplantain competition on wild rice growth and yield - Grand Rapids - 1982.

	Wild rice grown alone				Wild rice grown with waterplantain*			
Water depth	Plant number	Dry wt	Plant height	Grain yield	Plant number	Dry wt	Plant height	Grain yield
in.	/plot	gm/plant	cm	lb/A**	/plot	gm/plant	cm	lb/A**
1	12	6.2	206	213	8	4.0	148	67
4	27	10.0	177	1520	28	13.0	173	320
7	31	10.0	167	1120	34	10.0	143	280
11	26	7.0	183	1094	31	13.0	162	387
17	37	5.0	172	960	26	8.0	177	320
22	39	7.0	---	734	30	12.0	---	267

* Density of common waterplantain from corms was 1 plant/ft.

** 40% moisture.

and incidence of brown spot disease. Wild rice (K2) was solid seeded in 12 by 12 ft blocks at seeding rates necessary to obtain 1, 2, 4, 8 and 16 plants per square ft. An overhead sprinkler system was designed to keep the leaf canopy of some plots moist during the day. The sprinkler system intermittently moistened the leaf canopy for 3 minutes every 30 minutes. One set of plots which included all of the plant populations was misted, a second set was misted and artificially inoculated with brown spot, a third set was treated with Dithane M-45 and a fourth set was left untreated. Table 10 gives the results of the experiment.

Table 10. Wild rice yield as influenced by plant population, intermittent moistening of the leaf canopy, inoculation for brown spot or treating with a fungicide - Grand Rapids - 1982.

Treatment of leaf canopy	Plant number	Stem number	Grain moisture	Percent of leaf covered with lesions	Lesion size	Grain yield*
	$/ft^2$	$/ft^2$	%	%	mm	lb/A
Moistened	1.1	4.0	35	6.5	4.5	682
	2.0	5.1	44	21.5	4.2	762
	3.1	5.4	30	5.2	4.5	822
	3.8	7.2	38	10.2	4.0	880
	3.8	8.6	38	15.2	4.2	1007
Ave.	2.8a**	6.1a	37	11.7b	4.3ab	831bc
Moistened and inoculated	1.7	5.4	45	27.5	4.5	595
	2.0	5.6	41	26.3	4.5	660
	1.7	5.2	39	27.5	4.5	892
	4.2	6.5	39	27.5	4.8	882
	3.3	8.2	36	25.0	4.5	832
Ave.	2.6a	6.2a	40	26.8a	4.6a	772c
Treated with Dithane M-45	1.5	5.1	39	3.0	3.0	818
	2.0	6.1	33	1.0	3.0	870
	1.9	5.9	36	2.0	3.2	1118
	3.7	7.2	37	1.0	3.8	1128
	3.0	8.1	37	1.0	4.0	1232
Ave.	2.4a	6.5a	36	1.6c	3.4c	1033a
Untreated	1.7	5.6	39	1.0	4.2	815
	1.5	5.4	30	1.7	4.0	888
	2.4	6.1	37	2.0	2.8	828
	2.1	5.8	30	4.0	3.8	1035
	2.6	6.2	37	2.7	3.5	1028
Ave.	2.1a	5.8a	35	2.3c	3.7b	918ab
LSD .05	1.6	2.1	--	13.5	1.0	266

* 40% moisture

** Averages within a column that have the same letter are not significantly different according to Duncans multiple range test.

Table 11. Yield, grain moisture and percent dark, green and empty kernels of grain harvested from various seeding mixtures of an early and late variety - Grand Rapids - 1982.

Varieties in seed mixture	Percent of early and late variety in mix		Green kernels in harvested grain	Dark kernels in harvested grain	Empty kernels in harvested grain	Grain moisture	Grain* yield
	Early	Late	%	%	%	%	lb/A
K2E and Johnson	0	100	9.4	3.6	87.0	48	411
	20	80	15.3	6.1	78.6	46	516
	40	60	19.1	13.3	67.6	42	751
	60	40	27.4	15.1	57.5	42	960
	80	20	24.3	16.1	59.6	42	1071
	100	0	29.0	17.1	53.9	40	1163
K2E and K2	0	100	18.8	6.6	74.6	52	628
	20	80	19.4	9.3	71.3	48	783
	40	60	26.0	12.6	61.4	44	912
	60	40	27.9	16.9	55.2	40	1107
	80	20	28.9	12.4	58.7	40	963
	100	0	27.4	17.7	54.9	40	1214
		LSD .05	7.0	4.0	--	--	321

* Harvested when K2E had 40% grain moisture; weights at indicated moisture.

The desired plant populations were not achieved even though sufficient viable seed was planted. A considerable amount of the viable seed apparently did not establish a plant for some unknown reason(s). The highest plant population achieved was slightly more than 4 plants per square ft. Overall there was not a close relationship between disease severity and plant population even when the plots were inoculated and kept moist during the day. Perhaps the plant populations were not high enough to contribute to disease infection or other factors are more important in disease development.

Keeping the leaf canopy moist during the day had a significant influence on the amount of disease. The percent (26.8%) of the leaf covered with lesions was highest in the moistened and inoculated plots. The size of the lesions (4.6 mm) was also the greatest with this treatment. The average yield (772 lb/A) for this group of plots was lower than for the other three sets of plots. The amount of brown spot in this group of plots reduced the yield about 25% compared to the Dithane M-45 treated plots.

RESEEDING AN EARLY VARIETY INTO A LATE ONE

An experiment was conducted to investigate how much viable seed a late variety produces at the time the early variety is harvested. This information should be useful in changing fields to a new variety if the new variety is earlier than the existing one in the field. Various amounts of viable seed of the early variety K2E (Voyager) and the late variety Johnson were mixed to give the following ratios: 1) 20% K2E and 80% Johnson, 2) 40% K2E and 60% Johnson, 3) 60% K2E and 40% Johnson, 4) 80% K2E and 20% Johnson, 5) 100% K2E and 6) 100% Johnson. The same percentage seed mixtures were made using K2E and K2. The seed mixtures were planted in the spring at Grand Rapids. Table 11 shows the data obtained from this experiment.

The plots were harvested on August 11 when the variety K2E was judged to be ready for harvest. On this date the Johnson variety already had about 4% dark kernels while K2E had 17%. The total number (green + dark) of kernels was 13% for Johnson but 46.1% for K2E. Thus, many of the Johnson plants produced very few seeds at the time K2E was harvested. Grain yield increased as the percent of K2E seed increased in the seed mixture which was planted.

The K2 variety had 6.6% dark seeds while at the same date K2E had 17.7%. The total number of seeds (green + dark) was 25.4% for K2 and 45.1% for K2E when the plots were harvested. The difference in maturity for these two varieties is not as great as between K2E and Johnson; thus the variety K2 had more total filled kernels at the time K2E was harvested compared to Johnson. Fewer volunteer plants of K2 could be tolerated in a field than for the Johnson variety if K2E were to be planted as the new variety in a K2 or Johnson field.

SEED SURVIVAL

Seed Survival in the Soil

Samples of seeds which were buried in 1976 at Grand Rapids at three different soil depths in peat and mineral soil under three different flooding regimes were removed on October 6. Nylon mesh bags containing 550 seeds each were retrieved from each burial depth and flooding regime. Table 12 gives the number of seeds which survived after burial in the soil for 6 years.

Table 12. The influence of burial depth, soil type, and flooding regimes on seed survival after six years in the soil - Grand Rapids - 1982.

	Flooding regime and soil type					
Burial	Continuous flood		Continuous fallow		Winterfallow-summer flood	
depth	Mineral	Peat	Mineral	Peat	Mineral	Peat
	----------number of seeds*----------					
0 in.	0	0	0	0	0	0
2 in.	1	1	0	0	1	2
10 in.	6	0	0	0	1	1.

* Number that were still viable out of 550 seeds.

No seeds remained viable in the plots that were kept fallow (not flooded) since 1976. This was expected since no seeds were viable after 4 years in continuous fallow conditions. A few seeds still are viable under the continuous flooded or fallow-flood system. However, only when the seed was buried in the soil did some remain viable after 6 years of burial. No seed remained viable on the soil surface. This again was expected since no seeds remained viable on the soil surface after 2 years. Even though a few seeds are still viable after 6 years of burial, only 9% of the seeds remained viable after 3 years of burial in the best burial treatment which was the 10 inches deep in the continuously flooded mineral soil.

ACKNOWLEDGEMENT

We wish to thank Henry Schumer, plot coordinator at Grand Rapids, for his continued enthusiastic support of our research. His daily supervision was extremely helpful in the conduct of the experiments. The help of Joe Rust, Jim Boedicker and Dave Rabas at Grand Rapids was also appreciated. The cheerful help of Kristen Berge, undergraduate, and Mike McCellan, plot technician, throughout the year was greatly appreciated. The continued use of John Strait's hulling equipment was very much appreciated. The help Cletus Schertz gave in the moving of equipment was very appreciated. A number of growers, Kelly Petroski, Pete Olson, Franklin and Harold Kosbau, Art Hedstrom, Ray Skoe, James Diebold and George Landreth provided land or seed for our research. Their support is much appreciated.

WILD RICE BREEDING - 1982

R.E. Stucker, G.L. Linkert, L.K. Boze and W.E. Palm
Department of Agronomy and Plant Genetics

1. Release of K2E(2) as "Voyager" wild rice

The wild rice population K2E(2) was developed by 2 cycles of mass selection for early flowering in the variety K2. Description of the procedures was given in Minnesota Wild Rice Research 1979 and 1980. The population was grown in isolation at Grand Rapids in 1982 and 600 pounds of green seed were produced for the Minnesota Crop Improvement Association. Thirty acres of contract seed production were fall planted in 1982. Seed of K2E(2) will be available to growers for fall planting in 1983.

K2E(2) was evaluated in 1982 in fall and spring plantings at Grand Rapids, a fall planting at Waskish (Pete Olson's paddies), a fall planting at Rosemount and a spring planting at Excelsior. At Grand Rapids in the fall planting, 2 experiments were evaluated: the advanced yield trial and a test comparing K2E(2), Netum and K2. This test is identified as G.R. Eval. in Tables 1, 2 and 3. All other tests were part of the advanced yield trials and results will be presented in more complete tables later in the report. For purposes of describing K2E(2), Tables 1-3 are abstracted from the advanced yield trial tables. All plots consisted of 4 rows spaced 1 foot apart and 10 feet in length. Data were recorded on the center two rows of the plots. Heading date and harvest date are expressed as days after June 1. Yield is expressed as pounds of dry grain including hulls. Recovery percentage was not calculated for this report. The number of replicates in each trial is listed in the tables.

In 1981 K2E(2) flowered 6 days earlier than K2 and one day earlier than Netum in trials at Excelsior and Grand Rapids. In 1982, K2E(2) flowered 9 days earlier than K2, 3 days earlier than Netum and 12 days earlier than M3 (Table 1). The averages used here are presented in the "combined" column of Table 1. Variety means from the individual trials are given within the tables.

In 1981 at Excelsior, K2E(2) matured 7 days before K2. In the 1982 trials (Table 2), K2E(2) matured an average of 6 days earlier than K2, one day before Netum and 10 days earlier than M3. I believe that the difference in maturity is actually greater than the 5 to 6 days indicated, if moisture percentage at harvest is taken into consideration. (See subsequent advanced yield trial tables.)

Yield data are presented in Table 3 and the advanced yield trial tables. The values in Table 3 will not compare identically to the subsequent tables because of differing numbers of replicates. In the 1982 trials, K2E(2) was higher yielding than K2 in all tests except Rosemount. Netum outyielded K2 in 4 of the 6 trials.

Table 1. Flowering date of K2E2 in comparison to check cultivars in 1982.

Entry	Rst. fall	G.R. fall	G.R. eval.	Waskish fall	G.R. spring	Excel. spring	Combined (1982)
	Trials						
	days after June 1						
K2E2	35	30	31	47	32	46	36
K2	44	41	40	55	42	54	45
Netum	37	34	34	50	35	49	39
M3	45	41	--	56	43	55	48
Replicates	5	5	12	6	6	6	40

LSD (0.05) -- approximately 2.0 days for individual trials

Table 2. Harvest date of K2E2 in comparison to check cultivars in 1982.

Entry	Trials						
	Rst. fall	G.R. fall	G.R. eval.	Waskish fall	G.R. spring	Excel. spring	Combined (1982)
	---------------------- days after June 1 ----------------------						
K2E2	70	72	71	85	73	77	74
K2	78	76[3/]	77[3/]	91[3/]	79[3/]	79[2/]	80
Netum	71[1/]	73	71	87	77	78	75
M3	78	85	--	92	85	81	84
Replicates	5	5	12	6	6	6	38
LSD (statistical test of significance is not valid)							

1/ Average % dry weight at harvest suggests that Netum was more mature than K2E2.
2/ Average % dry weight at harvest suggests that K2E2 was more mature than K2.
3/ Average % dry weight at harvest suggests that K2 was harvested before it should have been (by 2 or 3 days) relative to K2E2.

Table 3. Grain yield of K2E2 in comparison to check cultivars in 1982.

Entry	Trials: Rst. fall	G.R. fall	G.R. eval.	Waskish fall	G.R. spring	Excel. spring	Combined (1982)
	lb per acre						
K2E2	1000	907	847	1252	801	1007	950[1]
K2	1286	602	737	959	749	887	835
Netum	857	724	770	1077	719	926	836
M3	919	1066	--	680	901	935	892
Replicates[2]	4	5	12	6	6	6	39
LSD (0.05)	182	197	95	197	147	133	59

[1] Probability that K2E2 exceeds Netum in dry weight of grain is greater than .99 based on the combined data.

Our K2 stands were typically poorer in establishment than the other entries. I believe the 1982 season favored the earlier varieties for some reason and that we harvested K2 a few days before we should have. We conclude from these trials that K2E(2) is significantly better yielding than Netum and we expect K2E(2) to equal K2 (the old K2) in yield on the average.

K2E(2) was 6 inches shorter than K2 at one location in 1981 and in 5 trials in 1982 (see advanced yield trial tables). K2E(2) was 4 inches shorter than Netum. No changes in flag leaf length or width and in plant color compared to K2 were detected in 1982. No changes in disease reaction were noted and we doubt if resistance to shattering has changed from that of K2. However, we did rogue the occasional tall shattering plants which occurred in the 1982 increase paddy and we removed "bottle brush" panicle types.

The K2E(2) population will be released under the name Voyager. Its description will be as follows:

> "Voyager has some resistance to shattering, is short to medium in height, and has early maturity. It has medium width leaves and a mixture of plant and panicle colors. Compared to K2, Voyager is about a week earlier at flowering and 4 to 6 days earlier at maturity. It is about 6 inches shorter, has somewhat less purple colored plants and is expected to equal or exceed old sources of K2 in yield."

Growers interested in planting Voyager in fall of 1983 should contact the Minnesota Crop Improvement Association for information.

2. Progress of the wild rice population "Dwarf"

"Dwarf" was developed by mass selection for short plant height (1979) in a population of short plants assembled by W.A. Elliott. The population has been maintained in isolation at Rosemount and selection for short plants has been carried out each year. We have attempted evaluation of Dwarf for 3 years now and have had repeated difficulty in achieving good tests. Our general description of Dwarf is as follows:

"Dwarf is characterized by very early maturity, short plant height and reduced foliage in the canopy compared to the available wild rice varieties. It also has large seed size and we believe better than average resistance to shattering." Prior to 1982, we would have added that Dwarf is very low yielding.

In 1982 Dwarf was included in the five advanced yield trials and a test to compare its performance with a source of Canadian rice from Pete Olson. Stands of Dwarf in the Excelsior AYT (Advanced Yield Trial) were very poor - we speculate that Dwarf was selectively favored by foraging ducks prior to emergence. Stands at Rosemount were good but Dwarf was destroyed by foraging blackbirds 2 days prior to our planned harvest. Quality of the plots was good to excellent in the remaining advanced yield trials at Grand Rapids and Waskish. Results of satisfactory yield trials (adequate stands and minimal bird damage) are presented in Table 4 and in the AYT tables. In comparison to Netum, Dwarf flowered 15 days earlier and was harvested 19 days earlier. In the 1982 tests at Grand Rapids and Waskish, the mean yield of Dwarf was 773 pounds per acre dry weight compared to 833 for Netum. Dwarf out-yielded Johnson in the Grand Rapids trials and was almost equal to Johnson's yield at Waskish. In our 1981 test, however, Dwarf was much lower in yield than Netum. Based on the 1982 results, Dwarf's yield performance appears good for a special purpose variety. It will be much earlier than anything else and much shorter (24 inches on the average).

Based on the 1982 results, we have been given permission to start a preliminary increase of Dwarf. The population has been fall planted in a one-acre isolated paddy at Landreth farms. Our objective of the Landreth planting is to increase the seed supply of Dwarf such that a larger paddy can be planted in 1983. The 1983 paddy will be used for combine tests to gain some idea of the importance of plant height and volume of material in combine losses at harvest. Cletus Schertz will be conducting the tests. Additionally we want to obtain yield data from larger plots than those in our advanced yield trials. Plans for official seed increase have not been established at this time.

3. Advanced yield trials

As indicated in the K2E(2) report, five advanced yield trials were planted in 1982: fall and spring planting at Grand Rapids, fall planting at Waskish on a Pete Olson paddy, fall planting at Rosemount and a spring planting at Excelsior. A trial was fall planted on one of Imle and Gunvalson's paddies at Gully but emergence was poor and the trial was abandoned. The trials were planted in a randomized complete block experimental design with six replicates in each trial. Each plot consisted of 4 rows spaced 1 foot apart and 10 feet in length. Plots were hand planted and the center two rows were hand harvested and threshed with a Vogel thresher. Flowering date, harvest date, plant height, green weight, dry weight, plant count and stem count were recorded. Flowering date and harvest date are expressed in days after June 1. Dry weight yield, expressed in pounds per acre, includes weight of hulls and a minimal amount of trash. Various problems in stand establishment occurred (some floating at Waskish, extreme nitrogen deficiency in one replicate at Grand Rapids, duck foraging and other unexplained problems at Rosemount) such that not all replicates provided data of usable quality. Thus, varying numbers of replicates were analyzed in the different trials. Results of individual trials are presented in Tables 5-9 and mean results over trials are presented in Table 10.

The entries in the 1982 tests require some explanation (see Table 5). M3 x Netum is a population resulting from the cross of early M3 plants with Netum, followed by a second cycle of selection for

Table 4. Summary of performance data on the Dwarf population compared to Netum in 1981 and 1982.

	Yield dry weight		Plant height		Harvest date[1/]	
Trial	Dwarf	Netum	Dwarf	Netum	Dwarf	Netum
	------lb/A------		----inches-----			
'82 Grand Rapids Fall	804	724	43	67	57	73
'82 Grand Rapids Spring	761	719	46	70	57	77
'82 Waskish	743	1142	52	71	64	87
'81 Grand Rapids	566	1160	43	72	58	81
Southern locations[2/]	200	927	38	63	60	75
Approximate LSD (0.05) (Dwarf vs Netum)		160		10		2

[1/] Days after June 1.

[2/] Mean of Excelsior and Rosemount tests. Dwarf plots were damaged severely by ducks and birds.

Table 5. Advanced yield trial results -- Grand Rapids 1982, fall planted, 5 replicates harvested.

Entry	Flowering[1/] date	Harvest[1/] date	Plant height (inches)	Yield[2/] (lb/A)	% dry weight
M3 x Netum	31	72	67	747	63.5
K2E2	30	72	65	907	64.6
M3E2	34	76	69	756	64.3
Netum	34	73	69	724	65.1
K2	41	75	72	602	61.5
M3	41	85	74	1066	65.2
Johnson	43	87	78	539	66.0
Dwarf	23	57	43	804	--
C. Johnson	54	94	91	719	59.1
LSD (0.05)	2	2	5	220	2.0
Test mean	37	77	70	763	63.6

1/ Days after June 1.
2/ Yield in pounds per acre dry weight.

early plants. Prior to 1982 results, I had in mind that it would be developed into a variety which is much earlier than M3 and with yield potential equal to or exceeding M3. K2E(2) will be released as a new variety named Voyager. M3E(2) is the result of 2 cycles of selection for early flowering in the variety M3. Dwarf has already been described in the previous section. California Johnson is a variety grown in California and was developed from seed of Johnson. Peter Van Eckardt harvested Johnson late, for several generations, with the idea that he could increase resistance to shattering. He has described California Johnson (in popular press) as now being more shattering resistant than Johnson. Those of you who observed our tests at Grand Rapids or Waskish will undoubtedly remember C. Johnson as being late, very tall, vigorous and wide leafed. C. Johnson did not mature at Waskish and was not harvested at Excelsior or Rosemount. It is not a usable variety in Minnesota and further we doubt if it has significantly increased resistance to shattering. We did not make seed retention measurements; our observations were subjective based on hand stripping and noting the shattering which occurred naturally.

The results from the 1982 advanced yield trials and the 1983 yield trials will be analyzed by Larry Boze for a Ph.D. thesis. The purpose of the extensive yield tests in 1982 and 1983 is to establish extent of testing and distribution of tests required to provide reliable yield results. The subject involves, primarily, the importance of genotype x environment interaction in wild rice. As will be noted later, genotype x environment interaction must be considered in designing an optimum testing procedure for wild rice in Minnesota. Mr. Boze will conduct an extensive analysis of the data following the 1983 harvest. This year we will present the results for your observation. Individual tests will not be discussed in any great detail.

In considering the yield values, note that no one variety was superior in all five tests. K2 was notably low in yield except at Rosemount. In most cases (percent dry weight is not available for the Rosemount trial) K2 had low percent dry weight in comparison to K2E(2) and Netum. I believe that we harvested the K2 plots before it reached a representative yield. Similarly, the low yield of M3 at Waskish (Table 7) was likely partially due to its immaturity at the time we harvested it. Establishing the appropriate stage of harvest for the varieties is difficult for us. By and large, we do relatively well in achieving a uniform percent dry weight. Our problem stems in part from the expense of travel; a plot that should wait another 2 or 3 days must be taken because we cannot afford to return at that time.

As you may note in Tables 5 and 6, C. Johnson was higher yielding than Johnson with yield comparable to the other varieties. You might note also that Dwarf was harvested about the same date at which C. Johnson started flowering and Dwarf was 3½ to 4 feet shorter!

K2 yielded very well at Rosemount (Table 9). A scale malfunction prevented calculation of percent dry matter at Rosemount. Thus,

Table 6. Advanced yield trial results -- Grand Rapids, spring planted 1982, 6 replicates harvested.

Entry	Flowering date [1/]	Harvest date [1/]	Plant height (inches)	Yield [2/] (lb/A)	% dry weight
M3 x Netum	34	75	70	842	64.1
K2E2	32	73	69	801	63.9
M3E2	34	78	77	925	63.6
Netum	35	78	71	719	64.7
K2	42	79	76	749	61.7
M3	43	85	78	901	63.1
Johnson	44	88	83	610	64.0
Dwarf	23	57	46	761	--
C.Johnson	57	101	89	815	--
LSD (0.05)	2	1	5	130	1.0
Test mean	38	79	73	792	63.6

1/ Days after June 1.
2/ Yield in pounds per acre dry weight.

Table 7. Advanced yield trial results - Waskish 1982, 4 replicates harvested.

Entry	Flowering[1/] date	Harvest[1/] date	Plant height (inches)	Yield[2/] (lb/A)	% dry weight
M3 x Netum	47	87	70	1069	66.7
K2E2	46	85	67	1212	66.3
M3E2	51	89	71	1019	64.6
Netum	50	87	71	1142	65.3
K2	55	91	72	929	63.0
M3	56	92	73	698	61.3
Johnson	56	92	79	751	61.2
Dwarf	34	64	53	743	64.0
LSD (0.05)	2	2.0	6	171	1.8
Test mean	49	86	70	945	64.0

1/ Days after June 1.

2/ Yield in pounds per acre dry weight.

Table 8. Advanced yield trial results - Excelsior 1982, 6 replicates harvested.

Entry	Flowering[1/] date	Harvest[1/] date	Plant height (inches)	Yield (lb/A)	% dry weight
M3 x Net	48	78	58	1018	65.7
K2E2	46	77	55	1007	66.2
M3E2	49	79	61	1048	65.3
Netum	49	78	63	926	64.9
K2	54	79	62	887	65.1
M3	55	81	63	935	64.2
Johnson	56	88	71	897	64.0
LSD (0.05)	2	0.8	5	177	1.5
Test mean	51	80	62	960	65.1

1/ Days after June 1.
2/ Yield in pounds per acre dry weight.

Table 9. Advanced yield trial results -- Rosemount 1982, 4 replicates harvested.

Entry	Flowering[1/] date	Harvest[1/] date	Plant height (inches)	Yield[2/] (lb/A)
M3 x Netum	35	72	61	890
K2E2	34	70	56	1000
M3E2	36	78	60	812
Netum	37	71	63	857
K2	44	78	64	1286
M3	45	78	65	919
Johnson	45	87	78	628
LSD (0.05)	2.0	1.0	4	209
Test mean	39.3	76.3	63.8	913

1/ Days after June 1.
2/ Yield in pounds per acre dry weight.

we cannot discuss the relative stage of maturity at harvest of K2 and K2E(2) in this trial.

The means of the entries over all tests are presented in Table 10. The entries are ranked in order of their mean yield. The problem of lower percent dry weight for K2 is evident: 62.8% dry weight compared to 65.2% for K2E(2). Nevertheless, we were pleased that K2E(2) showed the highest mean yield over all trials. Note also that K2E(2) had the highest percent dry weight even though it was harvested 2 days earlier than Netum or M3 x Netum. Based on the dry weight percentages, we believe that K2E(2) (Voyager) will be at least 5 days earlier than K2. The difference could have been more than a week if we had delayed harvest of K2 long enough to increase its percent dry weight to 65%.

In the row GE INTERACTION (bottom of table 10), we have indicated the significance level of variety x trial interaction in 1982. The interaction was not significant for plant height; the difference between plant heights for any two varieties tends to be almost constant regardless of where the varieties were tested. The implication of this is very important to us. We can select for height in our St. Paul locations and expect the height differences to be maintained in other environments. This consistency was not the case for yield, flowering date, or harvest date. Additional considerations indicate however, that maturity differences as measured by flowering date are relatively constant. I have no hesitation in breeding for early maturity at one location and expecting the differences to hold up in other locations throughout the state. Harvest maturity is a different case. The difference in harvest maturity of two varieties frequently changed from one trial to another. However, I am confident that most of the problem here comes from our inability to harvest varieties at an identical stage of maturity.

We look forward to obtaining another year of data for analysis of the Genotype x Environment interaction in wild rice. We fall planted the 1983 advanced yield trial materials at Waskish and at Grand Rapids. Spring plantings will be established at Grand Rapids and Excelsior.

4. Evaluation of competition from border rows in experiments using row plantings

The 1982 results provide a second year of data on plant-to-plant competition in wild rice. A detailed description of the experiment was given in Minnesota Wild Rice Research - 1981, pages 45-46 and will not be repeated here. Basically, we compare results from a single row plot without border rows to a 3-row plot from which data are taken only on the center row, and results from a 2-row plot without border rows to a 4-row plot from which data are taken only on the center two rows. The 1982 test was fall planted at Rosemount in a randomized complete block design with 9 replicates. A split-plot restriction was used: Netum and M3 comprised the whole-plot treatments and the 4 plot types comprised the sub-plot treatments. Plots were 12 feet in length with 1-foot spacing between rows within a

Table 10. Mean flowering date, harvest date, plant height, yield and % dry weight of wild rice entries averaged over trials conducted in 1982 (25 replicates in total).

Entry	Flowering date [1/]	Harvest date [1/]	Plant height (inches)	Yield [2/] (lb/A)	% dry [3/] weight
K2E2	38	75	63	969	65.2
M3E2	41	80	68	918	64.5
M3	48	84	71	913	63.4
M3 x Netum	39	77	65	909	65.0
K2	47	80	69	867	62.8
Netum	41	77	67	859	65.0
Dwarf [4/]	26	59	47	771	--
Johnson	49	88	78	690	63.8
LSD 0.05	1	1	2	78	0.8
GE INTERACTION [5/]	*	**	NS	**	--

1/ Days after June 1.
2/ Pounds per acre dry weight (includes hulls).
3/ Dry weight percentage does not include the Rosemount trial.
4/ Dwarf results from Waskish and from Grand Rapids fall and spring planting.
5/ *, **, NS: interaction significant at 5% level of probability, 1% or non-significant, respectively.

plot and a 1-foot skip row between plots. Data were taken on plant count, stem count and yield. Plots were hand harvested and threshed with a Vogel thresher. Yield data are expressed as grams of clean dry dehulled grain on a per row basis.

The effect of border row competition averaged over the varieties Netum and M3 in 1982 (Table 11) was similar to results from 1981. A single row planting of wild rice without border plants had a mean yield of 136 grams compared to 91 grams for a row which had border plants. That is an increase of 50% due to the plants' ability to make use of additional space in which to grow. This increase is due to compensation for available space. The effect in two-row plots is less (an increase of 31%). The compensation increase is at least partially due to an increase in number of stems per row and thus an increase in stems per plant.

The 1982 results of border row effect for each variety are presented in Table 12 for the single row plot type. In 1982 our stand counts were similar for Netum and M3. M3 showed a greater increase in yield due to space compensation than did Netum. Both varieties increased in number of stems per row but Netum had more stems per plant than did M3. Thus, wild rice compensates for available space (due to lower stand count per unit area) through increased tillering and increased yield per tiller.

Results of the competition experiment averaged over years are presented in Table 13 for the one-row and two-row comparisons by variety and Table 14 for the average across plot types. Based on the 2-year results, M3 has a greater capacity to compensate for low plant density than does Netum. The stems per plant data indicate that yield compensation is due to something other than increased stems per plant. Netum had a greater increase in stems per plant than M3 but had a smaller increase in yield.

The average result of reduced competition (no bordering plants) is presented in Table 14. The result for yield indicates a significant interaction of varieties x competition treatment. M3 has a significantly greater yield compensation capacity than Netum. Stems per row and stems per plant do not show the interaction.

I find the results of this experiment to be very interesting. The results from both years indicate that Netum and M3 do not differ in yield when evaluated in row plots with borders. I have no reason to doubt the results - but I find them difficult to believe. The implications of differential competition can be seen if the results are converted to pounds of dry dehulled grain per acre:

	Yield per acre	
Plant density based on	M3	Netum
a) bordered plots	652	652
b) 2-row unbordered	586	512
c) 1-row unbordered	544	448

Table 11. Effect of border row competition in wild rice plots (1982). Means of 12-foot plots, replicated 9 times and averaged for Netum and M3.

Plot type	Plants per row	Stems per row	Stems per plant	Yield[1/] per row
Single row	40	197	5.2	136
Two rows	37	162	4.7	117
Three rows[2/]	41	154	4.2	91
Four rows[3/]	38	139	3.9	89
LSD (0.05)	NS	20	0.8	15

1/ Yield in grams per row of dry dehulled grain.
2/ Single row with border rows.
3/ Two-row plot with border rows.

Table 12. Comparison of Netum and M3 evaluated in single row unbordered plots and single row bordered plots. Rosemount 1982.

Plot type	Grain yield[1/] (g)		Plant number	
	Netum	M3	Netum	M3
Single row (unbordered)	124	147	39	41
Single row (bordered)	88	93	38	43
LSD (0.05)	21		NS	

	Stems per row		Stems per plant	
	Netum	M3	Netum	M3
Single row (unbordered)	204	191	5.6	4.8
Single row (bordered)	156	152	4.9	3.6
LSD (0.05)	28		1.1	

[1/] Yield in grams per row of dry dehulled grain.

Table 13. Effect of border row competition in two wild rice varieties - combined data from Grand Rapids 1981 and Rosemount 1982 for single row and two row plots.

	Yield[1/] (g/row)		Stems per row		Stems per plant	
Plot type	Net	M3	Net	M3	Net	M3
Single row (unbordered)	112	136	166	175	5.8	4.4
Single row (bordered)	80	82	126	131	4.4	3.3
	Yield (g/row)		Stems per row		Stems per plant	
	Net	M3	Net	M3	Net	M3
Two-row (unbordered)	96	110	140	146	5.1	4.1
Two-row (bordered)	83	81	122	124	4.3	3.3
LSD (0.05)	14		19		0.7	

1/ Yield in grams per row of dry dehulled grain.

Table 14. Effect of reduced competition in Netum and M3 as measured in two plot sizes and 2 years.

	Yield[1/] (g/row)		Stems per row		Stems per plant	
Plot size	Netum	M3	Net	M3	Net	M3
Unbordered (reduced competition)	104	123	153	161	5.4	4.2
Bordered (competition)	82	82	124	128	4.3	3.3
difference	22	41	29	33	1.1	.9
Interaction	Significant		NS		NS	

1/ Yield in grams per row of dry dehulled grain.

M3 has the potential to yield much better than Netum under low stand densities. This in fact has little implication for a grower who worries about how to thin. Future work might be directed at studies on differences among varieties at very high densities.

The important implications of this research have to do with wild rice researchers who want to assess the effectiveness of a set of treatments by measuring yield of varieties. Uneven stands will have a big effect on yield performance but low, even stands may show differences because of yield compensation and thus also contribute to experimental variability.

5. Planting methods experiment

We have been concerned about non-uniform stands for quite some time. An experiment to investigate the usefulness of over-planting at a high rate followed by thinning the seedlings was planted at Excelsior in 1982. In our spring plantings we estimate the germination percentage of a seed source and plant at a rate which should give us a plant density of 3 to 4 plants per linear foot of row. Seed from a grower usually has a considerable amount of light seed and some trash. This can be partially removed by a seed cleaner if we get the seed directly from the combine. Usually the seed has been stored in water before we obtain it from a grower. We can still clean the seed by washing it in running water in a container. The light seed and trash will float off the good seed. We call this procedure washing in the subsequent discussion. We used four planting methods in the experiment: 1) compute germination percentage on unwashed seed and plant at a rate which should result in 4 germinable seed per linear foot of row; 2) compute germination percentage on washed seed and plant at 4 germinable seeds per foot of row; 3) plant washed seed at rate of 6 germinable seed per foot and thin the plots to 4 plants per foot of row at floating leaf stage; and 4) plant washed seed at 6 germinable seed per foot and thin to 4 plants per foot of row at first aerial leaf stage. We had a fifth treatment as well; plant in a different area of the paddy and transplant seedlings at 4 plants per foot of row when the seedlings were at first aerial leaf stage. We used three varieties, Netum, K2E(2), and M3 and the 5 planting methods to achieve a randomized complete block design with 5 replicates. Plots were standard 4 rows ten feet in length. Data were recorded for yield, stand count, and stems per plot. The data for the four seed planted treatments are presented in Table 15. Yield data is expressed as pounds of dry dehulled grain per acre.

The experiment was singularly a failure regarding thinning. We did not achieve a stand of more than four plants per linear foot of row except in a few plots. Thus no evaluation of thinning effect on yield was possible. The experiment was useful because of an extreme range in stand count, from 9 plants per 20 square feet of plot up to 124 plants per 20 square feet of plot. We had a significant replicate to replicate effect on stand which we attribute to water depth and duck foraging.

In Table 15, we show that our treatments had a significant effect on stand at harvest. The washing process significantly increased stand establishment. Further, planting at 6 germinable seed per foot significantly increased stand compared to the 4 plants per foot seeding rate. The plots seeded with unwashed seed had a significantly lower yield than the other treatments. However, there was no difference in yield due to the other treatments. I was particularly discouraged with the yield (Entry mean column) of K2E(2) compared to Netum. The mean stand count for K2E(2) plants was 28 plants per plot - 1.4 plants per square foot compared to 2.2 plants per square foot for Netum. The conclusion that Netum was higher yielding than K2E(2) would not be valid because the difference did not exceed the LSD of the comparison.

For the benefit of wild rice researchers, we continue with the discussion. I computed a covariance adjustment of yield based on stand count per plot and did not achieve an increase in efficiency. The distribution of yield values plotted against stand count showed a quadratic relationship; the distribution was linear for plots which had up to approximately 1.5 plants per square foot but then leveled off. In other words, after we reached 1.5 plants per square foot, yield of the plot was not related to stand density.

A square root transformation of plant count and a covariance analysis of yield based on square root of plants per plot was computed. The adjustment significantly reduced error mean square. Variety means adjusted for stand count are shown under the column "adjusted entry mean." K2E(2) when standardized for stand count significantly exceeded the mean of Netum at the 5% level of significance. Further, the plotting of plot yields against square root of plants per plot indicated a significantly improved fit to linear regression. Thus, I suggest that under some circumstances, we might be able to improve the efficiency of analysis of yield by using covariance adjustment. I think, however, that the procedure will be most useful when there is a wide range in stand counts with most of them on the low plant density end of the scale.

The experiment has one other interesting aspect. I believe that the optimum number of plants per square foot may be less than four as previously suggested by Oelke's early work on optimum density. This experiment, the previously discussed competition experiment, and the good yields that growers get on first year paddies with low stand density indicates to me that additional work is necessary to establish optimum density in wild rice research plots.

The transplanting treatment (data not presented) had low and variable yields. However, the stand establishment was excellent. Out of 80 plants per plot transplanted, 77 was the lowest number to survive. Tillering was substantially reduced in the transplanted plots.

6. Half-sib selection for yield

We completed the first year of an experiment to assess the usefulness of selecting for yield in wild rice populations using half-sib families

Table 15. Mean yield in pounds per acre of dehulled grain in planting methods experiment (Excelsior 1982).

Entry	Treatment[1/]				Entry mean	Adjusted[2/] entry mean	Mean stand count
	1	2	3	4			
K2E2	510	747	736	697	672	758	28
Netum	595	720	702	805	706	662	44
M3	632	732	807	761	733	691	42
Treatment mean	581	734	749	754			
Mean stand count	25	36	48	43			

LSD (0.05) for unadjusted difference between K2E2 and Netum = 95 lb/A

LSD (0.05) for adjusted difference between K2E2 and Netum = 90 lb/A

[1/] Trt. 1: unwashed seed, 4 germinable seed per linear foot of row.
Trt. 2: washed seed, 4 germinable seed per linear foot of row.
Trt. 3: washed seed, six germinable seed per linear foot of row, thin at floating leaf stage.
Trt. 4: Washed seed, six germinable seed per linear foot of row, thin at first aerial stage.

[2/] Entry means adjusted by analysis of covariance (x = square root of stand count).

planted in replicated, single-row, six-foot long plots. Wally Palm will be conducting the investigation as part of his Ph.D. thesis research. Only preliminary analyses are available.

One hundred fourteen half sib families of K2 were evaluated for flowering date, plant height and yield. A half-sib family is the progeny grown from seed of a single plant. We evaluated the families in 1982 at Grand Rapids and identified the best yielding families and the poorest yielding families. We saved some seed of each family at planting time and after harvest, removed the seed from the cold room to permit the families to germinate. Mr. Palm is in the process of intermating the best families and intermating the poorest families. Next year, we will evaluate the populations to see if yield selection among half-sib families is effective. Theoretical predictions from the 1982 results indicate that it should be successful. Palm was very interested in the apparent vigor differences in the greenhouse plants this fall. The "high" yielding families were much more vigorous in growth than the low selections. I should point out that we are not interested in a low yielding version of K2. The experiment is a way to get sound genetic information from both high and low selection.

Acknowledgements

We would like to thank the following people for their contribution to our project this past year:

Pete Olson contributed seed and paddy space for the advanced yield trial.

Paul Imle and John Gunvalson contributed paddy space for the advanced yield trial.

George Landreth contributed seed and a test site for the 1983 evaluation of Dwarf.

Art Hedstrom and Hugo Watson who prepared paddy space for the advanced yield trial (but we could not plant because of the weather) and who contributed seed to our project.

Henry Schumer for his leadership and help in carrying out our research at Grand Rapids.

Gerald Ochocki for his cooperation in providing equipment at the Horticultural Research Center at Excelsior.

WILD RICE DISEASE RESEARCH - 1982

A PROGRESS REPORT

January 22, 1983

Dr. James A. Percich, Project Leader
Elizabeth Hotchkiss, Research Associate
Clint Kohls, Research Assistant
Laura Schickli, Research Assistant

INTRODUCTION

In 1982 the plant pathology wild rice program lost Robert Bowden and M. Kosim Kardin through graduation, added two new graduate students and began work on a three to four year program relating plant health of paddy grown wild rice to chemical disease control, plant production methods (seed storage, planting, and stand density and fertilization), plant nutrition and the development of new field techniques to study brown spot epidemics and future testing of plant introductions for possible disease resistance.

The specific areas of investigation during 1982 were the following:

I. CHEMICAL CONTROL

A. Labeled and experimental fungicides were studied in the laboratory for their effectiveness in preventing spore germination and/or mycelial growth of several different fungal pathogens such as *Bipolaris oryzae* (formerly *Helminthosporium oryzae*), *Bipolaris sorokiniana* (formally *H. sativium*), *Drechslera gigantea*, *Collectotrichum* sp. and *Fusarium roseum graminearum* in nutrient medium amended with various concentrations of the selected fungicides. Greenhouse testing will be performed on those chemicals which demonstrate fungistatic and/or fungicidal properties followed by possible field experimentation in 1983 (Hotchkiss and Percich).

B. A Bravo 500 Flowable threshold study involving three different rates and various numbers of applications was performed at the North Central Experimentation at Grand Rapids, Minnesota. Severity of infection, yield, and residue analysis was determined to help achieve an emergency use label for paddy grown wild rice. (Percich and Hotchkiss).

II. PATHOGEN STUDIES

A. Epidemiology of brown spot caused by *B. oryzae* laboratory, greenhouse and field (grower operations and Rosemount Experiment Station at Rosemount, MN) studies will help determine the various environmental parameters such as air and water temperatures, relative humidity (amount and duration), wind (speed and direction), etc. on the deposition, germination, infection, colonization, lesion development and dispersal of B. oryzae. A crop-loss model will be generated in the next two years which will, hopefully, provide the grower a sound basis for effective economic and biological management decisions concerning the control of fungal brown spot. (Kohls).

B. Investigate the early infection events of B. oryzae on wild rice and the possible role fungicides may play during these events. (Schickli).

III. WILD RICE MANAGEMENT AND DISEASE STUDIES

A. A study to evaluate the effect of various planting and stand densities with and without irrigation and Dithane M-45 Flowable on the incidence and severity of brown spot was studied (In cooperation with Dr. E. Oelke, Dept. Agronomy and Plant Genetics).

B. Relationship between fertilization and plant nutrition on the incidence and severity of biotic and abiotic diseases (In cooperation with Drs. Grava and Bloom, Dept. Soil Science).

1. A study was initiated to study the role that nitrogen fertilization may play on the incidence and severity stem rot of wild rice caused by Sclerotium oryzae.

2. Techniques will be developed to attempt to grow wild rice plants in defined nutrient solutions alone or in nutrient solutions with acid-washed sagnum to study the relationship between plant nutrition (stress and/or excesses) on the development and severity of fungal brown spot.

IV. SCREENING FOR DISEASE RESISTANCE (In cooperation with Dr. R. Stucker, Dept. Agronomy and Plant Genetics)

A. Mixed inocula (5 isolated) of B. oryzae were isolated, maintained, prepared, and given to Dr. Stucker's staff to be used for evaluating his various research plant materials for possible sources of brown spot resistance. The plant pathology staff will, if needed, also provide expertise and advice concerning application equipment, inoculation procedures, evaluation of disease severity and plant response to the pathogen.

MATERIALS AND METHODS

I. Chemical Control

A. Laboratory fungicide screening. Several different protectant and systemic fungicides were each separately amended to potato dextrose broth PDB (Difco) at 0.01,.1, 1.0, and 10.0 μg/ml active ingredient into flasks containing 100 ml of PDB. Each flask was inoculated with a mycelial disc (10mm) of either Bipolaris oryzae (Breda de Haan) Shoemaker, B. sorokiniana (Sacc.) Shoemaker, Drechslera gigantea (Heald and Wolf) Ito., Fusarium roseum (Lk, emend Snyd. & Hans.), or Collectotrichum sp. which are the causal organisms for fungal brown spot, zonate eyespot, leaf and seedling blight, and anthracnose, respectively. The flasks were incubated for 5, 10, and 15 days on a reciprocating shaker(80 cycles/min) at 24 C. The resulting mycelial mat was removed using a funnel containing filter paper (Whatman No. 1) attached to a suction flask. The mycelia was dried at 55 C for 24 hr and immediately weighed. Each treatment was replicated 5 times. The following fungicides were each tested separately with the various test organisms:

1. Anilazine, 4,6-Dichloro-N-(2-chlorophenyl)-1,3,5 triazin-2-amine. Dyrene WP-50, Chemagro Inc.
2. Captan, N-(Trichloromethylthio)-4-cyclohexene-1,2-dicarboximide. Captan 50-WP, Chevron Chemical Co.
3. Captafol, cis-N-(1.1,2.2-Tetrachloroethylthio)-4-cyclohexene-1,2-dicarboximide. Difolitan WP-80, Chevron Chemical Co.
4. Chlorothalonil, (Tetrachloroisophthalonitrile). Bravo 500-F, Diamond Shamrock Co.
5. Cleary's 360 (Experimental fungicide)
6. Edifenphos, (O-ethyl, S, S,-diphenyl dithiosphosphate). Hinosan 50-EC, Chemagro Corp.
7. Fenapanil, (a-butyl-a-phenyl-1H-imadozole-1-propane nitrile). Sisthane-2EC, Rohm & Haas Co.
8. Halacrinate, (1-bromo-5-chloro-quinolin-8yl acrylate). Tilt (CGA-30599). CIBA-Geigy Corp.
9. Iprodione, 3-(3,5-dichlorophenyl)-N-(1-methylethyl)-2,4-dioxo-1-imidazolidine carboxamide. (RP-26019), Rhone Poulevc.
10. Mancozeb, (Coordination product of zinc and manganese ethylene bisdithiocarbamate). Dithane M-45 Flowable, Rohm & Haas Co.
11. Maneb, (Manganous ethylenebisdithiocarbamate). Dilhane M-22, Rohm & Haas Co.
12. RH-5781, (Experimental chemical). Rohm & Haas Co.
13. Top-Cop, ($CuSO_4$ + elemental S)

B. Bravo 500-F field trial. In 1982 a section of a research paddy at the North Central Experiment Station at Grand Rapids, MN was planted with the cultivar K-2 wild rice (*Zizania palustris* L) utilizing a randomized block design. Six 12 x 12 m (40 x 40 ft) blocks, each containing eleven 12 m rows having 120 plants at 0.1 m (4 in) intervals were fall planted. The fungicide was applied with a design backpack CO_2 pressurized sprayer system delivering 300 ml of material at 25 psi per plot, which is equivalent to a rate of 331 l/ha (35 gal/la). Chlorothalonil (Bravo 500-F) was applied at rates of either 2.34, 3.51, and 4.68 l/ha (2, 3 and 4 pt/a, respectively). The original fungicide application was on 20 July 1982 during boot and early flowering stages of plant development. The 2nd, 3rd, and 4th sprays, at the three different rates, were made at 10 day intervals following the 1st application. The controls consisted of inoculated and non-lots sprayed with water only. All treatments were replicated 6 times.

Inoculation of plants. Wild rice plants, cultivar K-2 were inoculated with 3 different single spored isolates of *B. oryzae* (Bo 64, Bo 11GU and Bo 67). The fungus was maintained on Difco potato dextrose agar (PDA) slants at 5 C and increased on PDA petri dishes at 24 C under 12 hr of near ultraviolte light for seven days. Spore suspensions were inoculated into a pre-moistened mixture of oats, barley and wheat (5:5:1) in stainless steel trays (16 x 57 x 70 cm). Aqueous inoculum suspensions containing approximately 1 x 10^6 macro- and micro-conidia per ml were sprayed on plants with the sprayer previously described. Fungal inoculations occurred on 8 and 16 July 1982. Secondary infection from artificial and naturally occurring inocula did occur.

Plant evaluation. All plots were hand harvested on August 18, 1982 eleven days after the last fungicide application. The grain from 100 plants per replicate plot was dried at 55 C for 72 hr, dehulled and weighed. An average disease index scale of increasing severity from 1 (no leaf lesions) to 5 (50% leaf area covered) was determined at late flowering and harvest for each test plot. Frozen stem, leaf and seed material from the treatment consisting of 4 applications at 4.68 l/ha (4 pt/a) were sent Dr. S. Miyazaki, Pesticide Research Center at Michigan State University in E. Lansing, MI for residue analysis.

Mean data in all tests were compared with Duncan's multiple range test at the 5% level of significance.

III. Fertilization and Disease Studies (In cooperation with Drs. John Grava and Paul Bloom, Department of Soil Science)

A. Nitrogen fertilization. The objective of this study was to determine if N applied at the pre-plant and/or at the boot stage of plant development at various rates would have an effect on the incidence and severity of stalk rot of wild rice caused by *Sclerotium oryzae* Cav. (Formally *Helminthosprium* or *signoideum*).

Sixty-four wild rice seedlings of the cultivar Netum were planted in wooden boxes which were 122 x 122 cm (4 x 4 ft) square. The boxes contained 20.3 cm (8 in) of Grand Rapids peat soil flooded to a depth of 12.7 cm (5 in). Sclerotia from *S. oryzae* were recovered from flooded paddies in Aitkin County in the Spring 1982. Sclerotial viability was determined by placing 50 sclerotia from each treatment replicate onto plates containing peptone-dextrose agar PDA (Difco) amended with Rose Bengal at 100 μg/ml and observed after 5 days incubation at 24 C. The sclerotia were inoculated into the test plants using a needle attached to a syringe containing 1 ml of a water-sclerotial suspension with approximately 35 sclerotia/ml while the test plants were in the 2nd or 3rd aerial leaf stage of development.

Nitrogen application. Preplant nitrogen Urea, (46-0-0) was incorporated prior to flooding at either 60 lb N/A or 120 lb N/A. The top-dress applications were hand-broadcasted onto the water at the jointing or early boot stages of plant development. The four different treatments utilized were as follows:

Total Nitrogen (lb/a)	Pre-plant (lb/a)	Boot (lb/a)
0	0	0
120	120	0
120	60	60
120	0	120

The levels of potassium (0-0-60) and phosphorous (0-46-0) were kept constant throughout at 40 lb K_2O/A and 60 lb P_2O_5 /A applied pre-plant, respectively. Each treatment was replicated 4 times. Ten leaf, stem, and grain samples were collected from each plot at harvest for weight and plant analysis determination. A stem rot disease index was determined for each treatment at harvest by rating each tiller according to the method adopted by Krause and Webster. Ten plants from each replicate were rated. The essentials of the scale are as follows:

1 = Healthy (H)	- No visible symptoms
2 = Light (L)	- Infection on leaf sheaths only
3 = Medium (M)	- Infection on outer culm surface
4 = Moderate (Mo)	- Infection penetrating to inner culm surface
5 = Severe (S)	- Culm shriveled from weakened, diseased tissue, on fungus mycelial growth on inner culm, sclerotia often present.

$$\text{Disease Index} = \frac{1(\#H) + 2\ (\#L) + 3(\#M) + 4\ (\#Mo) + 5\ (\#S)}{\text{Total number of tillers examined}}$$

The green weight yields consisted of three pickings over a 10 day period. The first two consisted of a rapping of the rice head against the side of a container to dislodge ripened kernels. At the third picking, heads were cut and run through rollers to remove all grain. After each harvest the grain was dried at 95-100 F for 3 days. The grain was then dehulled and seed quality was determined.

B. Nitrogen and Potassium. The objective of the study was to determine if differing rates of nitrogen and potassium could reduce stalk rot incidence and severity at a recommended and high rate of nitrogen. 40 lb N/A and 120 lb N/A were applied were applied pre-plant with either 0 lb K_2O/A, 60 lb K_2 O/A, or 200 lb K_2O/A. The level of phosphorus (0-46-0) was held constant throughout the experimental period at 40 lb P_2O_5/A. An outline of the various treatments is listed on the following page.

Treatment	lb. N/A	lb. K_2O/A
1.	40	0
2.	40	60
3.	40	200
4.	120	0
5.	120	60
6.	120	200

The inoculation of *S. oryzae*, method of plant analysis, harvesting, yield and grain quality determination were the same as previously described.

RESULTS:

Laboratory Fungicide Screening

A. *Bipolaris oryzae* and *B. sorokiniana*, causal organisms of fungal brown spot.

Nine protectant and two systemic fungicides were each separately tested for their ability to retard the growth of B. oryzae and B. sorokiniana in potato dextrose broth (PDB) amended at various fungicide concentrations. Captan, Cleary's 360, Edifenphos (Hinosan) and RH-5781 and no effect on either mycelial growth or sporulation of either fungus regardless of concentration (Table 1, A-D).

Anilagine (Dyrene) exhibited excellent control of fungal growth of both B. oryzae and B. sorokiniana at 0.1, 1.0 and 10.0 ug/ml through day 10 (Table 1-E). By day 15, the fungicide resulted fungal growth inhibition of B. oryzae and 1000 ug/ml for both the test fungi.

Chlorothalonil (Bravo 500-F) was fungistatic at 10 ug/ml for both fungi through day 10 (Table 1-G). Slow growth of both pathogens with no sporulation occurred at .1 and 1.0 ug/ml through day 10. By day 15 the fungi at all fungicide concentrations, except at 10.0 ug/ml, were showing good growth but without sporulation. Chlorothanoli has low solubility in water at low pH may have played a role in preventing the compound from being "available" to the fungus. However, the fungicide exhibited an excellent ability to prevent spore germination of both fungi at concentrations .1 ug/ml in liquid medium (unpublished data).

Mancozeb (Dithane M-45) prevented the growth sporulation of B. oryzae at .01, .1, 1.0 and 10.0 ug/ml and at 1.0 and 10.0 ug/ml through day 10 and 15, respectively (Table 1-H). B. sorokiniana was completely inhibited at both 10.0ug/ml. Little or no growth and sporulation occurred through day 15 at .01, .1 and 1.0 ug/ml (Table 2-H).

Maneb (Dithane M-22) demonstrated some growth and spore inhibition particularly at 10.0 ug/ml, throughout the test period (Table 1-I). However, the fungicide failed to control growth at concentrations less than 1.0 ug/ml.

The systemic fungicides tested, like the protectants, gave variable results in their ability to inhibit mycelial growth and sporulation of B. oryzae and B. sorokiniana.

Finapanil (Sisthane) evidenced good retardation of mycelial growth and sporulation of B. oryzae at 0.1, .1 , 1.0, and 10.0 ug/ml throughout the experimental period (Table 2-A). At 10.0ug/ml little or no fungal growth occurred by day 15. Similar results were obtained when the fungicide was tested against B. sorokiniana (Table 2-A).

The protectant-eradicant fungicide improdine (RP-26019) resulted in complete growth inhibition of B. oryzae at all concentrations, regardless of the period of incubation (Table 2-B). Its range of fungistatic activity was essentially as great against B. sorokiniana (Table 2-B).

In summary, the protective fungicides ranked in order of decreasing effectiveness against B. oryzae and B. sorokiniana, causal organisms of fungal brown spot were the following:

Most effective	1. Mancozeb (Dithane M-45)
	2. Anilazine (Dyrene)
	3. Chlorothalonil (Bravo 500-F)
	4. Captifol (Difolitan)
	5. Maneb
	6. RH-5781
Least Effective	7, 8, 9 Captan, Cleary's 360, Hinosan

Again, mancozeb (Dithane M-45) was superior to all others in its ability to inhibit mycelial growth and sprulation of the fungal brown spot organisms. It remains, except for the possible registration of chlorothalonil (Bravo), the only protective fungicide which is presently biologically, economically, and environmentally effective for use on wild rice. Mancozeb has been required to undergo labeling changes by EPA during the RPAR proceedings, which were initiated in 1977. The following are the new required changes effective January 1, 1983:

1. Add a wildlife warning for use of mancozeb on commercially grown rice, stating: "This product is toxic to fish. Discharge from treated areas may be hazardous to fish in neighboring areas. Do not contaminate water by cleaning of equipment or disposal of wastes."

2. Add a statement to label requiring protective clothing (long pants, long sleeve shirt, gloves, hat and boots) be worn during mixing and loading.

3. Highlight preharvest intervals on labels of non-commercial (homeowner) products."

   Source: Pesticide & Toxic Chemical News Vol. 10, Number 50 October 27, 1982.

The experimental results with two systemic fungicides (Finapanil and Iprodione) in their ability to control mycelial growth and sporulation were very gratifying. However, Finapanil was withdrawn from the market in 1982 for re-labeling by the manufacture and Iprodione because of cost and potential residue problems is not likely to be used on wild rice. Therefore, a systemic fungicide for fungal brown spot control on cultivated wild rice in Minnesota does not appear to be very promising in the very near future. Two compounds Tilt and Du-Ter which are presently labeled on white rice in the United States will be field tested on wild rice in 1983.

Drechslera gigantea

B. Drechslera gigantea, causal organism for zonate eyespot

The fungus *Drechslera gigantea* has become more frequent in cultivated wild rice fields over the past 3 years. It is often most abundant in fields which have plants infected with *Bipolaris oryzae*, the fungal brown spot organism. Four protectant fungicides were tested to determine if any one or more had fungistatic properties. Tilt, Top-Cop, and chlorothalonil did exhibit some ability to inhibit growth, but only at the highest concentration (10.0 ug/ml) tested (Table 3-A, B, and C). Mancozeb (Dithane M-45) was effective through day 10 at .1 and 1.0 ug/ml (Table 3-D). At 10.0 ug/ml the fungicide demonstrated good fungistatic activity through day 15. Additional fungicides will be studied to find compound(s) as or more effective than mancozeb.

C. Colletotrichum graminicola, causal organism of "anthracnose"

Test results using three protectant fungicides to control the growth of *C. graminicola* in PDB were unclear. The fungicide Tilt showed good growth supressent activity at only 1.0 and 10.0 ug/ml throughout the experimental period (Table 3-A). However, the fungus was not apparently affected until day 10, and then only at the two highest concentrations (Table 4-A).

The action of chlorothalonil was more consistent with reduction in growth being evident by day 5 at the 1.0 and 10.0 ug/ml (Table 4-B). Inhibition of mycelial growth was demonstrated through day 15 with 10.0 ug/ml amendment only.

Top-Cop had no clearly established fungistatic effect on *C. graminicola* (Table 4-C).

Therefore, it appears that Tilt and chlorothalonil can inhibit mycelial growth of *C. graminicola* effectively at either 1.0 or 10.0 ug/ml through a two week period. Additional fungicide screening is underway to identify more fungicides which may have use in controlling this pathogen.

D. *Fusarium roseum graminearum*, causal organism of a seedling blight and seed decay

To date, only four fungicides (chlorothalonil, mancozeb, Tilt and Top-Cop) have been tested to control the growth and sporulation of *F. roseum graminearum*. Only Top-Cop at .1,1.0 and 10.0 ug/ml resulted in any significant growth inhibition. Further investigation into the biology and control of this fungal pathogen is in progress.

A Summary:

The ability of various fungicides at differing concentrations to control the mycelial growth and/or sporulation of several fungal pathogens of wild rice in liquid culture (in vitro) is outlined below:

Pathogen	Chemical(s)
1. *Bipolaris oryzae*	Anilazine (Dyrene) Captifol (Difolitan) Chlorothalonil (Bravo 500-F) Mancozeb (Dithane M-45) Finapanil (Sisthane) Improdine (RP-26019)
2. *Bipolaris sorokiniana*	Same as for *B. oryzae* excluding Improdine (not tested)
3. *Drechslera gigantea*	Chlorothalonil Mancozeb Top-Cop Tilt
4. *Colletotrichum graminicola*	Chlorothalonil Tilt
5. *Fusarium roseum graminearum*	Top-Cop

Chlorothalonil (Bravo 500-Flowable) Brown Spot Control Study

Regardless of rate (4.6, 3.5, or 2.3 l/ha) or number of applications (3 or 4) at each rate, there was significant control of brown spot when compared to the inoculated but unsprayed control (Table 6). At 4.6 l/ha (4 pt/a) with either 4 or 3 applications there was only 1.3 and 3.1% of the leaf infected with *B. oryzae* and a resulting 35 and 32% seed weight increase over the inoculated control, respectively. Three applications of Bravo 500-F at 3.5 l/ha (3 pt/a) resulted in a significant 25% increase in yield (Table 6). However, the 3.5 l/ha rate with 4 applications did not result in an increase in yield. This was probably due to the randomized placement of 4 of 6 replications between control rows which resulted in severe and uncontrolled disease pressure. The other two treatment replicate plots yielded an average of 210 kg/ha which was a 29% increase over the control.

A rate of only 2.3 l/ha at either 4 or 3 applications resulted in a significant 17 and 12% increase respectively in yield when compared to the control (Table 6).

Therefore, it appears that Bravo 500-F at all rates and applications will give good leaf protection and significantly increase yields. Also, a rate of 3.5 l/ha at 3 applications will result in a safe, yet cost effective, margin of plant protection and expected yield increase. Field testing of Bravo 500-F at 4.6, 3.5 and 2.3 l/ha at 3 applications will be attempted in 1983 to investigate the possibility of reducing the proposed Bravo 500-F label (presently, 4.6 l/ha at 4 applications) on wild rice to a lower rate and numbers of application level. Again, favorable IR-4 residue analysis, Minn. Dept. Agriculture and grower support will be needed for this to occur. Published plant pathology research indicates that it is desirable to have an additional fungicide to the presently labeled Mancozeb (Dithane M-45) on paddy grown cultivated wild rice in Minnesota.

Effect of sprinkler irrigation on the development and severity of fungal brown spot caused by *Bipolaris oryzae*.

An overhead sprinkler irrigation system to help maintain high relative humidity and moisture in the wild rice canapy was designed and assembled at the North Central Experiment Station at Grand Rapids, Minnesota.

Past plant pathology efforts to create and sustain a fungal brown spot epidemic have been less than satisfactory; often requiring up to six different inoculations. This was due in large part by the cool evening temperatures (inhibiting fungus spore germination) and dry plant leaf tissue during the day preventing further spore infection. The brown spot fungal pathogens, *Bipolaris oryzae* and *B. sorokiniana* must have free water, near 100% relative humidity, and temperatures above 68 F for at least 4 hours for successful germination and infection.

The research site selected for this study was used in conjunction with Dr. E. Oelke who was studying the relationship between stand density and brown spot severity. Details relating to experimental design, methods and materials utilized and subsequent results can be found in his section of this research booklet.

Dithane flowable was applied at 14 day intervals beginning on July 8, 1982. The methods of fungicide application, inoculations, and evolution on disease severity is described in detail in the chlorothalonil (Bravo) section of this plant pathology report.

Results

The effect of the overhead sprinkler irrigation system on disease was dramatic (Table 5). Plants which were inoculated, misted and not treated with Dithane had 29.6% of their leaf area infected (Table 5). Even when the plants were not inoculated with the pathogen, but kept misted, there was a resulting 13.4% leaf area infection as compared to only 2.4% leaf area infected for the non-misted plants (Table 5). The non-misted and uninoculated plants treated with Dithane had only 1.8% of their leaf areas infected (Table 5).

Therefore, it was clearly demonstrated that misting either inoculated or uninoculated plants could result in a severe and sustained brown spot epidemic. We believe, that with proper refinement and re-design of the misting system at

Grand Rapids will, finally, have a reliable research setting to study fungal brown spot under severe but controlled conditions. It will now be possible to investigate the interaction of cultural practices and disease incidence and severity as well as critically evaluating new plant introductions for sources or possible disease resistance.

II. Epidemiology: Fungal Brown Spot Yield Reduction Study

During the summer of 1982 a study was conducted to determine the effect of varied levels of fungal brown spot on wild rice yields at the University of Minnesota Experiment Station at Rosemount, MN. A randomized complete block design with 5blocks and 5 replications per treatment was employed for this study. Treatments consisted of four levels of disease and a non-diseased control. The cultivar K-2 was planted in 7 x 10 feet. experimental plots to a final density of 2 plants/ft^2. Fungal brown spot was initiated in the plots at four stages of crop development: boot, heading, ¼ grain fill and milk, by inoculation with spores of Bipolaris oryzae. Experimental plots were kept free of disease prior to disease initiation by timely application of the protective fungicide Dithane M-45 (flowable).

Figure A indicates the fungicide application and spore inoculation schedules used. At harvest the inner 4 x 7 ft. area of each plot was picked by hand, dried, dehulled, graded and weighed. Grade 3 and above kernels were used in determining yields. Yield reduction is expressed as a comparison to control yields.

Results:

Fungal Brown Spot Yield Reduction

During flowering and grain maturation disease ratings were periodically recorded for each plot. The amount of disease was expressed as the percent of leaf area covered by brown spot. Varied levels of Bipolaris oryzae infection during pre-flowering, flowering and early grain fill stages of crop development had significant effects on yield reduction (Figure B). Disease-free plots averaged 774 lb/acre on a dry weight basis. Plots where disease was initiated in boot, heading and ¼grain fill stages showed yield reductions of 67%, 56%, and 32%, respectively. The least significant difference test (LSD) indicated boot and heading disease initiation treatment yields were not significantly different from each other. Similarly, disease initiated at the milk stage of development had no significant effect on yield. (Figure B).

The average percentage of leaf area diseased at four stages of plant development is tabulated in Figure C. In the more heavily diseased treatments, the older, lower leaves of a wild rice plant were found to be substantially more diseased than the younger, upper leaves of the plant, (Figure C). When such differences among leaves of a plant were apparent, disease ratings were recorded for the different leaves. The relative importance of these leaves to grain filling has not been determined. However, rating plants for disease by the three leaf method does seem to have some advantages in estimating yield reduction due to fungal brown spot.

Equation 1

Yield (lb. D.W./acre) =

784 lb/A - 13.5 lb/A % Disease on 2nd leaf -2.47 lb/A % disease on 3rd leaf

Disease readings for the second and third leaves during the late milk stage were used with regression equation 1 to account for 86 percent of the variation in yields seen in experimental plots.

Equation 2

Yield (lb. D.W./Acre) =

789.5 lb/A - 11.5 lb/A % Disease 1st leaf - 12.1 lb/A % Disease 2nd leaf - 2.16 lb/A %Disease 3 rd leaf

Disease readings from the first, second and third leaves during the late milk stage were used with multiple regression equation 2 to account for 87 percent of the variation in yields seen in experimental plots.

These equations indicate the upper most and second highest leaves are much more important in disease related yield reductions than is the third leaf. Generally, losses of approximately 12 lb/acre of dry processed rice were found in experimental plots per percent of brown spotted leaf area on each of the upper two leaves and approximately 2 lb/acre for each per cent of diseased leaf area on the third leaf.

This is a summary of results of the first year of a three year study to determine fungal brown spot associated yield reductions, forecast brown spot and efficiently schedule fungicide sprays for the purpose of decreasing economically important yield losses.

Commercial Field Disease Survey

During July and August 1982 fourteen commercial field s were inspected. Fields were visited from 3 to 6 times for the assessment of disease problems. Data collected throughout the season on the effects of weather and cultural practices will be used in the future for disease forecasting and fungicide spray scheduling. Disease severity of the following diseases were compiled for each field; fungal brown spot, bacterial brown spot, bacterial leaf streak, anthracnose, zonate eye spot, smut, ergot, phaeoseptoria leaf spot and stem rot. An improved disease rating scale was adopted for fungal brown spot, which was shown in 1980 and 1981 disease surveys to be the predominant disease problem.

Results: Commercial Field Disease Survey

The occurrenc e of disease in commercial fields is tabulated in Figure D. Ergot was not found in commercial fields surveyed but was present in experimental plots at Grand Rapids. Wheat streak mosaic virus symptoms were found in a single plant. Zonate Eyespot was found in approximately 1/3 of the survey fields (figure D). Anthracnose, phaeoseptoria leaf spot and bacterial brown spot were found in over 1/2 of survey fields, while smut was found in about 2/3 of the fields surveyed (Figure D). Of these diseases, anthracnose was the only one with a severity rating greater than 3% leaf area diseases in any field throughout the growing season (Figure D). Bacterial leaf streak fungal brown spot and stem rot were found in most the fields surveyed.

Figure E shows the progressive increase in leaf area with fungal brown spot through the growing season in surveyed fields. Five fields had disease severity ratings at milk stage high enough to give significant yield reductions according to data from the fungal brown spot yield reduction study (Figure E).

Results

III. Fertilization and Disease Studies

A. Nitrogen rate and time of application study

The relationship between the timing and the amount of nitrogen and the severity of stalk rot infection was not clearly established. Results of this investigation are reported in table 7.

The disease index for all treatments, except for the 120 lb N/a at boot, was not significantly different. A disease index of 1.5 for the 120 lb/a treatment at boot was lower than that for the other treatments, indicating some disease reduction.

The grain yield was increased above the control by all nitrogen treatments receiving a total of 120 lb N/a either preplant, boot, or in a splot application.

The percentage of highest quality grain (grade 4) ranged from a low of 51 to a high of 66 percent for treatments receiving 102 lb/a of N either preplant or at boot, respectively.

There appeared to be no consistent relationship between the dry weight of leaves and stems and the various nitrogen treatments (data not reported here).

Total uptake of nitrogen by the plant at harvest was affected by fertilizatio with nitrogen. Plants receiving nitrogen by split application (60 + 60 lb N/a) accumulated 621 mg N per plant compared to 341 mg for the control.

The results of this investigation support published data on white rice that delayed nitrogen application will reduce stem rot caused by _H. sigmoideum_ on wild rice. Split application of nitrogen was not, however, effective in reducing disease, even though it produced the highest yield. However, Keim and Webster (Phytopathology 64:178-183) were able to reduce stem rot of white rice by split applications of nitrogen.

The increase in grain quality associated with nitrogen application to wild rice at boot (table 7) may be due to a reduction in disease or an increased availability of nitrogen at grain fill. Stem rot of white rice has been reported to reduce both grain quality and panicle size (Ferriera and Webster, Phytopatholog 66:1151-1154).

The data of this investigation are rather limited. Only 40 plants per treatment were analyzed for percent N, dry weight and rated for disease. Also the plants were artificially inoculated to ensure infection, while most results on white rice have been from studies conducted in naturally infested fields.

Only limited conclusions can be drawn from this research. The data suggest that delayed application of nitrogen could reduce stem rot without a reduction in yield. This work must be repeated under controlled conditions as wel as in naturally infested fields under regular management practices. Particular attention should be given to the cause(s) of reduced grain quality.

B. Nitrogen and Potassium Rate Study

The grain yield and total N uptake by wild rice were increased by the 120 lb/A nitrogen treatment compared to the 40 lb/A rate (Table 8 and 9). Plants receiving only 40 lb N/A exhibited typical nitrogen deficiency symptoms. Apparently, a higher amount of fertilizer nitrogen is required for normal growth of wild rice in 4 x 4 ft boxes than under paddy conditions. Potassium uptake by the plant and the grain yield were increased by the 60 and 200 lb/A potassium rates above the Orate (Table 10 and 8).

The effects and interactions of various amounts of nitrogen and potassium on the severity of stalk rot caused by *Sclerotium oryzae*, were not clearly established (Table 8). This research effort will be repeated in 1983.

PUBLICATIONS - 1982

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ACKNOWLEDGEMENTS

Special thanks to Mr. Henry Schrumer and his staff at the North Central Experiment Station at Grand Rapids, MN. Also, the help and assistance of Drs. P. Bloom, J. Boedicker, J. Grava, E. Oelke and R. Stucker is greatly appreciated.

Figure A.

1982 Fungicide and inoculation schedule for fungal brown spot yield reduction study.

Date		Treatments				
Mo	Day	Boot	Heading	¼ Fill	Milk	Control
7	11	D[1]	D	D	D	D
7	26			D	D	D
7	27	I[2]				
7	31	I	I			
8	3				D	D
8	7	I	I	I		
8	10					D
8	19	I	I	I	I	

[1] D = Dithane

[2] I = Inoculation

Figure B.

Least Significant Difference[a] Comparison of Wild Rice Yields from Fungal Brown Spot Initiation Treatments.

	Treatments				
	Boot	Heading	¼ Fill	Control	Milk
Yield lb. D.W./Acre)	258	343[b]	524	774	805
% Loss[c]	67±10	56±6	32±10	0±14	0±14

(Underlining in the original groups Boot–Heading, ¼ Fill alone, and Control–Milk.)

a) LSD $_{0.05}$ = 114.2

b) Underlined treatment yields are not significantly different

c) % Loss is a comparison to control treatment yield

Figure C.

Fungal Brown Spot Yield Reduction Study for 1982. Average percent leaf area brown spotted for each treatment.

Date		Plant Stage	Treatments				
Mo	Day		Boot	Heading	¼ Fill	Milk	Control
7	27	Boot					
7	31	Heading	1%	0%	0%	0%	0%
8	3		1%	1%	0%	0%	0%
8	7	¼ Fill					
8	9		Tr/2.5/70[a]	Tr/1.5/50	Tr/1/30	0-Tr	0-Tr[b]
8	19	Milk					
8	21		6.2/20/100	4.25/14/82	3.4/8/76	Tr/Tr/1%	Tr

[a]Top Leaf/Second Leaf/Third Leaf

[b]Tr = Trace

Figure D.

Disease Survey Results Summary

Disease	% of Fields with Disease
Ergot	0
Wheat Streak Mosaic Virus	7
Zonate Eyespot	36
Phaeoseptoria leaf spot	57
Anthracnose	57
Bacterial Brown Spot	57
Smut	64
Bacterial Leaf Streak	86
Stem Rot	100
Fungal Brown Spot	100

Figure E. Progressive increase in fungal brown spot disease severity at commercial survey sites

County	Site	Cultivar	Date 6/22/82	7/7/82	7/8/82	7/14/82	7/19/82	7/28/82	8/4/82	8/5/82	8/11/82	8/12/82	Significant Losses
Aitkin	1	K2		1[a]		2		2	2		3		
Aitkin	2	Johnson		1		1		1	1		2		
Aitkin	3	K2		1		1		1	2		2		
Aitkin	4	K2		1		1		2	2		2		
Aitkin	5	K2		1		1		2	5		5		XXX
Beltrami	6	K2	1		1		1	1		1		2	
Beltrami	7	Netum	1		1		1			2		4	
Beltrami	8	Canadian			1		1	2		3		6	
Beltrami	9	Johnson						2		5		6	XXX
Beltrami	10	Netum						4		6		6	XXX
Beltrami	11	K2	0		1		1	2		5		6	XXX
Clearwater	12	K2	1		1		1			2		2	
Pennington	13	K2			1		1			2		2	
Polk	14	K2			1		1			5		5	XXX

% severity grade (diseased leaf area)

0 = 0 %	4 = 6 to 12 %	8 = 75 to 87 %
1 = trace	5 = 12 to 25 %	9 = 87 to 94 %
2 = trace to 3 %	6 = 25 to 50 %	10 = 94 to 97 %
3 = 3 to 6 %	7 = 50 to 75 %	11 = 97 to 100 %
		12 = 100 %

Table 1 (A-1). Effect of various protectant fungicides in Potato Dextrose Broth (PDB) at different concentrations on the growth of Bipolaris oryzae and B. sorokiniana, causal organisms of fungal brown spot of wild rice.

A. Captan

Incubation (days)	Average Dry Weight (mg)									
	B. oryzae					B. sorokiniana				
	0	.01[a]	0.1	1	10	0	.01	0.1	1	10
0	20	20	20	20	20	20	20	20	20	20
5	230	260	250	230	230	260	200	200	200	200
10	260	260	260	260	260	260	270	270	260	270
15	360	360	360	340	320	260	265	270	260	260

[a]Fungicide concentration in μg/me (ppm)

B. Cleary's 360

Incubation (days)	Average Dry Weight (mg)									
	B. oryzae					B. sorokiniana				
	0	.01	0.1	1	10	0	.01	0.1	1	10
0	20	20	20	20	20	20	20	20	20	20
5	230	260	260	260	260	240	280	290	280	260
10	260	260	260	260	260	260	265	270	280	260
15	360	360	360	330	330	260	265	270	260	260

C. RH-5781

Incubation (days)	Average Dry Weight (mg)									
	B. oryzae					B. sorokiniana				
	0	.01	0.1	1	10	0	.01	0.1	1	10
0	10	10	10	10	10	Not Tested				
5	490	230	320	150	270					
10	470	400	320	500	420					
15	580	630	600	480	---					

Table 1 (cont).

D. Edifenphos (Hinosan)

Incubation (days)	Average Dry Weight (mg)									
	B. oryzae					B. sorokiniana				
	0	.01	0.1	1	10	0	.01	0.1	1	10
0	20	20	20	20	20	20	20	20	20	20
5	304	300	320	340	300	270	260	300	300	300
10	318	300	320	330	330	270	260	280	280	300
15	318	320	320	320	330	270	270	275	280	290

E. Anilazine (Dyrene)

Incubation (days)	Average Dry Weight (mg)									
	B. oryzae					B. sorokiniana				
	0	.01	0.1	1	10	0	.01	0.1	1	10
0	20	20	20	20	20	20	20	20	20	20
5	230	70	20	20	20	240	80	20	30	20
10	240	150	120	130	30	260	90	30	40	20
15	260	150	130	160	41	260	160	70	83	43

F. Captifol (Difolitan)

Incubation (days)	Average Dry Weight (mg)									
	B. oryzae					B. sorokiniana				
	0	.01	0.1	1	10	0	.01	0.1	1	10
0	20	20	20	20	20	20	20	20	20	20
5	304	70	60	50	20	270	50	30	30	20
10	318	140	60	60	20	272	50	62	41	20
15	330	240	180	160	65	298	180	124	120	68

Table 1 (cont.)

G. Chlorothalonil (Bravo)

Incubation (days)	Average Dry Weight (mg)									
	B. oryzae					B. sorokiniana				
	0	.01	0.1	1	10	0	.01	0.1	1	10
0	20	20	20	20	20	20	20	20	20	20
5	260	190	80	40	20	240	180	70	90	20
10	330	260	160	82	20	260	280	140	90	20
15	330	330	300	246	80	300	298	280	270	108

H. Mancozeb (Dithane M-45)

Incubation (days)	Average Dry Weight (mg)									
	B. oryzae					B. sorokiniana				
	0	.01	0.1	1	10	0	.01	0.1	1	10
0	20	20	20	20	20	20	20	20	20	20
5	304	20	20	20	20	270	40	40	32	20
10	318	20	20	20	20	282	20	20	20	20
15	330	42	45	20	20	298	20	20	20	20

I. Maneb (Dithane M-22)

Incubation (days)	Average Dry Weight (mg)									
	B. oryzae					B. sorokiniana				
	0	.01	0.1	1	10	0	.01	0.1	1	10
0	20	20	20	20	20	20	20	20	20	20
5	260	280	280	200	100	240	250	220	170	80
10	330	260	290	210	180	260	290	270	230	165
15	330	300	230	190	150	260	290	270	280	225

Table 2 (A,B) Effect of two systemic fungicides in Potato Dextrose Broth (PDB) on the growth of *Bipolaris oryzae* and *B. sorokiniana* causal organisms of fungal brown spot of wild rice.

A. Finapanil (Sisthane)

Incubation (days)	Average Dry Weight (mg)									
	B. oryzae					*B. sorokiniana*				
	0	.01[a]	0.1	1	10	0	.01	0.1	1	10
0	20	20	20	20	20	20	20	20	20	20
5	304	40	40	40	22	270	40	40	40	20
10	318	41	40	40	22	272	40	40	40	31
15	330	40	40	40	22	298	30	30	39	30

[a]Fungicide concentration in µg/ml (ppm)

B. Improdione (RP-26019)

Incubation (days)	Average Dry Weight (mg)									
	B. oryzae					*B. sorokiniana*				
	0	.01	0.1	1	10	0	.01	0.1	1	10
0	20	20	20	20	20	20	20	20	20	20
5	304	20	20	20	20	270	20	20	20	20
10	318	20	20	20	20	272	20	20	20	20
15	330	20	20	20	20	298	24	38	39	20

Table 3 (A-D). Effect of four protectant fungicides in Potato Dextrose Broth on the mycelial growth of Drechslera gigantea, causal organism of zonate eyespot on wild rice.

A. Tilt

Incub. (days)	Av. dry wt (mg) Tilt (µg/ml)				
	0	.01[a]	0.1	1	10
0	10	10	10	10	10
5	66	58	54	60	12
10	68	136	56	76	36
15	62	164	102	74	36

B. Top-Cop

Incub. (days)	Av. dry wt (mg) Top-cop (µg/ml)				
	0	.01	0.1	1	10
0	10	10	10	10	10
5	34	28	28	28	26
10	76	36	80	60	28
15	62	68	80	102	22

[a]Fungicide concentration in mµ/mg (ppm)

C. Chlorothalonil

Incub. (days)	Av. dry wt (mg) Chlorothalonil (µg/ml)				
	0	.01[a]	0.1	1	10
0	10	10	10	10	10
5	44	37	32	32	22
10	68	30	30	10	12
15	176	150	180	103	105

D. Mancozeb

Incub. (days)	Av. dry wt (mg) Mancozeb (µg/ml)				
	0	.01	0.1	1	10
0	10	10	10	10	10
5	50	30	30	20	10
10	190	180	80	50	20
15	580	630	600	480	30

Table 4 (A-D). Effect of four protectant fungicides in Potato Dextrose Broth (PDB) on the mycelial growth of Colletotrichum graminicola, causal organism of anthracnose on wild rice.

A. Tilt

Incub. (days)	Ave. dry wt (mg) Tilt (μg/mg)				
	0	.01	0.1	1	10
1	10	10	10	10	10
5	32	26	32	22	16
10	85	58	42	14	16
15	450	550	510	96	98

[a]Fungicide concentration in μg/mg (ppm)

B. Chlorothalonil

Incub. (days)	Ave. dry wt (mg) Chlorothalonil (μg/ml)				
	0	.01	0.1	1	10
0	10	10	10	10	10
5	94	72	86	60	50
10	88	113	192	66	37
15	350	196	392	112	14

C. Top-Cop

Incub. (days)	Ave. dry wt (mg) Top-Cop (μg/ml)				
	0	.01	0.1	1	10
0	10	10	10	10	10
5	52	32	40	90	66
10	112	116	88	84	55
15	110	163	120	113	111

Table 4 (D) Effect of four protectant fungicides in Potato Dextrose Broth (PDB) on the mycelial growth of *Colletotrichum graminicola*, causal organism of anthracnose on wild rice.

D. Mancozeb

Incub. (days)	Ave. dry wt (mg) Mancozeb				
	0	.01	0.1	1	10
0	10	10	10	10	10
5	22	34	40	38	26
10	118	264	210	75	27
15	360	500	448	270	98

Table 5. Effect of Sprinkler Irrigation on the Development of Brown Spot Caused by *Bipolaris Oryzae* on Wild Rice.

Treatment	Average Percent Leaf Area Infected	Average Lesion Index (SAE)
Misted		
Inoculated	29.6	4.5
Non-Inoculated	13.4	4.3
Non-Misted		
No Dithane	2.4	3.8
Dithane	1.8	3.6

TABLE 5. EFFECT OF SPRINKLER IRRIGATION ON THE DEVELOPMENT OF BROWN SPOT CAUSED BY <u>BIPOLARIS ORYZAE</u> ON WILD RICE.

	AVERAGE PERCENT LEAF AREA INFECTED	AVERAGE LESION SIZE(mm)
MISTED		
INOCULATED	29.6	4.5
NON-INOCULATED	13.4	4.3
NON-MISTED		
NO DITHANE	2.4	3.8
DITHANE	1.8	3.6

TABLE 6. THE EFFECT OF CHLOROTHALONIL ON DISEASE SEVERITY AND RESULTING YIELD

TREATMENTS RATE kg/ha(pt/a)	NOS. APPLICATIONS	LEAF AREA INFECTED(%)	LESION SIZE(mm)	SEED WEIGHT Kg/ha (lbla)[y]	SEED WEIGHT INCREASE INOCULATED CONTROL(%)
A. 4.6 l/ha(4pt/a)	4	1.3	4.8	220 (198)[a] [1]	35[a]
	3	3.1	4.8	216 (194)[a]	32[a]
B. 3.5 l/ha(3pt/a)	4	4.7	4.6	142 (158)[c]	--
	3	4.4	4.8	204 (184)[ab]	25[b]
C. 2.3 l/ha(2pt/a)	4	4.0	4.9	191 (172)[b]	17[c]
	3	3.7	5.1	183 (165)[bc]	12[c]
D. CONTROL					
INOCULATED		21.2	5.2	163 (147)[d]	
NON-INOCULATED		20.8	5.6	167 (150)[cd]	

MEANS SEED WEIGHT OF 6 POOLED SAMPLES

[1]MEANS IN EACH COLUMN FOLLOWED BY THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT AT P=.05 ACCORDING TO DUNCAN'S MULTIPLE RANGE TEST.

Table 7. The effect of nitrogen rate and time of application on disease index, yield, grain quality and total nitrogen uptake.

Nitrogen Treatment, lb/a Preplant	Boot	Disease Index	Yield[1] lb/a	Grain Quality %	Total N Uptake mg/plant
0	0	2.2	894a[2]	61ab	341a
120	0	2.3	1222b	51a	486b
0	120	1.5	1327c	66b	526bc
60	60	2.4	1554d	56ab	621c

1) Yield of dehulled, dry (7% moisture) grain.

2) Means in each column followed by the same letter are not significantly different at the P = .05 according to Boniferoni's Least Significant Difference.

Table 8. The effect of nitrogen and potassium application on the disease severity and yield.

	Treatment lb/A		Disease	Yield[1]
	Nitrogen	Potassium	Index	lb/A
A	40	0	2.6	996 a[2]
B	40	60	3.1	1007 a
C	40	200	3.1	954 a
D	120	0	2.3	1086 ab
E	120	60	2.2	1188 c
F	120	200	2.6	1229 cd

1) Yield of dehulled, dry (7% moisture) grain

2) Means in each column followed by the same letter are not significantly different at P = .05 according to Duncan's Multiple Range Test

Table 9. Effect of Nitrogen and Potassium Application on Total Uptake of K by Wild Rice at Maturity, St. Paul, 1982.

	K Rate (lb/a) 0	60	2000	N Effect
	K mg/plant			
N Rate				
lb/A				
40	204	265	389	286
120	183	244	417	281
K Effect	193	254	403	
Significance				
N Effect	NS			
K Effect	**			
B.L.S.D. (0.05)	35			
Interaction				
N x K	NS			
C.V.,%	13			

Table 10. Effect of nitrogen and Potassium Application on Total Uptake of N by Wild Rice at Maturity, St. Paul, 1982.

	K Rate (lb/a) 0	60	2000	N Effect
	N mg/plant			
N Rate				
lb/A				
40	357	378	359	364
120	431	473	499	467
K Effect	394	425	429	
Significance				
N Effect	**			
K Effect	NS			
Interaction				
N x K	NS			
C.V.,%	10			

RASPBAR VS. SPIKE TOOTH CYLINDERS, FEED RATE, AND REEL ADJUSTMENTS ON COMBINES

Cletus Schertz, James Boedicker and Michael Lueders
Agricultural Engineering Department

The 1982 wild rice harvest research included: 1) evaluating the influence of feed rate on combine performance for two combines (one with cylinder and grate concave and one with spike tooth cylinder and concave), 2) quick test of typical combine, 3) evaluation of the influence of cylinder speed, 4) study of influence of reel index on net yield and 5) further evaluation of water separator.

Influence of Feed Rate on Combine Performance for Two Combines (One With Raspbar Cylinder and Grate Concave and One With Spike Tooth Cylinder and Concave)

A series of tests were made to assess the discharge losses for two combines (one with raspbar cylinder and one with spike tooth cylinder) at various feed rates of MOG (material other than grain). Side-by-side runs were made with the two combines at various speeds to effect different feed rates. The field was considered to be very uniform in crop condition and it was long enough to permit six runs in a single straight pass along one side of the field, with ample combine stabilization distance before each run. This permitted having six runs by one combine in a single pass and six runs by the other combine side-by-side with nearly the same travel speeds, respectively.

The results from field processing (involving the water separator, partial drying, etc.) of the discharge samples are listed in Table 1a and shown as graphs in Figures 1 and 2. This data from on-site analysis was completed before moving equipment away from the site. This is in contrast to a delay of several weeks or months before the lab analysis data became available.

These field tests were conducted on farmers' wild rice fields with farmers' combines. We appreciate the excellent cooperation from the farmers in permitting us to do these investigations and providing the land, combine, fuel, operator and general use of farm facilities.

Notes for Tables 1a, 1b, 2a, 2b, 3a and 3b

a) On-site analysis made use of the water separator for walker discharge samples and either air separator on a water tub separator for sieve discharge samples. or

b) As evaluated at completion of on-site processing (partial drying not dehulled and compared to green weight net yield). Only the sink portion ("floaters" from water separation not included).

c) Type cylinder -- RB for raspbar and ST for spike tooth.

d) By dehulling, sorting for over 2-1/2/64" width, drying, weighing, calculating at 7 percent Mwb and comparing to green weight.

e) Percent by weight of kernel pieces 1/4 inch or less in length in a dehulled sample.

f) By dehulling, sorting for over 2-1/2/64" width, drying, weighing, and calculating at 7 percent Mwb (This included both the "sinker" kernels and the "floater" kernels.)

The lab analysis data is tabulated in Table 1b and shown as graphs in Figures 3, 4 and 5.

Some observations and comments about the results are:

1. No attempt was made to optimize the combine adjustments. The combine adjustment (except for travel speed which was altered to effect changes in MOG rate) were those judged appropriate for the crop conditions and in use by the farmer.

2. For evaluation of walker losses and sieve losses, the on-site field data is a reasonably accurate indicator of the data to be found by subsequent lab analysis. On-site evaluation of samples for threshing loss has not been attempted.

3. A rise in losses with an increase in MOG rate is expected but is not evident from this data. (Except for perhaps the walker losses with the spike tooth cylinder.) This is not explained except that the combine(s) were capable of handling these increased levels of MOG rate without adversely affecting the discharge losses. Runs with higher rates that might have caused increases in discharge losses were not made.

4. Losses from the sieves is substantially higher for the combine with the spike tooth cylinder than for the combine with the raspbar cylinder. Part of this is explained because the raspbar cylinder does not tear and breakup the straw as much as the spike tooth cylinder. Breakup of the straw causes more material to enter upon the sieves and thereby cause an overload condition. This addition of material on the sieves is evident by comparison of the data for MOG rate over the sieves. The ratio of sieve MOG to walker MOG averaged 10.2 percent for the spike tooth cylinder and 7.2 percent for the raspbar cylinder.

5. The threshing losses for the spike tooth cylinder were higher than for the raspbar cylinder. No attempt was made to optimize the cylinder settings. Perhaps other cylinder settings could have reduced the threshing losses for either combine.

6. The average for the broken percentage from the raspbar cylinder was 3.7 percent and for the spike tooth cylinder was 2.9 percent.

Quick Test of Typical Combine

A quick test was made of a typical combine without alteration of any machine parameters. Two runs were made side-by-side to reduce influence from field variations. However, large differences were present in the net yield, MOG rates and combine performance. The results of these tests at site II are listed in Tables 2a and 2b.

Table 1a. Data from on-site analysis[a] of samples from Site I (Tests for influences from cylinder type and MOG rate.)

Run No. 82-	Type Cyl.[c]	Travel Speed, mph	Net Yield Green, lb/ac	MOG rate (material other than grain): Over Walker, lb/min	MOG rate: Over Sieve, lb/min	MOG rate: Total, lb/min	MOG rate: Total, lb/ac	Discharge Losses[b]: Walker, lb/ac	Discharge Losses: Walker, % of Net	Discharge Losses: Sieve, lb/ac	Discharge Losses: Sieve, % of Net
101	RB	1.5	669	182	14.5	196	4610	15	2.3	18	2.7
102	↓	1.6	699	190	12.7	202	4490	11	1.6	13	1.9
103	↓	1.6	790	164	12.2	176	3880	15	1.9	11	1.4
104	↓	1.0	888	85	9.8	95	3360	23	2.6	18	2.0
105	↓	1.0	766	110	9.4	119	4230	20	2.6	24	3.2
106	↓	1.2	717	121	11.2	132	3780	18	2.5	17	2.4
107	ST	1.6	544	197	19.7	217	4630	16	2.9	51	9.4
108	↓	1.6	553	159	17.5	176	3840	16	2.8	50	9.0
109	↓	1.4	648	170	19.5	190	4480	20	3.2	62	9.5
110	↓	1.2	784	121	15.0	136	3820	12	1.6	63	8.1
111	↓	1.2	727	114	14.1	128	3550	18	2.5	59	8.2
112	↓	1.0	693	82	12.0	94	3200	17	2.4	66	9.6
113	↓	1.8	635	245	22.4	267	5030	24	3.8	44	7.0
114	↓	2.1	623	260	16.0	276	4490	31	5.0	30	4.9
115	↓	2.2	748	218	24.2	242	3700	15	2.0	36	4.8
116	↓	2.4	815	243	20.8	264	3800	29	3.5	31	3.8
117	↓	2.2	796	278	15.8	294	4470	32	4.0	29	3.7
118	↓	2.7	654	176	18.3	194	2450	18	2.8	18	2.8
119	RB	2.0	708	242	15.5	257	4330	13	1.8	11	1.5
120	↓	2.2	748	275	14.1	289	4520	14	1.8	10	1.3
121	↓	2.4	812	245	12.2	257	3600	10	1.2	6	0.8
122	↓	2.3	830	267	16.3	283	4170	16	1.9	10	1.1
123	↓	2.0	839	282	17.0	299	5130	14	1.7	12	1.4
124	↓	2.1	787	276	17.9	294	4850	24	3.1	10	1.3

Table 1b. Data from lab analysis of samples from Site I (Tests for influences from cylinder type and MOG rate)

Run No. 82-	Type Cyl.[c]	Net Yield[d] % Recovery[d]	Net Yield[d] Processed lb/ac	Net Yield[d] % Broken[e]	Discharge Losses[f] Threshing lb/ac	Threshing % of Net	Walker lb/ac	Walker % of Net	Sieve lb/ac	Sieve % of Net	
101	RB	36.9	247	3.9	24	9.5	11	4.3	5	1.9	
102	↓	40.6	284	3.5	22	7.6	8	2.7	3	1.1	
103	↓	42.4	335	3.1	27	8.0	10	2.9	3	0.9	
104	↓	43.9	390	3.6	34	8.9	15	3.9	5	1.3	
105	↓	40.8	312	2.6	30	9.7	14	4.4	5	1.5	
106	↓	44.8	321	3.6	30	9.2	13	3.9	5	1.7	
107	ST	41.4	225	3.9	38	16.7	11	4.9	15	6.6	28.2
108	↓	43.1	238	4.2	30	12.7	13	5.3	18	7.4	25.4
109	↓	42.3	274	2.4	37	13.4	14	5.1	20	7.3	25.8
110	↓	46.2	362	3.6	45	12.4	10	2.6	24	6.6	21.6
111	↓	44.8	326	2.3	38	11.5	13	4.1	20	6.3	21.9
112	↓	47.3	328	3.4	32	9.6	12	3.7	25	7.7	21
113	↓	41.9	266	3.5	36	13.7	15	5.7	11	4.1	23.5
114	↓	44.1	275	3.5	38	13.9	20	7.2	8	3.0	24.1
115	↓	42.3	319	3.1	30	9.3	10	3.1	9	2.7	15.7
116	↓	44.4	362	2.8	34	9.3	22	5.9	8	2.2	17.4
117	↓	40.2	320	2.8	33	10.4	23	7.2	9	2.8	20.4
118	↓	46.7	305	2.7	31	10.2	14	4.6	6	1.8	16.6
119	RB	38.1	270	5.2	27	10.1	10	3.6	2	0.6	
120	↓	43.5	325	4.7	29	8.8	10	3.3	2	0.4	
121	↓	43.1	350	3.6	26	7.5	8	2.2	2	0.4	
122	↓	42.2	350	3.9	24	6.9	12	3.4	2	0.5	
123	↓	39.0	327	2.9	28	8.6	11	3.3	2	0.7	
124	↓	41.8	329	3.7	18	5.4	19	5.9	2	0.6	

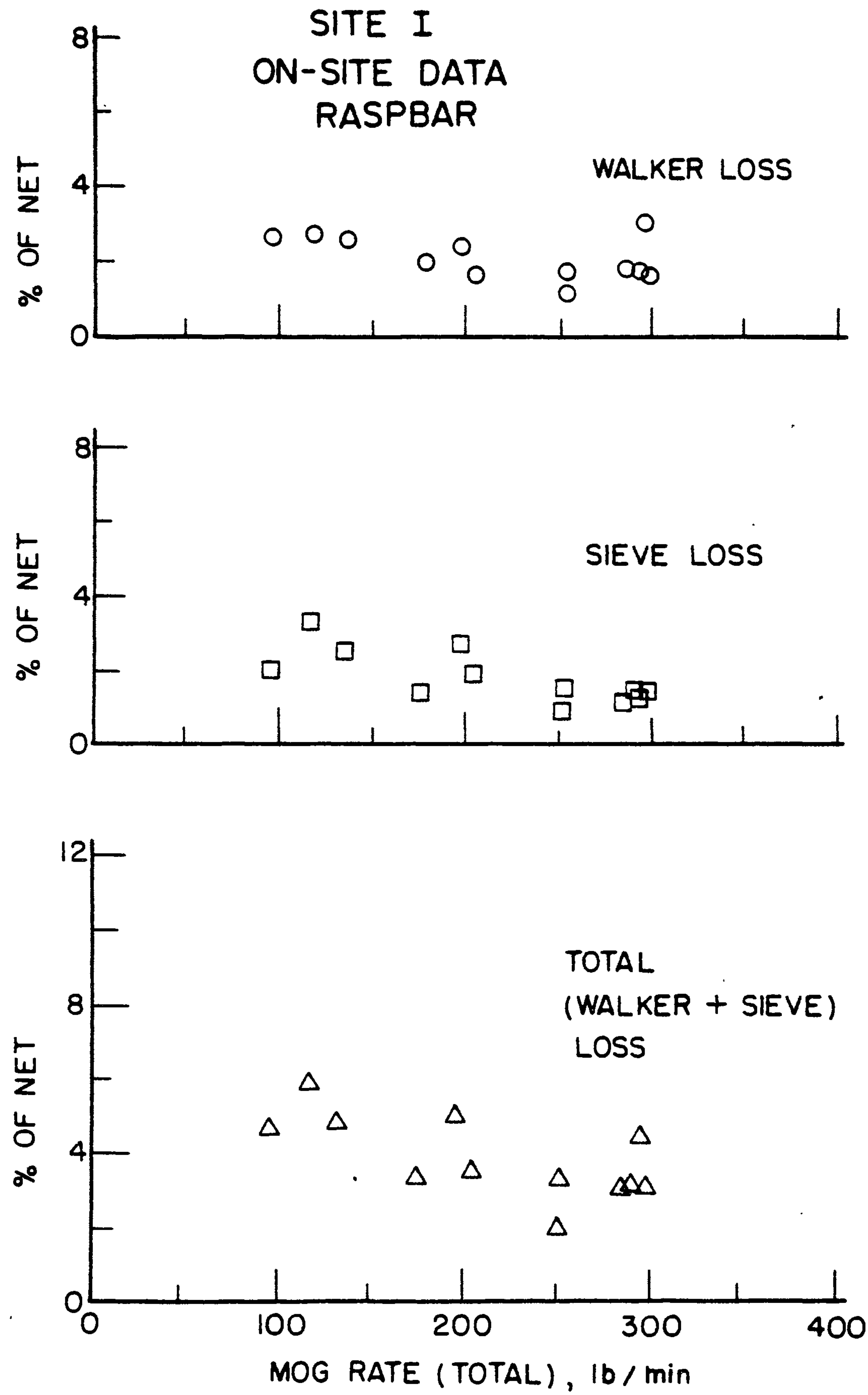

Figure 1. Walker losses and sieve losses for combine with raspbar cylinder as evaluated on-site.

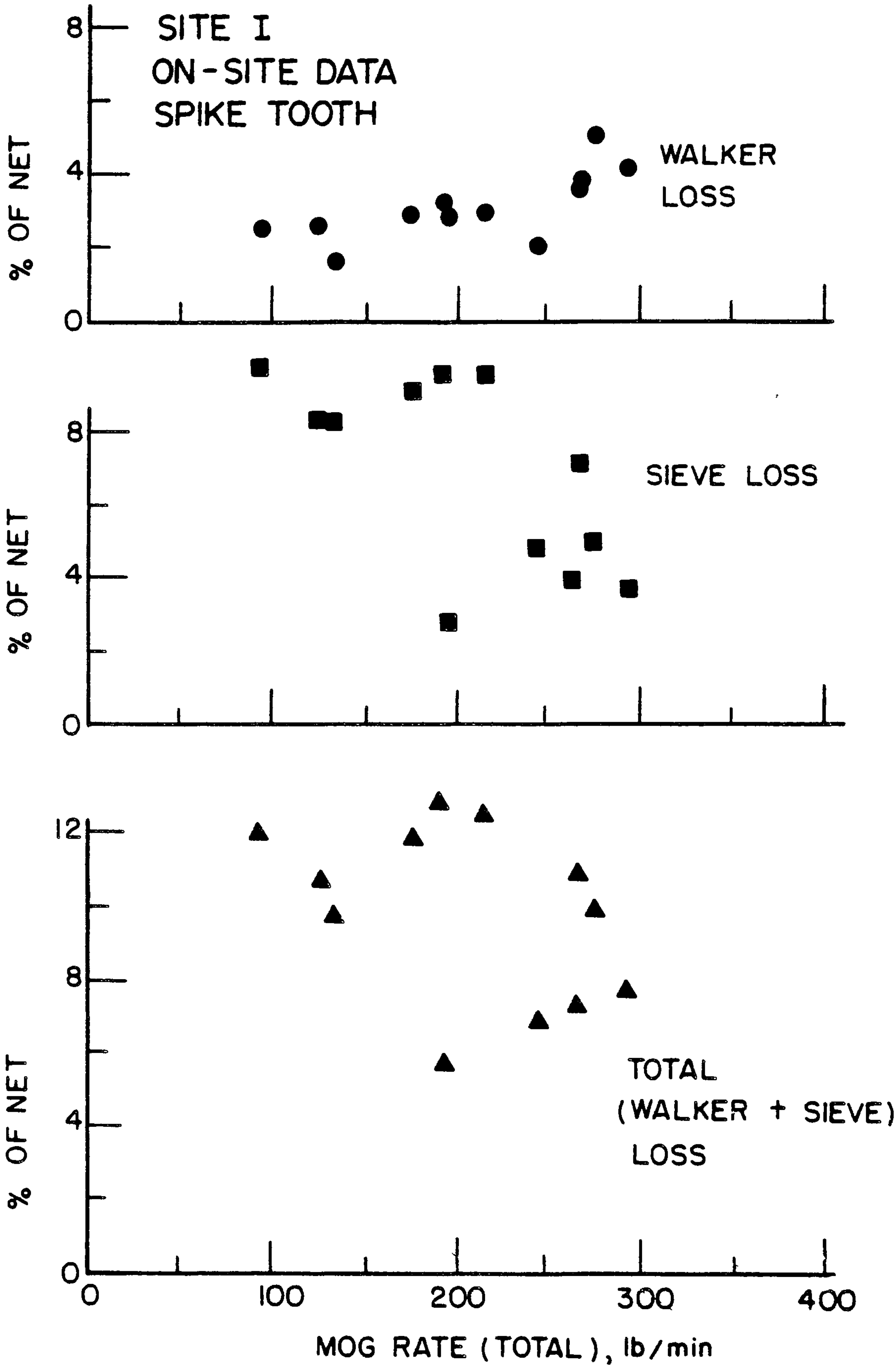

Figure 2. Walker losses and sieve losses for combine with spike tooth cylinder as evaluated on-site.

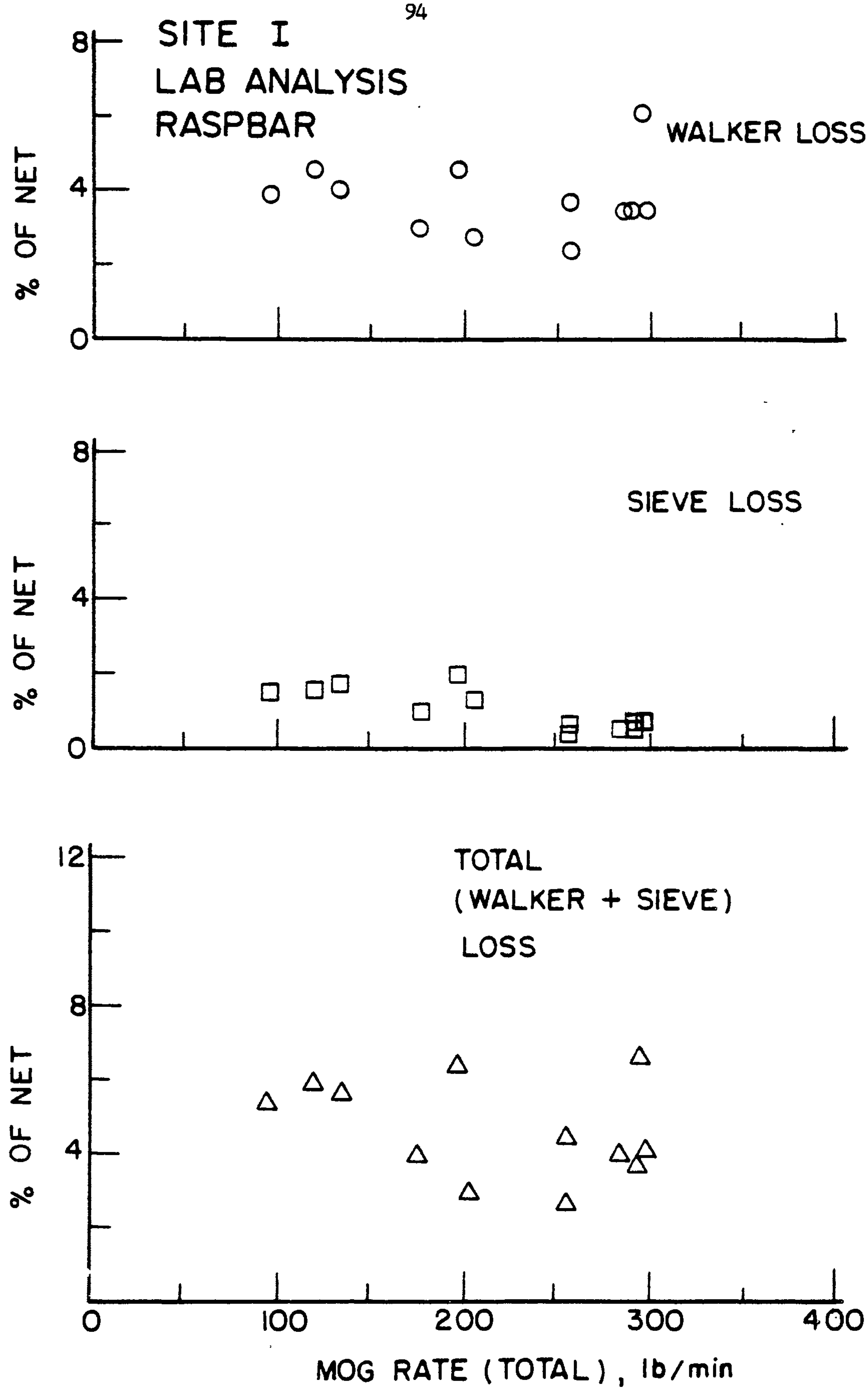

Figure 3. Walker losses and sieve losses for combine with raspbar cylinder as evaluated from lab analysis of samples.

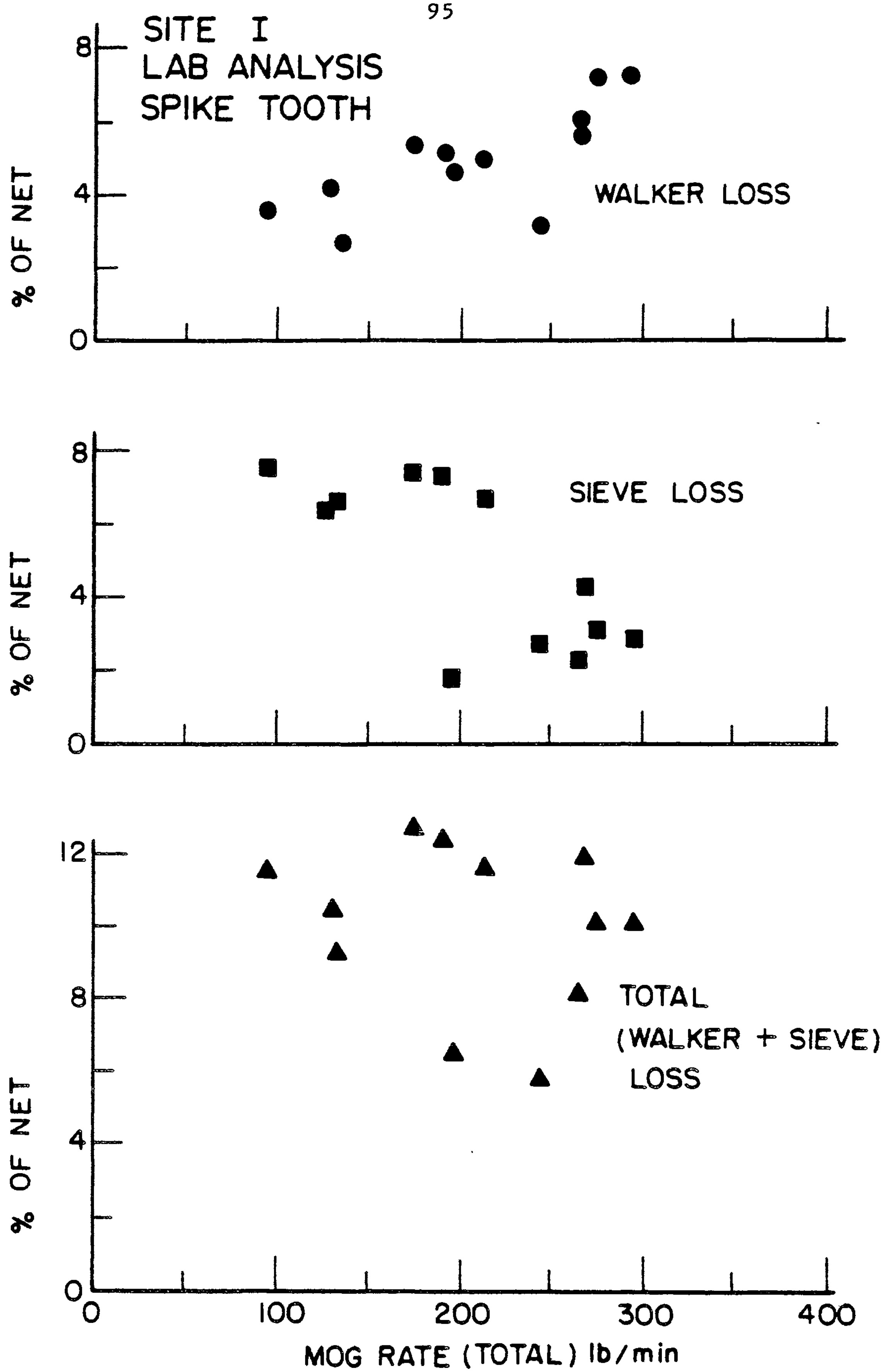

Figure 4. Walker losses and sieve losses for combine with spike tooth cylinder as evaluated from lab analysis of samples.

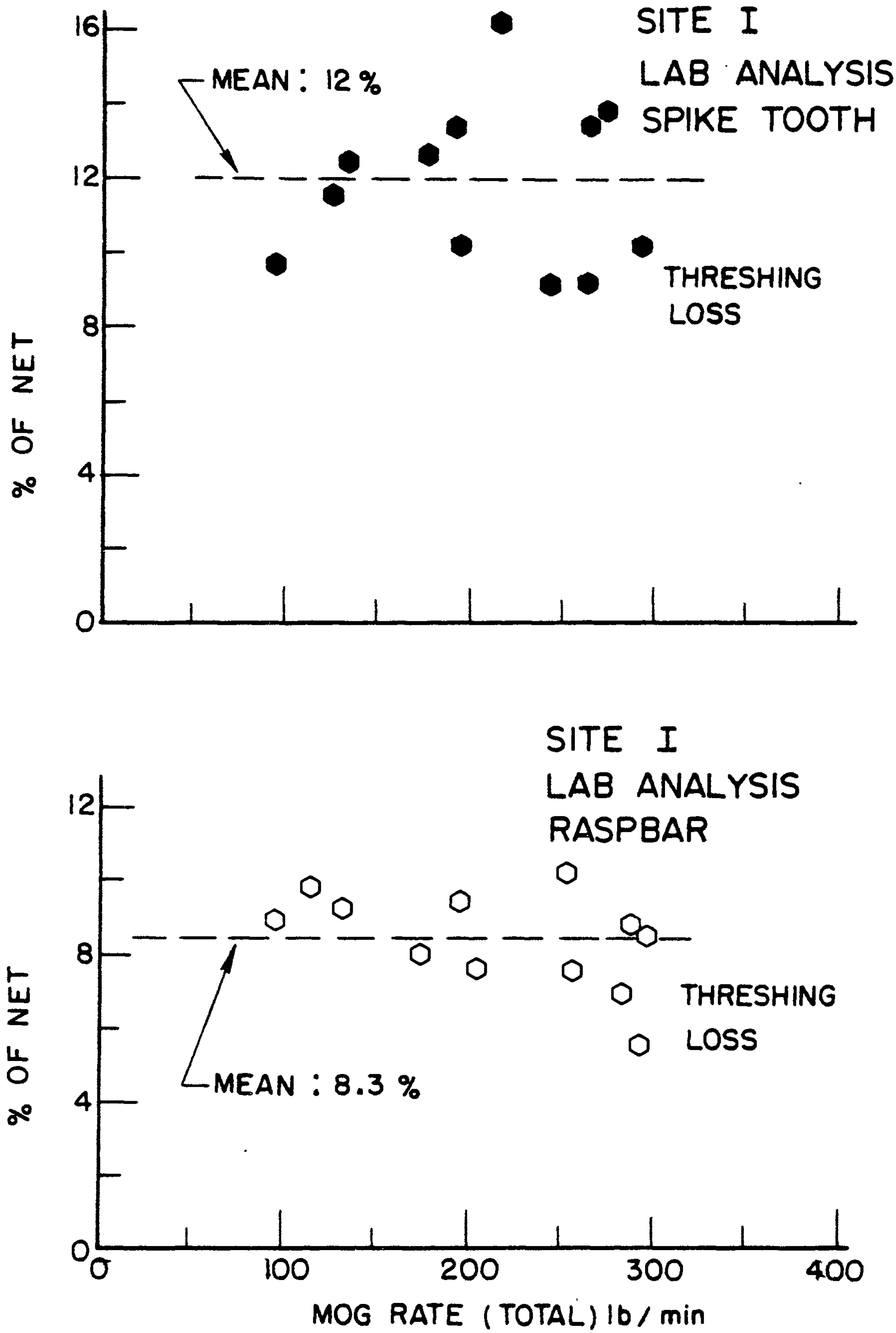

Figure 5. Threshing losses as evaluated from lab analysis of samples.

Table 2a. Data from on-site analysis[a] of samples from Site II
(Quick tests with no variation in machine set parameters)

Run No. 82-	Travel Speed, mph	Net Yield Green, lb/ac	MOG rate (material other than grain) Over Walker, lb/min	Over Sieve, lb/min	Total lb/min	Total lb/ac	Discharge Losses[b] Walker lb/ac	Walker % of Net	Sieve lb/ac	Sieve % of Net
201	4.1	371	245	14.5	260	2180	4	1.0	13	3.5
202	4.1	444	441	36.4	477	4015	39	8.8	80	18.0

Table 2b. Data from lab analysis of samples from Site II
(Quick tests with no variation in machine set parameters)

Run No. 82-	Net Yield[d] % Recovery[d]	Net Yield Processed lb/ac	Net Yield % Broken[e]	Discharge Losses[f] Threshing lb/ac	Threshing % of Net	Walker lb/ac	Walker % of Net	Sieve lb/ac	Sieve % of Net
201	43.2	149	3.0	8	5.5	2	1.6	1	0.8
202	45.4	166	2.9	15	9.2	23	13.7	18	10.5

Influence of Cylinder Speed

Combine performance as related to cylinder speed was measured at site III. The combine had a spike tooth cylinder and concave. During these tests, only the cylinder speed was adjusted and this was within the range of the variable speed drive available on the combine. See Table 3a and 3b for the specific data. Two runs were made at each of three cylinder speed settings. Evaluations were made of net yield, threshing loss, walker loss and sieve loss as well as MOG rates.

The following comments are provided:

1. For all the runs, the walker losses and sieve losses are low.

2. Threshing loss varied inversely with cylinder speed. However, adjustments of concave (which were not made) might have had an offsetting influence.

3. It appears that breakage percentage was not affected by cylinder speed.

4. Because of limited data, it's difficult to suggest a preferred cylinder speed.

Reel Index and Net Yield

At site IV, extensive tests were made of the influence of reel index on net yield. Reel index is the ratio of the reel to the combine travel speed. This is the same as the ratio of reel perpheral travel distance to the combine travel distance. For these tests a single combine was used and the only parameter intentionally adjusted was the reel speed. The travel speed was nearly constant (ranged from 2.4 to 2.6 mph) for all tests.

Each run for collection of the net yield was for a travel length of 150 ft. During this 150 ft net yield sample distance, the reel revolutions were counted to permit accurate calculation of the reel index. The sequence of the runs for the various reel index values was in a random order as the field was harvested. The results of this study are plotted in Figure 6. These data suggest that for these particular combine settings, a reel index near two or in excess of two is preferred. This relatively high reel index seems to be justified based on considerations of relatively tall crop in relation to reel diameter. A low reel index can cause excessive pushing forward of the crop as the reel bats enter the crop.

Table 3a. Data from on-site analysis[a] of samples from Site III
(Tests for influences from cylinder speed.)

Run No. 82-	Cyl. Speed rpm	Travel Speed, mph	Net Yield Green, lb/ac.	MOG rate (material other than grain): Over Walker, lb/min	Over Sieve, lb/min	Total lb/min	Total lb/ac	Discharge Losses[b]: Walker lb/ac	Walker % of Net	Sieve lb/ac	Sieve % of Net
301	655	1.8	686	162	35.8	198	3419	1.7	.2	4.6	.7
302	655	1.8	604	122	23.3	145	2567	1.5	.2	2.4	.4
303	440	1.8	739	206	25.5	232	4169	7.3	1.0	10.0	1.3
304	440	1.8	669	125	16.9	142	2511	5.8	.9	3.3	.5
305	550	1.8	728	135	29.3	164	2848	3.2	.4	4.2	.6
306	550	1.8	871	177	30.6	208	3616	3.9	.4	5.8	.7

Table 3b. Data from lab analysis of samples from Site III
(Tests for influences from cylinder speed)

Run No. 82-	Cyl. Speed, rpm	Net Yield: % Recovery[d]	Processed[d] lb/ac	% Broken[e]	Discharge Losses[f]: Threshing lb/ac	Threshing % of Net	Walker lb/ac	Walker % of Net	Sieve lb/ac	Sieve % of Net
301	655	43.3	278	3.2	5	1.8	1	0.4	6	2.2
302	655	41.9	269	4.5	5	1.8	1	0.3	3	1.3
303	440	41.0	324	2.5	20	6.3	5	1.6	11	3.5
304	440	39.9	304	3.8	14	4.7	4	1.3	6	1.8
305	550	41.6	315	4.0	9	2.9	2	0.7	7	2.1
306	550	39.7	403	3.4	8	2.0	2	0.6	9	2.3

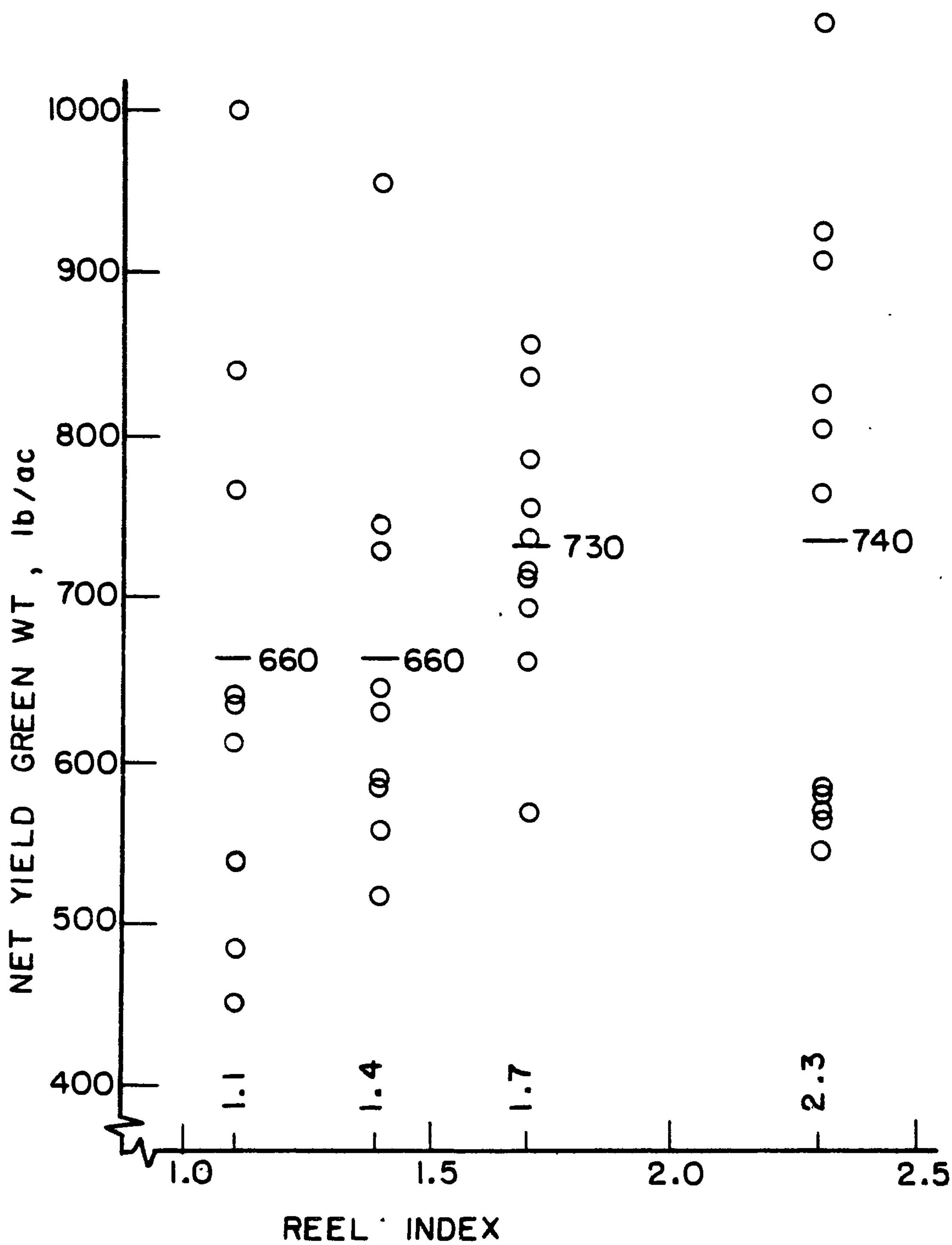

Figure 6. Net yield as influenced by reel index.

Further Evaluation of Water Separator

Additional tests were run in 1982 to evaluate the performance of the water separator used in on-site analysis of walker discharge samples. Procedures were practically identical to those of 1981 and are described more fully in last year's report.

Briefly, the tests were designed to independently evaluate the performance of the separator in: 1) separation of loose kernels (walker loss) and 2) retention of attach (unthreshed) kernels (threshing loss). Tests for the former were made with simulated walker discharge samples, each consisting of hand-harvested wild rice straw without panicles to which a known quantity of combine harvested wild rice had been added. Before adding the rice, the straw was [preconditioned] by feeding it through a parked combine. In companion tests known quantities of rice from the same source were mixed with water to determine the proportion of sinkers and floaters in the rice added to the preconditioned straw. These results were used to evaluate performance of the water separator in separation of sinkers and floaters, independently. Tests for retention of attached kernels employed quantities of actual walker discharge material that had been hand-sorted in an attempt to remove all loose kernels from the straw.

Results of 1982 tests to evaluate performance of the water separator are given in Table 4. Results from 1981 are also included for comparison purposes. Performance in separation of loose kernels was similarly high in both years ranging from 94 to 97 percent of the rice that had been added. Separation of the sinker fraction was essentially complete in all tests, and only a portion of the floater fraction was discharged from the separator with the straw. In tests with presorted (no loose kernels assumed) walker discharge material, 85 to 92 percent of the grain that entered the water separator was discharged from the separator with the straw. This level of performance is considered quite satisfactory given that the presorted straw probably still contained some loose kernels and other kernels were probably so loosely held to the panicles that the slightest disturbance would have detached them.

Although we have found no way to evaluate performance of the water separator on actual walker discharge samples, results of the tests we have performed suggest the water separator to be an effective tool in the analysis of these samples. In our favor is the fact that potential errors of misassignment of walker loss to threshing loss and vice versa, resulting respectively from the failure to separate some loose kernels and the detachment and separation of some unthreshed kernels, tend to offset each other.

Table 4. **Results of water separator evaluation expressed as percentages of grain contained in the sinkers, floaters and discharged straw on a dry, dehulled basis.**

Year	Rep	Sinkers(%)	Floaters(%)	Straw(%)
		Combine harvested grain only		
1981	1	86.9	13.1	
	2	86.2	13.7	
	AVG	86.6	13.4	
1982	1	88.3	11.7	
	2	87.0	13.0	
	3	88.3	11.7	
	AVG	87.9	12.1	
		Headless straw, combine harvested grain added		
1981	1	88.9 (99.1)*	8.4(60.6)	2.7
	2	86.8(101.9)	8.0(60.6)	5.4
	AVG	87.9(100.5)	8.2(60.6)	4.1
1982	1	87.2 (99.2)	9.4(77.7)	3.4
	2	87.3 (99.3)	9.8(81.0)	2.9
	AVG	87.3 (99.3)	9.6(79.4)	3.2
		Presorted walker discharge, no loose grain		
1981	1	6.8	1.7	91.5
	2	5.8	2.8	91.5
	AVG	6.3	2.3	91.5
1982	1	4.6	4.4	91.0
	2	4.7	4.3	91.0
	3	8.2	6.3	85.5
	AVG	5.8	5.0	89.2

*Figures in parenthesis are separation efficiency values for sinkers and floaters taken independently.

Wild Rice Parching, Hulling and Related Studies

John Strait, E. J. Donaldson, J. J. Boedicker

Wild rice processing research during 1982 included (a) continued development and study of the continuous-flow parcher, (b) hulling experiments and the construction of an experimental huller for use with the continuous-flow parcher and (c) preliminary studies related to the adjustment of the moisture content of finished wild rice.

Continuous Flow Parcher

Laboratory Studies

Data from two test runs on the continuous-flow parcher at Deerwood completed near the end of the 1981 processing season were included in last year's report. As discussed in the report and shown by the data presented, excessive kernel damage was experienced when the rice was further processed in the Deerwood plant.

Approximately 70 experimental runs were completed on the laboratory-scale continuous-flow parcher in an attempt to acquire information that could be used to improve the performance of the prototype parcher. Trials were completed to study the influence of operating variables such as flow rate of superheated steam, depth of product on the conveyors, increased depth of rice on the top conveyor, increased depth of rice on bottom conveyor, resident time, steam temperature to the parcher, and mixing of a limited quality of air with the steam in the return duct. We tried several pre-parching treatments including sprinkling and holding overnight, steaming, parboiling, soaking in warm and cold water and certain combinations of the above treatments. The parched rice was sampled for moisture content determination, hulled and graded by diameter into six size groups. The broken and unhulled kernels were sorted from each size group and weighed. Evaluation of the comparative effectiveness of the pre-parch treatments or the influence of the operating variables was based upon the percent by weight of whole, broken (1/4" or less in length) and unhulled kernels and the final moisture content.

Instead of including several tables and graphs in this report, the results of these tests will be summarized.

A consistent relationship was found between the flow rate of the superheated steam through the parcher and the incidence of broken kernels. Decreasing the flow rate resulted in a decrease in brokens. The minimum flow rate consistent with adequate moisture reduction for efficient hull removal resulted in least kernel damage. As the flow rate in the laboratory parchers decreased from maximum to minimum values as controlled by the setting of the damper at the entrance to the return duct, in one series of tests, broken kernels decreased from 6.58 percent to 3.61 percent of the finished rice. We were unable to reduce kernel damage by changes, within practical limits, in any of the other operating variables listed as compared to the 295°F steam temperature, 40 minute resident time and one-inch uniform bed depth which had been considered to give optimum results.

None of the pre-parch treatments proved to be beneficial in reducing kernel damage. In fact, most pre-parch treatments resulted in increased kernel damage as compared to direct parching of 1981 K-2 and Netum material. Kernel breakage was reduced, however, in 1980 and older wild rice. We attribute this to the restoration of the moisture in the rice which had been lost during extended frozen storage.

It is noted that in certain of these tests kernel breakage was as low as 3 percent with 1 percent unhulled kernels.

Parcher Modifications

As a result of experience from fall of 1981 and the studies conducted on the laboratory model continuous-flow parcher, some changes were made on the prototype at Deerwood prior to the 1982 processing season.

The woven wire conveyor belts were replaced with belts having a tighter weave. The parcher was originally equipped with 84-84 mesh, .035 in. wire-dia., woven wire belts with .234-in. rods on 3-in. centers and with attached RC 60 roller drive chain. The new belts are 144-96 mesh .035-in. and .028 in. wire dia. Rod diameter and spacing and drive chain are the same as the original belts. The 84-84 mesh belts allowed small kernels to pass through, and there appeared to be considerable carry over from the upper to lower flights. It seemed to be particularly desirable to reduce the amount of rice that collected in the parcher below the bottom belt.

The plywood deck with five openings covered with perforated sheet metal located above the top conveyor were removed. The perforated sheet metal below the bottom conveyor and extending about eight feet into the parching chamber from the steam inlet to the chamber was also removed.

The feeder hopper was changed so that green wild rice could be easily dumped into the feeder from a bucket on the front end of a tractor.

Stiffeners were added to the 12 paddle-type agitators in the parching chamber to reduce vibration and allow a wider range of operating speed.

The extensive laboratory tests referred to indicated that reducing the flow rate of the superheated steam through the parching chamber would increase the breaking strength of the finished wild rice kernels and decrease kernel breakage by the huller. A larger diameter driven pulley was installed on the recirculating fan to provide control of the steam flow rate at lower values than was previously possible.

Hulling and Handling Facilities

An experimental huller was designed and constructed for use with the continuous-flow parcher. The huller was positioned above the level of the parcher floor. Wild rice from the parcher was elevated onto a vibrating screening and feeding device constructed as part of the huller. After passing through the huller rolls and a hull separator the rice was collected in a large bag. The rice was later dipped from the bag and run through a fanning mill, usually within 24 hours, for cooling and cleaning and then returned to the bag for storage. Further processing, including cleaning and grading, was completed at a later date.

Results

Deerwood plant records showed that 280,680 pounds of green wild rice were parched by the continuous-flow parcher. It was in operation approximately 460 hours during the period of August 24 through September 16. Almost all of the rice parched was from medium fractions from the air stream separator. The weight processed was the weight of rice from the separator. Extended periods of rain resulted in unusually high moisture contents and, in some instances, an advanced state of decomposition of the rice at parching time. Most of the rice was two to three weeks past harvest when it was parched.

Table 1 shows test data derived from specific tests and for all the rice parched. Both measured and equivalent feed rates are shown. The equivalent feed rate was calculated as the amount of rice at 45% moisture content that would contain the same weight of water to be evaporated as was contained in the measured feed rate. Samples to be analyzed for broken kernels except season total were collected after the rice had passed from the huller through a hull removal device. Fuel used is based upon the measured feed rate. Lot 3 was a bag from a heavy fraction harvested August 18 which was separated and placed in the freezer August 19.

The overall performance of the continuous-flow parcher was, in our judgment, quite good. Equipment problems beyond the parcher limited its output to a substantial degree. Kernel damage does not seem excessive considering the condition of the rice at parching. Breakage from the fresher wild rice from the freezer was close to that which we have experienced in the laboratory. Fuel consumption figures are good and particularly so considering the high moisture content of the rice to the parcher. No significant mechanical problems were experienced other than with the intake air lock. The rotor was removed from the air lock because of a plugging problem resulting from very wet rice accumulating on the sheet metal feed baffle below the air lock.

Kernel strength of wild rice parched in the continuous-flow parcher appeared to be significantly improved over last year. However, we currently think that it is perhaps unlikely that the continuous-flow parcher can produce kernels as resistant to breakage by bending as those from a well operated rotary drum parcher where the resident time is much longer and assuming that the rice is in good condition when parched. Data presented later in this report will show that the softer rolls used on the experimental huller clearly resulted in less kernel damage than would have occurred had the rice been hulled with the harder rubber rolls commonly used by processors.

Hulling

One of our principal research objectives for 1982 was to conduct hulling experiments directed toward reducing kernel damage and increasing hulling efficiency. Data was needed for the design of the experimental huller which we intended to construct for use with the continuous-flow parcher. Experience indicated that the hardness of the material comprising the huller rolls was an important design factor to be considered.

Laboratory Experiments

An experimental huller was constructed for use in laboratory experiments. A pair of standard rolls were trued, and strips of neoprene of different hardness were fastened to the rolls with an adhesive. Six strips, each 3 5/16 inches wide, were attached. A feeder that could be positioned as required along the length of the rolls enabled us to hull and collect comparable samples from each of test strips. Roll clearance was adjustable. Five neoprene strips of 50, 56, 66, 73 and 86 durometer hardness and one red rubber strip of 66 durometer hardness were used. The finished rolls measured 10 1/8 inches in diameter. The ratio of roll speeds was three to two.

Lots of K-2 and Netum were parched in the laboratory continuous-flow parcher. Each lot was divided into 14 samples which were hulled in successive sections of the experimental rolls. Roll clearance was varied. The samples were substantially cleaned of hulls, and the broken, and the unhulled kernels were sorted and weighed.

Table 2 shows the results obtained. Roll clearance was varied between .002 inch and .020 inches. The number of available samples was limited so the range of roll spacing was not the same for all strips. The red rubber was inefficient with respect to hull removal and was not tested over a range of roll clearance. The data show that for a given roll clearance, as the durometer hardness* increases, kernel breakage increases, but the percentage of unhulled kernels decreases. The data have been plotted in Figures 1, 2 and 3 for roll clearances of .005", .010" and .015" respectively.

Figure 4 shows the data from Table 2 for 66 durometer neoprene where the percent of broken and unhulled kernels are plotted against roll clearance. For 66 durometer neoprene, as roll clearance increases, the percent of broken kernels decreases while the percent of unhulled kernels increases. The rates of change are most readily determined from the graphs.

Polyurethane was recommended as a huller roll covering because of its excellent resistance to abrasive wear. The rolls on our laboratory huller were covered with 62 durometer polyurethane 1/2" thick which resulted in a finished diameter of 12 inches. A series of samples of parched K-2 and Netum were hulled with the polyurethane rolls with the roll clearance set at six different values varying from .002" to .025". Three samples were run through

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* Durometer number is an arbitrary measure of hardness used by the rubber industry.

the 10 1/8" diameter neoprene rolls for comparison. The results are shown in Table 3 and plotted in Figure 5. It was concluded that polyurethane and neoprene had substantially equal hulling characteristics.

Experimental Huller

An experimental huller was designed and constructed to hull the rice parched in the continuous-flow parcher. The two huller rolls had an iron core 20 inches long and 9 3/4 inches in diameter covered with 1/2-inch thick 55 durometer polyurethane. The rolls were operated at speeds of 440 and 736 RPM. The huller was equipped with a vibrating combination scalper screen and feed pan.

The polyurethane rolls were effective provided the clearance was maintained at a low value, such as .005" or less. The rolls wore rapidly. They were resurfaced August 30 but were replaced with rolls covered with 62 durometer Hypalon three days later. Hypalon is an elastomer which is said to have good wear properties and is capable of operating at much higher temperatures compared to polyurethane. The Hypalon rolls were used for the remainder of the processing season and were reasonably durable. Wear increased the roll clearance by approximately .015" while hulling the product from an estimated 80,000 lbs of green rice.

Results of Tests with the Experimental Huller

Table 4 shows the results of a test conducted September 13 with the Hypalon covered rolls where the roll clearance was varied from .003" to .015" in equal increments. The wild rice was a medium fraction harvested August 25. As shown in Table 4, kernel breakage decreased slightly with increasing roll clearance. Increasing the roll clearance resulted in an increase in unhulled kernels. These data are plotted in Figure 6. The results of this test are generally consistent with laboratory results except that absolute values are different as would be expected with two very different lots of parched rice.

Comparison of Hullers

Five tests were completed where data were collected on divided samples of product from both the continuous-flow and the rotary drum parchers. One half of the sample was hulled by the experimental huller. The other half was hulled by the Deerwood plant huller which had 90 durometer rubber rolls.

The significant feature of these tests is the comparison of the hulling characteristics of 90 and 62 durometer hulling rolls. The absolute values obtained are not particularly important since they could have been influenced by differences in material characteristics other than hardness, roll clearance, roll diameter and other factors.

Table 5 gives the results of these tests along with the results obtained from a bag of 1982 heavy fraction that had been stored in the freezer. The results show the distinct advantage of softer hulling rolls in reducing kernel breakage. Breakage was consistently much lower with the softer rolls when the same rice was hulled in the two devices. However, the harder rolls gave more complete hulling in every instance. Laboratory studies show that as the hardness of the huller rolls decreases, roll clearance must be reduced and kept within closer tolerances in order to achieve good hulling.

A direct comparison of the two parching systems can be drawn only from tests 1A and 1B. Medium fraction wild rice harvested August 18 and from which the sample for test 1A was collected was being parched August 24 in the continuous-flow parcher. A single batch of this same rice was parched in a rotary drum parcher from which the test sample for 1A was collected. As shown in Table 5 the results of the tests 1A and 1B are substantially the same.

Durability of the Hulling Rolls

The rapid wear of the 55 durometer polyurethane rolls was unexpected based upon information obtained from persons in the rubber industry. The wear rate of the 62 durometer Hypalon rolls may prove to be within tolerable limits. If not, several options are available to correct the problem. A compromise may be to use somewhat harder rolls to gain reasonable wear and less critical clearance adjustment requirements at the expense of somewhat increased kernel damage. It may be possible to compensate for the somewhat accelerated wear of the softer rolls by providing for one or a combination of the following features in the design of the huller: an easily operated and accurate roll conditioning system, uniform feeding of rice along the entire length of the rolls, larger diameter rolls operated at reduced speeds, a minimum speed differential between rolls, and accurate roll clearance adjustment.

M.S. Thesis Research

Eric Donaldson is working on an M.S. thesis related to the hulling of wild rice. His research involves a study of the influence of physical properties and operating variables upon the performance characteristics of roll type hullers. His work is principally with Hypalon of different degrees of hardness. Kernel damage and hulling efficiency are important among the measurements included in the research. Results from this research should be very useful in the design of improved hullers for wild rice.

Adjustment of the Moisture Content of Finished Wild Rice

We have completed limited preliminary tests on adding moisture to finished wild rice to increase the moisture content to 10 or 12 percent wet basis. No problems have been encountered with small samples of 1/2 to 1 pound. We have noticed an increase in stress cracks visible under microscopic examination. We expect to do more research in this area before the 1983 processing season.

Table 1. Selected performance data obtained from the continuous-flow parcher at Deerwood during the 1982 processing season.

Lot No.	Separator Fraction, Test Identification	Date: Harvested	Date: Parched	Rice to Parcher: M.C. %	Rice to Parcher: Feed Rate, lb/hr	Rice to Parcher: Equivalent Feed Rate, lb/hr	Finished Rice: M.C. %	Finished Rice: Broken %	Propane Used: Gal/hr	Propane Used: Gal/1000 lb
1	Medium	8/25	9/15	66.4	612	903	4.8	11.7	8.7	14.3
1	Medium	8/25	9/15	68.0	718	1085	7.2	8.7	9.2	12.8
2	Heavy	8/25	9/16	56.0	773	962	5.6	13.6	9.2	11.9
2	Heavy (Capacity Test)	8/25	9/16	56.0	992	1335				
3	Heavy (From Freezer) (1)	8/18	9/16	37.9			7.0	6.4		
--	Season Total				610			12.7	8.0	13.1

(1) Separated and frozen August 19, 1982

Table 2. Influence of the hardness of huller roll covering material and roll clearance upon the percent of broken and unhulled kernels in finished wild rice.

Run Number		Material and Hardness,	Roll Clearance,	K-2 (1)		Netum (1)	
K-2	Netum	Durometer	Inches	Broken, % (2)	Unhulled, %	Broken %	Unhulled, %
H2-16	H3-16	Neoprene, 50	.002	4.02	5.67	1.81	4.65
H2-15	H3-15	Neoprene, 56	.002	4.84	1.01	2.05	0.84
H2-4	H3-4	Neoprene, 50	.005	2.80	20.74	1.47	15.68
H2-3	H3-3	Neoprene, 56	.005	3.40	11.13	1.71	7.11
H2-2	H3-2	Neoprene, 66	.005	7.69	0.31	3.52	0.80
H2-1	H3-1	Neoprene, 73	.005	10.55	0.29	4.83	0.44
H2-10	H3-10	Neoprene, 50	.010	3.76	26.96	2.39	20.30
H2-9	H3-9	Neoprene, 56	.010	3.80	22.37	1.51	18.46
H2-8	H3-8	Neoprene, 66	.010	6.56	1.48	3.59	1.32
H2-6	H3-6	Red Rubber, 66	.010	4.46	27.17	2.27	25.02
H2-7	H3-7	Neoprene, 73	.010	7.30	0.98	4.31	1.23
H2-5	H3-5	Neoprene, 86	.010	19.22	0.38	9.96	0.41
H2-13	H3-13	Neoprene, 66	.015	6.27	3.00	2.89	3.09
H2-12	H3-12	Neoprene, 73	.015	8.62	1.39	4.29	1.35
H2-11	H3-11	Neoprene, 86	.015	20.00	0.97	9.99	1.05
H2-14	H3-14	Neoprene, 86	.020	17.10	2.54	9.30	1.94

(1) Wild rice was harvested 1981, frozen and parched in the laboratory June 22, 1982 immediately prior to hulling.

(2) Kernel pieces 1/4" or less in length.

Table 3. Comparative hulling characteristics of polyurethane and neoprene covered huller rolls at selected roll clearances. Wild rice was from 1981 crop stored in freezer and parched July 15, 1982 in the laboratory continuous floor parcher.

			K-2		Netum	
Date	Roll Covering Material	Roll Clearance, Inches	Broken, % (3)	Unhulled, %	Broken, %	Unhulled, %
July 15	Polyurethane (1)	.002	6.83	0.52	3.64	0.74
July 15	Polyurethane	.005	6.69	0.64	3.29	0.72
July 15	Polyurethane	.010	6.53	0.88	2.93	1.06
July 15	Polyurethane	.015	6.46	2.22	2.85	1.80
July 15	Polyurethane	.020	6.61	2.96	3.30	2.42
July 15	Polyurethane	.025	5.10	9.35	2.17	6.19
July 15	Neoprene (2)	.005	6.72	0.39	3.19	0.51
July 15	Neoprene	.010	6.90	0.92		
July 15	Neoprene	.015			2.89	2.17

(1) 62 durometer polyurethane, 12" dia. rolls

(2) 66 durometer neoprene, 10 1/8" dia. rolls

(3) kernel pieces 1/4" or less in length.

Table 4. Influence of roll clearance upon the percent of weight a broken and unhulled kernels. Experimental huller with 62 durometer Hypalon rolls.

Separator Fraction	Date		Roll Clearance, Inches	Finished Rice	
	Harvested	Parched		Broken, %	Unhulled, %
Medium	8/25	9/13	.003	14.97	3.24
Medium	8/25	9/13	.005	14.55	2.91
Medium	8/25	9/13	.007	14.60	4.17
Medium	8.25	9/13	.009	13.60	4.53
Medium	8/25	9/13	.011	14.80	6.78
Medium	8/25	9/13	.013	12.76	8.91
Medium	8/25	9/13	.015	12.56	11.52

Table 5. Results of hulling experiments with hullers fully equipped with 62 and 90 durometer rolls.

Test No.	Date		Separator Fraction	Parcher	Experimental Huller (3)			Deerwood Plant Huller (4)		
	Harvested	Parched			Whole, %	Broken, %	Unhulled, %	Whole, %	Broken, %	Unhulled, %
1A	Aug. 18	Aug. 24	Medium (1)	R.D.	74.2	6.3	19.5	64.4	18.2	17.4
1B	Aug. 18	Aug. 24	Medium (1)	C.F.	76.5	6.9	16.6	65.0	19.4	15.6
2	Aug. 25	Sept. 15	Heavy	R.D.	56.7	14.8	28.5	62.3	28.5	9.2
3	Aug. 25	Sept. 16	Heavy	R.D.	71.5	6.5	22.0	71.3	18.3	10.4
4	Aug. 25	Sept. 15	Medium	C.F.	73.8	7.7	18.5	73.0	23.9	3.1
5	Aug. 25	Sept. 16	Heavy	C.F.	80.8	13.6	5.6	67.4	31.5	1.1
6	Aug. 18	Sept. 16	Heavy (2)	C.F.	90.7	6.4	2.9			

(1) Wild rice from the same lot

(2) Separated and placed in freezer August 19

(3) Equipped with 62 durometer Hypalon rolls

(4) Equipped with 90 durometer rubber rolls

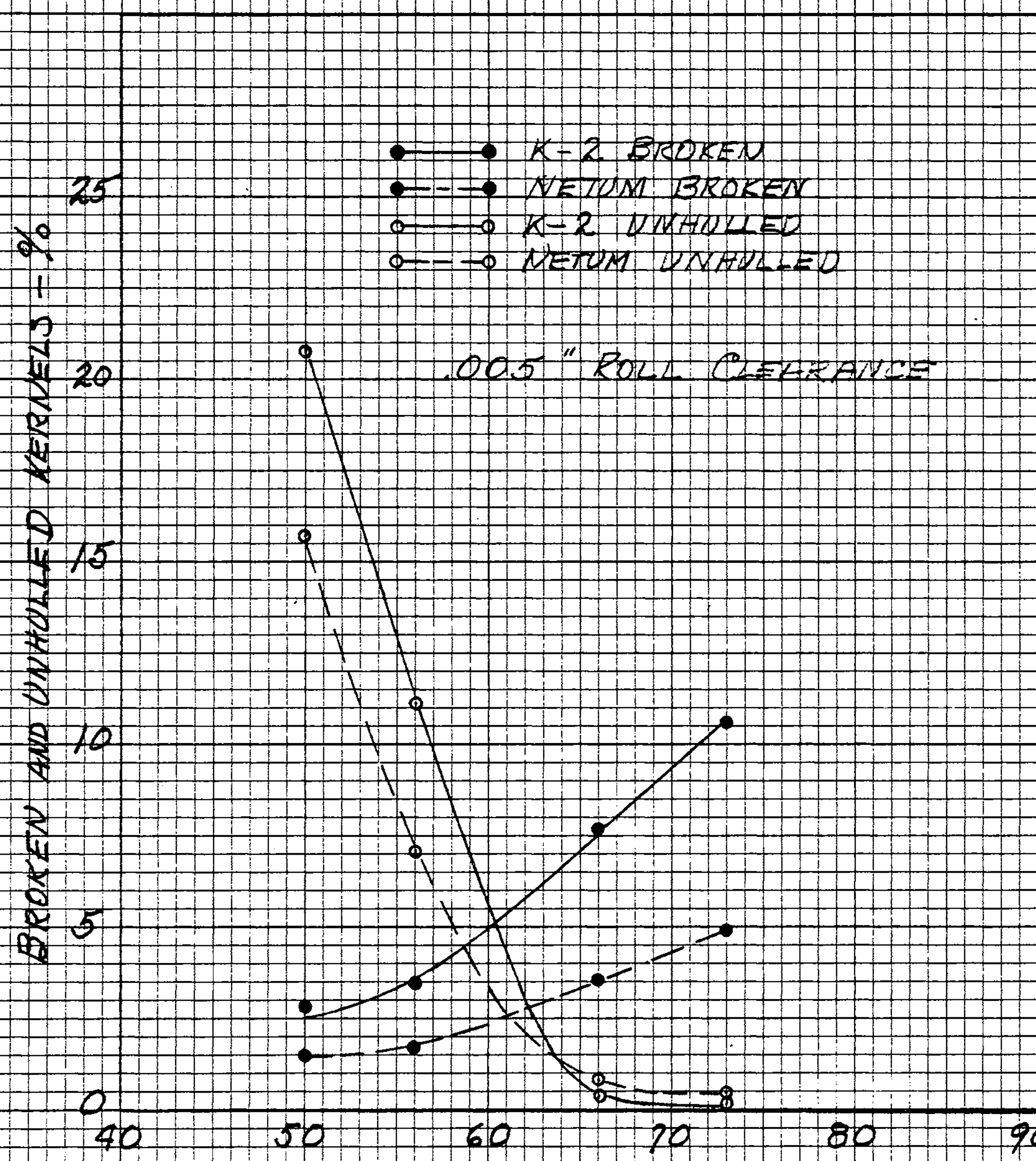

Figure 1. Influence of roll hardness upon kernel damage and hulling efficiency with roll clearance of .005 inches.

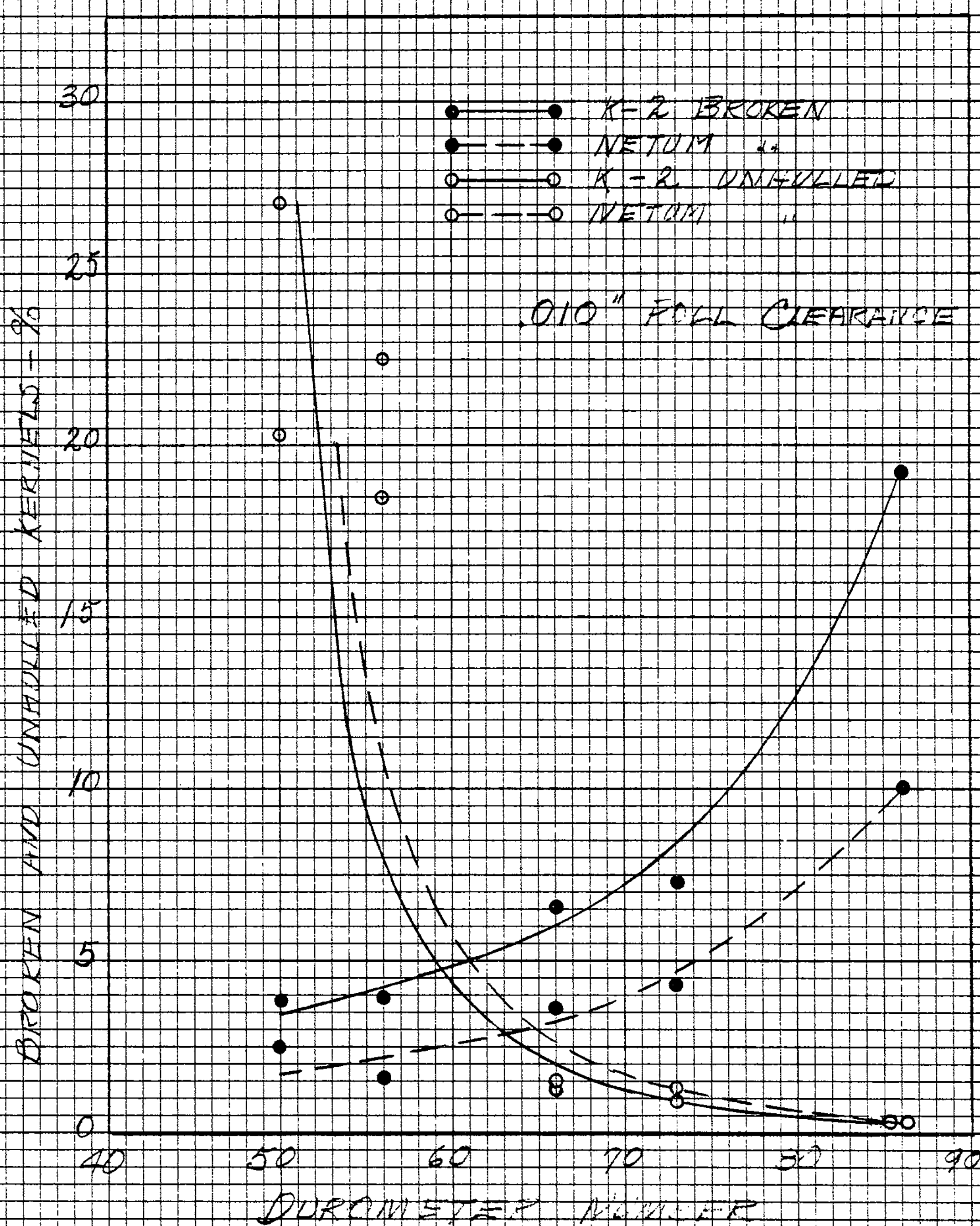

Figure 2. Influence of roll hardness upon kernel damage and hulling efficiency with roll clearance of .010 inches.

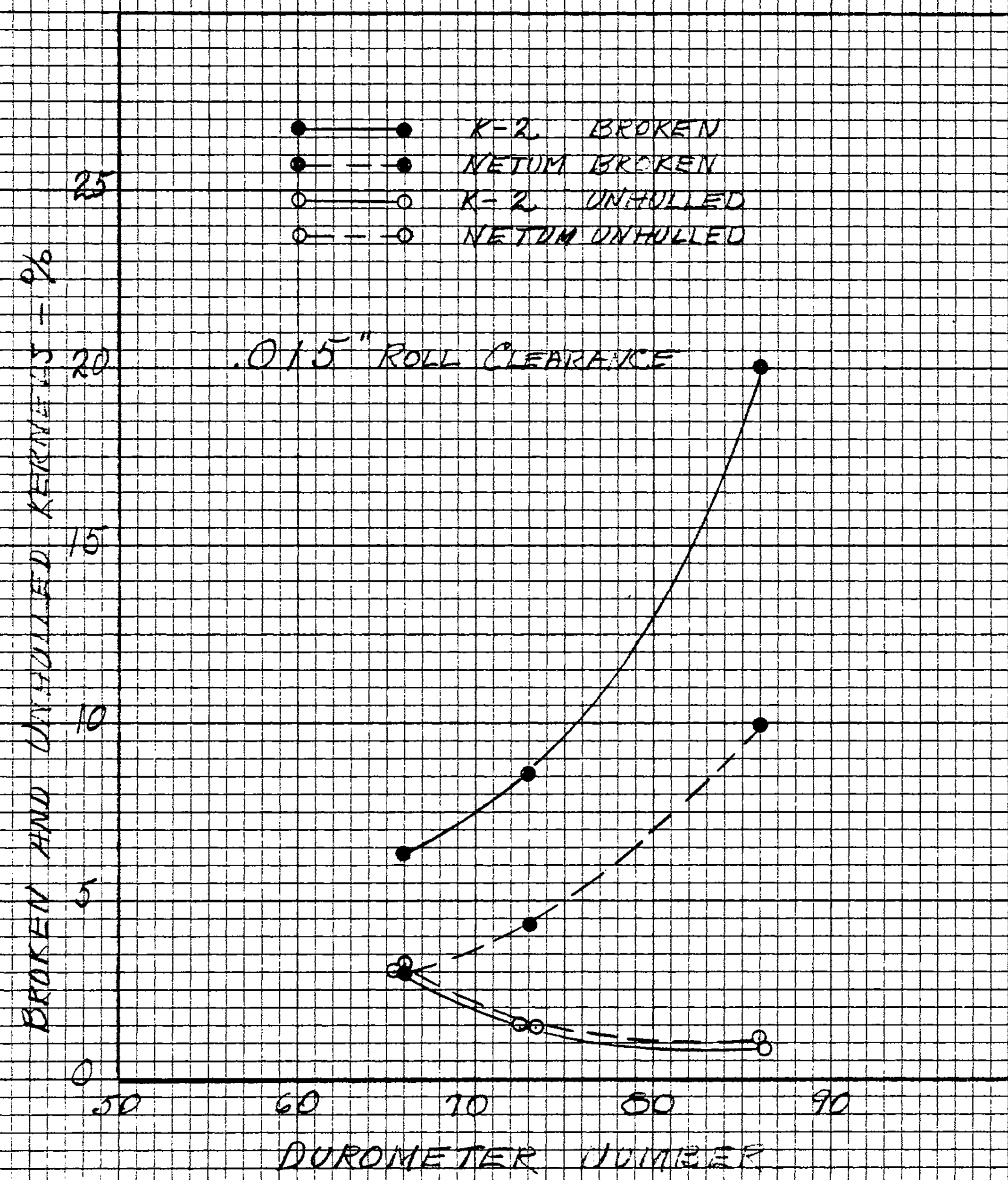

Figure 3. Influence of roll hardness upon kernel damage and hulling efficiency with roll clearance of .015 inches.

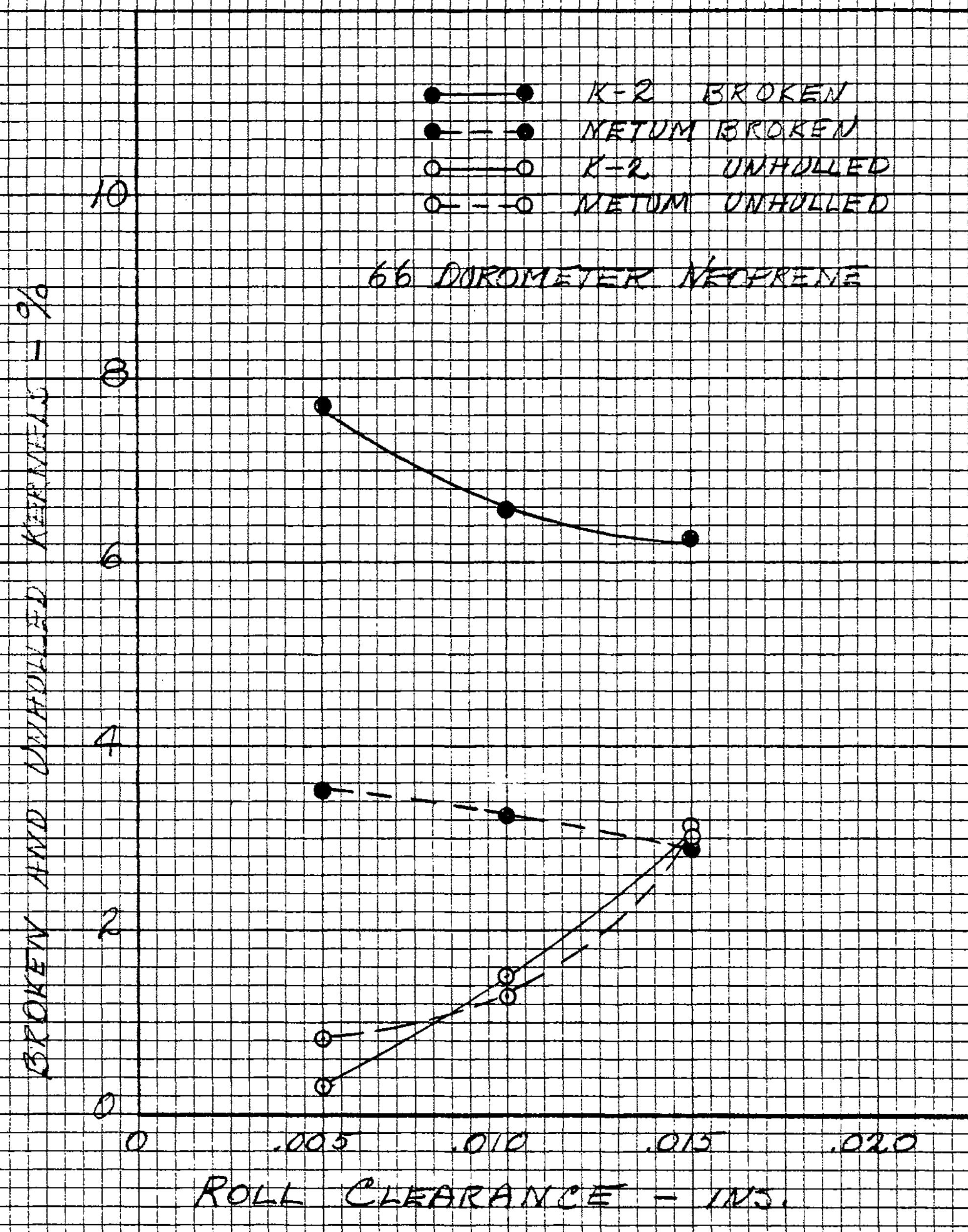

Figure 4. Influence of roll clearance upon kernel breakage and hull removal with 66 durometer neoprene rolls.

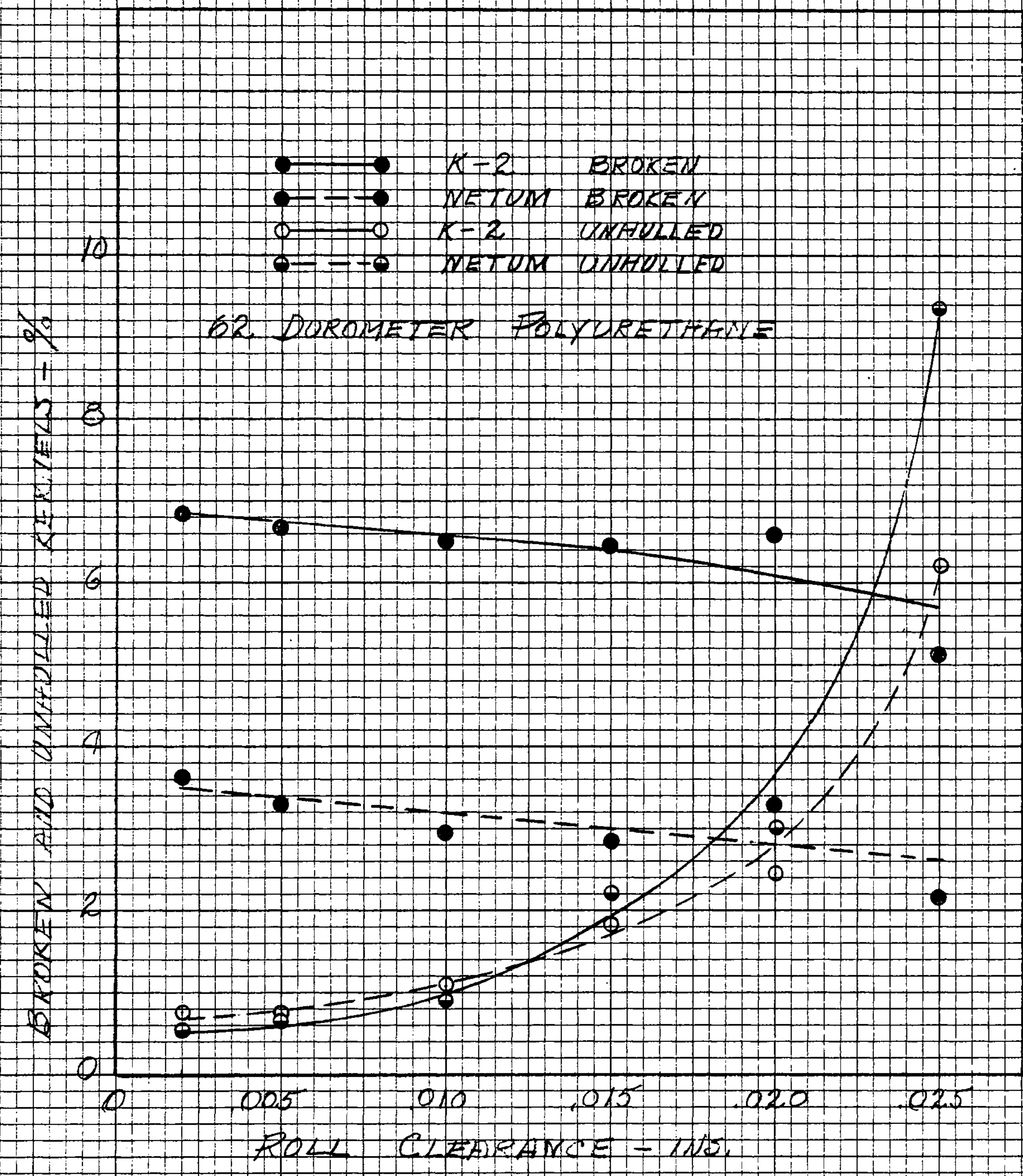

Figure 5. Percent of broken and unhulled kernels with laboratory huller having 62 durometer polyurethane rolls. Roll clearance was varied.

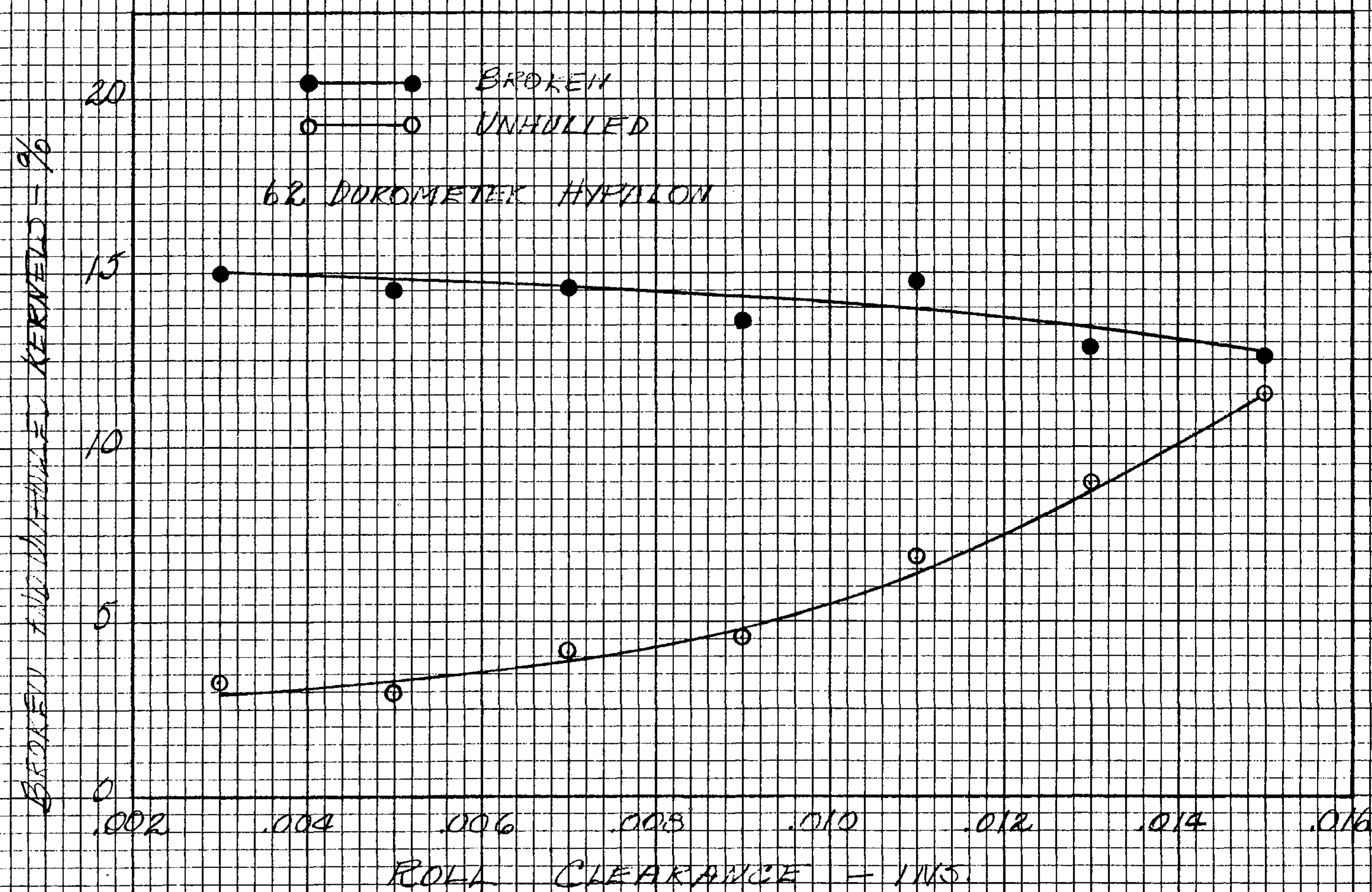

Figure 6. Broken and unhulled kernels from experimental huller at Deerwood. Test was done September 13, 1982.

Research on Economics of Wild Rice Marketing

R.P. Dahl and E.H. Winchell
Department of Agricultural and Applied Economics

Work began last November on a study of the economics of wild rice marketing. In general the study focuses on identifying and quantifying the economic forces operating in wild rice marketing. Five major objectives will be addressed.

(1) The existing market network will be described including sources of supply, intermediate buyers and processors, and final consumers.

(2) Data on historical trends in wild rice supply will be collected and analyzed to determine the changing structure of the producing sector.

(3) Data on historical trends in wild rice prices and consumption will be collected, and analyzed to estimate the market demand for wild rice and the sensitivity of market prices to changes in supply.

(4) The overall performance of the wild rice marketing system will be evaluated, and major problems delineated.

(5) Suggestions will be made on possible improvements in wild rice marketing.

Work so far has concentrated on familiarization with the wild rice industry. In addition to conducting a literature search, we have interviewed several knowledgeable individuals in the wild rice industry including representatives from the Minnesota DNR, the two marketing cooperatives, and the processors. In the next few months a survey of wild rice growers will be made through personal interview to obtain information on production, prices, and marketing channels for wild rice.