WILD RICE PRODUCTION RESEARCH-1994

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The total number of growing degree days in 1994 for the wild rice growing season was greater than for 1993 at all four locations, Aitkin, Grand Rapids, Waskish and Crookston (Tables 1 and 2). The average number of growing degree days in 1994 across all locations was 2829 compared to 2660 for 1993, thus the 1994 season was warmer than 1993. At Aitkin and Grand Rapids, April, May and June were warmer than 1993 while July and August were cooler. At Waskish and Crookston, April, May, June and July were warmer than in 1993 while August was cooler. June 1994 was particularly warmer than 1993 at Waskish and Crookston. Comparisons with the long term averages (normal) indicates that Aitkin and Waskish were warmer in 1994, while Grand Rapids and Crookston were cooler in 1994.

Table 1. Growing degree days[a] comparisons for 1993, 1994 and normal (61-90).

Month	Aitkin			Grand Rapids		
	1993	1994	Normal	1993	1994	Normal
	---------- GDD ----------					
April	53	114	127	67	114	130
May	413	494	417	395	496	434
June	616	726	646	605	726	674
July	778	762	779	807	800	858
August	794	673	683	834	720	768
Total	2654	2769	2652	2708	2856	2864

[a]Maximum + minimum temp. - 40°F; data from Mark Seeley, Soil Science Dept., U of MN

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Table 2. Growing degree days[a] comparisons for 1993, 1994 and normal (61-90).

Month	Waskish			Crookston		
	1993	1994	Normal	1993	1994	Normal
	GDD					
April	78	83	103	92	106	151
May	366	442	369	465	531	488
June	563	724	518	612	782	743
July	731	756	642	767	802	926
August	781	692	563	824	774	867
Total	2519	2697	2697	2760	2995	3175

[a]$\frac{\text{Maximum + minimum temp.}}{2}$ - 40°; data from Mark Seeley, Soil Science Dept., U of MN

Total precipitation was less in 1994 compared to 1993 at Aitkin and Waskish but more in 1994 than in 1993 at Grand Rapids and Crookston. The higher amount of rainfall in June at Grand Rapids and Crookston accounted for much of the increase compared to 1993. Compared to the normal (61-90) averages. Aitkin was the only location that had less rainfall in 1994 than normal. The other three locations were all considerably wetter in 1994 compared to normal.

Table 3. Precipitation comparisons for 1993, 1994 and normal (61-90)[a].

Month	Aitkin			Grand Rapids		
	1993	1994	Normal	1993	1994	Norma
	Inches					
April	2.63	4.69	2.30	2.82	2.91	2.10
May	6.47	3.11	2.88	3.07	2.20	3.04
June	5.43	4.82	4.09	3.83	10.66	4.11
July	5.45	2.27[b]	4.14	7.63	4.04	3.89
August	3.38	1.14	3.83	3.87	1.84	3.59
Total	23.36	16.03	17.24	21.22	21.65	16.73

[a]Data from Mark Seeley, Soil Science Dept., U of MN. [b] Precipitation for July taken from nearest DNR rain gauge in Aitkin County, township 47, range 27, section 26.

Table 4. Precipitation comparisons for 1993, 1994 and normal (61-90)[a].

Month	Waskish			Crookston		
	1993	1994	Normal	1993	1994	Normal
	----------	----------	Inches	----------	----------	----------
April	1.36	1.07	1.70	0.32	1.76	1.45
May	1.90	1.76	2.33	1.58	1.87	2.45
June	6.94	6.36	4.25	3.71	7.11	3.44
July	5.05	6.92	3.42	4.77	5.73	2.77
August	5.05	3.34	3.32	3.06	1.71	2.88
Total	20.30	19.45	15.02	15.02	18.18	12.99

[a]Data from Mark Seeley, Soil Science Dept., U of MN.

Total cultivated wild rice production in Minnesota was the same in 1994 compared to 1993 (Table 5). California production was less in 1994 compared to 1993 partly because of fewer acres.

Table 5. Minnesota and California paddy wild rice production[a] (1000 processed pounds).

Year	Production		Year	Production	
	Minnesota	California		Minnesota	California
1968	36	0	1981	2274	500
69	160	0	82	2697	880
70	364	0	83	3200	2500
71	608	0	84	3600	2500
72	1496	0	85	4200	7900
73	1200	0	86	5100	9000
74	1036	0	87	4200	4200
75	1233	0	88	4000	3500
76	1809	0	89	3978	4000
77	1031	0	90	4800	4200
78	1761	100	91	5500	5500
79	2155	200	92	6100	7500
80	2320	400	93	5300	7500
			94 [b]	5300	5000

[a]1968-1982 Minnesota values from Winchell and Dahl and 1983-1993 from Minnesota Department of Agriculture; California values from Marcum, Cooperative Extension Service, University of California. [b]Estimated value for 1994.

The total value of the 1994 crop is estimated at $8.74 M, the same as for 1993. The highest value was in 1986 when production was the fourth highest and prices were more per pound than in 1994 (Table 6).

Table 6. Processed wild rice harvested and value from cultivated fields in Minnesota

Year	Production	Price	Value
	1,000 lb	$/lb	$ Millions
1968	36	3.30	0.12
1969	160	2.55	0.41
1970	364	2.80	1.02
1971	608	2.70	1.64
1972	1,496	2.30	3.44
1973	1,200	2.05	2.46
1974	1,036	2.37	2.46
1975	1,233	2.50	3.08
1976	1,809	2.70	4.88
1977	1,031	4.35	4.48
1978	1,761	5.10	8.98
1979	2,155	5.01	10.80
1980	2,320	4.47	10.37
1981	2,274	3.79	8.62
1982	2,697	3.41	9.20
1983	3,200	3.35	10.72
1984	3,600	3.30	11.88
1985	4,200	2.97	12.47
1986	5,100	2.60	13.26
1987	4,200	1.50	6.30
1988	4,000	1.65	6.60
1989	3,978	1.65	6.56
1990	4,800	1.70	8.16
1991	5,300	1.70	9.01
1992	6,100	1.70	10.37
1993	5,300	1.65	8.74
1994[a]	5,300	1.65	8.74

[a]Estimated values for 1994.

Research

The 1994 research focused on a simulated hail study conducted at the North Central Experiment Station at Grand Rapids.

Simulated Hail on Wild Rice

Introduction: Since wild rice became a cultivated crop, it has been insured against hail loss for a total liability of $13,764,00 according to the record of the National Crop Insurance Services. Two years of previous research in 1980 and 81, indicated that leaf removal before flowering and leaf removal in combination with stem breakage during flowering and grain fill can substantially reduce grain yield. Yields were considerably reduced even when leaves were removed at the floating leaf growth stage. Since these studies were conducted 13 and 14 years ago, some current data was needed to make an assessment of the potential for damage to wild rice from hail.

Materials and Methods: Wild rice, variety K2, was planted with a cone plot planter on May 11, 1994, at the University of Minnesota, North Central Experiment Station at Grand Rapids. After planting, the paddy was immediately flooded to a depth of 6 inches. Individual plots consisted of 4 rows, 1 foot apart and 10 feet long, with each treatment replicated 4 times. Before planting the plot area was fertilized with 50 lbs/A of N and 40 lbs/A of K_2O. The fertilizer was incorporated into the soil with a rotovator. Plots were also top dressed with 30 lbs/A of N (urea) at flowering. Plant population was approximately 2 plants per square foot.

To simulate hail damage, 33, 67 and 100% of each leaf blade in a plot was cut off with a scissors at seven plant growth stages. Leaf tissue was removed at the floating leaf, aerial leaf, tillering, flowering, milk, soft dough, and 30% dark growth stages. At the last four growth stages the same percentages of stems were also bent to a 90 degree angle (not broken off) just below the panicle. Thus at the last four stages, the plots had both the leaves and stems injured. At these last four growth stages an additional set of plots were "beaten" with fresh willow branches until reaching approximately 50% leaf defoliation. There were a total of 26 treatments including the control. The treatment dates of the seven growth stages were: floating leaf, 6-9; aerial leaf, 6-23; tillering, 7-7; flowering, 7-20; milk, 8-4; soft dough, 8-16; and first dark 8-31. The treatments were made approximately every 2 weeks with the last one made the day before harvest. An 8 foot section from the center 2 rows was harvested for grain and straw yield.

Results and Discussion: Table 7 presents the results from the 1994 trial. Table 8 presents the yields and percent yield reductions, compared to the control, for the 3 years of trials. The 1994 results differed considerably from 1980 and 1981 when the treatments were made at the first four growth stages. Yield reductions did not occur in 1994 except when 100% of the leaf blades were removed at the tillering growth stage. Treatments made at the flowering, milk and soft dough stages resulted in similar yield reductions as in the 1980 and 1981 trials. However, the results of the treatments at the 30% dark stage were different compared to 1980 and 1981. No significant yield reductions were obtained from the leaf removal at 30% dark in 1994.

This probably was because the treatments were made the day before harvest rather than at first dark kernel stage as was the case in 1980 and 1981.

In all three years of testing, 100% leaf removal reduced yields the greatest when it occurred at flowering. In most cereals, yield losses are noted with plants that are stressed during this critical time.

The "beating with a willow branch" treatments at the last 4 stages were added treatments in 1994. The attempt with this treatment was to more accurately simulate hail injury. Significant yield losses occurred at all four growth stages with the highest losses at the soft dough growth stage. At the flowering and milk stages, the beating treatment had a lesser effect on yield loss than the 100% leaf removal with no difference between 100% leaf removal and beating at the milk growth stage. At the soft dough stage, the beating treatment had a much greater effect, reducing yield nearly twice as much as the 100% leaf removed. At the 30% dark stage, beating the plants reduced yield by 60% whereas leaf removals had no effect. A possible reason for the increased effect of the beating treatment on yield reduction is that the beating not only removed the leaf material but it also damaged or stripped the seed from the panicles and panicles off the stems. The 100% leaf removal and stem bending took away much of the ability of the plant to produce photosynthate and deliver it to the panicles, but the panicles themselves were not damaged, leaving the already developed grain intact.

In summary, it is very evident from the 3 years that leaf removal, combined with stem bending, even 33% of each leaf blade removed and 33% of the stems bent, will result in yield loss at the flowering, milk and soft dough stages of growth. Although beating plants with willow branches may seem unique, it appears to cause damage and yield losses that reflect that of a hail storm. During the critical grain filling period, maintaining good healthy leaf tissue and stems are very important in the production and movement of photosynthate to the grain. The milk stage of plant growth was the most vulnerable to yield reductions from the various treatments.

The yield data is not as conclusive when leaves were removed before flowering. In 2 of the 3 years, yield losses did occur but in 1994 this was not true. In most small grains (wheat, barley, oat etc.) plants usually recover from early leaf losses.

With the 3 years of data we can begin to develop a relationship of plant injury to yield loss which will be useful in determining losses from hail. However, it would be wise to repeat the experiment plus expand the effort to simulate wind losses at the later stages of growth. The Federal Crop Insurance Program is changing, thus having comprehensive information on plant injury and yield loss will be valuable.

Table 7. Influence of removing 33, 67, and 100% of leaves on wild rice plants at 7 stages of growth plus 33, 67, and 100% of stems broken at last 4 growth stages. Independent plots beat with a willow stick at last 4 stages of growth. - Grand Rapids, MN -1994

Growth Stage	Leaf removal	Plant number	Stem number	Panicle number	Plant height	50% Flower date	Straw dry weight	Grain weight	De-hulled grain	Recov-ery	Hulls
	%	/ft^2	/ft^2	/plant	cm	DAP[a]	lbs/A	lbs/A[b]	lbs/A	%	%
Floating leaf	33	1.9	8.2	4.4	179	75.3	3625	1700	879	51.6	20.9
	67	2.0	7.8	3.8	173	77.5	3423	1611	827	51.3	21.4
	100	2.1	8.6	4.1	169	77.0	3493	1750	898	51.4	21.3
Aerial leaf	33	1.9	8.5	4.3	176	76.0	3573	1600	844	52.7	19.3
	67	2.1	9.6	4.5	170	75.8	3535	1641	858	52.3	19.8
	100	2.2	10.0	4.4	173	77.0	3619	1738	900	51.7	20.7
Tillering	33	2.0	9.2	4.3	171	76.0	3748	1846	969	52.5	19.6
	67	1.8	8.5	4.6	159	76.3	3196	1545	815	52.8	19.1
	100	2.0	9.2	4.5	148	75.0	2156	1159	605	52.1	20.2
Flowering	33	1.8	7.9	4.1	165	76.5	3184	1520	794	52.2	20.0
	67	2.0	7.8	3.6	151	75.0	2593	1176	605	51.5	21.1
	100	2.0	6.8	3.1	131	73.8	1835	420	208	49.2	24.8
	Beat[c]	2.0	8.0	3.6	153	74.0	2644	1093	561	51.2	21.6
Milk	33	1.9	7.4	3.7	170	75.5	3180	1117	563	50.5	22.7
	67	1.7	7.7	4.4	160	76.8	3484	1090	548	50.3	22.9
	100	1.8	7.6	4.2	159	76.0	2635	575	275	47.5	27.2
	Beat[c]	2.0	7.7	3.1	146	75.8	3495	695	339	48.6	25.6

Table 7. (continued)

Growth Stage	Leaf removal	Plant number	Stem number	Panicle number	Plant height	50% Flower date	Straw dry weight	Grain weight	De-hulled grain	Recov-ery	Hulls
	%	/ft^2	/ft^2	/plant	cm	DAP[a]	lbs/A	lbs/A[b]	lbs/A	%	%
Soft dough	33	1.9	8.1	4.1	164	75.5	3354	1509	785	52.0	20.4
	67	1.9	8.2	4.1	165	75.5	3327	1216	616	50.7	22.4
	100	2.0	7.1	3.4	174	76.5	2317	772	375	48.5	25.7
	Beat[c]	2.0	7.7	2.9	165	75.5	3768	250	104	41.1	37.2
33% Dark	33	2.1	8.1	3.7	169	74.8	3546	1472	766	52.1	20.3
	67	2.0	7.5	3.7	169	76.0	2971	1434	750	52.3	19.8
	100	2.2	7.7	3.4	175	75.8	2795	1427	739	51.8	20.7
	Beat[c]	1.8	7.4	4.1	150	75.5	3006	555	271	48.8	25.3
Control	0	1.9	7.0	3.7	169	74.0	2753	1400	737	52.6	19.4
LSD (0.05)		0.3	1.5	0.7	13	1.8	640	263	135	1.8	2.7

[a] Days after planting.
[b] Corrected to 40% moisture.
[c] Plots beat with weeping willow tree branches to a point of approximately 50% leaf defoliation.

Table 8. Influence on yield of removing 33, 67, and 100% of leaves on wild rice plants at 7 stages of growth plus 33, 67, and 100% of stems broken at last 4 growth stages. Independent plots were beat with a willow stick at last 4 stages of growth. - Grand Rapids, MN -1994

Growth stage	Leaf removal	Grain yield at harvest				Grain yield reduction compared to control			
		1994	1981	1980	Ave.	1994	1981	1980	Ave.
	%	lbs/A[a]				%			
Floating leaf	33	1700	848	1169	1239	(21)[b]	19	20	6
	67	1611	712	1216	1180	(15)	32	17	11
	100	1750	657	558	988	(25)	37	62	25
Aerial leaf	33	1600	752	1216	1189	(14)	29	17	11
	67	1641	888	1423	1317	(17)	15	3	0
	100	1738	497	1335	1190	(24)	52	9	12
Tillering	33	1846	872	1415	1378	(32)	17	3	(4)
	67	1545	783	1508	1279	(10)	25	(3)	4
	100	1159	648	867	891	17	38	41	32
Flowering	33	1520	800	1482	1267	(9)	23	(1)	4
	67	1176	897	1116	1063	16	14	24	18
	100	420	272	288	327	70	74	80	75
	Beat[c]	1093	--	--	1093	22	--	--	22
Milk	33	1117	640	1415	1057	20	39	3	21
	67	1090	672	994	919	22	36	32	30
	100	575	328	831	578	59	69	43	57
	Beat[c]	695	--	--	695	50	--	--	50
Soft dough	33	1509	880	--	1195	(8)	16	--	4
	67	1216	912	--	1064	13	13	--	13
	100	772	440	--	606	45	58	--	52
	Beat[c]	250	--	--	250	82	--	--	82
First dark[d]	33	1472	808	--	1140	(5)	23	--	9
	67	1434	657	--	1046	(2)	37	--	18
	100	1427	583	--	1005	(2)	44	--	21
	Beat[c]	555	--	--	555	60	--	--	60
Control		1400	1045	1463	1303	0	0	0	0
LSD 0.05		263	256	585	--	--	--	--	--

[a] Corrected to 40% moisture. [b] Grain yield INCREASES compared to control ( ).
[c] Plots beat with weeping willow tree branches to a point of approximately 50% leaf defoliation. [d] Data from 1994 was taken at 33% Dark.

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