WILD RICE PRODUCTION AND PLANT DEVELOPMENT RESEARCH-1992

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The 1992 growing season was cooler than normal (61-90) at Aitkin, Grand Rapids and Crookston especially during the months of April and July (Tables 1 and 2). The total 1992 growing degree days (GDD) for the three locations averaged 286 less than for the long term (61-90) average. This difference was even greater when compared to 1991. The total 1992 GDD for these locations averaged 759 less than for 1991. This is the first year for reporting the growing season temperature at Waskish. The records for this location are not always complete so no comparison can be made for the 1991 and 1992 years but compared to the long term average Waskish in 1992 was actually slightly warmer; however, April and August were cooler than normal (Table 2).

Table 1. Growing degree days[a] comparisons for 1991, 1992 and normal (61-90).

Month	Aitkin			Grand Rapids		
	1991	1992	Normal	1991	1992	Normal
	GDD					
April	223	92	127	201	75	130
May	581	502	417	591	509	434
June	774	670	646	802	607	674
July	837	647	779	788	644	858
August	880	700	683	907	680	768
Total	3295	2611	2652	3289	2515	2864

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

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Table 2. Growing degree days[a] comparisons for 1991, 1992 and normal (61-90).

Month	Waskish 1991	Waskish 1992	Waskish Normal	Crookston 1991	Crookston 1992	Crookston Normal
	GDD					
April	M	66	103	212	91	151
May	M	493	369	635	584	488
June	M	625	518	866	642	743
July	M	656	642	853	669	926
August	870	415	563	961	720	867
Total	---	2255	2195	3527	2706	3175

[a]Maximum + minimum temp. / 2 - 40°F; data from Mark Seeley, Soil Science Dept., U of MN

Total precipitation for the 1992 growing season was less at Aitkin and Crookston while it was higher at Waskish and Grand Rapids than the long term (61-90) average (Tables 3 and 4). At Aitkin and Crookston precipitation was considerably lower in 1992 than for 1991 while at Grand Rapids it was higher.

Generally the 1992 cool growing season was favorable for wild rice. The plants tillered well and had a high kernel number on the panicles resulting in good yields. In addition, the cooler temperatures were not as favorable for development of brown spot leaf disease.

Table 3. Precipitation comparisons for 1991, 1992 and normal (61-90)[a].

Month	Aitkin 1991	Aitkin 1992	Aitkin Normal	Grand Rapids 1991	Grand Rapids 1992	Grand Rapids Normal
	Inches					
April	2.60	2.41	2.30	2.42	1.13	2.10
May	5.27	1.30	2.88	2.79	1.19	3.04
June	5.16	2.66	4.09	3.10	4.78	4.11
July	4.64	3.93	4.14	4.66	4.78	3.89
August	1.79	4.69	3.83	2.12	5.69	3.59
Total	19.46	14.99	17.24	15.09	17.57	16.73

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

Table 4. Precipitation comparisons for 1991, 1992 and normal (61-90)[a].

Month	Waskish 1991	Waskish 1992	Waskish Normal	Crookston 1991	Crookston 1992	Crookston Normal
	Inches					
April	M	1.45	1.70	3.10	0.98	1.45
May	M	1.58	2.33	3.74	1.97	2.45
June	M	2.32	4.25	4.36	4.30	3.44
July	M	4.13	3.42	3.22	1.86	2.77
August	2.33	6.05	3.32	0.94	3.58	2.88
Total	---	15.53	15.02	15.36	12.69	12.99

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

Total paddy wild rice production in Minnesota was more in 1992 compared to 1991 mostly because of higher per acre yields (Table 5). California production was also higher compared to 1991 due to a combination of more acreage and higher per acre yields.

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

Year	Production Minnesota	Production California	Year	Production Minnesota	Production California
1968	36	0	1980	2320	400
69	160	0	81	2274	500
70	364	0	82	2697	880
71	608	0	83	3200	2500
72	1496	0	84	3600	2500
73	1200	0	85	4200	7900
74	1036	0	86	5100	9000
75	1233	0	87	4200	4200
76	1809	0	88	4000	3500
77	1031	0	89	3978	4000
78	1761	100	90	4800	4200
79	2155	200	91	5300	5500
			92 [b]	5900	7500

[a]1968-1982 Minnesota values from Winchell and Dahl and 1983-1992 from Minnesota Department of Agriculture; California values from Marcum, Cooperative Extension Service, University of California. [b]Estimated value for 1992.

The total value of the 1992 crop is estimated at $9.74 M compared to $9.01 M for 1991. The increase is due to increased production. The highest value was in 1986 when production was the second highest and prices were more per pound than in 1992 (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[a]	5,900	1.65	9.74

[a]Estimated values for 1992.

Research

The 1992 research focused on obtaining grain samples for 2,4-D residue analysis, burreed control, crop rotation and photoperiod effect on plant growth and development.

Weed Control

Giant Burreed

The effort to control giant burreed was concentrated on fall and spring applications of herbicides. The trials were conducted in a paddy at Grand Rapids that was planted in 1987 with giant burreed. The paddy was never tilled but flooded each year to allow good establishment of giant burreed.

Combination of fall + early summer herbicide applications: On August 19, 1991 giant burreed plants were trimmed with a hedge trimmer leaving a 30-inch stubble to simulate normal combine harvest. Plot size was 20 x 20 ft and the experimental design was a randomized complete block with three replications. The herbicides were applied with a hand CO_2 sprayer at 25 psi using a total volume of 30 gal/A. Glyphosate (Roundup) was fall applied (August 19) at 1/2, 1 and 2 lb ai/A followed by an early summer (June 2) application of 1/2 lb ai/A onto the previous fall applied 1/2 lb ai/A, and 1 lb ai/A onto the previous fall applied 1 and 2 lb ai/A rates. One set of the 3 fall rates did not have any additional glyphosate applied to them in the early summer.

On June 2, 1992 before the late summer applications of glyphosate, there was little evidence of injury at the 1/2 and 1 lb ai/A rate but about a 50% control at the 2 lb ai/A rate. Compared to the 1990 fall applications, the 1991 fall applications were not as effective. ~~Very little growth of giant burreed was observed in the spring of 1991 after 1 or 2 lb ai/A of glyphosate were applied the previous fall~~; however, only the 2 lb ai/A rate reduced the growth of giant burreed the following spring. The additional 1/2 and 1 lb ai/A did not have much effect on giant burreed when observed at the end of the growing season.

Early summer applied herbicides: Two formulations of glyphosate (Roundup and Rodeo) at 1/2, 1 and 2 lb ai/A and imazapyr (Arsenal) at 1/2 and 1 lb ai/A were applied on June 29 to giant burreed before flowering. The Rodeo formulation was applied with a surfactant (X-77) at the rate of 1 quart/A. The herbicides were applied in the same manner as described as above. The plot size was 10 x 10 ft and replicated three times. Table 7 gives the giant burreed control ratings on August 5.

Table 7. Giant burreed injury ratings 5 weeks after treatment, 1992, Grand Rapids.

Herbicide	Rate	Injury
	lb ai/A	rating
Roundup	1/2	1
	1	1
	2	2
Rodeo + X-77	1/2	1
	1	1
	2	2
Arsenal	1/2	7
	1	7
Control	0	1
	LSD .05	2

Based on visual control ratings made near the end of the growing season, early summer applications of Roundup or Rodeo did not effectively control giant burreed. However, Arsenal gave very good control but this compound is not cleared for cropland use.

Based on several years work on giant burreed control, fall plowing, or flooding if feasible, will reduce giant burreed infestation but not give effective control. A fall application of Roundup at 2 lb ai/A after harvest will give reasonable control but the best way may be to keep badly infested fields out of wild rice for a year, flood in the spring, allow burreed to develop, drain and treat in late summer with 2 lb ai/A of Roundup.

Common Waterplantain

The project participated in the IR-4 (Interregional Research Project No. 4) Minor Crop Use Research Program to obtain the magnitude of 2,4-D residue on wild rice. This work was supported by IR-4 and the Minnesota Cultivated Wild Rice Research and Promotion Council.

2,4-D amine residue: In order to obtain full registration of 2,4-D for use in wild rice it is necessary to obtain grain and hull residue data to see if any 2,4-D remains in the edible grain after processing. We contacted IR-4 to help us develop the protocol and field research standard operating procedures. Rhone-Poulenc Ag Company supplied us with a gallon of specially analyzed (GLP) 2,4-D amine for our use.

The Franklin variety was planted on May 19 into paddy no. 7 and the woods paddy at Grand Rapids. The two paddies were separated by trees with the woods paddy serving as the untreated area. Ten blocks, each containing 28 rows spaced 1 ft apart and 20 ft long, were planted into paddy no. 7. Five blocks, each containing 28 rows 1 ft apart and 10 ft long, were planted into the woods paddy. On July 9, when wild rice was 25 in. tall and in the mid- to late-tillering stage, 1/4 lb ai/A of 2,4-D was applied to 4 blocks in paddy no. 7 and 1/2 lb ai/A of 2,4-D was applied to a different set of 4 blocks in paddy no. 7. The two treatments were separated by 2 untreated blocks. 2,4-D was applied with a hand-held CO_2 pressurized sprayer using 30 psi and 30 gallons of volume per acre. Four 20 ft rows were treated at a time. No injury to wild rice at either rate of 2,4-D was observed during the growing season.

On August 31 three of the four blocks from each 2,4-D treatment (paddy no. 7) and the check (woods paddy) were hand harvested and the threshed grain immediately taken to St. Paul where it was placed into a freezer for later processing. The original intent was to harvest 40 days after treatment; however, the cool weather delayed maturity and thus the first harvest could not be taken until 53 days after treatment. Even at this date the recovery was only around 15%. The last block of each treatment was harvested on September 11 when percent recovery was around 30. The grain samples were removed from the freezer and dried in a forced air dryer until it reached 240° F. The grain was immediately hulled while still hot with a small laboratory rubber-roller huller. The chaff was removed by air and collected. The parched grain and chaff were returned to the freezer and on October 15 the samples were removed and shipped to the Pesticide Analytical Laboratory, N.D. for 2,4-D residue analysis. The results will be forwarded to IR-4 who will send the analyses along with a detailed record of our procedure to EPA.

2,4-D control of common waterplantain: 2,4-D at 1/4, 1/2, 3/4 and 1 lb ai/A was applied to a pure stand of common waterplantain when all the leaves were fully emerged from the water (June 22) and also when the flowering stem (scape) was beginning to elongate. The experiment was conducted in the University paddies on the Vomela Wild Rice Farm. The plot size was 5 x 10 ft and the experimental design was a randomized complete block with three replications. The herbicides were applied with a hand CO_2 pressurized sprayer at 30 psi at a total volume of 30 gal/A. Table 8 presents the injury ratings, plant number and dry weights of common waterplantain after treatment with 2,4-D.

Table 8. The effect of 2,4-D amine applied at 4 rates and 2 dates to common waterplantain.

Herbicide	Rate	Injury[a]	Plant number	Total dry weight
	lb ai/A	rating	/50 ft^2	lb/A
	------- 6/22 (leaves fully emerged from water) ------			
2,4-D amine	1/4	5	10	338
	1/2	7	7	275
	3/4	10	0	0
	1	10	0	0
	0	1	18	636
	LSD .05	2	4	280
	------------ 6/27 (scape elongation) -----------			
2,4-D amine	1/4	4	12	384
	1/2	6	5	312
	3/4	7	4	169
	1	9	0	0
	0	1	19	726
	LSD .05	2	12	340

[a]4 weeks after treatment; 1=no injury and 10=complete kill.

The control of common waterplantain was better at the earlier date when all the leaves of each plant were fully emerged from the water compared to a week later when the flowering stem was elongating (Table 8). As in previous trials, the 1/4 and 1/2 lb/A rate gave 50 to 70% control and complete control was obtained with higher rates if applied early.

The full label for use of 2,4-D amine in wild rice will be for the 1/4 lb ai/A rate even though complete control of common waterplantain is not obtained at this rate. The reason for this is that in the past we have seen some injury to wild rice at higher rates. This year in our residue trial however we did not see any wild rice injury at the 1/2 lb ai/A rate.

Crop Rotation

The six 2-acre paddies which were in a 2 year rotation system during 1990 and 1991 on the Vomela Wild Rice Farm near Aitkin were again utilized to compare continuous wild rice with rotating wild rice with either fallow, canola or alfalfa. All six paddies were in wild rice production in 1991. In the fall of 1991 all paddies were rotovated. Paddies 1, 3 and 5 were seeded to wild rice and fertilized with 250 lb/A of 1-5-40-5S. Both were incorporated and then 19 gallons of 22-7-0 were injected. In the spring, before these paddies were flooded, 80 lb/A of P_2O_5 were broadcast onto the surface on a 40 ft strip on the east side of each paddy.

In the spring of 1992, paddies 2, 4 and 6 were divided into the same three strips as 2 years ago. The one strip that was left fallow all summer in 1990 was left fallow again in 1992; this was also the case for the alfalfa and canola strip. Before planting canola, variety Global, these strips were fertilized with 130, 20 and 100 lb/A of N, P_2O_5 and K_2O; and before planting alfalfa, variety Nitro, these strips were fertilized with 130, 20 and 100 lb/A of N, P_2O_5 and K_2O. The fertilizer was incorporated before planting alfalfa and canola on May 19. Canola was seeded at the rate of 12 lb/A with a 12-ft press-wheel drill with 6 in. spacing between rows. Alfalfa was seeded at the rate of 15 lb/A with a Brillion seeder.

We obtained a good stand of canola with an average of 9 plants per ft^2 at harvest and a yield of 1072 lb/A. The cool season was more favorable for canola than the warm summer of 1990 thus the yield was about 300 lb/A higher in 1992. Also this year, canola harvest did not occur until after wild rice harvest, therefore it did not interfere with wild rice harvest as it did in 1990. Alfalfa stands were only fair and with cooler temperatures, growth was slow; consequently smartweeds crowded out much of it, thus no yields were taken.

Unfortunately, wild rice in paddies 1, 3 and 5 was completely destroyed by crayfish. Evidence for this was clearly established since small enclosures, constructed by McDonald and Gunderson to keep out crayfish, had wild rice growing in them. In addition, we placed metal rings into the flooded paddies and water-seeded wild rice into them and outside an area surrounding the rings. Wild rice survived within the rings but not on the outside. McDonald and Gunderson also caught many crayfish in traps placed into the paddies. Based on these experiments, the results showed clearly that a high population of crayfish can completely destroy stands of wild rice.

Plant Development

Effect of Photoperiod on Plant Growth and Development. This study was conducted, analyzed and written by Tim Teynor, temporary researcher on the project.

Introduction: Three species of wild rice (*Zizania palustris*, *Z. aquatica*, and *Z. texana*) are native to North America and in the past 25 years this crop (*Z. palustris* L. Dore) has increased in commercial importance in the U.S.A. and Canada. A better understanding of the adaptation of *Zizania* species to environmental conditions is vital for the improvement of this crop's productivity in its native regions and new production areas. Research on the adaptation of wild rice has been conducted previously in Minnesota by Elliott (1974), Elliott et al. (1974), and Oelke et al. (1980, 1981, 1982) This study was conducted to determine the effect that different photoperiods or daylengths at a constant day and night temperature had on plant growth and development of native *Zizania* species. A major goal was to investigate the effect that different daylengths had on the flowering response. This knowledge would permit researchers to synchronize flowering times between different species or cultivars with different maturities, which would allow pollinations between species or cultivars and result in the faster development of adapted, productive cultivars.

Materials and Methods: Plants were grown in two growth chambers at a constant day-night temperature of 18°C. One chamber had an eight-hour photoperiod or short-day (SD) treatment supplied by cool-white fluorescent lamps with a high light level (i.e., photon flux density) of 390 $\mu mol\ m^{-2}\ sec^{-1}$. The other chamber had the same 8 hours of daylight (08:00-16:00), but with a four-hour night interruption (22:00-02:00) using incandescent lamps with a low light level of 23 $\mu mol\ m^{-2}\ sec^{-1}$ to provide a long-day (LD) photoperiod of 18 hours. Two seed sources of *Z. palustris*, one from Ontario, Canada and the cultivar K2 from Minnesota, and seed lots of *Z. aquatica* from northern Florida and *Z. texana* from southcentral Texas were evaluated. The K2 and *Z. aquatica* were replanted about four and six weeks after the first planting respectively, due to very poor germination. Seed of *Z. texana* germinated poorly and did not provide a sufficient number of plants to evaluate.

Flowering data were collected for the number of days from planting (start of SD or LD treatments) to the boot stage (DTB), awn emergence (DTA), full emergence of all female florets from the boot or leaf sheath (DTF), and full emergence of all male florets from the boot (DTM). Plant data recorded for *Z. palustris* were the heights of the flag leaf (FLHT) and panicle (PHT) on the main stem, and the numbers of: tillers (TIL), panicles (PAN), leaves on main stem (LFMS), and female florets (potential grain yield) on the main stem (FFL). Dry weights of the main stem (MSW), tillers (TW), and whole plant (PWT) were also collected. Similar data were recorded for nonflowering plants of *Z. aquatica*, which were heights of the tallest leaf (FLHT), number of tillers (TIL), and leaves on the main stem (LFMS). Plants remained in growth chambers until the flowering was completed or the termination of the experiment (235 days after first planting), if no flower development was observed.

Results: Photoperiod had a significant effect on plant growth and development for *Z. palustris* and *Z. aquatica* at a constant 18°C. The average flowering times for seed sources of *Z. palustris* were earlier in SDs than in LDs (Table 9). The Canadian seed source and K2 responded somewhat differently for flowering times in different photoperiods (Figure 1). The average flowering time for the Canadian wild rice was earlier under LDs and slightly later under SDs when compared to K2 (Table 10).

Conclusions: Plant heights for the flag leaf and panicle were taller for plants grown under LDs (Table 11). The average number of tillers, panicles, and the leaves and female florets on main stems were usually greater in LDs (Table 12), but in SDs, the response of K2 and the Canadian seed source were more similar (Figure 2). This luxuriant vegetative growth in LDs was also indicated by plant dry weights (Table 13). Plants of *Z. aquatica* did not flower in either photoperiod by the end of the study, which was 185 days after planting. Data collected for three common plant characters in both species also showed that the most vegetative growth occurred usually in LDs (Table 14). The relative performance of the three seed sources for these characters was also somewhat different in the SDs and LDs (Figure 3).

Postscript: Some of the *Z. aquatica* plants flowered eventually after the study ended. Plants were kept in the growth chambers in the same SDs or LDs for an additional six weeks and then moved in late September to a greenhouse with natural daylengths. A few plants started to reach the boot stage after four weeks in the greenhouse, or about 8.5 months after the seed was planted.

Table 9. Average flowering times of *Z. palustris* for number of days to boot stage (DTB), awn emergence (DTA), emergence of all female florets from boot (DTF), and emergence of all male florets from boot (DTM) in long- (LD) and short-day (SD) photoperiods at constant 18°C.

Photoperiod	Flowering Time DTB	DTA	DTF	DTM
LD	84.5	85.3	90.2	99.2
SD	66.7	67.7	70.1	74.5
$LSD_{(0.05)}$	1.5	1.6	1.6	1.8

Table 10. Flowering times of Canadian lake (C) and Minnesota 'K2' wild rice (*Z. palustris*) for average number of days to boot stage (DTB), awn emergence (DTA), emergence of all female florets from boot (DTF), and emergence of all male florets above boot (DTM) in long- (LD) and short-day (SD) photoperiods at constant 18°C.

Flowering Time	PHOTOPERIOD LD C	LD K2	LD $LSD_{(0.05)}$	SD C	SD K2	SD $LSD_{(0.05)}$
DTB	75.0	94.0	2.2	69.0	65.0	2.2
DTA	76.0	95.0	2.4	70.0	66.0	2.2
DTF	82.0	98.0	2.1	72.0	68.0	2.3
DTM	94.0	104.0	2.4	76.0	73.0	2.7

Table 11. Average plant heights (cm) of the flag leaf (FLHT) and panicle (PHT) on the main stem for *Z. palustris* in long- (LD) and short-day (SD) photoperiods at constant 18°C.

Photoperiod	Plant Height FLHT	PHT
LD	81.0	111.0
SD	46.0	68.0
$LSD_{(0.05)}$	3.5	4.9

Table 12. Average numbers of: tillers (TIL), panicles (PAN), leaves on main stem (LFMS), and female florets on main stem (FFL) for *Z. palustris* in long- (LD) and short-day (SD) photoperiods at constant 18°C.

Photoperiod	Plant Characters			
	TIL	PAN	LFMS	FFL
LD	2.6	2.5	4.8	62.0
SD	1.0	1.8	4.1	15.0
$LSD_{(0.05)}$	0.3	0.3	0.2	5.6

Table 13. Average plant dry weights (g) for the main stem (MSW), tiller(s) (TW), and whole plant (PWT) for *Z. palustris* in long- (LD) and short-day (SD) photoperiods at constant 18°C.

Photoperiod	Plant Dry Weights		
	MSW	TW	PWT
LD	3.0	2.3	5.3
SD	1.4	0.7	2.1
$LSD_{(0.05)}$	0.3	0.5	0.6

Table 14. Average height (cm) of the tallest leaf (FLHT) on the main stem, number of leaves on the main stem (LFMS), and tiller number (TIL) for seed sources of *Z. aquatica* (A) from Florida and *Z. palustris* from Canadian lakes (C) and Minnesota cultivar K2 evaluated in long- (LD) and short-day (SD) photoperiods at constant 18°C.

Photoperiod	Plant Characters			
	Seed Source	FLHT	LFMS	TIL
LD	A	130.7	9.5	1.4
	C	84.8	4.0	3.7
	K2	77.0	5.7	1.4
$LSD_{(0.05)}$		5.7	0.5	0.5
SD	A	83.6	9.1	2.4
	C	45.6	4.0	1.0
	K2	46.8	4.2	1.0
$LSD_{(0.05)}$		6.5	0.7	0.7

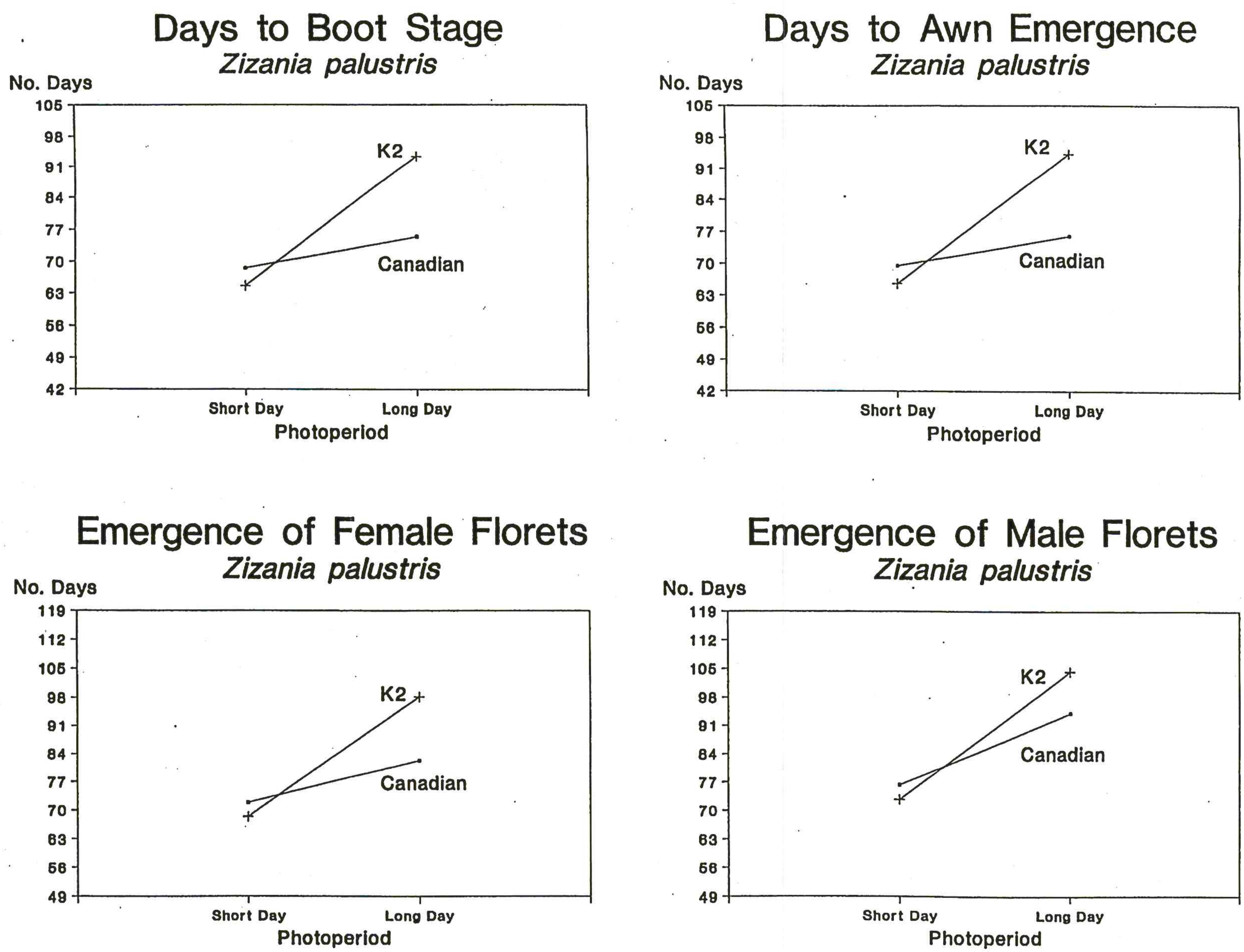

Figure 1. The variable responses (interactions) observed for average flowering times of seed sources of *Z. palustris* in short- and long-day photoperiods.

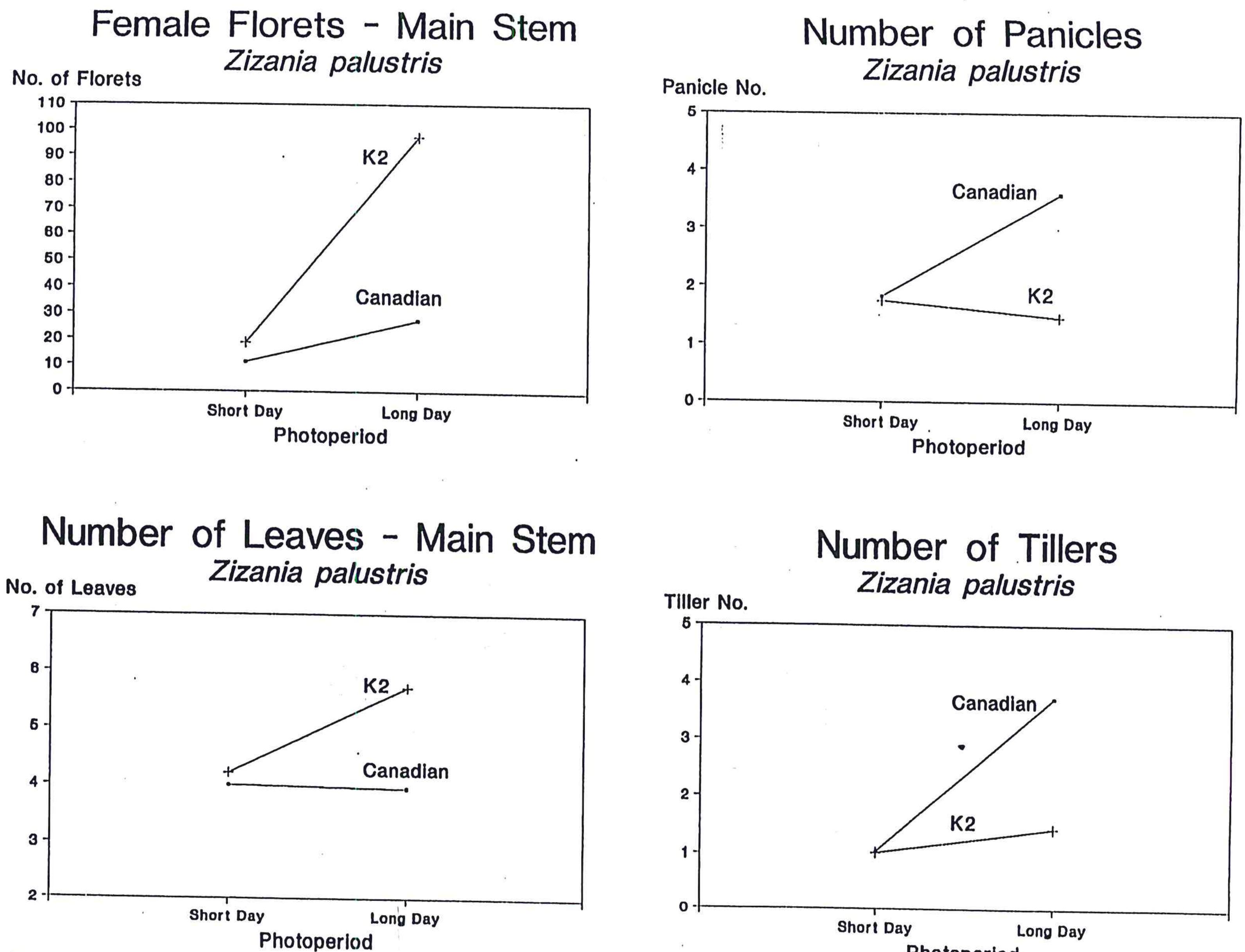

Figure 2. The relative performance observed for the Canadian seed source and K2 in different photoperiods for average numbers per plant of: female florets and leaves on main stems, panicles, and tillers.

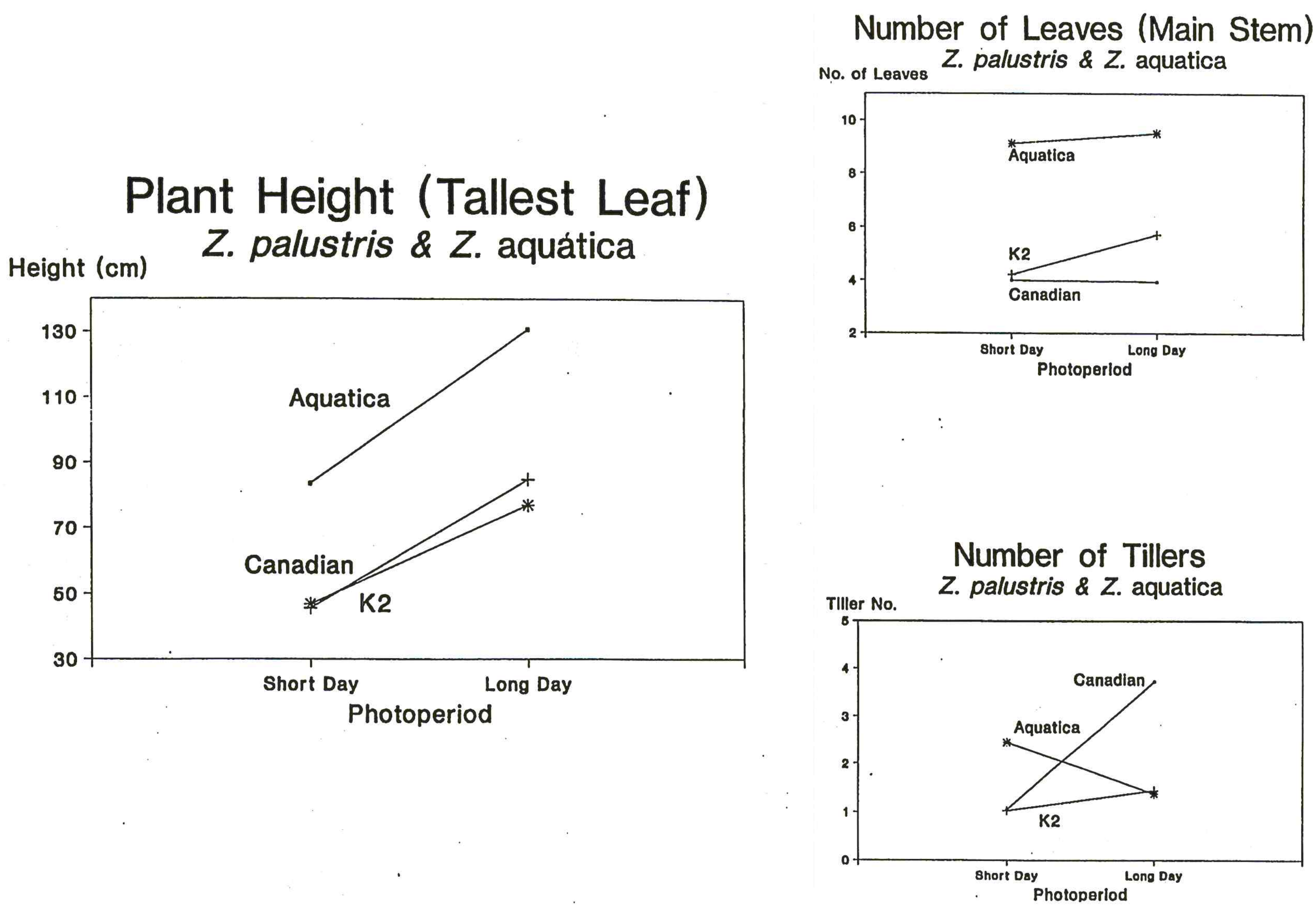

Figure 3. The variable responses observed for heights of the tallest leaf (FLHT), number of tillers (TIL), and leaves on the main stem (LFMS) for *Z. palustris* and *Z.aquatica* in different photoperiods.

CONCLUSIONS

This study has provided a better understanding of the effect that SD and LD photoperiods at a constant temperature of 18°C have on flowering in wild rice species:

1) Plants of *Z. palustris* flowered earlier in SDs than in LDs, which indicates that this species may be a quantitative SD plant for flowering under these environmental conditions. No flowering response was observed for *Z. aquatica* under either photoperiod after 185 days.

2) The average flowering times and some other plant characters observed for the Canadian seed source and K2 were slightly different relative to each other in each photoperiod. The performance differences observed for seed sources in different photoperiods (i.e., environmental interactions) indicated the need to develop cultivars with broader environmental adaptation for a uniform, stable productivity.

3) The K2 had less plant-to-plant variation for flowering times (better uniformity) than the Canadian wild rice and produced more female florets (potential grain yield) under either SDs or LDs.

4) Plants of *Z. palustris* evaluated in LDs were usually taller, had more tillers, panicles, and female florets than plants in SDs. A similar response was commonly observed for vegetative characters of *Z. aquatica* in these photoperiods.

The ability to control flowering times more precisely will result in the effective development of improved cultivars with broader adaptation and higher yields in current and new production areas. Future research should examine the effects of different light levels, photoperiods, and day-night temperatures on plant growth and development.

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Seed Storage and Viability of *Zizania texana* and *Zizania palustris*

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Texas wild rice (*Zizania texana* Hitchc.), a perennial aquatic grass, is native to a 2.5 mile length of the San Marcos River within the city of San Marcos in southcentral Texas. This species is endangered due to its limited habitat or range, decline in plant numbers over the past 60 years since it was first identified by Hitchcock (1933), and low seed production in native stands. Flowering will occur throughout the year if subfreezing temperatures do not occur frequently. Fresh seed has been reported to have dormancy (Power, 1990). Seed that was removed from plants and stored immediately in water with a low oxygen concentration started to germinate in about three weeks. In addition, freshly harvested seed that was stored in cold (3°C/37°F) water for four months was reported to germinate quickly in four days when placed in water with a low oxygen concentration. Dormancy may be due perhaps to embryo immaturity or presence of growth inhibitors within the seed. However, the slow germination may have been the result of an inappropriate oxygen concentration or temperature of the water, or an impermeable seed coat; and not due to an endogenous (internal), physiological dormancy.

The major objective of this study was to investigate whether seed viability of Texas wild rice was affected by drying seed to different moisture contents. Another goal of this study was to determine whether seed will germinate immediately after removal from dry storage when placed in water at a temperature of 20°C (70°F). The presence of dormancy in fresh seed of this species is similar to *Z. palustris* that must have dormancy requirements satisfied prior to germination by stratification for three months in cold water.

Materials and Methods

Seed of Texas wild rice was aquired from Southwest Texas State University (Power, 1990). The wild rice used for cultivation (*Z. palustris*) served as a control treatment or reference standard in the first run of this experiment, since previous seed-storage research used this species. The

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