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The Effect of Stand Thinning and Straw Management on The Productivity of Lake Grown Wild Rice in Saskatchewan[1]

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ABSTRACT

The effects of stand thinning, straw mulching and straw removal on the productivity of lake grown wild rice was investigated in northern Saskatchewan. Thinning, carried out by hand at the aerial leaf stage, removed from 50 to 75% of the stems. Although increased tillering was noted in some treatments, the number of tillers produced was not great enough to significantly increase stem densities and overall grain production was reduced. Grain production increased by about 3.5% in plots from which straw was removed in the spring using an aquatic weed harvester. Plots in which the bulk of the straw was mulched and returned to the lake bed were the most productive, suggesting that nutrients released from decomposing straw may be important for good growth of wild rice. However, none of the treatments appear to be justified as annual stand management practices designed to increase yields.

Key Words: Zizania palustris, straw mulching, straw removal, stand thinning, productivity.

INTRODUCTION

Wild rice (*Zizania palustris* L.) is an annual, emergent, aquatic cereal that has been grown commercially in northern Saskatchewan since the mid-1960's (Archibold *et al.* 1985). Numerous shallow lakes and slow moving rivers found in the southern boreal forest region provide ideal habitat, and the provincial government has actively encouraged the expansion of the industry. Currently, there are an estimated 5,500 ha in production and the 1988 harvest exceeded 800,000 kg. Saskatchewan laws prohibit the use of chemicals in northern water bodies, and artificial control of water depth is also illegal. These regulations are accepted by the growers who are actively promoting the natural quality of their long grain wild rice in the health food marketplace. However, yields are typically less than 100 kg ha^{-1}, and growers are interested in stand thinning and straw management as methods of increasing production.

Lake wild rice readily shatters and reseeds itself once established, hence stand densities generally increase in subsequent years. Wild rice, like any crop, is subject to intraspecific competition and grain production often declines as stand density increases (Weiner and Whigham, 1988). Thus, Archibold *et al.* 1985 reported an average of only 11 florets per panicle for plants growing at a density of 560 stems m^{-2}. Oelke *et al.* (1982) have recommended that wild rice cultivated in paddies in Minnesota be thinned to a density of 20-30 plants m^{-2} in the floating leaf stage to maximize yields through tillering.

At the end of a good crop year a considerable quantity of straw will remain in a lake. Lee (1986) reported biomasses ranging from 3,000 to 17,000 kg ha^{-1} for wild rice straw in lakes in Ontario: in Saskatchewan, straw production is typically less than 4000 kg ha^{-1} (Archibold, 1988).

If the straw persists as a floating mat into the following spring it might shade out new seedlings, and if it sinks during the winter, seeds on the lake bed might be smothered. This could be a causal factor in the cyclical patterns noted in long term production records since straw decomposition and nutrient release are slow in cool northern waters (Sain, 1984). Complete decomposition may take up to three years.

In this research, the effects of stand thinning and various straw treatments on lake wild rice production were evaluated. The lakes used in this study were located near La Ronge, Saskatchewan (55°6′N, 105°17′ W). Field work was completed during 1987.

METHODS

Thinning was carried out in late June in an extensive stand of wild rice when the plants were in the early aerial leaf stage. Three thinning treatments were used. In treatment 1, strips 1.25 meters wide were alternately cleared of all wild rice with the intervening 1.25 m strips left intact; in treatment 2 the cleared strips were 1.25 m wide and the uncleared strips were 60 cm wide. Treatment 3 resulted in a checker board pattern of 60 cm squares of wild rice separated from each other by 60 cm of open water. Three replicates of each treatment and four control plots were used; each plot was 8 by 8 m in size. All thinning was carried out by hand.

The straw clearing study commenced in mid-May as soon as the ice was off the lake. A small aquatic weed harvester was used to bring up straw from a 1.5 ha area of lake bed. A fence constructed of chicken wire was erected around the cleared area to prevent straw from drifting into the test plots. A second study evaluated the effect of depth of straw cutting and straw mulching on subsequent crop development. The initial work was carried out in mid-October, 1986, just prior to freezing, while the straw was

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still standing. Four treatments were used. Treatment A consisted of cutting the standing straw at the surface of the water and raking the residue out of the plot. In treatment B the straw was cut at the surface, mulched in a horticultural shredder mounted in a barge and the wet straw fragments returned to the lake bed. Treatments C and D repeated A and B except that the standing straw was cut about 30 cm below the water surface. Three replicate trials were established.

Stand density at all plots was recorded in twenty-five 0.5 by 0.5 m quadrats at the start of each experiment and repeated just prior to harvest. In September samples of mature plants were collected for morphological analysis including stem length, number of tillers, and number of florets. For each treatment, potential grain yield was calculated as the product of stem density, average number of seeds per stem and average seed weight. Analysis of variance was used to determine the significance of the results.

RESULTS AND DISCUSSION

Stand thinning. Stand density at the commencement of the thinning trials averaged 68.4 stems m^{-2}. By harvest time this had increased to 98.5 stems m^{-2} in the control plots, and was equivalent to 90.5 stems m^{-2} in treatment 1, 84.1 stems m^{-2} in treatment 2, and 107.6 stems m^{-2} in treatment 3. Preliminary data analysis indicated that no edge effect was apparent as a result of the different thinning treatments. The number of tillers increased as thinning became progressively more severe. Plants from treatment 1 and the control plots averaged 0.22 tillers (Table 1); this was significantly fewer than the 0.43 and 0.53 tillers noted in treatments 2 and 3. Stem length in the various treatment plots ranged from 125.7 cm to 128.9 cm. No significant differences were noted between treatments, but these stems were significantly shorter than the 137.5 cm recorded for the control plants. Significant differences in stem diameter, leaf length, and aerial biomass were also noted between treatment 1 and the control plants.

Treatment 1 plants averaged 20.9 seeds per panicle; this was significantly lower than the control plants which produced an average of 25.9 seeds. Seed counts for treatments 2 and 3 were 24.1 and 22.7 respectively. Seed weights, based on a sample of 250 seeds from each treatment, ranged from 39 mg to 43 mg and significant differences were noted between treatment 2 and both treatment 3 and the control. Thus, individual plants might be expected to yield from 1.09 g (treatment 1) to 1.49 g of seed (treatment 3); these were the only treatments which differed significantly.

The development of more tillers was the most apparent response of plants to thinning and it would be expected that this would lead to increased seed production at a site. However, seed production on the tillers in the treatment plots averaged 22.5 seeds per panicle compared to 32.9 seeds per panicle for the control plots. Excluding open water areas, a site consisting of plants with similar morphological characteristics to those recorded in treatment 1 would potentially yield 747.0 kg ha^{-1}. The equivalent yields for treatment 2 would be 1024.8 kg ha^{-1}, and 806.0 kg ha^{-1} in treatment 3, compared to 1088.6 kg ha^{-1} in the control plots. Thus, no improvement in seed production was noted within any area that had been thinned.

Straw removal. Average stem density in mid-July in the uncleared area was 31.4 m^{-2} compared to 55.9 m^{-2} in the cleared area: by the end of the growing season this had increased to 67.3 m^{-2} and 96.4 stems m^{-2} respectively. Despite significantly lower stem densities ($p \leq 0.05$), the majority of plants in the uncleared patch had developed stem and root tillers (Table 2). On average, these plants consisted of a main stem and 1.8 tillers compared to only 0.2 tillers in the cleared area. In addition, plants from the cleared area were also comparatively longer, thinner and lighter, and seed production was significantly reduced. Potential yield was 1251.1 kg ha^{-1} in the cleared area. This was not significantly different than the 1208.1 kg ha^{-1} calculated for the uncleared area. However, a significant increase in straw production was noted in the cleared plots. This suggests that clearing, once initiated, may need to be maintained if adverse growth conditions are to be avoided.

Wild rice yields from the cleared area were about 50 kg ha^{-1} higher than from the uncleared patch. Since one kilogram of green rice currently sells in Saskatchewan for about $1.25, this represents a return of $62.50 ha^{-1}. This

TABLE 1. MORPHOLOGICAL RESPONSE (MEAN ± S.E.) OF WILD RICE TO VARIOUS STAND THINNING TREATMENTS.

Plant characteristic	Thinning treatments[1] 1 n = 100	2 n = 105	3 n = 103	control n = 144
Number of tillers per plant	0.22 ± 0.04b[2]	0.43 ± 06a	0.53 ± 0.07a	0.22 ± 0.04b
Stem length (cm)	128.9 ± 1.7b	127.3 ± 1.7b	125.0 ± 1.5b	137.5 ± 1.3a
Basal diam. (mm)	2.7 ± 0.1b	2.9 ± 0.1ab	2.7 ± 0.1b	3.1 ± 0.1a
Leaf length (cm)	29.9 ± 1.6b	34.3 ± 1.4ab	33.5 ± 1.6ab	39.0 ± 1.3a
Aerial biomass (gm)	2.38 ± 0.16b	3.00 ± 0.18ab	2.61 ± 0.16ab	3.09 ± 0.15a
Number of florets per panicle (all stems)	20.9 ± 1.0b	24.1 ± 1.0ab	22.7 ± 1.0ab	25.9 ± 0.9a
Seed weight (gm)	40.2 ± 1.5bc	39.4 ± 2.9c	42.9 ± 2.5a	41.6 ± 1.7ab
Potential yield per plant (gm)	1.08 ± 0.8b	1.40 ± 0.8ab	1.49 ± 0.9a	1.38 ± 0.9ab

[1]See text for details of various thinning treatments used.
[2]Mean values followed by the same letter in a horizontal line are not significantly different at $p \leq 0.05$.

TABLE 2. THE EFFECT OF PARTIAL STRAW REMOVAL IN THE SPRING ON THE SUBSEQUENT PERFORMANCE OF WILD RICE (MEAN ± S.E.).

Plant characteristic	Treatment: cleared n = 79	Treatment: uncleared n = 93
Number of tillers per plant	0.23 ± 0.06	1.82 ± 0.17*
Stem length (cm)	141.8 ± 4.6	140.2 ± 3.2
Stem diameter (cm)	5.58 ± 0.21	5.66 ± 0.24
Number of seeds per panicle	32.4 ± 1.6	44.8 ± 2.0*
Shoot weight (gm)	3.49 ± 0.21	7.31 ± 0.63
Potential yield (kg ha^{-1})	1251.1 ± 60.3	1208.1 ± 53.5
Straw production (kg ha^{-1})	2746.3 ± 146.7	1751.9 ± 60.6*

*mean values are significantly different at $p \leq 0.05$.

is well below the cost of operating the equipment. Thus, removal of straw in the spring appears to be unjustified as an annual stand management practise.

Straw mulching. Mean stem density ranged from 237.0 to 263.1 stems m^{-2} in the treatment plots compared to 217.8 stems m^{-2} in the control plot (Table 3). Tillering was not profuse on any plants, and no significant differences were detected between treatments. Compared to the control plots, stem length was significantly reduced by both surface cut treatments, and all treatments resulted in significantly thinner stems. The average number of seeds per panicle ranged from 17.3 for treatment B to 20.1 for treatment D. Seed production on the control plants averaged 19.9 per panicle: this was equivalent to a potential yield of (1534.6 kg ha^{-1}). Potential yields for treatment C (1827.4 kg ha^{-1}), treatment D (1988.6 kg ha^{-1}), and treatment A (1911.6 kg ha^{-1}) were all significantly greater than the control. Only treatment B (1546.6 kg ha^{-1}) failed to increase potential yield significantly compared with the control. This was also the only treatment that resulted in reduced straw production.

The most significant increase in seed production resulted from the deep cut, mulch treatment. This suggests that it is not simply maximum straw removal that is important for significant stand improvement. Rather, suitable growing conditions result if straw bulk can be reduced while still retaining its constituent nutrients. Keenan and Lee (1988) have reported reductions in sediment nitrogen levels as high as 20 g m^{-2} over a 6-year period in a productive wild rice lake in Ontario. Because of the ban on fertilizer application in natural water bodies in Saskatchewan, straw mulching is viewed by some growers as a method of maintaining sediment nutrient levels. However, no equipment is presently available to carry out this work on a commercial basis in northern Saskatchewan. The improved yields noted in the deep cut, mulch plots represent a gross return of about $550 ha^{-1} to the grower. However, construction, operation and transport costs would considerably reduce this sum. In addition, most growers have insufficient acreage to justify added expenditures in an industry which presently realizes only marginal returns. Finally, it should be noted that the time between the end of harvest and lake freeze up is often very short. Indeed, during this period of field work a 1 cm crust of ice developed over the lake each night. In the spring, the new crop often begins germination before the ice is off the lake. This leaves very little time for stand management activities, which at best can only marginally enhance the profitability of the crop in this region.

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TABLE 3. THE EFFECT OF DIFFERENT STRAW TREATMENTS (MEAN ± S.E.) ON WILD RICE PERFORMANCE IN THE FOLLOWING GROWING SEASON.

Plant characteristic	Straw treatment[1]: A n = 55	B n = 64	C n = 60	D n = 48	Control n = 53
Stand density (stems m^{-2})	251.3 ± 16.3ab[2]	237.0 ± 17.2b	257.0 ± 15.5ab	263.1 ± 16.4a	217.8 ± 13.3c
Numbers of tillers per plant	0.11 ± 0.05a	0.03 ± 0.02a	0.02 ± 0.02a	0 ± 0a	0.02 ± 0.02a
Stem length (cm)	149.8 ± 2.5bc	148.3 ± 3.4c	153.3 ± 2.5b	155.8 ± 2.6ab	161.3 ± 2.1a
Stem diameter (mm)	3.26 ± 0.12bc	2.95 ± 0.11cd	2.92 ± 0.10d	3.33 ± 0.14b	3.62 ± 0.12a
Number of seeds per panicle	18.7 ± 1.1ab	17.3 ± 0.9b	18.3 ± 1.0ab	20.1 ± 1.3a	19.9 ± 0.8a
Shoot weight (gm)	1.77 ± 0.11b	1.70 ± 0.13b	1.65 ± 0.10b	1.93 ± 0.14ab	2.19 ± 0.11a
Potential yield (kg ha^{-1})	1911.6 ± 144.8a	1546.6 ± 89.8b	1827.4 ± 116.0a	1988.6 ± 132.1a	1534.6 ± 72.7b
Straw production (kg ha^{-1})	4007.2 ± 285.0ab	3911.7 ± 273.1c	4256.1 ± 239.2ab	4960.1 ± 326.7a	3999.1 ± 183.2bc

[1]See text for details of the straw treatments used.
[2]Mean values followed by the same letter in a horizontal line are not significantly different at $p \leq 0.05$.

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