Identification of Factors Involved in Wild Rice Flower Development.

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INTRODUCTION

Wild rice (*Zizania palustris* var. interior L) is a native aquatic natural resource with important functions in both wetland habitats and agricultural settings. Important aspects of our research are to identify genetic factors and environmental control for flower development. Information obtained from this research is vital in achieving an overall understanding of wild rice reproduction. This understanding will lead to better adaptations in wild rice growth and seed production.

The transition zone (TZ) of wild rice has been identified as the formation of hermaphroditic spikelets in the branch at the junction between the staminate and pistillate portions of the panicle from previous research (Liu and Troska, 1995; Liu et al, in press.). In this study, genetic effect on formation of the transition zone has been identified in some tillers of individual plants. Environmental effects on wild rice flower development have also been examined. A relative large sample size has been investigated to gain some quantitative information on the development of wild rice flower by combined field and lab research. The associations of TZ formation and anthesis with nitrogen levels and population density are explored.

MATERIALS AND METHODS

The different populations of wild rice (*Zizania palustris*) were grown at the University of Minnesota North Central Experiment Station in Grand Rapids during the summer of 1997. The data collection took place at a time when anthesis was at peak level.

To identify the genetic effect on TZ formation, the experiment consisted of two separate nutrient and population density extremes. One group of plants was subjected to no nitrogen fertilizer applications (topdresses) with a population density of 16 plants/ square foot (low nitrogen, high density). The second sampling group contained plants treated with two nitrogen topdresses and a population density of 4 plants/ square foot (high nitrogen, low density). Each treatment was then replicated three times in this experiment. Ten plants from each replicate of different treatments were identified as having a main-stem with a transition zone (TZ). Then the number of tillers with a TZ were counted in relation to the total number of tillers on that plant. A percentage of the number of TZ tillers vs. the total number of tillers in a plant was subsequently obtained. Percentage of the total number of TZ tillers in a treatment vs. the total number of tillers in that treatment was also obtained. The percentage of plants where one TZ tiller exists with

another TZ tiller on the same plant was also identified.

The experiment of testing nutrient and density effects consisted of two separate nutrient treatments with different population densities. These include: 1) no nitrogen fertilizer applications (topdresses) with a population of various plant density; 2) plants treated with two nitrogen topdresses and different population densities. Identification of the TZ and anthesis in flower development was done in the field by observation according to (Liu et al in press.). The data was then recorded in the field. This raw data was then brought back to the Duluth lab to be processed and analyzed using the Excel program.

In addition, different concentrations (low and high) of ethylene have been applied to the inner leaf sheath weekly for four weeks to test hormonal effects for flower development. Hormonal treatments were performed 4 weeks before anthesis. Analysis of flower developmental sequences has also been established by using computer image analysis in the lab. according to well-developed methods (Liu et al, in press.)

RESULTS AND DISCUSSION

Nitrogen and population density effects on TZ formation in the Franklin cultivar of wild rice (*Zizania palustris*) have been evaluated. Stages of flower development indicated by anthesis were measured in different treatments (Table 1 and Table 2). The large differences in timing of flower development have not been observed in both high (Table 1) and low (Table 2) nitrogen treatments with various plant density in the same population. However, an over all high degree of TZ formation have been identified in low nitrogen treatments (Table 4) compared with that of high nitrogen treatments (Table 3). In both low and high nitrogen treatments, density have some effects on TZ formation. In both case, low densities appears to lead more TZ account than high densities (Table 3 and 4). These results showed that TZ formation was affected by environmental variables. It can be further concluded that environmental factors (nutrient level and population density) have some degree of effects on floral development in wild rice.

The high degree of genetic effect on TZ formation has been identified. In low nitrogen and high density samples, an overall TZ percentage is 58.3 (Table 4). The percentage of plants where for every one TZ tiller that exists, there is another TZ tiller on that same plant is 96.7% (Table 5). In the high nitrogen and low density samples, an overall TZ percentage is 67 % (Table 5). The percentage of plants where for every one TZ tiller that exists, there is another TZ tiller on that same plant is 90% (Table 5). The high degree of correlation of a TZ in tillers from the same individual plants in different treatments suggests that there are significant genetic effects on flower development. For example, in both treatments there is at least a 90% chance of a plant having 2 TZ tillers on the same plant. In contrast, there is 10% chance of only one TZ tiller existing on an entire plant. These results showed that the occurrence of the TZ within plants is not a random developmental event. When a TZ occurs on the tiller in some plant, the chance of it being found again on another tiller within that same plant is at least 90%. This finding has significant applications in the field research. In particular, making genetic crosses to yield seeds for TZ plants. For instance, when a researcher goes to make a TZ cross, they know to only cross tillers of plants that have a main-stem with a TZ on it. This is of

particular importance because the crosses have to be made before emergence. This is a period in which you otherwise would not be able to see any TZ's on the pre-emerged tillers.

Our preliminary research indicated some hormonal effects on time of anthesis (data not shown). We are interested in testing hormonal effects on flower sex changes in the future research. In addition, computer image analysis also showed that bisexual flowers were initiated during the early stage of flower development in different wild rice populations (data not shown). In the future research, a critical index will be developed to measure how long the bisexual flower structures exist during development. The transition stage leading to formation of unisexual florets from bisexual floret will also be determined.

As a summary, results in this paper indicate that certain characteristics for floral development are affected by environmental factors (nitrogen level and population density). The occurrence of the TZ within a plant is a genetically determined trait and is not a random developmental event.

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References

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Table 1: Effects of high nitrogen concentration and various plant densities on anthesis of the wild rice flower.

	SUM	RATIO	MEAN	STANDARD ERROR
N=High. Den=0.5 plants/ft^2:				
Anthesis	53		17.67	5.36
Not Anthesis	46	1.2	15.33	1.201
N=High. Den=1 plant/ft^2:				
Anthesis	71		23.67	1.86
Not Anthesis	48	1.5	16	1.53
N=High. Den=2 plants/ft^2:				
Anthesis	70		23.33	2.91
Not Anthesis	50	1.4	16.67	2.91
N=High. Den=4 plants/ft^2:				
Anthesis	77		25.67	1.202
Not Anthesis	43	1.8	14.33	1.202
N=High. Den=8 plants/ft^2:				
Anthesis	63		21	2.65
Not Anthesis	57	1.1	19	2.65
N=High. Den=16 plants/ft^2:				
Anthesis	77		25.67	1.67
Not Anthesis	43	1.8	14.33	1.67

Table 2: Effects of low nitrogen concentration and various plant densities on anthesis of the wild rice flower.

	SUM	RATIO	MEAN	STANDARD ERROR
N=Low. Den=0.5 plants/ft^2:				
Anthesis	63		21	3.21
Not Anthesis	40	1.6	13.33	0.33
N= Low. Den=1 plant/ft^2:				
Anthesis	85		28.33	4.91
Not Anthesis	45	1.9	15	1.73
N= Low. Den=2 plants/ft^2:				
Anthesis	69		23	3.61
Not Anthesis	51	1.4	17	3.61
N= Low. Den=4 plants/ft^2:				
Anthesis	70		23.33	3.17
Not Anthesis	50	1.4	16.67	3.18
N= Low. Den=8 plants/ft^2:				
Anthesis	70		23.33	0.33
Not Anthesis	50	1.4	16.67	0.33
N= Low. Den=16 plants/ft^2:				
Anthesis	80		26.67	0.88
Not Anthesis	40	2	13.33	0.88

Table 3: Effects of high nitrogen concentration and various plant densities on the presence of the TZ on the wild rice flower.

	SUM	RATIO	MEAN	STANDARD ERROR
N=High. Den=0.5 plants/ft^2:				
W/TZ	31		10.33	2.19
W/o TZ	29	1.1	9.67	3.28
N=High. Den=1 plant/ft^2:				
W/TZ	55		18.33	0.88
W/o TZ	55	1	18.33	0.88
N=High. Den=2 plants/ft^2:				
W/TZ	53		17.67	1.86
W/o TZ	61	0.9	20.33	3.48
N=High. Den=4 plants/ft^2:				
W/TZ	56		18.67	2.96
W/o TZ	61	0.9	20.33	3.76
N=High. Den=8 plants/ft^2:				
W/TZ	52		17.33	2.85
W/o TZ	68	0.8	22.67	2.85
N=High. Den=16 plants/ft^2:				
W/TZ	46		15.33	2.33
W/o TZ	74	0.6	24.67	2.33

Table 4: Effects of low nitrogen concentration and various plant densities on the presence of the TZ on the wild rice flower.

	SUM	RATIO	MEAN	STANDARD ERROR
N=Low. Den=0.5 plants/ft^2:				
W/TZ	38		12.67	1.202
W/o TZ	31	1.2	10.33	1.45
N= Low. Den=1 plant/ft^2:				
W/TZ	67		22.33	0.67
W/o TZ	46	1.5	15.33	0.88
N= Low. Den=2 plants/ft^2:				
W/TZ	68		22.67	1.20
W/o TZ	52	1.3	17.33	1.20
N= Low. Den=4 plants/ft^2:				
W/TZ	48		16	1.73
W/o TZ	73	0.67	24.33	1.76
N= Low. Den=8 plants/ft^2:				
W/TZ	52		17.33	1.45
W/o TZ	68	0.76	22.67	1.45
N= Low. Den=16 plants/ft^2:				
W/TZ	58		19.33	2.73
W/o TZ	62	0.94	20.67	2.73

Table 5: Represented is two extremes for nitrogen concentration and plant density. In relation to these two extremes is the total # of tillers with and without TZ's. Also present is % plants with ≥2 TZ tillers on some plant.

Treatment	Total # Tillers*	Tillers W/TZ	≥2 Tillers in same plant (%).	Total (%) of TZ plants in treatment.
N=High. Den=Low.	127	85	90	67
N=High. Den=Low.	168	98	96.7	58.3

* Three replications for each treatment with ten plants counted in each replication.