GIBBERELLIC ACID USE IN STALE SEED BED RICE PRODUCTION

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Abstract. Uniform emergence and adequate stand establishment are often difficult to obtainin drill-seeded rice (Oryzagativa L.)cultural systems, especially with semidwarf varieties. Gibberellic acid (GA) is a plant growth regulator that has been shown to be effective as a seed treatment in these systems and has improved both uniformity in emergence and stand density. The use of GA seed treatments is very common in conventional tillage rice systems. It is not known how effective GA is in a stale seedbed rice system, where uniform emergence and stand establishment difficulties often occur. An experiment was conducted in 1997-1998 to evaluate a GA seed treatment in a stale seedbed rice system. Two levels of seed treatment (with and without GA) and four levels of seeding rate (50, 75, 100, and 125 lb/A in 1997; 25, 50, 75, and 100 lb/A in 1998) were utilized each year. In 1997, the study was conducted on a fall-prepared stale seedbed only. In 1998, two levels of tillage (conventional tillage and fall-prepared stale seedbed) were utilized. The variety Cypress was planted into a drill-seeded and delayed flood cultural system. Emergence, stand density, days to 50% heading, plant height, grain moisture, and grain yield were determined. Emergence and final stand density were increased with both GA seed treatment and increasing seeding rate in 1997, while seeding rate and tillage method influenced stand density in 1998. Seed treatment had a small effect on stand density 8 days after planting (DAP), but final stand densities at 28 DAP were similar. Plant height and grain moisture were not affected by seeding rate or seed treatment in 1997. Seeding rate did affect plant height in 1998, and height was slightly reduced at the two higher seeding rates. Grain moisture was lower with the GA seed treatment in 1997 but not in 1998. Grain yields were significantly lower with a 50-lb/A seeding rate and no seed treatment in 1997. Grain yields of all other treatment combinations were similar. In 1998, grain yield was affected by seeding rate and tillage, while GA seed treatment had no effect. Grain yields were much lower at the 25-lb/A seeding rate, and grain yields with conventional tillage were significantly higher than those with a stale seedbed system. Gibberellic acid seed treatment appears to be effective in improving emergence and stand establishment in stale seedbed rice. Higher seeding rates in stale seedbed systems will still be required to optimize both stand densities and grain yields.

INTRODUCTION

The first semidwarf rice variety developed in the U.S. was released for commercial production in 1982. The semidwarf characteristic offered a number of advantages over conventional or tall stature rice varieties. Improved lodging resistance, higher yield potential in both the main and ratoon crops, and more response to N fertilizers have resulted in semidwarf rice varieties dominating the southern rice-growing region. While the semidwarf varieties have increased yields and profitability in rice, it was soon recognized that poor seedling vigor and emergence were typical varietal characteristics that resulted in poor stand establishment and potential yield reductions. It was first reported in Louisiana that gibberellic acid (GA), a plant growth regulator, was effective in improving emergence in semidwarf rice varieties by increasing coleoptile and mesocotyl length (Dunand, 1987). Research in Arkansas reported similar results (Helms et al., 1988).

Earlier research with GA seed treatments was confined to conventional tillage systems (Dunand, 1993). In recent years, there has been considerable interest in stale seedbed rice production, and acreage devoted to this practice continues to increase. Rice emergence and stand establishment can be difficult in stale seedbed systems as well (Bollich, 1991). Soil compaction, inadequate moisture, and preplant vegetation are factors that contribute to poor stand establishment. The use of GA to enhance emergence in stale seedbeds offers potential to offset these undesirable conditions. The objectives of this study were to (1) evaluate the use of a GA seed treatment in stale seedbed rice and (2) determine the effect of seeding rate in combination with GA on rice emergence, stand establishment, and crop production.

MATERIALS AND METHODS

A 2-year study was conducted to evaluate the effectiveness of GA seed treatment on emergence and stand establishment of rice planted into a stale seedbed. The study was conducted at the South Unit of the Rice Research Station, Crowley, LA. The soil type was a Crowley silt loam (fine, mixed, thermic Typic Albaqualfs) typical of the southwest Louisiana rice-producing region. A randomized complete block design was used, with a 2 x 4 factorial arrangement of GA levels and seeding rates in 1997 and with a 2 x 4 x 2 factorial arrangement of GA levels, seeding rates, and tillage types in 1998. Gibberellic acid levels included none and a 1-g/cwt application each year. Seeding rates included 50, 75, 100, and 125 lb/A in 1997. In 1998, seeding rates were lowered to 25, 50, 75, and 100 lb/A. The study was conducted on a fall-prepared stale seedbed in 1997, while conventional tillage and a fall-prepared stale seedbed were evaluated in 1998. The stale seedbeds were prepared in October preceding rice planting each year. Preplant vegetation in the stale seedbed was controlled with Roundup Ultra at 1.0 lb ai/A and Gramoxone Extra at 0.62 lb ai/A. Tillage in the conventional seedbed was performed just prior to planting in 1998. A complete N-P-K fertilizer (21-63-63 in 1997; 30-60-60 in 1998) was applied preplant each year. A Marliss no-till grain drill with a 7-inch drill spacing was used to seed the stale seedbed treatments. A conventional drill with similar drill spacing was used to seed the conventional treatments. The variety Cypress was planted each year. Planting depth in the stale seedbed in 1997 and 1998 was 2 in and ½ in, respectively. Planting depth in the conventional seedbed in 1998 was 1 ½ in. The experiments were flush irrigated as needed to encourage emergence and stand establishment. At the 4-leaf growth stage, urea N was applied at rates of 90 and 150 lb N/A in 1997 and 1998, respectively. A permanent flood was then established and maintained until harvest drainage 75 to 80 days later. Pest control was conducted as required according to current labeled recommendations.

In 1997, stand density was determined at 11, 13, 18, 21, and 28 days after planting (DAP). In 1998, stand density was determined at 8 and 24 days after planting. Plant height, days to 50% heading (only in 1998) grain moisture, and grain yield were determined each year. Data were statistically analyzed using Anova procedures and Duncan's Multiple Range Test was used for mean separation (Gylling and Gylling, 1983).

RESULTS

Emergence and final stand densities were increased with GA seed treatment and by increasing seeding rate in 1997 (Table 1). Emergence was very low at 11, 13, and 18 DAP, and GA seed treatment increased stand density by 50%. As seeding rate increased during the early emergence stages, stand density also increased slightly. During the later stages of emergence (21 and 28 DAP), the GA was less effective with only a 10% average increase in stand density. Final stand densities increased as seeding rate increased, but stand density with the 50 lb/A seeding rate was below the minimum 10 plants/ft^2 required for optimizing grain yield. According to current recommendations, the optimum stand density for rice is 15 to 20 plants/ft^2 (Linscombe et al., 1999). Rice can be successfully produced at slightly lower stand densities with intensive management. Seed treatment and seeding rate affected emergence and final stand densities independently, and there were no interactions between these two factors.

Mature plant height was not affected by either GA seed treatment or increasing seeding rate. Research previously conducted in conventional tillage systems indicates that GA seed treatments have only minor effects on these variables (Dunand, 1992a). An interaction occurred between GA and seeding rate for both grain moisture and grain yield. Grain moisture was significantly lower with GA at the 50-lb/A seeding rate, while grain moistures at the other seeding rates were not influenced by GA seed treatment. The higher grain moisture at the 50-lb/A seeding rate without GA seed treatment was due to the extremely low stand density. Since a uniform application of N was applied on all treatments, N was probably excessive in this treatment due to the low stand density. Grain yield was also significantly increased by GA seed treatment at the lowest seeding rate of 50 lb/A, and GA had no effect at the other seeding rates. Previous research has also shown that GA has no direct effect on grain yield, but rather indirectly influences yield by affecting stand density (Dunand, 1992b). In this instance, there was a tremendous increase in stand density with GA. Final stand density with a seeding rate of 50 lb/A and no GA seed treatment was only 2 plants/ft^2, while at the same seeding rate with GA seed treatment, the final stand density was 7 plants/ft^2.

In 1998, emergence was affected by tillage and seeding rate (Table 2). Stand densities were higher with conventional tillage, and stand densities did not change from the initial evaluation at 8 DAP to the final determination at 24 DAP. Stand densities on the stale seedbed increased 33% between 8 and 24 DAP. There was an interaction between tillage and seeding rate for initial stand densities. With conventional tillage, initial stands increased 4 plants/ft^2 with each 25-lb/A seeding rate increase. With the stale seedbed, the increase was only 2 plants/ft^2 up to the 75-lb/A seeding rate and only 1 plant/ft^2 thereafter. There was a slight effect of GA seed treatment, and initial stand density increased by an average of 10% over the control at each seeding rate, regardless of tillage. Final stand densities were affected by tillage and seeding rate independently, and there was no interaction between these two factors. With conventional tillage, final stands exceeded the minimum of 10 plants/ft^2 at all seeding rates except the lowest rate of 25 lb/A. With the stale seedbed, final stands exceeded the minimum at the 75- and 100-lb/A seeding rates. The GA seed treatment had no effect on final stand. Plant growth regulator seed treatments are generally most effective on final stand densities with planting depths of at least 1 ½ in. In the conventional tillage seedbed, there was adequate soil moisture for germination and emergence at a 1 in depth, and planting any deeper was unnecessary. In contrast, the very firm stale seedbed resulted in a much more shallow seed placement where soil moisture was inadequate for proper germination and emergence. Most of the rice in the stale seedbed did not emerge until the experiment was flushed two weeks after planting, and some of the shallow-planted seed may have lost viability during that period.

Plant stature, crop maturity, and grain yield were affected differentially by tillage and seeding rate. The GA seed treatment had no influence on any of these variables. Mature plant height was affected only by seeding rate and decreased slightly with increasing seeding rate. An interaction occurred for days to 50% heading between tillage and seeding rate. Maturity was delayed by the 25-lb/A seeding rate in the conventional seedbed only but was delayed by the 25- and 50-lb/A seeding rate in the stale seedbed. Maturity was generally delayed at the lower seeding rates as was grain moisture in 1997 and was again a function of plant population and available fertilizer N. Grain moisture was affected in the same manner as days to 50% heading. Grain moisture was higher with the stale seedbed but decreased as seeding rate increased. This response was also thought to be due to differential plant population and available fertilizer N. The differences shown in grain moisture due to tillage and seeding rate approximate a difference of 1 to 2 days.

Overall grain yields with a 25-lb/A seeding rate were significantly lower than the yields resulting from all other seeding rates. Grain yield with the 75-lb/A seeding rate was also higher than the yield resulting from the 50-lb/A seeding rate. Yields were similar with seeding rates of 75 and 100 lb/A. Grain yield was significantly higher with conventional tillage and was probably due to higher stand densities.

DISCUSSION

These results indicate that GA seed treatment can improve emergence and stand establishment in stale seedbed rice when planting deep (> 1 ½ in). These effects are magnified as seeding rate decreases below the recommended seeding rate of 90 to 110 lb/A (Saichuk et al., 1998). In contrast, there are no benefits from GA with shallow planting.

When GA seed treatment increases seedling populations above the suboptimal level (<10 plants/ft^2), yield increases are due to higher stand densities. Similar effects of stand density on grain production are produced with increases in seeding rate under both conventional and stale seedbed tillage systems, and when conventional seedbed preparation permits planting to moisture and stale seedbed preparation does not.

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Table 1. The Effects of Seeding Rate and Gibberellic Acid(GA) Seed Treatment on Seedling Vigor and Crop Production in Stale Seedbed, Drill-seeded Rice. Rice Research Station, South Unit. Crowley, La. 1997.

Seeding rate	GA rate	Stand density (DAP)[1] 11	13	18	21	28	Plant height	Grain moisture	Grain yield at 12% moisture
lb/A	g/cwt	plants/ft^2					in	%	lb/A
50	0	1	1	2	2	2	41	22.4a	4271b
75	0	2	2	4	9	8	41	20.5ab	6186a
100	0	3	3	5	10	10	42	20.2b	6976a
125	0	3	3	7	14	14	41	19.3b	6627a
50	1	2	3	4	7	7	42	20.3b	6822a
75	1	3	4	5	10	10	41	19.5b	6387a
10	1	4	4	6	11	11	42	20.3b	6423a
125	1	4	4	8	14	14	42	20.0b	6417a
C.V., %		43.84	42.02	32.29	18.66	24.71	1.31	6.47	10.38
Standard deviation		1.14	1.14	1.61	1.80	2.31	1.38	1.31	650.2
						Main effects			
GA:									
0		2a	2a	4a	9a	9a	41	20.6	6015
1		3b	3b	6b	11b	10b	42	20.0	6468
Seeding rate									
50		1a	2a	3a	5a	4a	42	21.3	5546
75		2ab	3ab	5b	9b	9b	41	20.0	6286
100		3bc	3ab	6bc	11c	10b	42	20.2	6610
125		4c	4b	7c	14d	14c	41	19.6	6522
Interaction:									
GA x seeding rate		ns	ns	ns	ns	ns	ns	*	*

[1] Means followed by the same letter do not significantly differ (Duncan's Multiple Range Test, P=0.05). Discrepancies among mean stand density values and mean separation indicators are due to rounding.

Table 2. The Effects of Seeding Rate, Ga Seed Treatment, and Tillage on Seedling Vigor and Crop Production in Drill-Seeded Rice. Rice Research Station, South Unit. Crowley, La. 1998.

Seeding rate	Tillage	Stand density (DAP)[1] 8	Stand density (DAP)[1] 24	Days to 50% heading	Plant height	Grain moisture	Grain yield at 12% moisture
lb/A		plants/ft²			in	%	lb/A
25	Conventional	5ghi	6fg	88ab	36	20.4bcd	6736b-e
50	Conventional	11cd	11cd	84d	36	20.0cd	7261abc
75	Conventional	13c	15ab	84d	35	20.3bcd	7233abc
100	Conventional	19b	17a	83d	35	20.2cd	7296abc
25	Stale	2j	4g	90a	37	21.0b	5989fg
50	Stale	4ij	8ef	87bc	36	20.7bc	6517def
75	Stale	8d-g	13bcd	84cd	35	20.4bcd	6821b-e
100	Stale	9def	14abc	84d	36	20.0cd	7029bcd
C.V., %		21.69	18.88	2.29	1.81	2.08	5.82
Standard deviation		2.00	1.99	2.08	1.54	0.42	398.8
				Main Effects			
GA:							
0		9a	11	85	36	20.4	6860
1		10b	10	85	35	20.5	6842
Seeding rate:							
25		4	5a	88	37a	20.9a	6299a
50		7	9b	86	36ab	20.4b	6833b
75		11	13c	84	35b	20.3b	7164c
100		15	14c	83	35b	20.1b	7109bc
Tillage:							
Conventional		13	12a	84	36	20.2a	7189a
Stale		6	9b	86	36	20.6b	6513b
Interactions:							
GA x seeding rate		ns	ns	ns	ns	ns	ns
GA x tillage		ns	ns	ns	ns	ns	ns
Seeding rate x tillage		*	ns	*	ns	ns	ns
GA x seeding rate x tillage		ns	ns	ns	ns	ns	ns

[1] Means followed by the same letter do not significantly differ (Duncan's Multiple Range Test, P=0.05). Discrepancies among mean stand density values and mean separation indicators are due to rounding.