Effect of water management practices on N uptake, N use efficiency, and grain yield of rice grown in south Louisiana

M. Kongchum, D. L. Harrell, and S. D. Linscombe

H. Rouse Caffey Rice Research Station, Louisiana State University Agricultural Center, Rayne, Louisiana, USA

POSTER PRESENTATION

Abstract

Rice growth is dependent upon an adequate of supply of water which is becoming a limited resource. Producing one kilogram of irrigated rough rice is estimated to require between 600 to 2,000 liters of water, depending on the local climate, soil type, and rice variety. A field experiment was conducted at the Louisiana State University Agricultural Center H. Rouse Caffey Rice Research Station to evaluate the effect of water management practices on rice grain yield, nitrogen uptake and nitrogen use efficiency. The water management practices included conventional flooding, alternate wetting and drying irrigation and aerobic rice production systems. Four nitrogen rates of 0, 100, 135, and 170 kg N ha^{-1} were split applied one day before flooding and at panicle initiation utilizing two rice varieties; CL153 and CLXL729. Plant samples were collected at 50% heading for determining biomass and nitrogen uptake. Grain yield and yield components were obtained at harvest.

Nitrogen uptake was greater in the treatments received higher nitrogen application rates in all three water management treatments. The highest N uptake was observed in the alternate wet and dry treatment (135.6 kg N ha^{-1}) for variety CLXL729 receiving 170 kg N ha^{-1}. The highest grain yield was also measured in the alternate wetting and drying flooding treatment (12176 kg ha^{-1}).

Keywords: water management practices, drill-seeded, delayed flood, N uptake, nitrogen use efficiency

Introduction

Rice production is facing increasing competition from rapid urban and industrial development in terms of available freshwater resource (Bouman and Toung, 2001). Rice cultivation requires major use of water, and across the globe about one quarter to one-third of the world's developed freshwater resources are used to irrigate rice (Bouman, 2009). Today's rice production is facing increasing concerns of freshwater shortages due to water salinization of and drought events (Tuong and Bouman, 2003). The need for producing more rice with less water is crucial for food security, with irrigation playing a greater role in meeting future food needs than it in the past (Toung et al., 2004). Traditional continuous flooding for water seeded rice system provides a favorable water and nutrient supply under anaerobic conditions. However, the conventional system consumes a large amount of water (Nguyen et al., 2009). A number of water-saving technologies to reduce water use, to increase water use efficiency, and to maintain or increase production for rice-based systems have been developed in various rice growing areas. One of the most commonly practiced WSI techniques is alternate wetting and drying (AWD) irrigation (Bouman and Toung, 2001; Belder et al., 2004). In AWD, water is applied to irrigate the field depending on the weather condition and rice growth stages.

Globally there is increasing occurrence of extreme weather events including drought due to climate change, which can have significant impacts on rice agroecosystems. Water supply and timely flooding of fields are essential for optimum rice production (Bouman, 2009). With the high demand for water from all sectors, it has been estimated that by 2050, 15-20 million hectares of irrigated rice will suffer from some degree of water scarcity worldwide (Bouman and Aureus, 2009).

Rice in the United States is grown under a fully controlled irrigation water system. In Louisiana, there are various water management practices in rice farming, including delayed flooding, pinpoint flooding, and continuous flooding (Street and Bollich, 2002). On-farm wells are the major source of irrigation water for rice cultivation even though the region receives substantial rainfall. Dry seed delayed flood system is the predominant, where fields are dried approximately 3-4 weeks before permanent flood is applied.

While earlier research findings tended to emphasize that rice grain yield was highly related to the amount of water use (i.e. Castillo et al., 1992), some more recent studies have shown that rice grain yield could be potentially increased through alternative wetting and drying treatment (i.e. Zhao et al., 2009).

With unpredicted climate change scenarios, reducing water use is becoming increasingly important. The objective of this study is to investigate effect of water management practices for drill-seeded delayed flood system on nitrogen uptake, nitrogen use efficiency, and grain yield.

Material and methods

A field experiment was conducted to evaluate effect of water management practices on rice grain yield and nitrogen uptake at H. Rouse Caffey Rice Research Station, LSU Agricultural Center in 2016. Three water management practices included conventional flooding (delayed flooding), alternate wetting and drying, and aerobic irrigation were set as a main variable. Two rice varieties, CL153 and CLXL729 were grown in these water management systems. Nitrogen (urea) was equally split applied 2 times at 1 day before flooding and mid-season (panicle initiation) at the rate of 0, 100, 135, and 170 kg N ha^{-1}.

Nitrogen content and uptake were analyzed at 50% heading. Nitrogen use efficiency was also calculated at this growth stage. Yield and yield performance were collected at harvesting.

Results

Plant biomass at 50% heading was significantly different between water management treatments and nitrogen rates (Table 1). The lowest plant biomass was observed in aerobic water system. The higher N application rate was also resulted in greater biomass. Nitrogen uptake was also greater at the higher N application rate with the highest N uptake measured in alternate wetting and drying water management (135.6 kg N ha^{-1}). Grain yield was significantly different among water management treatments. Aerobic irrigation resulted in lowest grain yield in all nitrogen level as compared to conventional flooding and alternate wetting and drying.

Nitrogen use efficiency (NUE) was highest in alternate wetting and drying system at the N application rate of 100 kg ha^{-1} for variety CLXL729 (68%) followed by the same rate N rate and same variety in the aerobic system (66%). NUE appears to be greater in the treatment that had lower amount of water.

Table 1. Treatment means for the factorial analysis of the 3-way interaction (flooding systems, rice varieties, and N rates).

Description			Height	Moisture	Yield	Biomass	Tissue N	N Uptake	N fert Eff.
Rating Date			7/28/2016	7/28/2016	7/28/2016				
Rating Unit			cm	%	kg/ha	kg/ha	% N	kg/ha	%
Crop Stage Scale						50% HD	50% HD	50% HD	50% HD
Trt No.	Treatment Name	N Rate (kg/ha)							
1	Conventional flood CL153	0	77.5 hi	18.7 a-e	5989 gh	5516 fg	0.92 hij	50.4 hi	0 f
2	Conventional flood CL153	100	88.4 ef	19.2 a-d	9602 cde	8637 bcd	1.04 fgh	89.7 efg	39 de
3	Conventional flood CL153	135	92.7 cde	20.1 abc	10868 abc	9412 abc	1.24 cde	115.4 a-f	48 b-e
4	Conventional flood CL153	170	94.7 bcd	21.0 a	12066 a	8613 bcd	1.36 abc	117.7 a-e	40 de
5	Conventional flood CLXL729	0	90.9 def	16.9 d-g	7491 fg	7542 de	0.91 hij	68.4 gh	0 f
6	Conventional flood CLXL729	100	101.1 a	16.0 fg	10722 abc	9453 ab	1.15 efg	108.7 a-f	40 de
7	Conventional flood CLXL729	135	104.1 a	17.6 b-g	11419 ab	9738 ab	1.20 c-f	116.6 a-e	36 de
8	Conventional flood CLXL729	170	102.4 a	16.9 d-g	11439 ab	10499 a	1.22 cde	130.0 ab	36 de
9	Alternate Wet and Dry CL153	0	74.9 i	18.4 a-f	5899 h	4820 fg	0.88 hij	41.5 hi	0 f
10	Alternate Wet and Dry CL153	100	86.4 fg	19.2 a-d	9810 cde	9086 a-d	1.01 ghi	91.9 d-g	49 a-e
11	Alternate Wet and Dry CL153	135	91.4 def	20.5 a	10743 abc	9695 ab	1.31 b-e	126.7 ab	63 abc
12	Alternate Wet and Dry CL153	170	94.0 b-e	20.8 a	10987 abc	8197 bcd	1.21 c-f	98.6 c-f	31 e
13	Alternate Wet and Dry CLXL729	0	85.9 fg	15.7 g	5717 h	6408 ef	0.84 ij	53.8 hi	0 f
14	Alternate Wet and Dry CLXL729	100	93.5 b-e	15.8 fg	10862 abc	10473 a	1.18 def	125.5 abc	68 a
15	Alternate Wet and Dry CLXL729	135	98.6 abc	16.4 efg	11009 abc	9004 a-d	1.18 d-g	106.5 b-f	39 de
16	Alternate Wet and Dry CLXL729	170	99.1 ab	17.1 d-g	12176 a	9468 ab	1.42 ab	135.6 a	48 b-e
17	Aerobic CL153	0	68.6 j	20.3 ab	4652 h	4519 g	0.82 j	37.0 i	0 f
18	Aerobic CL153	100	81.3 gh	16.3 efg	9149 de	7371 de	1.20 c-f	88.5 fg	51 a-d
19	Aerobic CL153	135	82.0 gh	17.8 b-g	9626 cde	7969 b-e	1.30 b-e	103.1 b-f	49 a-e
20	Aerobic CL153	170	80.8 ghi	18.4 a-f	8884 ef	8136 b-e	1.53 a	124.4 abc	51 a-d
21	Aerobic CLXL729	0	82.0 gh	17.0 d-g	5836 h	4782 fg	0.92 hij	43.7 hi	0 f
22	Aerobic CLXL729	100	90.9 def	17.5 c-g	10287 b-e	8512 bcd	1.30 b-e	109.8 a-f	66 ab
23	Aerobic CLXL729	135	91.4 def	16.3 efg	10518 bcd	7493 de	1.34 bcd	98.6 c-f	41 de
24	Aerobic CLXL729	170	94.0 b-e	18.4 a-f	11456 ab	7659 cde	1.53 a	117.7 a-d	44 cde
LSD P=.05			6.1	2.68	1545	1771	0.173	27.6	19.7
Standard Deviation			4.3	1.89	1094	1255	0.123	19.5	13.9
CV			4.83	10.51	11.55	15.61	10.5	20.37	39.92
Replicate F			4.051	0.401	1.903	0.178	1.066	0.055	1.216
Replicate Prob(F)			0.0103	0.7524	0.1381	0.9112	0.3691	0.983	0.3104
Treatment F			17.41	3.085	17.319	7.731	11.619	9.688	10.432
Treatment Prob(F)			0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001

Means followed by the same letter or symbol do not significantly differ (P = 0.05, LSD)

Average grain yield over nitrogen rates was highest in the conventional flood irrigation but it was not significantly differ from the AWD. The hybrid CLXL729 had a higher grain yield than CL153 in all water management systems (Fig. 1). Nitrogen uptake for CL153 were 93, 90, and 89 kg ha^{-1} in CF, AWD and aerobic water system, respectively and the uptake of CLXL729 were 105, 105, and 93 kg ha^{-1} in CF, AWD, and aerobic water system, when averaged over N rates (Fig 2).

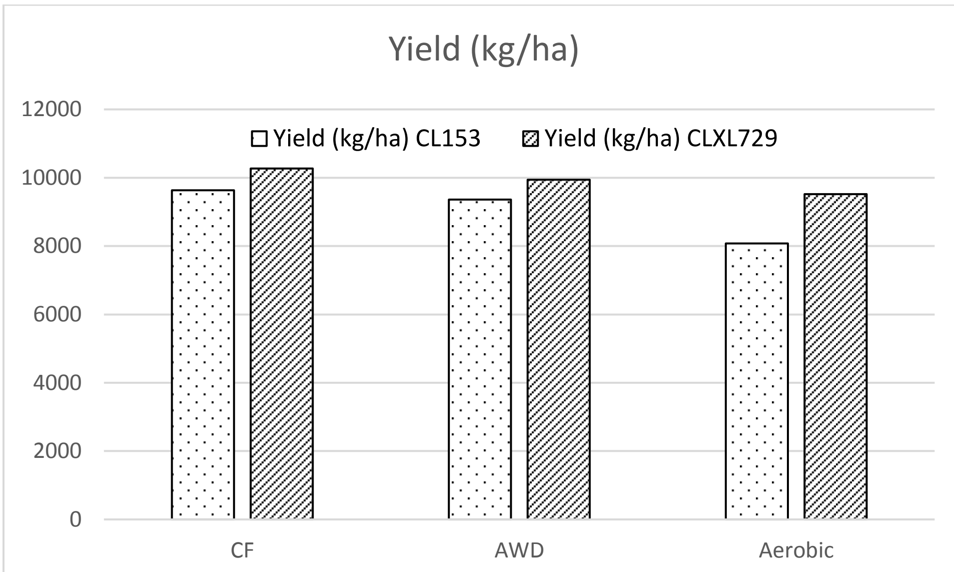

Figure 1. Effect of water management practices on grain yield (average over N rates).

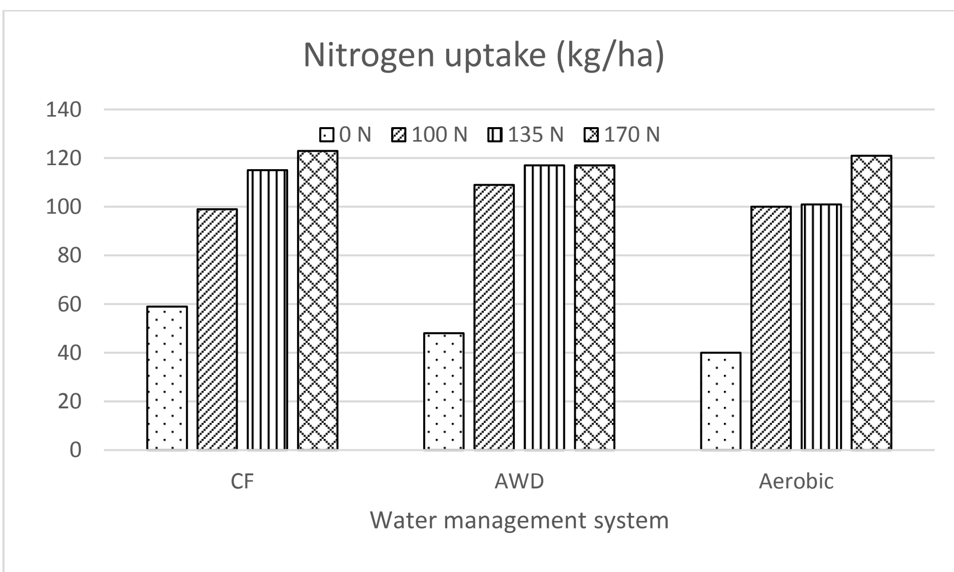

Figure 2. Effect of water management practices and N application rates on N uptake (average over 2 varieties).

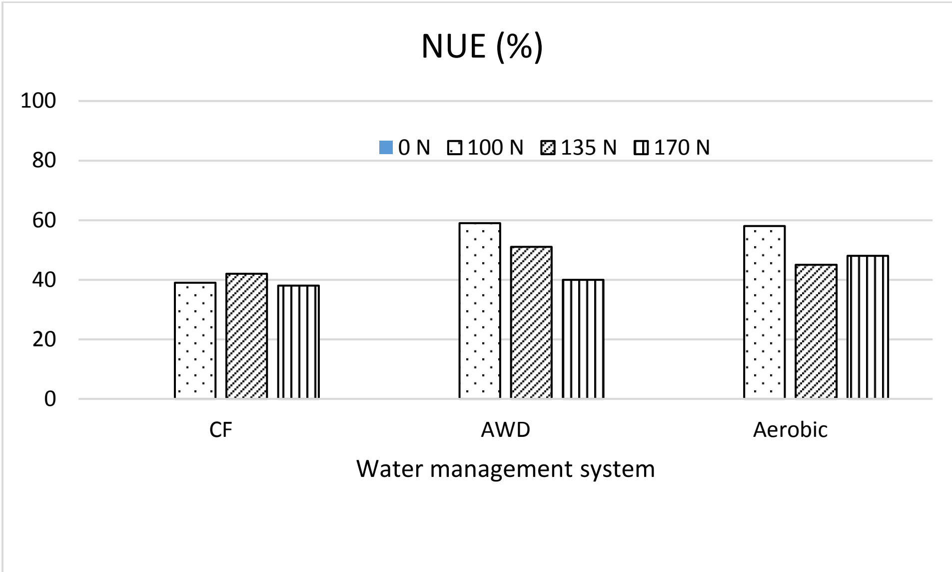

Figure 3. Effect of water management on nitrogen use efficiency (average over 2 varieties).

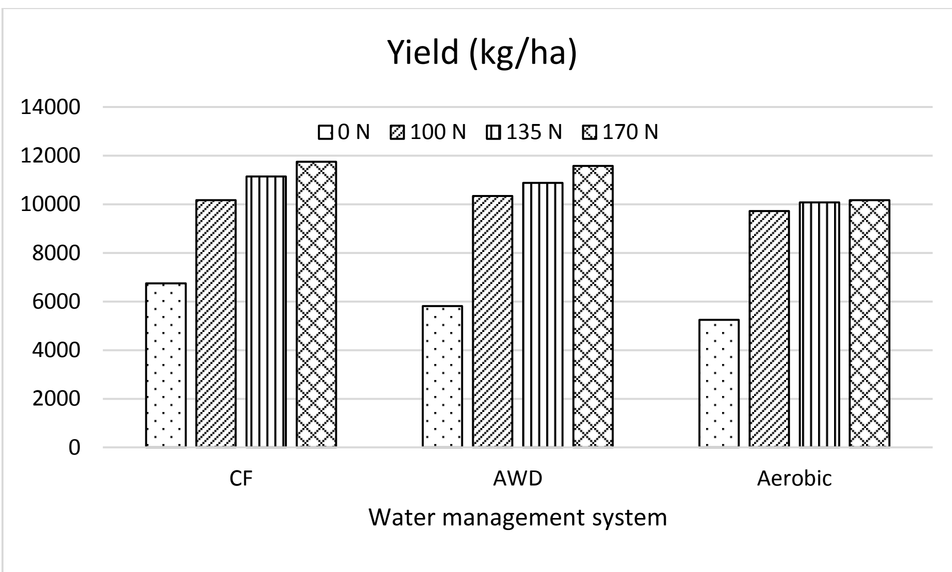

Figure 4. Effect of water management practices and N application rates on grain yield (average over 2 rice varieties).

Higher N application rates showed greater grain yield but was not significantly differ among 100, 135, and 170 kg N ha^{-1} (Fig 3). N uptake showed similar trend with the grain yield (Fig 4).

Conclusion

Grain yield in the AWD water treatment was slightly less than that for conventional flooding but was not significantly different. Nitrogen uptake and nitrogen use efficiency were significantly higher in the alternate wetting and drying as compared to conventional flooding. Our results indicated that alternate wetting and drying in the drill seeded, delayed flooded system could be used as an alternative water management practices.

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