Nitrogen Fertilization for Sprinkler Irrigated Rice

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Two challenges to pivot irrigated rice are nitrogen management and weed control. In 1988 and 1989, research at the Delta Center conducted by Steve Hefner and Paul Tracy showed fluctuating aerobic/anaerobic soil conditions inherent with a furrow-irrigated rice system may facilitate increased N losses. Soil and plant N concentrations indicated that the most efficient N application for furrow-irrigated rice occurred when the majority of N was applied 4 weeks after panicle differentiation.

A study was begun in 2008 to compare rice production with sprinkler irrigation to flood irrigation with different nitrogen fertilization programs. The objective is to reduce water use with sprinkler irrigated rice without using more nitrogen fertilizer or pesticides and produce equivalent or greater yields to flood irrigated rice. The research is partially funded by the Parks, Soils and Water Sales Tax and is administered by the Soil and Water Conservation Program in the Dept of Natural Resources. Valmont Industries, Inc. and Mid-Valley Irrigation donated the center pivot uses in the project.

Results from the first year of sprinkler irrigated rice research at the University of Missouri Delta Center indicate a water usage savings of 28% compared to the traditional flooding of rice fields. This comparison was made using a side inlet flooding system which has been shown to be up to 60% more efficient than the conventional cascade method of flooding. Additionally, grain yields from several sprinkler irrigated plots compared favorably and in many situations surpassed the grain yields with the same nitrogen treatments applied to the flooded study. During the course of these studies, many other production challenges were face. It has been our goal to meet these challenges with a systems approach as an alternative to developing entire studies to determine what may or may not work. Some of these challenges include selection of cultivars that may be better suited to this system, weed control programs and seeding rate adjustments. These studies have been and will continue to be conducted to determine if water, nitrogen and pesticide usage can be decreased with the use of sprinkler irrigation while producing equivalent or higher yield than in a flooded rice production system.

Application of treatments

Tests areas where sprinkler irrigation was to be used were planted on May 6, 2008 at the UM Delta Center Marsh Farm. The dry urea/flooded rice study used as a comparison was planted on May 23, 2008 at the UM Delta Center Lee Farm. First tiller nitrogen treatments for the sprinkler irrigated rice were applied on June 6 for both the dry urea and fertigation UAN studies. Flooded rice received the same treatments on June 23. The first fertigation treatment was applied in a split application on June 24 and July 1 due to a diluted solution being inadvertently used. The error was discovered and corrected. The subsequent fertigation treatments were applied with the correct rates on July 9, 16, 29 and August 13.

Midseason and late boot urea nitrogen treatments were applied on July 28 and August 13 for the pivot irrigated study, and on July 29 and August 15 for the flooded urea study.

Data Collection

SigmaScan photographic analysis and the yardstick method were used to determine nitrogen levels in the plants during the season. SigmaScan is a computer program that utilizes digital images and counts the number of green pixels present. Lower numbers of green pixels indicate a nitrogen deficiency, while higher numbers indicate a healthy plant canopy. A picture of each plot was taken, analyzed and averaged by treatment. The yardstick method has been used to determine a rice crops midseason nitrogen needs. By placing a yardstick between the rows of rice and counting the numbers on the yardstick not obscured by the plants leaves, an estimate of nitrogen needed can be made. Generally, the more numbers that are showing on a yardstick, the greater the rice yield response that can be expected from applying midseason nitrogen. SigmaScan photographs and yardstick readings were taken on July 30 and 23 for the dry urea/ pivot irrigated study, on July 29 and 27 for the fertigation study and on August 6 for the dry urea/flooded rice study. Grain from the pivot irrigated tests was harvested on August 24 and 25, and the flooded test was harvested on October 6. Subsamples from all plots were collected at harvest for milling quality analysis.

Results

Yield data from all three tests tended to be lower than expected due to shattering (grain falling off the plant) and lodging (plants falling over) as a result of heavy winds sustained from the remnants of Hurricane Ike on September 14. An estimate of these losses is presented in Table 1. Yields from the pivot irrigated/dry urea study had higher yields than the same nitrogen treatments applied to flooded rice for all three varieties/hybrids. Fertigation treatments yielded higher than the flooded dry urea for both the Clearfield variety and hybrid but not the conventional variety ‘Cybonnet’ (Figure 1) when 180 lb total N was applied.

The Clearfield hybrid also had higher yields in the fertigation study compared to the same hybrid in the dry urea/pivot irrigated study. At the 135 lb N/acre total rate, fertigation treatments with 50% of total nitrogen applied at the first tiller as dry urea yielded substantially higher than treatments with only 25% total nitrogen applied first tiller except when applied to the RiceTec CLXL730 hybrid (Figure 1). The yields for these treatments were higher than for the other varieties at the same fertility level, and were similar with 168 bu/ac for the 50% first tiller treatment and 175 bu/ac when only 25% of the nitrogen was applied at first tiller. The remaining nitrogen was applied in five fertigation treatments at 10 and 15% per application respectively. Timing had less affect on rice yields at the 180 lb N/acre rate of application (Figure 2).

Water usage (Figure 3) was lower for the pivot irrigated rice study as compared to the flooded study. Approximately 23 inches of water were applied to the sprinkler irrigated study area. The flooded test received approximately 32 inches of water throughout the growing season. This represents a decrease of 28 percent.

Yardstick measurements and SigmaScan readings were made on all plots to verify nitrogen use and plant health. In most cases the yardstick measurements and SigmaScan analysis correlated well with crop yields and reflected the nitrogen rate applied. Some examples are shown in Table 2. However, this was not always the case as weeds present in the plot, and therefore in the analyzed photographs, would increase the percentage of green pixels counted by the SigmaScan software. This seemed to be more common in the flooded test as algae and difficult to control aquatic weeds may have been present.

Other management practices which may need to be altered when growing rice with pivot irrigation include weed control programs and seeding rates. Flooding rice not only irrigates the crop but contributes 40-60% of the weed control. As a consequence, more herbicide applications may need to be made. Some conventional herbicide programs which may be useful with this production system are shown in Table 3. In addition, many “add-on” herbicides were helpful for pigweed control including penoxsulam (Grasp), bentazon/acifluorfen (Storm), carfentrazone (Aim), and triclopyr (Grandstand). The use of the Clearfield , herbicide resistant rice system may have little value in this system unless red rice becomes a problem. This system utilizes the herbicides NewPath (imazethapyr) and Beyond (imazamox) herbicides from the Acetolactase Synthase (ALS) family of herbicides. The main weed problem we faced in these studies was Palmer Amaranth. In many areas, this weed is resistant to ALS herbicides.

The low seeding rates of hybrids may also need to be increased when used in this system. The reduced number of rice plants in a given area took longer to close canopy. As a result weeds had more time to emerge and compete with the rice plants. We believe that a higher seeding rate may reduce this early season competition and allow for fewer herbicide applications later in the season.

Conclusion

In areas where quality and quantity of irrigation water are not suitable for the common cultural flooding method of rice production, it is reasonable to speculate that a pivot irrigation system could be used. Our studies have indicated that grain yields comparable to the flooding method are achievable and can even be surpassed with a center pivot sprinkler irrigation system. Not only would this system be suitable for areas where rice production is not practiced because of the topography and soil types not being conducive to flooding, but may be useful for producers in rice production already as a way to conserve water, and consequentially reduce fuel usage.

Nitrogen losses have been shown to be increased in furrow irrigated due to the soil fluctuating between anaerobic and aerobic states. These studies indicate that a fertigation system provides the best method of supplying the crops nitrogen requirements. Additionally, the amount of urea applied at the first tiller stage may be critical. When 50% of the total nitrogen was applied at this stage, 2 of the 3 varieties/hybrids yielded much higher than when only 25% was applied. This higher amount of N applied early in the season may allow fro a healthier more competitive crop. The remaining nitrogen is applied more or less as needed for the next 5 weeks. In this way we can limit the amount of N loss because there is little or no excess in the soil. In other words, we only apply what the crop can use.

Dry urea fertilization with this system was also shown to be effective, however not at the levels realized with the fertigation system. The probable cause for this is nitrogen loss due to volatilization and runoff. Urea is used for flooded rice production but only if the crop is going to be flooded soon or is already flooded. The pellets of urea convert from dissolved ammonia to ammonia gas when not incorporated into the soil. The nitrogen is then lost to the atmosphere. When the soil is flooded the ammonia gas is held by the flood water and reaches equilibrium with the soil and is still plant available. With this system, irrigating the crop may only cause more volatilization. As well, increasing the amount of irrigation with this system may lead to runoff of the urea because there are no structures such as levees to retain the water as there would be in a flooded production system. We believe these are the main reasons for the lower yields in the dry urea/pivot irrigated study compared to the fertigation study.

Varietal selection may be more important with this system also. Diseases such as blast are known to be more destructive when the rice plants are under water stress. Varieties and hybrids with higher levels of resistance to this and other diseases should be selected to insure that yield losses are kept to a minimum.

The first year of these studies offered a great deal of insight into the benefits of using this system and also some of the obstacles which must be overcome. While we were able to produce equivalent yields with less water and nitrogen, it appears that our pesticide usage may actually be increased with this system.

Additional research will reveal the best programs to reduce this input and should also help to increase crop yield further.

Table 1. Shattered kernel counts and yield loss estimates of three rice cultivars at the University of Missouri-Lee Farm on Sharkey clay flood irrigated.

Cultivar	Kernels/ft^2	Yield loss bushels/ acre†
Cybonnet	51	3
CL171	285	14
CLXL730	532	32

† Calculated from tables in the Arkansas Rice Production Handbook (Univ Ark Coop Ext Service Bull. MP192).

Table 2. Yardstick and SigmaScan readings for plots planted to Clearfield 171AR and receiving 135 lb total nitrogen per acre on pivot irrigated rice and flood irrigated check. Results were similar for Cybonnet and RiceTec CLXL730.

Method	Yardstick numbers showing	Green Pixels
Dry urea	18	85%
Fertigation	14	95%
Flood urea Sharkey clay check	14	98%

Table 3. Conventional herbicide programs, weed control ratings and cost per acre for pivot irrigated rice study. Ratings based on 0=no control, 100=complete weed control.

Program	Pigweed	Carpetweed	Morningglory	Cost/acre
	--------------% control-----------------			
Prowl fb Stam (2)	97	100	100	$40.89
Command fb Stam (2)	94	100	100	$45.16
Command fb Stam + Facet (2)	100	100	100	$69.66

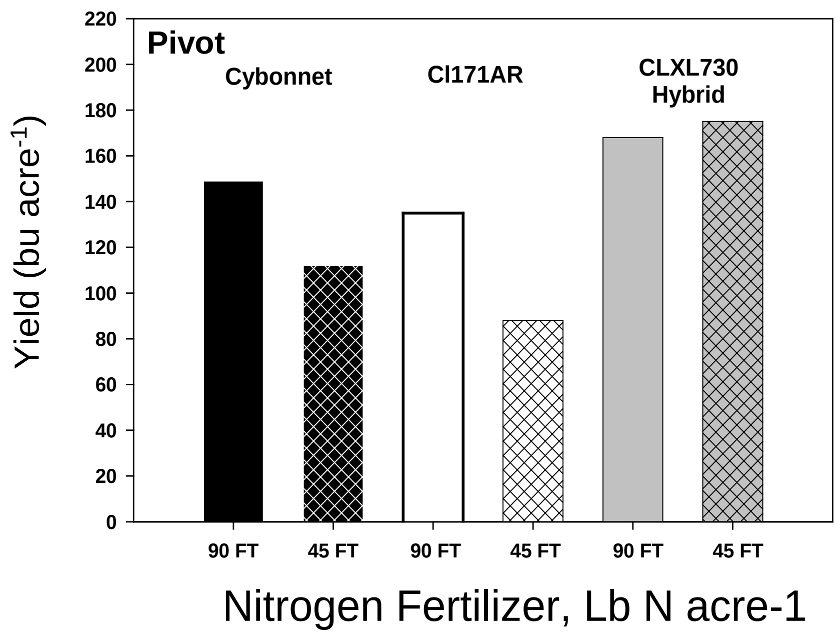

Figure 1. Rice yields of rice cultivars and hybrid supplied with 135 lb total N/acre split between dry and fertigation with 90 or 45 lb dry urea applied at first tiller (FT) on a Tiptonville silt loam and irrigated with center pivot system. Plots that received 90 and 45 lbs N per acre at first tiller were fertigated with five 9 lbs N/application and 18 lbs N/application, respectively, in 7 day intervals.

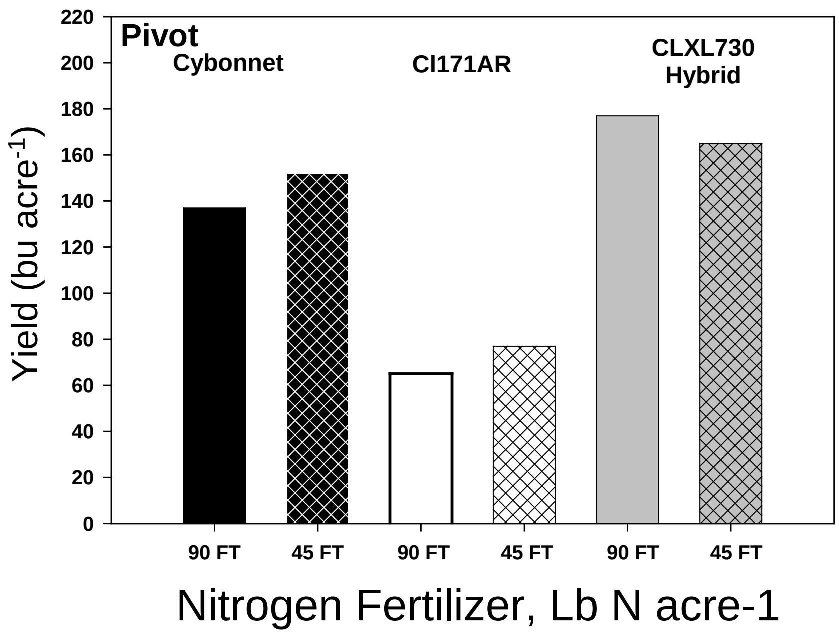

Figure 2. Rice yields of three cultivars supplied with 180 lb total N/acre split between dry and fertigation with 90 or 45 lb dry urea applied at first tiller (FT) on a Tiptonville silt loam and irrigated with center pivot system. Plots that received 90 and 45 lbs N per acre at first tiller were fertigated with five 14 lbs N/application and 20 lbs N/application, respectively, in 7 day intervals.

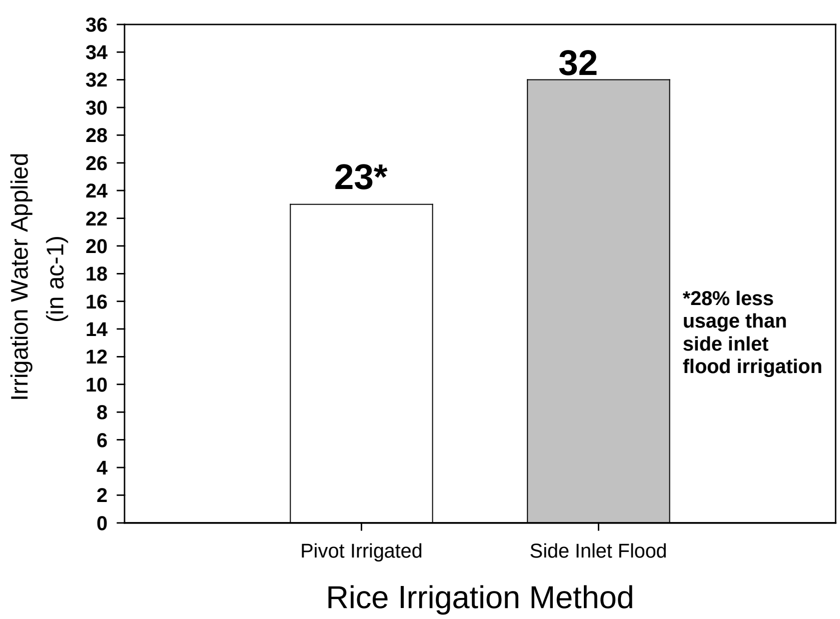

Figure 3. Irrigation applied with center pivot irrigation and side-inlet flooding on rice.