Competitiveness of Three New Rice Cultivars

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ABSTRACT

New rice cultivars have been released that have yield potential greater than 9,000 lb/acre. However, it is not well understood how these new, high-yielding cultivars respond to various weed-control levels. The most recent research established barnyardgrass threshold levels of 0.5 to 1 plant/ft² using older cultivars. A study was established 2003 at the Rice Research and Extension Center at Stuttgart, Ark., to evaluate the innate competitive abilities of three new rice cultivars at various seeding rates. Representatives from each of the three classes of long-grain rice were selected. ‘Wells’ represented conventional long-grain rice, ‘CL161’ represented semi-dwarf, imidazolinone-tolerant rice, and RiceTec ‘XL8’ represented hybrid, long-grain rice. A randomized complete block design with four replications was used. Treatments were arranged in a factorial arrangement, with factors consisting of three rice cultivars, four rice stand densities (3, 6, 12, and 24 plants/ft row), and four levels of weed control (25, 50, 75, and 100%). Cultivar and rice-stand density were not significant factors for rice yield. As barnyardgrass control increased, rice yield increased with all cultivars at all seeding rates. There was a significant rice-stand density by barnyardgrass-control interaction, and harvest index increased as rice stand decreased and barnyardgrass control increased. Canopy coverage analysis revealed that XL8 achieves canopy closure 1 week prior to CL161 and 2 weeks prior to Wells when averaged across rice stand densities.

INTRODUCTION

Barnyardgrass [Echinochloa crus-galli (L.) Beauv.] is the principal weed in rice (Oryza sativa L.) production (Holm et al., 1977) and is a problem weed in 42 countries
(Holm et al., 1979). It is found in 36 crops around the world (Holm et al., 1977) and in all rice production fields across the state of Arkansas (Carey et al., 1995). Young barnyardgrass plants look similar to rice plants and can be hard to differentiate. Barrett (1983) believes that many thousands of years of hand removal of barnyardgrass in Asia may have selected for this mimicry trait.

With the exception of red rice (*Oryza sativa* L.), barnyardgrass is the most competitive weed in rice production (Smith, 1974), resulting in 70% yield loss as a result of season-long interference with ‘Newbonnet’ rice (Smith, 1988). Stauber et al. (1991) found that one barnyardgrass plant spaced 16 in. from a rice plant reduced rice yields 27%. Some infestations of barnyardgrass have been shown to remove 60 to 80% of available nitrogen from soil (Holm et al., 1977).

Research has been conducted over the years to develop weed population threshold levels in rice production. These levels are affected by rice cultivar, soil fertility, and seeding rate (Hill et al., 1985). Stauber et al. (1991) showed that semi-dwarf cultivars compete less than conventional cultivars against full-season barnyardgrass competition. Barnyardgrass populations of 0.5 to 1 plants/ft² are threshold levels for control measures in rice production (Smith, 1988). Therefore, it is important to maintain barnyardgrass control in order to maximize yield potential.

Several new rice varieties and hybrids have become available for production in recent years. Many of these new cultivars have exceptional yield potential (Moldenhauer et al., 2001). A lack of data concerning the competitive ability of these new cultivars exists. The objective of this study was to determine if new, high-yielding rice cultivars differ among their competitive abilities and to quantify these differences based on yield parameters and canopy closure.

**PROCEDURES**

A study was established in 2003 at the Rice Research and Extension Center near Stuttgart, Ark., to evaluate the innate competitive abilities of three new rice cultivars, Wells, CL161, and RiceTec XL8 against natural infestations of barnyardgrass. The experiment was designed as a randomized complete block with a three by four by four factorial treatment arrangement with three factors. Factors consisted of three rice cultivars (Wells, CL161, and XL8), four rice-stand densities (3, 6, 12, and 24 plants/ft row), and four levels of weed control (20, 40, 70, and 100%). The three rice cultivars represented the major types of long-grain rice grown in the southern United States. Wells represented traditional-height, long-grain rice, CL161 represented semi-dwarf, long-grain rice, and XL8 represented hybrid, long-grain rice. Planting rates for rice-stand densities were established based on seed weights of the respective rice cultivars as established in the literature (Slaton and Cartwright, 2000). Levels of weed control consisted of four herbicide programs targeting 25, 50, 75, and 100% control based on visual observations. Visual weed-control evaluations were taken every two weeks until panicle initiation on a scale of 0 to 100% where 0 = no control and 100 = complete control. Levels of weed control were selected in an effort to create a range of weed control so
that the competitive abilities of these rice cultivars could be observed over a range of barnyardgrass control levels, thereby allowing the use of regression analysis to establish relationships between the cultivars and barnyardgrass control.

Plots were 6 ft wide by 16 ft long. Each plot consisted of eight drilled rows, spaced 7 in. apart. Rice seed was drill-seeded with a cone drill planter. Rice stand counts were taken 2 wk following emergence. Following rice maturity, 3.3-ft row of rice was hand-harvested from each plot. Number of panicles, total biomass, and seed weight were measured, and harvest ratio (seed weight/total aboveground biomass) for each plot was calculated. A mechanical small-plot harvester was used to harvest rice from plots once seed moisture levels were between 18 and 22%. Grain yield was measured and adjusted to 12% moisture prior to analysis.

Digital photographs were taken in 100% control plots 2, 5, 6, 7, and 8 wk after emergence to estimate canopy coverage of the three cultivars across the four rice-stand densities. Images were taken directly overhead of plots and saved in .jpg format. Pictures were imported into SigmaScan software, and canopy coverage was calculated for each image by counting the number of green pixels in relation to other pixels. This method has proven effective for measuring turfgrass cover (Richardson et al., 2001). Degree days were calculated based on the minimum and maximum daily temperatures and were used in the statistical analysis so that canopy coverage for the three cultivars could be regressed over thermal time. All yield parameters and canopy coverage data were analyzed using the PROC REG function in SAS (SAS, 2000).

RESULTS AND DISCUSSION

Rice Yield

The main effects of cultivar and rice stand were not significant for rice yield; therefore data were pooled across rice-stand densities and cultivars (Fig. 1). There was a quadratic relationship for yield. As barnyardgrass control increased from 60 to 100%, rice yield increased from 4,000 to 7,900 lb/acre.

Harvest Index

A significant rice-stand density by barnyardgrass-control interaction affected harvest index, and rice cultivar was not significant (Fig. 2). There was a linear relationship between rice stand and harvest index. As rice stand decreased, harvest index increased. This type of trend is expected because as rice plant population decreases, individual plants must compensate for voids in the canopy, thereby producing more leaf area and reproductive tillers. There was a quadratic relationship between barnyardgrass control and harvest index, similar to yield data. As barnyardgrass control increased between 60 and 100%, harvest index increased from 0.24 to 0.56.
Canopy Coverage

Figure 3 represents the interaction of thermal time by cultivar for canopy coverage. XL8 achieved canopy closure approximately 1 wk prior to CL161 and 2 wk prior to Wells. The main effect of rice-stand density was significant for Wells but not significant for CL161 or XL8 (Fig. 4). As rice stand decreased, canopy coverage significantly decreased for Wells, but not for CL161 or XL8. These data may help explain why seeding rates for hybrid rice are approximately one-third of that suggested for CL161 and Wells. However, the data suggest that rice-stand density is not significant for CL161, indicating that lower seeding rates may be sufficient for establishing canopy coverage. Wells has an erect-type growth habit and lower tillering than either CL161 or XL8. According to these data, lower canopy closure values for Wells do not correspond to yield or harvest index reductions.

SIGNIFICANCE OF FINDINGS

Results from this study indicate that there is not a significant yield or harvest index advantage with any one of these cultivars when compared to the others. However, this study is ongoing, and results are only representative of one year of data. Canopy coverage data indicate that seeding rates of XL8 and CL161 may be reduced if weeds are completely controlled. Seeding rate becomes a significant factor when considering the increased costs of these cultivars compared to traditional cultivars like Wells. Canopy coverage data also indicate that XL8 and CL161 fill the canopy 2 wk and 1 wk faster than Wells, respectively, which may lead to increased competitiveness with these cultivars early in the season.

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LITERATURE CITED


Fig. 1. Main effect of barnyardgrass control on rice yield. Data are pooled across cultivars and seeding rates.
Fig. 2. Interaction of rice-stand density and barnyardgrass control on rice harvest index. Data are pooled across cultivars.

Fig. 3. Main effect of thermal time on canopy coverage for three cultivars, Wells, CL161, and XL8. Data points represent canopy coverage readings 2, 5, 6, 7, and 8 wk after emergence.
Fig. 4. Interaction of seeding rate and thermal time on canopy coverage for three cultivars, Wells, CL161, and XL8.