Development of Short-Term Management Options for Rice Bacterial Panicle Blight Disease

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ABSTRACT

Field trials were conducted in 2012 at the University of Arkansas System Division of Agriculture Rice Research and Extension Center near Stuttgart, Ark., to evaluate the effects of planting date, water stress, seeding rate, and nitrogen (N) fertilizer on bacterial panicle blight disease of rice. In addition, preliminary tests were conducted both in the laboratory and greenhouse to develop an artificial seed inoculation technique for the study of chemical and non-chemical seed treatments. Late-planted plots had significantly higher disease incidence on both Bengal (susceptible variety) and Jupiter (moderately resistant variety) resulting in considerable yield and milling quality losses. Water stress showed more of a negative effect on yield than bacterial panicle blight disease for both inoculated and non-inoculated plots. Seeding rate and N fertilizer in split-plot tests showed no significant treatment effects on disease incidence, yield, or milling quality. The artificial seed inoculation method developed in the laboratory was effective for field study. Ultraviolet light, microwave, household antimicrobial agents, hot water, freezing, an industrial sanitation chemical, plant extracts, competitor bacteria, silver, and copper compounds were screened for their antibacterial activity on inoculated seeds. These screenings are at preliminary level and tests on seed germination are not complete.

INTRODUCTION

Bacterial panicle blight (BPB) has been observed in rice production fields of Arkansas and other southern states with increasing frequency since 1995 (Cartwright, pers. comm.). Extended hot summer nights are favorable to this disease which is thought to be primarily seedborne. The BPB was severe in 2010 and 2011 causing up to 60%
yield loss under environmental conditions favorable for the disease (Cartwright, pers. comm.) Panicle symptoms typically develop late in the season, which makes predicting disease occurrence difficult. Infected panicles have mostly blighted florets which first appear white to light gray with a dark-brown margin on the basal third of the tissue. Later, these florets turn straw-colored and may further darken toward the end of the season with growth of other opportunistic microorganisms. Heavily infected panicles remain upright due to lack of grain fill. There are no chemical options registered in the U.S. to protect or salvage the crop from the disease. This disease, which is dependent on weather and environmental conditions, is sporadic in nature and the causal agents survive in the soil, crop residues, and seeds. The purpose of this research is to examine cultural, chemical, and non-chemical management options that may be used solely or in combination to reduce BPB of rice until resistance is identified and incorporated into high yielding and adapted cultivars.

PROCEDURES

Land Preparation and Planting

Test fields which were cropped the previous year in rice and reported to have BPB were tilled and prepared in the early spring. A preplant fertilizer of Triple Super Phosphate (65 lb/acre), potassium chloride (100 lb/acre), and CoZinco (30 lb/acre) was applied. A burn down application of Gramoxon Inteon was applied to kill weeds and off-type rice. The area was then roto-tilled to loosen the soil and ensure a good seed bed. Planting was done with a Hege 1000 seed drill set to plant 8 rows on 8-inch row spacing approximately one inch deep. The plots were approximately 5 ft by 14 ft. After planting, the plots were rolled to ensure good soil-to-seed contact and to seal in moisture.

Evaluation of the Effects of Planting Date on Bacterial Panicle Blight Disease

Although more than one species of *Burkholderia* are involved in causing rice BPB disease, tests were carried out using only *B. glumae* because it was more frequently isolated from infected kernels in Arkansas. To obtain uniformly infected seeds and to ensure the survival of the bacteria until cotyledon emergence, an artificial inoculation method was developed. *B. glumae* from at least a 4-d old culture, grown on non-selective King’s B medium at 104 °F, was washed from a petri dish to obtain a 1-ml suspension. The bacterial suspension was mixed with 4 ml salt-sugar buffer (1 g yeast extract, 2.36 g NaCl, and 3.4 g sucrose/liter of distilled water) (Streeter, 2007). The mixture was infiltrated into 40 g of rice seed by applying a vacuum (25 in. Hg vacuum) for 5 min followed by restoring atmospheric pressure before repeating the vacuuming process a second time. Seeds were then covered with 8 g of talc (powder) to absorb excess liquid and to ease planting. The talc shield also was meant to serve as a buffer between soil and seeds until germination. After emergence, samples of cotyledons were tested for the presence of *B. glumae* on partially selective medium designated, CCNT (Kawaradani et
The CCNT agar is a medium containing 2 g of yeast extract, 1 g of polypepton, 4 g of inositol, 10 mg of cetrimide, 10 mg of chloramphenicol, 1 mg of novobiocin, 100 mg of chlorothalonil, and 18 g of agar in 1000 ml of distilled water, and adjusted to pH 4.8. Artificially inoculated seeds of Bengal (susceptible variety) and Jupiter (moderately resistant variety) were planted at the recommended seeding rate of 88 lb/acre on 20 March, 24 April, and 24 May as early, normal, and late planting dates (1st, 2nd, and 3rd), respectively. Plots were replicated four times using a completely randomized design (CRD). To obtain objective measurement on the disease, upright panicles with typical disease symptoms were counted as 100% infected and those that bent down slightly and with typical symptoms on the younger florets as 50%. The counts for 50% were later divided by two to maintain uniformity, and percentage disease incidence was calculated. This disease rating method was used for all field tests in this study.

**Evaluation of Water Stress on Bacterial Panicle Blight Disease**

Plots were planted on 22 May with Bengal, a BPB-susceptible variety, at the rate of 88 lb/acre. To further improve the chances of observing BPB, plots in two bays were planted with artificially inoculated seeds while plots in the other two bays were planted with non-inoculated seeds. Water treatments consisted of a conventional permanent flood or intermittent flood applied per bay. Intermittent flood treatment plots were allowed to dry down to a soil moisture content of approximately 40% before being re-flooded. Soil moisture was monitored and recorded by soil moisture sensors (Irrometer Co., Riverside, Calif.) placed at depths of 2 in. and 4 in. Water usage was recorded with flow meters (McCrometer, Hemet, Calif.) installed in each of the four bays of the test. The permanent flood bays remained flooded throughout the growing season until drained for harvest. The intermittent bays were allowed to dry down a total of three times during the growing season. All bays were drained on 28 September and allowed to dry for harvest. The test was harvested on 17 October.

**Evaluation of Effect of Seeding Rate and Nitrogen Fertilizer on Bacterial Panicle Blight Disease**

Seeding rate and N fertilizer effects on BPB disease incidence and severity were tested using a split plot design. *B. glumae*-inoculated seeds of Bengal and Jupiter were planted at a recommended seeding rate (88 lb/acre) and a high seeding rate (176 lb/acre) on 27 April. Two N rates were investigated: the NST*R recommended rate 150 lb N/acre and a rate of 180 lb N/acre. The fertilizer was applied at preflood.

**Evaluation and Testing of Chemical and Non-Chemical Seed Treatments**

Ultraviolet light, microwave, household antimicrobial agents, hot water, freezing, an industrial sanitation chemical, plant extracts, competitor bacteria, silver, and copper compounds were screened on artificially inoculated seeds with *B. glumae*. Seed
RESULTS AND DISCUSSION

With March and April planting dates, the average percent infected panicles per plot in Jupiter were 0.37% and 0.43% compared to Bengal 0.44% and 0.69%, respectively (Fig. 1). The latest planting date (24 May) appeared to have an extremely high effect on BPB disease incidence and severity on both varieties. The average percent of infected panicles in Jupiter was 49.4% while Bengal had 99%. Most of the panicles in Jupiter showed 50% infections (lower part of the panicles) while Bengal showed 100% (whole panicle).

Grain yield and milling quality also were adversely affected in the latest planting date. Although, the extent of the bird damage was not measured, grain yield in March-planted plots was influenced by bird feeding both before emergence and after heading. Therefore, parameter comparisons were made between April-planted and May-planted plots. In May planting, Bengal showed a 41% yield loss when compared to the yield from April planting. Likewise, Jupiter showed a 33% yield loss (Fig. 2). In both varieties, the yield losses were large. Head rice yields were similarly reduced in May-planted plots compared to April-planted plots causing 25% and 22% reductions in Bengal and Jupiter, respectively (Table 1).

Historically, early planting is generally encouraged to allow adequate time for plant development and grain fill and to escape some rice diseases such as blast. This study indicated March to April planting dates minimized BPB disease incidence resulting in lower effects on yield and grain quality. Observations in previous years showed BPB disease of rice to be severe with high temperatures, particularly extended nighttime air temperatures above 78 °F (D. Groth and R.D. Cartwright, pers. comm.). It is not yet well understood at which stage of the crop that temperature plays the greatest role and what other factors are involved. High humidity, together with prolonged high night temperatures could be key factors. It is likely that favorable temperature and humidity during the earlier crop stages up until boot or boot split allows the survival of the bacteria as an epiphyte if the inoculum source is in seed or soil. These bacteria then move up the crop canopy and eventually become established in the florets. Under lab conditions, *B. glumae* grows well on CCNT or King’s B media at temperatures between 98 °F to 104 °F. These bacteria also grow at room temperature but at a slower rate.

Bengal and Jupiter took nearly three months to reach boot stage. Stuttgart weather data indicated the average air maximums from 78.2 °F to 88.4 °F and the average minimums from 55.4 °F to 68.6 °F for the months of April to June, respectively. The average maximum for July and August was 93.6 °F and 87.1 °F while the minimum was 74.5 °F and 70.9 °F, respectively. Average minimum soil temperatures for July and August were 81 °F and 77.7 °F. Soil temperature may play a role in raising the humidity under the canopy creating a favorable microenvironment for the bacteria. However, there is no report on the role of soil temperature in the survival or multiplication of the bacteria. Seeds in all the three planting dates were inoculated similarly and hence, low disease incidence in the first two planting dates cannot be attributed to the absence of germination testes were carried out for those that showed some level of positive results in their antibacterial activity.
inoculum. The seed inoculation method was proven effective with the 3rd planting date where Bengal and Jupiter showed severe disease levels.

Observations from the field test in 2012 indicated that BPB disease on the third planting date became distinct within a week after tropical storm Isaac brought 2.53 inches of rain on 31 August. The non-inoculated border variety (Wells), on the west side of the inoculated plots, showed noticeable BPB disease pressure compared to the Wells planted on the east side of the inoculated plots. The rainy wind that blew east to west drove the bacteria from inoculated plots to the susceptible plants. This suggested windy rain as a possible dispersal mechanism and as an indicator of new infection after heading. The planting date experiment will be repeated for two more seasons.

In the water stress test, BPB incidence was greater in conventionally flooded plots than in intermittent flooded plots (data not shown). However, grain yields were lower in the intermittent flooded plots (data not shown) due to water stress. The soil moisture was lowered up to 40% causing the soil surface to crack and we waited a few days to re-establish the flood. This low level moisture resulted in rolled leaves because the plants were too stressed and possibly the stress condition was too extreme. This test will be conducted for the next two seasons with intermittent flushing instead of intermittent flooding.

Seeding rate and N fertilizer in a split-plot tests showed no treatment effects on disease incidence (data not shown). The lack of differences may be due to the planting time (26 April). Based on the planting date experiment described above, the disease pressure was much higher on late-planted (late May) than April-planted plots. The experiment will be repeated separating the fertility level and seeding rate treatments in randomized complete design. Planting will be in May after the 2nd week.

Preliminary tests of seed treatment for antibacterial activity on artificially inoculated seeds with *Burkholderia glumae* using ultraviolet light, microwave, household antimicrobial agents, hot water, freezing, an industrial sanitation chemical, plant extracts, competitor bacteria, silver, and copper compounds are still being screened.

**SIGNIFICANCE OF FINDINGS**

Bacterial panicle blight has been the most important disease in Arkansas rice causing millions of dollars loss in 2010 and 2011. While the development of resistant cultivars will offer the best long-term control, short-term disease management options such as adequate planting time, seeding rate, fertilizer amount, water management, and seed treatment options that we hypothesized may have effect on BPB disease intensity needed to be explored. Among these, the planting date experiment has shown clear indication that late-planted material had more incidence of disease.

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LITERATURE CITED
Streeter, J.G. 2007. Factors affecting the survival of Bradyrhizobium applied in liq-

Table 1. Effect of planting date on milling quality for
Bengal (a susceptible variety) and Jupiter (a moderately
resistant variety) as a result of bacterial panicle blight disease of rice.

<table>
<thead>
<tr>
<th>Planting date</th>
<th>Milling ( % head/% total )</th>
<th>Bengal</th>
<th>Jupiter</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 March</td>
<td>58/68</td>
<td>59/67</td>
<td></td>
</tr>
<tr>
<td>24 April</td>
<td>64/71</td>
<td>62/71</td>
<td></td>
</tr>
<tr>
<td>24 May</td>
<td>48/66</td>
<td>48/70</td>
<td></td>
</tr>
<tr>
<td>LSD (0.05)a</td>
<td></td>
<td>3.96/1.12</td>
<td></td>
</tr>
</tbody>
</table>

a LSD = least significant difference.
Fig. 1. Percent bacterial panicle blight (BPB) incidence in three planting dates on Bengal (a susceptible variety) and Jupiter (a moderately resistant variety) 2012.

Fig. 2. Grain yield (bu/acre) of Bengal (a susceptible variety) and Jupiter (a moderately resistant variety) as affected by bacterial panicle blight of rice in three planting dates.