Characterization of Herbicide-Resistant Biotypes of Barnyardgrass

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ABSTRACT

Barnyardgrass (*Echinochloa crus-galli*) biotypes, resistant to different herbicides, have been reported. An experiment was conducted to compare the growth characteristics of various barnyardgrass biotypes, (i.e., propanil-resistant from Poinsett County, Ark., quinclorac-resistant from Louisiana, quinclorac/propanil-resistant barnyardgrass from Craighead County, Ark., and susceptible barnyardgrass from Arkansas County) with the rice cultivar ‘Wells’ in a non-competitive environment at Stuttgart, Ark., in 2002 and 2003. Seeds were planted in the greenhouse and 28 seedlings of each barnyardgrass biotype and rice were transplanted into separate plots at 3 ft spacing. The top growth of four plants was harvested weekly and growth characteristics including height, number of tillers, leaf area, and dry weights were recorded at 4 to 10 weeks after emergence. The quinclorac-resistant barnyardgrass from Louisiana had a prostrate growth habit as compared to other barnyardgrass biotypes. There was no significant difference among the growth of barnyardgrass biotypes, but the growth of barnyardgrass was significantly different from rice. The quinclorac-resistant biotype was also taller than the others with an average height of 47 in., while rice was 28 in. tall. The quinclorac/propanil-resistant barnyardgrass produced 6 times more tillers (210) than rice (30) and the leaf area and biomass of barnyardgrass biotypes was about 9 times higher than rice. In addition, the quinclorac/propanil-resistant biotype had a leaf area of 852.5 in.\(^2\)/plant and a biomass of 1.54 lb/plant as compared to 99 in.\(^2\)/plant and 0.18 lb/plant in rice, 11 weeks after emergence.
INTRODUCTION

Barnyardgrass is one of the most important warm-season annual grass weeds in the world (Holm et al., 1977; Maun and Barrett, 1986; Rahn et al., 1968). As with other weeds it is capable of prolific seed production. Barnyardgrass produces seed over a long period if growing conditions permit (Norris et al., 1992). In a study by Smith (1974), barnyardgrass competition with dry-seeded rice (*Oryza sativa*) reduced grain yields from 8 to 79% beginning at crop emergence and lasting for periods ranging from 15 days to maturity.

The herbicide propanil was introduced in 1962 as a very effective herbicide to control barnyardgrass in rice and increased U.S. rice yields from 34 to 74% (Smith, 1965). Later its extensive use led to development of propanil-resistant barnyardgrass in the early 1990’s (Baltazar and Smith, 1994). The herbicide quinclorac was introduced for use in rice in 1992 and provided excellent control of propanil-resistant barnyardgrass over a wide window of application (Eastin, 1989). However, a biotype of barnyardgrass also became resistant to quinclorac. Two populations of quinclorac-resistant barnyardgrass have been confirmed in Arkansas (Lovelace et al., 1999).

Although barnyardgrass is one of the world’s worst rice weeds, relatively few studies have characterized its growth and development under field conditions (Norris, 1996). Competitive studies have been done with barnyardgrass and rice. Barnyardgrass has different growth habits. It can grow from upright to completely prostrate depending on competition (Norris, 1996). Selection intensity imposed on a weed population by herbicide use favors resistant plants and the mutation conferring herbicide resistance may have physiological disadvantages compared to a plant without competition (Holt and Thill, 1994). Experiments with triazine-resistant plants in the field have shown that resistant plants are less competitive than susceptible plants because in atrazine-resistant biotypes, a change in PSII has reduced the photosynthetic efficiency of the plants (Ahrens et al., 1983; Reboud and Bottraud, 1991). Limited research has been done on growth characteristics of resistant and susceptible biotypes of barnyardgrass. Therefore research is needed on the relative productivity and competitiveness of resistant and susceptible barnyardgrass biotypes and the variation on the basis of phenotypic and morphological characters.

The objective of this study is to compare morphological or phenotypic growth characteristics of barnyardgrass biotypes in a non-competitive environment.

MATERIALS AND METHODS

The field experiment was conducted in 2002 and 2003 at the Rice Research and Extension Center, Stuttgart, Ark. Rice cultivar ‘Wells’ and the following barnyardgrass biotypes were used: susceptible from Arkansas County, Ark.; propanil-resistant from Poinsett County, Ark.; quinclorac-resistant from Louisiana; and quinclorac/propanil-resistant from Craighead County, Ark.

The seeds of susceptible and resistant barnyardgrass were planted in small cells of peat moss medium in a greenhouse maintained at 72°F daytime and 64°F night
temperatures. The seeds of rice were planted in Ready Gro soil medium. All pots were
subirrigated by placing them in trays of water containing the nutrient solution “Miracle
Gro®” to supply essential nutrients to the plants. Plants were thinned to one plant per
pot when they reached the 2-leaf stage.

The plants grown in the greenhouse were transplanted in the field, according to
protocol as described by Weiderholt et al. (1996), in a non-competitive study on 28
May 2002 and 2003, 19 days after planting in the greenhouse, and all the plants were
at the 3- to 4-leaf stage. They were transplanted in the field at 3 ft spacing between
plants. There were seven subplots of four plants each for destructive sampling in
each main plot. In 2002, the plots were kept weed-free by spraying propanil at 4 lb/acre
on rice, propanil-resistant barnyardgrass, and quinclorac/propanil-resistant
barnyardgrass and by applying quinclorac at 0.375 lb/acre on quinclorac-resistant
barnyardgrass. Hand weeding was done on plots with susceptible barnyardgrass. In
2003, a preemergence application of pendimethalin at 1 lb/acre was done on all plots.
Weeds that emerged later were killed by spot application of glyphosate at 1.5 lb/acre
in both years. The plot area was flushed three times per week. The experimental
design was a split plot with biotype as the main plot, and harvest date as the split plot
with four replications.

Plant height, number of tillers, leaf area, and dry biomass were determined
weekly from 4 to 11 WAE. Each week, top growth of four plants from each subplot
was harvested by cutting at soil surface. Leaf area of the harvested plant material was
also determined weekly with a leaf-area meter. At maturity, the inflorescence was sepa-
rated from the shoots of individual plants. After removing the panicles and taking the
leaf area, individual harvested plants were kept in a drier for 15 days maintained at
145°F and then their dry weights were taken. The dry weight of seeds per plant for each
biotype was also taken and the total number of seeds from each 0.0022 lb sample was
counted, then the total number of seeds from each plant biomass was calculated.

RESULTS AND DISCUSSION

Morphological differences were found in heights, number of tillers, leaf area, and
biomass of different barnyardgrass biotypes. Some differences were clearly visible in
the field such as whether the biotypes were growing upright or prostrate to the ground.
Quinclorac-resistant barnyardgrass had a prostrate growth habit with most of its leaves
and stems growing prostrate to the ground, but some of the tillers grew upright.

There was year, biotype, and harvest interaction in the heights and leaf area, so
data for these parameters was analyzed separately for 2002 and 2003 (Table 1). There
were interactions across year, but at the end of the season during both years the
barnyardgrass biotypes had about the same height and leaf area. Quinclorac-resistant
biotypes had the maximum average heights of 43 in. in 2002 and 47 in. in 2003 11
WAE (Table 1). Average heights of barnyardgrass biotypes were as high as 1.5 times
taller than rice (28 in.) by the end of season. Quinclorac/propanil-resistant and
propanil-resistant barnyardgrass had profuse growth habits as indicated by the num-
ber of tillers they produced. They produced (210 and 180) seven and seven times, respectively, more tillers than rice (30), 11 WAE. Quinclorac-resistant barnyardgrass with its prostrate growth habit produced fewer tillers. Average height of rice cultivar Wells was about the same as propanil-resistant barnyardgrass, but Wells produced far fewer tillers than any of the barnyardgrass biotypes. The barnyardgrass had profuse growth and tillering habits which far out-performed rice and, hence, can severely reduce rice yields.

The average leaf area and dry weights of these biotypes were analogous to the number of tillers produced. As shown in table 1, quinclorac/propanil-resistant barnyardgrass had an average leaf area of about 852.5 in.\(^2\)/plant in 2002 and 930 in.\(^2\)/plant in 2003 that was greater than other barnyardgrass biotypes (Table 1). The situation was the same with biomass. Quinclorac/propanil-resistant barnyardgrass produced the maximum average dry weights (1.54 lb), because this biotype produced more tillers as compared to other biotypes. The biomasses were similar in both years. Also, susceptible, propanil-resistant, quinclorac/propanil-resistant barnyardgrass produced more seeds than quinclorac-resistant barnyardgrass. Quinclorac/propanil-resistant barnyardgrass produced 47,000 seeds/plant, which was greatest among barnyardgrass biotypes and was significantly different from the quinclorac-resistant biotype.

In general, resistant biotypes of barnyardgrass were as productive as susceptible biotypes. The much greater productivity of individuals as compared to rice is noteworthy.

**SIGNIFICANCE OF FINDINGS**

Morphological and phenotypic differences were evident among the biotypes of barnyardgrass, and also barnyardgrass had a more profuse growth habit as compared to rice. However herbicide-resistant barnyardgrass biotypes were equally competitive to herbicide-susceptible biotypes.

Herbicide-resistant biotypes should be expected to sustain themselves ecologically even when selective herbicides are not used.

**ACKNOWLEDGMENTS**

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**LITERATURE CITED**


### Table 1. Height, tillers, leaf area, and number of seeds for cultivars Wells rice and barnyardgrass biotypes 11 weeks after emergence.

<table>
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<tbody>
<tr>
<td>Wells-rice</td>
<td>28</td>
<td>28</td>
<td>30</td>
<td>99</td>
<td>102</td>
<td>0.18</td>
<td>---</td>
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<td>S-ECHCG</td>
<td>35</td>
<td>39</td>
<td>170</td>
<td>620</td>
<td>651</td>
<td>1.15</td>
<td>33,690</td>
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<tr>
<td>PR-ECHCG</td>
<td>43</td>
<td>39</td>
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<td>465</td>
<td>667</td>
<td>1.21</td>
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<tr>
<td>QR-ECHCG</td>
<td>43</td>
<td>47</td>
<td>100</td>
<td>682</td>
<td>806</td>
<td>1.52</td>
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<tr>
<td>Q/PR-ECHCG</td>
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<td>39</td>
<td>210</td>
<td>853</td>
<td>930</td>
<td>1.54</td>
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<td>11</td>
<td>140</td>
<td></td>
<td></td>
<td>0.14</td>
<td>12,400</td>
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</table>

× S-ECHCG = susceptible barnyardgrass; PR-ECHCG = propanil-resistant barnyardgrass; QR-ECHCG = quinclorac-resistant barnyardgrass; Q/PR-ECHCG = quinclorac/propanil-resistant barnyardgrass.