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Distance of Interference of Red Rice (*Oryza sativa*) in Rice (*O. sativa*)[1]

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Abstract

Three rice cultivars were grown to determine the distance at which red rice affects growth and grain yield. Red rice reduced grain yield of Lemont when rice plants grew within 71 and 53 cm of red rice in 1986 and 1988, respectively. Grain yield of Newbonnet was reduced when grown within 53 cm of red rice in both years. Grain yield of Tebonnet was reduced when grown within 53 and 36 cm of red rice in 1986 and 1988, respectively. Grain yield reduction in influenced areas averaged 35, 26 and 21% for Lemont, Newbonnet, and Tebonnet, respectively. As the distance increased at 10-cm increments from the red rice row, Lemont, Newbonnet, and Teboment grain yields increased 49 to 85, 32 to 40, and 24 to 33 g/m², respectively. Rice straw dry weight was reduced when Lemont and Tebonnet were grown within 71 and 36 cm of red rice in 1986 and 1988, respectively. Straw dry weight of Newbonnet was reduced when grown within 36 cm of red rice in both years. As the distance increased at 10-cm increments from the red rice row, Lemont, Newbonnet and Tebonnet straw biomass increased 22 to 46, 10 to 18, and 12 to 20 g/m², respectively. Rice panicles/m² were reduced when Lemont, Newbonnet, and Tebonnet were grown within 36, 18, and 18 cm of red rice, respectively. Rice grains/panicle were reduced when rice was grown within 71, 71, and 36 cm of red rice for Lemont, Newbonnet, and Tebonnet, respectively.

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Introduction

Red rice is a competitive weed of rice in the southern U.S. A density of five plants/m² reduced rice grain yield by 22% (Diarra et al., 1985). Also, red rice is difficult to control in rice with herbicides because it is genetically and physiologically similar to commercial rice (Craigmiles, 1978; Hoagland, 1978) and is tolerant to most herbicides that are tolerated by rice cultivars.

Weed interference can be researched by different experimental methods (Connolly, 1988; Fernandez-Quintanilla, 1988; Oliver, 1988; Van Groenendael, 1988). The most common methods include studies in which weed density and duration of interference are varied. Usually in the area of interference studies, the effect of individual weeds on crops is determined, but in field situations the patchy distribution of weeds should be considered in assessing crop-weed interactions. From this standpoint the method used in this interference study would be comparable to high densities in patches of red rice infestations that frequently occur in rice field. Effects of area of influence or interference have been conducted with several weed in soybeans (*Glycine max* L. Merr.) (Monks and Oliver, 1988), cotton (*Gossypium hirsutum* L.) (Bridges and Chandler, 1986), and rice (Baker et al., 1987; Smith, 1987). However, research has not been reported on the area of influence of red rice on rice.

Development of integrated weed management systems must be supported by a thorough understanding of the dynamics of weed populations obtained from weed interference studies (Fernandez-Quintanillia, 1988). Understanding of interference thresholds, biology, and growth habits of weeds in essential to timely, effective, economical weed control technology for profitable rice production (Smith, 1988). An integrated weed management system for rice includes a directed agroecosystem approach for the management and control of weed populations at threshold levels to prevent economic damage in current and future crops (Shaw, 1982).

The objective of this study was to determine the distance at which red rice plants affected growth and yield of commercial rice cultivars.

Materials and Methods

Field experiments were conducted in 1986 and 1988 at the University of Arkansas Rice Research and Extension Center, Stuttgart, to determine the distance of interference of red rice on three rice cultivars. Plots were on a Crowley silt loam (Typic Albaqualfs) with a pH of 5.5 and 6.5 in 1986 and 1988, respectively, and 1% organic matter. Because growth and development of rice and red rice were injured by soil alkalinity in 1987, results for that year are not reported.

Lemont, Newbonnet, and Tebonnet cultivars, with plant heights at maturity of 84, 102, and 112 cm (Ark. Coop Ext. Serv., 1990), respectively, were drill-seeded at 145, 123, and 134 kg/ha, respectively, in 18 rows with a row spacing of 18 cm in plots 3.2 m wide by 3 m long (Fig. 1). At the time of drill-seeding rice, red rice was hand seeded as a center (A) row of each plot at seeding rates equivalent to rice cultivars. In control plots the appropriate rice cultivar was substituted for the red rice in row A. The experiment was arranged as a split plot with three replications with rice cultivars in main plots and rice distance from red rice in subplots.

Rice and red rice were seeded on May 14, 1986 and May 16, 1988. Plants of both species emerged on May 22, 1986 and May 30, 1988 at an average density of 390 plants/m^2 which is a higher density than normal field populations of 220 to 320 plants/m^2 for rice (Ark. Coop. Ext. Serv., 1990).

For general weed control all plots were sprayed with a tank mixture of propanil [N-(3,4-dichlorophenyl) propanamide] plus bentazon [3-(1-methylethyl)-1H)-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide] at 4 plus 0.6 kg/ha, respectively, in 190 L/ha with a backpack sprayer. These treatments did not injure rice or red rice.

All plots received a total of 202, 151, and 123 kg/ha nitrogen applied in three increments as urea for Lemont, Newbonnet, and Tebonnet, respectively, because each cultivar requires different rates of nitrogen for optimum grain yield (Ark. Coop. Ext. Serv., 1990). The first application was on dry soil when rice was in the 5-leaf stage just before flooding. The second increment was applied into the floodwater when rice internodes were 1.3 cm long, while the third increment was applied into the floodwater 7 to 14 days after the second application. In 1986 phosphorus (45 kg/ha) and potassium (90 kg/ha) were applied to the previous soybean crop, but they were applied preplant incorporated to rice in 1988. Chelated zinc at 2.2 kg/ha was applied preplant in 1988 to prevent rice injury from high alkalinity.

Measurements were recorded separately for each row in the plot. Before harvest five rice panicles from each row were randomly selected for determining the number of filled grains/panicle. Six rows of rice on each side of a red rice row were hand harvested. All measurements at the same distance on each side of the red rice row were averaged for each cultivar. Three outside border rows on each side of the plot were not harvested.

Panicles were separated from the straw, counted, and threshed. Rough rice yields were adjusted to 12% moisture. The straw was dried in a forced-air oven at 70°C for 48 hours and weighed. Data were subjected at analysis of variance and regression analysis.

Results

Data for weed-free plots were averaged for all 12 rows harvested because there were no significant differences among rows. The interaction of the year by distance by cultivar for rough rice yields and rice straw dry weights was significant at the 5% level; therefore, data are separated for each year and cultivar. Because the year by distance intereaction for panicles/m^2 and grains/panicle was not significant, these data were combined over years for each cultivar.

Growth and yield of Lemont.--In 1986 Lemont yield was reduced 11 to 68% for rice grown within 18 to 71 cm of red rice. Grain yield of Lemont in 1988 was reduced 16 to 56% for rice grown within 18 to 53 cm of red rice. Distance of influence of red rice on rice yield was less in 1988 than in 1986 because red rice lodged over rice plants in 1986. Linear regression models described grain yield response to increased distance from red rice in both years, but the slope was greater in 1986 than in 1988 (Fig. 2). The regression equations indicate that Lemont grain yields increased 85 and 49 g/m^2 in 1986 and 1988, respectively, for each 10-cm increase in distance from the red rice row; this is a 31 and 14% increase for the two years, respectively, for each 10-cm increment.

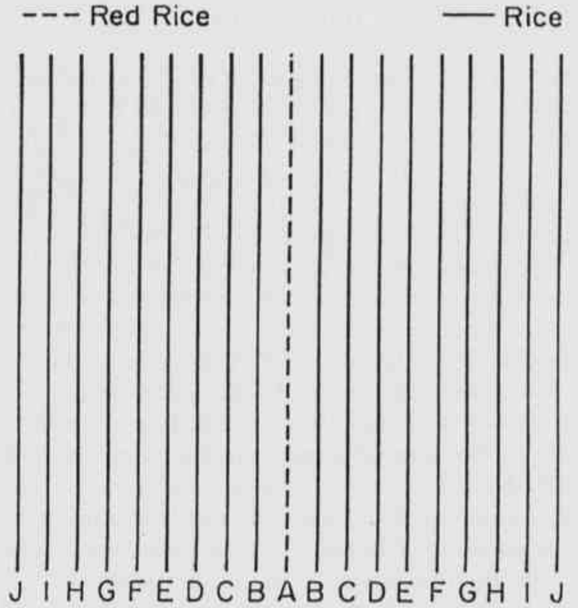

Fig. 1. Planting pattern for rice cultivars and red rice in plots. Data from rice rows B to G at the same distance on both sides of row A were combined and rows H, I, and J were borders. In the control plot the appropriate rice cultivars were substituted for red rice in row A.

Straw dry weight of Lemont was reduced within 71 and 36 cm from the red rice row in 1986 and 1988, respectively. Reductions were 16 to 46% and 14 to 35% in 1986 and 1988, respectively, compared to weed-free rice. Straw dry weight of Lemont increased linearly as the distance from red rice increased. (Fig. 3). Straw bionass increased 22 to 46 g/m² for each 10-cm increase that rice was grown form the red rice row.

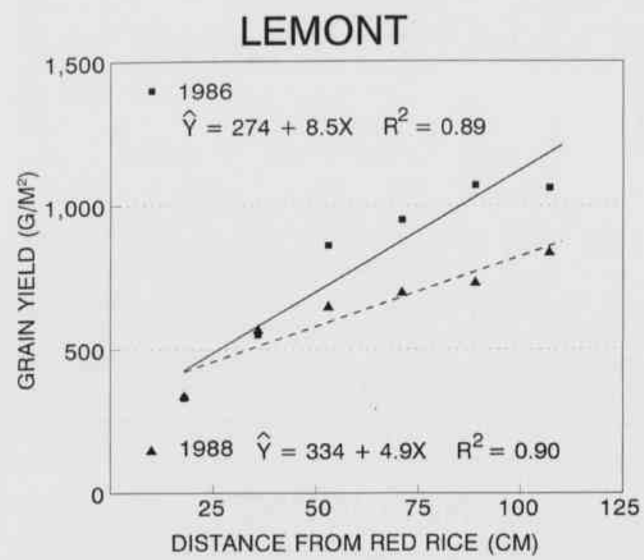

Fig. 2. Grain yield of Lemont rice when grown at different distances from red rice in 1986 and 1988. Grain yield of plots without red rice averaged 1080 and 765 g/m² in 1986 and 1988, respectively.

There was a quadratic response of rice panicles/m² with increased distance from red rice, but response of filled grains/panicle was linear (Fig. 4). Panicles/m² of Lemont were influenced within 36 cm of red rice with 19 to 37% reductions compared to weed-free rice. Filled grains/panicle were influenced within 71 cm from the red rice row with 13 to 55% reductions compared to weed-free rice. Shading of rice plants occurred by the red rice canopy over the rice because red rice was taller and had longer, droopier leaves than Lemont.

Growth and yield of Newbonnet.--Newbonnet grain yield was affected similarly in both years, although yields were greater in 1986 than in 1988 (Fig. 5). Red rice influenced grain yield of Newbonnet within 53 cm from red rice both years, with an average reduction of 26% and a range of 17 to 37% grain yield reduction when grown within 18 to 53 cm from the red rice row. Linear regression models described yield responses to increased distances from red rice (Fig. 5). Grain yields increased 32 to 40 g/m² for each 10-cm increase in distance that rice grew from the red rice row.

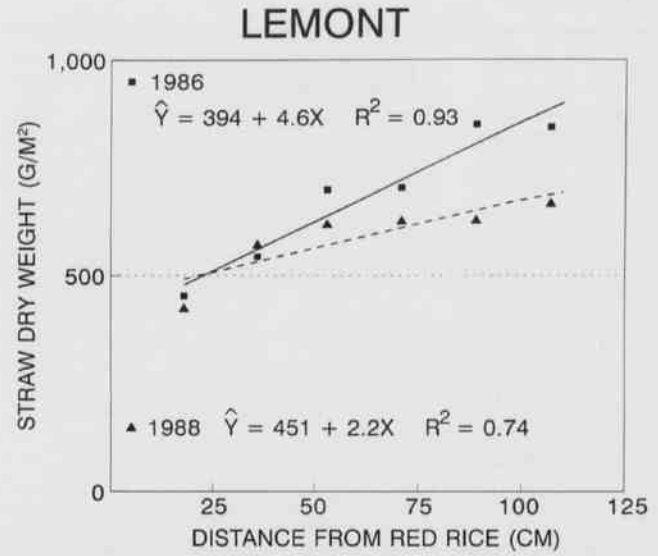

Fig. 3. Straw dry weight of Lemont rice when grown at different distances from red rice in 1986 and 1988. Straw dry weight of plots without red rice averaged 841 and 666 g/m² in 1986 and 1988, respectively.

Response of rice straw dry weight were similar to those of rice grain yield as distances increased form red rice (Fig. 6), but the affected distance was shorter for straw than for grain yield. Newbonnet straw biomass was reduced within 36 cm from red rice in both years, with an average reduction of 13% compared to weed-free rice. For each 10-cm increase in distance from the red rice row, grain yields improved 10 to 18 g/m².

Panicles/m² of Newbonnet were reduced within 18 cm from the red rice row with an 18% reduction at this distance, but filled grains/panicle were influenced with in71 cm from the red rice row, with 12 to 35% reductions compared to weed-free rice. The response of panicles/m² was quadratic, but that of filled grains/panicle was linear as the distance increased from the red rice row (Fig. 7).

Growth and yield of Tebonnet.--Grain yield of Tebonnet was reduced when rice was grown within 18 to 53 and 18 to 36 cm of the red rice row in 1986 and 1988, respectively. Red rice reduced grain yield of Tebonnet by 11 to 36% and 18 to 20% in 1986 and 1988, respectively, in affected distances compared with weed-free rice. Red rice reduced Tebonnet yield more in 1986 than in 1988 because red rice plants lodged on top of Tebonnet plants in 1986. A linear regression model described yield response to increased distances from the red rice row in both years, but the slope was greater in 1986 than in 1988

(Fig. 8). Tebonnet grain yields increased 24 to 33 g/m² for each 10-cm increment that the cultivar grew from the red rice row.

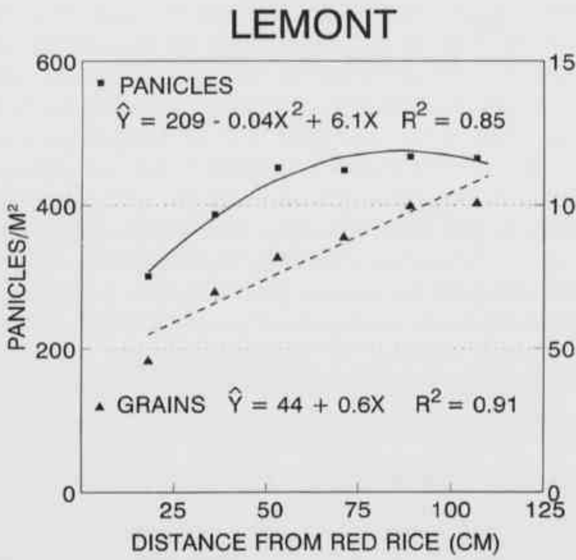

Fig. 4. Number of panicles and filled grains in panicles of Lemont rice when grown at different distances from red rice averaged for 1986 and 1988. Average values in control plots were 475 panicles/m² and 102 filled grains/panicle.

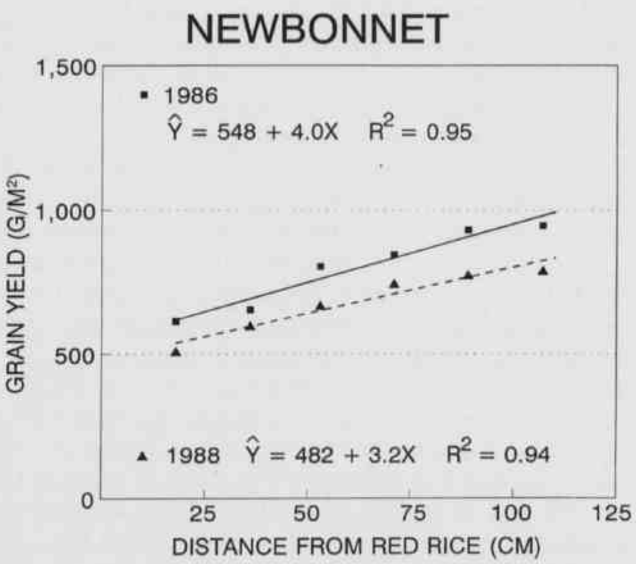

Fig. 5. Grain yield of Newbonnet rice when grown at different distances from red rice in 1986 and 1988. Grain yield of plots without red rice averaged 925 and 795 g/m² in 1986 and 1988, respectively.

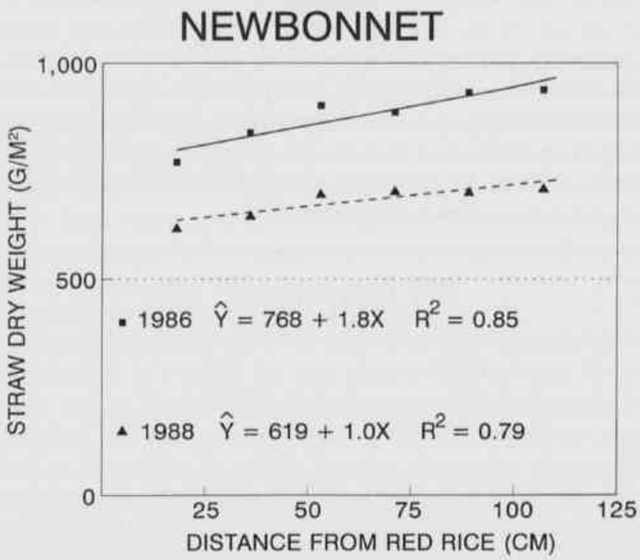

Fig. 6. Straw dry weight of Newbonnet rice when grown at different distances from red rice in 1986 and 1988. Straw dry weight of plots without red rice averaged 929 and 725 g/m² in 1986 and 1988, respectively.

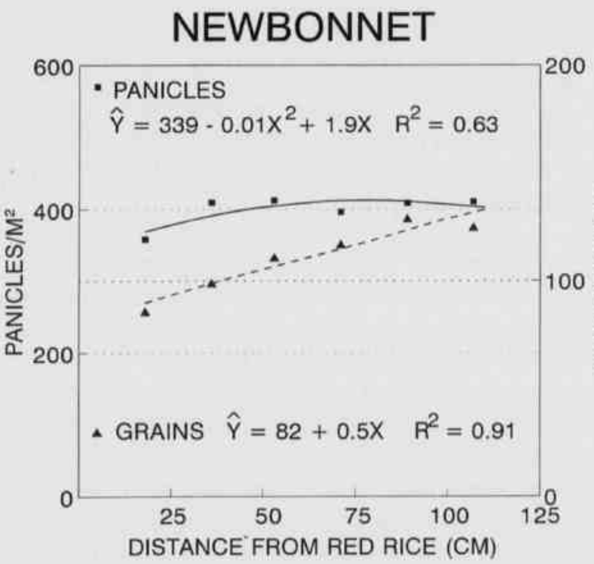

Fig. 7. Number of panicles and filled grains in panicles of Newbonnet rice when grown at different distances from red rice, averaged for 1986 and 1988. Average values in control plots were 438 panicles/m² and 133 filled grains/panicle.

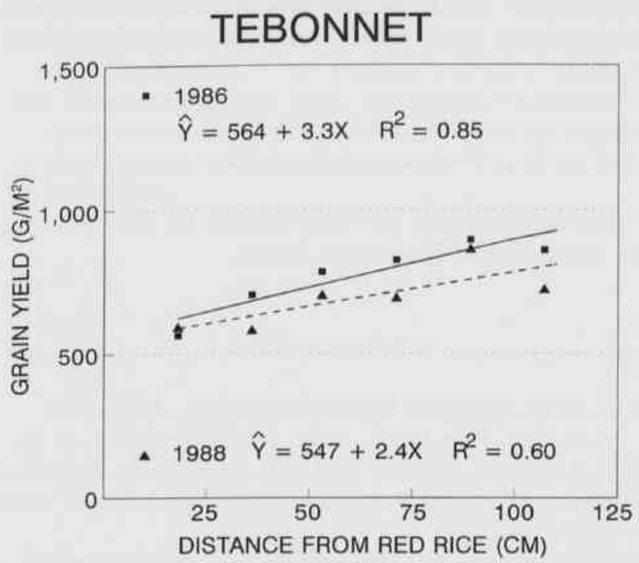

Fig. 8. Grain yield of Tebonnet rice when grown at different distances from red rice in 1986 and 1988. Grain yield of plots without red rice averaged 885 and 720 g/m² in 1986 and 1988, respectively.

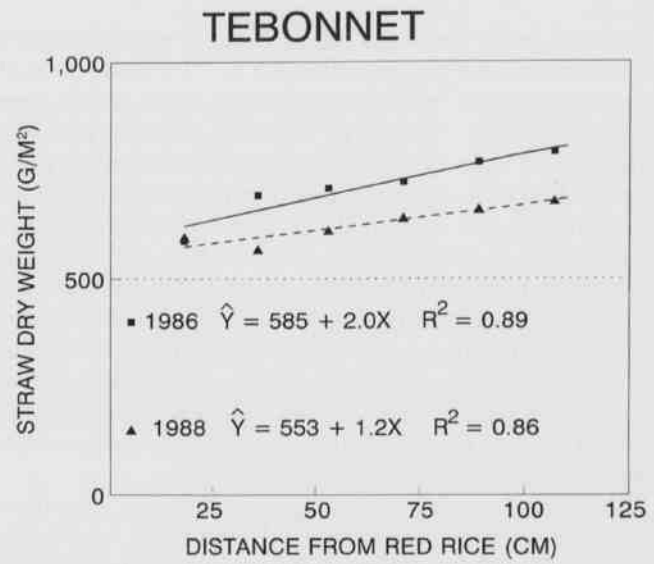

Fig. 9. Straw dry weight of Tebonnet rice when grown at different distances from red rice in 1986 and 1988. Straw dry weight of plots without red rice averaged 790 and 662 g/m² in 1986 and 1988, respectively.

Tebonnet straw dry weight was reduced within 71 and 36 cm from the red rice row in 1986 and 1988, respectively. Reductions of Tebonnet straw biomass were 8 to 26% and 10 to 14% for the two years, respectively compared with weed-free rice. Response of straw biomass was similar to that of grain yield of Tebonnet as the distance increased from the rice row. Tebonnet straw biomass increased 12 to 20 g/m² for each 10-cm increase in distance from the red rice row (Fig. 9). However, red rice reduced panicles/m² of Tebonnet in only the first rice row or 18 cm from the red rice row; a 10% reduction occurred when compared to weed-free rice. Red rice reduced filled grains/panicle in the first two rows or 36 cm of Tebonnet with a 17 to 28% reduction in affected distances. Filled grains/panicle was quadratic as distance from red rice increased (Fig. 10).

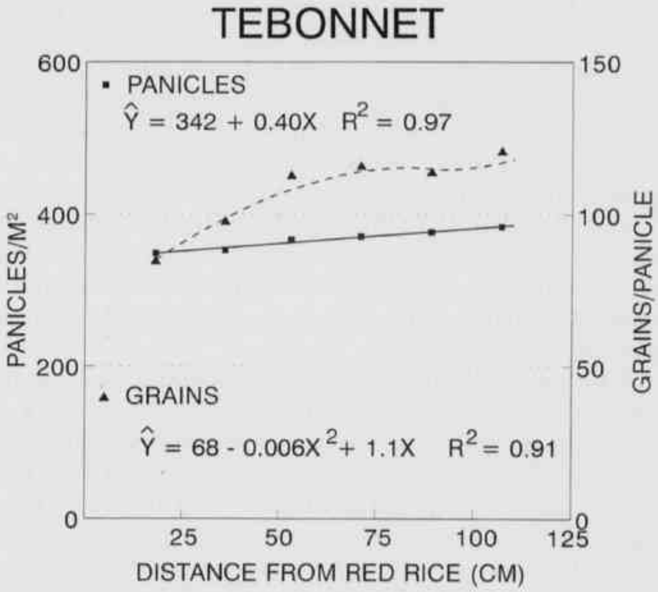

Fig. 10. Number of panicles and filled grains in panicles of Tebonnet rice when grown at different distances from red rice, averaged for 1986 and 1988. Average values in control plots were 389 panicles/m² and 118 filled grains/panicle.

Discussion

Lemont grain yield was reduced by an average of 35% when Lemont was grown within 53 to 71 cm of red rice. Reduction of grain yield averaged 26% when Newbonnet was grown within 53 cm of red rice. Grain yield was reduced 21% when Tebonnet was grown within 36 to 53 cm of red rice. Rice plants growing near red rice plants were affected more than those growing at greater distances from red rice. Lemont, Newbonnet, and Tebonnet at maturity have plant heights of 84, 102, and 112 cm, respectively (Ark. Coop. Ext. Serv., 1990). Short-statured crop plants compete less than tall plants with weeds (Jennings and Herrera, 1968; Smith, 1988). The use of plant growth regulators that would reduce plant height or biomass of red rice (Dunand et al., 1986) may reduce effects of red rice on rice.

Red rice interfered with grain yields of rice from greater distances than several weeds of soybeans. Common cocklebur (*Xanthium strumarium* L.), Palmer amaranth (*Amaranthus palmeri* S. Wats.), and tall morningglory (*Ipomoea purpuea* (L.) Roth) interfered with soybean yields when grown within 25, 25, and 12 cm, respectively of soybean plants (Oliver, 1988). However, devil's-claw (*Proboscidea louisianica* (Mill.) Thellung), velvetleaf (*Abutilon theophrasti* Medik.), and okra (*Abelmoschus esculentus* (L.) Moench) influenced cotton yields when grown within 2, 1, and 1 m, respectively, of cotton plants (Bridges and Chandler, 1986).

A basic assumption in weed-crop competition is that as a crop or weed plant grows from emergence to maturity, its interference zone form resources such as light, nutrients, and other growth requirements continues to expand until it meets another zone of neighboring plants (Fisher and Miles, 1973). The final dry matter yield of each plant is directly proportional to its area of interference. Generally plants first occupy space horizontally until all available horizontal space is occupied by either crop or weed plants.

The patchy distribution of weeds should be considered in assessing crop-weed interactions in the field. In interference studies it is commonly assumed that weeds are spatially homogeneously distributed and that they occur in monospecific stands in the field (Van Groenendael, 1988). Also, because the patchy distribution of weeds complicates crop-weed interactions, replacement method series are usually inadequate to assess competitive interactions in the field. Instead, additive experiments are more adequate to assess competition in field environments (Connolly, 1988). Therefore, use of regression response models relating crop growth and yield provides better methodology in assessing interactions involving patchy distribution of weeds. Although the method used in this study did not simulate the normal distribution of red rice in rice fields, red rice densities in the row would be comparable to high densities in patches of red rice infestations that frequently occur in rice fields.

Acknowledgements

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