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Mustard Seed Meal Soil Amendment and Varietal Resistance for Control of Seedling Disease in Organic Rice

Managing stand loss caused by seedling diseases (*Rhizoctonia solani* and other soilborne pathogens) is a challenge in organic rice production because no synthetic fungicides can be used for seed treatment. The use of mustard (brassica) seed meal as a biofumigant to control soilborne pathogens could offer an alternative to seed treatment fungicides. Biofumigation activities are produced through hydrolysis of glucosinolates in mustard seed meals by myrosinase under the presence of water. The mechanical cold-pressing process of mustard seeds to produce oil and seed meal byproducts does not trigger the hydrolysis of the glucosinolates due to the lack of water. Biofumigation chemicals are released for action once mustard seed meal is incorporated into soil. Mustard seed meal has been reported to have potential fungicidal, herbicidal, and insecticidal effects in many vegetables and field crops. However, no studies have been conducted in rice grown under flooded conditions.

A 2-year study was conducted as a split-plot design in a field under organic management to evaluate the performance of mustard seed meal soil amendment in combination with rice variety resistance for reduction in seedling disease and yield improvement. Main plots were soil amendments (mustard seed meal at 1,500 and 3,000 lb/ac, ryegrass green manure, and fallow) and subplots were rice varieties Cocodrie, Presidio, and XL753. Annual ryegrass was planted at 50 lb/ac in the fall and terminated in the subsequent spring. “Pescadero Gold” mustard seed meal (4.5-1.5-1.2, N-P-K) and winter annual ryegrass cover crop were incorporated into the soil at 3 weeks before rice planting. Seedling disease severity was assessed at 3 weeks after planting. Plots were harvested to determine rice grain yield.

Both mustard seed meal soil amendment treatments reduced % discolored root area and increased stand compared to the fallow and green manure treatments. XL753 had a lower % discolored root area and a higher stand density than did Cocodrie. Rice yield was greater with the low rate of mustard seed meal soil amendment than with fallow for both years. Yield was higher in XL753 than Presidio. Brassica seed meal soil amendment can reduce seedling disease and when its use is combined with a tolerant variety, such as a hybrid, can be an effective approach to reducing stand loss and improving yield under organic production.

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Update on Multistate Organic Rice IPM Research Project

The 3-year multistate organic rice IPM research project, funded by USDA-NIFA Organic Agriculture Research and Extension Initiative (OREI), was completed in 2018. Extensive research and extension activities have been conducted in Texas, Arkansas, and South Carolina to develop the strategies of using cover crops, soil amendments, rice varieties, and seed treatments for disease, weed and insect pest management, and grain yield improvement under organic production in the southern United States. This report summarizes the results and findings of this project.

***Cover crops and soil amendments**:* Cover crop trials were conducted at both Texas and Arkansas locations from 2016 to 2018. Each year, a trial was conducted at Beaumont, TX, consisting of four cover crop/soil amendment treatments (brassica 'Caliente 199', mustard seed meals, annual ryegrass, and winter fallow) and three rice varieties (Cocodrie, Presidio and XL753). The other was conducted at Pine Bluff, AR, consisting of three winter cover crops (crimson clover mixed with oats, cereal rye, and annual ryegrass) or one summer cowpea cover crop plus a fallow control. Winter cover crops were planted in the fall and incorporated into the soil during the subsequent spring 3 to 4 weeks before planting of rice. The summer cover crop was planted in the summer and incorporated in the fall. Ryegrass, cereal rye, oats, and cowpeas all produced sufficient aboveground biomass for weed suppression and provided benefits of N improvement (60 to 108 lb N/ac) for organic rice production. Crimson clover was difficult to establish, even as a mixture with cereal crops, due to a lack of tolerance to wet soil conditions in the winter. Likewise, the brassica cover crop did not perform well under wet weather conditions. However, a soil amendment with mustard seed meals (1,500 or 3,000 lb/ac, 4.5-1.5-1.2, N-P-K) was effective for not only maximizing the biofumigation activities of brassica materials for the control of soilborne pathogens and weeds, but also providing additional N, P and K. Mustard seed meal soil amendment significantly reduced seedling diseases, narrow brown leaf spot and brown spot. All the cover crops in combination with flooding reduced weed densities. No differences in the damage caused by rice water weevil were observed following any cover crop.

Organic rice varieties and seeding rate: Twenty, 15 and 12 varieties were tested in 2016 at Beaumont, TX; Pine Bluff, AR; and Charleston, SC, respectively. The ten best varieties selected from the 2016 trials were further evaluated at two seeding rates in 2017 and 2018 in Texas and Arkansas to optimize varietal performance. Jasmine 85, PI312777, Rondo, Tesanai 2, and the hybrids, XL723 and XL753, were among the best varieties having good seedling stands, aggressive growth, weed suppression, and high yield potential across the years and locations evaluated. Arborio, Charleston Gold, Express, and Tesanai 2 were among the best varieties having highest rice yields in the Charleston trial. These varieties are relatively taller and have a stronger ability to tiller, which may contribute to their higher yields and greater competition with weeds. Planting at 150% of recommended conventional seeding rate (120 and 60 lb/ac for inbreds and hybrids, respectively) was an effective method to improve stand and suppress weed growth. Charleston Gold, Jasmine 85, Jupiter, Wells, Rondo, Tesanai 2, XL723, and XL753 had high levels of resistance to narrow brown leaf spot. Della 2, Rex, Rondo, and XL753 were less susceptible to rice water weevil while Cocodrie and Presidio were among the varieties most susceptible to the insect pest.

Seed treatments: A field trial was conducted at the Beaumont site in 2016, 2017 and 2018 to evaluate the performance of seed treatment with gibberellic acid (GA) and the biocontrol agents Sonata (*Bacillus pumilus*), Integral (*B. subtilis*) and BioEnsure (fungal endophytes) using the two rice varieties Presidio and XL753. Seed treatment with Sonata, Integral or BioEnsure resulted in an increase in stand density. BioEnsure also improved whole and total milling yields whereas GA seed treatment increased plant height. Weed populations were lower in the plots of XL753 with GA seed treatment compared to Presidio. Compared to Presidio, XL753 had higher yield and better milling quality; XL753 had a greater stand and reduced narrow brown leaf spot and brown spot severities. Thus, GA and biocontrol agent seed treatments can improve stand and

plant growth. Combined with the use of XL753 and seed treatment with GA and biocontrol agent can improve stand establishment, weed suppression, and grain yield.

Economic analysis: A study was conducted to examine the factors affecting the economics of organic rice production in Texas and Arkansas. Data were collected from organic rice producers by interviews and then compared with conventional rice production data. Production inputs are less with organic rice compared to conventional rice. The main component necessary for profitable organic rice production is a guaranteed price premium, as organic yields are typically much lower than conventional yields. The price obtained for organic rice is generally twice that for conventional rice ($ 0.52/kg vs. $0.25/kg). The main barrier to entry into organic rice production is the 3-year waiting period required for certification of organic land. Selection of varieties with weed suppressive traits and proper water management are the key for weed control. A second study was conducted to determine seeding rates that maximize returns above the cost of seed in organic rice production. The results show that the Economic Optimum Seeding Rate (EOSR) for Presidio and XL753 was 71 and 42 lb/ac, respectively. Therefore, the organic rice EOSR for Presidio is comparable to the conventional optimum rate for Presidio, but the organic rice EOSR for XL753 is considerable higher than the conventional optimum rate for XL753. A third study was conducted to compare the economic returns of 13 rice varieties under both conventional and organic management using trial data from Texas. Based on mean net returns, the top rice varieties for organic management were Tesanai 2 ($712/ac), Jupiter ($608/ac), Jazzman ($587/ac), Wells ($536), Presidio ($422), and Rondo ($420), while the top varieties for conventional management were Jupiter ($272/ac), Sierra ($246/ac), Tesanai 2 ($230), Presidio ($191) and Cybonnet ($156).

On-farm demonstration trials: On-farm trials were conducted with established organic growers in 2018 to demonstrate the performance of improved management practices developed from this project on organic rice production under different management systems. The demonstration trials were established in Colorado and Jefferson Counties, Texas and in Charleston, South Carolina. There were two treatments in each trial: 1) improved management practices and 2) local farm management practices. The improved management practices refer to planting of Jasmine 85 (high yielding with disease and weed tolerance) at 120 lb/ac of seed (150% of conventional seeding rate) with GA and Sonata seed treatment for dry seeding production system or planting of Jasmine 85 at 120 lb/ac only for water seeding production system. Data collected from the Texas trials demonstrate that the improved management treatment can improve stand establishment, reduce narrow brown leaf spot, reduce weed density, and increase grain yield compared to the farm management treatment.

Significance of the findings to organic rice production: Our organic rice IPM project is the first multidisciplinary integrated organic rice research project in the US. We have developed the first two testing sites for organic rice research through this project. The results from this research have helped develop effective management practices that can minimize losses caused by disease, weed and insect pests and maximize organic rice productivity in the South. Winter cover crops (annual ryegrass and clovers) and brassica seed meal can suppress weeds and diseases and provide N and other nutrients that improve organic rice production. Selection of rice varieties (Jasmine 85, Rondo, Tesanai 2, XL753, etc.) that are tolerant to disease, weed and insect pests is the key to effective management of these pests, achieving profitable and sustainable production

of organic rice. Seed treatment with GA and increasing seeding rate can ensure adequate stands for weed suppression and yield potential. Seed treatment with biocontrol agents such as BioEnsure can reduce seedling diseases and improve stand establishment. Cost-benefit economic analyses from this project will help producers better manage input costs and increase economic returns. Through a variety of communication techniques, the project has reached a large national and global audience, most of whom are in Arkansas, California, Missouri, and Texas. Our outreach and extension activities included three organic rice field tours, 10 field days, four organic rice project advisory board meetings, four organic rice workshops, one organic rice symposium, and 18 local, national and international meetings. These activities have resulted in 32 abstract and article publications, 101 oral and poster presentations, and eight extension publications. This project has trained and supported 13 undergraduate students, one master graduate student and two PhD graduate students, four postdocs, five visiting scholars, and five technical support staff. In addition, we have produced the first Organic Rice Production

Guidelines document in the US that will help support farmers to produce organic rice profitably. For more information about this project, please visit the project webpage at http://bit.ly/299L2W5.

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