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ABSTRACTS

Evaluating the Efficacy of Benzobicyclon for Weedy Rice Control in Provisia Rice.

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Weedy rice (*Oryza sativa*) is difficult to control in Midsouth rice cropping systems due to its highly competitive and resilient nature, similarity to cultivated rice, and resistance to herbicides. Hence, there is a need for new modes of action in rice production. Gowan Company is currently pursuing registration of benzobicyclon, a Group 27 herbicide, as a post-flood option in rice. It will be the first 4-hydroxyphenylpyruvate dioxygenase-inhibiting herbicide commercially available in Midsouth rice production. In 2019, field experiments were conducted at the Pine Tree Research Station near Colt, AR and the Rice Research and Extension Center near Stuttgart, AR. The experiments were implemented as randomized complete block designs with four replications. The objective of the experiments was to evaluate benzobicyclon-containing weedy rice control programs, most of which contain Provisia™ herbicide, in Midsouth rice compared to currently used programs. The herbicides used in the experiments included Prowl H20 (pendimethalin), Bolero (thiobencarb), Warrant (acetochlor), Provisia (quizalofop), and Rogue (benzobicyclon). The herbicides were applied in various combinations and timings, except all Rogue applications were made post-flood. At PineTree, two weeks after the post-flood application, >98% weedy rice control was observed for all programs containing Provisia followed by a post-flood application of Rogue. At two weeks after the post-flood application, no more than 15% injury was observed from treatments containing Provisia followed by Rogue. At Stuttgart, two weeks after the post-flood application, >90% weedy rice control was observed for all treatments but were not significantly different. At two weeks after the post-flood application, <5% injury was observed from treatments containing Provisia followed by Rogue. These data suggest that the use of benzobicyclon in Provisia rice systems could be a viable weedy rice control option and may provide some protection against weedy rice evolving resistance to Provisia herbicide.

Development of Critical Rice Y-Leaf Potassium Concentrations during Reproductive Growth.

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Potassium (K) deficiency can limit rice (*Oryza sativa* L.) grain yield on soils with low exchangeable K. Symptoms of K deficiency are not always easy to visually diagnose during early reproductive growth and diagnostic tissue K concentrations are often growth-stage specific. Our primary objective was to i) characterize Y-leaf-K concentration response to K fertilization across time and ii) develop critical Y-leaf-K concentrations between the R1 and R4 growth stages for flood-irrigated rice. Ten Y-leaves were collected weekly during reproductive growth from selected fertilizer-K rates (0 to 149 kg K ha^{-1}) in thirteen trials with Mehlich-3 extractable soil-test K ranging from 32 to 164 mg K kg $soil^{-1}$ that were seeded with either a pure line (8) or hybrid (5) rice cultivar. The Y-leaves were dried, digested, and analyzed using traditional laboratory methods. The R1 growth stage was predicted using the DD10 program and rice development at each sample date expressed as growing degree days after R1 (GDDR1). The critical-K concentration across time was defined as the leaf-K concentration predicted to produce 95% of the maximum yield. A grain yield increase from K fertilization was measured at five of the thirteen trials. The five K-responsive trials were all seeded with a pure line cultivar with three of the responsive trials being long-term K fertilization trials where a response was expected. The remaining ten trials were located at five sites where trials with a hybrid and pure line cultivar were planted in adjacent areas. No yield response to fertilizer K was measured in either cultivar at three of the sites. At the remaining two sites, grain yield was increased by K fertilization in only the pure line cultivar. In the five K-responsive trials, rice receiving no fertilizer K produced 67 to 90% of the maximum yield produced by rice receiving fertilizer K. In general, Y-leaf K concentration in K-sufficient rice was greatest at the R1 stage and declined with rice development suggesting that the critical Y-leaf K concentration may also change across time. A multiple regression model that included GDDR1 and Y-leaf K concentration to predict relative yield from all of the trials (n=813) was significant and accounted for 44% of the relative yield variation. When the multiple regression was performed using data from the five trials seeded with a hybrid cultivar (n =300), the model was not significant and explained only 3% of the variability in relative yield. The same model with only the pure line cultivar data was significant with an r^2 value of 0.55 (n =513). The results suggest that the Y-leaf-K concentration can be used to assess the K nutritional status of pure line

cultivars during reproductive growth and hybrid cultivars may be less responsive to K fertilization and may produce maximal yield without fertilization on soils with lower K availability than pure line cultivars.

Efficacy of Selected Insecticides for Control of Soybean Loopers, *Chrysodeixis includens*, in Soybeans.

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Soybean loopers are an important pest of soybean in the Midsouthern U.S. and can cause extensive defoliation if not controlled. Trials were conducted in 2018 and 2019 to evaluate the efficacy of several insecticides for soybean looper control. Resistance to diamides, particularly chlorantraniliprole (Prevathon and Besiege) has been detected in the southeastern U.S. and concerns of tolerance/ resistance are obviously a concern for the Midsouth. While most of the insecticides in our study provided acceptable control, lambda-cyhalothrin provided little to no control of soybean looper.

Impact of Roller Carpet Applications of Dicamba on Soybean and Weed Control.

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With recent concerns over off-target dicamba movement from broadcast applications, alternatives to traditional broadcast herbicide applications are needed. Wick-based, herbicide applications were once used in row crops when control options were limited and crop tolerance to herbicides was marginal. While applying a herbicide like dicamba through a roller-carpet, wick-type applicator will not likely reduce volatility of the herbicide, it would greatly reduce the risk for physical drift from the treated field. To investigate the utility of a roller-carpet herbicide applicator in soybean cropping systems, two experiments were conducted to determine the most effective application methods in terms of weed control as well as to determine how these application methods would affect dicamba-resistant soybean. Both experiments were conducted at the Northeast Research and Extension Center using a randomized complete block design with four replications arranged as a 2 x 2 x 3 factorial comparing preemergence options, application timing, and application placement. Visible estimates of weed control were recorded at 7, 14, 21, and 28 days after the last application. Palmer amaranth control with roller carpet applications of dicamba were similarly as effective as broadcast applications without significantly injuring the soybean. This information will aid producers in determining if using a roller carpet applicator will be an effective tool in their operations.

Short-term Yield as Influenced by Winter Cover Crops in a Corn-Soybean Rotation.

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Corn (*Zea mays*)–soybean (*Glycine max*) rotations are a common crop production practice in Arkansas. Therefore, producers are always looking to maintain or increase yields while minimizing input costs. Introducing a cover crop could help obtain these goals; however, understanding the short–term effects on cash crop yields and profitability is essential for the adoption of cover cropping. The objective of this study was to determine the influence various winter cover crops have on corn and soybean yield both in the short and long-term. Four treatments included cereal rye (*Secale cereale*), Austrian winter pea (*Pisum sativum*. AWP), a mixture of black-seeded oat (*Avena sativa*) and AWP provided by the Soil Health Recommendation (SHR) tool, and an annual alternation of cereal rye (prior to soybean) and AWP (prior to corn). The experiment was conducted at Pine Tree Research Station near Colt, AR. At the initiation of the trial in 2016, the corn and soybean crops were planted following winter fallow. Corn in 2016 yielded 15,014 kg ha^{-1} and soybean yielded 3,700 kg ha-1. In 2017 corn following AWP had the highest numerical yield at 13,543 kg ha^{-1}; however, no significant differences were found amongst winter cover crop treatments. Soybean in 2017 maintained stable yield levels across treatments, with a general numerical trend of soybean following the SHR yielding the greatest, and soybean following fallow the lowest. In 2018 soybean following AWP and the alternating cereal rye-AWP treatment had statistically greater yields than the remaining treatments at 4,084 kg ha^{-1} and 4,011 kg ha^{-1}, respectively. Results show that soybean seemed to adapt well to the introduction of a cover crop with stable yields across both years. Corn yields varied largely due to poor stand establishment and added insect pressures associated with the introduction of cover crops to the production system.

Evaluating the Effects of Seeding Ratte and Planting Date on Grain Yield of Diamond Rice.

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Evaluation of seeding rates for rice, *Oryza sativa*, L., are conducted annually to determine appropriate seeding levels across a range of production and management conditions. In Arkansas, rice is planted from late March through mid-June each year. Therefore, evaluation of cultivar performance at various seeding rates across a range of planting dates is essential to ensure optimum seeding rates are selected to maximize rice production.

Diamond rice was seeded at 10, 20, 30, 40, and 50 seed per square foot at five or six planting dates at two locations in 2019. All seed was treated with an insecticide and fungicides according to common grower practice. Planting dates ranged from late March through June at both locations. Stand density and grain yield were evaluated at all planting dates at each location. Grain yield response to seeding rate was notable at both locations. Data suggests that current seeding rate recommendations based on planting date may need further study for future revision.

Does the Addition of Nitrogen and Potassium Fertilizers Aid Soybean in Recovery from Drift-rate Dicamba Injury?

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While providing an option for weed control, the increase in dicamba use in recent years has posed several new threats to non-dicamba soybean farmers in the form of physical drift and volatility. Soybean is extremely sensitive to dicamba, even at very low rates, such as when volatility or physical drift occur. The objective of this study was to determine if addition of the nutrients nitrogen (N) and potassium (K) would hasten soybean recovery from, or mitigate negative yield response to, low-dose dicamba injury. A field trial was established at the Arkansas Agricultural Research and Extension Center in Fayetteville, Arkansas in 2019. This trial was set up as a two-factor factorial with growth stage at application (R1 or R3) applied at 1/256X rate of dicamba as factor A and fertilization type as factor B. Injury data were collected using two scales, including a typical visible injury rating and the Behrens and Leuschen dicamba injury scale. At 4 weeks after the R1 application (3 weeks after the R3 application), fertilizer type had an effect on injury according to the visible injury and Behrens and Leuschen scales. Based on visible injury, plots receiving both N and K had lower injury compared to plots receiving neither N nor K as well as those receiving N alone. For the Behrens and Leuschen scale, plots receiving only K had lower injury than plots receiving neither N nor K as well as all other treatments. For visible injury ratings taken 2, 3, 4, 5, and 6 weeks after the R1 dicamba application plots receiving both N and K had the numerically lowest injury, although it was not always significant. For the Behrens and Leuschen scale, ratings taken at 2, 3, and 4 weeks after the R1 application plots receiving K alone had the numerically lowest injury, although not always significant. At 5 and 6 weeks after the R1 application, plots receiving N and K had the lowest injury. Nontreated plots with soybean receiving N and K consistently produced the highest amount of plant biomass while the opposite was true for treated plots.

Application Volume Effect on Herbicide Efficacy: Implications on Resistance Evolution.

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Effective weed control is critical to avoid yield loss from weed competition. For optimum efficacy, herbicides should be applied at the appropriate plant size, dose, and application volume. The use of low application volumes reduces herbicide application costs. However, this practice compromises coverage, reducing the amount of active ingredient reaching some of the weeds in the field. Survivors of repeated reduced doses at the plant level,due to insufficient coverage, will eventually produce offspring with higher herbicide tolerance. To determine how application volume affects the efficacy of foliar-applied rice herbicides, two field experiments were conducted at the Research Station, Rohwer, Arkansas in 2019. One test evaluated herbicide efficacy and the other evaluated crop safety. The crop safety test was broadcast-sprayed with general maintenance herbicides to keep the whole test weed-free. The efficacy test was not blanket-sprayed with maintenance herbicides. The experiment consisted of five herbicide treatments sprayed postemergence at 5, 10 and 20 GPA plus a check. The herbicide treatments were quinclorac (0.25 lb ai acre^{-1}), quinclorac + clomazone (0.25 + 0.3 lb ai acre^{-1}), quinclorac + propanil (4 + 0.25 lb ai acre^{-1}), quinclorac + fenoxaprop (0.25 + 0.11 lb ai acre^{-1}) and topramezone (0.0164 lb ae acre^{-1}). Each herbicide was sprayed with the recommended adjuvant. The treatments were arranged in a split-plot design with four replications. Visible weed control and rice injury ratings were recorded at 2 and 4 weeks after treatment (WAT). Rice was harvested using a small-plot combine. Data were subjected to analysis of variance, using the R agricolae package (R Core Team 2014, Vienna, Austria). When necessary, means were separated using Fisher's least significant difference (LSD) test ($\alpha = 0.05$). The interaction of herbicide treatment by application volume was significant for weed control. Quinclorac + propanil performed better than quinclorac alone, or the other standard herbicide treatments at 5 and 10 GPA. Quinclorac + fenoxaprop was best applied at 10 GPA. Topramezone, which is not labeled for rice, was more effective on grasses than the standard herbicides tested and performed best at 5 and 10 GPA. Overall, the herbicides were most effective at 10 GPA; lower spray volume compromises efficacy. However, this herbicide caused higher injury to rice compared to the standard rice herbicides**.** The interaction of herbicide by application volume was also significant on yield. Quinclorac alone, applied at 5 GPA, resulted in lower yield compared to quinclorac + propanil. Quinclorac applied alone resulted in significantly higher yield at 10 GPA than at 5 GPA. Rice performance also was generally better at 10 GPA than at 5 or 20 GPA. Therefore, for optimum weed control and rice yield, herbicides need to be applied at 10 GPA.

Is There Influence on Pre-Tassel Nitrogen Uptake by Side-Dress Nitrogen Rates in Furrow Irrigated Corn Production?

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Yield increase associated with pre-tassel nitrogen (N) applications in corn (*Zea mays*) show to rely greatly on side-dress N applications. The objective of this study was to predict the influence of side-dress N rates and its influence on pre-tassel N uptake and fertilizer-nitrogen recovery efficiency (FNRE). For this presentation 8 different treatments were used on a silt loam soil at the Pine Tree Research Station (PTBS), near Colt, AR and the Arkansas Agriculture Research and Extension Center (AAREC), near Fayetteville, AR. Two different timing applications were implemented; at late reproductive stage 1 (R1), and early tassel (PT). All treatments received 34 kg N ha^{-1} at pre-plant. One of the following N rates were used for side-dress at the V6-V8 growth stage; 90 or 112 kg N ha^{-1}. All side-dress treatments received either 50 kg N ha^{-1} or 0 kg N ha^{-1} for pre-tassel.

Soybean Phenology Prediction Tool for the mid-southern U.S.

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Soybean (*Glycine max* (L.) Merrill) vegetative growth stages are based on the number of nodes on the main stem beginning with V1 (fully developed leaf at the unifoliolate node). Key reproductive stages include first flower (R1), beginning seed growth (R5), physiological maturity (R7), and harvest maturity (R8). Based on time to flowering and maturity, soybean cultivars are classified into 13 maturity groups (MGs) from 000 to X. The ability to predict phenology can aid farmers in optimizing use of workforce and farm machinery, and scheduling management decisions that are phenology-dependent, such as irrigation and pesticide recommendations. Eco-physiology models can predict soybean development with equations describing daily development as a function of temperature, photoperiod, and cultivar sensitivity to these environmental conditions. However, these models require calibration with field data and a skilled user, limiting their agronomic application and adoption. We developed an interactive forecasting tool (SoyStage) using algorithms and previously calibrated coefficients from DSSAT-CROPGRO-Soybean. SoyStage predicts R1, R5, and R7 for emergence dates ranging from 14 March to 27 June in 7-day intervals, MGs 3.2 to 6.7 in one-half MG increments, and 2776 locations across the US Midsouth based on weather data from 1981 to 2016. Predictions from SoyStage agreed well with field observed phenological stages monitored during 2012-2014 at 27 site-years (RMSE $\leq$ 7.2 days). SoyStage can be accessed through the internet (http://soystage.hosted.uark.edu), requiring minimal inputs and predicting soybean phenology for a wide geographical area, MGs, and emergence dates.

Does Dicamba Accumulate in Soybean Seed Following Late Season Exposure?

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The release of new dicamba formulations to be applied over-the-top of Roundup Ready 2 Xtend (dicamba-resistant) soybean and XtendFlex (dicamba-resistant) cotton provided growers additional options to control multiple herbicide-resistant weeds, such as Palmer amaranth. However, applications can be problematic because of the sensitivity of non-dicamba-resistant soybean in neighboring fields. Recovery of non-dicamba-resistant soybean to off-target movement is more likely to occur when exposure occurs during vegetative rather than reproductive development. Post-flowering reproductive exposure of non-dicamba-resistant soybean to dicamba often leads to pod malformation and subsequent auxin-like injury to progeny. Yet, no publication to date has documented the presence of dicamba in seed. The purpose of this experiment was to determine if dicamba could be detected in seed of non-dicamba-resistant soybean exposed to the herbicide at late reproduction, using radiolabeled herbicide as a tracer. Non-dicamba-resistant soybean plants were grown in the greenhouse until the pod-filling growth stage and then treated with 1/200X of the recommended rate of 560 g ae/ha plus 0.25% v/v of nonionic surfactant. Immediately following the application, [14C]dicamba (approximately 6.4 kBq per plant) was applied to the adaxial surface of one trifoliate leaf located at the mid-portion of each plant. The greatest amount of [14C]dicamba recovered was in seeds and in pods, and these plant parts accumulated 44 and 38% of the total absorbed, respectively. Additional results showed that the full amount of the [14C]dicamba present in the soybean seeds was in the phytotoxic acid form, except for a single sample, in which one metabolite was detected (possibly, 5-hydroxy dicamba). Safety measures should be taken to avoid dicamba exposure to soybean plants, as those may affect seed quality of off-spring plants.

Effect of Planting Date, Seed Quality, and Seed Treatment on Soybean Stands and Yield.

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Soybean (*Glycine max*) production is negatively affected by seedling diseases. Seedlings diseases are commonly associated with cool, moist soils and may be caused by a complex of pathogens. Environmental conditions and pathogen diversity are limiting factors in achieving maximum plant stands and high yields. Seedling diseases are more severe with low vigor seeds. The primary control measure for seedling diseases is the use of seed treatments, but it is not always clear which seed treatments will be the most effective. The objective of this study was to compare the effect of commercially available soybean seed treatments on plant stand and yield in with high and low vigor seed across environments.

Field trials were conducted to evaluate the effects of nine seed treatments plus an untreated control on high and low quality soybean seeds from cultivar UA 5715 GT, at Rohwer Research Station in 2018 and 2019. The test was conducted as a randomized complete block design with 5 replications. The treatments were fludioxonil + mefenoxam (ApronMaxx® RFC), thiamethoxam (Cruiser® 5FS), thiamethoxam + mefenoxam + fludioxonil + sedaxane (CruiserMaxx® Vibrance® Beans), abamectin + thiamethoxam + mefenoxam + fludioxonil (Avicta Complete Beans), fludioxonil (Maxim® 4FS), sedaxane (Vibrance®), prothioconazole + penflufen + metalaxyl (EverGol Energy®), trifloxystrobin (Trilex®) and metalaxyl (Allegiance® – FL). The test was established on two planting dates (second week of May and first week of June) each year. Stand were counted 14 and 28 days after planting and yields were taken at harvest.

Seed treatments did not result in significantly higher stands than the untreated control with high vigor seed planted in either May or June in 2019 or planted in May in 2018. However, in the 2018 June planting, seed treated with EverGol Energy® resulted in significantly greater stand than the untreated control. No seed treatment had significantly higher yields than the control at any planting date in either year with high vigor seed.

Low vigor seed responded to seed treatments in each test. In 2018, CruiserMaxx® Vibrance® Beans resulted in significantly higher stands than the control in both May and June plantings. Several of the seed treatments also resulted in stands that were not significantly lower than the best seed treatment with the high quality seed. In 2019, all seed treatments resulted in stands significantly higher than the control and several treatments resulted in stands not significantly different than the best treatment with high quality seed. In 2018, Vibrance® in the early and late plantings and EverGol Energy® in the late planting had stands significantly lower than the low vigor control. In 2018, CruiserMaxx® Vibrance® Beans had significantly higher yields than the control, but in 2019 all seed treatments had greater yields than the control.

Overall, stands and yields were higher in May than June plantings and with high than low vigor seed. Seed treatments resulted in higher stands and yields, especially with low vigor seed, some treatments appeared to be phytotoxic with low vigor seed, but not high vigor seed.

Managing Nitrogen in Furrow-Irrigated Rice Production.

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Rice (*Oryza sativa* L.) grown in an upland environment, commonly known as furrow-irrigated rice (FIR), is gaining increasing popularity in the Mid-South. Nitrogen (N) management of FIR must differ from that of a typical delayed-flood rice environment due to the lack of a continuous flood, which facilitates greater N loss potential mainly via nitrification-denitrification. A study was initiated in 2018 and continued in 2019 to define optimum N management strategies for the FIR production system. Urea with an added urease inhibitor (n-butyl thiophosphoric triamide, or NBPT) was examined across multiple rates and timing schemes. Seven site years with a silt loam or sandy loam soil texture and four site years with a clayey soil texture were utilized. Grain yield, milling yield, and total N uptake were measured and analyzed by year, site, and location within the field (top versus bottom) due to significant interactions. It was hypothesized that a four-way split application would lead to the greatest rice grain yield and N uptake; however, yield data suggests that more than one viable N management option exists. In both 2018 and 2019 a three-way split application resulted in the greatest yield on a clayey soil texture, producing an average of 244 to 266 bu ac^{-1} in the upper portion of the field (no standing water) and 230 to 267 bu ac^{-1} in the lower portion of the field (delayed-flood environment). A two-, three-, or four-way split application optimized yield with several timing schemes on a silt loam and sandy loam soil texture, as all N management schemes excluding one single application and the untreated control were statistically insignificant at most sites but were confounded by greater variability compared to the clayey soils. Results across both soil textures in 2018 showed little correlation between total N uptake and yield. With this knowledge base, FIR producers in the Mid-South will be able to optimize N fertilizer applications to both increase yield and reduce inputs.

Optimizing Timing between Sequential Applications of Dicamba and Glufosinate.

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Fexapan®, Xtendimax® with VaporGrip®, and Engenia® labels do not allow for dicamba and glufosinate to be applied in mixture over-the-top of XtendFlex™ crops. Field experiments were conducted in 2019, in Crawfordsville, Marianna, and Keiser, AR, to evaluate the efficacy of dicamba followed by glufosinate and glufosinate followed by dicamba when applied at 0.2, 3, 7, 14, and 21-day intervals from the initial application on native Palmer amaranth populations. Field experiments were conducted to assess if the interval between sequential applications could be optimized to improve weed control when compared to dicamba and glufosinate POST herbicide programs. In two of the three experiments where Palmer amaranth was greater than 5 inches tall, dicamba followed by glufosinate at a 14-day interval provided consistently greater control than either sequence of dicamba and glufosinate at 0.2, 3 and 7-day intervals. Overall, dicamba followed by glufosinate at a 14-day interval provided equal or greater control than dicamba followed by dicamba or glufosinate followed by glufosinate at any interval. The addition of two effective modes of action for POST control of Palmer amaranth will mitigate the evolution of herbicide resistance and aid in preservation of currently available technologies.

Trajectories of PPO Resistance Evolution in Palmer Amaranth in Arkansas and Mississippi.

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The use of protoporphyrinogen oxidase IX (PPO) inhibitors control glyphosate- and ALS-resistant Palmer amaranth had selected for PPO-resistant resistant populations in the current decade. Resistance to PPO herbicides spread quickly across states. Target-site mutation is the principal resistance mechanism, but evidences of herbicide detoxification had been reported as well. This research surveyed the spread of PPO-resistant Palmer amaranth populations across the mid-southern US. This paper presents data on Arkansas and Mississippi. Sixty-four accessions from Arkansas (AR) and 47 from

Mississippi (MS) were collected from cotton and soybean fields in 2017 and tested for fomesafen resistance. Seeds were sown in two 50-cell trays and thinned to one plant per cell. When seedlings were 3- to 4-in tall, fomesafen (264 g ai ha-1) was sprayed at 187 L ha-1 spray volume. A non-ionic surfactant was added at 0.5% v v-1 and a susceptible accession was included as reference for herbicide efficacy. At 21 days after treatment, plant injury was individually evaluated using a 0 – 100% scale relative to the nontreated plants, where 0% corresponds to absence of symptoms and 100%, to total desiccation. Young leaf tissues were collected from 6 to 25 survivors of each accession and stored individually in -80 C until processing. Genomic DNA was extracted using a modified CTAB method and plants were genotyped for the presence or absence of the four known mutations in the PPO gene from Palmer amaranth (ΔG210, R128G/M and G399A) using a Taqman allelic discrimination assay. For the ΔG210, each plant was genotyped individually so frequency of the mutation could be determined. The other mutations are rare so DNA of up to 10 plants was pooled and used in the assay to determine presence of any mutation at the population level. Palmer amaranth response to fomesafen was analyzed using hierarchical clustering of injury and mortality data; accessions were classified according to number of mutations carried by its survivors. The accessions differed significantly in response to fomesafen and were grouped in three clusters. The first cluster included the 48 most sensitive accessions (34 from AR and 14 from MS) and had 95 and 86% average mortality and injury of survivors, respectively. Of these, 23 were controlled 100%. All accessions in clusters 2 were from AR. Cluster 2 had 88 and 39% average mortality and injury of survivors, respectively. All accessions in cluster 3 were from MS. The MS accessions had 38% mortality and 77% average injury of survivors. In other words, the AR accessions had high mortality but healthy survivors while the MS accessions had low mortality, but with highly injured survivors. Of the 71 accessions with survivors, the prevalence of ΔG210, G399A, R128G and R128M was 54, 25, 20 and 6%. Twenty four accessions had survivors but did not carry any mutations; 14 of these were in cluster 3, indicating the presence of non-target site resistance or novel mutations in the PPO gene among Palmer amaranth in AR. On the other hand, all accessions from the cluster 2 had PPO-mutations: one or two mutations per population were the most common. Cluster 2 had lower resistance level and ΔG210 is the prevalent mutation among these populations. In conclusion, 40% of the populations were classified as susceptible to fomesafen. The remaining accessions were almost equally divided in clusters 2 and 3 (33 and 30, respectively) where the survivors in cluster 3 had low level resistance to fomesafen. The ΔG210 mutation was the most prevalent mutation across accessions, followed by G399A, R128G and R128M. Fourteen accessions are potentially carriers of novel mutations, or evolved non-target site resistance mechanisms. Palmer amaranth in AR exhibit a different pattern of resistance evolution compared to those in MS.

Effect of S-metolachlor Application Timing on Herbicide Degradation in Captina Silt Loam.

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A field experiment and laboratory incubation study were conducted in summer 2019 at the experimental farm of the University of Arkansas (Fayetteville) to evaluate the effect of S-metolachlor application timing on its dissipation in a Captina silt loam soil. A randomized complete block experiment was established in the field with 4 replications. Four S-metolachlor treatments were tested: preemergence followed by postemergence application (PRE fb POST), preemergence only (PRE only), postemergence only (POST only), and a nontreated control. Roundup-Ready soybean was planted on June 11. Herbicide treatments were applied using a CO2 pressurized backpack sprayer delivering 20 GPA at 40 PSI with a spray boom fitted with a flat fan 8002 nozzle. Preemergence application of S-metolachlor (1.2 lb/A) was done within 2 days after planting and the field was irrigated at ½-inch within 24 hours after application by sprinkler irrigation. Postemergence application of S-metolachlor occurred at the third trifoliate growth stage and weeds in the nontreated plots were managed with a POST application of glyphosate at the labelled rate. Soil samples were 4 wk after POST application of S-metolachlor at 4-inch depth from the inner soybean rows. Soil samples were sieved and spiked with 0.75 ppm of analytical grade S-metolachlor. Five hundred grams of soil from each plot were incubated in duplicates in a growth chamber at 25oC and 100% relative humidity. S-metolachlor dissipation was evaluated at 7 time points (0, 1, 4, 7, 14, 28, 56 days after spiking). The concentration of S-metolachlor in each subsample was analyzed with a triple quadrupole Shimadzu TQ8040 GCMS using helium as the mobile phase. S-metolachlor was monitored at m/z 162. A first order degradation model was fitted to the data and half-life values were determined.

Evaluating the Efficacy of Loyant on Palmer Amaranth in Furrow Irrigated Rice.

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Palmer amaranth is the most troublesome weed of cotton and soybean in the Mississippi Delta region of Arkansas and is now one of the most problematic weeds of rice, especially in furrow-irrigated fields. One effective option for Palmer amaranth is 2,4-D; however, in some portions of the state, its use is severely limited by current restrictions. Two experiments were conducted in Marianna, Arkansas in 2019 to evaluate the effectiveness of Loyant (florpyrauxifen-benzyl) for Palmer amaranth control in furrow-irrigated rice production. Averaged over application timings, the effectiveness of Loyant on Palmer amaranth generally increased as rate increased. Averaged over Loyant rates, the herbicide was generally more effective as application timing was delayed from 2 to 4 weeks after planting (WAP), the exception being 5 WAP. The lack of sustained control from earlier applications are likely a result of subsequent emergence in the absence of a rice canopy and the lack of effective control at 5 WAP is attributed to the large weed size at application. Control of 8- to 10-inch tall Palmer amaranth at 4 WAP exceeded 90% when Loyant was applied at 6 fl oz/A. This level of control was not different from Loyant rates of 10 and 16 fl oz/A. Loyant does appear to be effective option for Palmer amaranth control in furrow-irrigated rice and will be widely used for control of this weed as furrow-irrigated rice acres continue to increase.

Impact of Rice Planting Arrangement on Stand Density and Grain Yield.

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In Mid-South rice (*Oryza sativa* L.) production, drill-seeding is the most common planting practice. Novel rice plant spacing and arrangement may be able to reduce seeding rates and increase yield by allowing improved plant density and quicker canopy coverage. Two experiments evaluating the impact of row spacing and planting arrangement on rice stand density and grain yield were conducted in 2019 at the Rice Research and Extension Center near Stuttgart, AR and at the Northeast Research and Extension Center near Keiser, AR. The row spacing study consisted of a pureline cultivar, Diamond, and a hybrid cultivar, XP753, planted at a range of seeding rates, which included 10, 20, 30, 40, and 50 seed ft2 for Diamond and 4, 7, 10, 13, and 16 seed ft2 for XP753 using drill row spacings of 3.25, 7.5, 10, and 15 inches. An additional study focusing on planting arrangement evaluated the same two cultivars on 7.5 inch spacing. However, seed was planted either in a single pass of one direction, or divided over two passes with the second pass perpendicular to the first. In the row spacing study, row width had a significant effect on grain yield of both cultivars at both locations. In the planting arrangement study, arrangement had a significant effect on grain yield only at a single location for each cultivar.

Efficacy of Selected Insecticides for Control of Cotton Bollworm, *Helicoverpa zea*, in Conventional Cotton.

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Selected insecticides were evaluated for control of cotton bollworm in a conventional cultivar from 2017 to 2019. The standard treatments included Prevathon at 14 and 20 oz/acre; Besiege at 7 and 10 oz/acre; Intrepid Edge at 8 oz/acre; Brigade 4.5 oz/acre + Prevathon 14 oz/acre; Brigade 6.4 oz/acre + Prevathon 20 oz/acre, and an untreated check. In 2017, treatments included Bifenthrin at 5.12 oz/acre. In 2018 treatments included Brigade 6.4 oz/acre + Acephate 0.075 lb ai/acre, and an experimental insecticide at three undisclosed rates. In 2019 Bifenthrin 5.12 oz was tank mixed with selected insecticides including Radiant 5 oz, Acephate 0.75 lb, Prevathon 14 oz, and Prevathon 20 oz. Fruit damage was extremely high in the untreated check and experimental, as well as bifenthrin alone and in some combinations. Rate responses were observed for all other insecticides.

Impact of Dicamba Exposure on Reproductive Rice.

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Engenia and XtendiMax with VaporGrip are labeled for preemergence and postemergence (POST) use in XtendFlex cotton and Roundup Ready 2 Xtend soybean. Despite its efficacy, labeled applications of Engenia and XtendiMax in both cotton and soybean have presented major concerns for off-target movement, primarily to non-dicamba-resistant soybean. Extensive research has been published regarding the effects of sublethal concentrations of dicamba at different growth stages in soybean; however, there is limited research investigating the impact of dicamba on reproductive rice. In order to determine the potential consequences of dicamba drift rates on reproductive rice, an experiment was conducted near Stuttgart, Arkansas in 2018 and 2019. Simulated drift rates of dicamba at 1, 1/10, 1/100, and 1,1000X rates, with 1X being 0.5 lb ae/A of dicamba were applied to rice at three reproductive growth stages. Treatments were arranged as a two-factor factorial, with the first factor being dicamba rate, and the second being rice growth stage. There were no significant treatment effects observed with 100-seed weight, although dicamba rate played a significant role on the relative average panicle weight with a 15 and 39% reduction at the 1/10 and 1X rate, respectively. The same trend translated to both average number of seeds per panicle and yield, with a decrease of approximately14 and 35%. With severe consequences only being observed at high dicamba concentrations, the threat off-target movement poses to rice is far less severe than what has been observed in soybean.

Evaluating the Economic Impact of Soybean Following Winter Cover Crops Vs. Double-Cropped Soybean.

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Winter cover crops have been shown to provide various benefits including improving soil health, but can have varying effects on the yield and performance of the successive cash crops. The objective of this study was to evaluate the effects of different winter cover crop species on the yield of the following soybean (*Glycine max L.*) crop in order to determine the economic feasibility of each cover crop species vs. winter fallow. The following treatments were implemented: winter fallow, winter wheat (*Triticum aestivum* L.) for grain, cereal rye (*Secale cereale*), black-seeded oats (*Avena sativa*), barley (*Hordeum vulgare*), Austrian winter pea (*Pisum sativum*), Blue lupin (*Lupinus angustifolius*), Mix 1 (cereal rye, crimson clover [*Trifolium incarnatum*], seven-top turnip [*Brassica rapa*]), Mix 2 (black oats and Austrian winter pea). Each winter cover crop treatment was planted on a silt loam soil at three research stations in Arkansas, which include the Vegetable Research Station (VRS) near Kibler, AR, the Rohwer Research Station (RRS) near Rohwer, AR, and the Pine Tree Research Station (PTRS) near Colt, AR. The results of the study showed no significant difference in soybean yield amongst treatments at the RRS. However, soybean yield was significantly lower following the winter wheat for grain treatment at VRS ($P<.0001$) and PTRS ($P=.0002$) and is a direct result of the later planting date of double-cropped soybean vs. soybean following cover crops. At most locations there was little to no difference in soybean yield following cover crops during the first year of the trial, but there were significant differences in the cost of each treatment. Based on the results of this study, double-cropped soybeans at PTRS and VRS performed poorly, and was not as profitable as other cover crop treatments. However, it was economically feasible to follow a winter wheat crop with soybeans at the RRS location.

Effects of Defoliation on Growth and Yield in Rice.

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Fall armyworm (FAW), *Spodoptera frugiperda*, is commonly found in rice in the mid-south, and has the potential to cause severe defoliation to the rice crop. The current threshold for armyworms in rice is based on a number of larvae per square foot. A defoliation based threshold would provide growers and consultants with a simple way to make economically sound decisions about controlling FAW. Rice plants in large field plots were mechanically defoliated at 0, 33, 66, and 100% with a weed eater at two-three leaf, early tiller, late tiller, and green ring growth stages across three planting dates. Large amounts of yield loss were observed when plants were defoliated either 66 or 100% at the green ring growth stage. A delay in 50% heading was also observed for all growth stages when plants were defoliated at 66 or 100%, ranging from 2 days at the 2-3

leaf growth stage to 28 days at the green ring growth stage. Yield loss and delays in heading were greater in the June planting date compared to the April or May planting date. This data will help form a defoliation based threshold in rice to help keep rice growers profitable.

Safening Effects of a Rice Seed Treatment to Differing Formulations of Acetochlor.

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Warrant® (microencapsulated, ME) and Harness® (emulsified concentrate, EC) are both formulations of acetochlor. Currently, no acetochlor formulation is labeled for use in rice production; however, pretilachlor, a less efficacious, chloroacetamide herbicide, is labeled for use in Asian rice production systems when combined with applications of fenclorim, a product developed by Ciba Geigy in the 1980's. Field trials were conducted in 2019 at Fayetteville, AR to evaluate the safening effects of fenclorim as a seed treatment when applying acetochlor. The experiment was designed as a split plot with the whole-plot factor being fenclorim seed treatment (0. 0.025, and 0.25% lb ai/lb of seed) and subplot factors being two acetochlor formulations (ME and EC) and three acetochlor rates (0.28, 0.56, and 1.13 lb ai/A) applied delayed preemergence (DPRE). Non-herbicide treated plots also included fenclorim at each rate. As rate of acetochlor increased, injury to rice likewise increased. Higher rates of fenclorim decreased injury to rice, indicative of a safening effect. As acetochlor rate decreased stand loss diminished and was comparable to the non-treated at the highest rates of the safener. Likewise, switching from EC to ME formulation caused less injury to rice. The highest rate of fenclorim (0.25% wt/wt) in combination with the ME formulation of acetochlor at 1.13 lb ai/A resulted in only 9% injury to rice whereas the EC formulation at the same acetochlor rate caused 56% injury in the absence of fenclorim. This research clearly shows that fenclorim applied as a seed treatment in combination with a ME formulation of acetochlor can result in commercial safety to the herbicide in drill-seeded rice.

Corn Nitrogen Fertility Management Based on Data from an Unmanned Aerial System.

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Corn (*Zea mays*) is one of the primary cereal crops worldwide with a yearly production of approximately one billion metric tons. The U.S. is the main global corn producer, contributing approximately 35% of the total production. Corn yield has increased 140% over the last four decades in part because of a 40% increase in N input over the same period. However, the excessive application of N for corn production raises environmental and economic concerns, emphasizing agricultural practices that lead to an efficient use of N. The objective of this study was to develop a prediction system for in-season N application using the Dark Green Color Index (DGCI) and plant tissue analysis. Seven site-years were planted with Pioneer hybrid 1197YHR. The treatment-structure was comprised of 14 N fertilization regimes with season total N rates ranging from 0 to 246 kg N ha^{-1} and with split-applications at preplant, V10, V12 and VT timings. At the phenological stages V10, V12, and VT, leaf samples were collected and RGB digital images were captured from the field at 30.5m above ground level with an unmanned aerial system. Images were processed to create an orthomosaic and data were exctracted from orthomosaics using Field Analyzer© to measure DGCI. Relative Grain Yield (RGY) was positively associated with tissue-N concentration (TNC) at V10 (r^2= 0.85, RMSE= 9.13 %). Additionally, DGCI and TNC at V10 were positively related (r^2=0.93, RMSE = 0.021). Likewise, DGCI at V10 and RGY were positively related (r^2=0.70, RMSE = 10.8 %). The associations established between TNC and RGY, TNC and DGCI, and DGCI and RGY for measurements made at V12 and VT were similar to those of measurements made at V10.

The Effects in Hybrid Rice from Late Season Nitrogen Applications on Milling, Yield, and Lodging.

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Rice (*Oryza sativa* L.) plays a major role in the agricultural and economic sectors of the Mid-south. Over the last two decades, the number of hybrid rice cultivars planted has increased to account for as much as 50% of the total rice planted. Hybrid rice exhibits many different qualities compared to pureline cultivars such as a lower seeding rate, increased tiller number, increased grain yield, and higher susceptibility to lodging. These differences require alterations to our traditional nitrogen (N) fertilizer application timing. Trials were established at two locations within the state one on a clay soil and another on a silt loam soil to compare the effects of N application timing and rate on hybrid rice grain and milling yield as well as stalk strength. The hybrid rice cultivars selected included RT XL 753 and RT Gemini 214 CL as they represent a significant portion of the hybrid rice planted within the state. Nitrogen treatments included six preflood rates ranging from 0-168 kg N ha^{-1} with an additional factor of 0 or 33 kg N ha^{-1} applied late season during the R3 or 'boot exertion' growth stage. Results indicate significant differences in grain and milling yield across locations and N fertilizer management treatments with the boot applications increasing grain yield and milling yield across some of the lower preflood N rates, but not consistently across the higher preflood N rates. Stalk strength data is currently being collected and analyzed, but it is expected that treatments receiving the late season N applications will have higher stalk strength and reduced incidence of lodging due to greater N and carbohydrate concentration in the lower portion of the rice stalk. The work presented here will better define the metabolic and physiologic functions behind the need for late season N applications to hybrid rice cultivars.

Nozzle Type and Arrangement Effect on Spray Coverage.

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Arkansas row crop producers face many challenges throughout the growing season. One of which includes maintaining necessary spray coverage to achieve optimum levels of weed control. Applicators need to know how to properly setup herbicide application equipment, specifically nozzles, for better results. The objective of this research was to evaluate how nozzle arrangement (direction of emitted spray) and droplet size impacted spray coverage.

Field experiments were conducted in a dry-seeded rice crop at the University of Arkansas at Pine Bluff Small Farm Outreach Center near Lonoke, Arkansas, and in an irrigated soybean crop at the Rohwer Research Station located near Rohwer, Arkansas. Rice and soybean were seeded in 19 and 97 cm row widths, respectively. Applications were made at 94 L ha^{-1} spray volume with a Bowman MudMaster. Treatments consisted of four nozzle types (AIXR, 3D, ULD, and TTI), three nozzle arrangements for the directional 3D and TTI nozzles (forward, backward, and alternating), and a nontreated control. This provided a total of nine treatments. Nozzle orifice sizes, spray pressures, and sprayer speeds were all selected to maintain the correct 94 L ha^{-1} spray volume while creating similar droplet size classifications between comparable nozzles. Data collection consisted of three water sensitive paper spray cards per plot: a horizontal card at the top of canopy, a vertical card facing towards the direction of the sprayer, and a vertical card facing away from the direction of the sprayer. The spray cards are initially a bright yellow color, but once any wet substance comes into contact with the card, they turn blue. The spray cards were placed at the top of the crop canopy on collection platforms that were attached to pieces of rebar driven into the ground near the center of each plot. Water sensitive cards were analyzed for spray coverage using DepositScan from the USDA-ARS Application Technology Research Unit. Data were then subjected to ANOVA using SAS v9.4.

Initial results indicated that overall greater spray coverage was achieved with the AIXR and 3D nozzles compared to the ULD and TTI nozzles. This is due to the AIXR and 3D nozzles emitting smaller droplet sizes and therefore, a greater number of droplets in a fixed spray volume were available to impact the spray card and plant surface compared to the ULD and TTI nozzles. Additionally, the alternating nozzle arrangement for the directional 3D and TTI nozzles provided overall more uniform spray coverage on the top, front, and back of the collection surfaces than the other nozzle arrangements and the straight-down spray emission of the AIXR and ULD nozzles. Overall, this research highlights differences in spray coverage were achieved based on the nozzle selection and arrangement. Applicators may achieve better weed control through enhanced and more uniform spray coverage by implementing the alternating nozzle arrangement when using directional nozzles such as the 3D and TTI nozzles.

Evaluating Currently Labeled Insecticides for Control of Tarnished Plant Bug, *Lygus lineolaris*, in Arkansas Cotton.

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Tarnished Plant Bug (*Lygus lineolaris*) is the number one insect pest in mid-south cotton production. This study, conducted as part of a regional Midsouth trial the past three years, was conducted to evaluate the efficacy of insecticides currently labeled for control of this pest. This trial was conducted to determine a base level of control to monitor insecticide resistance to individual insecticides, and to serve as a source of data for possible registration of new insecticides that may become available. These data were also used to ensure that current recommendations of these insecticides are still viable. Insecticides evaluated include: Transform, Centric, Vydate, Orthene, Brigade, Bidrin, Admire Pro, Carbine and Diamond. Treatments were initiated when a threshold of six TPB per ten row feet was found in the test area, and when a majority of the treatments exceeded threshold after the initial application. Results indicated that novaluron (Diamond) and sulfoxaflor (Transform) performed consistently better than many of the other insecticides. Many of the insecticides tested failed to provide any consistent level of adequate control.

Plant Bug Efficacy over Time in the Midsouthern US.

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Data from a total of 121 tarnished plant bug efficacy trials conducted in Arkansas from 2005 – 2019 were combined to evaluate the performance of insecticides classes over time. Based on this analysis, there were no changes in organophosphate, neonicotinoid, sulfoxamine, or benzoylurea efficacy. However, pyrethroid efficacy declined substantially over the same time period. Even with the decline in pyrethroid efficacy the addition of bifenthrin to acephate continued to increase control of plant bugs over acephate alone. Data from the past five years indicates acephate, dicrotophos, novaluron, and sulfoxaflor provide the greatest control of tarnished plant bug in cotton at 2-4 and 5-8 days after treatment.