MISSISSIPPI SOYBEAN PROMOTION BOARD
PROJECT NO. 04-2015 (YEAR 2)
2015 Annual Report

Title: Effect of Spray Additives on Spray Droplet Size, Coverage, and Crop Canopy Penetration

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BACKGROUND AND OBJECTIVES

25 – 70 cases of legal action involving off-target movement of pesticides are filed with the Bureau of Plant Industry each year. The vast majority of these cases involve herbicides. Spray drift involving insecticides is rarely reported as insecticides typically do not cause phytotoxicity (visual injury) or yield loss to adjacent crops. However, worldwide attention is currently focused on the effect of off-target movement of insecticides on pollinator species (bees). The European Union has banned all neonicotinoid insecticides due to potential effects on pollinator species.

Soybean and cotton varieties tolerant to the herbicides dicamba and 2, 4-D were released or are scheduled to be released in 2015 and 2016. Cotton and soybean varieties that do not have tolerance to either of these two herbicides are highly susceptible to spray drift from these products.

Previous research has shown that as little as one tablespoon of dicamba per acre from off target movement can cause significant yield reductions in soybeans. Efforts are underway by Mississippi State University scientists to address the effect of off-target movement of dicamba and 2, 4-D on soybean yield. However, little to no previous research exists regarding the effect of spray additives such as drift retardants on spray droplet size or canopy deposition. Given the cost of these products as well as the potential impacts of off-target movement, significant efforts are needed to address the effect of spray additives on spray droplet size and canopy deposition.

EXPERIMENTAL APPROACH AND OBJECTIVES

Objective. 1: Determine the impact of spray additives on spray droplet size using various commonly used pesticides

In order to determine spray droplet size, a wind tunnel facility with a diffracting laser system is required. Three such facilities exist worldwide: one at the University of Nebraska West Central Research and Extension Center in North Platte, NE; a second at a USDA facility in College Station, TX; and the third located in Australia.

The PI has an arrangement in place for use of the facility at the University of Nebraska free of charge. This facility has the capability to simulate ground and aerial application and determine spray droplet size from each. Commonly used pesticides and additives were examined to determine their effect on spray droplet size. Experiments were conducted using a randomized complete block design.

Objective 2: Determine the impact of spray additives on spray coverage and canopy penetration using various commonly used pesticides

Field experiments were conducted using pesticides and spray additives similar to objective one. Mylar cards were placed at various locations within the cotton canopy prior to pesticide application. Pesticide applications were made after which time cards were collected and used to determine percent canopy deposition. Experiments were conducted using randomized complete block design.

REPORT OF PROGRESS/ACTIVITY

Objective. 1: Determine the impact of spray additives or herbicides on spray droplet size using various commonly used pesticides

Experiments were conducted to determine the effects of a guar gum deposition aid, a polymer deposition aid, and an oil based deposition aid, as well as glyphosate and glufosinate herbicides on spray droplet size when tank mixed with Orthene® or Karate®. Studies were conducted at the University of Nebraska wind tunnel facility located in North Platte, NE. The wind tunnel (Figure 1) used was equipped with a diffracting laser (Figure 2) which was utilized to determine spray droplet size from the aforementioned treatments.

Spray solutions were mixed and applied to satisfy objective two, after which time the remaining solution was stored and shipped in a completely dark container to North Platte, NE. Droplet size is evaluated in the wind tunnel in the following manner. Air is supplied down the tunnel at a constant rate of 15 mph. A device is placed directly after the fan providing constant wind speed that directs airflow in a laminar manner. An additional fan is placed at the opposite end of the wind tunnel to facilitate constant air movement.

Immediately prior to said fan, a scrubbing system is in place to remove all pesticides from air moving out of the tunnel. Pesticides are applied through a CO_2 powered sprayer using a single spray nozzle (AIXR 110015 in this project) with 45 PSI. The diffracting laser system is located immediately prior to the scrubbing system and immediately after the spray nozzle. The spray nozzle moves downward causing the droplets to diffract the laser beam and droplet size is determined. Three droplet size measurements are collected each time the laser intercepts the spray pattern. Droplet size is determined by measuring the amount of light that is diffracted by the spray droplets as the spray pattern moves downward across the laser beam.

The addition of a polymer or guar gum deposition aid significantly increased spray droplet size compared to Orthene® or Karate® alone (Figure 1). The addition of polymer or guar gum deposition aids to Orthene® resulted in significantly larger droplets than when polymer or guar gum deposition aids were added to Karate®. However, the addition of polymer or guar gum deposition aids to both Orthene® and Karate® resulted in larger spray droplets than when adding oil deposition aids, glyphosate or glufosinate.

When applied with Orthene®, the addition of glyphosate, oil deposition aids, and glufosinate each significantly reduced spray droplet size. The addition of glufosinate to Orthene® resulted in the smallest spray droplets at approximately 285 microns. Results with Karate® differed somewhat from those with Orthene®. The addition of oil deposition aids to Karate® resulted in droplet size similar to when Karate® was applied alone. Droplet size was further reduced when glyphosate and glufosinate were applied with Karate®.

Variation in droplet size was observed when deposition aids or herbicides were added to Orthene® or Karate®. This is indicated as relative span (Figure 2). Relative span is determined by determining difference between spray droplets smaller than the DV10 value (10% of the spray droplets are smaller than this value) and the DV90 value (90% of the spray droplets are smaller than this value). The larger the relative span, the greater variation in droplet size produced. The addition of oil deposition aids to Orthene® resulted in similar relative span values to Orthene® applied alone. Relative span increased significantly when polymer and guar gum deposition aids as well as glyphosate and glufosinate were added to Orthene®. The greatest relative span with Orthene® was observed when glufosinate was tank mixed. The addition of all deposition aids and herbicides increased relative span when applying Karate®. Similar to results with Orthene®, oil deposition aids produced the least effect on relative span. Relative span increased significantly when glyphosate, glufosinate, polymer, and guar deposition aids were tank mixed with Karate®. The greatest relative span was produced when guar gum deposition aids were applied with Karate®.

The addition of polymer and guar gum deposition aids significantly reduced the amount of droplets less than 150 microns in size compared to Orthene® or Karate® applied alone or in combination with glyphosate, glufosinate, or oil deposition aids (Figure 3). The addition of oil deposition aids and glyphosate significantly increased the number of spray droplets produced which were less than 150 microns compared to Orthene® alone. The addition of glufosinate to Orthene® resulted in the greatest amount of droplets produced which were less than 150 microns in size at nearly 16% of the total droplets. Similarly, the addition of oil deposition aids and glyphosate increased the number of spray droplets produced that were less than 150 microns in size when applied with Karate®. Furthermore, the greatest percentage of droplets produced which were less than 150 microns in size occurred when glufosinate was applied with Karate®.

In summary, the effect of deposition aids on droplet size, droplet size variation, and percentage of droplets less than 150 micros in size varied depending on the tank mix combination. Polymer and guar gum deposition aids tended to increase droplet size with both Orthene® and Karate® and also tended to have minimal effects on droplet size variation (relative span) and percentage of droplets less than 150 microns in size. The addition of glyphosate and glufosinate decreased droplet size. Glufosinate, in particular, resulted in a significant decrease in droplet size, significant increase in droplet size variation, and increased the percentage of droplets produced that were less than 150 microns in size.

More data are needed to determine the effect of deposition aids in combination with glufosinate and glyphosate on spray droplet size, droplet size variation, and the number of droplets produced less than 150 microns in size. The addition of glyphosate and glufosinate decreased droplet size and as such, growers are urged to proceed with caution with applying these herbicides next to sensitive or susceptible vegetation.

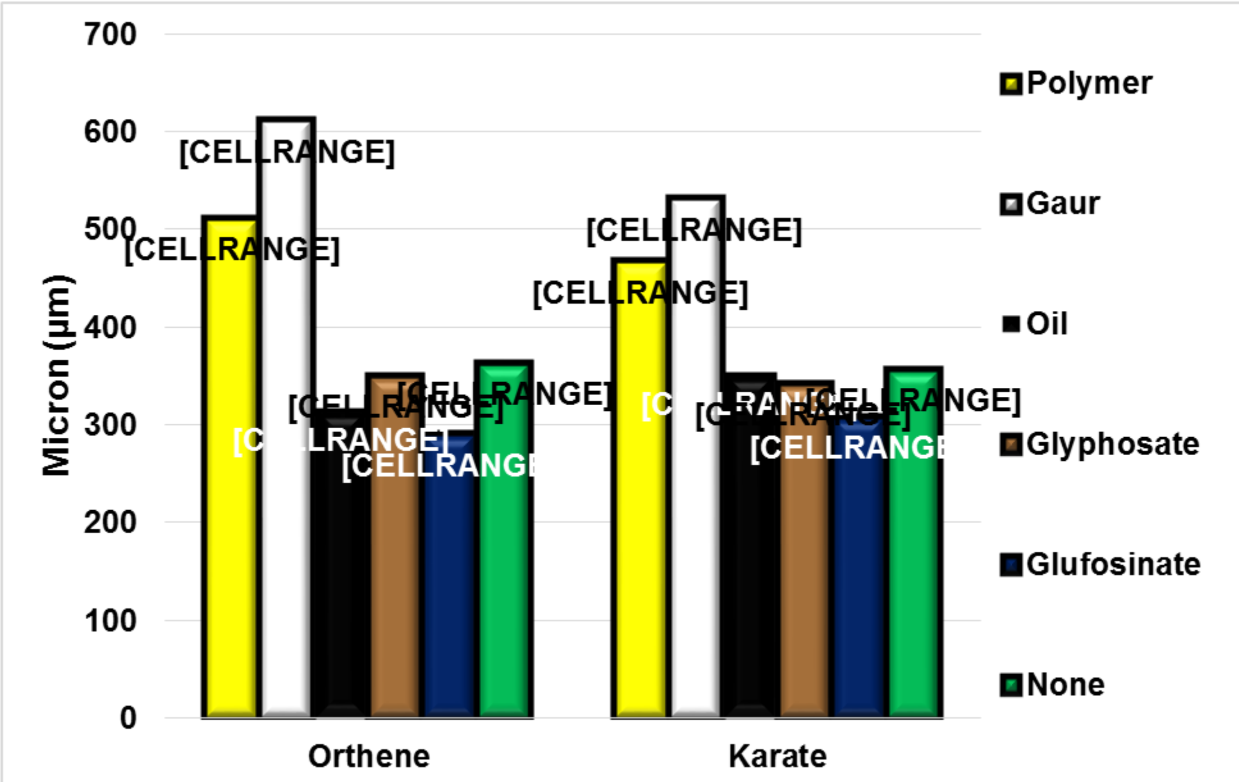

Figure 1. Volume mean diameter (VMD) of spray droplets produced with selected herbicides and deposition aids.

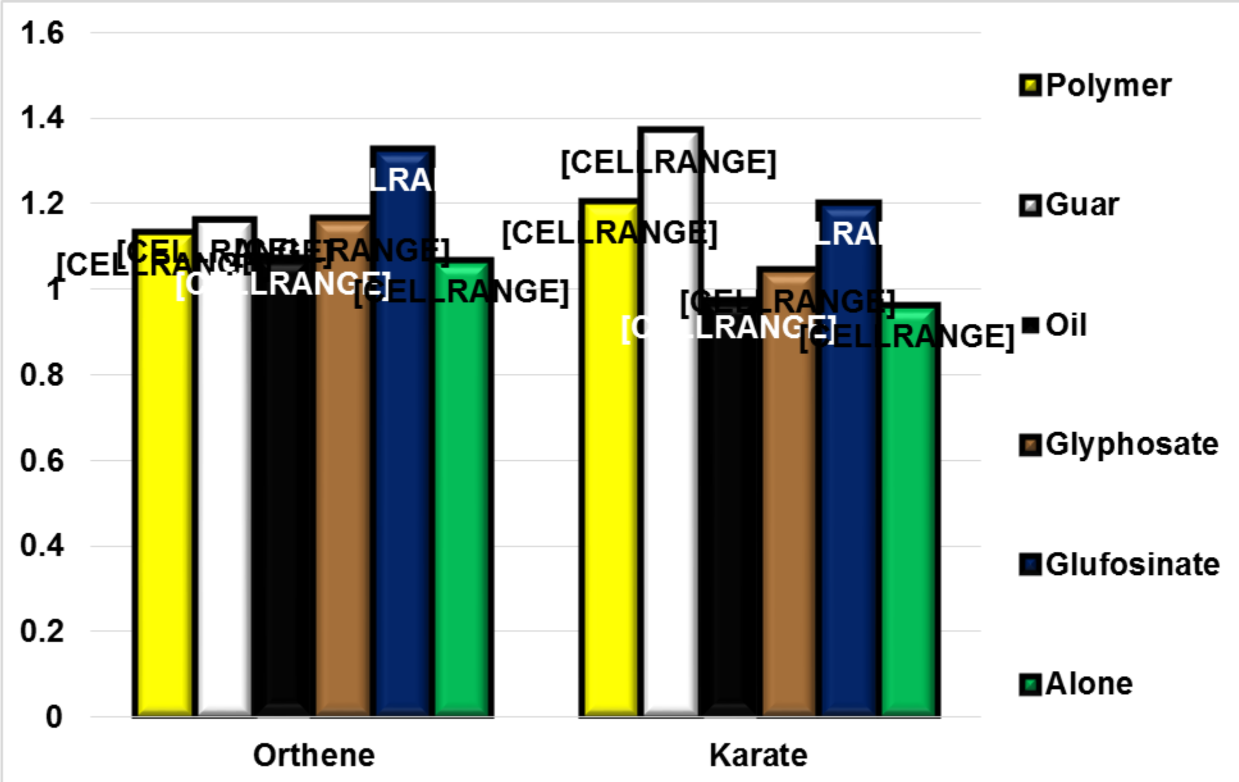

Figure 2. Relative span of spray droplets from tank mix combinations.

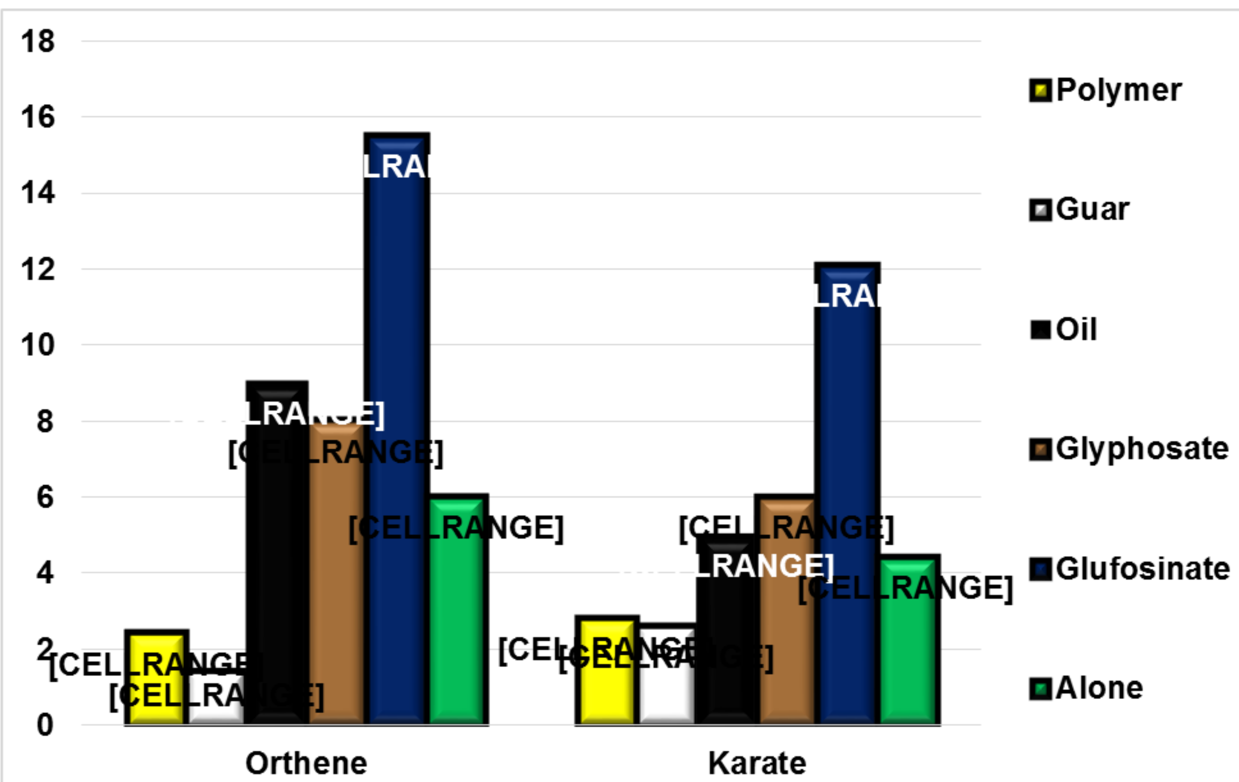

Figure 3. Percent of droplets smaller than 150 microns from tank mix combinations.

Objective 2: Determining the impact of spray additives or herbicides on spray coverage and canopy penetration using various commonly used insecticides in cotton.

Experiments were conducted to determine the effects of Orthene® and Karate® used either alone or in combination with oil, guar gum, and polymer tank additives. The herbicides Roundup Powermax and Liberty when applied in combination with Orthene® and Karate® were also evaluated. A photo degradable, fluorescing dye was included with each combination. Metal stands measuring 24” in height from the soil level were utilized in this experiment (Figure 4). Each stand consists of four card holders spaced equidistantly apart from the top of the crop canopy. Card holders spiral down the main beam of the stand in an attempt to mimic the structural makeup of a single plant. Card holders are placed at the top of the canopy, 6” downward, 12” downward, and 18” downward in the canopy. Mylar cards were then placed on each card holder and where held on using small paper clips. Stands were placed into the drill of cotton planted on 38” rows. In addition, one stand was placed with the bottom position perpendicular to the cotton row (back stand) (Figure 5) and an additional stand was placed in the same row with the bottom position running parallel to the cotton row (front stand) (Figure 6). The previously mentioned pesticides were applied using a Bowman Mudmaster equipped with AIXR 110015 spray tips at 56 PSI at three miles per hour. Immediately following the application (~ 90 seconds), cards were removed due to the photo degradability of the dye. Once removed cards were placed in the dark and kept cool. Deposition was determined using a fluorimeter.

Effect of herbicides or tank additives on canopy deposition on the back stand (Figure 7).

There were no differences at the top of the canopy, 6” downward, and 12” downward amongst stands. However, preliminary data indicate that treatments containing Orthene® in combination with a polymer tank additive increased the level of deposition by 296% when compared to Orthene® and water alone. It was also noted that when Orthene® was applied in combination with a guar gum tank additive, an 88% increase in deposition was observed. When Orthene® was applied in combination with oil a decrease of 15% was noted. When Orthene® was applied in combination with Roundup Powermax™, a 36% decrease in deposition was noted. When Karate was applied there were no differences among tank additives or herbicides with respect to level of deposition. Karate applied in combination with a guar gum, an oil, and Liberty decreased deposition.

Effect of herbicides or tank additives on canopy deposition on the front stand (Figure 8).

There were no differences in deposition at the top of the canopy, 6” downward, and 12” downward amongst stands. However, preliminary data indicate that treatments containing Orthene® in combination with Roundup Powermax™ increased deposition by 525% compared to Orthene® and water alone and resulted in the greatest level of deposition on the front stand. Orthene® in combination with Liberty® increased deposition by 88% compared to Orthene® plus water alone. When Orthene® or Karate® were applied with a guar gum, a decrease of 30-33% in deposition was observed. There were no differences in deposition observed amongst any of the treatments containing Karate®.

Based on preliminary data, if controlling off-target movement is the primary goal, using a polymer tank additive would have the greatest value with both of these insecticides. However, the use of Orthene® in addition with Roundup Powermax™ has value due to its ability to increase deposition.

Figure 4. Metal stands used to determine impact of deposition aids on pesticide deposition into the soybean canopy.

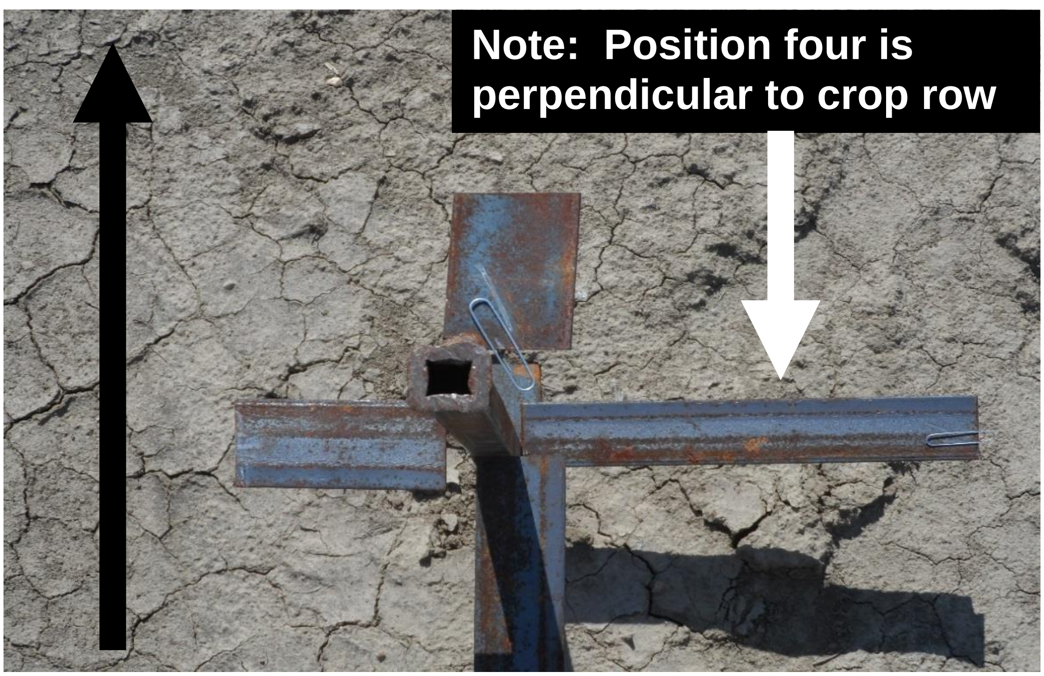

Figure 5. Position of back stand with the black line indicating crop row direction (Stands were placed directly in crop row)

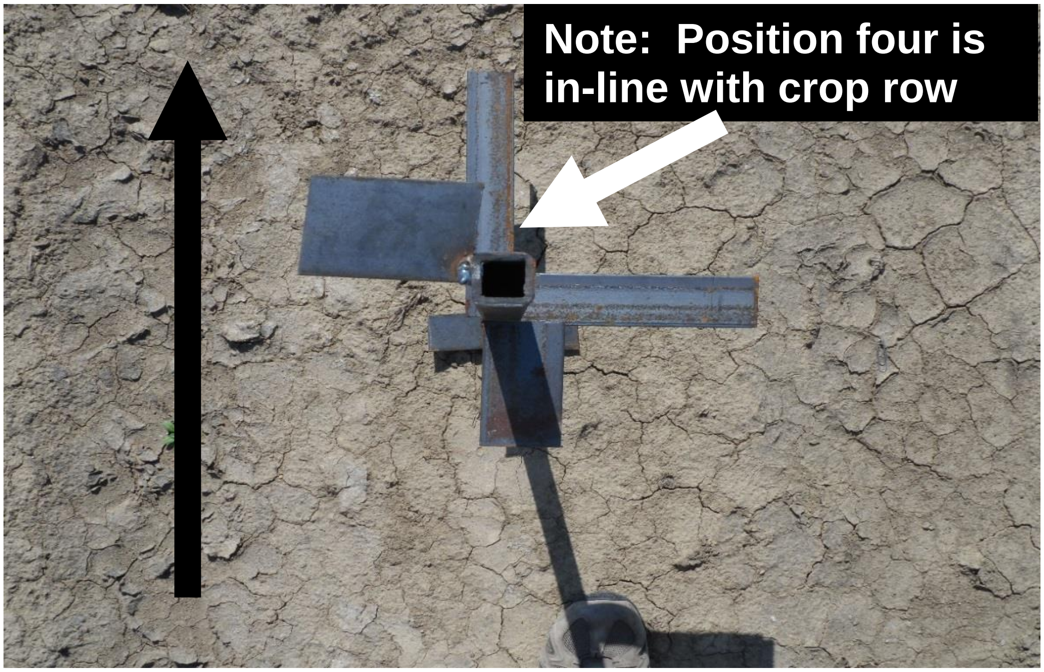

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Figure 6. Position of front stand with the black line indicating crop row direction (Stands were placed directly in crop row)

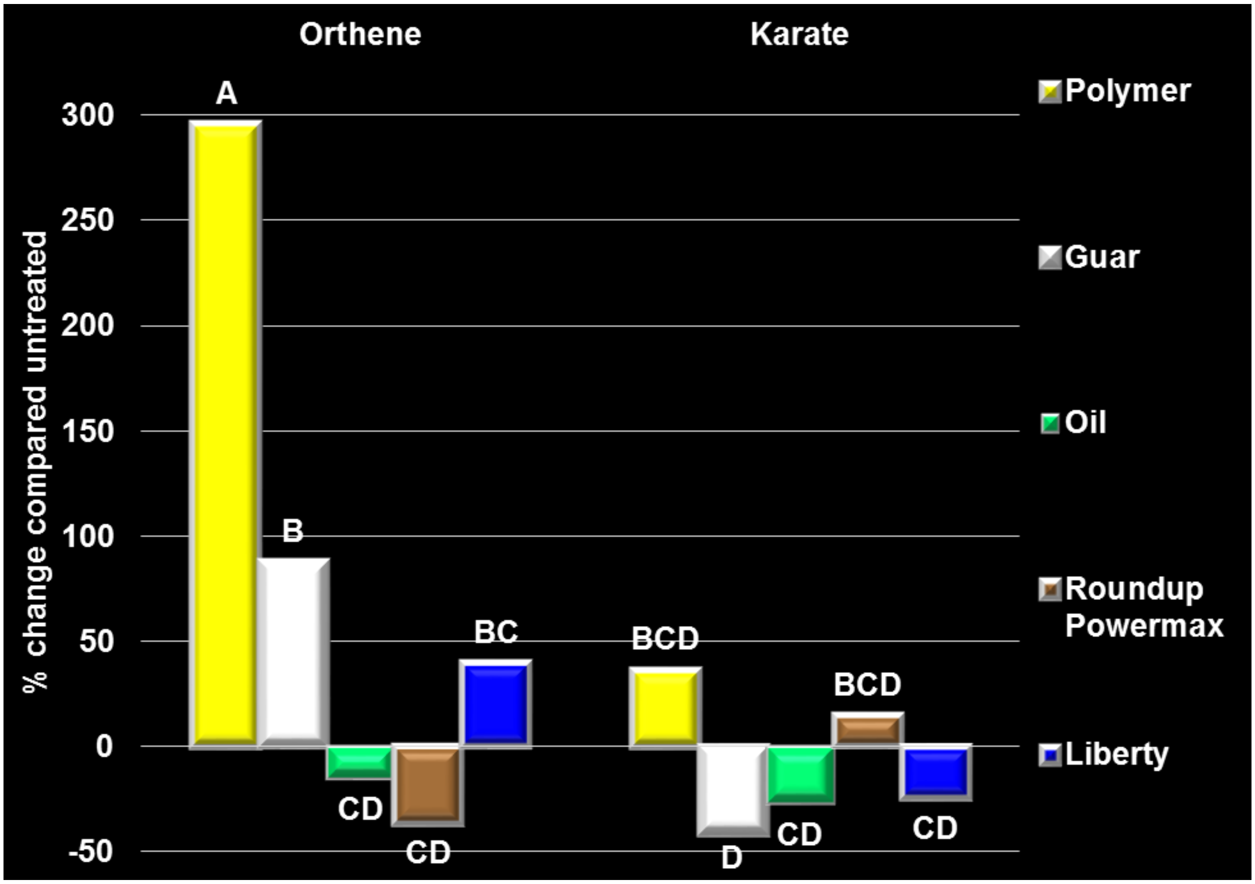

Figure 7. Deposition at position 4 on the back stand.

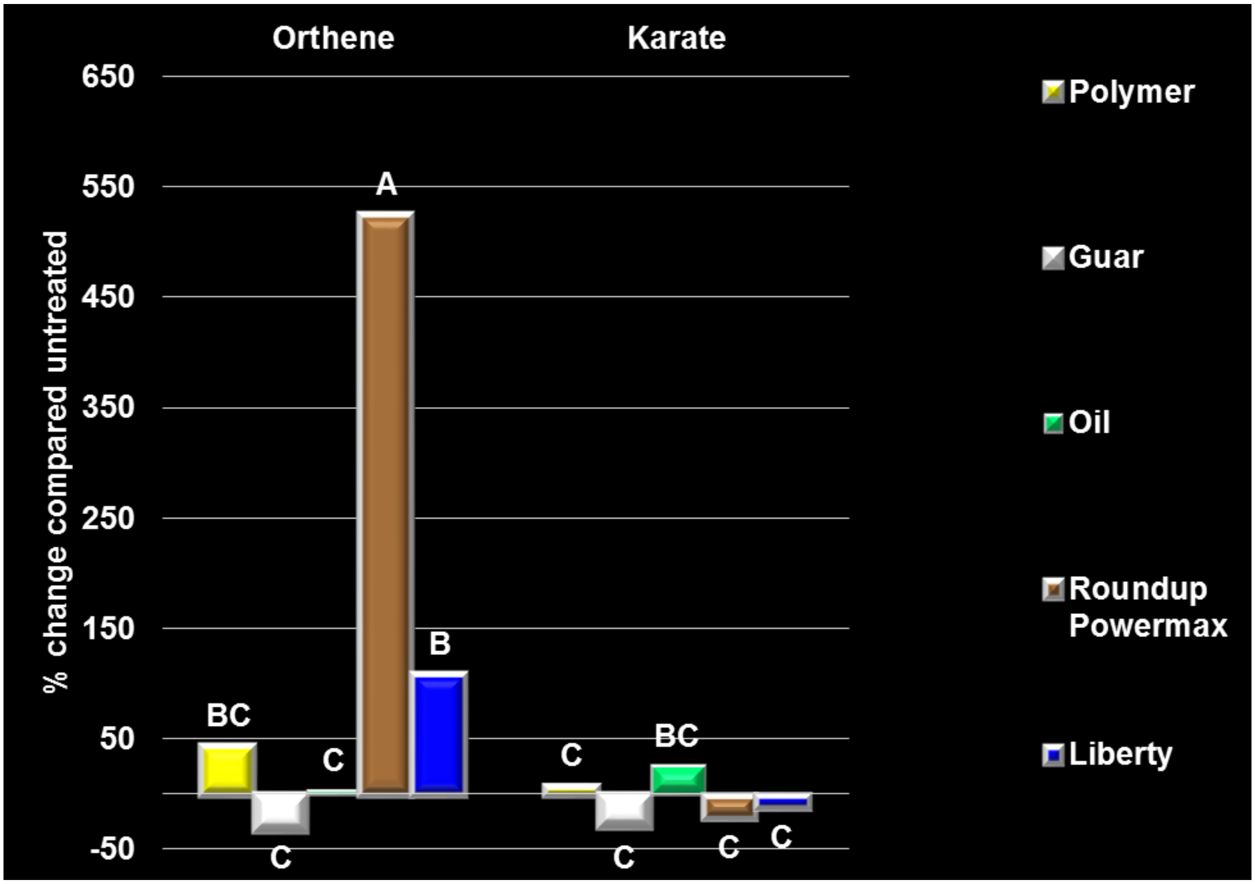

Figure 8. Deposition at Position 4 on the front stand.

Objective 3: Determine the impact of spray additives on spray coverage and canopy penetration using various commonly used insecticides in soybean.

Experiments were conducted to determine the effect of Orthene®, Karate®, and Intrepid® on soybean canopy deposition. A photo degradable, fluorescing dye was included with each application. Metal stands were constructed that were 24" in height and these stands were placed into the drill of soybeans planted on 38" rows (Figure 6). In addition, one stand was placed with the bottom position perpendicular to the soybean row (front stand) and an additional stand was placed in the same row with the bottom position running parallel to the soybean row (back stand). The previously mentioned pesticides were applied using a Bowman Mudmaster equipped with AIXR 110015 spray tips at 56 PSI at three miles per hour. Mylar spray cards were placed at four positions on each stand within the soybean canopy. Mylar cards were removed immediately after pesticide application and deposition was determined using a fluorimeter.

Data from stand with bottom position parallel to the soybean row (Figure 9).

Deposition of Karate® was similar at the top of the soybean canopy as well as 6", 12", and 18" downward from the apical meristem on the back stand. Compared to water alone, 89 – 102% of Karate® was deposited at each location from the top of the soybean canopy downward. These data indicate that Karate® penetrates the soybean canopy at similar levels to that of water, regardless of position within the soybean canopy. Deposition of Orthene® varied depending on level within the crop canopy. Deposition was similar at the top of the soybean canopy, 6", and 12" down from the apical meristem. However, at 18" downward from the apical meristem, 254% greater deposition was observed when Orthene® was applied compared to water alone. These data indicate that Orthene® changes the deposition characteristics within the soybean canopy compared to water alone. This could prove beneficial when trying to control insects that are located in the lower portions of the soybean canopy. Deposition of Intrepid® also differed depending on location in the crop canopy. Similar levels of Intrepid® deposition were observed at the apical meristem as well as 6" down from the apical meristem. However, 12" down from the apical meristem, greater deposition was observed. At 18" down from the apical meristem, a significant reduction in deposition occurred. These data indicate that Intrepid® will penetrate the soybean canopy at similar to somewhat greater levels than that of water until approximately 12" down from the apical meristem. After this point, deposition of Intrepid® is reduced.

Data from stand with bottom position perpendicular to the soybean row (Figure 10).

Deposition of Intrepid® was similar regardless of position from which data was collected in the soybean canopy. Deposition ranged from 62 – 94% compared to that water alone. These data indicate that when Intrepid® is added to the spray tank, deposition may be decreased compared to water alone. Deposition of Karate® was variable in nature. Similar levels of deposition were observed at the apical meristem as well as 12" down from the apical meristem with deposition ranging from 105 – 141% compared to water alone. However, deposition at the apical meristem was also similar to deposition 6" and 18" downward in the soybean canopy. Deposition at these levels ranged from 83 – 106% of what was observed with water alone. These data indicate that when Karate® is added to the spray tank, deposition is similar to that of water alone. Deposition of Orthene® was also somewhat variable in nature. Deposition at the apical meristem, 6" down, and 18" down was similar and ranged from 91 – 112% compared to water alone. However, at 12" down from the apical meristem, a significant reduction in deposition was observed. Only 59% deposition compared to water alone was observed at this point. Further data analysis is needed to determine if this was the result of an outlier in the data or if deposition was truly reduced at this level.

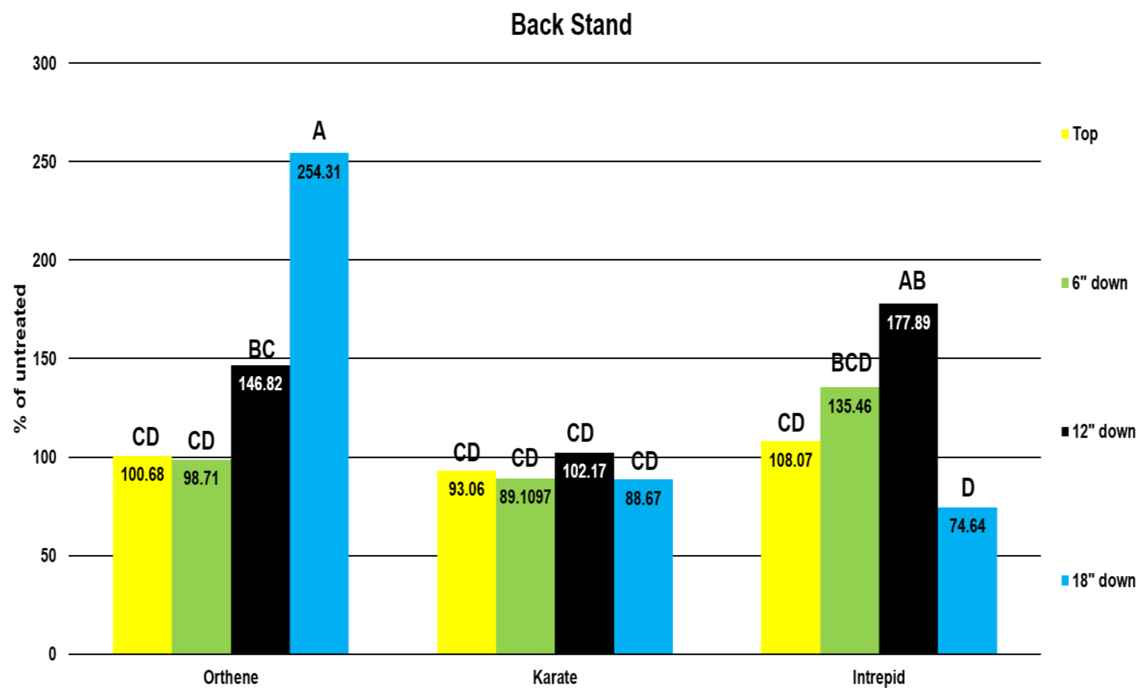

Figure 9. Effect of herbicides and deposition aids on deposition into the soybean canopy using the back stand (bottom position parallel to the row).

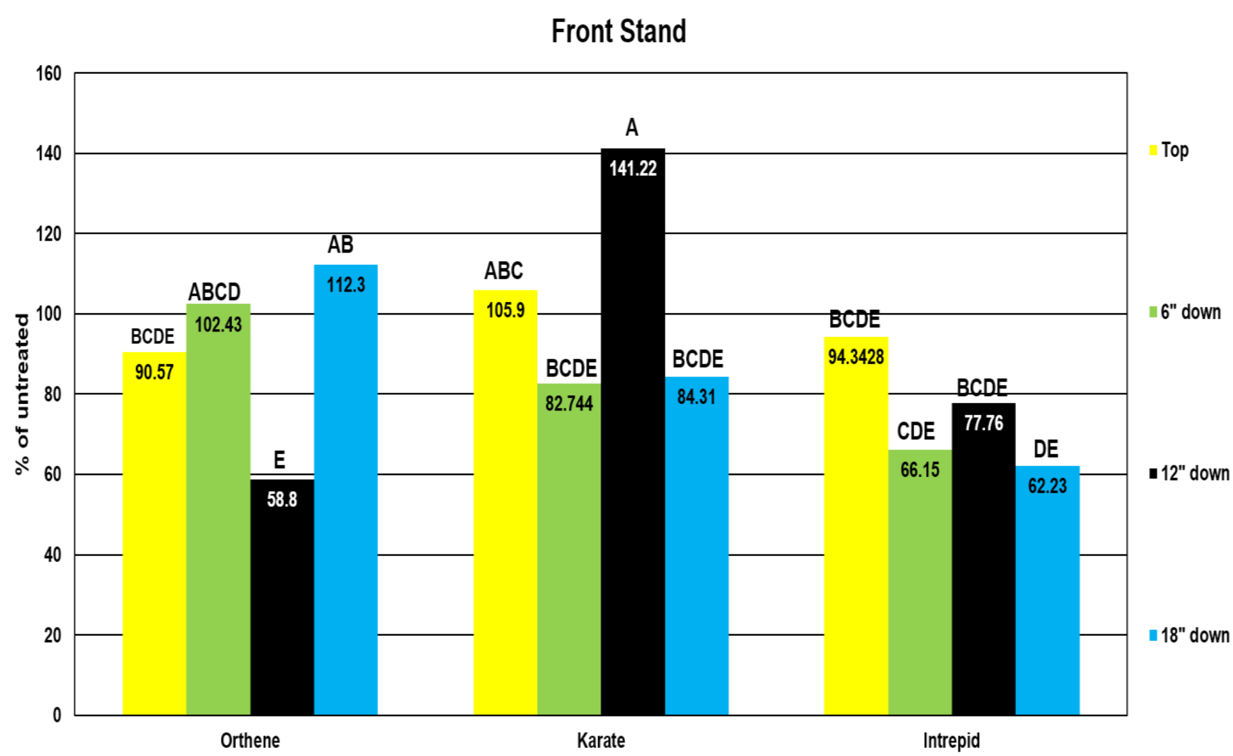

Figure 10. Effect of herbicides and deposition aids on deposition into the soybean canopy using the front stand (bottom position perpendicular to the row).

Objective 4: Determine the impact of spray additives on spray coverage and canopy penetration using new auxin chemistries in soybean.

Experiments were conducted to determine the effects of the tank combinations of MON 76832 + Flexstar, Roundup Powermax + Flexstar, Liberty + Clarity, Liberty + Enlist Duo, and Liberty + Flexstar on soybean canopy deposition. A photo degradable, fluorescing dye was included with each application. The previously mentioned pesticides were applied using a Bowman Mudmaster equipped with AIXR 110015 spray tips at 56 PSI at three miles per hour. Mylar spray cards were placed at four positions on each stand within the soybean canopy. Mylar cards were removed immediately after pesticide application and deposition was determined using a fluorimeter.

Data pooled across both stands placed in the soybean canopy (Figure 11 and 12).

There were no differences in deposition observed among stands; therefore data were pooled over stand. Deposition of MON 76832 + Flexstar, Roundup Powermax + Flexstar, Liberty + Clarity, Liberty + Enlist Duo, and Liberty + Flexstar were similar at the top of the canopy, 6”, and 18” downward from the apical meristem. However, at 12” downward from the apical meristem, treatments containing 623% more MON 76832+Flexstar was deposited compared to water alone. These data indicate that greater deposition occurred when this tank combination was applied to 24” soybean. The tank combination of MON 76832+Flexstar may penetrate the canopy at a greater rate and aid in control. These data indicate that at the top of the canopy, 6”, and 18” that all of the tested combinations performed similarly with respect to deposition. However, if applications have been delayed and glyphosate resistant Palmer amaranth is allowed to reach a height of 12” directly in in the soybean row, applications of MON 76832 + Flexstar may penetrate the canopy to a greater level than that of any of the other treatments tested in this study.

There were also no differences observed when applying tank additives in combinations with any of the above treatments at the top of the canopy, 6”, and 18” downward from the apical meristem. At 12” downward from the apical meristem, it was observed that the addition of an oil tank additive was beneficial to increasing canopy deposition when compared to polymer and guar gum additives. When an oil was added to the tank combination, a 4-fold (415%) in deposition was observed 12” downward from the apical meristem. These data are preliminary and only based on one year but indicate that although these tank additives have a positive effect when applying a herbicide to 24” soybeans.

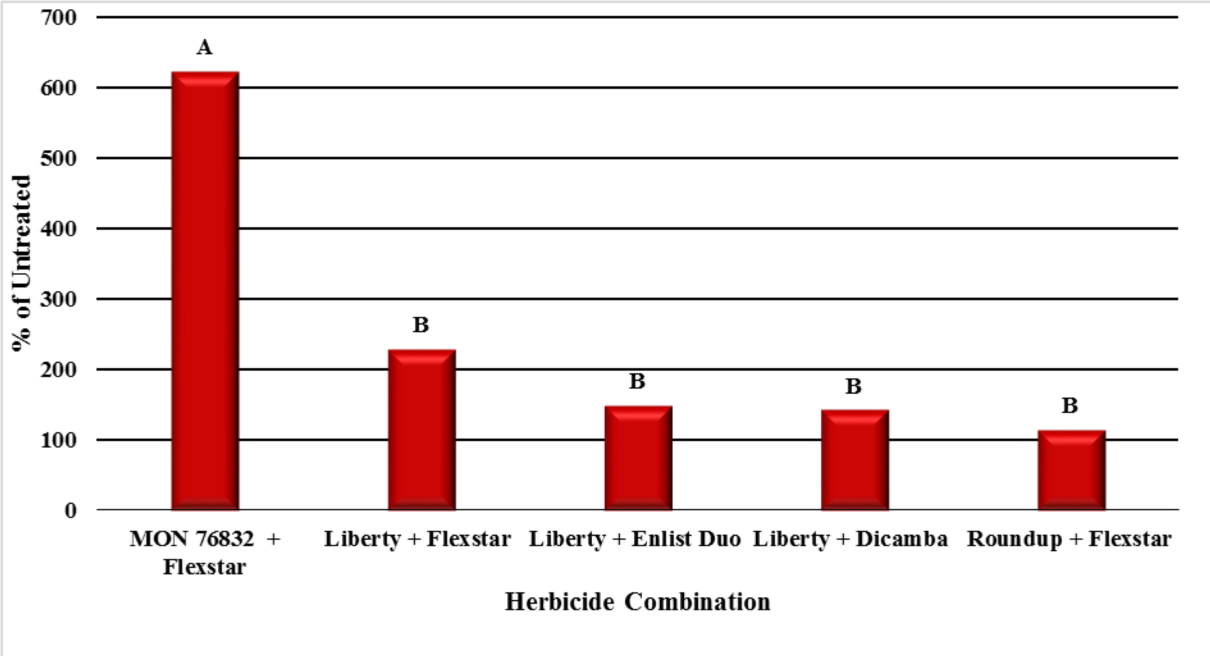

Figure 11. Effect of herbicide combinations on canopy deposition 12" downward into the soybean canopy.

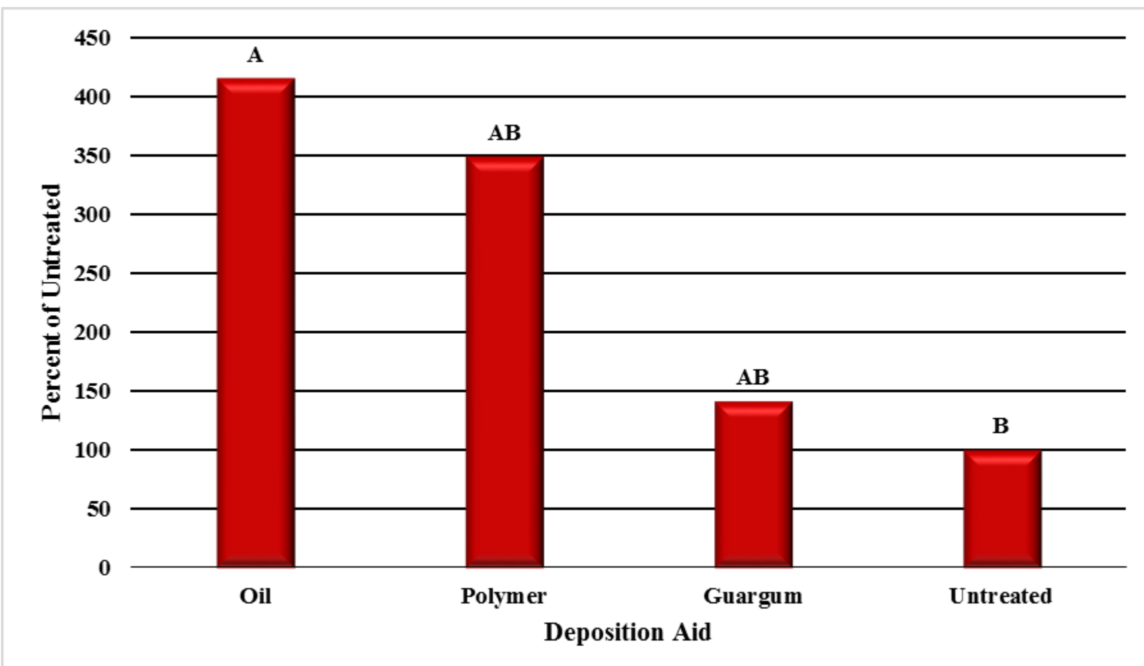

Figure 12. Effect deposition aid on herbicide combination deposition 12" downward into the soybean canopy.

Objective 5: **Determine the impact of spray additives on spray coverage and canopy penetration in new Auxin based herbicide systems in cotton.**

Experiments were conducted to determine the effects of the tank combinations of MON 119096 + Liberty, MON 76832, MON 76832 + Dual, MON 76832 + Warrant, and Enlist Duo on cotton canopy deposition. A photo degradable, fluorescing dye was included with each application. The previously mentioned pesticides were applied using a Bowman Mudmaster equipped with AIXR 110015 spray tips at 56 PSI at three miles per hour. Mylar spray cards were placed at four positions on each stand within the soybean canopy. Mylar cards were removed immediately after pesticide application and deposition was determined using a fluorimeter.

Data pooled across both stands placed in the cotton canopy (Data not Shown).

There were no differences in deposition observed among stands; therefore, data were pooled across stands. There were no significant differences in the level of deposition at 6", 12", and 18". However, differences in deposition at the top of the canopy were present. Regardless of tank additive, there was no increase in the level of deposition when adding MON 76832. When MON 76832 was applied in combination with Warrant™, deposition was maximized when it was applied alone, and was noted to be over two-fold greater deposition than deposition from combining with the oil or polymer. MON 76832 applied in combination with Dual™ resulted in similar deposition. Similarly, there were no differences noted amongst treatments receiving MON 119096 + Liberty™. Similar results were also observed when Enlist Duo was applied. There was no difference among any of the tank additives when compared to one another or when compared to the combination alone.

These data are preliminary in nature and only based on one year, but indicate that when applying these treatments on a large scale, the addition of a tank additive to increase canopy deposition is not warranted. Although in some instances there may have been a positive impact, the impact was not greater than that of using the herbicides alone.

Differences in stand orientation

Data indicate that significant differences in deposition due to stand orientation in the soybean row were present and thus differences in deposition between the two stands was observed. It was expected to see differences in pesticide deposition due to different interception points between the two stands. Further data analysis is needed to determine how to correctly process these data. No known projects similar to this are known to exist; therefore, there is no pre-determined formula for data analysis.

CONCLUSION

These data indicate that deposition aids tend to increase droplet size and decrease the number of droplets less than 150 microns in size. Spray droplets that are less than 150 microns in size are very susceptible to off-target movement, thus deposition aids may have utility in that respect. However, deposition aids also tend to increase the relative span of spray droplets which indicates greater variability in droplet size production depending on the product with which they are applied. Data from this project indicate that deposition aids are of limited utility with respect to increasing deposition in the crop canopy. It is concluded that deposition aids did not provide increased deposition. However, increased droplet size was observed when deposition aids were added. Increased droplet size is beneficial when off-target movement is a concern; however, in situations in which coverage is essential, increased droplet size may result in decreased efficacy. Thus, deposition aids should be used at the discretion of the individual grower and what his/her needs are with respect to droplet size, coverage, and off-target movement.

IMPACTS AND BENEFITS TO MISSISSIPPI SOYBEAN PRODUCERS

Given the current use of spray additives as well as the expected increase in use of spray additives following the release of auxin tolerant crops, this project has the potential to impact up to 40% of pesticide applications made to Mississippi soybean acres. This would equate to roughly 900,000 acres most of which would receive at least two pesticide applications. If these additives cost $2 per acre per application, the potential savings from not using additives exceeds $3.5 million. Preliminary data from this project indicates that deposition aids are of limited utility with respect to increasing deposition into the crop canopy. However, deposition aids did increase spray droplet size and reduced the number of spray droplets less than 150 microns in size. As a result, if spray drift is of concern, the addition of a deposition aid may be of limited benefit. However, the addition of a deposition aid will not stop off-target movement if application parameters such as wind speed, boom height, etc. exceed recommended values at the time of application. The utility of deposition aids is still in question and thus, growers are encouraged to invest financial resources elsewhere until further data is gathered and processed.

END PRODUCTS – COMPLETED OR FORTHCOMING

1. Graduate student presentation at the Beltwide Cotton Conferences
2. Graduate student presentation at the Future of Ag Student Competition at Mississippi State University.
3. Graduate student presentation at the Southern Weed Science Society Annual Meeting
4. Graduate student presentation at the Weed Science Society of America Annual Meeting
5. Data for Chapters 1& 2 of Ph.D. Student dissertation
6. Once data are finalized, data will be presented at field days, production meetings, short courses, etc.