Neonicotinoid Seed Treatments and their Use in IPM Programs in the Mid-South

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Value of Neonicotinoid Seed Treatments in the Mid-South

Farming is a business, period! More importantly, farming is one of the most risky businesses in the world, with respect to economics. In the current environment, farmers invest hundreds of thousands if not millions of dollars at planting and do not see a return on that investment until harvest, several months later. In the meantime, more can go wrong between planting and harvest than can go right, and farmers are walking a fine line between planting a crop the following season and being out of business. The notion that a farmer would spend additional money on a production practice that does not provide an economic return is foolish. Currently, seed costs are at an all time high, mainly due to elite cultivars and technology fees associated with transgenic traits (herbicide and insecticide resistance). Additionally, herbicide resistant weed species have made early season management more difficult and costly compared to a decade ago. As a result, farmers have reduced seed rates to minimum levels to offset some of the costs associated with planting. In general, in-season risk can be reduced with an earlier planting date. Numerous studies have shown that early production systems in soybean and cotton produce higher yields and incur lower risk from drought and pests than later plantings in the Mid-South (Heatherly 1999, Adams et al. 2013). However, earlier plantings do not come without their share of risks. Early spring conditions are often cool and damp in the Mid-South and can change from optimal to sub-optimal within a 24 hour period. As a result, seedling emergence and plant growth and development are often delayed, and the crop becomes more susceptible to insect and disease pests. Insecticides and fungicides applied as seed treatments are an important component of crop production to minimize the risk of stand losses from these pests, especially with early plantings when pest populations and weather conditions are difficult to predict.

In cotton, thrips are an annual pest that can significantly delay maturity and reduce yields. Their impact in cotton is often more dramatic in earlier plantings compared to later plantings. Thrips are also a pest of soybean, but their impact on soybean growth and development is minor. However, numerous other insect pests can impact soybean during the seedling stage. These include threecornered alfalfa hopper, bean leaf beetle, and various soil insects. Soil insects such as wireworms and white grubs are probably the most yield limiting insects in seedling soybean in the Mid-South because of the widespread adoption of soil conservation programs. Many growers in the Mid-South prepare their land during the late summer and early fall after the previous crop has been harvested. Those fields host a wide range of winter annual plants that support various soil inhabiting insects throughout the winter and early spring. Those winter annual weeds are allowed to grow and prosper in fields to prevent soil erosion. The growers apply a "burndown" herbicide 3 to 4 weeks before planting and plant into a stale seedbed. Lack of tillage during the spring allows the majority of the soil insects to survive and damage the crops planted into those fields when the crop seeds germinate and emerge. As a result, insecticide seed treatments are an integral component of integrated pest management programs for most crops in the Mid-South.

An experiment was recently conducted over a three year period at three locations in Mississippi to investigate the impact of planting date, soybean maturity group, and insecticide seed treatment on soybean yield and economics. The project was funded entirely by soybean checkoff dollars through the Mississippi Soybean Promotion Board. The treatments included three planting dates (mid-April, mid-May, and mid-June), five maturity groups (MG III, early MG IV, late MG IV, early MG V, and late MG V), and two seed treatments (fungicide only and fungicide + thiamethoxam). At all locations, the insecticide seed treatment resulted in yields significantly higher than the fungicide only treatment (Table 1) when averaged across all planting dates and maturity groups with an average yield advantage of 2.4 bushels per acre across all locations (Buehring et al. in review). It is also important to point out that the yield advantage was significant regardless of the overall yield potential of the site. Low yield environments benefitted equally to average and high yield environments.

Table 1. Soybean yield response to seed treatments, averaged over soybean maturity groups, planting dates, Verona, Stoneville and Starkville, MS.

Seed treatment	Verona	Starkville	Stoneville	Mean
	------------------------Yield (bu/acre)-------------------			
Apron	47.0 b[1]	26.5 b	61.9 b	45.1
Apron + Cruiser	50.3 a	28.3 a	64.0 a	47.5

[1]Within a column, numbers with the same letters are not significantly different at the 5% probability level.

More importantly, the use of an insecticide seed treatment resulted in a net economic return at all locations regardless of the market price used ($8/bu - $12/bu). Returns ranged from $1.40 per acre to $26.60 per acre when averaged across all other factors (Table 2). It is important to note that the market price received by growers in Mississippi over the last few years has been greater than $10.00/bu, and in many cases exceeds $12.00/bu.

Table 2. Apron + Cruiser seed treatment yield increase and returns above Cruiser seed treatment cost at a selected soybean market prices.

	Verona	Starkville	Stoneville	Avg.
Market	**------------Apron + Cruiser bu/acre increase------------------------**			
Price $/bu	**3.3**	**1.8**	**2.1**	**2.4**

	---------Returns $/acre above Apron + Cruiser treatment cost ($13/A)---			
8	13.40	1.40	3.80	6.30
10	20.00	5.00	8.00	11.00
12	26.60	8.60	12.20	15.80

Given the high input costs associated with soybean production in the Mid-South, these values could mean the difference between a net economic return for the grower and a net economic loss. Although insecticide seed treatments do provide a certain level of "insurance" for early season establishment and growth of soybean seedlings, the yield benefits and economic returns from these treatments in the Mid-South demonstrate their importance in soybean IPM.

The results from field corn are even more pronounced in the Mid-South region. Because of the relatively low planting populations and high soil insect pressure, stand loss due to the soil insect complex is common in the region. This is especially true in areas where the sugarcane beetle occurs. The soil insect complex is difficult to control in general and virtually impossible to control with foliar insecticides. Often visual symptoms of soil insect injury to field corn are not immediately apparent, and several weeks may pass before the full extent of the damage can be evaluated and replant decisions made. If replanting is required, the optimum planting window for corn has usually passed and yield potential declines substantially for plantings beyond the optimum window. Herbicides used in corn are often applied early and are not compatible with replanting of other crops suited for the Mid-South region, so late replants from stand loss pose a risk most farmers cannot bear. Insecticide seed treatments greatly reduce the risk from the soil insect complex in field corn in the Mid-South. The only alternatives to neonicotinoid seed treatments are in-furrow applications of granular or liquid broad spectrum organophosphate and pyrethroid insecticides.

In cotton, Cook et al. (2011) provided a review of thrips biology, crop injury, crop maturity, and yield impacts. They cited numerous studies that showed both yield increases and no yield response from thrips management in cotton. However, the authors cited research from Virginia (Herbert 2002) where yield increases averaged 339 lbs lint/A from thrips management. More recently, yield increases of 431 and 547 lb lint/A were observed in North Carolina and Virginia, respectively (Herbert et al. 2007) where aldicarb and seed treatments with imidacloprid were used. Similar results have not been published, but have been reported from the Mid-South (see http://www.utcrops.com/MultiState/Trials/2011/Cotton%20Thrips%20Regional%20Thrips.pdf). In general, thrips are considered a difficult pest to manage with foliar applied insecticides and multiple applications are needed with foliar sprays of broad spectrum insecticides to obtain satisfactory control. Because of this, thrips have been considered an annual pest of cotton in the Mid-South and some at-planting control option is always recommended.

Alternatives to Neonicotinoid Seed Treatments

Very few alternatives are available for early season insect control in cotton, soybeans, and corn in the Mid-South. The alternatives include granular or liquid insecticides that are applied in-furrow or banded over the open seed furrow. The alternative insecticides include organophosphates, carbamates, pyrethroids, and neonicotinoids (sprayed in-furrow). More importantly, these insecticides are applied at much higher rates when used in this manner compared with seed treatments. For example, one viable option to control the soil insect complex in corn and soybean includes chlorpyrifos (Lorsban) applied at 1.0 lb ai/A. In contrast, the maximum use rate for thiamethoxam applied as a seed treatment (Cruiser) in corn and soybean is 0.165 and 0.083 lb ai/A, respectively. This equates to an approximately 6 and 12-fold reduction in the total amount of active ingredient applied on a per acre basis when seed treatments are used. Similarly, imidacloprid is applied at approximately 0.04 lb ai/A when applied as a seed treatment in cotton. When imidacloprid is applied as an in-furrow spray (Admire Pro), it can be applied at a maximum use rate of 0.33 lb ai/A, an 8.25-fold increase. If thrips are controlled with foliar sprays in cotton, the maximum amount of active ingredient applied per acre can easily exceed 0.5 lb. Also, use of the neonicotinoids as seed treatments has been considered less likely to flare secondary pests compared to foliar sprays. Two-spotted spider mite has become an important early season pest of cotton in many areas of the Mid-South. This pest is generally maintained below economic densities by the actions of natural enemies. Foliar applications of broad spectrum insecticides such as acephate or dicrotophos (the most commonly used insecticides for foliar thrips control) will disrupt the natural enemy complex and allow spider mites to become established and threaten economic losses.

Seed Treatments as a Component of IPM in the Mid-South

As stated previously, early season insect pests are considered an important limiting factor to economic crop production in the Mid-South. Insect pests can delay maturity and cause significant yield reductions in most crops grown in the Mid-South. Management of these insects is complicated by the fact that many of them are not easily or economically controlled with foliar insecticide applications based on an economic threshold. In the Mid-South, the soil insect complex is difficult to predict prior to planting. Also, there are no foliar options available to effectively manage these pests. Therefore, the use of an at-planting insecticide is recommended in most crops in the Mid-South. Neonicotinoid seed treatments have been the product of choice for about the last decade because of their low use rates on a per acre basis, ease of use, reduced exposure to workers and handlers, and reduced impact to natural enemies. Neonicotinoid seed treatments are not innocuous and can impact natural enemy populations; however, their impact is much less than other at-planting options and foliar sprays. Because of these reasons and because early season insect pests are an annual economic problem in the Mid-South, neonicotinoid seed treatments are generally considered an integral component of IPM in most crops including cotton, corn, soybean, peanut, wheat, grain sorghum, and rice.

Rebuttal to: Heavy Costs: Weighing the Value of Neonicotinoid Insecticides in Agriculture

The paper titled "Heavy Costs: Weighing the Value of Neonicotinoid Insecticides in Agriculture" published by the Center for Food Safety is somewhat limited in scope. In their paper, the authors state "It appears EPA has overvalued the 'insurance' neonicotinoids offer against non-existent or insignificant pest pressures in many contexts." The information used to draw these conclusions is limited in scope. All of the conclusions from that paper are based on information from the midwestern and northeastern U.S. where they do not always see an economic benefit. In the southern U.S., insect pests are an annual yield limiting problem that impact profitable crop production in most crops. As a result, the conclusions drawn in this paper do not represent the entire U.S.

The authors of this paper reviewed 19 manuscripts published in refereed journals and based their conclusions off of those findings. The focus of this rebuttal will be on those papers that report neonicotinoid seed treatment use on crops that are grown in the Mid-South (corn, soybean, and wheat).

Corn

Cox et al. (2007):
This study was conducted in New York. The primary target was the soil insect complex. The authors state that "The experimental site was plowed and harrow-cultipacked a couple of days before planting in both years." Most of the soil insect complex that infests corn seedlings have long life cycles and are generally in the field at the time of planting. Any type of cultivation within a few days of planting will destroy a large percentage of the soil insect complex and most entomologists and pest managers would not expect to see much of a benefit from at-planting insecticides in this situation. In many areas of the country, USDA-NRCS programs promote conservation tillage to minimize soil loss and runoff from crop fields. In conservation tillage fields, the soil pest complex will be more robust than that observed with conventional tillage and the results would be much more dramatic and consistent. Despite tillage before planting, the authors state "The results of this study indicate that growers can safely use clothianidin seed treatments where soil insect damage is expected."

Jordan et al. (2012):
This study was conducted in Virginia. The primary target of this study was white grubs and wireworms. The white grub population consisted of primarily Japanese beetle in year 1 and Asiatic garden beetle in years 2 and 3. The wireworm population consisted of primarily *Conoderus* spp. in years 1 and 2. Overall, wireworm densities were low in year 3. The authors state that "The results of our study showed a direct relationship between fall white grub soil density, spring density, and subsequent stand and yield loss in corn." The authors also suggest that pest species complex may have impacted the differences they observed between years. As a side note, all of the fields used in this study were in corn fields following soybean. Results may have been more dramatic in corn fields following corn production the previous year.

Petzold-Maxwell et al. (2013):
This study was conducted in Iowa, Illinois, and Nebraska. The primary targets were *Diabrotica* spp. that included the western corn rootworm and northern corn rootworm, two species that do not occur in most areas of the Mid-South. The authors compared Poncho 1250 (clothianidin) to Aztec and Bt corn hybrids. Based on figure 1, the insects evaluated did not appear to cause a level of injury that would reduce yields. This is based on the fact that significant differences were observed in root injury on non-Bt corn, but no differences in yield were observed. The authors state that Cruiser 250 was used in the control treatment to manage other insect pests. This is a major flaw in the experimental design, because the insecticides are not being evaluated over the full spectrum of pests that may have been present.

Wilde et al. (2007):

This study was conducted in Kansas. The targets included several different soil and foliar pests. Damage from white grubs was significantly reduced. Also, significant yield losses were observed in the control plots where wireworms were present. Chinch bugs were also controlled and a significant yield benefit was observed. The authors suggest that Poncho and Cruiser have "great promise for growers dealing with a variety of early-season soil inhabiting and foliar pests."

Soybean

Cox et al. (2008):
This study was conducted in New York. The experimental site was chisel-plowed (deep tillage) the day before the first planting date and then disked-harrowed on the day of planting at each planting date. This would have eliminated numerous soil insect pests that may have impacted soybean growth and development. Results may be completely different when planting into a stale seedbed. The authors also state that this study was only conducted at 1 site in 2 years and acknowledge that more research is needed under more diverse conditions. This is a very limited study to use to draw broad conclusions and the results are not representative of the majority of soybean growing regions.

Cox and Cherney (2011):
This study was conducted in New York at 3 locations over a 2 year period. Fifty percent of the trials had a significant yield benefit from the use of a seed treatment. The authors converted yields to a percentage. This is meaningless without knowing what the actual yields were. If average yield was 20 bushels per acre, a 4% yield increase is probably not economical. However, if average yield was 60 bushels per acre, then a 4% yield increase would probably be economical. The authors also state that based on the seeding rate by seed treatment interaction for partial returns, that growers can attain maximum partial profit at seeding rates of almost 50,000 fewer seeds per hectare. This is an important finding given the high costs of seed.

Esker and Conley (2012):
This study was conducted in Wisconsin. The authors state at the beginning of the conclusions that "Results from this study indicated that seed treatments can be a cost effective component of soybean production although several factors must be considered, in particular environment and cultivar." In this study, the response of the economic return was highly dependent on grain sale price. The highest price that the authors used for their analysis ($0.44/kg) would equate to about $12.00/bushel, which is about the price growers receive in the Mid-South. In some years, the price can greatly exceed this value. As a result, the actual probability of breaking even is probably closer to the higher end of the range that the authors give and what is cited in the Center for Food Safety article.

Johnson et al. (2009):
This study was conducted in Iowa, Michigan, and Minnesota evaluating the use of see treatments against soybean aphid. The only year that soybean aphid had a significant impact on yields was in 2005, the year that the seed treatment was not evaluated. This most likely influenced the economic analysis in this study. The data for 2005 will make the IPM and prophylactic treatments look better than the seed treatment when averaged across all 3 years of the study. In

all cases, the seed treatment had fewer aphid days than the IPM and control treatments. This is despite the fact that the authors state that the seed treatment is gone before the aphids show up. If this is truly the case, how could the seed treatment have fewer aphid days than the IPM and control treatments? In Michigan, the seed treatment and prophylactic treatment yielded higher than the control and IPM programs.

McCornack and Ragsdale (2006):
This study was conducted in Minnesota with soybean aphid as the primary target. In all cases, yield was numerically greater in the in the thiamethoxam treatment compared to the control. There is no indication of how the data were analyzed in this paper. The analysis was broken out by year, but a combined analysis may have provided significant differences based on the trends.

Magalhaes et al. (2009):
This study was conducted in Nebraska against soybean aphid. The authors of the Center for Food Safety state that higher aphid populations may overwhelm seed treatments, but thiamethoxam held aphid populations below the economic threshold. Only imidacloprid was overwhelmed by aphids. No yields were reported in this study.

Ohnesorg et al. (2009):
This study was conducted in Iowa against soybean aphid. In this study, thiamethoxam provided similar yields to that observed with foliar sprays, but had less impact on natural enemies. Yields do not correlate well with aphid days suggesting that other insect pests may have been present. For instance, the number of aphid days was significantly lower in the 50 g thiamethoxam treatment than the 100 g thiamethoxam treatment. However, yields were greater in the 100 g treatment compared to the 50 g treatment.

Reisig et al. (2012):
This study was conducted in North Carolina and Virginia with thrips as the target pest. The authors state "In contrast to the mid-South, where a variety of insect pests are present in seedling soybean, the predominant insect pest of soybean in NC and VA is thrips." They also stated "The presence of other seedling pests may justify the continued use of neonicotinoid seed treatments in the mid-South."

Seagraves and Lundgren (2012):
This study was conducted in South Dakota against thrips and soybean aphid. The study was conducted over a 2 year period at 1 location.

Tinsley et al. (2012):
This study was conducted in Illinois against soybean aphid. The data in this experiment were not analyzed properly. It was analyzed as a factorial experiment, but every level of Factor B (insecticide treatment) was not included at every level of Factor A (Soybean Line). Therefore the interaction between soybean line and insecticide treatment is meaningless. No meaningful conclusions can be drawn from this experiment as it is presented.

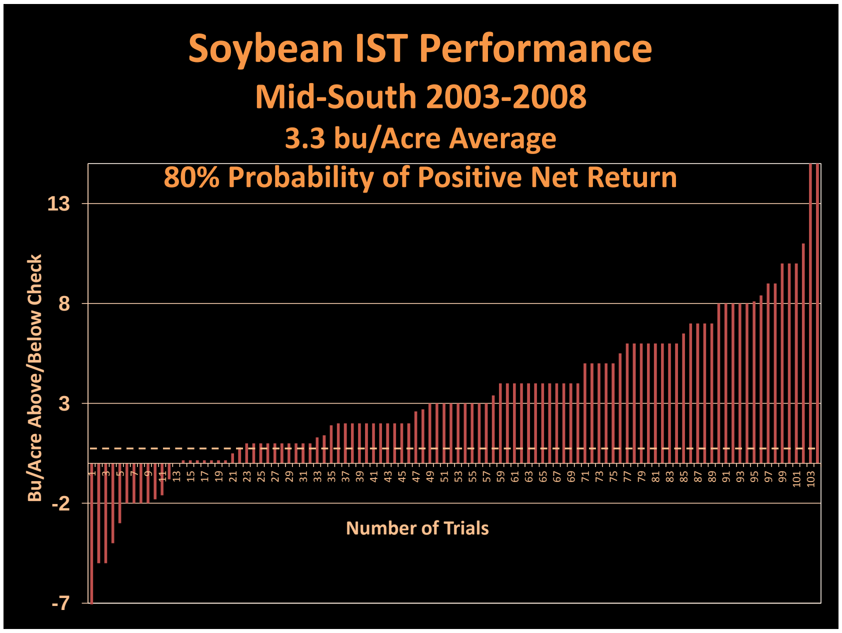
<u>Wheat</u>

Wilde eta al. (2001):
This study was conducted in Kansas and the primary targets included greenbug and Russian wheat aphid, as well as, Hessian fly. Imidacloprid and thiamethoxam provided outstanding early season control of both species at all rates. Control of late season populations was less consistent, but the highest rates reduced damage. Seed treatments also provided good early season control of Hessian fly. The authors concluded that seed treatments could be most useful in several situations. These included when a fall infestation is likely or if an insect problem is a chronic pest in a given area.

Royer et al. (2005):
This study was conducted in Oklahoma. Imidacloprid provided a significant yield benefit in most situations. Low rates provided significant yield protection and the most economic benefit. It also significantly reduced the incidence of barley yellow dwarf virus at all rates on all varieties. Profits were higher for all imidacloprid rates where BYDV occurred. The authors state "seed treated with imidacloprid has many environmentally and economically desirable qualities (e.g. low application rate, minimal worker exposure hazard, prevention of virus disease to the crop). If deployed prudently, an insecticide seed treatment offers a sensible tool to use in an IPM program."

Conclusions

Research from all areas of the U.S. demonstrates the importance of neonicotinoid seed treatments in many situations. The document from the Center for Food Safety highlighted refereed publications to support the conclusion that neonicotinoid seed treatments do not provide an economic benefit for producers. The current review of those papers suggests that neonicotinoid seed treatments can provide an economic benefit for growers in the regions where the research was conducted. Interpretation of selected manuscripts without considering all of the underlying factors that can influence the outcome can be dangerous. The papers reviewed represent a very small subset of all of the research on neonicotinoid seed treatments over the last 20 years and does not adequately represent the value of those treatments across the U.S. In the Mid-South, neonicotinoid seed treatments are recommended by University Research and Extension Specialists in multiple crops. Most of that research may not be published in refereed journals, but it should not be discounted. In the Mid-South, research on the efficacy and value of neonicotinoid seed treatments has been conducted since they were released and continue to be studied today. The figure below shows a summary of six years of trials conducted across the Mid-South (AR, MS, LA, TN, and MO) to evaluate the benefits of insecticide seed treatments. A total of 103 replicated trials indicates that there is an 80% probability that growers will receive a net economic benefit from the use of insecticide seed treatments in soybean. The yield advantage from using an insecticide seed treatment averaged 3.3 bushels per acre across all trials.



In the Mid-South, numerous insect pests infest and damage all row crops during the seedling stage, many of which cannot be managed with foliar insecticides. As a result, at-planting insecticides are recommended as a standard IPM practice in many crops in the Mid-South and have been recommended before the introduction of neonicotinoid seed treatments. Calling for widespread bans of this class of insecticides would cripple farmers of most crops in the Mid-South because viable alternatives are no longer available. Those alternatives included highly toxic, broad spectrum insecticides that provided a greater risk to the environment and human health than neonicotinoid seed treatments. For any group to call for these bans without providing realistic alternative solutions is completely irresponsible. Admittedly, one of the hazards associated with neonicotinoid seed treatments is the risk of planter lubricants and dust contaminated with the seed treatment being expelled from the exhaust of pneumatic planters. This is a problem that can easily be fixed through engineering of equipment. The agricultural chemical industry has already developed at least one alternative to talc and graphite as planter lubricants to reduce the amount of dust expelled from the exhaust. Additionally, planter companies and other individuals are working on systems to collect the dust from planters before it leaves the planter. An all out ban on neonicotinoid seed treatments would severely threaten the success of current IPM programs in the Mid-South because alternative controls would be much more detrimental to the balance of current cropping systems.

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