INSECTICIDE SEED TREATMENTS FOR CORN AND SOYBEAN

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Introduction

Recent history has demonstrated that cash grain producers can take nothing for granted when it comes to counting on favorable weather. The variability in our weather often makes us wonder, how is this possible? When Grandpa tells you "I remember back in '62, now that was a perfect year!" You may want to check his medication. So called "normal weather years" may indeed be something we have envisioned only in a dream (the best definition of a normal year may be to average the past 20 years together!). The harsh reality of working with Mother Nature is that she only allows us to think that we are in control. This past year was no exception. Weather extremes were not only state to state or county to county, but on a township to township level. With weather extremes comes crop stress in the form of poor seedling establishment and growth, inconsistent herbicide performance (and difficult application timing), pollenation concerns, drought anxiety, soil compaction, harvestability problems, etc. These elements are only further confounded by the presence of pests, whether it be weeds, diseases or insects. Recent warmer winters and hot, dry summers have only accelerated the onslaught of insect damage to our crops.

The benefits of our shorter rotations, namely corn-soybean, have reduced the need for extra equipment, streamlined labor and generally simplified our operations, but at what cost? We have less small grains and alfalfa in our rotations which can help minimize certain diseases, insects and weed pressures. We are actually selecting for specific problems instead of minimizing our contact with them. Early planting of soybeans provides a lush food source for emerging overwintered bean leaf beetles, early planted corn is a target for 1st generation European corn borer, etc. With our tight rotations we now have corn rootworm beetles laying eggs in soybean fields or simply delaying egg hatch until corn is grown again. Additionally, shorter rotations have caused spikes in corn and soybean diseases such as brown stem rot and soybean cyst nematode. With the expansion in acreage that soybeans have experienced its' no wonder that an insect like soybean aphid has emerged.

Do we give up and say, we are licked? No, it means that we have to be even more vigilant in our attempts to protect our crops and our potential yield. Potential yield can be thought of as what is in a bag of seed before it is opened. In that bag is 500 bushel corn or 100 bushel soybeans, this is its genetic potential. As soon as the e-z pull string is opened we lose yield. Lost yield comes from weather problems, planter skips, poor adjustments, poor seed to soil contact, compaction, herbicide damage, weed competition, diseases, insects, etc. etc. We need to find ways to control that yield slide. Examples are properly maintained planting and harvesting equipment, quality seed with high germination, proper soil fertility, and fungicide and insecticide seed treatments.

The idea of a fungicide seed treatment for corn is a no-brainer, try to buy corn seed without one. Similarly, soybean seed undergoes the same early season stresses and should have a fungicide seed treatment also. But, what about a seed applied insecticide? A relatively new idea on the market, this class of compounds is being targeted to protect seed and young plants from certain insect pests. It is this class of pesticides that will be covered in this paper.

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In the past 20 to 30 years as more producers have transformed to a corn-soybean rotation, less soil applied insecticides have been needed. In recent years insects are increasingly causing economic damage to crops. This has encouraged a revisit to the use of insecticides on our crops. However, many producers would prefer to not handle soil applied insecticides despite the fact that they are quite effective. Additionally, many newer planters do not have the necessary equipment to apply these insecticides. Recent advances in equipment technology has promoted the introduction of liquid in-furrow insecticides. Planters not originally equipped with insecticide boxes can now apply insecticides with specialized add-on equipment. However, some producers have had varying success with those materials or would prefer to not handle the liquids either. Still other options have included planter box treatments which have had good success, but once again it involves opening up a bag of material and mixing in the planter box with seed. Mixing consistency is not always perfect, plus dealing with excess residue at the bottom of the planter boxes.

Enter a new form: seed applied insecticides. Early attempts at commercial application had varying success, often resulting in excess fines, etc. in each bag of corn. More recently, the technology of applying insecticides to seed has improved, resulting in a more uniform and consistent application onto the seed. So the question is do seed applied insecticides perform? Are they cost-effective and do they provide necessary control of labeled insects?

Objectives

My first question was, with the aggressive marketing campaigns by both Gustafson and Syngenta, I wanted to separate the facts from the fiction, do seed applied insecticides work? The performance of seed-applied insecticides at high or CRW rates has been discounted in some areas. Comparative performance to more traditional soil applied insecticides against corn rootworm has been variable at best, but I have rarely seen grain yield data to back it up. My first objective was to investigate the performance of these seed applied insecticides in a continuous corn environment, rate for root feeding damage and measure final grain yield. My second objective was to test how these seed applied insecticides would perform in a corn-soybean rotation at low rates where so-called "secondary" pests are more common (i.e. where wireworm, seed corn maggot, white grub and flea beetle are more commonly the most aggressive pests, not corn rootworm).

Materials and Methods

Field observations of the performance of seed applied insecticides on field corn seed were initiated in 2000, using Gaucho (**imidacloprid,** Gustafson) in Whitewater, WI. Studies were expanded in 2001 and 2002 to include Gaucho, Prescribe (**imidacloprid**, Gustafson), Cruiser (**thiamethoxam**, Syngenta) and Poncho (**clothianidin**, Gustafson) treated corn and soybean seed into fields located in Whitewater, Milton and Janesville, WI in several corn and soybean crop rotation scenarios. These three locations were chosen due to different soil textures, historical climate and yield potential. Location 1, high yield potential (Janesville - Plano silt loam), location 2, average to high yield potential (Whitewater - Kidder sandy loam, Milford clay loam and Matherton silt loam), and location 3, average to high yield potential (Milton - St. Charles silt loam). Crop rotation scenarios included corn on previous soybean, corn on corn, and soybean on corn. Insecticides utilized at low (C-Sb) and high (C-C) rates were Cruiser at 0.125 and 1.25 mg/kernel; Gaucho at 0.16 mg/kernel; Prescribe at 1.34 mg/kernel; and Poncho at 0.25 and 1.25 mg/kernel; Regent (**fipronil**, BASF) at 2.1 and 4.2 oz/acre LIF; and Force 3G (**tefluthrin**, Syngenta) at 2.5 and 5.0 lbs/acre T-band.

Corn: Corn plots were all conventionally tilled (fall chisel, and spring field cultivator). Corn plots were planted into large-on-farm sized plots (15 feet x 1250 feet, approximately 0.43 acres), randomized and replicated four times, with a John Deere 6 row Model 7200 no-till Max Emerge II vacuum planter at 32,000 seeds/acre on 30" row spacings at a 2" depth. Planting date varied from April 25 to May 15. Corn hybrids ranged from Pioneer Hi-Bred 35R57/58 and 34G81/82; DSR 1005BT, 1412BT from Dairyland Seed Co.; DK 507, 537 and 567, from Dekalb Seed Division, Monsanto; 2488A, 2510B, 6510B from Jung Seed Genetics; and NK58-D1 and N45-T5 from Syngenta.

All seed contained Maxim XL, **(fludioxinil,** Syngenta) fungicide seed treatment as a base treatment. All plots received 200 lbs/acre 7-21-7 liquid starter fertilizer at planting. All corn on soybean plots were fertilized to optimum fertility levels using standard WI fertility recommendations (160 units N - 40 lb N credit due to previous soybean crop - 14 lb N from starter = 106 units N). All corn on corn plots were fertilized using standard WI fertility recommendations (160 units N - 14 lb N from starter = 146 units N). Nitrogen was applied as 28%N - UAN.

Plots were kept weed-free using a combination of pre and post emergent herbicides. All plots received 2.5 pt/acre Harness (**acetochlor,** Monsanto) + 1.0 lb/acre Atrazine (**atrazine**, generic) applied with liquid N as 28%N - UAN prior to planting. All plots received post emergent applications of either 6 oz Distinct (**dicamba + diflefenzopyr**, BASF), 3 oz Callisto (**mesotrione**, Syngenta) or 3.2 oz Hornet WDG **(flumetsulam + clopyralid**, Dow) at V6 (Ritchie, et al., 1989). Data collected included grain yield, grain moisture, test weight, V4 plant vigor, V4 stand density, harvest stand density, and corn rootworm larvae feeding evaluation based on Iowa State Ratings (1-6 injury scale) criteria on July 25th each year. Plots were harvested from October to November using an International Harvester 1460 combine (Case Corp.) and AgLeader PF3000 yield monitor (AgLeader Technology) with GPS. A Parker Model 150 weigh wagon (Parker Industries) was used for individual plot weights and yield monitor calibration.

Soybean: Soybean plots were all planted no-till into large on-farm sized plots (15 feet x 500 feet, approximately 0.17 acres), randomized and replicated four times with a John Deere 15 foot Model 750 No-till Grain Drill at 225,000 seeds per acre on 7.5" row spacings at a 1" depth. Planting date varied from April 28 to May 12. Soybean varieties included Dairyland Seed Company DSR228RR, Dekalb Seed Division, Monsanto DKB26-52 and Spangler SeedTech 249RR. All seed contained ApronMaxx (**fludioxynil + mefenoxam**, Syngenta) fungicide seed treatment as a base treatment, to compare against a standard untreated check.

Plots were kept weed-free using a combination of preplant and post emergent herbicides. All plot received 13 oz/acre Roundup UltraMax (**glyphosate**, Monsanto + 0.75 pt/acre 2,4-D amine (**2,4-D**, generic). All plots received post emergent applications of 26 oz/acre Roundup UltraMax + 3 oz Raptor (**imazamox**, BASF) at very early R1 (Ritchie, et al., 1989). Data collected included grain yield and grain moisture, V2 plant vigor, V2 plant density, harvest plant density, harvest plant height and lodging, bean leaf beetle feeding injury and soybean aphid density. Plots were harvested from late September to early October using an International Harvester 1460 combine and AgLeader PF3000 yield monitor with GPS. A Parker Model 150 weigh wagon was used for individual plot weights and yield monitor calibration.

Results and Discussion

2000 Results—Corn on Corn

In 2000, Gaucho was evaluated to study its effect on two hybrid isolines, Pioneer 35R57 and Pioneer 35R58. Grain yield and plant density per acre improved for each hybrid with the addition of seed applied Gaucho (Table 1). GPS yield maps produced by the combine reflected this yield enhancement (data not shown). Maximum yield monitor accuracy was obtained by keeping combine harvesting at a constant speed, and calibrating after each plot weight was measured by weigh wagon. Corn rootworm activity was minor and injury across treatments was not significant. Additionally, no major "secondary" insect pest was detected to account for the additional yield enhancement. Seed applied insecticides performed similarly to soil applied insecticide check.

Table 1. Means for corn on previous corn grain yield, root injury ratings and early plant density for two insecticide treatments at Whitewater, WI, 2000.

Hybrid	Treatment	Grain yield bu/a	Iowa State CRW (1-6)	Early plant density
35R57	UTC	173.7	2.9	29433
35R57	Gaucho	186.3	2.4	31200
35R57	Force 3G	185.3	1.9	30400
35R58	UTC	174.2	2.8	30667
35R58	Gaucho	185.4	2.5	31500
35R58	Force 3G	187.2	1.9	30199
LSD.10	**Seed treatment**	**3.9 bu/acre**	**NS**	**600 plants/acre**

2001 Results—Corn on Corn

Growing conditions in 2001 were generally not considered great for corn production. During June and July several weeks passed without rainfall. During these high heat periods corn showed symptoms of drought stress by rolling leaves and wilting. Despite obvious symptoms of stress, yields were generally good to excellent. At all three locations corn grain yield, plant stand and early vigor were improved when an insecticide was used (Table 2). Corn rootworm feeding was slightly more severe than in 2000 (Table 2 and Table 1). The addition of a seed applied insecticide generally reduced root injury ratings by 1.0 to 1.5 points. Seed applied insecticides and soil applied insecticide check performed similarly for yield and insect control. GPS yield maps demonstrated these yield effects (data not shown). Results in 2001 reflected 2000 results. Numerical root ratings favored soil applied insecticide check, yet not significantly from seed applied insecticide treatments.

2001 Results — Corn on Soybean

As an expansion of this research, several studies were organized to look at seed applied insecticides at low or reduced rates in a corn on previous soybean rotation (Table 3). Overall, grain yield, early vigor and plant density increased with these insecticide seed treatments, again no major "secondary" insect pest was detected. Reduced rates of standard insecticide checks were also tested. Yields were comparable between all insecticide treatments.

Table 2. Means for corn on previous corn grain yield, early plant vigor and density and root injury ratings for five insecticide treatments at Whitewater, Milton, and Janesville, WI, 2001.

Treatment	Grain yield bu/a	Early vigor (1-9)	Early plant density	Iowa State CRW (1-6)
UTC	138.2	4.7	22750	3.2
Prescribe 1.34	159.5	8.2	30117	1.7
Cruiser 1.25	156.8	8.3	30917	1.9
Poncho 1.25	163.8	8.0	31347	1.8
Force 3G	161.5	7.7	29583	1.4
LSD.10	**3.0**	**1.0**	**2464**	**0.5**

Table 3. Means for corn on previous soybean grain yield, early plant vigor and density for six insecticide treatments at Whitewater, Milton, and Janesville, WI, 2001.

Treatment	Grain yield bu/a	Early vigor (1-9)	Early plant density
UTC	172.6	5.7	23333
Gaucho 0.16	184.3	7.6	28750
Cruiser 0.125	181.7	7.3	27417
Poncho 0.25	182.2	7.3	28833
Force 3G (½ rate)	184.1	7.7	28167
Regent 4SC (½ rate)	185.2	7.3	26000
LSD.10	**4.5**	**0.8**	**1889**

2001 Results —Soybean

Curiosity naturally crossed over to soybeans to determine if insecticides applied on the seed would benefit soybean growth and yield. Table 4 illustrates that there were similar growth enhancements as were seen on corn. Most notable effect was due to excellent control of early feeding by bean leaf beetles and an improvement in stand above fungicide only treatment.

Table 4. Means of soybean grain yield, early plant density and bean leaf beetle feeding injury at Whitewater and Milton, WI, 2001.

Treatment	Grain yield bu/a	Early plant density	Bean leaf beetle injury %
UTC	42.6	137550	22.5
Fungicide only	45.4	150125	25.1
Fungicide + Gaucho 0.16	50.3	162500	3.8
Fungicide + Cruiser 0.125	51.6	165470	2.9
LSD.10	**2.6**	**5802**	**3.3**

2002 Results— Corn on Corn

2002 was another one of those years where the stress on our crops never seemed to end. Early season cool, damp conditions followed by an extended period of hot, dry weather where corn showed symptoms of wilting for nearly nine weeks in July and August. Surprisingly, there were some decent yields here and there, depending on the planting date and how soil was worked, and welcome spotty rainfall. Table 5 demonstrates the influence of insecticide on corn grown after corn at three locations. Similar to 2000 and 2001, yields, plant vigor and plant density were improved. Corn rootworm was increasingly present in 2002 compared to 2001 or 2000. Untreated checks exhibited classic goosenecking from corn rootworm damage. Soil applied insecticide check had the best numerical root rating, with Poncho not significantly different. The other seed applied insecticides had slightly higher root ratings, yet no real yield differences to all other insecticide treatments.

Table 5. Means of corn on previous corn grain yield, early plant vigor and density, and root injury ratings for five insecticide treatments at Whitewater and Janesville, WI, 2002

Treatment	Grain yield bu/a	Early plant vigor (1-9)	Early plant density	Iowa State CRW (1-6)
UTC	147.3	5.7	28246	4.5
Prescribe 1.34	163.9	7.3	31181	3.5
Cruiser 1.25	163.3	7.3	31195	3.6
Poncho 1.25	172.5	8.0	32303	3.0
Regent 4SC	166.6	6.2	27616	3.8
Force 3G	161.0	6.7	29355	2.9
LSD.10	**7.1**	**0.4**	**857**	**0.3**

2002 Results— Corn on Soybean

Corn grown after previous soybean also had improved plant performance due to an insecticide (Table 6). Grain yields were not significantly different between all insecticide treatments. However, plant vigor and density were better for the seed applied insecticide treatments.

Table 6. Means of corn on previous soybean grain yield, early plant vigor and density at Whitewater, Milton and Janesville, WI, 2002.

Treatment	Grain yield bu/a	Early plant vigor (1-9)	Early plant density
UTC	166.4	5.6	25171
Gaucho 0.16	185.7	7.0	27574
Cruiser 0.125	184.6	7.2	27522
Poncho 0.25	190.8	7.7	28271
Regent 4SC ½ rate	186.3	6.0	25347
Force 3G ½ rate	189.6	6.2	26116
LSD.10	**7.8**	**0.5**	**635**

2002 Results— Soybean

The influence of seed applied insecticides on soybean seed was even more dramatic in 2002 than was found in 2001 (Table 7). Bean leaf beetle feeding was much more severe in 2002. Early vigor and plant density were improved with seed applied insecticides. Bean leaf beetle feeding injury was greatly reduced by seed applied insecticides.

Table 7. Means of soybean grain yield, early plant vigor and density, and percent bean leaf beetle feeding injury at Whitewater and Janesville, WI, 2002.

Treatment	Grain yield bu/a	Early plant vigor (1-9)	Early plant density	Bean leaf beetle injury %
UTC	51.7	6.7	157000	40
Fungicide only	54.1	8.1	183000	45
Fungicide + Gaucho 0.16	61.7	8.4	196100	10
Fungicide + Cruiser 0.125	61.5	8.5	196000	10
Fungicide + Poncho 0.25	63.8	8.8	200000	5
LSD.10	**2.2**	**0.4**	**3800**	**7**

What About the Unknown/Hard-to-Quantify Responses Due to Seed-Applied Insecticides?

When a study is conducted to investigate specific parameters and their related effects on plant performance, those influences are so noted, but when additional unknowns influence yield, the real experiment begins. Seed applied insecticides like Gaucho and Cruiser seem to cause certain growth-enhancing effects on the crop. Whether through improved early stand establishment and vigor, more uniform stands, more rapid growth, taller plants, increased plant density or ability to handle stress (like drought) better than untreated plots. The effect is real, yet difficult to measure quantitatively. In the corn studies conducted, with the exception of corn rootworm and European corn borer, no other significant insect pests were detected beyond an occasional white grub, seed corn maggot or wireworm. So, what is really happening? That is unknown at present, but there is something occurring. With soybeans early bean leaf beetle feeding control was obvious as indicated by dead carcasses of beetles on the soil surface near treated plants. Soybean aphid numbers were reduced or at least delayed when a seed insecticide was used. Final yield supported this effect. More investigation is needed to pinpoint the effect of these treatments.

Conclusions

The good news is that seed applied insecticides are here [(Gaucho, Prescribe (2001), Cruiser (2003), Poncho (2004)] and available to producers. The bad news is that seed applied insecticides are not yet legal for use on soybean seed. Reports indicate that for 2003, nearly 25% of all corn seed will be treated with an insecticide, further reports indicate that in 2004 that number may include 50% of all corn seed.

Do they work? Yes, a multitude of on-farm based research supports the performance of seed applied insecticides. In my studies from 2000 to 2002 grain yield has improved 11 to 25 bu/acre for corn on corn when a seed applied insecticide was used. Overall, corn rootworm feeding injury was reduced 1.0-1.5 points compared to untreated check. In 2001 and 2002 grain yield improved 9 to 24 bu/acre for corn on previous soybean ground when a seed applied insecticide was used. Soybean data from 2001 and 2002 demonstrate more excitement in yield bumps of 7 to 12 bushel/acre partially from reduced bean leaf beetle feeding, possibly some from reducing aphid impact.

From improved early vigor, increased stands, and enhanced yields these compounds work. They are pre-applied and provided to growers in the bag, handling is easy, straight-forward and generally safer that more traditional soil applied or planter box treatments. A great advantage of these compounds is that they are systemically taken up by the plant, not labile in the soil.

Not all performance is seemingly due to insecticidal qualities, but also due to growth-enhancing characteristics not yet understood. Under early season stress, like cool wet conditions, these treatments may provide some stress defense mechanisms in the plant. Should this technology be carelessly used? No, like any management practice these must be placed properly in ones cropping program. As a seed treatment for corn-soybean rotations the additional $3.75 to $4.00 per acre is a small investment for the expected return. As a seed treatment for corn-corn rotations the cost is three to four times greater and there can be weaknesses in performance under heavy rootworm pressure. Placement depends on each individuals producers management and need. Should every producer at least try this technology? Absolutely!

Literature Cited

Additional information may be obtained from the following:

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