IMPACTS OF SEED LUBRICANTS ON SEEDLING ESTABLISHMENT AND YIELD: ON-FARM AND SMALL-PLOT TRIALS

Mark A. Boetel[1], Professor
Allen J. Schroeder[1], Research Specialist
Jacob J. Rikhus[1], Research Specialist
Norman R. Cattanach[2], Research Specialist
Amitava Chatterjee[2], Assistant Professor
Kelly J. Sharpe[3], Agronomist, Sales, Support

[1]Department of Entomology, North Dakota State University, Fargo, ND
[2]Soil Science Department, North Dakota State University, Fargo, ND
[3]GK Technology, Inc., Halstad, MN

Introduction:

Recently published research has implicated neonicotinoid seed treatment insecticides (e.g., Cruiser, Poncho, etc.) used for corn production in honey bee kills (Krupke et al. 2012). That research has raised major concerns that have precipitated public demands ranging from increased use restrictions to a complete ban on all uses of neonicotinoid insecticides. Those authors observed that seed-flow lubricants (e.g., talc) abrade seed-applied insecticides from corn seed coatings, and suggested that the resulting insecticide-laden dust is released into the air in exhaust plumes emitted from vacuum-based planters. As a result, they concluded that this subsequently can either directly or indirectly expose bees and potentially other pollinators. In response to public concerns and perceived risk to pollinators from these insecticides, the Environmental Protection Agency (EPA) issued a moratorium on any new uses of currently labeled neonicotinoid products in April of 2015.

Concerns relating to this “dust off” of neonicotinoid insecticides have also raised questions regarding whether talcum or other seed-flow lubricants are necessary during row crop planting. If lubricants are not needed in sugarbeet planting, or if a less-abrasive alternative than talcum could perform at least as well without negatively impacting seed delivery and seedling establishment, it may provide evidence to support continued federal registration of neonicotinoid seed treatment insecticides used in sugarbeet production.

This experiment was carried out to determine if seed-flow lubricants (i.e., talc, graphite, talc/graphite mixture, or Fluency Agent™) impact seed delivery, seedling establishment, or resulting sugarbeet yield parameters and revenue. This research could provide critical information to argue for maintaining neonicotinoid seed treatment registrations for use in sugarbeet if the EPA proposes a ban on using these materials in row crop production.

Materials and Methods:

This research involved two experiments that were carried out in grower-owned fields during the 2016 growing season. Study I involved a small-plot, replicated trial that was conducted near Hillsboro, ND. Study II was a large on-farm trial that was carried out by using conventional grower-owned equipment for planting and harvest. All seed-flow lubricant materials were applied at manufacturer-recommended rates.

Study I: Plots were planted on 19 May, 2016 by using a 6-row John Deere MaxEmerge II™ planter. The planter was adjusted to deliver seed at a depth of 1¼ inch and a rate of one seed every 4½ inches of row length. Treatments in Study I included the following: 1) John Deere Premium Seed Talc™ (Deere & Co., Moline, IL); 2) John Deere Powdered Graphite™; 3) John Deere Talc/Graphite™ combination seed lubricant (80% talc and 20% graphite); 4) Fluency Agent™ (Bayer Crop Science, Durham, NC); 5) Fluency™ II (a reformulated version from Bayer; NOTE: the “II” in Fluency II is a term created by the authors, not a trademarked name); and a no-lubricant control. Betaseed 83CN, a glyphosate-resistant sugarbeet seed variety in two sizes (miniature pellet ~9/64-inch diam.] and Pro200, an extra-large pellet (~12.5/64-inch diam.) was used for the experiment. All seed included Poncho Beta (i.e., clothianidin + betacyfluthrin at 60:8 g a.i./100,000 seeds, respectively) insecticidal seed treatment to minimize the risk of soil insect feeding injury introducing unwanted variability to the experiment. Each plot was six rows (22-inch spacing) wide with the four centermost rows treated. The outer “guard” rows, one on the outer side of each plot, served as untreated buffer rows. Each plot was 35 feet long, and 25-foot tilled alleys were maintained between replicates throughout the growing season. The experiment was arranged in a split-plot design with four replications of the treatments. Seed size was the whole-plot factor, and seed flow lubricant served as the sub-plot factor.

Treatment performance was compared using plant stand counts and yield parameters. Stand counts involved counting all living plants in all four 35-ft long rows of each plot. Counts were taken on 7 and 23 June, and July 7, which were 19, 35, and 49 days after planting (DAP), respectively. All plant stand count observations were converted to plants per 100 linear row ft.

Harvest: Treatment performance was also compared on the basis of sugarbeet yield parameters. Plots were harvested on 20 September. Immediately before harvest, the foliage was removed from all treatment plots by using a commercial-grade mechanical defoliator. After defoliation, all beets from the center two rows of each plot were extracted from the soil using a mechanical harvester and weighed in the field using a digital scale. A representative subsample of 12-18 beets was collected from each plot and sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for sucrose content and quality analysis.

Data analysis: All data from root injury ratings and harvest samples were initially subjected to analysis of variance (ANOVA) (SAS Institute, 2008) to determine whole- and sub-plot factor effects. Means were separated by using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

Study II: The on-farm trial was planted on 22 April, 2016 by using a 12-row John Deere 1730 MaxEmerge Plus™ planter. The planter was adjusted to deliver seed at a depth of 1¼ inch and a rate of one seed every 4¾ inches of row length, and was operated at 4.5 mph. Crystal 246RR glyphosate-resistant seed that was conditioned by using the XBeet® priming system was used for all treatments. All seed was formulated as miniature pellets, and included the following seed-applied protectants: 1) Poncho Beta insecticide (68 g a.i./100,000-seed unit); 2) Tachigaren fungicide (45 g a.i./ unit); and 3) Kabina ST fungicide (14 g a.i./unit). Each plot was 12 rows (22-inch spacing) wide by 900 ft in length. The experiment was arranged in a randomized complete block design with four replications of the treatments. Study II included all treatments used in Study I except the original formulation of Fluency Agent™.

Treatment performance was compared according to plant stand counts and yield parameters. Stand counts involved counting all living plants within 1/1000th ac long subsamples, of which four were taken at equally spaced intervals within the length of each treatment plot. Counts were taken on 9 and 28 May, and 1 June, which were 17, 28, and 40 days after planting (DAP), respectively. All plant stand count observations were converted to plants per 100 linear row ft before being subjected to statistical analysis.

Harvest: Sampling for harvest data was conducted twice on 20 September, 2016. Immediately before harvest, the foliage was removed from all treatment plots by using a commercial-grade mechanical defoliator. Preliminary harvest assessments involved using a conventional spade to manually pre-harvest subsamples. Each subsample was comprised of all roots from an 11.9-ft length of one of the center-most rows, and one subsample was collected at each of four locations within each treatment plot. Pre-harvest subsamples were collected at about the same locations within each plot that stand counts were taken throughout the growing season. Subsamples were bagged and labeled, then sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for sucrose content and quality analysis.

Machine harvesting entailed collecting all roots from each treatment plot with a conventional six-row Art's Way™ 690 sugarbeet harvester. Root tonnage data was collected from the on-board harvester yield monitoring system in 50-ft increments from within each plot. Quality analysis parameters from pre-harvest samples were used in combination with tonnage data from the harvester yield monitor to calculate recoverable sucrose yield from each plot.

Data analysis: All machine-harvest yield data were subjected to analysis of variance (ANOVA) using the general linear models (GLM) procedure (SAS Institute, 2008), and treatment means were separated using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance.

Results and Discussion:

Study I: Plant population (i.e., stand count) results from initial whole-plot (i.e., seed size) treatment comparisons appear in Table 1. On the first date (19 DAP), plant populations in plots planted with Pro200 (i.e., extra-large) seed were significantly greater than those in plots seeded with miniature pellets. That was the only date on which there was a significant difference in plant population between the two seed sizes tested. In addition, the stand counts taken at 35 and 49 DAP indicated that plant populations for the two seed sizes were nearly identical, with numerical differences between treatments of only three plants per 100 row ft. The relatively small (i.e., 3%) difference between seed sizes during the first stand count, combined with the fact that no significant differences were detected on subsequent dates, suggested that seed size did not play a major role in the results of this trial.

Table 1. Whole-plot effect of *seed size* on *plant population* in a comparison of sugarbeet seed-flow lubricants in a small-plot field trial (Study I), Hillsboro, ND, 2016

Treatment/ form.	Stand counts (plants / 100 row ft)		
	19 DAP[a]	35 DAP	49 DAP
Pro200	264 a	252 a	256 a
Mini	256 b	249 a	253 a
LSD (0.05)	4.64	NS	NS

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]DAP = days after planting

Yield results from the whole-plot factor (i.e., seed size) treatments in this trial appear in Table 2. There were no significant differences between seed sizes with regard to recoverable sucrose yield, root yield, or percent sucrose content. The relative lack of differences in plant populations (Table 1), coupled with these findings of no significant impacts of seed size on yield parameters, further suggested that the main-level factor of seed size most likely had no measurable effect on the overall results of this trial.

Table 2. Whole-plot effect of *seed size* on *yield parameters* in a comparison of sugarbeet seed-flow lubricants in a small-plot field trial (Study I), Hillsboro, ND, 2016

Treatment/ form.	Recoverable sucrose yield (lb/ac)	Root yield (T/ac)	Sucrose content (%)	Gross return ($/ac)
Pro200	7609 a	26.8 a	15.35 a	767
Mini	7260 a	25.8 a	15.22 a	719
LSD (0.05)	NS	NS	NS	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).

The initial ANOVA indicated no significant seed size × lubricant ($P > 0.05$) interactions for any of the three stand count dates in the experiment. As such, a combined analysis was carried out to compare seed flow lubricants on the basis of stand count data across both seed sizes. Results from the combined analysis are presented in Table 3. On the first date (i.e., 19 DAP), plant stands in Fluency Agent and Fluency Agent II plots were significantly greater than those in the graphite, talcum, and the no-lubricant control plots. However, it should be noted that the difference between the lowest average stands (i.e., 256 plants per 100 row ft), which were recorded for both talcum and the no-lubricant control, were only 3.8% lower than those for Fluency Agent II (i.e., 266 plants/100 row ft). Stand counts in the talcum/graphite mixture plots were intermediate relative to treatment plots and, therefore, were not statistically different from any other treatment at 19 DAP. There were no significant differences among the different seed lubricant treatments for either of the subsequent stand counts taken at 35 and 49 DAP, and none of the lubricants differed statistically from the no-lubricant control at those later counts.

Table 3. Effects of seed-flow lubricants on sugarbeet *plant population* in a small-plot field trial (Study I), Hillsboro, ND, 2016			
Treatment/ form.	**Stand count (plants / 100 row ft)**		
	19 DAP	**35 DAP**	**49 DAP**
Fluency Agent II	266 a	257 a	260 a
Fluency Agent	264 a	249 a	254 a
Talc/graphite mixture(80:20)	260 ab	254 a	259 a
Graphite	257 b	247 a	257 a
Talc	256 b	249 a	249 a
None	256 b	248 a	251 a
LSD (0.05)	6.59	NS	NS

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]DAP = days after planting

Yield results from this experiment appear in Table 4. Trends in the yield data were somewhat supportive of plant stand count data in that the lowest average sucrose yields occurred in the talcum and no-lubricant control plots. However, as observed in the stand count analyses, there were no statistical differences among lubricants or between any single lubricant and the no-lubricant control with regard to recoverable sucrose yield, root tonnage, or percent sucrose. Accordingly, there were only negligible differences in gross economic return among the entries tested.

Table 4. Effects of seed-flow lubricants on sugarbeet *yield parameters* in a small-plot field trial (Study I), Hillsboro, ND, 2016				
Treatment/ form.	**Recoverable sucrose yield (lb/ac)**	**Root yield (T/ac)**	**Sucrose content (%)**	**Gross return ($/ac)**
Graphite	7725 a	27.0 a	15.44 a	789
Fluency Agent	7472 a	26.5 a	15.29 a	745
Talc/graphite mixture(80:20)	7440 a	26.2 a	15.36 a	749
Fluency Agent II	7424 a	26.2 a	15.28 a	743
None	7275 a	25.9 a	15.21 a	717
Talc	7272 a	26.0 a	15.15 a	713
LSD (0.05)	NS	NS	NS	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).

Study II: Plant stand count data from the on-farm trial appear in Table 5. There were no significant differences in stands were observed among seed lubricants or between any lubricant and the no-lubricant control for any of the stand count dates. Trends in plant stands counted in the early portion of this experiment suggested a slight advantage by using the talc/graphite combination lubricant. However, numerical differences among treatments were only subtle, and many were either very similar or identical to those in the no-lubricant control plots.

Table 5. Effects of seed-flow lubricants on sugarbeet *plant populations* in an on-farm trial (Study II), Glyndon, MN, 2016				
Treatment/ form.	**Rate[a]**	**Stand Count (plants / 100 row ft)**		
		17 DAP[b]	**28 DAP**	**40 DAP**
Talc/Graphite Mix (80:20)	10.4 ml	162 a	175 a	177 a
Graphite	4 ml	158 a	174 a	174 a
Talc	20.4 ml	158 a	174 a	175 a
None	---	157 a	171 a	177 a
Fluency Agent II	29.6 ml	155 a	167 a	168 a
LSD (0.05)		NS	NS	NS

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]Lubricants were applied to seed at rates recommended by respective manufacturers, and are expressed in volume per unit (100,000-ct) of sugarbeet seed.
[b]DAP = days after planting

Yield results from hand-harvesting the plots in Study II are presented in Table 6. Excellent recoverable sucrose and root yields were recorded for all entries in this study, including the no-lubricant control. Yield trends closely corresponded to those from the plant stand assessments. There were no statistical differences with regard to recoverable sucrose, root yield, or percent sucrose content among the seed lubricants, or between any lubricant and the no-lubricant control. Another aspect of these results that corresponded with the plant stand data was that the top-yielding entry, with regard to both recoverable sucrose and root yield, was the talc/graphite combination lubricant.

Table 6. *Hand-harvested* yield in an on-farm trial of sugarbeet seed lubricants (Study II), Glyndon, MN, 2016					
Treatment/ form.	**Rate[a]**	**Recoverable sucrose yield (lb/ac)**	**Root yield (T/ac)**	**Sucrose content (%)**	**Gross return ($/ac)**
Talc/Graphite Mix (80:20)	10.4 ml	10,749 a	32.7 a	17.38 a	1,330
Fluency Agent II	29.6 ml	10,486 a	31.6 a	17.51 a	1,311
Graphite	4 ml	10,467 a	31.4 a	17.55 a	1,317
Talc	20.4 ml	10,336 a	31.7 a	17.18 a	1,265
None	---	9,336 a	28.9 a	16.77 a	1,131
LSD (0.05)		NS	NS	NS	

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]Lubricants were applied to seed at rates recommended by respective manufacturers, and are expressed in volume per unit (100,000-ct) of sugarbeet seed.

Yield results from machine-harvesting the plots in Study II appear in Table 7. Treatment performance patterns were very similar to those from hand-harvesting subsamples, however, when the yield data were analyzed at an alpha level of 0.1, significant differences between treatments were detected. The highest recoverable sucrose and root yields occurred in plots planted using the talc/graphite mix lubricant, and plots seeded using Fluency II and graphite also produced high yields, and were not statistically different from the talc/graphite treatment. Another pattern that was similar to those from the hand-harvested yield results in Study II and those from the small-plot trial (Study I) was that talc and the no-lubricant control were the lowest-performing treatments with respect to recoverable sucrose and root yield. With regard to gross revenue, the top three yielding entries (i.e., talc/graphite mixture, Fluency Agent II, and graphite) generated high levels of return that exceeded those from the no-lubricant control by between $127 and $167 per acre.

Table 7. *Machine-harvested* yield in an on-farm trial of sugarbeet seed lubricants (Study II), Glyndon, MN, 2016					
Treatment/ form.	**Rate[a]**	**Recoverable sucrose yield (lb/ac)**	**Root yield (T/ac)**	**Sucrose content (%)**	**Gross return ($/ac)**
Talc/Graphite Mix (80:20)	10.4 ml	9,915 a	30.2 a	17.4 a	1,223
Fluency Agent II	29.6 ml	9,868 ab	29.7 ab	17.5 a	1,235
Graphite	4 ml	9,846 ab	29.6 ab	17.6 a	1,235
None	---	9,056 bc	28.7 bc	16.8 a	1,068
Talc	20.4 ml	8,985 c	27.7 c	17.2 a	1,096
LSD (0.1)		847.8	1.45	NS	--

Means within a column sharing a letter are not significantly (P = 0.05) different from each other (Fisher's Protected LSD test).
[a]Lubricants were applied to seed at rates recommended by respective manufacturers, and are expressed in volume per unit (100,000-ct) of sugarbeet seed.

Given the highly consistent results between repeated plant population assessments and all yield parameters that were measured in the two experiments conducted for this project, it appears that the seed flow lubricants tested do not impose a statistically significant positive impact on sugarbeet seedling establishment, yield, or revenue. Trends across these studies may suggest that using the new product, Fluency Agent II (improved formulation) or including graphite, either as a single-component lubricant or in combination with talc, could occasionally optimize plant stands and yield, it cannot be concluded that using a seed lubricant during sugarbeet planting is absolutely necessary to achieve acceptable results when using a planter similar to those used in this experiment (i.e., John Deere MaxEmerge II or John Deere MaxEmerge Plus).

It should be noted that, while planting the Fluency II treatment plots in the on-farm trial, the onboard seed monitor reported the following error message: "DISABLED DUE TO ERRATIC SPACING". Therefore, we make the following recommendations: 1) the exclusion of a seed flow lubricant for use in sugarbeet planting is not recommended at this time; 2) growers interested in or deciding to use Fluency II should test this material on their own to determine its utility and safety for use with their individual planters; 3) use rates of the seed lubricants tested in these experiments should be made according to lubricant and/or planter manufacturer guidelines; and 4) growers that use planter makes and models other than those used in these experiments should carefully and extensively test the seed lubricant(s) they select to determine if they are safe for use with their planters.

Irrespective of the error message, the results of these experiments collectively suggest that reducing or eliminating talc from use in these planters does not appear to impose deleterious effects on sugarbeet stand establishment that translate to statistically significant yield loss. However, these results are only preliminary and, as such, this research should be repeated to confirm the results.

References Cited:

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