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

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Introduction:

Neonicotinoid seed treatment insecticides (e.g., Cruiser, Poncho, etc.) have been implicated in honey bee kills near corn production fields in Indiana (Krupke et al. 2012). Those authors observed that planter hopper box 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. The findings from that research have precipitated public demands ranging from additional use restrictions to a complete ban on all uses of neonicotinoid seed treatment insecticides. 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 surrounding this phenomenon have also raised questions as to 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, Fluency Agent™, or Fluency Advanced™ [referred to in previous reports as "Fluency II"]) 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 2017 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 (small-plot trial): Plots were planted on 15 May, 2017 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 Advanced™ (a reformulated version from Bayer; NOTE: this was referred to as "Fluency II in previous reports); 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 three 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 were made on 1, 15, and 29 June, 2017, which were 17, 31, and 45 days after planting (DAP), respectively. Those assessments involved counting all living plants in all four 35-ft long rows of each plot. Raw stand count observations were converted to plants per 100 linear row ft for the analyses.

Harvest: Treatment performance was also compared on the basis of sugarbeet yield parameters. The small-plot trial was harvested on 19 September, 2017. 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 stand count and harvest data were initially subjected to analysis of variance (ANOVA) (SAS Institute, 2008) to determine whole- and sub-plot factor effects. All mean comparisons were carried out by using Fisher's protected least significant difference (LSD) test at a 0.05 level of significance. The initial ANOVAs for the small-plot study at Hillsboro indicated no significant seed size × lubricant ($P > 0.05$) interactions for any of the three stand count dates or any of the yield parameters. As such, combined analyses was conducted to compare seed flow lubricants on the basis of stand count and yield data averaged across both seed sizes.

Study II (on-farm trial): The on-farm trial was planted on 1 May, 2017 by using a 12-row John Deere 1730 MaxEmerge Plus™ planter. The planter was operated at 4.5 mph, and adjusted to deliver seed 1¼ inch deep at a rate of one seed every 4¾ inches of row length. Betaseed 8572 seed was used for planting all treatments. All seed was formulated as miniature pellets, and was prepared with 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). All plots were also protected against seedling insect pests by applying Counter 20G at 5.9 lb product/ac in a modified (i.e., restricted to prevent granule deposition into seed furrow) band. The entire field also received a planting-time application of 10-34-0 (respective percentage of N, P, and K) starter fertilizer.

Study II included all treatments used in Study I, except the original formulation of Fluency Agent™. Each individual treatment plot was 12 rows (22-inch spacing) wide by 600 ft in length. The experiment was arranged in a randomized complete block design with three replications of the treatments.

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 24 May, and 1 and 22 June, which were 23, 31, and 52 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 in this experiment. Hand-harvested yield samples were collected on 12 October, 2017. Conventional drain spades were used to manually dig the samples, and each was comprised of all roots from within an 11.9-ft length of the same center-most row of each plot. One sample was collected at each of four locations within each treatment plot. Pre-harvest samples were collected at the same locations within each plot that stand counts were taken throughout the growing season. Samples were bagged and labeled, and sent to the American Crystal Sugar Company Tare Laboratory (East Grand Forks, MN) for sucrose content and quality analyses.

Machine harvesting procedures, which were carried out on 16 October, 2017, first involved removal of foliage from all treatment plots by using the grower's commercial-grade mechanical defoliator. Harvesting consisted of collecting all roots from each treatment plot with a conventional six-row Art's Way™ 690 sugarbeet harvester. Site-specific root tonnage data was collected from the on-board 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 (small-plot trial): Plant stand count results from the initial whole-plot (i.e., seed size) treatment comparisons appear in Table 1. On the first date (17 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. The stand counts taken at 31 and 45 DAP indicated that plant populations for the two seed sizes were nearly identical, with only numerical differences between treatments of only three plants per 100 row ft. The relatively small 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, 2017

Treatment/ form.	**Stand counts[a] (plants / 100 row ft)**		
	17 DAP[b]	**31 DAP**	**45 DAP**
Pro200	237 a	270 a	270 a
Mini	205 b	263 a	267 a
LSD (0.05)	20.8	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]Surviving plant stands were counted on June 1, 15, and 29, 2017, which were 17, 31, and 45 days after planting (DAP), respectively.
[b]DAP = days after planting

Yield results from the whole-plot factor (i.e., seed size) treatments in the small-plot 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 effects of seed size on yield parameters, further suggested that the main-level factor of seed size had no impact 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, 2017

Treatment/ form.	**Recoverable sucrose yield (lb/ac)**	**Root yield (T/ac)**	**Sucrose content (%)**	**Gross return ($/ac)**
Pro200	9,218 a	30.4 a	16.29 a	1,068
Mini	8,846 a	29.4 a	16.19 a	1,013
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).

Results from the combined analysis of plant stand counts for the small-plot trial are presented in Table 3. There were no significant differences in plant stands among any of the hopper-box lubricant treatments or between any lubricant and the no-lubricant control at any of the three stand count dates. Slight numerical differences in stand counts among treatments were somewhat apparent at the first stand count date (i.e., 17 DAP); however, by the last count (45 DAP), the average plant population in the treatment with the lowest plant stands (the no-lubricant control) had only 1.8% fewer plants per 100 ft of row than the treatment with the highest stands (talc/graphite mixture).

Table 3. Effects of seed-flow lubricants on sugarbeet *plant population* in a small-plot field trial (Study I), Hillsboro, ND, 2017				
Treatment/ form.	**Rate[a]**	**Stand count[b] (plants / 100 row ft)**		
		17 DAP[c]	**31 DAP**	**45 DAP**
Talc/graphite mixture (80:20)	10.4 ml	236 a	273 a	272 a
Talc	20.4 ml	225 a	273 a	271 a
Fluency Advanced	29.6 ml	208 a	271 a	271 a
Graphite	4 ml	207 a	269 a	270 a
Fluency Agent	29.6 ml	223 a	258 a	261 a
None	---	228 a	258 a	267 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]Surviving plant stands were counted on June 1, 15, and 29, 2017, which were 17, 31, and 45 days after planting (DAP), respectively.
[c]DAP = days after planting

Yield results from the small-plot experiment appear in Table 4. 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 content. Accordingly, there were only negligible differences in gross economic return among the entries tested. The highest overall gross economic returns in this study were achieved with the following treatments: talc/graphite mixture, talc, and graphite.

Table 4. Effects of seed-flow lubricants on sugarbeet *yield parameters* in a small-plot field trial (Study I), Hillsboro, ND, 2017					
Treatment/ form.	**Rate[a]**	**Recoverable sucrose yield (lb/ac)**	**Root yield (T/ac)**	**Sucrose content (%)**	**Gross return ($/ac)**
Graphite	4 ml	9,254 a	30.5 a	16.30 a	1,072
Talc	20.4 ml	9,235 a	30.1 a	16.40 a	1,087
Talc/graphite mixture (80:20)	10.4 ml	9,209 a	29.8 a	16.55 a	1,092
None	---	8,965 a	30.4 a	15.97 a	997
Fluency Advanced	29.6 ml	8,870 a	29.2 a	16.28 a	1028
Fluency Agent	29.6 ml	8,657 a	29.2 a	15.97 a	967
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.

Study II (on-farm trial): 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.

Table 5. Effects of seed-flow lubricants on sugarbeet *plant populations* in an on-farm trial (Study II), Glyndon, MN, 2017				
Treatment/ form.	**Rate[a]**	**Stand Count[b] (plants / 100 row ft)**		
		23 DAP[c]	**31 DAP**	**52 DAP**
Talc	20.4 ml	220 a	213 a	206 a
Talc/Graphite Mix (80:20)	10.4 ml	216 a	212 a	207 a
None	---	215 a	209 a	207 a
Fluency Advanced	29.6 ml	210 a	205 a	202 a
Graphite	4 ml	206 a	206 a	201 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]Surviving plant stands were counted on May 24, and on June 1 and 22, which were 23, 31, and 52 days after planting (DAP), respectively.
[c]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, 2017					
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	15,012 a	39.2 a	19.96 a	2,251
Talc	20.4 ml	14,800 a	39.0 a	19.82 a	2,198
None	---	14,649 a	38.1 a	20.04 a	2,201
Graphite	4 ml	14,323 a	37.1 a	20.08 a	2,162
Fluency Advanced	29.6 ml	13,919 a	35.9 a	20.13 a	2,110
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. The highest average recoverable sucrose yields occurred in plots planted using either Fluency Advanced or the talc/graphite mixture lubricant. Although no statistically significant, the no-lubricant control plots had the lowest recoverable sucrose and root yields. With regard to gross revenue, the top three entries included Fluency Advanced, the no-lubricant control, and the talc/graphite mixture.

Table 7. *Machine-harvested* yield in an on-farm trial of sugarbeet seed lubricants (Study II), Glyndon, MN, 2017					
Treatment/ form.	**Rate[a]**	**Recoverable sucrose yield (lb/ac)**	**Root yield (T/ac)**	**Sucrose content (%)**	**Gross return ($/ac)**
Fluency Advanced	29.6 ml	15,126 a	39.0 a	20.13 a	2,291
Talc/Graphite Mix (80:20)	10.4 ml	15,034 a	39.2 a	19.97 a	2,255
Talc	20.4 ml	14,958 a	39.4 a	19.83 a	2,226
Graphite	4 ml	14,932 a	38.7 a	20.07 a	2,252
None	---	14,546 a	37.9 a	20.04 a	2,290
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.

Given the highly consistent results between repeated plant population assessments and all yield parameters measured in the two experiments conducted for this project, it appears that the hopper-box seed flow lubricants tested do not impose a statistically significant positive or negative impact on sugarbeet seedling establishment, yield, or gross economic return. Trends across these two studies could suggest that using a talc/graphite mixture, such as the 80:20 product used in these trials, can occasionally optimize plant stands and yield; however, it cannot be concluded that using any seed lubricant during sugarbeet planting is absolutely necessary to achieve acceptable results with planters 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 Advanced 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 Advanced should test this material on a small acreage with their own planters to determine its utility and safety; 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 review their owner's manual to determine if a seed lubricant is recommended for their planter, as well as 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 and strongly 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. Therefore, growers could likely deploy insecticidal seed treatments in a safe and effective manner by using any hopper-box lubricant tested in this study (or by excluding a lubricant) without negatively impacting sugarbeet seedling establishment, yield, or gross economic return.

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