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Evaluation of seed-applied nematicides in on-farm trials

Tristan Mueller, Iowa Soybean Association On-Farm Network®; Peter Kyveryga, analytics, Iowa Soybean Association

Introduction

Soybean cyst nematodes (SCN) are one of the major soybean yield robbers in Iowa. It was estimated that there was more than 11 million bushels of soybeans lost due to SCN in Iowa just in 2014 (Bradley et al., 2015).

The primary management of SCN is with resistant soybean varieties. In recent years there have been several nematicidal seed-treatment products introduced to the market that may provide additional protection from SCN. These products can be classified into two broad categories, chemical and biological. Avicta and ILeVO are two of the primary chemical nematicides. Clariva, VOTiVO and N-HIBIT are some of biological nematicides available on the market (Tenuta and Tenuta, 2015).

Information about the effectiveness of biological nematicide seed treatments is limited across the Midwest. For example, one year study showed that Clariva increased soybean yields in two of 18 site locations in Minnesota (Porter et al., 2014).

Two objectives of this study were to (1) quantify soybean yield response and SCN control of biological nematicide Clariva across diverse soil and weather conditions in Iowa and (2) assess the difference between small-plot experiments done by Iowa State University (ISU) and replicated strip trials done by Iowa Soybean Association On-Farm Network.

Figure 1. Locations of ISA on-farm field scale and ISU small-plot experiments evaluating Clariva seed treatment in 2014.
**Methods**

In 2014, there were 15 on-farm replicated strip trials in northern Iowa and nine small-plot experiments (Tyálka et al., 2014) distributed across the state (Figure 1). The two seed treatments, Clariva Complete Beans – CruiserMaxx Advanced plus Vibrance plus Clariva (Clariva) and CruiserMaxx Advanced plus Vibrance (CruiserMaxx), were applied to SCN (PI88788) resistant or moderately resistant soybean varieties. In 2015, there were the same number of strip trials and small-plot experiments for Clariva and 17 strip trials and nine small plot experiments testing the effects of ILeVO on sudden death syndrome and SCN. The data from 2015 are not analyzed yet for this paper, but the summaries will be presented at the ICM Conference.

SCN soil samples for all small-plot experiments were collected at planting, mid-season, and harvest and most of the strip trials had soil samples taken after planting, mid-season, and at harvest. Plant stand counts were collected either before or at harvest in the strip trials. The georeferenced yield data were collected only for the on-farm strip trials.

Because SCN eggs were not detected in about 50% of the individual soil samples from ISA strip trials, a distribution of SCN egg counts was extremely right skewed. To normalize the data, a log (SCN egg count+1) transformation was used.

The egg count data were analyzed as individual scouting events and as a time series of the three scouting events simultaneously. For the combined ISU and ISA data, the effect of trial or location and nested replication within a trial were considered as random, drawing the inferences for the entire underlying population of similar fields across Iowa. Time series analyses also included the random effect of location and replications nested within each trial.

Spatially interpolated monthly average rainfall data (4-km grids) were downloaded from the Iowa Environmental Mesonet, Department of Agronomy, Iowa State University (http://mesonet.agron.iastate.edu/). Each field was assigned a rainfall value from a rainfall grid located nearest the field sampled.

Yield data were analyzed individually and across all trials. For individual trials, a randomization test was used to identify a meaningful effect of treatments. The randomization test was based on paired treatment comparisons within each block or replications. The p-values from randomization test were classified as “strong evidence” of significant yield difference (p-value < 0.05), “some evidence” of significant yield difference (p-value of 0.5 and 0.15) and “no-evidence” of significant yield difference (p-value > 0.15 or 0.2). All reports from individual trials are on-line at http://www.isafarmnet.com/onlinedb/index.php. All analyses were done in the R statistical software.

**Results**

**Yield response for individual trials**

Field-average yield responses to Clariva in individual ISA on-farm trials ranged from -1.2 to 4.6 bu/acre. Only four of 15 trials had a statistically significant positive yield response to Clariva based on results of a randomization test. Because of relatively small yield responses, it is very unlikely to detect statistically significant responses at individual locations, suggesting the need to give more consideration to data pooled across many locations.

**Yield response and random yield variation across all ISA and ISU trials**

The average yield increase to Clariva across 15 strip trials was 0.8 bu/acre, which was statistically significant (Table 1). With a 90% certainty the average yield response will range from 0.32 to 4.1 bu/acre.
Table 1 shows sources of random yield variation after accounting for the effect of the seed treatments on soybean yield from strip trial and small plot trials. About 90% of the total random yield variation for strip trial data was due to trial location. A much smaller portion, 5% of the total random yield variation, was due to differences among replications within each trial. The remaining unexplained variation, which is often called random noise, was about 2%.

Table 1. Mean yield difference between Clariva Complete Beans and CruiserMaxx + Vibrance seed treatments and sources of random yield variation after removing the effect of treatments across nine on-farm small-plot trials conducted by ISU and 15 field-scale replicated strip trials conducted by ISA.

<table>
<thead>
<tr>
<th>Source of random variation</th>
<th>Proportion of total variation</th>
<th>Standard deviation (90% CI)</th>
<th>Proportion of total variation</th>
<th>Standard deviation (90% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>58</td>
<td>8.8 [5.7, 13.6]</td>
<td>92</td>
<td>13.9 [10.2, 19.1]</td>
</tr>
<tr>
<td>Replications within trials</td>
<td>31</td>
<td>6.5 [5.6, 7.4]</td>
<td>5</td>
<td>3.1 [2.7, 3.7]</td>
</tr>
<tr>
<td>Residual or noise</td>
<td>11</td>
<td>3.8 [3.5, 4.2]</td>
<td>3</td>
<td>2.5 [2.3, 2.8]</td>
</tr>
</tbody>
</table>

The observations above suggest that across several locations, on-farm strip trials may have a larger power to detect significant yield differences. Also, because of larger variation in environmental factors (Table 1), on-farm trials can be more useful to detect whether a yield response significantly varies across different management or environmental conditions at the field level. The utility of small-plot experiments is that they are more versatile to compare several seed treatments or include treatments with other factors such as fertilizers, tillage, or disease control products. In contrary, it is often difficult to sample treatments in on-farm trials for SCN nematode egg count before or after planting because “as-applied” information about treatment location is not always immediately available from farmers.

Compared with small plot data, field-scale strip trial data showed twice as large random yield variation attributed to trial location but much smaller yield variation attributed to replications within trials and the remaining unexplained yield variation. The larger random noise for small plot data could be due to larger potential errors of measuring and interpolating yield data collected from relatively small size research plots.
For ISA data, logarithmically transformed SCN egg count numbers were relatively small (Table 2). More than half of the samples had zero egg counts on the original scale (Figure 2). None of the samples had more eggs than the ISU low infestation categories of up to 4000 eggs per 100cc of soil. The Clariva treatments reduced nematode egg counts during each sampling event, however, only the reduction of about 40% detected during the last sampling was statistically significant.

**Time series analysis of SCN egg count**

The analyses of individual SCN egg count observations collected during the three sampling events considered possible correlation between sampling timing that were closer to each other. From sampling event 1 to sampling 3, the SCN egg number significantly decreased. The Clariva treatment also significantly decreased the egg counts but those decreases were relatively small.

To normalize data, SCN egg counts were transformed using \( \text{LOG}(\text{SCN Egg count}+1) \) transformation. Averages were calculated from back transformed data.
Clariva effect on SCN egg counts

Table 2. Average SCN egg count reduction from using Clariva Complete Beans compared with CruiserMaxx + Vibrance during three samplings for ISA on-farm trials.

<table>
<thead>
<tr>
<th></th>
<th>Sampling 1 Reduction w/ Clariva</th>
<th>Sampling 2 Reduction w/ Clariva</th>
<th>Sampling 3 Reduction w/ Clariva</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average log (SCN egg=1)</td>
<td>44</td>
<td>28</td>
<td>14</td>
</tr>
<tr>
<td>Significant reduction</td>
<td>no evidence</td>
<td>no evidence</td>
<td>some evidence (at p&lt;0.05)</td>
</tr>
<tr>
<td>Number of trials scouted</td>
<td>11</td>
<td>13</td>
<td>12</td>
</tr>
</tbody>
</table>

Plant population density differences

For ISA strip trials, soybean plant population densities were measured twice during the season: in late June and late July to early August. Across all scouted trials, average plant stands were higher for Clariva treatments compared with CruiserMaxx treatment by 412 plants/acre during the first and by 1460 plants/acre for the second scouting (Table 3).

Seven of 10 trials had higher plant densities for the Clariva strips during the second scouting. While the trials with the larger plant population differences did not have the larger yield responses (data not shown), in general, the late July to early August scouting suggested some effects of the nematicide treatments.

While it is difficult to explain with these limited data, yield responses for the second scouting event strip trials tended to increase with the higher population densities found for the control seed treatment (data not shown).

Table 3. Average plant population increases from using Clariva Complete Beans compared with CruiserMaxx + Vibrance during two sampling events for strip trial data.

<table>
<thead>
<tr>
<th></th>
<th>Sampling 1</th>
<th>Sampling 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CruiserMaxx</td>
<td>Clariva</td>
<td>CruiserMaxx</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>Average plant population</td>
<td>106,986</td>
<td>107,398</td>
</tr>
<tr>
<td>Significant difference</td>
<td>no evidence</td>
<td>some weak evidence at p&lt;0.20</td>
</tr>
</tbody>
</table>
Effect of soil variables on SCN egg counts and plant density and across ISA trials

For ISA strip trial data, nematode egg count numbers for sampling areas from the control strips were related to proxy soil characteristics derived from the digital soil maps. A multiple regression model that had soil organic matter, soil pH, and corn suitability rating (CSR) values as soil productivity index explained about 30% variation in the transformed nematode counts for scouting event 1. The nematode infestation tended to increase with increased soil pH and CSR values and decreased with the higher soil organic matter.

For scouting events 2 and 3, the nematode count also tended to increase with an increase in soil pH and CSR values, but less than 15% variation was explained by these variables.

Multiple regression analyses of yield response across ISA and ISU trials

For a combined sample of ISU and ISA data, multiple regression analysis did not reveal any significant effects of field-level factors such as monthly or cumulative rainfall, average plant population density or mean log SCN egg count on yield response.

Summary

Although SCN egg counts were relatively low in ISA on-farm trials in 2014, a biological nematicide seed treatment Clariva has decreased SCN egg numbers by 15 to 40% when using resistant or moderate resistant soybean varieties. In about 70-80% of ISA individual trials yield increases to Clariva were not statistically significant but a small yield increase of 0.8 bu/acre was found significant with 90% of certainty across ISA’s 15 strip trials.

The remaining random yield variation (often called random yield noise) after accounting for the effect of the seed treatments was smaller in ISA field-scale trials. However yield variation associated with a trial location was smaller in ISU small-plot experiments.

This study shows a complementary value of small-plot, on-farm studies done by university researchers and field-scale, on-farm replicated strip trials done by farmers associated with a research network. The utility of small plots is to compare several products, chemistries or active ingredients at one location and provide evidence why specific products or chemistries work. The utility of on-farm, field-scale trials is in using participatory learning principles to identify when and where a given product or chemistry works and quantify the economic benefit of using the product across a range of farmer management practices, soil and weather conditions.

Acknowledgment

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References


