CYANTRANILIPROLE AND SPINOSAD RESIDUES IN FLUE-CURED TOBACCO

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From 2013 to 2015, research was conducted to estimate the maximum expected residue levels for the insecticides cyantraniliprole and spinosad following application to flue-cured tobacco. Data were generated in order to assist industry in establishing Guidance Residue Limits for both compounds. The insecticides were applied to fields of tobacco at maximum rates in accordance with the labeled rates and the harvested/cured leaf was analyzed in a lab for chemical residues. The findings indicated that the expected residues on cured leaf would be low or not quantifiable under existing detection techniques.

Additional key words: crop protection agents, *Nicotiana tabacum* L., pesticide residue

INTRODUCTION

As part of an ongoing research program at North Carolina State University, the insecticides cyantraniliprole and spinosad were evaluated in 3 environments over a 3-year period. Cyantraniliprole (3-bromo-1-(3-chloro-2-pyridinyl)-N-[4-cyano-2-methyl-6-[(methylamino)carbo nyl]phenyl]-1H-pyrazole-5-carboxamide) is a group 28 insecticide that received federal approval in spring 2017 for suppression of tobacco budworm, tobacco hornworm, and flea beetles. Spinosad (a mixture of spinosyn-A and spinosyn-D) is a group 5 insecticide currently labeled for suppression of thrips, tobacco budworm, and tobacco hornworm. The objective of this research was to establish the maximum expected residues on cured tobacco leaf that would result from a maximum labeled application of the specified compounds.

METHODS AND MATERIALS

Field experiments were conducted in 2013, 2014, and 2015 at the Lower Coastal Plain Research Station (LCPRS) in Kinston, NC to quantify pesticide residues of the selected active ingredients on flue-cured tobacco (*Nicotiana tabacum* L.). Tobacco was produced under practices recommended by the North Carolina Cooperative Extension Service (2), with the exception of treatments imposed. The cultivar 'NC 196' (Goldleaf Seed Co., Hartsville, SC) was planted in all environments. Individual plots were treated with 1 of 2 insecticides: cyantraniliprole (Verimark™, DuPont, Wilmington, DE 27709) or spinosad (Blackhawk® Naturalyte® Insect Control, Dow AgroSciences, Indianapolis, IN 46268).

Cyantraniliprole was applied in a single tray drench application immediately prior to transplanting. The material was delivered to 1 tray of transplants through a 2-L solution containing 1.98 L water and 0.02 L cyantraniliprole (equivalent of 0.99 L cyantraniliprole/ha) at an operating pressure of 138 kPa. Following cyantraniliprole application, transplants were rinsed with 2 L of water to promote soilless media infiltration of the solution. Both applications were completed with a CO_2 pressurized applicator containing a single TG-3 nozzle (TeeJet Spraying Systems Co., Wheaton, IL 60187). Spinosad was applied through 6 foliar treatments (total of 484.44 g a.i./ha) with a CO_2-pressurized backpack sprayer calibrated to deliver 186 L solution/ha and a 3-nozzle boom with 26-cm nozzle spacing at an operating pressure range of 172–207 kPa. Each nozzle contained a TX-12 Hollow Cone (TeeJet Spraying Systems Co., Wheaton, IL 60187) oriented 45 cm above the center of the plant; outside nozzles were angled 45° toward the center of the boom. Nozzle arrangement and orientation were selected to induce maximum exposure of plants to the selected materials.

Treatments were replicated 4 times and arranged in a randomized complete block design in all growing environments. All 4 rows in each plot were treated, with the 2 center rows being harvested, cured, and sampled for residue analysis. Row spacing and plot dimensions at the LCPRS were 55 cm by 111 cm. Transplanting dates, pesticide application dates, and harvest dates varied by location as well and are presented in Table 1. Once tobacco was harvested and cured, samples were collected from individual stalk positions and analyzed by Global Laboratory Services, Inc. in Wilson, NC. Each sample consisted of 6 leaves collected from each of 3 stalk positions (lower-, mid-, and upper-stalk) for a total of 18 leaves per plot. Where residues were detected (spinosad in all LCPRS environments) data were subjected to analysis of variance (ANOVA) and treatment means were separated using Fisher's Protected $LSD_{0.05}$ in SAS ver. 9.4 (SAS Institute Inc., Cary, NC 27513).

RESULTS AND DISCUSSION

Residues were below the limit of quantification (0.125 mg/kg) for cyantraniliprole in all environments. Alternatively, spinosad residues were detected and are reported by individual year and stalk position because of significant environment × treatment interaction. Where reported, primings 1 and 2 (Lug + Cutter) are combined and are represented in the "lower" stalk position, priming 3 (Leaf) is represented in the "middle" stalk position, and

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Table 1. Transplanting, pesticide application, and harvest dates at the LCPRS in 2013, 2014, and 2015.

Event	LCPRS 2013	LCPRS 2014	LCPRS 2015
Transplanting	April 15	April 29	May 01
Cyantraniliprole	April 15	April 29	May 01
Spinosad—first app.[a]	May 15	May 23	May 26
Spinosad—second app.	May 25	June 03	June 05
Spinosad—third app.	June 04	June 13	June 16
Spinosad—fourth app.	June 13	June 24	June 26
Spinosad—fifth appl.	June 28	July 03	July 07
Spinosad—sixth appl.	July 03	July 17	July 20
First harvest	July 18	July 21	July 27
Second harvest	July 24	July 31	August 05
Third harvest	August 14	August 27	September 01
Fourth harvest	August 20	August 27	September 10

[a] app., application.

priming 4 (Tip) is represented in the "upper" stalk position (Table 2).

Cyantraniliprole. Cyantraniliprole was applied through 1 tray drench application at a rate of 0.02 L cyantraniliprole/tray or 0.99 L cyantraniliprole/ha, for a total of 197.51 g a.i./ha. Across all environments, cyantraniliprole residues were never greater than 0.125 mg/kg, which was the analytical limit of quantification, in any stalk position. The lack of quantifiable residues was not surprising given the single application of cyantraniliprole occurred prior to transplanting.

At present, CORESTA does not have an established Guidance Residue Limit (GRL) for cyantraniliprole (1). However, the U.S. Environmental Protection Agency (EPA), under the auspices of the Food, Drug and Cosmetic Act, has established cyantraniliprole tolerances for 39 agricultural commodities that include agronomic and horticultural products as well as livestock products and feed additives (4). This regulatory list includes food crops such as Vegetables–Leafy (nonbrassica, Group 4) and Brassica–Leafy Vegetables (Group 5B) (4), both of which are similar to tobacco in terms of plant morphology and harvested product. The Environmental Protection Agency has a defined tolerance of 20 and 30 mg/kg for Groups 4 and 5B, respectively (4). Although use patterns and application rates may vary to a small degree among these food crops and tobacco, the EPA determination of safety for cyantraniliprole states the following, "…there is a reasonable certainty that no harm will result to the general population or to infants and children from aggregate exposure to cyantraniliprole residues" (4). Therefore, when the residue results from this study are paired with the limits established by EPA, it seems as if there could be a wide range of acceptability to the tobacco industry.

Table 2. Spinosad[a] residues by individual stalk position at LCPRS in 2013, 2014, and 2015.[b]

Stalk Position[c]	2013	2014	2015
		mg/kg	
Upper	0.125 a	0.125 b	0.125 a
Middle	0.125 a	0.125 b	0.125 a
Lower	0.363 a	1.353 a	0.173 a

[a] Combination of spinosyn-A and spinosyn-D, 0.125 mg/kg limit of quantification.

[b] Treatment means followed by the same letter within a given year are not significantly different.

[c] Upper, middle, and lower stalk positions represent tip, leaf, and cutter + lug leaves, respectively.

It should be noted that foliar applications of cyantraniliprole were not evaluated in this study and it is likely that this application pattern could increase residues beyond those documented. Should the cyantraniliprole label for tobacco include foliar applications, further research will be warranted to quantify residues in treated leaves more accurately.

Spinosad. Spinosad was applied in 6 foliar applications at a rate of 224.66 g spinosad/ha/application (80.88 g a.i./ha/application), for a total of 1,345.66 g spinosad/ha (484.44 g a.i./ha). Residues greater than the limit of quantification were always detected in the lower stalk position but never in the middle or upper stalk positions (Table 2). Residues were greatest in 2014 most likely due to the shortest preharvest interval (PHI) documented in this study (4 days) (Table 1). Residues were numerically lower in 2013 and 2015 (Table 2) as the PHI was increased to 15 and 7 days, respectively (Table 1). The intent of the research program was to apply materials as often as possible and as close to first harvest as the label would allow. However, given the large number of applications (6 total) and required spray rotation (10 days between applications), the researchers were unable to sync the final spinosad application and first harvest consistently to obtain the minimum PHI presented by the chemical label (3 days). Despite this issue, the results gained from this study do offer the possibility that spinosad residues should be very low or undetectable when the label is followed precisely or when the PHI is increased beyond the 3 days required by the federal label.

As with cyantraniliprole, CORESTA does not currently have a GRL for spinosad (1). In December 2015, EPA revised the spinosad tolerance list for 15 commodities (5). Although there are few commodities on the list that reflect the morphology and cultivation of tobacco, tolerance limits for the compound typically range from 0.02 to 1.0 mg/kg (5). The EPA determination of safety for spinosad reads identical to that for cyantraniliprole, "there is a reasonable certainty that no harm will result to the general population, or to infants and children from aggregate exposure to spinosad residue" (5). Ultimately, it appears that the residues of spinosad in flue-cured tobacco should be low enough to avoid concern from industry, the U.S. Food and Drug Administration, or consumers.

CONCLUSION

In general, the residues of cyantraniliprole and spinosad were relatively low in comparison to other pesticides that are not evaluated in this study, but are currently labeled for use in tobacco production and have established CORESTA GRLs (1). It can also be referenced, specifically for spinosad, that use patterns of evaluated compounds were designed to maximize CPA applications and active-ingredient exposure to treated plants. As was previously mentioned, spinosad was applied 6 times in each environment evaluated in this study; however, applications made by commercial producers are often far less. Toennisson and Burrack (3) report that from 2013 to 2015, applications of spinosad-based insecticides on commercial farming operations ranged from a low of 0.8 applications per season in 2013 to highs of 1.1 applications per season in 2014 and 2015. The void between the goal of maximum exposure and practical application creates difficulty with predicting potential cured leaf residues expected from grower use patterns; however, it can be theorized that residues of both pesticides would be low or not quantifiable when used in accordance with their respective labels.

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LITERATURE CITED

1. CORESTA. 2013. CORESTA guide No. 1: The concept and implementation of agrochemcial guidance residue levels (No. 1). CORESTA, Paris, France.

2. Fisher LR, ed. 2013. North Carolina State University: Flue-cured tobacco guide 2013 AG-187. Revised ed. North Carolina Cooperative Extension, Raleigh, NC.

3. Toennisson T, Burrack H. 2016. 2015 Flue-cured tobacco survey: Entomology survey data. Available from: https://tobacco.ces.ncsu.edu/2016/03/2015-flue-cured-tobacco-survey-entomology-survey-data/. Accessed 2016 May 2.

4. U.S. Food and Drug Administration. 2014. Cyantraniliprole; pesticide tolerances. Federal Register: 79 FR 6826. Available from: https://www.federalregister.gov/articles/2014/02/05/2014-02210/cyantraniliprole-pesticide-tolerances#h-24. Accessed 2016 Apr 3.

5. U.S. Food and Drug Administration. 2015. Food and Drug Administration. Spinosad; pesticide tolerances. Federal Register: 80 FR 80665. Available from: https://www.federalregister.gov/articles/2015/12/28/2015-32168/spinosad-pesticide-tolerances#h-21. Accessed 2016 Apr 4.