Southern Forest
Nursery Management Cooperative

RESEARCH REPORT 21-05

THE EFFECT OF MULTIPLE APPLICATIONS OF FLUOPYRAM (BROADFORM™) ON NEMATODE CONTROL AND LOBLOLLY PINE SEEDLING CHARACTERISTICS

by
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INTRODUCTION

Nematodes, which kill seedlings by feeding on roots, have historically been controlled in southern forest-tree nurseries either with the use of cover crops or soil fumigants such as methyl bromide (Cram and Fraedrich, 2005). While the production and application of methyl bromide in the U.S. was phased out between 1999 and 2005 due to health, safety, and environmental concerns, the forest seedling nursery industry remains one of the few sectors currently allowed by the EPA to use methyl bromide under the Critical Use Exemption clause. By definition, this Critical Use exemption acknowledges that there are "no technically and economically feasible alternatives or substitutes available" for methyl bromide in this application. The Southern Forest Nursery Management Cooperative (SFNMC) has tested alternative fumigation products since 1992 for weed, insect, fungi, and nematode control in bareroot nursery growing systems.

Alternative products for nematode control have emerged in vegetable and turf markets and are referred to as non-fumigant nematicides. Because these markets are much larger in scope than forest-tree nurseries, research on products for nematode control has been conducted more often for these sectors (Crow, et al. 2017; Desaeger, 2019; Hajihassani, 2021). Just as with herbicide testing and use, the SFNMC routinely 'borrows' products from other markets to test when a need arises in forest-tree nurseries. Spotty or 'hot spot' nematode damage is often observed in nursery beds with a history of nematodes, so a method of controlling and restricting nematode damage was needed. A member nursery approached the SFNMC staff with a new product, fluopyram, manufactured by Bayer CropScience as a fungicide that also had reported nematicidal properties. The product works by hindering cellular respiration in nematodes, thereby decreasing their energy source. According to the manufacturer's information, fluopyram has an unusually long half-life of six months to two years in the soil. Golf course turf trials conducted by the University of Florida showed that fluopyram provided nematode control for six to eight months (Crow, et al. 2017).

In 1998, the SFNMC conducted a nematode product trial at the same nursery used in this 2020 study (Carey and Bickerstaff, 1999). At that time, the population of nematodes found at sowing were high (over 1,000 nematodes per 100 cubic centimeters of soil), meaning that nematodes came in contact with newly-formed seedling roots soon after germination (Carey, 1998). A trial was designed to test fluopyram in this same nursery beginning at sowing and continuing in three different application regimens. Two different products each containing fluopyram

(Indemnify® and Broadform™) were considered for field trials. The first product, Indemnify®, is a Group 7 fungicide containing 34.5% fluopyram and is labeled for turf use only. The second product, Broadform™, is a Group 7 and 11 fungicide containing 21.4% fluopyram and 21.4% trifloxystrobin. Interestingly enough, the SFNMC previously tested trifloxystrobin (Compass®) in bareroot nursery seedling beds for fusiform rust control with no negative effects on pine seedling characteristics (Nadel, et al. 2021). The Broadform™ label lists acceptable places of use as:

> *"Ornamentals in residential and commercial landscapes, interiorscapes, field grown and container ornamentals in nurseries and greenhouses, lathhouses, shadehouses, and other enclosed structures; Crops in residential and commercial landscapes, interiorscapes, field grown and container crops in nurseries and greenhouses, lathhouses, shadehouses, and other enclosed structures."*

Because of the inclusion of field-grown crops in nurseries as an acceptable use on the Broadform™ label, this product was selected for further testing. Spray recommendations are listed for Christmas trees on the label, but specific *Pinus* species are not included.

METHODOLOGY

This trial was designed in 2020 to test the efficacy of nematicidal properties of fluopyram using four different spray treatments (application configurations) in a field fumigated with methyl bromide in the fall of 2018 at the ArborGen Nursery in Bullard, Texas. Because the application rates on the Broadform™ label are for fumigation uses only, no rate recommendations are available for the intended use of this study. The highest label rate allowed per year is 27.1 ounces per acre, so three different spraying schedules were developed using this this total allowable quantity in two, three, and four applications in the trial area. Non-treated control plots were randomly located in blocks with the remaining treatments. These spraying schedules are listed below:

Treatment	Quantity and Timing	Date
No sprays		
2 sprays	13.5 ounces per acre at sowing 13.5 ounces per acre at 21 days post-sowing	4/27/2020 5/18/2020
3 sprays	8.0 ounces per acre at sowing 11.0 ounces per acre at 21 days post-sowing 8.0 ounces per acre at 21 days after the second application	4/27/2020 5/18/2020 6/8/2020
4 sprays	6.75 ounces per acre at sowing 6.75 ounces per acre at 21 days after sowing 6.75 ounces per acre at 21 days after second application 6.75 ounces per acre at 21 days after third application	4/27/2020 5/18/2020 6/8/2020 6/29/2020

Spray applications began at sowing and concluded with the final application of the 4-spray series made 63 days after sowing in late June 2020.

The single soil sampling was conducted in April 2020 prior to any spray applications; these samples were shipped to the AU Nematode Lab for processing. Results of this sampling are in Table 2, which established the presence of nematodes in the trial area. Visible evidence of nematode damage was seen on 5-week-old seedlings in early June 2020.

The study area was 12 seedling beds in width by 520 feet in length. Treatment plots were 3 seedling beds in width by 130 feet in length, resulting in 4 block plots per 3 seedling beds and 16 plots in total. The size of this study area (approximately 0.8 acre) allowed for each treatment (including non-treated control treatment) to be replicated four times. To reduce the effect that movement of nematodes between plots might cause, all field counts and samples collected (soil and seedling) were made at reasonable distances from the ends of each plot.

Germination counts were made at 7 weeks post-sowing on June 15, 2020. Three counting frames per block plot were randomly placed for these counts. Results are included in Table 1.

In December 2020, samples of seedlings from within three counting frames per plot were collected from the field by ArborGen staff and shipped to the SFNMC laboratory for analysis. Seedlings from outside rows were bundled separately from interior row seedlings during collection. Bed density measurements were made by counting all seedlings (exterior and interior rows) from within each counting frame and calculating seedlings per square foot. Measurements of root collar diameters, shoot heights, and shoot and root dry weights were made on samples collected from interior rows only. Results of these measurements are included in Table 1. All data was analyzed and examined using Duncan's Multiple Range test and Dunnett's t-test at alpha = 0.05.

DISCUSSION AND RESULTS

Broadform™ is manufactured and labeled as a fungicide, and during product development was found to have contact nematicidal properties. Nematode populations from soil samples collected in April 2020 were most likely insufficient (mean of 45 nematodes/100 cc of soil) to cause much damage to young seedlings. Of those nematodes identified, the majority were stunt nematodes (89%). Inadequate soil sampling during the remainder of this 2020 trial resulted in no comparable data for nematode populations before, during, and after spray applications being available. The effects of applications of fluopyram (Broadform™) in amounts ranging from 6.75 ounces per acre (four applications) to 13.5 ounces per acre (two applications) had no effect on the growth of loblolly pine seedlings when compared to non-treated pine seedlings in the study area.

Nematode populations in annual crops, even in homogenous fields, appear in clumps or clusters, with uneven distribution (Abawi and Gugino 2007). Studies mapping nematode populations have shown differing spatial patterns in a single field (Quist et al. 2019). Because nematodes are not evenly distributed among or within plots, quantifying population size and predicting damage to seedlings is difficult even with intensive soil sampling. Little is known about the nematode level below which pine seedlings can tolerate root damage without above-ground symptoms appearing (Cram and Fraedrich 2009). The combination of insufficient soil sampling in this study and the uneven distribution of nematodes in general resulted in the uncertainty of knowing if nematode populations were high enough to cause seedling damage in this study later in the growing season.

MANAGEMENT IMPLICATIONS

No comparisons of pre-and post-treatment effects on nematode populations can be made from data in this trial due to insufficient soil samples included. However, comparisons of loblolly pine seedling characteristics measured at the end of the growing season resulted no differences in these attributes from the use of the fungicide/nematicide. It is recommended that this trial be repeated in 2021 with modifications made to product quantities and number of applications to reduce complexity, provide adequate coverage of the fungicide/nematicide in larger plots, and to increase the number of replications. Also, soil samples should be collected and processed throughout the growing season to compare effects of fluopyram on nematode populations between treated and non-treated plots.

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Table 1. Bareroot loblolly pine seedling characteristics treated with fluopyram (Broadform™) in multiple spraying regimens.

Treatment (Spraying regimen)	June 2020 density/ft^2	December 2020 density/ft^2	Shoot height (cm)	RCD (mm)	Root weight per tree (g)	Shoot weight per tree (g)
Control (no applications)	29.3	32.3	29.6	5.20	0.66	3.38
2 applications	31.1	33.8	28.9	5.10	0.67	3.35
3 applications	32.2	34.1	27.9	4.96	0.63	3.03
4 applications	32.6	33.2	29.3	5.00	0.62	3.22

Table 2. Mean numbers and percent of nematodes by type prior to initial application of fluopyram (Broadform™) in multiple spraying regimens in loblolly pine seedling beds.

Treatment (Spraying regimen)	Mean number per 100 cc soil	Stunt nematodes per 100 cc soil and percent of total	Stubby root nematodes per 100 cc soil and percent of total
Control (no applications)	61	55 (90.2%)	6 (9.8%)
2 applications	39	36 (92.3%)	3 (7.7%)
3 applications	44	37 (84.1)	7 (15.9%)
4 applications	36	32 (88.9%)	4 (11.1%)