**Sarritor Residual and Efficacy following turf applications (spring and experiments)**
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**Objective:** to evaluate the persistence and effectiveness of Sarritor [*Sclerotinia minor* (IMI 344141)] when applied for broadleaf weed control in turf.

**Executive Summary.**
Experiments were conducted to evaluate the efficacy of Sarritor on broadleaf weeds common to turfgrass in NC and to monitor the persistence of Sarritor using a lettuce plant bioassay. Significant differences were observed between spring and fall experiments. In the spring experiment Sarritor treatments resulted in little or no control of broadleaf weeds and very short persistence (as detected by the lettuce transplant bioassay). In contrast, lettuce transplant survival in the fall study was reduced for at least 8 weeks following Sarritor treatment. Additionally, in the fall experiments, field madder control with Sarritor was similar to that provided by an auxin herbicide mixture. However, the results were quite variable with some replicates exhibiting nearly complete control and other replicates of the same treatment with poor control. Dandelion plants were infected by Sarritor but no reduction in dandelion populations were observed. Fall applications of Sarritor provided temporary control of white clover similar to Fiesta (FeHEDTA) but by spring white clover had re-grown. These data suggest that environmental conditions in North Carolina will have very significant impacts on Sarritor efficacy and persistence. Variable weed control among replicates was also observed and should be the subject of further evaluations.

**Methods:** Experiments were conducted in the spring and fall of 2015 on established low-maintenance tall fescue turf at the Horticultural Science Field Laboratory, Raleigh NC. Residual and efficacy tests were treated on April 17, 2015 and October 21, 2015, in adjacent turfgrass areas. Environmental conditions following treatment in the spring were somewhat warmer and drier than in the fall experiment. Average daily high & low temperatures for the month after treatments in April and October were 23 & 12 C and 15 & 10 C, respectively. Average daily precipitation for the same time periods was 0.35 and 0.67 cm/day, respectively. Treatments included Sarritor IMI344141 at 40 g/m2 or 80 g/m2, Lesco 3-Way (2,4-D + MCPP + dicamba) at 1.7 kg ae/ha, and Fiesta (Fe-HEDTA) at 80 l/ha. Lesco 3-Way and Fiesta were applied using a $CO_2$ pressurized 2L bottle sprayer calibrated to deliver 50 GPA. Sarritor was applied in pre-weighed aliquots using a hand-held shaker jar. In the spring experiment, 1m x 1m plots were selected for relatively uniform populations of dandelion and white clover. Prior to treatment, the number of dandelions and percent coverage of white clover were recorded. Treatments were arranged in a randomized complete block design with 4 replications. Plots received about 0.5 in of rain the two days prior to treatment. For the fall experiment, turfgrass lacked uniform populations of dandelions so a 10 cm wide band through each replicate was treated with glyphosate in June 2015. Then seedling dandelion plants were planted into the bare strip. This provided a uniform population of dandelions and more uniform winter annual broadleaf weed emergence in early fall.

After treatment, the area was irrigated with about 0.25 in. In the spring, the irrigation occurred between one and two hours after FeHEDTA and Lesco 3-Way were applied. In the fall study, spray treatments were applied earlier to allow 2 hours drying time before irrigation was applied.

Persistence of Sarritor in plots was analyzed using romaine lettuce as a bioassay. At 0, 7, 14, 21, 28, 56, and 84 DAT, three 7-cm core samples were taken from each Sarritor and non-treated plot using a standard 1-inch diameter soil sample device. Between each experimental unit, the soil core sampler was sterilized in 10% hypochlorite solution and quadruple rinsed with water. Soil cores from each plot were combined, bagged, frozen then later sent to McGill College for PCR analysis. Romaine lettuce plugs were planted into the soil core sample holes, and mortality rates recorded weekly. Little mortality was observed 7 days after planting. By 14 days mycelium growth on lettuce and broadleaf weeds as well as significant mortality to the lettuce was observed. Number of surviving lettuce plants was recorded and percent mortality was calculated.

Weed control was evaluated in four separate tests. In the spring and fall residual experiments (described above), control of established white clover (*Trifolium repens*) and dandelion (*Taraxacum officinale*), and seedling field madder (*Sherardia arvensis*) was documented. Results from these tests suggested that multiple applications of Sarritor would be needed to maintain control of some species. Therefore, two additional experiments were conducted to compare the efficacy of a single vs two applications of Sarritor and Fe-HEDTA with industry standard auxinic herbicide mixture on common cool-season turfgrass weeds. One was in an area with established populations of winter annual weeds dominated by field madder, with 2 to 3 dandelions transplanted into the site about 4 months prior to treatment. The second experiment in a low maintenance turf area with and established stand of white clover. First treatments were applied on 12/8/2015; 2$^{nd}$ applications on 12/21/15. Treatments included Sarritor IMI 344141 at 80 g/m$^2$, Fiesta Fe-HEDTA at 59.1 kg a.i./ha, or Ttrimec 899 at 1.5 kg a.i. Sarritor was applied using a hand-held shaker jar, and Fiesta and Trimec were applied using a $CO_2$ pressurized bottle sprayer calibrated to deliver 50 GPA. Single and sequential applications of Sarritor or Fiesta were compared. Sequential treatments were applied on December 21, 2015, about 2 weeks after initial treatments. Treatments were arranged in a randomized complete block design with 3 replications. About 1.5 hours after treatment plots were overhead irrigated with about 0.25" of water. Just over 1 inch of natural rainfall occurred following the 2$^{nd}$ Sarritor and Fiesta treatments.

Percent weed control was visually evaluated using a 0 to 10 scale (means are multiplied by 10 to convert to % for presentation) where 0 = no weed control (equivalent to non-treated areas) and 10 = 100% necrosis or mortality of the weeds. Percent weed cover was estimated before and after treatments. Additionally, the number of dandelion plants within plots was counted before and after treatment.

## RESULTS: LETTUCE BIOASSAY

### *Spring Experiment*

In the spring experiment, lettuce seedlings planted into plots 1 week after treatment displayed no symptoms one week after planting. Two weeks after planting, survival of lettuce plants was reduced in plots treated with 80 g/m$^2$ of Sarritor, but not in plots treated with the lower dose. No evidence of Sarritor infection was observed on lettuce planted 2 weeks after treatment or later (See Table 1.). These results suggested that lettuce bioassay plants required at least 2 weeks to respond to the Sarritor and that Sarritor bioactivity was very short-lived in the soil.

Photo: In the 2015 spring experiment, no Sarritor residual was detected by lettuce bioassay beyond 1 week after application. Lettuce seedlings were transplanted into Sarritor treated plots 1, 2, 3, 4 and 8 weeks after treatment.

**Table 1.** Percent mortality of lettuce transplants, by treatment to planting interval (weeks after treatment). Treated April 17, 2015 and evaluated 2 weeks after planting

| Sarritor Dose ($g/m^2$) | Percent mortality of lettuce transplants, by treatment to planting interval (weeks after treatment). | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 8 |
| | % | | | | | |
| 0 | 5 a | NS | NS | NS | NS | NS |
| 40 | 38 ab | | | | | |
| 80 | 68 b | | | | | |

Means within a column followed by the same letter were not significantly different based upon

*Fall experiment*

In the fall experiment, significant mycelial growth and mortality of lettuce plants were observed (see photo below). Lettuce planted on the day of treatment exhibited nearly over 80% mortality 1 week after planting and 100% mortality by 2 weeks after planting. For later plantings, disease progression was a slower process with mortality increasing for 3 to 4 weeks after treatment (see Figure 1). Lettuce transplanted into plots 0, 1 or 2 weeks after treatment exhibited over 80% mortality within 21 days.

Mycelium from Sarritor treatment at the base of a dead lettuce seedling. Mortality of lettuce plants was observed between 1 and 2 weeks after planting into Sarritor-treated plots.

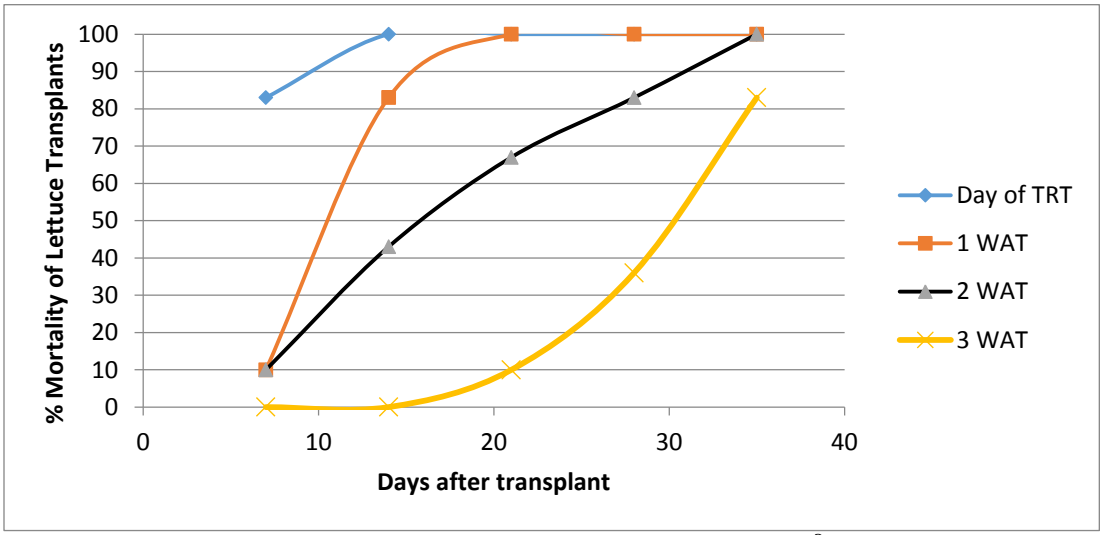


**Figure 1.** Percent mortality of lettuce transplants. Sarritor @ 80 g/m$^2$ applied on October 21, 2015. Lettuce planted 0, 1, 2, or 3 weeks after treatment (WAT) and evaluated 7, 14, 21 and 28 days after transplant. Lettuce evaluations were discontinued when freezing temperatures killed lettuce transplants.

Data from evaluations made 2 weeks after transplanting suggested that Sarritor persistence was less than 4 weeks (Figure 1). However, data recorded 3 to 9 weeks after treatment showed that lettuce transplant mortality continued to increase in Sarritor-treated plots (Figure 2 and Table 2). There were no differences between Sarritor doses. Sarritor produced essentially complete kill of lettuce plants transplanted up to 3 weeks after Sarritor treatment; about 80% mortality of lettuce transplanted 4 weeks after treatment ($P < 0.01$). Lettuce transplanted 8 weeks after treatment exhibited twice the mortality of lettuce transplanted into the non-treated turf ($P = 0.5$). Cold temperatures in the two weeks before the final evaluation could have resulted in an interaction between cold temperature stress and Sarritor infection. Regardless, lettuce transplanted into Sarritor treated turf exhibited increased mortality, relative to the non-treated turf (**Figure 2**), suggesting a much longer persistence than initially indicated by earlier evaluations.

**Table 2.** Percent mortality of lettuce transplants by transplant date (weeks after treatment), evaluated on December 26, 2015, 9 weeks after Sarritor treatment,. Freezing temperatures in late December damaged many plants in the test. Some mortality of plants in non-treated plots was observed, likely the result of freeze injury as no Sarritor mycelium was observed in the non-treated plots. All plants were killed by a freeze injury shortly after this evaluation.

| Sarritor Dose ($g/m^2$) | Percent mortality of lettuce transplants, by treatment to planting interval (weeks after treatment). | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 8 |
| | ----------%---------- | | | | | |
| 0 | 10 b | 10 b | 17 b | 33 b | 33 b | 25 c |
| 40 | 100 a | 100 a | 93 a | 93 a | 76 a | 77 ab |
| 80 | 100 a | 100 a | 100 a | 100 a | 83 a | 50 bc |

Means within a column followed by the same letter were not significantly different based upon an LSD procedure with P = 0.05.

**Figure 2.** Sarritor residual effects on transplanted lettuce plants. Photos taken December 14, 2015, about 7 weeks after treatment. Nontreated (Left) ; Sarritor @ 40 $g/m^2$ (Right) Note only 2 of 15 lettuce plants survived.

## Conclusions – Lettuce Bioassay for Sarritor Persistence

Under field conditions in NC, these data suggest very different results may be expected between spring and fall applications of Sarritor. From spring treatments, Sarritor appears to have little persistence. However, fall applications resulted in increased mortality of bioassay plants for at least 8 weeks. Weed control results support these conclusions. The reasons for differences are unknown but higher soil and air temperatures in the spring and early summer may have had detrimental effects on Sarritor performance and persistence.

## RESULTS – EFFICACY EXPERIMENTS

*Spring Experiment -- dandelion and white clover control with Sarritor, Fiesta and Auxin herbicide (single application of each).*

A single application of Fiesta resulted in rapid necrosis of dandelion, clover and other broadleaf weeds, but regrowth was observed two weeks after treatment (Figure 3). The auxin herbicide mixture acted more slowly than Fiesta but by four weeks after treatment provided the most effective broadleaf weed control including dandelion (Figure 3), white clover (Figure 4) and other broadleaf weeds. Overall broadleaf weed cover in auxin-treated plots was less than 10% compared to 82% cover in the non-treated plots (data not shown). Sarritor treatments resulted in infection of dandelion, clover and other broadleaf weeds and some foliar necrosis on some plants, but did not provide acceptable levels of weed control. At 80 g/m$^2$ up to 55% suppression of dandelion 2-weeks after treatment was observed, but regrowth was noted one week later (Figure 3). By 4 weeks after treatment no significant reduction in dandelion populations, % cover of white clover or mixed broadleaf weed cover was observed from either dose of Sarritor (Figures 3 & 4).

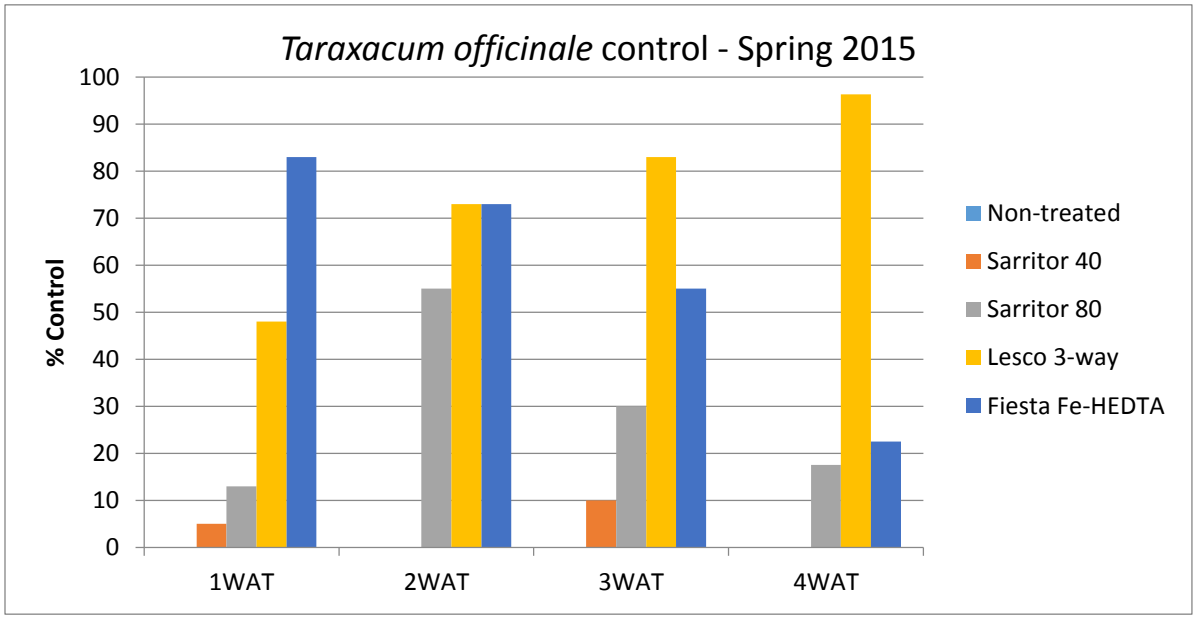


**Figure 3.** Percent control of *Taraxacum officinale* with Sarritor, Lesco 3-Way (2,4-D + MCPP+dicamba) and Fiesta (Fe-HEDTA) 1, 2, 3, and 4 weeks after treatment (WAT). Treatments were applied on April 17, 2015.

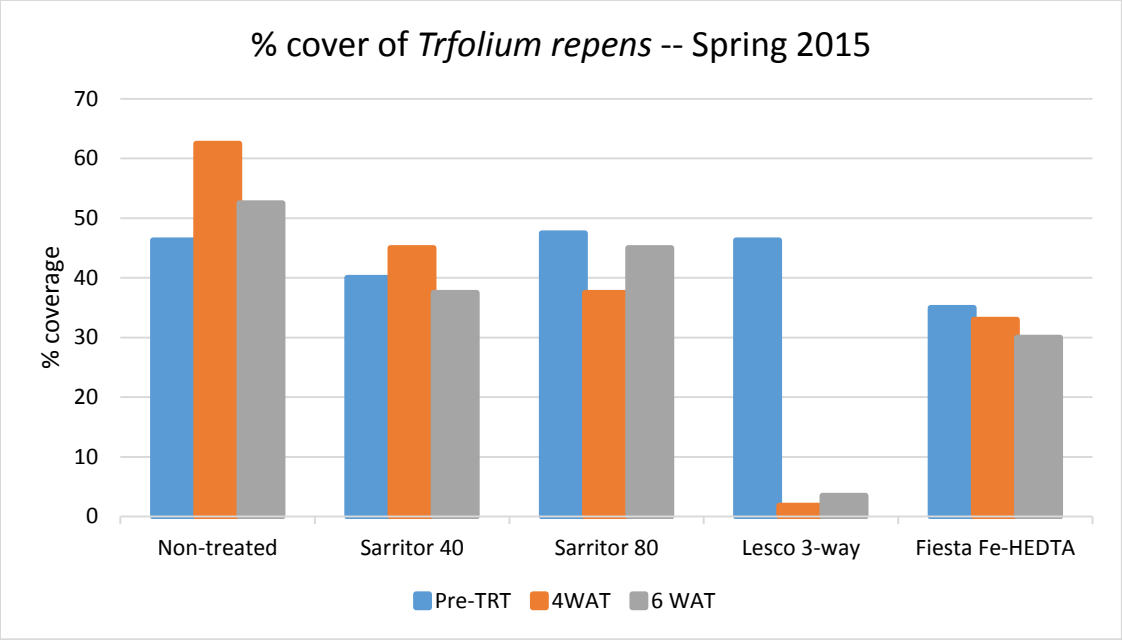


**Figure 4.** Percent cover of white clover (*Trifolium repens)*, evaluated before treatment (17 April), 4 and 6 weeks after treatment.

*Fall Experiment: dandelion and field madder control with Sarritor, Fiesta and Auxin herbicide (single application of each).*

As with the lettuce bioassay, Sarritor efficacy was much greater in the Fall experiment compared to the spring. Within one week of the first application, mycelium growth was observed(See photo to the right.) One week after treatment dandelion control was 30% with Fiesta but by 2 weeks after treatment, dandelions had resumed normal growth. Sarritor caused rapid necrosis of dandelion with up to 55% control 1 week after treatment (WAT) (Table 3). Control with Sarritor persisted for 3 weeks then declined. In contrast, control of field madder with Sarritor persisted for 4 weeks and was not different from that provided by the auxin herbicide mixture. Fiesta caused rapid necrosis of field madder but by 4 WAT plants were indistinguishable from the non-treated.

**Table 3.** Percent control of dandelion (*Taraxacum officinale*) and field madder (*Sherardia arvense*) following treatment on October 21, 2015; evaluated approximately 1 and 4 weeks after treatment.

| Treatment | Form-ulation | Unit | Dose | Unit | Dandelion | | Field Madder | |
|---|---|---|---|---|---|---|---|---|
| | | | | | 1 WAT | 4 WAT | 2 WAT | 4 WAT |
| Non-treated | | | | | 0 c | 0 c | 0 | 0 |
| Sarritor IMI 344141 | GR | | 40 | g/m2 | 40 ab | 23 b | 58 a | 48 a |
| Sarritor IMI 344141 | GR | | 80 | g/m2 | 55 a | 5 c | 65 a | 63 a |
| Lesco 3-way | 387.5 | g ae/L | 1.7 | kg ae/ha | 13 c | 55 a | 68 a | 63 a |
| 2,4-D | 285.5 | g ae/L | | | | | | |
| MCPP | 75.6 | g ae/L | | | | | | |
| Dicamba | 26.4 | g ae/L | | | | | | |
| Fiesta Fe-HEDTA | | | 80 | l/ha | 30 b | 0 c | 15 b | 0 b |

Percent weed control was visually evaluated 1, 2 and 4 weeks after treatment (WAT).

**Figure 5.** Sarritor-treated field madder plots (some clover present), two weeks after treatment in December 2015. Non-treated on left; treated in the middle and on the right (illustrating the variability observed between plots). Orange dots mark the corners of the plots.

Following the 2nd treatment on 12/21/15, Sarritor provided an average of 60 to 65% control of broadleaf weeds. However, the variability between replicates was significant. For example: in plots receiving 2 applications of Sarritor at 80 g/m$^2$ the percent weed control among the 4 replicates varied from 40% to 90% and broadleaf weed cover ranged from 5% to 75% (Figure 5). In contrast, plots treated with 2 applications of Fe-HEDTA ranged from 70% to 90% weed control and 5% to 30% broadleaf weed cover. Few differences were observed between one and two applications of Sarritor. Mycelium growth persisted in areas receiving a single application. But, as noted above this was not consistent in every replicate. It should be noted that variability between replicates could not be associated with any obvious causes – shading, soil moisture, inoculum lot number, distance from irrigation heads, soil type, etc.

Weather during the month of December was warm and moist, with an average daily high temperature of 18.7 C (66 F) and daily low of 9.3 C (49 F). Soil temperature averaged 13.2 C (56 F) for the same time period. These mild temperatures were accompanied by regular rainfall with about 89 mm (3.5 inches) during this time frame.

In the fall white clover control study, Sarritor provided 60% to 67% control of white clover in December evaluations (Table 4). A single application of Fiesta on December 8th was provided essentially no control of white clover by December 26th. However, two applications of Fiesta applied December 8 and 21 had reduced clover cover to 10% (= about 85% control). At the December 26th evaluation, the standard auxinic herbicide mixture, Trimec 899, had caused auxin-like injury symptoms but had not reduced white clover cover.

When evaluated the following spring Trimec 899 had reduced white clover cover by 100%. Clover re-growth had occurred in all other treatments and at the March evaluation, no reductions in white clover were detected from Sarritor or Fiesta treatments. These data demonstrate that Sarritor or Fiesta may significantly reduce white clover cover but repeated applications in the spring would likely be necessary to maintain and improve control of white clover.

**Table 4.** Percent control of white clover (*Trifolium repens*) following one or two applications of Sarritor, Fiesta or auxin herbicide. Weed control was visually evaluated 3 weeks after the 1st treatment (December 26 2015) or the following spring (March 2016).

| Treatment | Form Conc | Form Type | Rate | Rate Unit | # of applic | 3 WAT | Spring 2016 |
|---|---|---|---|---|---|---|---|
| | | | | | | ---------- % ---------- | |
| Non-treated | | | | | na | 0 d | 0.0 b |
| Sarritor IMI 344141 | | G | 80 | g/m2 | 1 | 60 ab | 17 b |
| Sarritor IMI 344141 | | G | 80 | g/m2 | 2 | 67 ab | 23 b |
| Fiesta Fe-HEDTA | 369.5 | L | 59.1 | kg ai/ha | 1 | 7 cd | 10 b |
| Fiesta Fe-HEDTA | 369.5 | L | 59.1 | kg ai/ha | 2 | 85 a | 17 b |
| TRIMEC 899 | 387.5 | L | 1.5 | kg ai/ha | 2 | 37 bc | 100 a |

**Conclusions – Sarritor efficacy on broadleaf weeds**.
Much better weed control was observed from fall applications of Sarritor compared to spring treatments. When weather conditions were conducive to infection (fall experiments), there was no clear dose response between 40 and 80 g/m$^2$. Initial data suggested that multiple applications would be necessary to extend the control of perennial weeds, but results were unclear if multiple applications would improve control to levels comparable to that provided by synthetic auxin herbicides. Variable control of weeds within a field, as observed in the fall experiments, would be problematic and should be investigated more thoroughly.