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**Short Title: yellow and knotroot foxtail control**

# Herbicide options for control of yellow and knotroot foxtail for possible use in turfgrass

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**Abstract**

Yellow and knotroot foxtail are two common weed species infesting turfgrass and pastures in the southeastern region of the United States. Yellow and knotroot foxtail share morphological similarities and are frequently misidentified by weed managers, thus leading to confusion in the herbicide selection. Greenhouse research was conducted to evaluate the response of yellow and knotroot foxtail to several turfgrass herbicides: pinoxaden (35 and 70 g ai $ha^{-1}$), sethoxydim (316 and 520 g ai $ha^{-1}$), thiencarbazone+dicamba+iodosulfuron (230 g ai $ha^{-1}$), nicosulfuron+rimsulfuron (562.8 g ai $ha^{-1}$), metribuzin (395 g $ha^{-1}$), sulfentrazone (330 g ai $ha^{-1}$), sulfentrazone+imazethapyr (504 g ai $hai^{-1}$), imazaquin (550 g ai $ha^{-1}$). All treatments controlled yellow foxtail >87% with more than 90% reduction of the biomass. By comparison, only sulfentrazone alone controlled knotroot foxtail 90% and completely reduced above-ground biomass. Sethoxydim (520 g ai $ha^{-1}$), metribuzin, and imazaquin controlled knotroot foxtail >70% at 28 DAA. In a rate response evaluation, non-linear regression showed yellow foxtail was approximately eight times more susceptible to pinoxaden and two times more susceptible to sethoxydim than knotroot foxtail based on log ($WR^{50}$) values, which were 50% reduction in fresh weight. Our research indicates that knotroot foxtail is more difficult to control across a range of herbicides making differentiation of these two species important before herbicides are applied.

**Nomenclature:** Knotroot foxtail, *Setaria parviflora* (Poir.) Kerguelen; yellow foxtail, *Setaria pumila* (Poir.) Roem. & Schult;

**Keywords:** control, foxtail, knotroot, setaria, turfgrass, weeds, yellow

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## Introduction

In the southeastern region of the United States, yellow and knotroot foxtail are two common species infesting managed and unmanaged turfgrass, pastures, roadsides, and some cropping systems (Bryson and DeFelice 2009; Hitchcock 1971). Yellow and knotroot foxtail belong to the genus *Setaria* which contains other major weeds such giant foxtail (*Setaria faberi* Herrm.), and green foxtail [*Setaria viridis* (L.) P. Beauv], forming the foxtail species-group (Dekker 2003). Yellow and knotroot foxtail originated from Asia and North America, respectively (Dekker 2003; Rominger 1962). Nevertheless, they share morphological similarities and are frequently misidentified by weed managers, thus leading to confusion in herbicide selection (Darmency and Dekker 2011).

Yellow and knotroot foxtail are annual and perennial weeds, respectively, with few options for effective chemical control in warm-season turfgrass. Pinoxaden, labeled in the United States for use on bermudagrass, controls yellow foxtail postemergence 95% at 0.001 kg $ha^{-1}$ but is not labelled for control of knotroot foxtail (Anonymous 2018; Peppers et al. 2020). Chlorsulfuron applied at 0.07 and 0.14 kg $ha^{-1}$ gave season-long control of yellow foxtail when applied at the early growth stage in Kentucky bluegrass, but it is not labeled in turfgrass (Maloy 1985). Little research has been done to gain an understanding of the chemical control of knotroot foxtail. In pasture conditions, hexazinone at 1.26 kg $ha^{-1}$ alone or mixed with nicosulfuron or metsulfuron controlled knotroot foxtail by more than 80% at 4 and 6 wk after application (Burns 2006). Nicosulfuron + metsulfuron applied at 0.04 kg $ha^{-1}$ controlled knotroot foxtail 70% in bermudagrass forage at the actively growing stage (Rusell 2021). Other herbicides could potentially control yellow and knotroot foxtail but are not currently labeled. For instance, thiencarbazone+dicamba+iodosulfuron is labeled for controlling yellow foxtail and giant foxtail but not knotroot foxtail.

The objectives of this research were to (1) evaluate the response of yellow foxtail and knotroot foxtail to several turfgrass herbicides and (2) evaluate the rate response of yellow and knotroot foxtail to increasing rates of pinoxaden and sethoxydim and estimate the application rate at which 50% ($I^{50}$) of both species are injured using a non-linear regression model.

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## Material and Methods

Research was conducted in 2021 and 2022 in a greenhouse to evaluate yellow and knotroot foxtail response to selected turfgrass herbicides. Two different studies were conducted (1) initial herbicide evaluation and (2) rate response evaluation of sethoxydim and pinoxaden. For both studies, seeds of yellow and knotroot foxtail were harvested from a local population in Montgomery, Alabama. Seeds were cleaned and stored at 4 C prior to the experiments. Seeds were planted in flats of potting medium and were then transplanted individually at two leaf state into 230 $cm^3$ pots, filled with sandy loam soil (Marvyn sandy loam). Pots were irrigated three times a d with overhead irrigation with approximately 5 mm of water. Fertilizer was applied (28-8-16 Miracle-Gro Water-Soluble All-Purpose Plant Food, Scotts Miracle-Gro Products Inc, Marysville, OH.) once a wk to promote growth as needed until the plants were healthy and established. After herbicide application, pots were not watered for approximately 24 hr to allow adequate leaf absorption. Herbicide applications were made at three to four leaf stages in all the experiments. All herbicide treatments were applied with a $CO_2$-pressurized sprayer, calibrated to deliver 280 L $ha^{-1}$ with a handheld four-nozzle boom (TeeJet TP8002 flat fan nozzles with 25 cm spacing; Spraying Systems Company, Wheaton, IL). A nonionic surfactant (Induce, Helena®, Chemical Company, Collierville, TN) was included in all treatments at 0.25% v/v. Treatments were compared with a non-treated control.

***Initial greenhouse evaluations.*** Two experiments were conducted at the Auburn University Weed Science Greenhouse in Auburn, AL (32.35°N, 85.29°W) in 32/28 C (+/-1 C d /n) conditions with an average relative humidity of 70%. Herbicides included: pinoxaden (35 and 70 g ai $ha^{-1}$) (Manuscript®, Syngenta Crop Protection, LLC, Greensboro, NC), sethoxydim (316, 520 g ai $ha^{-1}$) (Segment ™, BASF Corporation, Research Triangle Park, NC), thiencarbazone+dicamba+iodosulfuron (230 g ai $ha^{-1}$) (Celsius® WG, Bayer Crop Science, NC), nicosulfuron+rimsulfuron (562.8 g ai $ha^{-1}$) (Dupont™Steadfast®, Corteva ™ Agriscience, Wilmington, DE), metribuzin (395 g ai $ha^{-1}$) (Sencor®, Bayer Crop Science, NC) , sulfentrazone (330 g ai $ha^{-1}$) (Dismiss® CA, FMC Corporation, Philadelphia, PA), sulfentrazone+imazethapyr (504 g ai $ha^{-1}$) (Dismiss® South, FMC Corporation, Philadelphia, PA), imazaquin (550 g ai $ha^{-1}$) (Scepter T&O, AMVAC Chemical Corporation, Newport Beach, CA). Herbicides were selected based on the current herbicide label with yellow foxtail listed for control but not knotroot foxtail

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or both species are not listed on the label, but the herbicide has the potential to control grass species in turfgrass.

***Rate Response Evaluation*.** Due to the various response of the ACCase inhibiting herbicide pinoxaden and sethoxydim, a rate response screen studies for these herbicides were conducted in the greenhouse with the same environmental conditions as the previous evaluations. Pinoxaden and sethoxydim were applied at 9 different rates to generate a dose response curve. Pinoxaden rates were: 0, 2.21, 4.42, 8.8, 17.7, 35.4, 70.8, 141.4, 282.9, and 565.8 g ai $ha^{-1}$. Sethoxydim rates were 0, 19.8, 39.5, 79.0, 158.0, 316.1, 632.2, 1264.0, 2529.0, and 5057.2 g ai $ha^{-1}$.

***Statistical Analysis*.** All trials were arranged in a randomized complete block design with four replications and were repeated once. Weed control was visibly evaluated to the relative control using a scale 0% (no phytotoxic effect) to 100% (total plant death) scale at 28 d after application (DAA). Plants were clipped at the soil surface, and fresh above-ground biomass was recorded at 28 DAA. Data were subjected to ANOVA and mean comparison at a significance level of $P<0.05$ using R studio with package dplyr, ggplot2, agricolae, and FSA (Felipe and Muhammad 2020; Hadley et al. 2019; Ogle et al. 2022; RStudio 2020). Interactions of herbicide, herbicide rate, and run (repetition of the experiment in time) were analyzed with the visible plant injury and relative fresh weight as response variables. A significant interaction between runs was not detected based on herbicide evaluation by run interaction for greenhouse studies ($P \geq 0.05$); therefore, data were pooled across runs. Nonlinear regressions were modeled with DRC package in R studio (Ritz et al. 2015; RStudio 2020). Prior to modeling, nine pinoxaden and sethoxydim rates were transformed to log rates to maintain equal spacing between treatments, including the non-treated set to 0.04 and 0.99. Both species were modeled with appropriate models that best expressed plant response with the lowest Akaike Information Criterion as described by (Knezevic et al. 2007; Seefeldt et al. 2017). Plant visible injury for pinoxaden, sethoxydim, and above-ground biomass for sethoxydim were fitted to a four-parameter Weibull equation (Equation 1):

$$f(x) = C + (D - C) \times \exp\{-\exp[b(\log(x) - \log(e))]\}. \quad [1]$$

where f represents the percent, visible injury relative, to the nontreated control, x represents the log-transformed rate, C lower limit, D is the upper limit, b is the relative slope, and e represents

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the inflection point. This equation was used to calculate the $I_{50}$ value, which is the rate causing 50% of injuries. Above-ground biomass for pinoxaden was fitted to a 4 parameters Weibull model (Equation 2):

$$f(x) = C + \frac{(D-C)}{1+[\exp[b(logx-loge)]} \quad [2]$$

where f represents relative percent to the nontreated control, x represents the log-transformed rate, C lower limit, D is the upper limit, b is the relative slope, and e represents the inflection point. This equation was used to calculate the $WR_{50}$' which is the rate causing 50% biomass reduction relative to the non-treated. Above-ground biomass data were transformed into relative percentage of the nontreated control using the formula.

$$\%\, Relative = \frac{Mean\ Non\ treated - Mean\ Treatment}{Mean\ Non\ treated} \quad [3]$$

The relationship between the aboveground biomass and visual control was assessed using the Pearson correlation coefficient where 0 is no correlation, 1 is total positive correlation, and − 1 is total negative correlation using this equation:

$$\rho(x,y) = \frac{cov(x,y)}{\sigma_x \sigma_y} \quad [4]$$

Where $\rho(x,y)$ represent the Pearson correlation coefficient, $cov(x,y)$, the covariance between relative above-ground biomass and visual control. $\sigma_x$ the variance of visual control, and $\sigma_y$ the variance of relative above-ground biomass (Kotu and Deshpande 2018).

**Results and Discussion**

In the initial greenhouse evaluation, yellow and knotroot foxtail responded differently to the selected herbicides. All herbicides controlled yellow foxtail effectively with more than 85 % control at 28 DAA (Table 1). Above-ground biomass data followed the same pattern. All the herbicides reduced yellow foxtail above-ground biomass by more than 95% compared to the nontreated at 28 DAA. Knotroot foxtail was more difficult to control in general than yellow foxtail. Sulfentrazone controlled knotroot foxtail > 90 %, which was the best treatment. Metribuzin controlled knotroot foxtail 81%, imazaquin 71%, sethoxydim (high rate) 76%, and thiencarbazone+dicamba+iodosulfuron 70% control. All the other treatments controlled knotroot foxtail by less than 65%. Relative plant fresh-weight data follow the same pattern with visually estimated control data. The Pearson correlation between visual control and relative plant fresh-

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weight data at 28 DAA were 0.83 and 0.75, respectively for yellow and knotroot foxtail (Table 2). Sulfentrazone, metribuzin, sethoxydim (high rate), thiencarbazone+dicamba+iodosulfuron and imazaquin reduced the above ground by more than 90%. Nicosulfuron+rimsulfuron reduced knotroot foxtail biomass by 89%. However, pinoxaden (low and high rates) and sethoxydim low rates were less effective on knotroot foxtail with less than 50% biomass reduction.

Results from the rate response evaluation indicated that yellow foxtail is more susceptible to pinoxaden and sethoxydim that knotroot foxtail (Figure 1 and 2). The lack of fitted test was not significant for log-logistic and Weibull model with four parameters, demonstrating a proper choice for estimating $I^{50}$ and $WR^{50}$ (Ritz et al. 2015). Pinoxaden provided >80% yellow foxtail control but <15% control of knotroot foxtail at 35.4 g $ha^{-1}$. The $I_{50}$ value for yellow foxtail control was 6.7 g $ha^{-1}$ while for knotroot foxtail was 263 g $ha^{-1}$. Nevertheless, knotroot foxtail susceptibility to pinoxaden was quite different from yellow foxtail. The $I_{50}$ values for knotroot foxtail visible injury were 263 g $ha^{-1}$. Relative biomass data showed a similar trend with visual control with person correlation 0.72 and 0.61, respectively for yellow and knotroot foxtail. Pinoxaden reduced yellow foxtail biomass greater than 95% and knotroot foxtail by <20% at 8.8 g $ha^{-1}$. The WR50 value for yellow foxtail biomass was 1.73 g $ha^{-1}$ and for knotroot foxtail was 39.7 g $ha^{-1}$. Equation parameters and 95% confidence intervals for the visible injury and relative biomass data are displayed in Tables 3 and 4, respectively.

Sethoxydim data followed the same trend as pinoxaden. Sethoxydim control yellow foxtail by more than 95% at 316 g $ha^{-1}$ but knotroot foxtail was controlled <40% at the same rate. The $I^{50}$ value estimated were 102.4 and 2148.6 g $ha^{-1}$, respectively for yellow foxtail and knotroot foxtail. Sethoxydim reduced yellow foxtail biomass by greater than 90% at rates of 79.02 g $ha^{-1}$, and the $WR^{50}$ value estimated for yellow foxtail biomass reduction was 29.45 g $ha^{-1}$. Sethoxydim provided significant reduction of above-ground biomass, but none of the sethoxydim rates injured knotroot foxtail greater than 95%. It reduced knotroot foxtail biomass by greater than 70% at rates of 316.0 g $ha^{-1}$, and the $WR^{50}$ values estimated for knotroot foxtail biomass reduction was 219.14 g $ha^{-1}$. We detected a significant slope ($I_{50}$) difference between yellow and knotroot foxtail for both sethoxydim and pinoxaden. This estimation indicated that there was not equal susceptibility between yellow and knotroot foxtail for pinoxaden and sethoxydim. Furthermore, considering the relative biomass, those results indicated that yellow foxtail is more susceptible to pinoxaden and sethoxydim than knotroot foxtail.

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This study found that yellow foxtail responded differently than knotroot foxtail to the selected herbicides, and knotroot foxtail was more difficult to control. A published report showed that nicosulfuron + metsulfuron, two herbicides inhibiting acetolactate synthase, was one of the best treatments for knotroot foxtail suppression but did not provide complete control in bermudagrass hayfield (Bryson and DeFelice 2009). This study found nicosulfuron +rimsulfuron, reduce knotroot foxtail biomass by more than 80% but provided 60% control. Pinoxaden provides excellent control of yellow foxtail at the recommended label rate. Peppers et al. (2020) found a similar result with an $I_{50}$ of 3.4 g $ha^{-1}$. However, pinoxaden should not be considered for controlling knotroot foxtail even at the maximum recommended label rate. Sethoxydim (high labeled rate) effectively controlled yellow foxtail and reduced knotroot foxtail biomass by more than 60% at the maximum labeled rate. Differential herbicide responses in closely related species may be due to differential absorption, translocation, or metabolism or to inherent differences in the toxicity of the herbicides (Thompson 1972). Differential response in ACCase herbicides is observed in grass species. McCarty et al. (1990) discovered that there was a difference in centipedegrass (*Eremochloa ophiuroides*) and goosegrass (*Eleusine indica*) in sethoxydim metabolism. McCarty et al. (1990) also found that centipedegrass had less than 1% sethoxydim in its tissue, while goosegrass had 81% to 98% detected in its tissues 6 hr after application (McCarty et al. 1990). In crop species, tolerance to sethoxydim is associated with metabolism detoxification in wheat (*Triticum aestivum* L.) and modification at the membrane level in annual ryegrass (*Lolium rigidum*) (Dotray 1993; Hausler et al. 1991; Shimabukuro et al. 1979). Differential response of acetolactate synthase inhibiting herbicide in foxtail species is not uncommon. Satchivi et al. (2017) found a differential response in green and yellow foxtail to pyrosulam, with yellow foxtail being more sensitive than green foxtail. Such differential control is associated with a difference in the metabolism of acetolactate synthase sensitivity, as the sequence of ALS genes from both green and yellow foxtail revealed amino acid differences (Satchivi et al. 2017). However, these changes are not associated with known resistance-inducing mutations (Satchivi et al., 2017). Wang et al. (1995) have explored the variation of the detoxification mechanism of multiple herbicides in foxtails-resistant species to atrazine. This study found that giant, green, yellow, and knotroot foxtail have differences in glutathione-s-transferase activity for plant detoxification, and these enzyme activities were similar to those found in susceptible populations (Wang et al. 1995). Oliver and Schreiber (1971) found this

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differential metabolism rate, with yellow foxtails more susceptible to atrazine and propazine than green and giant foxtails. Thompson (1972) confirmed that yellow and giant foxtail metabolized atrazine and propazine slowly, whereas green foxtail metabolized faster. While those two closely related species have various metabolism rates to different herbicide families, it is important to comprehend those differences at genetic and ecologic levels. The foxtail species group exhibits considerable variability within and among species with genetic diversity and phenotypic plasticity (Dekker 2003). While yellow and knotroot foxtail originated from two continents (Dekker 2003), more investigation is needed to understand the relationship between local adaption and inherent herbicide susceptibility in those species.

## Practical Implications

Yellow and knotroot foxtail share morphological similarities and present phenotypic plasticity within and among species, making their differentiation challenging. The options to control yellow and knotroot foxtail simultaneously are limited. The results of this study suggested that sulfentrazone, thiencarbazone+dicamba+iodosulfuron, sethoxydim (high rate), and metribuzin can be considered for controlling yellow and knotroot foxtail at the recommended label rate. Pinoxaden, sethoxydim (low rate), nicosulfuron+rimsulfuron, imazaquin can control yellow foxtail but not knotroot foxtail at labeled rate. Since yellow and or knotroot are not listed on all herbicide labels used in the study, their use in certain situations is not recommended unless the herbicide label is updated. This study, conducted in a controlled environment, provides a basis for understanding potential herbicide control options for yellow and knotroot foxtail. Overall, our research indicates that knotroot foxtail is more difficult to control across a range of herbicides making differentiation of these two species important before herbicides are applied.

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## Competing Interests

The authors declare no conflicts of interest.

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Table 1. Yellow and knotroot foxtail control and above-ground biomass relative to the non-treated (%ABRN) in response to herbicide treatments at 28 d after application.

| | | Yellow foxtail | | | | Knotroot foxtail | | | |
|---|---|---|---|---|---|---|---|---|---|
| Treatment | Rate | Control | | %ABRN | | Control | | %ABRN | |
| | g ai ha$^{-1}$ | 28 DAA | | | | | | | |
| Pinoxaden (low) | 35 | 100 | a | 100 | a | 10 | bc | 14 | cd |
| Pinoxaden (high) | 70 | 87 | a | 96 | a | 20 | c | 30 | bcd |
| Sethoxydim (low | 316 | 100 | a | 100 | a | 40 | abc | 47 | abcd |
| Sethoxydim (high) | 520 | 100 | a | 100 | a | 77 | a | 94 | ab |
| Thiencarbazone+dicamba+iodosulfuron | 230 | 99 | a | 100 | a | 70 | ab | 90 | ab |
| Metribuzin | 395 | 100 | a | 99 | a | 81 | a | 96 | a |
| Nicosulfuron+rimsufuron | 563 | 98 | a | 98 | a | 64 | abc | 90 | ab |
| Sulfentrazone | 330 | 98 | a | 100 | a | 91 | a | 96 | a |
| Sulfentrazone+Imazethapyr | 504 | 93 | a | 100 | a | 62 | abc | 78 | abc |
| Imazaquin | 550 | 99 | a | 100 | a | 72 | a | 92 | a |

The values with the same letters in a column have no significant difference. Tukey HSD (*p=0.05).* Non-treated controls were not included in the analysis due to all rates by zero for control.

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Table 2: Correlation between relative above-ground biomass to the non-treated and percent control in initial herbicide evaluation (Study1) and in response to increasing rates of sethoxydim and pinoxaden (Study 2) at 28 d after application. Each value represents the Pearson correlation.

| Study | Yellow foxtail | Knotroot foxtail |
|---|---|---|
| Study1 | 0.83 | 0.75 |
| Study2-Pinoxaden | 0.72 | 0.61 |
| Study 2- Sethoxydim | 0.68 | 0.60 |

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Table 3. Best fit model for percent visible injury of yellow and knotroot foxtail in response to increasing rates of sethoxydim and Pinoxaden at 28 d after application.

| Herbicides | Species | [a]Equation | $I_{50}$ (g ai $ha^{-}$) | Estimate $I_{50}$ (95% CI) (g ai $ha^{-1}$) |
|---|---|---|---|---|
| Pinoxaden | yellow foxtail | $f(x) = 0.44 + (100.44) \times (1 - \exp\{-\exp[0.41(\log(x) - \log(16.05))]\})$ | 6.66 | [0.43; 12.89] |
| | knotroot foxtail | $f(x) = f(x) = -1.2 + (98.8) \times (1 - \exp\{-\exp[0.56(\log(x) - \log(503.2))]\})$ | 263 | [94.85; 431.14] |
| Sethoxydim | yellow foxtail | $f(x) = 23.1 + (100 - 23.1) \times (1 - \exp\{-\exp[1.21(\log(x) - \log(138.48))]\})$ | 102.35 | [62.10; 142.6] |
| | knotroot foxtail | $f(x) = -1.82 + (100 + 1.82) \times (1 - \exp\{-\exp[0.66(\log(x) - \log(3720))]\})$ | 2148.61 | [1270.65; 3026.57] |

[a] *Regression parameter determined by Weibull model with four parameters for Pinoxaden data defined by equation 1 :*

*Abbreviation: CI, confidence interval. $I_{50}$, Herbicide rate giving 50% control.*

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Table 4. Best fit model for relative above ground biomass to the non-treated of yellow and knotroot foxtail in response to increasing rates of sethoxydim and Pinoxaden at 28 d after application.

| Herbicides | Species | Equation | *$WR_{50}$ (g ai $ha^{-1}$)* | *Estimate $WR_{50}$ (95% CI) (g ai $ha^{-1}$)* |
|---|---|---|---|---|
| [a]Pinoxaden | yellow foxtail | $f(x) = \frac{100}{1 + [\exp - 0.74(logx - \log(0.55)]}$ | 1.73 | [1.36; 1.91] |
| | Knotroot foxtail | $f(x) = \frac{100}{1 + [\exp - 6.14(logx - \log(1.55)]}$ | 39.65 | [30.45; 47.97] |
| [b]Sethoxydim | yellow foxtail | $f(x) = 23.1 + 76.9 \times (1 - \exp\{-\exp[3.62(\log(x) - \log(32.59))]\})$ | 29.45 | [18.64; 40.26] |
| | knotroot foxtail | $f(x) = 9.1 + 89.9 \times (1 - \exp\{-\exp[2.25(\log(x) - \log(257.7))]\})$ | 219.14 | [152.66; 285.63] |

[a] Regression parameter determined by log-logistic with 4 parameters for pinoxaden.

[b] Regression parameter determined by Weibull model with four parameters for sethoxydim data defined by equation 1:

abbreviation: CI: Confidence interval. $WR_{50}$,: Herbicide rate giving 50% biomass reduction, respectively.

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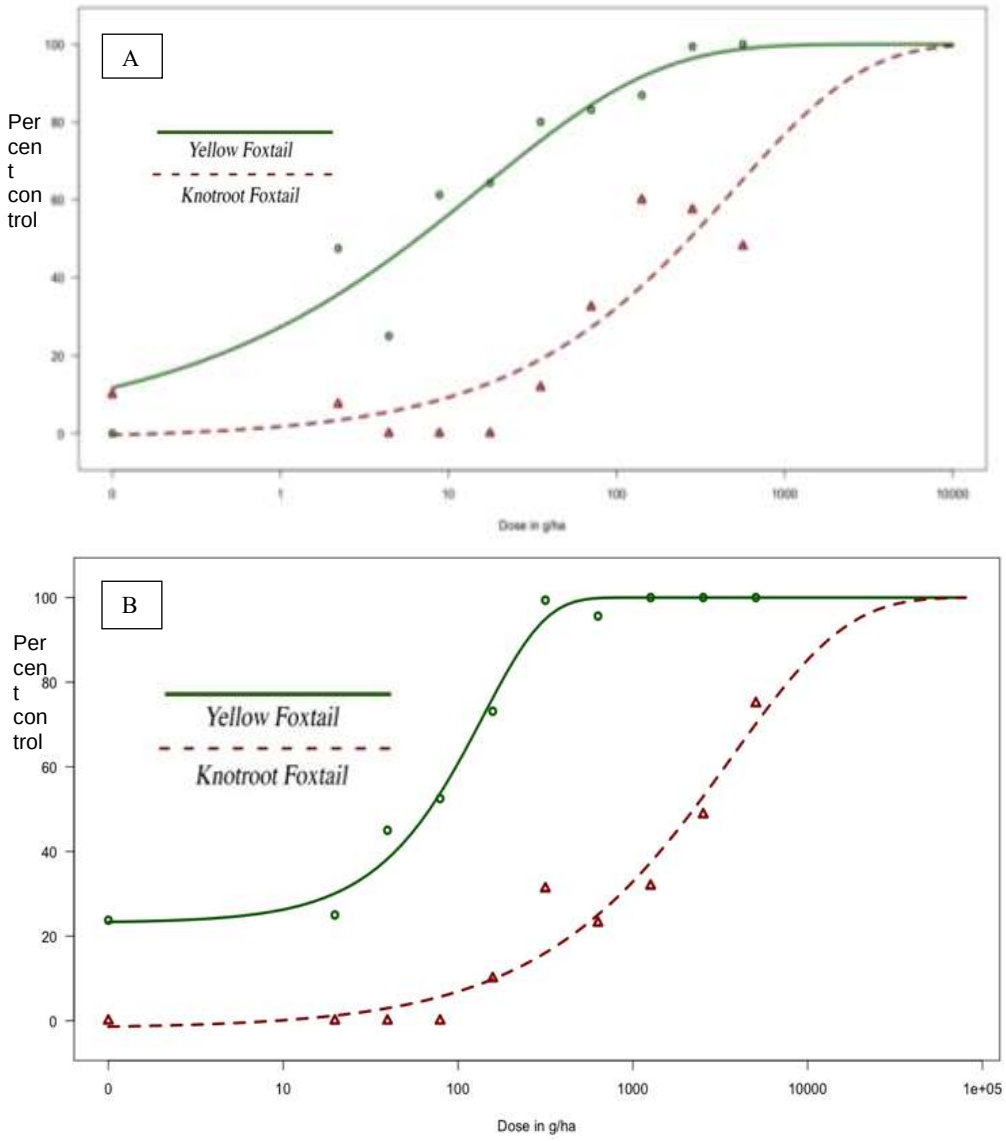


Figure 1. Percent visible injury to the nontreated control of yellow and knotroot foxtail 28 d after application with increasing rates of pinoxaden[A] and sethoxydim[B].

Regression parameter determined by Weibull model with four parameters: $f(x) = C + (D - C) \times \exp\{-\exp[b(\log(x) - loge)]\}$.

A: Pinoxaden B: Sethoxydim. Each bullet in the graph represents the average control for each treatment. Yellow foxtail: green line; Knotroot foxtail: red dashed line.

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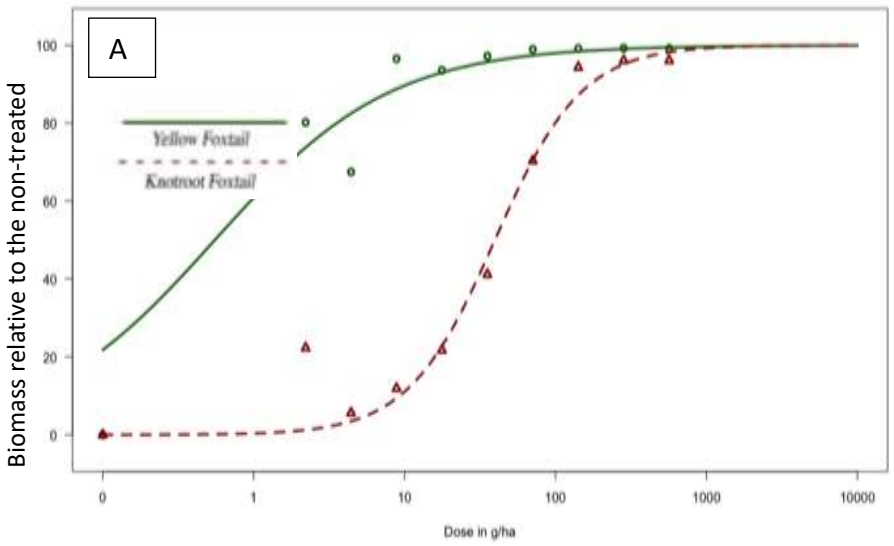


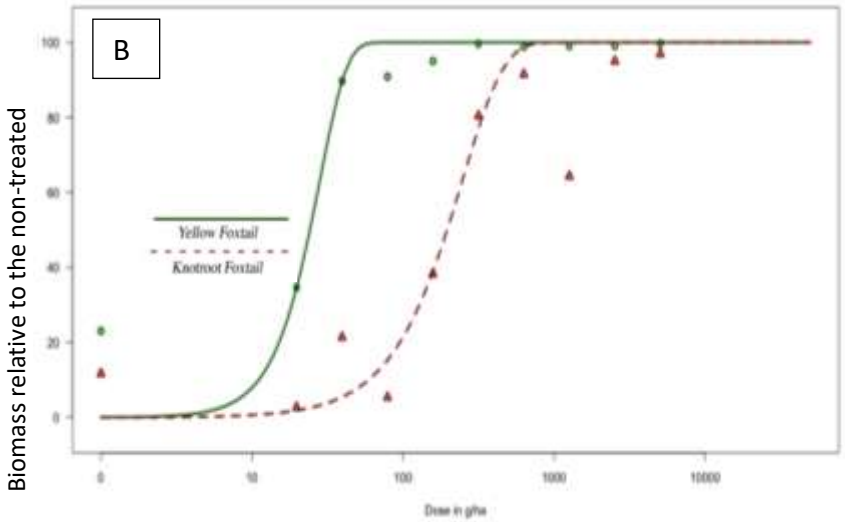


Figure 2. Biomass relative to the non-treated (ABGR) for yellow and knotroot foxtail at 28 d after application with increasing rates of pinoxaden[A] and sethoxydim[B].

[A]Regression parameter determined by log logistic with four parameters for pinoxaden:

$$f(x) = C + \frac{(D-C)}{1+[\exp\,[b(logx-loge)]}$$

[B]Regression parameter determined by Weibull model with four parameters for sethoxydim:

$$f(x) = C + (D - C) \times \exp\{-\exp[b(\log(x) - loge)]\}.$$

Each bullet in the graph represents the average ABGR for each treatment. Yellow foxtail: green line; Knotroot foxtail: red dashed line.

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