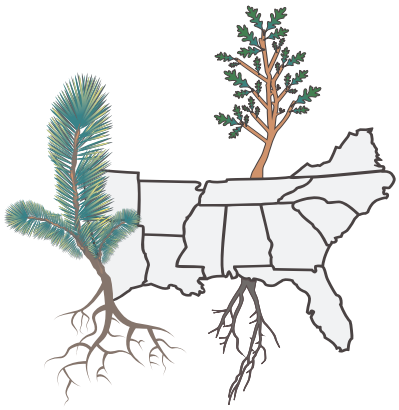

Auburn University Southern Forest Nursery Management Cooperative

RESEARCH REPORT 16-01

HERBICIDE TOLERANCE OF NATIVE PLANT SEEDLINGS IN NURSERY PRODUCTION SYSTEMS

by
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INTRODUCTION

Restoration of longleaf pine ecosystems is becoming increasingly popular with non-industrial landowners throughout the southeast. In addition, the America's Longleaf identified research areas that are needed in order to properly restore longleaf pine. One key research need concerned longleaf pine understory species and community composition, including guidelines and standards for the commercial production of longleaf pine understory plant species, and increased knowledge of the community composition and the species that comprise them (America's Longleaf, 2009). Due to the improvements of forest management, the commercial production of longleaf pine seedlings, financial incentives and increased knowledge of longleaf pine, restoration of this ecosystem has become more successful. Prior to the Conservation Reserve Program's (CRP) additional requirement of reestablishing native ground cover species, understory plants were not regularly grown for commercial purposes in nurseries. Today, since these understory ground covers have become recognized as an integral part of longleaf pine restoration they are being widely produced across the southeast. The increase in understory plant production has made it easier to incorporate native understory species into the ecosystems and increased the probability of successful ecosystem restoration. These native plant species are important because of the value that they bring to the ecosystem: ground cover and food for numerous wildlife species and a fuel source for prescribed fire (Van Lear et al, 2005; Outcalt et al, 1999). While the restoration program has made progress, there are some production issues that have impeded the process. Many forest nurseries have developed production systems to commercially grow native understory species in container systems similar to forest-tree production. However, in the native plant production areas, unwanted weeds can be significant issue in the production of these understory species. One of the larger concerns is that there are no herbicide guidelines to effectively control weeds that do not also adversely affect the understory native plant species. These trials were undertaken to determine the efficacy of currently available broad spectrum herbicides for the control of weed species commonly associated with the native plant production systems and their herbicide tolerance.

MATERIALS AND METHODS

Understory Plant Seedling Treatment – Goldsboro, NC. To evaluate herbicide efficacy and native seedling tolerance, five herbicides labeled for use in forest-tree nurseries were tested on the

understory container seedlings. These were: 1) halosulfuron-methyl, 2) lactofen, 3) oxyfluorfen (Goal 2XL®), 4) oxyfluorfen (GoalTender®) and 5) pendimethalin (Table 3.1). The herbicide treatments were applied over-the-top of germinated wiregrass (*Aristida beyrichiana*), muhly grass (*Muhlenbergia capillaris*) and Indian grass (*Sorghastrum nutans*) using a CO_2 powered applicator calibrated to deliver 234 liters of water per hectare (25 gallons of water per acre). The rates used were based on previous native plant trials and application information obtained from each herbicide label (Jackson et al, 2015). The herbicide treatments were applied as a post-emergence to the seedlings and both pre- and post-emergence to some weeds at two rates on July 3, 2013 (Table 1). The seedlings were sown eleven weeks prior to the herbicide application. Each treatment was applied to five container trays of each of the native plants, with five non-treated container trays of each plant species used as a control.

At 2, 3, 4, 6 and 8 weeks post treatment, the native plants in each tray were evaluated for herbicide injury using a rating scale of 1-9, where 1=no injury and 9=mortality (Kaiser and Kirkman, 2010). Data was analyzed using the PROC GLM in SAS (SAS version 9.3, SAS Institute Inc.) and treatment means were separated using both the Duncan and Dunnett's test with an alpha < 0.05.

Understory Plant Seedling Treatment – Moultrie, GA. This study was a replication of what was conducted in North Carolina the previous summer. To evaluate herbicide efficacy and native plant tolerance, four different herbicides labeled for use in nurseries were tested on the understory container seedlings at a second nursery that included 1) halosulfuron-methyl, 2) lactofen, 3) oxyfluorfen (Goal 2XL®), 4) pendimethalin (Table 2). The herbicide treatments were applied over-the-top of the plants using a CO_2 powered applicator calibrated at 234 l/ha (25 gallons per acre). The herbicides were applied as a post-emergence to the seedlings and both a pre- and post-emergence to some weeds on June 26, 2014 on, Indian grass and little bluestem, and wiregrass was sprayed on August 6, 2014. The Indian grass and little bluestem seedlings were sown six weeks prior to the herbicide application, and the wiregrass seedlings were sown eight weeks prior to the herbicide application. The difference in age at the time of application was due to scheduling and size of the seedlings. The herbicide rates were determined based on results from previous herbicide trials and from the herbicide labels. Each herbicide treatment was applied to five container trays of native understory plant seedlings with a total of 25 container trays of each native understory plant species.

At 1, 2, 3 and 6 weeks post treatment, Indian grass and little bluestem and 2, 4 and 6 weeks post application for wiregrass plants were examined for herbicide injury and mortality using the following scale: 1-9, where 1=no injury and 9=mortality (Kaiser and Kirkman, 2010). The data from Indian grass and little bluestem was sampled at different time than the wiregrass due to application dates and observed herbicide effects. Data was analyzed using the PROC GLM in SAS (SAS version 9.3, SAS Institute Inc.) and the treatment means were separated using both the Duncan and Dunnett's test with an alpha < 0.05.

RESULTS

Indian grass, muhly grass and wiregrass – Goldsboro, NC. Of the five herbicides (Table 1) that were used over the top of wiregrass seedlings, only oxyfluorfen (Goal 2XL® and GoalTender®) were detrimental to the understory plant seedlings. The high rates of oxyfluorfen (Goal 2XL® and GoalTender®) resulted in injury ratings of 5.6 and 5.4, respectively (Table 2). The other herbicide treatments did little to no damage to the wiregrass seedlings (injury ratings from 1.0 – 1.4) (Table 2). None of the herbicides applied to the muhly grass or Indian grass seedlings caused damage (injury ratings of 1.0) (Table 3 and 4).

Indian grass, little bluestem, and wiregrass – International Forest Company. Oxyfluorfen (Goal 2XL®) was the only herbicide that caused injury to the wiregrass seedlings (1.4) (Table 8), however, the injury was minimal and did not hinder the growth and viability of the seedlings. The other herbicide treatments were well tolerated by the wiregrass seedlings (injury ratings of 1.0) (Table 7). All four herbicides tested at IFCO caused minor damage to the Indian grass seedlings (injury ratings of 1.4 – 2.1 respectively) (Table 5). Although the treated seedlings were damaged when compared to the non-treated group, the injury was minimal and did not appear to cause any long term problems with the growth and viability of the seedlings later in the growing season. Only pendimethalin caused minor injury to the little bluestem seedlings (1.3) (Table 6). The other herbicides were tolerated by little bluestem. None of the herbicides, including pendimethalin, were detrimental or hindered the growth or viability of the seedlings.

DISCUSSION

These studies identified several herbicides that can be applied over the top of native grass seedlings in order to control weeds. The ability to minimize competition will benefit nurseries by providing another management tool to grow native plant seedlings more efficiently. Furthermore, the production of quality seedlings will benefit longleaf pine ecosystem restoration as outlined in America's Longleaf Restoration Initiative (America's Longleaf, 2009).

The ability of the native grass seedlings to tolerate herbicides is critical in identifying viable and successful herbicide treatments for control of weeds. The intent of using herbicides is to limit competition. However, if the herbicides are more detrimental than beneficial then one problem is being replaced by another. The need to limit competition without negatively affecting the native plant emphasizes the importance of finding the right herbicide(s) and the correct usage rate. Brockway et al (1998) conducted a plant cover, diversity and biomass study in which they reported that using a low rate of hexazinone can control woody species while benefiting the growth of wiregrass, a key longleaf ecosystem species. The site, which had become dominated by turkey oak (*Quercus laevis*), was treated with a low rate of hexazinone which reduced turkey oak in both the overstory and understory. The reduction of turkey oak provided available space and nutrients for wiregrass that was seen to increase for two growing seasons following the hexazinone treatment (Brockway et al, 1998).

Nursery trials conducted in North Carolina on native plants revealed that wiregrass does not tolerate compounds containing oxyflurofen (Goal 2XL® and GoalTender®) (Jackson et al, 2015).

Consequently, oxyfluorfen (Goal 2XL®) was examined a second time at IFCO the following year at half of the lowest rate that had been previously used in North Carolina (6 oz/ac). When used at this rate oxyfluorfen did minimal damage (1.4) to the seedlings, allowing its use and providing nursery managers with another herbicide treatment option to control weeds. These trials at North Carolina and IFCO revealed that wiregrass seedlings can tolerate a number of other herbicides which are already used in forest-tree nurseries. This is beneficial because the nurseries will be able to utilize herbicides that they already use on tree seedlings.

Weeds were not an issue in the nursery in 2014 and thus, a weed-control component to the study was not incorporated. Once the herbicides are known to be tolerated by the grass species it is important to know how well they will control weeds. Norcini et al (1997) evaluated the tolerance of wiregrass seedlings to six herbicides as well as the herbicides' ability to control bittercress (*Cardamine hirsuta*) competing with the wiregrass seedlings. They found that imazaquin and imazapic were moderately tolerated by the wiregrass seedlings, while the other four herbicides (isoxaben, oryzalin, oxadiazon, and isoxaben + trifluralin) were too detrimental to the wiregrass to be useful, regardless of their ability to control bittercress.

Due to the limited amount of native plant seedlings available at North Carolina, only two herbicides were evaluated on Indian grass and muhly grass; lactofen and halosulfuron-methyl. Both herbicides, at both rates, were tolerated by the Indian grass and muhly grass seedlings, with injury ratings of 1.0. When the trials were replicated the following year, the rate of halosulfuron-methyl and lactofen were increased, and the high rate of pendimethalin was used again, whereas the rate of oxyfluorfen (Goal 2XL) was decreased. Minor damage was caused by all four herbicide treatments at IFCO which was different from the complete lack of injury that was seen at North Carolina. This difference in results between the two study sites could be attributed to the change in herbicide rates as well as the age of the seedlings when the herbicide was applied. The grass seedlings in North Carolina were sprayed about 11 weeks after the seeds were sown whereas the grass seedlings at IFCO were sprayed at a younger age. The Indian grass and little bluestem grasses were sprayed about 6 weeks after sowing and the wiregrass seedlings were sprayed about 8 weeks after sowing. The wiregrass was sprayed at a later time than the Indian grass and little bluestem at IFCO because the seeds were not sown at the same time. Some of the herbicide rates were also adjusted based on the results seen in North Carolina (Table 1 and 2). All four herbicide treatments at IFCO were tolerated by the Indian grass and could be viable treatments for weed control. This is important because it provides the forest nursery with additional tools to use in order to limit competition to produce a better seedling, which also benefits the overall restoration effort.

Trials at IFCO indicated that little bluestem was even more tolerant than Indian grass seedlings to the herbicides and rates tested. Pendimethalin did minor injury to the little bluestem seedlings but the other herbicides were well tolerated. The ability of little bluestem seedlings to tolerate these commonly used herbicides suggests that they could be viable treatments in both forest-nursery and seed production areas.

The limited availability of muhly grass seedlings limited evaluation of this particular native plant species, making it difficult to provide recommendations. However, from what was tested, the muhly grass seedlings were tolerant of both rates of lactofen and halosulfuron-methyl. The next step in this herbicide evaluation would be to increase the rates of the herbicides to adequately

evaluate the tolerance of muhly grass to these herbicides. Also, the incorporation of more herbicides would be ideal to find more viable treatments to cover a broader spectrum of weeds.

Nurseries which grow these native grass seedlings for use in longleaf pine ecosystem restoration programs now have information and tools to use to produce the native plant material more efficiently. Knowing which herbicides are tolerated by the native grass species is critical, to allow effective control of weeds. All four species proved to be tolerant of the majority of the herbicide treatments that were evaluated. Oxyflurofen (Goal 2XL® or GoalTender®) should be used with caution. It can be tolerated by wiregrass when used at 6 oz ai/ac.

MANAGEMENT IMPLICATIONS

These studies identified several herbicides that can be applied over the top of native grass seedlings in order to control unwanted weeds. All of the treatments, with the exception of the oxyfluorfen (Goal 2XL® and GoalTender®) applications in North Carolina, are tolerated by the native grass seedlings and are acceptable applications for use in forest-tree nurseries. The ability to minimize competition will benefit nurseries by providing them with more management tools to grow native plant seedlings more efficiently. Furthermore, the production of quality seedlings will benefit longleaf ecosystem restoration.

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Table 1. 2013 North Carolina herbicide treatments applied to wiregrass (*Aristida beyrichiana*), Indian grass (*Sorghastrum nutans*) and muhly grass (*Muhlenbergia capillaris*).

Herbicide	Active Ingredient	Low Rate (L/ha)	High Rate (L/ha)
Cobra®	Lactofen	0.29	0.58
Goal 2XL®	Oxyflurofen	0.58	1.16
GoalTender®	Oxyflurofen	0.88	1.75
Pendulum Aquacap®	Pendimethalin	1.24	2.48
Sedgehammer®	Halosulfuron-methyl	35.01 g/ha	70.03 g/ha
Control		N/A	N/A

Table 2. 2014 IFCO herbicide treatments applied to wiregrass (*Aristida beyrichiana*), Indian grass (*Sorghastrum nutans*) and little bluestem (*Schizachyrium scoparium*).

Herbicide	Active Ingredient	Rate (L/ha)
Cobra®	Lactofen	0.58
Goal®	Oxyflurofen	0.44
Pendulum Aquacap®	Pendimethalin	2.48
Sedgehammer®	Halosulfuron-methyl	105.08 g/ha
Control	N/A	N/A

Table 3. 2013 North Carolina herbicide trial results of wiregrass (*Aristida beyrichiana*).

Herbicide	Application Rate (L/ha)	Average Injury[a]
Goal 2XL®	1.16	5.6 a**
GoalTender®	1.75	5.4 a
GoalTender®	0.88	3.9 b
Goal 2XL®	0.58	3.8 b
Cobra®	0.58	1.4 c
Cobra®	0.29	1.2 c
Sedgehammer®	2.47 g/ha	1.1 c
Pendulum Aquacap®	2.48	1.0 c
Pendulum Aquacap®	1.24	1.0 c
Sedgehammer®	1.27 g/ha	1.0 c
Control	N/A	1.0 c

[a] = Injury rating scale of 1-9 (1=no injury and 9=mortality) which was a measure of phytotoxicity due to herbicide exposure (Kaiser and Kirkman 2010).

** Means with different letters are significantly different ($p < 0.05$).

Table 4. 2013 North Carolina herbicide trial results of muhly grass (*Muhlenbergia capillaris*).

Herbicide	Application Rate (L/ha)	Average Injury[a]
Cobra®	0.58	1.0**
Cobra®	0.29	1.0
Sedgehammer®	70.03g/ha	1.0
Sedgehammer®	35.01g/ha	1.0
Control	N/A	1.0

[a] = Injury rating scale of 1-9 (1=no injury and 9=mortality) which was a measure of phytotoxicity due to herbicide exposure (Kaiser and Kirkman 2010).

** Means with different letters are significantly different ($p < 0.05$).

Table 5. 2013 North Carolina herbicide trial results of Indian grass (*Sorghastrum nutans*).

Herbicide	Application Rate (L/ha)	Average Injury[a]
Cobra®	0.58	1.0**
Cobra®	0.29	1.0
Sedgehammer®	70.03 g/ha	1.0
Sedgehammer®	35.01 g/ha	1.0
Control	N/A	1.0

[a] = Injury rating scale of 1-9 (1=no injury and 9=mortality) which was a measure of phytotoxicity due to herbicide exposure (Kaiser and Kirkman 2010).

** Means with different letters are significantly different ($p < 0.05$).

Table 6. 2014 IFCO herbicide trial results on Indian grass (*Sorghastrum nutans*).

Herbicide	Rate (L/ha)	Injury Rating[a]
Sedgehammer®	105.08 g/ha	2.1 a**
Goal 2XL®	0.44	2.0 a
Cobra®	0.58	1.5 b
Pendulum Aquacap®	2.48	1.4 b
Control	N/A	1.0 c

[a] = Injury rating scale of 1-9 (1=no injury and 9=mortality) which was a measure of phytotoxicity due to herbicide exposure (Kaiser and Kirkman 2010).

** Means with different letters are significantly different ($p < 0.05$).

Table 7. 2014 IFCO herbicide trial results on little bluestem (*Schizachyrium scoparium*).

Herbicide	Rate (L/ha)	Injury Rating[a]
Pendulum Aquacap®	2.48	1.3 a**
Goal 2XL®	0.44	1.0 b
Cobra®	0.58	1.0 b
Sedgehammer®	105.08 g/ha	1.0 b
Control	N/A	1.0 b

[a] = Injury rating scale of 1-9 (1=no injury and 9=mortality) which was a measure of phytotoxicity due to herbicide exposure (Kaiser and Kirkman 2010).

** Means with different letters are significantly different ($p < 0.05$).

Table 8. 2014 IFCO herbicide trial results on wiregrass (*Aristida beyrichiana*).

Herbicide	Rate (L/ha)	Injury Rating[a]
Goal 2XL®	0.44	1.4 a**
Cobra®	0.58	1.0 b
Pendulum Aquacap®	2.48	1.0 b
Sedgehammer®	105.08 g/ha	1.0 b
Control	N/A	1.0 b

[a] = Injury rating scale of 1-9 (1=no injury and 9=mortality) which was a measure of phytotoxicity due to herbicide exposure (Kaiser and Kirkman 2010).

** Means with different letters are significantly different ($p < 0.05$).

Figure 1. 2013 Indian grass seedlings grown in North Carolina.

Figure 2. 2013 muhly grass seedlings grown in North Carolina.

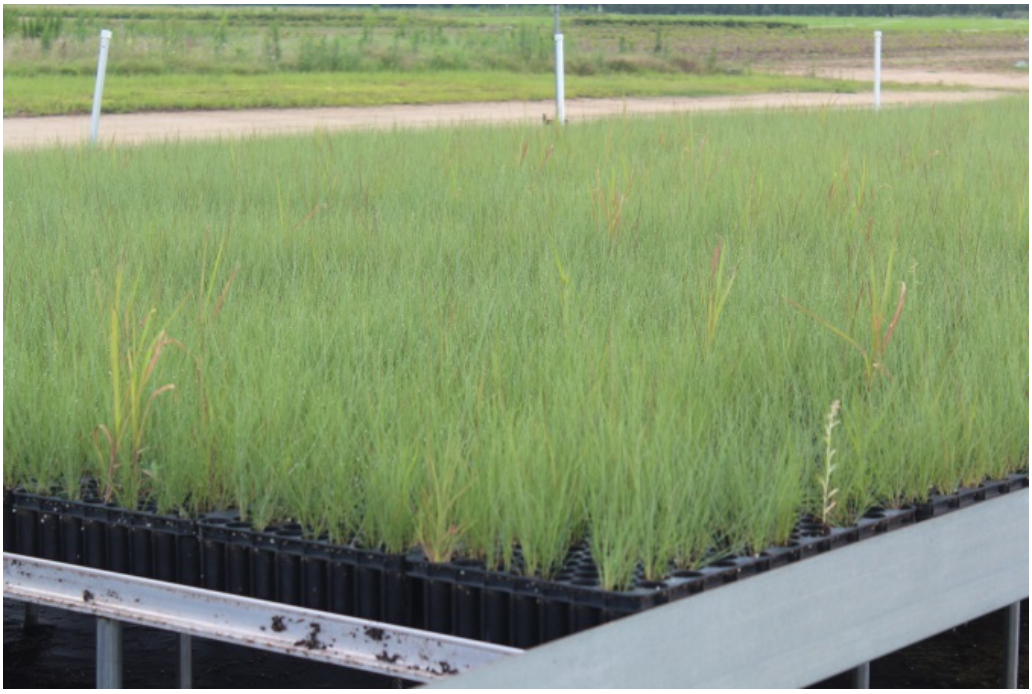

Figure 3. 2013 wiregrass seedlings grown in North Carolina.

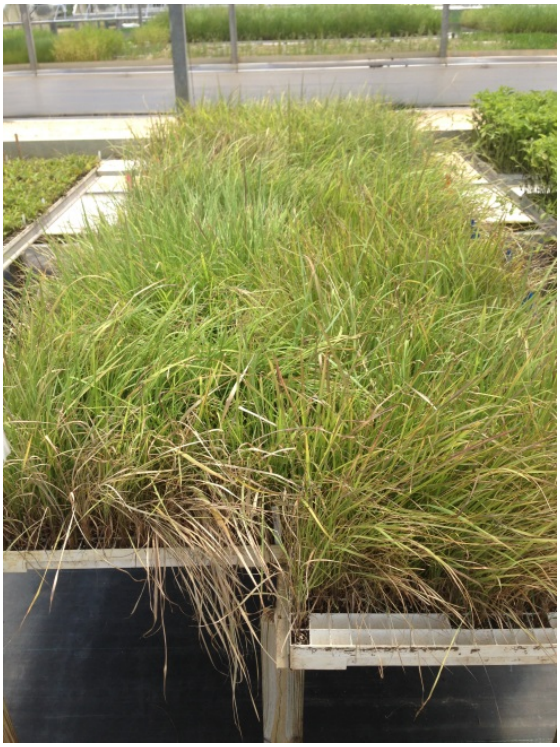

Figure 4. 2014 Indian grass grown at IFCO.

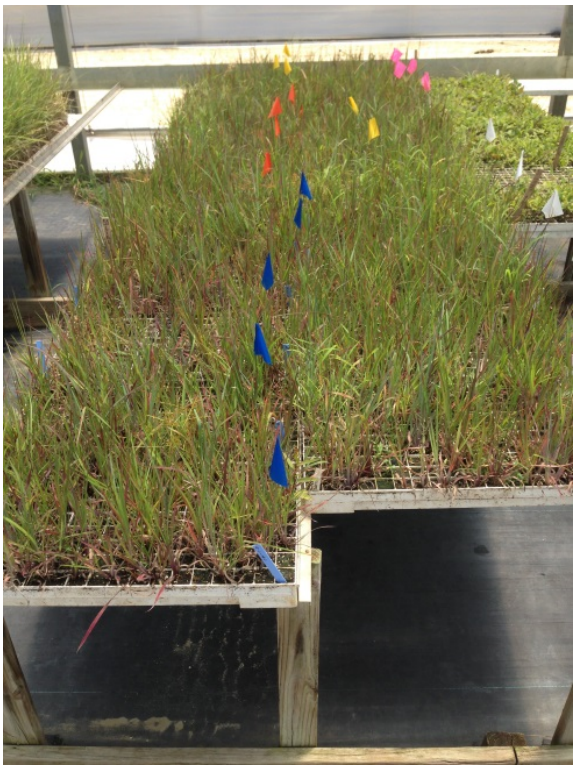

Figure 5. 2014 little bluestem grown at IFCO.

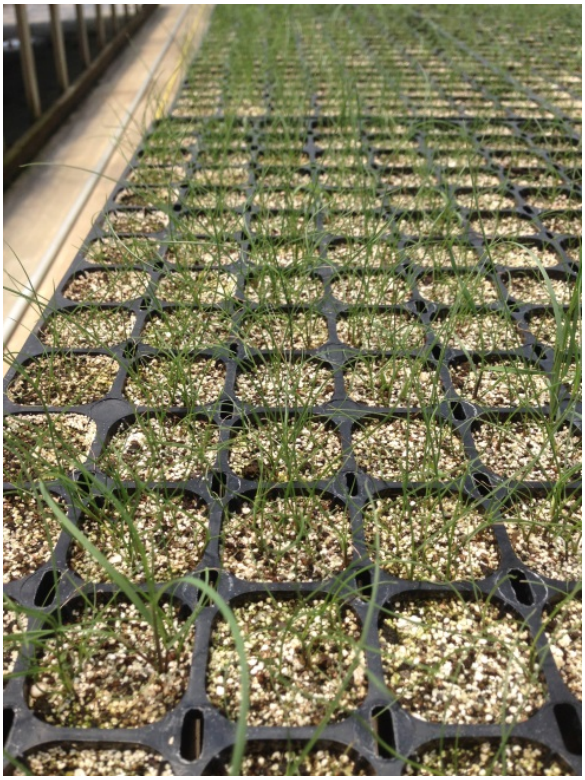

Figure 6. 2014 wiregrass seedlings grown at IFCO.