Pre-emerge herbicides and mulches for weed control in container-grown tree seedlings©

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INTRODUCTION

Seed propagation and seedling production in containers is a commonly used method for producing woody plant material for a range of applications including nursery stock liners and reforestation programs (Davis et al., 2008). Compared with bare root seedlings, container grown seedlings offer advantages such as an extended transplant season and increased transplant success (Fare, 2013). Some large-seeded species can be direct sown (ex. oak and hickory) into liner flats/containers while small-seeded species (ex. dogwood and yellow poplar) may need to be transplanted from plug trays. Weed control is a significant issue in containerized woody crop seedlings since plants may remain in the container for up to a year. Manually removing weeds is a time consuming and costly process due to the amount of labor required (Case et al., 2005). Additionally, agricultural labor has become difficult to maintain so nursery producers have fewer personnel to perform labor intensive tasks such as hand weeding (Rutan, 2016).

Weeding small seedlings/liners can also be a delicate process since the weed and crop roots intertwine and removing large weeds may damage crops. Pre-emergent herbicides are commonly used for weed control in container grown nursery stock, yet most products are not labeled for use in small containers [<10 cm (4 in.)] or in seedling production (Neal, 2016). Many pre-emergent herbicide labels recommend that herbicides be applied to plants after thorough irrigation and settling of substrate around the new transplants. Herbicide manufacturers are likely hesitant to approve products for use on small woody crop seedlings since they may be more susceptible to herbicide damage due to less developed root systems and/or the presence of tender foliage compared with larger plants or well established plants. Very little information is available regarding pre-emergent herbicide safety in container grown seedlings. Identifying safe and effective weed control options for woody crop seedling/liner production would benefit a large segment of ornamental crop production. The objective of this study was to evaluate the effects of mulch and pre-emergent herbicide applications on seedling growth.

MATERIALS AND METHODS

In May 2016, oak seeds [*Quercus acutissima* (sawtooth oak) and *Q. phellos* (willow oak)] were direct seeded into 8.9 cm (3.5 in.) containers filled with a 5 pine bark:1 peatmoss (by volume) substrate amended with controlled release fertilizer (Florikan 14-14-14; 4 lb yd^{-3}), dolomitic lime (4 lb yd^{-3}), and Micromax (0.75 lb yd^{-3}). In June 2016, seeds of *Cornus kousa* (dogwood), *Ginkgo biloba* (ginkgo), and *Magnolia virginiana* (sweetbay magnolia) were germinated in plug trays (128 cell) and transplanted to 8.9 cm containers. At 2 days after seeding (oaks) or 21 days after transplanting (other species) - mulches or pre-emergent herbicides were applied to containers and non-treated containers were used as controls (Table 1).

There were 9 replications per treatment per plant species, except for dogwood (7 replications) and gingko (6 replications). Mulches were applied to a depth of 0.8 cm (0.33 in.) and herbicides were applied using the labeled low rate. Spray-applied formulations were applied using a CO_2 sprayer calibrated to deliver 30 gallons $acre^{-1}$ at 30 psi using an 8003 flat fan nozzle (TeeJet Technologies, Glendale Heights, IL). Granular formulations were applied using a hand-shaker. The shoot height and stem diameter were recorded in August (oaks) and October (other species). Shoots were harvested and roots were washed to acquire shoot and root dry weight. Each plant species was treated as a separate experiment. All data were

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analyzed with linear models using the GLIMMIX procedure of SAS (Version 9.3; SAS Institute, Inc., Cary, North Carolina). Differences between treatment means were determined using the Shaffer-Simulated method (P<0.05).

Table 1. Shoot height of tree seedlings treated with a mulch or pre-emergent herbicide.

Treatment	Formulation	Shoot height (cm)				
		Sawtooth oak	Willow oak	Dogwood	Gingko	Sweetbay magnolia
Control	NA	35.9 ab[1]	36.2 a	15.6 ab	20.2 ab	21.4 a
Perlite	Mulch[2]	40.2 ab	33.4 a	17.1 a	20.9 ab	21.2 a
Pine Pellets	Mulch	35.2 ab	36.2 a	15.6 ab	23.5 a	19.2 a
Cedar Shavings	Mulch	36.3 ab	36.2 a	12.5 ab	22.1 ab	23.4 a
Trifluralin	Spray[3]	39.3 ab	32.9 a	9.4 ab	21.3 ab	21.4 a
Trifluralin	Granular	38.1 ab	32.1 a	11.1 ab	19.4 ab	22.7 a
Pendimethalin	Spray	38.4 ab	39.8 a	11.4 ab	21.7 ab	21.3 a
Pendimethalin	Granular	32.4 b	38.8 a	13.6 ab	22.3 ab	25.6 a
Isoxaben	Spray	42.3 a	38.9 a	6.8 b	20.8 ab	20.5 a
Trifluralin + Isoxaben	Granular	39.1 ab	34.7 a	13.8 ab	17.6 b	22.9 a
Prodiamine	Spray	39.6 ab	37.3 a	10.3 ab	19.4 ab	22.2 a

[1]Means followed by different letters within columns indicate significant difference at P<0.05 using the Shaffer-Simulated method.

[2]Mulches were applied to a depth of 0.8 cm (0.33 in.).

[3]Herbicides were applied using the labeled low rate (30 gal acre^{-1} application volume at 30 psi for liquid herbicide solutions).

RESULTS AND DISCUSSION

Overall, shoot height was statistically similar between seedlings in the control and seedlings in the remaining treatments for each species yet differences in shoot height among treatments varied within each species (Table 1). In particular, dogwood seedlings treated with isoxaben were significantly shorter compared with seedlings grown in perlite. Dogwood seedlings were stunted (yet not statistically) by all herbicide treatments compared with seedlings in the control, perlite, and pine pellets treatments. No significant differences in shoot height were observed among treatments for willow oak and sweetbay magnolia. Stem diameter was similar among all treatments for sawtooth oak, gingko, and sweetbay magnolia (Table 2). Dogwood stem diameter was significantly reduced for trifluralin (spray), isoxaben, and prodiamine compared with the control.

Shoot dry weight was similar among all treatments for sawtooth oak, gingko, and sweetbay magnolia, while shoot dry weight in the control was similar compared with all other treatments for willow oak (Table 3). With dogwood, shoot dry weight was greater in the control and perlite treatments compared with trifluralin (spray), isoxaben, and prodiamine. No differences occurred for root dry weight in sawtooth oak, willow oak, or sweetbay magnolia (Table 4). Although root dry weight varied within dogwood and gingko, the control treatments were statistically similar to all remaining treatments.

Overall, the herbicides and application rate evaluated in the study are safe to use on sawtooth and willow oak, gingko, and sweetbay magnolia. The labeled low herbicide application rate was used for this study, thus additional evaluations should be conducted using higher rates. Certain classes of herbicides may be more injurious to plants at potting or with developing roots. For example, herbicides in the dinitroaniline group (ex. trifluralin, prodiamine, and pendimethalin) can inhibit root development and reduce plant growth (Altland, 2003). Although not statistically significant, the reduced shoot and root dry weight observed for dogwood seedlings treated with trifluralin (spray) and prodiamine may have been a result of herbicide damage. Mulch applications did not significantly affect shoot growth, thus mulches should be considered as non-chemical options for weed control in seedling production.

Table 2. Stem diameter of tree seedlings treated with a mulch or pre-emergent herbicide.

Treatment	Formulation	Stem diameter (mm)				
		Sawtooth oak	Willow oak	Dogwood	Gingko	Sweetbay magnolia
Control	NA	3.04 a[1]	3.54 a	3.44 a	4.12 a	4.16 a
Perlite	Mulch[2]	2.94 a	3.34 a	3.35 a	4.45 a	4.30 a
Pine pellets	Mulch	2.89 a	3.29 a	2.94 ab	4.70 a	3.78 a
Cedar shavings	Mulch	2.97 a	3.31 a	2.43 ab	4.48 a	4.83 a
Trifluralin	Spray[3]	3.27 a	2.48 b	2.15 b	4.40 a	4.09 a
Trifluralin	Granular	2.84 a	3.01 ab	2.78 ab	4.00 a	4.54 a
Pendimethalin	Spray	3.10 a	3.35 a	2.53 ab	4.31 a	4.36 a
Pendimethalin	Granular	2.90 a	3.47 a	3.04 ab	4.75 a	4.92 a
Isoxaben	Spray	3.25 a	3.52 a	1.83 b	4.00 a	4.16 a
Trifluralin + isoxaben	Granular	3.18 a	3.14 ab	3.03 ab	3.71 a	4.67 a
Prodiamine	Spray	3.32 a	3.33 a	2.27 b	4.31 a	4.42 a

[1] Means followed by different letters within columns indicate significant difference at $P<0.05$ using the Shaffer-Simulated method.

[2] Mulches were applied to a depth of 0.8 cm (0.33 inch).

[3] Herbicides were applied using the labeled low rate (30 gal $acre^{-1}$ application volume at 30 psi for liquid herbicide solutions).

Table 3. Shoot dry weight (g) of tree seedlings treated with a mulch or pre-emergent herbicide.

Treatment	Formulation	Shoot dry weight (g)				
		Sawtooth oak	Willow oak	Dogwood	Gingko	Sweetbay magnolia
Control	NA	4.67 a[1]	3.89 ab	2.23 a	1.47 a	2.23 a
Perlite	Mulch[2]	4.69 a	4.17 ab	2.46 a	1.99 a	2.05 a
Pine Pellets	Mulch	4.12 a	3.75 ab	1.52 ab	2.17 a	1.66 a
Cedar Shavings	Mulch	4.34 a	3.75 ab	1.33 ab	2.18 a	2.80 a
Trifluralin	Spray[3]	5.55 a	2.27 b	0.82 b	1.79 a	2.02 a
Trifluralin	Granular	4.95 a	3.03 ab	1.16 ab	1.32 a	2.32 a
Pendimethalin	Spray	5.47 a	3.86 ab	1.32 ab	1.89 a	2.21 a
Pendimethalin	Granular	3.94 a	4.18 a	1.70 ab	2.32 a	2.75 a
Isoxaben	Spray	5.63 a	4.38 a	0.32 b	1.27 a	2.04 a
Trifluralin + Isoxaben	Granular	4.56 a	3.65 ab	1.69 ab	0.98 a	2.50 a
Prodiamine	Spray	6.19 a	3.84 ab	0.71 b	1.68 a	2.16 a

[1] Means followed by different letters within columns indicate significant difference at $P<0.05$ using the Shaffer-Simulated method.

[2] Mulches were applied to a depth of 0.8 cm (0.33 inch).

[3] Herbicides were applied using the labeled low rate (30 gal $acre^{-1}$ application volume at 30 psi for liquid herbicide solutions).

Although none of the products used in this study were labeled for use in container grown seedling or liner production, the results are promising and further evaluations on additional herbicide active ingredients and plant species should be considered. Many pre-emergent herbicides are not labeled for containers less than 10 cm (4 in.) wide, yet in this study only dogwood exhibited significant herbicide injury. Future studies will evaluate increased herbicide application rates and include additional plant species. The studies will also evaluate the effectiveness of various mulches and pre-emergent herbicides for controlling various weed species in small containers.

Table 4. Root dry weight (g) of tree seedlings treated with a mulch or pre-emergent herbicide.

Treatment	Formulation	Root dry weight (g)				
		Sawtooth oak	Willow oak	Dogwood	Gingko	Sweetbay magnolia
Control	NA	6.25 a[1]	4.51 a	1.22 ab	2.00 ab	2.22 a
Perlite	Mulch[2]	6.37 a	4.35 a	1.93 a	2.67 ab	2.28 a
Pine Pellets	Mulch	5.27 a	3.69 a	1.08 ab	3.09 a	1.67 a
Cedar shavings	Mulch	5.71 a	3.81 a	0.70 b	2.69 ab	2.95 a
Trifluralin	Spray[3]	6.43 a	2.68 a	0.51 b	2.20 ab	2.04 a
Trifluralin	Granular	6.39 a	4.05 a	0.72 b	1.62 ab	2.50 a
Pendimethalin	Spray	5.91 a	4.73 a	0.91 b	2.52 ab	2.46 a
Pendimethalin	Granular	5.33 a	4.35 a	1.00 b	2.28 ab	2.76 a
Isoxaben	Spray	5.38 a	4.64 a	0.30 b	1.78 ab	2.25 a
Trifluralin + isoxaben	Granular	6.38 a	3.98 a	1.03 ab	1.32 b	2.58 a
Prodiamine	Spray	7.44 a	4.40 a	0.42 b	1.70 ab	2.29 a

[1]Means followed by different letters within columns indicate significant difference at $P<0.05$ using the Shaffer-Simulated method.

[2]Mulches were applied to a depth of 0.8 cm (0.33 inch).

[3]Herbicides were applied using the labeled low rate (30 gal acre^{-1} application volume at 30 psi for liquid herbicide solutions).

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