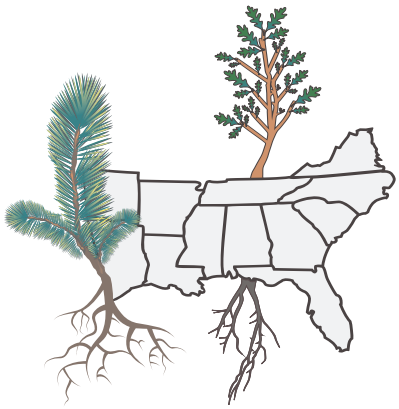

Auburn University Southern Forest Nursery Management Cooperative

RESEARCH REPORT 13-03

THE EFFECT OF HARDWOOD SEED SIZE, SPECIES AND NURSERY SOILS ON THE FORMATION OF STEM GALLS AND SEEDLING TOLERANCE TO APPLICATIONS OF PENDULUM® AQUACAP

by
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INTRODUCTION

The Nursery Cooperative has reported that pre-emergent applications of Pendulum® Aquacap (38.7% pendimethalin) in loblolly pine seedbeds effectively controls prostrate spurge. However, Pendulum® Aquacap has resulted in herbicide galls on loblolly pine seedlings if applied after germination of loblolly pine seed (Jackson 2012, South and Hill 2010). Examination of sowing dates and application dates indicate that application of PAC as little as 2 weeks post sowing could result in gall formation. Thus, timing is one factor as well as soil and possibly seedling genetics and soil temperatures. The effectiveness of PAC in controlling prostrate spurge in non-conifer seedling beds opens up a number of possible species by soil by timing issues. One of the first questions would be formation of herbicide galls on hardwood species as we have not tested Pendulum® Aquacap on hardwood seedbeds and monitored for phytotoxicity or gall formation. It is possible that seed size may be a factor in tolerance to PAC and gall formation. Seed size is an important indicator for predicting seedling vigor. A large seed compared to a small seed from a similar species will perform better and have a greater chance to survive because the amount of germination energy is greater in the large seed. Likewise, a larger seeded species will have more energy in the early growth stages than a smaller seeded species. The objectives of this particular trial were three-fold: Will Pendulum® Aquacap cause herbicide galls on hardwoods? Will seed size influence hardwood tolerance to Pendulum® Aquacap? And, finally, will soil type influence Pendulum® Aquacap phytotoxicity to hardwood seedlings?

METHODOLOGY

To answer these questions that the use of PAC has on tree species and seed size, two application rates of Pendulum® Aquacap at 34 and 68 oz/ac were tested at the time of sowing on seven hardwood species. The two rates of Pendulum AquaCap were applied by AU Nursery Cooperative personnel using a CO2 hand sprayer calibrated at 22 gallons per acre on the different hardwood seedling species. Each treatment plot was one seedling bed wide X 5 feet in length that was replicated five times. The experimental area were the seedlings in one treatment plot and 150 feet of one nursery bed was used plus 20 feet of buffer for each tree species in each nursery.

At the Native Forest Nursery in Chatsworth, GA silver maple, sweetgum, and sycamore were sown on April 15, 2012 and the herbicides were applied on April 18, 2012. Blackgum, pear, green ash, and red maple were sown on April 16, 2012 at the Arborgen SuperTree Nursery in Shellman, GA with herbicide treatments applied on April 17th, 2012 (Table 1). The nursery staff made observations and recorded abnormalities in seedling growth within the treated plots and reported that information to the Nursery Cooperative staff in Auburn. Prior to herbicide applications, soil samples were collected from the first six inches of soil in each treatment plot. The samples were pooled and analyzed for organic matter, pH, and soil texture (sand, silt, and clay contents). At the end of the growing season, seedlings in each treatment plot were lifted from inside a 9 x 48 inch frame placed in the center of the plot. At the Nursery Cooperative laboratory at Auburn University, seedling density, root collar diameter, height, and root/shoot dry weights was measured to determine seedling tolerance to the various herbicide treatments.

RESULTS AND DISCUSSION

Soil collected and analyzed at the Soil Testing Laboratory in Auburn University indicated different soil types for the two nurseries used in the pot trials. This was intentional as soil type affects herbicide activity. Soil samples from the Native Forest Nursery in Chatsworth, GA indicated a sandy loam (63:30:7) soil, with soil pH of 5.9 and organic matter content of 2.9%. Whereas the soil type from the ArborGen Supertree nursery in Shellman, GA was a sand (91:8:1), with a soil pH of 5.5 and an organic matter content of 1.1% (Table 1). At the end of the growing season seedling samples were collected and examined for herbicide galls on every stem and seedlings measured for growth parameters including root collar diameter, height, and seedling density. There were no significant differences in seedling densities in green ash, blackgum, pear, or red maple from the Arborgen Nursery in Shellman GA (Tables 1, 2, 3 and 4) when treated with 34 oz/ac of PAC at the time of sowing. While not significant at the 0.05% level, there appeared to be slight reductions (numerically) in density and plantable seedlings treated with 64 oz/ac of Pendulum® Aquacap for pear and red maple (Table 4 and 5).

In contrast, at the Native Forest Nursery in Chatsworth, GA PAC applied at the time of sowing over silver maple and sweetgum, was detrimental to seedling densities and seedling size (Tables

6 & 7). The reduction in seedling density for silver maple and sweetgum explains why RCD was significantly higher in both species and shoot weight was significantly higher in sweetgum at the 64 oz/ac rate. The beds sown to sycamore (even control plots) did not germinate so there is no data on the effects of PAC on this particular species and seed size.

In a perfect world, one would have sown the same species at the two nurseries and then would have been able to compare species, seed size across soil types. Because we don't live in a perfect world, the behavior of the two maple species (similar in seed size and the same Genus) suggests that soil type has some effect on the herbicides' mode of action on hardwood seedlings. At the SuperTree Nursery in Shellman, GA the PAC34 rate did not have any measureable effect on the performance of red maple, but has some deleterious action at the PAC68 rate (Table 5). In the heavier soils that are common at the Native Forest Nursery in Chatsworth, both rates of PAC were deleterious to silver maple (Table 6).

Within a nursery, however, it appears that susceptibility to the herbicide is not dependent on seed size as much as soil type based on the seedling response to the herbicide. For example, sweetgum (82,000 seeds/lb) and silver maple (1,780 seeds/lb) were both negatively affected by Pendulum® Aquacap at the Chatsworth Nursery (Table 6 and 7). In contrast, the four different species and seed sizes at the SuperTree Nursery in Shellman, behaved differently, independent of seed size. For example red maple and green ash, both with 20,000 seed /lb behaved differently with red maple negatively affected by the PAC68 rate, whereas the green ash was not (Table 5 vs Table 2). Since soil type appears to be more of a factor than seed size (along with species tolerance), Pendulum® Aquacap should not be used pre-emergently on heavier soils unless tested on small areas first. However, Pendulum® Aquacap applied pre-emergently on the lighter soil at the Arborgen Nursery resulted in only a slight reduction in density at the 34 oz/ac rate for green ash, pear, and red maple. Blackgum appeared to have an increase in density and plantable seedlings at 34 oz/ac.

Not surprisingly, tolerance to applications of PAC are hardwood species dependent, seed size independent and soil texture is important. When trying to control prostrate spurge with PAC in hardwoods, start with small plots at the time of sowing. Most importantly, there were no herbicide galls on any of the seedlings sampled and examined in the laboratory.

MANAGEMENT IMPLICATIONS

Susceptibility to Pendulum® Aquacap is NOT dependent on seed size as seedlings densities for both silver maple, a large seeded species, and sweetgum, a small seeded species, were negatively influenced by both the 34 and 68 oz/ac rates of Pendulum® Aquacap.

Susceptibility to Pendulum® Aquacap may be dependent on soil type as more phytotoxicity influences appeared in the heavy soils of Chatsworth, GA in silver maple and sweetgum.

There was a slight numerical, but statistically insignificant reduction in seedling density with Pendulum® Aquacap at 34 oz/ac for green ash, pear, and red maple on sandier soils from Shellman, GA. So species sensitivity to this herbicide should be tested.

Unlike in loblolly pine, herbicide gall formation was not observed on any of the hardwood species examined.

LITERATURE CITED

Jackson, D.P. 2012. Timing of Pendulum® AquaCap™ application influences the chance of gall formation on seedlings. Southern Forest Nursery Management Cooperative, School of Forestry and Wildlife Sciences, Auburn University. Management Alert 12-02.

South, D.B. and T. Hill. 2010. Tolerance of loblolly and slash pine seedlings to pendimethalin. Southern Forest Nursery Management Cooperative, School of Forestry and Wildlife Sciences, Auburn University. Research Report 10-04: 9 p.

Table 1. Nursery location soil type species treated and the relative hardwood seed size based on the number of seed per pound.

Nursery Location	Soil Texture Type	Hardwood Species	Number seed per lb*	Seed Sown	Pendulum AquaCap Application Date
Native Forest Nursery Chatsworth, GA	sandy loam (63:30:7) soil pH 5.9 organic matter 2.9%	Silver Maple	1,780	4/15/2012	4/18/2012
Supertree Nursery Shellman, GA	sand (91:8:1) soil pH 5.5 organic matter 1.1%	Blackgum	3,300	4/16/2012	4/17/2012
Supertree Nursery Shellman, GA	sand (91:8:1) soil pH 5.5 organic matter 1.1%	Pear	14,400	4/16/2012	4/17/2012
Supertree Nursery Shellman, GA	sand (91:8:1) soil pH 5.5 organic matter 1.1%	Green Ash	20,950	4/16/2012	4/17/2012
Supertree Nursery Shellman, GA	sand (91:8:1) soil pH 5.5 organic matter 1.1%	Red Maple	22,860	4/16/2012	4/17/2012
Native Forest Nursery Chatsworth, GA	sandy loam (63:30:7) soil pH 5.9 organic matter 2.9%	Sweetgum	82,000	4/15/2012	4/18/2012
Native Forest Nursery Chatsworth, GA	sandy loam (63:30:7) soil pH 5.9 organic matter 2.9%	Sycamore**	149,900	4/15/2012	4/18/2012

*Seed size data taken from Seeds of Woody Plants in the United States, Agricultural Handbook No. 450, USFS, Washington, D.C. 1974.

**Sycamore seed did not germinate in any of the plots at the Native Forest Nursery. No PAC data is presented for this species.

Table 2. Green ash seedling densities and seedling size after treatment with Pendulum® Aquacap at the time of sowing in 2012, Shellman, GA.

Treatment		Density		Culls		Plantable		RCD		Hgt		Shoot Wgt	
		seedlings/ft²		*seedlings/ft²*		*seedlings/ft²*		*mm*		*cm*		*grams*	
Control		28.1	a	6.7	a	21.4	a	6.9	a	29.1	a	2.1	a
PAC34		26.2	a	6.3	a	19.8	a	6.6	a	28.2	a	1.9	a
PAC68		25.8	a	6.0	a	19.8	a	7.5	a	30.2	a	2.6	a
LSD		*9.3*		*3.6*		*6.2*		*0.89*		*3.6*		*0.84*	
Source	df	----------P > F----------											
Treatment	2	0.8358		0.9166		0.8051		0.15		0.495		0.2376	

PAC34 and PAC68 is 34 and 68 oz/ac of Pendulum® Aquacap, respectively.

Table 3. Blackgum seedling densities and seedling size after treatment with Pendulum® Aquacap at the time of sowing in 2012, Shellman, GA.

Treatment		Density		Culls		Plantable		RCD		Hgt		Shoot Wgt	
		seedlings/ft²		*seedlings/ft²*		*seedlings/ft²*		*mm*		*cm*		*grams*	
Control		10.5	a	0.2	a	10.2	a	6.9	a	29.6	a	1.9	a
PAC34		13.6	a	0.8	a	12.8	a	6.3	a	28.4	a	1.6	a
PAC68		12.3	a	0.2	a	12.1	a	6.7	a	32.0	a	1.9	a
LSD		*3.0*		*0.91*		*3.0*		*0.77*		*5.1*		*0.47*	
Source	df	----------P > F----------											
Treatment	2	0.1281		0.3062		0.2035		0.1844		0.3231		0.2886	

PAC34 and PAC68 is 34 and 68 oz/ac of Pendulum® Aquacap, respectively.

Table 4. Pear seedling densities and seedling size after treatment with Pendulum® Aquacap at the time of sowing in 2012, Shellman, GA.

Treatment	Density		Culls		Plantable		RCD		Hgt		Shoot Wgt	
	seedlings/ft²		*seedlings/ft²*		*seedlings/ft²*		*mm*		*cm*		*grams*	
Control	11.3	a	1.8	a	9.4	a	6.4	a	44.7	a	6.0	a
PAC34	11.4	a	1.6	a	9.8	a	6.5	a	43.9	a	6.3	a
PAC68	9.0	a	1.2	a	7.8	a	6.9	a	45.3	a	7.2	a
LSD	*4.2*		*1.9*		*2.9*		*0.59*		*4.7*		*1.8*	
Source df	----------P > F----------											
Treatment 2	0.3822		0.7301		0.3061		0.1751		0.801		0.3628	

PAC34 and PAC68 is 34 and 68 oz/ac of Pendulum® Aquacap, respectively.

Table 5. Red maple seedling densities and seedling size after treatment with Pendulum® Aquacap at the time of sowing in 2012, Shellman, GA.

Treatment	Density		Culls		Plantable		RCD		Hgt		Shoot Wgt	
	seedlings/ft²		*seedlings/ft²*		*seedlings/ft²*		*mm*		*cm*		*grams*	
Control	7.4	a	0.86	a	6.5	a	7.2	a	26.0	a	1.8	a
PAC34	7.1	a	0.40	a	6.7	a	6.7	a	23.9	a	1.4	a
PAC68	4.6	a	0.86	a	3.7	a	9.4	a	21.5	a	1.3	a
LSD	*4.1*		*0.70*		*3.7*		*5.3*		*4.6*		*0.67*	
Source df	----------P > F----------											
Treatment 2	0.2776		0.2687		0.1774		0.5085		0.1474		0.2752	

PAC34 and PAC68 is 34 and 68 oz/ac of Pendulum® Aquacap, respectively.

Table 6. Silver maple seedling densities and seedling size after treatment with Pendulum® Aquacap at the time of sowing in 2012, Chatsworth, GA.

Treatment	Density *seedlings/ft²*		Culls *seedlings/ft²*		Plantable *seedlings/ft²*		RCD *mm*		Hgt *cm*		Shoot Wgt *grams*	
Control	15.3	a	4.4	a	10.9	a	5.1	b	40.0	a	2.5	a
PAC34	4.3	b	0.8	b	3.5	b	5.9	a	37.4	ab	3.2	a
PAC68	1.9	b	0.5	b	1.4	c	6.4	a	36.0	b	3.4	a
LSD	*3.2*		*2.4*		*1.7*		*0.55*		*3.2*		*0.99*	
Source df	----------P > F----------											
Treatment 2	<0.0001		0.0121		<0.0001		0.0023		0.0613		0.1352	

PAC34 and PAC68 is 34 and 68 oz/ac of Pendulum® Aquacap, respectively.

Table 7. Sweetgum seedling densities and seedling size after treatment with Pendulum® Aquacap at the time of sowing in 2012, Chatsworth, GA.

Treatment	Density *seedlings/ft²*		Culls *seedlings/ft²*		Plantable *seedlings/ft²*		RCD *mm*		Hgt *cm*		Shoot Wgt *grams*	
Control	20.8	a	10.4	a	10.4	a	5.3	b	65.1	a	5.5	b
PAC34	16.0	b	6.55	b	9.5	a	6.0	a	61.1	ab	6.5	ab
PAC68	10.5	c	3.95	c	6.55	b	6.4	a	52.4	b	7.9	a
LSD	*2.5*		*1.6*		*2.7*		*0.59*		*11.2*		*1.7*	
Source df	----------P > F----------											
Treatment 2	<0.0001		<0.0001		0.0304		0.0069		0.0786		0.0323	

PAC34 and PAC68 is 34 and 68 oz/ac of Pendulum® Aquacap, respectively.