Auburn University
Southern Forest Nursery
Management Cooperative

RESEARCH REPORT 14-03

EFFECT OF TIMING OF PAC APPLICATIONS 8, 12, AND 16 WEEKS AFTER SOWING ON HERBICIDE-INDUCED GALL FORMATION AND SEEDLING GROWTH.

by
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INTRODUCTION

Spurge (Chamaesyce maculate) is a troublesome weed in southern pine nurseries and, under some conditions, can stunt seedling growth (South and Hill 2008). Thirty years ago the weed was not even mentioned as an issue; today, spurge gets top billing right behind yellow and purple nut sedge (Starkey et al. in press). Of those herbicides commonly used, oxyfluorfen (e.g. Goal®) provides some level of pre-emergence control but once the weed germinates and becomes established, spurge is difficult to control with most selective herbicides. While trials with metsulfuron methyl have demonstrated effective control of emerged prostrate spurge (South and Hill 2007) this herbicide can cause stunting, especially when applied to young seedlings. Preliminary trials with post-emergence applications of the herbicide pendimethalin (applied prior to germination of spurge seed) provided good control of spurge in Alabama (South and Hill 2009). However, herbicide galls were produced on stems of seedlings near the groundline. In 2009, testing was expanded to determine if a pre-emergence application would also result in the production of herbicide galls. Because the pendimethalin injury on pine seedlings is similar to that reported with cotton (Miller and Crater 1980), we have speculated that factors such as heat and soil texture may also contribute to gall formation when PAC is applied after pine germination (South and Hill 2009).

Having recently shown that PAC-induced galls do not affect seedling survival (Enebak et al 2014), it is still Nursery Cooperative's recommendation to use PAC at the time of sowing. Numerous trials have shown that galls are formed when PAC is used from 8-10 weeks post sowing. The next question then "is there a later time in the growing season when seedlings are not susceptible to PAC-induced herbicide galls?" To answer that question, a timing trial was implemented that examined two rates of PAC (34 & 68 oz/a) applied at 8, 12, and 16 weeks post sowing to evaluate loblolly pine (Pinus taeda) seedlings for herbicide gall formation after post-emergent applications of Pendulum® AquaCap™ (38.7% pendimethalin) at three different times and at two application rates.

METHODOLOGY

To answer the question about the timing of PAC post-sowing applications has on the formation of herbicide galls and loblolly growth, two rates of Pendulum® AquaCap™ at 34 and 68 oz/ac were

tested on loblolly pine shown in Table 1. Post-emergent herbicide applications of Pendulum® AquaCap™ were applied by AU Nursery Cooperative personnel to loblolly pine 8, 12, and 16 weeks post-sow. The herbicide treatments were applied with a CO2 hand sprayer calibrated to broadcast a spray volume of 25 gallons per acre. Each treatment plot was one seedling bed wide by 10 feet in length, replicated five times. The experimental unit was the seedlings in one treatment plot and the experiment used 450 feet (10 ft plots X 9 treatments X 5 replications) of nursery bed space.

The nursery at the ArborGen Supertree nursery staff in Shellman, GA 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 the first herbicide application at 8 weeks post sowing, 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 (November 2013), 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 herbicide treatments (0, 34 & 68 oz/a) over the three treatment periods (8, 12 and 16 weeks post-sowing).

RESULTS AND DISCUSSION

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%. In previous studies nurseries with sandy soils (vs heavier) soils have had less gall formation at a given rate of PAC (Jackson and Brooks 2012, Enebak et al. 2013). Not surprising, as we have previously observed, the use of PAC at 68 oz/a at 8 weeks resulted in a significant number of herbicide-galled seedlings on the loblolly pine at the end of the growing season (Figure 1), with 0.0, 0.1 and 3.5 galled seedlings per ft^2, respectively (Table 2a). One of the unknown factors with the use of this herbicide is at 12 and 16 weeks post sowing applications. In this case, application of PAC at the 68 oz/a resulted in significantly more galled seedlings ($7.1/ft^2$) than either the control ($0.0\ ft^2$) or the 34 oz/a ($0.8\ ft^2$), galled seedlings respectively (Figure 1, Table 2b) at 12 weeks post sowing. In contrast, however, the use of PAC (34 oz/a) at 16 weeks post sowing resulted in no herbicide galls formed (Figure 1, Table 2c) while PAC (68 oz/a) at 16 weeks, while not significantly different from either the Check or PAC 34, did result in 0.6 seedlings ft^2 with a herbicide gall. As far as the other seeding quality characteristics, the use of PAC at 8, 12, or 16 weeks had no effect on root biomass (Figure 2, Tables 2b, 2c, 3b, 3c), seedling densities (Figure 3, Table 2a, 3a), shoot height (Table 2c, 3c) or RCD (Tables 2c, 3c). As shown in Research Report 14-02 (Enebak et al 2014), these herbicide galls do not affect seedling quality or survival, but galls on seedlings are generally considered a fusiform rust infection. Care should therefore be taken if one were to use the higher rate at 16 weeks post sowing. Overall, it is possible to use PAC at the time of sowing and again 16 weeks post sowing to prevent further spurge development.

MANAGEMENT IMPLICATIONS

- The application of at PAC at either the 34 oz/a or the 68 oz/a at 8 and 12 weeks post sowing will result in the formation of herbicide galls on loblolly pine stems. The higher the rate, the more galls were formed. This was expected.

- The application of PAC at the 34 oz/a at 16 weeks post sowing did not result in any gall formation. This was suspected; that the use of PAC beyond 12 weeks will result in fewer galls formed.

- The application of PAC at the 68 oz/a at 16 weeks did result in the formation of some galls (0.6 ft2). This amount may be too much for nursery production systems to accept.

- It is therefore possible to use the lower rate of PAC (34 oz/a) at 16 weeks post sowing to prevent further spurge development.

- Nursery Cooperative still recommends the use of PAC at the time of sowing to control spurge and avoid the formation of herbicide galls.

LITERATURE CITED

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Table 1. Herbicide treatments applied to loblolly pine 8, 12 and 16 weeks post-sowing at the ArborGen Supertree nursery in Shellman, GA 2013.

Application Time *(Weeks Post-Sow)*	**Post-emergent Herbicide** *(Trade Name)*	**Product** *(oz/ac)*
8	*Control*	0
8	Pendulum® AquaCap	34
8	Pendulum® AquaCap	68
12	*Control*	0
12	Pendulum® AquaCap	34
12	Pendulum® AquaCap	68
16	*Control*	0
16	Pendulum® AquaCap	34
16	Pendulum® AquaCap	68

Table 2a. Effect of PAC treatments at 8 weeks post sowing on seedling characteristics Shellman, GA 2013.

	8 Wk								
Trt	Galls* (ft^2)	Culls (ft^2)	Plant (ft^2)	Total (ft^2)	RtWgt (g)	ShtWgt (g)	RWR (%)	ShtHgt (cm)	RCD (mm)
Check	0.0	7.0	20.0	27.1	0.47	2.06	18	23.2	3.98
PAC 34	0.1	6.0	21.6	27.6	0.54	2.13	20	23.3	4.19
PAC 68	3.5	6.2	21.4	27.6	0.47	1.97	19	23.2	4.00

* If present different letters within a time of application indicate a significant difference among the treatment (Check, PAC 34 and PAC 68) means using Duncan's multiple range test at alpha = 0.05.

Table 2b. Effect of PAC treatments at 12 weeks post sowing on seedling characteristics Shellman, GA 2013.

	12 Wk								
Trt	Galls* (ft^2)	Culls (ft^2)	Plant (ft^2)	Total (ft^2)	RtWgt (g)	ShtWgt (g)	RWR (%)	ShtHgt (cm)	RCD (mm)
Check	0.0 a	4.6	20.6	25.3	0.59	2.64	18	23.8	4.34
PAC 34	0.8 a	4.7	22.8	27.6	0.59	2.74	17	24.1	4.32
PAC 68	7.14 b	4.6	22.5	27.1	0.50	2.45	17	24.2	4.26

* If present different letters within a time of application indicate a significant difference among the treatment (Check, PAC 34 and PAC 68) means using Duncan's multiple range test at alpha = 0.05.

Table 2c. Effect of PAC treatments at 16 weeks post sowing on seedling characteristics Shellman, GA 2013.

	16 Wk								
Trt	*Galls* (ft^2)*	*Culls (ft^2)*	*Plant (ft^2)*	*Total (ft^2)*	*RtWgt (g)*	*ShtWgt (g)*	*RWR (%)*	*ShtHgt (cm)*	*RCD (mm)*
Check	0.0 a	6.6	18.9 ab	25.5	0.59	2.54	19	23.7	4.32
PAC 34	0.0 a	6.8	21.3 a	28.0	0.56	2.27	19	23.5	4.26
PAC 68	0.6 a	8.7	16.8 b	25.6	0.58	2.56	18	23.4	4.42

* If present different letters within a time of application indicate a significant difference among the treatment (Check, PAC 34 and PAC 68) means using Duncan's multiple range test at alpha = 0.05.

Table 3a. Effect of PAC treatments at 8, 12 and 16 weeks post sowing on seedling characteristics Shellman, GA 2013.

	Galls* (ft^2)			Culls (ft^2)			Plant* ($ft^{2)}$		
	8 wk	12 wk	16 wk	8 wk	12 wk	16 wk	8 wk	12 wk	16 wk
Check	0.0 a	0.0 a	0.0 a	7.0	4.6	6.6	20.0 a	20.6 a	18.9 ab
PAC 34	0.14 a	0.8 a	0.0 a	6.0	4.7	6.8	21.6 a	22.8 a	21.3 a
PAC 68	3.5 b	7.14 b	0.6 a	6.2	4.6	8.7	21.4 a	22.5 a	16.8 b

* If present different letters within a time of application indicate a significant difference among the treatment (Check, PAC 34 and PAC 68) means using Duncan's multiple range test at alpha = 0.05.

Table 3b. Effect of PAC treatments at 8, 12 and 16 weeks post sowing on seedling characteristics Shellman, GA 2013.

	Total (ft^2)			RtWgt (g)			ShtWgt (g)		
	8 wk	12 wk	16 wk	8 wk	12 wk	16 wk	8 wk	12 wk	16 wk
Check	27.1	25.3	25.5	0.47	0.59 a	0.59	2.06	2.64	2.54
PAC 34	27.6	27.6	28.0	0.54	0.59 ab	0.56	2.13	2.74	2.27
PAC 68	27.6	27.1	25.6	0.47	0.50 b	0.58	1.97	2.45	2.56

* If present different letters within a time of application indicate a significant difference among the treatment (Check, PAC 34 and PAC 68) means using Duncan's multiple range test at alpha = 0.05.

Table 3c. Effect of PAC treatments at 8, 12 and 16 weeks post sowing on seedling characteristics Shellman, GA 2013.

	RWR (%)			ShtHgt (cm)			RCD (mm)		
	8 wk	12 wk	16 wk	8 wk	12 wk	16 wk	8 wk	12 wk	16 wk
Check	18	18	19	23.2	23.8	23.7	3.98	4.34	4.32
PAC 34	20	17	19	23.3	24.1	23.5	4.19	4.32	4.26
PAC 68	19	17	18	23.2	24.2	23.4	4.00	4.26	4.42

* If present different letters within a time of application indicate a significant difference among the treatment (Check, PAC 34 and PAC 68) means using Duncan's multiple range test at alpha = 0.05.

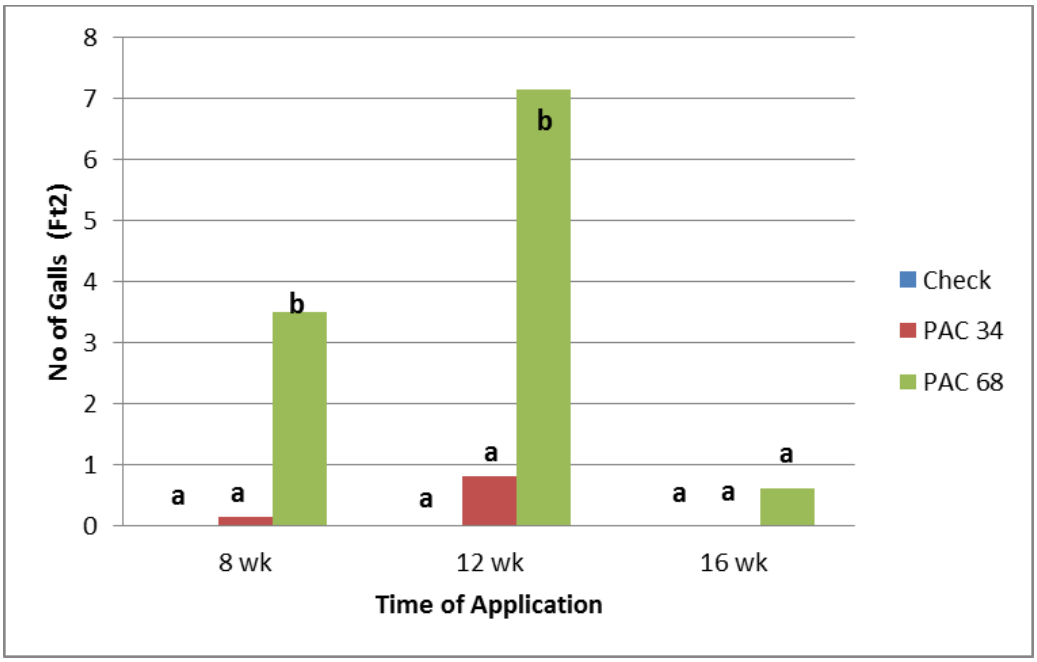

Figure 1. Effect of PAC timing post sowing and rate on the production of gall formation on loblolly pine – Shellman, GA 2013.

* If present different letters within a time of application indicate a significant difference among the treatment (Check, PAC 34 and PAC 68) means using Duncan's multiple range test at alpha = 0.05.

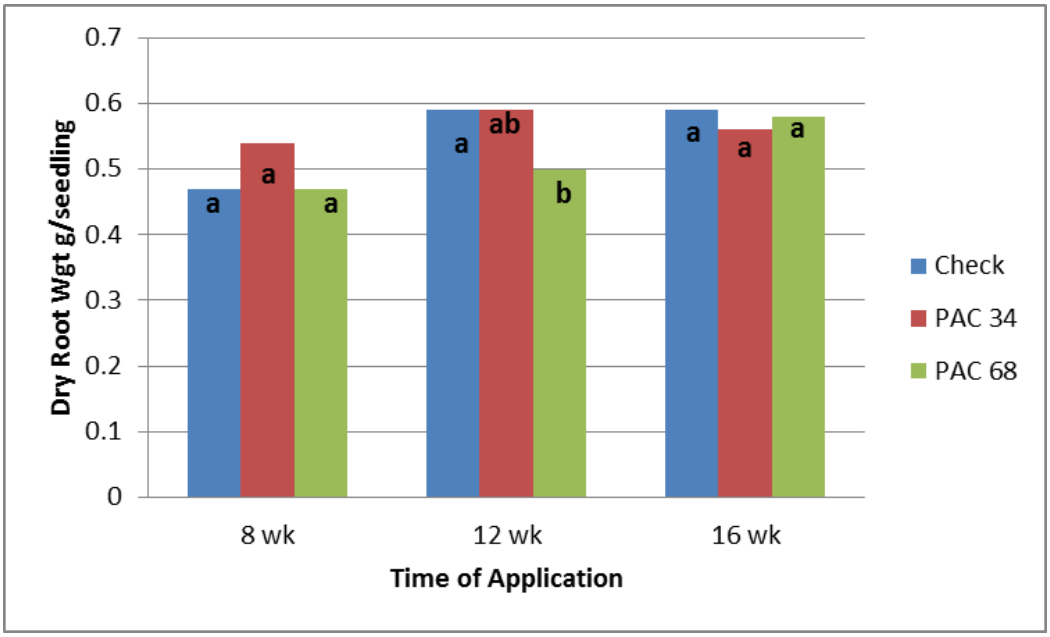

Figure 2. Effect of PAC timing post sowing and rate on loblolly pine seedling biomass production – Shellman, GA 2013.

* If present different letters within a time of application indicate a significant difference among the treatment (Check, PAC 34 and PAC 68) means using Duncan's multiple range test at alpha = 0.05.

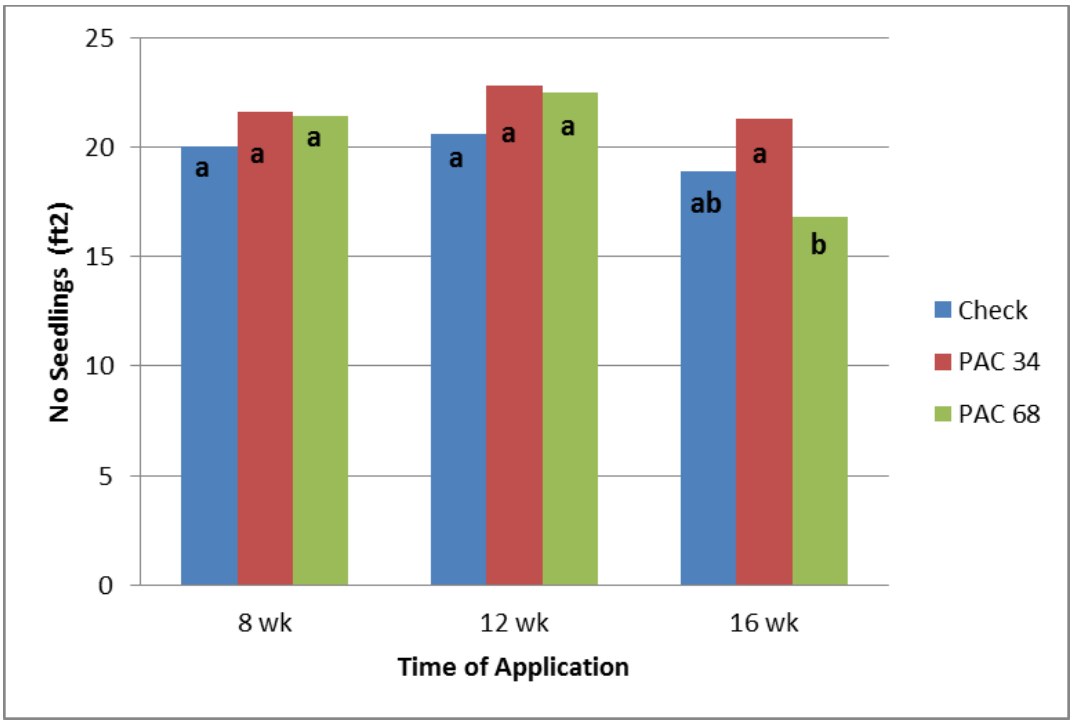

Figure 3. Effect of PAC timing post sowing and rate on loblolly pine seedling production – Shellman, GA 2013.

* If present different letters within a time of application indicate a significant difference among the treatment (Check, PAC 34 and PAC 68) means using Duncan's multiple range test at alpha = 0.05.