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TOLERANCE OF LOBLOLLY PINE AND SLASH PINE SEEDLINGS TO PENDIMETHALIN

by
Nina Payne and Scott Enebak

INTRODUCTION

Spurge (*Chamaesyce maculate*) is a troublesome weed in southern pine nurseries and, under some conditions, it can stunt seedling growth (South and Hill 2008). Oxyfluorfen (e.g. Goal®) provides some level of preemergence control but once it 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 very young seedlings.

Preliminary trials with postemergence 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 preemergence application would also result in the production of herbicide galls. The objective of this study was to determine if this herbicide could be applied at time of sowing without causing galls.

METHODOLOGY

Four studies were installed during the 2009 growing season. Plot size was one bed wide and 10-feet long. Pendimethalin (Pendulum-Aquacap®) was applied either once at sowing, once after emergence (e.g. June) or twice (May and again in June). In addition, a combination of pendimethalin plus dimethenamid (Freehand®) was applied at two rates. Freehand contains 1% pendimethalin and 0.75% dimethenamid. Each treatment was replicated five times. Five treatments were applied using a CO_2-backpack sprayer calibrated to apply 22 gallons per acre. The rate applied was either 34 or 68 ounces per acre (1 or 2 pounds a.i./acre/application). Two treatments of the granular herbicide were applied using a salt shaker. These rates were 100 and 200 lbs of product per acre. At the Elberta Nursery, one bed (containing three replications) was accidently sprayed with 32 ounces of Pendulum-Aquacap® on June 22. As a result, this trial was separated into two studies (one per bed).

An evaluation of spurge cover was made at the Camden Nursery in September (0 to 10 scale). Seedling densities (i.e. number of seedlings per square meter) were recorded using a 1'x 4' counting frame. Seedling samples were hand-lifted from the center of each plot and were transported to Auburn for analysis. Seedling height and root-collar diameter were measured on 25 seedlings per

plot. Oven-dry weights of shoots and roots were recorded for each 25-seedling sample. Seedlings were examined for galls (i.e. swellings) at the groundline. Data were subjected to ANOVA and treatment effects were compared using orthogonal contrasts.

RESULTS

Soil texture at the Camden Nursery had about 64% sand while soils at the other three nurseries contained more than 75% sand (Table 1). Sowing occurred in April and at three nurseries, the first postemergence application of pendimethalin was in June. At the Camden Nursery, the first postemergence application was made in late May (Table 2).

The study at the Camden Nursery was applied on "third-year" ground (ie. third crop after last fumigation). As a result, seedlings in control plots were stunted due to competition from prostrate spurge (Table 3). All treatments containing pendimethalin reduced the amount of spurge. By September, the ground treated with pendimethalin at sowing (2 lb a.i./acre) had only a small amount of spurge (Table 4). When pendimethalin was applied after spurge began to germinate, weed control was reduced. As a result, the postemergence application of 2 lb a.i./acre did not provide as effective weed control as did preemergence treatment. Tests at Elberta, Jesup and Trenton Nurseries were on areas where weeds were minimal. In these studies, control plots contained a small amount of weeds and no weed ratings were made.

Applying herbicides improved seed efficiency at both the Camden Nursery and Jesup Nursery (Table 3, 4, 5, 6). The treatments had no effect on stand density at Trenton (Tables 7, 8) and Elberta (Tables 8, 10, 11, 12). At the Elberta Nursery, a heavy rain occurred on May 6 and this event resulted in much bed erosion that greatly reduced seedbed density (Table 10, 12).

Applying pendimethalin postemergence to the pines increased root-collar diameter (RCD) at three nurseries (Camden, Jesup and Trenton). At the Jesup and Trenton Nurseries, this effect was partly due to an increase in the frequency of herbicide galls. At no nursery did the use of Pendulum Aquacap® reduce seedling height, shoot weight or root weight. In contrast, the high rate of the granular herbicide reduced height and shoot mass at the Trenton Nursery (Table 7, 8).

Pendimethalin caused herbicide galls to occur on seedlings at Elberta, Jesup and Trenton but no galls were detected at the Camden Nursery. Galls were more frequent when the herbicide was applied in June (2 to 22). If pendimethalin is applied only at time of sowing, the occurrence of herbicide galls was less than 7% (range was 0 to 6%). The maximum amount of herbicide galls (92%) occurred on bed 8 at the Elberta Nursery where two applications of pendimethalin were applied in June and a third occurred in July (Table 2).

MANAGEMENT IMPLICATIONS

These findings indicate that an application of pendimethalin (2 lb a.i./acre) at time of sowing (late April) has no observable negative effect on seedbed density but it did result in the formation of herbicide galls at two nurseries. One year's data is not sufficient to make any strong conclusions. However, it should be noted that a preemergence treatment resulted in the greatest control of spurge at the Camden Nursery. Since some spurge plants had emerged by the 5th of May, these weeds were not killed by the postemergence treatment. For effective control, pendimethalin should be applied

prior to germination of weed seed. In some irrigated soils, the half-life of pendimethalin is 10 to 32 days (Alister et al. 2009).

The reason why galls occur at some nurseries but not at others is unknown. It might be assumed that a clay content (of 19%) might explain why herbicide galls were not observed at the Camden Nursery in 2009. However, at the Camden Nursery in 2008, a single postemergence treatment (applied in May) resulted in 2% of the seedlings with herbicide galls (South and Hill 2009). In 2009, three treatments (for a total of 6 lb a.i./acre), did not result in formation of herbicide galls (data from a separate study). Genetics might also explain the variable response among nurseries. The number of pendimethalin induced herbicide galls in soybeans (*Glycine max*) depends on genotype (Glover and Schapaugh 2002). The genetics hypothesis is supported by observations by managers of pine nurseries that indicate some pine and some hardwood genotypes have more herbicide galls than others. A final hypothesis may involve the half-life of pendimethalin which, depending on the study, can range from 10 to 98 days (Lubyte et al. 2007; Alister et al. 2009).

Timing of herbicide application plays a significant role in gall formation. Although an application at the time of sowing can result in some gall formation, an application in June would result in a higher frequency of gall formation.

The use of a granular formulation (containing both pendimethalin and dimethenamid) showed no real advantage over the liquid formulation of pendimethalin. The cost of the granular formulation will be higher than a tank-mix of two, less expensive formulations.

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Table 1. Soil texture, organic matter (OM) and soil acidity of the loblolly pine nurseries.

Nursery	Texture	Sand	Silt	Clay	OM	pH
		---------- (%) ----------				
Camden	sandy loam	64	19	17	1.5	5.4
Elberta, bed 7	sandy loam	77	10	13	1.07	6.2
Elberta, bed 8	sandy loam	76	11	13	1.15	6.5
Jesup	sandy loam	85	7	8	1.2	5.7
Trenton	sandy loam	76	14	10	1.7	5.4

Table2. Sowing date, mulch type, application dates and lifting dates for studies in 2009.

Nursery	Sow Date	Mulch	Pre	Post	Post	Post	Lift date
Camden	4/28	Agrilock	5/5	5/26		6/30	9/30
Elberta, bed 7	4/28	Agrilock	5/6	6/16		7/14	1/13/10
Elberta, bed 8	4/28	Agrilock	5/6	6/16	6/22	7/14	1/13/10
Jesup	4/23	Agrilock	4/28	6/17		7/15	10/13
Trenton	4/10	Agrilock	4/22	6/2		7/1	10/19

Table 3. Analysis of Variance for loblolly pine seedlings as affected by herbicides at the Camden Nursery.

Source	df	Density	RCD	Height	Root	Shoot	Spurge
		----------Probability of a greater F-value----------					
Replication	4	0.9387	0.0061	0.0069	0.0028	0.2881	0.3035
Treatment	7	0.1957	0.0001	0.0001	0.0001	0.0265	0.0001
Control vs preemergence	(1)	0.0716	0.0004	0.0001	0.0001	0.0001	0.0001
Control vs postemergence	(1)	0.0095	0.0001	0.0001	0.0001	0.0001	0.0119
Pre- vs postemergence	(1)	0.5029	0.2179	0.2373	0.3314	0.4445	0.0006
1X vs 2X liquid	(1)	0.3692	0.0009	0.0058	0.0673	0.0053	0.0001
2X vs 1+1 liquid	(1)	0.768	0.005	0.001	0.0134	0.0001	0.0001
Control vs 1X granular	(1)	0.0744	0.0086	0.0001	0.0181	0.0005	0.0001
Control vs 2X granular	(1)	0.1233	0.0001	0.0001	0.0001	0.0001	0.0001
Error	28						

Table 4. Morphological characteristics for loblolly pine seedlings at the Camden Nursery. Least significant difference (LSD; α =0.05)

Treatment	rate	Density (#/m2)	RCD (mm)	Height (cm)	Root (g)	Shoot (g)	Spurge (% cover)
Control	0	173	3.1	19.6	0.166	1.37	100
Pre-pend	1	197	3.7	26.4	0.273	2.31	16
Pre-pend	2	192	4.1	28	0.294	2.48	2
Post-pend	1	181	3.6	25.1	0.245	2.04	36
Post-pend	2	199	4	27.7	0.288	2.58	10
Post-pend	1+1	196	3.5	24	0.225	1.83	44
Granular	1.75	191	3.5	25.1	0.226	2.03	24
Granular	3.5	189	3.9	27	0.275	2.31	14
(LSD)		*20.1*	*0.29*	*2.03*	*0.048*	*0.34*	*15*

Table 5. Analysis of Variance for slash pine seedlings as affected by herbicides at the Jesup Nursery.

Source	df	Density	RCD	Height	Root	Shoot	Galls
		----------Probability of a greater F-value----------					
Replication	4	0.0315	0.178	0.1266	0.0028	0.2881	0.9999
Treatment	7	0.0658	0.0905	0.5669	0.0001	0.0265	0.0017
Control vs preemergence	(1)	0.2688	0.5847	0.1356	0.0001	0.0001	0.9999
Control vs postemergence	(1)	0.0664	0.0633	0.1073	0.0001	0.0001	0.0124
Pre- vs postemergence	(1)	0.1779	0.3418	0.9732	0.3314	0.4445	0.0571
1X vs 2X liquid	(1)	0.7716	0.0855	0.8403	0.0673	0.0053	0.0571
2X vs 1+1 liquid	(1)	0.6816	0.3257	0.5857	0.0134	0.0001	0.3576
Control vs 1X granular	(1)	0.9999	0.3327	0.37	0.0181	0.0005	0.6436
Control vs 2X granular	(1)	0.4141	0.2767	0.9432	0.0001	0.0001	0.9999
Error	28						

Table 6. Morphological characteristics for slash pine seedlings at the Jesup Nursery. Least significant difference (LSD; α =0.05)

Treatment	rate	Density (#/m2)	RCD (mm)	Height (cm)	Root (g)	Shoot (g)	Galls (%)
Control	0	202	4.8	29.1	0.166	1.37	0
Pre-pend	1	209	4.8	29.5	0.273	2.31	0
Pre-pend	2	207	4.9	29.5	0.294	2.48	0
Post-pend	1	214	4.8	29.5	0.245	2.04	0
Post-pend	2	219	5	29.5	0.288	2.58	4.8
Post-pend	1+1	223	4.9	29.6	0.225	1.83	6.4
Granular	1.75	202	4.9	29.4	0.226	2.03	0.8
Granular	3.5	195	4.7	29.1	0.275	2.31	0
(LSD)		*18.6*	*0.22*	*0.68*	*0.048*	*0.34*	*3.5*

Table 7. Analysis of Variance for loblolly pine seedlings as affected by herbicides at the Trenton Nursery.

Source	df	Density	RCD	Height	Root	Shoot	Galls
		----------Probability of a greater F-value----------					
Replication	4	0.4017	0.0306	0.5111	0.0067	0.0631	0.4241
Treatment	7	0.5760	0.0757	0.0477	0.7784	0.0373	0.0005
Control vs preemergence	(1)	0.8300	0.4306	0.6158	0.2935	0.8069	0.9999
Control vs postemergence	(1)	0.8622	0.0271	0.3998	0.7073	0.2154	0.0177
Pre- vs postemergence	(1)	0.3706	0.6625	0.1454	0.9569	0.4478	0.0070
1X vs 2X liquid	(1)	0.4546	0.0724	0.2109	0.5286	0.1944	0.0006
2X vs 1+1 liquid	(1)	0.3427	0.4593	0.8708	0.6739	0.4063	0.0003
Control vs 1X granular	(1)	0.9511	0.7361	0.7040	0.5784	0.3536	0.9999
Control vs 2X granular	(1)	0.4591	0.4607	0.0388	0.8957	0.0511	0.9999
Error	28						

Table 8. Morphological characteristics for loblolly pine seedlings at the Trenton Nursery. Least significant difference (LSD; α =0.05)

Treatment	rate	Density (#/m2)	RCD (mm)	Height (cm)	Root (g)	Shoot (g)	Galls (%)
Control	0	98	5.2	25.7	0.844	3.97	0
Pre-pend	1	90	5.3	24.8	0.934	4.04	0
Pre-pend	2	98	5.5	25.1	0.899	4.27	0.8
Post-pend	1	110	5.3	25.4	0.941	4.09	0
Post-pend	2	91	5.7	27.7	0.884	4.71	5.6
Post-pend	1+1	101	5.5	27.5	0.841	4.33	0.8
Granular	1.75	102	5.2	25.2	0.787	3.55	0
Granular	3.5	95	5	22.5	0.83	3.05	0
(LSD)		*20.6*	*0.43*	*3.09*	*0.208*	*0.93*	*2.4*

Table 9. Analysis of Variance for loblolly pine seedlings as affected by herbicides on bed 7 at the Elberta Nursery.

Source	df	Density	RCD	Height	Root	Shoot	Galls
		----------Probability of a greater F-value----------					
Replication	1	0.0272	0.0635	0.0412	0.2462	0.0911	0.8811
Treatment	7	0.2848	0.6058	0.8246	0.5566	0.9911	0.0550
Control vs preemergence	(1)	0.1220	0.5571	0.6191	0.2108	0.4420	0.8629
Control vs postemergence	(1)	0.7163	0.2973	0.8974	0.1373	0.6692	0.0683
Pre- vs postemergence	(1)	0.9999	0.9146	0.6839	0.6529	0.8571	0.0466
1X vs 2X liquid	(1)	0.1032	0.5852	0.5808	0.5739	0.6655	0.0466
2X vs 1+1 liquid	(1)	0.3847	0.5834	0.8746	0.6926	0.9903	0.3136
Control vs 1X granular	(1)	0.8828	0.2532	0.9790	0.8737	0.5428	0.6559
Control vs 2X granular	(1)	0.1560	0.9183	0.7332	0.8885	0.7401	0.4634
Error	7						

Table 10. Morphological characteristics for loblolly pine seedlings on bed 7 at the Elberta Nursery. Least significant difference (LSD; α =0.05)

Treatment	rate	Density (#/m2)	RCD (mm)	Height (cm)	Root (g)	Shoot (g)	Galls (%)
Control	0	36	6.1	28.3	1.26	6.19	0
Pre-pend	1	39	5.7	28.1	1.16	5.77	4
Pre-pend	2	39	5.8	28.3	1.11	5.83	6
Post-pend	1	44	5.7	28.0	1.17	5.45	16
Post-pend	2	34	6.0	28.5	1.15	5.92	34
Post-pend	1+1	38	6.1	28.5	1.18	5.93	48
Granular	1.75	33	6.1	29.1	1.25	5.66	4
Granular	3.5	39	5.9	28.0	1.25	5.91	4
(LSD)		*8.9*	*0.61*	*1.73*	*0.195*	*1.96*	*30*

Table 11. Analysis of Variance for loblolly pine seedlings as affected by herbicides on bed 8 at the Elberta Nursery. All plots treated with pendimethalin on June 22.

Source	df	Density	RCD	Height	Root	Shoot	Galls
		----------Probability of a great F-value----------					
Replication	2	0.0072	0.1136	0.896	0.0435	0.3383	0.2124
Treatment	7	0.2213	0.716	0.7694	0.7614	0.7195	0.0001
Control vs preemergence	(1)	0.5185	0.2515	0.8253	0.5433	0.4776	0.1863
Control vs postemergence	(1)	0.8182	0.5723	0.4196	0.481	0.4139	0.0004
Pre- vs postemergence	(1)	0.1382	0.6982	0.3957	0.585	0.3142	0.0345
1X vs 2X liquid	(1)	0.263	0.4985	0.2404	0.9773	0.8467	0.0001
2X vs 1+1 liquid	(1)	0.9438	0.8379	0.8349	0.7582	0.7877	0.6031
Control vs 1X granular	(1)	0.4215	0.8946	0.2964	0.6176	0.2233	0.7249
Control vs 2X granular	(1)	0.404	0.7426	0.6105	0.4026	0.2732	0.0556
Error	14						

Table 12. Morphological characteristics for loblolly pine seedlings on bed 8 at the Elberta Nursery. All plots treated with pendimethalin on June 22. Least significant difference (LSD; α =0.05)

Treatment	rate	Density (#/m2)	RCD (mm)	Height (cm)	Root (g)	Shoot (g)	Galls (%)
Control	0+1	36	5.8	30.5	1.23	6.39	21
Pre-pend	1+1	45	5.3	29.0	1.00	4.91	6
Pre-pend	2+1	34	5.8	28.7	1.21	5.60	26
Post-pend	1+1	32	5.9	29.5	1.29	6.52	52
Post-pend	2+1	36	5.6	29.8	1.07	5.55	85
Post-pend	1+1+1	36	5.7	30.2	1.12	5.84	92
Granular	1.75+1	37	5.3	29.4	1.08	5.18	40
(LSD)		*9.9*	*0.95*	*3.5*	*0.37*	*2.27*	*27*