Auburn University
Southern Forest Nursery
Management Cooperative

RESEARCH REPORT 14-02

EFFECT OF PAC-INDUCED HERBICIDE GALLS ON SEEDLING GROWTH AND SURVIVAL 12 MONTHS AFTER OUTPLANTING

by
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INTRODUCTION

Applying pendimethalin (Pendulum® AquaCap™) for the control of prostrate spurge to nursery beds 4 to 8 weeks after sowing has been shown to cause galls on seedlings in some nurseries (South and Hill 2009; 2010). We suspect that certain environmental factors might explain gall formation at some nurseries and not at others as trials that examined genetics were inconclusive. It was suspected that the very few galls (14 out of 2,750 seedlings) observed on seedlings when Pendulum® AquaCap™ was applied within a week of sowing occurred when the herbicide came into contact with a newly germinated seed. Thus, Nursery Cooperative members have been cautioned since 2009 about herbicide galls forming on pine seedlings following the use of Pendulum® AquaCap™ (PAC) (pendimethalin) to control prostrate spurge (Chamaesyce maculate). It has been speculated that factors such as heat, soil texture, or seedling genetics may contribute to gall formation (Research Reports 09-01; 10-04; 11-05). However, if PAC is applied before seeds germinate, the chance of gall formation decreases significantly compared to applying PAC after seed germination. In PAC Nursery Cooperative trials from 2008 to 2010, 22% (731 of 3,250) of our test seedlings had galls when PAC was applied 14 days after sowing (matchstick stage) on up to 8 weeks post-sowing.

Some nursery managers are currently using PAC in their operational herbicide regime to control prostrate spurge. Therefore, it is important to define the term “at sowing” when it pertains to applying PAC. A seed is considered germinated when the seed coat is broken and the radicle has emerged, even if the seed has not lifted from the soil. Applying PAC one week after sowing could result in an application to germinated seed, thus increasing the chance of gall formation. In one nursery, applying PAC 8 to 13 days after sowing resulted in herbicide injury ranging in severity from slight swellings to more rounded galls with lesions. To minimize the chance of galls, applications of PAC should be made within 1-2 days of sowing that production unit.

However, one of the most common questions about the use of PAC and possibility of herbicide gall formation has been: “what will happen to loblolly pine seedlings with herbicide galls after outplanting”? This is an important question as forty+ years of landowner, planter and consulting forester education has taught everyone to avoid planting ‘galled seedlings’ due to the threat of fusiform rust infection.

Three previous studies that examined herbicide galls were inconclusive. One trial conducted by Jackson and Brooks (2012) was to determine how well seedlings with herbicide galls (stem treatments) could survive after outplanting compared to seedlings without herbicide galls. Seedlings remained outplanted from October 2011 to July 2012 and without irrigation from February 1 to May 1. Despite three months of drought, only three seedlings died in the outplanting trial. The herbicide galls did not affect seedling survival with galled and non-galled seedlings having 100% survival. Another Nursery Cooperative outplanting trial using bareroot loblolly pine resulted in seedlings having significantly higher survival without galls (45%) compared to those with PAC galls (24%) (unpublished data). However, the seedlings in that trial were outplanted in March, which may have confounded results as environmental conditions during March favor declines in survival compared to outplanting conditions from December to February (Venator 1985). In contrast, a bareroot seedling survival trial comparing seedlings with and without galls caused by the herbicide Barricade® (prodiamine) showed no difference in survival when outplanted in January (Carey 2000).

Therefore, to put the question to rest, this trial was undertaken to determine what affect PAC-induced herbicide galls have on seedling survival and seedling growth after out-planting under different planting conditions.

METHODOLOGY

On May 13, 2012, 8 weeks post sowing, a 120 linear feet of loblolly pine seedlings were treated with 68 oz/acre of Pendulum AquaCap in an attempt to induce herbicide gall formation. A similar distance of the same seedling bed was flagged and left non-treated (control). In November 2012, the seedling bed was visited and 600 seedlings with herbicide galls and 600 seedlings from the untreated portion (without PAC-induced galls) were hand-lifted and then out-planted in an unused part of a nursery. Seedlings were planted in 15 row increments, with 300 (half) of the 600 seedlings (galled or non-galled) planted deep (normal) while the other 300 were planted at the ground line (shallow). In addition to gall vs. non-gall, deep vs shallow, half the seedlings were irrigated over the duration of the trial while the other half did not receive any irrigation other than normal rainfall. Therefore, a replication consisted of a block of seedlings planted in a row that consisted of 15 seedlings planted; Galled/Deep, Galled/Shallow, Non-Galled/Deep, Non-Galled/Shallow, which were then either irrigated or non-irrigated. There were five replications of each block. In January 2014, 14 months after out-planting and 18 months after treatment with PAC, seedlings were measured for height, diameter at ground line and survival. The overall hypothesis tested was that galled seedlings, planted shallow and non-irrigated would have less survival than non-galled seedlings planted under similar conditions.

RESULTS AND DISCUSSION

Despite our best efforts to kill loblolly pine with PAC-induced herbicide galls, there was no effect of herbicide gall presence on seedling survival, ground line diameter or growth planted either deep or shallow (Tables 1 -4, Figures 1 and 2). In fact, when planted shallow without the benefit of water, the presence of herbicide galls increased seedling ground line diameter, seedling growth and seedling survival over non-galled seedlings planted under the same growing conditions (Table 2 and Figure 2). There was no difference in seedling characteristics under the other planting conditions when galled and non-galled seedlings were compared. One thing that

was observed was that irrigated seedlings were taller and had larger ground line diameters. Irrigated plots are shown in Figure 3a whereas non-irrigated plots are in Figure 3b.

This trial should put to rest the concerns about the outplanting of seedlings that may have herbicide-induced galls on the main stem due to late (post-germination) applications of PAC. As mentioned above, previous trials were ambiguous and conflicting and confounded due to planting sites (Carey 2000) and planting date (Jackson and Brooks 2012). This trial eliminated the confounding factors and mimicked both good and poor planting conditions and as well as good and bad growing season. Therefore, nursery managers should continue to use PAC at the time of sowing to minimize the risk of herbicide galls, but if they do occur, there should be no issues in outplanting those seedlings with the risk of survival or growth differences. Nursery Cooperative strongly encourages those that opt to use PAC as part of the weed control practices, to apply at the time of sowing.

MANAGEMENT IMPLICATIONS

Seedlings with herbicide-induced galls on the main stem had similar survival and growth rates as non-galled seedlings and could be outplanted with minimal risk.

LITERATURE CITED

Carey, B. 2000. Survival and growth of loblolly pine seedlings with or without Prodiamine caused basal galls did not differ after one year in the field. Southern Forest Nursery Management Cooperative, School of Forestry and Wildlife Sciences, Auburn University. Spring Newsletter.

Jackson, D.P and B. Brooks. 2012. Effects on herbicide gall formation and survival from applications of undiluted Pendulum AquaCap to loblolly pine seedlings. Auburn University Southern Forest Nursery Management Cooperative. Research Report 12-05, 10pp.

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Table 1. Loblolly pine seeding characteristics with and without herbicide galls 12 months after planting either deep or shallow **with irrigation** – Shellman, GA 2013.

	Shallow			Deep		
	RCD (mm)	**Hgt (cm)**	**Survival (%)**	**RCD (mm)**	**Hgt (cm)**	**Survival (%)**
Galls	26.6	37.6	100	23.5	38.3	98.6
No Galls	26.4	37.7	100	25.0	36.2	100

Letters, if present, denote significant differences among treatments using Duncan's Multiple Range test @ alpha=0.05 level.

Table 2. Loblolly pine seeding characteristics with and without herbicide galls 12 months after planting either deep or shallow **without irrigation** – Shellman, GA 2013.

	Shallow			Deep		
	RCD (mm)	**Hgt (cm)**	**Survival (%)**	**RCD (mm)**	**Hgt (cm)**	**Survival (%)**
Galls	19.2 a	25.7	100	18.9 a	26.7 a	98 a
No Galls	17.2 b	24.4	96	13.8 b	22.7 b	89 b

Letters, if present, denote significant differences among treatments using Duncan's Multiple Range test @ alpha=0.05 level.

Table 3. Loblolly pine seeding characteristics with and without herbicide galls 12 months after **planting deep** with or without irrigation – Shellman, GA 2013.

	Water			No Water		
	RCD (mm)	**Hgt (cm)**	**Survival (%)**	**RCD (mm)**	**Hgt (cm)**	**Survival (%)**
Galls	23.5	38.3	98.6	18.9 a	26.7 a	98 a
No Galls	25.0	36.2	100	13.8 b	22.7 b	89 b

Letters, if present, denote significant differences among treatments using Duncan's Multiple Range test @ alpha=0.05 level.

Table 4. Loblolly pine seeding characteristics with and without herbicide galls 12 months after **planting shallow** with or without irrigation – Shellman, GA 2013.

	Water			No Water		
	RCD (mm)	Hgt (cm)	Survival (%)	RCD (mm)	Hgt (cm)	Survival (%)
Galls	26.6	37.6	100	19.2 a	25.7	100
No Galls	26.4	37.7	100	17.2 b	24.4	96

Letters, if present, denote significant differences among treatments using Duncan's Multiple Range test @ alpha=0.05 level.

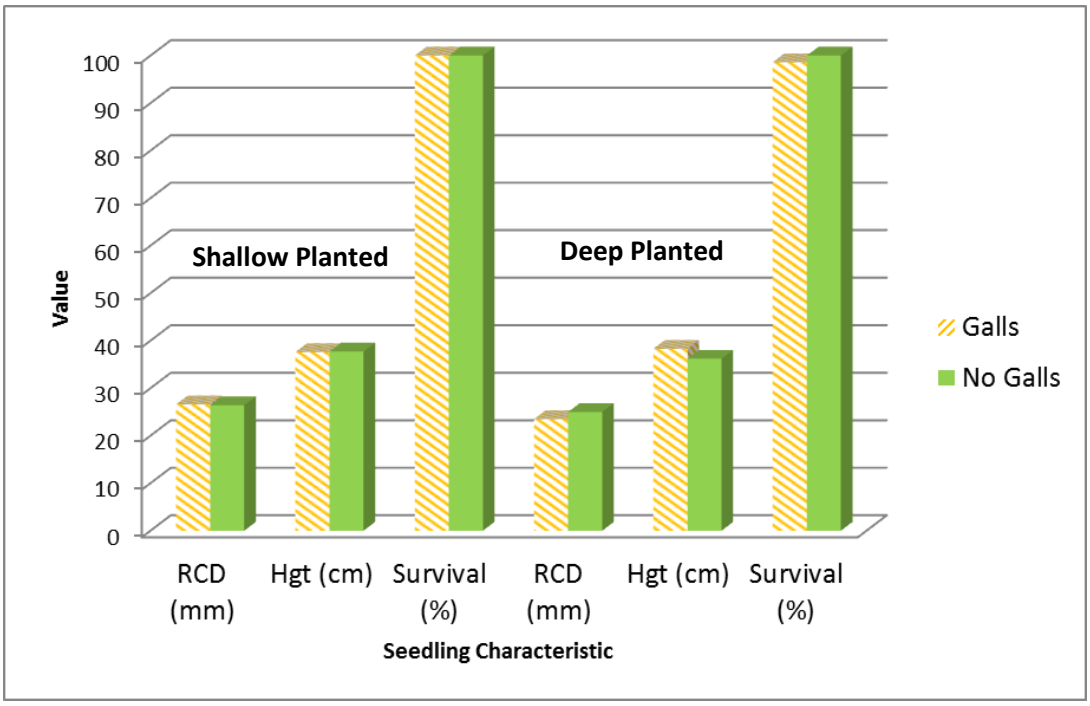

Figure 1. Loblolly pine seedling characteristics with and without herbicide galls 12 months after planting either deep or shallow **under irrigation**.

Letters, if present, denote significant differences among treatments using Duncan's Multiple Range test @ alpha=0.05 level.

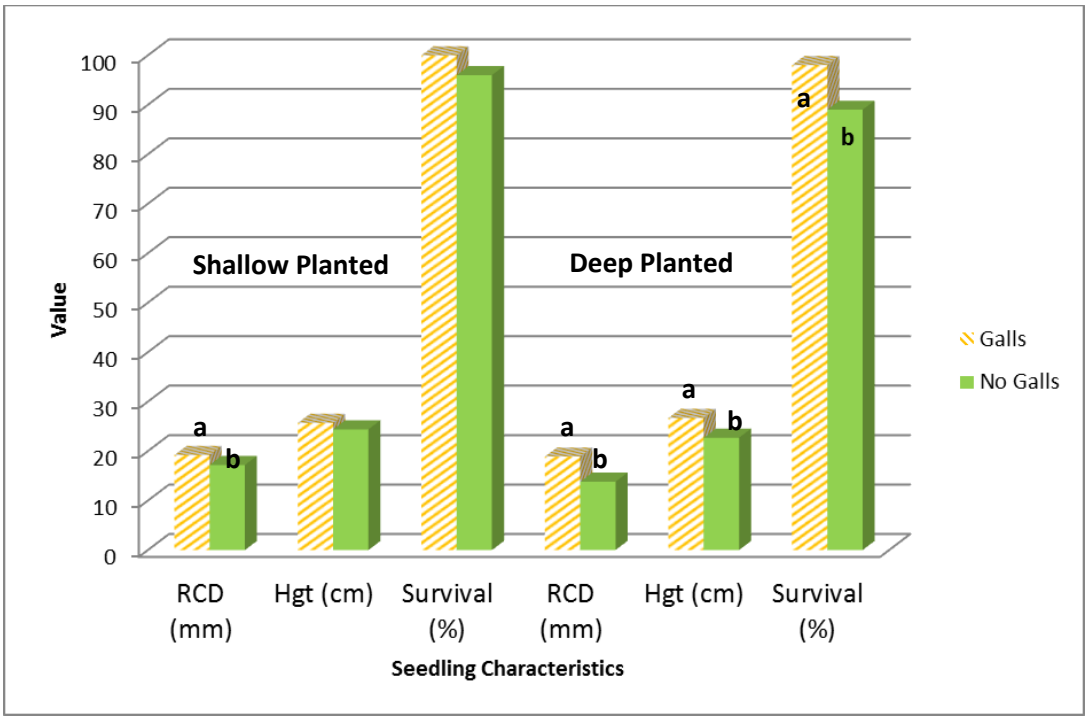

Figure 2. Loblolly pine seedling characteristics with and without herbicide galls 12 months after planting either deep or shallow **without irrigation**.

Letters, if present, denote significant differences among treatments using Duncan's Multiple Range test @ alpha=0.05 level.

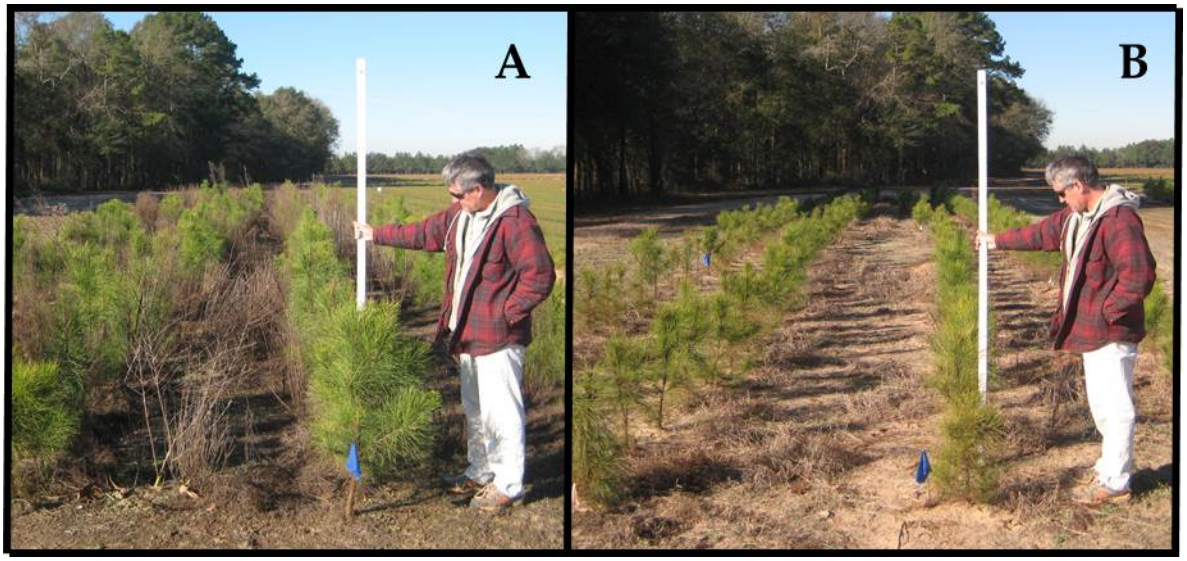

Figure 3. Seedlings with and without galls, planted deep or shallow, irrigated (A) and non-irrigated (B) 12 months after outplanting at the ArborGen Supertree Nursery in Shellman, GA 2013.