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Split-season herbaceous weed control for full-season seedling performance

Jimmie L. Yeiser
Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University

Andrew W. Ezell

SPLIT-SEASON HERBACEOUS WEED CONTROL FOR FULL-SEASON SEEDLING PERFORMANCE

Jimmie L. Yeiser and Andrew W. Ezell[1]

Abstract—Results from four loblolly pine (*Pinus taeda* L.) sites, one in each of MS and TX in 2001 and again in 2002, are presented. Twelve herbicide treatments and an untreated check were tested. Herbicide treatments were applied early (mid-March), late (mid-May), both timings, or not at all to achieve, early- late-, full-season, or no weed control. When averaged across all four sites and compared to the early treatment, bare ground was less from April through July and April through November on late treated and untreated plots, respectively. Full-season weed control provided numerically more bare ground than other treatments. When averaged across sites and compared to the early treatment, survival, total heights at ages one and two, and ground line diameters at age one were less on other treatments. Results are biologically important to managers. Many of the herbicide treatments tested can be applied early or late for the same cost but achieve excellent herbaceous weed control at different portions of the growing season. Early weed control consistently provided numerically more seedling performance than other treatments.

INTRODUCTION

Herbicidal site preparation and herbaceous weed control (HWC) were heavily researched during the 1980s. Then, one preparation method commonly preceded planting. Today, not just one but often two, three or more methods precede planting. Furthermore, regeneration lag is briefer now with sites prepared and replanted as quickly following harvest as possible.

Forest managers in the Southeastern United States are concerned about the negative impact of herbs on loblolly pine seedling performance. Herbaceous weeds are known to compete with newly planted seedlings for water, nutrients, light, and space (Nelson and others 1981, Tiarks and Haywood 1986, Zutter and others 1986). When compared to plantings without HWC, treated loblolly pine plantations are commonly characterized by increased planting survival that persists into mid-rotation (Clason 1987), enhanced growth (Creighton and others 1987, Glover and others 1989, Holt and others 1975), early commercial thinning (Glover and others 1989), and shorter rotations (Clason 1989 and Glover and others 1989). Therefore, HWC is a commonly accepted practice in loblolly pine plantation management.

Managers want to know when it is most critical for newly planted seedlings to be weed free. Discussions commonly revolve around several thoughts. The first thought pertains to soil moisture. In general, early in the growing season soil moisture is high and available. Newly planted pines and emerging weeds lack good root-soil contact. Both actively compete for resources while becoming established. Late in the growing season, pines and competitors have established root systems. Weeds consume and reduce resources otherwise available for seedlings at a time when resources are limited. When considering extremes in poorly and excessively drained sites, the above general relationships may not apply. That is, pine seedlings on poorly drained sites may benefit early from the moisture drain of weeds and therefore, need a late release from competitors. Similarly, pine seedlings on excessively well drained sites may be at high risk throughout the season to light competitor levels commonly of no concern on mesic sites. A second thought pertains to the timing of applications and seedling flushes. In spring, weeds emerge and seedlings flush about the same time. New flushes are more vulnerable to over-the-top herbicide treatments than hardened flushes. Thus, pre-emergence applications may offer more safety than post-emergence. Third, managers question the logic of controlling weeds early in the growing season to enhance survival and growth only to later in the same season allow unwanted competition to recolonize the planting site and reduce seedling growth.

The objective of this study was to apply herbicides over the top of newly-planted, loblolly pine seedlings for early-, late-, full-season, or no herbaceous weed control and quantify the resultant seedling survival and growth.

METHODS

A total of five sites were tested. Results from four sites will be presented. One site in TX and one in MS were tested during each of 2001 and 2002. Site characteristics and histories are summarized for comparison in tables 1 and 2.

Twelve herbicide treatments and an untreated check were tested at all sites (table 3). Oust XP, Oustar, Escort XP and Arsenal AC are standards for HWC. Eagre contains 5.4 pounds of glyphosate per gallon of product and lacks surfactant. Herbicides were applied early (mid-March), late (mid-May), both timings, or not at all to achieve early-, late-, full-season, or no weed control. Herbicides were applied at a total volume of 10 gallons per acre and in a 5-foot band centered over the top of seedlings. Treatment plots contained 16 seedlings each. Seedlings were planted on 8 by 10 foot spacing. For each test site, treatments were assigned to four randomized complete blocks. Data were analyzed with SAS using PROC GLM and Duncan's New Multiple Range Test ($P \leq 0.05$ level, SAS 1999).

[1]T.L.L. Temple Professor, Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, Nacogdoches, TX; Professor of Forestry, Mississippi State University Department of Forestry, Mississippi State, MS, respectively.

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Table 1—A summary of characteristics and history for the Texas sites

	Huntington, TX		Woden, TX	
Initiate	2001		2002	
Harvest	May-00		Wildfire summer 01	
Soil	Fine sandy silt loam, pH=5.2		Sandy loam, pH=5.0	
SP1	1-Sep-00 Arsenal AC+Garlon 4, 14oz+2q		None	
SP2	Oct-00, Burned		None	
SP3	Nov-00, Combination plowed		None	
Planted	Hand, 5-Feb-01		Machine, Feb-02	
Applied	9-Mar/11-May		19-Mar/20-May	
Cover	Pre<1%/Post>90%		Pre<1%/Post>50%	
Weed	Grass		Grass	
	Andropogon spp[a]	Panicgrasses	*Andropogon* spp	Panicgrasses
	Rye grass			
	Broadleaf		Broadleaf	
	Carolina nettle	Dogfennel	Horseweed	Poorjoe
	Purple cudweed	Late boneset	Purple cudweed	Venus lookingglass
	Venus lookingglass	Wild geranium	Wild geranium	
	Wooly croton			
			Semi-woody	
	Semi-woody		A. beautyberry	*Hypericum* spp
	A. beautyberry	*Hypericum* spp	*Rubus* spp	

[a]Names according to Miller and Miller (1999).

Table 2—A summary of site characteristics and history for the Mississippi sites

	Una, MS		Longview, MS	
Initiate	2001		2002	
Harvest	May 2000			
Soil	Silt Loam, pH=5.0		Falkner Silt Loam, pH=5.2	
SP1	Shear & windrowed Sep 2000		Sheared	
SP2	None		Combination plowed	
SP3	None		None	
Planted	Hand, Jan 2001		Hand, Jan 2002	
Applied	6-Mar/1-Jun		11-Mar/20-May	
Cover	Pre<1%/Post>80%		Pre<1%/Post>60%	
Weed	Grass		Grass	
	Andropoogon spp[a]	Panicgrasses	*Andropogon* spp	Panicgrasses
	Roundhead sedge		Dallisgrass	
	Broadleaf		Broadleaf	
	Blue vervain	Common ragweed	Common ragweed	Coneflower
	Desmodium spp	Goldenrod	*Desmodium* spp	Daisy fleabane
	Horseweed	Late boneset	Goldenrod	Horseweed
	Wild garlic	Wooly croton	Ironweed (Vernonia)	Late boneset
			Pokeberry	Rustweed
			Wooly croton	
	Vine		Vine	
	Japanese honeysuckle	Trumpetcreeper	Japanese honeysuckle	Poison-ivy
	Smilax spp	*Vitis* spp		
	Semi-woody		Semi-woody	
	Baccharis spp	*Rubus* spp	A. beautyberry	*Baccharis* spp
	Hypericum spp		*Rubus* spp	

[a]Names according to Miller and Miller (1999).

Table 3—Twelve herbicide treatments and an untreated check were tested at all sites. Treatments were applied early (mid-March), late (mid-May), both timings, or not at all to achieve early-, late-, full-season or no weed-free growing conditions for seedlings.

Weed-Free	Mid-March	Mid-May
Early	Oust XP 3oz	Untreated
Early	Oustar 13oz	Untreated
Early	Oustar 19oz	Untreated
Early	Arsenal AC+Oust XP 4+2oz	Untreated
Late	Untreated	Oust XP+Escort XP+Eagre 2+0.5+12oz
Late	Untreated (2002 only)	Arsenal AC+O XP 4+2oz (2002 only)
Full	Oustar 13oz	Escort XP 0.5oz
Full	Oustar 13oz	Oust XP 2.0oz
Full	Oustar 13oz	Eagre 12oz
Full	Oustar 13oz	Oust XP+Escort XP+Eagre 2+0.5+12oz
Full	Arsenal AC+Oust XP 4+2oz	Oust XP+Escort XP+Eagre 2+0.5+12oz
Full	Velpar L 32oz	Oust XP+Escort XP+Eagre 2+0.5+12oz
None	Untreated	Untreated

RESULTS AND DISCUSSION

Rainfall

Rainfall was very different in TX during 2001 and 2002. While total rainfall at Huntington was normal, the monthly distribution was badly skewed. For example, droughty months were April, May, July, August and September all of which were > 2 inches below the 29 year monthly mean. To counter this deficit, in June, Tropical Storm Allison provided 9.7 inches in 3 days, the only precipitation for the month. Likewise, December received over 7 inches. This brings the 2001 total for March through December to 38.1 inches while the 29 year total was 37.7 inches. In contrast, Woden rainfall from March through December 2002 deviated little from the 29 year monthly means. Therefore, 2001 and 2002 TX rainfall represents drought and average years and gives insight into extremes in seedling performance.

Weed Control

Numerical and statistical values for weed-free growing conditions (e.g., bare ground) are presented in table 4 and statistical differences expressed in days and months in table 5. Huntington, TX seedlings treated early were more weed-free May to June than those treated late. Woden, TX seedlings treated early were more weed free in April to May, in Una, MS it was June to July and in Longview, MS it was May only (tables 4 and 5). More bare ground was available for late than early treated seedlings during August to November at Huntington and October at Woden (tables 4 and 5). Full-season weed control provided more weed-free space than seedlings treated early during August to November in Huntington, October at Woden, September to November in Una and none in Longview. Untreated seedlings consistently had more competition than treated seedlings (tables 4 and 5).

Early and late timings in TX and Longview, MS provided more than 80 percent July bare ground. Weeds re-colonized plots slowly during hot summer months (table 4). It is no surprise, that bare ground levels on plots receiving full-season weed control were little better than that achieved with either an early or late treatment alone. At Una, MS bare ground for the late timing did not peak until August with weeds re-colonizing more rapidly than on plots treated for early or full-season weeds. At all sites, a portion of the successful re-colonization is attributed to *Hypericum* spp and A. beautyberry, semi-woody species whose tolerance to test herbicides is higher than pine seedlings.

When averaged across all four sites and expressed as a percent of early weed control, bare ground was similar in April for all treatments (table 6). In May and June, bare ground was similar for the late treatment and untreated plots and similar for early- and full-season treatments with the latter significantly better than the former. Bare ground was less for untreated than treated seedlings during months of July through November. October differences were probably of little biological significance since the growing season was largely over and differences reflect the invasion of winter

Table 4—Test plots were evaluated 30-210 (Apr-Nov) days after treatment (DAT) for bare ground (%). Herbicides were applied early (mid-March), late (mid-May), both timings, or not at all to achieve early-, late-, full-season or no weed control for loblolly pine seedlings.

Weed-Free	May	Jun	Jul	Aug	Sep	Oct	Nov	Apr	May	Jun	Jul	Aug	Sep	Oct
DAT	60 [a]	90	120	150	180	210	240	30	60	90	120	150	180	210
	HUNTINGTON, TX 2001							WODEN, TX 2002						
Early	90a	92a	85a	79b	74b	72b	72b	99a	98a	91a	91a	91a	91a	84b
Late	13b	26b	89a	92a	92a	90a	90a	84b	71b	85a	85a	94a	94a	94a
Full	90a	90a	96a	94a	93a	93a	93a	99a	99a	98a	98a	97a	97a	97a
None	12b	17b	28b	28c	22c	21c	21c	85b	63b	46b	46b	37b	31b	13c
	UNA, MS 2001							LONGVIEW, MS 2002						
Early	-	92a	98a	94a	78b	52b	45b	96a	95a	90a	83a	92a	87a	80a
Late	-	53b	25b	89a	62b	56b	35c	95a	63b	87a	86a	86a	88a	81a
Full	-	89a	92a	97a	91a	79a	65a	96a	87a	95a	84a	94a	92a	86a
None	-	60b [a]	19c	3c	0c	0c	0d	76b	48c	23b	1b	3b	0b	0b

[a] Means within a column sharing the same letter are not significantly different (Duncan's New Multiple Range test $P \leq 0.05$).

Table 5—Days (d) and months (m) of significantly reduced weed cover for sites and years. Herbicides were applied early (mid-March), late (mid-May), both timings, or not at all to achieve early-, late-, full-season or no weed control for loblolly pine seedlings.

Weed-Free	Early d m	Late d m	Full d m	None d m	Early d m	Late d m	Full d m	None d m
	HUNTINGTON, TX 2001				WODEN, TX 2002			
Early	-	60 May-Jun	0 0	210 May-Nov	-	60 Apr-May	0 0	210 Apr-Oct
Late	120 Aug-Nov	-	0 0	150 Jul-Nov	30 Oct	-	0 0	150 Jun-Oct
Full	120 Aug-Nov	60 May-Jun	-	210 May-Nov	30 Oct	60 Apr-May	-	210 Apr-Oct
None	0 0	0 0	0 0	-	0 0	0 0	0 0	-
	UNA, MS				LONGVIEW, MS			
Early	-	60,30 Jun-Jul, Nov	0 0	180 Jun-Nov	-	30 May	0 0	210 Apr-Oct
Late	0 0	-	0 0	150 Jul- Nov	0 0	-	0 0	210 Apr-Oct
Full	90 Sep-Nov	60, 90 Jun-Jul, Sep-Nov	-	180 Jun-Nov	0 0	30 May	-	210 Apr-Oct
None	0 0	0 0	0 0	-	0 0	0 0	0 0	-

annuals into plots. Because the same products and rates may be used in early and late timings, the cost is the same, yet control is significantly different in May and June. Negative values illustrate the months of major differences in HWC and emphasize the biological importance of careful treatment planning.

Pine Performance

In Huntington, TX, early- and full-season weed control provided similar age one seedling survival at 81 and 77 percent, respectively. The late treatment achieved 61 percent survival, less than both early and full, but greater than checks at 46 percent. This site was sprayed, burned and plowed. Even high intensity site preparation was not a guarantee against planting failure during a severe spring drought. At 545 planted seedlings per acre, the early-, late-, full-season and checks started the rotation with 442, 333, 420, and 251 seedlings per acre. By many standards, only the untreated checks would require a replant. This illustrates the importance of HWC at establishing a well stocked stand. Some non-industrial landowners and state agencies assisting non-industrial landowners do not practice herbaceous weed control in favor of reduced costs. This practice is not biologically based and warrants careful consideration. Survival at Huntington is dramatically lower than other sites illustrating the impact of local conditions on survival and reminding managers to understand the conditions causing performance departures at a specific site from the overall mean. Although little can be done about the weather, when possible, managers should focus on the causal agents reducing local survival to raise programmatic mean performance. In Woden, TX, age one and two survival exceeded 95 percent for all treatments. In Una, MS, age two survival ranged from a low of 82 for checks to 88 percent for all herbicide treatments. At these sites HWC and rainfall were good and resultant seedling survival was good. No statistical differences were detected at these two sites. Survival at Longview, MS is not available.

Growth extremes are represented by TX sites. Greatest treatment differences in growth were recorded at Huntington, TX (table 7). Total heights and ground line diameters after one year were similar for checks and late treated seedlings. fter two growing seasons, total heights and ground line diameters were greater on late than untreated check plots (table 8). At Woden, TX and both MS sites, greatest differences were between treated and untreated seedlings.

When averaged across all four sites, age one survival was statistically similar for all treatments but numerically lower for non-early treatments (table 8). Age one heights were statistically similar for seedlings receiving early- and full-season weed control, late- and full-season weed control and late and no weed control. Seedlings receiving early- and full-season HWC were taller than untreated checks. After two growing seasons, most statistical differences existed between treated and untreated seedlings. When seedling growth was expressed as a percent of the early treatment and averaged, negative values for periods of weed control, although not always statistically different, show lost growth. This is important to managers. The same products and rates, and thus the same cost, may be used for early- and late-timings with lost growth from late times. Full-season weed control comes with a higher cost and less growth than an early treatment.

In conclusion, age-two seedling performances across all four test sites revealed little statistical difference in growth between early-, late-, and full-season weed control. However, late- and full-season weed control provided seedlings that were numerically smaller than those released from weeds early in the season. This pattern was observed at all four individual sites as well. This suggests that early HWC does consistently provide some numerical growth advantage over late- or full-season weed control. Seedlings released with late HWC performed better than those receiving no weed control. The Huntington site demonstrated that HWC, even on intensively prepared sites, during drought years can be the difference in planting success and failure. Data support the practice of not investing in a second herbaceous weed

Table 6—Herbicides were applied early (mid-March), late (mid-May), both timings, or not at all to achieve early-, late-, full-season or no weed control for loblolly pine seedlings. Bare ground is averaged across all four sites and expressed as a percent of Early.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
DAT	30	60	90	120	150	180	210	240
Weed-Free								
Early	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0b	0.0a
Late	-8.1a	-48.9b	-31.0b	-18.2a	2.0a	2.1a	11.5ab	1.4a
Full	0.0a	-2.5a	2.0a	3.9a	7.7a	13.7a	26.0a	36.8a
None	-17.7a	-57.3b	-60.1b	-74.0b	-79.4b	-84.1b	-88.9c	-85.4b

Table 7—Herbicides were applied early (mid-March), late (mid-May), both timings, or not at all to achieve early-, late-, full-season or no weed control for loblolly pine seedlings. Mean seedling performance (total height (H), ground line diameter (GLD) was recorded in November 2001 (age 1) and 2002 (age 2).

Weed-Free	Nov H1 Ft	Nov GLD1 In	Nov H2 Ft	Nov GLD2 In		Nov H1 Ft	Nov GLD1 In	Nov H2 Ft	Nov GLD2 In
HUNTINGTON, TX					WODEN, TX				
Early	1.65a[a]	0.54a	4.40a	1.05a	Early	2.0a	0.48a	5.8a	1.63a
Late	1.26b	0.43b	3.35b	.78b	Late	1.9a	0.44ab	5.7ab	1.60a
Full	1.49a	0.53a	4.17a	1.05a	Full	2.0a	0.51a	5.9a	1.70a
None	1.13b	0.27c	2.54c	.43c	None	1.8a	0.38b	5.1b	1.38b
UNA, MS					LONGVIEW, MS				
Early	1.3a	0.35a	3.5a	0.89a	Early	1.2a	0.31a		
Late	1.3a	0.32a	3.3a	0.85a	Late	1.2a	0.31a		
Full	1.2a	0.37a	3.4a	0.90a	Full	1.1a	0.29a		
None	1.2b	0.26b	3.0b	0.64b	None	1.1a	0.24b		

[a]Means within a column sharing the same letter are not significantly different (Duncan's New Multiple Range test, $p<0.05$).

Table 8—Herbicides were applied early (Mid-March), late (mid-May), both timings, or not at all to achieve early-, late-, full-season or no weed control. Actual mean seedling performances after one (2001) and two (2002) growing seasons are presented for survival, height, and ground line diameter (S, H, GLD) and followed with values expressed as a percent of Early.

Weed-Free	Nov 2001 S1 (%)	Nov 2001 H1 (Ft)	Nov 2001 GLD1 (In)	Nov 2002 H2 (Ft)	Nov 2002 GLD2 (In)
			Actual Means		
Early	88.0a[a,b]	1.55a	0.42a	4.57a	1.19a
Late	81.3a	1.40bc	0.38a	4.11ab	1.08a
Full	86.7a	1.48ab	0.43a	4.49a	1.22a
None	74.7a	1.28c	0.29b	3.56b	0.81b
			Percent of Early		
Early	0.0a	0.0a	0.0a	0.0a	0.0a
Late	-8.2a	-9.9bc	-6.8a	-8.5a	-9.2a
Full	-1.6a	-5.4ab	-0.2a	-1.2a	1.4a
None	-16.3a	-17.9c	-23.6b	-18.1a	-24.8b

[a]Means within a column sharing the same letter are not significantly different (Duncan's New Multiple Range test, $p<0.05$).
[b]Survival means were numerically the same after one and two growing seasons.

treatment on moderately well-drained sites to achieve additional bare ground over that already achieved with one treatment.

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