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SITE PREPARATION FOR INTENSIVELY CULTURED HYBRID POPLAR PLANTATIONS

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ABSTRACT.—Five site preparation treatments consisting of combinations of tillage, contact herbicide (glyphosate), and pre-emergent herbicide (linuron) were tested for their effects on tree survival and growth. Treatments had little effect on tree survival, but effects on second-year tree height were significant and additive—i.e., tree height increased as the number of types and repetitions of site preparation increased. Best growth was obtained with a summer fallow-with-herbicide treatment consisting of two applications of glyphosate followed by plowing and repeated disking, plus spring disking and application of linuron at planting time. A comparable growth response was obtained from the less intensive fall-plow treatment consisting of one application of glyphosate followed by plowing and disking, plus spring disking and application of linuron at planting time. The least effective treatment was no-till, presumably because of lowered soil temperatures.

KEY WORDS: Intensive culture, weed control, glyphosate, linuron, no-till, tillage, fallowing, plantation establishment.

One of the important steps in establishing intensively cultured hybrid poplar (*Populus* spp.) plantations is site preparation to loosen the soil and help control weeds (Hansen *et al.* 1983). Once trees are planted, weed control becomes more difficult and often results in some tree mortality or reduced growth. So money spent on site preparation may be offset by even greater savings later on.

To reduce costs, site preparation for tree plantations has sometimes been done in strips or spots where the trees are planted (Lane and McComb 1953, Bey *et al.* 1975, von Althen 1981). However, hybrid poplar roots grow fast laterally, sometimes reaching 2.2 m by the end of the first growing season (Hansen 1981). Therefore, even at wide tree spacings of 3 by 3 m, tree roots would soon be forced to compete with the undisturbed weeds outside of the prepared areas. Von Althen (1981) showed that hybrid poplars (and other hardwoods) grew best when the entire site was plowed and disked. Reduced growth resulted when strips only 1.2 to 2.7 m wide were plowed and disked, and growth was poorer still in herbicided, no-till strips. No poplars survived in the untreated control. These results in no-till or untreated areas corroborate our own studies.

There are several common ways to prepare the entire site: (1) plowing and disking, (2) fallowing (repeated tillage for a season before planting), and (3) no-till (treating with herbicides). We tested five combinations of these site-preparation techniques to determine which results in the best survival and early growth of hybrid poplar.

METHODS

The study area is located at the North Central Forest Experiment Station's Harshaw Forestry Research Farm west of Rhinelander, Wisconsin. Before its development as a forestry research area, the Harshaw Farm had a 50-year history as a potato farm. Soils are a Padus series silt loam with a plow pan at 25 cm. Quackgrass (*Agropyron repens* (L.) Beauv.) is the main weed competitor; other significant weeds include yellow rocket (*Brassica* spp.), wild

Table 1.—*Schedule of treatments for five site preparation methods*

	Treatment dates[1]							
Sites preparation	**6/23**	**7/13**	**7/20**	**8/1-10[2]**	**10/6**	**11/6**	**4/15**	**5/4[5]**
Fallow w/herbicide	G	G	D,P	D	—	—	D,H	L
Fall plow	—	—	—	—	G	D,P,D	D,H	L
Fall deep-plow	—	—	—	—	G	D,P	LD[3]	L
Fallow	—	—	D,P	D	—	—	D,H	L
No-till	—	—	—	—	G	LD[4]	—	L

[1]Treatments were: G = glyphosate broadcast spray at 2.2 kg a.i./ha; P = plow; D = disk; LD = light disk; H = harrow; and L = linuron broadcast spray.
[2]Disked at about 2-week intervals.
[3]Light disking to smooth soil surface.
[4]Light disking to break up sod to permit planting with mechanical planter.
[5]Linuron applied to half of the split plots.

mustard (*Brassica Kaber* (D.C.) wheeler), lambsquarter (*Chenopodium album* (L.)), white cockle (*Lychnis alba* Mill.), marestail (*Conyza canadensis* (L.) Cronq.), and pigweed (*Amaranthus retroflexus* (L.)).

The five site preparation methods tested were: (1) fallowing during the summer before planting, (2) two initial applications of glyphosate (Roundup)[1] herbicide followed by fallowing during the summer, (3) one fall application of glyphosate followed by fall plowing (our most common practice), (4) one fall application of glyphosate followed by deep plowing to break up the plow pan and bring soil from the 30 to 40 cm depth to the surface to bury weed seed, and (5) no-till with one fall application of glyphosate (table 1). Glyphosate was applied at 2.2 kg active ingredient (a.i.)/ha (2 lbs a.i./ac) with a low pressure (20 p.s.i.) boom sprayer; plowing was done with a moldboard plow; disking was done with an offset disk followed by additional tillage with a spike-tooth harrow. To test the effects of a pre-emergent herbicide for extended weed control, linuron (Lorox) was applied at 1.7 kg a.i./ha (1.5 lbs a.i./ac) to half of each plot at the time of planting.

The experiment was a split-plot design with the five site-preparation treatments (main plots) arranged in three randomized complete blocks. The subplots for testing linuron were chosen randomly. Main plot size was 8 by 30 m split lengthwise into the two subplots. There were four rows of about 30 trees in each subplot with trees spaced at 1 by 1 m.

Soaked, unrooted hardwood cuttings of hybrid poplar clone NC-9922 were planted May 4, 1981. The 20-cm-long cuttings were machine planted 15 cm deep. The parentage of this clone is not known but it appears morphologically identical to NE-252 (NC-5334) *Populus deltoides* var. *angulata* ×*P. trichocarpa*.

[1]*Mention of trade names does not constitute endorsement of the products by the USDA Forest Service.*

The plots were irrigated from above with a cart-mounted traveling irrigation gun whenever soil moisture tension reached -0.5 bars at the 15-cm depth. In addition a 28 percent nitrogen solution was applied through the irrigation system at the rate of 168 kg/ha (150 lbs/ac) per year, with the application split between June and July.

Survival and heights of the 30 interior trees of each split plot were measured in the fall of 1981 and tree heights were remeasured in the fall of 1982. The data were analyzed by ANOVA.

RESULTS

Tree survival at the end of the first growing season did not differ significantly among the five site preparation treatments (85 to 92 percent) (table 2). Also, there were no significant differences in tree survival

Table 2.—*Relation of first-year survival and second-year average tree height to site preparation. Any two site preparation treatments not next to a common line are significantly different ($p \leq 0.05$). Pertinent standard errors are also given*

		Tree height-m		
Treatment	**Survival**	**Linuron**	**No-linuron**	**Difference**
	Percent			
Fallow w/ herbicide	87	2.63	2.33	0.30
Fall plow	92	2.49	2.10	.39
Fallow deep-plow	85	2.46	2.05	.41
Fallow	87	2.35	1.76	.59
No-till	87	2.03	1.71	.32
	Ave. =	2.39	1.99	

Standard error of mainplot treatment mean = ±0.09 (6 d.f.)
Standard error of subplot treatment mean = ±0.04 (15 d.f.)

between the linuron-treated subplots (89 percent) and the no-linuron subplots (86 percent). Since establishment-related mortality typically occurs during the first growing season, and very little additional mortality occurred the second year in these plantations, we did not analyze second-year survival.

At the end of the second year, however, mean tree height did differ significantly among the site preparation treatments ($P \leq 0.01$) and between the linuron-treated and control subplots ($P \leq 0.0001$) (table 2). The fallow-with-herbicide treatment resulted in the tallest trees, averaging 2.48 m in 2 years. The fall-plow and deep-plow treatments produced the next tallest trees, which were not significantly shorter than those in the top-ranked treatment, ($SE = \pm 0.09$). The fallow-without-herbicide treatment ranked fourth and the no-till treatment last. This ranking of site preparation treatments was the same in the subplots whether they received linuron or not. Thus, the site preparation treatments produced average tree heights ranging from 1.87 m (no-till) to 2.48 m (fallow-with-herbicide)—a 33 percent difference.

The application of linuron increased tree growth 0.30 to 0.59 m (a 20 percent gain) depending on site preparation treatment. Although the differences are not statistically significant, it is interesting to note that the greatest gain was associated with the fallow treatment, the only treatment that did not include glyphosate application before applying the linuron (table 1).

The effects of the site-preparation treatments were cumulative. Fallowing (tillage) produced a height gain of 3 percent (not significant) over that of no-till; adding two applications of glyphosate to the fallow treatment produced an additional height gain of 32 percent (significant) over that of the fallow treatment alone; and the application of linuron was responsible for an additional 13 percent increase (significant). This resulted in a 54-percent difference between the single treatment (no-till without linuron) and the combined treatment (fallow-with-herbicide plus linuron).

DISCUSSION

Apparently, increasing the number of types and repetitions of site preparation (to a point) has a cumulative effect on weed suppression, and consequently allows more tree growth. This explanation especially applies to rhizomatous or sod-forming grasses, such as quackgrass or fescue (*Festuca* spp.), which are both highly competitive and allelopathic (Kommedahl *et al.* 1959, Gabor and Veatch 1981, Peters and Mohammed Zam 1981, Todhunter and Beineke 1979). Cardina and Hartwig (1982) found that alfalfa seeded into quackgrass sod treated with glyphosate had greatly reduced yields. Toai and Linscott (1979) found that the phytotoxic effect of quackgrass residues dissipated faster at higher soil temperatures. This suggests that a combined site preparation system of a contact herbicide plus tillage is desirable to control allelopathic species and their residual toxic effects. The herbicide will kill the weed cover and tillage will increase soil temperature and speed up the microbial decomposition of residues and breakdown of allelopathic chemicals.

The poor performance of the no-till treatment in this test confirmed results of earlier trials in which we compared till and no-till site preparation systems. No-till and other practices that leave residues on the soil surface result in higher soil moisture in the plant root zone and lower spring soil temperatures (Crosson 1981). The moisture-retaining characteristic of no-till is an advantage on droughty soils, but is a disadvantage on poorly drained soils. Agricultural studies show that tillage practices (including no-till) that leave residues on the soil surface are better adapted to the longer and warmer growing seasons in the southern half of the corn belt and farther south (Larson 1980-1981). Based on the poor results of no-till on an imperfectly drained clay loam soil (von Althen 1981), and on our well drained silt loam soil, we conclude that no-till will probably not be as suitable as other site preparation methods involving tillage in these more northerly latitudes.

Linuron extends the duration of weed control during that critical early part of the plantation establishment period when most annual weeds are germinating. It reduces the need for cultivation or herbicide application in the first month after planting. Weed control applied soon after planting invariably damages or kills some new trees.

Deep-plowing was tested to determine if burying the topsoil with a thin layer of subsoil would prevent weed seed germination and thereby improve tree growth, or possibly reduce weed growth to the extent that linuron would not be needed. However, deep plowing did not fully achieve the test objectives because the plowing action mixed the subsoil and topsoil and deposited a discontinuous layer of subsoil of highly variable thickness on the soil surface. Possibly due partly to this, deep-plowing had about the same effect on tree height as fall-plowing, and did not reduce the need for linuron. Although deep-plowing broke up the plow pan, it did not increase tree height, suggesting that subsoiling may be of little benefit on this soil.

Fall-plowing is probably the best site preparation treatment from an operational standpoint. Although not quite as good as the fallow-with-herbicide treatment (but not significantly different), it does not require an idle growing season before planting as do the fallow treatments. Also, fall-plowing requires less energy than either deep-plowing, or the fallow treatments which require repeated disking (Vaughan *et al.* 1978). Our fall-plowing treatment is almost the same as that recommended by von Althen (1979) for abandoned agricultural land in southern Ontario.

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