Tree Planter's Notes, Vol. 36, No. 1 (1985)

Effects of Chemical Weed Control and Seedling Planting Depth on Survival and Growth of Aspen[1]

Gregory L. Reighard, Glenn Howe, and James W. Hanover

Graduate student, tree improvement specialist, and professor of forestry, respectively, Department of Forestry, Michigan State University, East Lansing, MI.

Deep-planting aspen seedlings by placing the root collar 15 centimeters below the soil surface reduced injury from simazine. Simazine gave excellent weed control, whereas diuron and linuron were not as effective. All three herbicides were toxic to sensitive poplar species, even at low concentrations. Survival was more important than early growth as a criterion for evaluating herbicides for aspen establishment.

Research interest in short-rotation tree plantations for biomass production, spawned by the energy crisis of the 1970's, continues to grow. Species of *Populus* are frequent choices for these plantations in the Lake States because of their fast growth and coppicing ability. Despite their popularity, inexpensive means for establishing such plantations have not been developed for most *Populus* species. Hybrid poplars, cottonwood (*Populus deltoides*), and quaking aspen (*Populus tremuloides* Michx.), along with most other hardwood species, need good site preparation and weed control in the first 2 to 3 years in order to be successfully established on abandoned fields (4, 13, 14). Cultivation is effective but expensive. Chemical weed control is an alternative method that is less expensive but more risky. Improved planting practices that include chemical weed control and exclude cultivation need to be developed and refined for all poplar species, especially the sensitive balsam poplars (*Populus balsamifera* L.) and aspens.

Much of the previous poplar research concerning preemergence herbicides has been directed at the black poplars (Section Aigeiros), balsam poplars (Section Tacamahaca), and their hybrids. Herbicide research on aspen (Section Leuce), however, has been limited. Because aspen is abundant and regenerates easily from established stands, planting it has received little interest in the past. With the recent upsurge of research on energy plantations, however, aspen is now being considered as a possible plantation species.

The work reported here tested the efficacy of three preemergence herbicides--simazine (2-chloro-4,6-bis(ethylamino)-s-triazine), diuron (3-(3,4- dichlorophenyl)-1,1-dimethylurea), and linuron (3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea) -- in controlling weed competition on an abandoned field in southern Michigan. These herbicides have been used previously in poplar plantations by numerous scientists, including von Althen (11, 14), Dickmann et al. (6), and Netzer and Noste (8). In conjunction with these herbicides, deep-planting of the seedlings and the use of plastic mulch were evaluated for protection from chemical injury. The purpose of these treatments was to find a system using chemicals that could be applied to planting aspen on abandoned farmland in Michigan.

Materials and Methods

An agricultural field that had been idle for 25 years was chosen as a planting site. The field is located in Ingham County (S 6 T3N R1W), MI. The soil series, a Marlette fine sandy loam, is classified as a mixed, mesic Glossoboric Hapludalf. The soil properties and chemistry of the Ap horizon were analyzed by the Michigan State University Soil Testing Laboratory. The soil contained 2.0 percent organic matter and 21.3 percent clay. Its pH was 6.7 and the cation exchange capacity was 6 milliequivalents per gram. Its texture class is sandy clay loam. The field was mowed in September 1980 and sprayed with 7 liters of glyphosate per hectare in 1-meter strips. The major vegetation cover at the time of spraying was quackgrass, *Agropyron repens* (L.) Beauv.

Nursery-grown 1+0 seedlings of bigtooth aspen (*Populus grandidentata* Michx.) and quaking aspen that had been lifted in March and stored in a refrigerated room were planted May 8,

[1] Michigan Agricultural Experiment Station Journal Article 11277.

1981, in five to seven tree plots in a randomized block design with seven replications. The trees were spaced 1.2 meters within rows and 2.4 meters between rows. There were eight plots (treatments) per replication. Each plot contained both species of aspen and was randomly assigned one of eight possible treatments (table 1). The dosage (2.8 kilograms of active ingredient per hectare) for all chemical treatments was an arbitrary concentration that fell within the lower range of application rates commonly used for these three herbicides. Optimal herbicide dosages were not tested. Planting procedures consisted of making a slit down each sprayed row with a tree planter and then hand planting the trees in the slit. The root collars of all trees in each treatment plot were placed either 3 or 15 centimeters below the soil surface. In one treatment, a 30-centimeter-square black plastic mulch was placed around each tree.

On May 12, all plots to receive an herbicide treatment were completely sprayed with a 9.5 liter Lofstrand (Model 1730) handsprayer that had been calibrated at 30 to 40 pounds per square inch. The control plots were hand cultivated. Rain (7.6 centimeters) fell on the test site from May 10 to May 15. Rainfall for May and June 1981 was normal. The following April (1982) all plots were sprayed with 2.8 kilograms (active ingredient) of simazine per hectare.

In May 1981, 1 month after spraying, herbicide injury to each tree was rated subjectively. In September 1981, weed control for each plot was evaluated. Tree heights were measured in the fall of 1981, 1982, and 1983. Diameters at 5 centimeters above ground level were measured in 1982 and 1983. Percent survival for each treatment was recorded for all 3 years.

Table 1—*Effects of eight herbicide treatments (2.8 kilograms active ingredient per hectare) on weed control and aspen growth and survival*

		Phytotoxicity		Growth data (treatment means)			
Planting depth	Other treatments	Herbicide injury rating[1] (aspen)	Weed control[2] (%)	1983 Survival (%)	1981 Height (m)	1983 Height (m)	1983 Diameter[3] (cm)
Simazine							
3 cm	—	0.67	87	62	0.67	2.7	3.1
15 cm	—	.12	89	89	.72	3.0	3.5
Regular	Plastic Mulch	.65	82	79	.74	2.7	3.2
Diuron							
3 cm	—	.69	59	77	.76	2.9	3.5
15 cm	—	.72	56	71	.75	3.2	3.5
Linuron							
3 cm	—	1.23	62	55	.69	2.8	3.1
15 cm	—	.92	62	61	.73	3.1	3.4
No herbicide							
3 cm	Cultivation	.00	100	98	.90	3.4	4.0
LSD (0.05)		.35	—	—	.13	—	—
Significance of F value		**	**	*	*	NS	NS

[1]Injury rating was 0 = no damage, 1 = yellow leaves, and 2 = yellow and black leaves.
[2]Percent of sprayed ground without live weeds.
[3]Diameter at 5 centimeters above ground surface.
* and **Significant at the 5 and 1 percent levels, respectively. NS = not significant

An analysis of variance was performed on plot means for each trait except survival and weed control. Herbicide damage ratings were tested for normality before analysis. The survival and weed control data were not normally distributed, so Friedman's two-way classification test (10) was used to detect differences. An LSD test was applied to the treatment means for the 1981 height and herbicide damage data. Correlations between years were generated for treatment means of height and diameter. Nonparametric rank correlations were calculated for the relationship of weed control to the treatment means for height and diameter.

Results

The results for each treatment are listed in table 1. The control and one simazine (deep-planting) treatment had the least herbicide injury and the best weed control. The two linuron treatments had the most initial herbicide damage. Simazine gave better weed control than either diuron or linuron. Deep-planting reduced chemical injury on simazine plots but not on the diuron or linuron plots.

The control treatment had the highest survival in each of the 3 years. One simazine (deep-planting) treatment also had good survival. The two linuron treatments and one other simazine (regular-planting) treatment gave poor survival. Deep-planting increased survival on simazine plots but not on the diuron and linuron plots. Few trees died after the first year; therefore, the survival rankings of the treatments remained unchanged throughout the 3 years.

First-, second-, and third-year heights and diameters were greatest in the control plots. Trees given the simazine (regular-planting) treatment generally showed the poorest height and diameter growth. In the second and third years, trees in the deep-planted plots of simazine, diuron, and linuron grew more than the regularly planted plots. This trend was also true for diameter except that there were no differences in diameter of trees in the diuron plots for the third year. The seedlings that were deep-planted appeared to suffer no detrimental physiological effects from the placement of the root collar 15 centimeters below the soil surface. This observation agreed with that of Benson (4), who reported that deep-planting aspen 10 to 30 centimeters above the root collar did not affect their establishment adversely.

Treatment means for height and diameter were significantly correlated at the 1-percent level between years 1981-82 and 1982-83 and at the 5-percent level for years 1981 and 1983 (table 2). Nonparametric rank correlations between weed control and growth data were low (r = .05 to 0.20) and nonsignificant at the 5-percent level of probability.

Discussion

Three years' results of height and diameter growth for each treatment indicate that cultivation alone was superior to all chemical treatments, but the differences became insignificant after the first growing season. The smaller and less significant correlation (table 2) of the treatment means for height between years 1981 and 1983 indicate that first-year treatment differences were decreasing with time, that is, the mean height of the poorest treatment increased from 74 percent (1981) to 79 percent (1983) of the mean

Table 2—*Year-to-year correlations of the treatment means for height and diameter of the experimental aspen seedlings* (df = 7)

Years correlated	r: Height	r: Diameter
1981 with 1982	0.84**	—
1981 with 1983	.77*	—
1982 with 1983	.97**	.95**

* and **Significant at the 5- and 1-percent levels, respectively.

height for the best treatment (table 1). The initial superiority in growth and survival of cultivated trees was attributed to the absence of both weed competition and phytotoxic effects from the chemical treatments, as well as increased soil aeration.

Simazine, diuron, and linuron are toxic to sensitive poplar species at low concentrations. These chemicals are principally taken up by root absorption. Jaciw (personal communication) observed in Ontario that deep-planted hybrids of white poplar (*P. alba*) and aspen were not damaged by simazine. Therefore, preventing contact of the root system with the herbicide is essential for establishing chemical-sensitive species such as aspen.

Roadhouse and Birk (9) found that simazine applied at a rate of 2.2 kilograms (active ingredient) per hectare on a cultivated field did not penetrate below the top 15 centimeters of soil during the first growing season. In addition, Weldon and Timmons (15) showed on a sandy clay loam and a loamy sand soil that diuron, when applied at rates of 2.2 and 4.5 kilograms (active ingredient) per hectare does not penetrate below 10 centimeters in the soil regardless of the amount of irrigation used. These findings suggest that deep-planting aspen seedlings 15 centimeters below the soil surface should minimize herbicide contact with the root system. The results with simazine here support this hypothesis. The one simazine (deep-planting) treatment had 89 percent survival after 3 years compared to 62 percent for the other simazine (regular-planting) treatment.

The diuron and linuron deep-planting treatments may fail to prevent herbicide injury because these two chemicals are more water soluble than simazine and are also absorbed by the foliage. The water solubility of simazine is 5 parts per million (2), compared with 42 for diuron and 75 parts per million for linuron (1). The planting slit may have opened slightly because of soil shrinkage from evapotranspiration; the soil texture of the Ap horizon contained 21 percent clay, which increases the soil shrinkage properties (12). During May, heavy rains could have carried more of the more water-soluble herbicides (diuron and linuron) down into the slit than the highly insoluble simazine.

Another possible reason for the increased damage in the diuron and linuron deep-planted treatments is that substituted urea herbicides, in contrast to simazine, are more readily absorbed by the foliage (1, 5, 7). At the time of the herbicide treatment, a few trees in each plot had new leaves just breaking through the bud scales. No attempt was made to cover the seedlings when each plot was sprayed because the spraying procedure was to simulate actual field application conditions. These early leafing seedlings suffered foliage injury and may have absorbed sufficient herbicide to kill them.

The effectiveness of plastic mulch in controlling chemical injury was intermediate when compared to the two simazine treatments. The plastic mulch (simazine) treatment had poorer survival than the deep-planting (simazine) treatment but better survival than the regular-planting (simazine) treatment. Although the plastic lessened simazine injury, it did not prevent it. The main problem with the plastic was that it collected and pooled the herbicide spray and then funneled some of the chemical through the plastic at the opening around the root collar. The use of plastic mulch around individual stems to prevent herbicide damage should be reevaluated because of its cost in labor and materials as well as its uncertain effectiveness.

The good to excellent (82 to 89 percent) weed control produced by simazine compared to the moderate (56 to 62 percent) weed control exhibited by diuron and linuron was due largely to the chemistry of the herbicides. The low soil organic matter (2.0 percent) and the slightly acidic pH (6.7) of the Ap horizon were favorable for chemical activity of all three herbicides. However, under these conditions simazine gave better weed control, partly because simazine-tolerant late-season grasses did not invade the simazine plots in late summer. Simazine was probably more persistent in the soil because it was more insoluble and less volatile than diuron and linuron.

Achieving excellent weed control (75 to 100 percent) by using moderate to high application rates of chemicals such as simazine may not be advisable because of the increased risk of mortality. This was the case with the simazine plots, which averaged 86 percent weed control compared to 60 percent for the diuron and linuron plots. Despite having better weed control, simazine (regular-planting) plots had poorer survival and growth after 3 years than did the diuron (regular-planting) plots.

The absence of significant correlations between first-year weed control and the 3 years of growth data suggested that the initial weed control, which was as low as 35 percent in some plots, was sufficient to avoid serious growth inhibition from weed competition. This lack of correlation between weeds and growth agreed with the results of Benson and Einspahr (3), who found that, when greater than 50 percent of the vegetative cover was controlled, low survival or reduced tree growth resulted, presumably from chemical toxicity. They concluded that complete control of weeds is not necessarily a good criterion of usefulness of herbicides. These results imply that prevention of herbicide injury while still achieving good survival and growth is a better strategy than trying to control all weeds. Therefore, on an average or better site, aspen can be successfully established even if weed control is 50 percent or less for the first growing season.

Literature Cited

1. Anderson, W.P. Weed science: principles. New York: West Publishing; 1977. 598 p.
2. Audus, L.J. The physiology and biochemistry of herbicides. New York: Academic Press; 1964. 555 p.
3. Benson, M.K.; Einspahr, D.W. Chemical control of vegetative competition in aspen plantings. Tree Planters' Notes 67: 15-17; 1964.
4. Benson, M.K. Breeding and establishment-and promising hybrids. In: Aspen Symposium Proc. Gen. Tech. Rep. NC-1, St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1972. p. 88-96.
5. Danfield, W.; Martishus, J.; Hansen, E. Application date affects herbicide tolerance of hybrid poplars. Res. Note NC-301. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1983
6. Dickmann, D.I.; Heiligmann, R.; Gottschalk, K. Herbicides aid establishment of unrooted poplar cuttings. Tree Planters' Notes 28 (34): 10-13; 1978.
7. Gilchrist, A.N. More herbicides for soil conservation tree nurseries. Proc. N.Z. Weed Pest Control Conf.: 104-106; 1981.
8. Netzer, D.A.; Noste, N.V. Herbicide trials in intensively cultured *Populus* plantations in northern Wisconsin. Res. Note NC-235. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1978.
9. Roadhouse, F.E.B.; Birk, L.A. Penetration of and persistence in soil of the herbicide 2-chloro-4,6-bis(ethylamino)-s-triazine (simazine). Canadian Journal of Plant Science 41: 252-260: 1961.
10. Steel, R.G.D.; Torrie, J.H. Principles and procedures of statistics. New York: McGraw-Hill; 1960. 481 p.
11. von Althen, F.W. Effects of site preparation and postplanting weed control on the survival and height growth of planted hardwood seedlings. Rep. O-X-248. Sault Ste. Marie, ON: Canadian Forest Service; 1976.
12. von Althen, F.W. Site preparation prevents re-opening of planting slits in heavy-textured soils. Forestry Chronicle 53: 166-167; 1977.
13. von Althen, F.W. Preliminary guide to site preparation and weed control in hardwood plantations in southern Ontario. Report O-X-288. Sault Ste. Marie, ON: Canadian Forest Service; 1979. 22 p.
14. von Althen, F.W. Planting studies with hybrid poplars and cottonwood in southwestern Ontario. Rep. 0-X332. Sault Ste. Marie, ON: Canadian Forest Service; 1981. 17 p.
15. Weldon, L.W.; Timmons, F.L. Penetration and persistence of diuron in soil. Weeds 9: 195-203; 1961.