√5

Cultivation and weed control for aspen seedling establishment in the southern Rocky Mountains[1]

JAMES T. FISHER AND ROBERT W. NEUMANN
Department of Horticulture, New Mexico State University, Las Cruces, NM, U.S.A. 88003

Received May 6, 1986

Accepted September 8, 1986

FISHER, J. T., and R. W. NEUMANN. 1987. Cultivation and weed control for aspen seedling establishment in the southern Rocky Mountains. Can. J. For. Res. **17**: 47–50.

Containerized aspen (*Populus tremuloides* Michx.) seedlings were planted at high-elevation sites in southern (May 1982) and northern (July 1983) New Mexico. Each plantation compared fall cultivation (20 cm depth), prior to planting the following spring or summer, with cultivation at the time of planting. Subtreatments of the tests included applications of the postemergent herbicide dalapon and the preemergents linuron, trifluralin, or simazine applied 2 to 3 weeks before planting. First season survival exceeded 75% for the best treatment at each site. Cultivation, in general, effectively reduced weed cover and improved seedling success. Fall cultivation, in particular, improved seedling survival and growth only at the relatively dry southern site. Except for spring-cultivated plots in the south, some herbicide applications improved weed control and seedling performance over cultivation alone. The combination of fall cultivation plus trifluralin is considered the best site preparatory treatment tested.

FISHER, J. T., et R. W. NEUMANN. 1987. Cultivation and weed control for aspen seedling establishment in the southern Rocky Mountains. Can. J. For. Res. **17**: 47–50.

Des semis de tremble (*Populus tremuloides* Michx.) en conteneurs furent plantés sur des terrains en altitude au sud (mai 1982) et au nord (juillet 1983) du Nouveau-Mexique. Chaque plantation permettait de comparer le labourage d'automne (profondeur de 20 cm) effectué avant la mise en terre le printemps ou l'été suivant avec le labourage effectué au moment de la mise en terre. Chaque traitement fut subdivisé pour étudier les effets de l'herbicide de post-émergence dalapon et ceux des herbicides de pré-émergence linuron, trifluralin ou simazine appliquée 2 à 3 semaines avant la mise en terre. La survie en fin de première saison dépassa 75% pour le meilleur traitement sur chaque type de terrain. En général, le labourage réduisit efficacement la compétition herbacée et améliora le comportement des semis. De façon plus particulière, le labourage automnal n'améliora la survie et la croissance des semis qu'à l'endroit du terrain relativement sec localisé au sud. À l'exception des parcelles du sud laborées au printemps, les herbicides ont amélioré le contrôle de la compétition herbacée et le comportement des semis par rapport au labourage seul. Le meilleur traitement combiné de préparation obtenu a consisté en un labourage automnal suivi d'une application de trifluralin.

[Traduit par la revue]

Introduction

The geographic range of quaking aspen (*Populus tremuloides* Michx.) in western North America spans more than 40° latitude. More than 200 000 ha are occupied in New Mexico, Arizona and the adjacent San Juan Basin (Jones and Trujillo 1975) where aspen forests provide many human benefits and renewable resources.

An important potential benefit of aspen is its role in redirecting the course of wildfire. In the southern Rockies, aspen has a lower fire potential than conifer types, and can povide a critical fuel break. Aspen flammability has been estimated to be less than half that of adjacent conifers (Fechner and Barrows 1976). This might explain why wildfires spreading from high elevation conifer forests have been observed to die out in aspen. Healthy aspen stands are regarded by fire managers as relatively fireproof. It follows that maintenance and establishment of aspen are useful fire management practices, particularly in mountin resort areas where ignition is likely and the potential for loss of resource value and life is great.

At present, land managers in the Southwest do not have a full understanding of the steps necessary to grow aspen seedlings reliably and efficiently, or of those steps leading to fuel-break establishment. Greenhouse, nursery, site preparation, and weed control practices leading to aspen establishment must be developed. This paper addresses the last two elements of the project, site preparation and weed control.

[1]New Mexico Agriculture Experiment Station journal article No. 1241.

Methods

Two separate experiments were established,one in the Sacramento Mountains of south-central New Mexico in May 1982, the other 14 months later in the Sangre de Cristo Mountains, 360 km to the north. The southern site (elevation, 2650 m) annually receives approximately 700 mm of precipitation, 550 mm of which are lost to evapotranspiration. The northern site (elevation, 2870 m) is more moist, averaging 900 mm precipitation and 400 mm evapotranspiration. Plantations were not irrigated but were fenced to preclude rodent and deer damage.

Similar split-block experimental designs were used for both studies. At each site, main treatments tested time of preplant cultivation. Plots were cultivated either (*i*) in the fall, after applying dalapon (2,2-dichloropropanic acid) at 5.6 kg active ingredient (ai)/ha, or (*ii*) spring or summer for the southern and northern sites, respectively. Subtreatments applied before planting at each site tested herbicides and cultivation: (*1*) linuron (*N'*-3,4-dichlorophenyl)-*N*-methoxy-*N*-methylurea) at 1.1 kg ai/ha; (*2*) linuron at 2.2 kg ai/ha; (*3*) trifluralin (2,6-dinitro-*N*,*N*-dipropyl-4-(trifluoromethyl)benzenamine) at 1.1 kg ai/ha; (*4*) trifluralin at 2.2 kg ai/ha; (*5*) simazine (6-chloro-*N*,*N'*-diethyl-1,3,5-triazine-2,4-diamine) at 2.7 kg ai/ha; (*6*) simazine at 4.5 kg ai/ha; (*7*) cultivation alone (no chemical applications); (*8*) check (the fall main plot received dalapon at 5.6 kg ai/ha, while the other main plot was not treated; (*9*) no treatment.

In September of the year before planting, the postemergent herbicide dalapon was applied to fall main plots at both sites, excluding the cultivation alone subplot. When the vegetation browned about 2 weeks later, plots were cultivated to a depth of approximately 20 cm. The dalapon subtreatment received no additional herbicides. Spring cultivation and application of preemergent herbicides linuron, trifluralin and simazine were completed the following April at the southern site. The same was done in early July at the northern site. All chemicals were

TABLE 1. Results for the southern site (planted May 1982)

Treatment	Soil moisture at planting (%) 0–15 cm depth	Soil moisture at planting (%) 15–30 cm depth	Survival (%), Sept. 1982	Height (cm), May 1983	Weed cover (%) Jul. 1982	Weed cover (%) Jul. 1983
Cultivation times*						
Fall	23.7*a*	30.7*a*	49.2*a*	9.1*a*	40.8*a*	47.0*a*
Spring	17.1*b*	24.8*b*	40.4*b*	6.6*b*	42.2*a*	50.8*a*
Fall cultivation subtreatments						
Linuron, kg ai/ha						
1.1			61.0*ab*	7.4*b*	43.3*abc*	42.8*a*
2.2			51.9*b*	9.0*b*	35.0*a*	56.5*a*
Trifluralin, kg ai/ha						
1.1			56.5*ab*	8.8*b*	42.0*abc*	45.8*a*
2.2			63.5*ab*	12.0*a*	38.3*ab*	41.8*a*
Simazine, kg ai/ha						
2.7			44.8*b*	9.2*b*	27.8*a*	46.8*a*
4.5			22.1*c*	7.0*b*	41.5*abc*	41.3*a*
Cultivation alone			44.8*b*	8.6*b*	57.5*c*	54.3*a*
Check (dalapon)			75.6*a*	8.4*b*	52.8*bc*	47.0*a*
Spring cultivation subtreatments						
Linuron, kg ai/ha						
1.1			42.3*a*	7.1*a*	46.3*a*	54.0*a*
2.2			46.5*a*	6.3*a*	41.8*a*	58.0*a*
Trifluralin, kg ai/ha						
1.1			44.2*a*	5.7*a*	47.8*a*	55.0*a*
2.2			37.5*a*	6.1*a*	32.3*a*	44.8*a*
Simazine, kg ai/ha						
2.7			39.8*a*	7.0*a*	43.8*a*	52.3*a*
4.5			29.2*a*	6.5*a*	40.0*a*	53.5*a*
Cultivation alone			43.8*a*	7.0*a*	43.8*a*	38.3*a*
Check			0.6*b*	8.3*a*	76.5*b*	61.8*a*

NOTE: Column values with the same letter are not significantly different ($p \leq 0.05$) as determined by the protected LSD. Survival and weed cover data were subjected to arcsine transformation (Little and Hills 1978) prior to analysis. Means presented are for the untransformed data.
*The seven subtreatments common to both main treatments (cultivation times) are combined for analysis.

applied with a calibrated, hand-held boom sprayer. Trifluralin was incorporated into the soil according to label directions.

Four-month-old containerized seedlings were sorted by size to ensure uniformity within each replication and were planted in May 1982 in the south and July 1983 in the north (2 to 3 weeks after the herbicide applications at each site). The volume of seedling containers was 160 cm^3 in the southern planting and 350 cm^3 in the northern. Larger containers were used at the northern site to improve the generally poorer survival observed in the earlier planting. Seedlings planted at the southern site were pruned to a uniform height of 20 cm after planting. Forty-tree rectangular plots were replicated four times at each site.

Seedling survival was evaluated 4 months after planting in the south and 11 months after planting in the north. Percent soil moisture was determined at planting and regularly for several weeks thereafter. Weed cover was evaluated periodically after planting by the point sampling method (Grieg-Smith 1957).

Height growth was measured at the southern site 1 year after planting. Height and basal stem caliper were measured 14 months after planting the northern site.

Data were analyzed as plot means via the protected LSD. Statistical differences discussed in this article are at the $p \leq 0.05$ level.

Results

The southern site (Table 1)

Survival

Seedling survival declined during the first growing season as midsummer drought took its toll on many seedlings in the study. By September 1982, nearly 100% mortality in untreated plots showed that cultivation, regardless of timing, markedly improved seedling survival. Survival for fall-cultivated plots was 49.2% and was statistically greater than 40.4% survival in spring-cultivated plots. Soil moisture at planting was significantly greater for fall-cultivated plots than it was for those cultivated in spring. Main treatment differences for soil moisture diminished as early season rains arrived, but fall cultivation, and its associated winter fallowing, resulted in additional soil moisture during the critical establishment period, and effectively increased seedling survival.

Fall–dalapon resulted in higher seedling survival (75.6%) than did other fall subtreatments, except trifluralin (63.5% for the high rate, 56.5% for the low rate) and linuron at the low rate (61.0%). Excluding the untreated control, survival rates for spring subtreatments did not differ significantly.

In both fall- and spring-cultivated plots, survival for cultivation alone plots was equal to or greater than survival for preemergent herbicide plots. That is, preemergent herbicides did not improve seedling survival in cultivated plots.

Height

Plantation-wide height was reduced 60–70% by first season main stem dieback. In May 1983, seedlings in fall plots averaged 9.1 cm in height and were significantly taller than seedlings in

TABLE 2. Results for the northern site (planted July 1983)

Treatment	Soil moisture at planting (%)		Survival (%), June 1984	Height (cm), Sept. 1984	Caliper (mm), Sept. 1984	Weed cover (%)	
	0–15 cm depth	15–30 cm depth				Nov. 1983	Sept. 1984
Cultivation times*							
Fall	31.1*a*	31.9*a*	67.1*a*	47.9*a*	5.6*a*	57.8*a*	77.8*a*
Summer	26.9*a*	23.7*b*	70.9*a*	51.9*a*	5.9*a*	48.2*a*	79.4*a*
Fall cultivation subtreatments							
Linuron, kg ai/ha							
1.1			69.4*ab*	47.6*b*	5.2*bc*	74.5*cde*	89.0*d*
2.2			78.1*a*	48.2*b*	5.6*b*	52.5*abc*	79.5*cd*
Trifluralin, kg ai/ha							
1.1			68.8*ab*	55.3*a*	6.3*a*	30.5*a*	69.8*ab*
2.2			73.1*a*	53.8*a*	6.2*a*	33.8*ab*	63.3*a*
Simazine, kg ai/ha							
2.7			66.3*abc*	43.7*bc*	5.3*bc*	74.3*de*	81.5*cd*
4.5			43.8*c*	47.9*b*	5.5*b*	55.5*bcd*	77.0*bc*
Cultivation alone			70.0*ab*	40.2*cd*	4.8*cd*	83.3*e*	84.8*cd*
Check (dalapon)			50.0*bc*	35.1*d*	4.5*d*	88.3*e*	87.8*d*
Summer cultivation subtreatments							
Linuron, kg ai/ha							
1.1			73.1*ab*	49.1*cd*	5.7*bc*	52.0*ab*	90.5*b*
2.2			78.1*a*	51.2*bcd*	5.9*abc*	54.5*ab*	80.8*a*
Trifluralin, kg ai/ha							
1.1			78.1*a*	55.5*ab*	6.2*ab*	35.3*a*	76.3*a*
2.2			71.3*ab*	57.6*a*	6.3*a*	38.0*a*	71.5*a*
Simazine, kg ai/ha							
2.7			55.6*b*	53.1*abc*	5.6*c*	53.8*ab*	81.8*a*
4.5			66.9*ab*	47.4*d*	5.8*abc*	36.0*a*	74.8*a*
Cultivation alone			73.1*ab*	49.1*cd*	5.6*c*	67.8*b*	80.5*a*
Check			53.8*b*	31.5*e*	3.8*d*	95.3*c*	94.3*b*

NOTE: Column values with the same letter are not significantly different ($p \leq 0.05$) as determined by the protected LSD. Survival and weed cover data were subjected to arcsine transformation (Little and Hills 1978) prior to analysis. Means presented are for the untransformed data.
*The seven subtreatments common to both main treatments (cultivation times) are combined for analysis.

spring plots (6.6 cm). The only cultivation–herbicide combination to result in superior growth was fall–trifluralin (2.2 kg ai/ha), which produced seedlings averaging 12.0 cm tall.

Weed control

Perennial grass sod, composed primarily of western wheatgrass (*Agropyron smithii* Rudb.) and Kentucky bluegrass (*Poa pratensis* L.), covered more than 75% of the ground area before cultivation. Western yarrow (*Achillea lanulosa* Nutt.), dandelion (*Taraxacum officinale* Weber), vetch (*Vicia sativa* L.), and other forbes were present among the grasses.

Two months after planting, percent weed cover did not differ significantly between cultivation times. Fall and spring plots averaged 40.8 and 42.2% cover, respectively. Preemergent herbicides, associated with either cultivation time generally did not differ in their respective effects on weed density. Among fall-cultivated subplots, only simazine at 2.7 kg ai/ha (27.8% cover), linuron at 2.2 kg ai/ha (35.0% cover), and trifluralin at 2.2 kg ai/ha (38.3% cover) provided significantly better weed control than cultivation alone (57.5% cover). Spring cultivation alone (43.8% cover) controlled weeds as well as any spring herbicide subtreatment, but all spring-culivated subplots were significantly less weedy than the untreated control (76.5% cover).

By July 1983, overall weed cover had risen to 47.0% for fall-cultivated plots and to 50.8% for plots cultivated in spring, but differences remained insignificant. The check plots averaged 61.8% cover, but no statistical differences were detected among subtreatments within either cultivation time. Composition of the weed species did not change over the test period.

The northern site (Table 2)

Survival

After experiencing generally poor survival at the southern site, seedlings for the northern site were grown in larger containers (350 cm^3) and planted at a later date (July) to minimize spring drought. Overall plantation survival was high, but because of later planting, winter fallowing effects associated with fall cultivation were diminished after the arrival of summer rains. Because of this, surface soil moisture was not significantly different for the two main plots. Nevertheless, moisture at a soil depth of 15 to 30 cm was still significantly greater at planting for fall-cultivated plots than for those cultivated in summer.

Eleven months after planting, survival for main treatments was 70.9% for fall plots and 67.1% for summer, but the difference was not significant. Within both fall and summer plots, no preemergent herbicide treatment produced a survival rate superior to that for cultivation alone.

Height

Initial seedling heights averaged 32 cm, ranging from 19 to

47 cm. Seedling dieback was not observed over the course of the study. Seedlings from summer plots averaged 51.9 cm tall and were not significantly taller than seedlings in fall plots (47.9 cm). Among fall subtreatments, the two trifluralin treatments resulted in significantly taller seedlings (55.3 cm for the low rate, 53.8 cm for the high rate). Seedlings in summer–trifluralin (2.2 kg ai/ha) plots averaged 57.6 cm and were significantly taller than those in other summer subtreatments, except those in plots treated with trifluralin at 1.1 kg ai/ha (55.5 cm) or simazine at 2.7 kg ai/ha (53.1 cm). Among summer subtreatments, seedling height was least in untreated plots (31.5 cm).

Basal stem caliper

At planting, seedlings averaged 2.2 mm basal stem caliper, ranging from 1.5 to 3.0 mm. Fourteen months later, summer plot seedlings averaged 5.9 mm basal stem caliper and were statistically equivalent to those from fall plots (5.6 mm). As with height, stem caliper was greatest in fall-planted trifluralin-treated plots, averaging 6.3 and 6.2 mm in basal stem caliper for the low and high rates of the herbicide, respectively. Among summer subtreatments, trees in trifluralin at 2.2 kg ai/ha plots (6.3 mm) had stem calipers larger than those in plots treated with linuron at 1.1 kg ai/ha (5.7 mm), simazine at 2.7 kg ai/ha (5.6 mm), cultivation alone (5.8 mm), or untreated (3.8 mm). The untreated plot produced seedlings with the smallest stem caliper.

Weed control

At the northern site, a dense sod occupied more than 90% of the area within plots before cultivation. Weeds included Kentucky bluegrass, timothy (*Phleum pratense* L.), western yarrow, dandelion, iris (*Iris missouriensis* Nutt.), and others.

Four months after planting, weed cover averaged 48.2% in summer- and 57.8% in fall-cultivated plots, but the difference was not significant. The low rate of trifluralin with fall cultivation provided better control (30.5% cover) than other fall treatments, except trifluralin at 2.2 kg ai/ha (33.8% cover) and linuron at 2.2 kg ai/ha (52.5% cover). Summer cultivation with herbicide subtreatments did not differ, but applications of trifluralin at both rates (35.3% cover for the low rate, 38.0% for the high rate) or simazine at the high rate (36.0% cover) provided better weed control than summer cultivation alone. Weed cover exceeded 95% in untreated check plots.

By September 1984, percent weed cover had increased considerably over what it was 10 months earlier, and again, cultivation times did not differ significantly (77.8% cover for fall and 79.4% cover for summer plots). Trifluralin (2.2 kg ai/ha) was the top-ranked fall subtreatment (63.3% cover), equalled only by trifluralin (1.1 kg ai/ha) with 69.8% average weed cover. Cultivation in summer alone (80.5% cover) controlled weeds as effectively as any herbicide tested with summer cultivation. Weed cover for the check plot averaged 94.3% and did not differ significantly from the 90.5% of the summer–linuron (1.1 kg ai/ha) plot. Composition of the weed species did not change over the test period.

Discussion and conclusions

Dense, perennial sod poses a formidable threat to aspen seedling establishment. Sod cultivation simplifies planting and reduces weed competition. Elimination of sod through cultivation was the single most effective treatment tested, evidenced by increased seedling survival or growth. At the southern site, seedling survival was significantly greater in cultivated plots than in untilled plots. In the north, cultivation did not influence survival, but did improve growth.

At the southern site, seedlings planted in fall-cultivated plots apparently benefitted from additional soil moisture stored during the fallow condition. At the northern site, moisture captured after fall cultivation improved growth, but apparently was not required for survival, as the trees were planted when summer rainfall occurred.

Preemergent herbicide applications did not benefit seedling survival at either site, and fall cultivation plus simazine at the high rate was phytotoxic to seedlings. However, trifluralin effectively and consistently reduced weed competition without damaging aspen seedlings in northern plots planted in the fall, and seedlings responded with superior growth. At the southern site, seedlings grew taller in fall-cultivated plots receiving trifluralin (2.2 kg ai/ha), although weed competition was equal to that in other plots.

Because moisture stress and weeds reduced either seedling growth or survival, or both, aspen planting sites should be cultivated. The moisture conserved through fall cultivation improves aspen seedling establishment, depending on the scarcity of soil moisture. Results from the southern site indicate dalapon applied before fall cultivation improves seedling survival over cultivation alone. Preemergent herbicide applications will not benefit seedling survival, but can improve seedling growth through better weed control. Fall cultivation with trifluralin application is considered to be the most effective site preparatory treatment tested.

Acknowledgements

We wish to express our appreciation to the Eisenhower Consortium and the USDA Forest Service for funding, through grant No. RM-81-160-GR, and to the Lincoln and Santa Fe National Forests for making land available for study sites. We are also grateful to John B. McRae for contributions to the project, to Dr. Winston Richards for analytical support, and to Dr. John Mexal for manuscript comments.

FECHNER, G. H., and J. S. BARROWS. 1976. Aspen stands as wildfire fuel breaks. Eisenhower Consortium Bull. No. 4.

GRIEG-SMITH, P. 1957. Quantitative plant ecology. Butterworth & Co., Ltd., London.

JONES, J. R., and D. P. TRUJILLO. 1975. Development of some young aspen stands in Arizona. USDA For. Serv. Res. Pap. RM-151.

LITTLE, T. M., and F. J. HILLS. 1978. Agricultural experimentation design and analysis. John Wiley & Sons, New York.