IMAZAQUIN AND PENDIMETHALIN USE FOR WEED CONTROL IN HYBRID POPLAR PLANTATIONS IN MICHIGAN: SECOND-YEAR RESULTS[1]

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ABSTRACT

Hybrid poplar cuttings of DN-34 and NM-6 were treated with combinations of imazaquin and pendimethalin at the start of their first two growing seasons. Herbicides were applied to cultivated, bare soil immediately after planting – before crop growth began. Herbicides were reapplied over the top of dormant trees and weeds that had become established at the beginning of the second year. Poplar in treated plots grew significantly taller than in untreated controls but not quite as well as in mechanically weeded plots. Crop growth increased as the application rate of each chemical increased. Survival in all treatment plots was excellent and better than in untreated control plots. No crop phytotoxicity was observed and no interaction between clones and chemical treatment was detected. Weed control was acceptable for all treatments and improved with increasing application rates. Broadleaf weeds (principally common lambsquarters, velvetleaf, and Canada thistle in the first year and horseweed and broadleaf plantain in the second year) and grasses (principally giant foxtail and witchgrass in the first year and quackgrass and barnyardgrass in the second year) became established. Test plantations were located in both Upper and Lower Michigan.

INTRODUCTION

The fiber of poplars like the native aspens is used to produce paper and oriented strand board in Michigan mills. It is the eighth most valuable agricultural crop in Michigan (Miller, 1998). The amount of harvestable aspen has been declining throughout the Lake States, resulting in increased costs. Shortages are expected to continue for several more decades (Potter-Witter and Ramm, 1992). Efforts are now underway in the upper Lake States to develop alternative sources of poplar fiber. One option being developed involves growing hybrid poplars using intensive farm-like methods. The added costs incurred by “Fiber Farms” can only be justified on productive sites, like the abandoned agricultural land in the region. The Michigan Department of Agriculture reports that there are more than 500,000 acres of abandoned farmland in Upper Michigan alone.

Establishing productive “Fiber Farms” requires intensive management of a number of key factors including taxa selection, site preparation, site fertility and moisture, and control of pests. Not least among these factors is the control of weeds during plantation establishment. Devising these controls can be difficult because: (1) few chemicals are labeled for this use, (2) some chemicals react differently from site to site (Netzer, et. al., 1998), and (3) some chemicals are toxic to certain taxa (Netzer, et. al., 1997; Netzer et. al., 1996). Two herbicides (imazaquin and pendimethalin) have recently been added to the arsenal of chemicals available for use in poplar plantations. Preliminary tests demonstrate that they are effective and safe on a wide range of sites and taxa. They are best used in combination on weed-free sites immediately after planting, while cuttings are still dormant.

Imazaquin can be safely applied to hybrid poplar either before planting or after planting as a preemergence, or a postemergence treatment (Quicke, 1998). When used alone it controls weeds best if applied several times over the course of the growing season (Quicke, et. al., 1999). Imazaquin is taken up by plants through either the roots or foliage and is translocated in the xylem. The chemical inhibits synthesis of certain amino

[1] This paper is distributed on-line at: http://www.maes.msu.edu/uptic/

acids and may disrupt photosynthate translocation. Resistance may depend on a plant's ability to metabolize the compound to non-mobile products (Ahrens, 1994).

Pendimethalin is phytotoxic when applied to actively growing poplar (Quicke and Hoien, 1997; Quicke et. al., 1997) but can be safely applied over dormant poplars (Quicke et. al., 1998). It is not effective in eliminating established weeds and is best applied to bare ground or in mixture with a broad-spectrum, knock-down herbicide (Quicke et. al., 1999). Pendimethalin is absorbed by plant roots and coleoptiles and is not readily translocated. Root development is inhibited in established plants and new seeds in the soil fail to emerge. Resistance may be due to oxidation of the compound or to root protein changes that prevent the chemical from binding (Ahrens, 1994).

BASF manufactures both chemicals. Imazaquin is labeled for use in poplar plantings as Scepter® 70 DG (dispersible granules with 70% active ingredient by weight). Pendimethalin is labeled for use in poplar plantings as Pendulum® 3.3 EC (emulsifiable concentrate with 3.3 pounds of active ingredient per gallon). A mixture of both chemicals is also labeled for use with poplar and is available as Squadron® (an emulsifiable concentrate with 2 pounds ai of pendimethalin and 0.33 pounds ai of imazaquin per gallon).

We applied several combinations of imazaquin and pendimethalin to new hybrid poplar plantings at two sites in Michigan and examined crop and weed response at the end of the first two growing seasons. First year results were reported by Miller and Bloese (1999) and this paper summarizes the results at the end of the second year of those trials.

MATERIALS AND METHODS

Two sites were selected for the trial: one in Michigan's Lower Peninsula near Lansing and the other in Michigan's Upper Peninsula near Escanaba. Both sites had previously been used for agriculture. The Lansing area has an average of 150 frost-free growing days each year and an average of 2,669 growing degree days[2]. Soil at that test site is a sandy clay loam and had previously been used for corn production. The Escanaba area has approximately 140 frost-free growing days each year and an average of 1,171 growing degree days[2]. Soil at this site is a fine sandy loam and had previously been used for hay production.

Because the Lansing site had been under cultivation for several years, it only required tilling to prepare it for planting. Sod covering the Escanaba site was eliminated by spraying with glyphosate in April of 1999 and rototilling two weeks later. Both sites were devoid of vegetation at the time of planting. The Lansing site was planted on 5/4/99 and the Escanaba site was planted one week later on 5/12/99. 10"-long unrooted cuttings of DN-34 (*Populus euramericana* cv. Eugenei [Carolina poplar]) and NM-6 (*P. nigra* x *P. maximowiczii*) were hand planted in a split-plot randomized block design with four blocks. Each block consisted of 10 planting rows, spaced 10' apart, forming the main plots. Ten cuttings of each taxa, spaced 4' apart, were grouped at either end of each row to form the sub-plots.

First-year herbicide treatments were applied on the day after planting, while the cuttings were still dormant. Second-year treatments were applied at the beginning of the second growing season before crop growth began. No weed control, other than the planned application of herbicides, was done in the second year. A small-plot, tractor-mounted, boom sprayer was used to apply 4'-wide bands of herbicide over each treated row. Mechanically weeded rows were kept free of weeds using a combination of hand weeding and rototilling every 30 days. Untreated plots received no weed control at all. An application error during the second year resulted in four plots at the Escanaba site receiving more pendimethalin than intended (Table 1).

Browsing from white-tailed deer was observed at both sites early in the first growing season. Electric fences were quickly erected to exclude the deer from the test areas. Deer damage was negligible for the

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[2] Growing degree days based on 50º F averaged over 30 years from 1951 to 1980 (MSU Climatology Department, 2002)

remainder of the test at the Lansing site, but additional damage occurred at the Escanaba site during the winter between the two growing seasons.

Total height of all trees was measured at the end of the second growing season. Diameter of all stems, at 1' above the ground, was also measured at that time. Any trees shorter than 1' were considered missing and excluded from the analysis. Survival was tabulated based on the number of trees left after the second growing season. An analysis of variance in final height and diameter of the trees was performed to discover significant differences between the two sites and two taxa and among the blocks and treatments.

Standardized heights and diameters were calculated for the various treatment levels and ranked. Tree height and diameter in each sub-plot was expressed as a percent of the block mean in which it was growing to eliminate block and site effects. These standardized heights and diameters were then averaged across taxa, blocks, and sites for each level of both herbicides.

Weed control at the end of both growing seasons was scored by making visual estimates of the portion of ground within each treated strip that was free of weeds. The proportion of each treated strip covered with broadleaf weeds as well as with grasses was also estimated. These values were averaged across blocks and sites. The principal weed species on both sites were identified at the end of each growing season.

RESULTS AND DISCUSSION

Results after the first growing season were reported previously (Miller and Bloese, 2000). This discussion focuses on the results at the end of the second season and on the general trends over the course of the study.

Significant differences in growth were found between the two test locations. Lansing trees averaged 15.6' tall and 2.2" in diameter after two years. Escanaba trees were about half that size; 7.2' tall and 0.9" in diameter at the end of the second year. This difference is readily explained by the fact that Lansing has nearly twice as many growing degree days as Escanaba. Significant growth differences were also observed between the two taxa. Overall, DN-34 grew 10.2' tall and 1.4" in diameter while NM-6 grew 12.7' tall and 1.7" in diameter after two years. Differences in taxal growth rates are common in test plantings, and were expected here.

Very few trees died. Survival averaged 98% in Lansing and 97% in Escanaba at the end of the second year. Almost all of the trees that died were in the untreated control plots. Lansing control plots averaged 92% survival and Escanaba control plots averaged 78% survival. Heavy weed competition in these areas contributed to the higher losses. No mortality could be attributed to herbicide treatment effects.

A summary of height and diameter growth within the various treatments is presented in Tables 2 and 3 respectively. In all cases growth increased as the amount of herbicide applied increased. All herbicide treatments produced trees that grew significantly better than the untreated controls but not usually as well as the mechanically weeded treatments. An exception can be noticed in the plots that mistakenly received the 8X rate of pendimethalin. These trees grew as well in height as the mechanically weeded trees.

Average weed control is presented in Table 4. Weed control was very good after the first year and was fair after the second year in plots that received the higher application rates. The weeds that invaded the site were an equal mixture of broadleaf and grass species. Weed control in plots receiving even the lowest application rates was significantly better than in untreated control plots. The first goal of this trial was to test the safety of these herbicides on two poplar taxa. Weed control effectiveness was a secondary interest. We presume that weed control during the second year could have been improved if additional mechanical or chemical methods had been employed to remove previously established weeds at the beginning of the second growing season.

No crop toxicity was noticed in any of the treatments on either of the clones used. No leaf discoloration or growth irregularities appeared throughout the trial. No evidence of growth reduction could be related to chemical effects (Table 2 and 3).

Both sites were nearly weed-free for the first 60 days after planting but several weed species did eventually invade the treated plots. The principal broadleaf weed invaders during the first year at Escanaba were Canada thistle (*Cirsium arvense* L.), tumble pigweed (*Amaranthus cannabinum* L.), and curley dock (*Rumex crispus* L.). First-year broadleaf weed species at the Lansing site included velvetleaf (*Abutilon theophrasti* Medic.) and common lambsquarters (*Chenopodium album* L.). During the first year, the most common grass at Escanaba was witchgrass (*Panicum capillare* L.) and at Lansing was giant foxtail (*Sataria feberi* Herrm.). Most of these weeds, with the exception of Canada thistle, probably could have been controlled with a postemergence application of imazaquin.

By the end of the second year the weed populations at both sites had changed considerably. Common broadleaves in Escanaba included broadleaf plantain (*Plantago rugelii* Dcne.), Canada thistle (as before), and hoary alyssum (*Berteroa incana* L.). Grasses there included the annuals barnyardgrass (Echinocholra *crusgalii* L.) and smooth crabgrass (*Digitaria ischaemum* Schreb.). The principle broadleaves in Lansing were horseweed (*Conyza Canadensis* L.) and dogbane (*Apocynum cannabinum* L.) while fall panicum (*Panicum dichotomiflorum* Mich.) and quackgrass (*Agropyron repens* L.) were the predominant grasses.

Most of the weed species that invaded the treatment plots can be controlled with these two herbicides, according to the product labels. As application rates increased, so did weed control and crop growth. Both were maximized in the plots that received the highest dose of herbicide. These plots nearly matched the growth of mechanically weeded plots. Imazaquin and pendimethalin when applied at labeled rates provide safe and effective weed control for the taxa of hybrid poplar tested here. We expect that poplar growth would be increased further with slightly higher application rates. It is important to point out that it is a violation of Federal law to apply herbicides in ways other than those outlined on the product label.

Michigan State University makes no endorsement or guarantee of the herbicides referred to in this publication.

Trees at the Escanaba location at the end of the first growing season.

Table 1. Weed control treatments applied to dormant hybrid poplar plantations in 1999 and 2000 at Escanaba, MI and Lansing, MI.		
Treatment Abbreviation*	Imazaquin (S) applied (lbs ai / acre)	Pendimethalin (S) applied (lbs ai / acre)
Control	No weed treatment applied	
Mechanical	Mechanically weeded every 30 days	
S1P0	0.125	0.0
S1P1	0.125	0.75
S1P2	0.125	1.50
S1P4	0.125	3.00
S1P8**	0.125	6.00
S2P0	0.25	0.0
S2P1	0.25	0.75
S2P2	0.25	1.50
S2P4	0.25	3.00
S2P8**	0.25	6.00

- -- The "S" in the abbreviation stands for imazaquin (or Scepter®) and the "P" stands for pendimethalin (Pendulum®). "1" represents the base rate while "2" represents twice the base rate, "4" represents four times the base rate, and "8" represents eight times the base rate.
- ** -- An application error at the Escanaba site resulted in four plots receiving this 8X rate of pendimethalin during the second year only.

Table 2. Total height of two-year-old hybrid poplar stems treated twice with combinations of pendimethalin and imazaquin. Growth has been standardized by expressing each sub-plot mean as a percentage of its respective block mean and averaging these percentages across all blocks. These numbers express relative growth for each application rate across taxa, blocks, and sites.

imazaquin rate (1X = 0.125 lbs ai/acre)	pendimethalin rate (1X = 0.75 lbs ai/acre)						
	0X	1X	2X	4X	8X	Mechanical	Grand Average
0X	60%[1]						60%
1X	90%	97%	101%	104%	126%		100%
2X	104%	100%	106%	106%	121%		105%
Mechanical						122%[2]	122%
Grand Average	85%	99%	104%	106%	123%	122%	

1. This treatment was an un-weeded control. No chemical or mechanical treatment was made.
2. This treatment was kept free of weeds throughout the study using mechanical means.

Table 3. Diameter (at 1' above the ground) of two-year-old hybrid poplar stems treated twice with combinations of pendimethalin and imazaquin. Growth has been standardized by expressing each sub-plot mean as a percentage of its respective block mean and averaging these percentages across all blocks. These numbers express relative growth for each application rate across taxa, blocks, and sites.

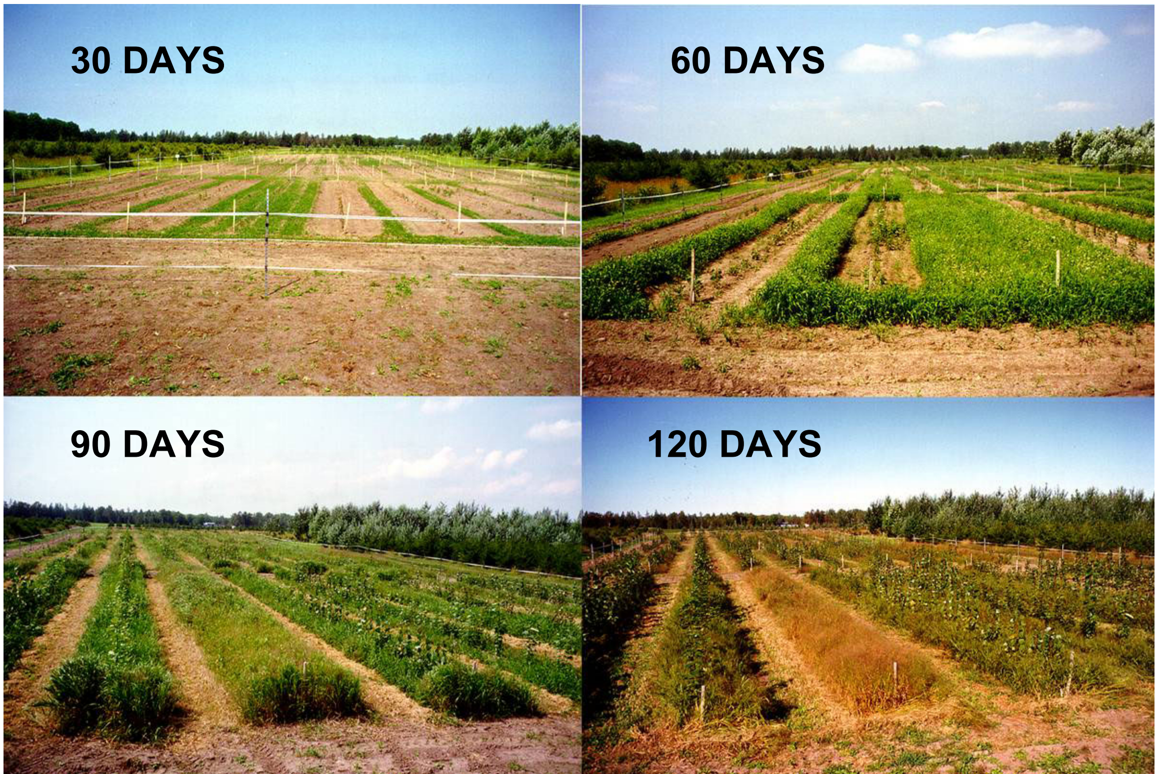
imazaquin rate (1X = 0.125 lbs ai/acre)	pendimethalin rate (1X = 0.75 lbs ai/acre)						
	0X	1X	2X	4X	8X	Mechanical	Grand Average
0X	46%[1]						46%
1X	84%	95%	102%	104%	133%		98%
2X	107%	98%	107%	112%	122%		106%
Mechanical						137%[2]	137%
Grand Average	79%	96%	104%	108%	127%	137%	

1. This treatment was an un-weeded control. No chemical or mechanical treatment was made.
2. This treatment was kept free of weeds throughout the study using mechanical means.

Table 4. Effectiveness of weed control at the end of the first two growing seasons in two hybrid poplar plantations receiving various combined rates of pendimethalin (P) and imazaquin (S).

Treatment[1]	Open Ground		Broadleaf Cover		Grass Cover	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Untreated	2%	0%	76%	44%	22%	56%
S1	45%	34%	39%	32%	16%	34%
S2	73%	56%	19%	18%	8%	26%
P0	44%	22%	44%	22%	12%	56%
P1	54%	42%	30%	26%	16%	32%
P2	62%	48%	24%	28%	14%	24%
P4	74%	58%	18%	22%	8%	20%
Mechanical	100%	100%	0%	0%	0%	0%

1. Most treatments consisted of a combination of imazaquin and pendimethalin. Treatments are summarized here as imazaquin level (for all levels of pendimethalin) and pendulum level (for all levels of imazaquin).



Sequence of views of the Escanaba site during the first year.

East Lansing site near the end of the second year.

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