Loss of Methyl Bromide Increases Need for Preemergence Herbicides in Woody Plant Seed and Liner Beds

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Significance to the Industry: Forests (tracts of native growth) and the urban forests (tree populations in urban settings) are increasingly important, for mitigating global pollution and climate change. The first step in forestry is the production of tree seedlings at forest seedling nurseries. The first steps in urban forestry can take three forms: 1) seedling production for root stocks to be grafted or budded with scions of selected tree cultivars; 2) seedlings for species such *Quercus* sp. or native plants (seed propagated); and, 3) asexually propagation such as cuttings or tissue culture for species grown on their own roots but vegetatively. Forest and ornamental nurseries provide healthy starting materials for reforestation and aforestation. Reforestation is the planting of trees on areas covered in recent history with forests. Aforestation is planting trees on areas not covered with forests for ≥50 years. Intensive seedling production relies on the ability of the nursery managers to meet quality and yield goals as well as certification that the plants are essentially pest-free. Weeds are a major cause of reduction of quality and yield goals. Herbicides found effective in this study cost less than $35.00/ ac, such Treflan 1 pt/ac rate and Barricade 10 oz/ac. Treflan, Barricade and Pendulum 2G caused no to minimal damage for all woody plant seedlings evaluated. The overall goal was to cut seedling growers weed control program cost by 30%. Using the herbicides listed above this could be accomplished. More work is needed with preemergence herbicides in seedling production nurseries. By 2015, Methyl Bromide (MeBr) will be completely phased out. The lack of alternative soil fumigants and preemergence herbicides for seedling production will dramatically reduce US seedling production and subsequently the durability of our future forests.

Nature of Work: Methyl Bromide (MeBr) has been used extensively as the soil fumigant of choice to manage fungal pathogens (e.g., *Fusarium*, *Alternaria*, *Phytophthora*, *Pythium, Rhizoctonia*, *Cylindrocladium* spp., *Cylindrocarpon*, and *Macrophomina*), nematodes (e.g., *Circonemoides*, *Helicotylenchus*), and yellow and purple nutsedge (species of *Cyperus*) in forest and herbaceous seedling nurseries of the US. In 1994, the Clean Air Act mandated 100% phase-

out of MeBr by 2001. MeBr has been phased out internationally because it depletes stratospheric ozone, which protects life on Earth from the harmful effects of the sun's ultraviolet radiation. In 1998, the phase-out schedule was revised to reduce production and import of MeBr by the following percentages of the 1991 baseline amounts: 25% in 1999, 50% in 2001, 70% in 2003 and 100% in 2005. Later developing countries were scheduled to freeze consumption in 2002 at 1995-98 levels and reduce all use by 2015. In 2015, MeBr will be gone. There will be no more *Critical Use Exemptions* that have essentially kept the seedling nurseries in business since 2005. There has been research over the years on alternative fumigants but none have proven to be as successful for weed control (in particular) as MeBr. We had planned to test the two of the most promising alternatives in these 2013 trails; Chloropicrin and Basamid with supplemental low-rates of preemergence herbicides. However, in 2012, additional regulations were placed on the use of Chloropicrin that made the use of this product impossible in these trials. Chloropicrin is a powerful tear gas; it is a highly hazardous material that can now only be used by specially trained and certified personnel. In consultation with growers, there was no desire to test Basamid (e.g. metam-sodium and dazomet) due to inconsistent pest management performance in previous trials.

Two growth stages were selected for woody plants. We hypothesized injury would be more significant for stage 1 seedlings versus stage 2: Stage 1) two to six weeks after the seedlings had emerged; Stage 2) transplant beds, two weeks after two year old seedlings were transplanted from seedbeds to the transplant beds. Trials were conducted at New Life Nursery, 3720 64th St. Holland, MI on deciduous and coniferous seedlings. Applications were applied in the early afternoon of May 22, 2013. There was a gentle rain, cloudy skies and the temperature was 55°F. Stage 1 trials consisted of nine treatments and four replicates that were randomized within each bed/species. Chemical treatments included trifluralin (Treflan 4 EC) (Helena Chemical Company, Collierville, TN, 38017) applied at (1/2 rate) 1qt and (1/4 rate) 1 pt. per acre; prodiamine (Barricade 4FL) (Syngenta Crop Protection, LLC, Greensboro, North Carolina, 27419) applied at (1/2 rate) 10 oz/ac; Barricade 4FL (1/4 rate) (5 oz/ac) plus Treflan 4EC (1/4 rate) (1pt/ac); oxyfluorfen + prodiamine (Biathlon) (OHP, Inc., Mainland, PA, 19451) applied at (1/4 rate) 50 lb/ac; pendimethalin (Pendulum 2G) (BASF Corporation, Research Triangle Park, NC 27709) applied at (1/2 rate) 100lb/ac and oxadiazon + pendimethalin (Jewel) (Scotts-Sierra Crop Protection Company, Marysville, OH 43041) applied at (1/2 rate) 50 lb/ac. The remaining two treatments to total nine were an untreated weeded check and an untreated weedy check. Three ft. X three ft. sections of beds with one ft. buffers between each were used. For Stage 2 trials, 12 treatments were conducted: dimethenamid-P + pendimethalin (FreeHand 1.75G) (BASF Corporation, Research Triangle Park, NC 27709) applied at (normal rate) 150 lb/ac; indaziflam (Marengo G) (OHP, Inc., Mainland, PA, 19451) applied at (½ rate) 50 lb/ac and (normal) 100lb/ac; oxyfluorfen + prodiamine (Biathlon) (OHP, Inc., Mainland, PA, 19451) applied at (3/4

rate) 150 lb/ac and (1/3 rate) 75 lb/ac; pendimethalin (Pendulum 2G) (BASF Corporation, Research Triangle Park, NC 27709) applied at (1/2 rate) 100lb/ac; oxadiazon + pendimethalin (Jewel) (Scotts-Sierra Crop Protection Company, Marysville, OH 43041) applied at (normal rate) 100 lb/ac; Barricade 4FL (1/4 rate) 5 oz/ac plus Treflan 4EC (1/2 rate) 1qt/ac; dimethenamid-P (Tower) + pendimethalin (Pendulum Aqua Cap) (BASF Corporation, Research Triangle Park, NC 27709) applied at (normal rates) 1 qt/ac + 1 qt/ac; and, isoxaben (Gallery) (Dow Agro Sciences, LLC, Indianapolis, IN 46268) applied at (1/3 rate) 0.65 lb.ac + Barricade 4FL (½ rate) 10 oz/ac. The remaining two treatments to total 12 were an untreated weeded check and an untreated weedy check. All herbicides and rates were chosen based on previous studies by the authors re crop safety on a wide range of materials (1, 2 and 3).

The Stage 1 trials at New Life were conducted on common lilac, *Syringa vulgaris;* black walnut, *Juglans nigra;* and, bur oak, *Quercus macrocarpa*. Soils at New Life are Saugatuck series sands. Soils were very deep and somewhat poorly drained with cemented subsoil. Saugatuck Series soils were formed by sandy glaciofluvial deposits on lake plains, till plains, and outwash plains (4). The lilac field had been fumigated prior to fall planting with MeBr at 400 lb/ac. Post planting, a thin layer of pine mulch was applied to the lilac field to decrease wind erosion of the sandy soils. The walnut and the bur oak were also fumigated with MeBr at 400 lb/ac prior to fall planting. Lilac had emerged approximately ¼ inch above the ground at time of application on May 22, 2013. Cotyledons were present and some seedlings had their first true leaves just expanding. Due to rains becoming heavy on May 22, 2013, applications to the oak and walnuts were conducted on June 19, 2013. Thus these two species were more advanced in growth versus the lilacs at time of application. The Stage 2 trials were conducted using Norway spruce, *Picea abies* that were being grown as 2+1 transplants (2 years in the seedbed) and transplanted two weeks before application (May 22) on May 8, 2013. They were approximately six inches tall at time of application. The spruce fields had not received MeBr prior to planting nor mulch post planting. Visual ratings of phytotoxicity were based on a scale of 0-10 with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable. Visual ratings of weed control were based on a 0-10 scale with 0 being no control and 10 perfect control with ≥7 commercially acceptable. Efficacy evaluations were only conducted in *Syringa* beds. Data was analyzed using SAS® GLM. Phytotoxicity effects of treatments were compared to the controls using Dunnett's t-test ($\alpha = 0.10$ and 0.05). Efficacy treatments were compared to each other using least significant difference (ls means). Evaluations were conducted every two weeks after application for 3 months or 12 WAT, unless otherwise stated.

Results and Discussion: The Stage 1 trials at New Life at 12 WAT showed very low phytotoxicity on the *Juglans* and the *Quercus* (Table 1). The damage on these species had been either passing on the *Quercus* as with Treflan 1 qt/ac and Biathlon 50 lb/ac, or non-existent

with the *Juglans* (Table 1). Averaged across all dates of evaluation, there were four treatments that were commercially acceptable (≤3) with the *Syringa*, Treflan 1pt/ ac, Treflan 1qt/ ac, Barricade 10 oz/ ac and Pendulum 2G (data not shown). At 8 WAT the Barricade and the Pendulum picked up phytotoxicity and exceeded the level of commercially acceptable (≥ 3) (Table 1).

Treflan 1pt/ ac, Treflan 1qt/ ac, Barricade 10 oz/ ac and Pendulum 2G provided significantly higher weed control than the un-weeded control at New Life (Table 3). Normal practice at New Life Nursery is zero tolerance of weeds, so the efficacy trial was unfortunately ended at 6 WAT, when it was inadvertently hand weeded by New Life staff (Table 3). Unfortunately, the weeding crew, also pulled out the plot markers at 8 WAT in the lilac and thus ended the phytotoxicity trial. We recommend that trials on woody plant seedlings be continued with Treflan, Barricade and Pendulum 2G at lower rates, with increased application frequencies, in future studies. The low phytotoxicity levels demonstrated with these products indicate their value and promise for further study in forest seedling and ornamental nurseries seed beds.

Trials on transplant beds of *Picea abies* seedlings at New Life Nursery, Holland, MI 2 WAT with Barricade + Treflan (5 oz/ac + 1 qt/ac) provided no injury and at 6 WAT. By 6 WAT, there was phytotoxicity greater than the control but still commercially acceptable (2.8 rating) (Table 2). At 2 WAT and 4 WAT with Marengo G 100 lb/ac there was no phytotoxicity. At 6 WAT, there was minimal phytotoxicity with Marengo G 100 lb/ac. At 8 to 12 WAT, phytotoxicity with Marengo G 100 lb/ac had increased but it was still in the commercially acceptable range (2.8 rating). (Table 2). Unfortunately there were no efficacy evaluations conducted in the *Picea abies* to judge the merit of Marengo 100 lb/ac in weed prevention. Although Jewel was the most efficacious treatment (Table 3) for *Syringa*, Jewel was also the most phytotoxic (Table 1). The best treatment taking into account phytotoxicity and efficacy (Table 3) was Biathlon 50 lb/ac or ¼ rate.

Table 1. Phytotoxicity of several ornamental herbicides in Stage 1 (emerged two to six weeks) seedling beds of *Syringa vulgaris*, *Juglans nigra,* and *Quercus macrocarpa*

Syringa vulgaris

Treatment	Rate	2 WAT[z]	4 WAT	6 WAT	8 WAT
Treflan	1 qt	2.0[yx]	1.0	0.8	2.0
Treflan	1 pt	2.8	1.0	0.8	1.0
Barricade 4FL	10 oz	3.5	0.5	1.5	3.5 **
Barricade 4FL + Treflan	5 oz + 1 pt	4.0	3.0 **	1.8 *	4.0 **
Biathlon	50 lb	5.0 *	2.0 **	2.0 **	3.5 **
Pendulum 2G	100 lb	3.8	2.0 **	1.0	4.3 **
Jewel	50 lb	8.3 **	5.3 **	5.5 **	6.3 **
Untreated weeded	--	2.0	0.0	0.0	0.0
Untreated	--	1.5	0.0	0.0	1.0

Juglans nigra

Treatment	Rate	2 WAT	4 WAT	6 WAT	8 WAT
Treflan	1 qt	1.0	0.0	1.0	0.5
Treflan	1 pt	0.8	0.3	0.8	1.3
Barricade 4FL	10 oz	0.5	0.5	0.3	0.5
Barricade 4FL + Treflan	5 oz + 1 pt	0.8	0.3	0.5	0.3
Biathlon	50 lb	0.3	0.0	0.3	0.3
Pendulum 2G	100 lb	0.0	0.3	0.5	1.0
Jewel	50 lb	0.3	0.3	0.3	0.5
Untreated weeded	--	0.3	0.3	1.5	0.8
Untreated	--	0.8	0.0	1.3	1.3

Quercus macrocarpa

Treatment	Rate	2 WAT	4 WAT	6 WAT	8 WAT
Treflan	1 qt	2.8	0.8	1.8	2.8
Treflan	1 pt	1.5	0.3	0.5	0.0
Barricade 4FL	10 oz	1.3	0.3	0.5	0.0
Barricade 4FL + Treflan	5 oz + 1 pt	2.3	0.5	0.5	0.8
Biathlon	50 lb	2.0	0.5	2.0	1.0
Pendulum 2G	100 lb	0.3	0.0	0.8	0.0
Jewel	50 lb	1.3	0.5	1.5	0.3
Untreated weeded	--	0.0	0.0	0.0	0.0
Untreated	--	0.3	0.5	0.0	0.0

z = weeks after treatment (WAT)

y = Visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable

x = Treatment means followed by *, ** are significantly different from the untreated weeded control based on Dunnett's t-test (α = 0.10 and 0.05, respectively

Table 2. Phytotoxicity of several ornamental herbicides on Stage 2 *Picea abies* seedlings at New Life Nursery, Holland, MI.

Treatment	Rate	2 WAT[z]	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT
FreeHand	150 lb	0.8[yx]	0.0	0.8	1.8	1.8	1.5

Marengo	50 lb	0.0	0.0		0.8	0.8		1.3		1.3	
Biathlon	150 lb	1.5	0.0		0.3	0.3		0.3		0.3	
Pendulum 2G	100 lb	0.8	1.5	**	1.8	2.8	**	3.0	**	2.3	*
Biathlon	75 lb	2.5	0.0		0.5	0.8		0.5		0.3	
Marengo	100 lb	1.0	1.0		1.5	3.0	**	2.8	**	2.8	**
Jewel	100 lb	0.5	0.0		0.5	1.0		0.0		0.0	
Barricade + Treflan	5 oz + 1 qt	2.0	0.8		1.3	2.5$^{\surd}$	*	2.0		2.8	**
Tower + Pendulum	1 qt + 1 qt	0.8	0.3		0.3	0.8$^{\surd}$		1.3		1.8	
Gallery + Barricade	0.65 lb +10 oz	1.0	0.5		1.5	1.8$^{\surd}$		1.5		1.3	
Untreated	--	0.5	0.0		0.3	0.0		0.0		0.0	
Untreated weeded	--	0.5	0.0		0.3	0.8		0.0		0.3	

z = weeks after treatment

y = Visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable

x = Treatment means followed by *, ** are significantly different from the untreated weeded control based on Dunnett's t-test (α = 0.10 and 0.05, respectively).

$\surd$ = indicates treatment was reapplied on this date

Table 3. Efficacy of several ornamental herbicides in seed beds at New Life Nursery, Holland, MI, May to June, 2013

		New Life[y]			
Treatment	Rate/ac	4 WAT[X]		6 WAT	
Treflan	1 qt	8.3[wv]	b	7.8	bc
Treflan	1 pt	7.5	b	7.6	cd
Barricade 4FL	10 oz	8.0	b	7.6	cd
Barricade 4FL + Treflan	5 oz + 1 pt	7.8	b	7.3	cd
Biathlon	50 lb	8.5	b	8.4	ab
Pendulum 2G	100 lb	8.3	b	7.3	cd
Jewel	50 lb	9.8	a	8.9	a
Untreated weeded	--	6.3	c	7.0	d
Untreated	--	6.0	c	6.1	e

y = treatment means were taken from a *Syringa* liner beds

x = weeks after treatment

w = visual ratings based on a 0-10 scale with 0 being no control and 10 perfect control with ≥7 commercially acceptable

v = treatment means followed by the same letter in the same column are not significantly different, based on ls means (α = 0.05)

Literature Cited:

1. Mathers, H. and L.T. Case. 2010. Phytotoxicity of Selected Herbicides to Ornamental Plants at Three Michigan Nurseries. 2010 Yearly Research Summary. http://basicgreen.osu.edu

2. Mathers, H. and L.T. Case. 2011. Phytotoxicity of several weed control products to selected ornamentals in Ohio. 2011 Yearly Research Summary. http://basicgreen.osu.edu

3. Mathers, H. and L.T. Case. 2012. State-wide Weed Control Initiative for Ohio Nurseries. Phytotoxicity of several weed control products to selected ornamentals in Ohio. 2012 Yearly Research Summary. http://basicgreen.osu.edu

4. National Cooperative Soil Survey - USDA. 2012. Saugatuck Series. https://soilseries.sc.egov.usda.gov/OSD_Docs/S/SAUGATUCK.html