Current Status of Herbicides for Controlling Invasive Knotweeds in the United States

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Herbicide Trials for Knotweed Control

• North American herbicide trials
  - Ahrens (1975) showed positive results from foliar glyphosate
  - Trial by Jennings and Fawcett (1977) tested foliar and cut stem applications of glyphosate and triclopyr
Herbicide Trials for Knotweed Control

- North American herbicide trials
  - Trial by Scott and Marrs (1985) used two applications of fosamine, glyphosate, simazine, triclopyr, and picloram
    - Picloram was by far the most effective, although glyphosate rate was probably too low (2 lbs ae/a)
  - Trial by Figueroa (1989) used 2,4-D, clopyralid, dicamba, glyphosate, imazapyr, and metsulfuron
    - Imazapyr, clopyralid, and glyphosate reduced stem number and height by more than 50% by one year after treatment
    - Only imazapyr maintained control (up to five years)
Herbicide Trials for Knotweed Control

• More recent trials
  - Crockett (2003) reported on work involving injection of glyphosate concentrate
    • 5 ml full-strength product into lower stem
    • 10 ml 50% product in water
  - Volmer (2006) reported on tests with imazapyr and glyphosate
    • Excellent control from 0.75 to 1.5%
  - Trials by Skibo (2006) showed some activity with mesotrione
Greenhouse Trial, 2003-04

- Knotweed plant material
  - Bohemian and giant knotweed shoots (Mount Vernon)
  - Himalayan knotweed shoots (Cape Disappointment)
  - Giant knotweed seedlings (Big Quilcene River)
  - Two separate populations of Bohemian knotweed seedlings (Japanese knotweed female parent, unknown male parent; Acme and Marblemount)
Greenhouse Trial, 2003-04
Materials and Methods

• Foliar treatments of glyphosate (Aquamaster), triclopyr (Garlon 3A or Renovate), or imazapyr (Arsenal or Habitat) applied in summer
  - 0.5% each
  - 1% each
  - 0.5% each in 2-way combinations
  - 0.3% each in 3-way combination

• All plants cut three weeks after treatment and re-growth monitored
Giant seedling

Bohemian transplants
Untreated

Three weeks after triclopyr at 1%
Early Bohemian Knotweed Injury
Glyphosate, 2003-04

% 

Glyphosate 0.5%
Glyphosate 1%
Gly + Tri
Gly + Impyr
Gly + Tri + Impyr

2 WAT
3 WAT
Before and after clipping
Bohemian knotweed re-growth

Eleven weeks after glyphosate at 0.5% (eight weeks after clipping)
Bohemian Knotweed Re-growth
2003-04

% re-growth (check = 100%)

- Gly 0.5%
- Tri 0.5%
- Impyr 0.5%
- Gly 1%
- Tri 1%
- Impyr 1%
- Gly + Tri
- Gly + Impyr
- Tri + Impyr
- Gly + Tri + Impyr
- Impic 0.5%
- Impic 1%
Bohemian Knotweed Re-growth
2003-04

% re-growth (check = 100%)

Gly 0.5%
Tri 0.5%
Impyr 0.5%
Gly 1%
Tri 1%
Impyr 1%
Gly + Tri
Gly + Impyr
Tri + Impyr
Gly + Tri + Impyr
Impic 0.5%
Impic 1%

11 WAT
Bohemian Knotweed Re-growth
2003-04

% re-growth (check = 100%)

11 WAT

Gly 0.5%
Tri 0.5%
Impyr 0.5%

Gly 1%
Tri 1%
Impyr 1%

Gly + Tri
Gly + Impyr
Tri + Impyr
Gly + Tri + Impyr
Impic 0.5%
Impic 1%
Field Knotweed Trials
Field Trials, 2003-05

Materials and Methods

• Giant knotweed (Big Quilcene River, Jefferson County, WA; Cathy Lucero, co-investigator)
  - Treated at early flowering

• Bohemian knotweed (Hutchinson Creek, Whatcom County, WA; Laurel Baldwin, co-investigator)
  - Treated at early flowering or after petal fall

• Each trial was two years long
Plots near Hutchinson Creek
Plots near Big Quilcene River

Plots near Hutchinson Creek
Field Trials, 2003-05

Materials and Methods

- Herbicides tested were glyphosate, triclopyr, or imazapyr
  - 33% herbicide wiped on lower three feet of intact stems
  - 33% herbicide wiped on stems cut at three feet
  - Stem injection of 2.5 or 5 mls of full strength herbicide

- Plots were circular, measuring 1 m in diameter, 4 replicates
Knotweed injection
New Knotweed Shoot Growth
Second Year Data, April

- No differences in control between species
- All three herbicides killed the crowns of treated stems, although wipe treatments (non-cut canes) were less effective
- No treatment effect on early spring growth (likely due to undergrowth of rhizomes originating from outside the plot)
- Early-bloom treatments in the field injured Bohemian knotweed more quickly than did post-bloom treatments, but there was no difference in stem kill by April
New Knotweed Shoot Growth
Second Year Data, August

• Still no major treatment differences between giant and Bohemian knotweed

• Still no differences in number of stems in treated plots
  – Control of knotweed crowns remained excellent for all treatments (except herbicide wipe)

• Herbicide symptoms were apparent up to four feet away from the application point
  – Most symptoms on knotweed, but other species showed symptoms
  – 22 incidences of 144 possible (15%)
Non-Target Symptomology

- Blackberry, 2 incidences (imazapyr)
- Red alder, 1 incidence (imazapyr)
- Reed canarygrass, 7 incidences (imazapyr)
- Salmonberry, 8 incidences (imazapyr and glyphosate)
- Snowberry, 4 incidences (imazapyr and triclopyr)
Greenhouse Symptomology Trial 2005

• Investigating the potential for glyphosate injury to non-target plants
  – Salmonberry (*Rubus spectabilis*) or thimbleberry (*R. parviflorus*) potted in sand along with knotweed
  – Knotweed treatments
    • Spray over pots (2%)
    • Leaf wipe (33% solution)
    • Injection (full-strength product)
Greenhouse Symptomology Trial 2005

- **Overspray** (2% glyphosate)
  - Average knotweed control **81%**
    - Nearly complete control of **giant** (100%) and **Himalayan** (98%)
    - **Bohemian** control only 68%
  - Average injury to salmonberry and thimbleberry **68%**
Greenhouse Symptomology Trial 2005

- **Leaf wipe (33% solution)**
  - Average knotweed control 89%
  - Nearly complete control of Bohemian (83%), giant (98%), and Himalayan (98%)
  - Average injury to salmonberry and thimbleberry 13%
Greenhouse Symptomology Trial
2005

• Injection (up to 5 ml glyphosate)
  - Average knotweed control 88%
    • Nearly complete control of Bohemian and giant (88 and 100%, respectively)
    • Could not inject Himalayan, but small drops of glyphosate enough to provide 63% control
  - Average injury to salmonberry and thimbleberry 26%
Injection Problems

Small diameter canes can’t be injected

Canes may split during injection

Photos by Cathy Lucero, Clallam County Noxious Weed Control Board
More Field Trials

- **Bohemian knotweed** (Mount Vernon)
  - 2005 ([aminopyralid](#), [imazapyr](#), [glyphosate](#), and [triclopyr](#))
    - One site treated at **full bloom**
    - Second site **mowed** in mid-summer, **re-growth** treated when about three to four feet tall
  - 2006 ([aminopyralid](#), [imazapyr](#), [glyphosate](#))
    - **Stems bent** and herbicides applied after ten days

- **Bohemian knotweed** (Pacific county, Kim Patten)
  - 2005 and 2006 tests involving **application timing** with [aminopyralid](#), [imazapyr](#), [glyphosate](#), and [triclopyr](#)
Aminopyralid does show activity, but still need fine-tuning of rates and tank mix partners
How Should Symptomatic Plants be Re-treated?
Field Knotweed Control Projects, Southwestern Washington, 2004-05

• $250K in funding from legislature for knotweed control work in southwestern Washington from July 1, 2004 to June 30, 2005
  – Some $ to me to estimate control from the various treatments
### Overview of six project sites and knotweed control strategies

<table>
<thead>
<tr>
<th>Project Location</th>
<th>Treatment site</th>
<th>Knotweed species</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clark</td>
<td>Upper East Fork Lewis River</td>
<td>Bohemian</td>
<td>Injection, 5 mls Aquamaster per stem</td>
</tr>
<tr>
<td>Clark</td>
<td>Lower East Fork Lewis River</td>
<td>Bohemian</td>
<td>Foliar, 1.5% Habitat</td>
</tr>
<tr>
<td>Lewis</td>
<td>Upper Cowlitz River</td>
<td>Bohemian</td>
<td>Foliar, 1.5% Aquamaster + 0.75% Habitat</td>
</tr>
<tr>
<td>Pacific</td>
<td>Willapa River</td>
<td>Bohemian</td>
<td>Foliar, 2% Aquamaster + 0.5% Habitat</td>
</tr>
<tr>
<td>Skamania</td>
<td>Washougal River</td>
<td>Japanese (?)</td>
<td>Injection, 5 mls Aquamaster per stem</td>
</tr>
<tr>
<td>WA State Parks</td>
<td>Beacon Rock</td>
<td>Japanese (?)</td>
<td>Injection, 5 mls Aquamaster per stem</td>
</tr>
</tbody>
</table>
Southwest Knotweed Field Sites

WSU NWREC
View to the south
View to the south

View to the Northwest
View to the north
Results of Treatments
Knotweed in June, 2005

• Visual knotweed control ranged from 88 to 94%
  - No significant differences between sites, but trend toward better control with imazapyr

• Stem numbers were reduced 63 to 80%
  - Estimated 17,000 to 33,500 stems per acre before treatment and 4,600 to 10,800 after treatment

• Stem height ranged from 10 to 20 inches tall
  - Expected height 72 inches (72 to 86% reduction)
Results of Treatments
June, 2005

• Injury to non-target vegetation among all treatments was < 10%
  - No apparent correlation between injury and application type or herbicide choice

• All new shoots in treated areas were from rhizomes/crown (no seedlings were found)

• Very little plant growth in any plot
  - Probably speaks more to competitive ability of these knotweeds prior to treatment than by the herbicides killing other species
  - Allelopathy?