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Final Report

Evaluation of Herbicides and Application Timing for Control of Japanese Knotweed

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16. Abstract

Testing was conducted from fall 2001 through spring 2003 to evaluate the efficacy of several herbicides, timing of application (foliar vs. dormant), and an alternative application method (Burch Wet Blade) for control of Japanese knotweed along highway rights-of-way.

Foliar treatments with glyphosate (Rodeo) in late spring, fall, or in the fall following a single spring mowing did not produce apparent kill in the season in which it was applied but essentially no greenup of treated plants occurred in the following spring. Triclopyr amine (Garlon 3A) gave rapid top kill of leaves and stems within a week or two, which persisted until the end of the growing season. When evaluated during the following spring, there was no evidence in the triclopyr plots that any treatment had occurred; triclopyr-treated plots all were green and healthy. Clopyralid (Transline) and dicamba DGA (Vanquish) caused minor, but temporary leaf curling and slight discoloration; metsulfuron methyl (Escort) produced essentially no visible symptoms. All plots treated with clopyralid, dicamba DGA, or metsulfuron-methyl were green and healthy the following spring. Combinations (tank mixing) of herbicides did not improve knotweed control. When glyphosate was combined with triclopyr amine, control was poorer than with glyphosate alone. This suggested possible interference of triclopyr amine with glyphosate.

Glyphosate (Rodeo) was applied at 0.5 to 2 gal/acre, with a retreatment of half of each plot in the summer. At the end of the growing season, only minor yellowing of leaves was apparent, in spite of the treatment rate or whether or not re-treatment occurred. In the spring, there was essentially complete kill in all but the 0.5 gal/acre treatments, and there were no obvious differences between areas receiving a single treatment vs. two treatments.

Preliminary evaluation of triclopyr ester (Garlon 4) and imazapyr (Arsenal) were conducted at two sites at the fall treatment dates. Garlon 4 did not produce any obvious kill that carried over into the following growing season. There was slight, but not acceptable reduction in the following spring of shoot heights of knotweed that had received fall treatment with imazapyr.

The use of the Burch Wet Blade to apply glyphosate (Rodeo), triclopyr amine (Garlon 3A), or imazapyr (Arsenal) in the summer did not produce any lasting effects on the knotweed. Substantial regrowth occurred throughout all of the treated plots by the following spring.

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INTRODUCTION

Japanese knotweed, *Fallopia japonica* (*Polygonum cuspidatum*, *Reynoutria japonica*) is native to eastern Asia. It was introduced as an ornamental from Japan to the United Kingdom in 1825 and from there into North America in the late nineteenth century (Pridham and Bing 1975; Patterson 1976; Conolly 1977). In North America, knotweed is found from Nova Scotia and Newfoundland south to North Carolina, throughout most of the Midwest, and in the coastal areas of Oregon and Washington (Patterson 1976; Locandro 1978; Pauly 1986). It is a common and serious perennial invader of terrestrial and riparian habitats in much of the eastern U.S. (Fernald 1950, Figueroa 1988, Hickman 1993, Patterson 1976). King (King 1966) called it ?one of the most persistent and aggressive of all perennial weeds.? Patterson (1976) indicated that knotweed was first identified in NC in 1946 and, at the time of the writing of his paper, was present in 27 counties. He also indicated that it ?has not yet become a serious weed in North Carolina?. Since then, Japanese knotweed has become one of the most difficult weed control problems, particularly along highways and roadsides throughout North Carolina, and very likely is present all 100 counties.

Of prime importance to the invasive nature of knotweed is its ability to reproduce readily by vegetative regeneration from stems if they fall into water or are transported by human activities (Brock et al 1995, Brock and Wade 1992, Child and Wade 1997). It is tolerant of a wide range of soil conditions (Richards et al. 1990) and adverse environmental conditions (Kubota et al 1988) and has a rapid growth rate (Child and Wade 1997, Crawley 1987). This plant emerges early and produces such dense thickets early in the season that other plants are is suppressed beneath its canopy during the growing season (Child and Wade 1997, Horn and Prach 1995, Sukopp and Sukopp 1988). It also produces a dense litter layer that suppresses seedling germination of native species (Richards et al. 1990). Successful management of Japanese knotweed requires long-term commitment using both chemical and mechanical methods (Child et al. 1992, Waal 1995). Other aspects of the biology, morphology, reproduction, and physiology of this plant have been described previously in detail (Beerling et al 1994, Child and Wade 1997).

Several techniques have been proposed for the control of knotweed, including cutting, grubbing and herbicide application. Several authors claim that cutting is not effective, based on the regeneration of shoots from rhizomes following cutting (Pridham and Bing 1975; Pauly 1986; Orchowski 1991). Palmer (1990) indicated that removal is not complete with cutting alone, but has been almost achieved in several cases and should be feasible with persistence, as repeated cutting reduces the rhizome reserves and, according to Seiger and Merchant (1990) eventually may give control. Mowing several times during the growing season may not be either economically or physically feasible for large infestations, however. Grubbing, or digging out of whole plants may be effective for very small areas, but it is extremely labor intensive and tends to spread the rhizome fragments (Palmer 1990).

Herbicide application appears to be the only practical technique for large-scale management of knotweed, particularly along highway rights-of-way areas. Several herbicides have been examined for efficacy on knotweed, including picloram, dicamba, clopyralid, triclopyr, imazapyr, 2,4-D, metsulfuron, and glyphosate. Picloram is not an option in NC due to the sensitivity of tobacco. Figueroa (1989) indicated that dicamba, 2,4-D, metsulfuron, and clopyralid were not effective at the rates examined in his study, but concluded that both glyphosate and imazapyr were effective. He stated further that glyphosate was more effective adjacent to paved roads. Imazapyr most likely would not be appropriate for broadcast applications along roadsides due to its soil persistence and extremely broad spectrum of activity, which tends to create bare ground and erosional conditions. Dicamba is nonselective as well as persistent in the soil and, particularly the DMA salt (Banvel), volatile when temperatures rise above approximately 85 F. The diglycolamine salt of dicamba (Vanquish) is less volatile and possibly could be used, but its non-selectivity still would limit the sites where it could be used. Unpublished data from studies at NCSU indicate that triclopyr (Garlon) will give significant leaf kill, but regrowth occurs rapidly. Based on previous research, glyphosate appears to have the best potential for controlling knotweed (Ahrens 1975; Pauly 1986; Beerling 1990). Application may be more effective in the fall when leaves are translocating photosynthate toward the root and rhizome system (Lynn et al 1979). Recent testing in NC suggested that two applications of glyphosate, the first in August, and the second about a month later would give complete control of knotweed (S.H. Kay, NCSU, unpublished data). Herbicide applications are indicated as being more effective when combined with cutting (Scott and Mars 1984; Orchowski 1991). The British Nature Conservancy Council (1989) recommends application of glyphosate in August following a cutting either in late spring or early summer. Repeated glyphosate applications may be needed over several years to get complete elimination of knotweed (Pauly 1986; Beerling 1990; Palmer 1990).

Control of knotweed with herbicides still has proven difficult along NC highway rights-of-way areas. This difficulty appears to be due both to concerns about potential impacts on nontarget vegetation along the right-of-way and to the possible tolerance of the knotweed to commonly-used right-of-way herbicides. It is uncertain whether or not the apparent herbicide tolerance is physiological in nature or an artifact related to the timing and/or frequency of application.

OBJECTIVES

The objectives of this project are to evaluate the timing of application of several herbicides for control of Japanese knotweed, including both foliar and dormant season treatments. Mowing followed by herbicide treatment also will be examined.

APPROACH

Four foliar herbicides, glyphosate, triclopyr amine, clopyralid, metsulfuron methyl, and the diglycolamine salt of dicamba (dicamba DGA) were applied using a CO_2 backpack sprayer and handgun to infestations of Japanese knotweed in September 2001, June 2002, and September 2002. One site treated in September 2002 had been mowed in early June 2002 and was used to evaluate the effects of an early-season mowing prior to late summer herbicide treatment. Each herbicide was applied in 100 gal/acre total volume alone at the maximum labeled rate for the product, or in combinations of two products, each at 1/2 maximum labeled rate. Individual plots were 15 to 25 feet long, depending on the size of the test site, and each treatment combination was replicated at least three times. We also examined soil treatment with dicamba DGA in late dormancy and early budbreak at two sites in late February and early April 2002, respectively. The types of treatments, sites, application dates and dates evaluated are summarized in Table 1.

Following recommendations in a meeting on June 5, 2002, we added a glyphosate rate test to determine whether or not reduced application rates (less than 2 gal/acre) and retreatment later in the season would provide acceptable control. An evaluation of alternative application technology (Burch Wet Blade) also was added at this time using glyphosate, triclopyr amine, and imazapyr. The rate test and Burch Blade test each were conducted at one site in June 2002, again with three replicates per treatment. The retreatment of the rate test occurred in September 2002. A preliminary assessment of foliar treatment with Triclopyr ester and imazapyr also was conducted on a total of three plots each spread over two September 2002 test sites.

We measured canopy height in each plot at the outset of each application period. We used visual estimates of the percent top kill, compared with an untreated check, at approximately four- to six-week intervals after treatment until frost to monitor the progress of each treatment. At the final evaluation in the spring following treatments, we estimated percent canopy cover and again measured canopy height.

RESULTS AND DISCUSSION

Late Dormancy/Early Budbreak Treatments

Dicamba DGA (Vanquish) applied to the soil at 0.25 to 1 gal/A (maximum labeled rate is 0.5 gal/A) during late dormancy at Winterville and during early budbreak at Hendersonville elicited growth regulator symptoms, including dwarfing of leaves, stem and leaf curling, and leaf discoloration. Leaves of treated plants never expanded to their normal sizes during the growing season, but shoots continued to elongate and reached heights only slightly, but not significantly, less than those of untreated plots (Table 2). Shoot numbers in treated plots also were reduced at all treatment rates above 0.25 gal/A. Percent control initially increased in direct proportion to the application rate, but, by early June of 2002, there was no evidence of any control regardless of application rate. Growth regulator symptoms still were evident at the end of the 2002 growing season, but all traces of the 2002 treatments were gone by the following spring. The results of the early budbreak treatments at Hendersonville were identical to those at the Winterville site (data not shown due to incomplete replication). These data indicate quite clearly that applications of Vanquish applied to the soil either in late dormancy or at early budbreak will not provide even temporary suppression of Japanese knotweed.

Foliar Herbicide Treatments

Spring and late summer herbicide evaluations. Late spring 2002 foliar treatments at Hendersonville (Table 3) and Marshall (Table 4) with five right-of-way herbicides either alone or in combination produced varying, but increasing symptoms on Japanese knotweed during the remainder of the 2002 growing season. Initial evaluations during the 2002 growing season suggested that Triclopyr amine (Garlon 3A) had the most activity on Japanese knotweed. Garlon 3A caused substantial top burn within one week of treatment and, within only four weeks, gave more than 80% top kill (leaves and stems). Almost complete top kill had occurred by the end of the growing season. Glyphosate (Rodeo) treatment caused increasing yellowing and leaf burn as the season progressed, but did not give complete top kill or approach an acceptable level of control by the end of the season of treatment (acceptable control is defined here as 85% or greater kill). Vanquish caused similar, but less pronounced growth regulator symptoms than Garlon 3A, and gave increasing kill as the season progressed, but produced acceptable kill by the end of the 2002 growing season only at the Hendersonville site (Table 3). The two other herbicides tested, clopyralid (Transline) and metsulfuron methyl (Escort) elicited only minor symptoms and gave poor control. Transline caused some minor leaf and shoot tip curling, whereas Escort cause very slight yellowing of the leaves. Combination treatments of Garlon 3A with either Rodeo or Transline produced good top kill by the end of the 2002 growing season. However, combining Rodeo with Transline did not improve efficacy over that of Rodeo alone by the end of the growing season. Also, the combination of Transline with Escort did not improve efficacy over either herbicide applied alone.

Evaluation of the spring treatments at the end of the growing season in which the treatments occurred gave completely misleading results regarding the efficacy of foliar applied herbicides for control of Japanese knotweed. If evaluations had not gone past the 2002 season, one would have concluded erroneously that Garlon 3A would be the best treatment and that the other herbicides, including Rodeo, would be ineffective on knotweed. At the spring 2003 evaluations, there was little evidence that any herbicide treatments had occurred, except in plots which had received glyphosate (Rodeo) applications (Tables 3 and 4). This is shown clearly in Figure 1 (Hendersonville) and Figure 2 (Marshall). Canopy heights were only slightly reduced in the Garlon 3A plots, and canopy cover was almost the same as the controls. Canopy cover and height were reduced significantly, and acceptable kill was observed in Rodeo treated plots. Control in the Rodeo + Transline plots were reduced slightly in comparison with plots treated only with Rodeo. Control in the Rodeo + Garlon plots was reduced even more in comparison with Rodeo alone. These observations suggested that the reduction in control was due either to interference between Rodeo and the second herbicide or to the fact that the application rate of Rodeo was only half that of the plots treated with Rodeo alone.

Late summer treatment with the same herbicides and combinations gave similar results as the same treatments applied during in the late spring. A brief observation made approximately one week after application (no data) showed rapid burn from Garlon 3A and no visible symptoms from any of the other herbicides or combinations. No further evaluations of these fall tests occurred during either the 2001 or 2002 growing seasons due to frost. Data from the fall 2001 test at Marshall (Table 5) and the 2002 fall tests at both Mars Hill (Table 6) and Stantonsburg (Table 7) showed that only plots which received Rodeo treatments maintained acceptable control during the following growing season. Figure 3 shows the checks, Rodeo, and Garlon 3A treatments at the spring evaluation and confirms the need for evaluation during the following growing season to avoid misleading conclusions. Once again, Garlon 3A combined with Rodeo, gave poorer control than either Rodeo alone or Rodeo + Transline. Garlon alone or combined with Transline gave very poor control. These data also seem to support the concept that Garlon 3A may be interfering with the efficacy of the glyphosate.

Herbicide application following mowing. Results of one test at Winterville (Table 8) in which the treatment area was mowed in late spring and herbicide treatments were applied in the late summer of 2002 suggested that there would be no advantage to mowing before applying herbicides. However, mowing several months prior to herbicide treatment also did not interfere with the efficacy of the treatments. The results for these tests were identical to those in which no mowing occurred, either applied in the late spring or in the fall. Evaluations in the spring of 2003 indicated that only plots treated with Rodeo gave control which would persist into the following growing season. Combination treatments of Rodeo + Garlon 3A again gave poorer control than Rodeo + Transline, providing further support for interference between Rodeo and Garlon 3A.

Glyphosate application rate/retreatment study. In this study, we applied glyphosate (Rodeo) at 0.5 to 2 gal/A in June 2002 at Marshall, with a retreatment of half of each plot six weeks later. Glyphosate damage in this study was similar to that observed in the Rodeo only plots in the late spring studies at Hendersonville and Marshall (Tables 3 and 4, respectively). The second application did not seem to boost the herbicide activity substantially during the remainder of the 2002 growing season. When evaluated in the spring of 2003, there was acceptable kill in the treated plots at the three higher application rates regardless of whether or not the plots had been retreated. These data suggest that the reduced activity observed in the other foliar treatment studies in which Rodeo and Garlon were tank mixed was not the effect of the reduced application rate of Rodeo in the tank mix as compared with that in the Rodeo only plots.

Preliminary evaluation of imazapyr and triclopyr ester. The purpose of this preliminary test was to examine imazapyr (Arsenal) as a foliar comparison with the Burch Wet Blade application of Arsenal (below) and to look at the ester formulation of triclopyr (Garlon 4) as a comparison with the amine formulation, Garlon 3A. Because of inadequate space, we split the test between the Stantonsburg and Winterville fall 2002 test sites. Data from this preliminary test (Table 9) suggest that Garlon 4 does not have any more activity than Garlon 3A (Tables 6 and 7) at either site, in spite of the fact that it contains 33% more triclopyr. Arsenal treatment at 0.25 gal/Acre reduced canopy height significantly during the following growing season but did not provide acceptable control. These data should not be considered definitive, as the study could not be conducted with adequate replication and had to be spread over two sites, one of which had been mowed earlier in the season (Winterville).

Alternative Application Technique Using the Burch Wet Blade

The Burch Wet Blade was examined to determine whether or not this method of application would remove the biomass of Japanese knotweed which causes visual impairment along highway rights-of-way and simultaneously give acceptable longer-term control without having to use high-profile spraying equipment and having concerns about off-target impacts of the treatments. Initial evaluations suggested that the Arsenal treatment might be effective and that neither the Garlon 3A nor the Rodeo treatments would give effective control (Table 10). Evaluation in the spring of 2003 suggested, however, that there was little carry-over of control into the subsequent growing season. Only small patches of control were seen in any of the test plots. There appeared to be slightly less knotweed cover in the Arsenal plots, in comparison with plots treated with the other two herbicides. The small patches showing some resemblance of control also coincided with the areas where two adjacent passes of the Burch Wet Blade came together and may have been artifacts of overlap of the treatment swaths. One might speculate that insufficient herbicide got into the cut stems to kill the massive root and rhizome system except in the zone of overlap. Growth around the edges of all plots was normal. Also, plots appeared to be in the process of reinfestation from untreated knotweed growing adjacent to the guard rail. It was quite obvious that the Burch Wet Blade would not be effective adjacent to a guard rail and that spraying of the guard rail area still would be required. This technique needs to be examined more thoroughly using larger plots and with other herbicides and application timings before any definite conclusions can be made concerning the efficacy of this application technique for control of Japanese knotweed along highway rights-of-way.

CONCLUSIONS

1. Soil applications of dicamba DGA (Vanquish) during late dormancy or early budbreak will not provide control of Japanese knotweed, even at elevated application rates.
2. Glyphosate (Rodeo) should give acceptable to excellent control of Japanese knotweed whether sprayed in the spring or in the fall, but this control will not be evident until greenup in the following growing season.
3. Mowing once in the spring prior to a fall treatment will not affect the efficacy of glyphosate for controlling Japanese knotweed.
4. Garlon 3A will give quick, but temporary top kill and will not provide any extended control into the following growing season.
5. We believe that the poor kill with Garlon observed one year after treatment was due to poor translocation to the root and rhizome system. The fact that Rodeo did give significantly better and acceptable control into the second growing season, even though there was little evidence of control at the end of the season in which it was applied, also seems to support the concept of poor translocation of Garlon 3A in comparison with Rodeo.

6. Clopyralid (Transline), metsulfuron methyl (Escort), and dicamba DGA (Vanquish) did not provide acceptable control.
7. There is no advantage to using tank mixes of any of the herbicides tested in this study. Control efficacy either remained the same or decreased with the tank mixes.
8. The observed reduction of control when triclopyr amine was tank mixed with glyphosate appears to be antagonism resulting most likely from the very rapid shoot kill by the triclopyr, in comparison with the very slow translocation and kill by glyphosate alone.
9. Glyphosate (Rodeo) applied at 1, 1.5, or 2 gal/Acre all gave similar control. Hence, reducing the foliar application rates should still provide acceptable control but at a lower cost per acre.
10. Retreatment of knotweed with glyphosate about six weeks following an initial application does not improve control.
11. Application of glyphosate, triclopyr amine, and imazapyr (Arsenal) using the Burch Wet Blade did not give acceptable control of Japanese knotweed in this study.
12. Preliminary observations suggest that foliar applications of either triclopyr ester (Garlon 4) or imazapyr in the fall will not control Japanese knotweed.

RECOMMENDATIONS

1. Large plots should be treated with glyphosate and triclopyr amine applied adjacent to each other at multiple locations in all DOT Divisions having knotweed problems throughout the state.
2. Avoid early-season (late spring) foliar glyphosate treatment, as the knotweed will continue to persist for the remainder of the growing season and cause visibility hazards.
3. Focus on late summer or early fall glyphosate treatments with one early season mowing about June to reduce the visibility problems that begin in late spring.
4. Large plot evaluations of glyphosate rates are warranted to determine whether or not the results observed in 2002-3 are meaningful.
5. Further testing of Burch Wet Blade on large plots at multiple locations is needed to give useful data on the value of this technique. Other herbicides also might be tested using this application technique.

IMPLEMENTATION AND TECHNOLOGY TRANSFER

1. Distribute copies of this report to all divisions.
2. Present results of the study at December NCVMA meeting.
3. Establish large-scale demonstrations in all knotweed-impacted divisions.

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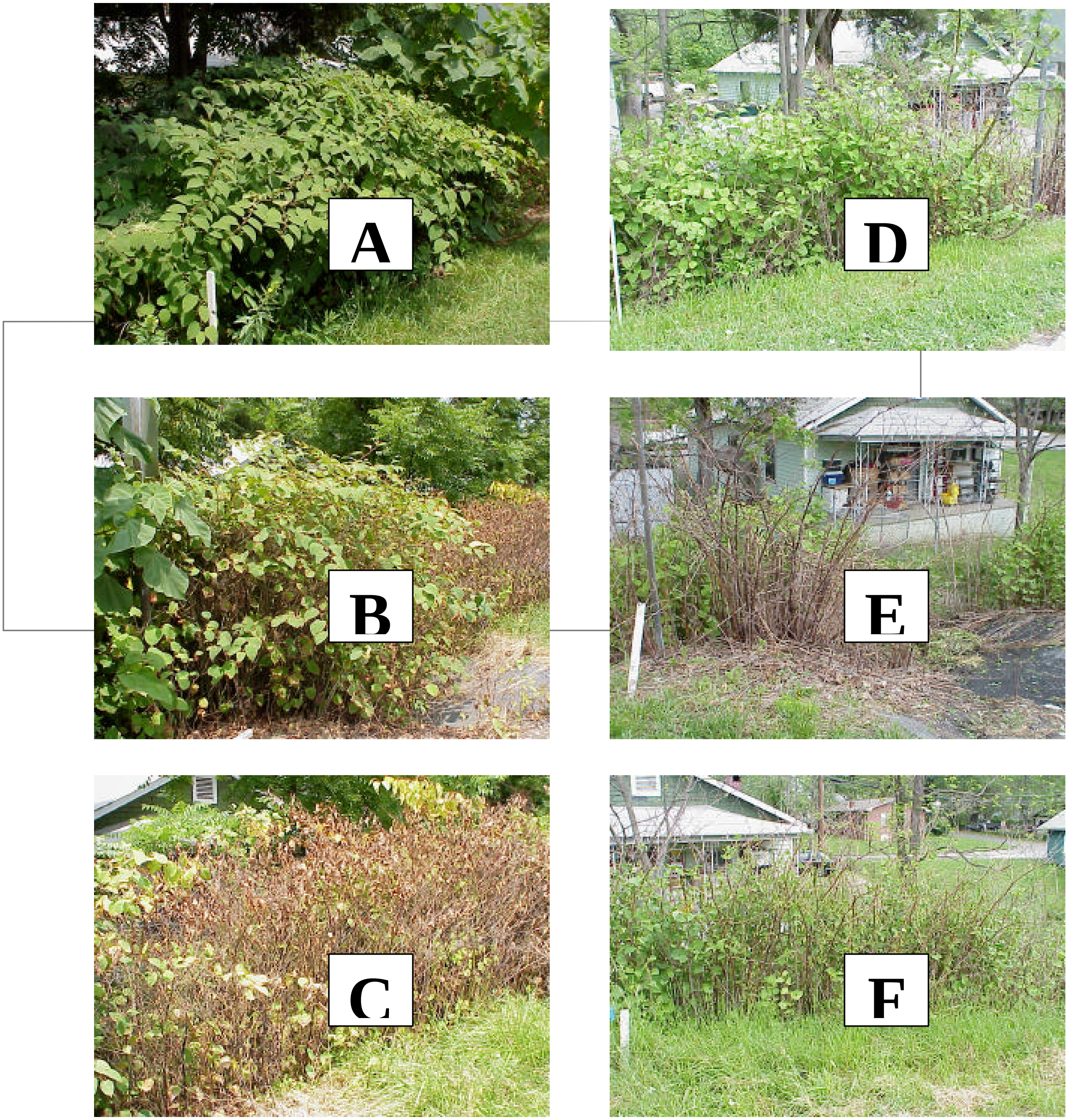

Figure 1. Spring 2002 treatments at Hendersonville. A, B, and C: check, glyphosate, and triclopyr amine treatments, respectively, 12 weeks after treatment; D, E, and F: check, glyphosate, and triclopyr amine treatments, respectively, in Spring 2003, one year after treatment.

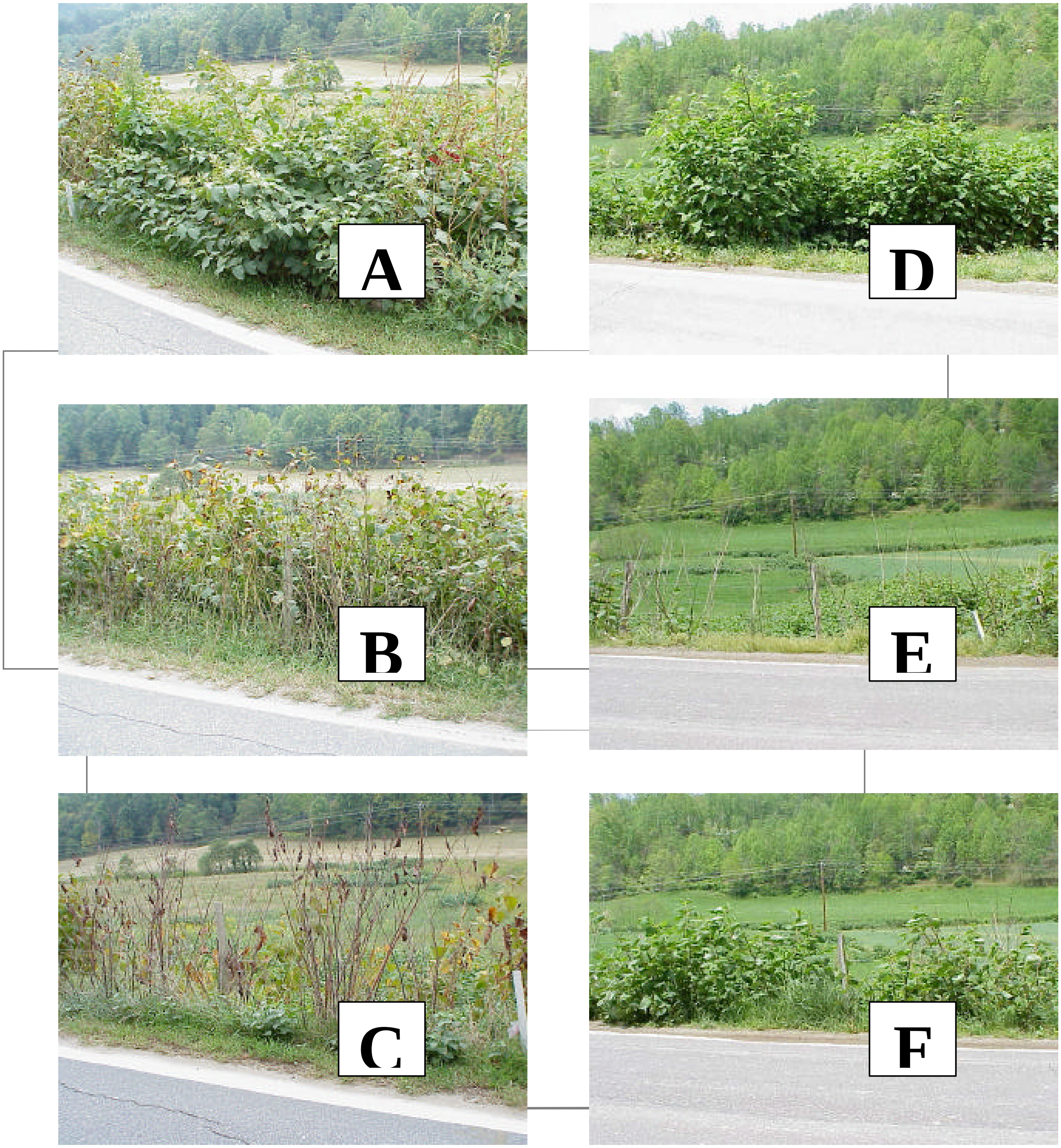

Figure 2. Spring 2002 treatments at Marshall. A, B, and C: check, glyphosate, and triclopyr amine treatments, respectively, 12 weeks after treatment; D, E, and F: check, glyphosate, and triclopyr amine treatments, respectively, in Spring 2003.

Figure 3. Fall 2002 treatments at Mars Hill. A, B, and C: check, glyphosate, and triclopyr amine treatments, respectively, in Spring 2003.

Table 1: Treatment Sites and Dates for 2001-2002 DOT Herbicide Tests on Japanese Knotweed

Type of treatment	Site	Date of treatment	Dates evaluated
foliar, late fall	Marshall	Sept 2001	9 May, 11 Jun (mowed)
late dormancy	Winterville	25 Feb 02	25 Apr, 7 Jun,
early budbreak	Hendersonville	4 Apr 02	8 May, 24 Jul
foliar, late spring	Hendersonville	11 Jun 02	17 Jun, 25 Jun, 24 Jul, 3 Sep,
foliar, late spring	Marshall	17 Jun 02	25 Jun, 2 Jul, 30 Jul, 13 Sep, 27 Sp
foliar, late spring, gly rate test	Marshall retreated 30 Jul 02	17 Jun 02	25 Jun, 2 Jul, 30 Jul, 13 Sep (12 wk)
Burch Wet Blade test	Marshall	25 Jun 02	30 Jul 02, 13 Sep (11 wat), 3 May 03
foliar, late summer, unmowed	Mars Hill	13 Sep 02	3 May 03
foliar, late summer, unmowed	Stantonsburg	24 Sep 02	21 Apr 03
foliar, late summer, mowed once	Winterville	24 Sep 02	21 Apr 03
garlon4/arsenal foliar late	Winterville/ Stantonsburg	24 Sep	21 Apr 03

Note: Light meter readings were taken under the knotweed on the NCSU campus on 11 Sep 02 (p. 91 in field book)

Table 2: Evaluation of late dormancy applications of the diglycolamine salt of dicamba (Vanquish) for control of Japanese knotweed.*

	-------- 25 Apr 03 -------		-- Percent control --	
Application rate, gal/acre	Canopy height, ft.	Number of shoots	25 Apr	7 Jun
0.00	4.3 (1.2)	26.7 (20.6)	0.0 (0.0)	0.0 (0.0)
0.25	3.8 (1.0)	25.7 (7.6)	15 (13.2)	0.0 (0.0)
0.50	3.5 (0.5)	14.6 (3.8)	35 (22.9)	0.0 (0.0)
0.75	3.5 (0.0)	12.0 (7.0)	70 (10)	0.0 (0.0)
1.00	3.0 (0.0)	8.3 (3.5)	80 (8.7)	0.0 (0.0)

*Data are means of 3 replicates ± (sd). Treatment occurred 25 Feb 02 at Winterville, NC (Pitt Co.).

Table 3: Evaluation of late spring foliar herbicide treatments at Hendersonville, NC (treated 11 June 02) for control of Japanese knotweed.*

Herbicide	Application rate, gal/acre	Canopy height when treated (ft)	percent kill 25 Jun 02	percent kill 24 Jul 02	percent kill 3 Sep 02	percent kill 3 May 03	Canopy height 3 May 03 (ft)
Check	N/A	6.0 (1.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	6.0 (0.0)
Rodeo	2	6.0 (1.0)	21.7 (7.6)	30.0 (26.0)	35.0 (21.8)	97.7 (2.5)	0.5 (0.5)
Garlon 3A	1.5	5.3 (0.6)	68.3 (16.1)	83.3 (10.4)	96.0 (1.7)	20.0 (8.7)	4.3 (0.6)
Transline	0.16	5.2 (0.8)	1.0 (0.0)	2.3 (2.3)	10.0 (7.1)	0.0 (0.0)	5.5 (0.7)
R + G	1 + 0.75	6.3 (0.6)	78.3 (7.6)	88.3 (7.6)	98.3 (0.6)	30.0 (14.1)	4.5 (0.7)
R + T	1 + 0.08	6.0 (1.0)	20.0 (5.0)	22.5 (24.7)	36.7 (37.9)	85.0 (8.7)	1.3 (0.6)
G + T	0.75 + 0.08	5.5 (0.5)	48.3 (28.4)	55.0 (27.8)	95.0 (0.0)	10.0 (5.0)	4.7 (0.6)
Escort	4 oz/acre	5.3 (0.6)	3.7 (2.3)	3.7 (2.3)	6.7 (2.9)	0.0 (0.0)	5.7 (0.6)
E + T	2 oz + 0.08	5.0 (1.0)	3.7 (2.3)	2.3 (2.3)	6.7 (2.9)	1.7 (2.9)	5.3 (0.6)
Vanquish	0.5	5.7 (1.2)	16.7 (10.4)	60.0 (20.0)	89.3 (7.5)	8.3 (7.6)	5.0 (1.0)

*Data are means of 3 replicates ± (sd). R+G= Rodeo + Garlon 3A; R + T= Rodeo + Transline; E + T= Escort + Transline.

Table 4: Evaluation of late spring foliar herbicide treatments at Marshall, NC (treated 17 Jun 02) for control of Japanese Knotweed.*

Herbicide	Application rate, gal/acre	Canopy height when treated, (ft)	percent kill 2 Jul 02	percent kill 30 Jul 02	percent kill 13 Sep 02	percent kill 3 May 03	Canopy height 3 May 03 (ft)
Check	N/A	5.7 (1.6)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	5.3 (0.6)
Rodeo	2	5.7 (0.8)	21.7 (7.6)	30.0 (26.0)	50.0 (17.3)	99.7 (0.6)	0.2 (0.3)
Garlon 3A	1.5	6.5 (1.0)	68.3 (16.1)	83.3 (10.4)	94.3 (4.0)	15.0 (13.2)	4.0 (0.0)
Transline	0.16	6.2 (1.3)	1.0 (1.0)	2.3 (2.3)	11.7 (2.9)	0.0 (0.0)	5.0 (1.0)
R + G	1 + 0.75	6.3 (1.8)	78.3 (7.6)	88.3 (7.6)	98.0 (0.0)	70.0 (27.8)	2.2 (1.4)
R + T	1 + 0.08	6.2 (2.1)	20.0 (5.0)	22.5 (24.7)	21.7 (2.9)	86.7 (15.3)	2.0 (2.0)
G + T	0.75 + 0.08	6.8 (0.8)	48.3 (28.4)	55.0 (27.8)	90.0 (5.0)	1.7 (2.9)	4.0 (1.0)
Escort	4 oz/acre	6.7 (1.9)	3.7 (2.3)	3.7 (2.3)	3.7 (2.3)	0.0 (0.0)	4.7 (1.2)
E + T	2 oz + 0.08	6.7 (1.9)	3.7 (2.3)	2.3 (2.3)	8.3 (5.8)	0.0 (0.0)	5.3 (1.5)
Vanquish	0.5	6.5 (1.5)	16.7 (10.4)	60.0 (20.0)	80.0 (10.0)	8.3 (10.4)	4.0 (0.0)

*Data are means of 3 replicates ± (sd). R+G= Rodeo + Garlon 3A; R + T= Rodeo + Transline; E + T= Escort + Transline.

Table 5: Efficacy of foliar herbicide treatments applied to in Japanese knotweed at Marshall, NC in September 2001. Data are the means of three replicates.*

Herbicide	Application rate, gal/A	Average shoot ht, ft	Percent control
Check	--	6.6	0
Rodeo (R)	2	1.0	97
Garlon 3A (G)	1.5	5.7	25
Transline (T)	0.16	6.7	33
R + G	1 + 0.75	2.0	92
R + T	1 + 0.08	2.7	64
G + T	0.75 + 0.08	6.3	12
Escort (E)	4 oz/A	6.3	7
E + T	2 oz + 0.08	5.3	7
Vanquish	0.5	5.0	57

*Evaluation occurred in May 2002. There was no further evaluation at this site, as local property owners cut down more than half of the test plots in early June.

Table 6: Evaluation of late summer foliar herbicide treatments at Mars Hill, NC (treated 13 Sep 02) for control of Japanese knotweed.*

Herbicide	Application rate, gal/acre	Canopy height when treated, (ft)	Canopy height 3 May 03 (ft)	Percent kill, 3 May 03
Check	N/A	0.0 (0.0)	6.5 (0.7)	0.0 (0.0)
Rodeo	2	5.8 (0.3)	0.8 (0.3)	95.0 (0.0)
Garlon 3A	1.5	6/8 (0.8)	6.7 (1.5)	3.3 (5.8)
Transline	0.16	6.3 (1.2)	6.3 (1.2)	26.7 (15.3)
R + G	1 + 0.75	5.5 (1.3)	1.0 (1.0)	91.7 (2.9)
R + T	1 gal + 0.08	6.3 (0.6)	0.7 (0.3)	96.3 (2.3)
G + T	0.75 + 0.08	5.8 (0.8)	7.0 (1.7)	3.3 (2.9)
Escort	4 oz/acre	5.7 (1.2)	6.3 (0.6)	0.0 (0.0)
E + T	2 oz + 0.08	6.0 (1.7)	7.3 (0.6)	10.0 (10.0)
Vanquish	0.5	6.3 (1.2)	4.2 (3.2)	60.0 (26.5)

*Data are means of 3 replicates ± (sd). R+G= Rodeo + Garlon 3A; R + T= Rodeo + Transline; E + T= Escort + Transline.

Table 7: Evaluation of late summer foliar herbicide treatments at Stantonsburg, NC (treated 24 Sep 02) for control of Japanese knotweed.*

Herbicide	Application rate, gal/acre	Canopy height when treated, (ft)	Canopy height, 21 Apr 03 (ft)	Percent kill 21 Apr 03
Check	N/A	5.7 (0.8)	6.0 (0.0)	0.0 (0.0)
Rodeo	2	5.3 (0.6)	1.3 (0.6)	91.7 (2.9)
Garlon 3A	1.5	5.2 (1.0)	4.7 (0.6)	0.0 (0.0)
Transline	0.16	4.7 (0.8)	5.0 (0.0)	8.3 (5.8)
R + G	1 + 0.75	5.0 (0.5)	4.7 (0.6)	5.0 (5.0)
R + T	1 + 0.08	5.0 (0.5)	2.0 (1.0)	71.7 (22.5)
G + T	0.75 + 0.08	5.5 (0.5)	5.3 (0.6)	3.3 (2.9)
Escort	4 oz/acre	5.3 (0.8)	5.7 (0.6)	0.0 (0.0)
E + T	2 oz + 0.08	5.5 (0.0)	6.0 (1.0)	8.3 (14.4)
Vanquish	0.5	5.3 (0.6)	4.7 (0.6)	26.7 (37.5)

*Data are means of 3 replicates ± (sd). R+G= Rodeo + Garlon 3A; R + T= Rodeo + Transline; E + T= Escort + Transline.

Table 8: Evaluation of late summer foliar herbicide treatments following a June mowing at Winterville, NC (treated 24 Sep 02) for control of Japanese knotweed.*

Herbicide	Application rate, gal/acre	Canopy height when treated, (ft)	Canopy height, 21 Apr 03 (ft)	Percent kill, 21 Apr 03
Check	N/A	2.5 (0.9)	4.7 (0.6)	0.0 (0.0)
Rodeo	2	2.2 (0.6)	1.0 (1.0)	90.0 (0.0)
Garlon 3A	1.5	2.2 (0.6)	3.3 (1.2)	23.3 (40.4)
Transline	0.16	2.2 (0.8)	3.7 (0.6)	16.7 (11.5)
R + G	1 + 0.75	2.2 (0.8)	3.3 (0.6)	20.0 (8.7)
R + T	1 gal + 0.08	2.3 (0.8)	1.7 (0.6)	63.3 (46.5)
G + T	0.75 gal + 0.08	2.5 (1.0)	3.7 (0.6)	13.3 (10.4)
Escort	4 oz/acre	2.3 (0.8)	4.3 (1.2)	0.0 (0.0)
E + T	2 oz + 0.08	2.2 (0.6)	4.0 (1.0)	1.7 (2.9)
Vanquish	0.5	2.3 (0.3)	2.7 (0.6)	30.0 (30.0)

*Data are means of 3 replicates ± (sd). R+G= Rodeo + Garlon 3A; R + T= Rodeo + Transline; E + T= Escort + Transline.

Table 9: Preliminary evaluation of foliar applications of Garlon 4 and Arsenal for control of Japanese knotweed.*

Site	Herbicide	Application rate, gal/acre	Canopy height when treated, (ft)		Canopy height, 21 Apr 03 (ft)		Percent kill, 21 Apr 03	
Stantonsburg	Check	N/A	6.5		6.0		0	
Winterville	Check	N/A	1.5		4.0		0	
Winterville	Check	N/A	3.0		5.0		0	
	means ± (sd)		3.7	(2.6)	5.0	(1.0)	0	(0)
Stantonsburg	Arsenal	0.25	6.0		2.0		85	
Winterville	Arsenal	0.25	2.5		3.0		10	
Winterville	Arsenal	0.25	2.3		3.0		10	
	means ± (sd)		3.6	(2.1)	2.7	(0.6)	35	(43.3)
Stantonsburg	Garlon 4	1.5	6.5		5.0		0	
Winterville	Garlon 4	1.5	2.5		3.0		5	
Winterville	Garlon 4	1.5	2.5		4.0		0	
	means ± (sd)		3.8	(2.3)	4.0	(1.0)	1.7	(2.9)

*Plots were treated 24 Sep 02. Summmary data are means of 3 replicates ± (sd). R+G= Rodeo + Garlon 3A; R + T= Rodeo + Transline; E + T= Escort + Transline. The Winterville site was mowed once during early June.

Table 10: Effects of herbicide application (treated 25 June 02) using the Burch Wet Blade mower/wiper application system on Japanese knotweed.*

Herbicide	Height (ft.) at treatment	Height (ft.), 13 Sep 03	Height (ft.) 3 May 03	Percent kill, 13 Sep 03	Percent kill 3 May 03
None	6 (0)	2.7 (0.6)	0 (0.0)	0 (0)	0 (0)
Rodeo	6 (0)	2.0 (1.3)	5.7 (0.6)	47 (42)	23 (32)
Garlon 3A	6 (0)	3.0 (1.0)	5.0 (1.0)	42 (33)	3 (6)
Arsenal	6 (0)	0.7 (0.3)	4.0 (1.0)	94 (4)	20 (10)

*Data are means of 3 replicates ± (sd).