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Research Reports:

# Influence of Timing and Rate of Glyphosate Applications on Conifer Growth[1]

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## Abstract

Glyphosate [*N*-(phosphonomethyl)glycine] was applied at four rates, 0.4, 0.8, 1.5 and 3.0 kg ai/ha (0.36, 0.71, 1.34 and 2.7 lb ai/A) each at four dates, May 26, July 14, September 10, and October 27, 1982, over Fraser fir (*Abies fraseri* (Pursh) Poir.), Norway spruce (*Picea abies* (L.) Karst.), and Canadian hemlock (*Tsuga canadensis* (L.) Carriere). Plants were treated in 1982 and evaluated in 1983 and 1984. Plant height best described the treatment effects for hemlock and fir. Plant height plus budset on the terminal best described treatment effects for spruce. Fir and spruce were tolerant to September and October applications of glyphosate, however, May and July treatments resulted in significant phytotoxicity. Hemlock plants were injured by May, July and September glyphosate treatments, but not bv similar applications in October. Injury to all species persisted into the 1984 season from single applications in 1982.

**Index words:** N-(phosphonomethyl)glycine, Canadian hemlock, Fraser fir, Norway spruce, *Abies fraseri*, *Picea abies*, *Tsuga canadensis*, woody landscape plants, Christmas trees

## Introduction

Glyphosate (Roundup) is often described as a non-selective herbicide, yet selective uses for glyphosate do exist. These selective uses have relied upon positional or temporal selectivity (i.e., directed or pre-plant applications); however, certain conifers and woody landscape plants have exhibited significant tolerance to foliar applications of the herbicide (1, 2, 4, 6, 7, 8). Previous studies have shown that application timing significantly affects glyphosate toxicity to perennial weeds (3, 11), deciduous fruit trees (9, 12), woody landscape plants (7), and conifers (5, 6, 7). The effect of application timing on glyphosate toxicity to woody perennials is species dependent (5, 6, 7, 9, 12). Deciduous fruit trees sustained significantly more injury from late summer and fall applications of glyphosate than from spring applications (12). Conversely, certain evergreen woody species and conifers are more tolerant of fall applications than

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of spring or summer treatments (5, 6, 7). King and Radosovich (5) observed that conifers were more tolerant of glyphosate, 2,4-D and triclopyr (Garlon) when annual growth had stopped (fall applications), than during the growing season. In those experiments maximum injury was correlated with leader or needle growth, as well as xylem water potential. Experiments evaluating glyphosate effects on woody perennials have shown that injury symptoms may persist for long periods of time (7, 9). In order to measure plant responses over time, destructive measurements of plant growth are often impractical due to the high cost per experimental unit and the large number of individuals required for destructive measurements over time. Such was the case in this experiment. Therefore, the objectives of this experiment were to (1) evaluate the influence of glyphosate application rate and timing on Canadian hemlock, Fraser fir, and Norway spruce growth, and (2) to evaluate various nondestructive measurement parameters for each species.

## Materials and Methods

Glyphosate was applied over-the-top of 3+2 Fraser fir (three years in the seedbed, plus two years in the transplant bed), 3+1 Norway spruce and 3+0 Canadian hemlock seedling transplants in a 4 × 4, rate by time factorial experiment. Glyphosate was applied with a $CO_2$ pressurized backpack sprayer equipped with a single flooding nozzle and calibrated to deliver 234 l/ha (25 gal/A)at 39 kPa (10 psi). Application rates were 0.4, 0.8, 1.5 and 3.0 kg ai/ha (0.36, 0.71, 1.34 and 2.7 lb ai/A); each applied at four dates; May 26, July 14, September 10, and October 17, 1982.

The experimental design utilized four replicates with three plants per plot in a completely randomized block design. Data for the three plants per plot were averaged to produce a single observation per treatment and replicate. Untreated plants were included as controls but were deleted from the data set for testing the influence of rate and time of application on injury. Deletion of these observations provided a balanced, complete 4 × 4 factorial data set. Data for the three species were analyzed separately. Measurement parameters were analyzed separately and in multivariate analyses[4] to determine which measurements were needed to describe the treatment effects.

On June 29, 1983, plants were visually evaluated on a scale of 0 to 100, where 0 = dead and 100 = best growth. Plant heights, measured in centimeters from ground level, of all species were also determined. Measurements of plant growth were made on October 30, 1983 and September 23, 1984 which was after growth had ceased for each season. Additional parameters measured on Fraser fir and Norway spruce were length of the terminal leader and number of branches in the apical whorl in 1982, 1983, and 1984. Budbreak on the current season's growth and budset on the terminal leader were determined for the 1983 and 1984 seasons of growth. Canadian hemlock plants produce multiple flushes of growth in one season and are irregularly branched; therefore, the measurements used for fir and spruce were not appropriate. Instead, plant width was measured to complement height and visual ratings. To facilitate measurements, plants were not sheared during the course of the study.

[4]MANOVA, Multivariate analysis of the variance; SAS Users guide: Statistics, 1982 edition, SAS Institute Inc., Box 8000, Cary, NC 27511.

## Results and Discussion

*Evaluation of Measurement Parameters.* A factorial correlation procedure on hemlock data produced very high correlation ($r \geq 0.93$, $p = 0.0001$) among all measured parameters. Therefore, the measurement of any one parameter sufficiently described the plant responses. Plant height measurements were rapid, simple, and produced lower coefficients of variability (C.V.) than did visual evaluations (Table 1). Therefore, plant height measurements will be used to discuss hemlock responses to glyphosate applications. Data from visual evaluation are also presented for comparison.

Similar correlation procedures for fir and spruce showed that measurement parameters were not highly correlated (Tables 2 and 3). This implied that a single measurement parameter was not adequate. To test this hypothesis, data were subjected to multivariate analyses and Rao's (10) "test for additional information." These tests indicated that yearly measurements of total plant height alone was sufficient to explain the influence of application timing and rate, and the interaction, on growth of Fraser fir. By the same tests, measurement of two parameters, i.e.: plant height and budset, were necessary to describe the effects of glyphosate treatments on Norway spruce. Measurements of plant height made in June and October of 1983 were weakly correlated ($r = 0.67$ and 0.60, for fir and spruce, resp.). Therefore, plant measurements are suggested in the fall, after growth has ceased for that season.

*Canadian Hemlock.* Rate and timing of glyphosate applications in 1982 significantly influenced plant growth in 1983 and 1984 (Table 1). Plant height decreased with increased rate for May, July and September applications. No significant injury resulted from October treatments.

*Fraser fir.* As indicated by the "test for additional information," plant height was used as the evaluation parameter. The other measurements are presented for comparison (Table 4). Applications of glyphosate in May and July of 1982 resulted in a significant decrease in plant growth, as measured by 1982, 1983 and 1984 plant heights (Table 4). Overall, application timing effects on total plant height were significant in 1982 and 1983, but were nonsignificant in 1984 (Table 4). However, single degree of freedom mean comparisons with the height of untreated plants in 1984 indicated a significant decrease in plant height resulting from May and July treatments with 3.0 kg ai/ha ($p = 0.01$ and 0.05, resp.). Elongation of the terminal leader in 1984 was unaffected by 1982 treatments (Table 4), indicating that normal plant growth had resumed. Plants treated in September and October exhibited no injury symptoms throughout the test.

Rate effects were nonsignificant in the year of treatment (Table 4). Rate effects became significant in 1983 when plants treated with the lower rates in May and July recovered from initial injury; whereas, those treated with the higher rates did not.

*Norway Spruce.* The influence of application timing on plant height was significant in 1982, 1983 and 1984 eval-

Table 1. Influence of application timing and rate on glyphosate toxicity to Canadian hemlock.

| Application[z] Time | Application Rate | Visual rating[y] | | Maximum height | |
|---|---|---|---|---|---|
| | | 1983 | 1984 | 1983 | 1984 |
| (month) | (kg/ha) | | | (cm) | |
| May | 0.4 | 56 | 40 | 94 | 109 |
| | 0.8 | 47 | 39 | 84 | 108 |
| | 1.5 | 18 | 18 | 46 | 66 |
| | 3.0 | 9 | 7 | 16 | 24 |
| June | 0.4 | 55 | 45 | 84 | 108 |
| | 0.8 | 41 | 25 | 67 | 74 |
| | 1.5 | 16 | 22 | 35 | 67 |
| | 3.0 | 3 | 3 | 15 | 16 |
| Sept. | 0.4 | 60 | 61 | 96 | 131 |
| | 0.8 | 52 | 45 | 84 | 99 |
| | 1.5 | 48 | 32 | 72 | 87 |
| | 3.0 | 35 | 28 | 64 | 74 |
| Oct. | 0.4 | 61 | 53 | 85 | 107 |
| | 0.8 | 52 | 42 | 85 | 99 |
| | 1.5 | 71 | 48 | 100 | 116 |
| | 3.0 | 67 | 58 | 96 | 120 |
| Untreated | | 75 | 49 | 110 | 120 |
| Statistics | | | | | |
| Rate | | ** | ** | ** | ** |
| Time | | ** | ** | ** | ** |
| Time by Rate | | ** | NS | ** | * |
| C.V. | | 36.9 | 51.7 | 27.1 | 34.7 |
| LSD (0.05) | | 22 | 25 | 26 | 42 |

[z]Application times were May 26, July 14, September 10 and October 27, 1982.

[y]Visual evaluations were on a percent scale where 0 = dead and 100 = best plants, whether treated or untreated. Evaluation dates were Oct. 30, 1983 and Sept. 23, 1984.

NS, *, **Nonsignificant (NS) or significant at the 5% (*) or 1% (**) levels.

Table 2. Correlation coefficients and associated probability values for Norway spruce data collected on October 30, 1983.

| | Maximum Height | Terminal Length | | Whorl count | | Budbreak | Budset | Visual Rating |
|---|---|---|---|---|---|---|---|---|
| | | 1982 | 1983 | 1982 | 1983 | | | |
| Height | — | 0.69 | 0.85 | 0.61 | 0.60 | 0.71 | 0.73 | 0.70 |
| Terminal length | | | | | | | | |
| 1982 | 0.0001 | — | 0.53 | 0.42 | 0.49 | 0.85 | 0.50 | 0.52 |
| 1983 | 0.0001 | 0.0001 | — | 0.59 | 0.53 | 0.54 | 0.85 | 0.65 |
| Whorl count | | | | | | | | |
| 1982 | 0.0001 | 0.0004 | 0.0001 | — | 0.50 | 0.49 | 0.58 | 0.70 |
| 1983 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | — | 0.61 | 0.57 | 0.75 |
| Budbreak | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | — | 0.55 | 0.63 |
| Budset | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | — | 0.67 |
| Visual Rating | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | — |

Table 3. Correlation coefficients and associated probability values for Fraser fir data collected on October 30, 1983.

| | Maximum Height | Terminal Length | | Whorl count | | Budbreak | Budset | Visual Rating |
|---|---|---|---|---|---|---|---|---|
| | | 1982 | 1983 | 1982 | 1983 | | | |
| Height | — | 0.72 | 0.90 | 0.61 | 0.54 | 0.54 | 0.69 | 0.66 |
| Terminal length | | | | | | | | |
| 1982 | 0.001 | — | 0.51 | 0.53 | 0.66 | 0.82 | 0.54 | 0.61 |
| 1983 | 0.0001 | 0.0001 | — | 0.57 | 0.42 | 0.38 | 0.68 | 0.63 |
| Whorl count | | | | | | | | |
| 1982 | 0.0001 | 0.0001 | 0.0001 | — | 0.50 | 0.41 | 0.36 | 0.70 |
| 1983 | 0.0001 | 0.0001 | 0.0003 | 0.0001 | — | 0.59 | 0.25 | 0.71 |
| Budbreak | 0.0001 | 0.0001 | 0.0003 | 0.0005 | 0.0001 | — | 0.34 | 0.56 |
| Budset | 0.0001 | 0.0001 | 0.0001 | 0.0029 | 0.0408 | 0.0047 | — | 0.38 |
| Visual Rating | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0014 | — |

**Table 4. Influence of application timing and rate on glyphosate toxicity to Fraser fir.**

| Application | | Total height | | | Length of the terminal | | | Whorl count | | | Budbreak | | Budset | | Budset per dm of terminal | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time[z] | Rate | 1982 | 1983 | 1984 | 1982 | 1983 | 1984 | 1982 | 1983 | 1984 | 1983 | 1984 | 1983 | 1984 | 1983 | 1984 |
| (month) | (kg/ha) | (cm) | | | | | | | | | | | | | (dm) | |
| May | 0.4 | 43 | 76 | 114 | 17 | 33 | 40 | 3.7 | 3.6 | 5.3 | 8.3 | 26 | 24 | 26 | 7.5 | 6.7 |
| | 0.8 | 44 | 78 | 124 | 18 | 34 | 46 | 3.7 | 3.2 | 5.2 | 8.2 | 30 | 28 | 32 | 8.4 | 7.0 |
| | 1.5 | 36 | 64 | 103 | 12 | 28 | 39 | 2.8 | 2.2 | 5.0 | 5.8 | 24 | 23 | 30 | 8.6 | 7.6 |
| | 3.0 | 30 | 52 | 86(**) | 10 | 21 | 34 | 1.7 | 1.4 | 4.4 | 5.2 | 21 | 21 | 28 | 9.8 | 8.6(**) |
| June | 0.4 | 36 | 65 | 108 | 13 | 30 | 40 | 2.4 | 2.3 | 4.3 | 4.9 | 23 | 23 | 29 | 7.9 | 7.2 |
| | 0.8 | 32 | 59 | 98 | 10 | 27 | 38 | 1.9 | 1.7 | 4.7 | 3.1 | 25 | 23 | 31 | 8.4 | 8.2(**) |
| | 1.5 | 34 | 60 | 108 | 9 | 26 | 43 | 2.5 | 1.2 | 4.1 | 4.4 | 19 | 18 | 29 | 6.9 | 6.7 |
| | 3.0 | 31 | 52 | 96(*) | 10 | 20 | 43 | 2.4 | 2.2 | 3.9 | 3.3 | 17 | 17 | 32 | 8.2 | 7.4 |
| Sept. | 0.4 | 33 | 58 | 103 | 11 | 25 | 42 | 2.7 | 2.4 | 4.2 | 5.6 | 20 | 18 | 29 | 7.7 | 6.9 |
| | 0.8 | 38 | 71 | 114 | 14 | 33 | 43 | 3.3 | 2.4 | 4.8 | 5.8 | 27 | 25 | 28 | 7.6 | 6.6 |
| | 1.5 | 36 | 66 | 110 | 14 | 30 | 45 | 3.5 | 2.9 | 5.0 | 6.7 | 22 | 23 | 27 | 7.7 | 6.0 |
| | 3.0 | 42 | 76 | 125 | 18 | 33 | 50 | 4.2 | 3.3 | 5.7 | 6.2 | 26 | 25 | 31 | 7.6 | 6.3 |
| Oct. | 0.4 | 40 | 73 | 116 | 14 | 33 | 46 | 4.0 | 2.6 | 5.2 | 6.4 | 26 | 25 | 31 | 7.6 | 6.7 |
| | 0.8 | 40 | 74 | 123 | 13 | 34 | 48 | 3.9 | 2.7 | 5.0 | 5.7 | 24 | 23 | 34 | 6.9 | 7.0 |
| | 1.5 | 40 | 76 | 125 | 17 | 36 | 50 | 4.2 | 2.8 | 5.2 | 7.5 | 29 | 26 | 29 | 7.3 | 5.8 |
| | 3.0 | 34 | 63 | 99 | 12 | 29 | 35 | 4.2 | 2.8 | 4.9 | 5.4 | 23 | 22 | 28 | 7.8 | 7.8(**) |
| Untreated | | 44 | 79 | 118 | 19 | 35 | 42 | 3.9 | 3.2 | 4.8 | 8.9 | 26 | 26 | 25 | 7.5 | 6.1 |
| Statistical analysis[y] | | | | | | | | | | | | | | | | |
| Rate | | NS | * | NS | NS | * | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Time | | * | ** | NS | ** | ** | NS | ** | ** | NS | ** | * | * | NS | NS | * |
| Rate by Time | | * | ** | * | ** | NS | NS | ** | ** | NS | NS | NS | NS | NS | NS | NS |
| C.V. | | 14.6 | 13.5 | 13.8 | 23.1 | 19.4 | 17.9 | 24.1 | 30.1 | 20.0 | 36.4 | 18.8 | 17.8 | 20.0 | 18.1 | 15.2 |
| LSD (0.05) | | 8 | 13 | 21 | 4 | 8 | 11 | 1.1 | 1.1 | 1.43 | 3.0 | 6 | 6 | 8 | 0.2 | 0.2 |

[z]Application dates were May 26, July 14, September 10, and October 17, 1982.

[y]Statistical analysis of rate and time effects was on the balanced data set with untreated checks deleted. Effects are designated as nonsignificant (NS) or significant at the 5% (*) or 1% (**) levels. Notations in parenthesis indicate means significantly different from the untreated checks; determined by single degree of freedom mean comparisons. These notations are included only where mean comparisons indicate important treatment effects which were masked in the overall analysis.

uations (Table 5). Injury resulted from May and July applications only. No significant injury resulted from September or October treatments. These data agree with the observations of Lund-Hoie (6), who determined that Norway spruce was more tolerant of fall applications than spring applications of glyphosate.

Rate effects and the rate by time interaction were nonsignificant in 1982 and 1983, but significant in the 1984 evaluations (Table 5). Plants treated with lower rates, sustained significant injury initially, but recovered by September of 1984. Plants treated with the higher rates had not recovered by the end of the experiment.

Similar responses were observed for the other parameters including budset, which was the parameter identified for measurement by the "test for additional information." Additionally, there was a significant increase in budset per decimeter (dm) of terminal in 1984. Since budset in 1983 was highly correlated with budbreak in 1984, the increased budset per dm of terminal in 1984 should reflect treatment differences in the 1985 growing season. Particularly noteworthy is that this effect of glyphosate treatment on 1984 budset is on tissue which was not present at the time of treatment.

These data indicated that fall applications of glyphosate over Fraser fir and Norway spruce for weed control are feasible. These results are consistent with the findings of other investigators working with similar species (1, 5, 6). In this experiment, plant height alone was sufficient to describe the effects of glyphosate on hemlock and fir; but plant height plus budset on the terminal were required for spruce evaluations. hemlock plants were more susceptible to glyphosate injury than fir or spruce; therefore, glyphosate contact with the foliage of hemlocks should be avoided. The probability and severity of injury to hemlocks may be reduced with late fall applications. Glyphosate applications over fir, spruce and hemlock in the spring and summer resulted in significant injury which persisted two or more years after application. Therefore, foliar applications of glyphosate to these species should be avoided during these times.

## Significance to the Nursery Industry

Results from this experiment indicated that Fraser fir, Norway spruce and Canadian hemlock are injured most severely by glyphosate applications in the spring, and that the injury symptoms may persist for up to three years. Thus we advocate that herbicide applicators avoid spring applications of glyphosate on or around these species. The potential for injury decreases through the season. Over-the-top applications were safe only in autumn after terminal buds were set and foliage was mature. Glyphosate applications around these species should be delayed as late as possible to benefit from the seasonal differences in conifer tolerance.

Research workers should note that simple plant height measurements are sufficient for glyphosate injury evaluations on Fraser fir and hemlock. Plant height and budset on the terminal were sufficient for Norway spruce. These simple, nondestructive measurements could save time and reduce the number of specimens required in long-term studies as compared to destructive harvests.

**Table 5. Influence of application timing and rate on glyphosate toxicity to Norway spruce.**

| Application | | Total height | | | Length of the terminal | | | Whorl count | | | Budbreak | | Budset | | Budset per dm of terminal | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time[z] | Rate | 1982 | 1983 | 1984 | 1982 | 1983 | 1984 | 1982 | 1983 | 1984 | 1983 | 1984 | 1983 | 1984 | 1983 | 1984 |
| (month) | (kg/ha) | (cm) | | | | | | | | | | | | | (dm) | |
| May | 0.4 | 34 | 53 | 83 | 9 | 19 | 26 | 2.5 | 3.2 | 4.3 | 4.9 | 16 | 13 | 23 | 7.2 | 8.7 |
| | 0.8 | 35 | 50 | 72 | 11 | 15 | 23 | 0.6 | 1.6 | 3.7 | 4.5 | 14 | 11 | 17 | 7.0 | 7.6 |
| | 1.5 | 22 | 36 | 52 | 4 | 14 | 18 | 0.8 | 0.9 | 2.3 | 1.6 | 11 | 10 | 16 | 7.3 | 8.7 |
| | 3.0 | 14 | 18 | 25 | 2 | 4 | 9 | 0.8 | 0.6 | 1.4 | 1.1 | 4 | 4 | 9 | 9.4 | 10.0(**) |
| June | 0.4 | 45 | 68 | 99 | 10 | 22 | 34 | 2.9 | 2.9 | 5.1 | 5.9 | 20 | 15 | 23 | 7.0 | 6.8 |
| | 0.8 | 35 | 52 | 82 | 7 | 18 | 29 | 1.4 | 1.9 | 4.4 | 5.0 | 17 | 11 | 22 | 6.5 | 7.4 |
| | 1.5 | 40 | 58 | 89 | 10 | 18 | 31 | 1.9 | 2.8 | 3.8 | 5.8 | 14 | 12 | 20 | 6.5 | 6.4 |
| | 3.0 | 36 | 50 | 66 | 8 | 14 | 17 | 0.8 | 1.8 | 2.5 | 3.9 | 12 | 9 | 15 | 6.4 | 9.0(*) |
| Sept. | 0.4 | 40 | 63 | 91 | 9 | 23 | 29 | 3.1 | 2.2 | 4.3 | 6.2 | 20 | 17 | 24 | 7.4 | 8.2 |
| | 0.8 | 36 | 59 | 89 | 9 | 23 | 30 | 2.0 | 2.3 | 4.2 | 5.7 | 19 | 16 | 25 | 7.3 | 8.0 |
| | 1.5 | 47 | 69 | 103 | 11 | 22 | 35 | 2.8 | 3.3 | 4.2 | 7.6 | 18 | 15 | 28 | 6.9 | 8.1 |
| | 3.0 | 41 | 62 | 96 | 11 | 21 | 33 | 2.8 | 2.9 | 4.9 | 7.1 | 21 | 16 | 25 | 8.0 | 7.8 |
| Oct. | 0.4 | 41 | 61 | 89 | 11 | 20 | 30 | 2.5 | 3.7 | 4.9 | 7.5 | 18 | 15 | 21 | 7.3 | 7.2 |
| | 0.8 | 39 | 61 | 94 | 9 | 22 | 33 | 2.3 | 3.0 | 3.3 | 5.0 | 17 | 14 | 26 | 6.8 | 8.0 |
| | 1.5 | 40 | 60 | 90 | 9 | 20 | 31 | 2.2 | 3.0 | 3.7 | 5.2 | 15 | 15 | 23 | 7.6 | 7.9 |
| | 3.0 | 43 | 64 | 94 | 10 | 21 | 31 | 2.0 | 3.3 | 4.4 | 5.9 | 19 | 14 | 21 | 6.6 | 6.7 |
| Untreated | | 43 | 67 | 99 | 10 | 24 | 32 | 2.8 | 4.0 | 4.9 | 6.8 | 20 | 17 | 23 | 7.0 | 7.3 |
| Statistical analysis[y] | | | | | | | | | | | | | | | | |
| Rate | | NS | NS | ** | NS | ** | * | ** | * | ** | NS | * | ** | * | NS | NS |
| Time | | ** | ** | ** | * | ** | ** | ** | ** | ** | ** | ** | ** | ** | NS | ** |
| Rate by Time | | NS | NS | ** | * | NS | * | NS | ** | ** | NS | NS | NS | NS | NS | NS |
| C.V. | | 26.3 | 22.6 | 20.0 | 36.2 | 25.9 | 23.3 | 36.2 | 32.3 | 22.1 | 46 | 29.2 | 25.3 | 23.6 | 20.2 | 15.4 |
| LSD (0.05) | | 14 | 17 | 23 | 4 | 67 | 9 | 1.0 | 1.1 | 1.2 | 3.3 | 7 | 7 | 7 | 0.2 | 0.2 |

[z]Application dates were May 26, July 14, September 10, and October 17, 1982.

[y]Statistical analysis of rate and time effects was on the balanced data set with untreated checks deleted. Effects are designated as nonsignificant (NS) or significant at the 5% (*) or 1%(**) levels. Notations in parenthesis indicate means significantly different from the untreated checks; determined by single degree of freedom mean comparisons. These notations are included only where mean comparisons indicate important treatment effects which were masked in the overall analysis.

***(Editoral Note:** This paper reports the results of research only, and does not imply registration of a pesticide under amended FIFRA. Before using any of the products mentioned in this research paper, be certain of their registration by appropriate state and/or federal authorities.)*

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