RESPONSE OF OKS 91-11 BERMUDAGRASS TO VARYING RATES OF TRINEXAPAC-ETHYL AND RESPONSE OF OKS 91-11 AND OKS 95-1 BERMUDAGRASS TO POSTEMEGENCE HERBICIDES

By

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Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1999

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 2001

RESPONSE OF OKS 91-11 BERMUDAGRASS TO

VARYING RATES OF TRINEXAPAC-ETHYL

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POSTEMEGENCE HERBICIDES

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ACKNOWLEDGMENTS

Appreciation is extended to my co-major advisers, Dr. Dennis L. Martin and Dr. Don S. Murray for the opportunity they gave me to pursue the Master of Science degree as well as for the advice, effort, and the encouragement they extended. I additionally appreciate all the many long hours Dr. Dennis L. Martin has spent reading and revising my thesis, abstracts, and presented papers. I also appreciate the other member of my graduate committee, Dr. Greg Bell, for his guidance, knowledge, teaching, and encouragement.

Thanks are extended to Dr. R. Brent Westerman, Dr. Mark L. Wood, Stacey R. Frazier, Cody J. Gray, Eric W. Palmer, Shea W. Murdock, Jerry W. Moore, Brad D. Pryor, Rodney L. Farris, and Deana S. Titus for their time and efforts to help me complete my research and dissertation. Additional thanks goes to Keith Reed and all the maintenance staff at the Oklahoma Turf Research Center for there support, work, and efforts to help complete my research.

I am deeply grateful for my wife, Kristi DeeAnn Scroggins, whose love, care, and support has allowed me to complete my graduate studies. I am thankful for the love and support of my parents (Tim and Pam Scroggins) and of my "in-laws" (Doug and Polly Mowdy).

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Thesis Format

This thesis was written in a format so that it could be submitted for publication in Weed Technolnology, a journal of the Weed Science Society of America.

Chapter I

Literature Review of Plant Growth Regulators

INTRODUCTION

Trinexapac-ethyl is a plant growth regulator (PGR) used to manage the growth of both cool and warm-season turfgrasses. Applications of PGRs, including trinexapac-ethyl, reduce mowing frequency, maintenance cost, and the amount of grass clippings (Johnson and Murphy, 1991). Other benefits, such as darker turf color, as well as increased density and quality are often observed after applying trinexapac-ethyl. Trinexapac-ethyl can be used in many situations. The most common use is on highly maintained areas of turfgrass, such as residential and commercial lawns, golf courses, sports fields, sod farms, and cemeteries. Trinexapac-ethyl is also used to reduce the need for edging turfgrass around buildings, curbs, driveways, sidewalks, fences, and trees. For any PGR to be effective, it must reduce shoot growth without causing injury to turfgrass plants.

CLASSIFICATION

The PGRs are applied to plants to reduce the amount of growth but they all don't effect the plant the same. There are two main types of growth regulators. Type I growth regulators include inhibitors, growth suppressors, and herbicide growth regulators. Inhibitors inhibit cell division in plants, and are applied prior to inflorescence initiation to suppress flowering. Some common inhibitor-type growth regulators include maleic hydrazide, chlorflurenol, and mefluidide. These growth regulators were introduced during the 1950's, 60's and 70's. Growth suppressors are chemicals that are applied to suppress or slow growth, while still allowing the plant to develop at slower rate (Watschke et al., 1992). An example of a growth suppressor is amidoclor, which was commercially introduced to the turf growth regulator market in 1985. In a study conducted by Kaufmann (1986b), he reported that amidochlor reduces the vertical growth rate of the crown meristems, and the root and intercalary leaf meristems were not effected. Kaufmann (1986b) referred to amidochlor as a grass growth suppressor because of its root-absorbed characteristics and mode of action work to first slow grass growth and then inhibit its growth. Amidoclor has been observed to inhibit seedhead development and suppress foliar growth of cool-season grasses by 50% for up to 6 weeks (McElroy et al., 1983; Sandbrink et al., 1983; Stehling et al., 1983). Type I growth regulators posses post-emergence herbicidal activity that has been shown to inhibit the growth and development of turfgrass at various rates (Watschke et al., 1992). Herbicide growth regulators are characterized as having a very narrow margin of safety and misapplications or over application can result in severe injury or death of the turfgrass stands (Kaufmann, 1986a). Common herbicides in this category include: glyphosate, chlorsulfuron, sulfometuron methyl, metsulfuron methyl, fluazifop-butyl, and sethoxydim (Watschke et al., 1992).

Type II PGRs inhibit gibberellic acid biosynthesis, thus reducing cell elongation and plant organ expansion. These PGRs act to suppress grass growth but do not inhibit it. Three of the most commonly used PGRs in turfgrass management (flurprimidol, paclobutrazol, and trinexapac-ethyl) are Type II chemicals (Lowe and Whitwell, 1999).

When comparing the two categories of PGRs, inhibitor-type (Type I) growth regulators provide quick initial suppression, yet at relatively short periods of time. Growth retardant (Type II) compounds, however, provide longer periods of growth suppression of turfgrass and dicots. However, Type II PGRs don't inhibit seedheads as effectively as Type I PGRs. Therefor, treatments using Type I growth inhibitors in combination with Type II growth retardants could provide the optimal vegetative suppression (Watschke et al., 1992).

PGR PROBLEMS

When incorporating a PGR into a maintenance program, one must look at the limitations that come with the use of a PGR. Turfgrass managers must note the possible problems that may arise from the use and/or incorrect use of growth regulators. Problems that may occur include phytotoxic injury, increased pest problems due to decreased growth and recuperative potential, and the stress to the plant during hot, dry periods.

Phytotoxicity on turfgrass is a major concern when the turf is highly maintained. When phytotoxicity is observed due to the application of PGR the effectiveness of the PGR is reduced and management goals are not met. In past experiments, Johnson (1990a, 1990b, and 1990c) reported that bahiagrass (*Paspalum notatum* Fluegge), unstated common bermudagrass (*Cynodon dactylon* (L.) Pers.), 'Tifway' hybrid bermudagrass [*C. dactylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy), and centipedegrass [*Eremochloa ophiuroides* (Munro) Hack.] had slight phytotoxic injury to treatments of PGRs, yet no turf quality reduction was shown. In more recent years, Bush et al. (1998) reported that trinexapac-ethyl applications to nonmowed carpetgrass (*Axonopus affinis* Chase) resulted in no phytotoxicity at rates of 0.16 and 0.32 kg ai/ha, while yellowing of turf leaves was reported at the 0.48 kg ai/ha rate. In this experiment, when comparing the nonmowed and mowed plots of carpetgrass treated with trinexapac-ethyl, the mowed and PGR treated turf exhibited a higher quality than the best nonmowed PGR treated turf. In an experiment by Johnson (1989), he reported severe PGR injury to tall fescue (*Festuca aruninacea* Schreb.) when sulfometuron was applied alone or tank mixed with either paclobutrazol or flurprimidol. In the same experiment, turf injury increased over time from applications of both sulfometuron and imazethapyr. Results from this study also indicated that when imazethapyr was applied at rates of 0.15 and 0.25 kg ai/ha turf injury ranged from 58 to 73%. When lower rates of imazethapyr (0.01 and 0.09 kg ai/ha), were applied, only slight phytotoxic injury was observed. In an experiment that evaluated the growth regulation provided by experimental PGR V-10029 and trinexapac-ethyl on five cool-season turfgrass species, V-10029 caused significant discoloration (>20%) in all turfgrass species at three different rates (Fagerness and Penner, 1998). Fagerness and Penner reported that turfgrass yellowing appeared within a week of application of V-10029 and persisted until 2 to 3 week after treatment. Applications of trinexapac-ethyl did not cause discoloration of any of the five cool-season grasses, annual bluegrass (*Poa annua* L.), creeping red fescue (*F. rubra* L.), Kentucky bluegrass (*P. pratensis* L.), perennial ryegrass (*Lolium perenne* L.), and creeping bentgrass (*Agrostis palustris* Huds.), used in their experiment.

PGRS IN SHADE

Enhanced vertical shoot growth is a shade avoidance mechanism for plants, but it is undesirable in turfgrass because of the increased mowing requirements (Qian et al., 1998). Research has been conducted regarding the effect of trinexapac-ethyl on 'Diamond' zoysiagrass [*Zoysia matrella* (L.) Merr.] in a shaded environment (Qian and Engelke, 1999 and Qian et al., 1998). Qian and Engelke (1999) reported improvement in turf quality, higher tillering numbers, and considerably increased root viability for all trinexapac-ethyl treatments when compared to a control. According to Qian et al. (1998), trinexapac-ethyl reduced the canopy height of zoysia grown at different levels of shade prior to mowing. Turf grown under 88% and 75% shade declined in quality with or without trinexapac-ethyl treatment, but the decline in quality of the trinexapac-ethyl treated turf occurred at a much slower rate.

MOWING FREQUENCY

PGRs reduce mowing frequency when they are applied at the correct rate and to the proper species of turf. Experiments have been conducted regarding the effect PGRs have on reducing mowing frequency (Johnson, 1989a and 1994). Johnson (1994) found that three applications of trinexapac-ethyl at 4-wk intervals plus three to five timely mowings effectively suppressed vegetative growth and seedhead emergence of Tifway bermudagrass during a 12-wk period. According to Goatley et al. (1998), when bahiagrass was mowed 3 or 7 days before treatment, the imidazolinone compound AC 263,222 consistently provided plant growth regulation through 6 WAT in all trials. Johnson (1989a) concluded from his experiment that when mefluidide was applied to tall fescue, the grass needed no mowing during the first 6 weeks; however, without mowing, shoot height reached 16.5 cm by 7 weeks. When the grass was mowed at 3 and 6 weeks at a height of 7 cm, the turf maintained an acceptable height of 12.3 cm for 7 weeks.

VEGETATIVE SUPPRESSION

Vegetative suppression is usually the primary goal for applying a PGR. Numerous experiments have been initiated to determine the effects that PGRs have on the suppression of turfgrasses (Fagerness and Penner, 1998; Fagerness and Yelverton, 1998; Johnson, 1994; Johnson, 1990b; Johnson, 1990c; Lowe and Whitwell, 1999; Pippin and Yelverton, 1997; Yelverton and Isgrigg, 1997). Johnson (1990c) reported vegetative suppression of bahiagrass for 3 and 4 WAT when imazethapyr was applied kg ai/ha.

Suppression increased to 6 WAT when treated twice with 0.08 kg ai/ha of imazethapyr. In an experiment by Pippin and Yelverton (1997), foliar growth of Tifway and common bermudagrass was suppressed by applications of trinexapac-ethyl. When trinexapac-ethyl was applied in a single application to Tifway at 0.10 and 0.07 kg ai/ha, foliar growth was reduced for up to 6 and 5 WAT, respectively. Common bermudagrass was suppressed for up to 3 WAT when trinexapac-ethyl was applied at 0.10 and 0.07 kg ai/ha. Kentucky bluegrass, tall fescue, and perennial ryegrass were suppressed by a maximum of 60% with a mean growth suppression in these species through 4 WAT of 38%, when trinexapac-ethyl was applied at a rate of 0.38 kg ai/ha (Fagerness and Penner, 1998).

CONCLUSION

PGRs can be an effective, useful tool in a turfgrass management program. Turfgrass species and cultivar will influence the type of PGR and the rate of product used. When the correct PGR is selected and used on an adapted turfgrass, the outcome can be cost effective and time saving. PGRs have become and will continue to be useful in the green industry.

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Chapter II

Response of OKS 91-11 Bermudagrass (*Cynodon dactylon*) to Varying Rates of Trinexapac-ethyl

Response of OKS 91-11 Bermudagrass (*Cynodon dactylon* L.) to Varying Rates of Trinexapac-ethyl

Abstract: Field experiments conducted in 1999 and 2000 at the Oklahoma State University Turf Research Center, Stillwater, OK evaluated the response of OKS 91-11, a recently developed seeded bermudagrass cultivar, to trinexapac ethyl (Primo Liquid®). This research was a combination of two separate studies that included two different management practices on the OKS 91-11 bermudagrass cultivar. The first study was conducted on a simulated golf course fairway using a 1.3 cm mowing height and the second study was on a simulated lawn using a 3.8 cm mowing height. Treatments used in the simulated fairway study were: untreated check, 0.05 kg ai/ha, 0.10 kg ai/ha, 0.15 kg ai/ha, and 0.20 kg ai/ha with 0.10 kg ai/ha being the labeled rate. Treatments used in the simulated lawn study were: untreated check, 0.1 kg ai/ha, 0.2 kg ai/ha, 0.3 kg ai/ha, 0.4 kg ai/ha, and 0.5 kg ai/ha with 0.3 kg ai/ha being the labeled rate of trinexapac-ethyl. Plots were visually rated for turf color, quality, and PGR phytotoxicity on a weekly basis for 8 wk after treatment (WAT). Shoot density was taken every 2 wk. Clippings were collected weekly for 8 WAT and measured for fresh and dry mass as well as a fresh mass volume. Turf visual quality initially decreased at the labeled rate and higher rates in both years of each study (5 to 20%). Treatments showed little difference in quality after 3 WAT. Turf in each study showed phytotoxic effects ranging from 1 to 20 % due to the application of trinexapac-ethyl. Phytotoxicity was observed more often on the lawn-simulated study than on the fairway-simulated study, and the higher the rate applied, the greater the phytotoxicity. Clipping weight reductions were highly significant during both years and in both studies, when the labeled rate and higher rates of trinexapac-ethyl were

applied. Clippings reduction ranged from 14 to 85% during a 6 wk span on the simulated fairway experiment while the simulated lawn experiment had reductions ranging from 37 to 85% during a 7 wk span. Due to the higher application rates in the simulated lawn study, clipping yields were reduced for a longer time than in the simulated fairway study (7 WAT and 5 WAT, respectively).

Nomenclature: Trinexapac-ethyl, 4-(cyclopropyl-a-hydroxymethylene)-3,5-dioxo-cyclohexanecarboxylic acid ethylester; OKS 91-11 bermudagrass, *Cynodon dactylon* (L.) Pers.

Additional index words: Plant growth regulator, turfgrass color, turfgrass quality, phytotoxicity injury, shoot counts, clipping yield reduction, clipping weights, clipping volume reduction, Primo Liquid®.

INTRODUCTION

Mowing is a time consuming and expensive task, conducted on parks, golf courses, commercial grounds, roadsides, and home lawns. At times, mowing can be dangerous, particularly on steep slopes. Plant growth regulators (PGRs) are frequently used to reduce mowing cost and mowing frequency in problem areas. For a PGR to be effective, it must not only reduce the growth rate of the turfgrass, but it must do so without minimal turf injury. Reduction in turfgrass visual quality and density, as a result of phytotoxic injury response, is undesirable in any high visual impact turf or home lawn. Increasing amounts of landscape debris, such as turf clippings, in the waste management stream have become a public concern. With grass clippings comprising 40 to 50% of the solid waste stream going into landfills during certain seasons of the year, PGRs offer a way to reduce the amount of yard waste entering these areas. Additionally golf course superintendents have an interest in PGR use to improve the quality of grasses growing on fairways, tees, and greens.

Plant growth regulators have become an important component of many turf management programs. They reduce mowing frequency and maintenance cost (Johnson and Murphy, 1991). Experiments have been conducted to analyze the effects of PGRs on turf species (Bush et al., 1998; Fagerness and Penner, 1998; Lowe and Withwell, 1999; Johnson, 1989, 1990a, 1990b, 1990c, 1992a, and 1992b; Johnson and Murphy, 1991;). Applications of trinexapac-ethyl at 0.20 kg ai/ha, followed by 0.10 kg ai/ha at 4 and 8 wk provided consistent vegetative growth suppression during both years of an experiment by Johnson (1994). In an experiment by Pippen and Yelverton (1997), they reported reduced foliar growth on common bermudagrass for up to 3 WAT when a single application of trinexapac-ethyl at a rate of 0.07 or 0.10 kg ai/ha was applied. Turf quality was reduced for 1 wk when trinexapac-ethyl was applied at 0.07 kg ai/ha followed by enhanced quality at week five for both rates. Past research has reported on turfgrass injury due to applications of PGRs (Johnson, 1989, 1990b, and 1994; Johnson and Murphy, 1991). Turf injury must be kept to a minimum when a PGR is applied. If growth suppression is achieved but at the cost of injury to the turf, then the turf manager has failed because of the unacceptable injury. OKS 91-11 bermudagrass was recently developed at Oklahoma State University (OSU) and are believed to have acceptable cold tolerance and resistant to spring dead spot disease. A study was initiated to determine the color, quality, phytotoxicity, clipping weight reduction, and clipping volume response of OKS 91-11 bermudagrass, managed at two different heights of cut, to varying rates of trinexapac-ethyl.

MATERIALS AND METHODS

Experimental Parameters. A total of four field experiments were conducted at the OSU Turf Research Center, Stillwater, OK, in 1999 and 2000. Two separate experiments were initiated in 1999 with one being managed as a simulated fairway with a 1.7 cm height-of-cut and the other managed as a simulated lawn at a height-of-cut of 3.8 cm. Both experiments were conducted on a 4-yr-old established stand of OKS 91-11 bermudagrass. The two experiments were located side by side in a sandy loam soil with a pH of 6.7 and an organic matter content of 2.1%. The experiments were arranged in a randomized complete block design with three replications. Plot size was 1.4 x 3.0 m. Urea (46-0-0) was applied at a rate of 49 kg N/ha to both experiments, every 4 to 5 wk during the growing season and prior to applications of treatments, as a maintenance fertilizer.

Nutralene (40-0-0) was applied at 98 kg N/ha at the time of treatment application to allow for an extended nitrogen release period during data collection. Irrigation was applied as needed to both experiments to prevent turf wilt. All treatments were applied using an air-pressurized bicycle sprayer calibrated to deliver 187 L/ha using 11003VS flat fan nozzles. Treatments were applied to each experiment on July 12, 1999 and on July 7, 2000.

Data Collection. Color, quality, and phytotoxicity ratings were taken weekly starting at 1 WAT and continuing for 8 WAT. These ratings were made visually on a 0 to 10 scale with 0 being the lowest color and quality or no injury and with 10 representing the highest color and quality or dead turf due to injury. Shoot counts were taken every 2 wk starting at 1 WAT and continuing through 7 WAT. Counts were taken using one random sample from each plot with shoots being counted in a 2.2 dm area. Clippings were collected on a weekly basis starting at 1 WAT and continuing for 8 WAT. Clippings were taken from the center of each plot in a 1.54 m^2 area. Clippings were collected using a John Deere walk behind, reel mower with catcher. Wet mass was determined within an hour of clipping collection; samples were then placed in dryers for 7 d at an average temperature of 49 C and reweighed for dry mass. Clipping volumes were determined weekly for each plot immediately following the wet mass determination by placing the fresh clippings in a pre measured beaker, sample was shaken to level, and a disk was placed on top of the sample that exerted a 10.7 kg/m^2 force.

Simulated Fairway Experiment. Five treatments were applied to the fairway-simulated experiment, which included an untreated check, 0.05, 0.10, 0.15, and 0.20 kg ai/ha of trinexapac-ethyl (Primo Liquid formulation). The fairway experiment was maintained by mowing twice a week throughout the growing season. One mowing each week was used for clipping collection to determine mass and volume.

Simulated Lawn Experiment. Six treatments were applied to the lawn-simulated experiment, which included an untreated check, 0.10, 0.20, 0.30, 0.40, and 0.50 kg ai/ha of trinexapac-ethyl. The experiment was maintained with a single mowing per week during which clippings were collected for mass and volume analysis.

Data Analysis. Dependent variables of visual color, quality, phytotoxicity, dry and wet clipping yield, and fresh clipping volume were analyzed using an analysis of variance (ANOVA) statistical model to test the effect of block, PGR treatment rate, and rating date. Single degree of freedom contrasts were made on data collected from turf receiving no treatment and the labeled rate for each experiment. Linear, quadratic, and cubic rate responses were also investigated. Response surfaces were developed using predicted means generated from a second order quadratic equation ($y = \text{intercept} \pm \text{date} \pm \text{date}^2 \pm \text{rate} \pm \text{rate}^2 \pm \text{date*rate} \pm \text{date}^2\text{*rate}^2 \pm \text{date*rate}^2 \pm \text{date}^2\text{*rate}$), to help visualize turf response to the independent variables.

RESULTS AND DISCUSSION

Simulated Fairway Experiment. Analysis of quality ratings revealed no significant differences due to rep or treatment rate and no linear, quadratic, or cubic effects of treatment rate were present in either 1999 or 2000 (Table 1). The analysis of quality ratings indicated significant rating date and rate by date interactions in both years. Color ratings responded in a similar manner to the quality ratings (data not shown). Phytotoxicity ratings varied significantly among the treatment rates in 1999 but not in 2000. A significant linear effect ($P=0.001$) was present between phytotoxicity ratings and PGR rate in 1999. Like the quality ratings, phytotoxicity varied significantly by date and significant rate by date interaction was indicated in both years. Analysis of dry clipping data indicated significant differences among rep and treatment rates for 1999 and only by rate in 2000. Dry clipping data fit a linear model in 1999 and 2000 ($P=0.01$ and $P=0.001$, respectively). Again significant differences in dry clipping yield were observed by date and the rate by date interaction was significant in both years ($P=0.001$, except 1999 dry clipping rate*date interaction $P=0.05$). Fresh clipping yield data and fresh clipping volume responded similarly to dry clippings with fresh clipping showing the same effects but to a greater degree due to the dampness of the leaves (data not shown). Clipping volume reacted according to the fluctuations seen in clipping weight (data not shown). Shoot counts were pooled over years and showed no significant differences based on rep, rate, date, or rate by date interaction (data not shown). Because of the significant differences in rate by date interaction in both years for quality, phytotoxicity, and dry clippings, response surfaces were generated to help the reader visualize theses differences among the rates over dates (Figures 1-6).

Quality ratings of turf treated with trinexapac-ethyl in 1999 decreased at 1 WAT compared to the untreated plots (Figure 1). At 1 WAT the same initial decrease in quality occurred in 2000 following treatment plus an addition decrease at 2 WAT for the labeled and higher use rates (Figure 2). Phytotoxicity was observed in both years of the experiment following treatment. In both years, the same trend of injury was observed (Figures 3 and 4). Phytotoxicity occurred initially at 1 WAT for all treated plots. Injury lasted for 2 and 3 WAT in both years at the labeled and higher rates. Phytotoxicity decreased in all plots after 3 WAT. Applications of trinexapac-ethyl decreased dry clipping yield in both years of the experiment (Figures 5 and 6). In 1999 clippings were significantly reduced at 1 WAT through 6 WAT with reductions corresponding to increasing treatment rate (Figure 5). Clippings were reduced from 14 to 85% during this period. In 2000, a significant reduction was observed at 1 WAT for all treated plots and reduction continued for 5 to 6 WAT. Increased rates resulted in decreased clippings (Figure 6). Dry clipping yield was reduced from 18 to 60% in 2000.

Turf in the simulated fairway experiment showed some quality reduction and phytotoxicity following treatment, but the effect was mainly observed at the higher use rates. Clipping yield and volume reduction was observed at all use rates of trinexapac-ethyl, with more reduction occurring at the higher application rates.

Simulated Lawn Experiment. Turf quality, phytotoxicity, and dry clipping yield varied significantly among use rates in both years (Table 2). A significant linear relationship existed between use rate and all three dependent variables ($P=0.001$, except 2000 dry clippings $P=0.01$) in both years. Analysis of quality, phytotoxicity, and dry clipping yield data revealed significant date and rate x date interaction in both years. Because of this rate x date interaction, response surfaces were generated to examine how the dependent variables responded to treatment rates over time (Figures 7-12). Color rating response was similar to quality rating response in both years. Fresh clipping yield and volumes responded similar to and according to the reported dry clipping response (data not shown). As no significant year effect or year interactions were present, shoot counts were again pooled over years. No significant effect was observed due to rep, rate, date, or rate by date interaction (data not shown).

In 1999, quality ratings initially decreased due to trinexapac-ethyl applications at 1 WAT. However, at 2 WAT quality decreased in all treated plots (Figure 7). This reduction in quality was observed for up to 6 to 7 WAT depending on the treatment rate. Quality ratings in 2000 showed a slightly different response. Quality was initially reduced at 1 WAT on all treated plots, but at 2 and 3 WAT the reduction was only observed at the labeled and higher rates (Figure 8). After 4 WAT quality ratings were similar among all treatments.

Phytotoxicity response correlated closely with quality reduction in each year. Injury in 1999 was observed initially at the higher rates (Figure 9). At 2 WAT all treated plots responded with some injury. At labeled and higher rates, phytotoxicity was present for up to 7 WAT in 1999. In 2000, increases in injury closely corresponded with the quality reduction that was observed, with an increase in injury at 1 WAT for the label and higher rates (Figure 10). The higher treatment rates resulted in injury for up to 5 to 6 WAT.

A reduction in dry clipping yield was observed due to applications of trinexapac-ethyl. Clipping yields were significantly lower at 2 WAT in 1999 with reductions of 37 to 85% depending on the treatment rate (Figure 11). A significant reduction in yield was present for up to 8 WAT for all treated plots, with yield reduction ranging from 55 to 100%. In 2000, clippings were reduced initially at 1 WAT and the effect was present for up to 6 to 7 WAT depending on treatment rate (Figure 12). Clippings were reduced from 9-59% in 2000. Higher use rates resulted in clipping reduction for up to 7 to 8 WAT in both years.

When looking at the responses of the simulated fairway and lawn experiments, quality was reduced in both experiments, but more reduction was observed in the simulated lawn than the simulated fairway experiment. Phytotoxicity responded in a same manner as quality, with higher injury observed on the simulated lawn experiment than the simulated fairway experiment. The different responses in reduction of turf quality and increased turf injury on OKS 91-11 is likely due to the different use rates that were used on these simulated areas. A reduction in clipping yield was found in both experiments. Again the simulated lawn experiment showed a longer period of reduction than the simulated fairway experiment. This effect was likely caused by the different use rates in each of these studies. When comparing the labeled rate to the lower rates used in each experiment, only a slight yield reduction was seen at lower rates for the simulated fairway experiment, while greater reduction was seen for a longer period of time in the simulated lawn experiment. When comparing the labeled rate to the higher rates in each experiment, greater clipping reduction was found at the higher rates.

When higher use rates of trinexapac-ethyl are used to achieve greater clipping reduction, more injury is expected to be observed and turf quality can also be expected to suffer. Results of this research suggest that close attention must be paid when selecting a use rate for trinexapac-ethyl. Additionally, it is very likely that the user must closely consider the individual cultivar within species as well as the turf cutting height when deciding upon a use rate. A higher use rate may not always benefit the turf manager, especially when turf color and quality must be sacrificed to achieve clipping reduction.

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Table 1. Analysis of variance on quality, phytotoxicity, and dry clipping yield data collected from the simulated fairway experiment on OKS 91-11 during 1999 and 2000.

		Mean Squares					
		1999			2000		
Source	df	Quality	Phyto [a]	Dry clippings	Quality	Phyto	Dry clippings
Rep	2	0.23	0.13	12,293.98**	0.13	0.01	7,321.25
Rate	4	0.93	1.16**	6,623.56*	0.20	0.14	27,134.90**
Linear	1	2.60	4.27***	21,727.92**	0.60	0.42	100,068.92***
Quadratic	1	0.67	0.30	3,242.86	0.05	0.00	7,294.80
Cubic	1	0.41	0.07	503.88	0.15	0.10	1,007.37
Error A	8	0.60	0.16	1,124.33	0.12	0.08	2,050.75
Date	7	9.73***[b]	4.82***	24,775.83***	1.57***	1.41***	107,533.07***
Rate * Date	28	0.43***	0.52***	1,025.18*	0.15*	0.13**	11,600.68***
Error B	70	0.14	0.10	525.40	0.08	0.07	1,587.93

[a] Phyto = phytotoxicity.

[b] Significant differences indicated with * = 0.05, ** = 0.01, and *** = 0.001 probability levels.

Table 2. Analysis of variance on quality, phytotoxicity, and dry clipping yield data collected from the simulated lawn experiment on OKS 91-11 during 1999 and 2000.

		Mean Squares						
		1999				2000		
Source	df	Quality	Phyto [a]	df [b]	Dry clippings	Quality	Phyto	Dry clippings
Rep	2	0.09	0.58	2	7,185.11*	0.15	0.15	490.71
Rate	5	3.93***[c]	3.87**	5	28,276.18***	1.83***	1.23***	79,478.61*
Linear	1	15.62***	16.40***	1	97,457.99***	8.57***	5.26***	359,345.46**
Quadratic	1	3.58**	0.64	1	31,541.96**	0.45	0.88**	19,472.28
Cubic	1	0.31	2.13	1	10,417.98*	0.09	0.01	12,502.04
Error A	10	0.26	0.48	10	1,708.38	0.15	0.08	20,847.20
Date	7	11.69***	6.90***	6	3,948.29***	4.63***	1.09***	212,372.08***
Rate * Date	35	0.38***	0.52***	30	487.22**	0.52***	0.28***	11,953.29***
Error B	84	0.13	0.14	72	201.14	0.12	0.06	4,822.78

[a] Phyto = phytotoxicity.

[b] Dry clipping weights were unable to be measured at 1 WAT in 1999, df are adjusted accordingly.

[c] Significant differences indicated with * = 0.05, ** = 0.01, and *** = 0.001 probability levels.

Figure 1. Response surface for quality ratings as a function of trinexapac-ethyl rate and rating date in the simulated fairway experiment conducted on OKS 91-11 during 1999. Treatments applied on July 12. Graph was generated using the equation: Quality = 6.61 + 0.66 Date (D) - 0.07 D^2 - 33.29 Rate (Rt) + 79.05 Rt^2 + 8.89 D*Rt + 0.00 D^2*Rt^2 - 11.43 D*Rt^2 - 0.58 D^2*Rt. $R^2 = 0.97$. ***.

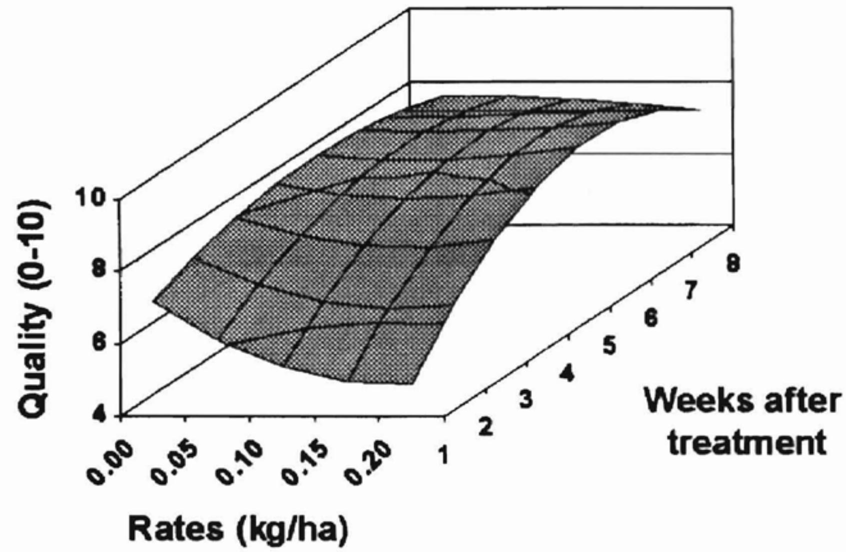


Figure 2. Response surface for quality ratings as a function of trinexapac-ethyl rate and rating date in the simulated fairway experiment conducted on OKS 91-11 during 2000. Treatments applied on July 7. Graph was generated using the equation: Quality = 9.74 + 0.11 Date (D) - 0.01 D^2 - 16.11 Rate (Rt) + 29.29 Rt^2 + 6.81 D*Rt + 1.19 D^2*Rt^2 - 12.38 D*Rt^2 - 0.65 D^2*Rt. $R^2 = 0.88$. ***.

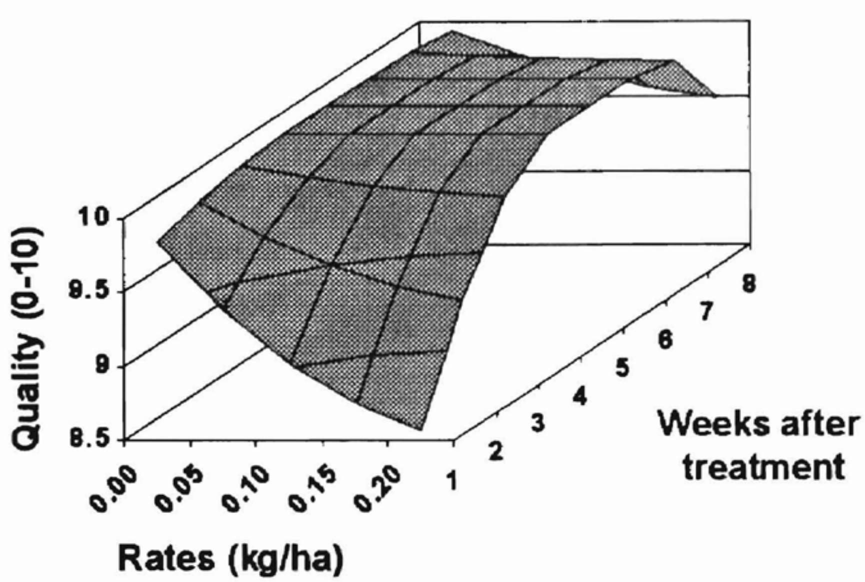


Figure 3. Response surface for phytotoxicity ratings as a function of trinexapac-ethyl rate and rating date in the simulated fairway experiment conducted on OKS 91-11 during 1999. Treatments applied on July 12. Graph was generated using the equation: Phytotoxicity (Phyto) = -0.16 + 0.06 Date (D) - 0.01 D^2 + 36.15 Rate (Rt) - 75.48 Rt^2 - 15.25 D*Rt - 3.57 D^2*Rt^2 + 35.24 D*Rt^2 + 1.46 D^2*Rt. $R^2 = 0.96$. ***.

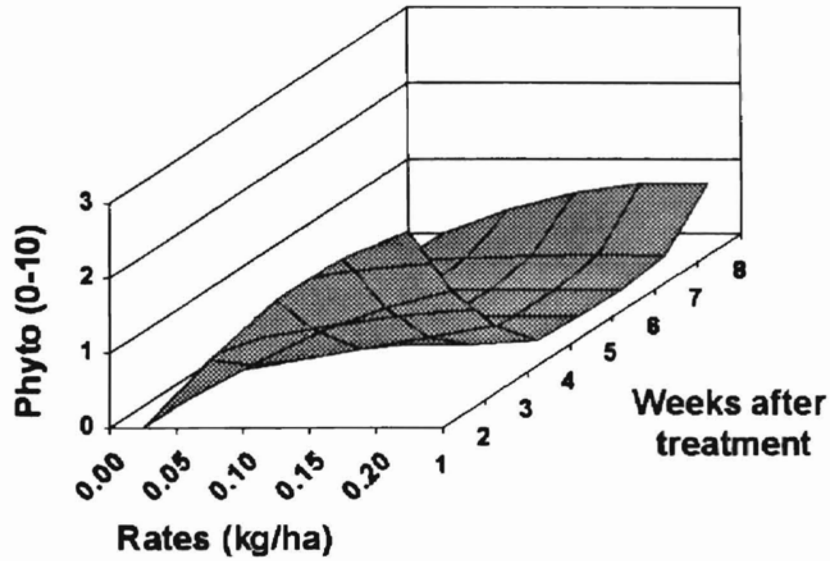


Figure 4. Response surface for phytotoxicity ratings as a function of trinexapac-ethyl rate and rating date in the simulated fairway experiment conducted on OKS 91-11 during 2000. Treatments applied on July 7. Graph was generated using the equation: Phytotoxicity (Phyto) = 0.31 - 0.13 Date (D) + 0.01 D^2 + 10.25 Rate (Rt) + 0.00 Rt^2 - 4.33 D*Rt +0.00 D^2*Rt^2 - 0.00 D*Rt^2 + 0.42 D^2*Rt. $R^2 = 0.86$. ***.

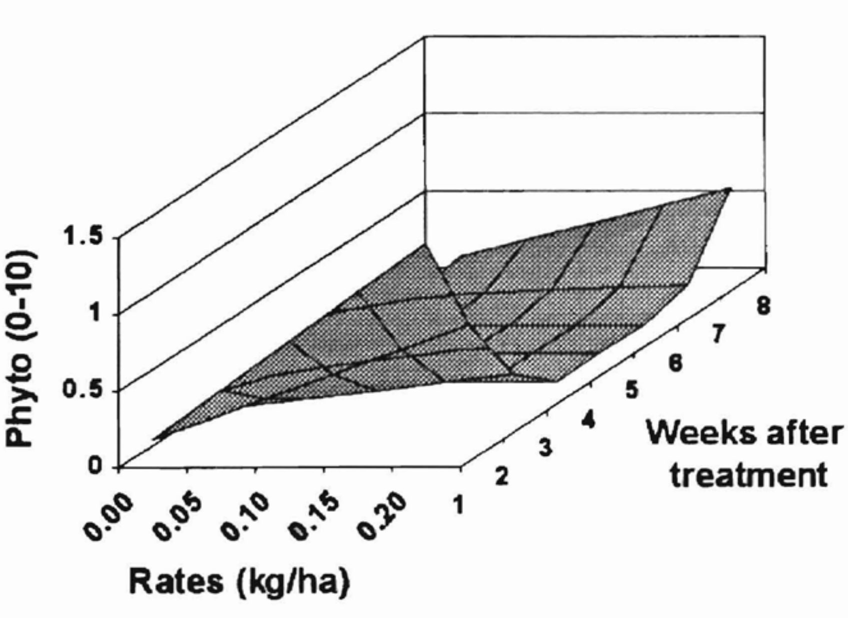


Figure 5. Response surface for dry clipping yield as a function of trinexapac-ethyl rate and sampling date in the simulated fairway experiment conducted on OKS 91-11 during 1999. Treatments applied on July 12. Graph was generated using the equation: Yield = -41.37 + 61.57 Date (D) - 6.80 D^2 - 106.95 Rate (Rt) + 763.96 Rt^2 - 77.14 D*Rt + 29.86 D^2*Rt^2 - 205.79 D*Rt^2 + 9.47 D^2*Rt. $R^2 = 0.83$. **.

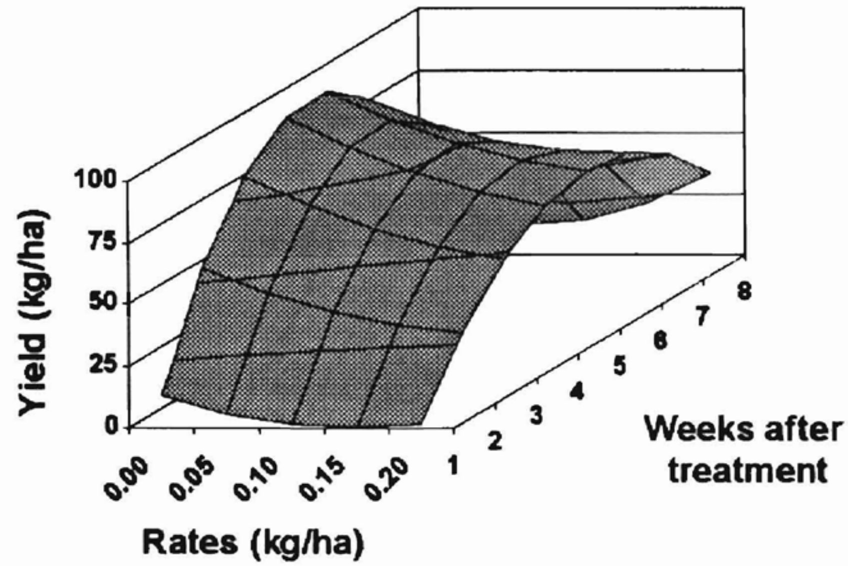


Figure 6. Response surface for dry clipping yield as a function of trinexapac-ethyl rate and sampling date in the simulated fairway experiment conducted on OKS 91-11 during 2000. Treatments applied on July 7. Graph was generated using the equation: Yield = 154.70 + 63.73 Date (D) - 9.70 D^2 - 2030.43 Rate (Rt) + 7049.03 Rt^2 + 286.42 D*Rt + 43.41 D^2*Rt^2 - 1515.75 D*Rt^2 - 9.98 D^2*Rt. $R^2 = 0.91$. ***.

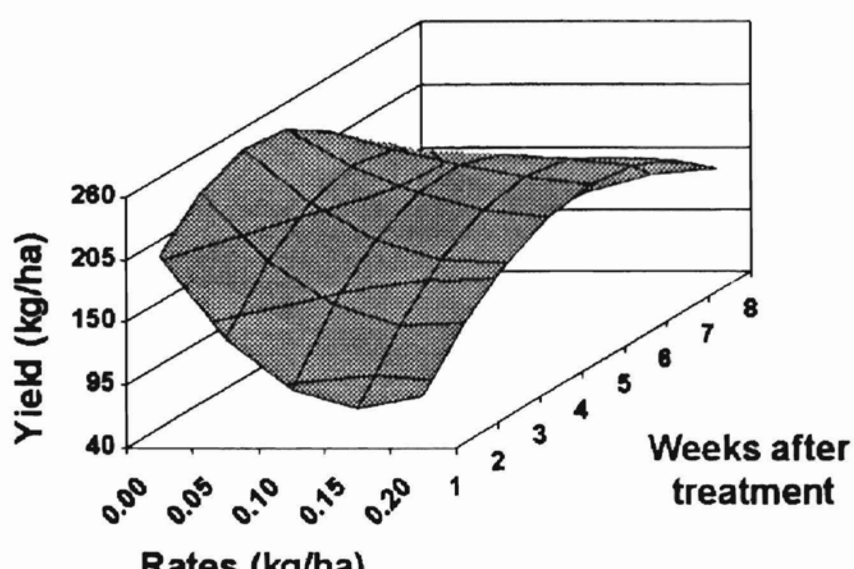


Figure 7. Response surface for quality ratings as a function of trinexapac-ethyl rate and rating date in the simulated lawn experiment conducted on OKS 91-11 during 1999. Treatments applied on July 12. Graph was generated using the equation: Quality = 4.05 + 1.85 Date (D) - 0.18 D^2 + 4.09 Rate (Rt) - 4.69 Rt^2 - 5.68 D*Rt - 0.67 D^2*Rt^2 + 5.36 D*Rt^2 + 0.73 D^2*Rt. R^2 = 0.96. ***.

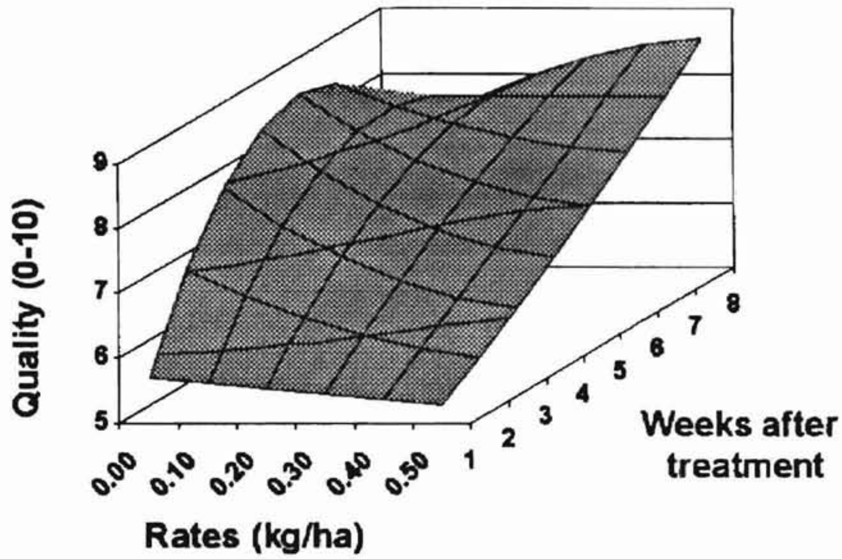


Figure 8. Response surface for quality ratings as a function of trinexapac-ethyl rate and rating date in the simulated lawn experiment conducted on OKS 91-11 during 2000. Treatments applied on July 7. Graph was generated using the equation: Quality = 10.52 - 0.57 Date (D) + 0.07 D^2 - 11.44 Rate (Rt) + 11.23 Rt^2 + 5.49 D*Rt + 0.86 D^2*Rt^2 - 7.71 D*Rt^2 - 0.53 D^2*Rt. R^2 = 0.86. ***.

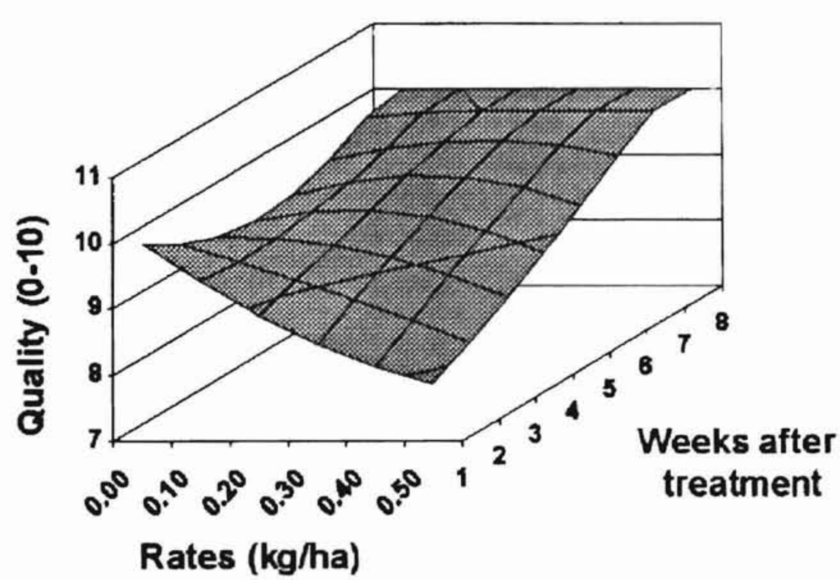


Figure 9. Response surface for phytotoxicity ratings as a function of trinexapac-ethyl rate and rating date in the simulated lawn experiment conducted on OKS 91-11 during 1999. Treatments applied on July 12. Graph was generated using the equation: Phytotoxicity (Phyto) = 1.09 - 0.38 Date (D) + 0.03 D^2 - 10.07 Rate (Rt) + 20.31 Rt^2 + 6.55 D*Rt + 0.82 D^2*Rt^2 - 8.63 D*Rt^2 - 0.73 D^2*Rt. R^2 = 0.95. ***.

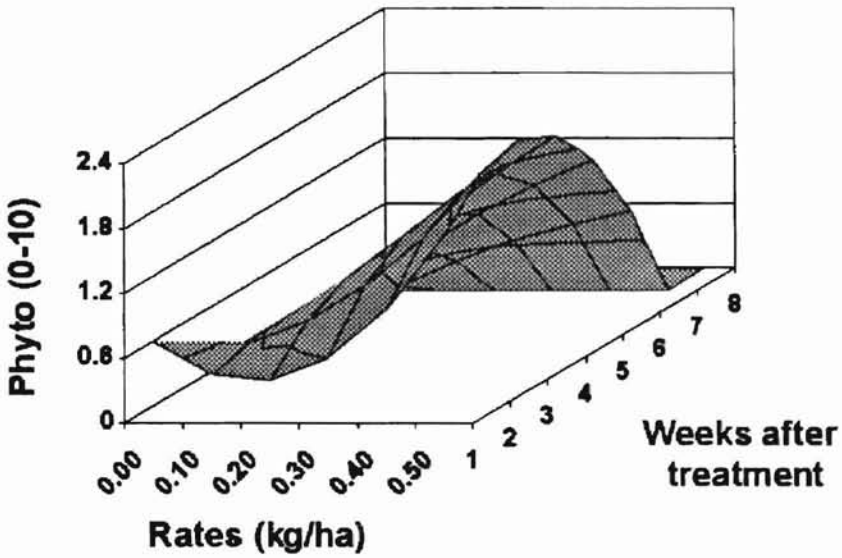


Figure 10. Response surface for phytotoxicity ratings as a function of trinexapac-ethyl rate and rating date in the simulated lawn experiment conducted on OKS 91-11 during 2000. Treatments applied on July 7. Graph was generated using the equation: Phytotoxicity (Phyto) = - 0.01 + 0.03 Date (D) - 0.01 D^2 - 0.12 Rate (Rt) + 5.77 Rt^2 - 0.66 D*Rt - 0.11 D^2*Rt^2 - 0.15 D*Rt^2 + 0.10 D^2*Rt. R^2 = 0.76. **.

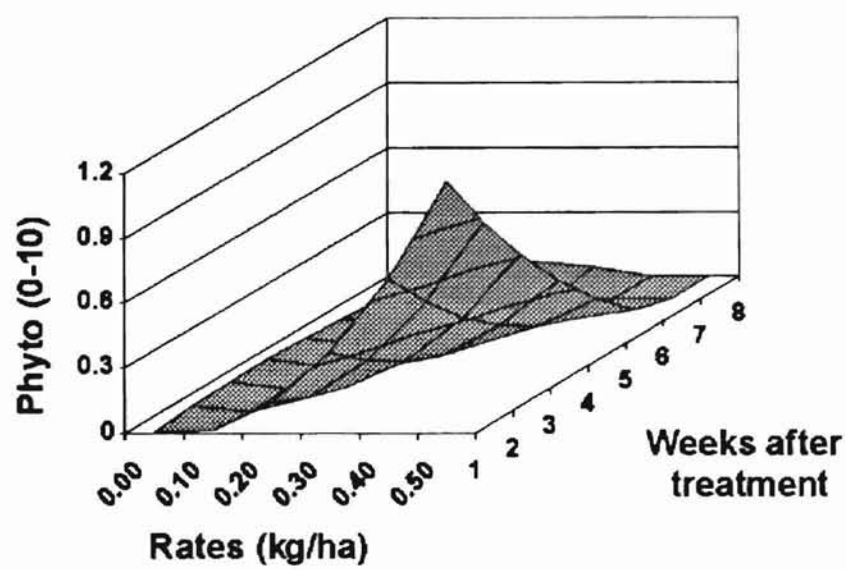


Figure 11. Response surface for dry clipping yield as a function of trinexapac-ethyl rate and sampling date in the simulated lawn experiment conducted on OKS 91-11 during 1999. Treatments applied on July 12. Graph was generated using the equation: Yield = - 167.70 + 113.55 Date (D) - 10.63 D^2 + 1321.16 Rate (Rt) - 2042.83 Rt^2 - 881.17 D*Rt - 146.06 D^2*Rt^2 + 1358.76 D*Rt^2 + 92.31 D^2*Rt. $R^2 = 0.92$. ***.

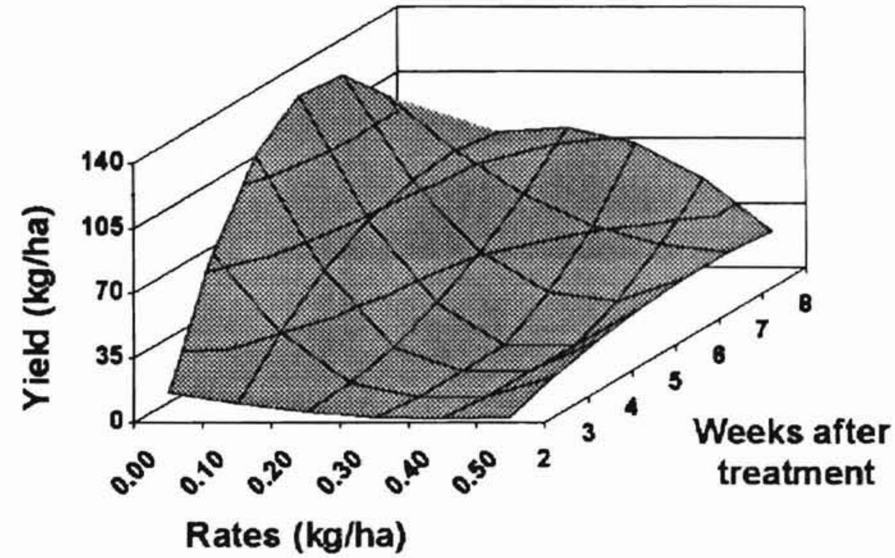
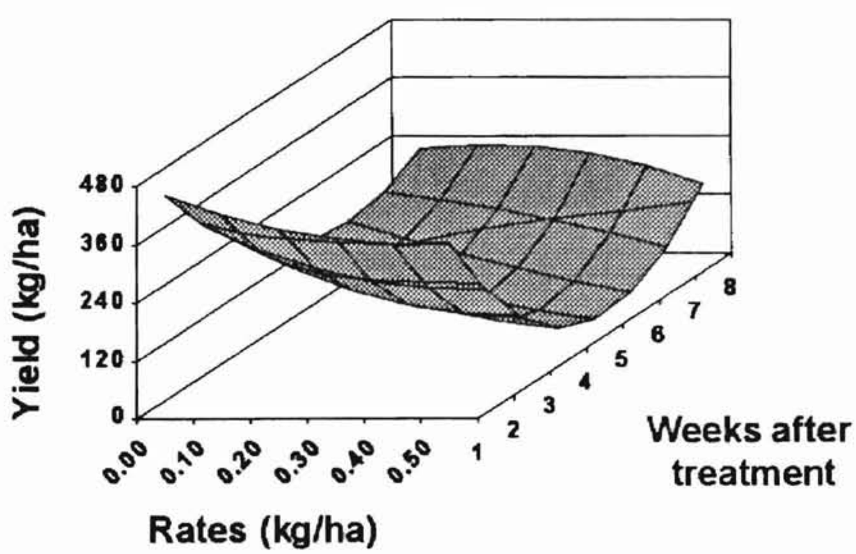


Figure 12. Response surface for dry clipping yield as a function of trinexapac-ethyl rate and sampling date in the simulated lawn experiment conducted on OKS 91-11 during 2000. Treatments applied on July 7. Graph was generated using the equation: Yield = 596.54 - 146.72 Date (D) + 12.37 D^2 - 287.93 Rate (Rt) + 387.23 Rt^2 - 207.60 D*Rt - 38.35 D^2*Rt^2 + 187.88 D*Rt^2 + 32.64 D^2*Rt. $R^2 = 0.89$. ***.



Chapter III

Literature Review of Postemergence Herbicides

INTRODUCTION

Turfgrass managers constantly wage the war against weeds. Most managers control weeds by use of a pre (PRE) or postemergent (POST) herbicide. Due to the push of integrated pest management (IPM), herbicide use and availability has become a serious issue. IPM programs have forced many turf managers to come up with new ideas and ways of combating the pest problems that arise. IPM doesn't mean pest management without chemicals, instead it's a program that involves good, sound cultural practices and management to try to prevent pests. If these practices fail, the next step involves pest suppression followed by the next option of chemical control. IPM is intended to help prevent problems that misused chemicals cause to our environment. As turf managers, we must be conscious of the environment at all times.

Since herbicides are still an integral part of IPM, they must be used in the correct manner and according to the Federal label. When herbicides are not applied correctly, or to the wrong turf species or cultivar, and/or at the wrong time of year, serious turf injury can occur. Turf injury can also be observed when herbicides are applied according to the Federal label. The turfgrass may be sensitive to the chemical only for a short period of time and the short-term injury may be acceptable. Since turfgrass species and cultivars perform differently, research becomes very important in determining what chemicals turfgrasses can withstand or tolerate and which chemicals result in unacceptable injury.

HERBICIDE USE

Weeds are aggressive competitors for moisture, sunlight, and nutrients, making them the number one pest problem in lawns, golf courses, and sport fields. Because weeds are a problem pest, they present many experienced turf managers with the challenge of control. Cultural controls, such as mowing and fertilization programs, should be the first measures for controlling these problem pests. When these control measures do not result in sufficient amounts of suppression, chemical means of control may be used. There are two main groups of herbicides used on turfgrass, "PREs" and "POSTs". PREs are normally applied prior to germination of the weed. POSTs are applied to germinated weeds such as perennial and annual grasses, broadleaves, and sedges. Most weed management programs rely on both types of herbicides to achieve a satisfactory control level.

Most POST herbicides are applied to growing turf, thus making turf more susceptible to injury. Since growing turf is more susceptible to injury, caution must be used when selecting the appropriate herbicide to use. If this precaution is not taken, severe and unacceptable turf injury may occur.

WARM-SEASON TURF INJURY

Herbicides can cause injury to turf in many different ways and situations. Herbicides can cause phytotoxic symptoms of turf chlorosis resulting in turf turning yellow, red, purple, dull grey-green, etc. Herbicides can also cause reductions in turf quality, reduced turfgrass establishment, reduced vigor or recuperative potential, and can effect turfgrass root growth.

Past research has shown that some POST applied herbicides cause undesirable and unacceptable injury to warm-season turfgrass (Baird, 1997; Johnson, 1997a; McCarty, 1991; McCarty and Colvin, 1992; Porter, 1996). Baird et al. (1997) reported injury on African bermudagrass (*Cynodon. transvaalensis* Burt-Davy) due to 1x (60%) and 2x (84%) rate of triclopyr at 7 DAT. Significant turf injury also occured from 2,4-D +

mecoprop (MCPP) + dicamba at both 1x (29%) and 2x (84%) rates at 7 DAT. In another experiment by Baird et al. (1997), when triclopyr and 2,4-D + MCPP + dicamba treatments were applied during warmer conditions, application resulted in greater turf injury of <88% for triclopyr and <66% for the 2,4-D + MCPP + dicamba treatments. When MSMA was applied in Griffin, GA in June to plots previously treated with dithiopyr, common bermudagrass [*C. dactylon* (L.) Pers.] injury ranged from 29 to 42% in 1995 and from 11 to 25% in 1996 (Johnson, 1997a). In an experiment by McCarty (1991), he demonstrated that high rates of diclofop-methyl (3.4 and 4.5 kg ai/ha) plus MSMA (2.2 kg ai/ha) injured 'Tifgreen' and 'Tifdwarf' bermudagrass [*C. dayctylon* (L.) Pers. X *C. transvaalensis*], 20 and 19%, respectively. According to McCarty and Colvin (1992), 'Oasis' (= 609) buffalograss [*Buchloe dactyloides* (Nutt). Engelm.] showed unacceptable turf quality at 10 DAT following applications of asulam, dicamba, sethoxydim, sulfometuron, triclopyr, 2,4-D, and 2,4-D + mcpp + dicamba. In that same experiment 'Prairie' buffalograss quality was unacceptable at 10 DAT for plots treated with 2,4-D, asulam, atrazine, dicamba, MSMA, sethoxydim, sulfometuron, and 2,4-D + MCPP + dicamba. They concluded that herbicides (MSMA, asulam, and sethoxydim) used for POST grass control caused initial moderate to severe damage to Prairie and Oasis buffalograss. Fry and Upham (1994) reported 31 to 43% plot injury when seedling buffalograss was treated with fenoxaprop-ethyl, triclopyr + 2,4-D, and 2,4-D + MCPP + dicamba. Porter (1996) reported significant injury to centipedegrass [*Eremochloa ophiuroides* (Munro) Hack.] treatments of acifluorfen, fomesafen, and lactofen at 2 WAT. All three herbicides were registered and experimental herbicides for POST weed control.

Many experiments have confirmed that turfgrass roots are effected by herbicides (Fishel and Coats, 1993 and 1994; Sharpe et al., 1989). Fishel and Coats (1993) reported that certain concentrations of dithopyr, oryzalin, pendimethalin, and prodiamine in the soil profile would reduce root weight. From these results, they concluded that herbicide movement into zones of root initiation may cause injury to turfgrasses with a rhizomatous growth habit, thus causing a potential inhibition of bermudagrass root elongation. Research by Sharpe et al. (1989) illustrated severe root reduction on plots treated with various rates of bensulide, imazapyr, napropamide, sethoxydim, and sulfometuron. Of the herbicides tested by Sharpe et al. (1989), only imazapyr caused enough injury to preclude its use on mature 'Tifway' bermudagrass sod as all other herbicides tested were tolerated by the bermudagrass.

COOL-SEASON TURF INJURY

Like warm-season turfgrass, cool-season turf is also susceptible to herbicide injury. Perennial ryegrass quality declined linearly with increasing halosulfuron-methyl (HM) rates (between 0.04 and 0.14 kg ai/ha) (Fry et al., 1995). Fry et al. also reported that bentazon (1.12 and 1.68 kg ai/ha) caused a slight reduction in the quality of creeping bentgrass (*Agrostis paulustris* Huds.) and Kentucky bluegrass (*Poa pratensis* L.). Bentazon treatments caused moderate to severe unacceptable injury, which persisted for 3 to 5 WAT. Higgins et al. (1987) reported that treatments of fenoxaprop, fluazifop, haloxyfop, popenate, sethoxydim, and xylafop all reduced bentgrass color to an unacceptable level through 28 DAT. They also reported that all herbicides reduced bentgrass density though 28 DAT. Many experiments have reported on the response of tall fescue (*Festuca arundinacea* Schreb) to herbicides (Johnson, 1987 and 1997b;

McCarty et al., 1989). Johnson (1987) reported severe tall fescue injury to single applications of sethoxydim, sulfometuron, and metsulfuron. In 1997, Johnson reported reduced tall fescue quality by 14% when pendimethalin was applied at 3.4 kg ai/ha. In that same study, oryzalin applied at 2.2 and 0.8 kg ai/ha reduced quality by 41 to 46% and 8 to 11%, respectively. Tall fescue treated with MSMA at 2.2 kg ai/ha, reduced turf quality from 13 to 21%. According to an experiment by McCarty et al. (1989), 'Clemfine' tall fescue was not tolerant to fluazifop, sethoxydim, haloxyfop, or xylafop, thus resulting in turf injury. In an experiment looking at the effects that quinclorac had on chewings fescue (*F. rubra* var. *commutata* Guad. 'Jamestown'), Neal and Senesac (1993) reported that fesuce quality was reduced from 10 to 30% when quinclorac was applied at 1.1 or 2.2 kg ai/ha.

INJURY PREVENTION

When turfgrass injury occurs due to the correct application of a herbicide, we ask ourselves what else can we do to prevent this injury? There are some reported practices of applying fertilizer with herbicides to help prevent or speed up recovery from injury. Another cultural practice that has been reported upon, is the influence of iron (Fe) applications to increase bermudagrass tolerance to some herbicides (Carrow and Johnson, 1992; Johnson et al., 1990). According to Johnson et al. (1990), they reported that Fe significantly decreased injury and improved turfgrass quality and color of Tifway bermudagrass when applied with herbicide treatment. In that same experiment, Fe was applied initially after the application of MSMA and resulted in less turf injury for 4 to 18 DAT. When Fe was applied after applications of MSMA + metribuzin and MSMA +

imazaquin, injury was reduced for up to 4 days and 4 to 10 days, respectively compared to the respective herbicides applied alone.

CONCLUSION

Weeds are a continuous problem for turf managers, homeowners, and even farmers. The control of weeds can be very costly. They become even more costly when control is ignored for a period of time. Herbicides play an important role in controlling these obnoxious weeds. Herbicides are only a small part of the total weed control process, but with out them weeds would eventually get the upper hand. Because herbicides are an important part of any weed control program, we must use them in a safe and proper way so as to forever preserve the privilege for herbicide use.

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Chapter IV

Response of OKS 91-11 and OKS 95-1 Bermudagrass (*Cynodon dactylon* L.) to Postemergence Herbicides.

Response of OKS 91-11 and OKS 95-1 Bermudagrass (*Cynodon dactylon* L.) to Postemergence Herbicides.

Abstract: Field experiments were conducted in 2000 to evaluate the response of OKS 91-11 and OKS 95-1, two recently developed seeded bermudagrass cultivars, to commonly used post-emergence herbicides. Bermudagrasses were maintained at a 1.3 cm height of cut. Treatments were applied at both 1x and 2x the Federal label rate. Treatments included: untreated check, 2,4-D + mecoprop (MCPP) + dicamba (1.86 and 3.72 kg ai/ha), triclopyr + clopyralid (0.84 and 1.68 kg ai/ha), imazaquin (0.56 and 1.12 kg ai/ha), MSMA (3.39 and 6.78 kg ai/ha), MSMA + metribuzin (3.39 + 0.18 and 6.78 + 0.36 kg ai/ha), metribuzin (0.56 and 1.12 kg ai/ha), pronamide (1.68 and 3.36 kg ai/ha), halosulfuron-methyl (0.05 and 0.10 kg ai/ha), bentazon (1.25 and 2.50 kg ai/ha), quinclorac (0.84 and 1.66 kg ai/ha), and diclofop-methyl (1.14 and 2.28 kg ai/ha). Plots were visually rated for quality and phytotoxicity for up to 8 wk after treatment (WAT). Clippings were collected weekly for up to 8 WAT and measured for dry mass. Quality reductions and turfgrass injury was observed due to the applications of 2,4-D + MCPP + dicamba, triclopyr + clopyralid, imazaquin, MSMA, metribuzin, and MSMA + metribuzin. Triclopyr + clopyralid treatments showed quality reduction for up to 28 DAT depending on the rate and cultivar. Turfgrass injury from applications of triclopyr + clopyralid ranged from 3 to 70% depending on the treatment. Because of this injury, dry clipping weight reduction was observed for up to 28 DAT. Imazquin treatments resulted in a decline in quality of OKS 91-11 and OKS 95-1 ranging from 7 to 21 DAT. Phytotoxicity was observed from imazaquin treatments and reduced clipping weights

resulted for up to 21 DAT. Treatments that included MSMA resulted in an initial decline in turf quality and phytotoxicity but recovery occured by 14 DAT.

Nomenclature: 2,4-D; bentazon; dicamba; diclofop-methyl; halosulfuron-methyl; imazaquin; mecoprop; metribuzin; MSMA; pronamide; triclopyr; OKS 91-11 and OKS 95-1 common bermudagrass, *Cynodon dactylon* (L.) Pers.

Additional index words: phytotoxicity, turfgrass, seeded bermudagrass.

Abbreviations: WAT, weeks after treatment; DAT, days after treatment; OSU, Oklahoma State University.

INTRODUCTION

Weeds create a continuous problem for many turfgrass managers. Due to the problems these weeds cause, the primary control measures after optimum mowing, fertilization, and irrigation are applied is the use of pre (PRE) and postemergence (POST) herbicides. For a herbicide to be effective in a turf management program, it must provide adequate weed control without causing undesirable injury.

Experiments have been conducted to determine the effect that herbicides have on turf species and their tolerance to a specific herbicide (Bell et al., 2000; Callahan, 1976; Johnson and Duncan, 1997; Johnson, 1975, 1976, 1978, 1995, and 1997; McCarty et al., 1991; Murdoch et al., 1997). Bell et al. (2000) reported herbicide injury to both 'OKS 91-11' common bermudagrass [*Cynodon dactylon* (L.) Pers.] and 'Midlawn' hybrid bermudagrass [*C. dactylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy] when using triclopyr, triclopyr + clopyralid, MSMA, MSMA + metribuzin, and 2,4-D + MCPP + dicamba. Both 1x and 2x the Federally labeled rates of each herbicide were applied and observed in that experiment. In a experiment conducted by McCarty et al. (1991), various rates of diclofop, MSMA, and metribuzin all reduced the quality of 'Tifway' hybrid bermudagrass and 'Ormond' common bermudagrass at 7 DAT. In that same experiment Ormond common bermudagrass showed no reduction in turf quality when averaged across all rates. Quality, however, was reduced when MSMA and metribuzin treatments were applied. Johnson (1995) stated that PRE and POST herbicides affect the performance of seeded bermudagrass differently. His work indicated that POST applications of MSMA + metribuzin, dicamba, diclofop, and 2,4-D + MCPP + dicamba were injurious to four seeded common bermudagrass cultivars (unstated common, 'Cheyenne', 'Tropica', and 'Sahara'). Johnson reported injury to common (18%), Sahara (25%), and Tropica (8%) bermudagrass when MSMA plus metribuzin was applied at 2.2 + 0.1 kg ai/ha. He also reported that the treatment 2,4-D + MCPP + dicamba was more injurious to bermudagrass when applied at the recommended rate (1.1 + 0.6 +0.1 kg ai/ha), ranging from 36 to 51%, injury than any other POST herbicide (13 to 29% injury) applied at recommended rates. In a separate experiment by Johnson (1997), diclofop-methyl, MSMA, and MSMA + metribuzin caused various degrees of injury within a few days after treatment.

Bermudagrass is adapted to the subtropical and tropical parts of the United States and to portions of the turfgrass transition zone between temperate and subtropical zones. Bermudagrass cultivars must exhibit cold tolerance to be considered acceptable turf in the transition zone and some of the northern edges of the subtropics. Many cultivars have been released that have this acceptable cold tolerance. OKS 91-11 and 'OKS 95-1' common bermudagrasses are two recently developed seeded cultivars that are believed to have acceptable cold tolerance and perform well in the southern United States (Anonymous 1995). Both culitvars were developed at Oklahoma State University (OSU). OKS 91-11 became commercially available in the Spring of 2000, while OKS 95-1 is still considered an experimental cultivar.

While numerous studies have been conducted concerning the effect of PRE and POST applied herbicides on bermudagrass cultivars, only one experiment (Bell et al., 2000) has been performed on OKS 91-11. Bell et al. (2000) studied the tolerance of OKS 91-11 and Midlawn bermudagrass to POST applied herbicides. No work has been conducted on the promising OKS 95-1 cultivar, therefore, this experiment focused on the color, quality, phytotoxicity, and clipping mass response of OKS 91-11 and OKS 95-1 bermudagrasses to commonly used POST herbicides.

MATERIALS AND METHODS

Experimental Parameters. Two separate experiments were conducted in 2000 on mature stands of OKS 91-11 and OKS 95-1 bermudagrass that had been established in 1999 at the OSU Turfgrass Research Center, Stillwater OK. Turf was mowed three times per week at a height of 1.3 cm. Nitrogen fertilizer (46-0-0) was applied every 4 to5 wk throughout the growing season at a rate of 49 kg N/ha as a maintenance fertilizer. Nutralene, a slow release fertilizer (40-0-0), was applied at the time of treatment application to give an extended fertilization period during data collection to encourage consistent color and growth during the experimental period. Nutralene was applied at a rate of 98 kg N/ha. Both experiments received irrigation to prevent wilt.

. In 2000, the first experiment was treated on the May 23 and the second was treated on the July 29. These experiments will be referred to as the May and July experiments, respectively. Experiments were arranged in randomized complete blocks with 23 treatments and three replications. Plot sizes were 1.4 by 2.6 m on both experiments. The May experiment was conducted on a loam soil having a pH of 7.2 and 2.2% organic matter (OM), with the July experiment conducted on a silt loam having a pH of 6.9 and 0.2% OM. Treatments included an untreated check and both 1x and 2x the Federal label rate for 2,4-D + MCPP + dicamba [1.86 (1.1 + 0.6 + 0.1) and 3.72 (2.2 + 1.2 + 0.2) kg ai/ha], triclopyr + clopyralid (0.84 and 1.68 kg ai/ha), imazaquin (0.56 and 1.12 kg ai/ha), MSMA (3.39 and 6.78 kg ai/ha), MSMA + metribuzin (3.39 + 0.18 and 6.78 + 0.36 kg ai/ha), metribuzin (0.56 and 1.12 kg ai/ha), pronamide (1.68 and 3.36 kg ai/ha), halosulfuron-methyl (0.05 and 0.10 kg ai/ha), bentazon (1.25 and 2.50 kg ai/ha), quinclorac (0.84 and 1.66 kg ai/ha), and diclofop-methyl (1.14 and 2.28 kg ai/ha). All treatments were applied with a nonionic surfactant (25% v/v), except for the MSMA treatment which included surfactant already in the formulation and the quinclorac treatment which received crop oil concentrate (2.3 L/ha). All herbicide treatments were applied using an air pressurized bicycle sprayer at 188 L/ha using 11003VS flat fan spray nozzles. Plots were visually rated for quality and phytotoxicity on 1, 3, and 5 DAT and continued on a weekly basis for 8 wk after treatment (WAT). A rating scale of 0 to 10 was used, with 0 equaling very poor quality or no phytotoxicity. A rating of 10 equaled very high quality and the highest level of herbicide injury. Clippings were collected from the center of each plot in a 1.4 m^2 area using a John Deere walk behind, reel mower with catcher weekly for up to 8 WAT. Fresh mass was taken within an hour of clipping collection, samples were placed in a drying facility with an average temperature of 49 C for 7 d, and then reweighed for dry clipping mass and converted to kg/ha.

Data Analysis. Data were analyzed using an analysis of variance procedure (ANOVA) model to test the effects of block, herbicide treatment, and rating date on the variables quality, phytotoxicity, and dry clipping weights. The ANOVA procedure was conducted using Statistical Analysis Systems software (SAS). The experiments were analyzed as a split plot, split in time, with cultivars as the main plots, herbicide treatments within cultivars as sub plots, and rating dates within herbicide treatments within cultivars as sub-sub plots. Treatment means were separated using a protected LSD test when appropriate main or interaction effects were found significant in the ANOVA at $P \leq 0.05$.

RESULTS AND DISCUSSION

Turf Quality. Visual ratings from the May and July experiments indicated that a number of the POST herbicides caused significant decreases in turf quality (Tables 1 and 2). The 2,4-D + MCPP + dicamba treatments caused quality reductions on both OKS 91-11 and OKS 95-1 in the July experiment at both 1x and 2x rates. The 1x rate (1.86 kg ai/ha) caused reductions that started at 7 DAT for both cultivars and continued through 14 DAT on OKS 95-1. The 2x rate (3.72 kg ai/ha) caused quality decline starting at 7 DAT and continuing through 21 and 28 DAT on OKS 95-1 and OKS 91-11, respectively. Triclopyr + clopyralid treatments caused quality decline in both experiments and on both cultivars. The 1x rate (0.84 kg ai/ha) of triclopyr + clopyralid resulted in quality decreases in the May experiment ranging from 7 DAT to 21 DAT for both culitvars. In the July experiment, the 1x rate reduced turf quality from 7 DAT until 28 DAT. The 2x rate (1.68 kg ai/ha) treated plots showed reductions in quality ranging from 7 DAT to 28 DAT for both cultivars, in both experiments. Imazaquin treatments caused quality reductions that were observed on both cultivars, and were observed on days ranging from 7 to 21 DAT. Treatments containing MSMA resulted in initial reductions in turf quality but recovered by 14 DAT. Metribuzin applied at 0.56 and 1.12 kg ai/ha in the May experiment caused significant reductions in quality of OKS 95-1 and OKS 91-11 at 7 DAT and 7 through 14 DAT, respectively.

Phytotoxicity. Herbicide injury was observed in both experiments from a number of POST herbicides (Tables 3 and 4). The July experiment indicated that 2,4-D + MCPP + dicamba applied at 1.86 or 3.72 kg ai/ha caused injury ranging from 7 to 37%, with injury lasting from 7 to 28 DAT depending on the cultivar and rate. Both 1x and 2x rates of triclopyr + clopyralid caused phytotoxicity in both experiments and on both cultivars. Injury ranged from 3 to 23% during the May experiment, with more injury being observed on OKS 95-1 than OKS 91-11. In the July experiment, turf showed the most response to triclopyr + clopyralid treatments, with injury ranging from 13 to 70% on both culitvars. The injury from triclopyr + clopyralid treatments lasted for 28 DAT for the labeled rate and up to 35 DAT (data not shown) for the 2x rate. Imazaquin treatments in the May experiment caused injury ranging from 3 to 10% depending on rate. During the July experiment, a higher degree of turf injury was observed from the two different rates of imazaquin on both cultivars. Significant injury ranged from 13 to 33% during the July experiment. As one may expect, treatments involving MSMA showed initial significant phytotoxicity ranging anywhere from 7 to 27%. The higher injury was observed on the 2x labeled rate for all treatments that included MSMA. Quinclorac treatments caused significant injury (10 to 13%) to both cultivars in the July experiment. Weather conditions may have influenced the differences in observed injury seen in the May and July experiments, as the average maximum temperatures during the May and July experiments were 29 C and 36 C, respectively (Figure 1).

Dry Clipping Yield. Triclopyr + clopyralid and imazaquin applied at both 1x and 2x rates caused significant decreases in dry clipping mass for both cultivars (Tables 5 and 6). The 2,4-D + MCPP + dicamba treatments resulted in significant decreases in clipping yield on at least one day of collection during the July experiment. Triclopyr + clopyralid treatments showed the most clipping yield reduction compared to all other treatments. Yields were reduced from 7 to 14 DAT during the May experiment for both culitvars. Data from the July experiment indicated that clipping yields were reduced for up to 28

DAT on both cultivars when both 1x and 2x rates of triclopyr + clopyralid were applied. Clipping yields on both cultivars were reduced an additional week (35 DAT) during the July experiment when triclopyr + clopyralid was applied at 1.68 kg ai/ha (data not shown). Imazaquin treatments caused initial decreases in clipping yields, with significant decreases lasting for up to 21 DAT depending on treatment rate. An increase in clipping yield was observed due to the application of imazaquin in both experiments, on both cultivars, and at both rates at 28 DAT.

Some POST herbicides can cause quality reductions, turfgrass injury, and clipping mass reductions to OKS 95-1 and OKS 91-11 even when applied at the Federally labeled rates. Triclopyr + clopyralid, imazaquin, and metribuzin applications will cause unacceptable injury for different periods of time when applied during warm temperatures. Applications of MSMA will show phytotoxic symptoms within the first wk after application, but will grow out of the injury by 2 WAT. Attention must be paid when selecting an appropriate POST herbicide to use on these two new cultivars, as well as, how much of that herbicide is actually being applied.

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Table 1. Quality ratings for OKS 95-1 in 2000 following POST herbicide treatments.

		Ratings by days after treatment									
		May					July				
Herbicide	Rate	3	7	14	21	28	3	7	14	21	28
	kg/ha	0 to 10 scale[a]									
Untreated		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
2,4-D + MCPP +dicamba	1.86	10.0	10.0	10.0	10.0	10.0	10.0	8.0*	7.3*	9.3	9.3
2,4-D + MCPP +dicamba	3.72	10.0	9.7	10.0	10.0	10.0	10.0	8.7*	6.3*	8.7*	9.3
Triclopyr + clopyralid	0.84	9.7	9.0*	9.0*	9.7	10.0	10.0	8.0*	4.7*	8.0*	8.0*
Triclopyr + clopyralid	1.68	10.0	9.0*	7.7*	9.3*	9.0*	10.0	7.3*	4.0*	4.7*	6.7*
Imazaquin	0.56	10.0	9.3*	10.0	9.7	10.0	10.0	8.0*	8.7*	9.7	10.0
Imazaquin	1.12	10.0	9.0*	9.7	9.3*	10.0	10.0	8.0*	8.7*	9.0	10.0
MSMA	3.39	10.0	10.0	10.0	10.0	9.7	10.0	9.3	10.0	10.0	10.0
MSMA	6.78	9.3*[b]	8.7*	9.7	10.0	9.7	9.3*	9.0*	10.0	10.0	10.0
MSMA + metribuzin	3.39 + 0.18	9.0*	8.7*	10.0	10.0	10.0	9.3*	9.7	10.0	10.0	10.0
MSMA + metribuzin	6.78 + 0.36	8.0*	7.7*	10.0	10.0	10.0	8.0*	9.0*	10.0	10.0	10.0
Metribuzin	0.56	10.0	8.7*	10.0	10.0	10.0	10.0	9.7	9.7	10.0	10.0
Metribuzin	1.12	10.0	7.7*	9.3*	9.7	10.0	10.0	8.3*	9.7	10.0	10.0
Pronamide	1.68	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Pronamide	3.36	10.0	10.0	10.0	10.0	10.0	10.0	10.0	9.7	10.0	10.0
Halosulfuron	0.05	10.0	9.7	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Halosulfuron	0.10	10.0	10.0	10.0	10.0	9.7	10.0	10.0	10.0	10.0	10.0
Bentazon	1.25	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Bentazon	2.50	10.0	10.0	10.0	10.0	10.0	10.0	9.7	10.0	10.0	10.0
Quinclorac	0.84	10.0	10.0	10.0	10.0	10.0	10.0	9.0*	10.0	10.0	10.0
Quinclorac	1.68	10.0	9.7	10.0	10.0	10.0	10.0	9.3	9.0*	10.0	10.0
Diclofop-methyl	1.14	10.0	10.0	10.0	10.0	10.0	10.0	9.7	10.0	10.0	10.0
Diclofop-methyl	2.28	10.0	10.0	10.0	10.0	10.0	10.0	9.0*	10.0	10.0	10.0
LSD(0.05)		0.4	0.5	0.4	0.4	0.3	0.3	0.8	1.0	1.1	0.7

[a] 0 to 10 scale; 0 = very poor quality and 10 = very high quality.

[b] Asterisks (*) indicates significant reductions in quality compared to the untreated plots (P = 0.05).

Table 2. **Quality ratings for OKS 91-11 in 2000 following POST herbicide treatments.**

		Ratings by days after treatment									
		May					July				
Herbicide	Rate	3	7	14	21	28	3	7	14	21	28
	kg/ha	0 to 10 scale[a]									
Untreated		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
2,4-D + MCPP +dicamba	1.86	10.0	9.7	10.0	10.0	9.7	10.0	9.0*	9.7	10.0	10.0
2,4-D + MCPP +dicamba	3.72	10.0	9.3*[b]	10.0	10.0	9.7	10.0	8.3*	7.7*	9.0*	9.3*
Triclopyr + clopyralid	0.84	10.0	9.0*	8.7*	9.7*	9.7	9.7	8.7*	6.7*	8.3*	8.7*
Triclopyr + clopyralid	1.68	10.0	9.3*	9.0*	10.0	9.7	9.7	8.3*	5.3*	7.3*	7.7*
Imazaquin	0.56	10.0	9.0*	10.0	9.3*	10.0	10.0	8.0*	8.0*	9.3	10.0
Imazaquin	1.12	10.0	9.0*	9.0*	9.0*	9.7	10.0	7.7*	6.7*	8.7*	9.7
MSMA	3.39	9.7	9.3*	10.0	10.0	10.0	10.0	9.7	10.0	10.0	10.0
MSMA	6.78	10.0	9.0*	10.0	10.0	10.0	7.7*	9.0*	10.0	10.0	10.0
MSMA + metribuzin	3.39 + 0.18	9.0	8.0*	10.0	10.0	10.0	9.3	9.3	10.0	10.0	10.0
MSMA + metribuzin	6.78 + 0.36	8.7	8.3*	10.0	10.0	10.0	7.3*	9.0*	10.0	10.0	10.0
Metribuzin	0.56	10.0	9.0*	10.0	10.0	9.7	10.0	9.3	10.0	10.0	10.0
Metribuzin	1.12	9.7	9.0*	9.7*	10.0	9.7	10.0	9.0*	10.0	10.0	10.0
Pronamide	1.68	10.0	9.7	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Pronamide	3.36	10.0	10.0	10.0	10.0	10.0	10.0	9.7	10.0	10.0	10.0
Halosulfuron	0.05	10.0	10.0	10.0	10.0	10.0	10.0	9.7	10.0	10.0	10.0
Halosulfuron	0.10	10.0	10.0	10.0	10.0	10.0	10.0	9.7	10.0	10.0	10.0
Bentazon	1.25	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Bentazon	2.50	9.7	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Quinclorac	0.84	10.0	10.0	10.0	10.0	10.0	10.0	8.7*	9.7	10.0	10.0
Quinclorac	1.68	10.0	9.7	10.0	10.0	10.0	10.0	8.7*	9.7	10.0	10.0
Diclofop-methyl	1.14	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Diclofop-methyl	2.28	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
LSD(0.05)		0.4	0.5	0.3	0.3	0.5	0.9	0.8	0.9	0.7	0.4

[a] 0 to 10 scale; 0 = very poor quality and 10 = very high quality.

[b] Asterisks (*) indicates significant reduction in quality compared to the untreated plots (P = 0.05).

Table 3. Phytotoxicity ratings for OKS 95-1in 2000 following POST herbicide treatments.

		Ratings by days after treatment									
		May					July				
Herbicide	Rate	3	7	14	21	28	3	7	14	21	28
	kg/ha	0 to 10 scale[a]									
Untreated		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2,4-D + MCPP +dicamba	1.86	0.0	0.0	0.0	0.0	0.0	0.0	2.0*	3.0*	0.7	0.3
2,4-D + MCPP +dicamba	3.72	0.0	0.3	0.0	0.0	0.0	0.0	1.3*	3.7*	1.7*	0.7
Triclopyr + clopyralid	0.84	0.0	1.0*	1.0*	0.3	0.0	0.0	2.0*	5.3*	3.0*	2.0*
Triclopyr + clopyralid	1.68	0.0	1.0*	2.3*	0.7*	0.7*	0.0	3.0*	7.0*	6.0*	4.0*
Imazaquin	0.56	0.0	0.7*	0.0	0.3	0.0	0.0	2.0*	1.7*	0.3	0.0
Imazaquin	1.12	0.0	1.0*	0.3	0.7*	0.0	0.0	2.0*	1.3*	1.0	0.0
MSMA	3.39	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
MSMA	6.78	0.7*[b]	1.3*	0.3	0.0	0.0	0.7*	1.0*	0.0	0.0	0.0
MSMA + metribuzin	3.39 + 0.18	1.0*	1.3*	0.0	0.0	0.0	0.7*	0.3	0.0	0.0	0.0
MSMA + metribuzin	6.78 + 0.36	2.7*	2.3*	0.0	0.0	0.0	2.0*	1.0*	0.0	0.0	0.0
Metribuzin	0.56	0.0	1.3*	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0
Metribuzin	1.12	0.0	2.3*	0.7*	0.3	0.0	0.0	1.7*	0.3	0.0	0.0
Pronamide	1.68	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pronamide	3.36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Halosulfuron	0.05	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Halosulfuron	0.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bentazon	1.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bentazon	2.50	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Quinclorac	0.84	0.0	0.0	0.0	0.0	0.0	0.0	1.0*	0.0	0.0	0.0
Quinclorac	1.68	0.0	0.3	0.0	0.0	0.0	0.0	0.7	1.0*	0.0	0.0
Diclofop-methyl	1.14	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Diclofop-methyl	2.28	0.0	0.0	0.0	0.0	0.0	0.0	1.0*	0.0	0.0	0.0
LSD(0.05)		0.4	0.5	0.4	0.4	0.2	0.3	0.9	0.9	1.0	0.8

[a] 0 to 10 scale; 0 = no phytotoxicity and 10 = highest degree of phytotoxicity.

[b] Asterisks (*) indicates significant herbicide injury compared to the untreated plots (P = 0.05).

Table 4. Phytotoxicity ratings for OKS 91-11 in 2000 following POST herbicide treatments.

		Ratings by days after treatment									
		May					July				
Herbicide	Rate	3	7	14	21	28	3	7	14	21	28
	kg/ha	0 to 10 scale[a]									
Untreated		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2,4-D + MCPP +dicamba	1.86	0.0	0.3	0.0	0.0	0.0	0.0	1.0*	0.3	0.0	0.0
2,4-D + MCPP +dicamba	3.72	0.0	0.7*	0.0	0.0	0.0	0.0	1.7*	2.3*	1.0*	0.3
Triclopyr + clopyralid	0.84	0.0	1.0*	1.0*	0.3*	0.0	0.3	1.3*	3.3*	2.0*	1.3*
Triclopyr + clopyralid	1.68	0.0	0.7*	1.0*	0.0	0.0	0.3	1.7*	4.7*	3.3*	2.7*
Imazaquin	0.56	0.0	1.0*	0.0	0.7*	0.0	0.0	2.3*	2.0*	0.7	0.0
Imazaquin	1.12	0.0	1.0*	1.0*	1.0*	0.3*	0.0	2.3*	3.3*	1.7*	0.3
MSMA	3.39	0.0	0.7*	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
MSMA	6.78	0.0	1.0*	0.0	0.0	0.0	2.0*	1.0*	0.0	0.0	0.0
MSMA + metribuzin	3.39 + 0.18	0.7*[b]	2.0*	0.0	0.0	0.0	0.7	0.7	0.0	0.0	0.0
MSMA + metribuzin	6.78 + 0.36	2.0*	1.7*	0.0	0.0	0.0	2.7*	1.0*	0.0	0.0	0.0
Metribuzin	0.56	0.0	1.0*	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
Metribuzin	1.12	0.3*	1.0*	0.3*	0.0	0.0	0.0	1.0*	0.0	0.0	0.0
Pronamide	1.68	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pronamide	3.36	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Halosulfuron	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Halosulfuron	0.10	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Bentazon	1.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bentazon	2.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Quinclorac	0.84	0.0	0.0	0.0	0.0	0.0	0.0	1.3*	0.3	0.0	0.0
Quinclorac	1.68	0.0	0.0	0.0	0.0	0.0	0.0	1.3*	1.0*	0.0	0.0
Diclofop-methyl	1.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diclofop-methyl	2.28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSD(0.05)		0.3	0.5	0.2	0.3	0.2	0.8	0.9	0.9	0.8	0.5

[a] 0 to 10 scale; 0 = no phytotoxicity and 10 = highest degree of phytotoxicity.

[b] Asterisks (*) indicates significant herbicide injury compared to the untreated plots (P = 0.05).

Table 5. Dry clipping matter produced by OKS 95-1 in 2000 following POST herbicide treatments.

		Yield by days after treatment							
		May				July			
Herbicide	Rate	7	14	21	28	7	14	21	28
	kg/ha	kg/ha							
Untreated		94.0	67.4	82.2	86.6	454.3	334.9	305.8	314.1
2,4-D + MCPP +dicamba	1.86	75.3	53.4	67.7	76.2	445.6	197.7*	230.9	218.1
2,4-D + MCPP +dicamba	3.72	82.8	50.9	66.4	80.8	405.3	203.2*	235.7	235.5
Triclopyr + clopyralid	0.84	44.5*[a]	39.7*	71.8	81.6	342.9	161.0*	166.0*	187.0*
Triclopyr + clopyralid	1.68	36.9*	21.9*	62.9	79.9	326.9	129.1*	125.3*	107.6*
Imazaquin	0.56	34.7*	53.7	82.7	137.2*	377.9	169.1*	307.0	533.6*
Imazaquin	1.12	24.4*	27.7*	70.5	122.7*	440.9	193.8*	284.1	559.0*
MSMA	3.39	97.8	72.9	80.0	91.9	499.0	370.5	338.4	293.0
MSMA	6.78	87.5	72.0	68.1	76.1	555.1	400.0	337.0	332.5
MSMA + metribuzin	3.39 + 0.18	94.4	57.6	62.0	92.0	558.9	366.5	384.8	325.3
MSMA + metribuzin	6.78 + 0.36	99.6	57.7	61.9	73.5	481.5	362.9	419.4*	269.3
Metribuzin	0.56	92.1	53.9	64.3	80.8	592.6	353.8	368.2	288.7
Metribuzin	1.12	112.8	65.0	92.2	80.6	551.4	322.9	336.9	289.6
Pronamide	1.68	98.5	66.8	72.4	100.4	490.5	287.2	315.7	244.3
Pronamide	3.36	128.3*	74.3	87.5	119.4	729.9*	395.3	382.8	313.9
Halosulfuron	0.05	70.3	52.5	53.1*	74.3	511.0	293.2	303.9	317.0
Halosulfuron	0.10	81.9	56.5	60.78	83.2	557.6	317.4	338.9	265.9
Bentazon	1.25	92.8	63.9	76.6	87.2	467.5	316.4	258.7	293.5
Bentazon	2.50	89.0	54.6	62.0	83.7	574.6	400.0	274.2	307.9
Quinclorac	0.84	119.5*	60.1	77.2	92.9	570.0	327.5	325.2	346.6
Quinclorac	1.68	121.8*	64.7	71.7	82.2	618.0	330.5	387.4	343.2
Diclofop-methyl	1.14	90.25	54.3	66.0	78.4	611.3	350.8	337.8	335.5
Diclofop-methyl	2.28	102.2	74.7	73.6	90.6	449.9	296.0	272.4	280.1
LSD(0.05)		25.3	20.0	22.7	34.4	208.4	106.5	111.6	125.8

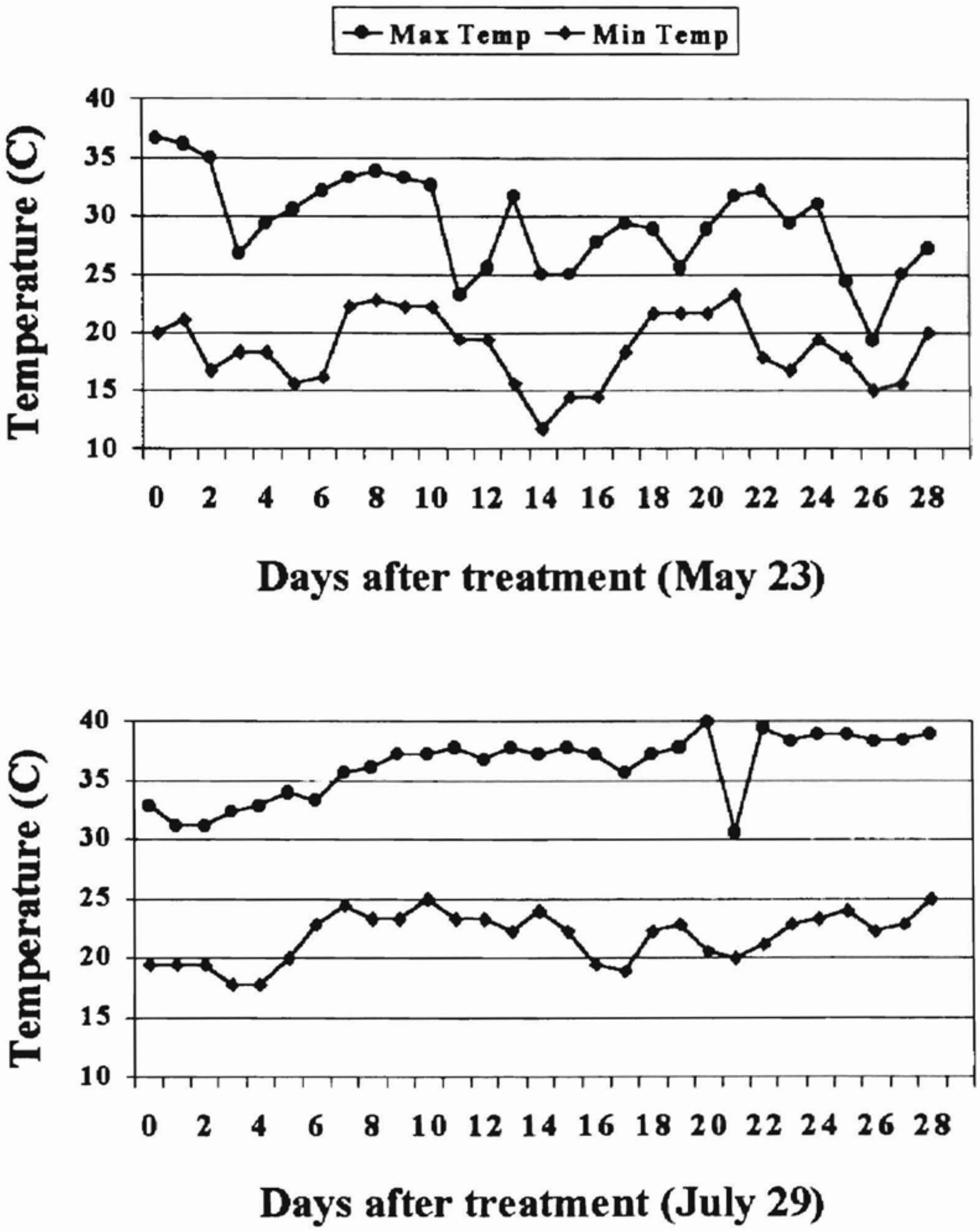
[a] Asterisks (*) indicates significant differences in clipping weight compared to the untreated plots (P = 0.05).

Table 6. Dry clipping matter produced by OKS 91-11 in 2000 following POST herbicide treatments.

		Yield by days after treatment							
		May				July			
Herbicide	Rate	7	14	21	28	7	14	21	28
	kg/ha	kg/ha							
Untreated		98.5	69.4	88.5	117.5	539.0	317.1	312.6	316.2
2,4-D + MCPP +dicamba	1.86	92.4	62.4	79.4	129.1	341.4*	249.0	276.2	259.9
2,4-D + MCPP +dicamba	3.72	71.4	63.9	74.3	118.0	422.2	268.7	297.7	202.5*
Triclopyr + clopyralid	0.84	48.7*[a]	48.3	75.4	129.2	326.0*	143.2*	194.6*	160.2*
Triclopyr + clopyralid	1.68	33.0*	31.8*	73.2	135.1	244.6*	104.1*	126.4*	86.4*
Imazaquin	0.56	42.7*	59.6	177.4*	265.1*	273.4*	141.6*	259.3	425.5*
Imazaquin	1.12	30.8*	37.3*	121.0	238.6*	257.7*	97.6*	179.5*	367.3
MSMA	3.39	103.7	89.5	99.9	153.2	440.6	327.2	359.7	304.8
MSMA	6.78	85.3	74.5	72.4	126.8	449.5	373.2	315.5	314.7
MSMA + metribuzin	3.39 + 0.18	106.5	66.0	72.0	103.2	323.1*	272.7	280.5	255.0
MSMA + metribuzin	6.78 + 0.36	123.4	76.6	94.3	137.1	361.4	260.8	311.2	317.5
Metribuzin	0.56	132.8	65.2	68.3	79.7	471.2	315.1	325.4	281.4
Metribuzin	1.12	99.4	59.1	60.5	92.4	515.6	367.6	335.9	247.4
Pronamide	1.68	81.1	58.8	67.9	109.8	432.3	304.0	303.2	231.8
Pronamide	3.36	85.7	66.0	75.3	105.9	548.0	336.5	344.0	329.6
Halosulfuron	0.05	104.4	77.1	100.4	156.6	499.6	327.6	360.3	303.9
Halosulfuron	0.10	79.0	47.9	64.6	93.6	319.3*	299.9	283.5	235.0
Bentazon	1.25	84.6	54.5	68.8	123.8	530.8	340.8	330.5	350.1
Bentazon	2.50	92.1	74.5	80.4	132.9	478.0	305.3	316.2	320.1
Quinclorac	0.84	145.7*	85.7	118.5	169.2	451.9	334.6	335.8	300.2
Quinclorac	1.68	125.3	82.7	106.4	151.8	411.0	268.6	290.1	308.6
Diclofop-methyl	1.14	113.9	77.0	91.3	145.5	565.2	355.7	368.1	356.6
Diclofop-methyl	2.28	111.9	75.4	87.8	140.8	371.9	291.3	345.0	298.5
LSD(0.05)		43.4	27.9	48.6	71.0	193.0	82.5	95.5	100.3

[a] Asterisks (*) indicates significant differences in clipping weight compared to the untreated plots (P = 0.05).

Figure 1. Maximum and minimum temperatures during the data collection period of the May and July experiments in 2000.



APPENDIX

Appendix Table 7. Color ratings for OKS 95-1 in 2000 following POST herbicide treatments.

		Ratings by days after treatment									
		May					July				
Herbicide	Rate	3	7	14	21	28	3	7	14	21	28
	kg ha^{-1}	0 to 10 scale[b]									
Untreated		9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
2,4-D + MCPP +dicamba	1.86	9.0	9.0	9.0	9.0	9.0	9.0	7.0*	6.7*	8.3	8.3
2,4-D + MCPP +dicamba	3.72	9.0	8.7	9.0	9.0	9.0	9.0	7.7*	6.0*	7.7*	8.3
Triclopyr + clopyralid	0.84	9.0	8.0*	8.0*	8.7	9.0	9.0	7.0*	4.7*	7.0*	7.0*
Triclopyr + clopyralid	1.68	9.0	8.0*	6.7*	8.3*	8.0*	9.0	6.3*	3.3*	4.3*	5.7*
Imazaquin	0.56	9.0	8.3*	9.0	8.7	9.0	9.0	7.0*	7.7*	8.7	9.0
Imazaquin	1.12	9.0	8.0*	8.7*	8.3*	9.0	9.0	7.0*	7.7*	8.0*	9.0
MSMA	3.39	9.0	9.0	9.0	9.0	8.7*	9.0	8.3	9.0	9.0	9.0
MSMA	6.78	8.3*[a]	7.7*	8.7*	9.0	8.7*	8.3*	8.0*	9.0	9.0	9.0
MSMA + metribuzin	3.39 + 0.18	8.0*	7.7*	9.0	9.0	9.0	8.3*	8.7	9.0	9.0	9.0
MSMA + metribuzin	6.78 + 0.36	6.3*	6.7*	9.0	9.0	9.0	7.0*	8.0*	9.0	9.0	9.0
Metribuzin	0.56	9.0	7.7*	9.0	9.0	9.0	9.0	8.7	8.7	9.0	9.0
Metribuzin	1.12	9.0	6.7*	8.3*	9.0	9.0	9.0	7.3*	8.7	9.0	9.0
Pronamide	1.68	9.0	9.0	9.0	8.7	9.0	9.0	9.0	9.0	9.0	9.0
Pronamide	3.36	9.0	9.0	9.0	9.0	9.0	9.0	9.0	8.7	9.0	9.0
Halosulfuron	0.05	9.0	8.7	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Halosulfuron	0.10	9.0	9.0	9.0	9.0	8.7*	9.0	9.0	9.0	9.0	9.0
Bentazon	1.25	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Bentazon	2.50	9.0	9.0	9.0	9.0	9.0	9.0	8.7	9.0	9.0	9.0
Quinclorac	0.84	9.0	9.0	9.0	9.0	9.0	9.0	8.0*	9.0	9.0	9.0
Quinclorac	1.68	9.0	8.7	9.0	9.0	9.0	9.0	8.3	8.0*	9.0	9.0
Diclofop-methyl	1.14	9.0	9.0	9.0	9.0	9.0	9.0	8.7	9.0	9.0	9.0
Diclofop-methyl	2.28	9.0	9.0	9.0	9.0	9.0	9.0	8.0*	9.0	9.0	9.0
LSD(0.05)		0.4	0.5	0.4	0.4	0.3	0.3	0.8	0.7	0.9	0.7

[a] Asterisks (*) indicates significant reductions in color compared to the untreated plots (P = 0.05).

[b] 0 to 10 scale; 0 = very poor color, 10 = very high color.

Appendix Table 8. Color ratings for OKS 91-11 in 2000 following POST herbicide treatments.

		Ratings by days after treatment									
		May					July				
Herbicide	Rate	3	7	14	21	28	3	7	14	21	28
	kg ha^{-1}	0 to 10 scale[b]									
Untreated		9.0	9.0	9.0	9.0	0.9	9.0	9.0	9.0	9.0	9.0
2,4-D + MCPP +dicamba	1.86	9.0	8.7	9.0	9.0	8.7	9.0	8.0*	8.7	9.0	9.0
2,4-D + MCPP +dicamba	3.72	9.0	8.3*	9.0	9.0	8.7	9.0	7.3*	7.0*	8.3*	8.7
Triclopyr + clopyralid	0.84	9.0	8.0*	8.0*	8.7*	8.7	8.7	7.7*	6.7*	7.3*	7.7*
Triclopyr + clopyralid	1.68	9.0	8.3*	8.0*	9.0	8.7	8.7	7.3*	5.3*	6.7*	6.7*
Imazaquin	0.56	9.0	8.0*	9.0	8.3*	9.0	9.0	7.0*	7.7*	8.3*	9.0
Imazaquin	1.12	9.0	8.0*	8.0*	8.0*	8.3*	9.0	6.7*	6.7*	7.7*	8.7
MSMA	3.39	9.0	8.3*	9.0	9.0	8.7	9.0	8.7	9.0	9.0	9.0
MSMA	6.78	9.0	8.0*	9.0	9.0	9.0	7.0*	8.0*	9.0	9.0	9.0
MSMA + metribuzin	3.39 + 0.18	8.3*[a]	7.0*	9.0	9.0	9.0	8.3	8.3	9.0	9.0	9.0
MSMA + metribuzin	6.78 + 0.36	7.0*	7.3*	9.0	9.0	9.0	6.7*	8.0*	9.0	9.0	9.0
Metribuzin	0.56	9.0	8.0*	9.0	9.0	8.7	9.0	8.3	9.0	9.0	9.0
Metribuzin	1.12	8.7*	8.0*	8.7*	9.0	8.7	9.0	8.0*	9.0	9.0	9.0
Pronamide	1.68	9.0	8.7	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Pronamide	3.36	9.0	9.0	9.0	9.0	9.0	9.0	8.7	9.0	9.0	9.0
Halosulfuron	0.05	9.0	9.0	9.0	9.0	9.0	9.0	8.7	9.0	9.0	9.0
Halosulfuron	0.10	9.0	9.0	9.0	9.0	9.0	9.0	8.7	9.0	9.0	9.0
Bentazon	1.25	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Bentazon	2.50	9.0	9.0	9.0	9.0	9.0	9.0	9.0	8.7	9.0	9.0
Quinclorac	0.84	9.0	9.0	9.0	9.0	9.0	9.0	7.7*	8.7	9.0	9.0
Quinclorac	1.68	9.0	8.7	9.0	9.0	9.0	9.0	7.7*	8.0*	9.0	9.0
Diclofop-methyl	1.14	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Diclofop-methyl	2.28	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
LSD(0.05)		0.3	0.5	0.2	0.3	0.5	0.7	0.8	0.6	0.5	0.4

[a] Asterisks (*) indicates significant reductions in color compared to the untreated plots ($P = 0.05$).

[b] 0 to 10 scale; 0 = very poor color, 10 = very high color.

Appendix Table 9. Wet clipping matter produced by OKS 95-1 in 2000 following POST herbicide treatments.

		Yield by days after treatment							
		May				July			
Herbicide	Rate	7	14	21	28	7	14	21	28
	kg ha^{-1}	kg ha^{-1}							
Untreated		303.7	223.4	233.9	335.9	1560.1	838.7	830.7	796.8
2,4-D + MCPP +dicamba	1.86	247.8	182.2	194.0	266.4	886.5*	474.0*	684.8	639.7
2,4-D + MCPP +dicamba	3.72	258.3	173.0	185.9	279.3	837.3*	450.5*	677.8	674.0
Triclopyr + clopyralid	0.84	130.3*[a]	122.6*	204.9	290.8	1153.9	305.6*	489.4	531.8
Triclopyr + clopyralid	1.68	106.5*	78.2*	193.6	285.4	948.5	192.6*	287.5*	297.0*
Imazaquin	0.56	120.7*	170.9	243.5	477.0*	1178.5	473.6*	978.4	1547.3*
Imazaquin	1.12	88.2*	90.2*	209.4	443.7	1060.8	554.0	982.4	1602.7*
MSMA	3.39	329.2	244.6	231.4	324.7	1003.4	1047.7	987.8	841.5
MSMA	6.78	296.2	233.5	198.6	265.0	1682.8	1130.3	1000.0	907.3
MSMA + metribuzin	3.39 + 0.18	339.7	166.5	184.2	325.5	1419.1	1056.3	1145.8	871.1
MSMA + metribuzin	6.78 + 0.36	322.0	202.4	180.4	259.1	1310.4	1039.3	1272.7	736.6
Metribuzin	0.56	335.5	183.9	184.4	276.2	1553.5	999.6	1115.8	745.1
Metribuzin	1.12	405.7*	212.6	273.2	278.8	1654.2	896.0	1009.6	777.7
Pronamide	1.68	327.6	212.2	206.4	341.7	1471.9	738.4	878.9	691.5
Pronamide	3.36	425.3	239.9	251.5	399.2	1818.1	1139.8*	1152.0	872.0
Halosulfuron	0.05	233.9	165.0	154.2*	255.1	1118.1	781.3	842.2	817.2
Halosulfuron	0.10	271.8	187.2	172.6	278.6	1643.8	816.6	945.5	682.6
Bentazon	1.25	300.7	204.8	206.7	290.0	1446.6	816.5	740.9	774.0
Bentazon	2.50	291.2	177.2	178.9	295.5	1432.1	1038.7	792.8	824.2
Quinclorac	0.84	385.9*	198.1	218.6	321.1	1818.0	865.0	954.3	927.2
Quinclorac	1.68	374.5	196.8	202.8	282.3	1523.1	864.1	1117.5	928.7
Diclofop-methyl	1.14	298.4	181.1	190.9	269.8	1413.2	952.8	983.8	935.2
Diclofop-methyl	2.28	329.6	242.3	210.3	313.3	1363.1	820.2	808.7	740.3
LSD(0.05)		82.0	60.2	65.7	118.7	673.3	300.1	344.0	360.2

[a] Asterisks (*) indicates significant differences in clipping weight compared to the untreated plots (P = 0.05).

Appendix Table 10. Wet clipping matter produced by OKS 91-11 in 2000 following POST herbicide treatments.

		Yield by days after treatment							
		May				July			
Herbicide	Rate	7	14	21	28	7	14	21	28
	kg ha^{-1}	kg ha^{-1}							
Untreated		323.9	243.9	250.6	403.8	1680.7	920.8	966.8	857.5
2,4-D + MCPP +dicamba	1.86	309.9	226.4	244.2	439.4	1026.8	639.4*	863.4	724.3
2,4-D + MCPP +dicamba	3.72	256.4	239.9	224.8	417.4	1108.3	747.7	998.3	604.2
Triclopyr + clopyralid	0.84	152.3*[a]	171.6	244.4	462.9	931.2*	344.4*	618.3	475.3*
Triclopyr + clopyralid	1.68	104.7*	117.7*	235.5	487.1	935.4*	205.6*	376.4*	262.3*
Imazaquin	0.56	139.7*	229.0	577.1*	957.1*	846.3*	407.9*	897.0	1273.8*
Imazaquin	1.12	106.6*	121.9	395.0	861.8*	1031.9	242.4*	623.7	1125.9
MSMA	3.39	386.0	327.8	315.1	594.0	1471.0	937.2	1065.9	811.2
MSMA	6.78	308.2	271.5	223.1	445.1	1136.1	1139.3	995.1	818.8
MSMA + metribuzin	3.39 + 0.18	384.3	233.6	220.9	367.2	1039.1	841.3	876.7	694.3
MSMA + metribuzin	6.78 + 0.36	475.1	285.7	293.5	490.0	1019.6	805.3	1043.0	898.2
Metribuzin	0.56	454.4	227.7	200.5	273.6	1428.7	974.3	1062.6	762.1
Metribuzin	1.12	356.4	215.7	182.5	321.4	1540.6	1174.6	1089.8	687.9
Pronamide	1.68	293.1	203.5	200.0	377.0	1270.9	859.2	888.4	600.7
Pronamide	3.36	281.0	222.5	223.9	358.6	1434.3	976.0	1057.9	876.2
Halosulfuron	0.05	356.3	266.0	295.9	543.4	1406.1	961.1	1119.0	810.0
Halosulfuron	0.10	271.1	166.6	165.2	332.7	1268.9	832.9	842.9	640.7
Bentazon	1.25	301.1	180.6	209.9	427.8	1783.7	972.2	1021.0	907.3
Bentazon	2.50	317.3	250.5	248.9	462.9	1217.9	833.5	949.3	815.8
Quinclorac	0.84	518.5*	300.0	365.8	593.7	1445.5	972.7	1070.7	852.5
Quinclorac	1.68	454.0	291.3	329.0	525.9	1571.0	746.8	931.6	881.8
Diclofop-methyl	1.14	411.7	262.7	275.1	504.7	1740.4	1019.3	1116.8	972.7
Diclofop-methyl	2.28	398.5	249.2	261.2	492.3	1272.5	833.1	1037.9	812.2
LSD(0.05)		154.4	97.6	156.0	244.3	667.9	248.0	350.4	295.0

[a] Asterisks (*) indicates significant differences in clipping weight compared to the untreated plots (P = 0.05).

Appendix Table 11. Color ratings for OKS 95-1 in 1999 following POST herbicide treatments.

Herbicide	Rate[a]	Ratings by days after treatment							
		August				September			
		7	14[b]	21	28	7	14	21	28
	kg ha^{-1}	0 to 10 scale[d]							
Untreated		8.3	-	-	8.7	8.0	8.0	8.0	8.0
2,4-D + MCPP +dicamba	1.86	6.7*[c]	-	-	9.0	8.0	7.7	8.0	8.0
2,4-D + MCPP +dicamba	3.72	6.0*	-	-	9.0	8.0	7.3*	7.3*	7.7*
Triclopyr + clopyralid	0.84	5.7*	-	-	7.7	7.0*	5.7*	5.7*	6.3*
Triclopyr + clopyralid	1.68	4.3*	-	-	6.3*	7.0*	4.7*	4.7*	5.3*
Imazaquin	0.56	7.0*	-	-	9.0	8.0	8.0	8.0	8.0
Imazaquin	1.12	7.7	-	-	8.7	7.3	8.0	8.3	8.0
MSMA	3.39	8.3	-	-	9.0	7.7	8.0	8.0	8.0
MSMA	6.78	7.3	-	-	9.0	8.0	8.0	8.0	8.0
MSMA + metribuzin	3.39 + 3.36	7.7	-	-	9.0	7.7	8.0	8.0	8.0
MSMA + metribuzin	6.78 + 6.72	7.0*	-	-	8.7	6.7*	8.0	8.0	8.0
Metribuzin	10.48	6.3*	-	-	8.7	7.0*	7.3*	8.0	8.0
Metribuzin	20.96	4.7*	-	-	9.0	7.0*	7.3*	7.7	8.0
Pronamide	1.68	8.7	-	-	9.0	7.7	7.7	8.0	8.0
Pronamide	3.36	8.3	-	-	9.0	7.7	8.0	8.0	8.0
Halosulfuron	0.05	8.7	-	-	9.0	8.0	8.0	8.0	8.0
Halosulfuron	0.10	8.7	-	-	8.3	8.0	7.7	8.0	8.0
Bentazon	1.25	8.7	-	-	8.3	8.3	8.0	8.0	8.0
Bentazon	2.50	8.3	-	-	8.7	8.0	8.0	8.0	8.0
Quinclorac	0.84	8.0	-	-	9.0	7.3	8.0	8.0	8.0
Quinclorac	1.68	7.3	-	-	9.0	7.7	7.7	8.0	8.0
Diclofop-methyl	1.14	8.0	-	-	9.0	7.7	8.0	8.0	8.0
Diclofop-methyl	2.28	7.3	-	-	8.7	8.0	8.0	8.0	8.0
LSD(0.05)		1.3	-	-	1.0	0.9	0.5	0.4	0.3

[a] Treatments with metribuzin were applied at a higher than Federal labeled rate by human error in 1999.

[b] Color ratings at 14 and 21 DAT in the August 1999 experiment were incorrectly taken and were removed from the data set.

[c] Asterisks (*) indicates significant reductions in color compared to the untreated plots (P = 0.05).

[d] 0 to10 scale; 0 = very poor color, 10 = very high color.

Appendix Table 12. Color ratings for OKS 91-11 in 1999 following POST herbicide treatments.

		Ratings by days after treatment							
		August				September			
Herbicide	Rate[a]	7	14[b]	21	28	7	14	21	28
	kg ha^{-1}	0 to 10 scale[d]							
Untreated		8.7	-	-	7.3	8.0	8.0	8.0	8.0
2,4-D + MCPP +dicamba	1.86	6.7*[c]	-	-	7.7	7.3	7.7	7.7	8.0
2,4-D + MCPP +dicamba	3.72	5.7*	-	-	6.0*	6.3*	6.3*	6.7*	7.3*
Triclopyr + clopyralid	0.84	5.7*	-	-	7.0	6.7*	5.7*	5.7*	5.7*
Triclopyr + clopyralid	1.68	5.0*	-	-	4.0*	6.0*	5.3*	5.3*	5.3*
Imazaquin	0.56	6.7*	-	-	7.0	7.7	7.3*	7.3	8.0
Imazaquin	1.12	7.3	-	-	7.0	7.3	6.7*	7.3	7.3*
MSMA	3.39	7.3	-	-	8.0	7.7	8.0	8.0	8.0
MSMA	6.78	7.3	-	-	7.7	7.7	8.0	8.0	8.0
MSMA + metribuzin	3.39 + 3.36	6.3*	-	-	7.7	7.0*	8.0	7.7	8.0
MSMA + metribuzin	6.78 + 6.72	5.7*	-	-	7.7	6.7*	8.0	8.0	8.0
Metribuzin	10.48	5.7*	-	-	7.7	6.7*	7.7	7.3	8.0
Metribuzin	20.96	5.0*	-	-	7.7	5.7*	7.0*	8.0	8.0
Pronamide	1.68	7.3	-	-	8.3	8.0	7.7	8.0	8.0
Pronamide	3.36	9.0	-	-	8.0	8.0	7.7	7.7	8.0
Halosulfuron	0.05	8.7	-	-	8.0	8.0	8.0	8.0	8.0
Halosulfuron	0.10	9.0	-	-	8.0	8.0	8.0	8.0	8.0
Bentazon	1.25	8.7	-	-	8.0	8.0	8.0	8.0	8.0
Bentazon	2.50	9.0	-	-	8.0	8.0	8.0	8.0	8.0
Quinclorac	0.84	6.7*	-	-	7.7	7.0*	8.0	7.7	8.0
Quinclorac	1.68	6.3*	-	-	7.0	6.3*	7.3*	7.3	8.0
Diclofop-methyl	1.14	8.3	-	-	8.0	8.0	8.0	8.0	8.0
Diclofop-methyl	2.28	8.0	-	-	7.3	8.0	8.0	8.0	8.0
LSD(0.05)		1.3	-	-	1.0	0.7	0.6	0.7	0.4

[a] Treatments with metribuzin were applied at a higher than Federal labeled rate by human error in 1999.

[b] Color ratings at 14 and 21 DAT in the August 1999 experiment were incorrectly taken and were removed from the data set.

[c] Asterisks (*) indicates significant reductions in color compared to the untreated plots (P = 0.05).

[d] 0 to10 scale; 0 = very poor color, 10 = very high color.

Appendix Table 13. Quality ratings for OKS 95-1 in 1999 following POST herbicide treatments.

		Ratings by days after treatment							
		August				September			
Herbicide	Rate[a]	7	14	21	28	7	14	21	28
	kg ha^{-1}	0 to 10 scale[c]							
Untreated		8.3	8.3	9.0	9.0	8.0	8.0	8.3	8.0
2,4-D + MCPP +dicamba	1.86	6.7*[b]	7.0*	8.0	9.0	8.0	8.0	8.3	8.0
2,4-D + MCPP +dicamba	3.72	6.7*	6.7*	7.7*	8.7	8.0	8.0	7.3*	7.7
Triclopyr + clopyralid	0.84	6.0*	5.7*	5.7*	7.7*	7.7	5.7*	6.0*	6.7*
Triclopyr + clopyralid	1.68	4.7*	4.7*	4.3*	6.3*	7.3*	5.0*	5.0*	5.3*
Imazaquin	0.56	7.0*	8.0	9.0	9.0	8.3	8.0	8.7	8.0
Imazaquin	1.12	7.7	8.0	8.7	9.0	8.0	8.0	8.3	8.0
MSMA	3.39	8.3	8.7	9.0	9.0	8.0	8.0	8.0	8.0
MSMA	6.78	7.7	8.3	8.7	9.0	8.0	8.0	8.3	8.0
MSMA + metribuzin	3.39 + 3.36	7.7	8.3	9.0	9.0	8.3	8.0	8.0	8.0
MSMA + metribuzin	6.78 + 6.72	7.0*	7.3	8.7	8.7	7.7	8.0	8.0	8.0
Metribuzin	10.48	6.7*	7.0*	8.3	9.0	8.0	7.7*	8.0	8.0
Metribuzin	20.96	5.0*	6.0*	7.3*	9.0	8.0	8.0	7.7*	8.0
Pronamide	1.68	8.7	8.3	9.0	9.0	8.0	8.0	8.0	8.0
Pronamide	3.36	8.3	8.3	9.0	9.0	7.7	8.0	8.0	8.0
Halosulfuron	0.05	8.7	8.0	9.0	9.0	8.0	8.0	8.3	8.0
Halosulfuron	0.10	8.7	8.0	8.7	8.3	8.3	8.0	8.0	8.0
Bentazon	1.25	8.7	8.3	8.7	8.3	8.3	8.0	8.0	8.0
Bentazon	2.50	8.3	8.3	8.7	8.7	8.0	8.0	8.3	8.0
Quinclorac	0.84	8.0	8.3	9.0	9.0	8.0	8.0	8.0	8.0
Quinclorac	1.68	7.3	8.0	9.0	9.0	8.3	8.0	8.0	8.0
Diclofop-methyl	1.14	8.0	8.0	8.7	9.0	8.0	8.0	8.3	8.0
Diclofop-methyl	2.28	7.7	8.0	9.0	8.7	8.0	8.0	8.0	8.0
LSD(0.05)		1.1	1.1	1.0	1.0	0.6	0.3	0.6	0.3

[a] Treatments with metribuzin were applied at a higher than Federal labeled rate by human error in 1999.

[b] Asterisks (*) indicates significant reductions in quality compared to the untreated plots (P = 0.05).

[c] 0 to10 scale; 0 = very poor quality, 10 = very high quality.

Appendix Table 14. Quality ratings for OKS 91-11 in 1999 following POST herbicide treatments.

		Ratings by days after treatment							
		August				September			
Herbicide	Rate[a]	7	14	21	28	7	14	21	28
	kg ha^{-1}	0 to 10 scale[c]							
Untreated		8.7	8.0	7.7	7.7	8.0	8.0	8.0	8.0
2,4-D + MCPP +dicamba	1.86	7.0*[b]	6.7*	6.7	8.0	7.7	7.7	8.0	8.0
2,4-D + MCPP +dicamba	3.72	5.7*	5.3*	5.0*	6.0*	6.7*	7.0*	7.0*	7.3*
Triclopyr + clopyralid	0.84	6.3*	6.0*	5.3*	6.3*	7.0*	6.0*	6.0*	6.0*
Triclopyr + clopyralid	1.68	5.3*	4.3*	4.0*	4.3*	6.7*	5.7*	5.3*	5.3*
Imazaquin	0.56	7.3*	6.7*	7.3	7.0	7.7	7.7	7.3*	8.0
Imazaquin	1.12	7.0*	5.7*	6.3*	7.0	7.7	6.7*	7.3*	7.3*
MSMA	3.39	7.7*	6.7*	7.3	8.3	8.0	8.0	8.0	8.0
MSMA	6.78	7.3*	7.3	7.7	8.3	8.0	8.0	8.0	8.0
MSMA + metribuzin	3.39 + 3.36	6.7*	7.7	7.0	8.0	7.3*	8.0	7.7	8.0
MSMA + metribuzin	6.78 + 6.72	5.7*	6.3*	7.3	7.7	7.0*	8.0	8.0	8.0
Metribuzin	10.48	6.0*	6.7*	7.0	8.0	7.3*	8.0	7.3*	8.0
Metribuzin	20.96	5.0*	6.3*	6.3*	7.7	6.3*	8.0	8.0	8.0
Pronamide	1.68	7.7*	8.0	8.0	8.3	8.0	8.0	8.0	8.0
Pronamide	3.36	9.0	8.0	8.0	8.3	8.0	8.0	7.7	8.0
Halosulfuron	0.05	8.7	7.7	7.7	8.0	8.0	8.0	8.0	8.0
Halosulfuron	0.10	9.0	8.0	8.3	8.0	8.0	8.0	8.0	8.0
Bentazon	1.25	8.7	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Bentazon	2.50	9.0	8.0	8.0	8.7	8.0	8.0	8.0	8.0
Quinclorac	0.84	7.3*	7.7	7.7	8.3	7.3*	8.0	7.7	8.0
Quinclorac	1.68	7.0*	7.3	7.0	7.3	7.0*	8.0	7.3	8.0
Diclofop-methyl	1.14	8.7	8.0	8.3	8.0	8.0	8.0	8.0	8.0
Diclofop-methyl	2.28	8.3	7.3	7.7	7.7	8.0	8.0	7.7	8.0
LSD(0.05)		1.0	1.1	1.1	1.2	0.6	0.6	0.6	0.3

[a] Treatments with metribuzin were applied at a higher than Federal labeled rate by human error in 1999.

[b] Asterisks (*) indicates significant reductions in quality compared to the untreated plots (P = 0.05).

[c] 0 to10 scale; 0 = very poor quality, 10 = very high quality.

Appendix Table 15. **Phytotoxicity ratings for OKS 95-1 in 1999 following POST herbicide treatments.**

		Ratings by days after treatment							
		August				September			
Herbicide	Rate[a]	7	14	21	28	7	14	21	28
	kg ha^{-1}	0 to 10 scale[c]							
Untreated		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2,4-D + MCPP +dicamba	1.86	2.0*[b]	1.3	0.3	0.0	0.0	0.3	0.0	0.0
2,4-D + MCPP +dicamba	3.72	3.0*	3.0*	1.0*	0.0	0.0	0.7*	0.7*	0.3
Triclopyr + clopyralid	0.84	3.7*	5.3*	3.7*	1.3*	1.0*	4.3*	3.7*	2.0*
Triclopyr + clopyralid	1.68	5.3*	7.3*	5.7*	2.3*	1.3*	5.3*	5.3*	4.7*
Imazaquin	0.56	1.7*	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Imazaquin	1.12	1.0	0.7	0.0	0.0	0.7	0.0	0.0	0.0
MSMA	3.39	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0
MSMA	6.78	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSMA + metribuzin	3.39 + 3.36	0.7	0.3	0.0	0.0	0.7	0.0	0.0	0.0
MSMA + metribuzin	6.78 + 6.72	1.3	1.7*	0.3	0.0	1.7*	0.0	0.0	0.0
Metribuzin	10.48	2.3*	2.3*	0.3	0.0	1.0*	1.0*	0.0	0.0
Metribuzin	20.96	5.0*	3.3*	1.3*	0.0	1.0*	0.7*	0.3	0.0
Pronamide	1.68	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0
Pronamide	3.36	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Halosulfuron	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Halosulfuron	0.10	0.0	0.0	0.3	0.7	0.0	0.3	0.0	0.0
Bentazon	1.25	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Bentazon	2.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quinclorac	0.84	0.3	0.3	0.0	0.0	0.7	0.0	0.0	0.0
Quinclorac	1.68	1.0	0.3	0.0	0.0	0.7	0.3	0.0	0.0
Diclofop-methyl	1.14	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Diclofop-methyl	2.28	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSD(0.05)		1.5	1.7	0.8	1.1	0.7	0.6	0.6	0.4

[a] Treatments with metribuzin were applied at a higher than Federal labeled rate by human error in 1999.

[b] Asterisks (*) indicates significant differences in herbicide injury compared to the untreated plots (P = 0.05).

[c] 0 to10 scale; 0 = no phytotoxicity, 10 = highest degree of phytotoxicity.

Appendix Table 16. Phytotoxicity ratings for OKS 91-11 in 1999 following POST herbicide treatments.

		Ratings by days after treatment							
		August				September			
Herbicide	Rate[a]	7	14	21	28	7	14	21	28
	kg ha^{-1}	0 to 10 scale[c]							
Untreated		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2,4-D + MCPP +dicamba	1.86	1.7	2.3*	1.3	0.7	0.7	0.3	0.0	0.0
2,4-D + MCPP +dicamba	3.72	4.0*[b]	5.3*	4.0*	3.3*	2.0*	2.0*	1.3*	0.7*
Triclopyr + clopyralid	0.84	3.0*	4.7*	4.0*	1.7	1.3*	4.3*	4.0*	4.0*
Triclopyr + clopyralid	1.68	4.3*	6.0*	6.0*	6.0*	2.7*	4.0*	4.3*	4.7*
Imazaquin	0.56	1.0	1.7*	1.3	1.7	0.3	0.7	0.7	0.0
Imazaquin	1.12	2.0*	3.7*	2.7*	1.7	0.7	1.7*	0.7	0.7*
MSMA	3.39	0.7	1.7*	0.7	0.0	0.3	0.0	0.0	0.0
MSMA	6.78	1.7	1.3	0.7	0.3	0.3	0.0	0.0	0.0
MSMA + metribuzin	3.39 + 3.36	2.7*	1.3	1.3	0.7	1.0	0.0	0.3	0.0
MSMA + metribuzin	6.78 + 6.72	3.7*	1.7*	0.7	0.7	1.7*	0.0	0.0	0.0
Metribuzin	10.48	3.7*	2.7*	1.0	1.3	1.7*	0.3	0.7	0.0
Metribuzin	20.96	4.7*	3.0*	2.0*	0.7	3.7*	1.0*	0.0	0.0
Pronamide	1.68	0.7	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Pronamide	3.36	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Halosulfuron	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Halosulfuron	0.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bentazon	1.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bentazon	2.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quinclorac	0.84	1.7	1.3	0.3	0.7	1.3*	0.0	0.3	0.0
Quinclorac	1.68	2.3*	1.3	1.3	2.0*	2.0*	0.7	0.7	0.0
Diclofop-methyl	1.14	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Diclofop-methyl	2.28	0.7	1.0	0.3	1.3	0.0	0.0	0.0	0.0
LSD(0.05)		1.7	1.6	1.6	1.9	1.1	0.9	0.7	0.5

[a] Treatments with metribuzin were applied at a higher than Federal labeled rate by human error in 1999.

[b] Asterisks (*) indicates significant differences in herbicide injury compared to the untreated plots (P = 0.05).

[c] 0 to10 scale; 0 = no phytotoxicity, 10 = highest degree of phytotoxicity.

Appendix Table 17. Wet clipping matter produced by OKS 95-1 in 1999 following POST herbicide treatments.

		Yield by days after treatment							
		August				September			
Herbicide	Rate[a]	7	14	21	28	7	14	21[c]	28
	kg ha^{-1}	kg ha^{-1}							
Untreated		347.6	253.7	442.3	826.0	1004.2	338.5	-	226.8
2,4-D + MCPP +dicamba	1.86	101.7*[b]	106.4	212.7	373.1*	696.9	308.0	-	251.6
2,4-D + MCPP +dicamba	3.72	83.6*	79.5*	161.6*	310.9*	541.0	225.8	-	169.5
Triclopyr + clopyralid	0.84	53.7*	48.2*	104.3*	305.2*	508.5	83.1*	-	123.9
Triclopyr + clopyralid	1.68	53.9*	25.8*	54.9*	172.9*	412.9*	41.1*	-	79.8*
Imazaquin	0.56	185.7	288.4	650.7	1214.5	537.2	175.9	-	193.7
Imazaquin	1.12	104.1*	166.0	402.0	914.5	684.7	271.1	-	350.0
MSMA	3.39	454.4	371.8	514.7	751.5	907.0	379.9	-	235.9
MSMA	6.78	406.3	406.8	519.9	594.9	1214.7	508.7	-	260.3
MSMA + metribuzin	3.39 + 3.36	401.8	317.5	435.7	605.8	1333.4	349.6	-	309.3
MSMA + metribuzin	6.78 + 6.72	364.8	327.7	448.5	635.1	894.3	292.8	-	144.7
Metribuzin	10.48	299.8	199.4	303.4	636.3	1045.4	280.9	-	177.3
Metribuzin	20.96	215.3	169.9	287.8	465.1	1158.9	417.2	-	188.1
Pronamide	1.68	483.2	343.8	548.1	844.8	926.9	308.4	-	178.8
Pronamide	3.36	438.3	378.7	626.0	904.9	720.5	300.6	-	190.3
Halosulfuron	0.05	336.3	351.9	464.5	746.8	778.8	284.6	-	190.1
Halosulfuron	0.10	362.3	226.4	323.9	511.0	1195.5	308.5	-	211.6
Bentazon	1.25	279.2	167.4	292.0	430.1	1053.9	305.3	-	164.6
Bentazon	2.50	354.7	238.0	405.7	690.7	1180.0	367.7	-	279.1
Quinclorac	0.84	297.6	273.4	513.8	715.4	813.2	292.4	-	166.4
Quinclorac	1.68	201.0	181.8	351.2	621.6	702.5	326.2	-	180.9
Diclofop-methyl	1.14	492.0	315.3	436.5	649.1	790.0	299.0	-	154.4
Diclofop-methyl	2.28	352.9	262.7	349.2	509.6	876.7	274.7	-	164.9
LSD(0.05)		163.8	173.4	250.3	389.7	536.4	183.0	-	138.0

[a] Treatments with metribuzin were applied at a higher than Federal labeled rate by human error in 1999.

[b] Asterisks (*) indicates significant differences in clipping weight compared to the untreated plots (P = 0.05).

[c] Clippings not taken at 21 DAT during the September experiment due to inclement weather.

Appendix Table 18. Wet clipping matter produced by OKS 91-11 in 1999 following POST herbicide treaments.

		Yield by days after treatment							
		August				September			
Herbicide	Rate[a]	7	14	21	28	7	14	21[c]	28
	kg ha^{-1}	kg ha^{-1}							
Untreated		329.3	232.2	357.3	582.5	678.4	244.4	-	130.2
2,4-D + MCPP +dicamba	1.86	107.2*[b]	83.3*	175.2	413.8	416.3	193.4	-	112.2
2,4-D + MCPP +dicamba	3.72	95.9*	50.0*	70.8*	149.5*	339.4*	167.1	-	101.0
Triclopyr + clopyralid	0.84	66.7*	48.4*	70.8*	165.2*	310.1*	74.0*	-	56.0*
Triclopyr + clopyralid	1.68	59.3*	21.4*	14.0*	18.8*	188.1*	35.9*	-	40.4*
Imazaquin	0.56	45.6*	56.8*	186.2	449.5	230.8*	96.7*	-	126.1
Imazaquin	1.12	36.8*	19.9*	91.1*	408.8	158.6*	36.6*	-	53.5*
MSMA	3.39	253.4	250.2	373.6	531.1	423.7	219.2	-	95.7
MSMA	6.78	280.1	222.2	296.1	450.3	680.9	324.6	-	164.8
MSMA + metribuzin	3.39 + 3.36	238.2	222.6	279.2	324.3	579.3	274.0	-	110.8
MSMA + metribuzin	6.78 + 6.72	201.8	126.2	196.8	400.2	443.7	172.5	-	68.3
Metribuzin	10.48	240.6	111.2*	177.8	419.5	654.2	265.9	-	119.2
Metribuzin	20.96	184.7	98.6*	113.1*	309.5	373.4*	185.5	-	57.4*
Pronamide	1.68	321.7	225.9	350.8	583.1	552.7	206.3	-	98.9
Pronamide	3.36	394.6	236.1	423.5	735.7	561.0	292.3	-	152.0
Halosulfuron	0.05	222.2	205.7	324.4	491.1	348.7*	148.0	-	54.1*
Halosulfuron	0.10	452.2	251.1	404.6	731.7	729.7	315.6	-	166.8
Bentazon	1.25	266.1	186.3	320.6	499.8	654.1	243.1	-	139.7
Bentazon	2.50	320.3	218.6	418.9	684.1	620.6	299.8	-	167.8
Quinclorac	0.84	291.6	220.1	322.7	528.3	774.9	377.9*	-	179.5
Quinclorac	1.68	220.1	201.3	238.6	398.3	476.7	297.7	-	164.3
Diclofop-methyl	1.14	423.8	220.9	437.7	667.9	807.3	257.6	-	156.7
Diclofop-methyl	2.28	353.4	213.2	323.2	538.2	573.6	222.9	-	104.0
LSD(0.05)		180.8	117.9	197.2	313.6	264.0	109.7	-	72.0

[a] Treatments with metribuzin were applied at a higher than Federal labeled rate by human error in 1999.

[b] Asterisks (*) indicates significant differences clipping weight compared to the untreated plots (P = 0.05).

[c] Clippings not taken at 21 DAT during the September experiment due to weather.

Appendix Table 19. Dry clipping matter produced by OKS 95-1 in 1999 following POST herbicide treatments.

		Yield by days after treatment							
		August				September			
Herbicide	Rate[a]	7	14	21	28	7	14	21[c]	28
	kg ha^{-1}	kg ha^{-1}							
Untreated		125.4	88.2	135.7	256.0	315.9	113.1	-	81.6
2,4-D + MCPP +dicamba	1.86	39.0*[b]	36.5*	68.9	125.0*	294.2	99.4	-	89.1
2,4-D + MCPP +dicamba	3.72	31.5*	23.6*	48.5*	98.0*	236.7	75.8	-	56.6
Triclopyr + clopyralid	0.84	20.6*	13.2*	29.3*	87.3*	194.2	34.5*	-	38.0
Triclopyr + clopyralid	1.68	23.4*	5.5*	13.1*	49.3*	169.3	19.6*	-	27.3*
Imazaquin	0.56	62.5*	89.2	180.1	370.1*	191.2	58.3	-	69.4
Imazaquin	1.12	35.7*	40.3	122.7	280.3	175.8	88.1	-	123.7
MSMA	3.39	160.7	121.4	158.9	220.9	365.3	130.5	-	77.6
MSMA	6.78	143.3	128.6	158.7	176.7	376.0	157.9	-	87.1
MSMA + metribuzin	3.39 + 3.36	149.0	102.0	132.3	195.7	416.1	128.8	-	110.4
MSMA + metribuzin	6.78 + 6.72	135.3	103.7	134.1	196.3	279.8	94.1	-	47.3
Metribuzin	10.48	106.8	63.7	92.1	196.5	354.8	89.1	-	62.8
Metribuzin	20.96	78.8	54.8	74.3	148.3	451.9	130.5	-	60.6
Pronamide	1.68	194.1	118.1	167.8	267.2	304.8	106.5	-	60.2
Pronamide	3.36	136.0	125.5	189.5	283.4	248.5	104.0	-	67.6
Halosulfuron	0.05	137.5	85.0	142.8	241.7	301.3	106.4	-	62.6
Halosulfuron	0.10	140.2	78.7	100.4	167.0	383.2	108.8	-	72.6
Bentazon	1.25	105.0	59.1	89.8	145.3	396.3	110.8	-	61.7
Bentazon	2.50	133.0	84.0	122.7	202.0	403.0	127.6	-	98.3
Quinclorac	0.84	118.8	90.8	157.9	221.1	266.5	103.1	-	57.7
Quinclorac	1.68	77.2	62.4	111.7	199.0	275.6	113.0	-	60.0
Diclofop-methyl	1.14	193.0	108.2	138.4	211.4	271.4	99.3	-	53.8
Diclofop-methyl	2.28	145.2	87.8	110.3	169.5	321.1	97.8	-	52.2
LSD(0.05)		61.9	51.3	75.5	110.1	192.2	57.5	-	50.1

[a] Treatments with metribuzin were applied at a higher than Federal labeled rate by human error in 1999.

[b] Asterisks (*) indicates significant differences in clipping weight compared to the untreated plots (P = 0.05).

[c] Clippings not taken at 21 DAT during the September experiment due to weather.

Appendix Table 20. Dry clipping matter produced by OKS 91-11 in 1999 following POST herbicide treatments.

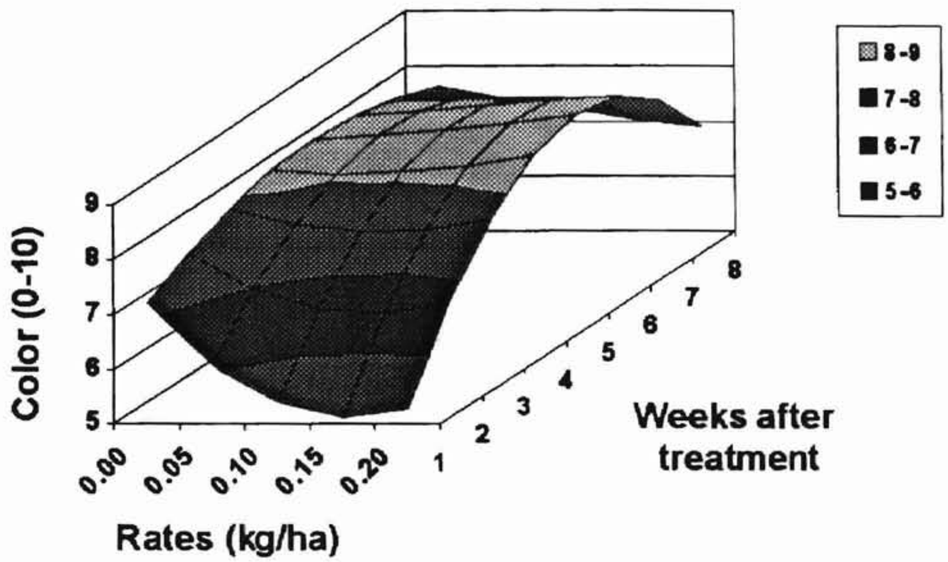
		Yield by days after treatment							
		August				September			
Herbicide	Rate[a]	7	14	21	28	7	14	21[c]	28
	kg ha^{-1}	kg ha^{-1}							
Untreated		122.7	76.6	104.8	170.6	234.3	84.1	-	44.4
2,4-D + MCPP +dicamba	1.86	34.8*[b]	25.0*	48.0*	121.7	147.7	67.4	-	33.2
2,4-D + MCPP +dicamba	3.72	33.1*	10.2*	9.2*	37.4*	127.1*	56.7	-	30.1
Triclopyr + clopyralid	0.84	22.1*	9.8*	16.0*	43.7*	109.5*	27.2*	-	11.8*
Triclopyr + clopyralid	1.68	20.0*	3.9*	0.3*	4.0*	68.6*	13.7*	-	6.4*
Imazaquin	0.56	10.5*	13.5*	48.9	129.1	73.1*	30.5*	-	37.7
Imazaquin	1.12	9.7*	5.1*	24.9*	118.1	60.0*	14.4*	-	14.6*
MSMA	3.39	78.1	72.2	106.5	130.4	143.3	74.9	-	29.5
MSMA	6.78	35.6	65.5	82.6	124.0	224.1	102.1	-	52.6
MSMA + metribuzin	3.39 + 3.36	72.8	63.3	77.9	94.4	198.9	84.6	-	39.0
MSMA + metribuzin	6.78 + 6.72	68.3	34.3*	50.6	112.2	132.0	55.8	-	21.9
Metribuzin	10.48	79.0	29.2*	50.5	121.0	216.7	86.9	-	39.7
Metribuzin	20.96	61.9	25.2*	28.1*	90.8	132.7	61.5	-	15.7*
Pronamide	1.68	101.3	68.2	100.0	171.1	172.3	74.5	-	34.0
Pronamide	3.36	133.1	76.2	125.5	222.3	174.6	96.8	-	55.4
Halosulfuron	0.05	76.3	64.2	98.4	153.5	108.8*	57.2	-	15.8
Halosulfuron	0.10	154.4	81.6	119.3	218.7	284.3	109.3	-	53.3
Bentazon	1.25	95.8	58.1	90.0	150.5	240.1	88.1	-	47.9
Bentazon	2.50	116.3	69.8	120.8	206.9	204.5	102.2	-	58.8
Quinclorac	0.84	114.8	74.1	101.9	156.9	261.4	125.6*	-	67.3
Quinclorac	1.68	80.7	55.9	73.4	118.4	153.3	94.94	-	45.8
Diclofop-methyl	1.14	137.5	68.7	123.4	193.8	270.3	94.85	-	53.9
Diclofop-methyl	2.28	126.6	67.7	97.8	162.4	216.4	79.2	-	34.4
LSD(0.05)		67.0	38.4	56.6	89.4	105.7	33.8	-	26.4

[a] Treatments with metribuzin were applied at a higher than Federal labeled rate by human error in 1999.

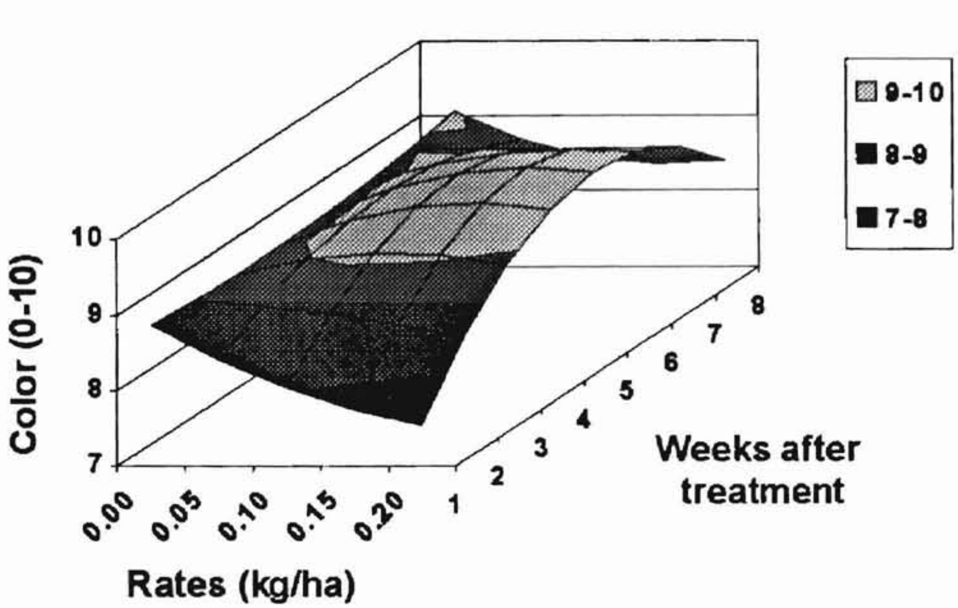
[b] Asterisks (*) indicates significant differences in clipping weight compared to the untreated plots (P = 0.05).

[c] Clippings not taken at 21 DAT during the September experiment due to weather.

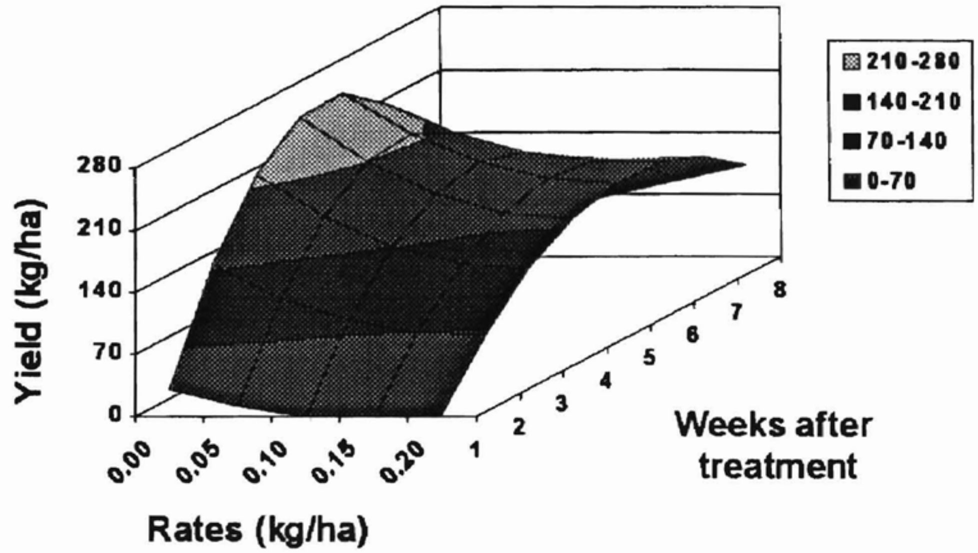
Appendix Figure 13. Response surface for color ratings as a function of trinexapac-ethyl rate and rating date in the simulated fairway experiment conducted on OKS 91-11 during 1999. Graph was generated using the equation: Color = 6.68 + 0.60 Date (D) - 0.06 D^2 - 40.77 Rate (Rt) + 122.74 Rt^2 + 14.95 D*Rt + 2.98 D^2*Rt^2 - 38.57 D*Rt^2 - 1.30 D^2*Rt. R^2 = 0.94. ***.



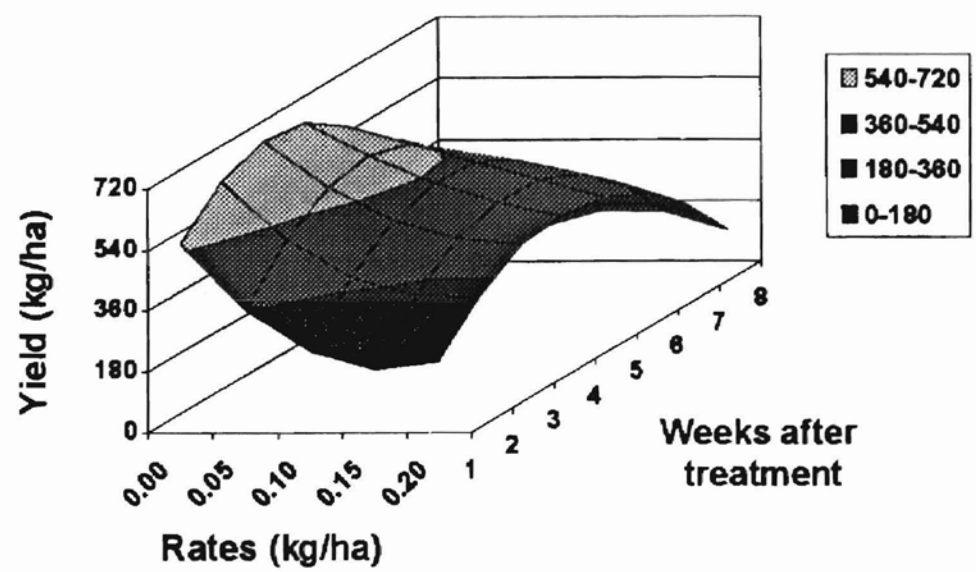
Appendix Figure 14. Response surface for color ratings as a function of trinexapac-ethyl rate and rating date in the simulated fairway experiment conducted on OKS 91-11 during 2000. Graph was generated using the equation: Color = 8.94 - 0.09 Date (D) + 0.01 D^2 - 21.75 Rate (Rt) + 48.21 Rt^2 + 13.24 D*Rt + 4.17 D^2*Rt^2 - 35.71 D*Rt^2 - 1.46 D^2*Rt. R^2 = 0.87. ***.



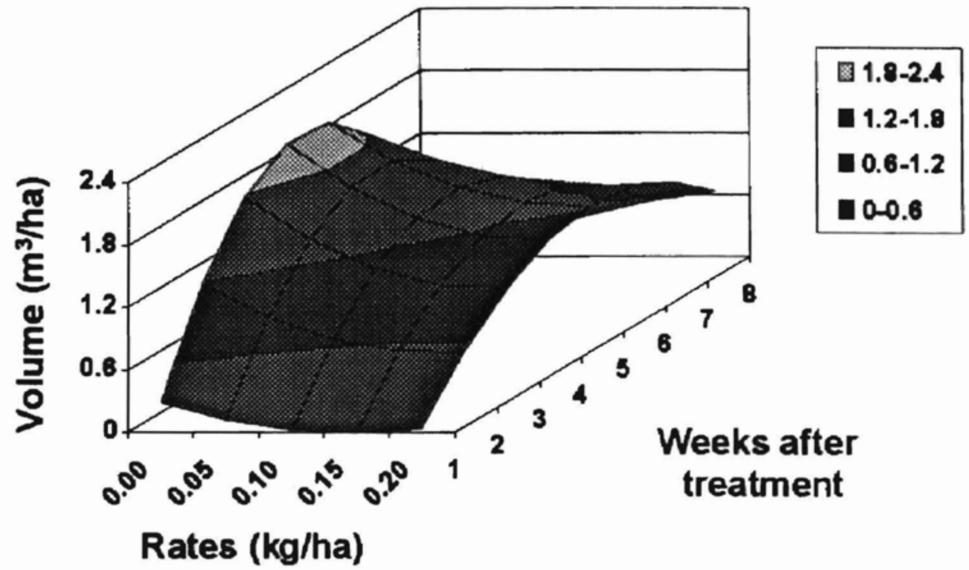
Appendix Figure 15. Response surface for wet clipping yield as a function of trinexapac-ethyl rate and sampling date in the simulated fairway experiment conducted on OKS 91-11 during 1999. Graph was generated using the equation: Yield = - 121.03 + 171.23 Date (D) - 18.96 D^2 + 106.06 Rate (Rt) + 523.30 Rt^2 - 655.79 D*Rt - 163.05 D^2*Rt^2 + 1237.93 D*Rt^2 + 85.69 D^2*Rt. R^2 = 0.88. ***.



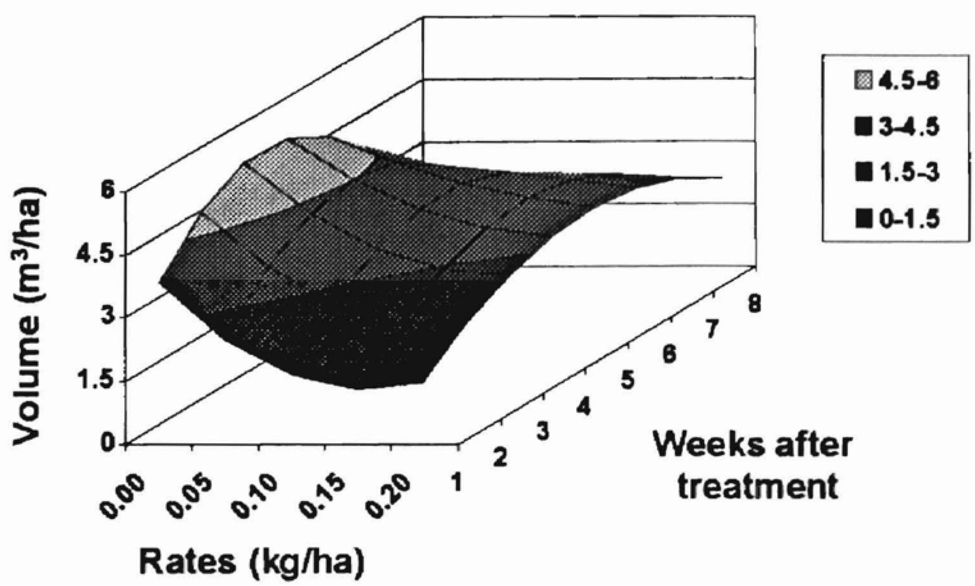
Appendix Figure 16. Response surface for wet clipping yield as a function of trinexapac-ethyl rate and sampling date in the simulated fairway experiment conducted on OKS 91-11 during 1999. Graph was generated using the equation: Yield = 386.79 + 204.91 Date (D) - 31.79 D^2 - 5337.33 Rate (Rt) + 18279.00 Rt^2 + 611.13 D*Rt + 78.64 D^2*Rt^2 - 3732.23 D*Rt^2 + 49.26 D^2*Rt. R^2 = 0.92. ***.



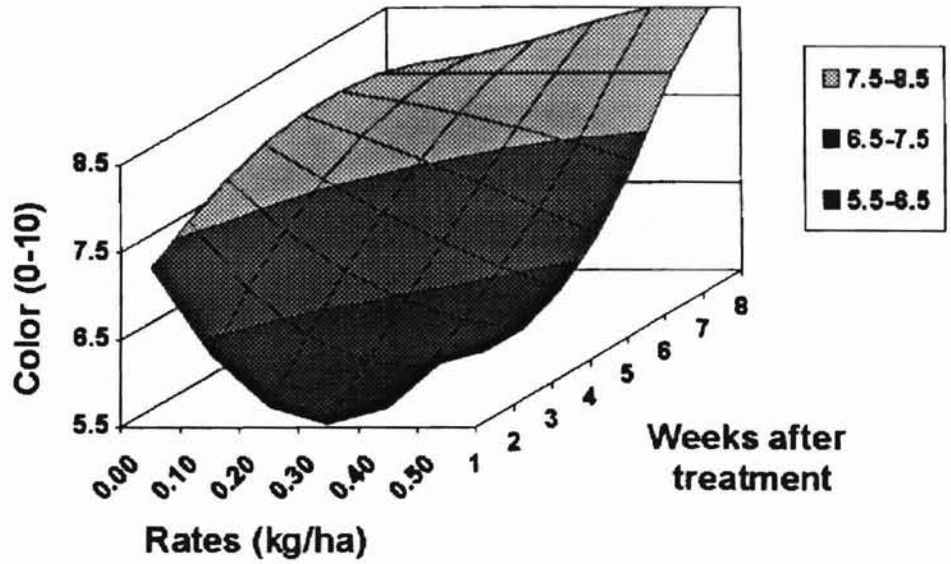
Appendix Figure 17. Response surface for fresh clipping volumes as a function of trinexapac-ethyl rate and sampling date in the simulated fairway experiment conducted on OKS 91-11 during 1999. Graph was generated using the equation: Volume = $-0.93 + 1.37$ Date (D) $- 0.16 D^2 + 0.90$ Rate (Rt) $- 3.51 Rt^2 - 5.71 D{*}Rt - 1.69 D^2{*}Rt^2 + 12.11 D{*}Rt^2 + 0.77 D^2{*}Rt$. $R^2 = 0.81$. **.



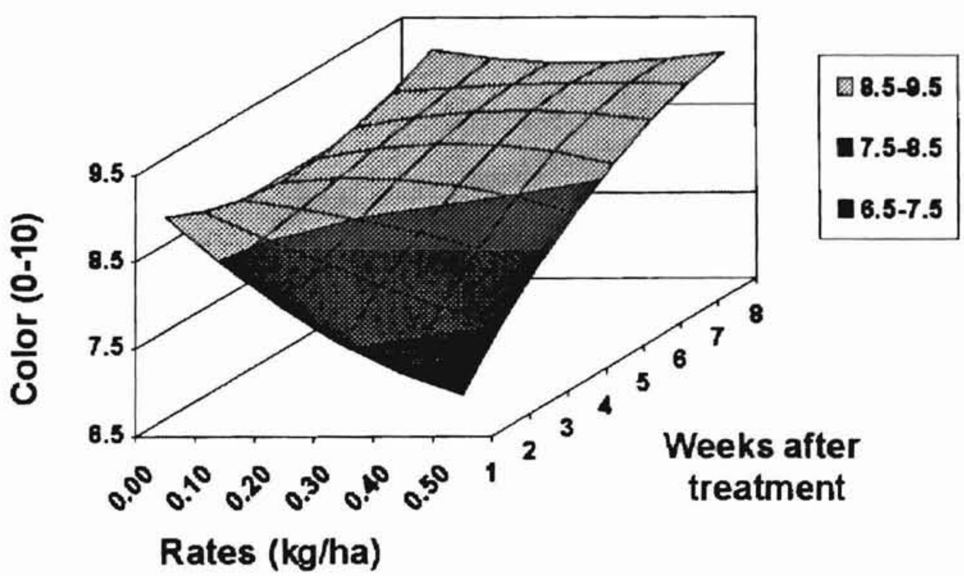
Appendix Figure 18. Response surface for fresh clipping volumes as a function of trinexapac-ethyl rate and sampling date in the simulated fairway experiment conducted on OKS 91-11 during 2000. Graph was generated using the equation: Volume = $2.14 + 1.95$ Date (D) $- 0.28 D^2 - 30.48$ Rate (Rt) $+ 110.51 Rt^2 - 2.52 D{*}Rt - 1.80 D^2{*}Rt^2 - 8.00 D{*}Rt^2 + 1.18 D^2{*}Rt$. $R^2 = 0.93$. ***.



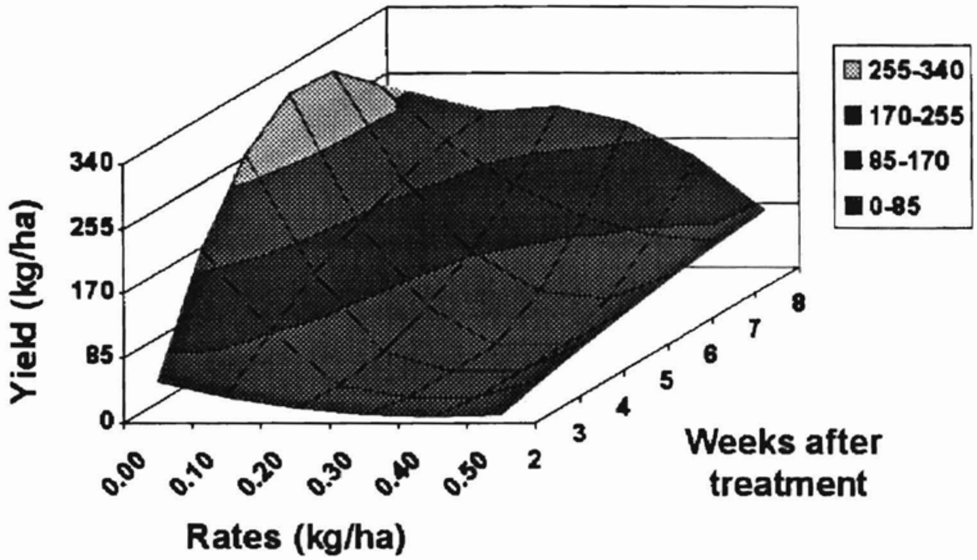
Appendix Figure 19. Response surface for color ratings as a function of trinexapac-ethyl rate and rating date in the simulated lawn experiment conducted on OKS 91-11 during 1999. Graph was generated using the equation: Color = 6.96 + 0.40 Date (D) - 0.04 D^2 - 15.08 Rate (Rt) + 29.17 Rt^2 + 3.45 D*Rt + 0.89 D^2*Rt^2 - 10.42 D*Rt^2 - 0.18 D^2*Rt. R^2 = 0.97. ***.



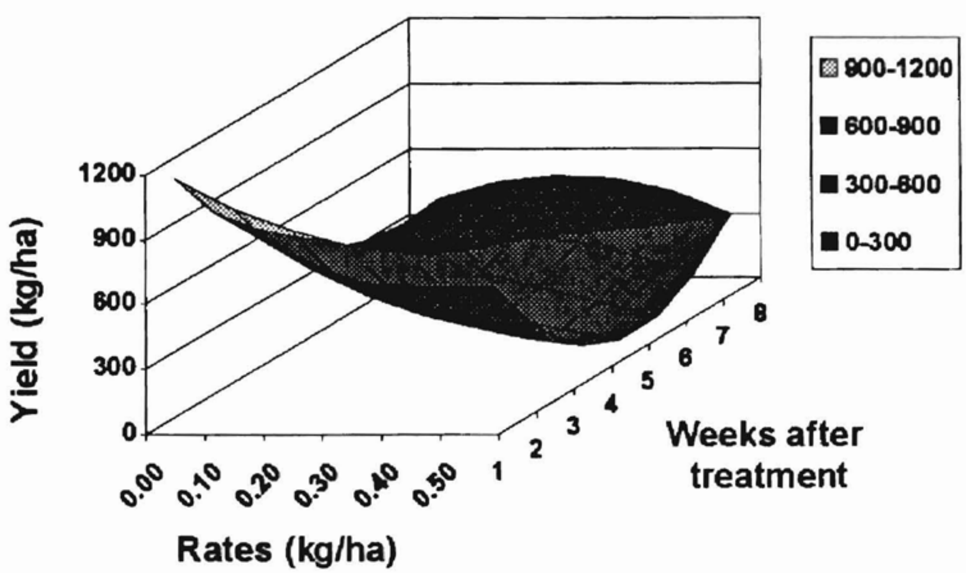
Appendix Figure 20. Response surface for color ratings as a function of trinexapac-ethyl rate and rating date in the simulated lawn experiment conducted on OKS 91-11 during 2000. Graph was generated using the equation: Color = 9.28 - 0.29 Date (D) + 0.03 D^2 - 10.13 Rate (Rt) + 8.76 Rt^2 + 4.30 D*Rt + 0.52 D^2*Rt^2 - 5.00 D*Rt^2 - 0.40 D^2*Rt. R^2 = 0.92. ***.



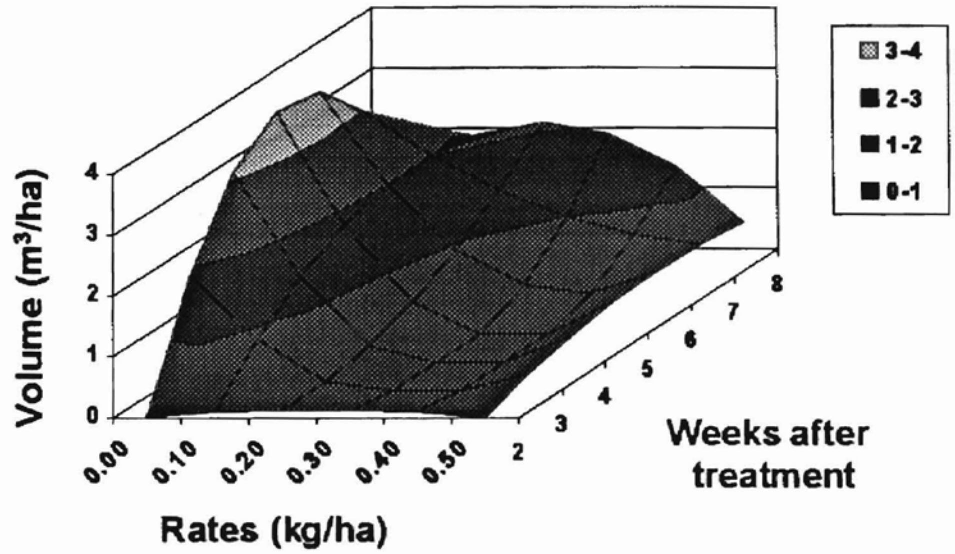
Appendix Figure 21. Response surface for wet clipping yield as a function of trinexapac-ethyl rate and sampling date in the simulated lawn experiment conducted on OKS 91-11 during 1999. Graph was generated using the equation: Yield = - 366.95 + 258.19 Date (D) - 23.79 D^2 + 3184.34 Rate (Rt) - 4986.33 Rt^2 - 2160.78 D*Rt - 361.75 D^2*Rt^2 + 3361.82 D*Rt^2 + 226.94 D^2*Rt. $R^2 = 0.91$. ***.



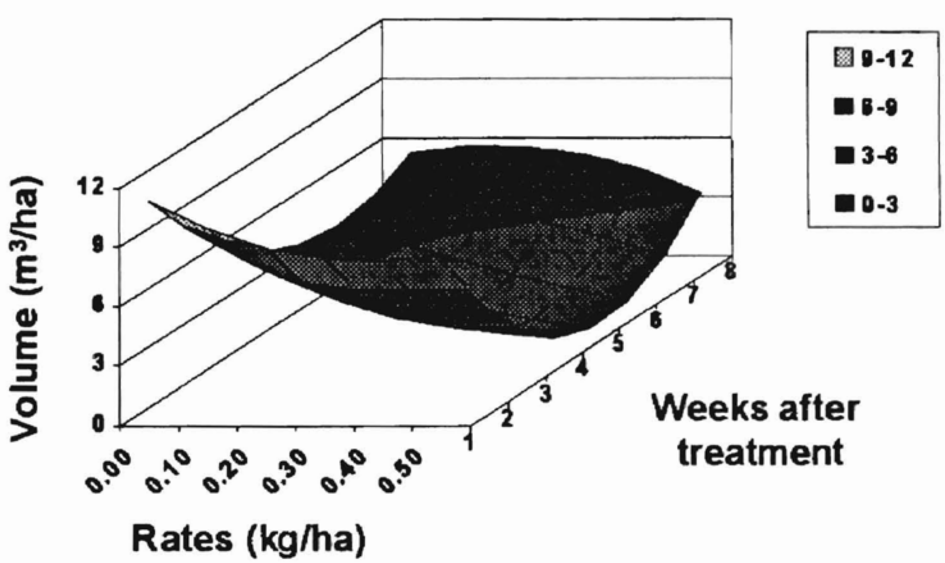
Appendix Figure 22. Response surface for wet clipping yield as a function of trinexapac-ethyl rate and sampling date in the simulated lawn experiment conducted on OKS 91-11 during 2000. Graph was generated using the equation: Yield = 1482.08 - 320.17 Date (D) + 22.73 D^2 - 1096.08 Rate (Rt) + 1318.26 Rt^2 - 559.01 D*Rt - 124.45 D^2*Rt^2 + 549.37 D*Rt^2 + 102.25 D^2*Rt. $R^2 = 0.91$. ***.



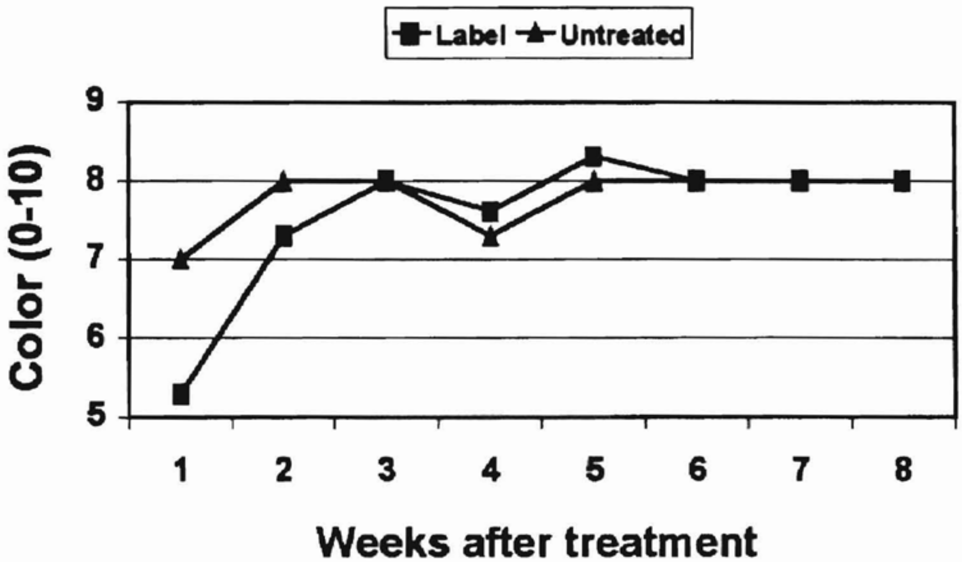
Appendix Figure 23. Response surface for fresh clipping volume as a function of trinexapac-ethyl rate and sampling date in the simulated lawn experiment conducted on OKS 91-11 during 1999. Graph was generated using the equation: Volume = - 5.73 + 3.54 Date (D) - 0.33 D^2 + 45.46 Rate (Rt) - 70.60 Rt^2 - 28.06 D*Rt - 4.64 D^2*Rt^2 + 43.54 D*Rt^2 + 2.92 D^2*Rt. R^2 = 0.92. ***.



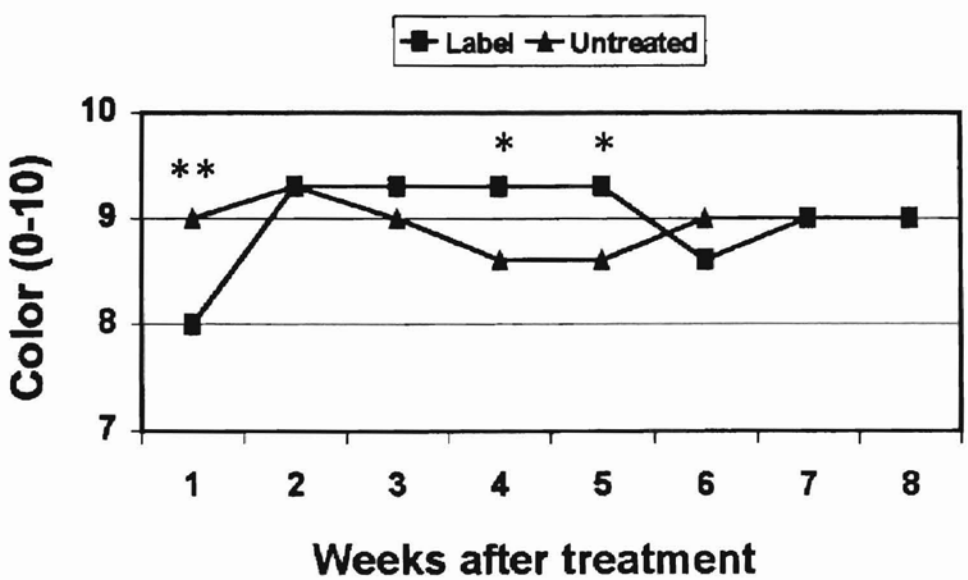
Appendix Figure 24. Response surface for fresht clipping volume as a function of trinexapac-ethyl rate and sampling date in the simulated lawn experiment conducted on OKS 91-11 during 2000. Graph was generated using the equation: Volume = 14.65 - 3.59 Date (D) + 0.30 D^2 - 13.25 Rate (Rt) + 20.69 Rt^2 - 3.95 D*Rt - 0.89 D^2*Rt^2 + 2.21 D*Rt^2 + 0.78 D^2*Rt. R^2 = 0.92. ***.



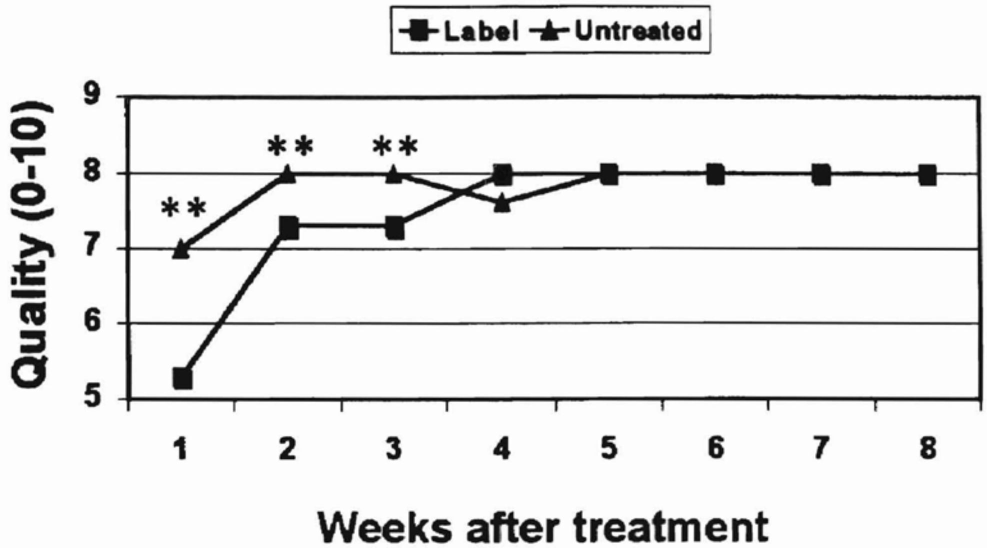
Appendix Figure 25. Untreated and 1x labeled rate treatment contrast for color ratings from the simulated fairway experiment conducted on OKS 91-11 in 1999. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



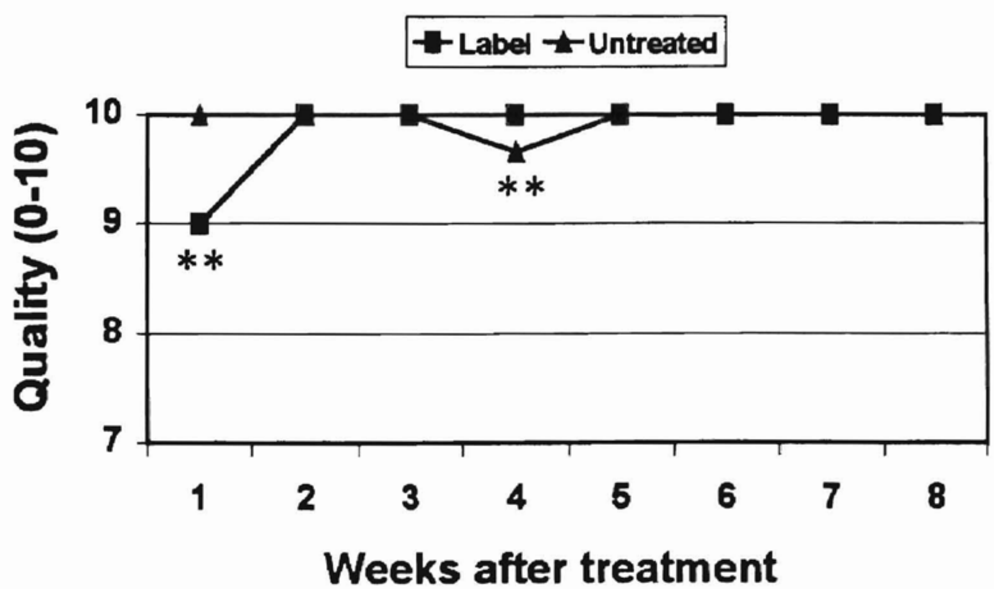
Appendix Figure 26. Untreated and 1x labeled rate treatment contrast for color ratings from the simulated fairway experiment conducted on OKS 91-11 in 2000. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



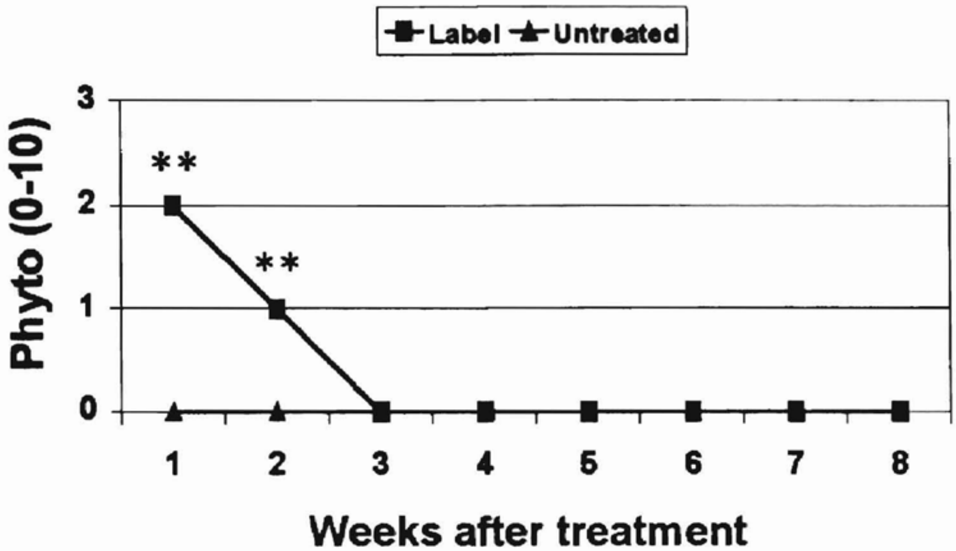
Appendix Figure 27. Untreated and 1x labeled rate treatment contrast for quality ratings from the simulated fairway experiment conducted on OKS 91-11 in 1999. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



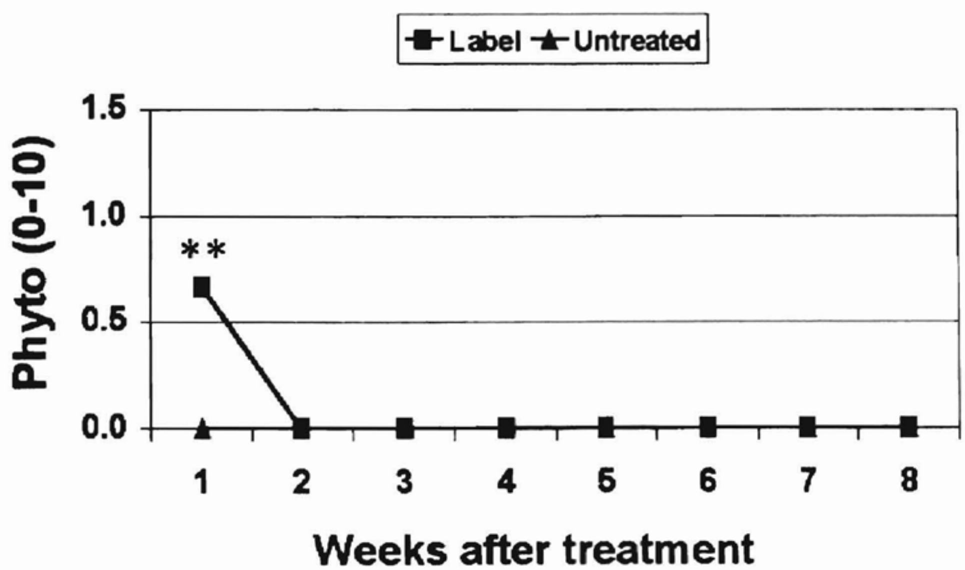
Appendix Figure 28. Untreated and 1x labeled rate treatment contrast for quality ratings from the simulated fairway experiment conducted on OKS 91-11 in 2000. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



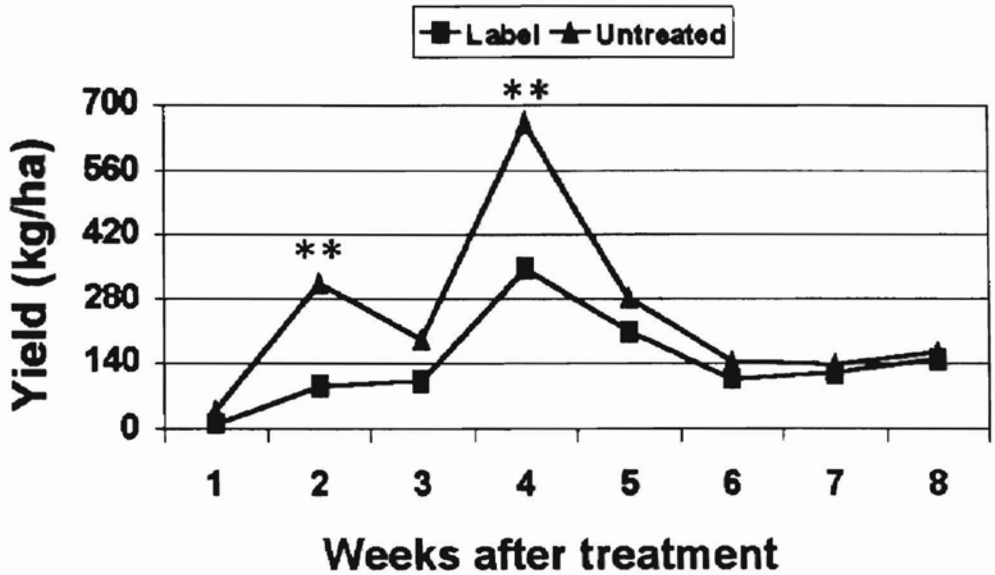
Appendix Figure 29. Untreated and 1x labeled rate treatment contrast for phytotoxicity ratings from the simulated fairway experiment conducted on OKS 91-11 in 1999. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



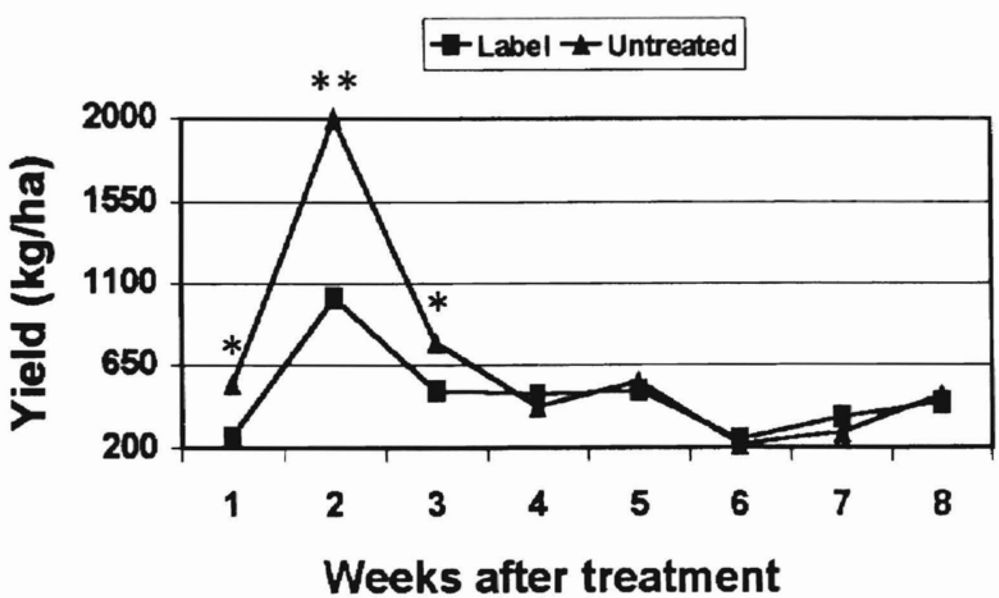
Appendix Figure 30. Untreated and 1x labeled rate treatment contrast for phytotoxicity ratings from the simulated fairway experiment conducted on OKS 91-11 in 2000. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



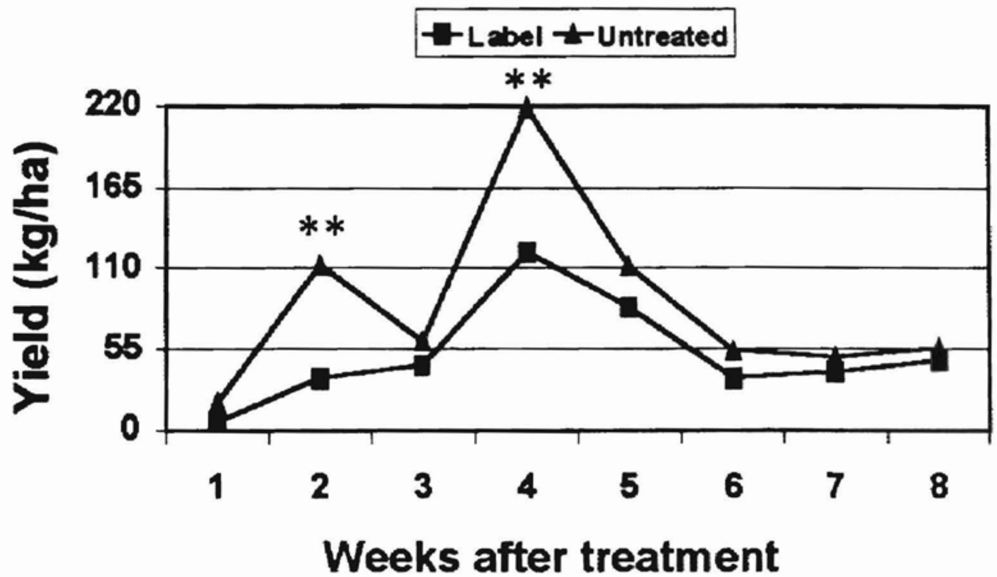
Appendix Figure 31. Untreated and 1x labeled rate treatment contrast for wet clipping yield from the simulated fairway experiment conducted on OKS 91-11 in 1999. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



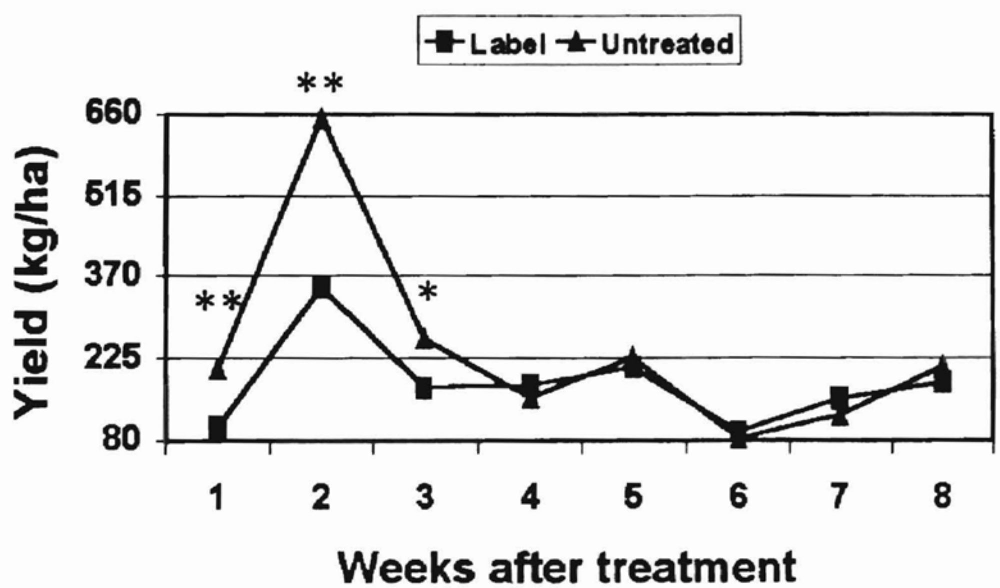
Appendix Figure 32. Untreated and 1x labeled rate treatment contrast for wet clipping yield from the simulated fairway experiment conducted on OKS 91-11 in 2000. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



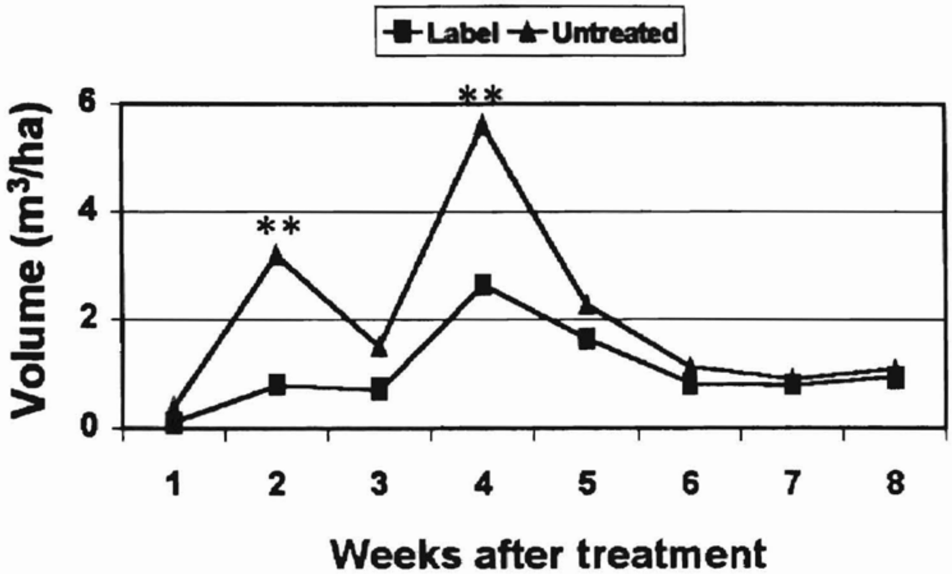
Appendix Figure 33. Untreated and 1x labeled rate treatment contrast for dry clipping yield from the simulated fairway experiment conducted on OKS 91-11 in 1999. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



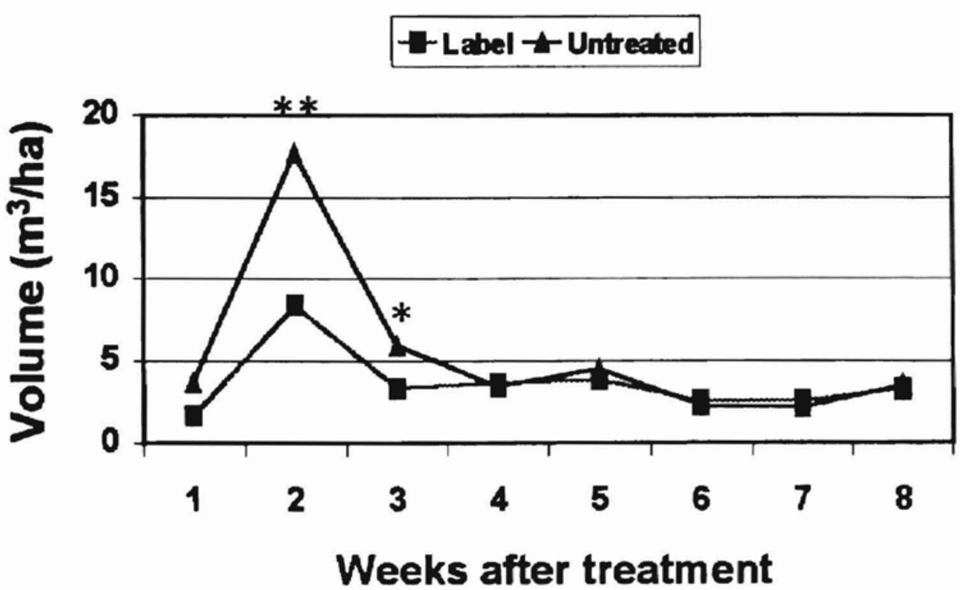
Appendix Figure 34. Untreated and 1x labeled rate treatment contrast for dry clipping yield from the simulated fairway experiment conducted on OKS 91-11 in 2000. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



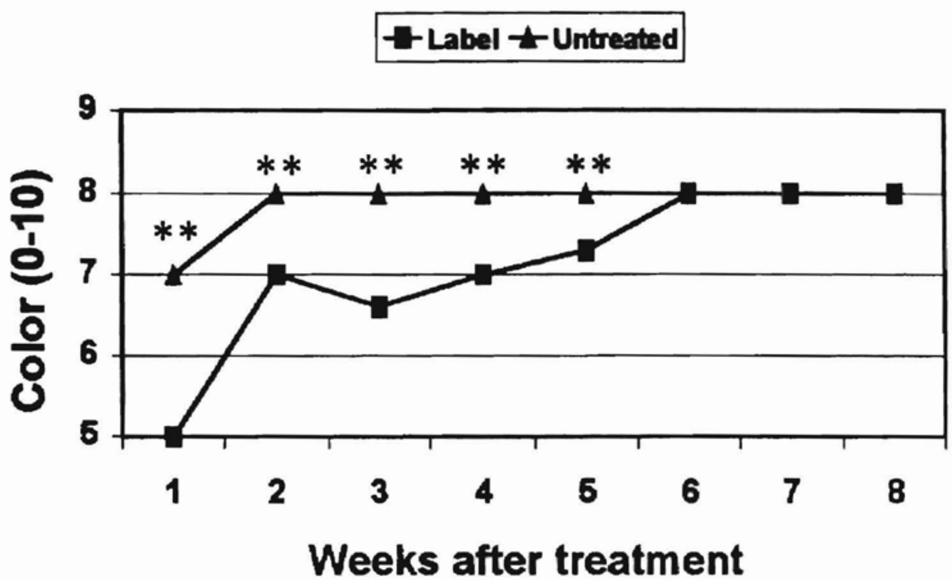
Appendix Figure 35. Untreated and 1x labeled rate treatment contrast for clipping volume from the simulated fairway experiment conducted on OKS 91-11 in 1999. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



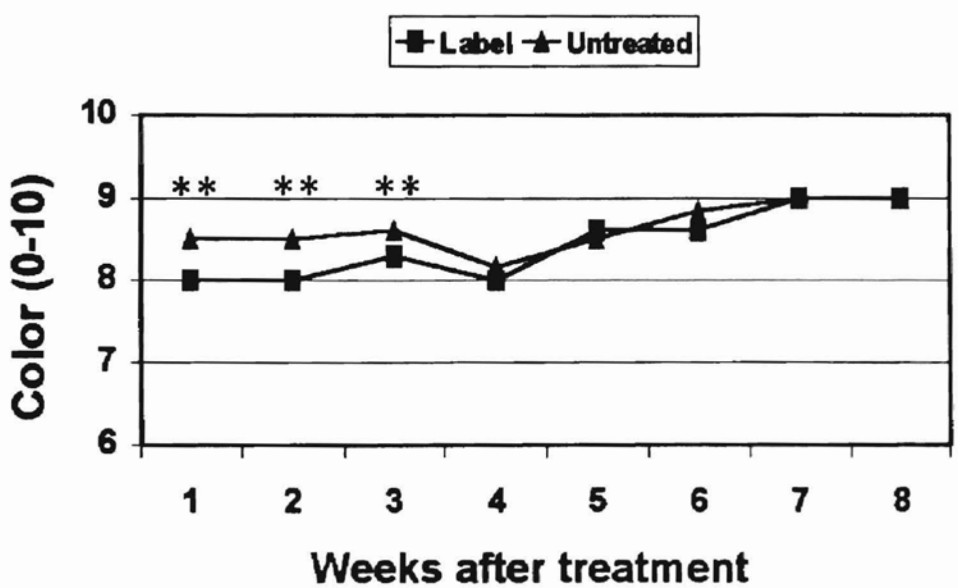
Appendix Figure 36. Untreated and 1x labeled rate treatment contrast for clipping volume from the simulated fairway experiment conducted on OKS 91-11 in 1999. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



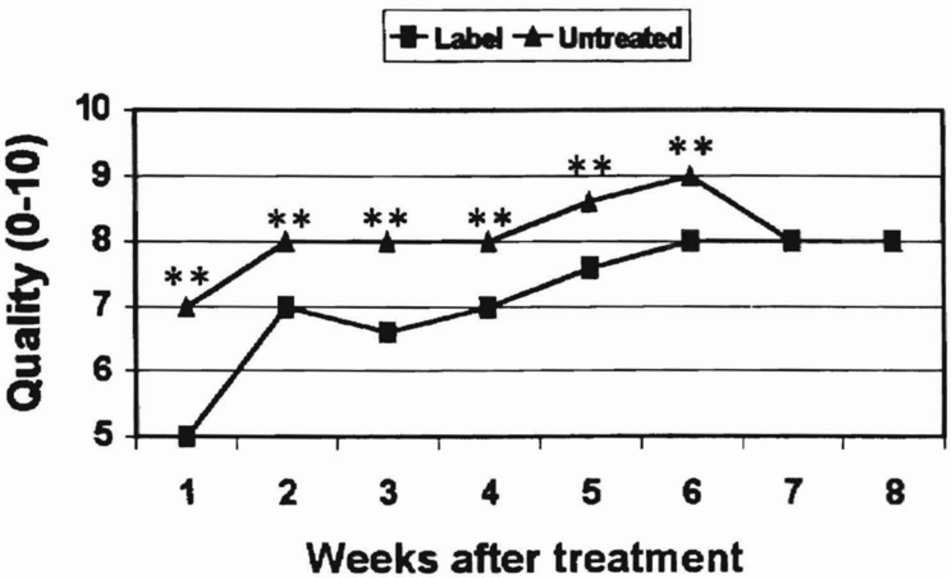
Appendix Figure 37. Untreated and 1x labeled rate treatment contrast for color ratings from the simulated lawn experiment conducted on OKS 91-11 in 1999. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



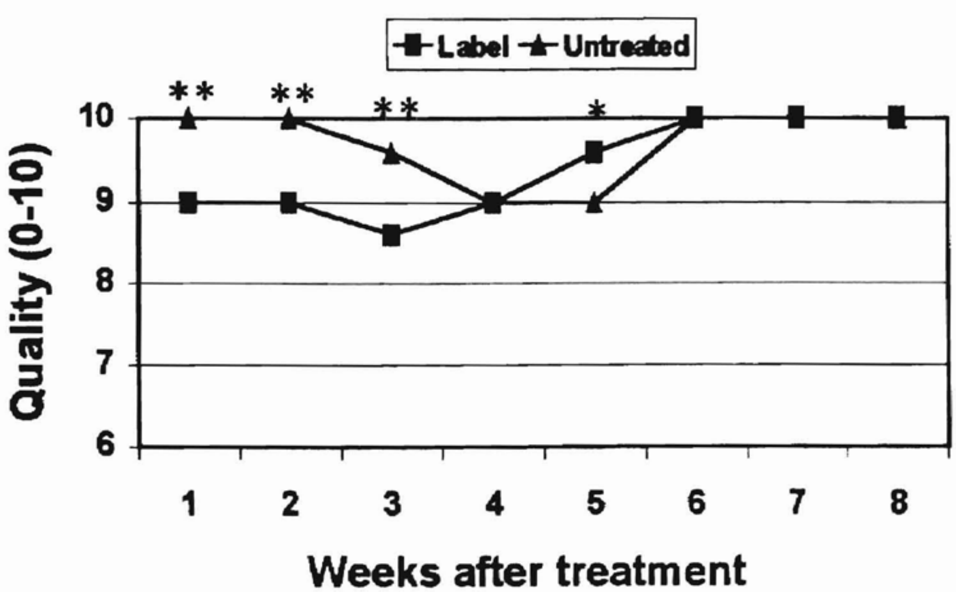
Appendix Figure 38. Untreated and 1x labeled rate treatment contrast for color ratings from the simulated lawn experiment conducted on OKS 91-11 in 2000. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



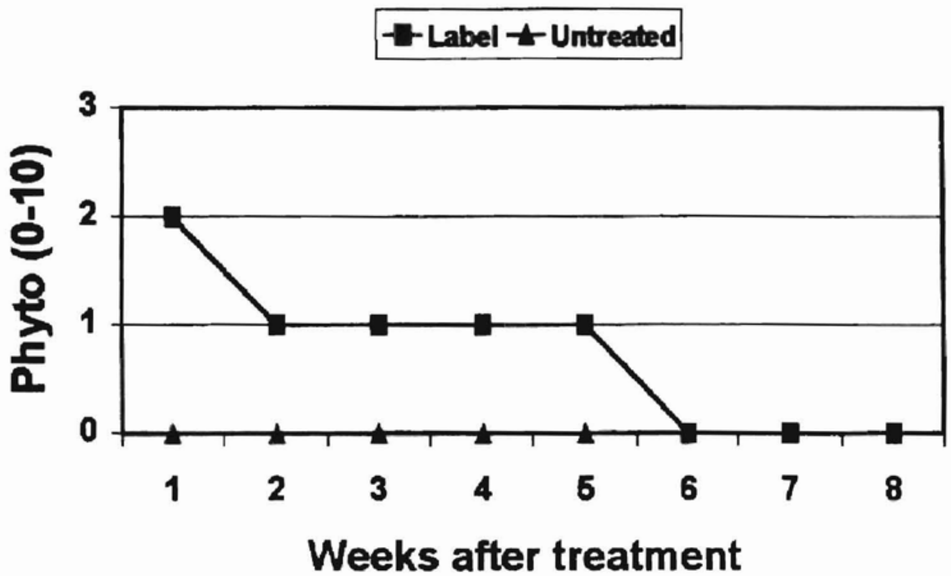
Appendix Figure 39. Untreated and 1x labeled rate treatment contrast for quality ratings from the simulated lawn experiment conducted on OKS 91-11 in 1999. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



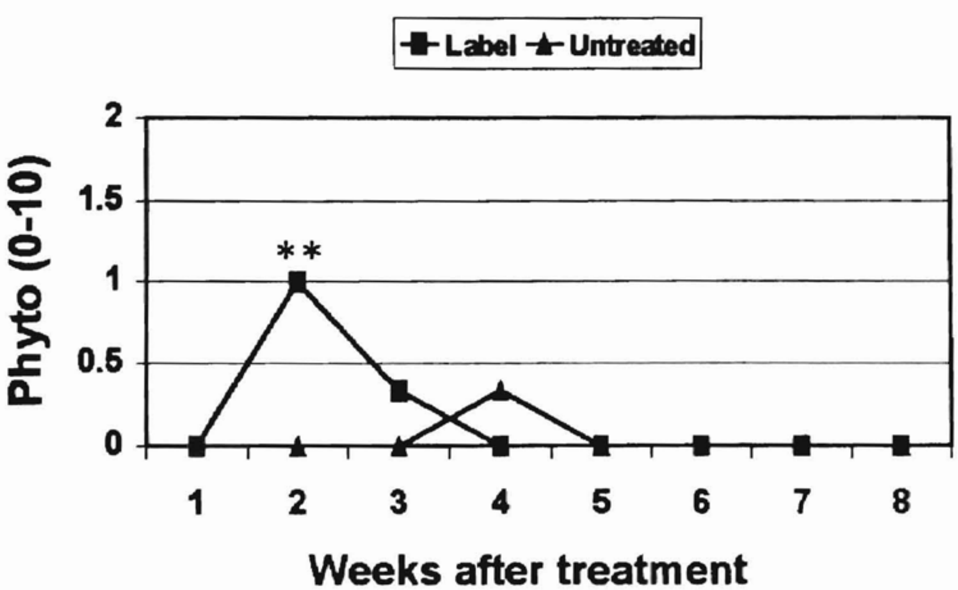
Appendix Figure 40. Untreated and 1x labeled rate treatment contrast for quality ratings from the simulated lawn experiment conducted on OKS 91-11 in 2000. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



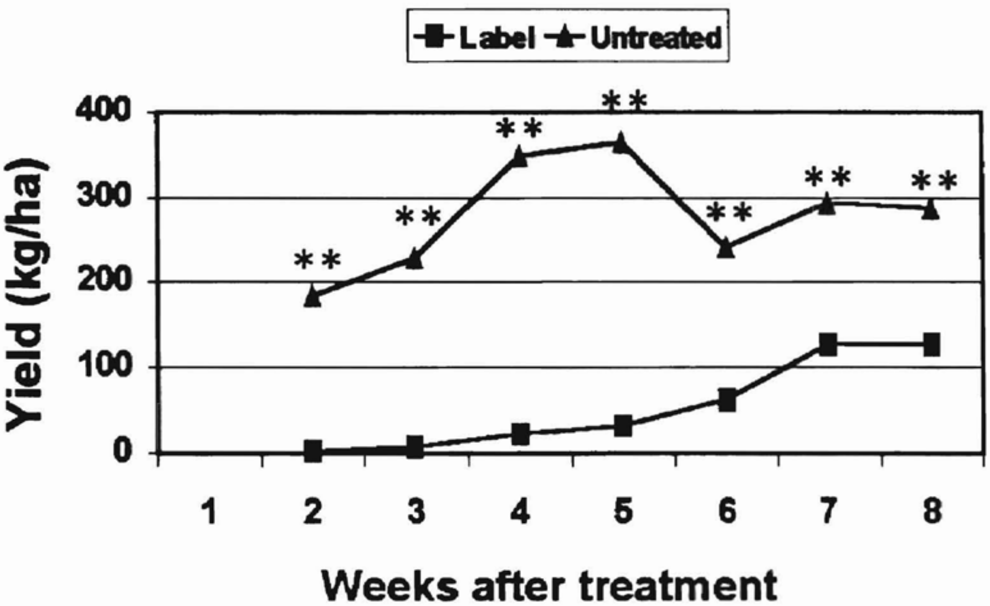
Appendix Figure 41. Untreated and 1x labeled rate treatment contrast for phytotoxicity ratings from the simulated lawn experiment conducted on OKS 91-11 in 1999. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



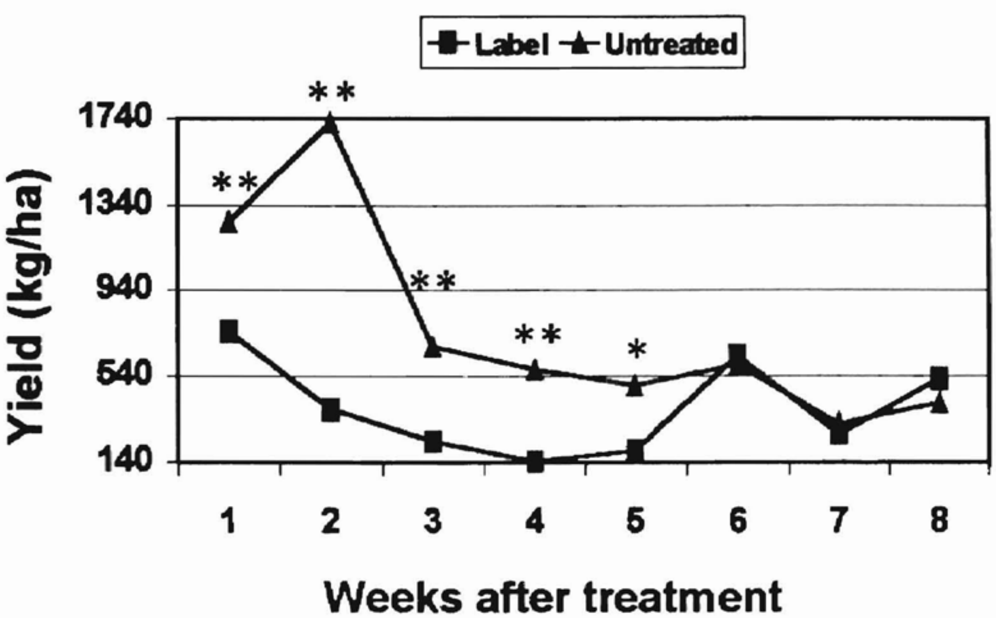
Appendix Figure 42. Untreated and 1x labeled rate treatment contrast for phytotoxicity ratings from the simulated lawn experiment conducted on OKS 91-11 in 2000. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



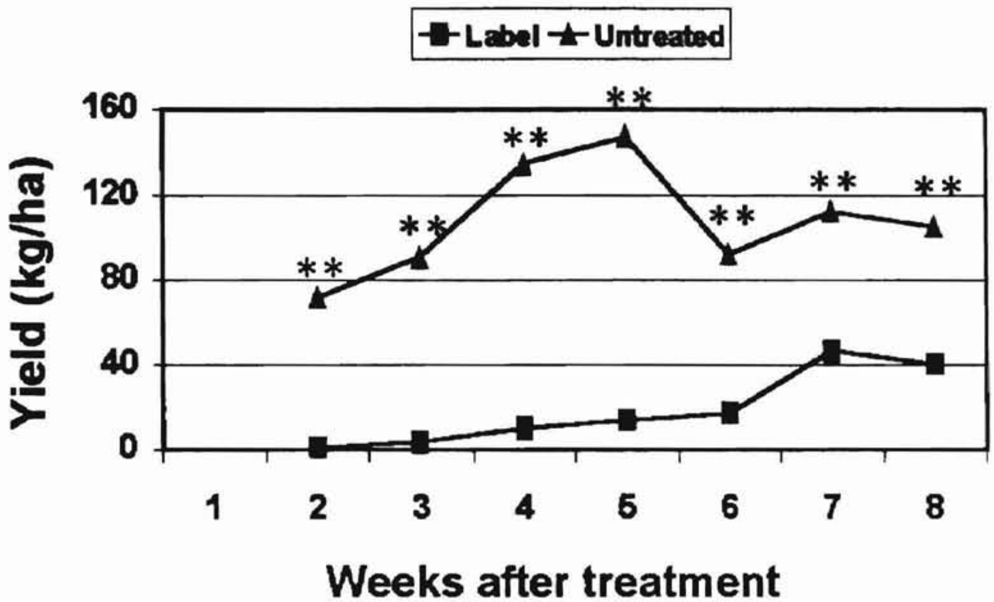
Appendix Figure 43. Untreated and 1x labeled rate treatment contrast for wet clipping yield from the simulated lawn experiment conducted on OKS 91-11 in 1999. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



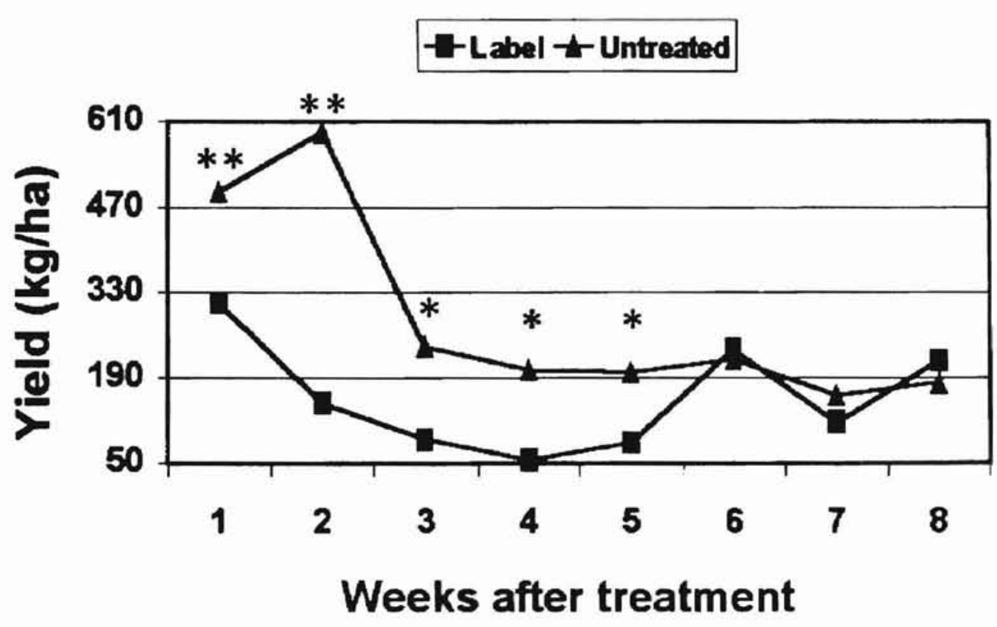
Appendix Figure 44. Untreated and 1x labeled rate treatment contrast for wet clipping yield from the simulated lawn experiment conducted on OKS 91-11 in 2000. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



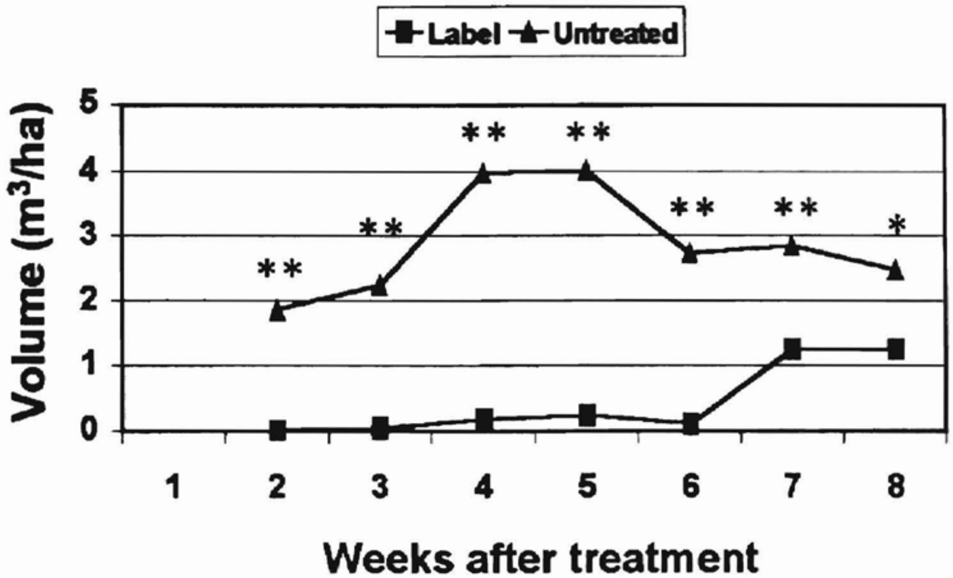
Appendix Figure 45. Untreated and 1x labeled rate treatment contrast for dry clipping yield from the simulated lawn experiment conducted on OKS 91-11 in 1999. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



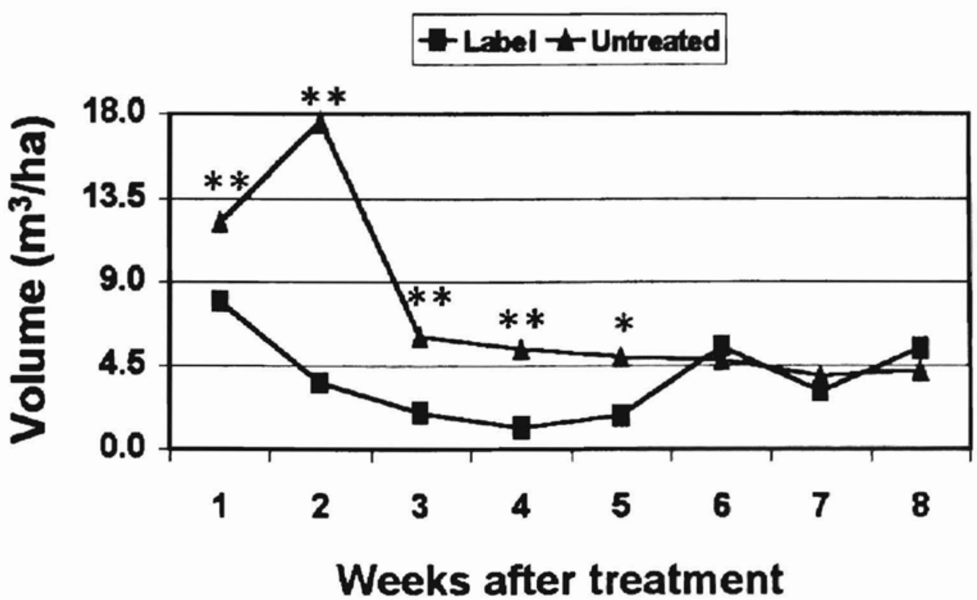
Appendix Figure 46. Untreated and 1x labeled rate treatment contrast for dry clipping yield from the simulated lawn experiment conducted on OKS 91-11 in 2000. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



Appendix Figure 47. Untreated and 1x labeled rate treatment contrast for clipping volume from the simulated lawn experiment conducted on OKS 91-11 in 1999. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



Appendix Figure 48. Untreated and 1x labeled rate treatment contrast for clipping volume from the simulated lawn experiment conducted on OKS 91-11 in 2000. Asterisks (*) and (**) represents statistical differences at the probability level 0.05 and 0.01 , respectively.



VITA γ

Timothy Brian Scroggins

Candidate for the Degree of

Master of Science

Thesis: RESPONSE OF OKS 91-11 BERMUDAGRASS TO VARYING RATES OF TRINEXAPAC-ETHYL AND RESPONSE OF OKS 91-11 AND OKS 95-1 BERMUDAGRASS TO POSTEMERGENCE HERBICIDES

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Experience: Operated a lawncare service during high school and throughout the pursuit of a Bachelor of Science degree. Worked as a field research assistant and as a Graduate Research Assistant throughout the pursuit of a Bachelor of Science degree and Master of Science degree in the Plant and Soil Sciences Department, Oklahoma State University, Stillwater, Oklahoma, January 1996 to the present.

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