PFOS: A TOXICITY TEST TO DETERMINE THE EFFECTS OF THE TEST SUBSTANCE ON SEEDLING EMERGENCE OF SEVEN SPECIES OF PLANTS

FINAL REPORT

WILDLIFE INTERNATIONAL, LTD. PROJECT NUMBER: 454-110

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and

OECD Guideline for Testing of Chemicals
Proposal for Revision of Guideline 208: Terrestrial Non-Target Plant Tests

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GOOD LABORATORY PRACTICE COMPLIANCE STATEMENT

SPONSOR: 3M Corporation

TITLE: PFOS: A Toxicity Test to Determine the Effects of the Test Substance On Seedling Emergence of Seven Species of Plants

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This study was conducted in compliance with Good Laboratory Practice Standards as published by the U.S. Environmental Protection Agency in 40 CFR Part 160, 17 August 1989; OECD Principles of Good Laboratory Practice (ENV/MC/CHEM(98)17); and Japan MAFF, 59 NohSan, Notification No. 3850, Agricultural Production Bureau,10 August 1984, with the following exception:

The stability of the test substance under storage conditions at the test site was not determined in accordance with Good Laboratory Practice Standards.

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John R. Porch — Date: 30 May 2003

SPONSOR REPRESENTATIVE:

Susan A. Beach — Date: 6/2/03

QUALITY ASSURANCE STATEMENT

This study was examined for compliance with Good Laboratory Practice Standards as published by the U.S. Environmental Protection Agency in 40 CFR Part 160, 17 August 1989; OECD Principles of Good Laboratory Practice (ENV/MC/CHEM(98)17); and Japan MAFF, 59 NohSan, Notification No. 3850, Agricultural Production Bureau, 10 August 1984. The dates of all audits and inspections and the dates that any findings were reported to the Study Director and Laboratory Management were as follows:

		DATE REPORTED TO:	
ACTIVITY	DATE CONDUCTED	STUDY DIRECTOR	MANAGEMENT
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All inspections were study-based unless otherwise noted.

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REPORT APPROVAL

SPONSOR: 3M Corporation

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TABLE OF CONTENTS

Title/Cover Page 1

Good Laboratory Practice Compliance Statement 2

Quality Assurance Statement 3

Report Approval 4

Table of Contents 5

Summary 8

Introduction 9

Purpose 9

Experimental Design 9

Materials and Methods 10
- Test Substance 10
- Preparation and Soil Incorporation of Test Substance 10
- Test Species 10
- Test Soil 11
- Planting of Seeds 11
- Watering of Seedlings 12
- Environmental Conditions 12
- Pesticide and Metal Screening of Well Water and Soil 12
- Observations and Measurements 12
- Soil Sampling and Analysis 13
- Tissue Sampling and Analysis 13
- Data Analyses 14

Results 15
- Analytical Chemistry 15
- Biological Results 18

Conclusions 19

References 20

TABLE OF CONTENTS
(continued)

TABLES

Table 1 Seedling Condition Rating System 21

Table 2 Effects of PFOS on Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test with Alfalfa 22

Table 3 Effects of PFOS on Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test with Flax 23

Table 4 Effects of PFOS on Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test with Lettuce 24

Table 5 Effects of PFOS on Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test with Onion 25

Table 6 Effects of PFOS on Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test with Ryegrass 26

Table 7 Effects of PFOS Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test with Soybean 27

Table 8 Effects of PFOS Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test with Tomato 28

Table 9 Observed NOEC and Calculated ECx Estimates for PFOS on Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test 29

APPENDICES

Appendix 1 Personnel Involved in the Study 30

Appendix 2 Changes to the Protocol 31

Appendix 3 Certificate of Analysis 32

Appendix 4 The Analysis of PFOS In Soil and Seven Species of Plants In Support of Wildlife International, Ltd. Project No.: 454-110 35

Appendix 5 Environmental Conditions 77

Appendix 6 Test Results, Alfalfa 83

Appendix 7 Test Results, Flax 90

TABLE OF CONTENTS
(continued)

Appendix	8	Test Results, Lettuce	97
Appendix	9	Test Results, Onion	104
Appendix	10	Test Results, Ryegrass	111
Appendix	11	Test Results, Soybean	118
Appendix	12	Test Results, Tomato	125
Appendix	13	Bulk Soil Characterization	132
Appendix	14	Results of Water and Soil Pesticide Screening	133

SUMMARY

WILDLIFE INTERNATIONAL, LTD. PROJECT NO: 454-110

TEST SUBSTANCE: Perflourooctanesulfonate, Potassium Salt (PFOS)

STUDY TITLE: PFOS: A Toxicity Test to Determine the Effects of the Test Substance on Seedling Emergence of Seven Species of Plants

GUIDELINES: OECD Guideline for Testing of Chemicals, Proposal for Revision of Guideline 208: Terrestrial Non-Target Plant Tests
OPPTS 850.4100 (Public Draft)
OPPTS 850.4225 (Public Draft)

NOMINAL TEST LEVELS: 0 (Control), 3.91, 15.6, 62.5, 250, 1000 mg a.i./kg dry soil

TEST DATES:

STUDY INITIATION:	November 12, 2001
Experimental Start (OECD):	November 12, 2001
Experimental Start (EPA):	November 12, 2001
Experimental Termination:	August 28, 2002
STUDY COMPLETION:	May 30, 2003

LENGTH OF TEST: Emergence Portion: 21 days
Extended Growth Portion: up to 205 days (varies by species)

TEST SPECIES: Alfalfa (*Medicago sativa*), Flax (*Linum usitatissimum*), Lettuce (*Lactuca sativa*), Onion (*Allium cepa*), Ryegrass (*Lolium perenne*), Soybean (*Glycine max*), Tomato (*Lycopersicon esculentum*)

RESULTS:

Species: Common name (Latin name)	Family	Relative Sensitivity EC_{25} (mg a.i./kg)	Endpoint
Lettuce (*Lactuca sativa*)	Compositae	6.79	Height
Ryegrass (*Lolium perenne*)	Gramineae	7.51	Shoot Weight
Tomato (*Lycopersicon esculentum*)	Solanaceae	11.7	Shoot Weight
Onion (*Allium cepa*)	Liliaceae	12.9	Shoot Weight
Alfalfa (*Medicago sativa*)	Leguminosae	53.3	Shoot Weight
Flax (*Linum usitatissimum*)	Linaceae	81.6	Shoot Weight
Soybean (*Glycine max*)	Leguminosae	160	Shoot Weight

INTRODUCTION

This seedling emergence study was conducted for 3M Corporation at the Wildlife International, Ltd. greenhouse facility in Easton, Maryland. The in-life portion of the test was conducted from November 12, 2001 to June 5, 2002. Raw data generated at Wildlife International, Ltd., the study protocol, and a copy of the final report were filed in the archives located on the Wildlife International, Ltd. site. Key personnel involved in the study are listed in Appendix 1.

PURPOSE

The purpose of the study was to determine the effects of Perflourooctanesulfonate, Potassium Salt (PFOS) on the seedling emergence and growth of seven species of plants.

EXPERIMENTAL DESIGN

There were two parts to this study. The first part was a twenty-one day seedling emergence test. The second part, an extended growth period, followed immediately. The experimental design for the overall study consisted of a negative control and five treatment groups, with four replicate pots in each group. To begin the twenty-one day portion of the test, ten seeds were planted in each pot. Test concentrations of PFOS were made by soil incorporation to each treatment group prior to the planting of seeds. The nominal test substance concentrations were 3.91, 15.6, 62.5, 250, and 1000 mg of PFOS per kilogram of dry soil (mg a.i./kg). These rates were selected based on the results of a non-GLP rangefinding test, and are not necessarily indicative of expected environmental concentrations. A control group, which received no test substance incorporation, was maintained concurrently.

Seeds were impartially assigned to growth pots on the day of test initiation. The replicate pots were placed in a randomized block design on a greenhouse table after planting. Observations of emergence were made on Days 7, 15, and 21. On day 21, observations of height, and assignment of plant condition scores were made. Fresh weights were conducted on all replicates containing more than one living seedling. Where possible, one seedling from each replicate was then left to grow until plants produced fruit (i.e., the extended growth period), whereupon, plants and fruit were clipped and weighed independently.

MATERIALS AND METHODS

The study was conducted according to the procedures outlined in the protocol, "PFOS: A Toxicity Test to Determine the Effects of the Test Substance on Seedling Emergence of Seven Species of Plants." Changes to the approved protocol are listed in Appendix 2. The methods used in conducting this study were based upon procedures specified in the OECD Proposal for Revision of Guideline 208: Terrestrial Non-Target Plant Tests (1) and the U.S. Environmental Protection Agency Series 850 - Ecological Effects Test Guidelines OPPTS Numbers 850.4100 (2) and 850.4225 (3).

Test Substance

The test substance was received from 3M Corporation on October 29, 1998, and was assigned Wildlife International, Ltd. identification number 4675. The test substance was a white powder identified as FC-95; lot number 217; with a reanalysis date of August 31, 2006. Information provided by the Sponsor indicated a test substance purity of 86.9%. The test substance was stored at ambient room temperature.

Preparation and Soil Incorporation of Test Substance

The test soil was prepared by mixing PFOS into bulk test soil with a measured soil moisture of 15%. Test substance for treatment groups 3.91, 15.6, 62.5, 250, and 1000 mg a.i./kg was prepared by weighing five known weights (0.2690, 1.1, 4.3, 17.1, and 68.5 g) of PFOS. Approximately 1000 g was removed from a measured 70 kg of bulk soil and mixed with weighed test substance for each test concentration. The remaining 69 kg of bulk soil was placed into soil mixer, and the 1 kg of soil with test substance was added. The constituents were then mixed for ten minutes in order to prepare the test soil for each treatment group. Soils were mixed from lowest to highest concentration to avoid cross-contamination. The negative control soil was prepared prior to the treatment groups, but in the same manner, except no test substance was added. At the completion of mixing, the test soils were sampled to provide material for analytical confirmation of the test concentrations. Analytical samples were stored at ambient room conditions for up to four days after their collection until they were processed for analysis.

Test Species

The common and scientific names for the seven species tested, the seed source, and their approximate planting depths are listed below:

Test Species / Variety:	Seed Source:	Planting Depth
Alfalfa (*Medicago sativa*) / None Given	Frontier Natural Products, Norway, IA , USA	6 mm
Flax (*Linum usitatissimum*) /None Given	Arrowhead Mills, Hereford, TX, USA	6 mm
Lettuce (*Lactuca sativa*) / Summertime	Territorial Seed Co., Cottage Grove, OR, USA	6 mm
Onion (*Allium cepa*) / Texas Grano	Territorial Seed Co., Cottage Grove, OR, USA	6 mm
Ryegrass (*Lolium perenne*)/ Manhattan 3	Meyer Seed Co., Baltimore, MD, USA	6mm
Soybean (*Glycine max*) / Green Envy	Johnny's Selected Seeds, Albion, ME, USA	20 mm
Tomato (*Lycopersicon esculentum*) / Rutgers	Meyer Seed Co., Baltimore, MD, USA	6 mm

These species were chosen because they represent ecologically important families, and are readily cultivated test organisms that are widely used in research. An additional consideration was to select species which could be grown to fruiting relatively quickly, while maintaining a reasonable plant size. Seeds were selected from a single size class within each species in order to reduce the potential for bias from differing seed sizes. Seeds used in this study were not treated with fungicides, insecticides or repellents prior to test initiation.

Test Soil

The soil used for the test represented a loam soil, and was composed of kaolinite clay, industrial quartz sand, and peat mixed in a 2:25:1 ratio (w:w:w). Crushed limestone was added to buffer the pH of the soil, and a slow-release fertilizer was added to provide nutrients essential for plant growth. A sample of soil representative of that used in this study was sent to Agvise Laboratories, Inc., in Northwood, North Dakota, for analysis of the particle size distribution and organic matter content of the soil (Appendix 13). The soil was determined to consist of 49% sand, 30% silt, and 21% clay, with an organic matter content of 2.1%. The soil pH was measured by Wildlife International Ltd. to be 7.79. A copy of the complete report from Agvise Laboratories, Inc. was filed in the archives at Wildlife International, Ltd. along with the raw data for this study.

Planting of Seeds

Seeds were planted in plastic pots (approximately 16 cm in diameter and 12 cm deep) on the day of test substance application. A template was used to gently compact the soil and leave ten uniform holes for planting. One indiscriminately selected seed was then planted in each hole, for a total of ten seeds in each pot. Personnel then closed the holes by slightly depressing the soil surface with their fingers.

Watering of Seedlings

Water lost through transpiration and evaporation was replaced by subirrigation with well water from the greenhouse facility. Seedlings were subirrigated as needed during the test to minimize the potential for the leaching of the test substance through the soil. Subirrigation trays were filled to a predetermined depth to help standardize the amount of water delivered to each tray. The days on which watering occurred are listed in Appendix 5.

Environmental Conditions

The environmental conditions (light intensity, temperature, and relative humidity) during the test are summarized in Appendix 5. The temperature within the greenhouse was controlled with a Wadsworth MicroStep S/A Environmental Control System. Artificial lighting was used to supplement natural sunlight in order to provide a uniform 14-hour photoperiod. The light intensity, temperature, and relative humidity within the greenhouse were continuously monitored during the test with a Campbell CR-10 datalogger.

Pesticide and Metal Screening of Well Water and Soil

The well water and soil used for plant studies are analyzed periodically for pesticide and metals. No analytes were measured at levels that were expected to have an impact on the study (Appendix 14). Reports for the latest analyses are stored in the archives at the Wildlife International, Ltd. site in Easton, Maryland.

Observations and Measurements

Observations on Days 7 and 15 were conducted to document seedling emergence. Observations on Day 21 were made to document seedling emergence and growth, and to determine the condition of individual seedlings. Observations consisted of noting whether emergence had or had not occurred, and assessing the condition of each seedling. Emergence was defined as the presence of visible plant tissue at the surface of the soil. Seedling condition was described by noting the presence or absence of possible signs of phytotoxicity such as necrosis, leaf wrinkle, chlorosis, plant lodging or plant stunting. Each emerged seedling was then assigned a numerical score (see Table 1) that described the plant condition (4). Condition score is a subjective or qualitative assessment that determines whether damage is slight, moderate, or severe. A score of 10 does not mean that 10% of the plant is showing the effect (e.g. chlorosis), merely that the severity of the effect (e.g. chlorosis) is very slight.

On day 21, seedling height was measured to the nearest whole centimeter from the surface of the soil to the tip of the tallest leaf (alfalfa, flax, lettuce, onion, and ryegrass) or to the apical meristem (soybean and tomato). All living seedlings except one per replicate (when available) were then clipped at soil level, combined, and weighed within 5 minutes of clipping. The total weight of the shoots was divided by the number of seedlings weighed in order to calculate the mean weight per plant. The one plant per replicate, when available, which was not sacrificed was allowed to grow for participation in the extended growth test. Alfalfa, flax, soybean, and tomato were grown until fruit production. Onions were grown until an enlarged bulb was evident. Lettuce was grown until adequate leaf tissue was available for analysis. Ryegrass seed production was anticipated, but was not observed.

Soil Sampling and Analysis

On the day of test soil preparation (November 12, 2001), three soil samples were collected from each treatment group to verify the test concentrations and determine the homogeneity of the test substance in the carrier (soil). One sample was collected from the control group. Day 0 samples were collected from the soil from each test group remaining after pots were filled for planting. On day 21 and at termination of the last test species, two soil samples were collected from the treatment groups to verify and determine homogeneity of the test substance in the soil. One sample was collected from the control group on both sampling dates. These samples were collected from test pots. Day 21 samples were collected by removing a small portion of soil from the surface and placing it in the sample container. Test termination samples were collected on June 5, 2002 using a soil core sampler which removed a cylindrical core of the soil from the surface to near the bottom of the test pot. Since the test was terminated on different days for the various species, the test termination soil samples were collected from the pots containing ryegrass, which was the last species to terminate. Samples were stored at ambient room conditions until analysis was begun on August 14, 2002. Chemical analysis of the soil used in this study was performed by Wildlife International, Ltd. (Appendix 4). The test substance was used to prepare calibration standards.

Tissue Sampling and Analysis

On Day 21, December 3, 2001, following observations of emergence, and measurements of height and fresh weight, three samples of plant tissue were taken from each species at each test concentration, and analyzed for PFOS. The three samples were obtained from a composite of tissue

from each of three replicate pots. Three additional plant tissue samples were taken from the single plant remaining in each replicate, when available, for each species at each test concentration at test termination of the extended growth period. Plants from the fourth replicate in each group, when present, were used to determine the moisture content of plant tissue at the end of each portion of the test (21-day and extended growth). Samples were stored frozen until analysis. Chemical analysis of the plant tissue collected in this study was performed by Wildlife International, Ltd. (Appendix 4). The test substance was used to prepare calibration standards. Dates of test termination for each species are listed below:

Species	Date of Test Termination
Alfalfa	April 2, 2002
Flax	February 14, 2002
Lettuce	January 18, 2002
Onion	January 18, 2002
Ryegrass	June 5, 2002
Soybean	January 18, 2002
Tomato	February 14, 2002

Data Analyses

Statistical analyses were used to aid in the evaluation of effects of test substance application on seedling emergence, survival, shoot weight, and height. These variables were defined for statistical analysis as follows:

Seedling Emergence: The number of emerged seedlings per ten planted seeds in each pot.

Survival: The number of emerged seedlings in each pot that were living at test termination per ten planted seeds.

Shoot Weight: The mean shoot weight of sacrificed living emerged seedlings in each pot.

Height: The average height of living emerged seedlings in each pot.

Test data were evaluated to determine the no-observed-effect-concentration (NOEC) and lowest-observable-effect-concentration (LOEC) for condition and growth. The NOEC is defined as the maximum test substance concentration that shows no adverse phytotoxic effects and below which no phytotoxic effects are manifested. The LOEC is defined as the lowest test substance concentration used in the study that shows an adverse effect on a variable of interest. Mean seedling emergence,

survival, weight, and height of the control and treatment groups were compared with Dunnett's t-test, using the DUNNETT option of the GLM (general linear model) procedure of SAS version 8 (5). Significance was determined at the level of 0.05 ($p<0.05$). Dunnett's test was used to aid in establishing the NOEC by determining which treatment groups differed significantly from the control group.

Statistical analyses for species also included the determination of effect rates (EC estimates) and their confidence limits using the non-linear regression analysis of Bruce and Versteeg (6) when reductions in test endpoints among one or more treatment groups were 25% or more relative to control means. Analyses were conducted using the NLIN procedure of SAS version 8 (5). EC_x values (i.e. EC_{25} and EC_{50}) were defined as the test substance application rates that caused an x% change in the treatment group mean emergence, dry weight, or height relative to the control group. EC_x estimates were calculated using nominal test concentrations and treatment group mean values with the following equation:

$$R = \begin{cases} R_0 \cdot \Phi[(\log(EC_x)-\log(C))/\sigma + Z_x] & C>0 \\ R_0 & C=0 \end{cases}$$

where

R	= the predicted biotic response at concentration C
R_0	= the predicted biotic response for controls
$\Phi[\ ]$	= the cumulative area under the standard, normal distribution
$\log(EC_x)$	= the logarithm of the predicted ER giving an x percentage of decrease in the biological parameter vs. the control
Z_x	= the normal deviate above which x percentage of the area of the standard normal distribution lies.
σ	= the standard deviation of the normal distribution

Effects on survival were designated as LC_x values, and were calculated using the method described above.

If the fit of the data to the regression model was poor, or if confidence intervals were not calculated, the EC_x estimates were calculated using linear interpolation (7).

RESULTS

Analytical Chemistry

Artificial Soil. Samples of artificial soil collected on Days 0 and 21, and at test termination were submitted and analyzed for PFOS. All negative control artificial soil samples were <LOQ for PFOS. Day 0 analyses of the 3.91, 15.6, 62.5, 250, and 1000 mg a.i./kg treatment levels had mean measured values of 3.61, 11.1, 50.8, 276, and 998 mg a.i./kg, corresponding to 92.3%, 71.2%, 81.3%, 110%, and 99.8% of the nominal concentrations, respectively (Appendix 4.19). PFOS measured

values for test termination samples are presented in Appendix 4.20. The 3.91, 15.6, 62.5, 250 and 1000 mg a.i./kg treatment levels had mean measured values of 1.29, 3.56, 16.2, 157 and 474 mg a.i./kg, corresponding to 33.0%, 22.8%, 25.9%, 62.8% and 47.4% of the nominal concentrations, respectively at test termination. A representative ion chromatogram of an artificial soil test sample is presented in Appendix 4.21.

Day 21 Samples. The results of soil and tissue analyses of samples collected on Day 21 were not considered representative of the actual levels of PFOS in soil and tissue, and are therefore not reported. The measured levels of PFOS in soil samples were generally well above nominal. The apparently high concentrations were thought to be an artifact resulting from two factors. First, the process of subirrigation during the test was thought to concentrate PFOS near the soil surface of test pots. Second, the samples were collected by removing a small amount of soil from the top of the soil profile. In addition, tissue samples collected on Day 21 were thought to have been inadvertently contaminated during collection. Due to the small size of the seedlings on Day 21, and the apparently high levels of PFOS at the soil surface, it was determined that soil particles were attached to the seedlings and biased the analytical results.

Plant Tissues. Samples of fruit tissue from five species of plant (alfalfa, flax, onion, soybean, and tomato) grown in negative control and PFOS-treated artificial soils were collected at test termination (for a given species) and analyzed for PFOS residues. Samples of vegetative tissue from seven species of plant (alfalfa, flax, lettuce, onion, ryegrass, soybean, and tomato) grown in negative control and PFOS-treated artificial soils were collected at experimental termination (for a given species) and analyzed for PFOS residues. Measured PFOS concentrations are presented in Appendices 4.22 – 4.33. Representative ion chromatograms of plant fruit and vegetative tissue test samples are presented in Appendices 4.34 and 4.35, respectively.

The results of tissue analyses are summarized by species in the following tables.

Alfalfa – Total days of exposure = 141

Nominal Soil Concentration (mg a.i./kg)	Measured PFOS Concentration (mg a.i./kg dry weight) in:	
	Vegetation	Fruit
Control	<2.7	<6.4
3.91	6.2	<6.4
15.6	4.2	<6.4
62.5	11	<6.4
250	16	<6.4
1000	None living	None living

Flax – Total days of exposure = 94

Nominal Soil Concentration (mg a.i./kg)	Measured PFOS Concentration (mg a.i./kg dry weight) in:	
	Vegetation	Fruit
Control	<2.4	<0.12
3.91	5.0	0.23
15.6	19	1.4
62.5	55	2.6
250	Insufficient sample	Insufficient sample
1000	None living	None living

Lettuce – Total days of exposure = 67

Nominal Soil Concentration (mg a.i./kg)	Measured PFOS Concentration (mg a.i./kg dry weight) in:	
	Vegetation	Fruit
Control	<5.5	Not applicable
3.91	8.6	Not applicable
15.6	11	Not applicable
62.5	42	Not applicable
250	Insufficient sample	Not applicable
1000	None living	Not applicable

Onion – Total days of exposure = 67

Nominal Soil Concentration (mg a.i./kg)	Measured PFOS Concentration (mg a.i./kg dry weight) in:	
	Vegetation	Fruit
Control	<4.7	0.50
3.91	<4.7	3.1
15.6	11	22
62.5	Insufficient sample	Insufficient sample
250	None living	None living
1000	None living	None living

Ryegrass – Total days of exposure = 205

Nominal Soil Concentration (mg a.i./kg)	Measured PFOS Concentration (mg a.i./kg dry weight) in:	
	Vegetation	Fruit
Control	<3.3	Not applicable
3.91	8.2	Not applicable
15.6	31	Not applicable
62.5	49	Not applicable
250	66	Not applicable
1000	None living	Not applicable

Soybean – Total days of exposure = 67

Nominal Soil Concentration (mg a.i./kg)	Measured PFOS Concentration (mg a.i./kg dry weight) in:	
	Vegetation	Fruit
Control	<6.0	<0.18
3.91	16	1.4
15.6	36	0.87
62.5	63	1.2
250	110	3.2
1000	None living	None living

Tomato – Total days of exposure = 94

Nominal Soil Concentration (mg a.i./kg)	Measured PFOS Concentration (mg a.i./kg dry weight) in:	
	Vegetation	Fruit
Control	<7.6	<0.47
3.91	<7.6	<0.47
15.6	34	1.1
62.5	50	0.95
250	Insufficient sample	Insufficient sample
1000	None living	None living

Biological Results

The LOEC, NOEC, EC_x, and LC_x for the various parameters of each of the seven species are summarized in the tables below. Results of the test are summarized by species in Tables 2 through 8. Complete results are presented by species in Appendices 6 through 12.

Species	21-day Emergence				21-day Survival			
	LOEC	NOEC	EC_{25}	EC_{50}	LOEC	NOEC	EC_{25}	EC_{50}
Monocots:	(All units mg a.i./kg)							
Onion (*Allium cepa*)	250	62.5	50.8	208	62.5	15.6	47.1	57.3
Ryegrass (*Lolium perenne*)	250	62.5	203	344	250	62.5	174	310
Dicots:								
Alfalfa (*Medicago sativa*)	1000	250	372	745	250	62.5	251	452
Flax (*Linum usitatissimum*)	1000	250	399	599	250	62.5	144	226
Lettuce (*Lactuca sativa*)	1000	250	393	564	250	62.5	257	386
Soybean (*Glycine max*)	>1000	1000	>1000	>1000	>1000	1000	>1000	>1000
Tomato (*Lycopersicon esculentum*)	1000	250	311	474	62.5	15.6	68.7	105

Species	21-day Height				21-day Shoot Weight			
	LOEC	NOEC	EC_{25}	EC_{50}	LOEC	NOEC	EC_{25}	EC_{50}
Monocots:	(All units mg a.i./kg)							
Onion (*Allium cepa*)	62.5	15.6	29.1	46.5	15.6	3.91	12.9	28.1
Ryegrass (*Lolium perenne*)	15.6	3.91	46.3	131	15.6	3.91	7.51	53.8
Dicots:								
Alfalfa (*Medicago sativa*)	250	62.5	102	249	250	62.5	53.3	146
Flax (*Linum usitatissimum*)	250	62.5	97.6	140	250	62.5	81.6	119
Lettuce (*Lactuca sativa*)	3.91	<3.91	6.79	39.9	3.91	<3.91	8.92	20.1
Soybean (*Glycine max*)	250	62.5	284	464	250	62.5	160	326
Tomato (*Lycopersicon esculentum*)	62.5	15.6	22.1	93.9	62.5	15.6	11.7	28.5

CONCLUSIONS

The relative sensitivities and most sensitive endpoints for the seven test species in response to soil-incorporated PFOS based on 21-day results are listed below:

Species Common name (Latin name)	Family	Relative Sensitivity EC_{25} (mg a.i./kg)	Endpoint
Lettuce (*Lactuca sativa*)	Compositae	6.79	Height
Ryegrass (*Lolium perenne*)	Gramineae	7.51	Shoot Weight
Tomato (*Lycopersicon esculentum*)	Solanaceae	11.7	Shoot Weight
Onion (*Allium cepa*)	Liliaceae	12.9	Shoot Weight
Alfalfa (*Medicago sativa*)	Leguminosae	53.3	Shoot Weight
Flax (*Linum usitatissimum*)	Linaceae	81.6	Shoot Weight
Soybean (*Glycine max*)	Leguminosae	160	Shoot Weight

There were no additional findings of phytotoxicity at the termination of the extended growth portion of the test.

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Table 1

Seedling Condition Rating System

Rating	Category	Description
0	No Effect	No noticeable effect
10		Effect barely noticeable
20	Slight Effect	Some effect, not apparently detrimental
30		Effect more pronounced, not obviously detrimental
40		Effect moderate, plants appear able to recover
50	Moderate Effect	More lasting effect, recovery somewhat doubtful
60		Lasting effect, recovery doubtful
70		Heavy injury, loss of individual leaves
80	Severe Effect	Plant nearly destroyed, a few surviving leaves
90		Occasional surviving leaves
100	Complete Effect	Death of entire plant

Rating scale adapted from:

Frans, Robert E. and Ronald E. Talbert. 1977. Design of Field Experiments and the Measurement and Analysis of Plant Responses. Pages 15-23 in B. Truelove, ed. Research Methods in Weed Science. Southern Weed Science Society, Auburn University, Alabama.

Table 2

Effects of PFOS on Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test with ALFALFA

Test Concentration (mg a.i./kg)	Number of Emerged Seedlings (% Reduction) Day 7 (Mean ± SD)	Day 15 (Mean ± SD)	Day 21 (Mean ± SD)	Seedling Survival (% Reduction) (Mean ± SD)	Shoot Weight (g) (% Reduction) (Mean ± SD)	Height (cm) (% Reduction) (Mean ± SD)
Control	8.75 ± 1.50	9.00 ± 1.15	9.00 ± 1.15	8.75 ± 0.96	0.12 ± 0.013	6.5 ± 0.64
3.91	8.25 ± 0.50 (6%)	8.50 ± 0.58 (6%)	8.50 ± 0.58 (6%)	8.25 ± 0.50 (6%)	0.11 ± 0.033 (4%)	6.4 ± 0.75 (2%)
15.6	7.75 ± 1.50 (11%)	8.00 ± 1.41 (11%)	8.00 ± 1.41 (11%)	8.00 ± 1.41 (9%)	0.10 ± 0.022 (15%)	5.4 ± 0.76 (16%)
62.5	7.00 ± 1.15 (20%)	8.00 ± 1.15 (11%)	8.00 ± 1.15 (11%)	8.00 ± 1.15 (9%)	0.10 ± 0.010 (11%)	6.1 ± 0.90 (6%)
250	7.00 ± 1.41 (20%)	7.25 ± 1.71 (19%)	7.25 ± 1.71 (19%)	6.25 ± 1.71* (29%)	0.03 ± 0.008* (78%)	2.8 ± 0.52* (57%)
1000	2.50 ± 2.89* (71%)	2.50 ± 2.89* (72%)	3.25 ± 3.30* (64%)	1.50 ± 1.73* (83%)	0.02 ± 0.008* (87%)	1.0 ± 0.00* (85%)

* Treatment group mean is significantly different from the control mean (Dunnett's test, $p<0.05$).
Mean ± SD - Treatment group mean plus or minus one standard deviation.

Table 3

Effects of PFOS on Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test with FLAX

Test Concentration (mg a.i./kg)	Number of Emerged Seedlings (% Reduction) Day 7 (Mean ± SD)	Day 15 (Mean ± SD)	Day 21 (Mean ± SD)	Seedling Survival (% Reduction) (Mean ± SD)	Shoot Weight (g) (% Reduction) (Mean ± SD)	Height (cm) (% Reduction) (Mean ± SD)
Control	7.25 ± 1.26	7.25 ± 1.26	7.25 ± 1.26	7.25 ± 1.26	0.19 ± 0.029	8.9 ± 0.27
3.91	6.50 ± 1.00 (10%)	7.00 ± 1.41 (3%)	7.25 ± 1.50 (0%)	6.75 ± 1.26 (7%)	0.18 ± 0.022 (8%)	8.7 ± 0.90 (3%)
15.6	8.00 ± 0.82 (-10%)	8.00 ± 0.82 (-10%)	8.00 ± 0.82 (-10%)	8.00 ± 0.82 (-10%)	0.18 ± 0.023 (10%)	8.8 ± 0.80 (2%)
62.5	8.50 ± 1.00 (-17%)	8.50 ± 1.00 (-17%)	8.50 ± 1.00 (-17%)	8.50 ± 1.00 (-17%)	0.16 ± 0.017 (18%)	8.2 ± 0.54 (8%)
250	7.25 ± 1.71 (0%)	7.25 ± 1.71 (0%)	7.25 ± 1.71 (0%)	3.25 ± 1.50* (55%)	0.02 ± 0.009* (91%)	1.3 ± 0.35* (86%)
1000	0* (100%)	0* (100%)	0* (100%)	0* (100%)	N/A	N/A

* Treatment group mean is significantly different from the control mean (Dunnett's test, $p<0.05$).
N/A – Not applicable since there were no surviving plants at measurement.
Mean ± SD - Treatment group mean plus or minus one standard deviation.

Table 4

Effects of PFOS on Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test with LETTUCE

Test Concentration (mg a.i./kg)	Number of Emerged Seedlings (% Reduction) Day 7 (Mean ± SD)	Day 15 (Mean ± SD)	Day 21 (Mean ± SD)	Seedling Survival (% Reduction) (Mean ± SD)	Shoot Weight (g) (% Reduction) (Mean ± SD)	Height (cm) (% Reduction) (Mean ± SD)
Control	8.75 ± 0.50	8.75 ± 0.50	8.75 ± 0.50	8.75 ± 0.50	0.38 ± 0.060	6.4 ± 0.51
3.91	9.00 ± 0.82 (-3%)	9.00 ± 0.82 (-3%)	9.00 ± 0.82 (-3%)	9.00 ± 0.82 (-3%)	0.25 ± 0.051* (35%)	5.0 ± 0.56* (23%)
15.6	8.75 ± 1.50 (0%)	9.00 ± 1.15 (-3%)	9.00 ± 1.15 (-3%)	9.00 ± 1.15 (-3%)	0.24 ± 0.081* (36%)	5.0 ± 1.07* (23%)
62.5	8.50 ± 1.29 (3%)	8.50 ± 1.29 (3%)	8.50 ± 1.29 (3%)	8.50 ± 1.29 (3%)	0.05 ± 0.019* (88%)	2.6 ± 0.43* (59%)
250	8.00 ± 1.41 (9%)	8.00 ± 1.41 (9%)	8.25 ± 1.26 (6%)	6.75 ± 0.96* (23%)	0.01 ± 0.006* (98%)	1.0 ± 0.06* (84%)
1000	1.25 ± 1.26* (86%)	1.25 ± 1.26* (86%)	1.25 ± 1.26* (86%)	0.50 ± 0.58* (94%)	0.00 ± 0.000* (100%)	1.0 ± 0.00* (84%)

* Treatment group mean is significantly different from the control mean (Dunnett's test, $p<0.05$).
Mean ± SD - Treatment group mean plus or minus one standard deviation.

Table 5

Effects of PFOS on Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test with ONION

Test Concentration (mg a.i./kg)	Number of Emerged Seedlings (% Reduction) Day 7 (Mean ± SD)	Day 15 (Mean ± SD)	Day 21 (Mean ± SD)	Seedling Survival (% Reduction) (Mean ± SD)	Shoot Weight (g) (% Reduction) (Mean ± SD)	Height (cm) (% Reduction) (Mean ± SD)
Control	8.00 ± 0.82	8.50 ± 1.29	8.75 ± 1.50	8.50 ± 1.29	0.10 ± 0.006	8.1 ± 0.55
3.91	8.50± 1.29 (-6%)	9.00 ± 1.41 (-6%)	9.25 ± 0.96 (-6%)	9.00 ± 1.15 (-6%)	0.09 ± 0.015 (15%)	7.3 ± 0.49 (9%)
15.6	7.75 ± 0.50 (3%)	8.25 ± 0.50 (3%)	8.25 ± 0.50 (6%)	8.00 ± 0.82 (6%)	0.07 ± 0.006* (31%)	7.3 ± 0.15 (10%)
62.5	5.00 ± 2.00* (38%)	6.25 ± 2.63 (26%)	6.25 ± 2.63 (29%)	3.25 ± 0.50* (62%)	0.02 ± 0.019* (77%)	2.6 ± 0.83* (68%)
250	2.00 ± 2.45* (75%)	4.00 ± 3.16* (53%)	4.00 ± 3.16* (54%)	0* (100%)	N/A	N/A
1000	0* (100%)	0* (100%)	0* (100%)	0* (100%)	N/A	N/A

* Treatment group mean is significantly different from the control mean (Dunnett's test, $p<0.05$).
N/A – Not applicable since there were no surviving plants at measurement.
Mean ± SD - Treatment group mean plus or minus one standard deviation.

Table 6

Effects of PFOS on Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test with RYEGRASS

Test Concentration (mg a.i./kg)	Number of Emerged Seedlings (% Reduction) Day 7 (Mean ± SD)	Day 15 (Mean ± SD)	Day 21 (Mean ± SD)	Seedling Survival (% Reduction) (Mean ± SD)	Shoot Weight (g) (% Reduction) (Mean ± SD)	Height (cm) (% Reduction) (Mean ± SD)
Control	7.75 ± 0.96	8.00 ± 0.82	8.00 ± 0.82	8.00 ± 0.82	0.12 ± 0.025	16.9 ± 0.69
3.91	8.50 ± 1.00 (-10%)	9.25 ± 0.96 (-16%)	9.25 ± 0.96 (-16%)	9.25 ± 0.96 (-16%)	0.11 ± 0.013 (12%)	15.4 ± 1.28 (9%)
15.6	7.50 ± 1.91 (3%)	9.00 ± 0.82 (-13%)	9.00 ± 0.82 (-13%)	9.00 ± 0.82 (-13%)	0.07 ± 0.014* (39%)	13.7 ± 0.77* (19%)
62.5	7.50 ± 0.58 (3%)	8.25 ± 0.96 (-3%)	8.50 ± 1.29 (-6%)	8.25 ± 0.96 (-3%)	0.08 ± 0.014* (32%)	13.6 ± 0.92* (19%)
250	4.00 ± 1.41* (48%)	5.75 ± 1.26* (28%)	5.75 ± 1.26* (28%)	5.25 ± 2.22* (34%)	0.01 ± 0.006* (91%)	3.7 ± 0.97* (78%)
1000	0* (100%)	0.25 ± 0.50* (97%)	0.75 ± 0.50* (91%)	0.75 ± 0.50* (91%)	0.03 ± 0.010* (76%)	2.0 ± 0.00* (88%)

* Treatment group mean was significantly different from the control mean (Dunnett's test, $p<0.05$)
Mean ± SD - Treatment group mean plus or minus one standard deviation.

Table 7

Effects of PFOS on Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test with SOYBEAN

Test Concentration (mg a.i./kg)	Number of Emerged Seedlings (% Reduction) Day 7 (Mean ± SD)	Day 15 (Mean ± SD)	Day 21 (Mean ± SD)	Seedling Survival (% Reduction) (Mean ± SD)	Shoot Weight (g) (% Reduction) (Mean ± SD)	Height (cm) (% Reduction) (Mean ± SD)
Control	9.75 ± 0.50	10.00± 0.00	10.00 ± 0.00	10.00 ± 0.00	3.63 ± 0.583	28.3 ± 4.17
3.91	9.75 ± 0.50 (0%)	9.75 ± 0.50 (3%)	9.75 ± 0.50 (3%)	9.75 ± 0.50 (3%)	3.64 ± 0.236 (0%)	26.8 ± 3.17 (5%)
15.6	9.50 ± 0.58 (3%)	9.50 ± 0.58 (5%)	9.50 ± 0.58 (5%)	9.50 ± 0.58 (5%)	3.63 ± 0.330 (0%)	26.9 ± 3.31 (5%)
62.5	10.00 ± 0.00 (-3%)	10.00 ± 0.00 (0%)	10.00 ± 0.00 (0%)	10.00 ± 0.00 (0%)	4.00 ± 0.302 (-10%)	30.7 ± 2.51 (-8%)
250	10.00 ± 0.00 (-3%)	10.00 ± 0.00 (0%)	10.00 ± 0.00 (0%)	9.75 ± 0.50 (3%)	2.07 ± 0.310* (43%)	22.5 ± 2.26* (21%)
1000	9.75 ± 0.50 (0%)	10.00 ± 0.00 (0%)	10.00 ± 0.00 (0%)	10.00 ± 0.00 (0%)	0.57 ± 0.047* (84%)	4.1 ± 0.39* (85%)

* Treatment group mean is significantly different from the control mean (Dunnett's test, $p<0.05$).
Mean ± SD - Treatment group mean plus or minus one standard deviation.

Table 8

Effects of PFOS on Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test with TOMATO

Test Concentration (mg a.i./kg)	Number of Emerged Seedlings (% Reduction) Day 7 (Mean ± SD)	Day 15 (Mean ± SD)	Day 21 (Mean ± SD)	Seedling Survival (% Reduction) (Mean ± SD)	Shoot Weight (g) (% Reduction) (Mean ± SD)	Height (cm) (% Reduction) (Mean ± SD)
Control	6.50 ± 1.91	9.00± 0.82	9.25 ± 0.96	9.25 ± 0.96	0.35 ± 0.143	5.2 ± 0.75
3.91	6.50 ± 1.73 (0%)	8.00 ± 1.15 (11%)	8.25 ± 1.50 (11%)	8.25 ± 1.50 (11%)	0.40 ± 0.081 (-14%)	5.6 ± 0.31 (-7%)
15.6	5.25 ± 2.99 (19%)	8.25 ± 1.71 (8%)	8.25 ± 1.71 (11%)	8.00 ± 1.41 (14%)	0.28 ± 0.108 (19%)	4.8 ± 0.94 (9%)
62.5	5.50 ± 1.91 (15%)	8.25 ± 1.71 (8%)	8.50 ± 1.73 (8%)	6.75 ± 0.96* (27%)	0.08 ± 0.029* (79%)	2.6 ± 0.14* (50%)
250	1.25 ± 1.50* (81%)	7.25 ± 0.96 (19%)	7.25 ± 0.96 (22%)	0.75 ± 0.96* (92%)	0.03 ± N/A* (91%)	2.0 ± 0.00* (62%)
1000	0* (100%)	0.75 ± 1.50* (92%)	1.00 ± 1.41* (89%)	0* (100%)	N/A	N/A

* Treatment group mean is significantly different from the control mean (Dunnett's test, $p<0.05$).
N/A – Not applicable since there were no surviving plants at measurement.
Mean ± SD - Treatment group mean plus or minus one standard deviation.

Table 9

Observed NOEC and Calculated ECx Estimates for PFOS on Seedling Emergence, Survival, Shoot Weight, and Height in a 21-Day Seedling Emergence Test

Species	Endpoint (NOEC) (mg ai/kg)		Estimate	Lower 95% CL (mg ai/kg)	Upper 95% CL
Alfalfa	Emergence	EC_{25}	372	202	688
	(250)	EC_{50}	745	541	>1000
	Survival	LC_{25}	251	178	353
	(62.5)	LC_{50}	452	364	563
	Height	EC_{25}	102	26.8	391
	(62.5)	EC_{50}	249	106	584
	Weight	EC_{25}	53.3	4.12	690
	(62.5)	EC_{50}	146	27.3	783
Flax	Emergence	EC_{25}	399	126	461
	(250)	EC_{50}	599	402	641
	Survival	LC_{25}	144	103	177
	(62.5)	LC_{50}	226	160	368
	Height	EC_{25}	97.6	81.3	117
	(62.5)	EC_{50}	140	125	158
	Weight	EC_{25}	81.6	46.0	145
	(62.5)	EC_{50}	119	79.4	178
Lettuce	Emergence	EC_{25}	393	300	515
	(250)	EC_{50}	564	474	671
	Survival	LC_{25}	257	220	301
	(62.5)	LC_{50}	386	344	433
	Height	EC_{25}	6.79	<3.91	226
	(0.0)	EC_{50}	39.9	3.88	410
	Weight	EC_{25}	8.92	<3.91	58.3
	(0.0)	EC_{50}	20.1	5.26	77.1
Onion	Emergence	EC_{25}	50.8	12.2	195
	(62.5)	EC_{50}	208	<3.91	644
	Survival	LC_{25}	47.1	<3.91	>1000
	(15.6)	LC_{50}	57.3	17.5	188
	Height	EC_{25}	29.1	<3.91	904
	(15.6)	EC_{50}	46.5	8.94	242
	Weight	EC_{25}	12.9	<3.91	>1000
	(3.91)	EC_{50}	28.1	1.99	396
Ryegrass	Emergence	EC_{25}	203	131	313
	(62.5)	EC_{50}	344	254	465
	Survival	LC_{25}	174	107	281
	(62.5)	LC_{50}	310	223	432
	Height	EC_{25}	46.3	4.63	464
	(3.91)	EC_{50}	131	28.8	597
	Weight	EC_{25}	7.51	<3.91	>1000
	(3.91)	EC_{50}	53.8	<3.91	>1000
Soybean	Emergence	EC_{25}	>1000	-[1]	-
	(1000)	EC_{50}	>1000	-	-
	Survival	LC_{25}	>1000	-	-
	(1000)	LC_{50}	>1000	-	-
	Height	EC_{25}	284	172	468
	(62.5)	EC_{50}	464	333	648
	Weight	EC_{25}	160	69.1	372
	(62.5)	EC_{50}	326	189	561
Tomato	Emergence	EC_{25}	311	208	464
	(250)	EC_{50}	474	360	625
	Survival	LC_{25}	68.7	45.0	105
	(15.6)	LC_{50}	105	77.8	143
	Height	EC_{25}	22.1	<3.91	>1000
	(15.6)	EC_{50}	93.9	10.3	852
	Weight	EC_{25}	11.7	<3.91	217
	(15.6)	EC_{50}	28.5	<3.91	213

[1] – Confidence intervals could not be determined.

Appendix 1

Personnel Involved In the Study

The following key personnel were involved in the conduct or management of this study:

(1) Henry O. Krueger, Ph.D., Director of Aquatic Toxicology/Terrestrial Plants and Insects
(2) John R. Porch, Supervisor of Terrestrial Plant and Insect Studies
(3) Andrew J. Brignole, Biologist
(4) Raymond L. Van Hoven, Ph.D., Scientist
(5) Willard B. Nixon, Ph.D., Director of Chemistry

Appendix 2

Changes to Protocol

This study was conducted according to the approved protocol with the following changes:

1 The protocol was amended to include procedures regarding day 21 data and soil sample collection as well as extended growth portion of the test.
2 The protocol was amended to include procedures for data and soil sample collection at test termination.
3 The soil was composed of kaolinite clay, industrialized quartz sand, and peat mixed in a 2:25:1 ratio with regards to weight. The soil consisted of 49% sand, 30% silt, and 21% clay.
4 Observations of emergence were made on Day 15 rather than 14.
5 The sponsor's representative was changed.

Appendix 3

Certificate of Analysis

INTERIM CERTIFICATE OF ANALYSIS

Revision 1(9/7/00)

Centre Analytical Laboratories COA Reference #: 023-018A

3M Product: PFOS, Lot 217

Reference #: SD-018

Purity: 86.9%

Test Name	Specifications	Result
Purity[1]		**86.9%**
Appearance	White Crystalline Powder	Conforms
Identification NMR		Positive
Metals (ICP/MS) 1. Calcium 2. Magnesium 3. Sodium 4. Potassium[2] 5. Nickel 6. Iron 7. Manganese		 1. 0.005 wt./wt.% 2. 0.001 wt./wt.% 3. 1.439 wt./wt.% 4. 6.849 wt./wt.% 5. <0.001 wt./wt.% 6. 0.005 wt./wt.% 7. <0.001 wt./wt.%
Total % Impurity (NMR)		1.93 wt./wt.%
Total % Impurity (LC/MS)		8.41 wt./wt.%
Total % Impurity (GC/MS)		None Detected
Related Compounds – POAA		0.33 wt./wt.%
Residual Solvents (TGA)		None Detected
Purity by DSC		Not Applicable[3]
Inorganic Anions (IC) 1. Chloride 2. Fluoride 3. Bromide 4. Nitrate 5. Nitrite 6. Phosphate 7. Sulfate[4]		 1. <0.015 wt./wt.% 2. 0.59 wt./wt.% 3. <0.040 wt./wt.% 4. <0.009 wt./wt.% 5. <0.006 wt./wt.% 6. <0.007 wt./wt.% 7. 8.76 wt./wt.%
Organic Acids [5] (IC) 1. TFA 2. PFPA 3. HFBA 4. NFPA		 1. <0.1 wt./wt.% 2. <0.1 wt./wt.% 3. 0.10 wt./wt.% 4. 0.28 wt./wt.%
Elemental Analysis[6]: 1. Carbon 2. Hydrogen 3. Nitrogen 4. Sulfur 5. Fluorine	 1. Theoretical Value = 17.8% 2. Theoretical Value = 0% 3. Theoretical Value = 0% 4. Theoretical Value = 5.95% 5. Theoretical Value = 60%	 1. 12.48 wt./wt.% 2. 0.244 wt./wt.% 3. 1.74 wt./wt.% 4. 8.84 wt./wt.% 5. 54.1 wt./wt.%

Appendix 3
(continued)
Certificate of Analysis

INTERIM CERTIFICATE OF ANALYSIS

Centre Analytical Laboratories COA Reference #: 023-018A

Date of Last Analysis: 08/31/00

Expiration Date: 08/31/01

Storage Conditions: Frozen ≤-10°C

Re-assessment Date: 08/31/01

[1]Purity = 100% - (sum of metal impurities, 1.45% +LC/MS impurities, 8.41%+Inorganic Fluoride, 0.59%+NMR impurities, 1.93%+organic acid impurities, 0.38%+POAA, 0.33%)

Total impurity from all tests = 13.09%
Purity = 100% - 13.09% = 86.9%

[2]Potassium is expected in this salt form and is therefore not considered an impurity.

[3]Purity by DSC is generally not applicable to materials of low purity. No endotherm was observed for this sample.

[4]Sulfur in the sample appears to be converted to SO_4 and hence detected using the inorganic anion method conditions. The anion result agrees well with the sulfur determination in the elemental analysis, lending confidence to this interpretation. Based on the results, the SO_4 is not considered an impurity.

[5]TFA	Trifluoroacetic acid
HFBA	Heptafluorobutyric acid
NFPA	Nonofluoropentanoic acid
PFPA	Pentafluoropropanoic acid

[6]Theoretical value calculations based on the empirical formula, $C_8F_{17}SO_3^-K^+$ (MW=538)

This work was conducted under EPA Good Laboratory Practice Standards (40 CFR 160).

Appendix 3
(continued)
Certificate of Analysis

Centre Analytical Laboratories, Inc.
3048 Research Drive State College, PA 16801 www.centrelab.com
Phone: (814) 231-8032 Fax: (814) 231-1253 or (814) 231-1580

INTERIM CERTIFICATE OF ANALYSIS

Revision 3

Centre Analytical Laboratories COA Reference #: 023-018A

LC/MS Purity Profile:

Impurity	wt./wt. %
C4	1.22
C5	1.33
C6	4.72
C7	1.14
Total	**8.41**

Note: The C4 and C6 values were calculated using the C4 and C6 standard calibration curves, respectively. The C5 value was calculated using the average result from the C4 and C6 standard curves. Likewise, the C7 value was calculated using the average result from the C6 and C8 standard curves.

Prepared By: _____ 10/11/01
Charles Simons Date
Scientist, Centre Analytical Laboratories

Reviewed By: _____ 10/11/01
John Flaherty Date
Laboratory Manager, Centre Analytical Laboratories

Appendix 4

The Analysis of PFOS In Soil and Seven Species of Plants

In Support of

Wildlife International, Ltd. Project No.: 454-110

INTRODUCTION

Soil and plant tissue (vegetative and fruit) samples were collected from a plant toxicity study designed to determine the effects of Perfluorooctanesulfonate, Potassium Salt (PFOS) to seven species of plants. This study was conducted by Wildlife International, Ltd. for 3M Corporation and identified as Project Number 454-110. The chemistry phase of this study was conducted at the Wildlife International, Ltd. analytical chemistry facility in Easton, Maryland using high performance liquid chromatography with triple quadrupole mass spectrometric detection (HPLC/MS/MS). Samples were prepared and analyzed between November 15, 2001 and August 28, 2002.

MATERIALS AND METHODS

Test Substance

The test substance used for this study was Wildlife International, Ltd. identification number 4675. The test substance was used to prepare calibration and matrix fortification samples.

Analytical Methodology

Artificial Soil

Submitted artificial soil samples were analyzed for PFOS following procedures documented in Wildlife International, Ltd. study number 454C-120 entitled "Analytical Method Validation for the Determination of Perfluorooctanesulfonate, Potassium Salt (PFOS) in Artificial Soil" (8). The entire submitted soil sample was blended for approximately two minutes prior to sub-sampling the requisite 10-g aliquot for the analytical determination. The sub-samples were extracted with methanol, agitated for a minimum of 30 minutes on a gyratory shaker table at approximately 250 rpm, and vacuum filtered with qualitative filter paper. The retained soil was triple rinsed with methanol. The filtrate was then transferred to a 200-mL volumetric flask and brought to volume with methanol. Approximately 20 milliliters of each sample was transferred to a separate vial or tube and centrifuged for approximately 5 minutes at 2000 rpm. Dilutions into the calibration range of the HPLC/MS/MS methodology were performed with a solution of 50% methanol (HPLC grade, 99.9+%) and 50% NANOpure® water. Samples were then analyzed by direct injection. Concentrations of PFOS were determined by reverse-phase high performance liquid chromatography using a Hewlett-Packard Model 1100 High Performance Liquid Chromatograph (HPLC) with a Perkin-Elmer API 3000LC Mass Spectrometer equipped with a Perkin-Elmer TurboIonSpray ion source. Chromatographic separations were achieved using a

Keystone Betasil C_{18} column (50 mm × 2.0 mm, 3 µm particle size) fitted with a Keystone Javelin C_{18} guard column (20 mm x 2.0 mm). A method flowchart for PFOS determinations in artificial soil is provided in Appendix 4.1 and the instrument parameters are summarized in Appendix 4.2.

Plant Tissue

Submitted plant tissue samples were analyzed for PFOS following procedures documented in Wildlife International, Ltd. study number 454C-125 entitled "Analytical Method Validation for the Determination of Perfluorooctanesulfonate, Potassium Salt (PFOS) in Plant Tissues" (9). Vegetative *(i.e.* stems and leaves) and fruit tissues were processed and analyzed using the same procedures. The entire submitted plant sample was manually shredded, cut, and/or blended as appropriate. If sufficient sample quantity was available, one-gram aliquots of each homogenate were weighed into vials for analytical determination. Numerous study samples (*i.e.* Day 21 vegetative tissues) were quantity limited. Therefore, the following criterion was implemented: If a given replicate (A, B, or C) for a test level contained ≥0.5 g of tissue, the replicate was individually analyzed. If two or more replicates contained <0.5 g, the replicates were composited. Composited replicates were analyzed when the composite weight was ≥0.5 g.

Plant sub-samples were extracted in the vials with ten milliliters of methanol. Extraction consisted of manual shaking for approximately one minute followed by approximately 30 minutes of agitation on a gyratory shaker table set at approximately 250 rpm. The sub-samples were then centrifuged for approximately ten minutes at approximately 2000 rpm. Dilutions into the calibration range of the HPLC/MS/MS methodology were performed with a solution of 50% methanol (HPLC grade, 99.9+%) and 50% NANOpure® water. Samples were then analyzed by direct injection using the same instrumental conditions as described for the determination of PFOS in soil (Appendix 4.2). A method flowchart for the determination of PFOS in plant tissues is provided in Appendix 4.3.

Primary and Secondary Stock Solutions

All primary and secondary stock preparations were adjusted for the purity of the test substance (86.9%). Details on the preparation of the stock solutions of PFOS are provided in Appendix 4.4. The primary and secondary stocks were used for preparation of calibration standards and matrix fortification samples.

Calibration Standards and Calibration Curves

Calibration standards of PFOS, prepared in 50:50 methanol: NANOpure® water by appropriate dilution of the 0.00100 µg a.i./ µL stock solution of PFOS in methanol (Appendix 4.4), were analyzed with each soil and plant tissue sample set. For soil analyses, PFOS calibration standards ranged in concentration from 1.00 to 10.0 µg a.i./L. For plant tissue analyses, PFOS calibration standards ranged in concentration from 0.400 to 5.00 µg a.i./L. The calibration standard series was injected at the beginning and end of each run, and one standard was injected, at a minimum, after every five samples. The same and most prominent peak response for PFOS was utilized to monitor PFOS in all calibration and study samples. No attempt was made to quantify PFOS on the basis of individual isomeric components. Linear regression equations were generated using peak area responses versus the respective concentrations of the calibration standards. Typical calibration curves for PFOS determinations in artificial soil and plant tissues are presented in Appendices 4.5 and 4.6, respectively. Representative ion chromatograms of low- and high-level PFOS calibration standards are presented in Appendices 4.7 and 4.8.

The concentrations of PFOS in the samples were determined by substituting peak area responses into the applicable linear regression equation. Concentrations were calculated on a dry weight basis using moisture determination data submitted with the samples. An example of the calculations for a representative artificial soil sample is included in Appendix 4.9.

Limits of Quantitation

Artificial Soil

The method limit of quantitation (LOQ) in artificial soil was 1.18 mg a.i./kg on a dry-weight basis and was calculated as the product of the lowest calibration standard (1.00 µg a.i./L = 0.00100 mg a.i./L), the weight/volume dilution factor of the matrix blank samples (1000) divided by the percent solids for the test system soil (84.9%).

Plant Tissue - Fruit

Method LOQs in plant fruit tissues were reported on a dry-weight basis and were calculated for each plant fruit species, except alfalfa, as the product of the low-level calibration standard concentration, the weight/volume dilution factor of the matrix blank samples, divided by the percent solids determined for the fruit species negative control samples. The presence of

contamination and/or interferent matrix species in alfalfa fruit tissue necessitated a unique LOQ definition relative to the other plant fruit species. For alfalfa fruit, the LOQ was calculated on a dry-weight basis as the maximum mg PFOS/kg equivalent concentration observed in the negative control extract rounded upward to the nearest tenth mg a.i./kg value (see Limits of Quantitation-Plant Tissue- Vegetative).

Plant Tissue - Vegetative

Method LOQs in plant vegetative tissues were reported on a dry weight basis and were calculated as the maximum mg PFOS/kg equivalent concentration observed in the negative control extracts for each plant vegetative tissue species, rounded upward to the nearest tenth mg a.i./kg value. As was the case for alfalfa fruit, unidentified matrix interferences were often evident in selected negative control samples at levels above the low standard equivalent LOQ definition (see Limits of Quantitation, Plant Tissue – Fruit). Further, the magnitude of the matrix interference was highly variable within a set of negative controls for a given vegetative tissue species, thereby negating use of an averaged background correction approach.

Matrix Fortifications and Matrix Blanks

Artificial Soil

Selected 20.0-g aliquots of artificial soil matrix were fortified with the appropriate stock solutions of PFOS prepared in methanol using a gas-tight syringe. The fortified soils were then homogenized with blending for approximately two minutes. A 10-g aliquot of each homogenized fortified soil sample was weighed into a tared weigh boat and transferred to an 8-oz. French-square bottle for extraction. The matrix blanks were unfortified artificial soil.

Along with the sample analyses, three matrix blanks were analyzed to determine possible interferences. No interferences were observed at or above the LOQ during the sample analyses (Appendix 4.10). A representative ion chromatogram of a matrix blank sample in artificial soil is presented in Appendix 4.11.

Artificial soil samples were fortified at 2.36, 118, and 1410 mg a.i./kg (dry weight basis) and analyzed concurrently with the samples to determine the mean procedural recovery. The method yielded mean procedural recoveries of 83.9%, 89.0% and 86.5%, respectively (Appendix

4.10). Sample measured concentrations were not corrected for the mean procedural recoveries. A representative ion chromatogram of a matrix fortification sample in artificial soil is presented in Appendix 4.12.

Plant Tissues

Selected aliquots (approximately 1.00 g) of negative control plant tissues were fortified with appropriate stock solutions of PFOS prepared in methanol using a gas-tight syringe. A matrix blank was prepared with unfortified negative control plant tissue.

Fruit and vegetative plant tissue samples were fortified at target nominal concentrations of 0.050, 0.50, and 50.0 mg a.i./kg (wet weight basis) and analyzed concurrently with the samples to determine mean procedural recoveries. In fruit tissue, the mean procedural recoveries ranged from 86.3 to 117% of nominal concentrations (Appendix 4.13). Sample measured concentrations were not corrected for the mean procedural recoveries. Representative ion chromatograms of a matrix blank and a matrix fortification sample in a plant fruit tissue are presented in Appendices 4.14 and 4.15, respectively. In vegetative tissue, the mean procedural recoveries ranged from 88.0 to 110% of nominal concentrations (Appendix 4.16). Sample measured concentrations were not corrected for the mean procedural recoveries. Representative ion chromatograms of a matrix blank and a matrix fortification sample in a plant vegetative tissue are presented in Appendices 4.17 and 4.18, respectively.

RESULTS

Artificial Soil

Samples of artificial soil collected on Days 0 and 21, and at test termination were submitted and analyzed for PFOS. All negative control artificial soil samples were <LOQ for PFOS. Day 0 analyses of the 3.91, 15.6, 62.5, 250, and 1000 mg a.i./kg treatment levels had mean measured values of 3.61, 11.1, 50.8, 276, and 998 mg a.i./kg, corresponding to 92.3%, 71.2%, 81.3%, 110%, and 99.8% of the nominal concentrations, respectively (Appendix 4.19). PFOS measured values for test termination samples are presented in Appendix 4.20. The 3.91, 15.6, 62.5, 250 and 1000 mg a.i./kg treatment levels had mean measured values of 1.29, 3.56, 16.2, 157 and 474 mg a.i./kg, corresponding to 33.0%, 22.8%, 25.9%, 62.8% and 47.4% of the nominal concentrations, respectively. A representative ion chromatogram of an artificial soil test sample is presented in Appendix 4.21.

Plant Tissues

Samples of fruit tissue from five species of plant (alfalfa, flax, onion, soybean, and tomato) grown in negative control and PFOS-treated artificial soils were collected at test termination (for a given species) and analyzed for PFOS residues. Samples of vegetative tissue from seven species of plant (alfalfa, flax, lettuce, onion, ryegrass, soybean, and tomato) grown in negative control and PFOS-treated artificial soils were collected at experimental termination (for a given species) and analyzed for PFOS residues. Measured PFOS concentrations are presented in Appendices 4.22 – 4.33. Representative ion chromatograms of plant fruit and vegetative tissue test samples are presented in Appendices 4.34 and 4.35, respectively.

Appendix 4.1

Analytical Method Flowchart for the Processing of PFOS in Soil

Prepare QC samples in soil matrix from the appropriate methanol stocks. Weigh approximately 20.0 g of soil matrix for each QC into a tared weigh boat. Record weights. Transfer to 8-oz. French square glass bottles. Fortify each soil sample with the appropriate volume of PFOS stock solution in methanol with a gas-tight syringe. Allow to air dry. The matrix blank is unfortified soil matrix.

↓

For each QC and test sample, transfer the entire contents from the 8-oz French square glass bottle to a blender. Homogenize each sample for approximately 2 minutes. Place the entire homogenate into a Ziploc® bag.

↓

Weigh approximately 10.0 grams of each study sample into a tared weigh boat. Record weights. Transfer to 8 oz. French square bottles.

↓

For each sample, measure 100 mL of methanol with a graduated cylinder and transfer into the French square bottle.

↓

Cap bottles and place on shaker table. Allow the samples to shake for a minimum of 30 minutes at approximately 250 rpm.

↓

Vacuum filter with qualitative filter paper and rinse retained soil 3 times with methanol into filtrate.

↓

Transfer the filtrate into a 200-mL volumetric flask and bring to volume with methanol. Mix well with several repeat inversions.

↓

Transfer approximately 20 mL of each sample into a separate glass centrifuge tube or scintillation vial and cap. Centrifuge samples for approximately 5 minutes at 2000 rpm.

↓

Prepare appropriate dilution(s) to bring final concentration into the calibration range of the LCMS methodology. For all dilutions, use 50% methanol:50% NANOpure® water dilution solvent, gas-tight syringes, and Class A volumetric glassware.

↓

Ampulate and submit sample for HPLC/MS/MS analysis.

Appendix 4.2

Typical HPLC/MS/MS Operational Parameters

INSTRUMENT:	Hewlett-Packard Model 1100 High Performance Liquid Chromatograph with a Perkin-Elmer API 3000 Mass Spectrometer Operated in multiple ion reaction monitoring (MRM) mode.
ION SOURCE:	Perkin-Elmer TurboIonSpray
ANALYTICAL COLUMN:	Keystone Betasil C_{18} (50 mm × 2.0 mm, 3-µm particle size)
GUARD COLUMN:	Keystone Javelin C_{18} cartridge (20 mm × 2 mm)
OVEN TEMPERATURE:	40°C
STOP TIME:	5.00 min
FLOW RATE:	250 µL/min
MOBILE PHASE:	30% NANOpure® Water with 0.1% Formic Acid: 70% Methanol
INJECTION VOLUME:	5.0 µL
PFOS PEAK RETENTION TIME:	Approximately 4 minutes
PFOS MONITORED MASS:	499.0 amu → 99.1 amu

Appendix 4.3

Analytical Method Flowchart for the Processing of PFOS in Plant Tissue

Remove samples from frozen storage. Homogenize samples with manual shredding, cutting and/or blending, as appropriate. Weigh the appropriate number of 1-g aliquots of each homogenate into a tared vial.

↓

Quality control samples are prepared from 1-g aliquots of homogenized negative control plant tissue. Fortify matrix fortification samples with the appropriate PFOS stock solution(s) in methanol using gas-tight syringe(s). The matrix blank is unfortified plant matrix.

↓

For each sample, measure 10.0 mL of methanol with a glass Class A volumetric pipette. Cap the vials and shake manually for a minimum of one minute.

↓

Place samples on gyratory shaker table and shake at a setting of 250 rpm for approximately thirty minutes.

↓

Centrifuge the vials at approximately 2000 rpm for approximately 10 minutes.

↓

Prepare appropriate dilutions of study and QC samples to bring concentrations within the calibration range of the PFOS LCMS methodology: Partially fill Class A volumetric flasks with 50%: 50% methanol/ NANOpure® water dilution solvent. Add appropriate volume of sample with a gas-tight syringe and bring to volume with dilution solvent. Process matrix blank samples using the same dilution and aliquot volumes as for the lowest fortification level. Cap and mix well by several repeat inversions. Store the remaining original methanol extracts in the walk-in cooler.

↓

Transfer an aliquot of each sample to an autosampler vial and submit for HPLC/MS/MS analysis.

Appendix 4.4

Analytical Stocks and Standards Preparation

A 10.0 µg a.i./µL primary stock solution of PFOS was prepared by weighing 1.1508 g of the test substance on an analytical balance. The test substance was brought to 100-mL final volume with methanol. Secondary stock solutions (1.00, 0.100, 0.0100, 0.00100, and 0.000100 µg a.i./µL) of PFOS in methanol were prepared from the primary stock by serial volumetric dilution. The calibration standards were prepared in 50% (v/v) methanol in NANOpure® water. The following shows dilution schemes for the sets of calibration standards employed for determination of PFOS in soil and plant tissues:

Calibration Standards for Determination of PFOS in Soil

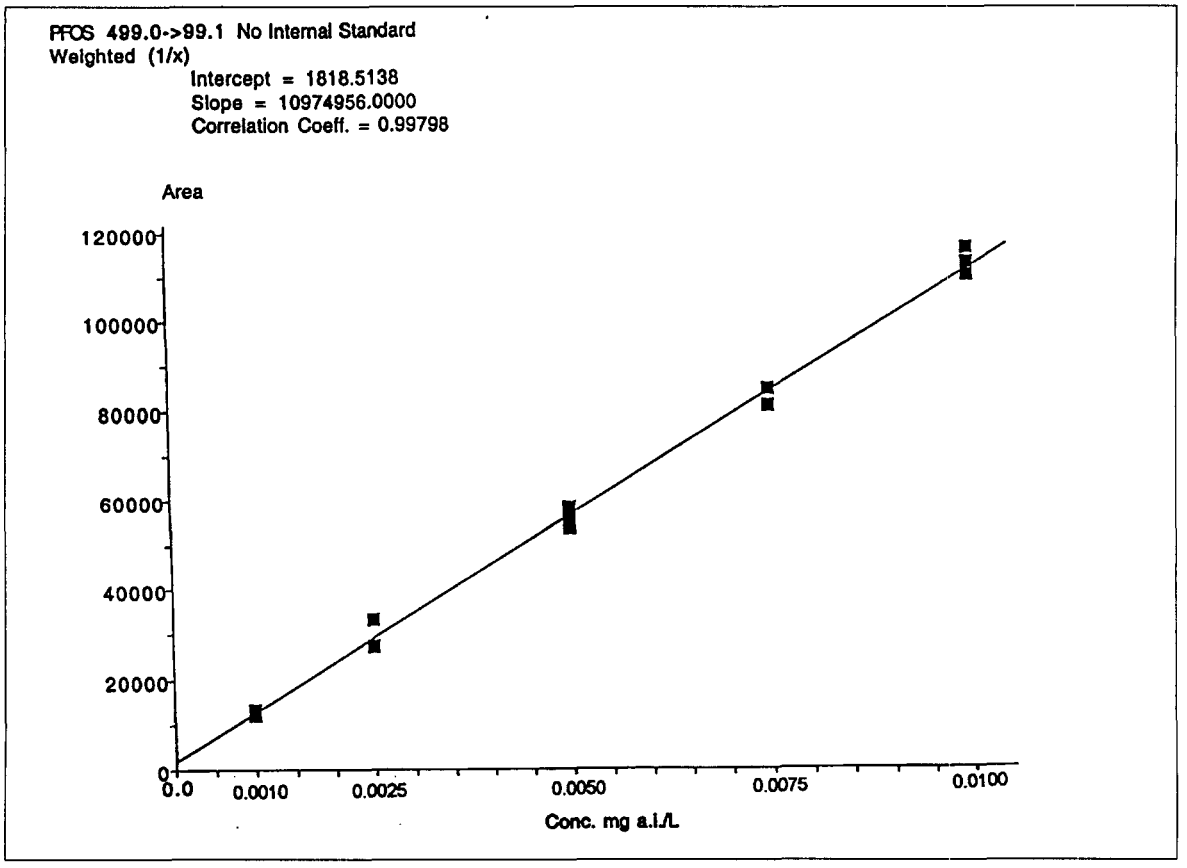
Stock Concentration (µg a.i./µL)	Aliquot (µL)	Final Volume (mL)	Standard Concentration (µg a.i./L)
0.00100	100	100	1.00
0.00100	250	100	2.50
0.00100	500	100	5.00
0.00100	750	100	7.50
0.00100	1000	100	10.0

Calibration Standards for Determination of PFOS in Plant Tissues

Stock Concentration (µg a.i./µL)	Aliquot (µL)	Final Volume (mL)	Standard Concentration (µg a.i./L)
0.00100	40.0	100	0.400
0.00100	50.0	100	0.500
0.00100	100	100	1.00
0.00100	250	100	2.50
0.00100	350	100	3.50
0.00100	500	100	5.00

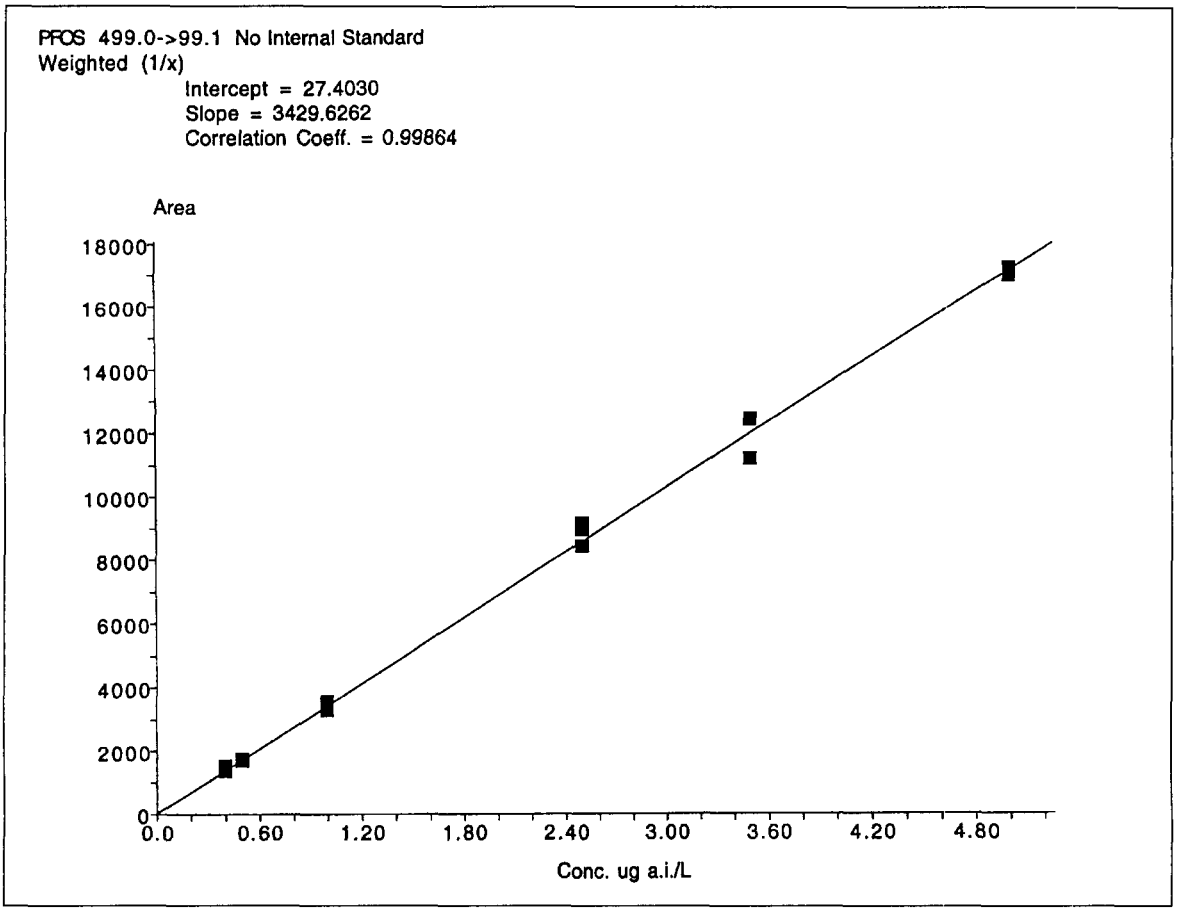
Appendix 4.5

Typical Calibration Curve for PFOS Determinations in Artificial Soil



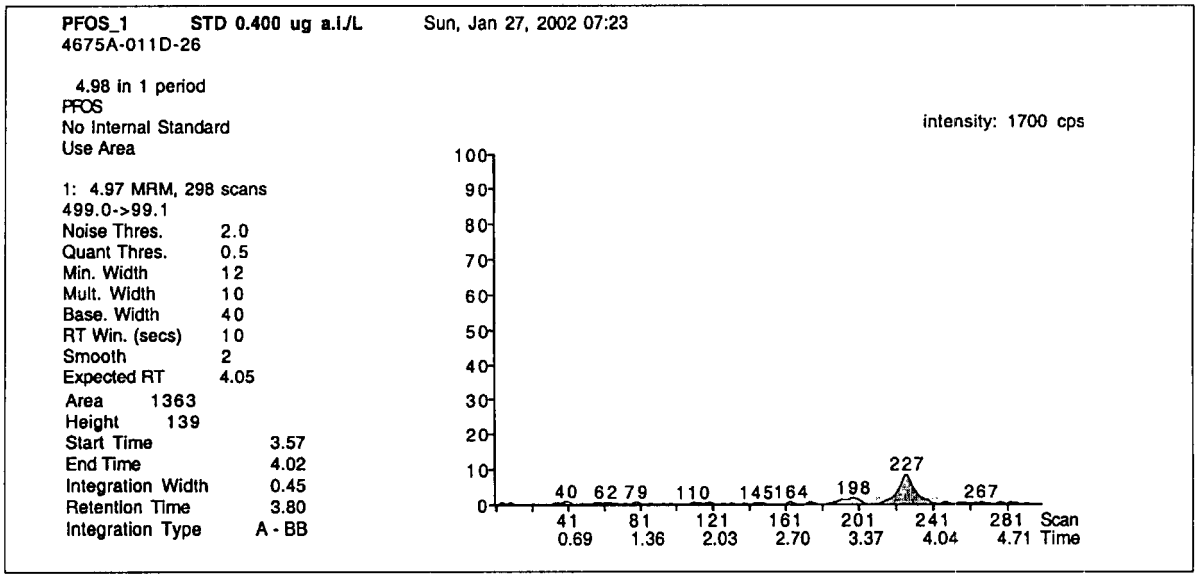
Appendix 4.6

Typical Calibration Curve for PFOS Determinations in Plant Tissues



Appendix 4.7

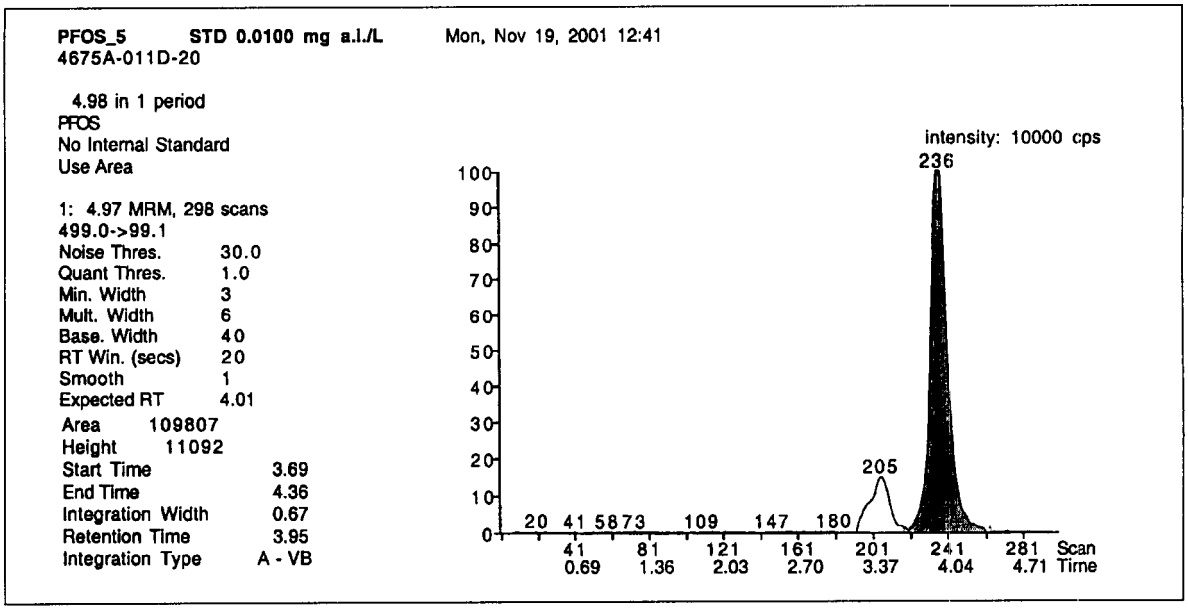
Representative Chromatogram of a Low-Level PFOS Calibration Standard



Nominal concentration: 0.400 µg a.i./L.

Appendix 4.8

Representative Chromatogram of a High-Level PFOS Calibration Standard



Nominal concentration: 10.0 µg a.i./L.

Appendix 4.9

Example Calculations for a Representative Sample

The analytical result and percent recovery of PFOS in artificial soil for sample number 454-110-10, nominal concentration of 62.5 mg a.i./kg, was calculated using the following equations:

$$C = \frac{PA - b}{m}$$

where PA = peak area
m = slope of the line
C = concentration
b = y - axis intercept

Using the appropriate regression data from the sample analysis sequence (Appendix 4.5), the concentration in the final sample solution was calculated as:

$$C = \frac{28656 - 1818.5138}{10974956} = 0.002445 \text{ mg a.i./L}$$

The measured concentrations of PFOS in the artificial soil sample determined as follows:

$$\text{Concentration PFOS (mg a.i./kg)} = \frac{(C) \times (V_e) \times (V_{f1}) \times (V_{f2})}{(W) \times (V_{i1}) \times (V_{i2}) \times (\%\text{Solids})}$$

where C = Concentration (mg a.i./L) as determined above
V_e = Extraction Volume (100 mL)
V_{i1} = First Initial Volume (100 mL)
V_{i2} = Second Initial Volume (0.0500 mL)
V_{f1} = First Final Volume (200 mL)
V_{f2} = Second Final Volume (50.0 mL)
W = Weight of extracted sample (10.0 g)

$$\text{Concentration PFOS (mg a.i./kg)} = \frac{0.002445 \times 100 \times 200 \times 50.0}{10.0 \times 100 \times 0.0500 \times 0.849}$$

$$\text{Concentration PFOS (mg a.i./kg)} = 57.60$$

$$\text{Percent of Nominal Concentration} = \frac{\text{PFOS (mg a.i./Kg) in sample}}{\text{PFOS (mg a.i./Kg) nominal}} \times 100$$

$$= \frac{57.60}{62.5} \times 100 = 92.2\%$$

Calculated with HPLC/MS/MS instrument software: MacQuan, version 1.6.

Appendix 4.10

Artificial Soil Matrix Blanks and Fortifications Analyzed Concurrently During Sample Analysis

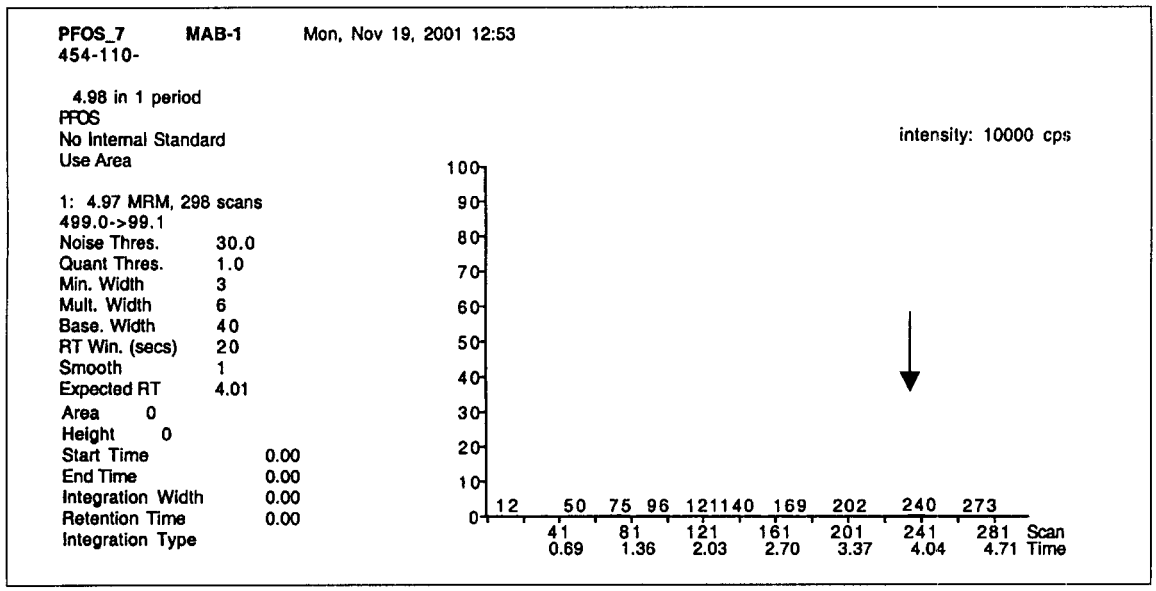
Sample Number (454-110-)	Sample Type	Sampling Interval	PFOS Concentration (mg a.i./kg) Fortified	PFOS Concentration (mg a.i./kg) Measured[1]	Percent Recovered[1]	Mean Measured (mg a.i./kg)	Mean Percent Recovery
MAB – 1	Soil Matrix Blank	Initiation	0.0	< 1.18[2]	--	< 1.18	--
MAB – 3	Soil Matrix Blank	Termination	0.0	< 1.18	--	--	
MAS – 1	Soil Matrix Fortification	Initiation	2.36	2.24	95.1	2.12	89.8
MAS – 7	Soil Matrix Fortification	Termination	2.36	1.99	84.4		
MAS – 2	Soil Matrix Fortification	Initiation	118	108	91.3	106	89.8
MAS – 8	Soil Matrix Fortification	Termination	118	104	88.1		
MAS – 3	Soil Matrix Fortification	Initiation	1410	1270	90.0	1290	91.5
MAS – 9	Soil Matrix Fortification	Termination	1410	1310	93.1		
				Overall Mean =	90.3		
				Standard Deviation =	3.78		
				CV =	4.19		
				N =	6		

[1]Measured and Percent Recovered values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.

[2]The method limit of quantitation (LOQ) in artificial soil was 1.18 mg a.i./kg on a dry-weight basis and was calculated as the product of the lowest calibration standard (0.00100 mg a.i./L) and the weight/volume dilution factor of the matrix blank samples (1000) divided by the percent solids for the test system soil (84.9%).

Appendix 4.11

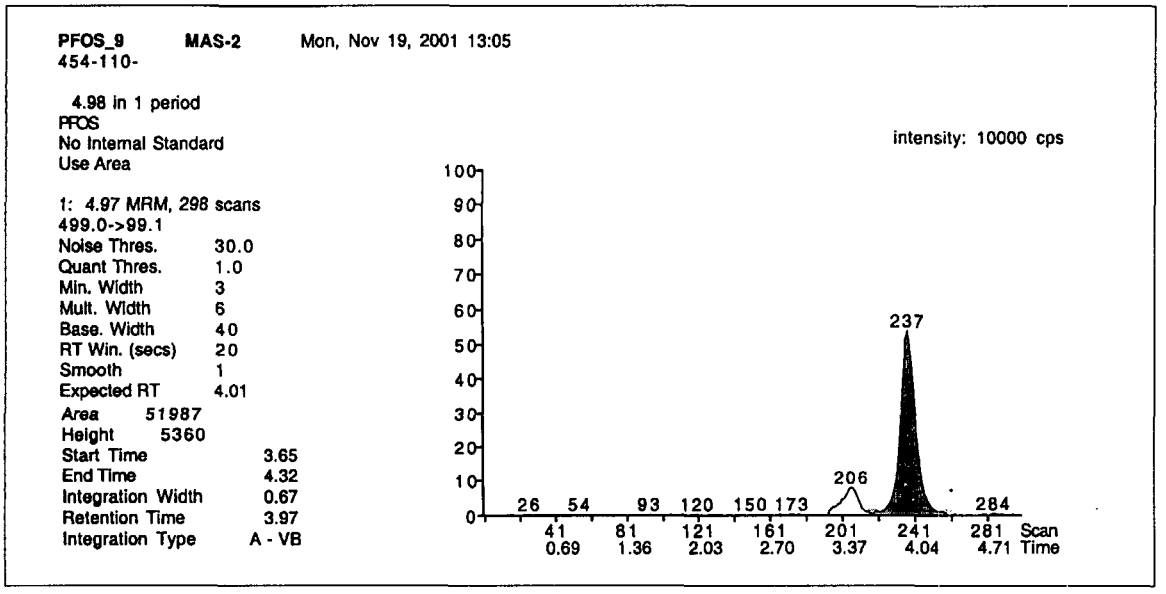
Representative Chromatogram of an Artificial Soil Matrix Blank Sample



Sample Identification: 454-110-MAB-1. The arrow indicates the retention time of PFOS.

Appendix 4.12

Representative Chromatogram of an Artificial Soil Matrix Fortification Sample



Sample Identification: 454-110-MAS-2.

Nominal Concentration: 118 mg a.i./kg (dry-weight basis).

Appendix 4.13

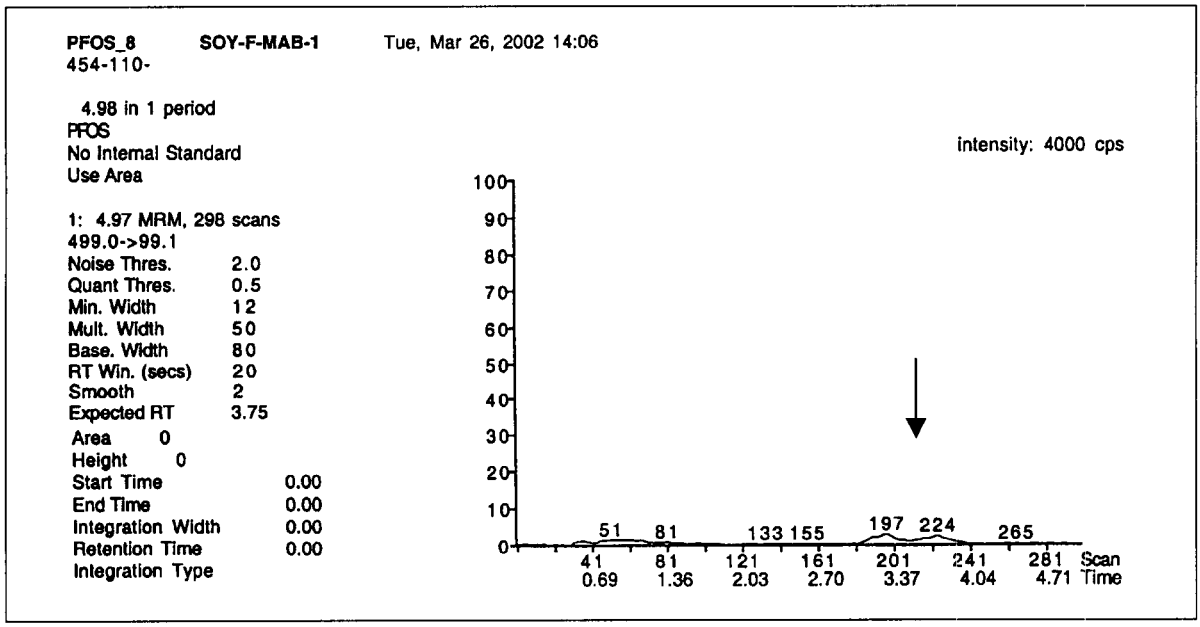
Fruit Tissue Matrix Blanks and Fortifications Analyzed Concurrently During Sample Analysis

Sample			PFOS Concentration (mg a.i./kg)	Measured[1,2]		
Number (454-110-)	Type	Sampling Interval	Fortified[3]	Wet-Weight Basis	Dry-Weight Basis	Percent Recovered[1]
alf-f-MAB-1	Alfalfa Matrix Blank	Termination	0.0	3.09[4]	8.43[4]	--
alf-f-MAS-3	Alfalfa Fortification	Termination	50.0	50.4	138	101
flx-f-MAB-1	Flax Matrix Blank	Termination	0.0	< 0.040	< 0.12	--
flx-f-MAS-1	Flax Fortification	Termination	0.0495	0.0581	0.170	117
flx-f-MAS-2	Flax Fortification	Termination	0.503	0.521	1.52	104
flx-f-MAS-3	Flax Fortification	Termination	47.9	44.4	130	92.7
oni-f-MAB-1	Onion Matrix Blank	Termination	0.0	< 0.040	< 0.42	--
oni-f-MAS-1	Onion Fortification	Termination	0.0490	0.0477	0.494	97.3
oni-f-MAS-2	Onion Fortification	Termination	0.467	0.451	4.68	96.6
oni-f-MAS-3	Onion Fortification	Termination	47.9	51.4	533	107
soy-f-MAB-1	Soybean Matrix Blank	Termination	0.0	< 0.040	< 0.18	--
soy-f-MAS-1	Soybean Fortification	Termination	0.0500	0.0508	0.222	102
soy-f-MAS-2	Soybean Fortification	Termination	0.496	0.478	2.09	96.4
soy-f-MAS-3	Soybean Fortification	Termination	50.0	47.9	209	95.7
tom-f-MAB-1	Tomato Matrix Blank	Termination	0.0	< 0.040	< 0.47	--
tom-f-MAS-1	Tomato Fortification	Termination	0.0498	0.0468	0.554	93.9
tom-f-MAS-2	Tomato Fortification	Termination	0.495	0.427	5.05	86.3
tom-f-MAS-3	Tomato Fortification	Termination	47.8	42.3	501	88.6

[1]Measured and Percent Recovered values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly.
[2]The method limit of quantitation (LOQ) in fruit tissue was calculated as the product of the lowest calibration standard (0.000400 mg a.i./L) and the weight/volume dilution factor of the matrix blank sample.
[3]Fortified PFOS concentrations are presented on a wet-weight basis.
[4]The method limit of quantitation (LOQ) in alfalfa fruit tissue (6.4 mg a.i./kg on a dry-weight basis = 2.3 mg a.i./kg on a wet-weight basis) was calculated as the maximum mg PFOS/kg equivalent concentration measured in negative control sample extracts rounded upward to the nearest tenth mg a.i./kg.

Appendix 4.14

Representative Chromatogram of a Plant Fruit Tissue Matrix Blank Sample

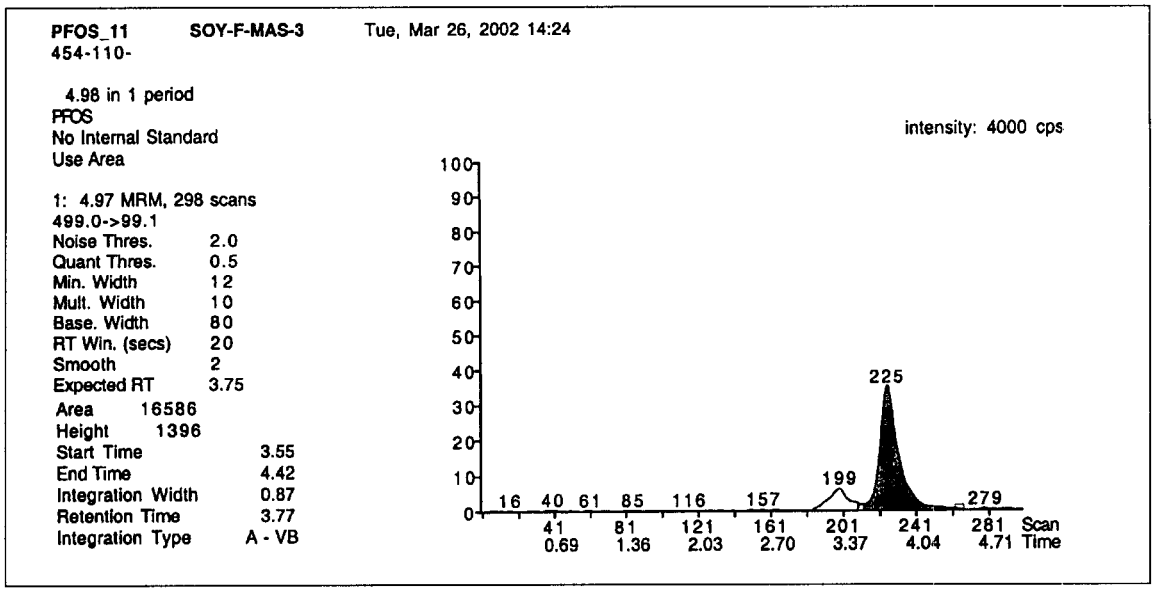


Sample Identification: 454-110-SOY-F-MAB-1 (soybean matrix).

The arrow indicates the retention time of PFOS.

Appendix 4.15

Representative Chromatogram of a Plant Fruit Tissue Matrix Fortification Sample



Sample Identification: 454-110-SOY-F-MAS-3 (soybean matrix).

Nominal Concentration: 50.0 mg a.i./kg (wet-weight basis).

Appendix 4.16

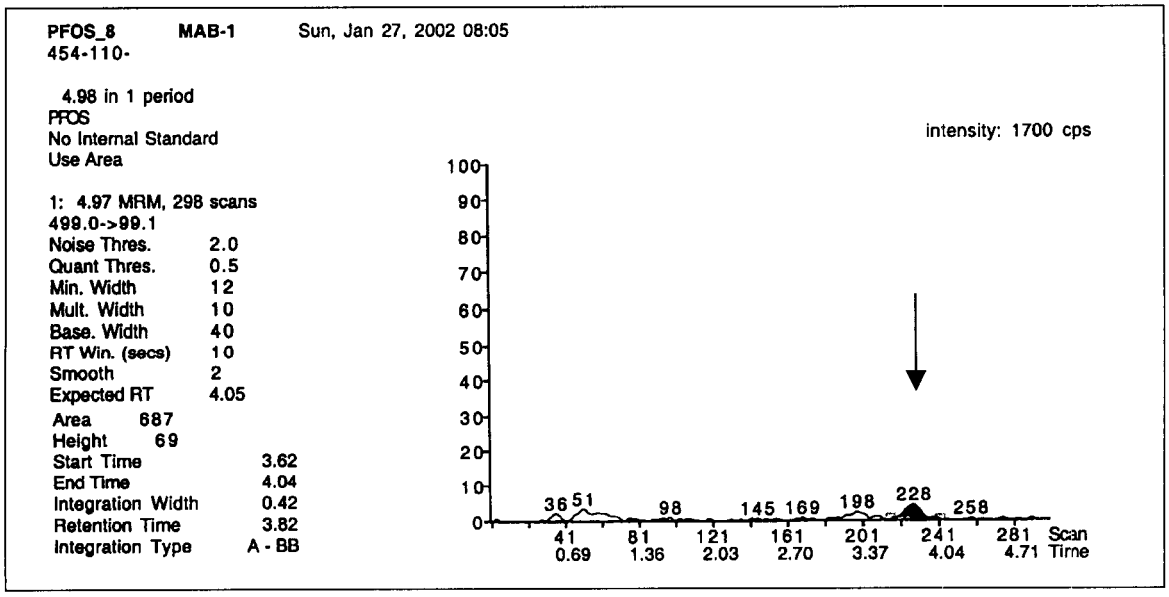
Vegetative Tissue Matrix Blanks and Fortifications Analyzed Concurrently During Sample Analysis

Sample			PFOS Concentration (mg a.i./kg)	Measured[1,2]		
Number (454-110-)	Type	Sampling Interval	Fortified[3]	Wet-Weight Basis	Dry-Weight Basis	Percent Recovered[1]
alf-v-MAB-1	Alfalfa Matrix Blank	Termination	0.0	< 0.84	< 2.7	--
alf-v-MAS-3	Alfalfa Fortification	Termination	48.1	44.2	142	91.9
flx-v-MAB-1	Flax Matrix Blank	Termination	0.0	< 0.72	< 2.4	--
flx-v-MAS-3	Flax Fortification	Termination	48.8	47.5	158	97.3
let-v-MAB-1	Lettuce Matrix Blank	Termination	0.0	< 0.46	< 5.5	--
let-v-MAS-2	Lettuce Fortification	Termination	0.502	0.536	6.37	107
let-v-MAS-3	Lettuce Fortification	Termination	50.4	48.8	579	96.7
oni-v-MAB-2	Onion Matrix Blank	Termination	0.0	< 0.42	< 4.7	--
oni-v-MAS-5	Onion Fortification	Termination	50.1	44.1	492	88.0
rye-v-MAB-1	Ryegrass Matrix Blank	Termination	0.0	< 1.8	< 3.3	--
rye-v-MAS-2	Ryegrass Fortification	Termination	49.5	54.3	100	110
soy-v-MAB-1	Soybean Matrix Blank	Termination	0.0	< 2.4	< 6.0	--
soy-v-MAS-2	Soybean Fortification	Termination	49.3	48.4	119	98.1
tom-v-MAB-1	Tomato Matrix Blank	Termination	0.0	< 1.4	< 7.6	--
tom-v-MAS-3	Tomato Fortification	Termination	48.8	49.9	281	102

[1]Measured and Percent Recovered values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly.
[2]The method limit of quantitation (LOQ) in each vegetative tissue was calculated as the maximum mg PFOS/kg equivalent concentration measured in negative control extracts for that tissue rounded upward to the nearest tenth mg a.i./kg.
[3]Fortified PFOS concentrations are presented on a wet-weight basis.

Appendix 4.17

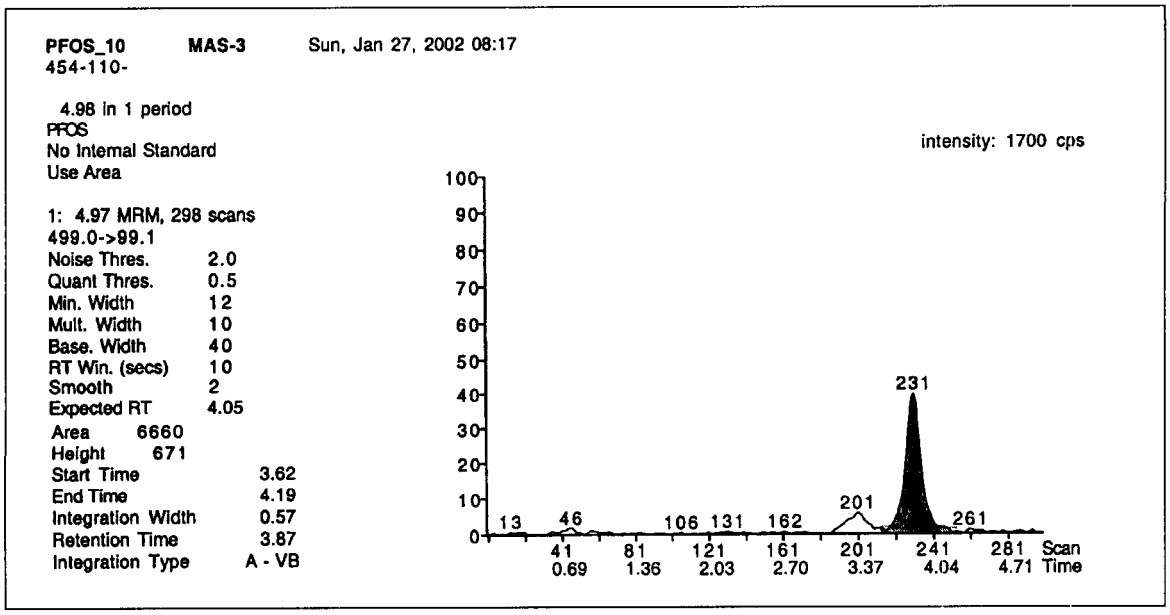
Representative Chromatogram of a Plant Vegetative Tissue Matrix Blank Sample



Sample Identification: 454-110-LET-V-MAB-1 (lettuce matrix).
The arrow indicates the retention time of PFOS.

Appendix 4.18

Representative Chromatogram of a Plant Vegetative Tissue Matrix Fortification Sample



Sample Identification: 454-110-LET-V-MAS-3 (lettuce matrix).
Nominal Concentration: 50.4 mg a.i./kg (wet-weight basis).

Appendix 4.19

Day 0 Recoveries for PFOS in Artificial Soil

Sample		PFOS Concentration (mg a.i./kg)		Mean	Mean
Number (454-110-)	Nominal Concentration	Measured[1]	Percent Recovered[1]	Measured (mg a.i./kg)	Percent Recovery
01	0.0	< 1.18[2]	--	<1.18	--
02	3.91	3.43	87.7	3.61	92.3
03	3.91	2.83	72.4		
04	3.91	4.56	117		
05	15.6	11.1	71.1	11.1	71.2
06	15.6	11.2	72.0		
07	15.6	86.4[3]	554[3]		
08	62.5	50.0	80.0	50.8	81.3
09	62.5	44.7	71.6		
10	62.5	57.6	92.2		
11	250	415	166	276	110
12	250	244	97.5		
13	250	170	67.9		
14	1000	1070	107	998	99.8
15	1000	983	98.3		
16	1000	942	94.2		
		Overall Mean =	92.5		
		Standard Deviation =	26.0		
		CV =	28%		
		N =	14		

[1]Measured and Percent Recovered values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.
[2]The method limit quantitation (LOQ) in artificial soil was 1.18 mg a.i./kg on a dry-weight basis and was calculated as the product of the lowest calibration standard (0.00100 mg a.i./L) and the weight/volume dilution factor of the matrix blank samples (1000) divided by the percent solids for the test system soil (84.9%).
[3]Statistical outlier. Data excluded from Mean Measured calculation.

Appendix 4.20

Termination Recoveries for PFOS in Artificial Soil

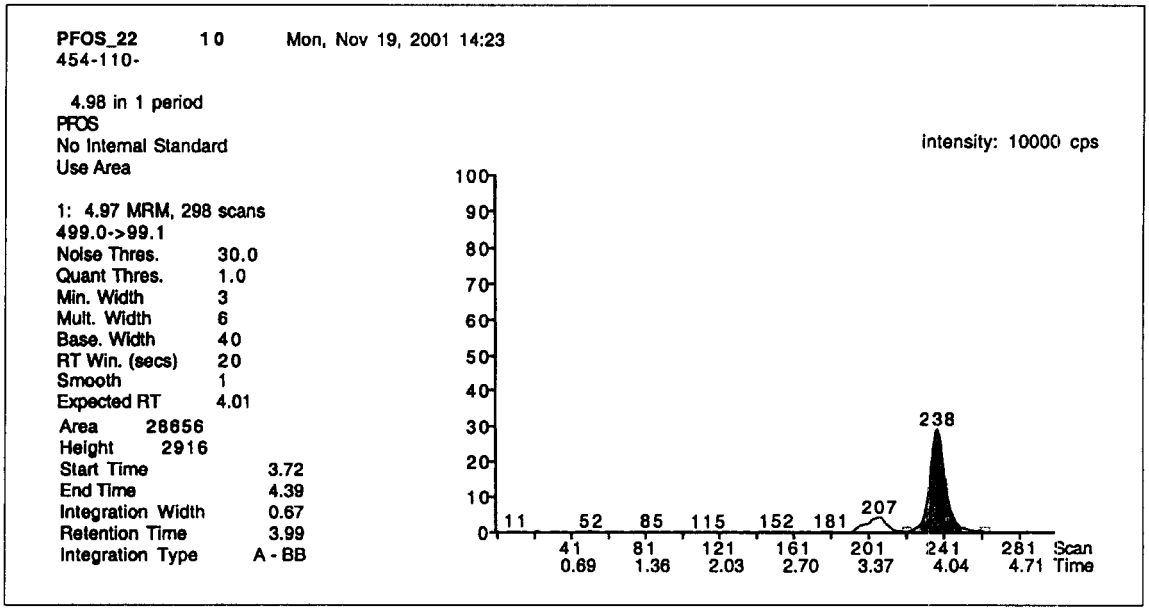
Sample		PFOS Concentration (mg a.i./kg)		Mean	Mean
Number (454-110-)	Nominal Concentration	Measured[1]	Percent Recovered[1]	Measured (mg a.i./kg)	Percent Recovery
28	0.0	< 1.18[2]	--	<1.18	--
29	3.91	1.21	31.0	1.29	33.0
30	3.91	1.36	34.7		
31	15.6	4.91	31.5	3.56	22.8
32	15.6	2.21	14.2		
33	62.5	16.3	26.1	16.2	25.9
34	62.5	16.1	25.8		
35	250	153	61.4	157	62.8
36	250	161	64.5		
37	1000	432	43.2	474	47.4
38	1000	515	51.5		
		Overall Mean =	38.4		
		Standard Deviation =	16.4		
		CV =	43%		
		N =	10		

[1]Measured and Percent Recovered values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.

[2]The method limit quantitation (LOQ) in artificial soil was 1.18 mg a.i./kg on a dry-weight basis and was calculated as the product of the lowest calibration standard (0.00100 mg a.i./L) and the weight/volume dilution factor of the matrix blank samples (1000) divided by the percent solids for the test system soil (84.9%).

Appendix 4.21

Representative Chromatogram of an Artificial Soil Test Sample



Sample Identification: 454-110-10.

Nominal Concentration: 62.5 mg a.i./kg (dry-weight basis).

Appendix 4.22

Termination Measured Values for PFOS in Alfalfa Vegetative Tissue

Sample		PFOS Concentration (mg a.i./kg)	Mean Measured (mg a.i./kg)
Number (454-110-)	Nominal Exposure	Measured[1]	
alf-v-19	0.0	< 2.7[2]	< 2.7
alf-v-20	0.0	< 2.7	
alf-v-21	0.0	< 2.7	
alf-v-22	3.91	< 2.7	6.16
alf-v-23	3.91	< 2.7	
alf-v-24	3.91	6.16	
alf-v-25	15.6	5.66	4.2
alf-v-26	15.6	2.74	
alf-v-27	15.6	< 2.7	
alf-v-28	62.5	12.9	11.2
alf-v-29	62.5	9.66	
alf-v-30	62.5	11.1	
alf-v-31	250	14.2	15.8
alf-v-32	250	15.8	
alf-v-33	250	17.3	
alf-v-34[3]	1000	--	--
alf-v-35[3]	1000	--	
alf-v-36[3]	1000	--	

[1]Measured values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.
[2]The method limit of quantitation (LOQ) in alfalfa vegetative tissue (2.7 mg a.i./kg on a dry-weight basis) was calculated as the maximum mg a.i./kg equivalent concentration measured in negative control extracts rounded upward to the nearest tenth mg a.i./kg.
[3]No sample was collected due to mortality at this concentration.

Appendix 4.23

Termination Measured Values for PFOS in Alfalfa Fruit Tissue

Sample		PFOS Concentration (mg a.i./kg)	Mean Measured (mg a.i./kg)
Number (454-110-)	Nominal Exposure	Measured[1]	
alf-f-1[3]	0.0	< 6.4[2]	< 6.4
alf-f-2[3]	0.0		
alf-f-3[3]	0.0		
alf-f-4[4]	3.91	--	< 6.4
alf-f-5[4]	3.91	--	
alf-f-6	3.91	< 6.4	
alf-f-7[3]	15.6	< 6.4	< 6.4
alf-f-8[3]	15.6		
alf-f-9[3]	15.6		
alf-f-10[3]	62.5	< 6.4	< 6.4
alf-f-11[3]	62.5		
alf-f-12[3]	62.5		
alf-f-13[3]	250	< 6.4	< 6.4
alf-f-14[3]	250		
alf-f-15[3]	250		
alf-f-16[5]	1000	--	--
alf-f-17[5]	1000	--	
alf-f-18[5]	1000	--	

[1] Measured values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.
[2] The method limit of quantitation (LOQ) in alfalfa fruit tissue (6.4 mg a.i./kg on a dry-weight basis) was calculated as the maximum mg PFOS/kg equivalent concentration measured in negative control extracts rounded upward to the nearest tenth mg a.i./kg.
[3] A composite sample was made of all samples collected at this concentration.
[4] There was insufficient sample weight (<0.5 g) available for analysis.
[5] No sample was collected due to mortality at this concentration.

Appendix 4.24

Termination Measured Values for PFOS in Flax Vegetative Tissue

Sample		PFOS Concentration (mg a.i./kg)	Mean
Number (454-110-)	Nominal Exposure	Measured[1]	Measured (mg a.i./kg)
flx-v-19	0.0	< 2.4[2]	< 2.4
flx-v-20	0.0	< 2.4	
flx-v-21	0.0	< 2.4	
flx-v-22	3.91	4.56	4.95
flx-v-23	3.91	6.43	
flx-v-24	3.91	3.85	
flx-v-25	15.6	13.1	18.8
flx-v-26	15.6	26.4	
flx-v-27	15.6	17.0	
flx-v-28	62.5	54.7	55.0
flx-v-29	62.5	72.7	
flx-v-30	62.5	37.5	
flx-v-31[3]	250	--	--
flx-v-32[4]	250	--	
flx-v-33[4]	250	--	
flx-v-34[3]	1000	--	--
flx-v-35[3]	1000	--	
flx-v-36[3]	1000	--	

[1] Measured values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.
[2] The method limit of quantitation (LOQ) in flax vegetative tissue (2.4 mg a.i./kg on a dry-weight basis) was calculated as the maximum mg a.i./kg equivalent concentration measured in negative control extracts rounded upward to the nearest tenth mg a.i./kg.
[3] No sample was collected due to mortality at this concentration.
[4] There was insufficient sample weight (<0.5g) available for this analysis.

Appendix 4.25

Termination Measured Values for PFOS in Flax Fruit Tissue

Sample		PFOS Concentration (mg a.i./kg)	Mean
Number (454-110-)	Nominal Exposure	Measured[1]	Measured (mg a.i./kg)
flx-f-1	0.0	< 0.12[2]	< 0.12
flx-f-2	0.0	< 0.12	
flx-f-3	0.0	< 0.12	
flx-f-4	3.91	0.217	0.230
flx-f-5	3.91	0.277	
flx-f-6	3.91	0.195	
flx-f-7	15.6	1.07	1.36
flx-f-8	15.6	0.622	
flx-f-9	15.6	2.41	
flx-f-10	62.5	1.26	2.56
flx-f-11	62.5	2.20	
flx-f-12	62.5	4.23	
flx-f-13[3]	250	--	--
flx-f-14[4]	250	--	
flx-f-15[4]	250	--	
flx-f-16[3]	1000	--	--
flx-f-17[3]	1000	--	
flx-f-18[3]	1000	--	

[1] Measured values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.
[2] The method limit of quantitation (LOQ) in flax fruit tissue was 0.12 mg a.i./kg on a dry-weight basis and was calculated as the product of the lowest calibration standard (0.000400 mg a.i./L) and the weight/volume dilution factor of the matrix blank samples (100) divided by the percent solids for the negative control fruit tissue (34.3%).
[3] No sample was collected due to mortality at this concentration.
[4] There was insufficient sample weight (<0.5 g) available for analysis.

Appendix 4.26

Termination Measured Values for PFOS in Lettuce Vegetative Tissue

Sample		PFOS Concentration (mg a.i./kg)	Mean
Number (454-110-)	Nominal Exposure	Measured[1]	Measured (mg a.i./kg)
let-v-19	0.0	< 5.5[2]	< 5.5
let-v-20	0.0	< 5.5	
let-v-21	0.0	< 5.5	
let-v-22	3.91	12.2	8.63
let-v-23	3.91	6.16	
let-v-24	3.91	7.52	
let-v-25	15.6	15.5	10.6
let-v-26	15.6	7.06	
let-v-27	15.6	9.26	
let-v-28	62.5	39.8	41.9
let-v-29	62.5	58.9	
let-v-30	62.5	27.0	
let-v-31[3]	250	--	--
let-v-32[3]	250	--	
let-v-33[3]	250	--	
let-v-34[4]	1000	--	--
let-v-35[4]	1000	--	
let-v-36[4]	1000	--	

[1] Measured values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.
[2] The method limit of quantitation (LOQ) in lettuce vegetative tissue (5.5 mg a.i./kg on a dry-weight basis) was calculated as the maximum mg a.i./kg equivalent concentration measured in negative control extracts rounded upward to the nearest tenth mg a.i./kg.
[3] There was insufficient sample weight (<0.5 g) available for analysis.
[4] No samples were collected due to mortality at this concentration.

Appendix 4.27

Termination Measured Values for PFOS in Onion Vegetative Tissue

Sample		PFOS Concentration (mg a.i./kg)	Mean
Number (454-110-)	Nominal Exposure	Measured[1]	Measured (mg a.i./kg)
oni-v-19	0.0	< 4.7[2]	< 4.7
oni-v-20	0.0	< 4.7	
oni-v-21	0.0	< 4.7	
oni-v-22	3.91	< 4.7	< 4.7
oni-v-23	3.91	< 4.7	
oni-v-24	3.91	< 4.7	
oni-v-25	15.6	5.86	10.6
oni-v-26	15.6	15.4	
oni-v-27	15.6	< 4.7	
oni-v-28[3]	62.5	--	--
oni-v-29[3]	62.5	--	
oni-v-30[4]	62.5	--	
oni-v-31[4]	250	--	--
oni-v-32[4]	250	--	
oni-v-33[4]	250	--	
oni-v-34[4]	1000	--	--
oni-v-35[4]	1000	--	
oni-v-36[4]	1000	--	

[1] Measured values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.
[2] The method limit of quantitation (LOQ) in onion vegetative tissue (4.7 mg a.i./kg on a dry-weight basis) was calculated as the maximum mg a.i./kg equivalent concentration measured in negative control extracts rounded upward to the nearest tenth mg a.i./kg.
[3] There was insufficient sample weight (<0.5 g) available for analysis.
[4] No sample was collected due to mortality or lack of emergence at this concentration.

Appendix 4.28

Termination Measured Values for PFOS in Onion Fruit Tissue

Sample		PFOS Concentration (mg a.i./kg)	Mean
Number (454-110-)	Nominal Exposure	Measured[1]	Measured (mg a.i./kg)
oni-f-1	0.0	0.517	0.502
oni-f-2[3]	0.0	--	
oni-f-3	0.0	0.487	
oni-f-4	3.91	5.81	3.13
oni-f-5	3.91	0.453	
oni-f-6[3]	3.91	--	
oni-f-7	15.6	< 0.42[2]	22.2
oni-f-8	15.6	19.7	
oni-f-9	15.6	24.6	
oni-f-10[3]	62.5	--	--
oni-f-11[3]	62.5	--	
oni-f-12[4]	62.5	--	
oni-f-13[4]	250	--	--
oni-f-14[4]	250	--	
oni-f-15[4]	250	--	
oni-f-16[4]	1000	--	--
oni-f-17[4]	1000	--	
oni-f-18[4]	1000	--	

[1] Measured values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.
[2] The method limit of quantitation (LOQ) in onion fruit tissue was 0.42 mg a.i./kg on a dry-weight basis and was calculated as the product of the lowest calibration standard (0.000400 mg a.i./L) and the weight/volume dilution factor of the matrix blank samples (100) divided by the percent solids for the negative control fruit tissue (9.65%).
[3] There was insufficient sample weight (<0.5 g) available for analysis.
[4] No sample was collected due to mortality or lack of fruit production at this concentration.

Appendix 4.29

Termination Measured Values for PFOS in Ryegrass Vegetative Tissue

Sample		PFOS Concentration (mg a.i./kg)	Mean
Number (454-110-)	Nominal Exposure	Measured[1]	Measured (mg a.i./kg)
rye-v-19	0.0	< 3.3[2]	< 3.3
rye-v-20	0.0	< 3.3	
rye-v-21	0.0	< 3.3	
rye-v-22	3.91	7.13	8.18
rye-v-23	3.91	8.70	
rye-v-24	3.91	8.70	
rye-v-25	15.6	13.8	31.4
rye-v-26	15.6	49.0	
rye-v-27	15.6	< 3.3	
rye-v-28	62.5	42.5	48.7
rye-v-29	62.5	67.0	
rye-v-30	62.5	36.7	
rye-v-31	250	31.9	66.1
rye-v-32	250	37.5	
rye-v-33	250	129	
rye-v-34[3]	1000	--	--
rye-v-35[3]	1000	--	
rye-v-36[3]	1000	--	

[1] Measured values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.
[2] The method limit of quantitation (LOQ) in ryegrass vegetative tissue (3.3 mg a.i./kg on a dry-weight basis) was calculated as the maximum mg a.i./kg equivalent concentration measured in negative control extracts rounded upward to the nearest tenth mg a.i./kg.
[3] No sample was collected due to mortality or lack of emergence at this concentration.

Appendix 4.30

Termination Measured Values for PFOS in Soybean Vegetative Tissue

Sample		PFOS Concentration (mg a.i./kg)	Mean
Number (454-110-)	Nominal Exposure	Measured[1]	Measured (mg a.i./kg)
soy-v-19	0.0	< 6.0[2]	< 6.0
soy-v-20	0.0	< 6.0	
soy-v-21	0.0	< 6.0	
soy-v-22	3.91	17.7	15.6
soy-v-23	3.91	10.0	
soy-v-24	3.91	19.1	
soy-v-25	15.6	29.3	35.8
soy-v-26	15.6	48.9	
soy-v-27	15.6	29.3	
soy-v-28	62.5	63.9	63.3
soy-v-29	62.5	70.7	
soy-v-30	62.5	55.4	
soy-v-31	250	64.2	114
soy-v-32	250	175	
soy-v-33	250	103	
soy-v-34[3]	1000	--	--
soy-v-35[3]	1000	--	
soy-v-36[3]	1000	--	

[1] Measured values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.

[2] The method limit of quantitation (LOQ) in soybean vegetative tissue (6.0 mg a.i./kg on a dry-weight basis) was calculated as the maximum mg a.i./kg equivalent concentration measured in negative control extracts rounded upward to the nearest tenth mg a.i./kg.

[3] No sample was collected due to mortality at this concentration.

Appendix 4.31

Termination Measured Values for PFOS in Soybean Fruit Tissue

Sample		PFOS Concentration (mg a.i./kg)	Mean
Number (454-110-)	Nominal Exposure	Measured[1]	Measured (mg a.i./kg)
soy-f-1	0.0	< 0.18[2]	< 0.18
soy-f-2	0.0	< 0.18	
soy-f-3	0.0	< 0.18	
soy-f-4	3.91	0.947	1.40
soy-f-5	3.91	0.339	
soy-f-6	3.91	2.91	
soy-f-7	15.6	0.464	0.874
soy-f-8	15.6	1.63	
soy-f-9	15.6	0.528	
soy-f-10	62.5	1.14	1.20
soy-f-11	62.5	1.14	
soy-f-12	62.5	1.33	
soy-f-13	250	1.57	3.21
soy-f-14	250	5.56	
soy-f-15	250	2.49	
soy-f-16[3]	1000	--	--
soy-f-17[3]	1000	--	
soy-f-18[3]	1000	--	

[1] Measured values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.
[2] The method limit of quantitation (LOQ) in soybean fruit tissue was 0.18 mg a.i./kg on a dry-weight basis and was calculated as the product of the lowest calibration standard (0.000400 mg a.i./L) and the weight/volume dilution factor of the matrix blank samples (100) divided by the percent solids for the negative control fruit tissue (22.9%).
[3] No sample was collected due to mortality at this concentration.

Appendix 4.32

Termination Measured Values for PFOS in Tomato Vegetative Tissue

Sample		PFOS Concentration (mg a.i./kg)	Mean
Number (454-110-)	Nominal Exposure	Measured[1]	Measured (mg a.i./kg)
tom-v-19	0.0	< 7.6[2]	< 7.6
tom-v-20	0.0	< 7.6	
tom-v-21	0.0	< 7.6	
tom-v-22	3.91	< 7.6	< 7.6
tom-v-23	3.91	< 7.6	
tom-v-24	3.91	< 7.6	
tom-v-25	15.6	12.5	33.8
tom-v-26	15.6	27.9	
tom-v-27	15.6	61.1	
tom-v-28	62.5	70.9	50.1
tom-v-29	62.5	44.5	
tom-v-30	62.5	34.9	
tom-v-31[3]	250	--	--
tom-v-32[4]	250	--	
tom-v-33[4]	250	--	
tom-v-34[4]	1000	--	--
tom-v-35[4]	1000	--	
tom-v-36[4]	1000	--	

[1] Measured values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.
[2] The method limit of quantitation (LOQ) in tomato vegetative tissue (7.6 mg a.i./kg on a dry-weight basis) was calculated as the maximum mg a.i./kg equivalent concentration measured in negative control extracts rounded upward to the nearest tenth mg a.i./kg.
[3] There was insufficient sample weight (<0.5 g) available for analysis.
[4] No sample was collected due to mortality or lack of emergence at this concentration.

Appendix 4.33

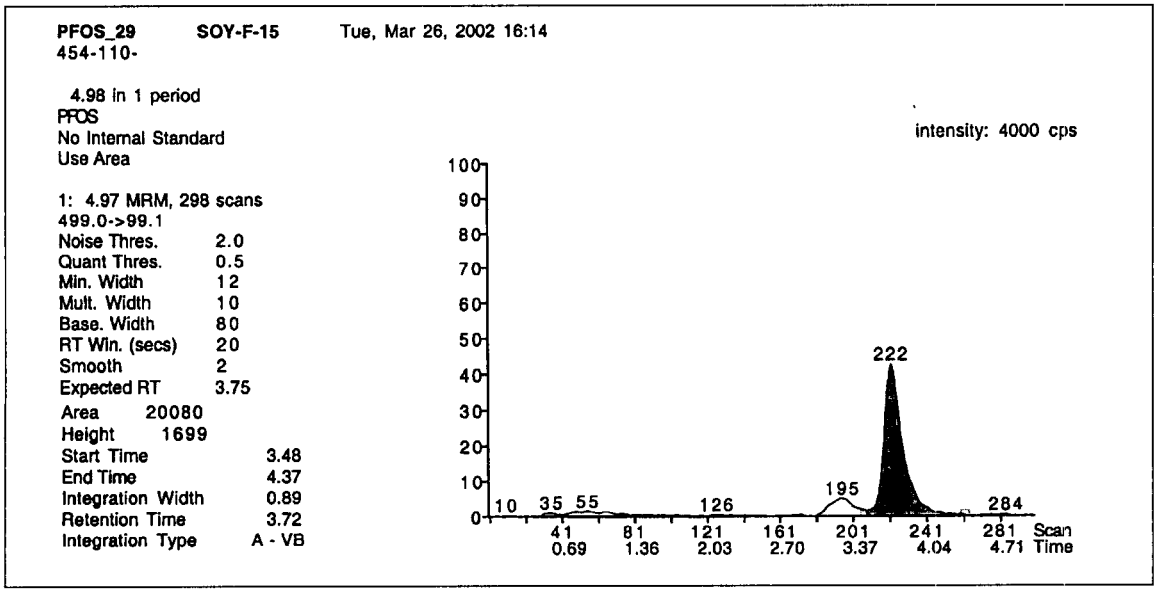
Termination Measured Values for PFOS in Tomato Fruit Tissue

Sample		PFOS Concentration (mg a.i./kg)	Mean Measured (mg a.i./kg)
Number (454-110-)	Nominal Exposure	Measured[1]	
tom-f-1	0.0	< 0.47[2]	< 0.47
tom-f-2	0.0	< 0.47	
tom-f-3	0.0	< 0.47	
tom-f-4[3]	3.91	--	< 0.47
tom-f-5	3.91	< 0.47	
tom-f-6	3.91	< 0.47	
tom-f-7	15.6	< 0.47	1.05
tom-f-8	15.6	1.51	
tom-f-9	15.6	0.580	
tom-f-10	62.5	0.946	0.946
tom-f-11	62.5	< 0.47	
tom-f-12	62.5	< 0.47	
tom-f-13[3]	250	--	--
tom-f-14[4]	250	--	
tom-f-15[4]	250	--	
tom-f-16[4]	1000	--	--
tom-f-17[4]	1000	--	
tom-f-18[4]	1000	--	

[1] Measured values were calculated using MacQuan, version 1.6 software. Manual calculations may vary slightly. Results reported on a dry-weight basis.
[2] The method limit of quantitation (LOQ) in tomato fruit tissue was 0.47 mg a.i./kg on a dry-weight basis and was calculated as the product of the lowest calibration standard (0.000400 mg a.i./L) and the weight/volume dilution factor of the matrix blank samples (100) divided by the percent solids for the negative control fruit tissue (8.45%).
[3] There was insufficient sample weight (<0.5 g) available for analysis.
[4] No sample was collected due to mortality or lack of emergence at this concentration.

Appendix 4.34

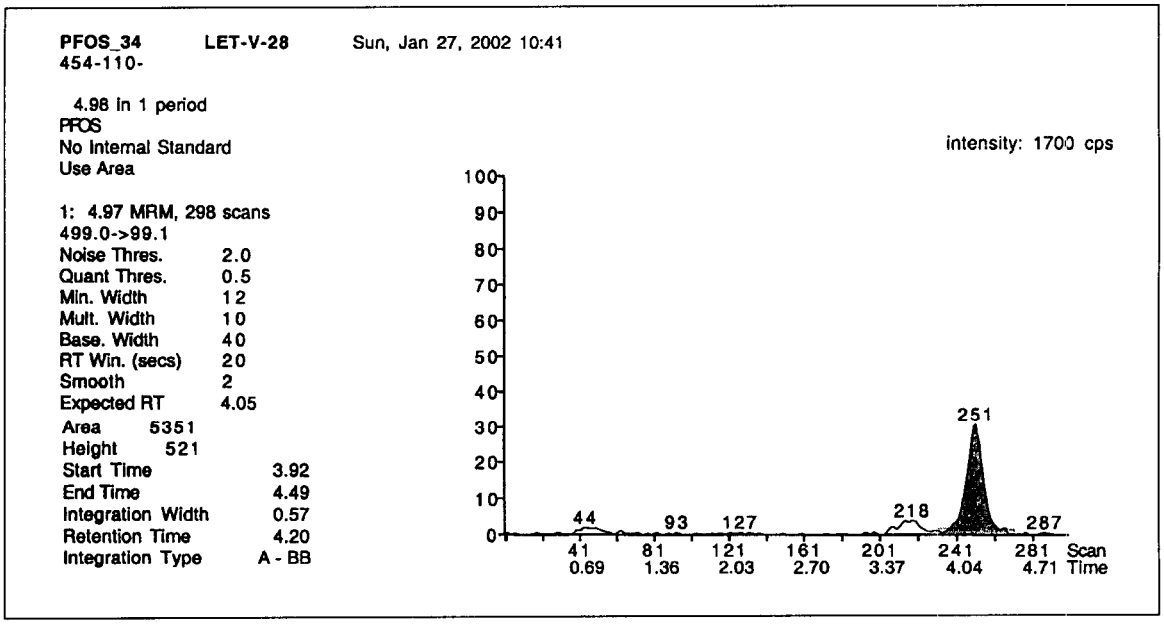
Representative Chromatogram of a Plant Fruit Tissue Test Sample



Sample Identification: 454-110-SOY-F-15 (soybean matrix).

Appendix 4.35

Representative Chromatogram of a Plant Vegetative Tissue Test Sample



Sample Identification: 454-110-LET-V-28 (lettuce matrix).

Appendix 5

Environmental Conditions

Date	Temperature (°C) Minimum	Maximum	Mean	Relative Humidity (%) Minimum	Maximum	Mean	Light Intensity Moles PAR[3]
11/12/01[1]	15.9	26.8	19.7	11	32	23	14.9
11/13/01	16.3	26.8	19.8	13	41	27	19.8
11/14/01[1]	16.4	26.2	20.1	17	72	39	19.7
11/15/01	16.4	27.0	20.5	20	63	39	18.6
11/16/01	16.6	28.8	21.0	21	63	42	17.9
11/17/01[1]	16.4	25.5	19.9	27	63	44	17.4
11/18/01[1]	16.3	26.7	20.1	21	54	38	18.9
11/19/01	16.4	26.6	20.5	30	81	50	18.0
11/20/01	16.3	26.7	19.9	13	81	40	20.3
11/21/01[1]	16.2	27.0	19.7	12	51	33	19.9
11/22/01	16.3	28.0	20.2	14	47	32	18.9
11/23/01[1]	16.4	26.6	20.4	16	57	34	19.3
11/24/01	16.7	25.0	20.8	46	75	60	18.3
11/25/01	18.0	25.9	21.2	42	83	64	17.6
11/26/01[1]	16.7	26.7	20.9	31	85	59	18.7
11/27/01	16.5	24.9	20.4	35	75	53	17.3
11/28/01[1]	17.9	26.1	20.9	47	80	66	17.5
11/29/01	17.7	25.6	21.0	49	81	68	17.5
11/30/01	18.2	26.3	21.5	54	85	70	17.3
12/01/01	16.8	28.5	21.3	36	83	61	18.2
12/02/01[2]	16.4	26.8	20.0	22	55	39	16.1
12/03/01	16.4	32.0	20.9	19	55	37	17.8
12/04/01	16.5	26.8	20.6	20	57	40	18.1
12/05/01[1]	16.7	29.4	21.3	17	59	40	18.5
12/06/01	16.7	28.2	21.0	29	62	47	18.0
12/07/01[1]	16.8	25.5	20.4	33	68	50	16.1
12/08/01	16.7	24.3	19.9	28	71	47	17.5
12/09/01	16.6	27.2	20.0	16	71	38	18.7
12/10/01	16.4	24.5	19.6	23	53	36	16.9
12/11/01[1]	16.4	26.1	19.9	31	68	49	17.8
12/12/01[1]	16.3	25.3	19.6	29	66	48	15.4
12/13/01	16.6	24.2	19.9	47	79	60	17.3
12/14/01	16.8	24.0	20.3	54	80	70	17.3
12/15/01[1]	16.4	26.7	19.8	16	77	34	16.9
12/16/01	16.1	27.2	19.6	13	38	27	17.9
12/17/01	16.4	25.3	19.6	30	73	43	17.5

[1] Indicates days on which all species were watered.
[2] Indicates days on which alfalfa, lettuce, ryegrass, and soybean trays were watered.
[3] PAR – Photosynthetically Active Radiation

Appendix 5
(continued)
Environmental Conditions

Date	Temperature (°C) Minimum	Maximum	Mean	Relative Humidity (%) Minimum	Maximum	Mean	Light Intensity Moles PAR[10]
12/18/01[1]	16.5	27.3	19.8	16	79	43	18.3
12/19/01[1]	16.4	26.4	19.7	19	53	34	17.1
12/20/01	16.2	27.6	19.5	10	54	25	20.1
12/21/01[1]	16.1	26.4	19.4	11	33	20	20.3
12/22/01	16.1	27.5	19.4	11	32	24	19.6
12/23/01[1]	15.3	26.4	19.6	14	57	30	17.9
12/24/01[1]	16.2	26.7	19.5	14	62	35	17.0
12/25/01[1]	15.3	28.3	19.3	9	29	21	19.6
12/26/01[1]	15.3	27.3	19.2	12	31	21	19.9
12/27/01[2]	15.1	25.9	19.0	10	32	21	20.2
12/28/01	14.8	25.4	18.7	16	40	28	17.6
12/29/01	14.8	25.6	18.9	15	37	25	17.9
12/30/01[3]	14.8	27.3	18.6	8	24	17	21.8
12/31/01[4]	14.8	27.2	18.6	9	31	20	22.2
01/01/02[5]	14.7	27.0	18.7	9	26	20	20.0
01/02/02	14.8	28.0	18.5	11	40	25	19.2
01/03/02	14.9	23.1	17.9	20	37	28	18.8
01/04/02	14.9	27.4	18.6	10	41	25	19.7
01/05/02	14.9	27.3	19.1	11	46	29	20.5
01/06/02[6]	15.0	24.4	18.4	24	55	40	16.6
01/07/02[4]	14.8	21.9	18.1	30	54	42	17.4
01/08/02	14.8	26.5	18.6	11	45	28	19.3
01/09/02[5]	14.9	24.4	18.9	20	51	35	18.4
01/10/02[7]	16.1	23.9	19.6	28	58	43	17.5
01/11/02	16.1	25.9	19.4	19	61	43	16.8
01/12/02[4]	15.1	27.5	19.8	15	54	36	19.2
01/13/02[8]	16.2	27.7	19.9	12	57	34	21.0
01/14/02[9]	16.1	25.5	19.8	17	61	36	18.4
01/15/02	15.4	27.7	20.0	17	62	39	19.4
01/16/02	15.2	27.9	19.6	15	52	35	20.7
01/17/02[1]	15.5	24.5	19.8	23	56	40	18.6

[1] Indicates days on which all species were watered.
[2] Indicates days on which soybean and tomato were watered.
[3] Indicates days on which alfalfa, lettuce, ryegrass, soybean, and tomato were watered.
[4] Indicates days on which tomato was watered.
[5] Indicates days on which soybean was watered.
[6] Indicates days on which flax, lettuce, onion and ryegrass were watered.
[7] Indicates days on which alfalfa, flax, lettuce, onion, and ryegrass were watered.
[8] Indicates days on which all species watered except tomato.
[9] Indicates days on which alfalfa, flax, lettuce, and onion were watered.
[10] PAR – Photosynthetically Active Radiation

Appendix 5
(continued)
Environmental Conditions

Date	Temperature (°C) Minimum	Maximum	Mean	Relative Humidity (%) Minimum	Maximum	Mean	Light Intensity Moles PAR[5]
01/18/02	14.9	26.8	19.9	12	51	33	20.1
01/19/02	14.7	22.9	19.2	29	58	41	17.4
01/20/02[1]	14.7	26.2	19.3	17	61	41	14.3
01/21/02[2]	15.1	24.7	19.5	30	67	50	17.8
01/22/02[3]	15.1	27.8	19.9	15	59	39	21.3
01/23/02[3]	15.5	24.3	19.7	38	78	54	17.9
01/24/02	16.4	25.5	20.4	47	84	64	17.7
01/25/02	15.1	27.6	19.8	14	84	46	20.6
01/26/02[4]	15.1	27.6	19.9	14	63	43	21.1
01/27/02[4]	15.3	27.3	19.9	21	67	44	19.9
01/28/02	16.4	29.1	20.9	18	71	51	19.6
01/29/02	16.3	27.2	20.8	25	78	51	18.2
01/30/02	16.8	30.7	21.7	31	78	55	19.2
01/31/02[3]	16.7	24.4	20.0	42	76	57	18.2
02/01/02[3]	16.2	29.4	20.8	33	78	55	17.5
02/02/02[4]	15.1	28.2	19.7	12	49	30	22.9
02/03/02[4]	15.0	26.4	19.7	15	56	36	20.3
02/04/02[3]	14.4	26.7	18.9	14	58	35	17.3
02/05/02	14.4	27.8	18.9	10	43	24	23.4
02/06/02[3]	15.0	25.3	19.5	14	55	33	20.9
02/07/02	15.2	24.1	19.4	32	62	48	17.6
02/08/02	15.0	26.5	19.8	17	69	43	21.4
02/09/02	15.0	26.7	19.9	19	67	44	20.6
02/10/02	15.2	26.8	20.2	33	79	55	17.2
02/11/02	15.1	26.4	19.8	15	74	42	23.3
02/12/02	15.0	26.0	19.6	14	55	35	19.5
02/13/02	15.0	25.9	19.7	11	53	30	22.2
02/14/02	15.0	30.8	19.6	11	52	30	24.6
02/15/02	15.0	25.1	19.6	20	56	39	18.1
02/16/02	16.4	27.6	20.8	11	55	33	23.7
02/17/02[2]	14.9	28.0	19.9	14	51	31	21.5
02/18/02	14.5	27.2	19.5	12	57	30	24.8
02/19/02	14.9	26.5	20.0	12	56	33	22.7
02/20/02	16.5	25.8	20.7	27	75	47	18.4
02/21/02	16.4	26.7	20.6	21	78	48	15.6

[1] Indicates days on which alfalfa, flax, onion, ryegrass and tomato were watered.
[2] Indicates days on which alfalfa and ryegrass were watered.
[3] Indicates days on which all trays were watered.
[4] Indicates days on which alfalfa, flax, ryegrass, and tomato were watered.
[5] PAR – Photosynthetically Active Radiation

Appendix 5
(continued)
Environmental Conditions

Date	Temperature (°C) Minimum	Maximum	Mean	Relative Humidity (%) Minimum	Maximum	Mean	Light Intensity Moles PAR[3]
02/22/02[1]	15.4	26.6	20.2	16	60	37	22.6
02/23/02	15.2	27.9	19.8	17	53	37	20.2
02/24/02	15.1	27.0	19.9	13	58	33	24.5
02/25/02	15.0	26.7	20.0	13	68	40	19.0
02/26/02	16.3	26.7	20.7	22	67	46	16.9
02/27/02	14.5	25.8	19.3	15	56	33	22.7
02/28/02[1]	14.5	28.2	19.5	12	46	28	26.2
03/01/02[1]	14.8	27.3	19.8	11	75	36	25.5
03/02/02	15.1	24.6	19.6	28	82	57	17.1
03/03/02	15.7	25.1	20.1	34	89	61	16.8
03/04/02[2]	14.7	27.0	19.0	12	39	26	19.8
03/05/02[2]	14.5	25.9	19.0	13	57	30	13.8
03/06/02[1]	15.2	25.7	19.9	18	56	36	14.8
03/07/02[1]	16.2	26.1	20.6	17	62	34	16.1
03/08/02	16.2	27.2	21.1	19	76	43	16.3
03/09/02	16.6	31.2	22.5	32	77	57	19.1
03/10/02	15.9	28.5	20.6	8	74	28	26.6
03/11/02[2]	15.0	26.3	19.5	11	44	24	14.0
03/12/02[1]	15.1	25.1	19.9	25	65	40	18.2
03/13/02	16.5	24.1	20.3	44	71	55	18.4
03/14/02[1]	16.6	27.0	20.8	29	70	51	14.0
03/15/02	16.5	27.0	21.8	42	73	56	14.0
03/16/02[1]	16.4	30.5	21.6	31	78	54	17.0
03/17/02	16.2	24.1	19.9	31	63	44	18.9
03/18/02[1]	16.2	24.6	19.8	39	67	55	17.6
03/19/02	16.3	26.2	20.2	24	65	43	16.2
03/20/02[2]	16.4	23.9	20.1	44	73	55	17.5
03/21/02	15.1	25.9	20.1	23	72	41	14.7
03/22/02[2]	14.1	27.0	19.0	11	34	20	14.7
03/23/02	14.9	25.5	19.8	14	43	26	13.8
03/24/02[1]	15.6	25.7	20.5	14	53	31	13.5
03/25/02[1]	16.8	25.8	20.6	23	55	38	14.0
03/26/02[2]	16.9	25.2	20.6	37	82	52	17.8
03/27/02	16.4	26.5	20.1	25	83	45	14.8
03/28/02[2]	16.0	25.2	20.2	16	55	35	14.1
03/29/02	16.9	25.4	20.9	29	64	43	14.2

[1] Indicates days on which alfalfa and ryegrass were watered.
[2] Indicates days on which alfalfa were watered.
[3] PAR – Photosynthetically Active Radiation

Appendix 5
(continued)
Environmental Conditions

Date	Temperature (°C) Minimum	Maximum	Mean	Relative Humidity (%) Minimum	Maximum	Mean	Light Intensity Moles PAR[3]
03/30/02[1]	16.8	29.7	22.3	23	78	49	18.5
03/31/02	16.6	25.4	20.5	37	76	57	18.6
04/01/02	16.6	25.4	20.6	18	74	43	14.0
04/02/02[2]	16.7	25.8	21.4	21	74	43	15.5
04/03/02	16.5	30.9	22.0	32	80	51	14.9
04/04/02[2]	15.9	25.3	20.3	16	51	28	14.3
04/05/02[2]	16.6	26.1	20.4	14	46	27	14.3
04/06/02[2]	15.2	25.9	20.3	13	48	27	14.5
04/07/02	15.7	26.1	20.4	13	64	32	14.8
04/08/02	16.9	25.4	21.1	28	73	49	14.8
04/09/02[2]	17.3	25.3	21.6	41	87	66	14.9
04/10/02[2]	17.1	25.4	21.1	29	89	55	14.0
04/11/02	17.0	25.9	21.0	29	66	47	14.3
04/12/02[2]	17.4	25.6	21.2	44	85	62	16.6
04/13/02	17.0	28.0	22.1	53	89	71	15.5
04/14/02	18.7	27.5	23.1	57	88	71	14.5
04/15/02[2]	19.8	30.0	23.7	49	84	70	16.1
04/16/02	20.2	29.7	24.7	54	87	71	14.2
04/17/02[2]	19.5	31.6	24.9	51	86	69	15.1
04/18/02	20.1	28.8	24.0	57	86	73	14.5
04/19/02[2]	19.5	30.3	23.5	55	86	72	16.1
04/20/02	19.6	28.5	23.0	56	86	70	14.5
04/21/02	16.7	25.4	20.7	34	79	56	18.7
04/22/02[2]	16.5	26.4	20.8	28	77	52	18.0
04/23/02	16.3	25.5	20.7	20	59	34	13.4
04/24/02[2]	17.3	26.1	21.2	20	64	39	13.8
04/25/02	16.4	24.9	20.9	30	70	53	17.3
04/26/02	16.4	25.4	20.8	19	69	43	14.1
04/27/02	16.8	25.5	21.0	28	77	51	12.8
04/28/02	17.5	26.7	21.9	61	88	75	17.2
04/29/02[2]	16.7	27.1	20.8	29	77	48	15.6
04/30/02[2]	16.5	25.7	21.1	29	77	47	13.6
05/01/02[2]	17.7	25.4	21.5	30	79	57	13.8
05/02/02	17.9	26.9	22.6	64	84	75	15.0
05/03/02[2]	17.1	25.5	21.3	20	82	41	13.7
05/04/02	16.5	25.6	21.0	22	72	44	14.3

[1] Indicates days on which alfalfa and ryegrass were watered.
[2] Indicates days on which ryegrass was watered.
[3] PAR – Photosynthetically Active Radiation

Appendix 5
(continued)
Environmental Conditions

Date	Temperature (°C) Minimum	Maximum	Mean	Relative Humidity (%) Minimum	Maximum	Mean	Light Intensity Moles PAR[2]
05/05/02	17.3	25.5	21.3	33	72	56	13.8
05/06/02[1]	17.7	25.5	21.8	34	72	55	12.8
05/07/02	18.5	27.2	22.7	51	85	71	16.1
05/08/02	18.2	28.0	22.3	41	83	62	15.5
05/09/02	17.8	25.5	21.9	47	88	67	16.9
05/10/02[1]	18.3	26.1	22.2	47	84	64	14.2
05/11/02[1]	17.8	25.6	21.6	20	67	47	13.6
05/12/02	18.8	27.4	23.3	41	86	67	13.8
05/13/02[1]	18.6	29.2	23.7	57	87	74	13.9
05/14/02[1]	16.7	26.2	20.9	23	58	39	14.0
05/15/02	16.7	26.0	21.3	26	65	44	13.5
05/16/02[1]	17.7	26.0	22.4	36	66	56	13.5
05/17/02[1]	20.3	28.7	23.3	48	78	65	14.0
05/18/02	16.7	25.2	21.3	30	84	55	16.6
05/19/02	16.6	25.8	21.1	19	62	40	13.1
05/20/02[1]	17.4	25.4	21.2	19	59	38	13.8
05/21/02[1]	17.4	26.0	21.1	22	49	36	14.5
05/22/02	17.3	26.5	21.3	23	57	41	13.7
05/23/02[1]	17.4	25.6	21.3	35	73	52	13.1
05/24/02	17.7	25.4	22.4	42	76	63	13.3
05/25/02[1]	18.4	25.8	22.3	48	82	64	14.5
05/26/02	18.0	26.9	23.0	58	87	74	13.5
05/27/02	19.3	27.6	23.7	61	84	72	14.4
05/28/02[1]	19.4	27.9	23.7	60	83	72	14.4
05/29/02	19.6	28.0	23.5	59	84	73	15.3
05/30/02[1]	18.7	28.1	23.6	62	87	74	14.5
05/31/02[1]	20.1	28.9	25.1	66	87	77	14.2
06/01/02	22.0	27.6	24.9	59	90	74	13.5
06/02/02[1]	20.1	29.2	24.0	35	90	63	14.3
06/03/02	19.2	25.8	22.5	38	68	54	14.5
06/04/02[1]	20.2	26.7	23.3	55	81	68	14.7
06/05/02	21.9	30.5	26.2	62	91	76	14.1

[1] Indicates days on which ryegrass was watered.
[2] PAR – Photosynthetically Active Radiation

Appendix 6.1

Alfalfa Emergence

Day 7

Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	7	10	10	8	*4*	8.75	1.50
3.91 mg a.i /kg	8	9	8	8	*4*	8.25	0.50
15.6 mg a.i./kg	9	9	7	6	*4*	7.75	1.50
62.5 mg a.i./kg	6	6	8	8	*4*	7.00	1.15
250 mg a.i./kg	8	5	7	8	*4*	7.00	1.41
1000 mg a.i./kg	0	0	5	5	*4*	2.50	2.89

Day 15

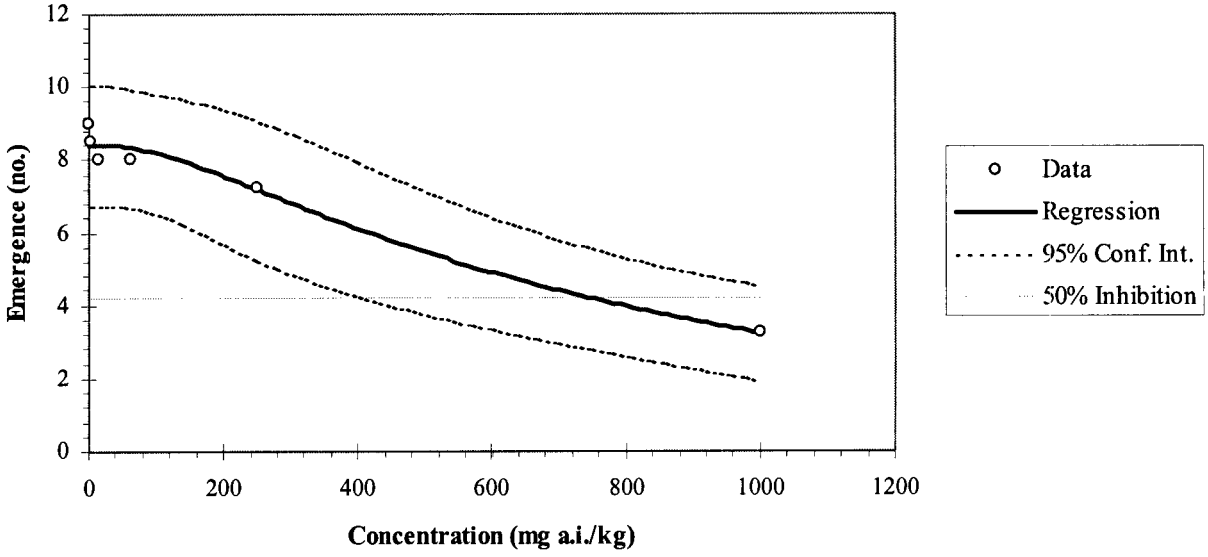
Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	8	10	10	8	*4*	9.00	1.15
3.91 mg a.i./kg	8	9	9	8	*4*	8.50	0.58
15.6 mg a.i./kg	9	9	8	6	*4*	8.00	1.41
62.5 mg a.i./kg	7	7	9	9	*4*	8.00	1.15
250 mg a.i./kg	9	5	7	8	*4*	7.25	1.71
1000 mg a.i./kg	0	0	5	5	*4*	2.50	2.89

Day 21

Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	8	10	10	8	*4*	9.00	1.15
3.91 mg a.i./kg	8	9	9	8	*4*	8.50	0.58
15.6 mg a.i./kg	9	9	8	6	*4*	8.00	1.41
62.5 mg a.i./kg	7	7	9	9	*4*	8.00	1.15
250 mg a.i./kg	9	5	7	8	*4*	7.25	1.71
1000 mg a.i./kg	0	1	5	7	*4*	3.25	3.30

Appendix 6.2

Mean Alfalfa Emergence on Day 21



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
372.306	201.512	687.860	8.4045	0.4470	0.97096

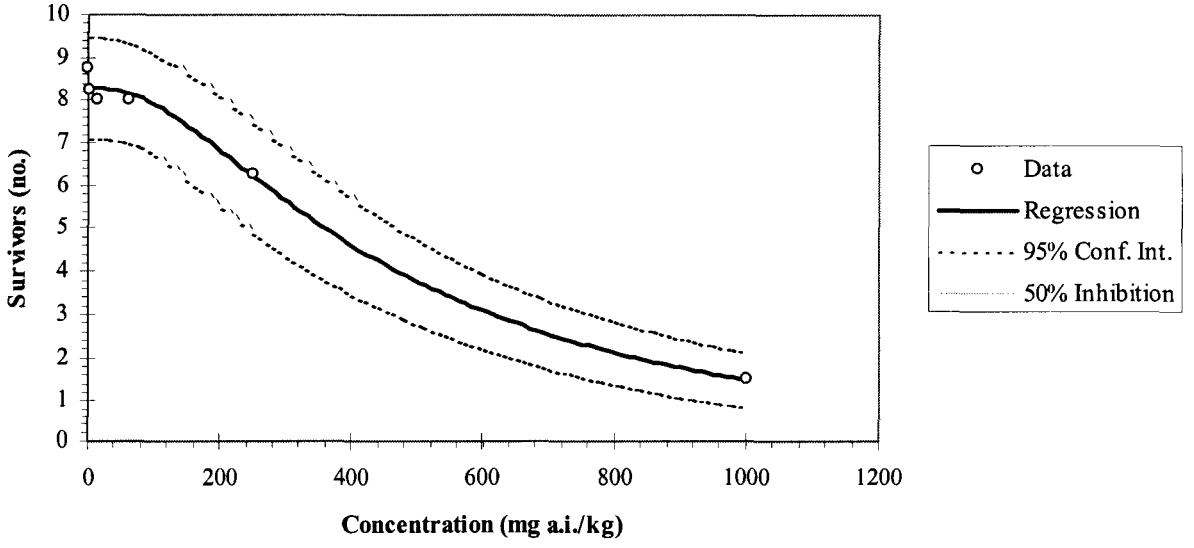
EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
745.418	540.879	1027.07	8.4045	0.4470	0.97096

Appendix 6.3

Alfalfa 21-Day Survival

Day 21

Treatment Group	Number of Living Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	8	9	10	8	*4*	8.75	0.96
3.91 mg a.i./kg	8	9	8	8	*4*	8.25	0.50
15.6 mg a.i./kg	9	9	8	6	*4*	8.00	1.41
62.5 mg a.i./kg	7	7	9	9	*4*	8.00	1.15
250 mg a.i./kg	8	4	6	7	*4*	6.25	1.71
1000 mg a.i./kg	0	1	1	4	*4*	1.50	1.73



Curve Parameters

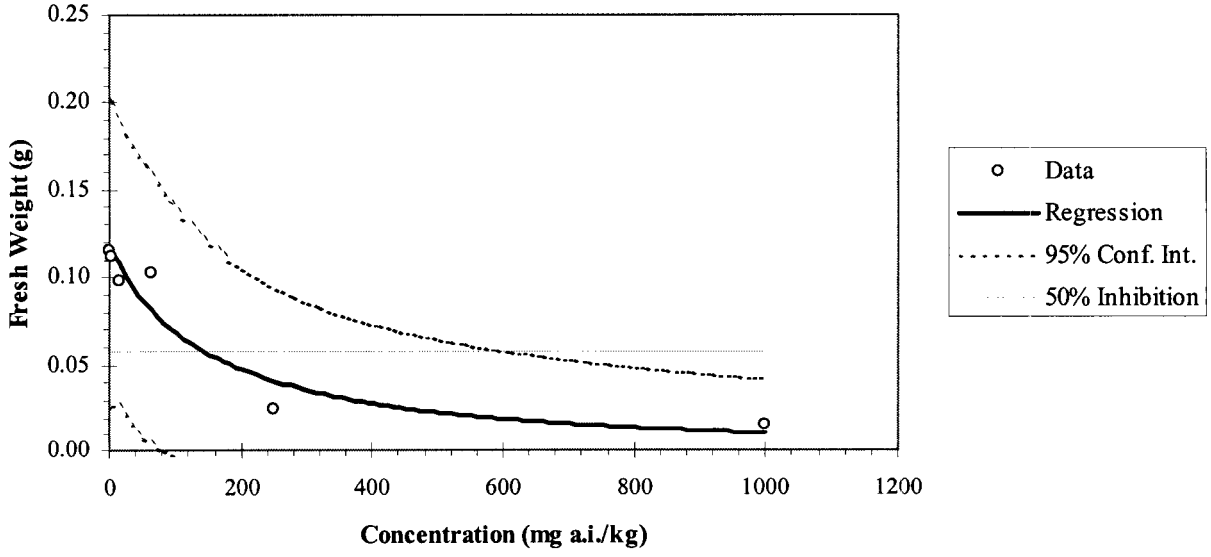
EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
251.073	178.402	353.265	8.2801	0.3790	0.99162

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
452.272	363.580	562.730	8.2801	0.3790	0.99162

Appendix 6.4

Alfalfa Mean Seedling Fresh Weight, Day 21

Treatment Group	Mean Weight (g) for Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	0.11	0.10	0.12	0.13	*4*	0.12	0.013
3.91 mg a.i./kg	0.10	0.10	0.16	0.09	*4*	0.11	0.033
15.6 mg a.i./kg	0.08	0.12	0.08	0.11	*4*	0.10	0.022
62.5 mg a.i./kg	0.11	0.10	0.09	0.12	*4*	0.10	0.010
250 mg a.i./kg	0.03	0.01	0.03	0.03	*4*	0.03	0.008
1000 mg a.i./kg	-	0.02	0.02	0.01	*3*	0.02	0.008



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
53.2844	4.11623	689.763	0.1144	0.6492	0.90534

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
146.049	27.2521	782.528	0.1144	0.6492	0.90534

Appendix 6.5

Alfalfa Seedling Height on Day 21

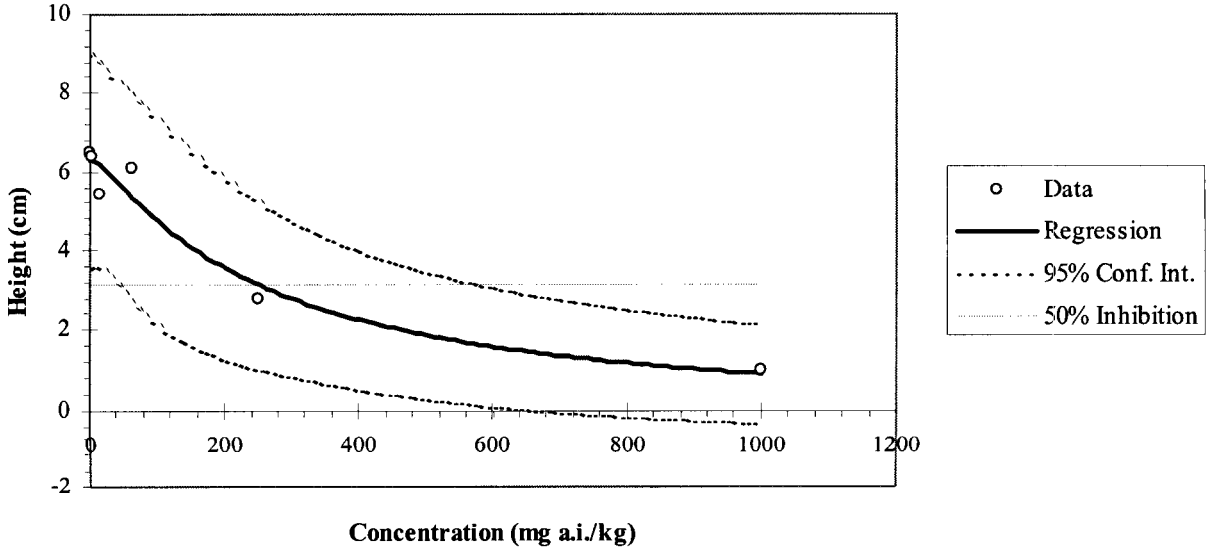
Treatment Group	Replicate	Height (cm) for Plant Number:										*n*	Mean	Std. Dev.
		1	2	3	4	5	6	7	8	9	10			
Control	A	.	.	6	6	6	3	6	12	6	4	8	6.1	2.64
	B	.	5	3	4	8	4	7	5	5	11	9	5.8	2.49
	C	7	4	8	8	6	6	8	8	6	8	10	6.9	1.37
	D	.	.	10	5	6	10	5	6	5	10	8	7.1	2.42
3.91 mg/kg	A	.	.	5	5	8	7	5	9	5	4	8	6.0	1.77
	B	.	7	5	10	4	6	8	6	7	11	9	7.1	2.26
	C	.	.	11	10	6	5	5	7	3	8	8	6.9	2.70
	D	.	.	6	9	4	6	7	4	4	4	8	5.5	1.85
15.6 mg a.i./kg	A	.	5	8	8	5	4	4	5	4	3	9	5.1	1.76
	B	.	5	8	7	5	5	5	5	9	4	9	5.9	1.69
	C	.	.	2	2	5	8	3	5	7	4	8	4.5	2.20
	D	.	.	.	.	6	7	7	7	5	5	6	6.2	0.98
62.5 mg a.i./kg	A	.	.	5	6	5	5	7	5	6	.	7	5.6	0.79
	B	.	.	.	6	5	5	8	7	4	12	7	6.7	2.69
	C	.	6	4	3	6	4	5	7	9	2	9	5.1	2.15
	D	.	8	5	9	8	10	7	4	6	6	9	7.0	1.94
250 mg a.i./kg	A	.	.	3	4	2	3	4	3	2	3	8	3.0	0.76
	B	.	.	.	.	.	.	2	2	2	2	4	2.0	0.00
	C	.	.	.	.	1	4	2	3	5	4	6	3.2	1.47
	D	.	.	.	4	4	2	3	3	2	2	7	2.9	0.90
1000 mg a.i./kg	A	.	.	.	.	.	.	.	.	.	.	0		
	B	.	.	.	.	.	.	.	.	.	1	1	1.0	
	C	.	.	.	.	.	.	.	.	.	1	1	1.0	
	D	.	.	.	.	.	.	1	1	1	1	4	1.0	0.00

The "." symbol indicates that the seedling either did not emerge or died prior to measurement.

Appendix 6.6

Alfalfa Mean Seedling Height on Day 21

Treatment Group	Mean Height (cm) for Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	6.1	5.8	6.9	7.1	*4*	6.5	0.6
3.91 mg a.i./kg	6.0	7.1	6.9	5.5	*4*	6.4	0.8
15.6 mg a.i./kg	5.1	5.9	4.5	6.2	*4*	5.4	0.8
62.5 mg a.i./kg	5.6	6.7	5.1	7.0	*4*	6.1	0.9
250 mg a.i./kg	3.0	2.0	3.2	2.9	*4*	2.8	0.5
1000 mg a.i./kg	.	1.0	1.0	1.0	*3*	1.0	0.0



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
102.447	26.8287	391.201	6.2793	0.5720	0.93960

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
249.058	106.292	583.579	6.2793	0.5720	0.93960

Appendix 6.7

Alfalfa Seedling Condition, Day 21

Treatment Group	Replicate	Condition (score.sign)[1] for Plant Number:										*n*	Mean	Std. Dev.
		1	2	3	4	5	6	7	8	9	10			
Control	A	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
	B	100.-	0.-	50.N	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	15	33.7
	C	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	D	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
3.91 mg a.i./kg	A	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
	B	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	C	.	100.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	11	33.3
	D	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
15.6 mg a.i./kg	A	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	90.N	0.-	*9*	10	30.0
	B	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	C	.	.	70.N	30.N	0.-	0.-	0.-	0.-	0.-	0.-	*8*	13	25.5
	D	.	.	.	.	0.-	0.-	0.-	0.-	0.-	0.-	*6*	0	0.0
62.5 mg a.i./kg	A	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	.	*7*	0	0.0
	B	.	.	.	0.-	30.N	0.-	0.-	0.-	0.-	0.-	*7*	4	11.3
	C	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	D	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
250 mg a.i./kg	A	.	100.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	11	33.3
	B	.	.	.	.	.	100.-	0.-	0.-	0.-	0.-	*5*	20	44.7
	C	.	.	.	100.-	80.N	0.-	0.-	0.-	0.-	0.-	*7*	26	44.3
	D	.	.	100.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	13	35.4
1000 mg a.i./kg	A	.	.	.	.	.	.	.	.	.	.	*0*		
	B	.	.	.	.	.	.	.	.	.	0.-	*1*	0	
	C	.	.	.	.	.	100.-	100.-	100.-	100.-	60.N	*5*	92	17.9
	D	.	.	100.-	100.-	100.-	.	80.N	60.N	0.-	80.N	*7*	74	36.0

[1]The "." symbol indicates that the seedling did not emerge. A score of 0 indicates a normal seedling, while a score of 100 indicates a dead seedling. Intermediate scores are assigned to indicate the relative severity of observed signs of toxicity.
N - Necrosis

Appendix 7.1

Flax Emergence

Day 7

Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	7	9	6	7	*4*	7.25	1.26
3.91 mg a.i./kg	7	5	7	7	*4*	6.50	1.00
15.6 mg a.i./kg	8	9	7	8	*4*	8.00	0.82
62.5 mg a.i./kg	9	9	9	7	*4*	8.50	1.00
250 mg a.i./kg	8	9	5	7	*4*	7.25	1.71
1000 mg a.i./kg	0	0	0	0	*4*	0.00	0.00

Day 15

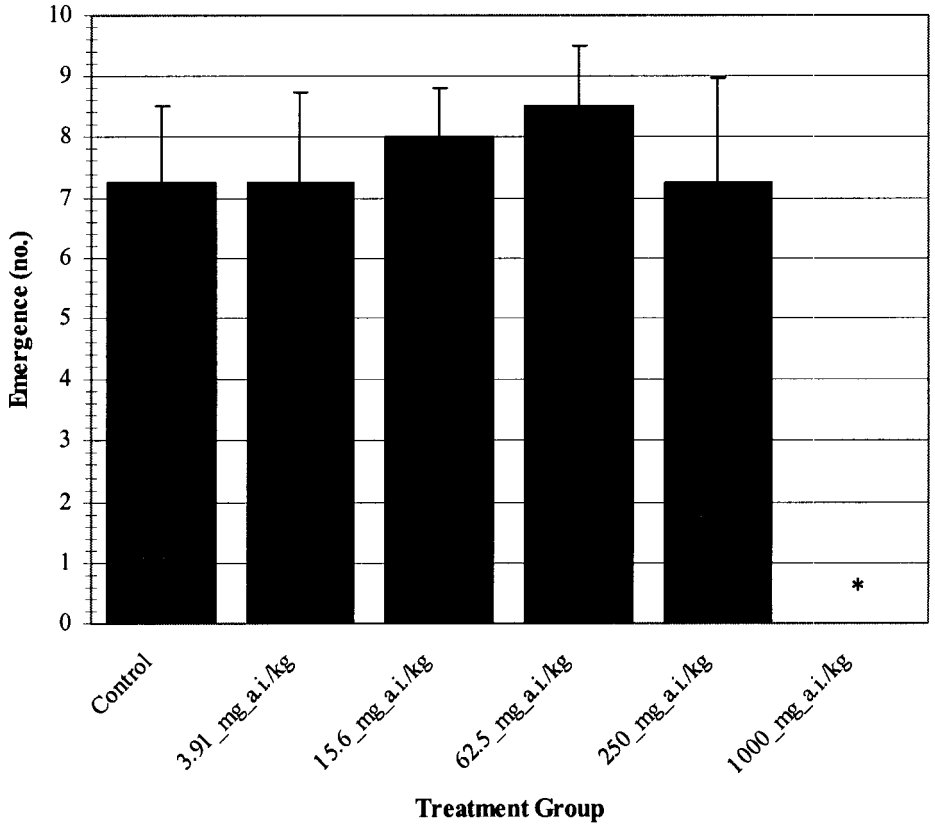
Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	7	9	6	7	*4*	7.25	1.26
3.91 mg a.i./kg	7	5	8	8	*4*	7.00	1.41
15.6 mg a.i./kg	8	9	7	8	*4*	8.00	0.82
62.5 mg a.i./kg	9	9	9	7	*4*	8.50	1.00
250 mg a.i./kg	8	9	5	7	*4*	7.25	1.71
1000 mg a.i./kg	0	0	0	0	*4*	0.00	0.00

Day 21

Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	7	9	6	7	*4*	7.25	1.26
3.91 mg a.i./kg	8	5	8	8	*4*	7.25	1.50
15.6 mg a.i./kg	8	9	7	8	*4*	8.00	0.82
62.5 mg a.i./kg	9	9	9	7	*4*	8.50	1.00
250 mg a.i./kg	8	9	5	7	*4*	7.25	1.71
1000 mg a.i./kg	0	0	0	0	*4*	0.00	0.00

Appendix 7.2

Mean Flax Emergence on Day 21



* Treatment group mean is significantly different from the control mean (Dunnett's test, $p<0.05$)

The non-linear regression technique failed to generate useable results. Therefore, linear interpolation was used.

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit
398.7069	126.1605	460.7759

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit
599.1379	401.8809	640.5172

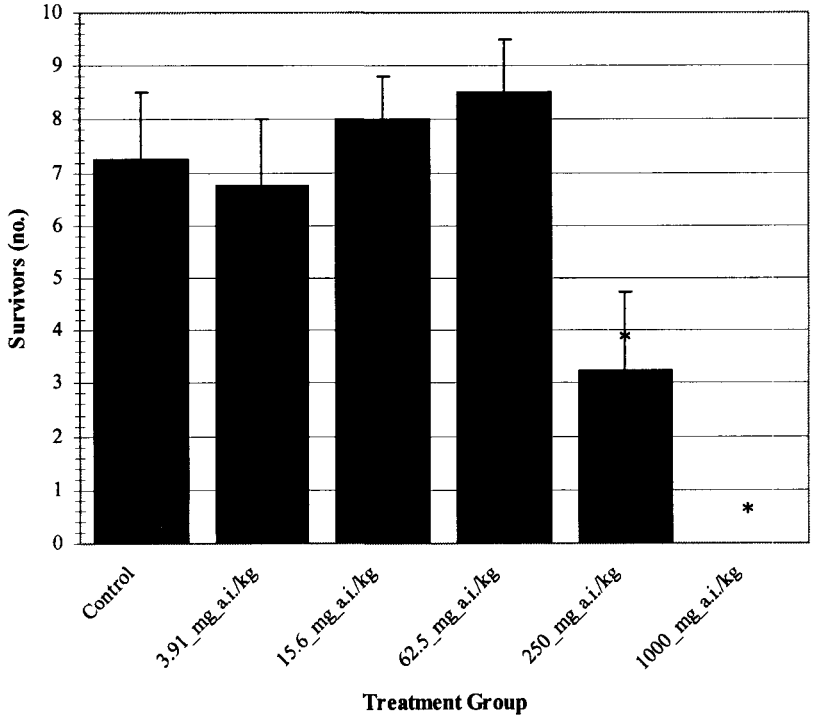
EC_{25} and EC_{50} estimates calculated by linear interpolation using the ICPIN program (7).

Appendix 7.3

Flax 21-Day Survival

Day 21

Treatment Group	Number of Living Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	7	9	6	7	*4*	7.25	1.26
3.91 mg a.i./kg	7	5	8	7	*4*	6.75	1.26
15.6 mg a.i./kg	8	9	7	8	*4*	8.00	0.82
62.5 mg a.i./kg	9	9	9	7	*4*	8.50	1.00
250 mg a.i./kg	1	4	4	4	*4*	3.25	1.50
1000 mg a.i./kg	0	0	0	0	*4*	0.00	0.00



* Treatment group mean is significantly different from the control mean (Dunnett's test, $p<0.05$)

The non-linear regression technique failed to generate useable results. Therefore, linear interpolation was used.

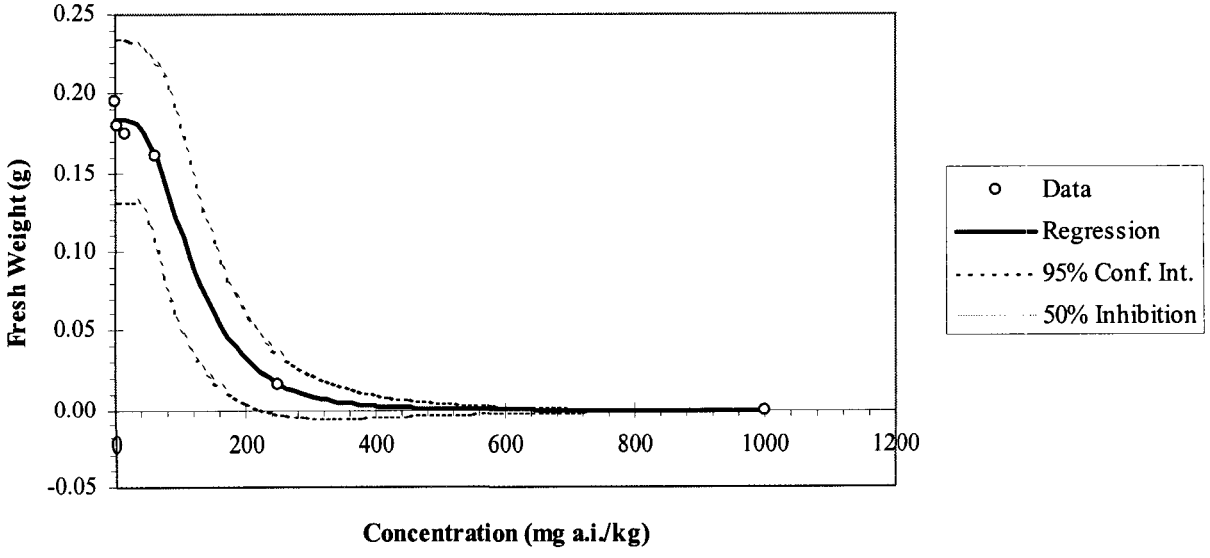
Effect Rate	Effect Concentration	Lower 95% Confidence Limit	Upper 95% Confidence Limit
EC_{25}	144.1964	103.4821	177.3710
EC_{50}	225.8929	159.6256	367.5893

EC_{25} and EC_{50} estimates calculated by linear interpolation using the ICPIN program (7).

Appendix 7.4

Flax Mean Seedling Fresh Weight, Day 21

Treatment Group	Mean Weight (g) for Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	0.16	0.19	0.19	0.23	*4*	0.19	0.029
3.91 mg a.i./kg	0.21	0.19	0.16	0.17	*4*	0.18	0.022
15.6 mg a.i./kg	0.21	0.16	0.16	0.17	*4*	0.18	0.023
62.5 mg a.i./kg	0.17	0.17	0.14	0.17	*4*	0.16	0.017
250 mg a.i./kg	.	0.01	0.02	0.02	*3*	0.02	0.009
1000 mg a.i./kg	.	.	.	.	*0*	.	.



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
81.5831	46.0151	144.644	0.1833	0.2420	0.99000

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
118.796	79.3780	177.828	0.1833	0.2420	0.99000

Appendix 7.5

Flax Seedling Height on Day 21

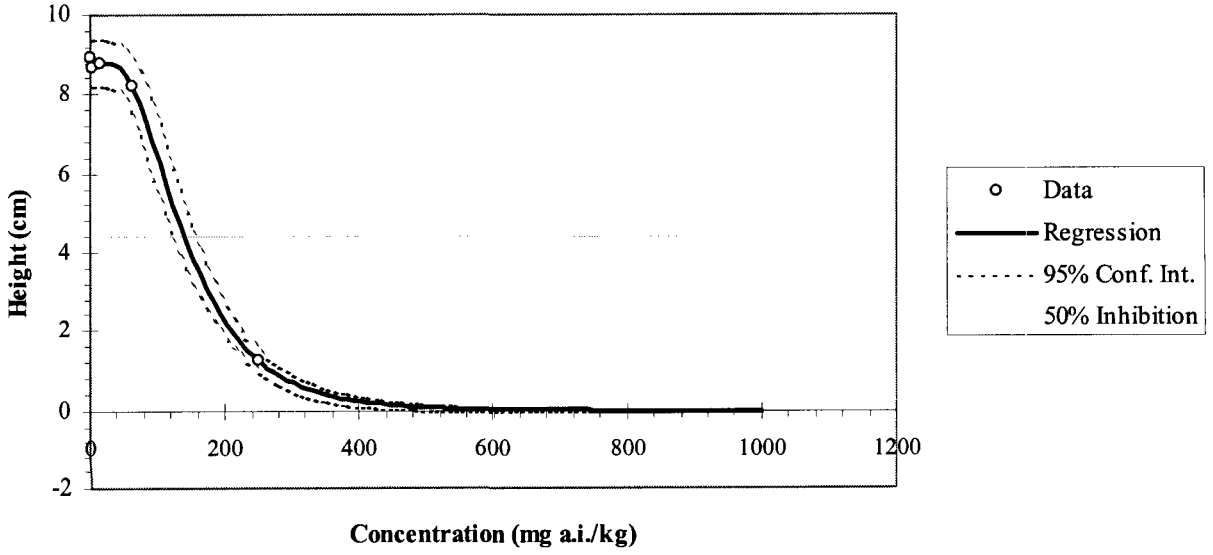
Treatment Group	Replicate	Height (cm) for Plant Number:										*n*	Mean	Std. Dev.
		1	2	3	4	5	6	7	8	9	10			
Control	A	.	.	.	5	9	9	9	8	10	10	*7*	8.6	1.72
	B	.	5	9	9	9	12	10	11	12	5	*9*	9.1	2.62
	C	.	.	.	.	11	11	8	9	9	5	*6*	8.8	2.23
	D	.	.	.	10	8	11	7	10	9	9	*7*	9.1	1.35
3.91 mg a.i./kg	A	.	.	.	8	8	10	9	10	10	10	*7*	9.3	0.95
	B	.	.	.	.	.	9	11	9	9	10	*5*	9.6	0.89
	C	.	.	8	11	6	8	1	11	11	9	*8*	8.1	3.40
	D	.	.	.	7	8	3	8	10	9	9	*7*	7.7	2.29
15.6 mg a.i./kg	A	.	.	9	10	8	11	10	9	11	10	*8*	9.8	1.04
	B	.	9	10	8	9	8	11	9	9	9	*9*	9.1	0.93
	C	.	.	.	9	8	11	11	6	9	2	*7*	8.0	3.16
	D	.	.	6	8	8	10	9	7	8	10	*8*	8.3	1.39
62.5 mg a.i./kg	A	.	5	8	10	10	8	10	11	7	8	*9*	8.6	1.88
	B	.	11	12	9	10	9	5	13	9	1	*9*	8.8	3.70
	C	.	9	8	8	11	10	3	5	6	10	*9*	7.8	2.64
	D	.	.	.	9	3	7	9	9	10	7	*7*	7.7	2.36
250 mg a.i./kg	A	.	.	.	.	.	.	.	.	.	1	*1*	1.0	
	B	.	.	.	.	.	.	2	1	1	1	*4*	1.3	0.50
	C	.	.	.	.	.	.	1	1	1	1	*4*	1.0	0.00
	D	.	.	.	.	.	.	1	2	2	2	*4*	1.8	0.50
1000 mg a.i./kg	A	.	.	.	.	.	.	.	.	.	.	*0*		
	B	.	.	.	.	.	.	.	.	.	.	*0*		
	C	.	.	.	.	.	.	.	.	.	.	*0*		
	D	.	.	.	.	.	.	.	.	.	.	*0*		

The "." symbol indicates that the seedling either did not emerge or died prior to measurement.

Appendix 7.6

Flax Mean Seedling Height on Day 21

Treatment Group	Mean Height (cm) for Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	8.6	9.1	8.8	9.1	*4*	8.9	0.27
3.91 mg a.i./kg	9.3	9.6	8.1	7.7	*4*	8.7	0.90
15.6 mg a.i./kg	9.8	9.1	8.0	8.3	*4*	8.8	0.80
62.5 mg a.i./kg	8.6	8.8	7.8	7.7	*4*	8.2	0.54
250 mg a.i./kg	1.0	1.3	1.0	1.8	*4*	1.3	0.35
1000 mg a.i./kg	.	.	.	.	*0*	.	.



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
97.6338	81.3392	117.166	8.7913	0.2340	0.99938

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
140.411	124.825	157.943	8.7913	0.2340	0.99938

Appendix 7.7

Flax Seedling Condition, Day 21

Treatment Group	Replicate	Condition (score.sign)[1] for Plant Number:										*n*	Mean	Std. Dev.
		1	2	3	4	5	6	7	8	9	10			
Control	A	.	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*7*	0	0.0
	B	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	40.USC	*9*	4	13.3
	C	.	.	.	.	0.-	0.-	0.-	0.-	0.-	0.-	*6*	0	0.0
	D	.	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*7*	0	0.0
3.91 mg a.i./kg	A	.	.	100.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	13	35.4
	B	.	.	.	.	.	0.-	0.-	0.-	0.-	0.-	*5*	0	0.0
	C	.	.	0.-	0.-	0.-	0.-	80.LC	0.-	0.-	0.-	*8*	10	28.3
	D	.	.	100.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	13	35.4
15.6 mg a.i./kg	A	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
	B	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	C	.	.	.	0.-	0.-	0.-	0.-	0.-	0.-	80.USC	*7*	11	30.2
	D	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
62.5 mg a.i./kg	A	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	B	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	C	.	0.-	0.-	0.-	0.-	0.-	40.N	0.-	0.-	0.-	*9*	4	13.3
	D	.	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*7*	0	0.0
250 mg a.i./kg	A	.	.	100.-	100.-	100.-	100.-	100.-	100.-	100.-	90.USC	*8*	99	3.5
	B	.	100.-	100.-	100.-	100.-	100.-	50.USC	90.USC	70.USC	90.USC	*9*	89	17.6
	C	.	.	.	.	.	100.-	90.USC	80.USC	80.USC	80.USC	*5*	86	8.9
	D	.	.	.	100.-	100.-	100.-	80.USC	80.USC	80.USC	80.USC	*7*	89	10.7
1000 mg a.i./kg	A	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	B	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	C	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	D	.	.	.	.	.	.	.	.	.	.	*0*	.	.

[1]The "." symbol indicates that the seedling did not emerge. A score of 0 indicates a normal seedling, while a score of 100 indicates a dead seedling. Intermediate scores are assigned to indicate the relative severity of observed signs of toxicity.
USC – Unshed Seed Coat, LC – Leaf Curl, N - Necrosis

Appendix 8.1

Lettuce Emergence

Day 7

Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	9	8	9	9	*4*	8.75	0.50
3.91 mg a.i./kg	8	9	9	10	*4*	9.00	0.82
15.6 mg a.i./kg	10	7	8	10	*4*	8.75	1.50
62.5 mg a.i./kg	9	7	8	10	*4*	8.50	1.29
250 mg a.i./kg	10	7	7	8	*4*	8.00	1.41
1000 mg a.i./kg	3	0	1	1	*4*	1.25	1.26

Day 15

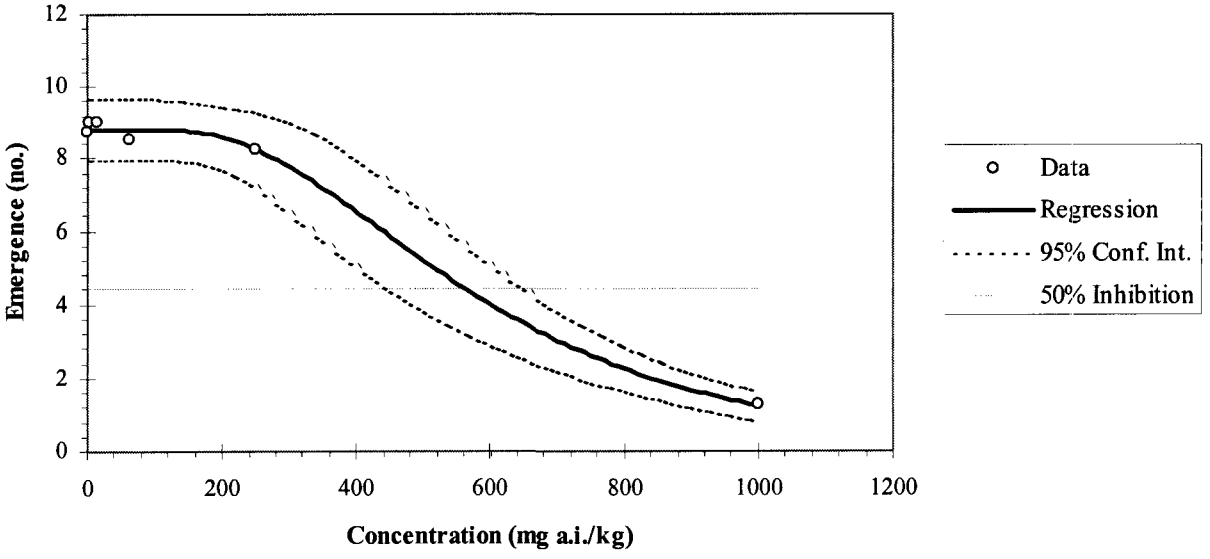
Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	9	8	9	9	*4*	8.75	0.50
3.91 mg a.i./kg	8	9	9	10	*4*	9.00	0.82
15.6 mg a.i./kg	10	8	8	10	*4*	9.00	1.15
62.5 mg a.i./kg	9	7	8	10	*4*	8.50	1.29
250 mg a.i./kg	10	7	7	8	*4*	8.00	1.41
1000 mg a.i./kg	3	0	1	1	*4*	1.25	1.26

Day 21

Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	9	8	9	9	*4*	8.75	0.50
3.91 mg a.i./kg	8	9	9	10	*4*	9.00	0.82
15.6 mg a.i./kg	10	8	8	10	*4*	9.00	1.15
62.5 mg a.i./kg	9	7	8	10	*4*	8.50	1.29
250 mg a.i./kg	10	8	7	8	*4*	8.25	1.26
1000 mg a.i./kg	3	0	1	1	*4*	1.25	1.26

Appendix 8.2

Mean Lettuce Emergence on Day 21



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
393.369	300.193	515.466	8.8126	0.2320	0.99632

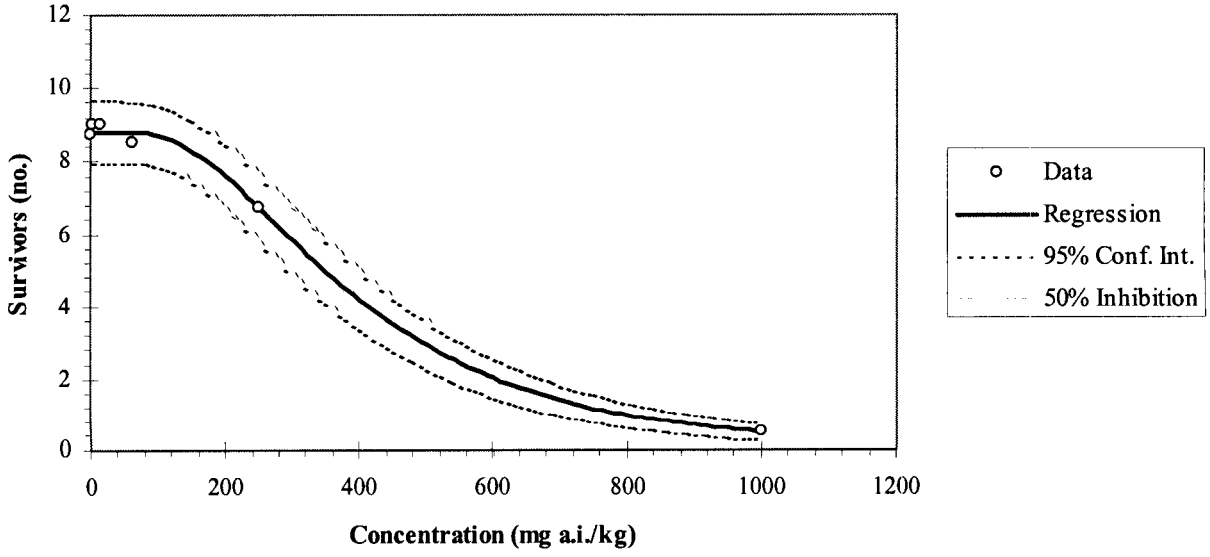
EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
564.027	474.024	671.120	8.8126	0.2320	0.99632

Appendix 8.3

Lettuce 21-Day Survival

Day 21

Treatment Group	Number of Living Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	9	8	9	9	*4*	8.75	0.50
3.91 mg a.i./kg	8	9	9	10	*4*	9.00	0.82
15.6 mg a.i./kg	10	8	8	10	*4*	9.00	1.15
62.5 mg a.i./kg	9	7	8	10	*4*	8.50	1.29
250 mg a.i./kg	8	6	7	6	*4*	6.75	0.96
1000 mg a.i./kg	1	0	0	1	*4*	0.50	0.58



Curve Parameters

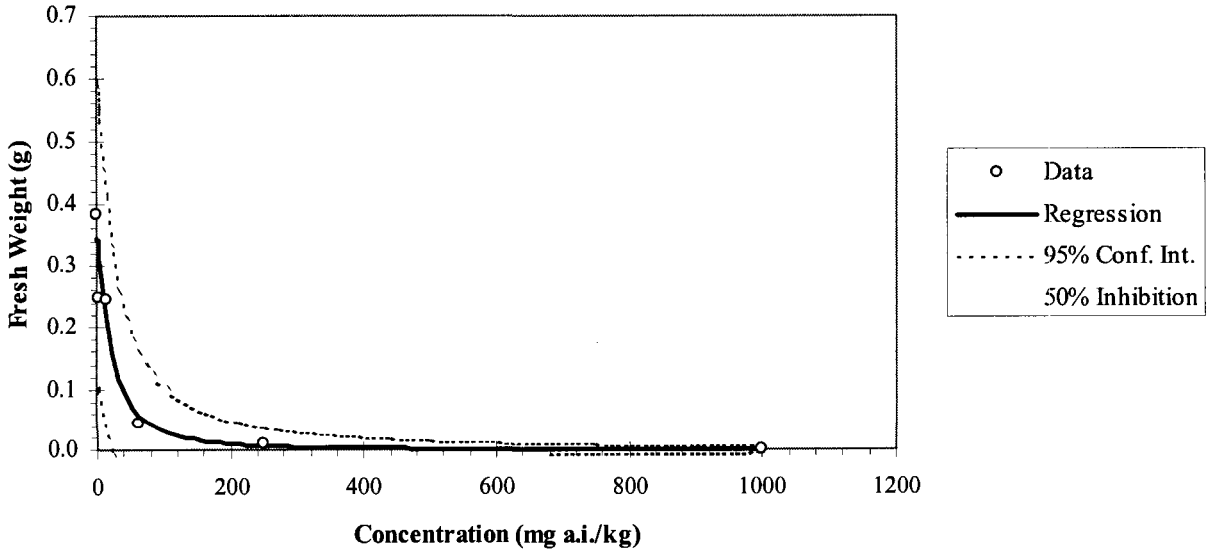
EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
257.276	220.141	300.677	8.8166	0.2613	0.99719

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
386.011	343.795	433.411	8.8166	0.2613	0.99719

Appendix 8.4

Lettuce Mean Seedling Fresh Weight, Day 21

Treatment Group	Mean Weight (g) for Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	0.46	0.38	0.32	0.38	*4*	0.38	0.06
3.91 mg a.i./kg	0.21	0.28	0.20	0.30	*4*	0.25	0.05
15.6 mg a.i./kg	0.32	0.13	0.27	0.26	*4*	0.24	0.08
62.5 mg a.i./kg	0.06	0.03	0.06	0.03	*4*	0.05	0.02
250 mg a.i./kg	0.01	0.01	0.02	0.00	*4*	0.01	0.01
1000 mg a.i./kg	0.00	.	.	0.00	*2*	0.00	0.00



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
8.92483	1.36490	58.3445	0.3466	0.5242	0.94722

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
20.1419	5.26260	77.1081	0.3466	0.5242	0.94722

Appendix 8.5

Lettuce Seedling Height on Day 21

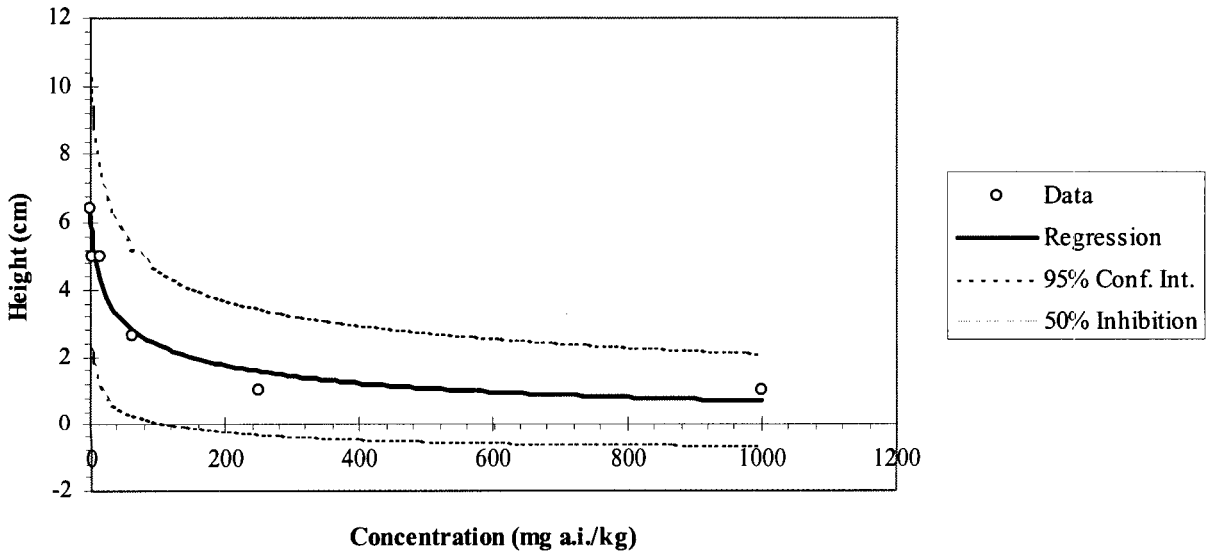
Treatment Group	Replicate	Height (cm) for Plant Number:										*n*	Mean	Std. Dev.
		1	2	3	4	5	6	7	8	9	10			
Control	A	.	6	7	8	9	5	6	8	7	8	*9*	7.1	1.27
	B	.	.	8	9	6	8	4	5	6	5	*8*	6.4	1.77
	C	.	4	5	4	8	5	6	10	5	6	*9*	5.9	1.96
	D	.	6	7	8	6	6	6	6	5	7	*9*	6.3	0.87
3.91 mg a.i./kg	A	.	.	6	5	5	4	4	5	7	5	*8*	5.1	0.99
	B	.	5	5	6	7	7	7	5	4	4	*9*	5.6	1.24
	C	.	6	6	3	4	6	3	3	3	4	*9*	4.2	1.39
	D	7	4	4	3	7	6	3	4	7	5	*10*	5.0	1.63
15.6 mg a.i./kg	A	4	5	6	7	4	6	5	6	8	10	*10*	6.1	1.85
	B	.	.	4	4	3	5	3	5	3	2	*8*	3.6	1.06
	C	.	.	4	7	6	6	4	5	8	4	*8*	5.5	1.51
	D	6	4	5	6	3	4	5	5	7	2	*10*	4.7	1.49
62.5 mg a.i./kg	A	.	5	5	2	2	2	2	3	2	2	*9*	2.8	1.30
	B	.	.	.	3	2	2	3	2	2	5	*7*	2.7	1.11
	C	.	.	5	4	5	1	2	3	2	2	*8*	3.0	1.51
	D	2	3	2	1	1	2	2	2	3	2	*10*	2.0	0.67
250 mg a.i./kg	A	.	.	1	2	1	1	1	1	1	1	*8*	1.1	0.35
	B	.	.	.	.	1	1	1	1	1	1	*6*	1.0	0.00
	C	.	.	.	1	1	1	1	1	1	1	*7*	1.0	0.00
	D	.	.	.	.	1	1	1	1	1	1	*6*	1.0	0.00
1000 mg a.i./kg	A	.	.	.	.	.	.	.	.	.	1	*1*	1.0	.
	B	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	C	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	D	.	.	.	.	.	.	.	.	.	1	*1*	1.0	.

The "." symbol indicates that the seedling either did not emerge or died prior to measurement.

Appendix 8.6

Lettuce Mean Seedling Height on Day 21

Treatment Group	Mean Height (cm) for Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	7.1	6.4	5.9	6.3	*4*	6.4	0.51
3.91 mg a.i./kg	5.1	5.6	4.2	5.0	*4*	5.0	0.56
15.6 mg a.i./kg	6.1	3.6	5.5	4.7	*4*	5.0	1.07
62.5 mg a.i./kg	2.8	2.7	3.0	2.0	*4*	2.6	0.43
250 mg a.i./kg	1.1	1.0	1.0	1.0	*4*	1.0	0.06
1000 mg a.i./kg	1.0	.	.	1.0	*2*	1.0	0.00



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
6.79360	0.20399	226.204	6.5025	1.1396	0.94294

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
39.8749	3.87972	409.732	6.5025	1.1396	0.94294

Appendix 8.7

Lettuce Seedling Condition, Day 21

Treatment Group	Replicate	Condition (score.sign)[1] for Plant Number:										*n*	Mean	Std. Dev.
		1	2	3	4	5	6	7	8	9	10			
Control	A	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	B	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
	C	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	D	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
3.91 mg a.i./kg	A	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
	B	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	C	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	D	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
15.6 mg a.i./kg	A	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	B	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
	C	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
	D	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	40.N	*10*	4	12.6
62.5 mg a.i./kg	A	.	0.-	0.-	50.N	30.N	0.-	50.N	50.N	50.N	40.N	*9*	30	23.5
	B	.	.	.	40.N	40.N	40.N	40.N	40.N	30.N	20.N	*7*	36	7.9
	C	.	.	0.-	20.N	0.-	0.-	50.N	30.N	50.N	50.N	*8*	25	23.3
	D	40.N	40.N	40.N	40.N	30.N	30.N	40.N	50.N	30.N	50.N	*10*	39	7.4
250 mg a.i./kg	A	100.-	100.-	80.N	0.-	40.N	0.-	60.N	0.-	60.N	0.-	*10*	44	42.0
	B	.	.	100.-	100.-	0.-	40.N	0.-	0.-	30.N	40.N	*8*	39	41.6
	C	.	.	.	60.N	0.-	30.N	40.N	40.N	40.N	0.-	*7*	30	22.4
	D	.	.	100.-	100.-	30.N	80.N	0.-	40.N	50.N,LC	30.N	*8*	54	36.2
1000 mg a.i./kg	A	.	.	.	.	.	.	.	100.-	100.-	80.N	*3*	93	11.5
	B	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	C	.	.	.	.	.	.	.	.	.	100.-	*1*	100	.
	D	.	.	.	.	.	.	.	.	.	90.USC	*1*	90	.

[1]The "." symbol indicates that the seedling did not emerge. A score of 0 indicates a normal seedling, while a score of 100 indicates a dead seedling. Intermediate scores are assigned to indicate the relative severity of observed signs of toxicity.
N – Necrosis, USC – Unshed Seed Coat, LC – Leaf Curl

Appendix 9.1

Onion Emergence

Day 7

Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	8	7	8	9	*4*	8.00	0.82
3.91 mg a.i./kg	10	8	9	7	*4*	8.50	1.29
15.6 mg a.i./kg	8	8	7	8	*4*	7.75	0.50
62.5 mg a.i./kg	4	8	4	4	*4*	5.00	2.00
250 mg a.i./kg	5	3	0	0	*4*	2.00	2.45
1000 mg a.i./kg	0	0	0	0	*4*	0.00	0.00

Day 15

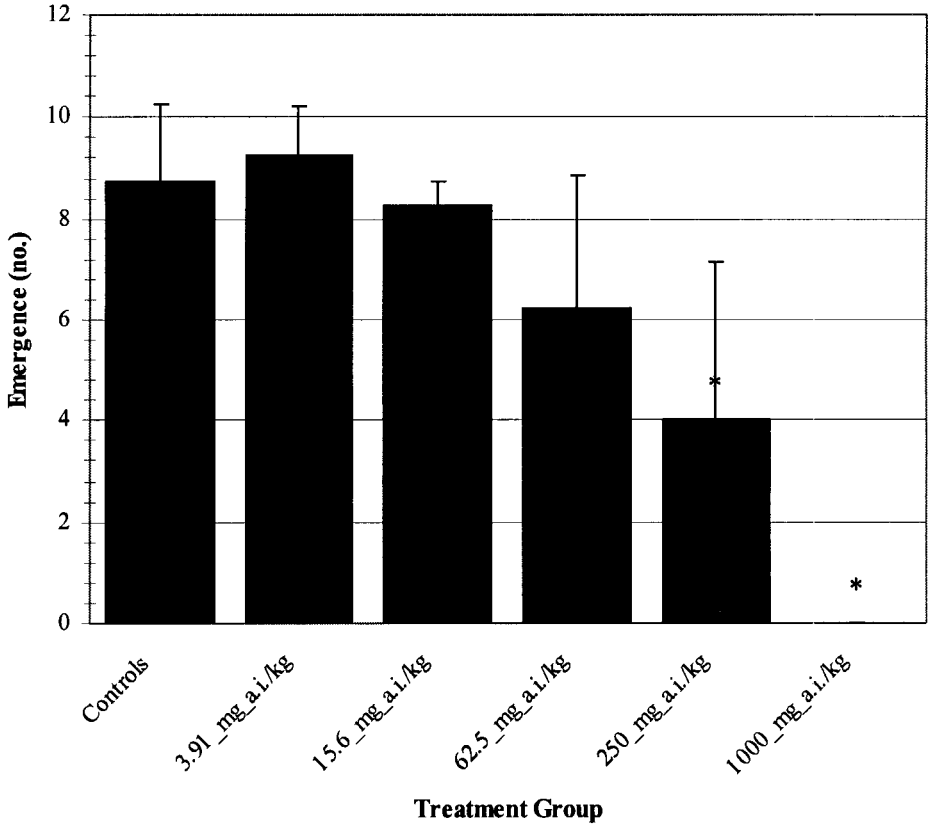
Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	8	7	9	10	*4*	8.50	1.29
3.91 mg a.i./kg	10	10	9	7	*4*	9.00	1.41
15.6 mg a.i./kg	8	9	8	8	*4*	8.25	0.50
62.5 mg a.i./kg	5	10	6	4	*4*	6.25	2.63
250 mg a.i./kg	5	8	2	1	*4*	4.00	3.16
1000 mg a.i./kg	0	0	0	0	*4*	0.00	0.00

Day 21

Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	8	7	10	10	*4*	8.75	1.50
3.91 mg a.i./kg	10	10	9	8	*4*	9.25	0.96
15.6 mg a.i./kg	8	9	8	8	*4*	8.25	0.50
62.5 mg a.i./kg	5	10	6	4	*4*	6.25	2.63
250 mg a.i./kg	5	8	2	1	*4*	4.00	3.16
1000 mg a.i./kg	0	0	0	0	*4*	0.00	0.00

Appendix 9.2

Mean Onion Emergence on Day 21



*Treatment group mean is significantly different from the control mean (Dunnett's test, $p<0.05$).

The non-linear regression technique failed to generate useable results. Therefore, linear interpolation was used.

Effect Rate	Effect Concentration	Lower 95% Confidence Limit	Upper 95% Confidence Limit
EC_{25}	50.7750	12.1515	194.5350
EC_{50}	208.3333	-25.0000	644.2308

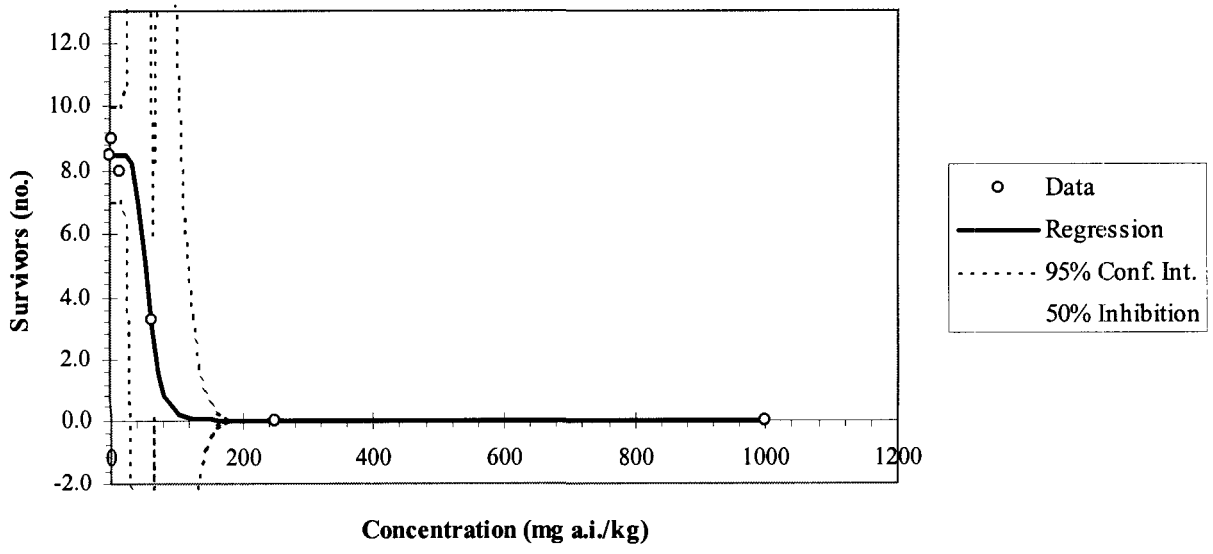
EC_{25} and EC_{50} estimates calculated by linear interpolation using the ICPIN program (7).

Appendix 9.3

Onion 21-Day Survival

Day 21

Treatment Group	Number of Living Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	8	7	9	10	*4*	8.50	1.29
3.91 mg a.i./kg	10	10	8	8	*4*	9.00	1.15
15.6 mg a.i./kg	7	9	8	8	*4*	8.00	0.82
62.5 mg a.i./kg	3	4	3	3	*4*	3.25	0.50
250 mg a.i./kg	0	0	0	0	*4*	0.00	0.00
1000 mg a.i./kg	0	0	0	0	*4*	0.00	0.00



Curve Parameters

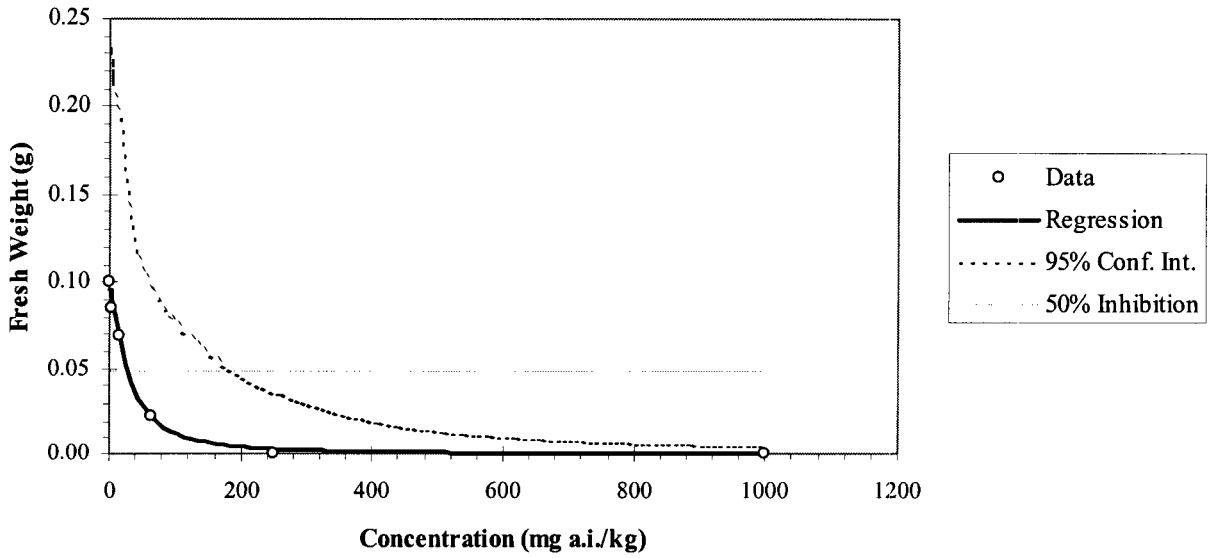
EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
47.0977	0.99238	2234.60	8.5000	0.1262	0.99445

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
57.2928	17.4622	187.975	8.5000	0.1262	0.99445

Appendix 9.4

Onion Mean Seedling Fresh Weight, Day 21

Treatment Group	Mean Weight (g) for Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	0.10	0.09	0.10	0.10	*4*	0.10	0.006
3.91 mg a.i./kg	0.06	0.09	0.09	0.10	*4*	0.09	0.015
15.6 mg a.i./kg	0.06	0.06	0.08	0.07	*4*	0.07	0.006
62.5 mg a.i./kg	0.02	0.05	0.03	0.00	*4*	0.02	0.019
250 mg a.i./kg	.	.	.	.	*0*	.	.
1000 mg a.i./kg	.	.	.	.	*0*	.	.



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
12.9092	0.16110	1034.67	0.0957	0.5011	0.98693

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
28.1125	1.99434	396.369	0.0957	0.5011	0.98693

Appendix 9.5

Onion Seedling Height on Day 21

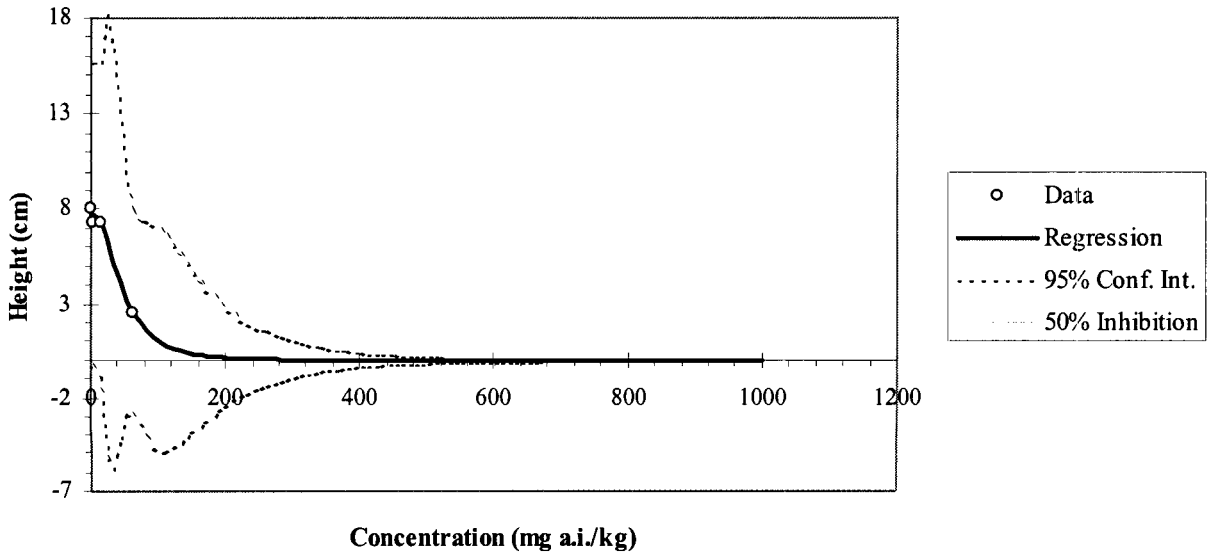
Treatment Group	Replicate	Height (cm) for Plant Number:										*n*	Mean	Std. Dev.
		1	2	3	4	5	6	7	8	9	10			
Control	A	.	.	13	4	8	9	9	5	13	8	*8*	8.6	3.25
	B	.	.	.	8	7	7	8	7	8	8	*7*	7.6	0.53
	C	7	7	10	7	9	7	13	8	8	.	*9*	8.4	2.01
	D	2	7	7	8	8	10	10	14	8	2	*10*	7.6	3.60
3.91 mg a.i./kg	A	7	6	7	6	7	8	7	7	7	5	*10*	6.7	0.82
	B	8	8	9	5	7	8	8	8	7	7	*10*	7.5	1.08
	C	.	.	8	8	9	9	7	7	7	8	*8*	7.9	0.83
	D	.	.	8	9	9	8	1	8	7	8	*8*	7.3	2.60
15.6 mg a.i./kg	A	.	.	.	5	6	5	11	8	8	9	*7*	7.4	2.23
	B	.	12	3	8	8	8	6	7	8	6	*9*	7.3	2.40
	C	.	.	9	14	6	8	1	8	7	4	*8*	7.1	3.80
	D	.	.	8	5	7	9	8	3	9	8	*8*	7.1	2.10
62.5 mg a.i./kg	A	.	.	.	.	.	.	.	3	2	4	*3*	3.0	1.00
	B	.	.	.	.	.	.	4	5	2	1	*4*	3.0	1.83
	C	.	.	.	.	.	.	.	3	1	5	*3*	3.0	2.00
	D	.	.	.	.	.	.	.	1	1	2	*3*	1.3	0.58
250 mg a.i./kg	A	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	B	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	C	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	D	.	.	.	.	.	.	.	.	.	.	*0*	.	.
1000 mg a.i./kg	A	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	B	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	C	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	D	.	.	.	.	.	.	.	.	.	.	*0*	.	.

The "." symbol indicates that the seedling either did not emerge or died prior to measurement.

Appendix 9.6

Onion Mean Seedling Height on Day 21

Treatment Group	Mean Height (cm) for Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	8.6	7.6	8.4	7.6	*4*	8.1	0.55
3.91 mg a.i./kg	6.7	7.5	7.9	7.3	*4*	7.3	0.49
15.6 mg a.i./kg	7.4	7.3	7.1	7.1	*4*	7.3	0.15
62.5 mg a.i./kg	3.0	3.0	3.0	1.3	*4*	2.6	0.83
250 mg a.i./kg	.	.	.	.	*0*	.	.
1000 mg a.i./kg	.	.	.	.	*0*	.	.



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
29.0737	0.93476	904.066	7.6985	0.3025	0.98600

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
46.5050	8.94129	241.824	7.6985	0.3025	0.98600

Appendix 9.7

Onion Seedling Condition, Day 21

Treatment Group	Replicate	Condition (score.sign)[1] for Plant Number:										*n*	Mean	Std. Dev.
		1	2	3	4	5	6	7	8	9	10			
Control	A	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
	B	.	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*7*	0	0.0
	C	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	100.-	*10*	10	31.6
	D	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
3.91 mg a.i./kg	A	0.-	0.-	0.-	40.CL	0.-	0.-	0.-	0.-	0.-	0.-	*10*	4	12.6
	B	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	C	.	100.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	11	33.3
	D	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
15.6 mg a.i./kg	A	.	.	100.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	13	35.4
	B	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	C	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
	D	.	.	0.-	0.-	0.-	0.-	0.-	60.N	0.-	0.-	*8*	8	21.2
62.5 mg a.i./kg	A	.	.	.	.	.	100.-	100.-	0.-	0.-	0.-	*5*	40	54.8
	B	100.-	100.-	100.-	100.-	100.-	100.-	0.-	0.-	0.-	0.-	*10*	60	51.6
	C	.	.	.	.	100.-	100.-	100.-	0.-	0.-	0.-	*6*	50	54.8
	D	.	.	.	.	.	.	100.-	0.-	0.-	0.-	*4*	25	50.0
250 mg a.i./kg	A	.	.	.	.	.	100.-	100.-	100.-	100.-	100.-	*5*	100	0.0
	B	.	.	100.-	100.-	100.-	100.-	100.-	100.-	100.-	100.-	*8*	100	0.0
	C	.	.	.	.	.	.	.	.	100.-	100.-	*2*	100	0.0
	D	100.-	.	.	.	.	.	.	.	.	.	*1*	100	.
1000 mg a.i./kg	A	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	B	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	C	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	D	.	.	.	.	.	.	.	.	.	.	*0*	.	.

[1]The "." symbol indicates that the seedling did not emerge. A score of 0 indicates a normal seedling, while a score of 100 indicates a dead seedling. Intermediate scores are assigned to indicate the relative severity of observed signs of toxicity.
N – Necrosis, CL - Chlorosis

Appendix 10.1

Ryegrass Emergence

Day 7

Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	7	9	7	8	*4*	7.75	0.96
3.91 mg a.i./kg	9	9	9	7	*4*	8.50	1.00
15.6 mg a.i./kg	8	6	10	6	*4*	7.50	1.91
62.5 mg a.i./kg	7	7	8	8	*4*	7.50	0.58
250 mg a.i./kg	6	4	3	3	*4*	4.00	1.41
1000 mg a.i./kg	0	0	0	0	*4*	0.00	0.00

Day 15

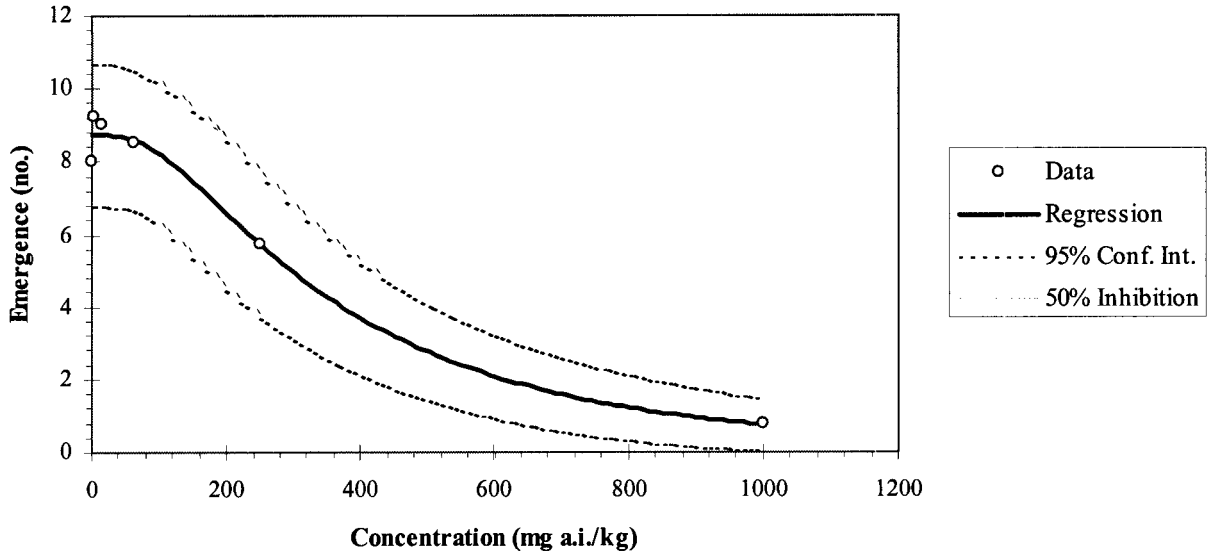
Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	8	9	7	8	*4*	8.00	0.82
3.91 mg a.i./kg	9	10	10	8	*4*	9.25	0.96
15.6 mg a.i./kg	9	9	10	8	*4*	9.00	0.82
62.5 mg a.i./kg	7	8	9	9	*4*	8.25	0.96
250 mg a.i./kg	6	4	7	6	*4*	5.75	1.26
1000 mg a.i./kg	1	0	0	0	*4*	0.25	0.50

Day 21

Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	8	9	7	8	*4*	8.00	0.82
3.91 mg a.i./kg	9	10	10	8	*4*	9.25	0.96
15.6 mg a.i./kg	9	9	10	8	*4*	9.00	0.82
62.5 mg a.i./kg	7	8	9	10	*4*	8.50	1.29
250 mg a.i./kg	6	4	7	6	*4*	5.75	1.26
1000 mg a.i./kg	1	1	0	1	*4*	0.75	0.50

Appendix 10.2

Mean Ryegrass Emergence on Day 21



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
202.675	131.220	313.040	8.7223	0.3400	0.98361

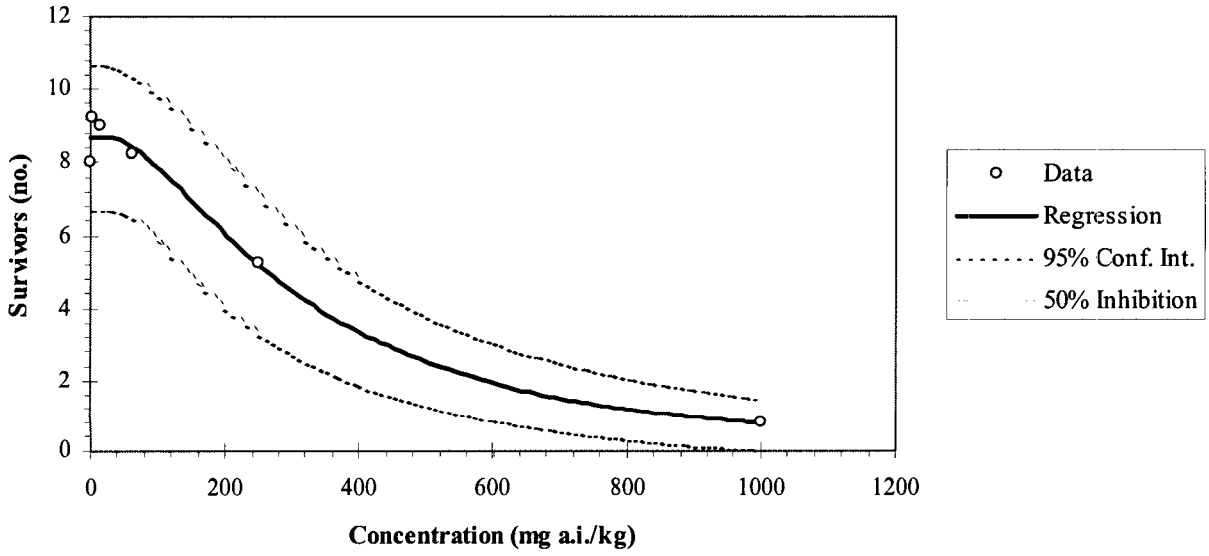
EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
343.637	253.805	465.265	8.7223	0.3400	0.98361

Appendix 10.3

Ryegrass 21-Day Survival

Day 21

Treatment Group	Number of Living Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	8	9	7	8	*4*	8.00	0.82
3.91 mg a.i./kg	9	10	10	8	*4*	9.25	0.96
15.6 mg a.i./kg	9	9	10	8	*4*	9.00	0.82
62.5 mg a.i./kg	7	8	9	9	*4*	8.25	0.96
250 mg a.i./kg	6	2	7	6	*4*	5.25	2.22
1000 mg a.i./kg	1	1	0	1	*4*	0.75	0.50



Curve Parameters

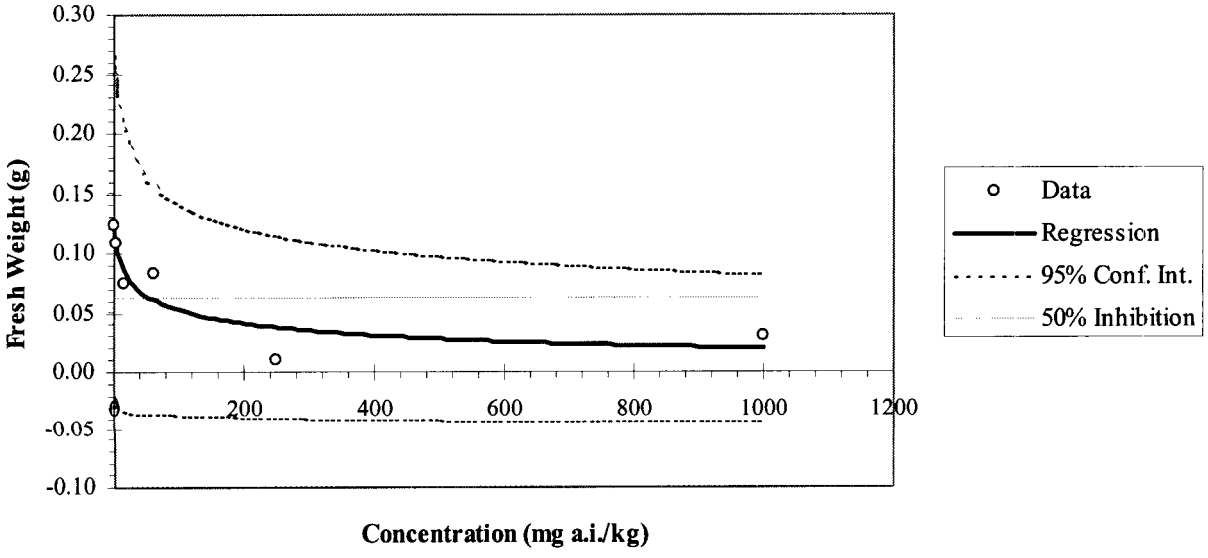
EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
173.500	107.029	281.255	8.7020	0.3740	0.98409

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
310.099	222.844	431.618	8.7020	0.3740	0.98409

Appendix 10.4

Ryegrass Mean Seedling Fresh Weight, Day 21

Treatment Group	Mean Weight (g) for Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	0.12	0.09	0.12	0.16	*4*	0.12	0.025
3.91 mg a.i./kg	0.09	0.12	0.12	0.11	*4*	0.11	0.013
15.6 mg a.i./kg	0.07	0.06	0.09	0.08	*4*	0.07	0.014
62.5 mg a.i./kg	0.07	0.07	0.10	0.09	*4*	0.08	0.014
250 mg a.i./kg	0.01	0.02	0.01	0.01	*4*	0.01	0.006
1000 mg a.i./kg	0.03	0.04	.	0.02	*3*	0.03	0.010



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
7.50585	0.003860113	14594.86	0.1262	1.26881	0.92024

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
53.8022	0.41620	6953.44	0.1262	1.2681	0.83214

Appendix 10.5

Ryegrass Seedling Height on Day 21

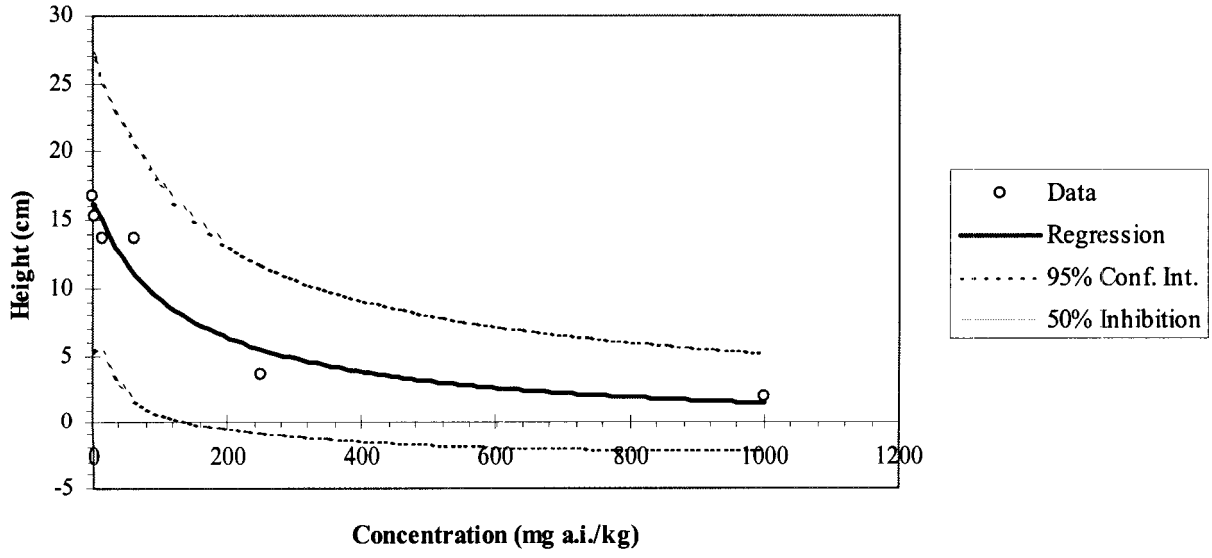
Treatment Group	Replicate	Height (cm) for Plant Number:										*n*	Mean	Std. Dev.
		1	2	3	4	5	6	7	8	9	10			
Control	A	15	15	21	20	16	16	11	20	.	.	*8*	16.8	3.37
	B	.	10	15	14	22	17	19	12	19	19	*9*	16.3	3.87
	C	.	.	.	17	18	11	22	20	19	18	*7*	17.9	3.44
	D	.	.	18	18	19	15	14	19	16	13	*8*	16.5	2.33
3.91 mg a.i./kg	A	.	13	17	15	16	12	20	16	17	12	*9*	15.3	2.65
	B	18	17	18	20	18	21	18	15	21	6	*10*	17.2	4.34
	C	18	16	9	15	14	6	21	13	17	17	*10*	14.6	4.40
	D	.	.	12	16	14	14	10	15	15	19	*8*	14.4	2.67
15.6 mg a.i./kg	A	12	13	13	9	19	12	12	14	17	.	*9*	13.4	2.96
	B	.	19	19	11	21	8	9	14	9	5	*9*	12.8	5.72
	C	19	14	16	13	19	13	8	14	11	11	*10*	13.8	3.49
	D	.	.	14	13	21	12	19	12	14	12	*8*	14.6	3.46
62.5 mg a.i./kg	A	.	.	.	9	5	16	18	17	15	12	*7*	13.1	4.74
	B	.	.	20	9	6	10	13	15	14	17	*8*	13.0	4.54
	C	.	20	12	19	16	4	15	16	18	15	*9*	15.0	4.77
	D	.	15	12	10	17	13	13	7	15	19	*9*	13.4	3.61
250 mg a.i./kg	A	.	.	.	.	4	5	6	4	5	3	*6*	4.5	1.05
	B	.	.	.	.	.	.	.	.	5	4	*2*	4.5	0.71
	C	.	.	.	2	6	2	2	2	2	5	*7*	3.0	1.73
	D	.	.	.	.	4	2	1	4	3	2	*6*	2.7	1.21
1000 mg a.i./kg	A	.	.	.	.	.	.	.	.	.	2	*1*	2.0	.
	B	.	.	.	.	.	.	.	.	.	2	*1*	2.0	.
	C	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	D	.	.	.	.	.	.	.	.	.	2	*1*	2.0	.

The "." symbol indicates that the seedling either did not emerge or died prior to measurement.

Appendix 10.6

Ryegrass Mean Seedling Height on Day 21

Treatment Group	Mean Height (cm) for Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	16.8	16.3	17.9	16.5	*4*	16.9	0.69
3.91 mg a.i./kg	15.3	17.2	14.6	14.4	*4*	15.4	1.28
15.6 mg a.i./kg	13.4	12.8	13.8	14.6	*4*	13.7	0.77
62.5 mg a.i./kg	13.1	13.0	15.0	13.4	*4*	13.6	0.92
250 mg a.i./kg	4.5	4.5	3.0	2.7	*4*	3.7	0.97
1000 mg a.i./kg	2.0	2.0	.	2.0	*3*	2.0	0.00



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
46.3554	4.63127	464.088	16.2180	0.6693	0.92846

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
131.099	28.7740	597.173	16.2180	0.6693	0.92846

Appendix 10.7

Ryegrass Seedling Condition, Day 21

Treatment Group	Replicate	Condition (score.sign)[1] for Plant Number:										*n*	Mean	Std. Dev.
		1	2	3	4	5	6	7	8	9	10			
Control	A	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	.	.	*8*	0	0.0
	B	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	C	.	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*7*	0	0.0
	D	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
3.91 mg a.i./kg	A	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	B	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	C	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	D	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
15.6 mg a.i./kg	A	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	.	*9*	0	0.0
	B	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	C	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	D	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
62.5 mg a.i./kg	A	.	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*7*	0	0.0
	B	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
	C	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	D	100.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	10	31.6
250 mg a.i./kg	A	.	.	.	.	10.N	0.-	10.N	10.N	10.N	0.-	*6*	7	5.2
	B	.	.	.	.	.	.	100.-	100.-	0.-	0.-	*4*	50	57.7
	C	.	.	.	30.N	0.-	20.N	20.N	20.N	40.N	0.-	*7*	19	14.6
	D	.	.	.	.	0.-	50.N	90.N	0.-	0.-	0.-	*6*	23	38.3
1000 mg a.i./kg	A	.	.	.	.	.	.	.	.	.	10.N	*1*	10	.
	B	.	.	.	.	.	.	.	.	.	30.N	*1*	30	.
	C	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	D	.	.	.	.	.	.	.	.	.	0.-	*1*	0	.

[1]The "." symbol indicates that the seedling did not emerge. A score of 0 indicates a normal seedling, while a score of 100 indicates a dead seedling. Intermediate scores are assigned to indicate the relative severity of observed signs of toxicity.
N - Necrosis

Appendix 11.1

Soybean Emergence

Day 7

Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	10	10	10	9	*4*	9.75	0.50
3.91 mg a.i./kg	10	10	9	10	*4*	9.75	0.50
15.6 mg a.i./kg	9	10	10	9	*4*	9.50	0.58
62.5 mg a.i./kg	10	10	10	10	*4*	10.00	0.00
250 mg a.i./kg	10	10	10	10	*4*	10.00	0.00
1000 mg a.i./kg	9	10	10	10	*4*	9.75	0.50

Day 15

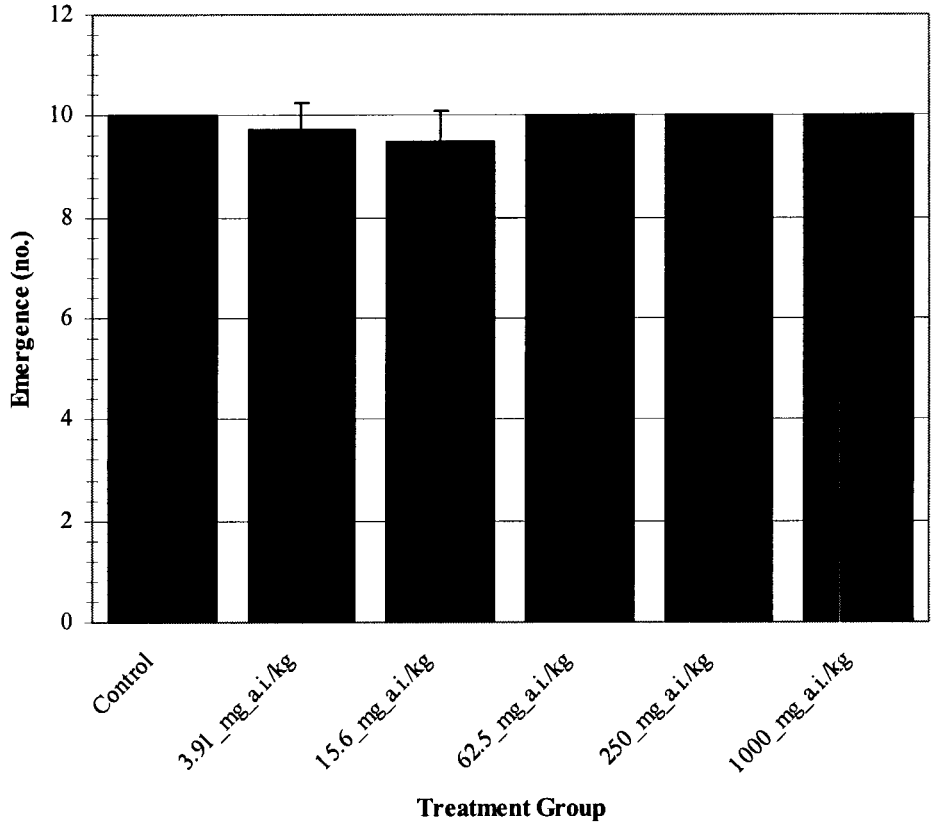
Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	10	10	10	10	*4*	10.00	0.00
3.91 mg a.i./kg	10	10	9	10	*4*	9.75	0.50
15.6 mg a.i./kg	9	10	10	9	*4*	9.50	0.58
62.5 mg a.i./kg	10	10	10	10	*4*	10.00	0.00
250 mg a.i./kg	10	10	10	10	*4*	10.00	0.00
1000 mg a.i./kg	10	10	10	10	*4*	10.00	0.00

Day 21

Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	10	10	10	10	*4*	10.00	0.00
3.91 mg a.i./kg	10	10	9	10	*4*	9.75	0.50
15.6 mg a.i./kg	9	10	10	9	*4*	9.50	0.58
62.5 mg a.i./kg	10	10	10	10	*4*	10.00	0.00
250 mg a.i./kg	10	10	10	10	*4*	10.00	0.00
1000 mg a.i./kg	10	10	10	10	*4*	10.00	0.00

Appendix 11.2

Mean Soybean Emergence on Day 21



No treatment group mean is significantly different from the control mean (Dunnettt's test, $p>0.05$).

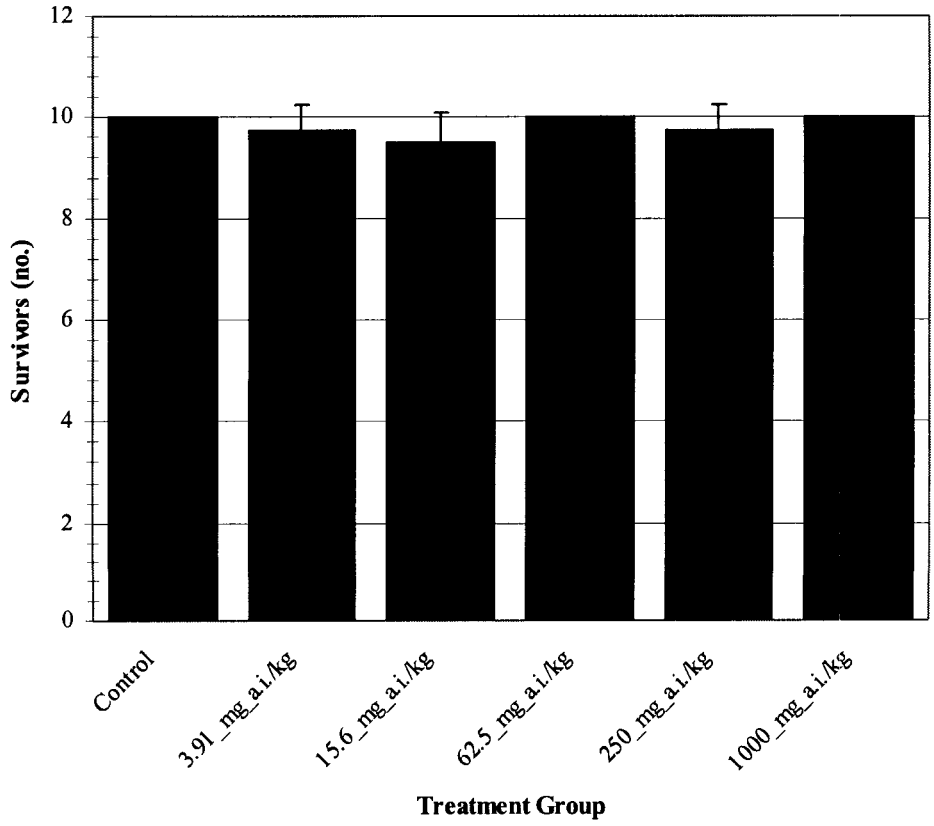
No regression was conducted due to the lack of effects.

Appendix 11.3

Soybean 21-Day Survival

Day 21

Treatment Group	Number of Living Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	10	10	10	10	*4*	10.00	0.00
3.91 mg a.i./kg	10	10	9	10	*4*	9.75	0.50
15.6 mg a.i./kg	9	10	10	9	*4*	9.50	0.58
62.5 mg a.i./kg	10	10	10	10	*4*	10.00	0.00
250 mg a.i./kg	9	10	10	10	*4*	9.75	0.50
1000 mg a.i./kg	10	10	10	10	*4*	10.00	0.00



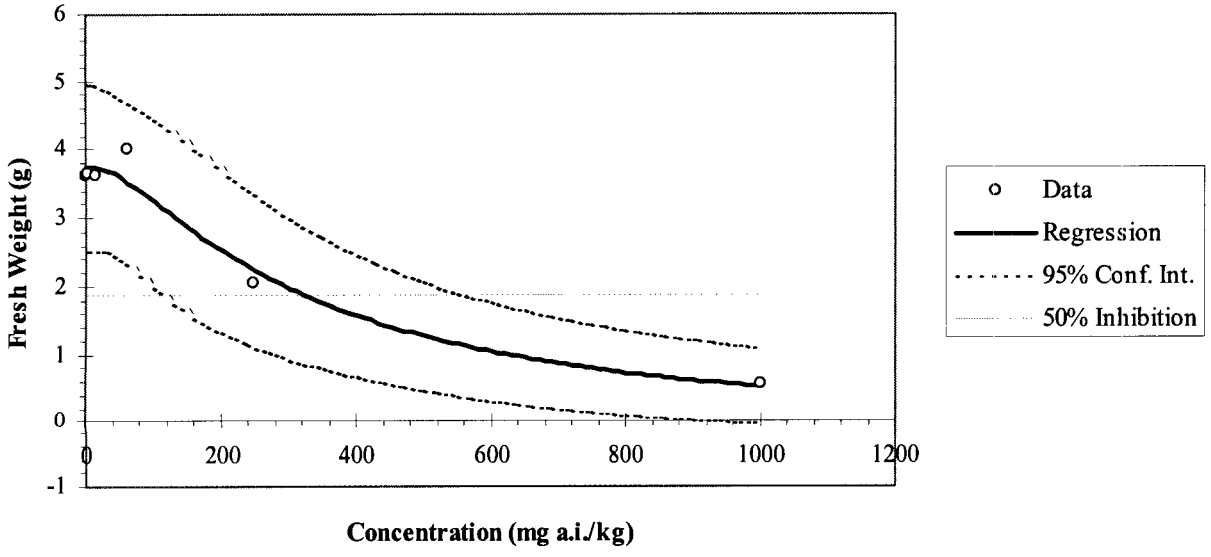
No treatment group mean is significantly different from the control mean (Dunnett's test, $p>0.05$).

No regression was conducted due to the lack of effects.

Appendix 11.4

Soybean Mean Seedling Fresh Weight, Day 21

Treatment Group	Mean Weight (g) for Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	3.42	4.46	3.55	3.10	*4*	3.63	0.583
3.91 mg a.i./kg	3.75	3.92	3.49	3.41	*4*	3.64	0.236
15.6 mg a.i./kg	3.94	3.59	3.80	3.18	*4*	3.63	0.330
62.5 mg a.i./kg	3.81	3.71	4.12	4.37	*4*	4.00	0.302
250 mg a.i./kg	2.36	2.11	1.63	2.18	*4*	2.07	0.310
1000 mg a.i./kg	0.62	0.60	0.53	0.54	*4*	0.57	0.047



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
160.325	69.1194	371.878	3.7487	0.4565	0.95631

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
325.762	189.234	560.661	3.7487	0.4565	0.95631

Appendix 11.5

Soybean Seedling Height on Day 21

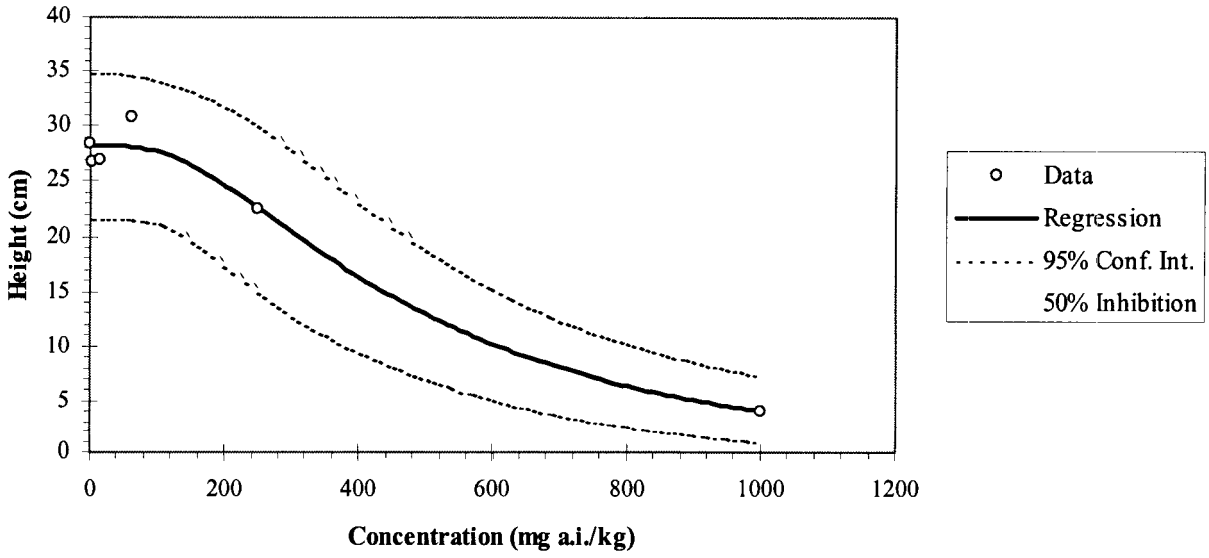
Treatment Group	Replicate	Height (cm) for Plant Number:										*n*	Mean	Std. Dev.
		1	2	3	4	5	6	7	8	9	10			
Control	A	25	28	28	25	24	28	25	14	31	35	*10*	26.3	5.46
	B	32	39	38	34	27	33	31	34	39	19	*10*	32.6	6.10
	C	31	29	24	33	30	33	29	35	29	36	*10*	30.9	3.51
	D	18	13	13	23	23	24	33	30	30	28	*10*	23.5	7.04
3.91 mg a.i./kg	A	33	36	33	27	28	35	31	24	29	31	*10*	30.7	3.74
	B	27	25	26	21	34	22	37	28	21	38	*10*	27.9	6.37
	C	.	22	30	30	27	25	20	13	24	21	*9*	23.6	5.36
	D	28	29	19	30	26	20	33	15	29	21	*10*	25.0	5.85
15.6 mg a.i./kg	A	.	29	31	29	32	26	27	32	41	25	*9*	30.2	4.76
	B	20	21	24	29	29	25	30	15	29	24	*10*	24.6	4.88
	C	28	33	23	30	29	28	32	31	27	31	*10*	29.2	2.90
	D	.	23	24	24	22	19	25	27	20	28	*9*	23.6	2.96
62.5 mg a.i./kg	A	23	28	29	33	28	19	32	25	28	28	*10*	27.3	4.11
	B	34	31	32	36	31	31	35	38	13	34	*10*	31.5	6.92
	C	34	38	31	32	31	28	29	23	32	29	*10*	30.7	3.95
	D	32	36	33	29	31	35	37	33	35	32	*10*	33.3	2.45
250 mg a.i./kg	A	.	20	22	21	28	27	17	28	28	12	*9*	22.6	5.70
	B	29	31	20	20	19	21	4	27	31	29	*10*	23.1	8.27
	C[1]	22	24	17	18	20	20	21	16	22	14	*10*	19.4	3.10
	D	21	25	24	23	25	23	29	26	29	23	*10*	24.8	2.62
1000 mg a.i./kg	A	2	1	3	3	4	8	5	2	5	3	*10*	3.6	2.01
	B	4	3	6	4	6	4	3	4	4	3	*10*	4.1	1.10
	C	3	5	3	4	6	3	8	5	6	2	*10*	4.5	1.84
	D	5	4	3	5	4	4	4	5	6	3	*10*	4.3	0.95

The "." symbol indicates that the seedling either did not emerge or died prior to measurement.

Appendix 11.6

Soybean Mean Seedling Height on Day 21

Treatment Group	Mean Height (cm) for Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	26.3	32.6	30.9	23.5	*4*	28.3	4.17
3.91 mg a.i./kg	30.7	27.9	23.6	25.0	*4*	26.8	3.17
15.6 mg a.i./kg	30.2	24.6	29.2	23.6	*4*	26.9	3.31
62.5 mg a.i./kg	27.3	31.5	30.7	33.3	*4*	30.7	2.51
250 mg a.i./kg	22.6	23.1	19.4	24.8	*4*	22.5	2.26
1000 mg a.i./kg	3.6	4.1	4.5	4.3	*4*	4.1	0.39



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
284.053	172.346	468.274	28.1676	0.3162	0.97727

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
464.195	332.583	647.888	28.1676	0.3162	0.97727

Appendix 11.7

Soybean Seedling Condition, Day 21

Treatment Group	Replicate	Condition (score.sign)[1] for Plant Number:										*n*	Mean	Std. Dev.
		1	2	3	4	5	6	7	8	9	10			
Control	A	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	B	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	C	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	D	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
3.91 mg a.i./kg	A	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	B	0.-	0.-	0.-	30.LC	0.-	0.-	0.-	0.-	0.-	0.-	*10*	3	9.5
	C	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	D	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
15.6 mg a.i./kg	A	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	B	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	C	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	D	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
62.5 mg a.i./kg	A	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	B	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	40.LC	0.-	*10*	4	12.6
	C	0.-	0.-	0.-	0.-	0.-	0.-	0.-	30.LC	0.-	0.-	*10*	3	9.5
	D	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
250 mg a.i./kg	A	100.-	0.-	0.-	20.CL	0.-	0.-	0.-	0.-	0.-	0.-	*10*	12	31.6
	B	0.-	0.-	0.-	0.-	0.-	0.-	90.N	0.-	20.LC	0.-	*10*	11	28.5
	C	20.LC	0.-	0.-	0.-	20.CL	0.-	0.-	0.-	0.-	10.LC	*10*	5	8.5
	D	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
1000 mg a.i./kg	A	50.SC	60.SC	40.N	50.N	40.N	60.LC	40.N	50.N	40.LC	50.N	*10*	48	7.9
	B	50.N	70.SC,N	30.LC	40.LC,N	20.LC	50.N	50.N	60.N	30.LC	50.N	*10*	45	15.1
	C	80.N	70.N	60.USC	70.SC,N	60.SC,N	50.SC,N	40.LC	40.LC	40.LC	90.SC	*10*	60	17.6
	D	40.LC	50.N	70.N	60.N	50.N	30.LC	40.N	50.USC	60.N	60.N	*10*	51	12.0

[1] The "." symbol indicates that the seedling did not emerge. A score of 0 indicates a normal seedling, while a score of 100 indicates a dead seedling. Intermediate scores are assigned to indicate the relative severity of observed signs of toxicity. N – Necrosis, LC – Leaf Curl, SC – Stem Curl, USC – Unshed Seed Coat, CL - Chlorosis

Appendix 12.1

Tomato Emergence

Day 7

Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	9	7	5	5	*4*	6.50	1.91
3.91 mg a.i./kg	6	6	5	9	*4*	6.50	1.73
15.6 mg a.i./kg	6	2	9	4	*4*	5.25	2.99
62.5 mg a.i./kg	8	4	6	4	*4*	5.50	1.91
250 mg a.i./kg	0	3	2	0	*4*	1.25	1.50
1000 mg a.i./kg	0	0	0	0	*4*	0.00	0.00

Day 15

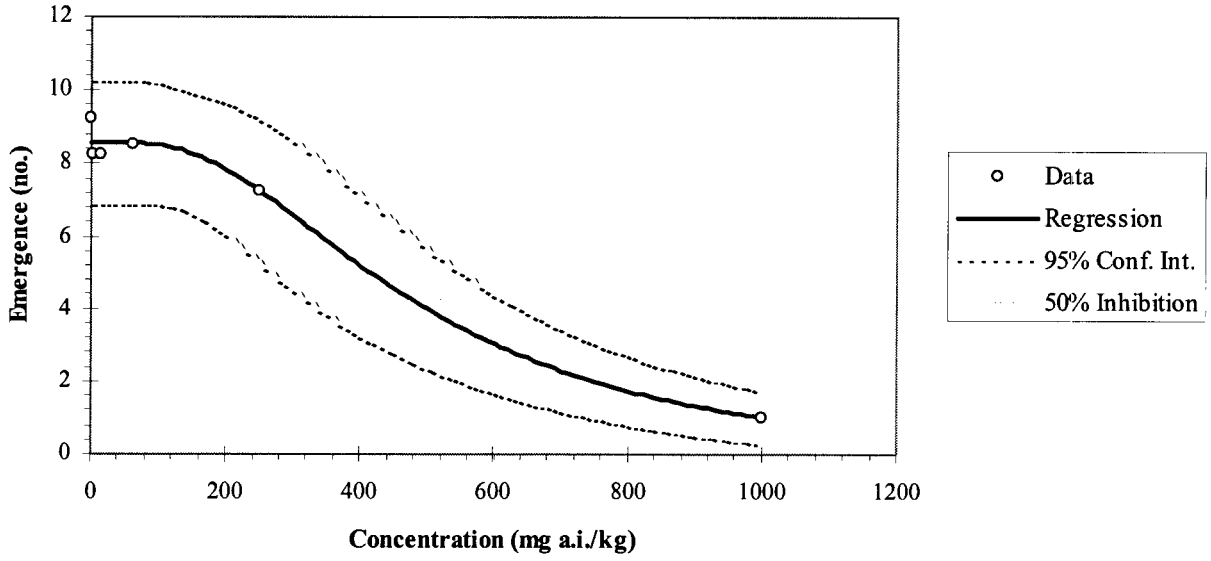
Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	10	9	9	8	*4*	9.00	0.82
3.91 mg a.i./kg	9	7	7	9	*4*	8.00	1.15
15.6 mg a.i./kg	9	8	10	6	*4*	8.25	1.71
62.5 mg a.i./kg	10	6	8	9	*4*	8.25	1.71
250 mg a.i./kg	6	8	8	7	*4*	7.25	0.96
1000 mg a.i./kg	3	0	0	0	*4*	0.75	1.50

Day 21

Treatment Group	Number of Emerged Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	10	10	9	8	*4*	9.25	0.96
3.91 mg a.i./kg	9	7	7	10	*4*	8.25	1.50
15.6 mg a.i./kg	9	8	10	6	*4*	8.25	1.71
62.5 mg a.i./kg	10	6	9	9	*4*	8.50	1.73
250 mg a.i./kg	6	8	8	7	*4*	7.25	0.96
1000 mg a.i./kg	3	1	0	0	*4*	1.00	1.41

Appendix 12.2

Mean Tomato Emergence on Day 21



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
310.670	207.874	464.408	8.5640	0.2721	0.98557

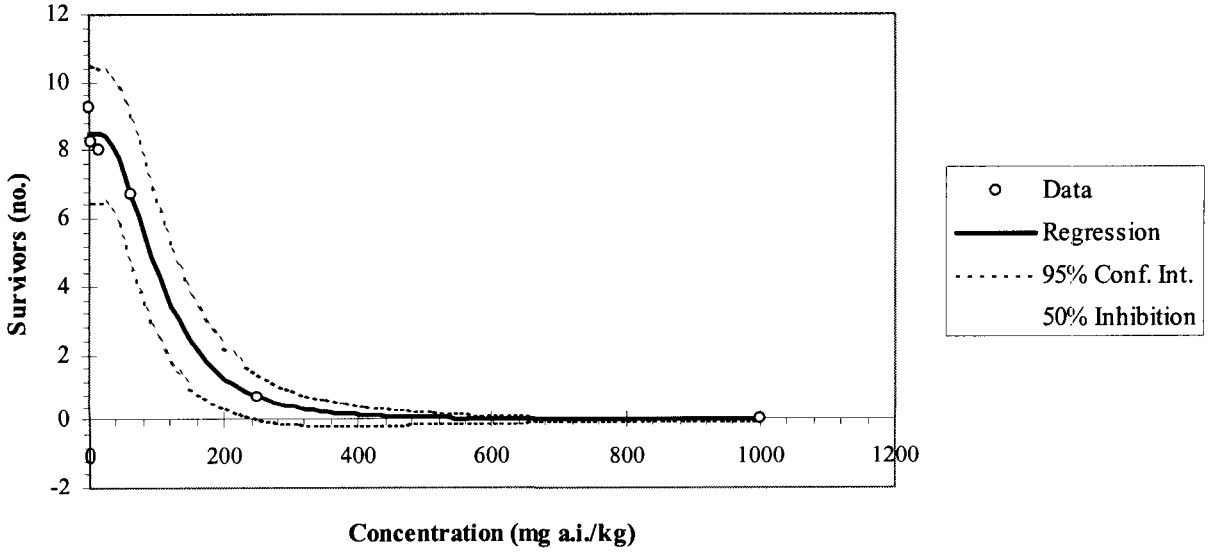
EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
474.133	359.832	624.741	8.5640	0.2721	0.98557

Appendix 12.3

Tomato 21-Day Survival

Day 21

Treatment Group	Number of Living Seedlings in Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	10	10	9	8	*4*	9.25	0.96
3.91 mg a.i./kg	9	7	7	10	*4*	8.25	1.50
15.6 mg a.i./kg	9	8	9	6	*4*	8.00	1.41
62.5 mg a.i./kg	8	6	6	7	*4*	6.75	0.96
250 mg a.i./kg	2	0	0	1	*4*	0.75	0.96
1000 mg a.i./kg	0	0	0	0	*4*	0.00	0.00



Curve Parameters

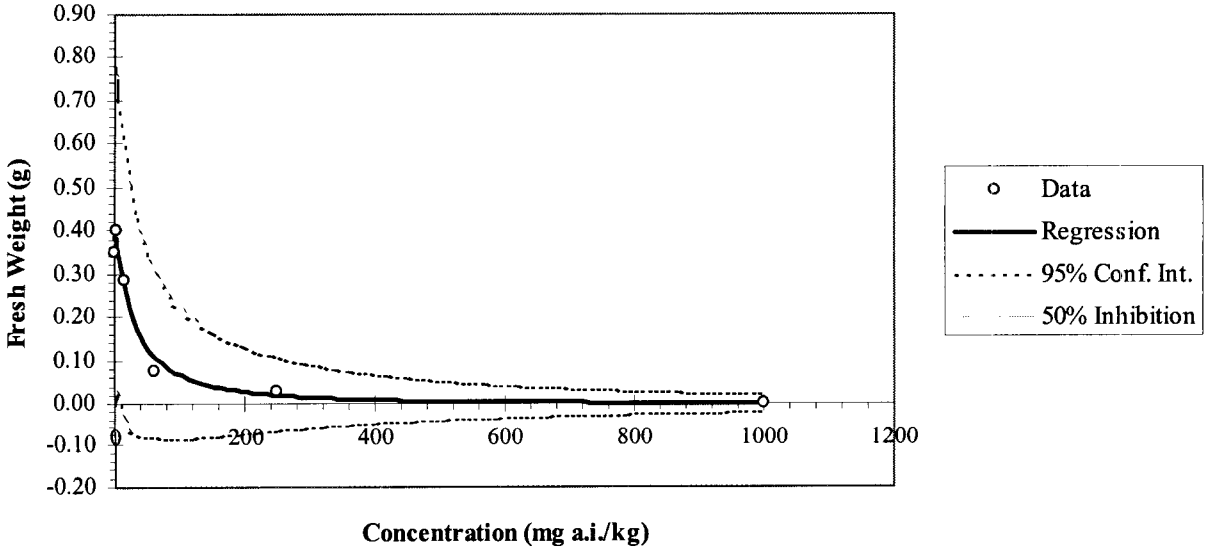
EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
68.6594	45.0091	104.761	8.5031	0.2763	0.98988

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
105.463	77.7857	142.988	8.5031	0.2763	0.98988

Appendix 12.4

Tomato Mean Seedling Fresh Weight, Day 21

Treatment Group	Mean Weight (g) for Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	0.31	0.23	0.56	0.31	*4*	0.35	0.143
3.91 mg a.i./kg	0.42	0.29	0.49	0.40	*4*	0.40	0.081
15.6 mg a.i./kg	0.30	0.13	0.39	0.32	*4*	0.28	0.108
62.5 mg a.i./kg	0.06	0.12	0.07	0.06	*4*	0.08	0.029
250 mg a.i./kg	0.03	.	.	.	*1*	0.03	.
1000 mg a.i./kg	.	.	.	.	*0*	.	.



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
11.7031	0.63139	216.920	0.3874	0.5734	0.93492

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
28.5102	3.80978	213.354	0.3874	0.5734	0.93492

Appendix 12.5

Tomato Seedling Height on Day 21

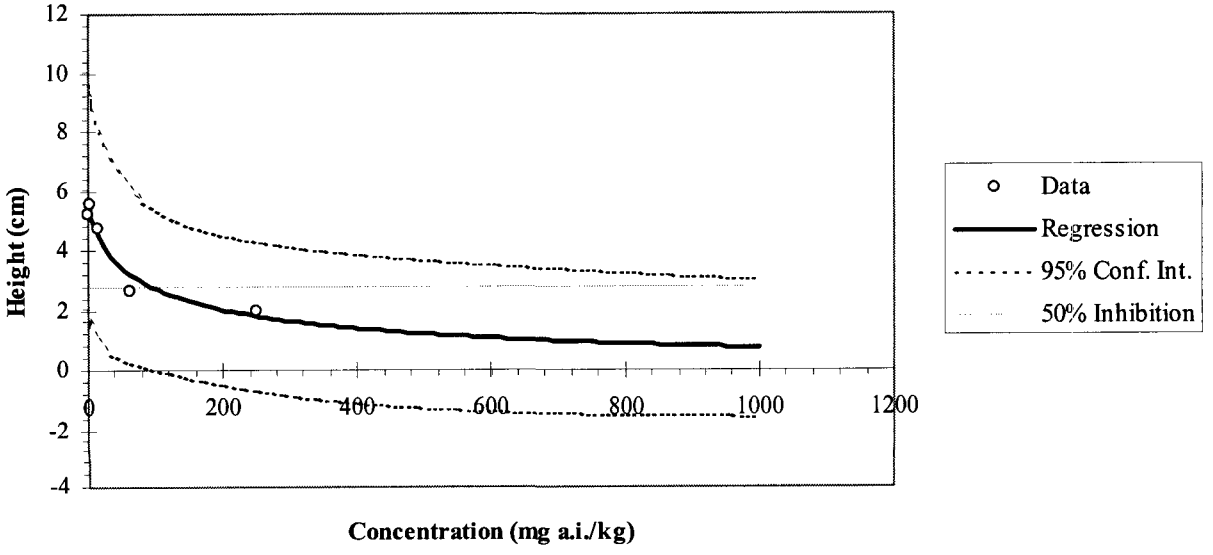
Treatment Group	Replicate	Height (cm) for Plant Number:										*n*	Mean	Std. Dev.
		1	2	3	4	5	6	7	8	9	10			
Control	A	5	4	6	5	4	7	5	6	7	4	*10*	5.3	1.16
	B	6	6	2	4	3	2	4	5	7	3	*10*	4.2	1.75
	C	.	8	6	6	5	6	6	6	6	5	*9*	6.0	0.87
	D	.	.	4	7	3	4	9	5	6	5	*8*	5.4	1.92
3.91 mg a.i./kg	A	.	7	5	6	4	7	6	8	5	6	*9*	6.0	1.22
	B	.	.	.	7	5	7	5	3	7	4	*7*	5.4	1.62
	C	.	.	.	5	6	3	5	6	5	7	*7*	5.3	1.25
	D	5	6	5	8	5	7	6	2	6	6	*10*	5.6	1.58
15.6 mg a.i./kg	A	.	6	7	3	2	3	5	4	4	7	*9*	4.6	1.81
	B	.	.	3	4	2	5	4	2	3	5	*8*	3.5	1.20
	C	.	5	4	5	3	4	6	7	8	7	*9*	5.4	1.67
	D	.	.	.	.	5	5	7	4	5	7	*6*	5.5	1.22
62.5 mg a.i./kg	A	.	2	2	3	3	2	.	3	3	4	*8*	2.8	0.71
	B	.	.	.	.	3	3	2	2	3	3	*6*	2.7	0.52
	C	.	.	.	.	3	3	4	2	2	2	*6*	2.7	0.82
	D	.	.	3	2	2	3	2	2	3	.	*7*	2.4	0.53
250 mg a.i./kg	A	.	.	.	.	.	.	.	.	2	2	*2*	2.0	0.00
	B	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	C	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	D	.	.	.	.	.	.	.	.	.	2	*1*	2.0	.
1000 mg a.i./kg	A	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	B	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	C	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	D	.	.	.	.	.	.	.	.	.	.	*0*	.	.

The "." symbol indicates that the seedling either did not emerge or died prior to measurement.

Appendix 12.6

Tomato Mean Seedling Height on Day 21

Treatment Group	Mean Height (cm) for Replicate: A	B	C	D	*n*	Mean	Std. Dev.
Control	5.3	4.2	6.0	5.4	*4*	5.2	0.75
3.91 mg a.i./kg	6.0	5.4	5.3	5.6	*4*	5.6	0.31
15.6 mg a.i./kg	4.6	3.5	5.4	5.5	*4*	4.8	0.94
62.5 mg a.i./kg	2.8	2.7	2.7	2.4	*4*	2.6	0.14
250 mg a.i./kg	2.0	.	.	2.0	*2*	2.0	0.00
1000 mg a.i./kg	.	.	.	.	*0*	.	.



Curve Parameters

EC_{25}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
22.1411	0.45165	1085.43	5.5594	0.9299	0.91119

EC_{50}	Lower 95% Confidence Limit	Upper 95% Confidence Limit	R_0	σ	r^2
93.8642	10.3348	852.315	5.5594	0.9299	0.91119

Appendix 12.7

Tomato Seedling Condition, Day 21

Treatment Group	Replicate	Condition (score.sign)[1] for Plant Number:										*n*	Mean	Std. Dev.
T		1	2	3	4	5	6	7	8	9	10			
Control	A	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	B	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
	C	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	D	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*8*	0	0.0
3.91 mg a.i./kg	A	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	B	.	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*7*	0	0.0
	C	.	.	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*7*	0	0.0
	D	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	0	0.0
15.6 mg a.i./kg	A	.	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*9*	0	0.0
	B	.	.	40.N	0.-	0.-	0.-	30.N	40.N	0.-	0.-	*8*	14	19.2
	C	100.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	0.-	*10*	10	31.6
	D	.	.	.	.	0.-	0.-	0.-	10.LC	0.-	0.-	*6*	2	4.1
62.5 mg a.i./kg	A	100.-	50.N	50.N	40.N	30.N	50.N	100.-	50.N	50.N	0.-	*10*	52	29.7
	B	.	.	.	.	0.-	0.-	20.N	0.-	20.N	20.N	*6*	10	11.0
	C	.	100.-	100.-	100.-	0.-	40.N	0.-	0.-	40.N	70.N	*9*	50	44.2
	D	.	100.-	0.-	10.N	30.N	20.N	20.N	20.N	20.N	100.-	*9*	36	37.5
250 mg a.i./kg	A	.	.	.	.	100.-	100.-	100.-	100.-	70.N	70.N	*6*	90	15.5
	B	.	.	100.-	100.-	100.-	100.-	100.-	100.-	100.-	100.-	*8*	100	0.0
	C	.	.	100.-	100.-	100.-	100.-	100.-	100.-	100.-	100.-	*8*	100	0.0
	D	.	.	.	100.-	100.-	100.-	100.-	100.-	100.-	80.N	*7*	97	7.6
1000 mg a.i./kg	A	.	.	.	.	.	.	.	100.-	100.-	100.-	*3*	100	0.0
	B	.	.	.	.	.	.	.	.	.	100.-	*1*	100	.
	C	.	.	.	.	.	.	.	.	.	.	*0*	.	.
	D	.	.	.	.	.	.	.	.	.	.	*0*	.	.

[1] The "." symbol indicates that the seedling did not emerge. A score of 0 indicates a normal seedling, while a score of 100 indicates a dead seedling. Intermediate scores are assigned to indicate the relative severity of observed signs of toxicity.
N – Necrosis, LC – Leaf Curl

Appendix 13

Bulk Soil Characterization

AGVISE LABORATORIES

604 Highway 15
P.O. Box 510
Northwood, ND 58267
(700) 587-6010
FAX (700) 587-6013
email: agvise@polarcomm.com
Homepage: agviselabs.com

AGVISE Soil Characterization Report

Submitting firm = WILDLIFE INT. LTD.
Protocol or Study No = NA
Sample ID. = GHS-01-04
Trial ID. = NA
Date Received = 10-1-01
Date Reported = 10-11-2001

AGVISE Lab No	01- 1274
Percent Sand	49
Percent Silt	30
Percent Clay	21
USDA Textural Class (hydrometer method)	Loam
Bulk Density (disturbed) gm/cc	1.04
Cation Exchange Capacity (meq/100 g)	9.0
% Moisture at 1/3 Bar	23.8
Percent Organic Matter	2.1
pH in 1:1 soil:water ratio	5.0

Base Saturation Data

Cation	Percent	ppm
Calcium	33.4	600
Magnesium	14.8	160
Sodium	5.3	110
Potassium	4.6	160
Hydrogen	41.9	38

These tests were completed in compliance of 40 CFR Part 160.

Robert Deutsch — Date 10-11-01
Soil Scientist/Analytical Investigator

Appendix 14

Results of Water and Soil Pesticide Screening

Wildlife International, Ltd. Well Water: Pesticides and Organics

Component	Measured Concentration (ppb or ng/g)	Component	Measured Concentration (ppb or ng/g)
Acephate	< 50	Diazinon	< 50
Alachlor	< 50	Dichlobenil	< 50
Aldicarb sulfone	< 50	Dichloran	< 50
Aldicarb sulfoxide	< 50	Dichlorvos	< 50
Aldrin	< 50	Diclofop methyl	< 50
Alpha-BHC	< 50	Dicofol	< 50
Ametryne	< 50	Dicrotophos	< 50
Atrazine	< 50	Dieldrin	< 50
Azinphos-ethyl	< 50	Dimethoate	< 50
Azinphos-methyl	< 50	Dioxathion	< 50
Beta-BHC	< 50	Diphenamid	< 50
Bifenox	< 50	Diphenylamine	< 50
Bitertanol	< 50	Disulfoton	< 50
Bromacil	< 50	Diuron	< 50
Bromophos-methyl	< 50	Endosulfan I	< 50
Bromoxynil octanoic acid ester	< 50	Endosulfan II	< 50
Captafol	< 50	Endrin	< 50
Carbaryl	< 50	Endrin ketone	< 50
3-hydroxy Carbofuran	< 50	EPN	< 50
Carbofuran	< 50	Ethalfluralin	< 50
Carbophenothion	< 50	Ethion	< 50
cis-Chlordane	< 50	Ethoprop	< 50
trans-Chlordane	< 50	Ethoxyquin	< 50
Chlordimeform	< 50	Etridiazole	< 50
Chlorfenson	< 50	Fenamiphos	< 50
trans-Chlorfenvinphos	< 50	Fenarimol	< 50
Chlorobenzilate	< 50	Fenobucarb	< 50
Chloroneb	< 50	Fenpropathrin	< 50
Chloropropham	< 50	Fensulfothion	< 50
Chloropropylate	< 50	Fenthion	< 50
Chloroxuron	< 50	Fentrothion	< 50
Chlorpyrifos-ethyl	< 50	Fluzifop-P-butyl	< 50
Chlorpyrifos-methyl	< 50	Fonofos	< 50
Chlorthal	< 50	Heptachlor	< 50
Coumaphos	< 50	Heptachlor epoxide	< 50
Crotoxyphos	< 50	Hexachlorobenzene	< 50
Cyanazine	< 50	Isazophos	< 50
Cyfluthrin I	< 50	Isofenphos	< 50
Cypermethrin I	< 50	Leptophos	< 50
o,p'-DDD	< 50	Lindane	< 50
o,p'-DDE	< 50	Linuron	< 50
p,p'-DDD	< 50	Malathion	< 50
p,p'-DDE	< 50	Metalaxyl	< 50
o,p'-DDT	< 50	Methamidophos	< 50
p,p'-DDT	< 250	Methidathion	< 50
DEF	< 50	Methiocarb	< 50
Demeton-O	< 50		

[1]Analyses performed by Exygen Research on samples collected on July 24, 2001.

Appendix 14
(continued)
Results of Water and Soil Pesticide Screening

Wildlife International, Ltd. Well Water: Pesticides And Organics (Page 2)

Component	Measured Concentration (ppb or ng/g)	Component	Measured Concentration (ppb or ng/g)
Methomyl	< 50	Promecarb	< 50
Methoxychlor	< 250	Prometryne	< 50
Methyl parathion	< 50	Pronamide	< 50
Metolachlor	< 50	Propanil	< 50
Metribuzin	< 50	Propargite	< 50
cis-Mevinphos	< 50	Propham	< 50
Mirex	< 50	Propoxur	< 50
Monocrotophos	< 50	Pyrethrin I	< 50
Myclobutanil	< 50	Quinalphos	< 50
1-Napthol	< 50	Quinomethionate	< 50
Napropamide	< 50	Quizalofop-ethyl	< 50
Nitrapyrin	< 50	Ronnel	< 50
Norflurazon	< 50	Simazine	< 50
Oxadiazon	< 50	Simetryn	< 50
Oxamyl	< 50	Sulprofos	< 50
Oxyfluorfen	< 50	Terbacil	< 50
Paraoxon	< 50	Terbufos	< 50
Parathion	< 50	Tetrachlorovinphos	< 50
Pendemethalin	< 50	Tetradifon	< 50
Pentachloronitrobenzene	< 50	Thiobencarb	< 50
cis-Permethrin	< 50	Thiobendazole	< 50
Perthane	< 50	Thionazin	< 50
Phorate	< 50	THPI	< 50
Phosalone	< 50	Tilt I	< 50
Phosphamidon	< 50	Tilt II	< 50
Piperalin	< 50	Tridemefon	< 50
Pirimicarb	< 50	Trifluralin	< 50
Pirimiphos-ethyl	< 50	Trimethyl carbamate	< 50
Pirimiphos-methyl	< 50	Vegedex	< 50
Profenfos	< 50	Vinclozolin	< 50
Profluoralin	< 50		

Metals

	(ppm or mg/L)		(ppm or mg/L)
Aluminum	< 0.2	Manganese	< 0.015
Arsenic	< 0.01	Mercury	< 0.0002
Beryllium	< 0.005	Molybdenum	< 0.015
Cadmium	< 0.005	Nickel	< 5
Calcium	< 50	Potassium	< 50
Chromium	< 0.01	Selenium	< 0.005
Cobalt	< 5	Silver	< 0.01
Copper	< 0.025	Sodium	< 50
Iron	< 5	Zinc	< 0.02
Magnesium	< 50		

[1]Analyses performed by Exygen Research on samples collected on July 24, 2001.

Appendix 14
(continued)
Results of Water and Soil Pesticide Screening

Wildlife International, Ltd. Greenhouse Soil: Pesticides and Organics

Component	Measured Concentration (ppb or ng/g)	Component	Measured Concentration (ppb or ng/g)
Acephate	< 50	Diazinon	< 50
Alachlor	< 50	Dichlobenil	< 50
Aldicarb sulfone	< 50	Dichloran	< 50
Aldicarb sulfoxide	< 50	Dichlorvos	< 50
Aldrin	< 50	Diclofop methyl	< 50
Alpha-BHC	< 50	Dicofol	< 50
Ametryne	< 50	Dicrotophos	< 50
Atrazine	< 50	Dieldrin	< 50
Azinphos-ethyl	< 50	Dimethoate	< 50
Azinphos-methyl	< 50	Dioxathion	< 50
Beta-BHC	< 50	Diphenamid	< 50
Bifenox	< 50	Diphenylamine	< 50
Bitertanol	< 50	Disulfoton	< 50
Bromacil	< 50	Diuron	< 50
Bromophos-methyl	< 50	Endosulfan I	< 50
Bromoxynil octanoic acid ester	< 50	Endosulfan II	< 50
Captafol	< 50	Endrin	< 50
Carbaryl	< 50	Endrin ketone	< 50
3-hydroxy Carbofuran	< 50	EPN	< 50
Carbofuran	< 50	Ethalfluralin	< 50
Carbophenothion	< 50	Ethion	< 50
cis-Chlordane	< 50	Ethoprop	< 50
trans-Chlordane	< 50	Ethoxyquin	< 50
Chlordimeform	< 50	Etridiazole	< 50
Chlorfenson	< 50	Fenamiphos	< 50
trans-Chlorfenvinphos	< 50	Fenarimol	< 50
Chlorobenzilate	< 50	Fenobucarb	< 50
Chloroneb	< 50	Fenpropathrin	< 50
Chloropropham	< 50	Fensulfothion	< 50
Chloropropylate	< 50	Fenthion	< 50
Chloroxuron	< 50	Fentrothion	< 50
Chlorpyrifos-ethyl	< 50	Fluzifop-P-butyl	< 50
Chlorpyrifos-methyl	< 50	Fonofos	< 50
Chlorthal	< 50	Heptachlor	< 50
Coumaphos	< 50	Heptachlor epoxide	< 50
Crotoxyphos	< 50	Hexachlorobenzene	< 50
Cyanazine	< 50	Isazophos	< 50
Cyfluthrin I	< 50	Isofenphos	< 50
Cypermethrin I	< 50	Leptophos	< 50
o,p'-DDD	< 50	Lindane	< 50
o,p'-DDE	< 50	Linuron	< 50
p,p'-DDD	< 50	Malathion	< 50
p,p'-DDE	< 50	Metalaxyl	< 50
o,p'-DDT	< 50	Methamidophos	< 50
p,p'-DDT	< 250	Methidathion	< 50
DEF	< 50	Methiocarb	< 50
Demeton-O	< 50		

[1]Analyses performed by Exygen Research on samples collected on July 24, 2001.

Appendix 14
(continued)
Results of Water and Soil Pesticide Screening

Wildlife International, Ltd. Greenhouse Soil: Pesticides And Organics (Page 2)

Component	Measured Concentration (ppb or ng/g)	Component	Measured Concentration (ppb or ng/g)
Methomyl	< 50	Promecarb	< 50
Methoxychlor	< 250	Prometryne	< 50
Methyl parathion	< 50	Pronamide	< 50
Metolachlor	< 50	Propanil	< 50
Metribuzin	< 50	Propargite	< 50
cis-Mevinphos	< 50	Propham	< 50
Mirex	< 50	Propoxur	< 50
Monocrotophos	< 50	Pyrethrin I	< 50
Myclobutanil	< 50	Quinalphos	< 50
1-Napthol	< 50	Quinomethionate	< 50
Napropamide	< 50	Quizalofop-ethyl	< 50
Nitrapyrin	< 50	Ronnel	< 50
Norflurazon	< 50	Simazine	< 50
Oxadiazon	< 50	Simetryn	< 50
Oxamyl	< 50	Sulprofos	< 50
Oxyfluorfen	< 50	Terbacil	< 50
Paraoxon	< 50	Terbufos	< 50
Parathion	< 50	Tetrachlorovinphos	< 50
Pendemethalin	< 50	Tetradifon	< 50
Pentachloronitrobenzene	< 50	Thiobencarb	< 50
cis-Permethrin	< 50	Thiobendazole	< 50
Perthane	< 50	Thionazin	< 50
Phorate	< 50	THPI	< 50
Phosalone	< 50	Tilt I	< 50
Phosphamidon	< 50	Tilt II	< 50
Piperalin	< 50	Tridemefon	< 50
Pirimicarb	< 50	Trifluralin	< 50
Pirimiphos-ethyl	< 50	Trimethyl carbamate	< 50
Pirimiphos-methyl	< 50	Vegedex	< 50
Profenfos	< 50	Vinclozolin	< 50
Profluoralin	< 50		

Metals

	(ppm or mg/Kg)		(ppm or mg/Kg)
Aluminum	< 15300	Manganese	< 230
Arsenic	< 3.83	Mercury	1.17
Beryllium	< 1.91	Molybdenum	1.68
Cadmium	< 1.91	Nickel	< 1910
Calcium	< 7660	Potassium	< 76600
Chromium	10.7	Selenium	< 1.91
Cobalt	< 1910	Silver	< 3.83
Copper	< 9.57	Sodium	< 1910
Iron	< 76600	Zinc	13.6
Magnesium	< 1470		

[1]Analyses performed by Exygen Research on samples collected on July 24, 2001.