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Title: Rattail Fescue (*Vulpia myuros*) Control in Italian Ryegrass (*Lolium multiflorum*) Grown for Seed

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Italian ryegrass growth and production from positionally selective applications and sublethal rates of a nonselective herbicide were compared to growth and production when treated with diuron applied preemergence as a broadcast treatment and safened by activated carbon applied over the crop row. In the positionally selective treatments, herbicide spray was directed to leave an untreated zone over the crop row at planting. Growth analysis indicated no detectable differences when Italian ryegrass safened by directed spray was compared to Italian ryegrass safened by activated carbon. The major difference between systems was greater weed control in the crop row for carbon-safened treatments.

The non-safened application superimposed sublethal diuron rates over Italian ryegrass and rattail fescue grown in varying densities and proportions. Growth analysis of monoculture stands indicated differences due to planted density, species, and herbicide, whereas growth analysis of plants grown as space-planted individuals indicated difference due to species only. Diuron at the rates applied did not affect seed yield or above ground dry weight.

Soil samples were taken in crop rows where diuron was applied as directed spray or broadcast spray safened by carbon. Samples were assayed and soil profile concentrations mapped. To assist future investigators' understanding of the role rainfall plays in herbicide movement from directed applications, elementary rainfall depth and occurrence models were examined. The Markov and mixed-exponential models adequately described rainfall occurrence and depth patterns for Corvallis, Oregon.

Rattail Fescue (*Vulpia myuros*) Control in Italian Ryegrass (*Lolium multiflorum*) Grown for Seed

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Typed by researcher for Carlos C. Reyes

DEDICATION

In memory of my grandfather Antonio Lopez, the old coyote

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RATTAIL FESCUE (<u>VULPIA</u> <u>MYUROS</u>) CONTROL IN ITALIAN RYEGRASS (<u>LOLIUM</u> <u>MULTIFLORUM</u>) GROWN FOR SEED

GENERAL INTRODUCTION

Rattail fescue (*Vulpia myuros* (L.) K.C. Gmel), a native of Europe, was found on the west coast of the United States as early as 1838-1842 (Robbins et al., 1970)[1]. Its rough awn aids in dispersal by, and create a nuisance for man and livestock. Long and slender in shape, the seed is difficult to clean from other grass seeds because it plugs wire-cloth air-screen separators. Although it is not currently a severe threat to grass seed production in the Pacific Northwest, rattail fescue is a high seed producer, and can be a serious competitor with crops (Scott and Blair, 1987).

Without selective herbicides, grass weed control in grass crops grown for seed is difficult. In the 1970's Lee (Lee, 1981; 1978; 1973) developed application schemes in grasses grown for seed using activated carbon as a safener (adsorbent) to nonselective, preemergence herbicides. During the 1980's, dependence upon activated carbon planting increased when atrazine (6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine) use in grasses grown for seed was prohibited because of grazing restrictions.

Use of activated carbon has not been without problems. Quality (finely and homogeneously ground) carbon is not

[1]Citation of this section found in bibliography.

available in all areas. The added expense of materials, special application equipment, and accelerated equipment wear make its use feasible only in crops commanding sufficient price. As an alternative to selectivity by an adsorbent, Mueller-Warrant (Mueller-Warrant, 1987) began to investigate selectivity by directed simazine (6-chloro-N,N'-dimethyl-1,3,5-triazine-2,4-diamine) spray at planting (leaving an untreated band over the seed row). This approach was not without problems either. Determining a suitable untreated band width over the crop row was complicated by harsh winter conditions. The effects of freezing and thawing in saturated soil on herbicide movement are not well documented.

Chapter 1 compares grass seedling response to several directed spray herbicides in greenhouse and growth chamber studies. Some of the herbicides were further tested as directed sprays in field studies. Based on stand establishment, crop yield, and known soil behavior, diuron was selected as the herbicide treatment to repeat additional field studies. Soil samples from the untreated band (1988 and 1989) and the carbon treated band (1989) were excavated, assayed, and diuron concentration in the soil was mapped.

Chapter 2 investigated an alternative to both carbon-banding and directed-sprays. To eliminate the added expenses of carbon-banding, and avoid the risk of injury present with directed-spray, diuron was applied preemergence at sublethal rates over the top of an addition series experiment planted to Italian ryegrass and rattail fescue. Growth measurements were taken to determine if the presence of herbicide altered competitive abilities of either species.

Chapter 3 was inspired by my previous work in herbicide degradation, and this current work on mobility of banded herbicides in soil. Research in herbicide degradation and leaching has evolved considerably. Investigators often account for soil and herbicide chemical and physical properties in their studies and simulations. Soil temperature can now be controlled in chamber, greenhouse, and field studies. Although rainfall application can be simulated by elaborate devices (Peterson and Bubenzer, 1986; Weber et al., 1986), its depth and occurrence patterns are overlooked. Understanding of herbicide response to realistic wet and dry cycles may help predict pesticide persistence and leaching. For this reason, elementary rainfall depth and occurrence models were reviewed and tested for their application to rainfall data of Corvallis, Oregon.

Each chapter was written as an individual paper.

CHAPTER 1

GRASS SEED CROP RESPONSE TO DIRECTED OR CARBON-BAND SAFENED DIURON

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ABSTRACT

As an alternative to safening by activated carbon bands (14, 15, 16), greenhouse and growth chamber studies were conducted to evaluate directed application of nonselective preemergence herbicides for safety in Lolium multiflorum Lam. and Lolium perenne L., and efficacy in Vulpia myuros (L.) K.C. Gmel.. In fall 1988, herbicides causing minimal injury to L. multiflorum and L. perenne in the chamber and greenhouse studies were applied at planting in the field as directed sprays, leaving 8.9- or 6.4-cm wide untreated bands over the top of the crop row.

Based on potential crop recovery after stand thinning, crop susceptibility, and known soil behavior, diuron (N'-3,4-dichlorophenyl)-N,N-dimethylurea), was selected to repeat the field study in 1989 in L. multiflorum. Crop growth analyses of responses to diuron applied as a directed spray (leaving an 8.9-cm untreated band over the crop row) or broadcast spray safened by carbon-banding on the seed row were compared, and showed no differences.

Soil samples were taken to an 8-cm depth across the crop row (1-cm intervals) in the 8.9-cm untreated band (1988 and 1989), and the carbon safened band (1989) for diuron. Resulting soil concentrations were mapped in one (vertical concentration, 1988 and 1989) and two (vertical and horizontal concentration, 1989) dimensions.

INTRODUCTION

One means of imparting herbicide selectivity is to use safeners in the form of antidotes (1), or adsorbents in the soil (3). A commonly used adsorbent to establish grass crops for seed in Oregon is activated carbon. Activated carbon applied over the seed row at planting as a 2.5-cm wide band protects the crop from preemergence applied herbicides such as diuron (14, 15, 16).

The activated carbon planting system has disadvantages of cost and handling. In addition to the added input cost for activated carbon, the spray equipment is subject to accelerated wear from the abrasive slurry. Such added expense renders carbon application most feasible in seed crops commanding premium price. Handling is cumbersome, as spray and nurse tanks must be constantly agitated. Calibration is messy and difficult.

An alternative to adsorbents is herbicide placement. Placement can be subsurface (7, 11, 24), or, on-surface as a directed spray (12). On-surface directed spray has two advantages over carbon banding. The first advantage is absence of cost for carbon, special equipment, or accelerated equipment wear. The second advantage is that equipment is nearly identical to that used for conventional broadcast spraying and modification is easy. Successful application and performance of directed herbicide spray might be a simple, low-cost alternative to safening by carbon-band application.

The two objectives of this study were to compare the responses of Lolium multiflorum Lam. (common) and Lolium perenne L. (Premier) to directed versus carbon-band safened broadcast diuron (N'-3,4-dichlorophenyl)-N,N-dimethylurea), and to map diuron concentrations in the soil zone safened by either the directed-spray or the carbon-band application.

MATERIALS AND METHODS

Greenhouse and growth chamber studies. Greenhouse and growth chamber studies were conducted as preliminary investigations using soil from the location where the field studies were to be established. The uppermost 10 cm of a Woodburn silt loam soil (fine-silty, mixed mesic Aquultic Argixeroll pH 6.1, 3% organic matter) was collected during May 1988 from the Hyslop Agronomy Farm near Corvallis, Oregon. After air drying to 1.6% moisture (g g^{-1}), soil was passed through a chopper to break large clods while maintaining structure, then sieved through hardware cloth (6.4 X 6.4 mm opening).

Plastic pots (12 X 7.6 X 5.7 cm) containing 410 g soil to a 4-cm depth were broadcast seeded (approximately 1000 seeds m^{-2}) with rattail fescue (Vulpia myuros (L.) K.C.

Gmel.), Lolium multiflorum (LOLMU hereafter (23)), or Lolium perenne (LOLPE) and topped to a 0.5-cm depth with 120 g of soil. A note card was affixed to the rim of each pot along the longest axis to shield one-half the surface from herbicide spray.

A compressed air chamber sprayer equipped with an 8002-E nozzle was used to deliver imazapyr ((±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-3-pyridinecarboxylic acid), chlorpropham (1-methylethyl 3-chlorophenylcarbamate), metolachlor (2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide), oryzalin (4-(dipropylamino)-3,5-dinitrobenzenesulfonamide), cinmethylin (exo-1-methyl-4-(1-methylethyl)-2-[(2-methylphenyl)methoxy]-7-oxabicyclo[2.2.1] heptane), diuron, or atrazine (6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine) at 0.11, 3.36, 1.12, 0.84, 1.12, 2.69, or 2.24 kg ai ha^{-1} in 346 L ha^{-1} at 207 kPa. The additional herbicides were included for comparison and screening. Note cards were removed after treatment.

Treated pots were arranged in a randomized block design, intermixed and surrounded by soil-filled, unplanted and untreated 'dummy' pots. Dummy pots along the perimeter favored even air flow around and surface evaporation from treated pots. Intermixed dummy pots where weighed to determine the amount of moisture applied to each study with a 'fog-it' nozzle, thus maintaining better integrity of treated soil surfaces by eliminating unnecessary handling of the pots. Use of the 'fog-it' nozzle permitted irrigation without displacing treated soil on to untreated soil surfaces.

The greenhouse study (4 replications, treatment on 27 June 1988) initial irrigation after herbicide treatment was 5 ml pot^{-1} each 0.5 hr for 5.5 hr. Subsequent irrigation was 5 ml pot^{-1} three times a day (at 0800, 1200, and, 1700 hr) until 6 July 1988, and 10 ml pot^{-1} twice daily (at 0800 and 1700 hr) for the remainder of the study. The irrigation schedule provided enough moisture for growth without leaving standing water on the soil surface. Average daily temperature cycled from a night time low of 13 to a day time high of 18° C.

To evaluate species response to herbicides under contrasting stress conditions, two growth chamber studies (3 replications each) were initiated 4 September 1988. One study was irrigated to maintain a surface (dry study hereafter) that would dry daily, while the other was irrigated to maintain a surface that remained moist (wet study). The dry study was irrigated 5 ml pot^{-1} daily, whereas, the wet study was irrigated 15 and 10 ml pot^{-1} on 4 and 5 September, and 5 ml pot^{-1} thereafter. The wet study initial irrigation left 3 ml pot^{-1} standing water for 3 minutes. Both studies were conducted simultaneously in the same chamber where daily temperature and light cycled from 6° C, 12 hours dark to 18° C, 12 hours light.

On 2 August or 20 October 1988 the distance from the edge of the treated zone to the nearest seedling in the untreated half of each pot was recorded for the greenhouse or growth chamber studies, respectively. Distances from untreated control pots to the nearest seedling were also recorded to account for irregularities in seed dispersal.

Field studies, 1988. Following standard seedbed preparation for grass seed crops, on 7 October 1988 (Hyslop Field Laboratory) atrazine, metolachlor, diuron, simazine (6-chloro-N,N'-diethyl-1,3,5-triazine-2,4-diamine), or oryzalin at 2.24, 1.12, 2.69, 2.24, or 0.84 kg ai ha^{-1}, respectively, were applied at seeding as directed sprays in two studies: one planted to LOLMU (11.2 kg ha^{-1}), the other planted to LOLPE (2.8 kg ha^{-1}). The directed applications left 6.4- and 8.9-cm wide untreated bands over the top of the planted row. Each study was conducted as a randomized block design, replicated three times. Seed was planted 1.5-cm deep on 30.5-cm centers in 10-m long by 5-row wide plots. Except for a 2.5-cm sprinkler irrigation on 26 October 1988, conventional cropping practices were used. Weeds were permitted to grow in untreated control plots.

Herbicides were applied by a planter mounted compressed air sprayer traveling at 3.4 km hr^{-1} (8002 E nozzles, 207 kPa, 370 L ha^{-1}). Conditions during application were clear and calm, at 17° C air, and 15° C soil.

During the first seven days of December 1988, point intercept measurements for seedlings (to compare stand establishment) were taken each centimeter along a 185 cm length from the 3 center rows of each plot. On 7 January 1989 one block of soil 31-cm long by 6-cm wide by 8-cm deep was excavated from each diuron-treated plot having an 8.9-cm untreated zone over the crop row in the LOLMU study. The soil sampler was placed so its shortest axis at 16 cm was located over the crop row. Soil blocks were taken to a field laboratory where each 1-cm section along the longest dimension was separated (yielding 31 8-cm long by 6-cm wide by 1-cm deep soil slabs), bagged and labeled with its horizontal coordinate in centimeters across the crop row. The interior longitudinal walls of the sampler had opposing parallel grooves (at 1 cm intervals) to guide a knife through the soil. For simplicity, sample intervals on the x-axis (perpendicular to the crop row) were labeled in reference to the 16 cm center, eg, the 1-, 16- and 31-cm intervals were labeled as -15, 0 and 15 cm (Figure 1.1). Samples were stored at -18° C until extracted and assayed for diuron. On 30 June 1989, 8-m lengths of the three center rows in each plot were harvested for seed.

Field studies, 1989. Following standard seedbed preparation for grass seed crops, on 6 September and 11 October 1989 diuron (2.69 kg ai ha^{-1}) was applied at seeding as directed spray or broadcast spray in LOLMU (11 kg seed ha^{-1}). The directed application left a 8.9-cm untreated band over the top of the planted row, whereas, in the broadcast application the crop seed was protected by a 2.5-cm activated carbon band (336 kg ha^{-1}) sprayed over the top of the planted row (15). Activated carbon is a recognized safener for LOLMU (3) and was considered a control treatment for comparison. Each study was duplicated so destructive plant growth measurements could be taken from one and soil samples excavated from the other.

Each study was conducted as a randomized block design, replicated three times. Seed was planted 1.5-cm deep on 30.5-cm centers in 20-m long by 5-row wide plots. To encourage herbicide movement into the soil, 3-hour long, 4-cm deep irrigations were repeated twice a week until 11 November 1990. Other than irrigation, conventional cropping practices were used. Soil sample plots were kept vegetation free with broadcast glyphosate (N-(phosphonomethyl)glycine) applications. Half of each of the plots used for growth measurements was overseeded with _Vulpia myuros_ (VLPMY) at 500 m^{-2}. Growth measurements were not taken from overseeded plot halves.

Herbicides were applied by a planter mounted compressed air sprayer traveling at 3.36 km hr^{-1} (8002 E nozzles, 207 kPa, 370 L ha^{-1}). Activated charcoal slurry was applied by a planter mounted pump sprayer (8009 SS nozzles, 20.7 kPa, 1100 L ha^{-1}) Conditions during the 6 September application (early application hereafter) were calm and clear, at 25° C air, and 17° C soil. Conditions during the 11 October application (late application hereafter) were overcast and calm, at 12° C air, and 11° C soil.

Immediately after herbicide application and prior to irrigation, the dye sodium fluorescein (0.15 kg L^{-1} in pH 12 NaOH solution) was sprayed in a additional study using the same application equipment. A camera, mounted in a darkbox illuminated by a Sylvania f15t8 blb black light blue lamp (22), was used to capture the fluorescent spray image on Kodak T-MAX 400 professional film through a Cokin 'A.0001, coef. + 1/3 yellow' filter. Exposure time was 45 s at aperture f3.5. Film speed was advanced to 1600 ASA by the manufacturer's recommended procedure (13). A 10-cm reference bar was included in each photograph.

In the early and late studies, six weeks after planting, 3-m stand counts were taken from the three center rows of each plot. Additionally, the width of the overseeded VLPMY stand in the untreated or carbon treated region was recorded. Individual plants from each plot were harvested for leaf area (measured with a LICOR LI-3100 leaf area meter), height (soil surface to tip of uppermost leaf), and above ground biomass measurements throughout the growing season (Table 1.1). Values for oven-dry above ground biomass (WT), height (HT), leaf area (LA), leaf area ratio (LAR), relative growth rate (RGR), and net assimilation rate (NAR) were used as dependent variables in orthogonal polynomial contrasts with sampling day after planting (time) specified as the level values (spacing of constructed polynomial). Data were fitted by polynomials of up to the third order for time. The order of precedence for selecting significant descriptive curves was as follows: order of polynomial > interaction > main effect. The procedure (using first-order derivatives of polynomials describing changes in mass through time) of Hunt (10) was used to calculate RGR. All values were calculated for each experimental unit. Analyses were conducted using the General Linear Models, Repeated Measures Procedure in PC-SAS software (21). Natural log transformation of the dependent variables were used when appropriate. On 29 June 1990, 8-m of the three center rows in each plot were harvested for seed.

From 26 through 28 days after spraying, one block of soil (31-cm long by 6-cm wide by 8-cm deep) was excavated from each plot of the duplicate early and late study (both directed and broadcast spray treatments). Sampler placement was as previously described. Soil blocks were taken to a field laboratory where each 1-cm section along the longest dimension was separated. Each resulting 8-cm long by 6-cm wide by 1-cm deep slab was further sectioned by 1-cm intervals along its 8-cm vertical dimension, yielding eight 6-cm long by 1-cm wide by 1-cm deep segments for each of 31 slabs. The second sectioning represented depth along the y-axis. For simplicity, sample intervals along the y-axis were labeled in reference to the soil surface (0 to 1 cm sample depth = interval 1) with the deepest sample interval being from 7 to 8 cm (sample interval 8). Samples were bagged and labeled with their two dimensional (x,y) coordinates in cm (Figure 1.2). Sampling was extremely time consuming, therefore, only one replication was completed each day. Samples were stored at -18° C until extracted and assayed for diuron.

Diuron extraction and detection. A modified method of McKone (17) was used for extraction. For the 1989 soil samples, two-thirds (approximately 5 g) of each sample was weighed and placed in a 250-ml erlenmeyer flask for extraction. The remaining third was used for moisture determination. Extraction was by 30 ml of methanol on an orbital platform shaker (225 rpm) for 1 h. The resulting slurry was centrifuged for 3 minutes at 3000 rpm. The methanol-diuron mixture was decanted through Whatman No. 42 filter paper. Resulting filtrate was evaporated to dryness under a fume hood at room temperature (24 h) and the residue re-dissolved in 2 ml of hexane. The extraction procedure for the 1988 samples was identical except for the volume of methanol, which was increased to accommodate the larger soil samples.

A modified method of Deleu and Copin (6) was used for gas-liquid chromatographic detection on a Hewlett-Packard 5890A chromatograph fitted with a nitrogen-phosphorous detector, a 25-m by 0.32-mm by 0.17-um (length by inside diameter by film thickness) capillary column, and an

Hewlett-Packard 3392 integrator. The conditions employed were as follows: column coating, HP-5 (5% phenyl silicone gum phase); carrier and makeup gas flow rates, He, at 1 and 30 ml min^{-1}, respectively; H_2 and air flow rates, 4 and 110 ml min^{-1}, respectively; injector, column, and detector temperatures, 250, 130, and 275^0 C, respectively. The hot needle technique (8) was used to inject 1-ml samples on to a split (9:1) injector port liner.

Standard solutions with concentrations in the range 0.01-10.0 ng per 1 ul injection gave a linear response.

Mapping diuron concentration in soil. Herbicides concentration representing the vertical by horizontal dimensions for the 1989 data were regressed (by replication) using a quadratic polynomial for the response surface (2). Additionally, surfaces were represented as smoothed (by 3 nearest neighbors of a point) bivariate interpolations (18) in the G3GRID procedure of SAS/GRAPH (20). Prior to use in regression and bivariate interpolation analysis, actual concentration values were standardized by converting to a percentage of herbicide found at surface locations -15,1 and 15,1. It was assumed these locations were remote enough not to be influenced by diffusion into the untreated zone or carbon band.

Herbicide concentrations along the y dimension for a given x location were then summed so the 1989 data could be compared to the 1988 data. Resulting concentrations were standardized in a manner similar to the previous description. Data in this form were analyzed by regression.

RESULTS AND DISCUSSION

Greenhouse and growth chamber studies. The distance measured to the nearest seedling reflects three possible processes: first is actual soil movement of the herbicide via diffusion or mass flow; second is root growth into the treated zone; third is a combination of the two activities. Analysis of variance for the distance to the nearest seedling in the greenhouse study indicated that only herbicide caused differences. In the dry and wet studies the herbicide by species interaction was significant (Table 1.2). Distance to seedlings in cinmethylin-treated pots were greatest overall, regardless of species (Tables 1.3, 1.4, and 1.5). Distances to all diuron-treated species were relatively short in the greenhouse and wet studies. Although distance to diuron-treated LOLMU was short in the wet study, distance to the remaining species was moderate. Distance to all oryzalin-treated species was short in the greenhouse study and moderate in the dry and wet studies. The remaining responses vary between the three studies. Differences are likely due to species susceptibility and root growth patterns as well as fluctuations in herbicide availability, due to changes in adsorption, under different environmental conditions. The effects of temperature and moisture on herbicide adsorption are documented (4, 5).

Growing conditions were optimal in the greenhouse, whereas conditions were more stressed in the dry and wet studies. Based on the greenhouse study results, cinmethylin and imazapyr were dropped as future treatments for field studies.

Field studies, 1988. Analysis of variance for the 1988 LOLPE study indicates the herbicide by untreated width over the crop row (6.4 or 8.9 cm) interaction altered point intercept and seed yield (Table 1.6). Point intercepts for all 6.4-cm untreated widths, except for atrazine, were poor (Table 1.7). Stand establishment was also poor for oryzalin at the 8.9-cm untreated width. Atrazine applied at the 8.9-cm untreated width provided the best response, whereas diuron at 8.9- and atrazine at 6.4-cm untreated widths produced intermediate responses.

Seed yield response was best to simazine, atrazine, or diuron at the 8.9-cm untreated width (Table 1.8). Oryzalin resulted in poor yield at both untreated widths. The remaining treatments ranged between the best to the poorest responses. The ranking of seed yield means for each herbicide improved, decreased, or was unchanged when compared to the point intercept results. The unchanged position for atrazine (8.9-cm untreated width) indicates the herbicide had no effect. Improved position in the ranking reflects crop recovery (eg diuron, 8.9-cm), whereas lowered position indicates continuing deterioration (metolachlor, 6.4-or 8.9-cm).

Analysis of variance for the 1988 LOLMU study show that the herbicide by untreated width interaction changed the point intercept response, whereas only herbicide or untreated width main effects changed seed yield (Table 1.9). Stand establishment was best for diuron at the 8.9-cm width, or atrazine at either width. Response to oryzalin was poor, while the remaining treatments were intermediate (Table 1.10). These results are similar to results of the 1988 LOLPE study.

Seed yield responded independently to herbicide and untreated width. When herbicides were considered, regardless of untreated width, only oryzalin yield was less. When untreated width was consider, regardless of herbicide, yield was best for the 8.9-cm untreated width (Tables 1.11 and 1.12).

Field studies, 1989. Because of the greater economic feasibility of applying carbon in LOLPE, LOLMU's greater ability to recover from early stand loss, and because of known diuron behavior in soil, only LOLMU studies were continued in 1989.

Early and late study repeated measures analysis of variance of contrasts with time (sampling day after planting) indicated that although time was significant, no difference in HT, LAR, LA, NAR, RGR, or WT could be attributed to spray versus carbon banded diuron in linear, quadratic, or cubic trends over time (Table 1.13 and 1.14).

The similarities in treatment response can easily be seen (Figures 1.3 through 1.8). This implies the 8.9-cm wide untreated zone was comparable to a 2.5-cm wide carbon band for safening LOLMU from diuron.

Crop yield with or without VLPMY overseeding, head count at harvest, or crop seedling population were the same for the directed-spray or carbon-banded broadcast-diuron treatments in the early and late studies. The only difference found was that the width of VLPMY infestation within the crop row was greater in the directed spray diuron treatment (Tables 1.15, 1.16 and 1.17). The presence of overseeded VLPMY reduced LOLMU yield by an average of 34 percent.

Diuron mapping in soil. Herbicide concentration in vertical samples for 1988 (natural logarithm of standardized data) or 1989 (standardized data) were fitted to a quadratic equation using sample distance from left to right across the crop row as the independent variable. For 1989 soils, samples were assayed to the depth where 0.01 ppm or less was observed. This resulted in a 7-and 5-cm assay depth for the early and late studies, respectively. Results indicate that both linear and quadratic terms of width (distance from crop row at 0 cm) were significant (Table 1.18). Regression was more adequate for description in the 1989 data (Figure 1.9). Additionally, a larger sampling width was necessary to represent the 1989 data.

Photographs of the fluorescent dye indicate that the untreated surface was approximately 8-cm wide for the carbon broadcast spray treatment, versus 2.5-cm wide for the carbon banded treatment (Figure 1.10).

Response surface regression analysis for natural log of the standardized data indicated that change in concentration across sample width as a linear function was not significant for any regressed replication (regardless of application technique or time). The width-squared term was significant for all diuron concentrations except the late application broadcast spray with carbon (Tables 1.19 through 1.22). Estimates of the surfaces produced near flat descending saddles (Figure 1.11). Visual observation of the data revealed that directed spray treatments form a descending valley, whereas, carbon banded treatments form a descending ridge that turns into a descending valley (Figure 1.11). Because quadratic polynomials excluded surface details and failed to represent surface concentration at the shoulder of the sample width, a biavariate interpolation was used in lieu of a response surface regression analysis for graphic representation (Figures 1.12 through 1.16).

It is believed that the observed ridge represents diuron extracted from carbon because the ridge maximum is at the surface in the crop row at location 0,1. Additionally, the concentration at the ridge maximum is greater than the concentrations at the standardization points 1,-15 or 1,15. The carbon in the soil may have protected absorbed diuron from losses to diffusion, microbial breakdown, and hydrolysis. The plotted surface behaves like a descending ridge to about half of the sample depth, followed by a short segment where width appears to have little influence on concentration. The plotted surface then gently descends to form a relaxed 'V'. It is not known how far the carbon moved horizontally or laterally from its application band, however, carbon veins to the 2-cm depth below the application point were visible during sample partitioning (carbon concentrations not visible to the naked eye may have moved further from the application point). Dispersal of carbon might explain why untreated widths need to be greater than carbon band widths for comparable crop safety (19).

Plots of directed spray surfaces started as 'U' in shape and ended as a very relaxed 'V'. One very distinct difference between the directed and carbon band spray treatments is that the surface in the directed spray is more irregular. Herbicide found below the seed row at 1,0 may be a result of horizontal movement above or below the surface. Physically displaced soil treated particles on the surface (due to sprinkler irrigation) may have moved into the untreated region and released minute amounts of herbicide.

The asymmetric nature of some carbon banded or broadcast spray surfaces across the sampling width likely reflects uneven application due to field irregularities.

The results indicate that directed-diuron spray treatments may be a economically feasible alternative to safening by carbon-banding. Although stand establishment was reduced by directed diuron spray applications, resulting yield was unaffected. It is possible this result may be observed only in aggressive growing and tillering crops such as LOLMU (15).

The compromise between crop row weed control and crop injury dictates untreated width. Grass crop injury from directed simazine has been reported to increase when saturated soils freeze (19). Stand reductions are stressful and may leave the crop less resilient to pathogen or insect attack. Additionally, if a weed species not controlled by diuron is present, it may severely compete with a stressed crop. An alternative to risking severe crop injury or stand reductions might be to broadcast sublethal rates of a non-selective herbicide, temporarily suppressing crop and weed growth, hopefully giving the crop an added competitive advantage.

Mapping of diuron in soil displayed movement into untreated soil. The results reflect response to field environmental conditions, and will likely vary from season to season. To understand diuron behavior, studies should be conducted under well controlled laboratory conditions.

The manner in which variables in such studies are managed has become more realistic; for example, growth chamber temperature and light can be programmed to ramp on cycles, rather than abruptly change. Additionally, delivery systems can better simulate the physical attributes of rainfall. However, rainfall application schemes oversimplify amount and occurrence patterns. Because pesticide leaching and diffusion vary with the amount and duration of soil moisture, it is reasonable to assume that amount and occurrence patterns are an important factor in determining herbicide movement from treated bands into the untreated crop row. Therefore, Chapter 3 will address elementary rainfall amount (depth) and occurrence models to assist those interested in further investigation.

Table 1.1. Sampling schedule for 1989 growth analysis.

Study	Days After Planting										
Early	13	20	27	35	48	62	76	90	104	146	200	259
Late	21	28	35	42	49	56	70	122	166	225		

Table 1.2. Greenhouse and growth chamber study analysis of variance for distance (cm) to nearest seedling.

	Greenhouse Study			Dry Study			Wet Study		
Source	DF	Mean Sq.	Pr>F	DF	Mean Sq.	Pr>F	DF	Mean Sq.	Pr>F
BLOCK	3	0.1460	0.5459	2	0.0343	0.7382	2	0.6352	0.0538
SPECIES	2	0.1237	0.5481	2	3.7693	0.0001	2	9.5372	0.0001
HERB	7	5.3091	0.0001	7	6.5098	0.0001	7	28.2012	0.0001
HRB*SP	14	0.1425	0.768	14	1.4942	0.0001	14	2.3115	0.0001
ERROR	69	0.2040		46	0.1122		46	0.2040	

Table 1.3. Seedling response to herbicide in greenhouse study.

Herbicide	kg ai ha^{-1}	Distance[a] (cm)
CINMETHYLIN	1.12	2.02 A
IMAZAPYR	0.11	1.49 B
METOLACHLOR	1.12	1.28 BC
ATRAZINE	2.24	1.11 CD
CHLORPROPHAM	3.36	0.90 D
DIURON	2.29	0.52 E
ORYZALIN	0.84	0.2 EF
CHECK	0	0.07 F
LSD		0.37

[a]Distance to nearest seedling. Means followed by the same letter do not differ (p=0.05).

Table 1.4. Seedling response to herbicide by species interaction in dry study.

Species	Herbicide	kg ai ha^{-1}	Distance[a] (cm)
VLPMY	IMAZAPYR	0.11	3.83 A
VLPMY	ATRAZINE	2.24	3.53 AB
LOLMU	ATRAZINE	2.24	3.23 BC
LOLPE	CINMETHYLIN	1.12	2.76 CD
VLPMY	CINMETHYLIN	1.12	2.7 CD
LOLMU	CINMETHYLIN	1.12	2.63 D
VLPMY	METOLACHLOR	1.12	2.23 DE
LOLPE	METOLACHLOR	1.12	2 EF
VLPMY	DIURON	2.69	1.66 FG
LOLMU	CHLORPROPHAM	3.36	1.53 FGH
VLPMY	ORYZALIN	0.84	1.53 FGH
LOLMU	ORYZALIN	0.84	1.4 GHI
LOLPE	DIURON	2.69	1.36 GHI
LOLPE	ATRAZINE	2.24	1.3 GHI
LOLMU	METOLACHLOR	1.12	1.26 GHI
LOLPE	CHLORPROPHAM	3.36	1.23 GHI
VLPMY	CHLORPROPHAM	3.36	1.23 GHI
LOLPE	IMAZAPYR	0.11	1.13 GHI
LOLPE	ORYZALIN	0.84	1.1 HI
LOLMU	IMAZAPYR	0.11	0.96 IJ
LOLMU	DIURON	2.69	0.53 JK
LOLPE	CHECK	0	0.16 K
LOLMU	CHECK	0	0.1 K
VLPMY	CHECK	0	0.1 K
LSD			0.55

[a]Distance to nearest seedling. Means followed by the same letter do not differ ($p=0.05$).

Table 1.5. Seedling response to herbicide by species interaction in wet study.

Species	Herbicide	kg ai ha^{-1}	Distance[a] (cm)	
VLPMY	CHLORPROPHAM	3.36	6.2	A
VLPMY	CINMETHYLIN	1.12	6.06	A
LOLMU	CINMETHYLIN	1.12	5.96	A
LOLPE	CINMETHYLIN	1.12	5.63	AB
VLPMY	METOLACHLOR	1.12	5.03	B
VLPMY	ATRAZINE	2.24	3.43	C
LOLPE	METOLACHLOR	1.12	2.8	CD
LOLPE	IMAZAPYR	0.11	2.63	DE
LOLMU	CHLORPROPHAM	3.36	2.53	DEF
LOLPE	CHLORPROPHAM	3.36	2.36	DEFG
LOLMU	METOLACHLOR	1.12	2.33	DEFG
VLPMY	IMAZAPYR	0.11	2.3	DEFGH
LOLMU	ORYZALIN	0.84	2.23	DEFGH
LOLMU	IMAZAPYR	0.11	2.03	EFGH
LOLPE	ATRAZINE	2.24	1.86	FGHI
LOLPE	ORYZALIN	0.84	1.83	FGHI
VLPMY	ORYZALIN	0.84	1.63	GHI
VLPMY	DIURON	2.69	1.56	HI
LOLPE	DIURON	2.69	1.26	IJ
LOLMU	ATRAZINE	2.24	1.2	IJ
LOLMU	DIURON	2.69	0.6	JK
VLPMY	CHECK	0	0.1	K
LOLPE	CHECK	0	0.0666	K
LOLMU	CHECK	0	0.0333	K
LSD			0.74	

[a]Distance to nearest seedling. Means followed by the same letter do not differ (p=0.05).

Table 1.6. Analysis of variance for point intercept and total seed mass in LOLPE for 1988 directed herbicide spray.

Source	DF	Intercept[a] Mean Sq.	Intercept[a] Pr>F	Seed Total[b] Mean Sq.	Seed Total[b] Pr>F
BLOCK	2	120.44	0.2201	28.51	0.3709
HERB	4	2233.93	0.0001	7254.67	0.0001
UNTRT[c]	1	4156.74	0.0001	7453.17	0.0004
HERB*UNTRT	4	327.26	0.0109	448	0.0001
ERROR	18	73.05		27.19	

[a]As percent of weedy control.
[b]As percent of weedy control.
[c]UNTRT: 6.4 or 8.9 cm untreated zone.

Table 1.7. Point intercept response (1988) for LOLPE to herbicide by untreated width interaction.

Herbicide	kg ai ha^{-1}	Untreated Width (cm)	Intercept[a]
ATRAZINE	2.24	8.9	93.0 A
DIURON	2.69	8.9	74.4 B
ATRAZINE	2.24	6.4	61 BC
SIMAZINE	2.24	8.9	48.4 C
METOLACHLOR	1.12	8.9	48.1 C
SIMAZINE	2.24	6.4	31.7 D
METOLACHLOR	1.12	6.4	30.4 D
DIURON	2.69	6.4	30.0 D
ORYZALIN	0.84	8.9	29.0 D
ORYZALIN	0.84	6.4	22.4 D
LSD			14.6

[a]As percent of weedy control=178. Means followed by the same letter do not differ (p=0.05).

Table 1.8. Seed yield response (1988) for LOLPE to herbicide by untreated width interaction.

Herbicide	kg ai ha^{-1}	Untreated Width (cm)	Seed[a] Yield
SIMAZINE	2.24	8.9	101.4 A
ATRAZINE	2.24	8.9	101.1 A
DIURON	2.69	8.9	101.0 A
METOLACHLOR	1.12	8.9	76.7 B
SIMAZINE	2.24	6.4	69.4 BC
ATRAZINE	2.24	6.4	60.7 CD
DIURON	2.69	6.4	53.5 D
METOLACHLOR	1.12	6.4	41.5 E
ORYZALIN	0.84	8.9	2.4 F
ORYZALIN	0.84	6.4	0 F
LSD			8.9

[a]As percent of weedy control=51 g m^{-2}. Means followed by the same letter do not differ ($p=0.05$).

Table 1.9. Analysis of variance for point intercept and total seed mass in LOLMU (1988) for directed spray herbicide.

		Intercept[a]		Seed Total[b]	
Source	DF	Mean Sq.	Pr>F	Mean Sq.	Pr>F
BLOCK	2	68.67	0.0782	7609.3	0.0001
HERB	4	6308.73	0.0001	14760.6	0.0001
UNTRT[c]	1	1391.43	0.0001	4858.3	0.0045
HERB*UNTRT	4	219.81	0.0003	839.27	0.1685
ERROR	18	23.3		460.52	

[a]As percent of weedy control.
[b]As percent of weedy control.
[c]UNTRT: 6.4 or 8.9 cm untreated zone.

Table 1.10. Point intercept response of LOLMU (1988) to herbicide by untreated width interaction.

Herbicide	kg ai ha^{-1}	Untreated Width (cm)	Intercept[a]
ATRAZINE	2.24	8.9	102.85 A
DIURON	2.69	8.9	97.38 A
ATRAZINE	2.24	6.4	95.32 A
METOLACHLOR	1.12	8.9	75.63 B
DIURON	2.69	6.4	63.94 C
METOLACHLOR	1.12	6.4	59.90 CD
SIMAZINE	2.24	8.9	56.01 D
SIMAZINE	2.24	6.4	46.67 E
ORYZALIN	0.84	8.9	14.69 F
ORYZALIN	0.84	6.4	12.63 F
LSD			8.27

[a]As percent of weedy control=178. Means followed by the same letter do not differ (p=0.05).

Table 1.11. Seed yield response of LOLMU (1988) to herbicide.

Herbicide	kg ai ha^{-1}	Seed[a] Yield
DIURON	2.69	118.8 A
METOLACHLOR	1.12	117.7 A
SIMAZINE	2.24	113.6 A
ATRAZINE	2.24	104.1 A
ORYZALIN	0.84	34 B
LSD		26

[a]As percent of weedy control=256 g m^{-2}. Means followed by the same letter do not differ (p=0.05).

Table 1.12. Seed yield response of LOLMU (1988) to untreated width.

Untreated Width (cm)	Seed[a] Yield
8.9	69.32 A
6.4	55.69 B
LSD	3.7

[a]As percent of weedy control=256 g m^{-2}. Means followed by the same letter do not differ (p=0.05).

Table 1.13. Early study repeated measures analysis of variance of contrast with time.

Source	Response[a]	DF	Time*1[b] Mean Sq.	Time*1[b] Pr>F	Time*2 Mean Sq.	Time*2 Pr>F	Time*3 Mean Sq.	Time*3 Pr>F
MEAN	lnHT	1	86.78389	0.0001	22.83288	0.0001	21.72883	0.0001
HERB[c]		1	0.001669	0.6434	0.036718	0.0808	0.003724	0.5089
ERROR		6	0.00703		0.008349		0.007555	
MEAN	lnLAR	1	0.385371	0.0332	21.63537	0.0001	0.993103	0.0085
HERB		1	0.000743	0.9078	0.000327	0.9283	0.022207	0.586
ERROR		6	0.050911		0.037109		0.067107	
MEAN	lnLA	1	474.5962	0.0001	204.3865	0.0001	85.36957	0.0001
HERB		1	0.000633	0.9178	0.001227	0.8395	0.040454	0.5585
ERROR		6	0.054649		0.027412		0.105494	
MEAN	NAR	1	0.000032	0.0002	0.00053	0.0001	2.87E-05	0.0001
HERB		1	0	0.9419	8.4E-07	0.5303	0	0.9274
ERROR		6	4.6E-07		1.89E-06		3.7E-07	
MEAN	RGR	1	0.027156	0.0001	0.242621	0.0001	0.00481	0.0001
HERB		1	9.5E-06	0.7122	6.83E-05	0.77	1.9E-06	0.7643
ERROR		6	6.35E-05		0.00073		1.93E-05	
MEAN	lnWT	1	447.9338	0.0001	93.02596	0.0001	67.94738	0.0001
HERB		1	4.39E-06	0.9959	0.000287	0.9052	0.002715	0.9156
ERROR		6	0.152656		0.018598		0.222257	

[a]ln:Natural log transformation; HT:Height; LAR:Leaf area ratio; LA:Leaf area; NAR:Net assimilation rate; RGR:Relative growth rate; WT:Oven dry above ground biomass.
[b]Time*n:Represents the nth degree polynomial contrast for time as days after planting.
[c]Herb:Directed spray no carbon (8.9-cm untreated width) or broadcast spray over carbon.

Table 1.14. Late study repeated measures analysis of variance of contrasts with time.

Source	Response[a]	DF	Time*1[b] Mean Sq.	Time*1[b] Pr>F	Time*2 Mean Sq.	Time*2 Pr>F	Time*3 Mean Sq.	Time*3 Pr>F
MEAN	lnHT	1	91.03154	0.0001	0.503279	0.0001	0.388116	0.0097
HERB[c]		1	0.000331	0.8316	0.000981	0.5435	0.009212	0.5864
ERROR		6	0.00671		0.002367		0.027895	
MEAN	lnLAR	1	8.230881	0.0001	45.12648	0.0001	8.806043	0.0001
HERB		1	0.035094	0.5798	0.040336	0.5725	0.146883	0.2624
ERROR		6	0.102482		0.113276		0.096024	
MEAN	lnLA	1	787.9213	0.0001	61.9829	0.0001	19.03573	0.0001
HERB		1	0.162799	0.5052	0.129142	0.1579	0.727214	0.1001
ERROR		6	0.324247		0.049656		0.192701	
MEAN	lnNAR	1	15.396257	0.0001	43.671826	0.0001	8.8949	0.0001
HERB		1	0.106695	0.3037	0.074518	0.4878	0.137834	0.2722
ERROR		6	0.084353		0.136468		0.094314	
MEAN	lnRGR	1	1.112288	0.0392	0.012036	0.0348	0.000214	0.0828
HERB		1	0.264049	0.2479	0.0052	0.1244	0.000156	0.1259
ERROR		6	0.161216		0.001631		0.000049	
MEAN	lnWT	1	635.0896	0.0001	1.334712	0.0386	1.947416	0.0026
HERB		1	0.349064	0.1986	0.313827	0.248	0.220444	0.1482
ERROR		6	0.167165		0.191758		0.080114	

[a]ln:Natural log transformation; HT:Height; LAR:Leaf area ratio; LA:Leaf area; NAR:Net assimilation rate; WT:Oven dry above ground biomass; RGR:Relative growth rate.
[b]Time*n:Represents the nth degree polynomial contrast for time as days after planting.
[c]Herb:Directed spray no carbon (8.9-cm untreated width) or broadcast spray over carbon.

Table 1.15. Early 1989 directed or broadcast spray diuron analysis of variance.

Source	DF	Yield (no VLPMY) Mean Sq.	Pr>F	Yield (with VLPMY) Mean Sq.	Pr>F	Head Count (per plant) Mean Sq.	Pr>F	Population (per m^{-2}) Mean Sq.	Pr>F	Infested Width (cm) Mean Sq.	Pr>F
BLOCK	3	10207.68	0.1208	15408.67	0.0140	4.33	0.7182	540.04	0.5228	0.48	0.0429
HERB[a]	1	370.32	0.7101	69.14	0.7676	8	0.4153	180.5	0.6159	14.39	0.0004
ERROR	3	2215.83		661.11		9		580.08		0.04	

[a]HERB: Directed spray, no carbon, or broadcast spray over carbon.

Table 1.16. Late 1989 directed or broadcast spray diuron analysis of variance.

Source	DF	Yield (no VLPMY) Mean Sq.	Pr>F	Yield (with VLMPY) Mean Sq.	Pr>F	Head Count (per plant) Mean Sq.	Pr>F	Population (per m^{-2}) Mean Sq.	Pr>F	Infested Width (cm) Mean Sq.	Pr>F
BLOCK	3	32663.00	0.0521	28687.52	0.0019	5.5	0.2498	299.79	0.8299	0.15	0.9341
HERB[a]	1	11935.13	0.1674	347.16	0.3704	8	0.1612	3081.12	0.1811	20.06	0.0243
ERROR	3	3629.95		314.14		2.33		1023.45		1.12	

[a]HERB: Directed spray, no carbon, or broadcast spray over carbon.

Table 1.17. Early and late 1989 directed or broadcast spray diuron treatment means.

Treatment	Yield[a] (no VLMPY)	Yield (with VLPMY)	Head Count (per plant)	Population (per m^{-2})	Infested Width(cm)
Early carbon	590.12	396.3	9.5	382.63	1.96
Early direct	603.73	390.42	11.5	351.46	4.64
Late carbon	794.73	552.83	10.75	506.89	3.22
Late direct	871.98	539.65	8.75	378.12	6.39

[a]Seed yield in g m^{-2}.

Table 1.18. Regression coefficients for diuron concentration (Ln(percent)) through sampling depth in soil profile.

		1988		1989 (Early)		1989 (Late)	
Parameter	**DF**	Param **Est**	Prob >|T|	Param **Est**	Prob **>|T|**	Param **Est**	Prob **>|T|**
INTERCEPT	1	0.2072	0.0027	1.2011	0.0001	1.2678	0.0001
WIDTH(W)	1	-0.3456	0.0001	-0.3084	0.0001	-0.3146	0.0001
W*W	1	0.0295	0.0295	0.0221	0.0001	0.0225	0.0001
r^2		0.8754		0.9398		0.9339	

Table 1.19. Response surface regression coefficients in early application broadcast spray with carbon for diuron concentration (Ln(percent)).

		REP 1		REP 2		REP 3	
Para-meter	DF	Est	Prob >|T|	Est	Prob >|T|	Est	Prob >|T|
INTERCEPT	1	2.816419	0	2.406964	0	1.867662	0
WIDTH(W)	1	0.000741	0.9943	0.029334	0.7557	-0.04395	0.6506
DEPTH(D)	1	-1.79965	0	-1.70675	0	-1.31685	0
W*W	1	-0.12863	0.0024	-0.11084	0.0039	-0.09467	0.0142
D*W	1	0.00039	0.9865	-0.00413	0.8448	0.00769	0.7229
D*D	1	0.123984	0	0.115667	0	0.070487	0.0004
r^2		0.9592		0.9630		0.9565	

Table 1.20. Response surface regression coefficients in late application broadcast spray with carbon for diuron concentration(Ln(percent)).

Parameter	DF	REP 1 Est	REP 1 Prob >|T|	REP 2 Est	REP 2 Prob >|T|	REP 3 Est	REP 3 Prob >|T|
INTERCEPT	1	2.02436	0.0015	1.939988	0.0004	2.762021	0
WIDTH(W)	1	-0.09401	0.613	0.018644	0.9025	-0.01592	0.9176
DEPTH(D)	1	-1.83268	0.0002	-1.58178	0.0001	-2.44028	0
W*W	1	0.04135	0.5376	-0.02322	0.6727	-0.07368	0.1941
D*W	1	0.041816	0.4573	-0.01162	0.8001	0.002899	0.9502
D*D	1	0.131755	0.06	0.067407	0.2281	0.226903	0.0005
r^2		0.9064		0.9471		0.9398	

Table 1.21. Response surface regression coefficients in early application directed spray, no carbon for diuron concentration (Ln(percent)).

Parameter	DF	REP 1 Est	REP 1 Prob >|T|	REP 2 Est	REP 2 Prob >|T|	REP 3 Est	REP 3 Prob >|T|
INTERCEPT	1	-1.05401	0	-1.03791	0.0002	-0.79735	0.0131
WIDTH(W)	1	-0.01077	0.6385	-0.00313	0.9328	0.014772	0.738
DEPTH(D)	1	-0.85467	0	-0.92996	0	-0.98124	0
W*W	1	0.038329	0	0.040953	0	0.04942	0
D*W	1	0.005539	0.2814	0.000179	0.9827	-0.00431	0.6623
D*D	1	0.045033	0.0001	0.060161	0.0011	0.061454	0.0049
r^2		0.9084		0.7729		0.7498	

Table 1.22. Respcnse surface regression coefficients in late application directed spray, no carbon for diuron concentration (Ln(percent).

Parameter	DF	REP 1 EST	REP 1 PROB >|T|	REP 2 EST	REP 2 PROB >|T|	REP 3 EST	REP 3 PROB >|T|
INTERCEPT	1	-0.42936	0.1198	-0.4296	0.0868	0.116366	0.5128
WIDTH(W)	1	0.006609	0.8492	0.035973	0.2563	-0.00512	0.8208
DEPTH(D)	1	-1.2184	0	-0.79527	0.0001	-1.83264	0
W*W	1	0.047968	0	0.027369	0	0.038148	0
D*W	1	-0.00367	0.726	-0.00697	0.4645	0.00116	0.8647
D*D	1	0.06726	0.046	0.000877	0.9767	0.17972	0
r^2		0.9041		0.9025		0.9503	

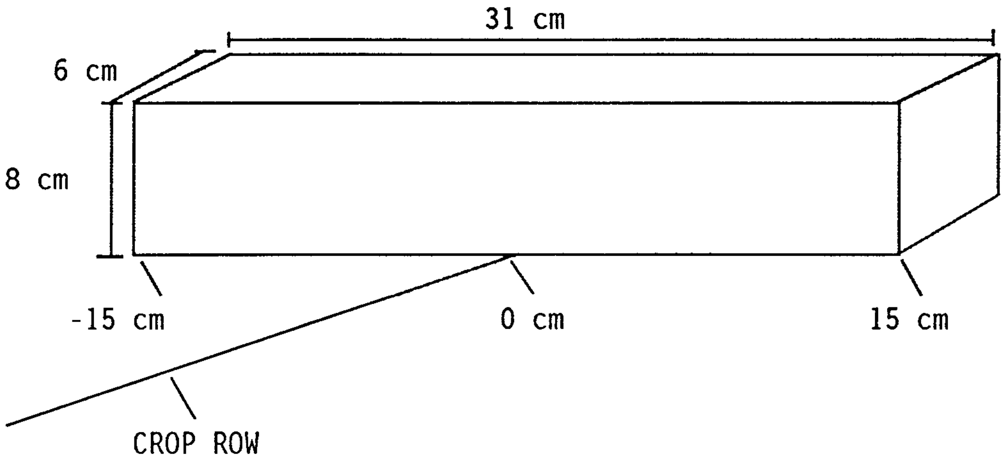


Figure 1.1. Longitudinal equitorial axis of soil sampler (0 cm) placement over crop row. The 8 cm by 31 cm side walls were aligned perpendicular to crop row.

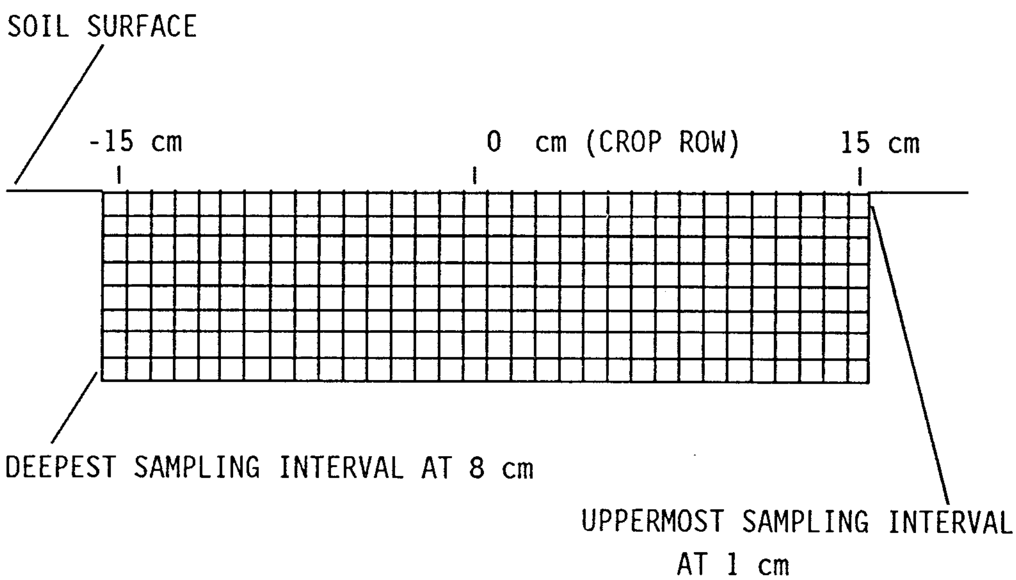


Figure 1.2. Two dimensional coordinates (x,y) of soil samples.

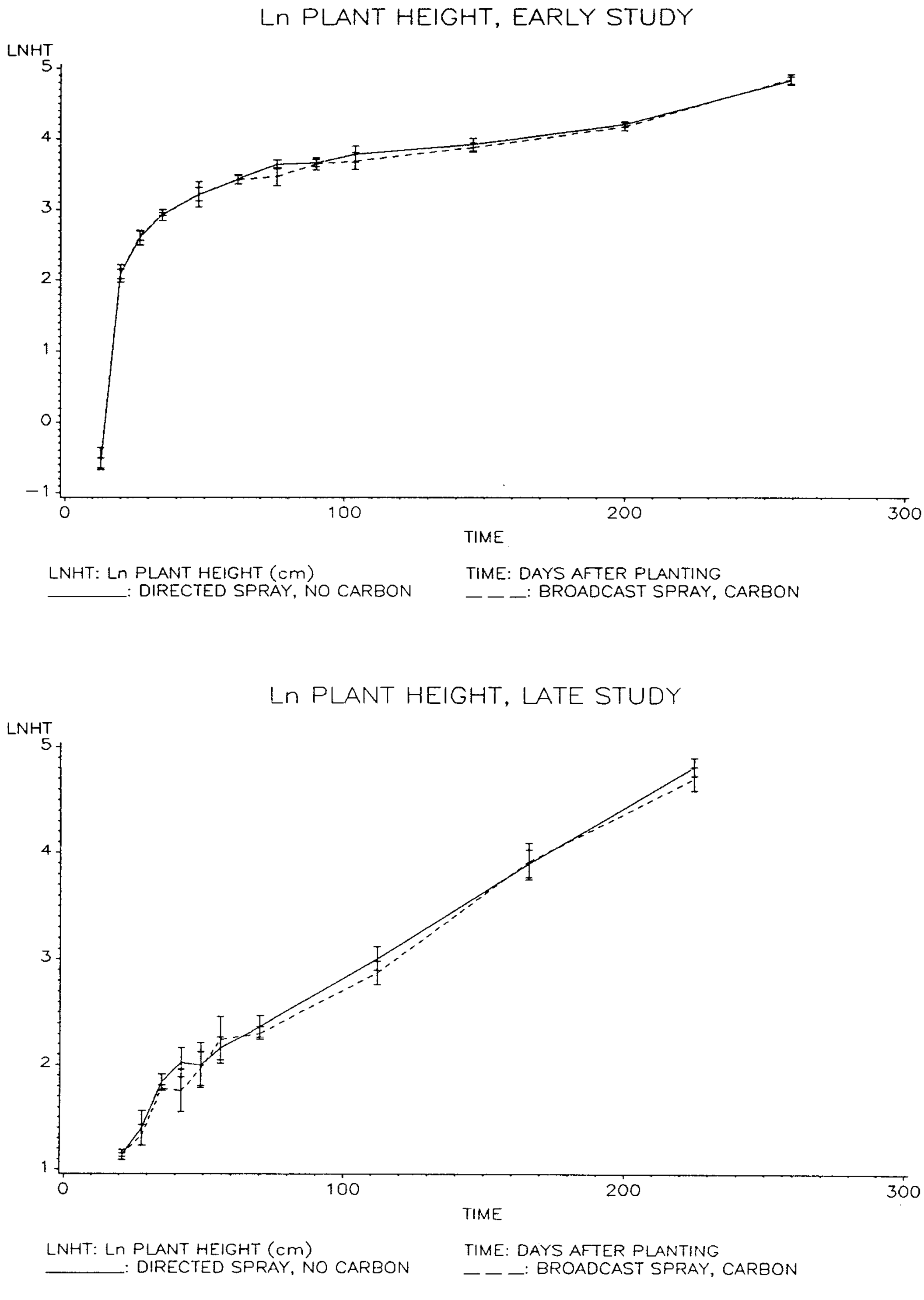
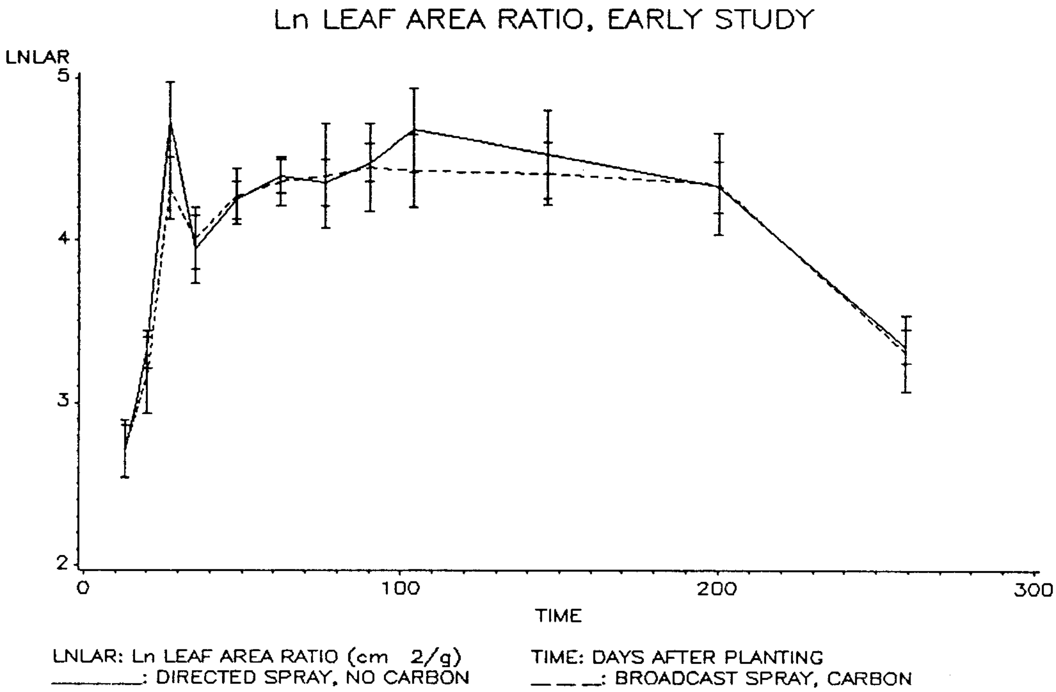


Figure 1.3. Plant height in early (top) and late (bottom) 1989 field studies. Error bars represent one standard deviation of mean.



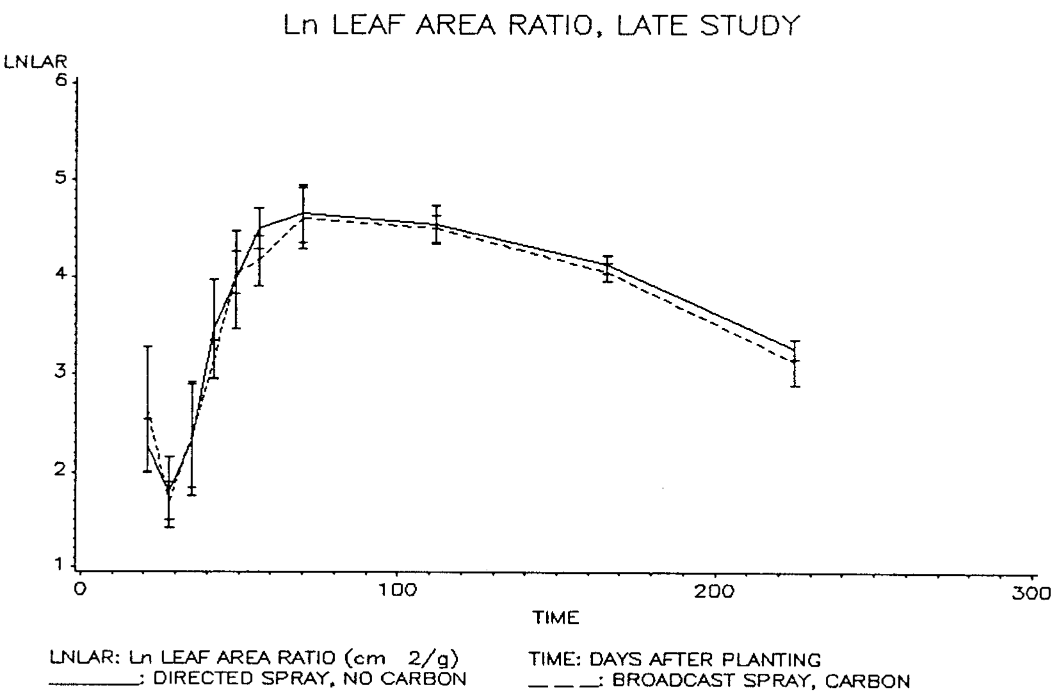


Figure 1.4. Leaf area ratio in early (top) and late (bottom) 1989 field studies. Error bars represent one standard deviation of mean.

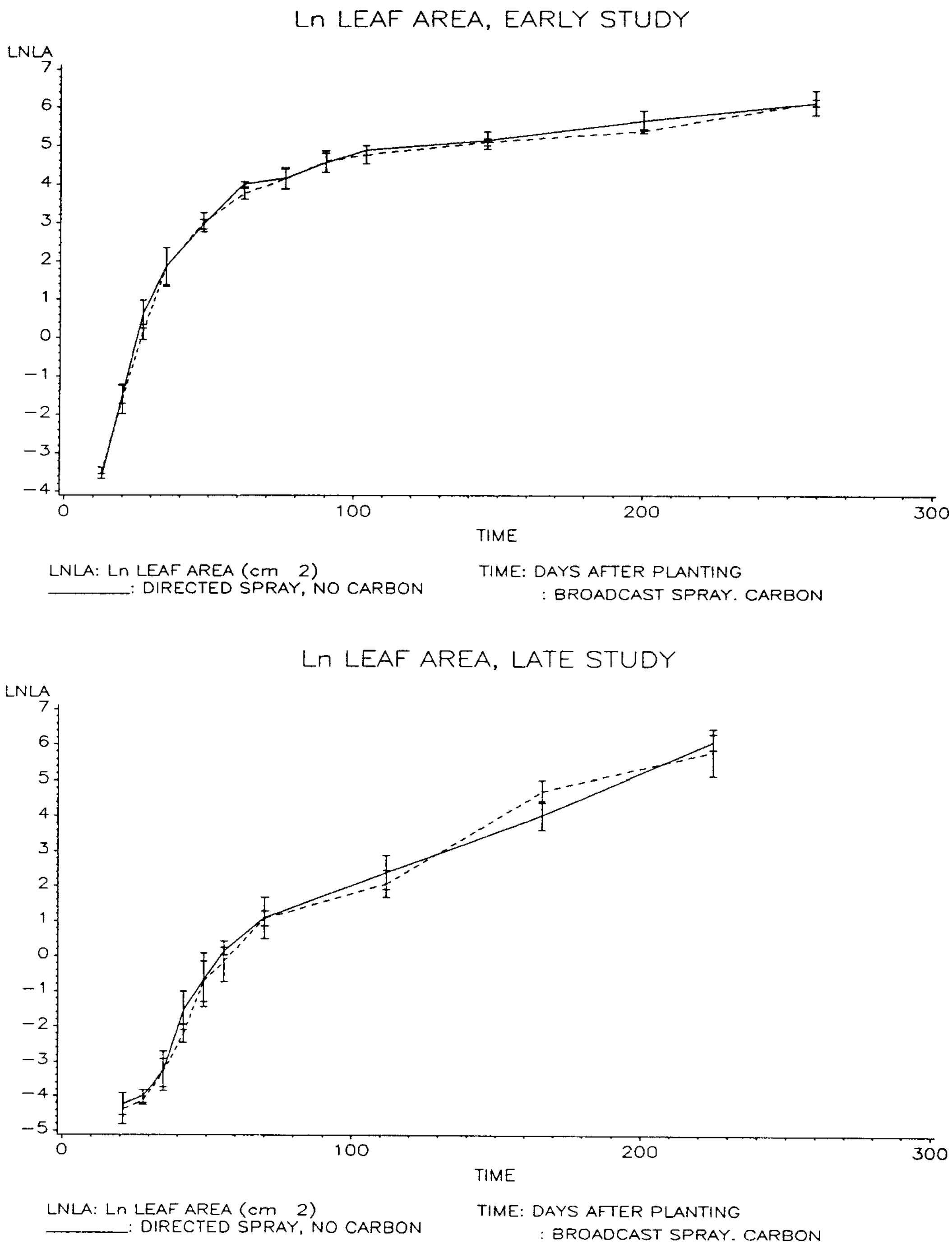


Figure 1.5. Leaf area in early (top) and late (bottom) 1989 field studies. Error bars represent one standard deviation of mean.

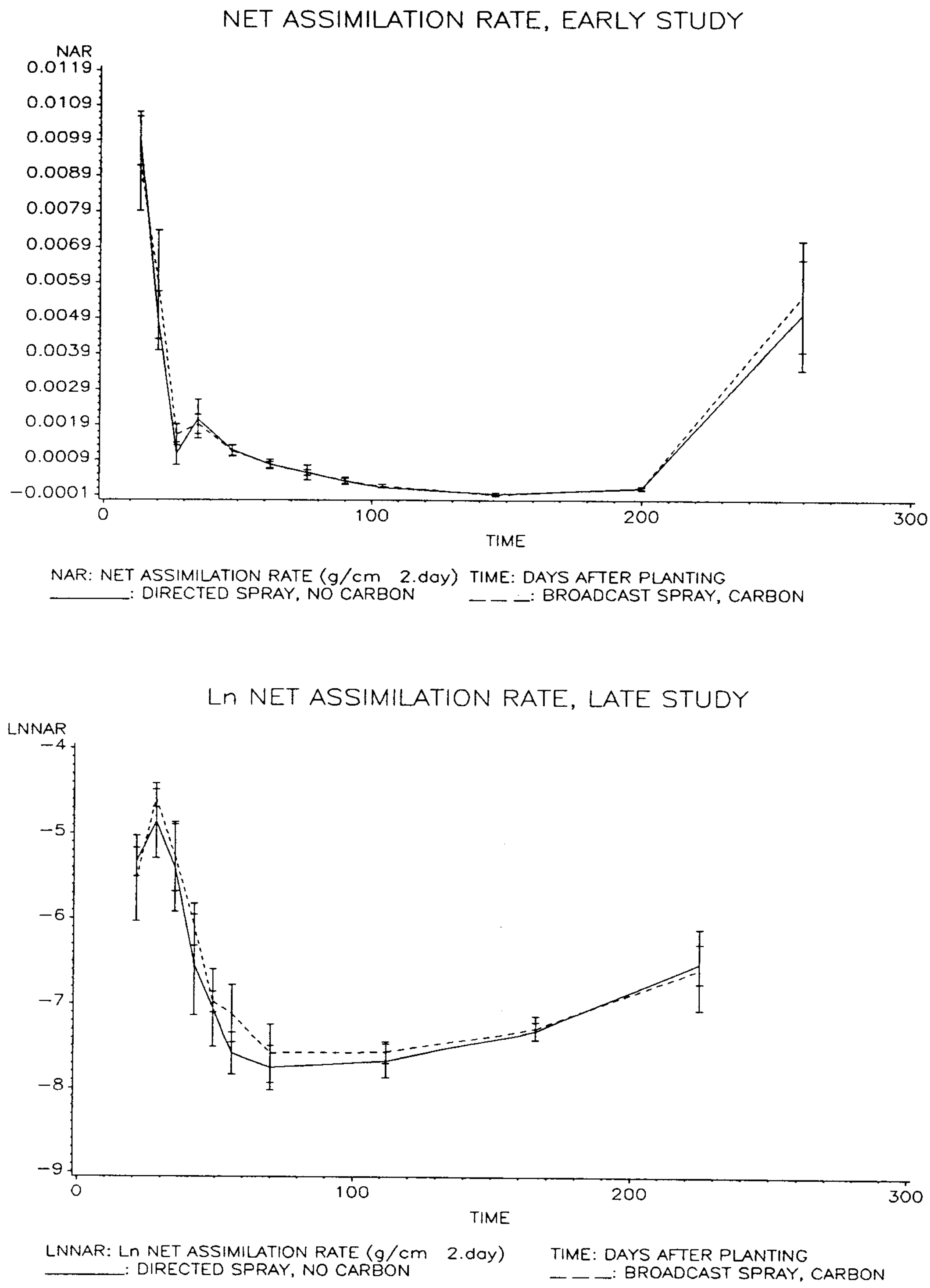
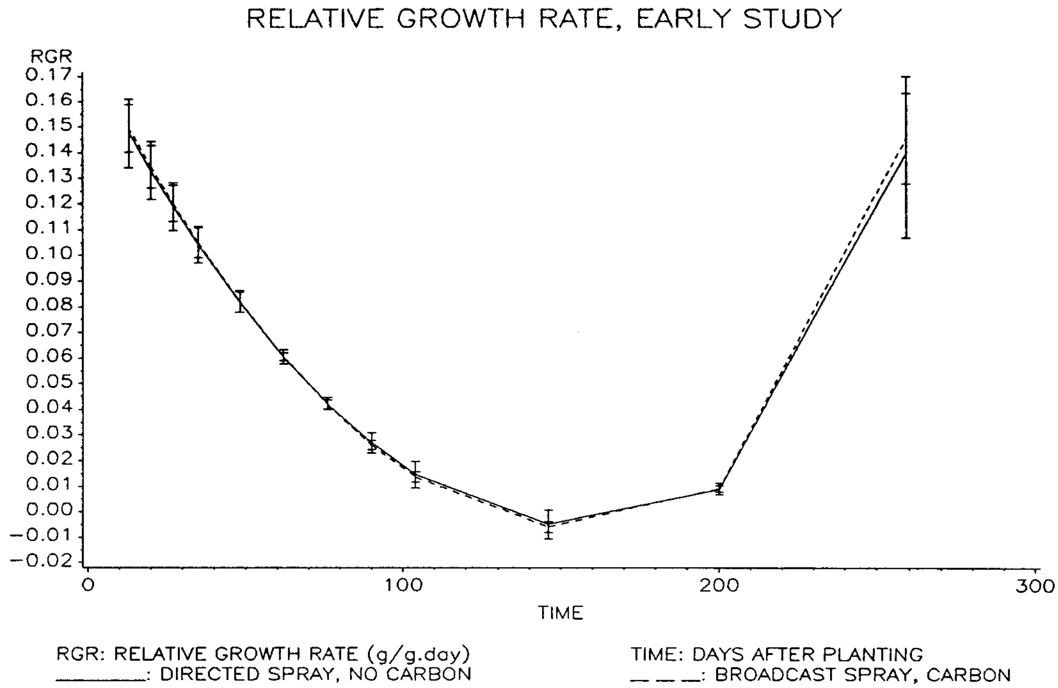


Figure 1.6. Net assimilation rate in early (top) and late (bottom) 1989 field studies. Error bars represent one standard deviation of mean.



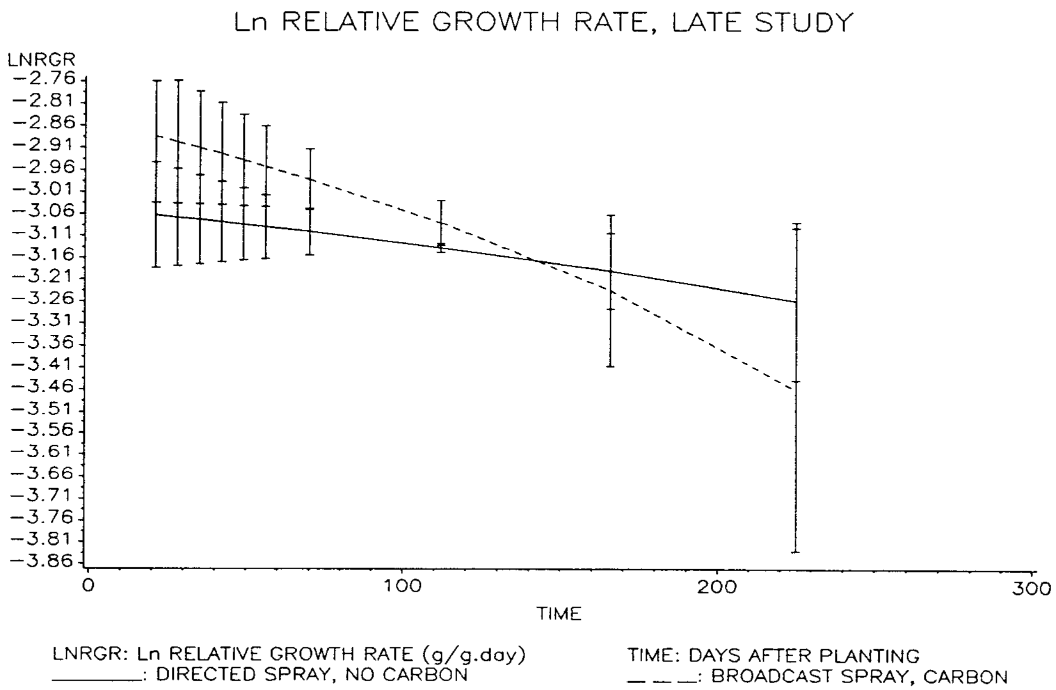
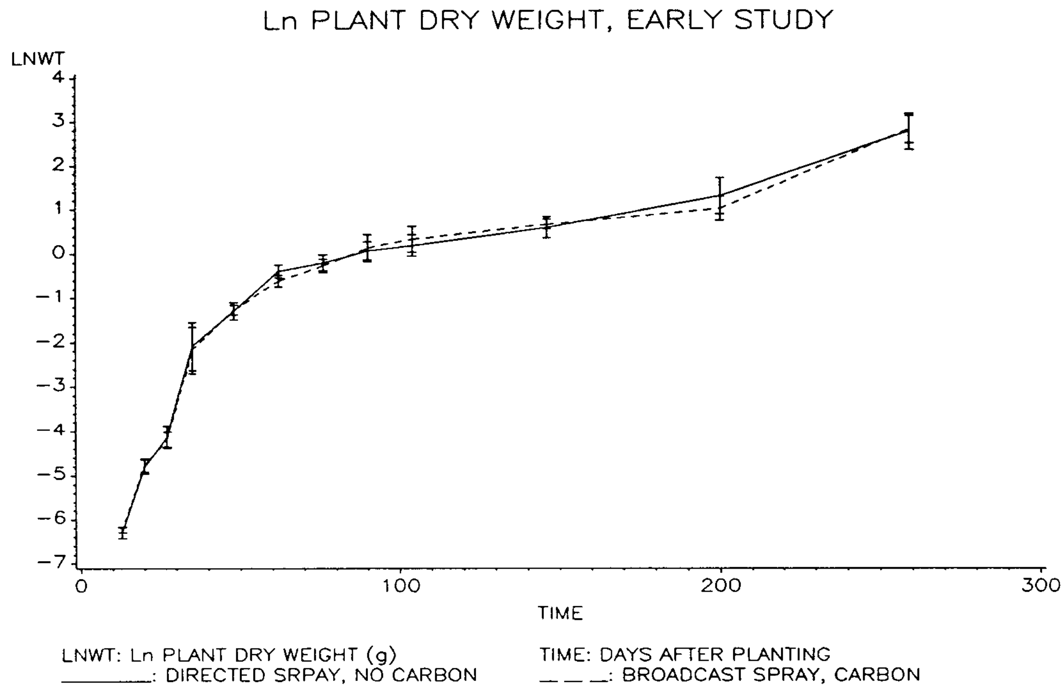


Figure 1.7. Relative growth rate in early (top) and late (bottom) 1989 field studies. Error bars represent one standard deviation of mean.



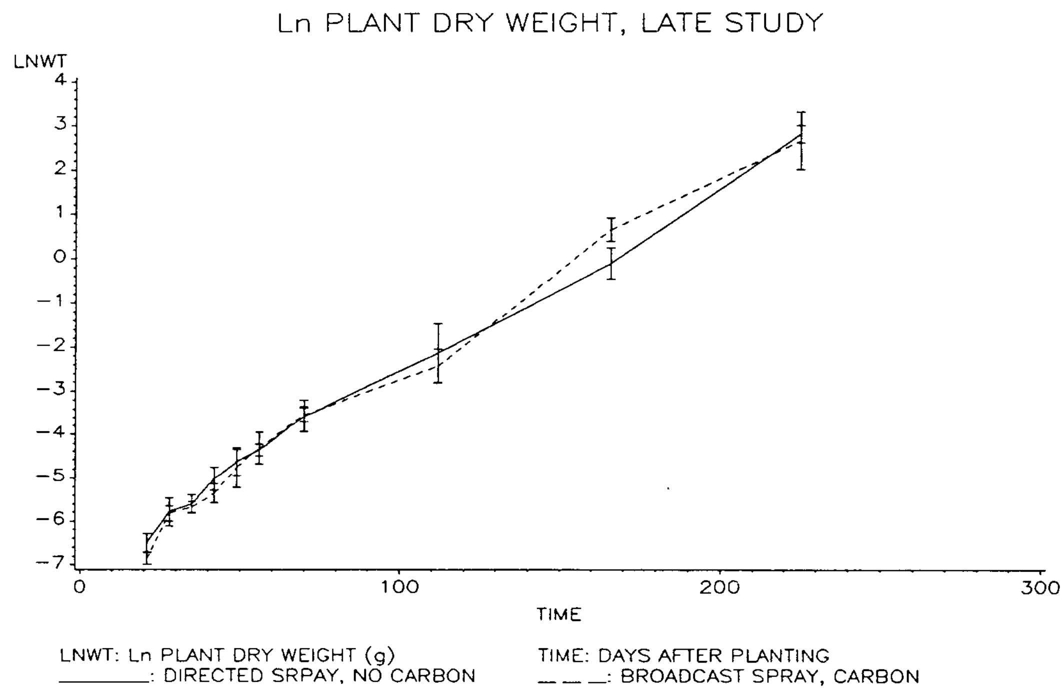


Figure 1.8. Plant dry weight in early (top) and late (bottom) 1989 field studies. Error bars represent one standard deviation of mean.

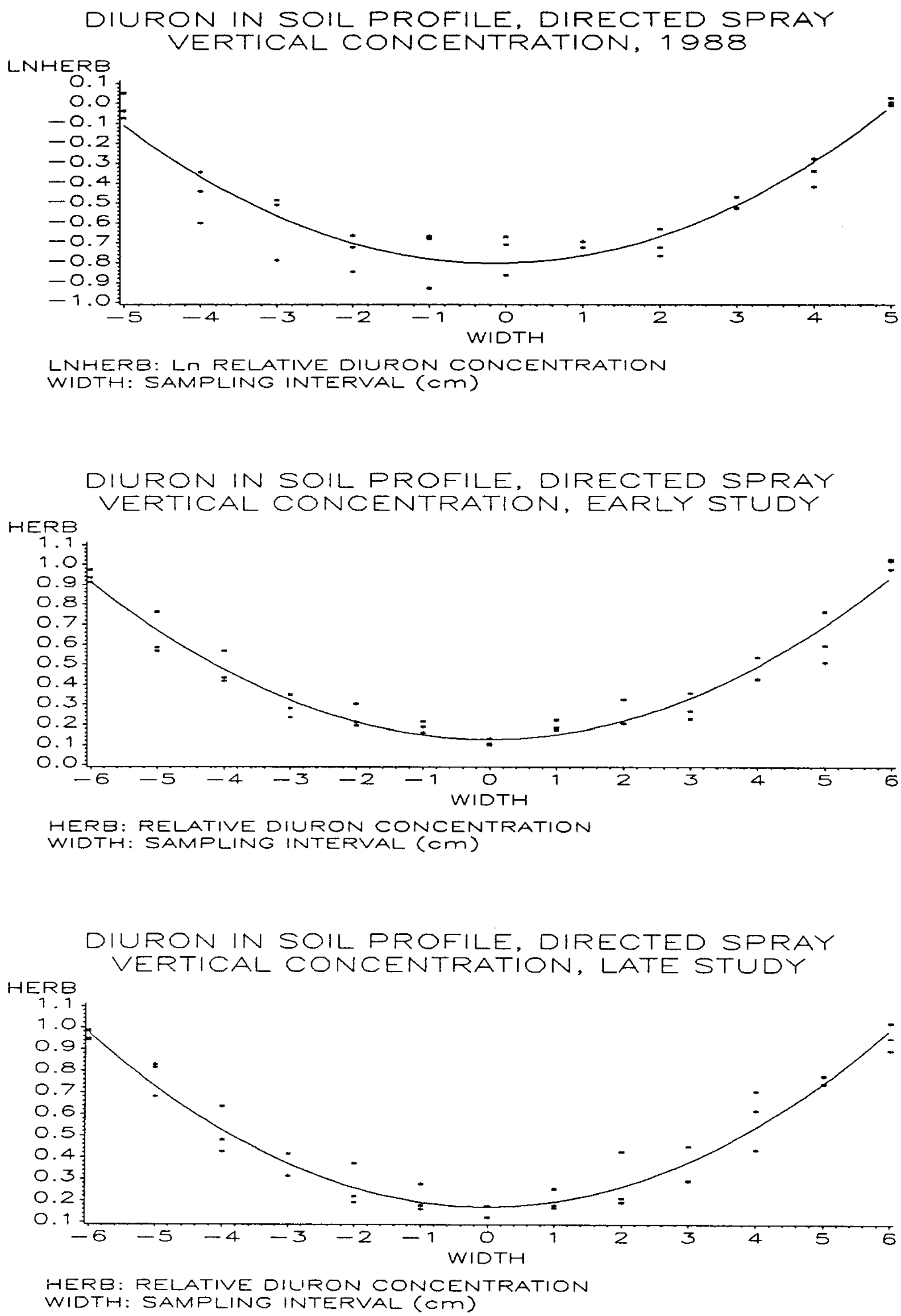


Figure 1.9. Diuron concentration in vertical profile for 1988 (top, r^2=0.87), early (middle, r^2=0.93), and late (bottom, r^2=0.93) studies. Crop row at WIDTH 0. Values standardized to concentration at WIDTH -15 and 15.

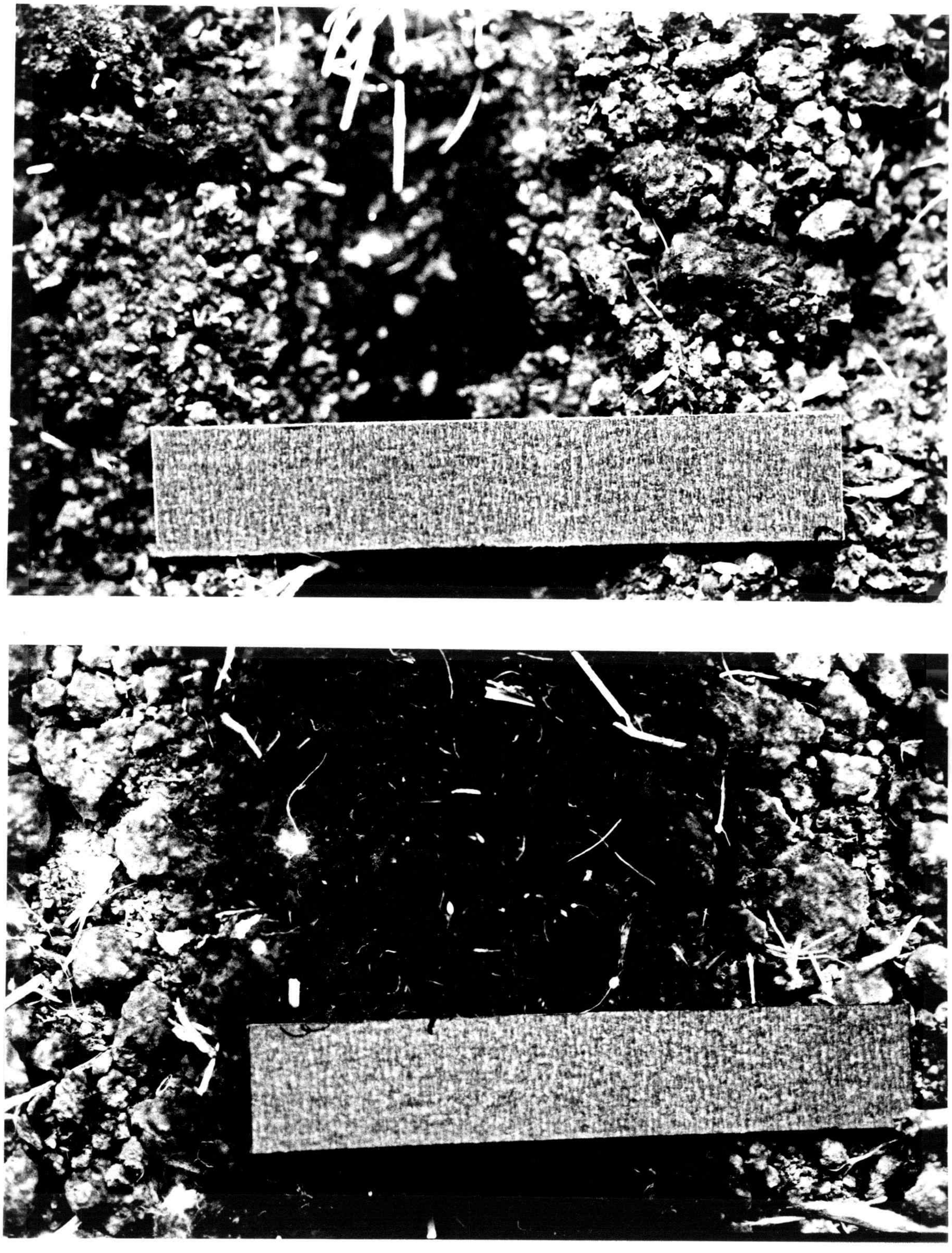
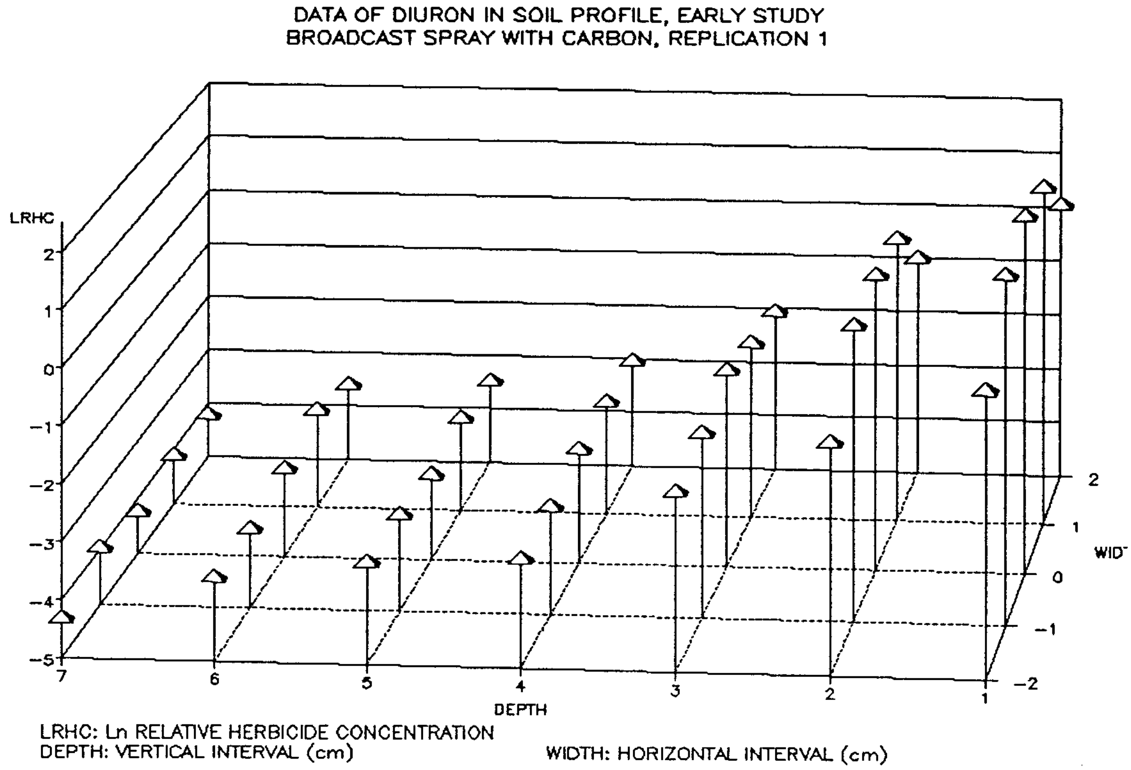


Figure 1.10. Fluorescent image of broadcast spray with carbon (top), and directed spray, no carbon (bottom).



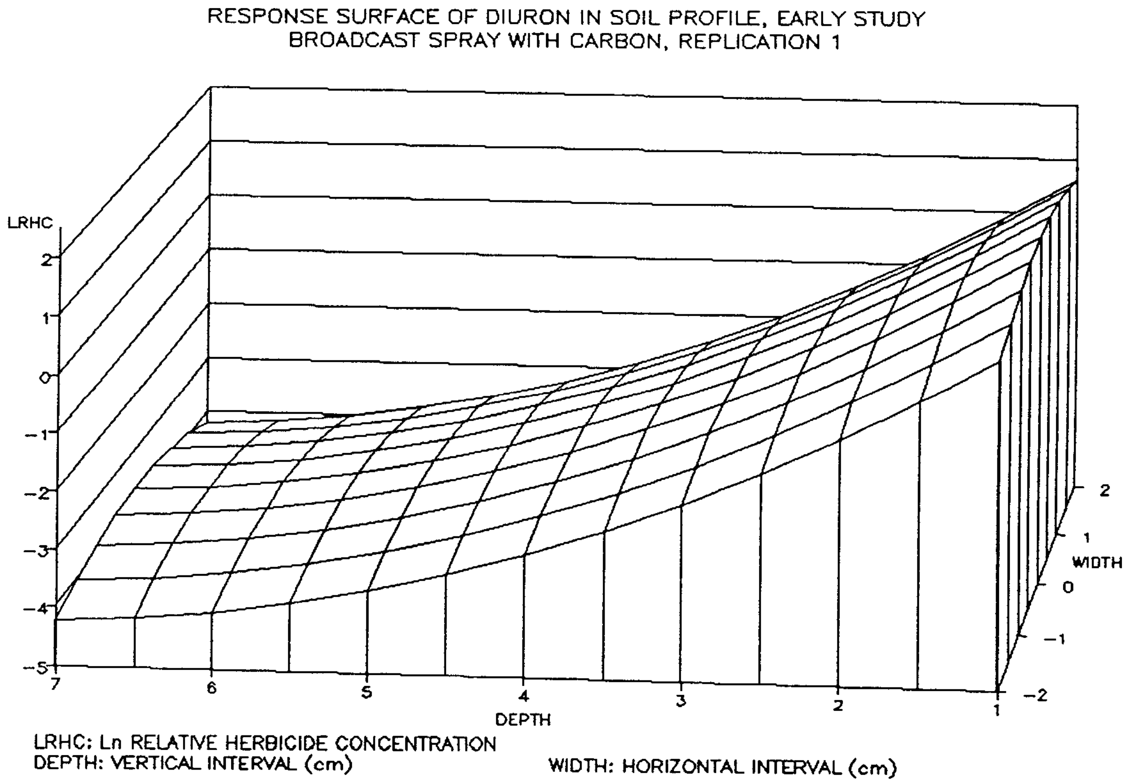
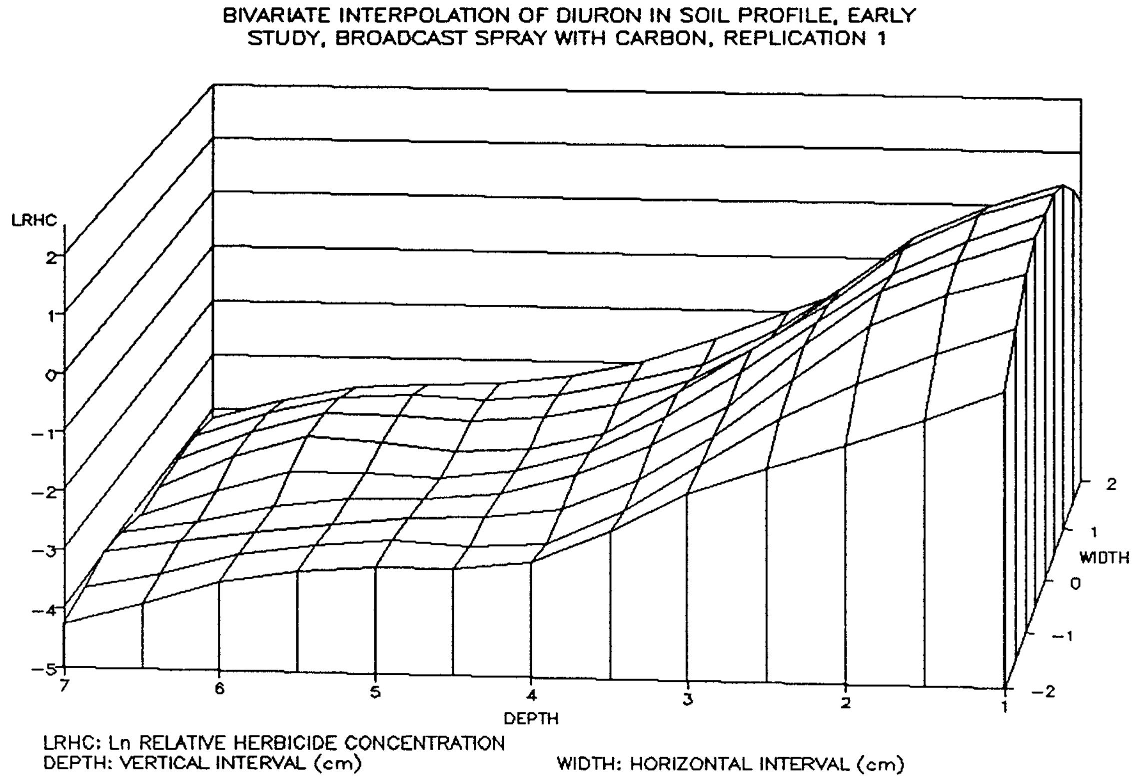


Figure 1.11. Data (top) and quadratic polynomial response surface (bottom, r^2=0.95) for diuron in soil profile, broadcast spray with carbon, early study, replication 1. Values standardized to concentration at WIDTH ± 15, DEPTH 1.



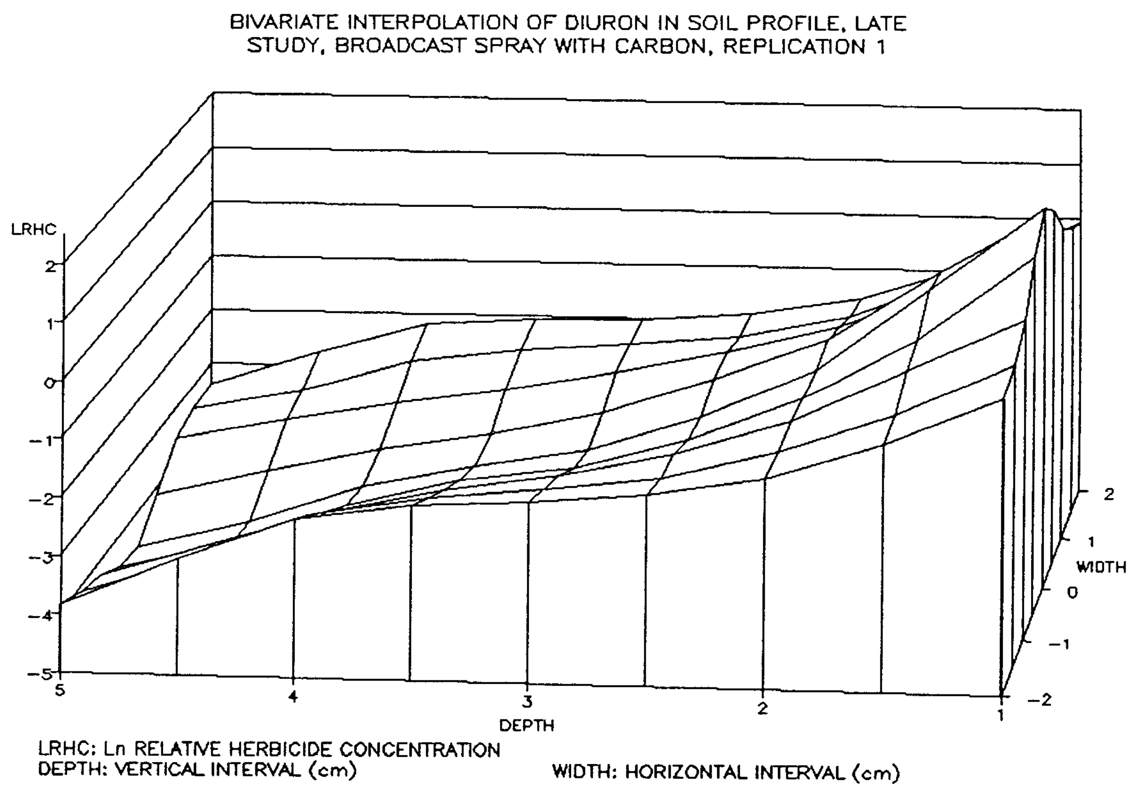
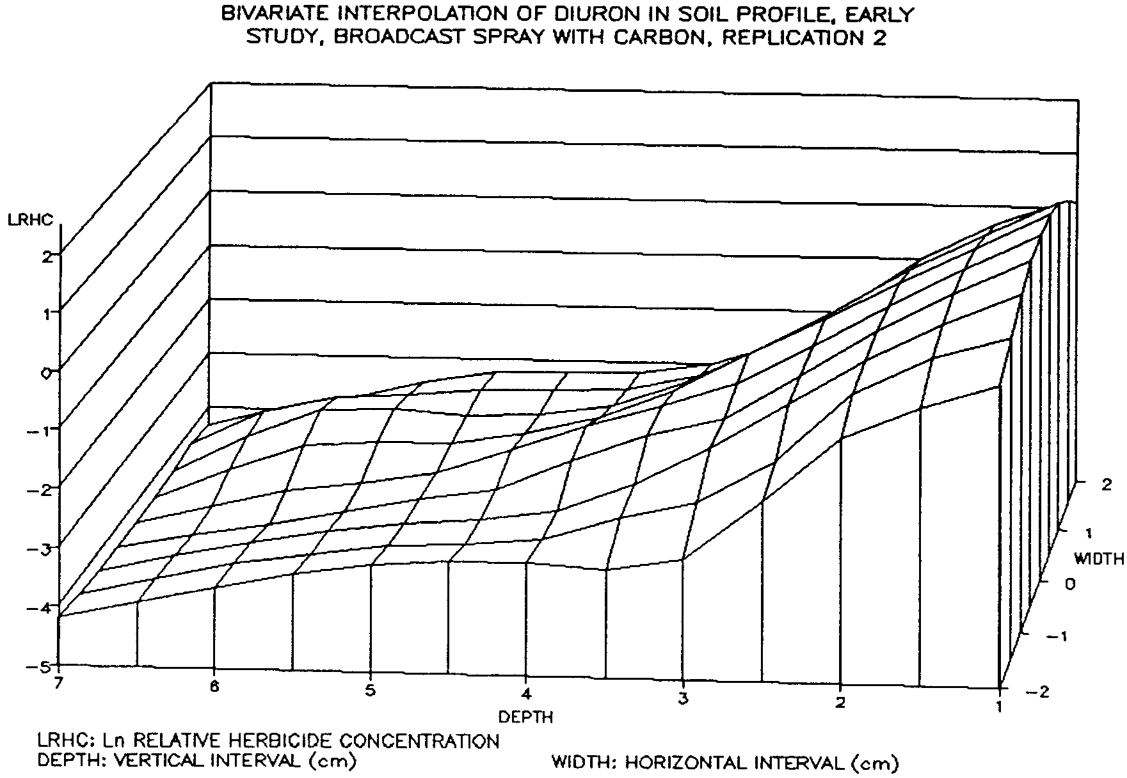


FIGURE 1.12. Bivariate interpolation of diuron in soil profile for early (top) and late (bottom) study, broadcast spray with carbon, replication 1. Values standardized to concentration at WIDTH ± 15, DEPTH 1.



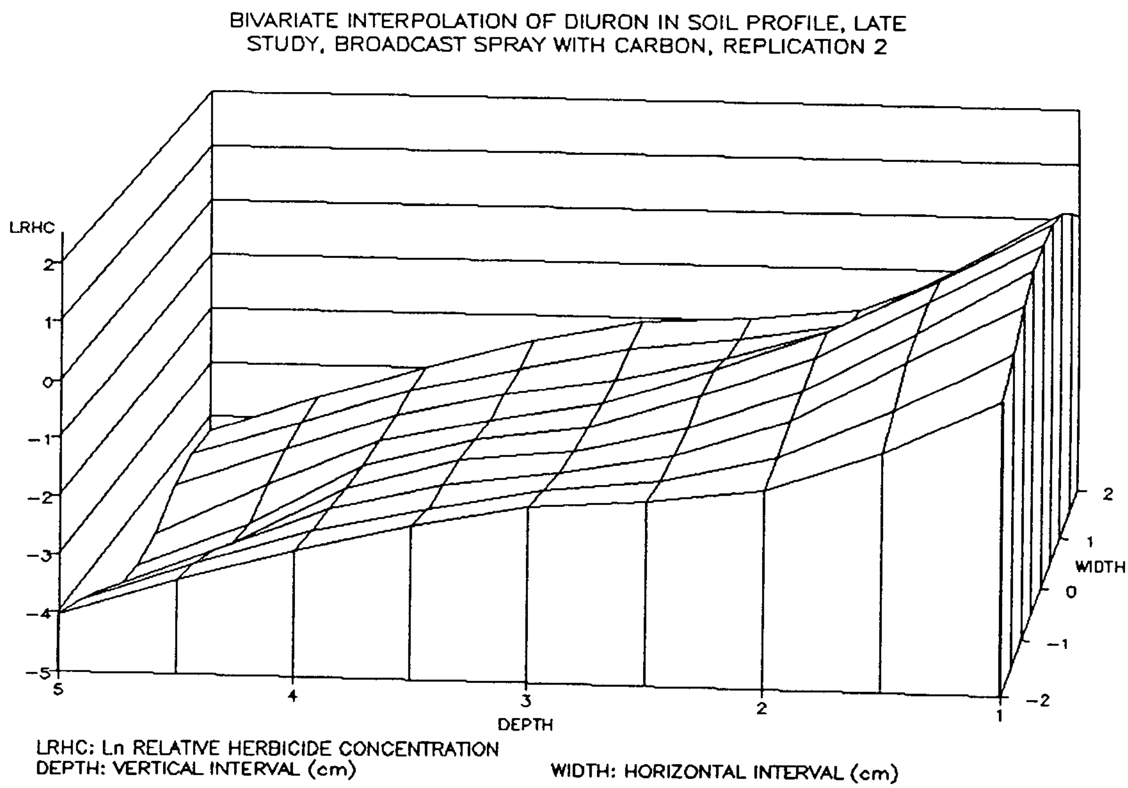


FIGURE 1.13. Bivariate interpolation of diuron in soil profile for early (top) and late (bottom) study, broadcast spray with carbon, replication 2. Values standardized to concentration at WIDTH ± 15, DEPTH 1.

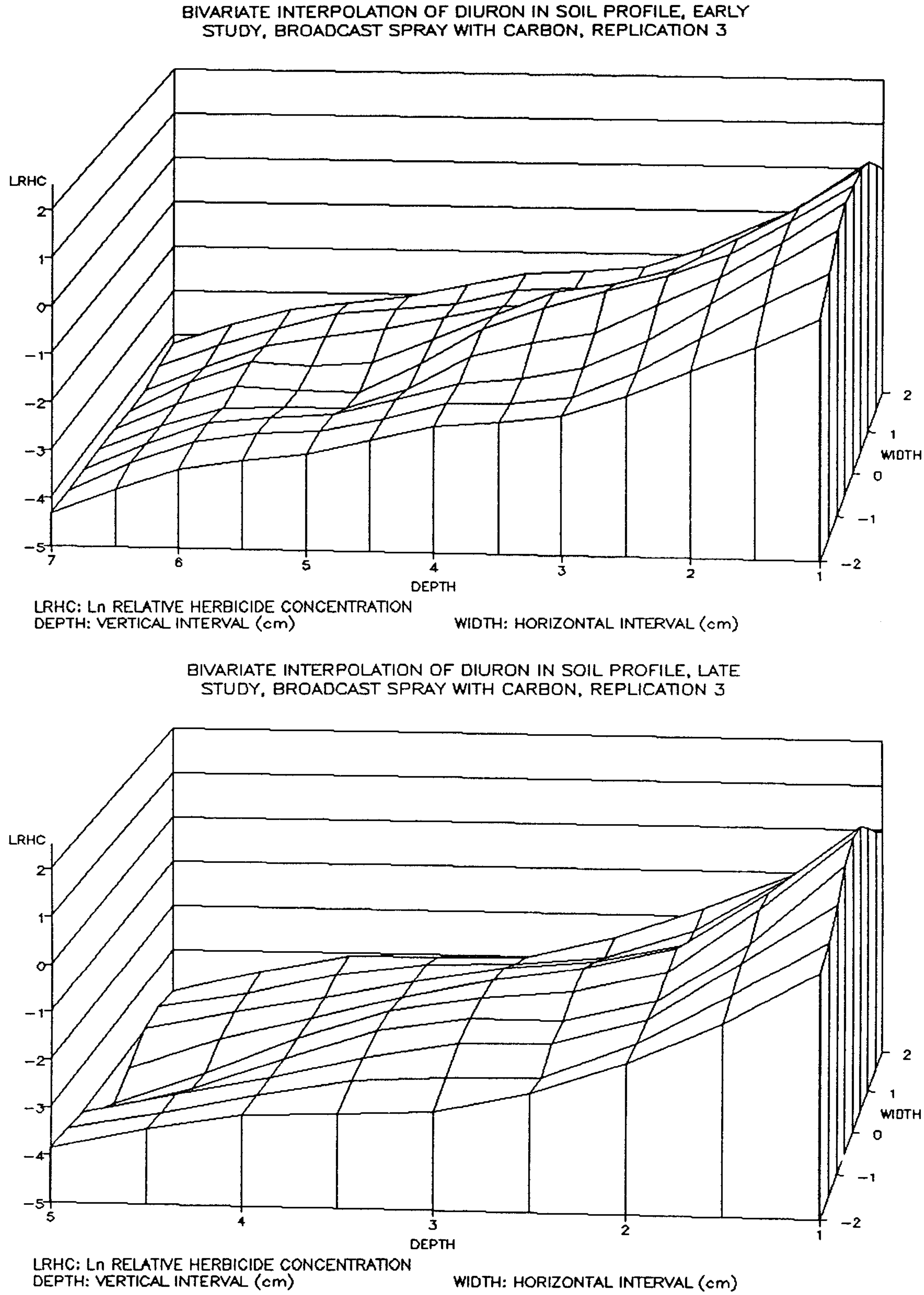
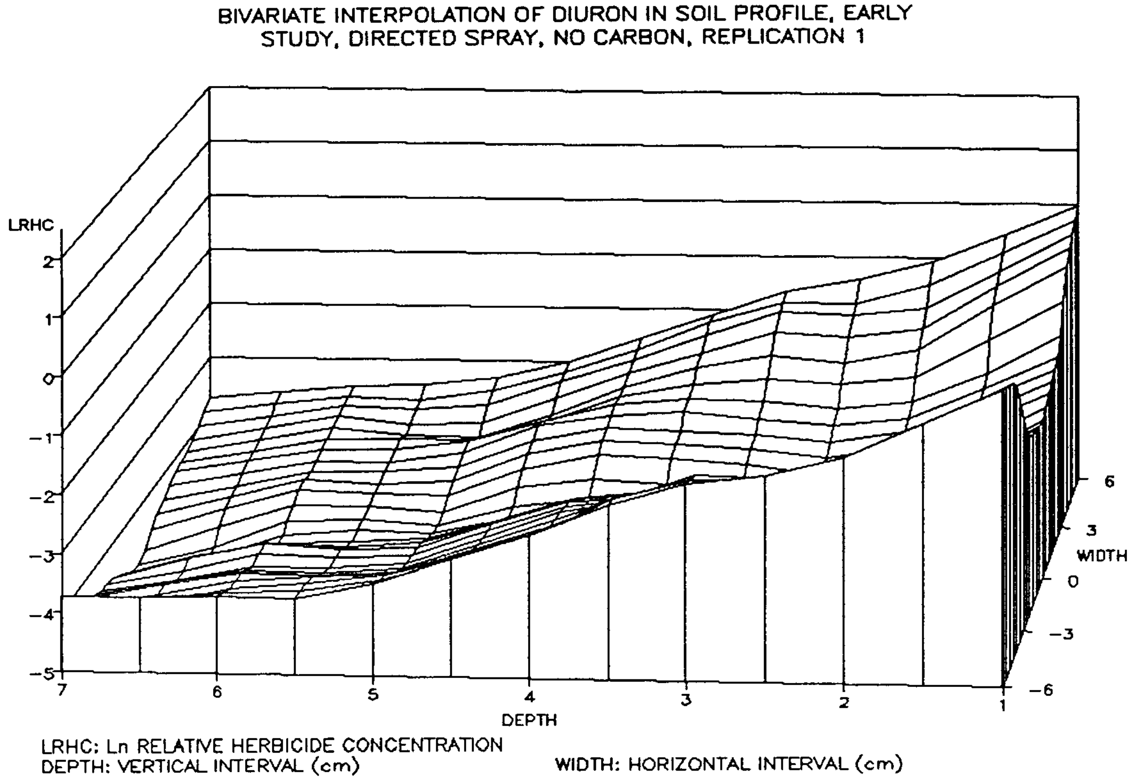


FIGURE 1.14. Bivariate interpolation of diuron in soil profile for early (top) and late (bottom) study, broadcast spray with carbon, replication 3. Values standardized to concentration at WIDTH ± 15, DEPTH 1.



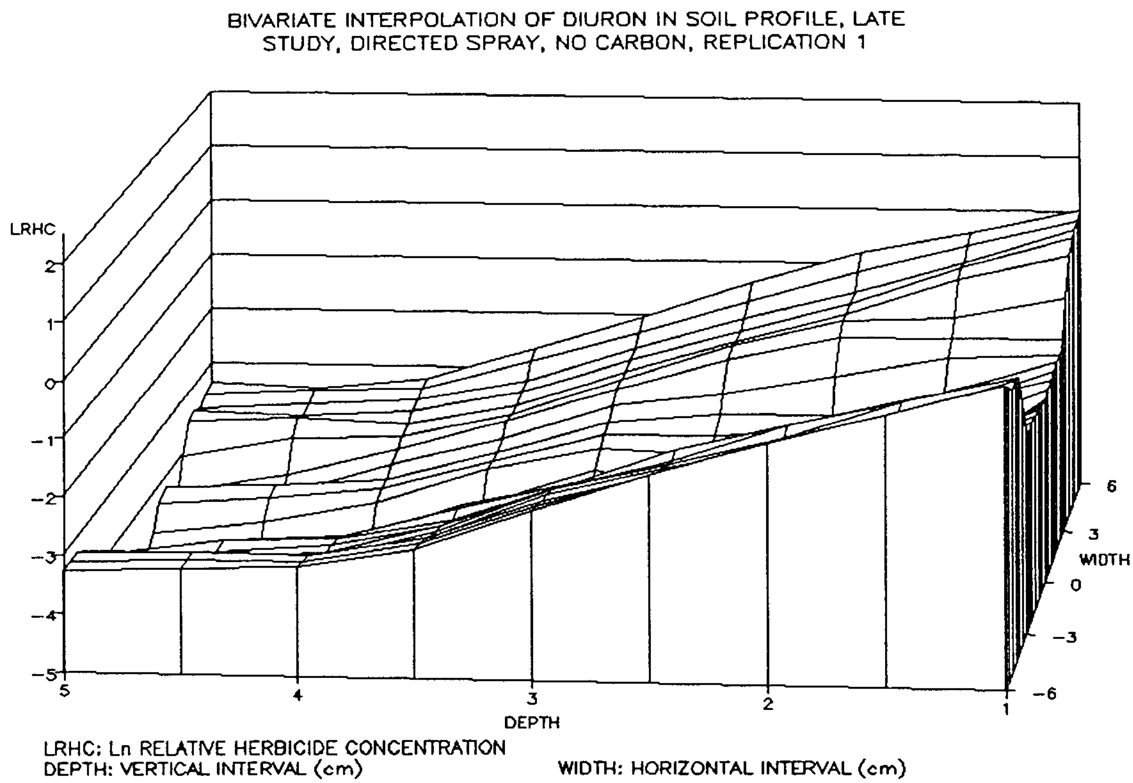
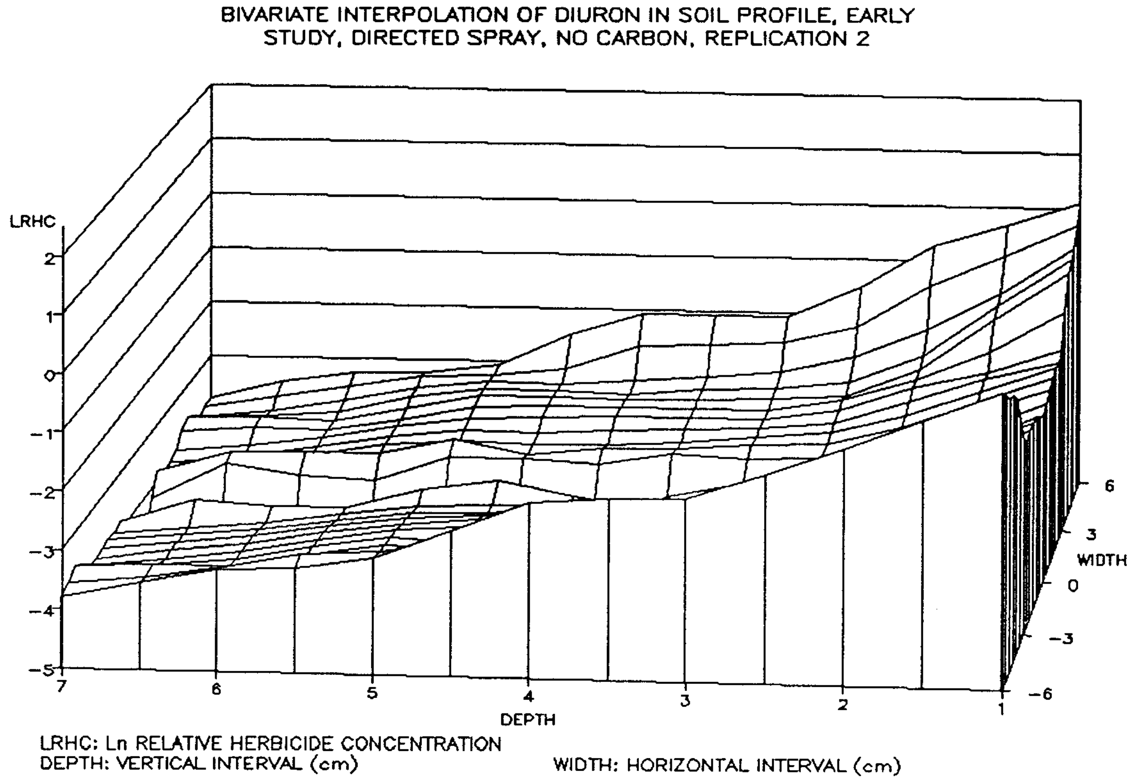


FIGURE 1.15. Bivariate interpolation of diuron in soil profile for early (top) and late (bottom) study, directed spray, no carbon, replication 1. Values standardized to concentration at WIDTH ± 15, DEPTH 1.



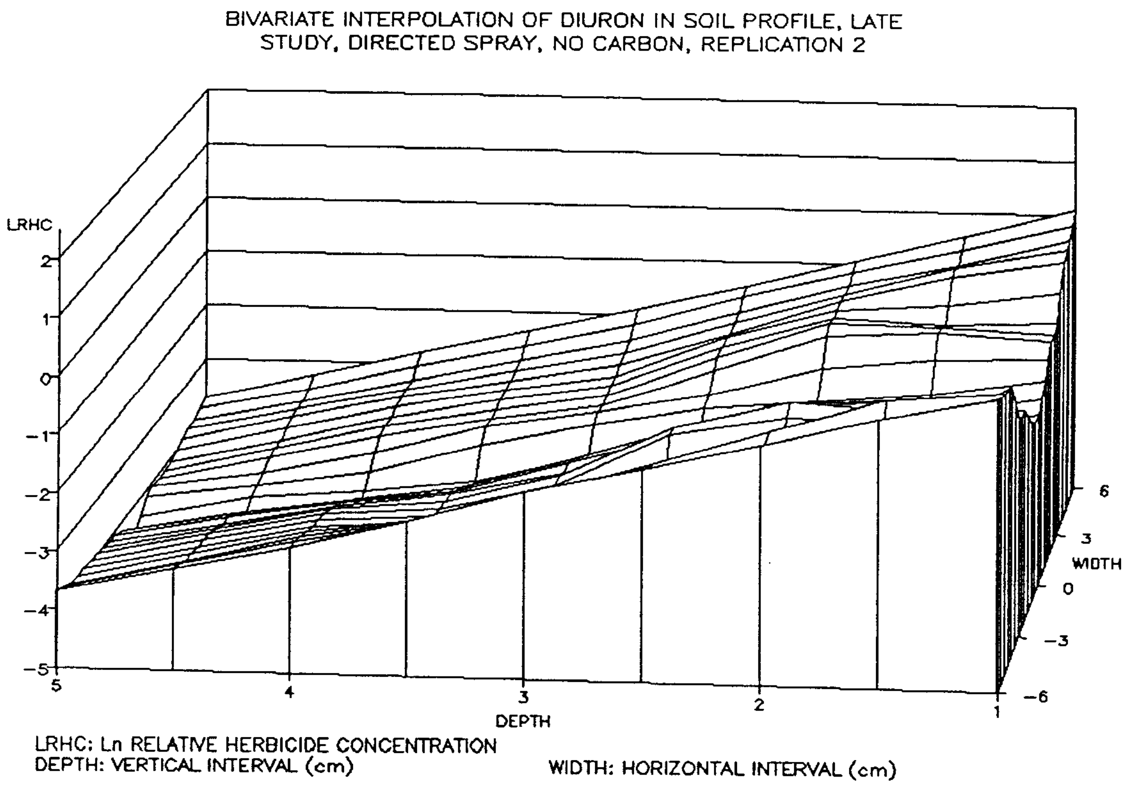


FIGURE 1.16. Bivariate interpolation of diuron in soil profile for early (top) and late (bottom) study, directed spray, no carbon, replication 2. Values standardized to concentration at WIDTH ± 15, DEPTH 1.

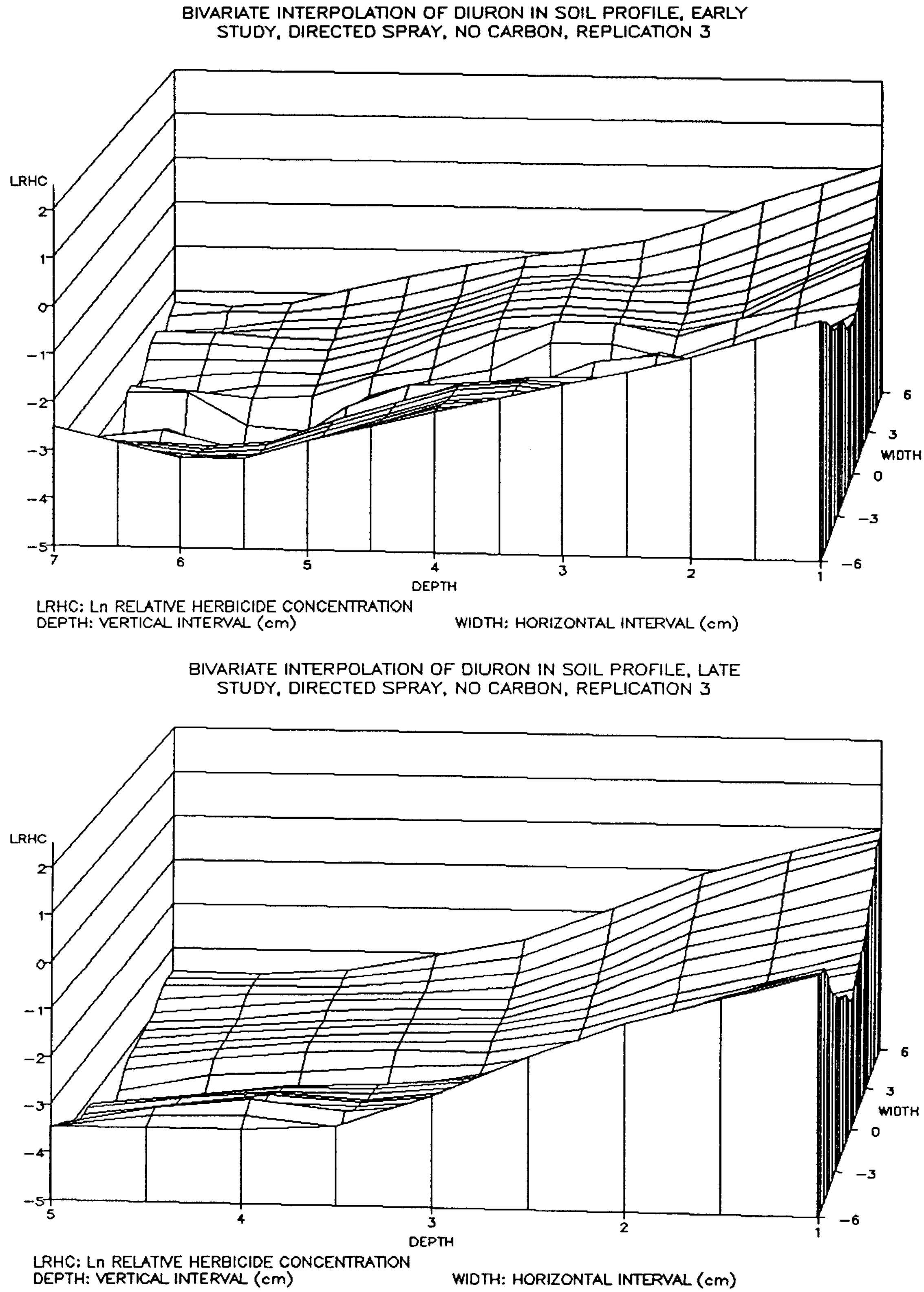


FIGURE 1.17. Bivariate interpolation of diuron in soil profile for early (top) and late (bottom) study, directed spray, no carbon, replication 3. Values standardized to concentration at WIDTH ± 15, DEPTH 1.

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CHAPTER 2

GROWTH OF DIURON-TREATED ITALIAN RYEGRASS AND RATTAIL FESCUE IN PURE AND MIXED STANDS

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ABSTRACT

Sublethal rates of diuron (N'-(3,4-dichlorophenyl)-N,N-dimethylurea) were superimposed over Italian ryegrass (Lolium multiflorum Lam. 'common') and rattail fescue (Vulpia myuros (L.) K.C. Gmel.) grown in pure and mixed stands. Treatments were arranged in a addition series, representing all possible Italian ryegrass populations (5 and 4 densities for 1988 and 1989) by rattail fescue populations (5 and 4 densities for 1988 and 1989) by diuron treatments (3 rates). In 1989, growth analysis was performed on monoculture stands and on individuals for both species.

Although herbicide affected rattail fescue leaf area index in 1988, and various growth analysis measurements for both species in 1989, no affect on seed yield or above ground oven dry weight was observed. The presence of rattail fescue reduced Italian ryegrass seed yield at some densities and proportions in mixed stands, however, the effect was overcome when Italian ryegrass density was increased.

INTRODUCTION

Herbicide selectivity between crops and weeds may be the result of inherent differences in metabolism or target site sensitivity. Where no inherent basis exists, selectivity can sometimes be imparted by use of safeners or herbicide placement in space or time. Another alternative would be to temporarily suppress crop and weed growth with a sublethal dose of a relatively nonselective herbicide, in hopes of shifting the competitive advantage to the crop. Such a desirable shift could occur if the weed was more susceptible to the herbicide than the crop. Aside from the obvious advantage of reducing herbicide input, manipulating competitive advantage in this manner without eliminating weeds has potential to shift competitive advantage away from an undesirable balance or enhance a desirable advantage. However, tolerating weeds above a critical threshold can reduce crop yield, contaminate seed crops, or make harvesting difficult. Advances in mechanical technology may eventually overcome the latter two disadvantages.

A crop-weed-herbicide combination that could test the stated alternative approach to conventional control measures is LOLMU (18) grown for seed, infested with VLPMY, and treated with a sublethal diuron application. At reported densities of up to 43,000 seedlings m^{-2} (13) VLPMY can be a serious competitor. The diuron label recommends using 1.33 to 3 times more herbicide for Italian ryegrass control compared to rattail fescue control (5).

Growth measurement can be used to explain differences in plant performance (10). Typically, plant growth analysis is used to distinguish differences among species grown in a homogeneous environment. Effects of beneficial resources, such as nutrients (2, 3), cultivar (4, 16), or a change in environment (11, 17) on growth have all been investigated. Effects of negative resources, such as herbicides, on species in mixture have also been investigated (7). Changes in plant performance can be evaluated by measuring growth under levels of resources (positive or negative), and intra- or interspecific competition.

The objective of this study was to determine the effect of sublethal diuron application on competitive ability and resource allocation patterns of LOLMU and VLPMY when grown alone and in mixture of the two species.

MATERIALS AND METHODS

1988 Season. After seedbed preparation during the previous year, the study area was kept weed-free using broadcast glyphosate (N-(phosphonomethyl)glycine) applications. On 27 September 1988 the soil surface was prepared for planting by tilling to only a 1.9 cm-depth to minimize disturbance of the weed seed bank. The next day, experimental treatments were arranged in an addition series (9) as a split plot design replicated three times with main plots arranged in strips. LOLMU was drilled (8 rows on 30.5-cm row spacings) as whole plot treatments in an east-west orientation. Treatments in a north-south orientation were factorial combinations of diuron rate and VLPMY density. VLPMY was broadcast by hand in 3.65-m wide strips. Densities were 0, 119, 198, 595, and 1190 seeds m^{-2} (3.36, 5.60, 16.81, and 33.63 kg ha^{-1}) for LOLMU, and 0, 100, 400, 1600, 6400 seeds m^{-2} for VLPMY. VLPMY densities were represented three times across each block. After pressing the seed into the soil with a roller, a compressed-air, push-sprayer was used to apply diuron at 0, 0.28, or 0.56 kg ai ha^{-1} (delivered in 243 L ha^{-1}, using 8002 nozzles, at 172 Kpa) over each VLPMY density. Overall, 5 LOLMU by 5 VLPMY by 3 diuron levels were present in each block (Figure 2.1).

Undesirable volunteer species were eliminated by hand weedings and herbicide applications (0.56 + 0.018 kg ai ha^{-1} bromoxynil (3,5-dibromo-4-hydroxybenzonitrile) + thifensulfuron (methyl 3-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]-2-thiophenecarboxylate)). The herbicide was delivered at 122 L ha^{-1} (207 kPa) using a trailer mounted sprayer equipped with 8002 nozzles. Except for a 2.5-cm irrigation after diuron application, conventional cropping practices were used.

At 60 and 90 days after planting, leaf area index (LAI) perpendicular to LOLMU rows was measured by counting the number of times a pin sent down through the canopy intercepted each species. Data were analyzed using analysis of variance for the split block variation of a split-plot design (8).

During the first week of July, a 1-m^2 total above ground subsample was hand harvested from each plot. Plants were separated by species, oven dried, and weighed.

During the second week of July the entire vegetative and reproductive output in a 5.1-m^2 area was harvested from each plot using a small plot harvester. Samples were bagged, oven dried, weighed, and threshed for seed. The ratio of plant material in subsamples was applied to the harvested plot weights to determine vegetative output of each species. Threshed seed was cleaned and separated on a brush and wire cloth cleaner to determine reproductive output of each species. After testing for herbicide interaction using analysis of variance, data were analyzed by regression using the reciprocal-yield transformation, according to the methods suggested by Spitters (14, 15). Reciprocal of the per-plant weight of species 1 in mixture with species 2 is

$$1/w_1 = b_{1,0} + b_{1,1}N_1 + b_{1,2}N_2 \qquad (2.1)$$

The w and N terms represent weight and plant density. The first subscript of a coefficient is the species biomass being calculated, and the second subscript is the associated species.

1989 Season. For the competition study, field preparation and maintenance, planting, sampling, seed cleaning, and data analysis were as described for the 1988 season. The highest planting density for each species as well as LAI measurements were eliminated. Planting was on 12 September, and subsampling and harvest were during the last week of June.

Stands of monocultures (same planting densities as in competition study) and individuals (planted as 1 plant 0.09-m^{-2}, thinned to 1 plant 0.37-m^{-2} at 30 days after planting) were established adjacent to the competition study for growth analysis of both species. Diuron was applied at the same rates used in the competition study. Each study was established as a randomized block design, replicated three times. Plants from each plot were harvested for leaf area (measured with a LICOR LI-3100 leaf area meter), height (soil surface to tip of uppermost leaf), and above ground oven dry weight measurements throughout the growing season (Table 2.1). Values for oven dry above ground weight (WT), height (HT), leaf area (LA), leaf area ratio (LAR), relative growth rate (RGR), and net assimilation rate (NAR) were used as dependent variables in orthogonal polynomial contrasts with sampling day after planting (time) specified as the level values (spacing of constructed polynomial). Data were fitted by polynomials of up to the third order for time. The order of precedence for selecting significant descriptive curves was as follows: order of polynomial > interaction effects > main effects. The procedure (first derivative of polynomial describing changes in mass over time) of Hunt (6) was used to calculate RGR. All LAR, RGR, and NAR values were calculated for each experimental unit.

Analyses were conducted using the General Linear Models, Repeated Measures Procedure in PC-SAS software (12). Natural log transformation of the dependent variables were used in analysis. Differences between treatments were determined by testing for coincident regression lines using dummy (indicator) variables (19).

RESULTS AND DISCUSSION

Growth measurements, 1988. Analysis of variance indicated LOLMU LAI in the 1988 competition study changed with LOLMU population at 60 days after planting (DAP), and with LOLMU and VLPMY population 90 DAP (Table 2.2). At 60 DAP, response to LOLMU population was greatest at the highest density, least at the two lowest densities, and intermediate at 595 m^{-2} (Table 2.3). Response at 90 DAP to LOLMU density shifted to where it was greatest at the two highest densities (Table 2.4). The 198 and 119 m^{-2} densities resulted in moderate and lowest responses, respectively. Response was inversely related to VLPMY density. Adequate moisture and nutrients, as well as immature canopy development at 60 DAP likely explain the delayed response to the presence of VLPMY. The onset of competition for resources likely explains the species interaction at 90 DAP.

Analysis of variance indicated VLPMY LAI in the 1988 competition study changed with VLPMY population at 60 DAP. At 90 DAP, LOLMU density, VLPMY density, and diuron application rate all affected VLPMY LAI (Table 2.2). Response 60 and 90 DAP followed relative order of VLPMY density, whereas, it was inversely related to LOLMU density at 90 DAP. VLPMY LAI was the same at both 0 or 0.28 kg ai ha^{-1} diuron, but lower LAI was observed at 0.56 kg ai ha^{-1} (Table 2.4). Adequate moisture and nutrients, as well as immature canopy development at 60 DAP likely explains the delayed response to the presence of LOLMU. Reaction to diuron apparently reflects differences in species susceptibility as listed on the product label (5).

Growth analysis, 1989. In the study of individual plants (individual study hereafter), species differences were present for all growth measurements except for relative growth rate (no explainable differences). No other source of variation was significant. A second degree polynomial separated differences between species over time for HT and WT ($p=0.0533$) measurements, whereas, a third degree polynomial was required for LAR, LA, and NAR (Tables 2.5 and 2.6). The rate of change over time for WT decreased for both species, whereas, for HT it decreased in LOLMU and increased in VLPMY (Figures 2.2 and 2.3). Decreases in the rates of change for LA, LAR, and NAR at 90 DAP reflect decelerated growth due to the onset of winter (Figures 2.4, 2.5, and 2.6). Although the net relative weight gain per unit leaf area (NAR) was greater for VLPMY for most of the season, measurements of actual plant size were greater for LOLMU.

In the monoculture study, a second degree polynomial explained differences between LAR, whereas, a third degree polynomial was required for the remaining growth measurements (Table 2.7).

The herbicide (diuron) by population (LOLMU or VLPMY density) interaction explained differences in height. A test for coincidence of all possible paired curve combinations indicated LOLMU densities at any diuron level responded differently than VLPMY densities at any diuron level (Tables 2.8a and 2.8b).

When LOLMU density was 119 or 198 at any diuron level, height was not different when compared to any other LOLMU density by diuron combinations. The LOLMU (119 or 198) by diuron = 0.56 kg ai ha^{-1} response was less during the initial 132 days when compared to LOLMU 595 density by diuron = 0 kg ai ha^{-1} combination (Figures 2.7a, b, and c). The LOLMU (119 or 198) by diuron = 0.56 kg ai ha^{-1} response was less after 34 days when compared to LOLMU 595 density by diuron = 0.28 kg ai ha^{-1} combination. Regardless of seasonal differences for LOLMU HT, a similar response was observed at the end of the season for all LOLMU density by diuron combinations.

When VLPMY HT at all density levels by diuron at 0.28 or 0.56 kg ai ha^{-1} combinations were compared, no difference existed, except for VLPMY 400 at 0.28 diuron vs VLPMY 400 at 0.56 diuron. When VLPMY at 400 or 1600 and 0 diuron combinations were compared to remaining treatments, only

VLPMY at 400 or 1600 and 0.56 diuron were different. VLPMY HT at density 100 and 0 diuron was greater when compared to all other VLPMY density by diuron level combinations, except for VLPMY at 100 or 400 combined with 0.28 diuron (similar response). The interaction between density and diuron for HT is somewhat inconsistent and difficult to interpret. The results are likely due to the combined effects of herbicide phytotoxicity and intraspecific competition. As density increases, the amount of herbicide available per plant decreases, however, intraspecific competition increases. At some level of competitive stress, plants may be more susceptible to diuron. Increases and decreases in efficacy of diuron in LOLMU as density increases have been observed elsewhere (1). Regardless of seasonal differences for VLPMY HT, a similar response was observed at the end of the season for all VLPMY densities by diuron combinations.

The density by species factor explained differences in LAR, with no effect of diuron (Table 2.9). A test for coincidence of all possible paired combinations indicated LAR was different between species and similar among density levels within a species (Table 2.9, Figure 2.8). LOLMU response was greater than VLPMY response until 190 days.

Contrast analysis indicated differences among LA were explained by diuron rate and density in a cubic polynomial of time (Table 2.7). In tests for coincidence, all VLPMY densities responded differently than LOLMU densities (Table 2.10). LOLMU curves terminate at a similar point, whereas

VLPMY curves have unique end points (Figure 2.9). Response to the 0 and 0.28 diuron levels were similar, and different from diuron at 0.56 (Table 2.11, Figure 2.10).

Contrast analysis indicated differences in NAR were associated with diuron levels (Table 2.7). In a test for coincidence, response to diuron at 0 or 0.28 were similar, whereas response at 0.56 was different (Table 2.12, Figure 2.11).

Difference among RGR was explained by both diuron and planting density (Table 2.7). Within a species, response at the two lowest densities was similar, and greater than that at the highest density. LOLMU RGR was greater than VLPMY RGR during the final portion of the growing season (Table 2.13, Figure 2.12). The responses for 0 and 0.28 diuron were similar to each other, and different from the 0.56 diuron response (Table 2.14, Figure 2.13).

Difference among WT was also due to both diuron and density (Table 2.7). All VLPMY densities responded differently when compared to one another (Table 2.15, Figure 2.14). The two lowest levels of LOLMU density were similar, and differed from that at the highest density (Table 2.15, Figure 2.14). Within a species, the vertical positioning of the curves was inverse to density. This result is expected for WT of individuals, since WT of individuals at lower densities should be greater due to reduced competition. LOLMU curves terminate at a similar point, whereas VLPMY curves have unique ending points. WT averaged over both species at the two lowest levels of diuron were similar, and different from that at the highest diuron rate (Table 2.16, Figure 2.15). WT differences explained by herbicide resulted in a greater response for 0.56 diuron after 128 days. Although all plots were hand weeded, the task was laborious and not always timely. Plots treated with the higher diuron rate likely had reduced volunteer weed numbers, and therefore reduced competition from untested species. This effect was also evident in other growth measurements involving WT and separated by diuron level (RGR and NAR).

Despite seasonal differences in growth measurements between species in the monoculture study, final observations were often similar.

Competition study analysis. Analysis of variance for the 1988 competition study seed yield and above ground oven dry biomass indicated the LOLMU by VLPMY density interaction was significant for both LOLMU and VLPMY. The same interaction was significant for the 1989 seed yield and biomass of VLPMY. Individual species densities, but not their interactions, were significant for 1989 LOLMU seed yield, whereas, only LOLMU density was significant for its biomass. Diuron level was not significant in either study. Therefore, data were pooled across herbicide levels for regression analysis (Tables 2.17 and 2.18).

Addition series models (1988) described 43 to 93 percent of variation for reciprocal per plant seed yield or reciprocal per plant biomass as a linear function of density in mixtures (Table 2.19). Analysis of harvest index (14) explained less variation than actual seed yield, therefore, only seed yield was used (data not shown). Although in all models intraspecific competition was more important, relative competition coefficients approached unity for VLPMY measurements. This indicated that LOLMU density had nearly the same affect on VLPMY measurements as VLPMY density. The large relative competition coefficient for LOLMU measurements indicated VLPMY density had less impact than LOLMU density (Figures 2.16 through 2.19).

Results for the 1989 addition series explained 52 to 94 percent of variation for reciprocal per plant seed yield or reciprocal per plant biomass as a linear function of density in mixtures (Table 2.20). Analysis of harvest index explained less variation than actual seed yield, therefore only seed yield was used (data not shown). Intraspecific competition coefficients were more important for LOLMU measurements, whereas, interspecific competition coefficients were more important for VLPMY measurements. In the VLPMY measurements, one LOLMU had the impact of approximately seven VLPMY (Figures 2.20 through 2.23).

The changes in relative competitive abilities and importance of inter- or intraspecific competition from 1988 to 1989 might be caused by many factors. One possible explanation is that elimination of the highest density for VLPMY in 1989 may have removed a large source of variation, as plants in the highest VLPMY density frequently failed to produce any harvestable produce seed. Another possible explanation is that VLPMY matured faster in 1988. Many VLPMY plants were still green and immature during the 1989 harvest, regardless of species proportion or density.

The growth measurements which correlated most strongly with relative competitive ability for 1989 were LAR (relative plant leafiness) and HT (Table 2.21). The results indicate size was the trait contributing most to competitive ability.

Overall, LOLMU was a superior competitor when compared to VLPMY at the tested densities. The addition of diuron altered plant performance during the season, however, it did not make any difference in reciprocal seed yield or weight per plant. It is likely the effects of the sublethal diuron treatments were short lived. When residues were no longer biologically significant, plants were able to resume growth similar to untreated plants. Normal growth probably resumed early enough in the season for plants to exhibit no seed or above ground biomass losses at the end of the season.

The Spitter's analysis successfully predicted LOLMU seed yield when VLPMY density was 100, 400, or 1600 in 1988. LOLMU predicted yield was high when VLPMY density was 0, or 6400. For the 1989 data, LOLMU seed yield was successfully predicted when VLPMY density was 0. When VLPMY density was

100, LOLMU predicted seed yield was slightly high. At VLPMY densities of 400 or 1600, the Spitter's analysis successfully predicted LOLMU seed yield at high and low LOLMU densities. Predicted values were slightly high at moderate LOLMU densities (Appendix Tables 2.10 and 2.11).

Review of the competition study data indicates in 1988 LOLMU seed yield was not affected by VLPMY presence until VLPMY density was 1600 and LOLMU density was 119. When LOLMU density was 198 or greater, presence of VLPMY at 1600 had no affect on LOLMU seed yield. When VLPMY density was 6400, all LOLMU densities exhibited seed yield reduction.

In 1989 lower VLPMY densities affected LOLMU seed yield when compared to 1988 results. LOLMU yield was reduced when VLPMY density was 400 and LOLMU density was 119. An increase of LOLMU density to 198 recovered seed yield. When VLPMY density was 1600, LOLMU yield did not recover until LOLMU density was 595 (Appendix Tables 2.10 and 2.11).

LOLMU seed yield recovered from the presence of VLPMY at higher LOLMU densities when 1989 data are compared to 1988 data. Although the results indicate LOLMU can tolerate the presence of some VLPMY, the threshold of tolerance varied between the two years. The lower LOLMU tolerance of 1989 may be attributed to the VLPMY remaining in a vegetative state for a longer time. VLPMY continued to increase in size instead of producing seed. The size increase may have shaded LOLMU and resulted in reduce seed yield.

Increased herbicide pressure would likely result in final seed and above ground biomass differences. Although such a treatment would be difficult to interpret if it resulted in growth suppression compounded by population reduction, the end result would be beneficial if the competitive advantage of the crop was enhanced.

Table 2.1. Sampling schedule for 1989 growth analysis.

Study[a]	Days After Planting										
Mono	13	21	27	34	41	57	71	86	128	190	244	
Ind	13	21	27	34	41	48	62	76	90	132	186	245

[a]Mono: Monoculture stand study; Ind: Individual stand study.

Table 2.2. Analysis of variance for 1988 competition study leaf area index.

Source[a]	DF	LOLMU 60 DAP Mean Sq.	LOLMU 60 DAP Pr>F	LOLMU 90 DAP Mean Sq.	LOLMU 90 DAP Pr>F	DF	VLPMY 60 DAP Mean Sq.	VLPMY 60 DAP Pr>F	VLPMY 90 DAP Mean Sq.	VLPMY 90 DAP Pr>F
BLOCK(B)	2	0.183	0.008	15.378	0.0001	2	0.084	0.3811	0.611	0.1621
LPOP(L)	3	8.697	0.0003	13.209	0.0053	4	0.087	0.3989	14.468	0.0001
ERROR(BL)	6	0.224		1.042		8	0.076		0.542	
VPOP(V)	4	0.027	0.3134	44.467	0.0001	3	37.347	0.0001	69.705	0.0001
HERB(H)	2	0.006	0.7325	0.147	0.8772	2	0.202	0.3658	4.034	0.0204
V*H	8	0.019	0.5	1.108	0.5	6	0.169	0.5	0.505	0.5
L*V	12	0.036	0.1885	0.449	0.923	12	0.037	0.9868	0.269	0.8329
L*H	6	0.029	0.2937	0.046	0.9995	8	0.042	0.961	0.228	0.8526
L*V*H	24	0.027	0.3157	0.219	0.9991	24	0.057	0.9728	0.200	0.9512
ERR(VH)	112	0.019		1.095		110	0.169		0.500	

[a]LPOP: LOLMU population; VPOP: VLPMY population; HERB: Diuron application rate.

Table 2.3. LOLMU leaf area index response, in 1988 competition study, to LOLMU or VLPMY population at 60 or 90 DAP[a].

60 DAP		90 DAP			
LPOP[b]	MEAN	LPOP	MEAN	VPOP	MEAN
1190	1.01 A	1190	3.09 A	0	4 A
595	0.81 B	595	2.97 A	100	3.27 B
198	0.19 C	198	2.37 B	400	2.61 C
119	0.13 C	119	1.93 C	1600	1.91 D
				6400	1.16 E
LSD	0.0797		0.2725		0.3047

[a]DAP: Days after planting.
[b]LPOP: LOLMU population; VPOP: VLPMY population.
Means followed by the same letter do not differ (p=0.05).

Table 2.4. VLPMY leaf area index response, in 1988 competition study, to VLPMY or LOLMU population, or herbicide at 60 or 90 DAP[a].

60 DAP		90 DAP					
VPOP[b]	MEAN	LPOP	MEAN	VPOP	MEAN	HERB	MEAN
6400	2.12 A	0	3.31 A	6400	3.8 A	0	2.54 A
1600	0.93 B	198	2.44 B	1600	2.84 B	0.28	2.35 A
400	0.34 C	119	2.18 BC	400	1.55 C	0.56	2.03 B
100	0.07 D	595	1.95 C	100	1.05 D		
		1190	1.65 D				
LSD	0.1232		0.2685		0.2401		0.208

[a]DAP: Days after planting.
[b]LPOP: LOLMU population; VPOP: VLPMY population;
HERB: Diuron application rate (kg ha^{-1}).
Means followed by the same letter do not differ (p=0.05).

Table 2.5. Individual study repeated measure analysis of variance of time contrasts, 1989.

Source	Resp[a]	DF	Time*1[b] Mean Sq	Time*1[b] Pr>F	Time*2 Mean Sq	Time*2 Pr>F	Time*3 Mean Sq	Time*3 Pr>f
MEAN	lnHT(cm)	1	178.3774	0.0001	0.1043	0.1408	2.1513	0.0001
HERB(H)[c]		2	0.0051	0.927	0.0091	0.8065	0.0113	0.6449
SPEC(S)		1	1.1736	0.0013	0.5166	0.0043	0.0433	0.2126
H*S		2	0.0793	0.3438	0.0908	0.1578	0.0169	0.5261
ERROR		12	0.0679		0.0419		0.0250	
MEAN	lnLAR(dm^2/g tot wt)	1	45.4297	0.0001	169.5494	0.0001	20.1067	0.0001
HERB(H)		2	0.2049	0.0563	0.0370	0.6026	0.0246	0.7316
SPEC(S)		1	4.4613	0.0001	2.0728	0.0002	1.6772	0.0005
H*S		2	0.0608	0.3654	0.0036	0.9501	0.0327	0.6631
ERROR		12	0.0555		0.0701		0.0769	
MEAN	lnLA(cm^2)	1	3082.258	0.0001	516.5397	0.0001	116.2473	0.0001
HERB(H)		2	0.0293	0.8152	0.5056	0.2076	0.0581	0.7016
SPEC(S)		1	18.5388	0.0001	0.0306	0.7469	3.1690	0.0008
H*S		2	0.1959	0.2871	0.3202	0.3527	0.0923	0.5745
ERROR		12	0.1412		0.2813		0.1591	
MEAN	lnNAR(g/dm^2.day)	1	210.022	0.0001	104.1959	0.0001	26.6247	0.0001
HERB(H)		2	1.0786	0.1156	0.0633	0.8146	0.0788	0.5855
SPEC(S)		1	6.3863	0.0023	2.0342	0.0252	1.5572	0.0067
H*S		2	0.2878	0.5150	0.1673	0.5911	0.0048	0.9662
ERROR		12	0.4082		0.3033		0.1403	
MEAN	lnRGR(g/g.day)	1	63.8184	0.0001	5.5456	0.0001	0.7396	0.0006
HERB(H)		2	0.713	0.3078	0.167	0.3426	0.035	0.3831
SPEC(S)		1	0.2209	0.5365	0.009	0.8045	0.0002	0.9806
H*S		2	0.5899	0.3709	0.1854	0.3082	0.0486	0.2753
ERROR		12	0.5427		0.1412		0.0334	
MEAN	lnWT(g)	1	2379.287	0.0001	94.2141	0.0001	39.6617	0.0001
HERB(H)		2	0.3891	0.0893	0.2727	0.4789	0.0426	0.6851
SPEC(S)		1	4.8113	0.0001	1.5991	0.0533	0.2353	0.168
H*S		2	0.0619	0.6338	0.3571	0.3878	0.0322	0.75
ERROR		12	0.1308		0.3480		0.1093	

[a]ln:Natural log HT:Height; LAR:Leaf area ratio; LA:Leaf area; NAR:Net assim. rate; WT:Oven dry above ground weight; RGR:Rel. growth rate. [b]Time*n:The nth degree polynomial contrast for time. [c]HERB:Diuron rate; SPEC:LOLMU or VLPMY. Measurements as per plant.

Table 2.6. Test of coincidence of species curves for growth measurements.

Measurement[a]	Minimum P level
lnHT	0.01
lnLAR	0.01
lnLA	0.01
lnNAR	0.01
lnRGR	NS
lnWT	0.01

[a]ln: Natural logarithm transformation.

Table 2.7. Monoculture study repeated measure analysis of variance of time contrast, 1989.

Source	Resp[a]	DF	Time*1[b] Mean Sq	Time*1[b] Pr>F	Time*2 Mean Sq	Time*2 Pr>F	Time*3 Mean Sq	Time*3 Pr>f
MEAN	lnHT(cm)	1	578.8908	0.0001	0.0036	0.5904	11.3381	0.0001
HERB(H)[c]		2	0.0560	0.1502	0.0027	0.8018	0.0421	0.0276
POP(P)		5	0.7948	0.0001	1.1225	0.0001	0.1408	0.0001
H*P		10	0.0244	0.5667	0.0182	0.1914	0.0520	0.0002
ERROR		36	0.0280		0.0124		0.0106	
MEAN	lnLAR(dm^2/g tot wt)	1	7.2056	0.0001	164.139	0.0001	0.1379	0.2056
HERB(H)		2	0.9965	0.0109	0.1187	0.3154	0.0023	0.9727
POP(P)		5	7.5000	0.0001	0.7396	0.0001	0.0987	0.3338
H*P		10	0.1419	0.6894	0.1249	0.2919	0.0720	0.5702
ERROR		36	0.1938		0.0996		0.0830	
MEAN	lnLA(cm^2)	1	5231.477	0.0001	801.4208	0.0001	124.887	0.0001
HERB(H)		2	8.6458	0.0001	0.6199	0.0213	1.5998	0.0064
POP(P)		5	31.1072	0.0001	0.9545	0.0002	3.6871	0.0001
H*P		10	0.4559	0.3688	0.3094	0.0461	0.2766	0.4558
ERROR		36	0.4039		0.1443		0.2745	
MEAN	lnNAR(g/dm^2.day)	1	133.3307	0.0001	468.3431	0.0001	8.3119	0.0001
HERB(H)		2	1.0079	0.0186	2.7896	0.0029	0.4796	0.0184
POP(P)		5	7.2843	0.0001	1.7431	0.0037	0.1044	0.4417
H*P		10	0.1980	0.5557	0.3051	0.6603	0.1709	0.1464
ERROR		36	0.2236		0.3989		0.1060	
MEAN	lnRGR(g/g.day)	1	85.8997	0.0001	89.2975	0.0001	7.2491	0.0001
HERB(H)		2	0.0845	0.5226	2.4109	0.0016	0.3881	0.0004
POP(P)		5	0.5072	0.0063	3.6641	0.0001	0.2077	0.001
H*P		10	0.0791	0.7864	0.3675	0.3259	0.0528	0.2383
ERROR		36	0.1277		0.3060		0.0386	
MEAN	lnWT(g)	1	4850.372	0.0001	240.1788	0.0001	133.3267	0.0001
HERB(H)		2	14.4604	0.0001	0.4380	0.0279	1.6566	0.0028
POP(P)		5	9.2924	0.0001	0.3847	0.0115	2.7947	0.0001
H*P		10	0.7657	0.2313	0.1202	0.3976	0.3937	0.1321
ERROR		36	0.5572		0.1106		0.2387	

[a]ln:Natural log; HT:Height; LAR:Leaf area ratio; LA:Leaf area; NAR:Net assim. rate; RGR: Rel. growth rate; WT:Oven dry above ground weight. [b]Time*n:The nth degree polynomial contrast for time. [c]HERB:Diuron rate; POP:LOLMU or VLPMY density. Measurements as per plant.

Table 2.8a. Comparison of paired LOLMU curves at diuron and population levels for monoculture study natural log of height, 1989[a].

DIURON (kg ai/ha)	LOLMU POP m^{-2}	DIURON (kg ai/ha) 0		0.28			0.56		
		LOLMU POP m^{-2}							
		198	595	119	198	595	119	198	595
0	119	NS	NS	NS	NS	NS	NS	NS	NS
	198		NS	NS	NS	NS	NS	NS	NS
	595			NS	NS	NS	*	*	NS
0.28	119				NS	NS	NS	NS	NS
	198					NS	NS	NS	NS
	595						*	*	NS
0.56	119							NS	NS
	198								NS

[a]A test for coincidence of all possible paired curve combinations indicated LOLMU HT at any density combined with any herbicide level was different from HT of VLPMY at any density combined with any herbicide level (data not shown). LOLMU and VLPMY results are therefore separated into two tables (2.8a and 2.8b) to facilitate interpretation.

Table 2.8b. Comparison of paired VLPMY curves at diuron and population levels for monoculture study natural log of height, 1989.[a]

		DIURON (kg ai/ha)							
		0		0.28			0.56		
		VLPMY POP m^{-2}							
DIURON (kg ai/ha)	VLPMY POP m^{-2}	400	1600	100	400	1600	100	400	1600
0	100	*	**	NS	NS	*	*	*	**
	400		NS	NS	NS	NS	NS	**	**
	1600			NS	NS	NS	NS	**	**
0.28	100				NS	NS	NS	NS	NS
	400					NS	NS	*	NS
	1600						NS	NS	NS
0.56	100							NS	NS
	400								NS

[a]A test for coincidence of all possible paired curve combinations indicated LOLMU HT at any density combined with any herbicide level was different from HT of VLPMY at any density combined with any herbicide level (data not shown). LOLMU and VLPMY results are therefore separated into two tables (2.8a and 2.8b) to facilitate interpretation.

Table 2.9. Comparison of paired curves at population levels for monoculture study natural logarithm of leaf area ratio, 1989[a].

	POP m^{-2}				
POP m^{-2}	L119	L198	V400	L595	V1600
V100	**	**	NS	**	NS
L119		NS	**	NS	**
L198			**	NS	**
V400				**	NS
L595					**

[a]V:VLPMY; L:LOLMU.

Table 2.10. Comparison of paired curves at population levels for monoculture study natural logarithm of leaf area, 1989[a].

POP m^{-2}	POP m^{-2} L119	L198	V400	L595	V1600
V100	**	**	NS	**	**
L119		NS	**	*	**
L198			**	NS	**
V400				**	**
L595					**

[a]V:VLPMY; L:LOLMU.

Table 2.11. Comparison of paired curves at herbicide levels for monoculture study natural logarithm of leaf area, 1989.

DIURON (kg ai/ha)	DIURON (kg ai/ha) 0.28	0.56
0	NS	*
0.28		*

Table 2.12. Comparison of paired curves at herbicide levels for monoculture study natural logarithm of net assimilation rate, 1989.

DIURON (kg ai/ha)	DIURON (kg ai/ha) 0.28	0.56
0	NS	**
0.28		**

Table 2.13. Comparison of paired curves at population levels for monoculture study natural logarithm of relative growth rate, 1989[a].

POP m^{-2}	POP m^{-2} L119	L198	V400	L595	V1600
V100	**	**	NS	**	**
L119		NS	**	NS	**
L198			**	**	**
V400				**	**
L595					**

[a]V:VLPMY; L:LOLMU

Table 2.14. Comparison of paired curves at herbicide levels for monoculture study natural logarithm of relative growth rate, 1989.

DIURON (kg ai/ha)	DIURON (kg ai/ha) 0.28	0.56
0	NS	**
0.28		**

Table 2.15. Comparison of paired curves at population levels for monoculture study natural logarithm of weight, 1989[a].

POP m^{-2}	POP m^{-2}				
	L119	L198	V400	L595	V1600
V100	**	**	*	**	**
L119		NS	**	**	**
L198			**	**	**
V400				**	*
L595					**

[a]L:LOLMU; V:VLPMY.

Table 2.16. Comparison of paired curves at herbicide levels for monoculture study natural logarithm of weight, 1989.

DIURON (kg ai/ha)	DIURON (kg ai/ha)	
	0.28	0.56
0	NS	**
0.28		**

Table 2.17. Analysis of variance for 1988 competition study biomass and yield

Source[a]	DF	LOLMU Seed[b] Mean Sq.	LOLMU Seed[b] Pr>F	LOLMU Biomass Mean Sq.	LOLMU Biomass Pr>F	DF	VLPMY Seed Mean Sq.	VLPMY Seed Pr>F	VLPMY Biomass Mean Sq.	VLPMY Biomass Pr>F
BLOCK(B)	2	0.0461	0.0007	2.3769	0.0105	2	0.0005	0.6656	9.3506	0.0001
LPOP(L)	3	2.7431	0.0001	296.9137	0.0001	4	0.2491	0.0001	16.4479	0.0003
ERROR(BL)	6	0.0143		0.5004		8	0.0005		0.7754	
VPOP(V)	4	0.1210	0.0029	91.95	0.0001	3	0.7676	0.0001	177.6852	0.0001
HERB(H)	2	0.0010	0.9166	1.6847	0.1815	2	0.0012	0.4741	2.0738	0.1731
V*H	8	0.0115	0.5	0.7914	0.5	6	0.0015	0.5	0.8704	0.5
L*V	12	0.0396	0.0441	17.6425	0.0001	12	0.0665	0.0001	8.6542	0.0051
L*H	6	0.0071	0.7106	0.7287	0.5267	8	0.0009	0.744	0.2947	0.9204
L*V*H	24	0.0048	0.9526	0.4054	0.9019	24	0.0005	0.9519	0.3009	0.9711
ERR(VH)	112	0.0114		0.7950		110	0.0015		0.8599	

[a]LPOP: LOLMU population; VPOP: VLPMY population; HERB: Diuron application rate. [b]Seed and biomass in g m^{-2}.

Table 2.18. Analysis of variance for 1989 competition study biomass and yield

Source[a]	DF	LOLMU Seed[b] Mean Sq.	LOLMU Seed[b] Pr>F	LOLMU Biomass Mean Sq.	LOLMU Biomass Pr>F	DF	VLPMY Seed Mean Sq.	VLPMY Seed Pr>F	VLPMY Biomass Mean Sq.	VLPMY Biomass Pr>F
BLOCK(B)	2	0.0506	0.0354	25.3228	0.4333	2	0.0027	0.6863	0.3273	0.2663
LPOP(L)	2	4.3179	0.0002	801.7154	0.0039	3	1.5134	0.0001	174.3603	0.0001
ERROR(BL)	4	0.0278		26.8311		6	0.0028		0.2097	
VPOP(V)	3	0.1654	0.0266	5.2891	0.9144	2	0.9201	0.0001	117.4888	0.0003
HERB(H)	2	0.0686	0.1488	27.4505	0.4658	2	0.0018	0.6704	2.9973	0.1784
V*H	6	0.0257	0.5	31.5443	0.5	4	0.0042	0.5	1.0960	0.5
L*V	6	0.0695	0.1262	35.3236	0.4471	6	0.5403	0.0002	75.6465	0.0005
L*H	4	0.0402	0.2974	23.9099	0.5884	6	0.0031	0.6398	2.4155	0.2321
L*V*H	12	0.0103	0.9161	27.1581	0.6129	12	0.0058	0.4017	1.5326	0.4025
ERR(VH)	66	0.0257		31.5792		64	0.0042		1.0947	

[a]LPOP: LOLMU population; VPOP: VLPMY population; HERB: Diuron application rate. [b]Seed and biomass in g m^{-2}.

Table 2.19. Summary of best seed yield or biomass linear models for competition in mixture between LOLMU and VLPMY in 1988[1].

	i=LOLMU, j=VLPMY				i=VLPMY, j=LOLMU			
	1/LOLMUy		1/LOLMUw		1/VLPMYy		1/VLPMYw	
Parameter	Est.	Pr>T	Est.	Pr>T	Est.	Pr>T	Est.	Pr>T
$b_{i,0}$	-0.12226	0.726	0.007503	0.0039	1.421951	0.0001	0.075939	0.4095
$b_{i,i}N_i$	0.012989	0.0001	0.000723	0.0001	0.005117	0.0001	0.00114	0.0001
$b_{i,j}N_j$	0.000423	0.0001	0.00014	0.0001	0.003146	0.0001	0.00059	0.0001
Competitive Ability	30.7068		5.1642		1.6265		1.9322	
R^2		0.8136		0.8995		0.4318		0.9362

[1]y:seed yield of individual; w:above ground dry weight of individual.

Table 2.20. Summary of best seed yield or biomass linear models for competition in mixture between LOLMU and VLPMY in 1989[1].

	i=LOLMU, j=VLPMY				i=VLPMY, j=LOLMU			
	1/LOLMUy		1/LOLMUw		1/VLPMYy		1/VLPMYw	
Parameter	Est.	Pr>T	Est.	Pr>T	Est.	Pr>T	Est.	Pr>T
$b_{i,0}$	-0.50387	0.0061	-0.00382	0.6763	0.242986	0.0001	0.004809	0.5646
$b_{i,i}N_i$	0.01138	0.0001	0.000673	0.0001	0.007064	0.0001	0.000793	0.0001
$b_{i,j}N_j$	0.000642	0.0001	1.33E-05	0.0733	0.051555	0.0001	0.005432	0.0001
Competitive Ability	17.7258		50.6015		0.137		0.1459	
R^2		0.8637		0.8938		0.9429		0.5273

[1]y:seed yield of individual; w:above ground dry weight of individual.

Table 2.21. Correlations between relative competitive ability and growth analysis parameters for 1989 competition study.

Growth Parameter	Correlation
HT	0.9358
LAR	0.9085
LA	0.8758
NAR	-0.8547
RGR	-0.6993
WT	0.8899

LOLMU AT 0 m^{-2}	VLMPY AT	VLMPY AT	VLMPY AT	VLMPY AT	VLMPY AT	VLMPY AT	VLMPY AT	VLMPY AT	VLMPY AT	VLMPY AT	VLMPY AT	VLMPY AT	VLMPY AT	VLMPY AT	VLMPY AT
LOLMU AT 119 m^{-2}	0 m^{-2}	100 m^{-2}	400 m^{-2}	1600 m^{-2}	6400 m^{-2}	0 m^{-2}	100 m^{-2}	400 m^{-2}	1600 m^{-2}	6400 m^{-2}	0 m^{-2}	100 m^{-2}	400 m^{-2}	1600 m^{-2}	6400 m^{-2}
LOLMU AT 198 m^{-2}	+ DIURON	+ DIURON	+ DIURON	+ DIURON	+ DIURON	+ DIURON	+ DIURON	+ DIURON	+ DIURON	+ DIURON	+ DIURON	+ DIURON	+ DIURON	+ DIURON	+ DIURON
LOLMU AT 595 m^{-2}	AT 0.00	AT 0.00	AT 0.00	AT 0.00	AT 0.00	AT 0.28	AT 0.28	AT 0.28	AT 0.28	AT 0.28	AT 0.56	AT 0.56	AT 0.56	AT 0.56	AT 0.56
LOLMU AT 1190 m^{-2}	kg ai ha^{-1}	kg ai ha^{-1}	kg ai ha^{-1}	kg ai ha^{-1}	kg ai ha^{-1}	kg ai ha^{-1}	kg ai ha^{-1}	kg ai ha^{-1}	kg ai ha^{-1}	kg ai ha^{-1}	kg ai ha^{-1}	kg ai ha^{-1}	kg ai ha^{-1}	kg ai ha^{-1}	kg ai ha^{-1}

Figure 2.1. Treatment placement for 1988 competition study. Each box represents a LOLMU density by VLPMY density by diuron rate. Treatments are arranged systematically solely for illustrative purposes, and were actually applied in randomized strips in a split block design; relative dimensions not to scale.

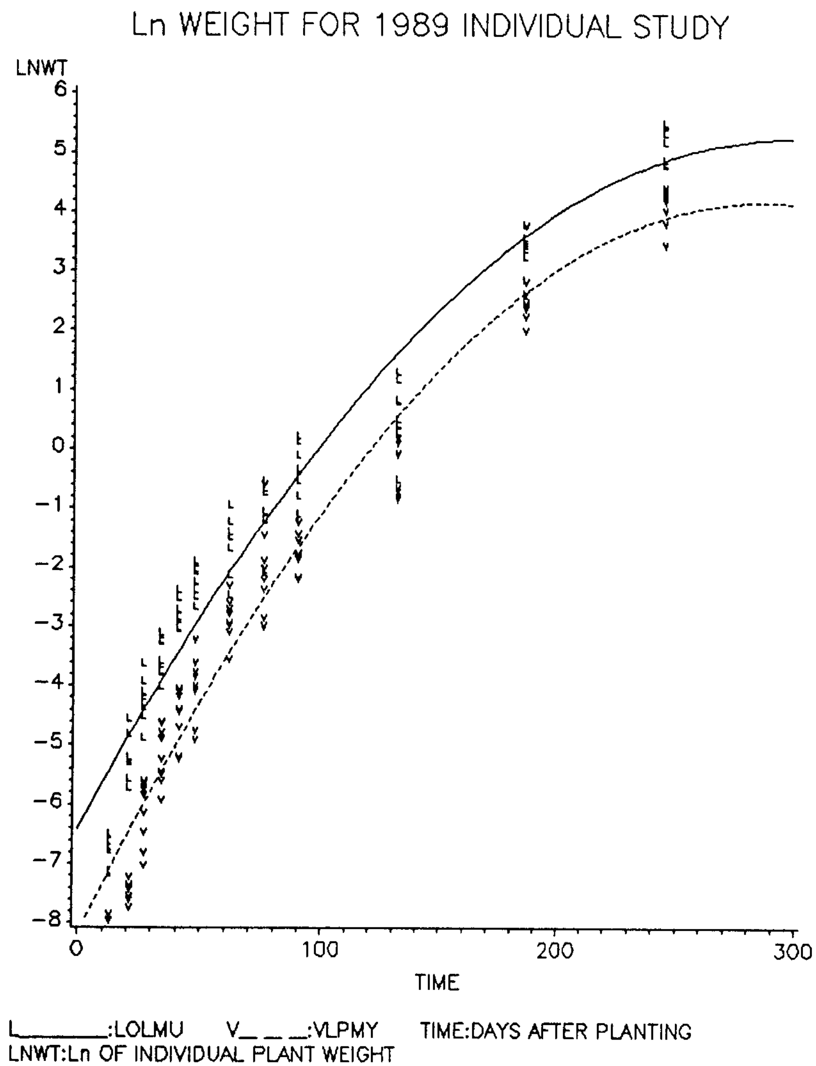


Figure 2.2. Ln weight by species for 1989 individual study.

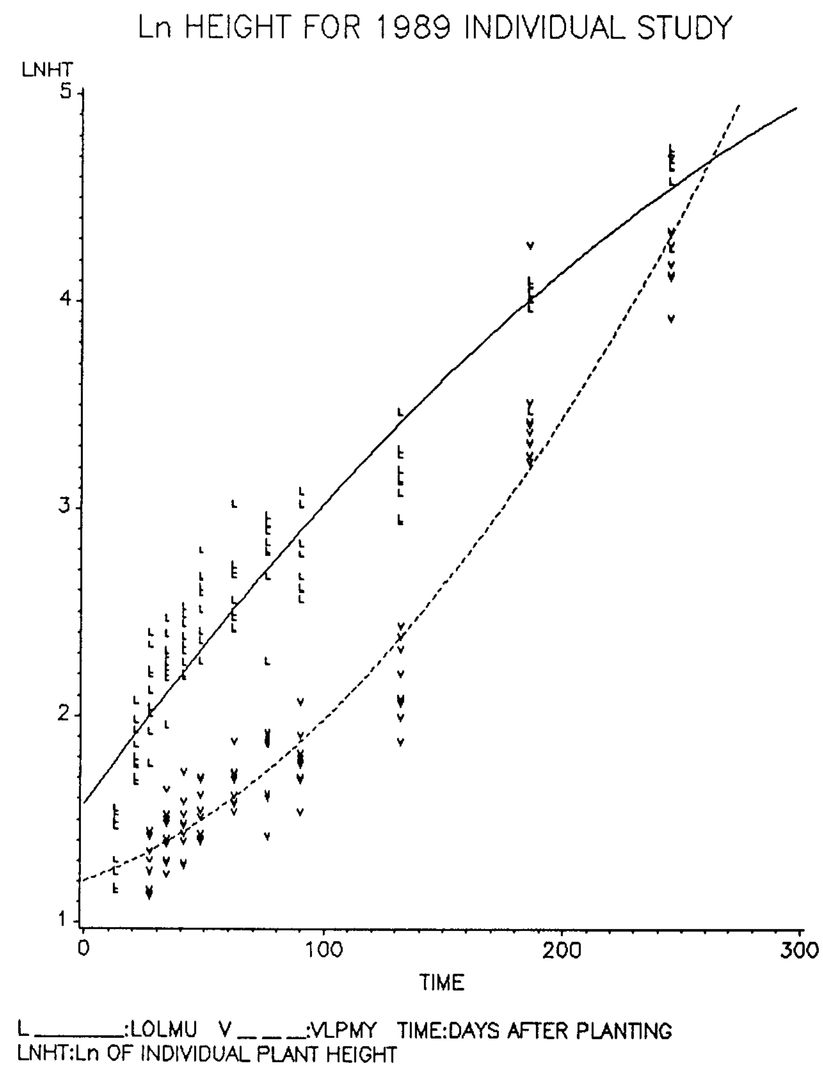


Figure 2.3. Ln height by species for 1989 individual study.

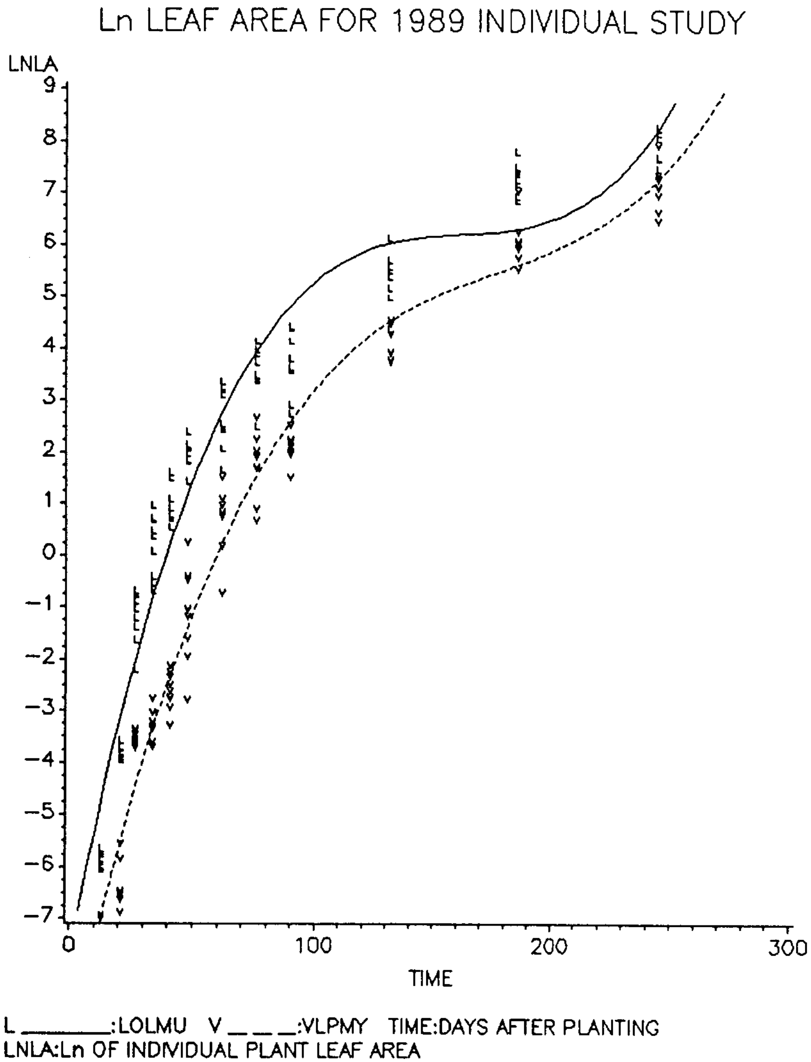


Figure 2.4. Ln leaf area by species for 1989 individual study.

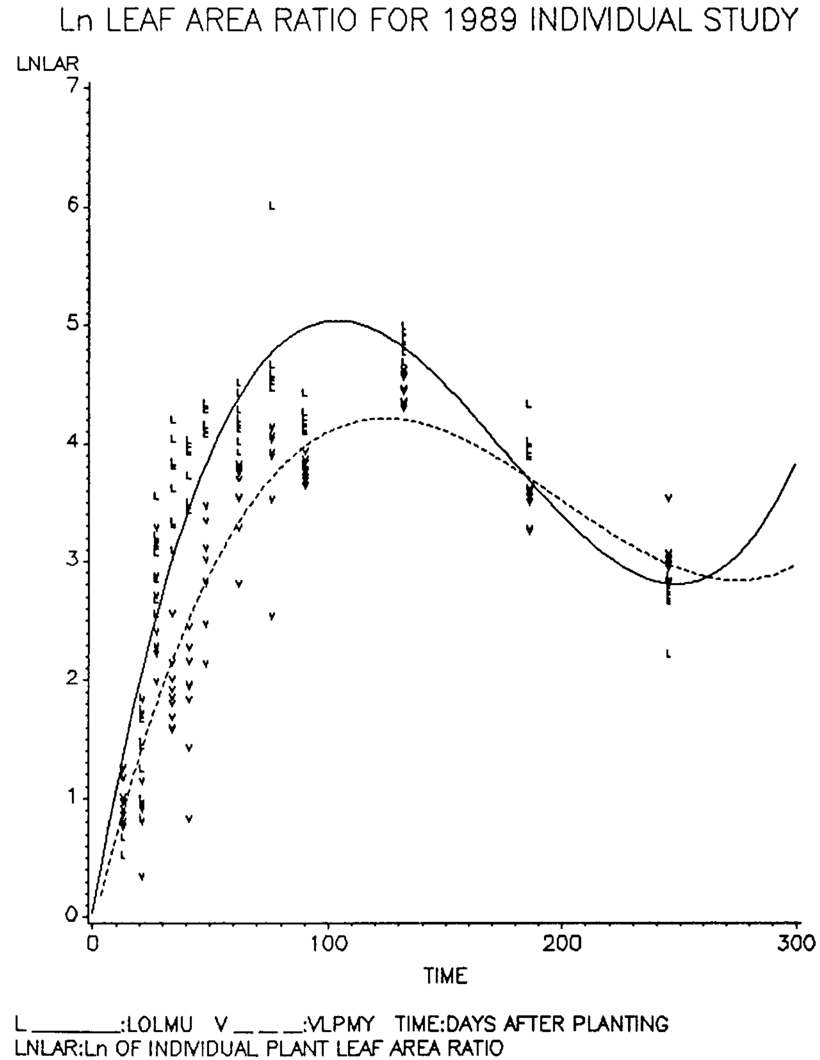


Figure 2.5. Ln leaf area ratio by species for 1989 individual study.

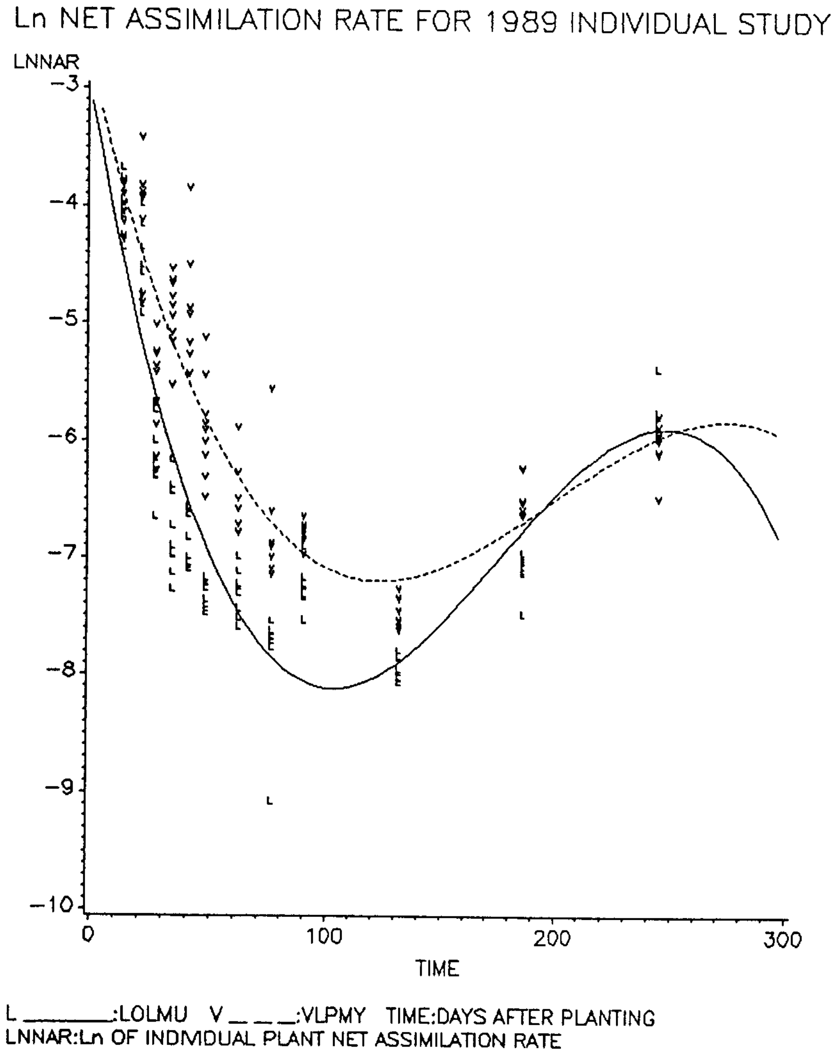


Figure 2.6. Ln net assimilation rate by species for 1989 individual study.

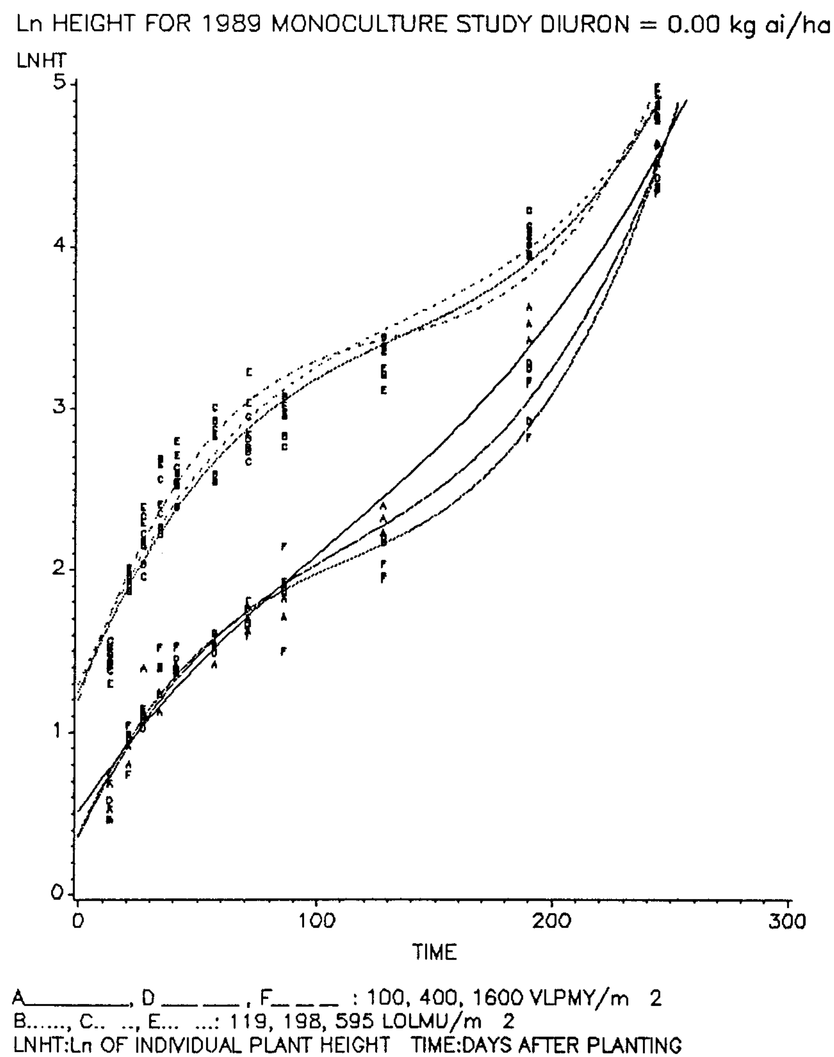


Figure 2.7a. Ln height by diuron (0) and species interaction, 1989 monoculture study.

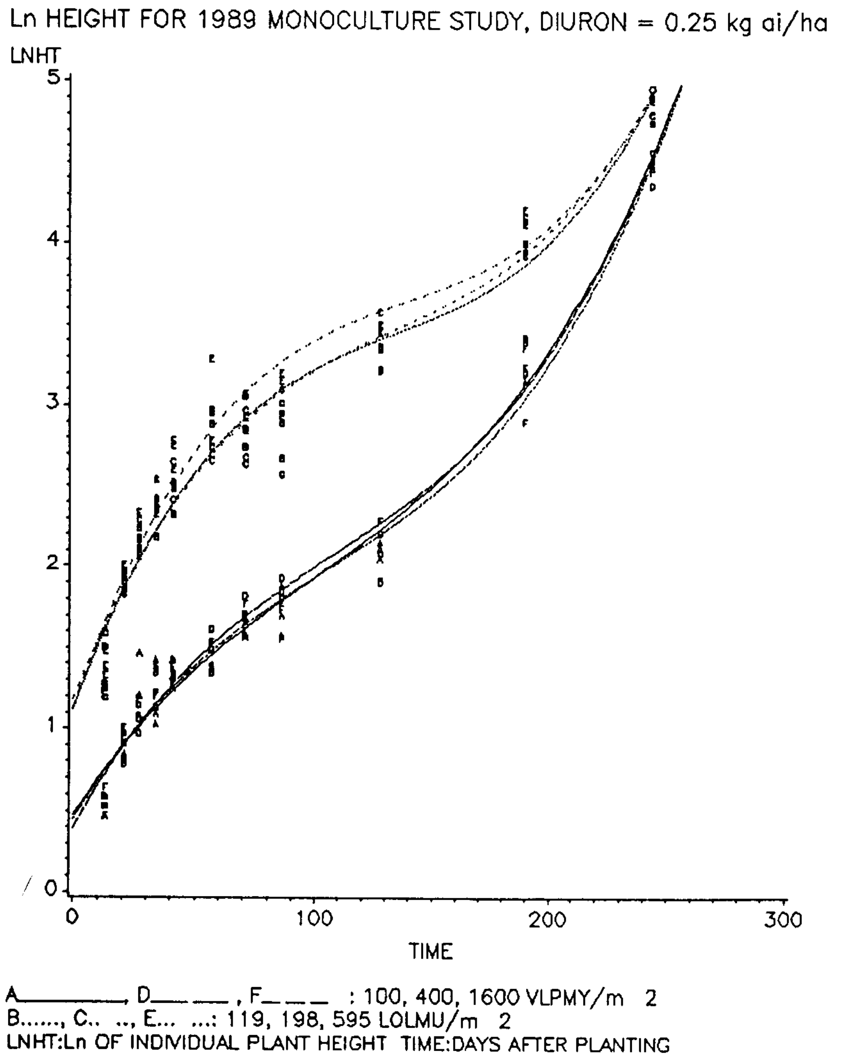


Figure 2.7b. Ln height by diuron (0.25) and species interaction, 1989 monoculture study.

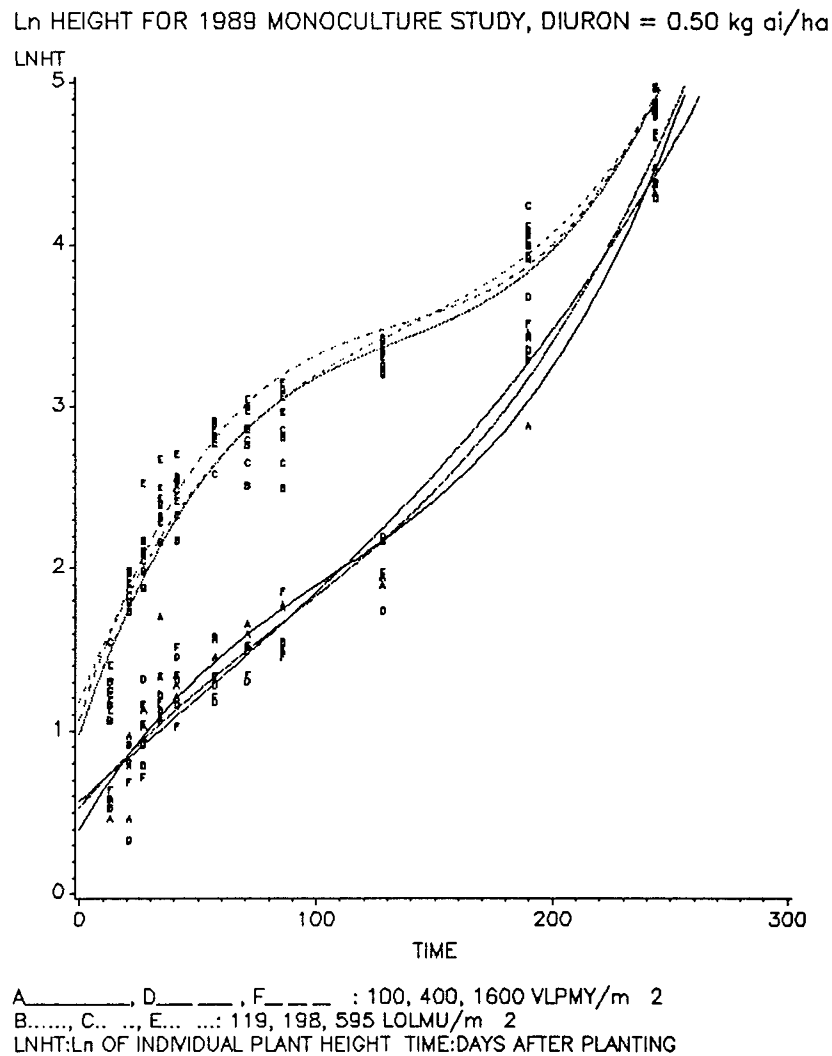


Figure 2.7c. Ln height by diuron (0.5) and species interaction, 1989 monoculture study.

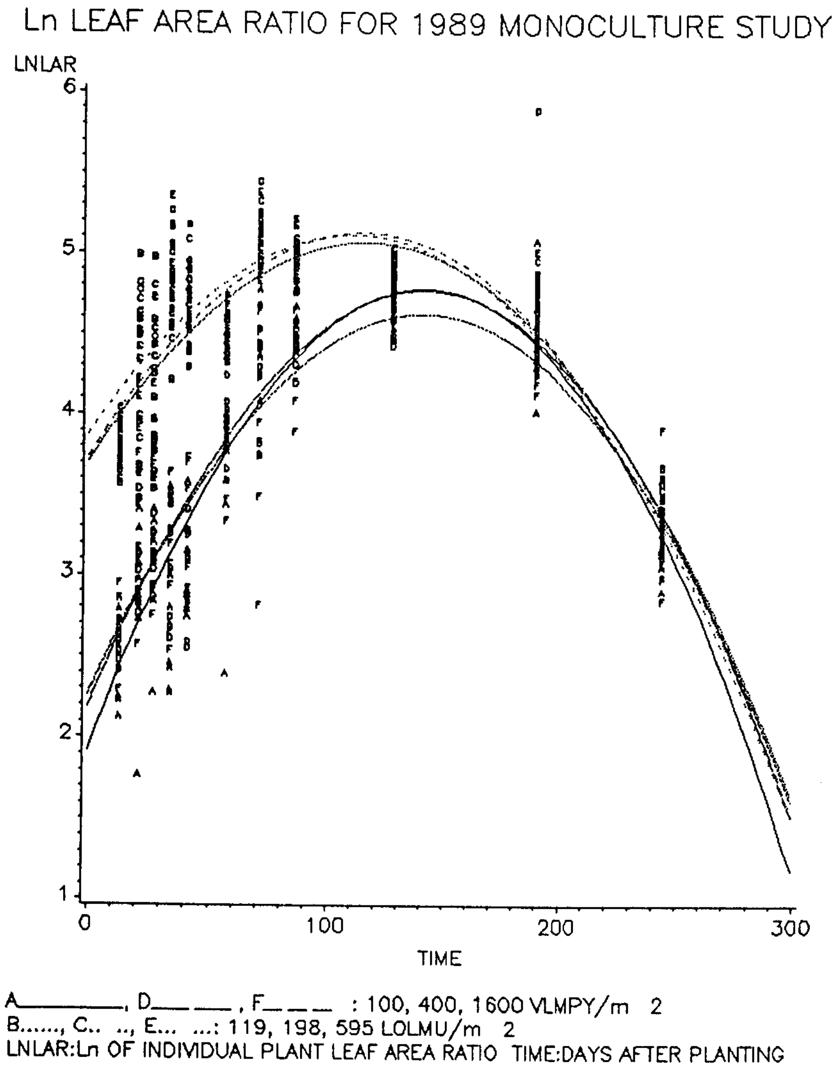


Figure 2.8. Ln leaf area ratio by population, 1989 monoculture study.

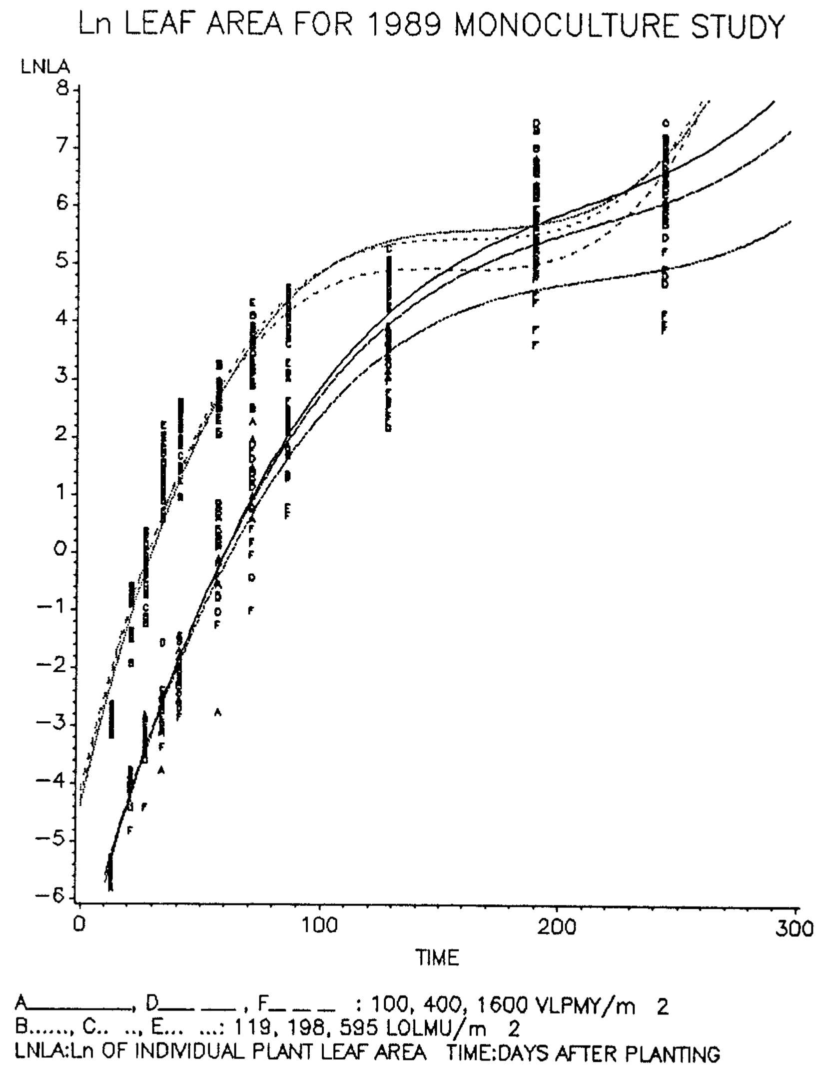


Figure 2.9. Ln leaf area by population, 1989 monoculture study.

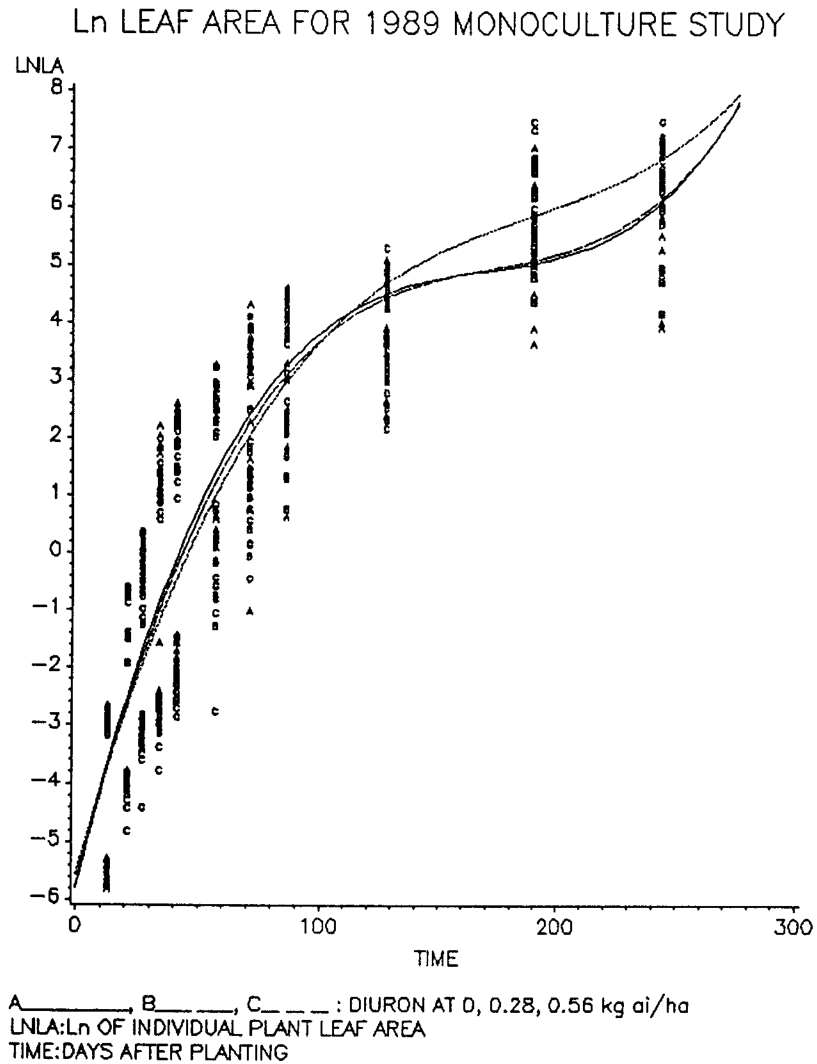


Figure 2.10. Ln leaf area by diuron level, 1989 monoculture study.

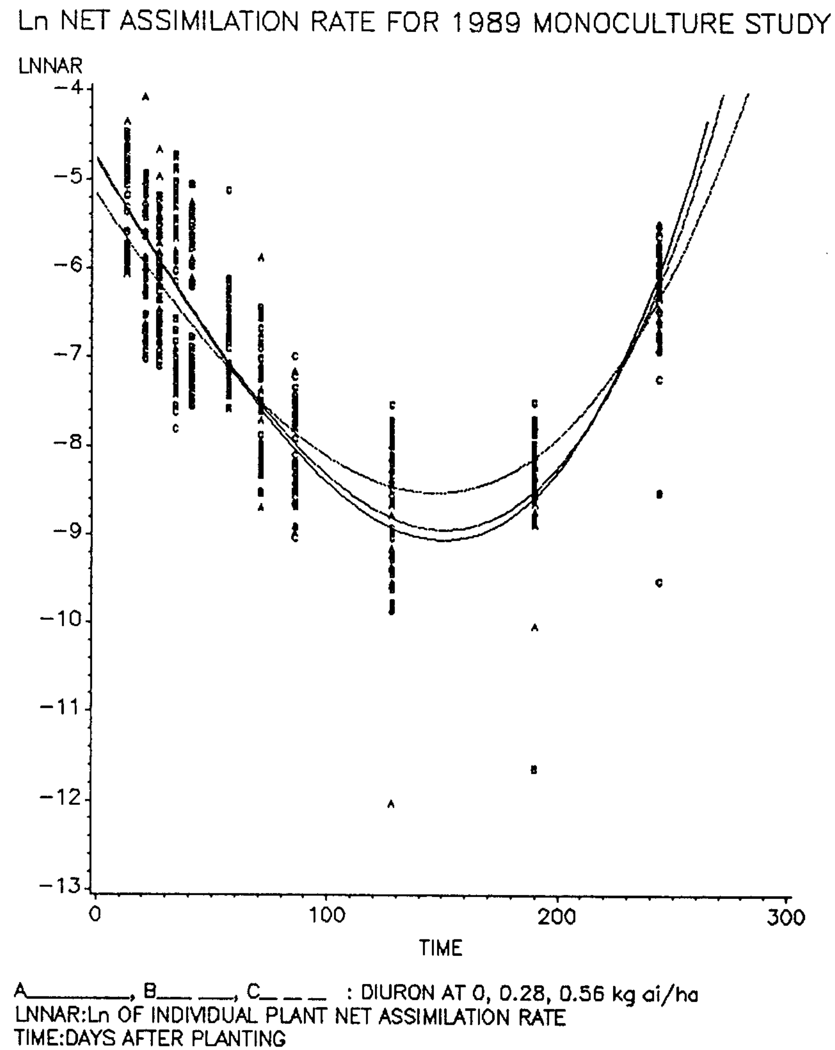


Figure 2.11. Ln net assimilation rate by diuron level, 1989 monoculture study.

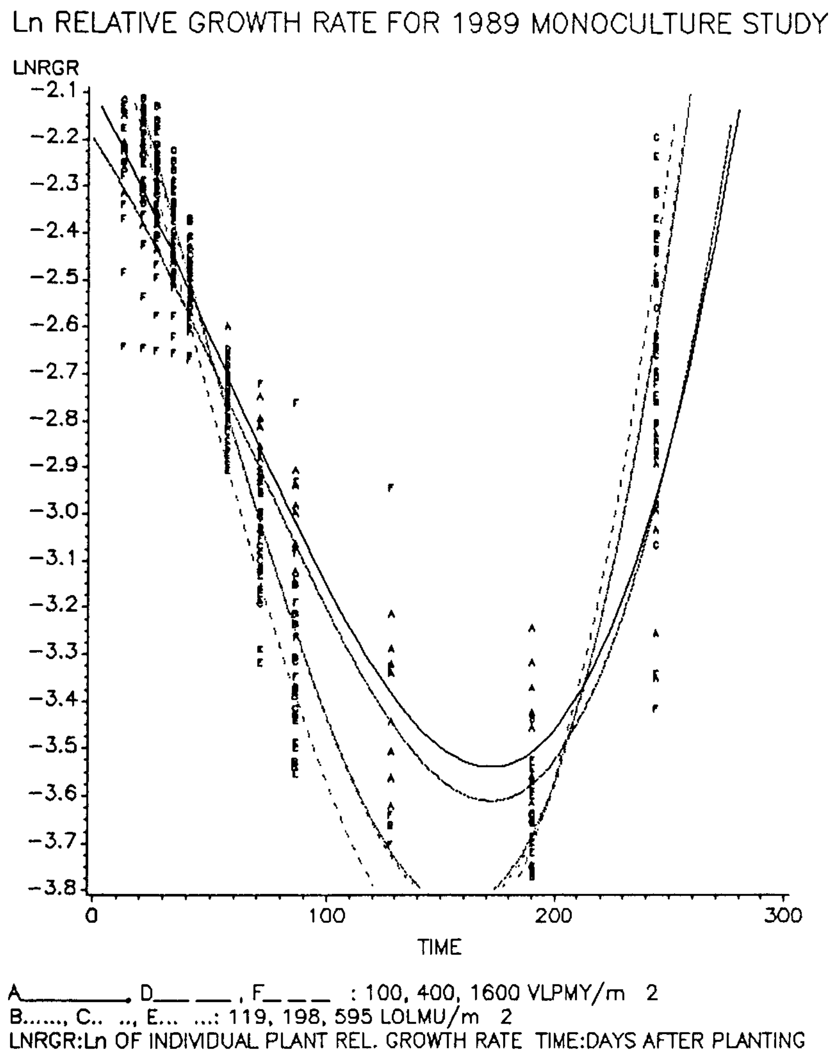


Figure 2.12. Ln relative growth rate by population, 1989 monoculture study.

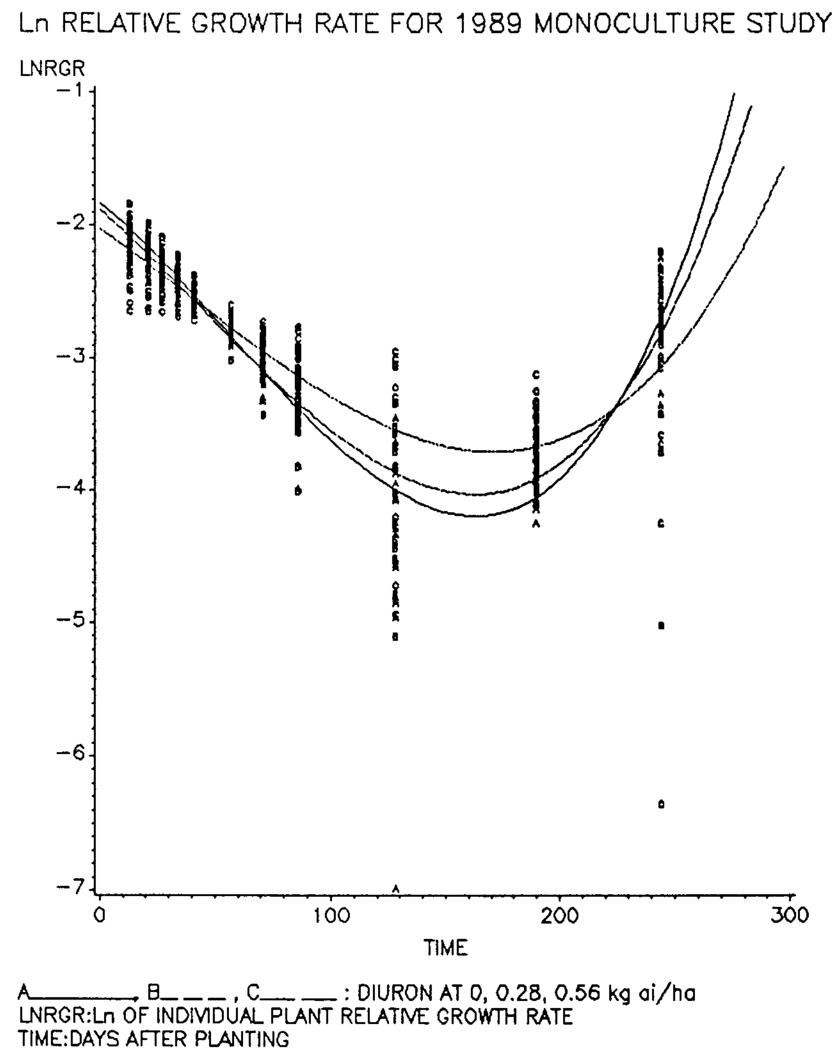


Figure 2.13 Ln relative growth rate by diuron level, 1989 monoculture study.

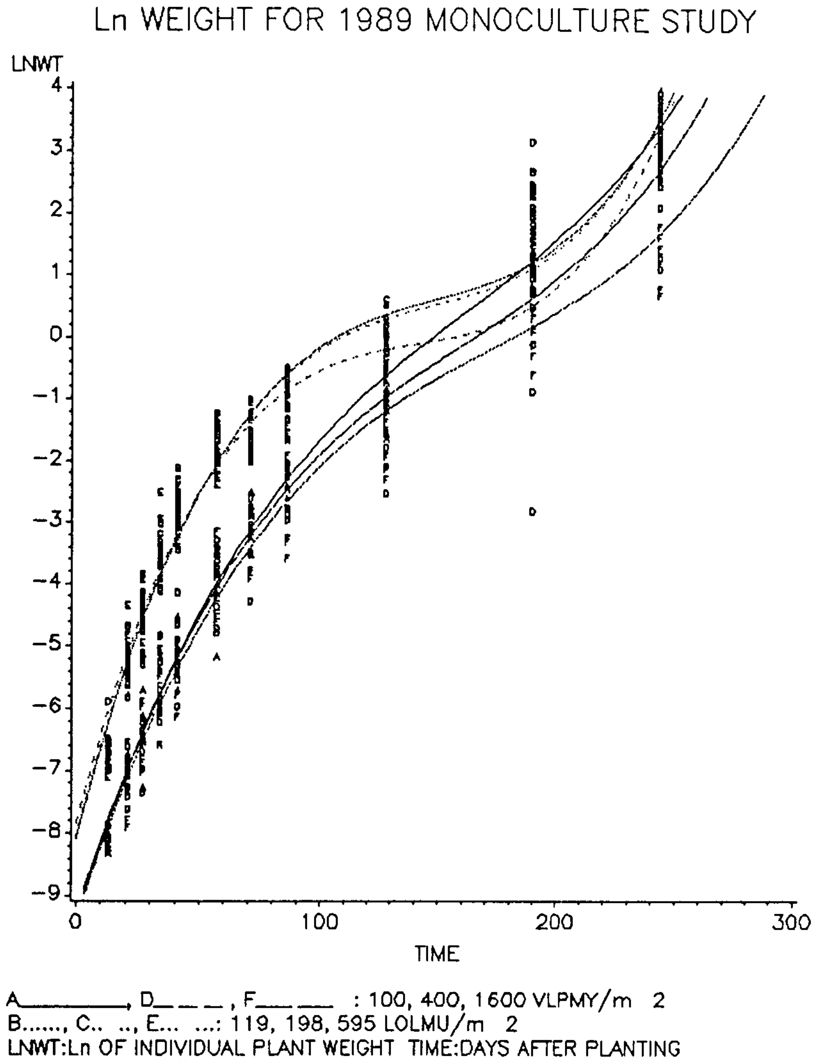


Figure 2.14. Ln weight by population, 1989 monoculture study.

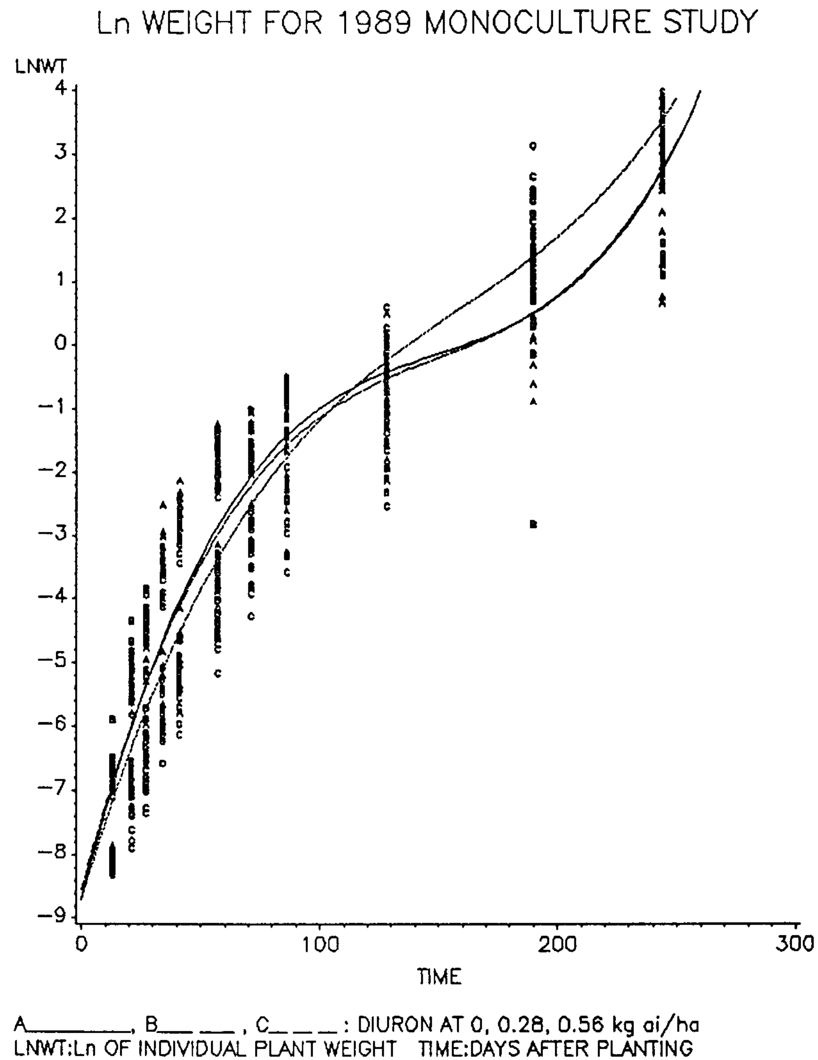


Figure 2.15. Ln weight by diuron level, 1989 monoculture study.

RECIPROCAL LOLMU PER PLANT SEED YIELD IN MIXTURE, 1988

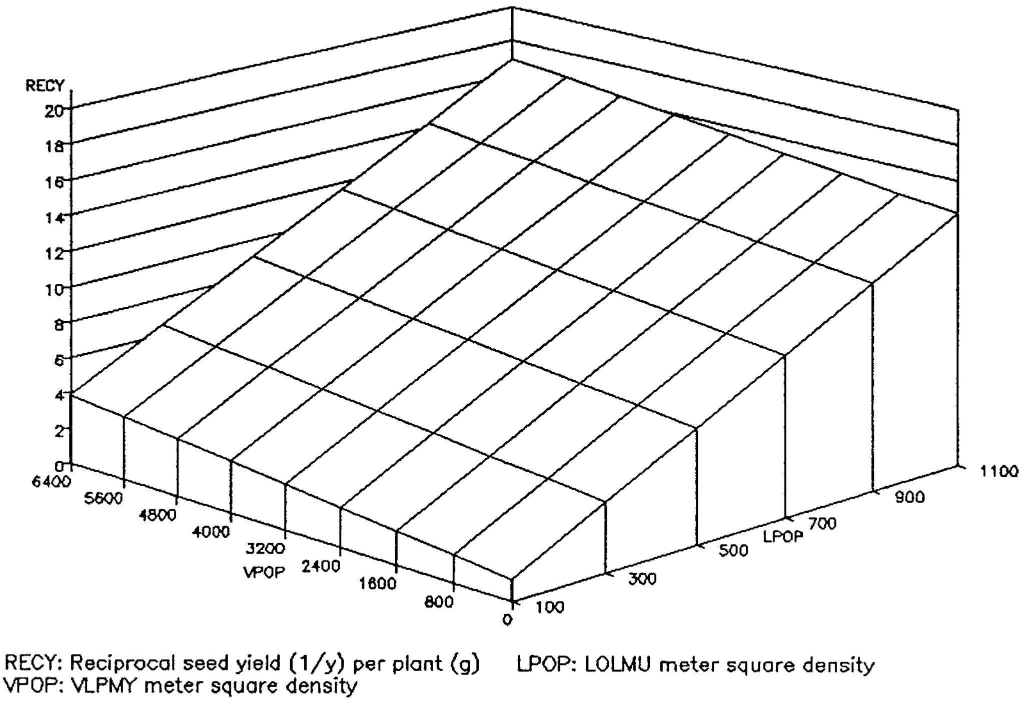


Figure 2.16. Reciprocal per plant LOLMU seed yield in mixture, 1988, r^2=0.81.

RECIPROCAL LOLMU PER PLANT DRY WEIGHT IN MIXTURE, 1988

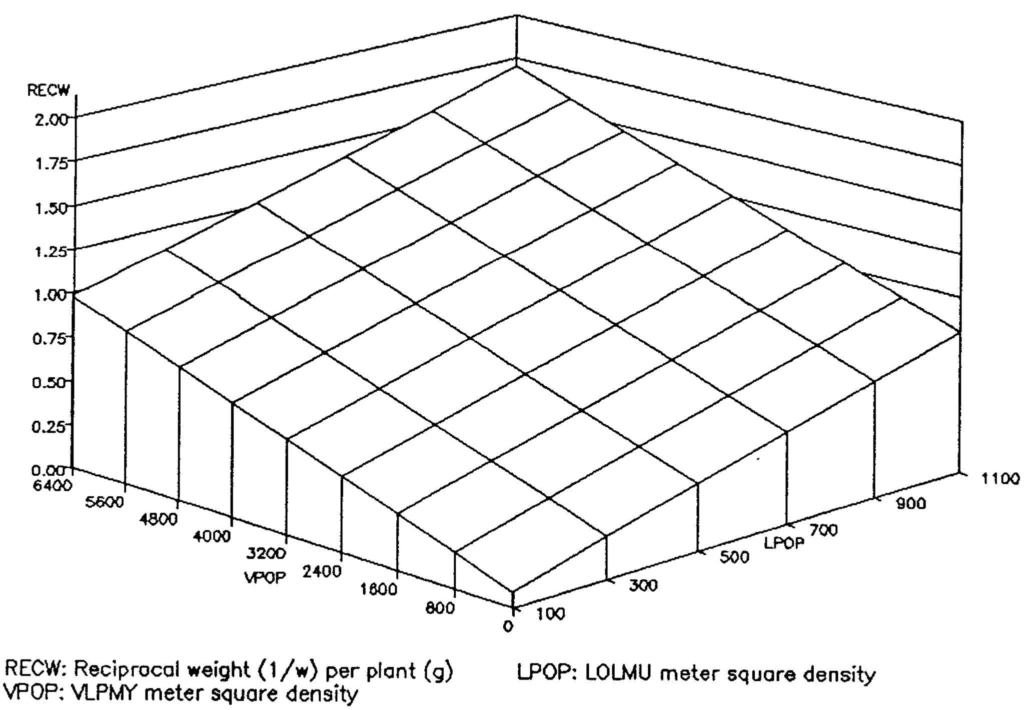
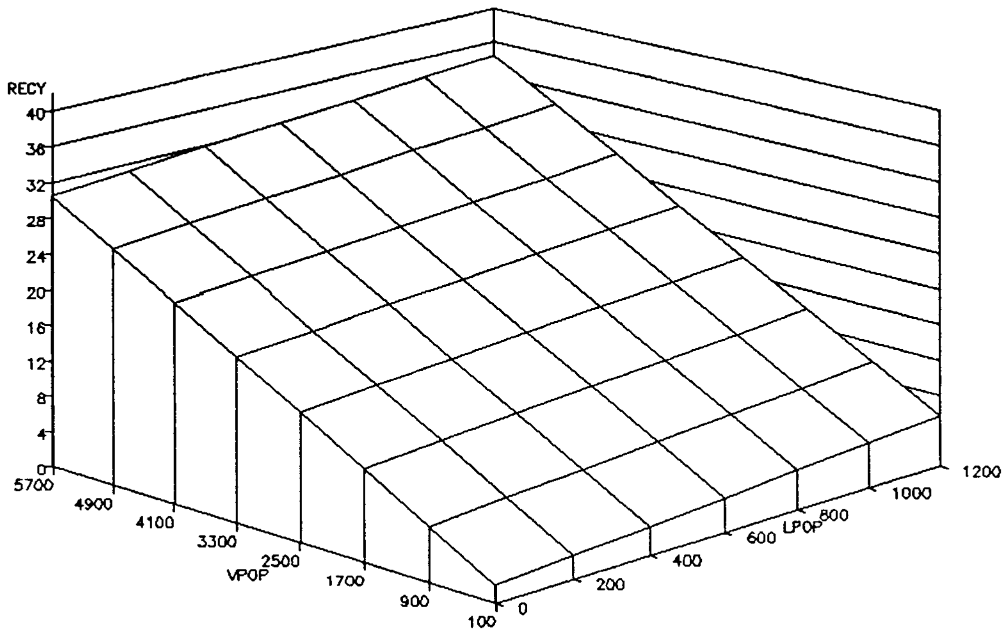


Figure 2.17. Reciprocal per plant LOLMU dry weight in mixture, 1988, r^2=0.89.

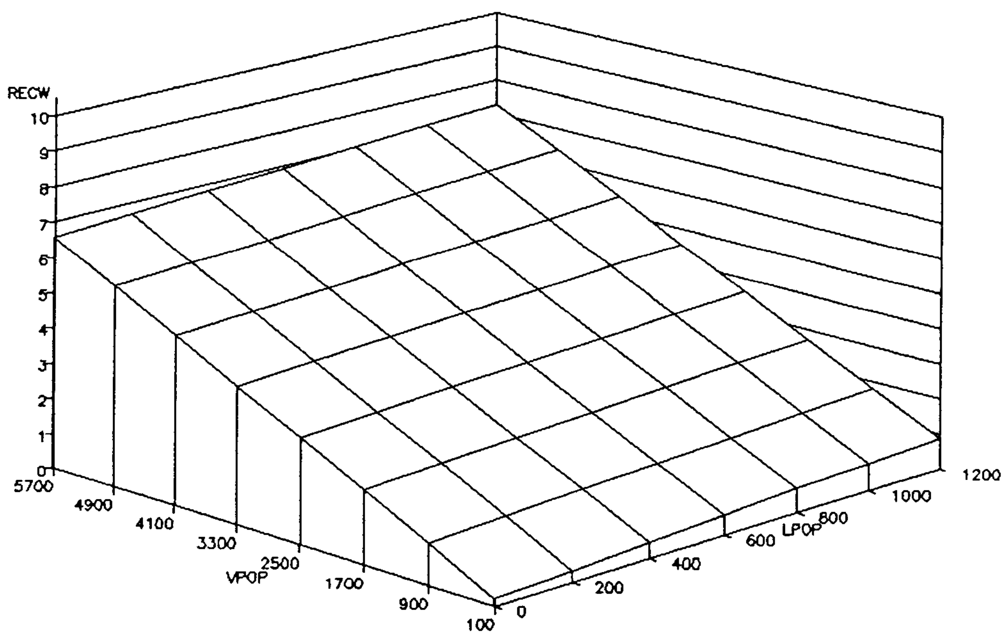
RECIPROCAL VLPMY PER PLANT SEED YIELD IN MIXTURE, 1988



RECY: Reciprocal seed yield (1/y) per plant (g) LPOP: LOLMU meter square density
VPOP: VLPMY meter square density

Figure 2.18. Reciprocal per plant VLPMY seed yield in mixture, 1988, r^2=0.43.

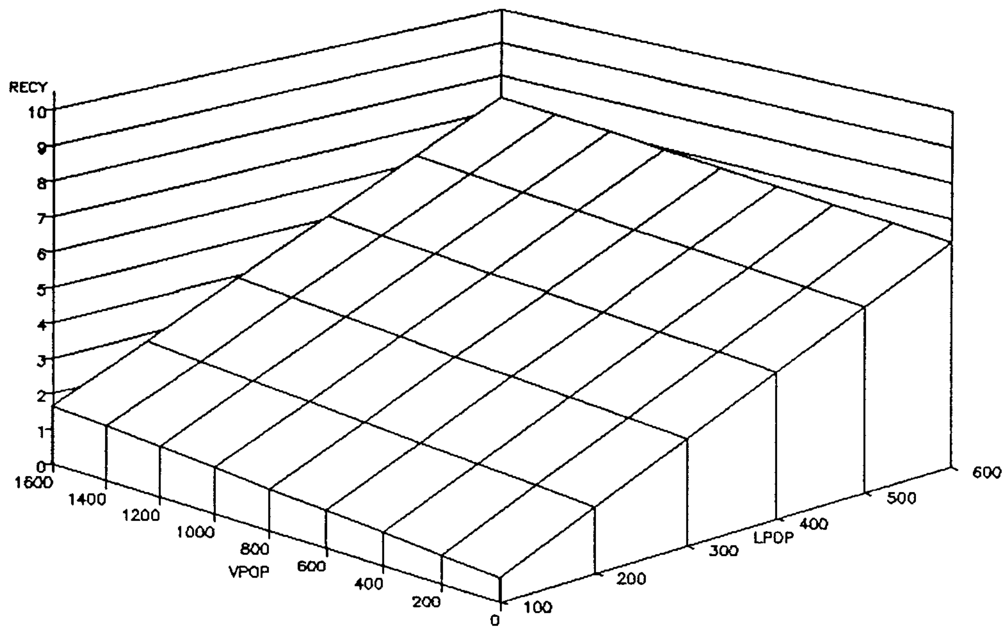
RECIPROCAL VLPMY PER PLANT DRY WEIGHT IN MIXTURE, 1988



RECW: Reciprocal weight (1/w) per plant (g) LPOP: LOLMU meter square density
VPOP: VLPMY meter square density

Figure 2.19. Reciprocal per plant VLPMY dry weight in mixture, 1988, r^2=0.93.

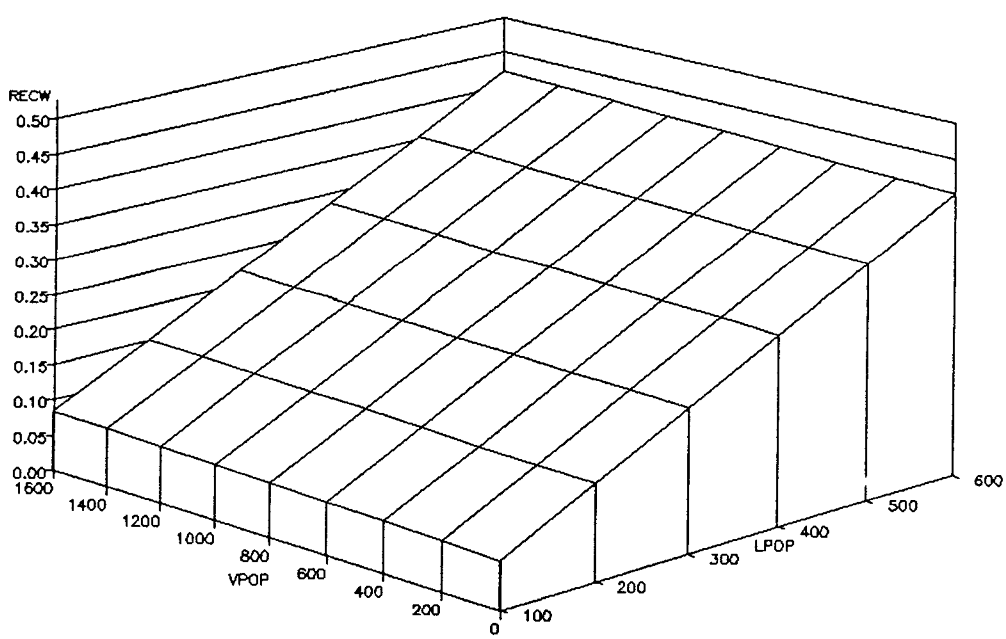
RECIPROCAL LOLMU PER PLANT SEED YIELD IN MIXTURE, 1989



RECY: Reciprocal seed yield (1/y) per plant (g) LPOP: LOLMU meter square density
VPOP: VLPMY meter square density

Figure 2.20. Reciprocal per plant LOLMU seed yield in mixture, 1989, r^2=0.86.

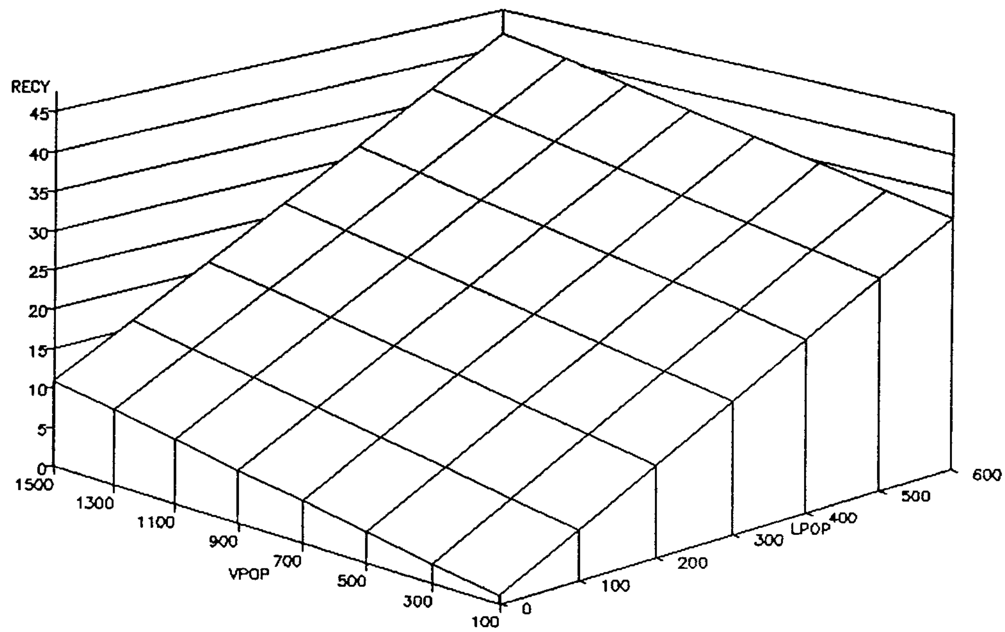
RECIPROCAL LOLMU PER PLANT DRY WEIGHT IN MIXTURE, 1989



RECW: Reciprocal weight (1/w) per plant (g) LPOP: LOLMU meter square density
VPOP: VLPMY meter square density

Figure 2.21. Reciprocal per plant LOLMU dry weight in mixture, 1989, r^2=0.89.

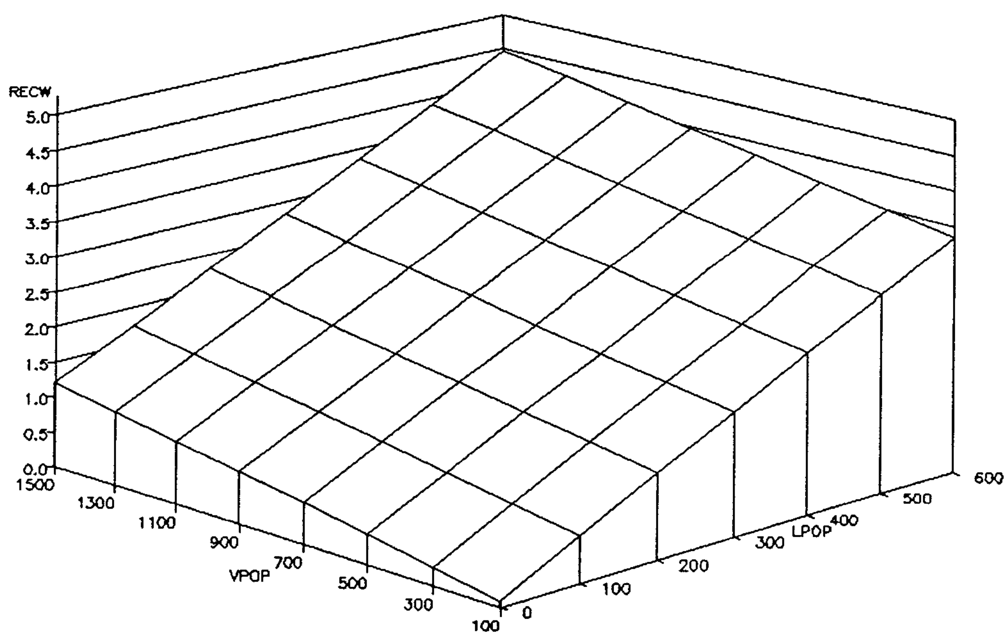
RECIPROCAL VLPMY PER PLANT SEED YIELD IN MIXTURE, 1989



RECY: Reciprocal seed yield (1/y) per plant (g) LPOP: LOLMU meter square density
VPOP: VLPMY meter square density

Figure 2.22. Reciprocal per plant VLPMY seed yield in mixture, 1989, r^2=0.94.

RECIPROCAL VLPMY PER PLANT DRY WEIGHT IN MIXTURE, 1989



RECW: Reciprocal weight (1/w) per plant (g) LPOP: LOLMU meter square density
VPOP: VLPMY meter square density

Figure 2.23. Reciprocal per plant VLPMY dry weight in mixture, 1989, r^2=0.52.

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CHAPTER 3

REPRESENTING RAINFALL OCCURRENCE AND DEPTH FOR PESTICIDE LEACHING AND DEGRADATION SIMULATIONS

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ABSTRACT

Elementary models for describing rainfall occurrence and depth are reviewed, and applied to meteorological records of Corvallis, Oregon. Daily first-order Markov transition and binomial probabilities were computed for observed rainfall records. First-order Markov-dependent models described observed probability distribution of rainy days per period, wet- and dry-run lengths, and first rainfall day better than binomial models of sequential independence. Calculated Markov distributions enabled identification of typical and extreme rainfall occurrence patterns. Observed rainfall depth was more closely represented by a mixed-exponential distribution rather than a simple-exponential distribution probability-density function.

INTRODUCTION

Field studies of pesticide leaching and degradation are difficult and expensive to conduct. Because waiting for average and extreme meteorological test conditions to occur can take years, supplemental laboratory leaching studies are used to expedite the process and reduce variability.

As methods for studying pesticide behavior in the environment are improved to reflect more realistic conditions, models can better account for the environmental fate of pesticides. Laboratory leaching experiments make use of soil thin-layer, thick-layer, or soil column chromatography (10). Degradation experiments require sampling and assaying pesticide-treated soil. Access to computers has made mathematical simulation popular; simulations have become increasingly sophisticated and accurate by including interpretations from field and laboratory leaching and degradation studies, soil physical and chemical properties, and pesticide chemical properties.

Leaching is directly related to water mass flow through soil. Degradation can be directly related to water by chemical hydrolysis, or indirectly by microbial activity. Lack of water prevents leaching and greatly reduces degradation.

While elaborate delivery systems have been developed (4,9), schemes for applying water in studies or mathematical simulations of leaching and degradation often oversimplify amounts and occurrence patterns of rainfall. Amounts are simplified by using averages; occurrence patterns are reduced to daily application, application every other day, every two days, and so on, facilitating interpretation of results. Such schemes can resemble irrigation schedules, however, they reflect natural rainfall poorly. Although simple occurrence and depth patterns are necessary for studying causes of leaching and degradation, realistic prediction additionally requires application schemes reflecting local environmental conditions. Because rainfall varies, simulating "typical" or "extreme" conditions is difficult (2).

One way to improve methods of study is to better simulate rainfall occurrence and amounts. The objectives of this paper are to review the first-order Markov-dependent and the binomial models of sequential independence for daily rainfall occurrence (1,8), to review the exponential and mixed-exponential models for rainfall amount (6), and to determine which models better describe observed occurrence patterns and depth of rainfall at Corvallis, Oregon.

MATERIALS AND METHODS

Rainfall occurrence models. The binomial model assumes that each day of rain is independent of any other day. The frequency, f_i, of rainfall occurrence, e, on day i is defined as

$$f_i = P(e_i = w) = 1 - P(e_i = d), \qquad (3.1)$$

where w represents wet day and d represents dry day.

The Markov model (1, 8) assumes that each day of rain depends on the occurrence or non-occurrence of rain on the previous day. The frequency of a wet day on day i, f_{wi}, and a dry day on day i, f_{di}, are defined as

$$f_{wi} = P(e_i = w \mid e_{i-1} = w), \qquad (3.2)$$

and

$$f_{di} = P(e_i = d \mid e_{i-1} = d). \tag{3.3}$$

Calculation of f_{wi} from historical weather data is as

$$f_{wi} = Y_{wi,\ i-1}/Y_{wi-1}, \tag{3.4}$$

where $Y_{wi,\ i-1}$ is the number of years day i and i - 1 received rain, and Y_{wi-1} is the number of years rain fell on day i - 1. Similarly, calculation of f_{di} from historical weather data is as

$$f_{di} = Y_{di,\ i-1}/Y_{di-1}. \tag{3.5}$$

Probability, p, of n rainy days per m-day interval. Gabriel and Neumann (1) define the unconditional probability of n wet days during an m-day interval for the Markov model as

$$p(n,m) = f_0[p_1(n,m)] + (1 - f_0)[p_0(n,m)] \tag{3.6}$$

where f_0 is the probability of rain at the start of the interval, $p_1(n,m)$ is the probability of n wet days during an m-day interval after an initial wet day, and $p_0(n,m)$ is the probability n wet days during an m-day interval after an initial dry day. The value $p_1(n,m)$ is defined as

$$p_1(n,m) = f_w^n f_d^{m-n} \sum_{c=1}^{c_1} \binom{n}{a}\binom{m-n-1}{b-1}\left(\frac{1-f_w}{f_d}\right)^b\left(\frac{1-f_d}{f_w}\right)^a \tag{3.7}$$

where $\binom{\alpha}{\beta}$ is the number of α distinct things taken β at a time. The summation upper limit, c_1, for eq. (3.7) is

$$c_1 = m + 1/2 - |2n - m + 1/2| \qquad n < m$$
$$c_1 = 0 \text{ if } n = m \tag{3.8}$$

and a and b are least integers not smaller than 1/2(c - 1) and 1/2c, respectively.

The value $p_0(n,m)$ is defined as

$$p_0(n,m) = f_w^n f_d^{m-n} \sum_{c=1}^{c_0} \binom{n-1}{b-1} \binom{m-n}{a} \left(\frac{1-f_w}{f_d}\right)^a \left(\frac{1-f_d}{f_w}\right)^b . \qquad (3.9)$$

The upper summation limit, c_0, for (3.9) is

$$c_0 = m + 1/2 - |2n - m - 1/2| \qquad n > 0$$
$$c_0 = 0 \text{ if } n = 0 \qquad (3.10)$$

and a and b are least integers as previously defined. The value for f_w and f_d in eqs. (3.7) and (3.9) are calculated from period averages of eqs. (3.2) and (3.3), respectively. The success of eq. (3.6) relies on reasonably stable f_d and f_w for the period.

The probability of n wet days during an m-day interval for sequentially independent events is a simple binomial distribution defined as

$$p(n,m) = \sum_{n}^{m} f_i^n (1-f_i)^{m-n} . \qquad (3.11)$$

Distribution of wet- and dry-run lengths. A wet- or dry-run of length k is a series of k wet or dry days preceded and followed by dry- or wet-days, respectively. Gabriel and Neumann (1) define the probability occurrence of a wet-run, w, k days in length, at period averaged f_{wi} for the period beginning day i as

$$p_{wi}(w=k) = (1-f_{wi+k})\, f_{wi}^{k-1} \qquad (3.12)$$

and, analogously for a dry run,

$$p_{di}(d=k)=(1-f_{di+k})\,f_{di}^{k-1} \tag{3.13}$$

To accommodate unstable f_d and f_w for the period k, Smith and Schreiber (8) redefine eqs. (3.12) and (3.13) as

$$p_{wi}(w=k)=(1-f_{wi+k})\prod_{j=i+1}^{i+k-1} f_{wj} \tag{3.14}$$

and

$$p_{di}(d=k)=(1-f_{di+k})\prod_{j=i+1}^{i+k-1} f_{dj}. \tag{3.15}$$

For sequentially independent events (binomial model), Smith and Schreiber (8) define the probability occurrence of a wet-run, w, k days in length, at constant f_i for the period beginning day i as

$$p_i(w=k)=f_i^{k-1}(1-f_i) \tag{3.16}$$

and, analogously for a dry run,

$$p_i(d = k) = f_i(1 - f_i)^{k-1}. \tag{3.17}$$

To accommodate an unstable f for the period k, Smith and Schreiber redefine eqs. (3.16) and (3.17) as

$$p_i(w=k)=(1-f_{i+k})\prod_{j=i+1}^{i+k-1} f_j \tag{3.18}$$

and

$$p_i(d=k)=f_{i+k}\prod_{j=i+1}^{i+k-1}(1-f_j). \tag{3.19}$$

First rainfall day, s, probability. The probability of rainfall starting on day s = n, n = 1,2,..., m, for a Markov-dependent process, given day i = 0, is defined by Smith and Schreiber (8) as

$$p(s=n)=(1-f_{dn})\prod_{i=1}^{n-1} f_{di}. \tag{3.20}$$

For a sequentially independent process, the starting day probability is

$$p(s=n)=f_n\prod_{i=1}^{n-1}(1-f_i). \tag{3.21}$$

Goodness of fit for all occurrence models to historical data was tested using a X^2 test.

Rainfall depth model. Richardson (6) compared the exponential, two-parameter gamma, and mixed-exponential probability-density functions for depicting rainfall depth. He suggested use of the exponential function for describing hydrologic processes sensitive to cumulative rainfall (e.g. water yield), because of ease of use and parameter estimation. The mixed-exponential model was suggested to estimate hydrologic processes sensitive to extremes in daily rainfall amounts, as well as cumulative rainfall.

The simple exponential distribution probability-density function for rainfall depth, D, is

$$p(D = x) = be^{-bx}, \tag{3.22}$$

where b is a distribution parameter and x is rainfall amount.

The mixed-exponential distribution-probability density function for rainfall depth, D, is

$$p(D = x) = wae^{-ax} + (1 - w)be^{-bx}. \qquad (3.23)$$

The distribution is the sum of two exponentially distributed random variables with parameters a and b, and weighing factor w.

Equations 3.22 and 3.23 were used as functions in a derivative-free nonlinear regression analysis in SAS (5,7). The analysis calculated optimum values for the constants of a function by converging from suggested initial values until the residual sum of squares could no longer be reduced. Suggested starting values were w = 0.75, a = 0.1, b = 0.5, and b = 0.1 for eqs. (3.23) and (3.22).

Richardson notes that eq. (3.23) reduces to (3.22) when w = 1. He compares models by determining how well each described observed rainfall statistics such as rainfall depth, annual maximum daily rainfall, and monthly rainfall. A less cumbersome method is available to compare models. When w = 0, eq. (3.23) reduces to eq. (3.22). Therefore model pairs can be subjected to an F test to determine if the additional terms added to the exponential distribution model significantly improves mathematical description of observed rainfall depth data. The test described by Neter et al. (3) is

$$F = \frac{SSE_r - SSE_f}{df_r - df_f} \div MSE_f \qquad (3.24)$$

where r = reduced model, f = full model, SSE = sum squared error term, df = degrees of freedom, MSE = mean squared error, reduced model = the equation with fewest terms, and full model = the equation with the greatest number of terms. The numerator degrees of freedom = $df_r - df_f$, and the denominator degrees of freedom = df_f.

Cumulative rainfall dependency. Spearman's rank correlation coefficients, r_s, were calculated for the pairs: cumulative rainfall for a 90-day period with number of rainfall days during a 90-day period, and cumulative rainfall for a 90-day period with average rainfall per day for a 90-day period.

Rainfall data. A 24-hour total rainfall of $\geq$ 0.01 inch was considered a rainfall event. Cumulative rainfall was recorded at 0800 every day; therefore, storms starting on the previous day after 0800 were included in the next day. No distinction was made between multiple storms in one day. Each model was fitted to 64 years of data from 1921 to 1984 for October 2 to December 30. Intervals of 15 days were used for eqs. (3.6) through (3.11). Equations (3.12) through (3.19) were fitted to 30-day intervals. Equations (3.20) through (3.23) were fitted to the entire 90-day period.

RESULTS AND DISCUSSION

Probability, p, of n rainy days per m-day interval. The Markov-dependent model (eq.(3.6)) closely matched observed probabilities, whereas, the binomial model (eq.(3.11)) under-weighted extreme and over-weighted median observed probabilities (Figure 3.1). Goodness of fit to historical data was superior when described by the Markov model (Table 3.1).

Distribution of wet- and dry-run lengths. The Markov-dependent models (eqs.(3.16 & 3.17)) matched observed wet- and dry-run length probability distributions better than binomial models (eqs. (3.12 & 3.13), Tables 3.2 & 3.3). Analogous equations for unstable f_d, f_w, and f (eqs. 3.14 & 3.15, 3.18, & 3.19) matched observed wet- and dry-run length data more poorly than the Markov-dependent and binomial models (results not show).

First rainfall day, s, probability. The Markov-dependent model represented starting day probability (eq. (3.20), X^2 = 4.105, d.f. = 7) better when compared to the binomial model (eq. (3.21), X^2 = 48.070, d.f. = 5, Figure 3.2). Both the observed data and the Markov-dependent model indicated the cumulative probability of rain exceeded 50 % by day 4, or October 6, at Corvallis, Oregon.

Rainfall depth model. The mixed-order exponential model described observed rainfall per day better than the exponential model (F = 547.915, with 2, 203 d.f., Figure 3.3). Both the observed data and the mixed-order exponential models indicated that a rainfall depth per day of 0.2 inches, or 5 mm, had a 50 % cumulative probability.

Cumulative rainfall dependency. The Spearman's rank correlation coefficients for number of rainy days and average daily rainfall depth per 90-day period, when paired with cumulative rainfall, were $r_s = 0.3094$ and $r_s = 0.8158$.

The Markov-dependent models described observed rainfall data distributions better than binomial models. Varied goodness of fit in the Markov models was attributed to inability to represent outliers in observed data; whereas, reduced fit in binomial models was attributed to improperly weighted distributions in addition to inability to represent outliers (Figure 3.1). Reduced degrees of freedom for binomial models was caused by overweighing at the median of distributions which forced combination of extreme classes.

As the peak of the rainy season approached, the increase in rainfall was reflected by a decrease in f_d, and increase in f_w, and an increase in f (Tables 3.1, 3.2, and 3.3). This result is also observed in similar studies (1,6).

The Spearman's rank correlation coefficients indicate total rainfall differences from year to year were positively and strongly correlated to changes in average rainfall amount per day for the given period. A representative simulation of rainfall for our data would emphasize changes in average amount per day rather than occurrence patterns. Wet- and dry-day run lengths and occurrence could be kept constant at weighted means of their Markov-dependent probability-density distributions while average rainfall per day is varied to represent different years. Probabilities of "extreme" or "typical" years can be determined by considering probabilities of daily rainfall amounts.

Rainfall patterns were best represented by Markov-dependent models. Rainfall depth was best represented by the mixed-exponential model. Although the models are descriptive and not predictive, the smooth probability distributions generated for occurrence and depth can be used as a guideline when representing rainfall. Realistic representation of rainfall will benefit field and laboratory studies, as well as mathematical simulation of pesticide leaching and degradation.

Table 3.1. X^2 values for rainy days per interval.

Season Day Period	Markov					Binomial		
	f_d^*	f_w	f_0	X^2	d.f.	f	X^2	d.f.
02-16	0.806	0.648	0.203	5.119	6	0.352	17.401	5
17-31	0.711	0.696	0.281	2.534	6	0.472	21.277	6
32-46	0.702	0.772	0.562	1.470	7	0.569	23.013	5
47-61	0.674	0.784	0.625	12.96	5	0.594	29.783	4
62-76	0.650	0.782	0.703	4.575	7	0.629	29.131	5
77-91	0.618	0.795	0.515	2.789	7	0.650	22.089	5

*$f_{wi} = P(e_i = w \mid e_{i-1} = w)$, period averaged
$f_{di} = P(e_i = d \mid e_{i-1} = d)$, period averaged
$f_i = P(e_i = w) = 1 - P(e_i = d)$, f_0 and f, period start and period averaged.

Table 3.2. X^2 values for wet run length distribution.

Season Day Period	Markov			Binomial		
	f_w	X^2	d.f.	f	X^2	d.f.
02-31	0.672	53.575	11	0.412	161.570	8
32-61	0.778	30.516	11	0.582	192.727	6
62-91	0.789	30.915	8	0.639	287.498	4

Table 3.3. X^2 values for dry run length distribution.

Season Day Period	Markov			Binomial		
	f_d	X^2	d.f.	f	X^2	d.f.
02-31	0.758	40.881	11	0.412	194.929	6
32-61	0.688	8.056	8	0.582	332.257	4
62-91	0.634	19.450	7	0.639	334.529	4

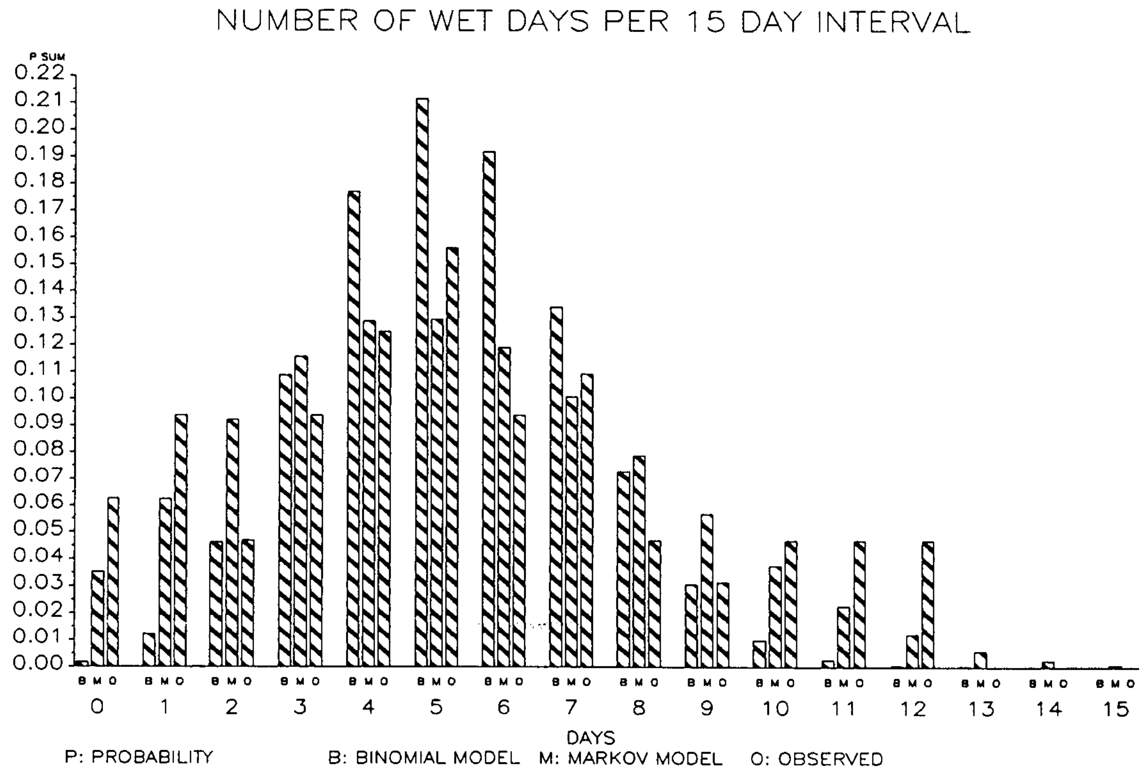

Figure 3.1. Observed, Markov (x^2=5.11), and binomial (x^2=17.40) distribution of the number of wet days per 15 day interval (first 15 day interval of season).

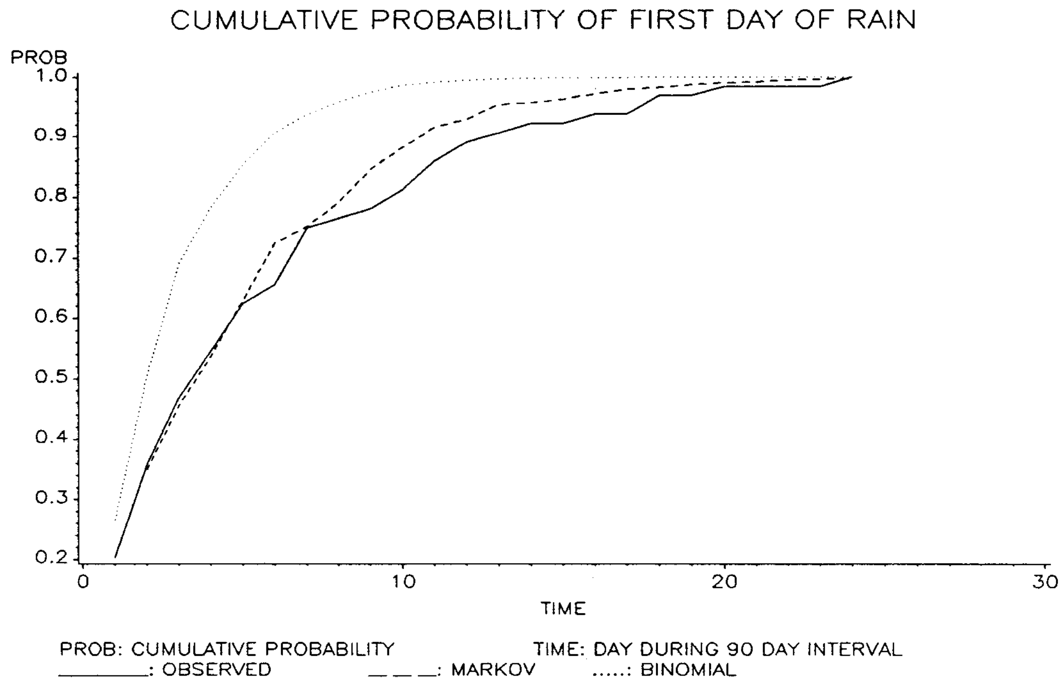

Figure 3.2. Observed, Markov (x^2=4.1), and binomial (x^2=48.07) cumulative probability for first day of rain in the 90 day interval.

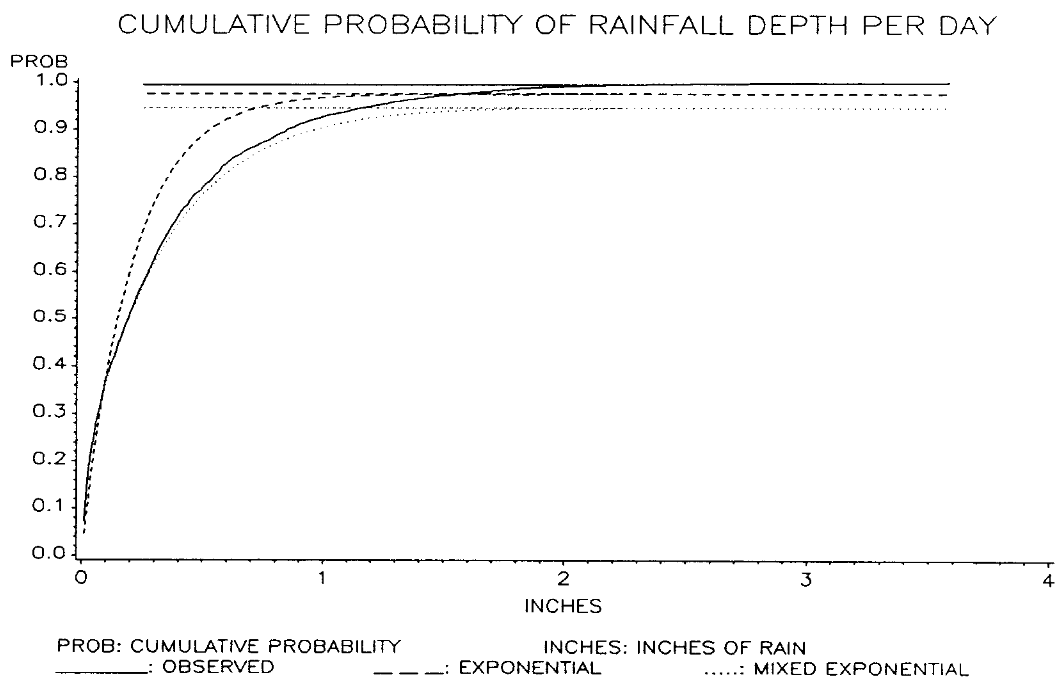

Figure 3.3. Observed, exponential, and mixed exponential cumulative probability for rainfall depth per day.

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CHAPTER 4

GENERAL CONCLUSIONS

In this dissertation, two alternatives to using activated carbon as a safener to preemergence, nonselective herbicide treatments in establishing Italian ryegrass grown for seed were investigated. Additionally, elementary models for rainfall depth and occurrence were reviewed and tested on data from Corvallis, Oregon.

Greenhouse and growth chamber study results correspond in most cases with response of grasses to directed herbicide sprays in the field. The exception was oryzalin, with which above ground growth in the field developed normally until early spring, and then the plants died. Examination revealed club-like roots, characteristic of oryzalin injury. I concluded that the underdeveloped roots were able to meet the lower growth requirements through winter. When spring arrived, moisture and nutrient uptake were insufficient and the crop died. Greenhouse and growth chamber studies were too short or not stressed enough to exhibit such a response.

The directed herbicide spray study results were encouraging. However, I recognize that conditions of freezing saturated soils have caused inconsistent results in crop response to directed herbicide sprays. Possible causes for increased injury include root breakage, seedling heave into treated soil, increased plant susceptibility due to stress, and herbicide movement. Further investigation of directed herbicide sprays in aggressive growing grasses therefore resilient to stand thinning is encouraged.

The increased diuron concentration found in the crop row when mapped for the broadcast application over carbon was unexpected. Its presence reinforces the concept of biological availability. That is, although laboratory analysis can detect minute amounts of herbicide residues, not all residues are biologically significant.

In the competition studies, plant growth was altered by diuron. However, the effect was not great enough to manifest itself in seed yield or final above ground biomass. A higher rate of diuron should have been used in the studies. Such a study could be difficult to interpret because the effects of herbicide suppression on growth might be compounded by stand reductions. If the competitive balance was shifted in favor of the crop in such a study, use of this cultural practice would likely be limited to pasture, range, or forest production, where there is no direct consumer demand for unblemished commodities.

The Markov and mixed-exponential models adequately described rainfall occurrence and depth patterns for Corvallis, Oregon. Although current meteorological research employs models that are much more sophisticated, these models are easy to work with and do a good job for summarizing rainfall in our region. I hope that as research on herbicide degradation and leaching evolves, the nature of rainfall depth and occurrence patterns will be incorporated into studies.

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APPENDIX

Appendix Table 1.1. Parts per million diuron soil residue.

Study[1]	Block	Depth Interval	Width Interval	PPM
B1	1	1	-2	4.1696
B1	1	2	-2	3.225878
B1	1	3	-2	3.214167
B1	1	4	-2	1.377151
B1	1	5	-2	1.248908
B1	1	6	-2	1.198597
B1	1	7	-2	1.095199
B1	1	1	-1	0.976098
B1	1	2	-1	0.378818
B1	1	3	-1	0.374851
B1	1	4	-1	0.236964
B1	1	5	-1	0.177151
B1	1	6	-1	0.170263
B1	1	7	-1	0.154419
B1	1	1	0	0.133936
B1	1	2	0	0.05396
B1	1	3	0	0.05373
B1	1	4	0	0.05063
B1	1	5	0	0.046658
B1	1	6	0	0.046153
B1	1	7	0	0.041661
B1	1	1	1	0.040642
B1	1	2	1	0.038576
B1	1	3	1	0.037887
B1	1	4	1	0.034129
B1	1	5	1	0.032439
B1	1	6	1	0.032204
B1	1	7	1	0.029924
B1	1	1	2	0.028881
B1	1	2	2	0.028339
B1	1	3	2	0.019288
B1	1	4	2	0.017221
B1	1	5	2	0.015536
B1	1	6	2	0.015029
B1	1	7	2	0.013995
B1	2	1	-2	1.090596
B1	2	2	-2	0.420138
B1	2	3	-2	0.051206
B1	2	4	-2	0.04579
B1	2	5	-2	0.041625
B1	2	6	-2	0.026598
B1	2	7	-2	0.015219
B1	2	1	-1	2.311817
B1	2	2	-1	0.69419
B1	2	3	-1	0.141718
B1	2	4	-1	0.045298
B1	2	5	-1	0.034466
B1	2	6	-1	0.023397
B1	2	7	-1	0.013447

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
B1	2	1	0	2.911374
B1	2	2	0	0.790251
B1	2	3	0	0.190655
B1	2	4	0	0.084195
B1	2	5	0	0.034431
B1	2	6	0	0.023634
B1	2	7	0	0.012706
B1	2	1	1	2.412112
B1	2	2	1	0.677991
B1	2	3	1	0.156081
B1	2	4	1	0.052191
B1	2	5	1	0.040973
B1	2	6	1	0.042672
B1	2	7	1	0.013188
B1	2	1	2	1.103944
B1	2	2	2	0.414968
B1	2	3	2	0.07484
B1	2	4	2	0.041393
B1	2	5	2	0.039355
B1	2	6	2	0.023205
B1	2	7	2	0.013199
B1	3	1	-2	0.976893
B1	3	2	-2	0.319938
B1	3	3	-2	0.118902
B1	3	4	-2	0.091088
B1	3	5	-2	0.049197
B1	3	6	-2	0.034179
B1	3	7	-2	0.013107
B1	3	1	-1	2.81564
B1	3	2	-1	0.562403
B1	3	3	-1	0.136717
B1	3	4	-1	0.093734
B1	3	5	-1	0.047126
B1	3	6	-1	0.036769
B1	3	7	-1	0.013159
B1	3	1	0	3.260487
B1	3	2	0	0.716209
B1	3	3	0	0.306577
B1	3	4	0	0.129467
B1	3	5	0	0.031341
B1	3	6	0	0.03435
B1	3	7	0	0.012641
B1	3	1	1	2.506991
B1	3	2	1	0.446401
B1	3	3	1	0.125842
B1	3	4	1	0.091662
B1	3	5	1	0.052305
B1	3	6	1	0.034697

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
B1	3	7	1	0.012279
B1	3	1	2	0.982341
B1	3	2	2	0.287882
B1	3	3	2	0.102361
B1	3	4	2	0.084412
B1	3	5	2	0.047043
B1	3	6	2	0.034179
B1	3	7	2	0.015179
B1	1	1	-3	1.32041
B1	1	1	-4	1.65414
B1	1	1	-5	1.40747
B1	1	1	-6	1.32041
B1	1	1	-7	1.7412
B1	1	1	-8	1.5961
B1	1	1	-9	1.42198
B1	1	1	-10	1.5961
B1	1	1	-11	1.7412
B1	1	1	-12	1.42198
B1	1	1	-13	1.37845
B1	1	1	3	1.40747
B1	1	1	4	1.37845
B1	1	1	5	1.33492
B1	1	1	6	1.37845
B1	1	1	7	1.33492
B1	1	1	8	1.26237
B1	1	1	9	1.34943
B1	1	1	10	1.56708
B1	1	1	11	1.36394
B1	1	1	12	1.3059
B1	1	1	13	1.63963
B1	2	1	-3	1.86852
B1	2	1	-4	2.2341
B1	2	1	-5	1.92945
B1	2	1	-6	1.99038
B1	2	1	-7	1.76697
B1	2	1	-8	2.4372
B1	2	1	-9	2.4372
B1	2	1	-10	1.88883
B1	2	1	-11	2.29503
B1	2	1	-12	2.31534
B1	2	1	-13	2.19348
B1	2	1	3	1.97007
B1	2	1	4	1.90914
B1	2	1	5	1.8279
B1	2	1	6	1.84821
B1	2	1	7	2.2341
B1	2	1	8	1.99038
B1	2	1	9	1.84821

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
B1	2	1	10	1.92945
B1	2	1	11	1.97007
B1	2	1	12	1.92945
B1	2	1	13	1.86852
B1	3	1	-3	1.87307
B1	3	1	-4	1.75721
B1	3	1	-5	2.3172
B1	3	1	-6	2.20134
B1	3	1	-7	2.1241
B1	3	1	-8	1.89238
B1	3	1	-9	1.75721
B1	3	1	-10	2.1241
B1	3	1	-11	1.87307
B1	3	1	-12	1.83445
B1	3	1	-13	1.83445
B1	3	1	3	1.77652
B1	3	1	4	1.83445
B1	3	1	5	1.89238
B1	3	1	6	1.77652
B1	3	1	7	1.67997
B1	3	1	8	1.79583
B1	3	1	9	2.3172
B1	3	1	10	2.18203
B1	3	1	11	2.08548
B1	3	1	12	1.81514
B1	3	1	13	1.7379
B2	1	1	-2	1.020934
B2	1	2	-2	0.239505
B2	1	3	-2	0.148343
B2	1	4	-2	0.101059
B2	1	5	-2	0.021367
B2	1	1	-1	1.767902
B2	1	2	-1	0.279066
B2	1	3	-1	0.098215
B2	1	4	-1	0.047651
B2	1	5	-1	0.014437
B2	1	1	0	5.605871
B2	1	2	0	0.296826
B2	1	3	0	0.064987
B2	1	4	0	0.031064
B2	1	5	0	0.009625
B2	1	1	1	1.817132
B2	1	2	1	0.281021
B2	1	3	1	0.114573
B2	1	4	1	0.058968
B2	1	5	1	0.028393
B2	1	1	2	0.932146
B2	1	2	2	0.213648

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
B2	1	3	2	0.131153
B2	1	4	2	0.112619
B2	1	5	2	0.03409
B2	2	1	-2	0.983734
B2	2	2	-2	0.194214
B2	2	3	-2	0.13299
B2	2	4	-2	0.056496
B2	2	5	-2	0.017499
B2	2	1	-1	2.278392
B2	2	2	-1	0.279196
B2	2	3	-1	0.100992
B2	2	4	-1	0.048496
B2	2	5	-1	0.010499
B2	2	1	0	2.97201
B2	2	2	0	0.369839
B2	2	3	0	0.096993
B2	2	4	0	0.043497
B2	2	5	0	0.0055
B2	2	1	1	2.42157
B2	2	2	1	0.277559
B2	2	3	1	0.099931
B2	2	4	1	0.046496
B2	2	5	1	0.0119
B2	2	1	2	1.057078
B2	2	2	2	0.171463
B2	2	3	2	0.12699
B2	2	4	2	0.04945
B2	2	5	2	0.0138
B2	3	1	-2	1.112798
B2	3	2	-2	0.156222
B2	3	3	-2	0.051472
B2	3	4	-2	0.045013
B2	3	5	-2	0.020888
B2	3	1	-1	2.119153
B2	3	2	-1	0.164166
B2	3	3	-1	0.091356
B2	3	4	-1	0.0406
B2	3	5	-1	0.017946
B2	3	1	0	4.013239
B2	3	2	0	0.200353
B2	3	3	0	0.105031
B2	3	4	0	0.039885
B2	3	5	0	0.008903
B2	3	1	1	2.283319
B2	3	2	1	0.161518
B2	3	3	1	0.087767
B2	3	4	1	0.041547
B2	3	5	1	0.019315

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
B2	3	1	2	0.960556
B2	3	2	2	0.159929
B2	3	3	2	0.048561
B2	3	4	2	0.046487
B2	3	5	2	0.019123
B2	1	1	-3	2.4936
B2	1	1	-4	2.2858
B2	1	1	-5	1.89098
B2	1	1	-6	2.01566
B2	1	1	-7	2.36892
B2	1	1	-8	1.91176
B2	1	1	-9	1.95332
B2	1	1	-10	2.01566
B2	1	1	-11	1.89098
B2	1	1	-12	1.99488
B2	1	1	-13	1.9741
B2	1	1	3	1.91176
B2	1	1	4	1.80786
B2	1	1	5	2.03644
B2	1	1	6	1.95332
B2	1	1	7	2.03644
B2	1	1	8	1.8702
B2	1	1	9	2.24424
B2	1	1	10	2.2858
B2	1	1	11	1.93254
B2	1	1	12	2.34814
B2	1	1	13	2.4936
B2	2	1	-3	1.7119
B2	2	1	-4	1.76596
B2	2	1	-5	1.65784
B2	2	1	-6	2.1624
B2	2	1	-7	1.9822
B2	2	1	-8	1.94616
B2	2	1	-9	1.6218
B2	2	1	-10	1.69388
B2	2	1	-11	1.56774
B2	2	1	-12	1.67586
B2	2	1	-13	2.03626
B2	2	1	3	2.05428
B2	2	1	4	2.1624
B2	2	1	5	1.63982
B2	2	1	6	1.63982
B2	2	1	7	1.74794
B2	2	1	8	1.69388
B2	2	1	9	1.65784
B2	2	1	10	1.74794
B2	2	1	11	1.9822
B2	2	1	12	1.76596

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
B2	2	1	13	1.72992
B2	3	1	-3	1.03103
B2	3	1	-4	1.09901
B2	3	1	-5	1.29162
B2	3	1	-6	1.3596
B2	3	1	-7	1.03103
B2	3	1	-8	1.11034
B2	3	1	-9	1.08768
B2	3	1	-10	1.06502
B2	3	1	-11	1.2463
B2	3	1	-12	1.2463
B2	3	1	-13	1.09901
B2	3	1	3	1.04236
B2	3	1	4	1.11034
B2	3	1	5	1.07635
B2	3	1	6	1.04236
B2	3	1	7	1.3596
B2	3	1	8	1.05369
B2	3	1	9	1.28029
B2	3	1	10	1.22364
B2	3	1	11	1.0197
B2	3	1	12	1.06502
B2	3	1	13	0.98571
D1	1	1	-6	4.29252
D1	1	2	-6	1.333
D1	1	3	-6	0.814
D1	1	4	-6	0.333
D1	1	5	-6	0.14
D1	1	6	-6	0.108
D1	1	7	-6	0.105727
D1	1	1	-5	3.491
D1	1	2	-5	0.879
D1	1	3	-5	0.70805
D1	1	4	-5	0.233
D1	1	5	-5	0.121
D1	1	6	-5	0.091
D1	1	7	-5	0.0575
D1	1	1	-4	2.643
D1	1	2	-4	0.595
D1	1	3	-4	0.4655
D1	1	4	-4	0.214
D1	1	5	-4	0.094
D1	1	6	-4	0.088774
D1	1	7	-4	0.055
D1	1	1	-3	1.118
D1	1	2	-3	0.294
D1	1	3	-3	0.24175
D1	1	4	-3	0.201

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
D1	1	5	-3	0.08
D1	1	6	-3	0.073
D1	1	7	-3	0.046
D1	1	1	-2	0.633
D1	1	2	-2	0.23
D1	1	3	-2	0.177
D1	1	4	-2	0.18
D1	1	5	-2	0.078
D1	1	6	-2	0.081853
D1	1	7	-2	0.0425
D1	1	1	-1	0.5396
D1	1	2	-1	0.167206
D1	1	3	-1	0.158
D1	1	4	-1	0.145
D1	1	5	-1	0.068
D1	1	6	-1	0.06
D1	1	7	-1	0.035
D1	1	1	0	0.471
D1	1	2	0	0.124
D1	1	3	0	0.10258
D1	1	4	0	0.104689
D1	1	5	0	0.063
D1	1	6	0	0.065617
D1	1	7	0	0.028
D1	1	1	1	0.5756
D1	1	2	1	0.17237
D1	1	3	1	0.149638
D1	1	4	1	0.170156
D1	1	5	1	0.080506
D1	1	6	1	0.086
D1	1	7	1	0.0405
D1	1	1	2	0.6525
D1	1	2	2	0.212265
D1	1	3	2	0.193
D1	1	4	2	0.209
D1	1	5	2	0.099
D1	1	6	2	0.089
D1	1	7	2	0.051
D1	1	1	3	0.90466
D1	1	2	3	0.27069
D1	1	3	3	0.265186
D1	1	4	3	0.238
D1	1	5	3	0.118
D1	1	6	3	0.097
D1	1	7	3	0.0635
D1	1	1	4	2.436
D1	1	2	4	0.515
D1	1	3	4	0.44881

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
D1	1	4	4	0.247
D1	1	5	4	0.095
D1	1	6	4	0.11
D1	1	7	4	0.068
D1	1	1	5	3.3355
D1	1	2	5	0.836
D1	1	3	5	0.7619
D1	1	4	5	0.307
D1	1	5	5	0.131
D1	1	6	5	0.123
D1	1	7	5	0.082
D1	1	1	6	4.3778
D1	1	2	6	1.484
D1	1	3	6	0.84252
D1	1	4	6	0.344359
D1	1	5	6	0.16081
D1	1	6	6	0.132
D1	1	7	6	0.10458
D1	2	1	-6	1.5307
D1	2	2	-6	0.555
D1	2	3	-6	0.224
D1	2	4	-6	0.19975
D1	2	5	-6	0.0736
D1	2	6	-6	0.058
D1	2	7	-6	0.034633
D1	2	1	-5	1.0406
D1	2	2	-5	0.265
D1	2	3	-5	0.122
D1	2	4	-5	0.07735
D1	2	5	-5	0.068
D1	2	6	-5	0.0455
D1	2	7	-5	0.043473
D1	2	1	-4	0.787
D1	2	2	-4	0.138
D1	2	3	-4	0.08
D1	2	4	-4	0.076895
D1	2	5	-4	0.065487
D1	2	6	-4	0.0435
D1	2	7	-4	0.032
D1	2	1	-3	0.285
D1	2	2	-3	0.128
D1	2	3	-3	0.071
D1	2	4	-3	0.069515
D1	2	5	-3	0.06
D1	2	6	-3	0.042
D1	2	7	-3	0.031667
D1	2	1	-2	0.257
D1	2	2	-2	0.116

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
D1	2	3	-2	0.058
D1	2	4	-2	0.06035
D1	2	5	-2	0.0552
D1	2	6	-2	0.039
D1	2	7	-2	0.031
D1	2	1	-1	0.25
D1	2	2	-1	0.089
D1	2	3	-1	0.053
D1	2	4	-1	0.04845
D1	2	5	-1	0.052
D1	2	6	-1	0.036
D1	2	7	-1	0.020667
D1	2	1	0	0.1907
D1	2	2	0	0.068
D1	2	3	0	0.036
D1	2	4	0	0.0102
D1	2	5	0	0.00504
D1	2	6	0	0.002421
D1	2	7	0	0.000773
D1	2	1	1	0.229667
D1	2	2	1	0.089
D1	2	3	1	0.059
D1	2	4	1	0.051
D1	2	5	1	0.0544
D1	2	6	1	0.0375
D1	2	7	1	0.023667
D1	2	1	2	0.255
D1	2	2	2	0.101
D1	2	3	2	0.066
D1	2	4	2	0.05355
D1	2	5	2	0.05512
D1	2	6	2	0.0405
D1	2	7	2	0.027667
D1	2	1	3	0.27
D1	2	2	3	0.127
D1	2	3	3	0.068
D1	2	4	3	0.06715
D1	2	5	3	0.0616
D1	2	6	3	0.041
D1	2	7	3	0.031333
D1	2	1	4	0.8082
D1	2	2	4	0.134
D1	2	3	4	0.074
D1	2	4	4	0.06885
D1	2	5	4	0.069964
D1	2	6	4	0.0425
D1	2	7	4	0.043178
D1	2	1	5	0.9714

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
D1	2	2	5	0.209
D1	2	3	5	0.092
D1	2	4	5	0.07395
D1	2	5	5	0.0688
D1	2	6	5	0.046
D1	2	7	5	0.032333
D1	2	1	6	1.7054
D1	2	2	6	0.753
D1	2	3	6	0.195
D1	2	4	6	0.19295
D1	2	5	6	0.0712
D1	2	6	6	0.05936
D1	2	7	6	0.034967
D1	3	1	-6	1.120016
D1	3	2	-6	0.493093
D1	3	3	-6	0.26594
D1	3	4	-6	0.142159
D1	3	5	-6	0.074983
D1	3	6	-6	0.050222
D1	3	7	-6	0.092979
D1	3	1	-5	0.823813
D1	3	2	-5	0.199955
D1	3	3	-5	0.122972
D1	3	4	-5	0.126971
D1	3	5	-5	0.053988
D1	3	6	-5	0.037522
D1	3	7	-5	0.040789
D1	3	1	-4	0.538878
D1	3	2	-4	0.153314
D1	3	3	-4	0.117973
D1	3	4	-4	0.110663
D1	3	5	-4	0.050489
D1	3	6	-4	0.030548
D1	3	7	-4	0.039697
D1	3	1	-3	0.418905
D1	3	2	-3	0.110663
D1	3	3	-3	0.102594
D1	3	4	-3	0.103976
D1	3	5	-3	0.046686
D1	3	6	-3	0.026005
D1	3	7	-3	0.027902
D1	3	1	-2	0.372916
D1	3	2	-2	0.105976
D1	3	3	-2	0.097983
D1	3	4	-2	0.080122
D1	3	5	-2	0.036888
D1	3	6	-2	0.017139
D1	3	7	-2	0.015622

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
D1	3	1	-1	0.222949
D1	3	2	-1	0.096138
D1	3	3	-1	0.092089
D1	3	4	-1	0.044646
D1	3	5	-1	0.029971
D1	3	6	-1	0.012277
D1	3	7	-1	0.017291
D1	3	1	0	0.213952
D1	3	2	0	0.007516
D1	3	3	0	0.005418
D1	3	4	0	0.003828
D1	3	5	0	0.001919
D1	3	6	0	0.00128
D1	3	7	0	0.001153
D1	3	1	1	0.232947
D1	3	2	1	0.103401
D1	3	3	1	0.086455
D1	3	4	1	0.04611
D1	3	5	1	0.024784
D1	3	6	1	0.012334
D1	3	7	1	0.024438
D1	3	1	2	0.409907
D1	3	2	2	0.116427
D1	3	3	2	0.100288
D1	3	4	2	0.08415
D1	3	5	2	0.031124
D1	3	6	2	0.02196
D1	3	7	2	0.016141
D1	3	1	3	0.431902
D1	3	2	3	0.127954
D1	3	3	3	0.102133
D1	3	4	3	0.09683
D1	3	5	3	0.040922
D1	3	6	3	0.028876
D1	3	7	3	0.027786
D1	3	1	4	0.494888
D1	3	2	4	0.179959
D1	3	3	4	0.118732
D1	3	4	4	0.10951
D1	3	5	4	0.047262
D1	3	6	4	0.036311
D1	3	7	4	0.03972
D1	3	1	5	0.799819
D1	3	2	5	0.26594
D1	3	3	5	0.12219
D1	3	4	5	0.115274
D1	3	5	5	0.051873
D1	3	6	5	0.039481

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
D1	3	7	5	0.030158
D1	3	1	6	1.272038
D1	3	2	6	0.537878
D1	3	3	6	0.210951
D1	3	4	6	0.141787
D1	3	5	6	0.086209
D1	3	6	6	0.045418
D1	3	7	6	0.043988
D1	1	1	-7	4.18855
D1	1	1	-8	4.10037
D1	1	1	-9	5.7317
D1	1	1	-10	3.9681
D1	1	1	-11	4.76172
D1	1	1	-12	4.62945
D1	1	1	-13	4.58536
D1	1	1	7	4.27673
D1	1	1	8	3.65947
D1	1	1	9	5.15853
D1	1	1	10	4.05628
D1	1	1	11	4.01219
D1	1	1	12	4.36491
D1	1	1	13	4.23264
D1	2	1	-7	1.463
D1	2	1	-8	1.4322
D1	2	1	-9	2.002
D1	2	1	-10	1.386
D1	2	1	-11	1.6632
D1	2	1	-12	1.617
D1	2	1	-13	1.2782
D1	2	1	7	1.4168
D1	2	1	8	1.4938
D1	2	1	9	1.6016
D1	2	1	10	1.8018
D1	2	1	11	1.4014
D1	2	1	12	1.5246
D1	2	1	13	1.4784
D1	3	1	-7	1.09535
D1	3	1	-8	1.07229
D1	3	1	-9	1.4989
D1	3	1	-10	1.0377
D1	3	1	-11	1.24524
D1	3	1	-12	1.21065
D1	3	1	-13	0.95699
D1	3	1	7	1.06076
D1	3	1	8	1.11841
D1	3	1	9	1.19912
D1	3	1	10	1.34901
D1	3	1	11	1.04923

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
D1	3	1	12	1.14147
D1	3	1	13	1.10688
D2	1	1	-6	2.694129
D2	1	2	-6	0.952447
D2	1	3	-6	0.273911
D2	1	4	-6	0.099066
D2	1	5	-6	0.087972
D2	1	1	-5	1.887893
D2	1	2	-5	0.636794
D2	1	3	-5	0.242921
D2	1	4	-5	0.088971
D2	1	5	-5	0.088423
D2	1	1	-4	1.820412
D2	1	2	-4	0.578563
D2	1	3	-4	0.223928
D2	1	4	-4	0.06298
D2	1	5	-4	0.065198
D2	1	1	-3	0.522831
D2	1	2	-3	0.559819
D2	1	3	-3	0.171944
D2	1	4	-3	0.058981
D2	1	5	-3	0.043986
D2	1	1	-2	0.460851
D2	1	2	-2	0.143484
D2	1	3	-2	0.139797
D2	1	4	-2	0.050984
D2	1	5	-2	0.033989
D2	1	1	-1	0.441857
D2	1	2	-1	0.10877
D2	1	3	-1	0.102093
D2	1	4	-1	0.03099
D2	1	5	-1	0.010996
D2	1	1	0	0.40087
D2	1	2	0	0.037028
D2	1	3	0	0.070977
D2	1	4	0	0.013995
D2	1	5	0	0.007234
D2	1	1	1	0.436172
D2	1	2	1	0.115503
D2	1	3	1	0.108965
D2	1	4	1	0.037988
D2	1	5	1	0.020993
D2	1	1	2	0.455853
D2	1	2	2	0.159683
D2	1	3	2	0.130958
D2	1	4	2	0.042986
D2	1	5	2	0.035988
D2	1	1	3	0.511835

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
D2	1	2	3	0.496839
D2	1	3	3	0.180942
D2	1	4	3	0.056982
D2	1	5	3	0.024992
D2	1	1	4	1.755433
D2	1	2	4	0.583811
D2	1	3	4	0.193937
D2	1	4	4	0.067293
D2	1	5	4	0.067503
D2	1	1	5	2.180295
D2	1	2	5	0.64979
D2	1	3	5	0.223928
D2	1	4	5	0.080974
D2	1	5	5	0.064979
D2	1	1	6	2.368234
D2	1	2	6	1.032666
D2	1	3	6	0.295537
D2	1	4	6	0.09197
D2	1	5	6	0.079747
D2	2	1	-6	2.64532
D2	2	2	-6	1.116915
D2	2	3	-6	0.452128
D2	2	4	-6	0.159285
D2	2	5	-6	0.069539
D2	2	1	-5	2.262828
D2	2	2	-5	1.046921
D2	2	3	-5	0.330081
D2	2	4	-5	0.143825
D2	2	5	-5	0.05695
D2	2	1	-4	1.901856
D2	2	2	-4	0.090993
D2	2	3	-4	0.086188
D2	2	4	-4	0.127787
D2	2	5	-4	0.055812
D2	2	1	-3	0.807173
D2	2	2	-3	0.772462
D2	2	3	-3	0.212257
D2	2	4	-3	0.118792
D2	2	5	-3	0.052802
D2	2	1	-2	0.723959
D2	2	2	-2	0.679578
D2	2	3	-2	0.198013
D2	2	4	-2	0.101037
D2	2	5	-2	0.048021
D2	2	1	-1	0.443806
D2	2	2	-1	0.539959
D2	2	3	-1	0.191391
D2	2	4	-1	0.084035

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
D2	2	5	-1	0.044068
D2	2	1	0	0.388971
D2	2	2	0	0.25406
D2	2	3	0	0.096528
D2	2	4	0	0.057675
D2	2	5	0	0.031205
D2	2	1	1	0.538115
D2	2	2	1	0.333496
D2	2	3	1	0.199713
D2	2	4	1	0.077813
D2	2	5	1	0.045229
D2	2	1	2	0.81377
D2	2	2	2	0.82178
D2	2	3	2	0.214557
D2	2	4	2	0.111833
D2	2	5	2	0.046663
D2	2	1	3	0.868196
D2	2	2	3	0.854935
D2	2	3	3	0.230878
D2	2	4	3	0.11759
D2	2	5	3	0.047663
D2	2	1	4	1.98215
D2	2	2	4	0.895934
D2	2	3	4	0.258401
D2	2	4	4	0.128922
D2	2	5	4	0.054996
D2	2	1	5	2.24683
D2	2	2	5	0.906931
D2	2	3	5	0.304737
D2	2	4	5	0.133892
D2	2	5	5	0.0583
D2	2	1	6	3.069078
D2	2	2	6	1.089917
D2	2	3	6	0.414067
D2	2	4	6	0.169603
D2	2	5	6	0.066995
D2	3	1	-6	2.990526
D2	3	2	-6	0.98675
D2	3	3	-6	0.197984
D2	3	4	-6	0.090993
D2	3	5	-6	0.090516
D2	3	1	-5	2.727388
D2	3	2	-5	0.616951
D2	3	3	-5	0.12599
D2	3	4	-5	0.128984
D2	3	5	-5	0.070994
D2	3	1	-4	1.297896
D2	3	2	-4	0.363971

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
D2	3	3	-4	0.092993
D2	3	4	-4	0.079994
D2	3	5	-4	0.050996
D2	3	1	-3	0.851932
D2	3	2	-3	0.326974
D2	3	3	-3	0.083993
D2	3	4	-3	0.076994
D2	3	5	-3	0.046996
D2	3	1	-2	0.568954
D2	3	2	-2	0.220982
D2	3	3	-2	0.074994
D2	3	4	-2	0.061995
D2	3	5	-2	0.044996
D2	3	1	-1	0.489961
D2	3	2	-1	0.143988
D2	3	3	-1	0.066995
D2	3	4	-1	0.052996
D2	3	5	-1	0.030998
D2	3	1	0	0.317975
D2	3	2	0	0.11999
D2	3	3	0	0.053996
D2	3	4	0	0.035997
D2	3	5	0	0.021998
D2	3	1	1	0.459963
D2	3	2	1	0.167987
D2	3	3	1	0.065995
D2	3	4	1	0.060995
D2	3	5	1	0.037997
D2	3	1	2	0.539957
D2	3	2	2	0.199984
D2	3	3	2	0.077994
D2	3	4	2	0.066103
D2	3	5	2	0.045996
D2	3	1	3	0.762135
D2	3	2	3	0.316975
D2	3	3	3	0.078994
D2	3	4	3	0.067995
D2	3	5	3	0.051182
D2	3	1	4	1.259792
D2	3	2	4	0.439526
D2	3	3	4	0.089993
D2	3	4	4	0.080994
D2	3	5	4	0.056995
D2	3	1	5	2.480735
D2	3	2	5	0.670946
D2	3	3	5	0.12399
D2	3	4	5	0.082993
D2	3	5	5	0.078775

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
D2	3	1	6	2.840904
D2	3	2	6	0.975107
D2	3	3	6	0.203984
D2	3	4	6	0.094
D2	3	5	6	0.08607
D2	1	1	-7	2.19925
D2	1	1	-8	2.15295
D2	1	1	-9	3.0095
D2	1	1	-10	2.0835
D2	1	1	-11	2.5002
D2	1	1	-12	2.24555
D2	1	1	-13	2.4076
D2	1	1	7	2.43075
D2	1	1	8	1.92145
D2	1	1	9	2.70855
D2	1	1	10	2.1298
D2	1	1	11	2.10665
D2	1	1	12	2.29185
D2	1	1	13	2.2224
D2	2	1	-7	2.6353
D2	2	1	-8	2.57982
D2	2	1	-9	3.6062
D2	2	1	-10	2.4966
D2	2	1	-11	2.99592
D2	2	1	-12	2.9127
D2	2	1	-13	2.69078
D2	2	1	7	2.55208
D2	2	1	8	2.30242
D2	2	1	9	2.88496
D2	2	1	10	3.24558
D2	2	1	11	2.52434
D2	2	1	12	2.74626
D2	2	1	13	2.66304
D2	3	1	-7	2.76545
D2	3	1	-8	2.70723
D2	3	1	-9	3.7843
D2	3	1	-10	2.6199
D2	3	1	-11	3.14388
D2	3	1	-12	3.05655
D2	3	1	-13	2.41613
D2	3	1	7	2.67812
D2	3	1	8	2.82367
D2	3	1	9	3.02744
D2	3	1	10	3.40587

Appendix Table 1.1. Diuron soil residue in parts per million (ppm), continued.

Study	Block	Depth Interval	Width Interval	PPM
D2	3	1	11	2.64901
D2	3	1	12	2.88189
D2	3	1	13	2.79456

[1]Where B1 = Early study, broadcast spray; B2 = Late study, broadcast; D1 = Early study, directed spray; D2 = Late study, directed spray.

Appendix Table 2.1. Test of coincidence for curves describing natural log of height in monoculture study for diuron by population interaction over time.[1]

M	Ca[2]	Cb	RDF	RSS	EDF	ESS	F	SIG
F	1	2	8	448.698	58	1.459		
R	1	2	4	432.964	62	17.193	156.350	**
F	1	3	8	460.060	58	1.834		
R	1	3	4	442.501	62	19.393	138.779	**
F	1	4	8	307.262	58	1.146		
R	1	4	4	307.041	62	1.367	2.793	*
F	1	5	8	466.484	58	1.895		
R	1	5	4	447.031	62	21.349	148.815	**
F	1	6	8	302.672	58	1.684		
R	1	6	4	302.148	62	2.208	4.510	**
F	1	7	8	303.694	58	1.516		
R	1	7	4	303.479	62	1.731	2.057	NS
F	1	8	8	450.729	58	1.737		
R	1	8	4	434.897	62	17.569	132.143	**
F	1	9	8	451.270	58	2.013		
R	1	9	4	435.437	62	17.846	114.032	**
F	1	10	8	306.240	58	1.350		
R	1	10	4	306.072	62	1.518	1.803	NS
F	1	11	8	470.566	58	1.765		
R	1	11	4	450.840	62	21.490	162.017	**
F	1	12	8	301.541	58	1.393		
R	1	12	4	301.247	62	1.687	3.060	*
F	1	13	8	296.709	58	2.180		
R	1	13	4	296.279	62	2.610	2.859	*
F	1	14	8	438.182	58	2.192		
R	1	14	4	424.625	62	15.748	89.666	**
F	1	15	8	445.425	58	1.718		
R	1	15	4	430.571	62	16.572	125.360	**
F	1	16	8	296.556	58	2.173		
R	1	16	4	296.056	62	2.672	3.333	*
F	1	17	8	458.922	58	2.017		
R	1	17	4	441.242	62	19.698	127.064	**
F	1	18	8	298.933	58	1.806		
R	1	18	4	298.461	62	2.279	3.787	**
F	2	3	8	592.719	58	1.849		
R	2	3	4	592.661	62	1.908	0.457	NS
F	2	4	8	439.921	58	1.161		
R	2	4	4	423.343	62	17.739	206.879	**
F	2	5	8	599.143	58	1.910		
R	2	5	4	598.892	62	2.162	1.910	NS
F	2	6	8	435.330	58	1.699		
R	2	6	4	418.174	62	18.855	146.388	**
F	2	7	8	436.353	58	1.531		
R	2	7	4	417.898	62	19.986	174.719	**
F	2	8	8	583.388	58	1.752		
R	2	8	4	583.362	62	1.778	0.219	NS
F	2	9	8	583.929	58	2.028		

Appendix Table 2.1. Test of coincidence for curves describing natural log of height in monoculture study for diuron by population interaction over time (continued).

M	Ca	Cb	RDF	RSS	EDF	ESS	F	SIG
R	2	9	4	583.917	62	2.040	0.086	NS
F	2	10	8	438.899	58	1.365		
R	2	10	4	421.486	62	18.778	184.887	**
F	2	11	8	603.225	58	1.780		
R	2	11	4	602.939	62	2.066	2.328	NS
F	2	12	8	434.200	58	1.408		
R	2	12	4	415.814	62	19.794	189.259	**
F	2	13	8	429.368	58	2.195		
R	2	13	4	409.320	62	22.243	132.417	**
F	2	14	8	570.841	58	2.207		
R	2	14	4	570.694	62	2.353	0.961	NS
F	2	15	8	578.084	58	1.733		
R	2	15	4	578.057	62	1.759	0.224	NS
F	2	16	8	429.215	58	2.188		
R	2	16	4	407.688	62	23.714	142.651	**
F	2	17	8	591.581	58	2.032		
R	2	17	4	591.463	62	2.150	0.842	NS
F	2	18	8	431.592	58	1.822		
R	2	18	4	410.554	62	22.860	167.426	**
F	3	4	8	451.283	58	1.537		
R	3	4	4	432.766	62	20.053	174.648	**
F	3	5	8	610.506	58	2.285		
R	3	5	4	610.364	62	2.427	0.897	NS
F	3	6	8	446.693	58	2.074		
R	3	6	4	427.536	62	21.231	133.884	**
F	3	7	8	447.715	58	1.907		
R	3	7	4	427.238	62	22.384	155.695	**
F	3	8	8	594.751	58	2.127		
R	3	8	4	594.673	62	2.205	0.526	NS
F	3	9	8	595.292	58	2.403		
R	3	9	4	595.241	62	2.454	0.307	NS
F	3	10	8	450.261	58	1.741		
R	3	10	4	430.877	62	21.124	161.436	**
F	3	11	8	614.587	58	2.155		
R	3	11	4	614.468	62	2.274	0.798	NS
F	3	12	8	445.562	58	1.784		
R	3	12	4	425.139	62	22.207	165.992	**
F	3	13	8	440.730	58	2.570		
R	3	13	4	418.560	62	24.740	125.047	**
F	3	14	8	582.203	58	2.582		
R	3	14	4	581.873	62	2.913	1.854	NS
F	3	15	8	589.446	58	2.108		
R	3	15	4	589.326	62	2.228	0.827	NS
F	3	16	8	440.577	58	2.563		
R	3	16	4	416.907	62	26.233	133.882	**
F	3	17	8	602.944	58	2.408		
R	3	17	4	602.866	62	2.485	0.466	NS
F	3	18	8	442.955	58	2.197		

Appendix Table 2.1. Test of coincidence for curves describing natural log of height in monoculture study for diuron by population interaction over time (continued).

M	Ca	Cb	RDF	RSS	EDF	ESS	F	SIG
R	3	18	4	419.783	62	25.368	152.898	**
F	4	5	8	457.707	58	1.598		
R	4	5	4	437.536	62	21.769	183.008	**
F	4	6	8	293.894	58	1.387		
R	4	6	4	293.822	62	1.458	0.750	NS
F	4	7	8	294.917	58	1.219		
R	4	7	4	294.814	62	1.322	1.224	NS
F	4	8	8	441.952	58	1.439		
R	4	8	4	425.317	62	18.075	167.509	**
F	4	9	8	442.493	58	1.716		
R	4	9	4	425.774	62	18.435	141.273	**
F	4	10	8	297.463	58	1.053		
R	4	10	4	297.437	62	1.078	0.346	NS
F	4	11	8	461.788	58	1.468		
R	4	11	4	441.117	62	22.139	204.174	**
F	4	12	8	292.764	58	1.096		
R	4	12	4	292.696	62	1.164	0.903	NS
F	4	13	8	287.931	58	1.882		
R	4	13	4	287.746	62	2.068	1.431	NS
F	4	14	8	429.405	58	1.894		
R	4	14	4	415.098	62	16.201	109.473	**
F	4	15	8	436.648	58	1.420		
R	4	15	4	420.902	62	17.166	160.695	**
F	4	16	8	287.779	58	1.875		
R	4	16	4	287.192	62	2.462	4.534	**
F	4	17	8	450.145	58	1.720		
R	4	17	4	431.675	62	20.190	155.680	**
F	4	18	8	290.156	58	1.509		
R	4	18	4	289.730	62	1.935	4.091	**
F	5	6	8	453.117	58	2.135		
R	5	6	4	432.428	62	22.824	140.469	**
F	5	7	8	454.139	58	1.967		
R	5	7	4	431.811	62	24.295	164.517	**
F	5	8	8	601.175	58	2.188		
R	5	8	4	600.958	62	2.405	1.437	NS
F	5	9	8	601.716	58	2.464		
R	5	9	4	601.464	62	2.715	1.478	NS
F	5	10	8	456.685	58	1.801		
R	5	10	4	435.541	62	22.946	170.154	**
F	5	11	8	621.011	58	2.216		
R	5	11	4	620.898	62	2.330	0.742	NS
F	5	12	8	451.987	58	1.844		
R	5	12	4	429.787	62	24.044	174.476	**
F	5	13	8	447.154	58	2.631		
R	5	13	4	423.115	62	26.670	132.457	**
F	5	14	8	588.627	58	2.643		
R	5	14	4	588.031	62	3.239	3.271	*
F	5	15	8	595.870	58	2.169		

Appendix Table 2.1. Test of coincidence for curves describing natural log of height in monoculture study for diuron by population interaction over time (continued).

M	Ca	Cb	RDF	RSS	EDF	ESS	F	SIG
R	5	15	4	595.469	62	2.570	2.683	*
F	5	16	8	447.002	58	2.642		
R	5	16	4	421.139	62	28.486	142.891	**
F	5	17	8	609.368	58	2.468		
R	5	17	4	609.274	62	2.562	0.549	NS
F	5	18	8	449.379	58	2.258		
R	5	18	4	424.161	62	27.475	161.916	**
F	6	7	8	290.326	58	1.756		
R	6	7	4	290.122	62	1.961	1.690	NS
F	6	8	8	437.362	58	1.977		
R	6	8	4	420.142	62	19.197	126.268	**
F	6	9	8	437.903	58	2.253		
R	6	9	4	420.565	62	19.591	111.562	**
F	6	10	8	292.872	58	1.590		
R	6	10	4	292.740	62	1.722	1.203	NS
F	6	11	8	457.198	58	2.005		
R	6	11	4	435.845	62	23.358	154.387	**
F	6	12	8	288.174	58	1.633		
R	6	12	4	288.063	62	1.744	0.982	NS
F	6	13	8	283.341	58	2.420		
R	6	13	4	283.115	62	2.646	1.352	NS
F	6	14	8	424.814	58	2.432		
R	6	14	4	409.925	62	17.322	88.762	**
F	6	15	8	432.057	58	1.958		
R	6	15	4	415.686	62	18.329	121.224	**
F	6	16	8	283.189	58	2.413		
R	6	16	4	282.404	62	3.197	4.711	**
F	6	17	8	445.555	58	2.257		
R	6	17	4	426.487	62	21.325	122.456	**
F	6	18	8	285.566	58	2.047		
R	6	18	4	285.021	62	2.591	3.856	**
F	6	8	8	438.384	58	1.809		
R	7	8	4	419.824	62	20.370	148.716	**
F	7	9	8	438.925	58	2.085		
R	7	9	4	420.317	62	20.693	129.364	**
F	7	10	8	293.895	58	1.422		
R	7	10	4	293.865	62	1.453	0.308	NS
F	7	11	8	458.221	58	1.837		
R	7	11	4	435.387	62	24.671	180.158	**
F	7	12	8	289.196	58	1.465		
R	7	12	4	289.178	62	1.484	0.180	NS
F	7	13	8	284.364	58	2.252		
R	7	13	4	284.315	62	2.301	0.313	NS
F	7	14	8	425.837	58	2.264		
R	7	14	4	409.713	62	18.388	103.239	**
F	7	15	8	433.080	58	1.790		
R	7	15	4	415.506	62	19.364	142.317	**
F	7	16	8	284.211	58	2.245		

Appendix Table 2.1. Test of coincidence for curves describing natural log of height in monoculture study for diuron by population interaction over time (continued).

M	Ca	Cb	RDF	RSS	EDF	ESS	F	SIG
R	7	16	4	283.987	62	2.469	1.445	NS
F	7	17	8	446.577	58	2.090		
R	7	17	4	426.027	62	22.640	142.573	**
F	7	18	8	286.588	58	1.879		
R	7	18	4	286.475	62	1.992	0.871	NS
F	8	9	8	585.961	58	2.306		
R	8	9	4	585.949	62	2.317	0.070	NS
F	8	10	8	440.930	58	1.643		
R	8	10	4	423.444	62	19.129	154.254	**
F	8	11	8	605.256	58	2.058		
R	8	11	4	605.017	62	2.297	1.683	NS
F	8	12	8	436.231	58	1.686		
R	8	12	4	417.745	62	20.173	158.926	**
F	8	13	8	431.399	58	2.473		
R	8	13	4	411.246	62	22.626	118.145	**
F	8	14	8	572.872	58	2.485		
R	8	14	4	572.768	62	2.589	0.608	NS
F	8	15	8	580.115	58	2.011		
R	8	15	4	580.075	62	2.051	0.289	NS
F	8	16	8	431.246	58	2.466		
R	8	16	4	409.541	62	24.171	127.618	**
F	8	17	8	593.613	58	2.310		
R	8	17	4	593.548	62	2.375	0.405	NS
F	8	18	8	433.624	58	2.100		
R	8	18	4	412.446	62	23.277	146.221	**
F	9	10	8	441.471	58	1.919		
R	9	10	4	423.920	62	19.470	132.564	**
F	9	11	8	605.797	58	2.334		
R	9	11	4	605.557	62	2.574	1.490	NS
F	9	12	8	436.772	58	1.962		
R	9	12	4	418.219	62	20.516	137.067	**
F	9	13	8	431.940	58	2.749		
R	9	13	4	411.722	62	22.967	106.626	**
F	9	14	8	573.413	58	2.761		
R	9	14	4	573.289	62	2.885	0.651	NS
F	9	15	8	580.656	58	2.287		
R	9	15	4	580.636	62	2.307	0.129	NS
F	9	16	8	431.787	58	2.742		
R	9	16	4	410.098	62	24.431	114.686	**
F	9	17	8	594.154	58	2.586		
R	9	17	4	594.064	62	2.676	0.502	NS
F	9	18	8	434.165	58	2.376		
R	9	18	4	412.965	62	23.575	129.365	**
F	10	11	8	460.767	58	1.671		
R	10	11	4	439.144	62	23.294	187.542	**
F	10	12	8	291.742	58	1.3		
R	10	12	4	291.714	62	1.328	0.316	NS
F	10	13	8	286.910	58	2.086		

Appendix Table 2.1. Test of coincidence for curves describing natural log of height in monoculture study for diuron by population interaction over time (continued).

M	Ca	Cb	RDF	RSS	EDF	ESS	F	SIG
R	10	13	4	286.806	62	2.189	0.717	NS
F	10	14	8	428.383	58	2.098		
R	10	14	4	413.282	62	17.199	104.332	**
F	10	15	8	435.626	58	1.624		
R	10	15	4	419.078	62	18.172	147.701	**
F	10	16	8	286.757	58	2.079		
R	10	16	4	286.375	62	2.461	2.663	*
F	10	17	8	449.123	58	1.924		
R	10	17	4	429.732	62	21.315	146.137	**
F	10	18	8	289.134	58	1.713		
R	10	18	4	288.881	62	1.966	2.140	NS
F	11	12	8	456.068	58	1.714		
R	11	12	4	433.313	62	24.469	192.409	**
F	11	13	8	451.235	58	2.501		
R	11	13	4	426.651	62	27.086	142.508	**
F	11	14	8	592.709	58	2.513		
R	11	14	4	592.122	62	3.100	3.384	*
F	11	15	8	599.952	58	2.039		
R	11	15	4	599.584	62	2.406	2.613	*
F	11	16	8	451.083	58	2.494		
R	11	16	4	424.831	62	28.746	152.610	**
F	11	17	8	613.449	58	2.338		
R	11	17	4	613.375	62	2.413	0.460	NS
F	11	18	8	453.460	58	2.128		
R	11	18	4	427.725	62	27.862	175.338	**
F	12	13	8	282.211	58	2.129		
R	12	13	4	282.172	62	2.168	0.261	NS
F	12	14	8	423.684	58	2.141		
R	12	14	4	407.628	62	18.197	108.706	**
F	12	15	8	430.927	58	1.667		
R	12	15	4	413.402	62	19.192	152.392	**
F	12	16	8	282.058	58	2.122		
R	12	16	4	281.747	62	2.433	2.127	NS
F	12	17	8	444.425	58	1.967		
R	12	17	4	423.974	62	22.417	150.753	**
F	12	18	8	284.435	58	1.756		
R	12	18	4	284.258	62	1.933	1.462	NS
F	13	14	8	418.852	58	2.928		
R	13	14	4	401.253	62	20.527	87.144	**
F	13	15	8	426.095	58	2.454		
R	13	15	4	406.958	62	21.591	113.066	**
F	13	16	8	277.226	58	2.909		
R	13	16	4	277.031	62	3.103	0.970	NS
F	13	17	8	439.592	58	2.753		
R	13	17	4	417.396	62	24.949	116.877	**
F	13	18	8	279.603	58	2.543		
R	13	18	4	279.504	62	2.641	0.562	NS
F	14	15	8	567.568	58	2.466		

Appendix Table 2.1. Test of coincidence for curves describing natural log of height in monoculture study for diuron by population interaction over time (continued).

M	Ca	Cb	RDF	RSS	EDF	ESS	F	SIG
R	14	15	4	567.497	62	2.537	0.418	NS
F	14	16	8	418.699	58	2.921		
R	14	16	4	399.636	62	21.983	94.622	**
F	14	17	8	581.065	58	2.765		
R	14	17	4	580.789	62	3.041	1.447	NS
F	14	18	8	421.076	58	2.555		
R	14	18	4	402.485	62	21.145	105.504	**
F	15	16	8	425.942	58	2.447		
R	15	16	4	405.408	62	22.981	121.678	**
F	15	17	8	588.308	58	2.291		
R	15	17	4	588.139	62	2.461	1.073	NS
F	15	18	8	428.319	58	2.080		
R	15	18	4	408.228	62	22.172	140.001	**
F	16	17	8	439.44	58	2.746		
R	16	17	4	415.560	62	26.625	126.067	**
F	16	18	8	279.450	58	2.535		
R	16	18	4	279.386	62	2.600	0.367	NS
F	17	18	8	441.817	58	2.380		
R	17	18	4	418.481	62	25.715	142.143	**

[1]M: Model, where F=full and R=reduced
Ca Cb: Compared pair of curve 'a' versus curve 'b'
RDF: Regression degrees of freedom
RSS: Regression sum of squares
EDF: Error degrees of freedom
ESS: Error sum of squares
[2]Paired curve identification where:

No.	Diuron (kg ai ha^{-1})	Species	Population
1	0.00	VLPMY	100
2	0.00	LOLMU	119
3	0.00	LOLMU	198
4	0.00	VLPMY	400
5	0.00	LOLMU	595
6	0.00	VLPMY	1600
7	0.28	VLPMY	100
8	0.28	LOLMU	119
9	0.28	LOLMU	198
10	0.28	VLPMY	400
11	0.28	LOLMU	595
12	0.28	VLPMY	1600
13	0.56	VLPMY	100
14	0.56	LOLMU	119
15	0.56	LOLMU	198
16	0.56	VLPMY	400
17	0.56	LOLMU	595
18	0.56	VLPMY	1600

Appendix Table 2.2. Test of coincidence for curves describing natural log of leaf area ratio in monoculture study for population effect over time[1].

M	Ca[2]	Cb	RDF	RSS	EDF	ESS	F	SIG
F	1	2	6	3275.093	192	25.864		
R	1	2	3	3223.924	195	77.033	126.615	**
F	1	3	6	3348.703	192	23.310		
R	1	3	3	3286.363	195	85.650	171.153	**
F	1	4	6	2696.433	192	41.178		
R	1	4	3	2695.672	195	41.939	1.181	NS
F	1	5	6	3314.418	192	22.883		
R	1	5	3	3258.882	195	78.418	155.324	**
F	1	6	6	2648.407	192	29.793		
R	1	6	3	2647.557	195	30.642	1.825	NS
F	2	3	6	4012.371	192	20.327		
R	2	3	3	4011.771	195	20.927	1.889	NS
F	2	4	6	3360.101	192	38.195		
R	2	4	3	3316.726	195	81.571	72.679	**
F	2	5	6	3978.086	192	19.899		
R	2	5	3	3977.967	195	20.018	0.382	NS
F	2	6	6	3312.075	192	26.809		
R	2	6	3	3271.167	195	67.718	97.655	**
F	3	4	6	3433.711	192	35.642		
R	3	4	3	3379.808	195	89.545	96.789	**
F	3	5	6	4051.696	192	17.346		
R	3	5	3	4051.45	195	17.592	0.909	NS
F	3	6	6	3385.686	192	24.256		
R	3	6	3	3334.707	195	75.234	134.505	**
F	4	5	6	3399.426	192	35.214		
R	4	5	3	3352.081	195	82.559	86.046	**
F	4	6	6	2733.415	192	42.124		
R	4	6	3	2732.48	195	43.059	1.420	NS
F	5	6	6	3351.4	192	23.828		
R	5	6	3	3306.416	195	68.812	120.820	**

[1]M: Model, where F=full and R=reduced
Ca Cb: Compared pair of curve 'a' versus curve 'b'
RDF: Regression degrees of freedom
RSS: Regression sum of squares
EDF: Error degrees of freedom
ESS: Error sum of squares
[2]Paired curve identification where:

No.	Species	Population
1	VLPMY	100
2	LOLMU	119
3	LOLMU	198
4	VLPMY	400
5	LOLMU	595
6	VLPMY	1600

Appendix Table 2.3. Test of coincidence for curves describing natural log of leaf area in monoculture study for population effect over time[1].

Ca[2]	Cb	SSRF	SSRR	DFF	DFR	SSEF	DFEF	F	SIG
1	2	2941.954	2618.069	9	5	68.147	189	224.565	**
1	3	2922.902	2568.062	9	5	62.720	189	267.316	**
1	4	2880.795	2878.711	9	5	69.505	189	1.416	NS
1	5	2750.483	2408.565	9	5	69.036	189	234.016	**
1	6	2665.861	2644.401	9	5	71.972	189	14.088	**
2	3	2847.102	2846.141	9	5	71.132	189	0.637	NS
2	4	2804.988	2479.671	9	5	77.924	189	197.256	**
2	5	2675.176	2670.166	9	5	76.956	189	3.075	*
2	6	2591.098	2212.465	9	5	79.347	189	225.468	**
3	4	2785.835	2430.956	9	5	72.598	189	230.969	**
3	5	2655.964	2652.82	9	5	71.689	189	2.071	NS
3	6	2571.822	2165.045	9	5	74.145	189	259.223	**
4	5	2613.847	2276.132	9	5	78.484	189	203.315	**
4	6	2529.701	2519.187	9	5	80.943	189	6.137	**
5	6	2400.364	2020.732	9	5	79.501	189	225.626	**

[1]SSRF: Regression sum of squares, full model
SSRR: Regression sum of squares, reduced model
DFF: Degrees of freedom, full model
DFR: Degrees of freedom, reduced model
SSEF: Error sum of squares, full model
DFEF: Error degrees of freedom, full model
Ca Cb: Compared pair of curve 'a' versus curve 'b'
[2]Paired curve identification where:

No.	Species	Population
1	VLPMY	100
2	LOLMU	119
3	LOLMU	198
4	VLPMY	400
5	LOLMU	595
6	VLPMY	1600

Appendix Table 2.4. Test of coincidence for curves describing natural log of leaf area in monoculture study for diuron effect over time[1].

Ca[2]	Cb	SSRF	SSRR	DFF	DFR	SSEF	DFEF	F	SIG
1	2	4616.776	4615.097	9	5	676.604	387	0.240	NS
1	3	4962.65	4943.349	9	5	740.605	387	2.521	*
2	3	4957.188	4943.973	9	5	742.973	387	1.720	NS

[1]SSRF: Regression sum of squares, full model
SSRR: Regression sum of squares, reduced model
DFF: Degrees of freedom, full model
DFR: Degrees of freedom, reduced model
SSEF: Error sum of squares, full model
DFEF: Error degrees of freedom, full model
Ca Cb: Compared pair of curve 'a' versus curve 'b'
[2]Paired curve identification where:

No.	Diuron ($kg\ ai\ ha^{-1}$)
1	0.00
2	0.28
3	0.56

Appendix Table 2.5. Test of coincidence for curves describing natural log of net assimilation rate in monoculture study for diuron effect over time[1].

M	Ca[2]	Cb	RDF	RSS	EDF	ESS	F	SIG
F	1	2	8	19018.83	385	197.891		
R	1	2	4	19018.19	389	198.539	0.314	NS
F	1	3	8	19281.7	387	173.962		
R	1	3	4	19273.99	391	181.674	4.289	**
F	2	3	8	19074.87	386	187.396		
R	2	3	4	19067.55	390	194.720	3.771	**

[1]M: Model, where F=full and R=reduced
Ca Cb: Compared pair of curve 'a' versus curve 'b'
RDF: Regression degrees of freedom
RSS: Regression sum of squares
EDF: Error degrees of freedom
ESS: Error sum of squares
[2]Paired curve identification where:

No.	Diuron ($kg\ ai\ ha^{-1}$)
1	0.00
2	0.28
3	0.56

Appendix Table 2.6. Test of coincidence for curves describing natural log of relative growth rate in monoculture study for diuron effect over time[1].

Ca[2]	Cb	SSRF	SSRR	DFF	DFR	SSEF	DFEF	F	SIG
1	2	1610.791	1605.082	9	5	6.149	189	43.869	**
1	3	1585.099	1580.406	9	5	4.073	188	54.148	**
1	4	1560.133	1559.872	9	5	7.848	188	1.565	NS
1	5	1651.797	1641.627	9	5	12.305	188	38.844	**
1	6	1648.353	1644.609	9	5	18.274	189	9.679	**
2	3	1659.25	1659.193	9	5	8.508	188	0.312	NS
2	4	1634.269	1629.986	9	5	12.298	188	16.368	**
2	5	1725.962	1724.906	9	5	16.726	188	2.966	NS
2	6	1722.473	1714.377	9	5	22.740	189	16.822	**
3	4	1608.623	1605.115	9	5	10.176	187	16.115	**
3	5	1700.251	1698.963	9	5	14.669	187	4.104	**
3	6	1696.861	1689.266	9	5	20.583	188	17.343	**
4	5	1675.258	1667.204	9	5	18.472	187	20.383	**
4	6	1672.014	1669.551	9	5	24.241	188	4.775	**
5	6	1763.451	1750.883	9	5	28.925	188	20.420	**

[1]SSRF: Regression sum of squares, full model
SSRR: Regression sum of squares, reduced model
DFF: Degrees of freedom, full model
DFR: Degrees of freedom, reduced model
SSEF: Error sum of squares, full model
DFEF: Error degrees of freedom, full model
Ca Cb: Compared pair of curve 'a' versus curve 'b'
[2]Paired curve identification where:

No.	Species	Population
1	VLPMY	100
2	LOLMU	119
3	LOLMU	198
4	VLPMY	400
5	LOLMU	595
6	VLPMY	1600

Appendix Table 2.7. Test of coincidence for curves describing natural log of leaf area in monoculture study for diuron effect over time[1].

Ca[2]	Cb	SSRF	SSRR	DFF	DFR	SSEF	DFEF	F	SIG
1	2	3350.1	3349.486	9	5	35.216	384	1.671	NS
1	2	3301.793	3296.081	9	5	46.395	386	11.880	**
2	3	3279.33	3276.587	9	5	43.397	385	6.081	**

[1]SSRF: Regression sum of squares, full model
SSRR: Regression sum of squares, reduced model
DFF: Degrees of freedom, full model
DFR: Degrees of freedom, reduced model
SSEF: Error sum of squares, full model
DFEF: Error degrees of freedom, full model
Ca Cb: Compared pair of curve 'a' versus curve 'b'
[2]Paired curve identification where:

No.	Diuron ($kg\ ai\ ha^{-1}$)
1	0.00
2	0.28
3	0.56

Appendix Table 2.8. Test of coincidence for curves describing natural log of weight in monoculture study for diuron effect over time[1].

Ca[2]	Cb	SSRF	SSRR	DFF	DFR	SSEF	DFEF	F	SIG
1	2	3491.446	3369.509	9	5	46.687	189	123.406	**
1	3	3472.575	3349.18	9	5	45.365	189	128.521	**
1	4	4567.961	4563.392	9	5	80.612	189	2.677	*
1	5	3401.814	3276.995	9	5	46.435	189	127.008	**
1	6	4635.004	4613.321	9	5	53.339	189	19.206	**
2	3	2392.167	2392.082	9	5	49.174	189	0.081	NS
2	4	3487.597	3347.507	9	5	84.377	189	78.448	**
2	5	2321.803	2316.673	9	5	49.847	189	4.863	**
2	6	3554.365	3373.56	9	5	57.379	189	148.886	**
3	4	3469.28	3328.668	9	5	82.501	189	80.531	**
3	5	2303.657	2299.716	9	5	47.801	189	3.895	**
3	6	3535.916	3355.365	9	5	55.636	189	153.335	**
4	5	3399.132	3264.38	9	5	82.959	189	76.748	**
4	6	4631.353	4624.629	9	5	90.831	189	3.497	*
5	6	3465.62	297.651	9	5	56.240	189	141.116	**

[1]SSRF: Regression sum of squares, full model
SSRR: Regression sum of squares, reduced model
DFF: Degrees of freedom, full model
DFR: Degrees of freedom, reduced model
SSEF: Error sum of squares, full model
DFEF: Error degrees of freedom, full model
Ca Cb: Compared pair of curve 'a' versus curve 'b'
[2]Paired curve identification where:

No.	Species	Population
1	VLPMY	100
2	LOLMU	119
3	LOLMU	198
4	VLPMY	400
5	LOLMU	595
6	VLPMY	1600

Appendix Table 2.9. Test of coincidence for curves describing natural log of weight in monoculture study for diuron effect over time[1].

Ca[2]	Cb	SSRF	SSRR	DFF	DFR	SSEF	DFEF	F	SIG
1	2	6343.095	6342.366	9	5	304.124	387	0.231	NS
1	3	6929.547	6902.335	9	5	341.631	387	7.706	**
2	3	6958.447	6934.785	9	5	346.705	387	6.603	**

[1]SSRF: Regression sum of squares, full model
SSRR: Regression sum of squares, reduced model
DFF: Degrees of freedom, full model
DFR: Degrees of freedom, reduced model
SSEF: Error sum of squares, full model
DFEF: Error degrees of freedom, full model
Ca Cb: Compared pair of curve 'a' versus curve 'b'
[2]Paired curve identification where:

No.	Diuron ($kg\ ai\ ha^{-1}$)
1	0.00
2	0.28
3	0.56

Appendix Table 2.10. Predicted (Spitter's) and observed reciprocal seed yield for an individual, 1988[1].

LPOP	VPOP	BLK	OLY	OVY	PLY	PVY
0	0	1	0	0	0	0
0	0	2	0	0	0	0
0	0	3	0	0	0	0
0	0	1	0	0	0	0
0	0	2	0	0	0	0
0	0	3	0	0	0	0
0	0	1	0	0	0	0
0	0	2	0	0	0	0
0	0	3	0	0	0	0
119	0	1	0.745	0	0.703	0
119	0	2	0.607	0	0.703	0
119	0	3	0.586	0	0.703	0
119	0	1	0.865	0	0.703	0
119	0	2	0.824	0	0.703	0
119	0	3	0.436	0	0.703	0
119	0	1	0.785	0	0.703	0
119	0	2	0.911	0	0.703	0
119	0	3	0.564	0	0.703	0
198	0	1	0.169	0	0.408	0
198	0	2	0.385	0	0.408	0
198	0	3	0.288	0	0.408	0
198	0	1	0.501	0	0.408	0
198	0	2	0.529	0	0.408	0
198	0	3	0.341	0	0.408	0
198	0	1	0.241	0	0.408	0
198	0	2	0.563	0	0.408	0
198	0	3	0.422	0	0.408	0
595	0	1	0.171	0	0.131	0
595	0	2	0.158	0	0.131	0
595	0	3	0.151	0	0.131	0
595	0	1	0.221	0	0.131	0
595	0	2	0.224	0	0.131	0
595	0	3	0.143	0	0.131	0
595	0	1	0.086	0	0.131	0
595	0	2	0.184	0	0.131	0
595	0	3	0.125	0	0.131	0
1190	0	1	0.078	0	0.065	0
1190	0	2	0.076	0	0.065	0
1190	0	3	0.061	0	0.065	0
1190	0	1	0.071	0	0.065	0
1190	0	2	0.102	0	0.065	0
1190	0	3	0.082	0	0.065	0
1190	0	1	0.066	0	0.065	0
1190	0	2	0.054	0	0.065	0
1190	0	3	0.06	0	0.065	0
0	100	1	0	0.756	0	0.517
0	100	2	0	0.8	0	0.517
0	100	3	0	0.548	0	0.517
0	100	1	0	0.489	0	0.517

Appendix Table 2.10. Predicted (Spitter's) and observed reciprocal seed yield for an individual, 1988 (continued).

LPOP	VPOP	BLK	OLY	OVY	PLY	PVY
0	100	2	0	0.72	0	0.517
0	100	3	0	0.602	0	0.517
0	100	1	0	0.593	0	0.517
0	100	2	0	0.537	0	0.517
0	100	3	0	0.807	0	0.517
119	100	1	0.985	0.267	0.682	0.433
119	100	2	0.737	0.207	0.682	0.433
119	100	3	0.719	0.2	0.682	0.433
119	100	1	0.634	0.207	0.682	0.433
119	100	2	0.576	0.211	0.682	0.433
119	100	3	0.609	0.23	0.682	0.433
119	100	1	0.671	0.244	0.682	0.433
119	100	2	0.58	0.249	0.682	0.433
119	100	3	0.506	0.223	0.682	0.433
198	100	1	0.527	0.263	0.401	0.391
198	100	2	0.323	0.2	0.401	0.391
198	100	3	0.372	0.267	0.401	0.391
198	100	1	0.575	0.263	0.401	0.391
198	100	2	0.426	0.233	0.401	0.391
198	100	3	0.371	0.178	0.401	0.391
198	100	1	0.459	0.204	0.401	0.391
198	100	2	0.309	0.194	0.401	0.391
198	100	3	0.277	0.133	0.401	0.391
595	100	1	0.142	0.23	0.131	0.263
595	100	2	0.159	0.256	0.131	0.263
595	100	3	0.15	0.226	0.131	0.263
595	100	1	0.164	0.182	0.131	0.263
595	100	2	0.133	0.156	0.131	0.263
595	100	3	0.104	0.222	0.131	0.263
595	100	1	0.061	0.194	0.131	0.263
595	100	2	0.126	0.267	0.131	0.263
595	100	3	0.142	0.197	0.131	0.263
1190	100	1	0.093	0.255	0.065	0.176
1190	100	2	0.091	0.248	0.065	0.176
1190	100	3	0.074	0.189	0.065	0.176
1190	100	1	0.043	0.211	0.065	0.176
1190	100	2	0.066	0.222	0.065	0.176
1190	100	3	0.05	0.241	0.065	0.176
1190	100	1	0.07	0.281	0.065	0.176
1190	100	2	0.052	0.236	0.065	0.176
1190	100	3	0.071	0.185	0.065	0.176
0	400	1	0	0.318	0	0.288
0	400	2	0	0.345	0	0.288
0	400	3	0	0.288	0	0.288
0	400	1	0	0.268	0	0.288
0	400	2	0	0.284	0	0.288
0	400	3	0	0.334	0	0.288
0	400	1	0	0.358	0	0.288
0	400	2	0	0.313	0	0.288

Appendix Table 2.10. Predicted (Spitter's) and observed reciprocal seed yield for an individual, 1988 (continued).

LPOP	VPOP	BLK	OLY	OVY	PLY	PVY
0	400	3	0	0.38	0	0.288
119	400	1	0.873	0.093	0.628	0.26
119	400	2	0.749	0.092	0.628	0.26
119	400	3	0.632	0.095	0.628	0.26
119	400	1	0.886	0.091	0.628	0.26
119	400	2	0.665	0.096	0.628	0.26
119	400	3	0.522	0.07	0.628	0.26
119	400	1	0.849	0.093	0.628	0.26
119	400	2	0.844	0.098	0.628	0.26
119	400	3	0.698	0.11	0.628	0.26
198	400	1	0.46	0.071	0.382	0.244
198	400	2	0.331	0.087	0.382	0.244
198	400	3	0.222	0.07	0.382	0.244
198	400	1	0.391	0.104	0.382	0.244
198	400	2	0.258	0.094	0.382	0.244
198	400	3	0.536	0.094	0.382	0.244
198	400	1	0.431	0.082	0.382	0.244
198	400	2	0.429	0.073	0.382	0.244
198	400	3	0.376	0.066	0.382	0.244
595	400	1	0.159	0.071	0.129	0.187
595	400	2	0.144	0.056	0.129	0.187
595	400	3	0.126	0.051	0.129	0.187
595	400	1	0.159	0.076	0.129	0.187
595	400	2	0.124	0.067	0.129	0.187
595	400	3	0.13	0.061	0.129	0.187
595	400	1	0.14	0.06	0.129	0.187
595	400	2	0.173	0.065	0.129	0.187
595	400	3	0.089	0.063	0.129	0.187
1190	400	1	0.074	0.068	0.065	0.139
1190	400	2	0.081	0.041	0.065	0.139
1190	400	3	0.055	0.044	0.065	0.139
1190	400	1	0.072	0.074	0.065	0.139
1190	400	2	0.094	0.049	0.065	0.139
1190	400	3	0.062	0.044	0.065	0.139
1190	400	1	0.078	0.07	0.065	0.139
1190	400	2	0.059	0.074	0.065	0.139
1190	400	3	0.057	0.061	0.065	0.139
0	1600	1	0	0.106	0	0.104
0	1600	2	0	0.074	0	0.104
0	1600	3	0	0.076	0	0.104
0	1600	1	0	0.084	0	0.104
0	1600	2	0	0.102	0	0.104
0	1600	3	0	0.08	0	0.104
0	1600	1	0	0.096	0	0.104
0	1600	2	0	0.094	0	0.104
0	1600	3	0	0.09	0	0.104
119	1600	1	0.512	0.046	0.476	0.1
119	1600	2	0.593	0.051	0.476	0.1
119	1600	3	0.522	0.049	0.476	0.1

Appendix Table 2.10. Predicted (Spitter's) and observed reciprocal seed yield for an individual, 1988 (continued).

LPOP	VPOP	BLK	OLY	OVY	PLY	PVY
119	1600	1	0.535	0.05	0.476	0.1
119	1600	2	0.652	0.051	0.476	0.1
119	1600	3	0.462	0.053	0.476	0.1
119	1600	1	0.63	0.042	0.476	0.1
119	1600	2	0.719	0.041	0.476	0.1
119	1600	3	0.502	0.035	0.476	0.1
198	1600	1	0.272	0.043	0.32	0.098
198	1600	2	0.302	0.042	0.32	0.098
198	1600	3	0.334	0.055	0.32	0.098
198	1600	1	0.388	0.043	0.32	0.098
198	1600	2	0.408	0.04	0.32	0.098
198	1600	3	0.29	0.046	0.32	0.098
198	1600	1	0.423	0.044	0.32	0.098
198	1600	2	0.388	0.044	0.32	0.098
198	1600	3	0.262	0.045	0.32	0.098
595	1600	1	0.098	0.032	0.121	0.087
595	1600	2	0.116	0.04	0.121	0.087
595	1600	3	0.116	0.033	0.121	0.087
595	1600	1	0.083	0.034	0.121	0.087
595	1600	2	0.122	0.028	0.121	0.087
595	1600	3	0.112	0.041	0.121	0.087
595	1600	1	0.122	0.03	0.121	0.087
595	1600	2	0.132	0.031	0.121	0.087
595	1600	3	0.141	0.028	0.121	0.087
1190	1600	1	0.06	0.03	0.062	0.075
1190	1600	2	0.071	0.024	0.062	0.075
1190	1600	3	0.051	0.023	0.062	0.075
1190	1600	1	0.063	0.02	0.062	0.075
1190	1600	2	0.053	0.016	0.062	0.075
1190	1600	3	0.049	0.021	0.062	0.075
1190	1600	1	0.07	0.025	0.062	0.075
1190	1600	2	0.042	0.019	0.062	0.075
1190	1600	3	0.069	0.02	0.062	0.075
0	6400	1	0	0.024	0	0.029
0	6400	2	0	0.03	0	0.029
0	6400	3	0	0.026	0	0.029
0	6400	1	0	0.028	0	0.029
0	6400	2	0	0.023	0	0.029
0	6400	3	0	0.024	0	0.029
0	6400	1	0	0.031	0	0.029
0	6400	2	0	0.03	0	0.029
0	6400	3	0	0.028	0	0.029
119	6400	1	0.401	0.017	0.242	0.029
119	6400	2	0.465	0.018	0.242	0.029
119	6400	3	0.33	0.016	0.242	0.029
119	6400	1	0.334	0.018	0.242	0.029
119	6400	2	0.417	0.018	0.242	0.029
119	6400	3	0.448	0.015	0.242	0.029
119	6400	1	0.434	0.018	0.242	0.029

Appendix Table 2.10. Predicted (Spitter's) and observed reciprocal seed yield for an individual, 1988 (continued).

LPOP	VPOP	BLK	OLY	OVY	PLY	PVY
119	6400	2	0.052	0.017	0.242	0.029
119	6400	3	0.487	0.015	0.242	0.029
198	6400	1	0.31	0.013	0.194	0.029
198	6400	2	0.192	0.014	0.194	0.029
198	6400	3	0.249	0.015	0.194	0.029
198	6400	1	0.213	0.015	0.194	0.029
198	6400	2	0.192	0.014	0.194	0.029
198	6400	3	0.272	0.013	0.194	0.029
198	6400	1	0.311	0.013	0.194	0.029
198	6400	2	0.204	0.013	0.194	0.029
198	6400	3	0.263	0.012	0.194	0.029
595	6400	1	0.116	0.012	0.097	0.028
595	6400	2	0.075	0.011	0.097	0.028
595	6400	3	0.081	0.012	0.097	0.028
595	6400	1	0.111	0.012	0.097	0.028
595	6400	2	0.082	0.012	0.097	0.028
595	6400	3	0.09	0.011	0.097	0.028
595	6400	1	0.098	0.011	0.097	0.028
595	6400	2	0.083	0.013	0.097	0.028
595	6400	3	0.103	0.012	0.097	0.028
1190	6400	1	0.047	0.01	0.055	0.026
1190	6400	2	0.04	0.011	0.055	0.026
1190	6400	3	0.042	0.011	0.055	0.026
1190	6400	1	0.181	0.011	0.055	0.026
1190	6400	2	0.044	0.009	0.055	0.026
1190	6400	3	0.052	0.009	0.055	0.026
1190	6400	1	0.067	0.011	0.055	0.026
1190	6400	2	0.129	0.009	0.055	0.026
1190	6400	3	0.05	0.009	0.055	0.026

[1]Where LPOP is LOLMU population per square meter, VPOP is VLPMY population per square meter, BLK is block, PLY is predicted LOLMU yield, PVY is predicted VLPMY yield, OLY is observed LOLMU yield, and OVY is observed VLPMY yield.

Appendix Table 2.11. Predicted (Spitter's) and observed reciprocal seed yield for an individual, 1989.

LPOP	VPOP	BLK	OLY	OVY	PLY	PVY
0	0	1	0	0	0	0
0	0	1	0	0	0	0
0	0	1	0	0	0	0
0	0	2	0	0	0	0
0	0	2	0	0	0	0
0	0	2	0	0	0	0
0	0	3	0	0	0	0
0	0	3	0	0	0	0
0	0	3	0	0	0	0
119	0	1	1.044	0	1.176	0
119	0	1	0.913	0	1.176	0
119	0	1	0.797	0	1.176	0
119	0	2	1.096	0	1.176	0
119	0	2	0.742	0	1.176	0
119	0	2	1.05	0	1.176	0
119	0	3	0.94	0	1.176	0
119	0	3	1.102	0	1.176	0
119	0	3	1.324	0	1.176	0
198	0	1	0.848	0	0.572	0
198	0	1	0.562	0	0.572	0
198	0	1	0.437	0	0.572	0
198	0	2	0.323	0	0.572	0
198	0	2	0.506	0	0.572	0
198	0	2	0.543	0	0.572	0
198	0	3	0.656	0	0.572	0
198	0	3	0.498	0	0.572	0
198	0	3	0.513	0	0.572	0
595	0	1	0.102	0	0.16	0
595	0	1	0.171	0	0.16	0
595	0	1	0.163	0	0.16	0
595	0	2	0.222	0	0.16	0
595	0	2	0.172	0	0.16	0
595	0	2	0.112	0	0.16	0
595	0	3	0.225	0	0.16	0
595	0	3	0.126	0	0.16	0
595	0	3	0.16	0	0.16	0
0	100	1	0	1.258	0	1.053
0	100	1	0	1.289	0	1.053
0	100	1	0	1.062	0	1.053
0	100	2	0	0.798	0	1.053
0	100	2	0	0.83	0	1.053
0	100	2	0	1.648	0	1.053
0	100	3	0	0.915	0	1.053
0	100	3	0	1.106	0	1.053
0	100	3	0	1.031	0	1.053
119	100	1	1.079	0.149	1.093	0.141
119	100	1	0.783	0.13	1.093	0.141
119	100	1	0.794	0.142	1.093	0.141
119	100	2	0.706	0.162	1.093	0.141

Appendix Table 2.11. Predicted (Spitter's) and observed reciprocal seed yield for an individual, 1989 (continued).

LPOP	VPOP	BLK	OLY	OVY	PLY	PVY
119	100	2	0.801	0.145	1.093	0.141
119	100	2	1.142	0.122	1.093	0.141
119	100	3	0.882	0.131	1.093	0.141
119	100	3	0.881	0.15	1.093	0.141
119	100	3	1.453	0.15	1.093	0.141
198	100	1	0.584	0.048	0.551	0.09
198	100	1	0.384	0.107	0.551	0.09
198	100	1	0.608	0.082	0.551	0.09
198	100	2	0.48	0.071	0.551	0.09
198	100	2	0.364	0.064	0.551	0.09
198	100	2	0.644	0.032	0.551	0.09
198	100	3	0.463	0.052	0.551	0.09
198	100	3	0.633	0.032	0.551	0.09
198	100	3	0.663	0.061	0.551	0.09
595	100	1	0.243	0.023	0.158	0.032
595	100	1	0.132	0.039	0.158	0.032
595	100	1	0.152	0.03	0.158	0.032
595	100	2	0.183	0.107	0.158	0.032
595	100	2	0.179	0.014	0.158	0.032
595	100	2	0.17	0.026	0.158	0.032
595	100	3	0.155	0.084	0.158	0.032
595	100	3	0.257	0.012	0.158	0.032
595	100	3	0.217	0.057	0.158	0.032
0	400	1	0	0.376	0	0.326
0	400	1	0	0.326	0	0.326
0	400	1	0	0.291	0	0.326
0	400	2	0	0.319	0	0.326
0	400	2	0	0.33	0	0.326
0	400	2	0	0.366	0	0.326
0	400	3	0	0.356	0	0.326
0	400	3	0	0.314	0	0.326
0	400	3	0	0.274	0	0.326
119	400	1	0.625	0.043	0.903	0.109
119	400	1	0.806	0.037	0.903	0.109
119	400	1	1.039	0.042	0.903	0.109
119	400	2	0.495	0.029	0.903	0.109
119	400	2	0.752	0.038	0.903	0.109
119	400	2	1.116	0.036	0.903	0.109
119	400	3	0.807	0.05	0.903	0.109
119	400	3	0.835	0.053	0.903	0.109
119	400	3	0.92	0.034	0.903	0.109
198	400	1	0.652	0.019	0.498	0.075
198	400	1	0.908	0.017	0.498	0.075
198	400	1	0.632	0.023	0.498	0.075
198	400	2	0.427	0.026	0.498	0.075
198	400	2	0.425	0.013	0.498	0.075
198	400	2	0.776	0.019	0.498	0.075
198	400	3	0.572	0.012	0.498	0.075
198	400	3	0.686	0.017	0.498	0.075

Appendix Table 2.11. Predicted (Spitter's) and observed reciprocal seed yield for an individual, 1989 (continued).

LPOP	VPOP	BLK	OLY	OVY	PLY	PVY
198	400	3	0.732	0.021	0.498	0.075
595	400	1	0.163	0.011	0.153	0.03
595	400	1	0.197	0.013	0.153	0.03
595	400	1	0.121	0.013	0.153	0.03
595	400	2	0.173	0.017	0.153	0.03
595	400	2	0.158	0.022	0.153	0.03
595	400	2	0.165	0.017	0.153	0.03
595	400	3	0.176	0.01	0.153	0.03
595	400	3	0.175	0.011	0.153	0.03
595	400	3	0.143	0.008	0.153	0.03
0	1600	1	0	0.08	0	0.087
0	1600	1	0	0.126	0	0.087
0	1600	1	0	0.076	0	0.087
0	1600	2	0	0.143	0	0.087
0	1600	2	0	0.07	0	0.087
0	1600	2	0	0.124	0	0.087
0	1600	3	0	0.09	0	0.087
0	1600	3	0	0.118	0	0.087
0	1600	3	0	0.073	0	0.087
119	1600	1	0.914	0.026	0.533	0.057
119	1600	1	0.617	0.011	0.533	0.057
119	1600	1	0.619	0.01	0.533	0.057
119	1600	2	0.526	0.024	0.533	0.057
119	1600	2	0.423	0.008	0.533	0.057
119	1600	2	0.695	0.016	0.533	0.057
119	1600	3	0.606	0.015	0.533	0.057
119	1600	3	0.653	0.024	0.533	0.057
119	1600	3	0.698	0.026	0.533	0.057
198	1600	1	0.48	0.008	0.36	0.046
198	1600	1	0.616	0.011	0.36	0.046
198	1600	1	0.468	0.01	0.36	0.046
198	1600	2	0.288	0.01	0.36	0.046
198	1600	2	0.327	0.008	0.36	0.046
198	1600	2	0.528	0.009	0.36	0.046
198	1600	3	0.341	0.007	0.36	0.046
198	1600	3	0.405	0.012	0.36	0.046
198	1600	3	0.453	0.005	0.36	0.046
595	1600	1	0.105	0.009	0.137	0.024
595	1600	1	0.102	0.006	0.137	0.024
595	1600	1	0.103	0.009	0.137	0.024
595	1600	2	0.127	0.007	0.137	0.024
595	1600	2	0.191	0.008	0.137	0.024
595	1600	2	0.115	0.006	0.137	0.024
595	1600	3	0.13	0.007	0.137	0.024
595	1600	3	0.126	0.008	0.137	0.024
595	1600	3	0.173	0.007	0.137	0.024

[1]Where LPOP is LOLMU population per square meter, VPOP is VLPMY population per square meter, BLK is block, PLY is predicted LOLMU yield, PVY is predicted VLPMY yield, OLY is observed LOLMU yield, and OVY is observed VLPMY yield.