# EFFECTS OF NO-TILL AND FALL PLOWING ON PESTICIDE MOVEMENT IN RUNOFF AND TILE DRAINAGE

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# EXECUTIVE SUMMARY


The present study examines the effects of no-till versus fall moldboard plowing in a corn-soybean rotation on losses in surface runoff and tile drainage of four of the most widely used herbicides: atrazine, alachlor, metolachlor and metribuzin. The study is being conducted on an experimental site in which runoff and tile drainage water quality have been continuously monitored for 15 years.

The results for 1987-1989 are presented and show:

1. The years 1987 and 1988 were below normal in rainfall while 1989 had above normal precipitation.

2. Highest concentrations and loads of all four herbicides were found with surface runoff in the period just after application.

3. Very few tile drainage events had detectable pesticides and few of those exceeded the EPA health advisories for the four herbicides.

4. Losses in runoff and tile drainage of the four herbicides were in the order: atrazine > alachlor > metolachlor > metribuzin. These differences are attributable to a combination of application rate (atrazine, alachlor, metolachlor and metribuzin were applied at annual rates of 2, 2.5, 2, and 0.5 lb/ac, respectively), and the longer residence time of atrazine.

5. There were no significant differences in runoff, tile flow, and pesticide losses between no-till and fall plowing.

6. There was very little carryover of applied pesticides from one year to another.

# INTRODUCTION

Conservation tillage, including no-till, is becoming an increasingly significant practice among corn and soybean farmers in the U.S.. Conservaton tillage has been promoted as an effective erosion control practice, and is the basis for nonpoint source phosphorus control in much of the Great Lakes (Wall et al., 1989). Conservation tillage has been adopted by many farmers because, in addition to erosion control, its reduces fuel and laborrequirements. It is expected that this practice will continue to grow as farmers streamline their operations, and as pressure on agriculture to reduce nonpoint source pollution increases.

In recent years, there has been growing concern by the public for groundwater contamination by pesticides and nitrate from agricultural practices. While surveys of farm wells in Ohio (Baker et al., 1989) suggest little widespread contamination of groundwater with nitrate and pesticides, there is good evidence for seasonal contamination of surface waters in midwestern corn and soybean producing states, like Ohio, by commonly used herbicides (Baker, 1987a). Therefore, while the public perception is that groundwater is being contaminated with agricultural chemicals, the reality is that there is a greater problem with surface water contamination.

The pesticides being reported in surface and well waters are almost exclusively the most widely used corn and soybean herbicides. Notable among these are atrazine and alachlor, the most popular corn herbicides, and metolachlor and metribuzin, among the most popular soybean compounds. Alachlor, atrazine, metolachlor and metribuzin were used in Ohio in 1986 as follows (Waldron, 1989a, 1989b):

| Common Name | Trade Name | Quantity Applied (1000 lbs) | 1986 Rank |
|---|---|---|---|
| Alachlor | Lasso | 5,809 | 1 |
| Atrazine | AAtrex | 4,537 | 2 |
| Metolachlor | Dual | 3,882 | 3 |
| Metribuzin | Sencor, Lexone | 936 | 7 |

These compounds are quite water soluble, have low soil-water partition coefficients, and with the exception of atrazine have low residence times in soil (a few months for alachlor, metolachlor and metribuzin, up to a year for atrazine). Baker (1987a) has suggested that the high seasonal concentrations of these compounds in Ohio's surface waters is due to a combination of surface runoff at time of application and leaching of the compounds through tile lines back into the surface water system. It should also be noted that leachability to tile lines is a qualitative indicator of the compound's potential to leach to groundwater.

There have been suggestions that use of no-till may increase the contamination of groundwater by pesticides; this is based on two assumptions:

1) that no-till produces greater leaching than plowed soils because of better structure in no-till. This assumption is supported by studies (e.g, Hall et al., 1989) showing greater volume of leachate under no-till, and the greater presence of macropores in no-till soils (Lal et al., 1989a). On the other hand, Baker (1987b) summarized research on relative runoff and subsurface drainage of midwestern soils and found that there was no consistent effect of no-till on runoff and leaching. Lal et al. (1989b) actually found slightly more tile leachate with fall plowing than with no-till when analyzing data from the present study at Hoytville, Ohio.

2) that use of no-till requires greater application rates of herbicides and insecticides. Fawcett (1987) addressed this issue and found that actual use of pesticide was little different in no-till than in plowed soils.

In order to address these questions, a study was initiated in 1987 on the long-term runoff and tile drainage plots at Hoytville, Ohio to determine the effects of no-till and fall moldboard plowing on runoff and tile drainage of alachlor, atrazine, metolachlor and metribuzin in a corn-soybean rotation. Carryover effects from one crop to another were also studied.

# METHODS AND MATERIALS

## Study Site

The study is located at the NW Branch, Ohio Agricultural Research and Development Center (OARDC) in Wood County, Ohio. It is on a Hoytville silty clay soil (fine, illitic, mesic Mollic Ochraqualf), a poorly-drained soil formed in late Wisconsin high-lime glacial till. It is high in organic matter, has near neutral pH and has high fertility levels. Details of the site and soil characteristics are given in Logan 1979; Logan and Stiefel, 1979; Logan, 1987; Lal et al., 1989a,b.

## Experimental Monitoring

The runoff and tile drainage experiment was established in 1974 and has been in continuous operation since that time. This makes it perhaps the longest continuously operated tillage/tile drainage experiment in the U.S. There are eight plots arranged in two blocks of four plots (Figure 1). Each plot is 0.04 ha (12.2 m x 32.3 m), is separated from adjacent plots at the surface by a grassed berm, and has a plastic barrier around the perimeter to a depth of 1.5 m. Surface slope is less than 1% and runoff is collected at one end by a concrete gutter with a drain which conducts the runoff to a sump in the sampling building. There is a 10-cm diameter corrugated plastic tile placed in the center of each plot at a depth of 1 m with a slope of 0.2%. Tile drainage is conducted by plastic pipe to anothe sump in the sample room. Samples are automatically pumped from the fiberglas sumps to a refrigerated compartment (4 $^{0}$C) by a calibrated sump pump. Elapsed pumping time per event is recorded and used to calculate flow. A continuous, integrated sample is removed from the pump discharge by a narrow orfice inserted into the discharge tube. The samples are collected in glass bottles in the refrigerated compartment, and kept there until transfer to the analytical lab in Columbus, usually no more than one week.

## Experimental Design

Since 1975, the first year of cropping, the eight plots have been split into two tillage treatments: no-till and fall moldboard plowing. At the same time, the plots have been in some kind of corn-soybean rotation. In the initial years, the rotation was corn-corn-soybean-soybean, but since 1986 it has been corn-soybean. In the present scheme, one block of four plots (Figure 1) is in corn and the other is in soybeans. Tillage plots were randomly assigned to each of the two blocks in 1974 and have remained unchanged since (Figure 1).

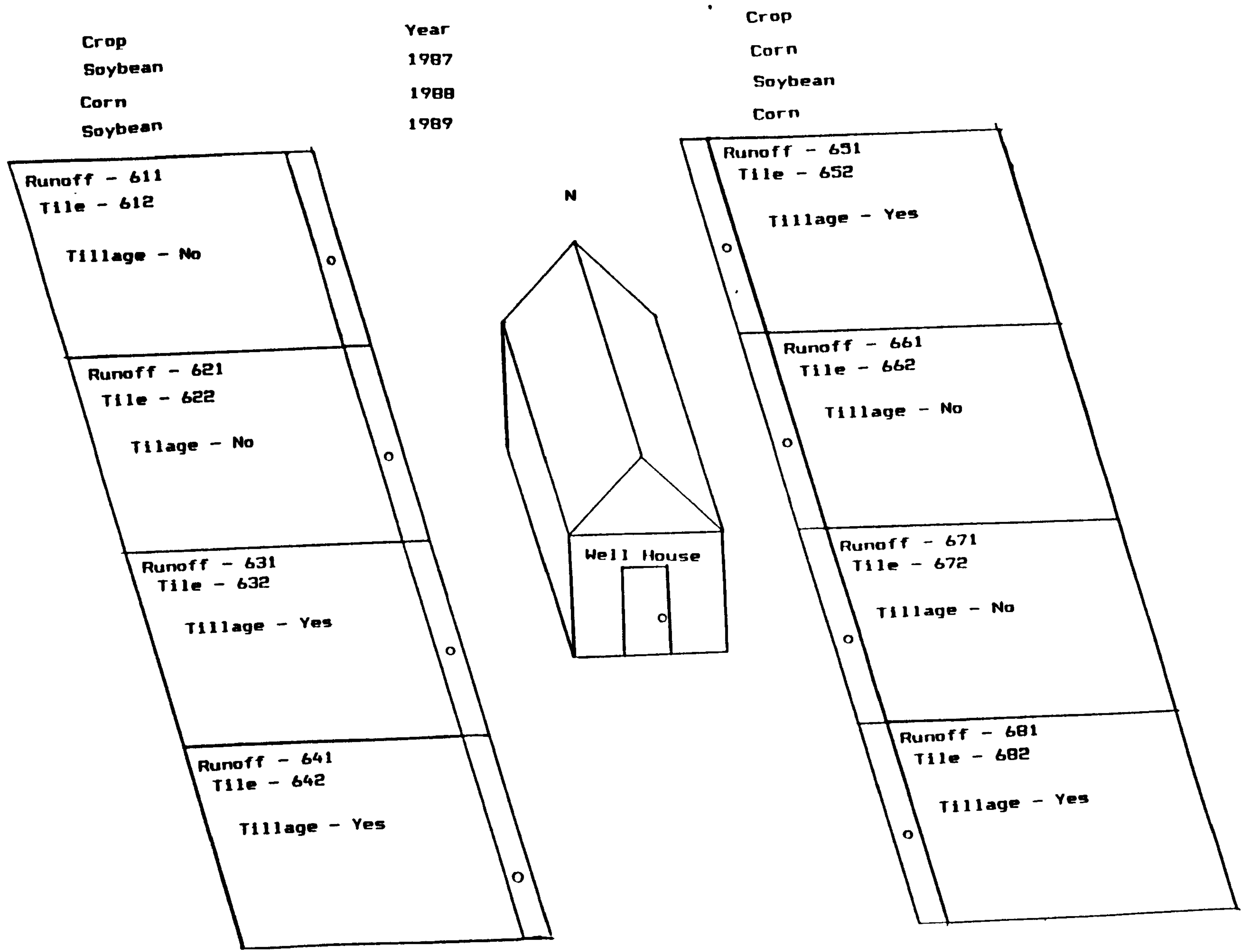



Figure 1. Layout of the experimental site showing assignment of plots by tillage treatment.

Two corn herbicides are used: alachlor and atrazine, while the soybean herbicides are metolachlor and metribuzin. Table 1 gives dates of application and application rates for 1987-1989. Rates are in accordance with extension recommendations.

## Sample Handling and Analysis

Runoff and tile drainage water samples are analyzed for the four target compounds using gas chromatography. A number of other compounds are routinely screened at the same time but are not reported here. They include: trifluralin, EPTC, butylate, simazine, terbufos, metalaxyl, cyanazine and pendimethalin. Trace amounts of these compounds are occasionally found and their presence is attributed to drift from adjacent experimental areas or from precipitation. Pesticides in precipitation are being monitored as part of this study (see below).

Two methods have been used to concentrate pesticides for GC analysis: liquid-liquid extraction and solid-phase extraction. Liquid-liquid extraction was used in 1987-88 and solid-phase extraction in 1989.

### Liquid-liquid Extraction

Samples (approximately 500 mL) are accurately weighed into a 1-L glass beaker. Approximately 70 mL methylene chloride is used to rinse the sample bottle and this is then transferred to the beaker. The contents of the beaker are then transferred to a clean, dry, 2-L separatory funnel. The sample is mixed by inverting the funnel by hand for about 2 min. The funnel is then placed in a sonic bath to break up any emulsions that may have formed. The methylene chloride phase is removed from the funnel and dried in $Na_2SO_4$ columns. Methylene chloride is used to rinse the column, and $N_2$ gas is used to force all solvent from the column. Collected samples are frozen until rotoevaporation. Samples are thawed for about 15 min. just prior to rotoevaporation and then placed in a clean, dry round-bottom flask. The flask is rinsed with acetone and methylene chloride and the solvent evaporated on the rotoevaporator. The sample is transferred to the flask and the sample bottle rinsed with small amounts of methylene chloride. The sample is rotoevaporated at 70-100 rpm with the flask in a water bath at 40-42 $^{o}C$. When the volume in the flask is about 5-10 mL, 10 mL hexane are added and the sample is evaporated to dryness. A micropipet is used to add 1.00 mL of isopropyl alcohol to the flask. The contents are swirled and transferred into a previously cleaned 1.8 mL vial with septum for GC analysis.

Samples were extracted without prior filtering. Runoff samples have rarely had sediment concentrations greater than

Table 1. Summary of herbicide application (1987-1989).

| Crop | Date Applied | Pesticide Applied | Application Rate (lb./ac) |
|---|---|---|---|
| | | 1987 | |
| corn | May 1 | atrazine | 2.00 |
| corn | May 1 | alachlor | 2.50 |
| soybean | May 13 | metalochlor | 2.00 |
| soybean | May 13 | metribuzin | 0.38 |
| | | 1988 | |
| corn | May 2 | atrazine | 2.00 |
| corn | May 2 | alachlor | 2.00 |
| soybean | May 5 | metalochlor | 4.00 |
| soybean | May 5 | metribuzin | 0.50 |
| | | 1989 | |
| corn | June 27 | atrazine | 2.00 |
| corn | June 27 | alachlor | 2.50 |
| soybean | June 27 | metalochlor | 2.00 |
| soybean | June 27 | metribuzin | 0.50 |

500 mg/L, and tile drainge samples are usually less than 50-100 mg/L sediment (Logan, 1987). Given the low partition coefficients of these four compounds, much less than 1% of the pesticide would be associated with the sediments at these sediment concentrations. The sediment from this clay-textured soil is very fine-grained and tends to stay in suspension. Most of the sediment partitioned into the water layer in the separatory funnel or was held by the glass wool on top of the $Na_2SO_4$ column.

If water remained in the sample after rotoevaporation, it was removed by filtering the sample through 25 g $Na_2SO_4$ held in a funnel on top of an amber glass bottle. Small aliquots of methylene chloride are used to transfer all of the sample to the filter. The sample is returned to the round-bottom flask and rotoevaporation is repeated.

Solid-phase Extraction

A preliminary study was conducted to evaluate the effectiveness of solid-phase extraction (SPE) for the concentration of pesticides for GC analysis. Prepackaged commercial cartridges containing 3 mL Cyclohexyl (J.T. Baker disposable cyclohexyl columns) were selected from several available commercially. Results of the preliminary study showed that recovery of the four target herbicides by Cyclohexyl eluted with ethyl acetate was: 106-113% for atrazine, 101-104% for metribuzin, 110-124% for alachlor, and 114 to 127% for metolachlor.

A 500.0 mL water sample is weighed into a glass beaker. The contents are filtered through Whatman No. 1 filter paper to remove sediments. Based on the known water-sediment partition coefficients of the target compounds, we calculated that the sample would have to contain in excess of 2000 mg/L in order to contain more than 1% of the pesticide in the sediment. In 14 years of monitoring, we have never exceeded this level in tile drainage and only occasionally in runoff from the plowed plots. Where the sample appears on inspection to contain heavy sediments, the sediment concentration is determined and, if the concentration exceeds 2000 mg/L, the sample is extracted by liquid-liquid extraction. Otherwise, the sediment is discarded.

The filtered water sample is passed through the SPE column by way of a teflon tube attached to the top of the column. A weak vacuum is pulled from the bottom of the column and the filtrate is discarded. After allowing the column to drain until just dry, the pesticide is eluted with 2 1-mL aliquots of ethyl acetate which are collected in a septum-sealed vial for GC analysis.

Gas Chromatographic Analysis

Pesticides are analyzed in concentrated samples by gas chromatography using a Varian Model 3500 capillary GC with autosampler and nitrogen-phosphorus detector. A Chrompack capillary column (50 m in length, 0.35 mm OD and 0.25 mm ID) is used. Data is collected on a Spectra Physics Model 4290 intergrator and transferred automatically to a microcomputer equipped with Varian's Labnet chromatography software.

The GC is calibrated against a mixed standard containing 1 mg/L of each compound screened. Azobenzene is used in both standards and samples as an internal standard. A 144-uL aliquot of concentrated sample is transferred by microsyringe to a 1.5 mL autosampler vial with a 250 uL insert. Six uL of azobenxene (25 mg/L) is added. The vial is capped with a teflon-coated septum and placed on the autosampler. The normal run sequence on the autosampler is: standard, five samples, standard, three samples, a standard run as a sample (placed at random on the autosampler carousel), and finally an ethyl acetate vial to ensure all material is forced off the column. Wash vials are inserted between each injected vial.

A sample chromatogram is presented in Figure 2.

Quality Assurance/Quality Control

A detailed QA/QC plan was prepared as part of the original grant propopsal and is available from the Principal Investigator or the Grants Officer. QA/QC comprises three components: 1) pesticide standards and blanks and instrumentaion calibration; 2) recovery of spiked samples; and 3) blind field duplicates.

All standards are made up in Nanopure water passed through an organic removal column. Primary analytical standards are used for standards. These were obtained from the pesticide manufacturer or from the U.S. EPA (Research Triangle, NC). Organically pure water was used for all final rinses of glassware and syringes. The GC is calibrated against a 1-mg/L mixed standard with 1 mg/L azobenzene added as internal standard. The instrument is recalibrated at least every five samples during a run.

A large volume of sample was composited from field samples and refrigerated as is. Subsamples were spiked with mixed standard and internal standard (standard was 10 mg/L for liquid-liquid extraction and 5 mg/L for SPE), and spiked and unspiked subsamples were analyzed every 10 samples. Results are reported as spiked and unspiked values and percent recovery by date of analysis for each compound. Results are presented separately for liquid-liquid and SPE extractions.

A blind field duplicate sample was prepared at the site for each event by splitting one of the runoff or tile drainage

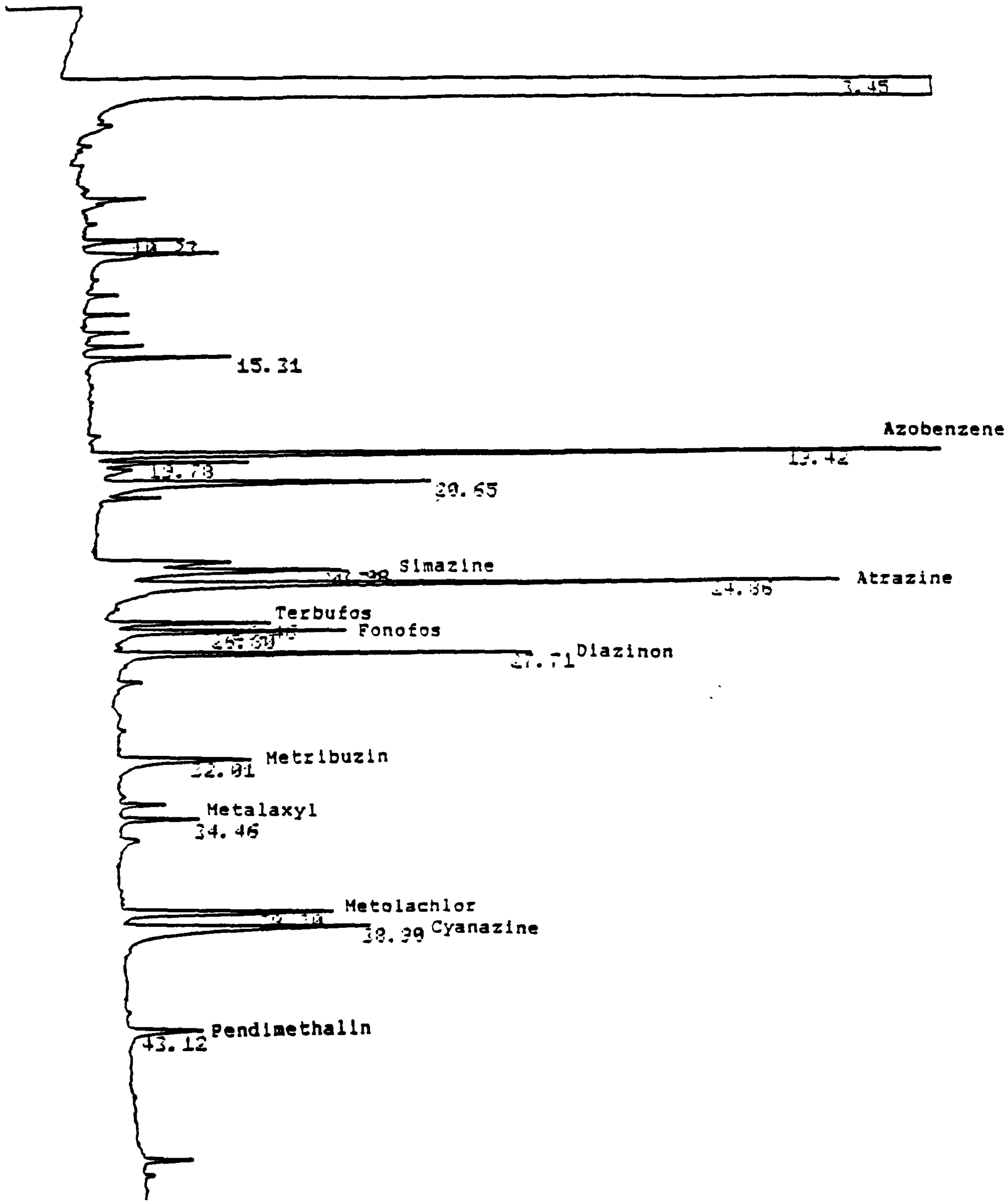



Figure 2. An example chromatogram produced with the Varian 3500 capillary gas chromatograph equipped with a nitrogen-phosphorus detector and 50 m column.

samples at random into two subsamples. Results are calculated as percent deviation for those samples with detectable pesticide.

## Multiresidue Soil Pesticide Extraction

As part of our monitoring scheme, a multiresidue soil extraction procedure is being developed to extract and determine pesticides associated with the plot soil (Adewunmi and Logan, 1989). This method is designed to extract many classes of pesticides in a single extraction process. Such a multiresidue procedure is necessary for several reasons. First, the plots contain carryovers from previous pesticide applications. Second, pesticides that were not applied on our plots but carried over by drifts from neighboring experimental plots and other farms are being detected in laboratory analysis. Third, this multiresidue approach saves time and resources that would otherwise have been used to individually extract each pesticide. And lastly, the principal compounds involved in this project belong to three classes: s-triazine (atrazine), anilide (alachlor and metolachlor) and as-triazinone (metribuzin); this requires a method that is able to effectively extract the three classes of herbicides.

In developing this procedure, six pesticide classes, five single solvents, three mixed solvents and three extraction techniques were investigated. Some of these solvents have been previously used to extract either individual pesticides or classes of pesticides while others have not been used at all. Hoytville soil was spiked with analytical grade pesticide standard solutions and incubated for seven days before being extracted. Samples were subsequently extracted with acetone, methanol, hexane, methylene chloride, iso-octane and 1:1 mixtures of methylene chloride-methanol, iso-octane-methylene chloride and iso-octane-methanol. Extractions were carried out for 30 min on ultrasonic bath, and on rotary-action and wrist-action shakers, and filtered extracts were analyzed as previously described.

## Collection and Analysis of Pesticides in Precipitation

Routine laboratory analyses have detected and identified compounds that were not used on our plots but carried over by drift from neighboring farms or deposited in rainfall. Therefore, in addition to monitoring runoff and tile drainage, a wet/dry fall precipitation automatic collector was installed beside the plots. The sampler/collector was modified to pass the collected water samples through a hole in the wetfall bucket into a solid-phase extraction column (SPE) which is specific in retaining organic compounds. A 1-cm diameter polyethylene syringe was packed to a depth of 5 cm with Cyclohexyl which was contained by plugs of glass wool. A teflon valve connected to the syringe was used to adjust flow rate through the SPE. A quick-connect assembly is used so that syringes can be removed after each rainfall event and replaced with new ones. The SPE column is then brought back to the laboratory for pesticide elution and analysis.

Greenhouse and laboratory evaluations of the sampler and the SPE column were carried out before field installation. This involved spiking 3300 mL of ultrapure water equivalent to 4.48 cm (1.76 inches) of rainfall with pesticide standard solution and letting the water flow through the sampler and the SPE column. The pesticides were then eluted from the SPE column and analyzed on the GC. Four solvents: ethyl acetate, hexane, methanol and 2-propanol, and a solvent mixture (1:1 2-propanol-ethyl acetate) were compared for effectiveness in eluting the pesticides from the column. In addition, we determined the minimum volume of solvent required to elute the compounds from the column. SPE columns were sequentially desorbed with the appropriate solvent in 1 mL aliquots and collected separately. The extracts were made to volume and analyzed. Before being re-used, the test column was washed with 1:1 hexane-ethyl acetate and 1:1 dilute acetic acid-methanol solutions, which were concentrated to dryness on a rotary evaporator, redissolved in 1 mL ethyl acetate, and analyzed for pesticides.

# RESULTS AND DISCUSSION

## Precipitation, Runoff and Tile Flow

### Precipitation

Table 2 summarizes precipitation at the Hoytville station for 1987, 1988 and 1989 compared to the long-term record of 36 years. The long-term record indicates that rainfall is fairly well distributed throughout the year, with a peak in April-August and a minimum in December-February. Greatest runoff and tile drainage on this site has been from March through the end of May because of the greater rainfall and the low evapotranspiration (ET). There is a tendency for some tile flow in the late fall as the soil profile rewets with decreased ET after crop harvest, and with November rains.

Rainfall in 1987, 1988 and 1989 has been very atypical. In 1987, every month except August and December had below average rainfall. Rainfall was particularly low in March and April when runoff and tile drainage is usually greatest, and November rain was also low. In 1988, the drought was even more severe. Rainfall was below normal in every month except November where rain was 2 cm greater than normal, and in October where it was normal. May and June rains were particularly low, and this had a major impact on pesticide losses as applied material was not solubilized for some time after application. In 1989, there was a complete reversal of the drought pattern of 1987-1988. Rainfall has been below average in February, July and August, but was normal in March, April, September and October, and above average in January, May and June. May and June rainfall was particularly high and precluded any field operations and crop planting until late in June. Pesticides were not applied until June 27 in 1989.

### Runoff

Tables 3, 4, and 5 give precipitation, runoff and tile flow by event and plot for 1987, 1988, and 1989, respectively. In 1987, the greatest storm was only 2.31 cm (June 1) and greatest runoff occurred in June 1-2, June 23 and October 12. In 1988, significant runoff only occurred on October 18 with the largest storm of the year of 3.15 cm. In 1989, the largest storms associated with runoff or tile drainage to date were on March 28 (2.08 cm), April 4 (3.43 cm), May 26 (4.34 cm), May 31 (3.25 cm), June 4 (3.71 cm), and July 28 (5.84 cm). Of the 1989 storms, only the one on July 28 occurred after pesticide application that year.

There were no significant effects of tillage on runoff in the three years when considered by month. Treatment effects are difficult to quantify in this experimental design

Table 2. Precipitation in 1987, 1988, 1989 and long-term average at Hoytville, Ohio.

| | Precipitation (cm) | | | |
|---|---|---|---|---|
| Month | Long-term | 1987 | 1988 | 1989 |
| January | 4.60 | 1.57 | 1.24 | 5.36 |
| February | 3.96 | 1.02 | 2.06 | 1.40 |
| March | 6.76 | 3.69 | 3.30 | 6.43 |
| April | 8.36 | 3.76 | 4.78 | 8.43 |
| May | 8.46 | 7.80 | 1.22 | 13.49 |
| June | 9.42 | 8.51 | 0.94 | 10.87 |
| July | 9.83 | 4.34 | 6.07 | 6.17 |
| August | 8.15 | 8.08 | 4.68 | 3.81 |
| September | 7.11 | 2.84 | 2.98 | 7.26 |
| October | 5.77 | 3.76 | 5.43 | 5.03 |
| November | 7.11 | 4.75 | 9.53 | -- |
| December | 6.35 | 6.07 | 3.98 | -- |

Table 3. Precipitation, runoff (R) and tile drainage (T) (all in cm) by plot in 1987.

| Date | Precipi-tation | Plot No. 1 R | 1 T | 2 R | 2 T | 3 R | 3 T | 4 R | 4 T | 5 R | 5 T | 6 R | 6 T | 7 R | 7 T | 8 R | 8 T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 2 | 1.78 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.01 | -- | 0.01 | -- | 0.06 | -- |
| May 11 | 0.00 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.01 | -- | -- | -- | -- | -- | -- |
| May 18 | 1.98 | 0.06 | -- | 0.07 | -- | -- | -- | 0.06 | -- | 0.06 | -- | 0.06 | -- | 0.06 | -- | 0.06 | -- |
| May 19 | 0.76 | -- | 0.03 | -- | 0.19 | 0.03 | 0.04 | -- | 0.03 | 0.01 | -- | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.12 |
| June 1 | 2.31 | 0.04 | -- | 0.04 | -- | 0.04 | -- | 0.04 | -- | 0.03 | -- | 0.04 | -- | -- | -- | 0.03 | -- |
| June 2 | 0.33 | 0.17 | -- | 0.17 | -- | 0.15 | -- | 0.10 | -- | 0.16 | -- | 0.18 | -- | 0.24 | -- | 0.16 | -- |
| June 5 | 0.00 | -- | 0.42 | -- | 1.05 | -- | 0.17 | -- | 0.24 | -- | 0.16 | -- | 0.03 | -- | 0.55 | -- | 0.23 |
| June 13 | 1.30 | 0.07 | -- | 0.11 | -- | 0.08 | -- | 0.06 | -- | 0.05 | -- | 0.06 | -- | 0.05 | -- | 0.05 | -- |
| June 20 | 1.42 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.02 | -- | -- | 0.05 |
| June 23 | 0.97 | 0.11 | 0.18 | 0.99 | 0.19 | 0.17 | 0.08 | 0.10 | 0.10 | 0.09 | -- | 0.12 | -- | 0.07 | -- | 0.10 | 0.09 |
| July 2 | 0.71 | -- | 0.10 | -- | 0.18 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sept. 17 | 0.18 | 0.04 | -- | 0.06 | -- | 0.05 | -- | -- | -- | 0.05 | -- | 0.28 | -- | 0.05 | -- | 0.05 | -- |
| Oct. 12 | 0.03 | 0.04 | -- | 1.39 | -- | 1.23 | -- | 0.06 | -- | 0.06 | -- | 0.06 | -- | 0.07 | -- | -- | -- |
| Oct. 26 | 0.18 | 0.04 | -- | 0.08 | -- | 0.05 | -- | 0.06 | -- | 0.04 | -- | 0.29 | -- | 0.04 | -- | 0.04 | -- |
| Oct. 27 | 0.76 | -- | -- | -- | -- | -- | -- | -- | -- | 0.03 | -- | 0.03 | -- | -- | -- | -- | -- |
| Nov. 9 | 0.94 | -- | -- | -- | -- | -- | -- | -- | -- | 0.04 | -- | 0.04 | -- | -- | -- | -- | -- |
| Nov. 26 | 2.18 | -- | -- | -- | -- | -- | -- | -- | -- | 0.10 | -- | 0.58 | -- | -- | -- | -- | -- |
| Dec. 8 | 0.46 | -- | -- | -- | -- | -- | -- | -- | -- | 0.10 | -- | 0.09 | -- | -- | -- | -- | -- |
| Dec. 12 | 0.48 | -- | -- | -- | -- | -- | -- | -- | -- | 0.03 | -- | 0.25 | -- | -- | -- | -- | -- |
| Dec. 15 | 2.08 | -- | -- | -- | -- | -- | -- | -- | -- | 0.08 | -- | 0.29 | -- | -- | -- | -- | -- |
| Dec. 21 | 0.28 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.03 | 0.12 | -- | -- | -- | -- |
| Total | 19.13 | 0.57 | 0.73 | 2.91 | 1.61 | 1.80 | 0.29 | 0.48 | 0.37 | 0.93 | 0.17 | 2.43 | 0.17 | 0.63 | 0.57 | 0.57 | 0.49 |

Table 4. Precipitation, runoff (R) and tile drainage (T) (all in cm) by plot in 1988.

| Date | Precipitation | Plot No. 1 R | 1 T | 2 R | 2 T | 3 R | 3 T | 4 R | 4 T | 5 R | 5 T | 6 R | 6 T | 7 R | 7 T | 8 R | 8 T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. 20 | 0.41 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.14 | -- | -- | -- | -- | -- |
| Feb. 2 | 0.48 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.16 | 0.34 |
| Feb. 16 | 0.00 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.15 |
| Apr. 20 | 0.25 | 0.03 | 1.36 | 0.04 | 1.07 | 0.05 | -- | 0.04 | -- | 0.04 | 0.20 | 0.04 | 0.22 | 0.04 | 0.07 | 0.04 | 0.56 |
| July 11 | 1.85 | 0.08 | -- | 0.13 | -- | 0.06 | -- | 0.06 | -- | 0.06 | -- | 0.06 | -- | 0.05 | -- | -- | -- |
| July 20 | 0.46 | 0.03 | -- | 0.08 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Aug. 16 | 0.20 | 0.03 | -- | 0.04 | -- | 0.04 | -- | 0.04 | -- | -- | -- | 0.04 | -- | -- | -- | 0.03 | -- |
| Aug. 24 | 1.12 | 0.04 | -- | 0.02 | -- | 0.06 | -- | -- | -- | 0.06 | -- | 0.06 | -- | 0.06 | -- | -- | -- |
| Aug. 29 | 2.11 | 0.06 | 0.03 | 0.01 | 0.07 | 0.08 | -- | 0.08 | -- | 0.08 | -- | 0.08 | -- | 0.07 | -- | 0.07 | -- |
| Sept. 6 | 0.03 | 0.03 | -- | 0.08 | -- | 0.04 | -- | 0.05 | -- | 0.05 | -- | 0.04 | -- | 0.04 | -- | 0.04 | -- |
| Oct. 18 | 3.15 | 0.11 | -- | 2.12 | -- | 5.37 | -- | 0.15 | -- | 0.12 | -- | 0.61 | -- | 0.11 | -- | 11.69 | -- |
| Total | 10.06 | 0.41 | 1.39 | 2.52 | 1.14 | 5.70 | -- | 0.42 | -- | 0.41 | 0.20 | 1.07 | 0.22 | 0.37 | 0.07 | 12.03 | 1.05 |

Table 5. Precipitation, runoff (R) and tile drainage (T) (all in cm) by plot in 1989.

| Date | Precipi-tation | Plot No. 1 R | 1 T | 2 R | 2 T | 3 R | 3 T | 4 R | 4 T | 5 R | 5 T | 6 R | 6 T | 7 R | 7 T | 8 R | 8 T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. 4 | 0.25 | 0.09 | 0.52 | 2.28 | 0.52 | 0.01 | -- | 0.00 | -- | 0.10 | 0.02 | 0.11 | 0.05 | 0.10 | 0.01 | 0.11 | 0.66 |
| Jan. 6 | 1.80 | 0.08 | 0.20 | 0.09 | 0.28 | 0.06 | 0.19 | 0.08 | 0.08 | 0.10 | 0.00 | 0.07 | 0.00 | 0.07 | 0.00 | 0.08 | 0.13 |
| Jan. 10 | 0.00 | 0.18 | 2.17 | 0.22 | 2.60 | 0.12 | 2.52 | 0.10 | 2.78 | 0.05 | 0.49 | 0.32 | 0.66 | 0.13 | 0.60 | 0.15 | 2.14 |
| Jan. 27 | 1.24 | 0.41 | 1.80 | 0.11 | 1.40 | 0.10 | 0.66 | 0.10 | 0.90 | 0.08 | 0.37 | 0.09 | 0.47 | 0.07 | 0.39 | 0.08 | 1.26 |
| Feb. 14 | 0.08 | 0.03 | 1.20 | 0.05 | 0.91 | 0.05 | 0.13 | 0.04 | 0.01 | 0.05 | 0.06 | 0.04 | 0.01 | 0.03 | 0.01 | 0.03 | 0.57 |
| Feb. 22 | 0.28 | 0.04 | 0.52 | 0.09 | 0.66 | 0.09 | -- | 0.05 | -- | 0.05 | -- | 0.03 | -- | 0.04 | -- | 0.05 | -- |
| Mar. 6 | 0.76 | 0.03 | -- | 0.04 | -- | 0.03 | -- | 0.04 | -- | 0.03 | -- | 0.03 | -- | 0.03 | -- | 0.03 | -- |
| Mar. 20 | 0.61 | 0.02 | -- | 0.04 | 1.17 | 0.03 | 2.77 | 0.03 | 0.06 | 0.03 | 0.04 | 0.03 | 0.01 | 0.03 | 0.01 | 0.04 | 0.50 |
| Mar. 28 | 2.08 | 0.05 | -- | 0.09 | 1.34 | 0.07 | 0.73 | 0.07 | 1.14 | 0.06 | 0.76 | 0.06 | 0.73 | 0.06 | 0.58 | 0.05 | 1.89 |
| Mar. 30 | 1.24 | -- | 1.34 | -- | -- | -- | 0.17 | -- | -- | -- | 0.42 | -- | 0.21 | -- | 0.08 | -- | 0.65 |
| Mar. 31 | 0.23 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.26 | -- | -- |
| Apr. 4 | 3.43 | 0.28 | 3.31 | 0.50 | 2.97 | 0.20 | 4.03 | 0.19 | 4.37 | 0.20 | 2.48 | 1.69 | 3.23 | 0.61 | 2.60 | 0.20 | 4.42 |
| Apr. 7 | 0.05 | -- | 1.47 | -- | 1.30 | -- | 1.35 | -- | 1.25 | -- | 1.48 | -- | 0.70 | -- | 0.34 | -- | 1.29 |
| Apr. 18 | 1.27 | 0.04 | -- | 0.08 | -- | 0.06 | -- | 0.07 | -- | 0.06 | -- | 0.06 | -- | 0.06 | -- | 0.05 | -- |
| Apr. 25 | 0.86 | 0.03 | 1.77 | 0.04 | 1.43 | 0.03 | -- | 0.03 | -- | 0.03 | -- | 0.03 | -- | 0.03 | -- | 0.03 | 0.33 |
| May 8 | 0.15 | 0.06 | 0.59 | 0.09 | 0.67 | 0.07 | -- | 0.07 | -- | 0.07 | -- | 0.07 | -- | 0.07 | -- | 0.06 | 11.06 |
| May 10 | 0.76 | 0.02 | -- | 0.03 | -- | 0.03 | -- | 0.03 | -- | 0.03 | -- | 0.03 | -- | 0.03 | -- | 0.03 | -- |
| May 15 | 0.51 | 0.02 | 0.84 | 0.04 | 0.97 | 0.03 | 0.06 | 0.05 | -- | 0.03 | -- | 0.03 | -- | 0.03 | -- | 0.03 | 0.63 |
| May 16 | 0.51 | 0.01 | -- | 0.02 | -- | 0.01 | -- | 0.01 | -- | 0.01 | -- | 0.01 | -- | 0.01 | -- | 0.01 | -- |
| May 23 | 1.40 | 0.05 | -- | 0.07 | -- | 0.06 | -- | 0.06 | -- | 0.05 | -- | 0.06 | -- | 0.06 | -- | 0.05 | -- |
| May 24 | 1.32 | 0.03 | -- | 0.04 | -- | 0.03 | -- | 0.04 | -- | 0.04 | -- | 0.03 | -- | 0.05 | -- | 0.03 | -- |
| May 26 | 4.34 | 0.27 | -- | 0.74 | -- | 0.06 | -- | 0.13 | -- | 0.15 | -- | 1.62 | -- | 0.70 | -- | 0.24 | -- |
| May 31 | 3.25 | 0.10 | 3.75 | 0.14 | 4.93 | 0.14 | 4.93 | 0.12 | 5.69 | 0.14 | 3.18 | 0.41 | 2.35 | 0.29 | 4.62 | 0.31 | 5.56 |
| June 4 | 3.71 | 0.07 | -- | 0.18 | -- | 0.18 | -- | 0.34 | -- | 0.70 | -- | 1.59 | -- | 0.67 | -- | 0.62 | -- |
| June 5 | 0.36 | -- | 3.09 | -- | 3.48 | -- | 4.00 | -- | 4.08 | -- | 2.83 | -- | 0.58 | -- | 0.13 | -- | 3.48 |
| June 8 | 0.05 | -- | 0.68 | -- | 0.49 | -- | 0.04 | -- | 0.01 | -- | 0.08 | -- | 0.01 | -- | .00 | -- | 0.11 |
| June 16 | 0.20 | 0.07 | -- | 0.12 | -- | 0.12 | 0.52 | 0.09 | 0.31 | 0.11 | 0.17 | 0.11 | 0.07 | 0.12 | 0.07 | 0.10 | -- |
| June 19 | 1.24 | -- | 1.40 | -- | 1.44 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1.00 |
| June 23 | 0.03 | 0.08 | 0.89 | 0.12 | 0.89 | 0.10 | 0.31 | 0.09 | 0.21 | 0.09 | 0.19 | 0.09 | 0.09 | 0.12 | 0.07 | 0.09 | 0.73 |
| July 5 | 0.46 | 0.02 | 0.40 | 0.03 | 0.47 | 0.02 | -- | 0.02 | -- | 0.02 | -- | 0.02 | -- | 0.02 | -- | 0.02 | 0.09 |
| July 12 | 0.71 | 0.02 | -- | 0.04 | -- | 0.03 | -- | 0.03 | -- | -- | -- | 0.03 | -- | 0.02 | -- | 0.02 | -- |
| July 20 | 2.03 | -- | -- | -- | -- | -- | -- | 0.09 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| July 21 | 0.30 | 0.05 | 0.06 | 0.07 | 0.24 | 0.07 | -- | -- | -- | 0.09 | -- | 0.07 | -- | -- | -- | 0.06 | -- |
| July 28 | 5.84 | 0.03 | -- | 0.05 | -- | 0.05 | -- | -- | -- | 0.03 | -- | 0.04 | -- | 0.10 | -- | 0.03 | -- |
| Total | 41.38 | 2.15 | 26.00 | 5.42 | 28.16 | 1.82 | 22.40 | 1.94 | 20.87 | 20.87 | 12.56 | 6.74 | 9.17 | 3.53 | 3.53 | 2.59 | 36.49 |

because of the small number of events and the relatively large variation between events. Lal et al. (1989b) summarized the runoff data from these plots for the period 1975-1980 and found that there were few overall differences in mean annual runoff between plowed and no-till plots. With low rainfall, there was greater runoff from the plowed plots than from no-till. As rainfall increased, differences in runoff decreased. Logan (1987) and Lal et al. (1989b) have attributed this to the effect of macropores in the no-till plots in increasing infiltration and decreasing runoff. At higher rainfall rates, the limiting factor in infiltration is the saturated hydraulic conductivity of this heavy clay soil which is quite low.

## Tile Drainage

Tables 3, 4, and 5 indicate that there was very little tile flow in 1987 and 1988 because of the drought, but tile flow was extensive in 1989. There were a total of four tile flow events in 1987 (May 19, June 5 and 23, and July 2). In 1988, there were zero to three events per plot. The most significant of these was on April 20. In 1989, tile drainage was extensive throughout the year. The winter was quite warm and the tile lines flowed from January onward. Tile flows exceeding 2 cm occurred on January 10, April 4, May 31, and June 5. None of these events occurred before pesticide application on June 27.

There were no significant effects of tillage on tile flow. As with runoff, this is primarily attributable to the small number of events that occurred in 1987-1989. Analysis of the 1976-1980 record (Lal et al., 1989b) showed that there was no difference in tile flow between the two tillage treatments.

In the period 1987-1989, very few tile flow events occurred after pesticide application in the same year. It is necessary, then, to examine data for the following year to determine if there was any significant leaching to the tile. Given the relatively low residence time in the soil of all of the applied herbicides except atrazine, detection in these later tile events was expected to be low.

## Losses of Applied Pesticides in Runoff and Tile Drainage

Pesticides in runoff and tile drainage are given in Tables 6 through 21 by plot. Data is summarized by month for each year, and precipitation, flow, loads and flow weighted mean concentrations are presented for the four applied herbicides. Flow weighted mean (FWM) concentration is the total load divided by the total concentration for a month and gives weight to the larger events. Figures 3 through 36 present continuous plots of runoff and tile flow versus precipitation for individual events, and flow versus

Table 6. Pesticides in runoff (Plot 1, NT)

| Period | Ppt (cm) | Flow (cm) | Load (g/ha) | | | | Flow Weighted Mean (ug/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Atrazine | Alachlor | Metalochlor | Metribuzin | Atrazine | Alachlor | Metalochlor | Metribuzin |
| **1987 (soybean)** | | | | | | | | | | |
| May | 7.80 | 0.060 | 0.002 | 0.000 | 0.000 | 0.005 | 0.4 | 0.0 | 0.0 | 0.8 |
| June | 8.51 | 0.390 | 0.090 | 0.000 | 1.130 | 1.275 | 2.3 | 0.0 | 29.0 | 3.2 |
| July | 4.34 | --- | --- | --- | --- | --- | --- | --- | ---- | --- |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | 0.040 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 0.0 | 0.0 |
| October | 3.76 | 0.080 | 0.001 | 0.000 | 0.004 | 0.000 | 0.1 | 0.0 | 0.5 | 0.0 |
| November | 4.75 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.15 | 0.570 | 0.093 | 0.000 | 1.134 | 1.280 | 1.6 | 0.0 | 19.9 | 22.5 |
| **1988 (corn)** | | | | | | | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | 0.030 | 0.002 | 0.001 | 0.004 | 0.001 | 0.8 | 0.5 | 1.2 | 0.2 |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | 0.110 | 0.063 | 0.052 | 0.039 | 0.009 | 5.8 | 4.8 | 3.6 | 0.8 |
| August | 4.68 | 0.125 | 0.071 | 0.092 | 0.025 | 0.002 | 5.6 | 7.4 | 2.0 | 0.2 |
| September | 2.98 | 0.070 | 0.026 | 0.025 | 0.004 | 0.004 | 3.7 | 3.6 | 0.5 | 0.5 |
| October | 5.43 | 0.110 | 0.018 | 0.024 | 0.000 | 0.000 | 1.6 | 2.2 | 0.0 | 0.0 |
| November | 9.53 | 0.070 | 0.007 | 0.009 | 0.000 | 0.000 | 1.1 | 1.3 | 0.0 | 0.0 |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | 0.515 | 0.187 | 0.204 | 0.071 | 0.015 | 3.6 | 4.0 | 1.4 | 0.3 |
| **1989 (soybean)** | | | | | | | | | | |
| January | 5.36 | 0.350 | 0.313 | 0.117 | 0.019 | 0.000 | 9.0 | 3.3 | 0.5 | 0.0 |
| February | 1.40 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 6.43 | 0.022 | 0.002 | 0.000 | 0.000 | 0.000 | 0.8 | 0.0 | 0.0 | 0.0 |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | 0.916 | 0.170 | 0.253 | 0.000 | 0.037 | 1.9 | 2.8 | 0.0 | 0.4 |
| June | 10.87 | 0.072 | 0.021 | 0.008 | 0.000 | 0.000 | 2.9 | 1.1 | 0.0 | 0.0 |
| July | 6.17 | 0.119 | 0.203 | 0.040 | 29.745 | 11.886 | 17.3 | 3.4 | 2499.6 | 998.8 |
| Total | 52.15 | 1.479 | 0.709 | 0.418 | 29.764 | 11.923 | 4.8 | 2.8 | 201.2 | 80.6 |

Table 7. Pesticides in runoff (Plot 2, NT)

| Period | Ppt (cm) | Flow (cm) | Load (g/ha) | | | | Flow Weighted Mean (ug/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Atrazine | Alachlor | Metalochlor | Metribuzin | Atrazine | Alachlor | Metalochlor | Metribuzin |
| 1987 (soybean) | | | | | | | | | | |
| May | 7.80 | 0.070 | 0.003 | 0.000 | 0.000 | 0.006 | 0.4 | 0.0 | 0.0 | 0.8 |
| June | 8.51 | 1.310 | 0.247 | 0.009 | 5.300 | 1.276 | 1.9 | 0.1 | 40.5 | 9.7 |
| July | 4.34 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | 0.060 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 0.0 | 0.0 |
| October | 3.76 | 1.470 | 0.024 | 0.000 | 0.185 | 0.012 | 0.2 | 0.0 | 1.3 | 0.1 |
| November | 4.75 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.15 | 2.910 | 0.274 | 0.009 | 5.484 | 1.293 | 0.9 | .0 | 18.8 | 4.4 |
| 1988 (corn) | | | | | | | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | 0.040 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 0.0 | 0.0 |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | 0.210 | 14.584 | 5.162 | 0.000 | 0.000 | 694.5 | 245.8 | 0.0 | 0.0 |
| August | 4.68 | 0.070 | 0.102 | 0.014 | 0.013 | 0.002 | 14.6 | 2.0 | 1.9 | 0.3 |
| September | 2.98 | 0.180 | 0.058 | 0.008 | 0.010 | 0.000 | 3.2 | 0.4 | 0.5 | 0.0 |
| October | 5.43 | 2.120 | 0.032 | 0.071 | 0.064 | 0.000 | 1.5 | 0.3 | 0.3 | 0.0 |
| November | 9.53 | 0.100 | 0.011 | 0.000 | 0.000 | 0.000 | 1.1 | 0.0 | 0.0 | 0.0 |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | 2.720 | 14.788 | 5.255 | 0.087 | 0.002 | 54.4 | 19.3 | 0.3 | .0 |
| 1989 (soybean) | | | | | | | | | | |
| January | 5.36 | 2.590 | 0.168 | 0.163 | 0.306 | 0.000 | 0.6 | 0.6 | 1.2 | 0.0 |
| February | 1.40 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 6.43 | 0.038 | 0.002 | 0.000 | 0.000 | 0.000 | 0.4 | 0.0 | 0.0 | 0.0 |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | 1.095 | 0.096 | 0.198 | 0.000 | 0.000 | 0.9 | 1.8 | 0.0 | 0.0 |
| June | 10.87 | 0.104 | 0.025 | 0.005 | 0.008 | 0.000 | 2.4 | 0.5 | 0.7 | 0.0 |
| July | 6.17 | 0.110 | 0.020 | 0.028 | 4.770 | 1.470 | 1.8 | 2.5 | 433.6 | 133.6 |
| Total | 52.15 | 3.937 | 0.310 | 0.394 | 5.084 | 1.470 | 0.8 | 1.0 | 12.9 | 3.7 |

Table 8. Pesticides in runoff (Plot 6, NT)

| Period | Ppt (cm) | Flow (cm) | Load (g/ha) | | | | Flow Weighted Mean (ug/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Atrazine | Alachlor | Metalochlor | Metribuzin | Atrazine | Alachlor | Metalochlor | Metribuzin |
| | | | | | | 1987 (corn) | | | | |
| May | 7.80 | 0.090 | 0.039 | 0.042 | 0.007 | 0.000 | 4.3 | 4.7 | 0.7 | 0.0 |
| June | 8.51 | 0.400 | 0.223 | 0.426 | 0.036 | 0.000 | 5.6 | 10.6 | 0.9 | 0.0 |
| July | 4.34 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | 0.280 | 0.006 | 0.000 | 0.000 | 0.000 | 0.2 | 0.0 | 0.0 | 0.0 |
| October | 3.76 | 0.440 | 0.010 | 0.000 | 0.000 | 0.000 | 0.2 | 0.0 | 0.0 | 0.0 |
| November | 4.75 | 0.620 | 0.018 | 0.000 | 0.005 | 0.000 | 0.3 | 0.0 | 0.1 | 0.0 |
| December | 6.07 | 0.660 | 0.179 | 0.010 | 0.001 | 0.000 | 2.7 | 0.2 | .0 | 0.0 |
| Total | 46.15 | 2.490 | 0.474 | 0.478 | 0.048 | 0.000 | 1.9 | 1.9 | 0.2 | 0.0 |
| | | | | | | 1988 (soybean) | | | | |
| January | 1.24 | 0.140 | 0.065 | 0.000 | 0.000 | 0.000 | 4.6 | 0.0 | 0.0 | 0.0 |
| February | 2.06 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | 0.040 | 0.006 | 0.002 | 0.000 | 0.000 | 1.5 | 0.6 | 0.0 | 0.0 |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | 0.120 | 0.054 | 0.000 | 20.971 | 3.893 | 4.5 | 0.0 | 1747.6 | 324.4 |
| August | 4.68 | 0.176 | 0.008 | 0.033 | 1.756 | 0.105 | 0.4 | 1.9 | 99.8 | 6.0 |
| September | 2.98 | 0.040 | .000 | 0.001 | 0.091 | 0.003 | 0.1 | 0.3 | 22.7 | 0.9 |
| October | 5.43 | 0.610 | 0.000 | 0.000 | 0.492 | 0.022 | 0.0 | 0.0 | 8.1 | 0.4 |
| November | 9.53 | 0.080 | 0.000 | 0.000 | 0.053 | 0.003 | 0.0 | 0.0 | 6.7 | 0.3 |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | 1.206 | 0.133 | 0.036 | 23.363 | 4.026 | 1.1 | 0.3 | 193.7 | 33.4 |
| | | | | | | 1989 (corn) | | | | |
| January | 5.36 | 0.500 | 0.058 | 0.017 | 0.640 | 0.030 | 1.2 | 0.3 | 12.8 | 0.6 |
| February | 1.40 | 0.039 | 0.003 | 0.000 | 0.045 | 0.032 | 0.8 | 0.0 | 11.6 | 0.8 |
| March | 6.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | 0.119 | 0.005 | 0.011 | 0.047 | 0.000 | 0.4 | 0.9 | 3.9 | 0.0 |
| June | 10.87 | 0.020 | 0.003 | 0.004 | 0.013 | 0.000 | 1.4 | 2.1 | 6.4 | 0.0 |
| July | 6.17 | 0.128 | 1.262 | 0.922 | 0.065 | 0.000 | 98.6 | 72.0 | 5.1 | 0.0 |
| Total | 52.15 | 0.806 | 1.331 | 0.954 | 0.810 | 0.062 | 16.5 | 11.8 | 10.1 | 0.8 |

Table 9. Pesticides in runoff (Plot 7, NT)

| Period | Ppt (cm) | Flow (cm) | Load (g/ha) Atrazine | Load (g/ha) Alachlor | Load (g/ha) Metalochlor | Load (g/ha) Metribuzin | Flow Weighted Mean (ug/L) Atrazine | Flow Weighted Mean (ug/L) Alachlor | Flow Weighted Mean (ug/L) Metalochlor | Flow Weighted Mean (ug/L) Metribuzin |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1987 (corn) | | | | |
| May | 7.80 | 0.090 | 0.029 | 0.028 | 0.001 | 0.000 | 3.2 | 3.1 | 0.1 | 0.0 |
| June | 8.51 | 0.380 | 0.321 | 0.149 | 0.056 | 0.000 | 8.4 | 3.9 | 1.5 | 0.0 |
| July | 4.34 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | 0.050 | 0.001 | 0.000 | 0.000 | 0.000 | 0.2 | 0.0 | 0.0 | 0.0 |
| October | 3.76 | 0.110 | 0.001 | 0.000 | 0.000 | 0.000 | 0.1 | 0.0 | 0.0 | 0.0 |
| November | 4.75 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.15 | 0.630 | 0.351 | 0.176 | 0.057 | 0.000 | 5.6 | 2.8 | 0.9 | 0.0 |
| | | | | | | 1988 (soybean) | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | 0.040 | 0.005 | 0.002 | 0.000 | 0.000 | 1.2 | 0.6 | 0.0 | 0.0 |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | 0.050 | 0.000 | 0.000 | 2.985 | 0.419 | 0.0 | 0.0 | 597.0 | 83.8 |
| August | 4.68 | 0.130 | 0.013 | 0.035 | 0.719 | 0.064 | 1.0 | 2.7 | 55.3 | 4.9 |
| September | 2.98 | 0.040 | .000 | 0.001 | 0.029 | 0.002 | 0.1 | 0.3 | 7.2 | 0.6 |
| October | 5.43 | 0.110 | 0.000 | 0.000 | 0.032 | 0.000 | 0.0 | 0.0 | 2.9 | 0.0 |
| November | 9.53 | 0.100 | 0.002 | 0.000 | 0.049 | 0.002 | 0.2 | 0.0 | 4.9 | 0.2 |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | 0.470 | 0.020 | 0.038 | 3.815 | 0.487 | 0.4 | 0.8 | 81.2 | 10.4 |
| | | | | | | 1989 (corn) | | | | |
| January | 5.36 | 0.300 | 0.031 | 0.000 | 0.209 | 0.010 | 1.0 | 0.0 | 7.0 | 0.3 |
| February | 1.40 | 0.027 | 0.001 | 0.000 | 0.007 | 0.000 | 0.2 | 0.0 | 2.6 | 0.0 |
| March | 6.43 | 0.029 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 0.0 | 0.0 |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | 0.118 | 0.005 | 0.007 | 0.027 | 0.000 | 0.4 | 0.6 | 2.2 | 0.0 |
| June | 10.87 | 0.030 | 0.003 | 0.000 | 0.011 | 0.000 | 1.0 | 0.0 | 3.5 | 0.0 |
| July | 6.17 | 0.126 | 3.304 | 1.479 | 0.075 | 0.017 | 262.2 | 117.4 | 6.0 | 1.3 |
| Total | 52.15 | 0.630 | 3.344 | 1.486 | 0.328 | 0.027 | 53.1 | 23.6 | 5.2 | 0.4 |

Table 10. Pesticides in runoff (Plot 3, CONV)

| Period | Ppt (cm) | Flow (cm) | Load (g/ha) | | | | Flow Weighted Mean (ug/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Atrazine | Alachlor | Metalochlor | Metribuzin | Atrazine | Alachlor | Metalochlor | Metribuzin |
| | | | | | | 1987 (soybean) | | | | |
| May | 7.80 | 0.030 | 0.034 | 0.069 | 0.000 | 0.000 | 11.3 | 23.0 | 0.0 | 0.0 |
| June | 8.51 | 0.440 | 0.044 | 0.005 | 0.743 | 0.372 | 1.0 | 0.1 | 16.9 | 8.5 |
| July | 4.34 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | 0.050 | 0.001 | 0.000 | 0.010 | 0.001 | 0.1 | 0.0 | 0.2 | 0.2 |
| October | 3.76 | 1.280 | 0.002 | 0.000 | 0.087 | 0.002 | .0 | 0.0 | 0.7 | .0 |
| November | 4.75 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.15 | 1.800 | 0.080 | 0.073 | 0.840 | 0.375 | 0.4 | 0.4 | 4.7 | 2.1 |
| | | | | | | 1988 (corn) | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | 0.080 | 0.006 | 0.005 | 0.007 | 0.000 | 0.8 | 0.7 | 0.8 | 0.0 |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | 0.060 | 4.016 | 3.138 | 0.000 | 0.000 | 669.3 | 523.0 | 0.0 | 0.0 |
| August | 4.68 | 0.180 | 0.067 | 0.059 | 0.024 | 0.004 | 3.7 | 3.3 | 1.3 | 0.2 |
| September | 2.98 | 0.100 | 0.052 | 0.015 | 0.006 | .000 | 5.2 | 1.5 | 0.6 | .0 |
| October | 5.43 | 5.370 | 0.938 | 0.248 | 0.000 | 0.000 | 1.7 | 0.5 | 0.0 | 0.0 |
| November | 9.53 | 0.090 | 0.015 | 0.003 | 0.000 | 0.000 | 1.6 | 0.3 | 0.0 | 0.0 |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | 5.880 | 5.094 | 3.467 | 0.036 | 0.004 | 8.7 | 5.9 | 0.1 | .0 |
| | | | | | | 1989 (soybean) | | | | |
| January | 5.36 | 0.190 | 0.030 | 0.005 | 0.012 | 0.001 | 1.6 | 0.3 | 0.6 | .0 |
| February | 1.40 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 6.43 | 0.028 | 0.003 | 0.000 | 0.000 | 0.000 | 1.0 | 0.0 | 0.0 | 0.0 |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | 0.156 | 0.026 | 0.027 | 0.000 | 0.000 | 1.6 | 1.7 | 0.0 | 0.0 |
| June | 10.87 | 0.091 | 0.037 | 0.018 | 0.007 | 0.000 | 4.1 | 2.0 | 0.8 | 0.0 |
| July | 6.17 | 0.090 | 0.030 | 0.032 | 4.830 | 1.049 | 3.3 | 3.6 | 536.7 | 116.6 |
| Total | 52.15 | 0.555 | 0.126 | 0.083 | 4.849 | 1.050 | 2.3 | 1.5 | 87.4 | 18.9 |

Table 11. Pesticides in runoff (Plot 4, CONV)

| Period | Ppt (cm) | Flow (cm) | Load (g/ha) | | | | Flow Weighted Mean (ug/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Atrazine | Alachlor | Metalochlor | Metribuzin | Atrazine | Alachlor | Metalochlor | Metribuzin |
| 1987 (soybean) | | | | | | | | | | |
| May | 7.80 | 0.060 | 0.065 | 0.038 | 0.000 | 0.000 | 10.8 | 6.4 | 0.0 | 0.0 |
| June | 8.51 | 0.300 | 0.037 | 0.000 | 2.225 | 0.246 | 1.2 | 0.0 | 74.2 | 8.2 |
| July | 4.34 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 3.76 | 0.180 | 0.005 | 0.004 | 0.012 | 0.000 | 0.3 | 0.2 | 0.7 | 0.0 |
| November | 4.75 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.15 | 0.540 | 0.106 | 0.042 | 2.237 | 0.246 | 2.0 | 0.8 | 41.4 | 4.6 |
| 1988 (corn) | | | | | | | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | 0.040 | 0.002 | 0.000 | 0.000 | 0.000 | 0.5 | 0.0 | 0.0 | 0.0 |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | 0.060 | 3.122 | 2.304 | 0.000 | 0.000 | 520.4 | 383.9 | 0.0 | 0.0 |
| August | 4.68 | 0.216 | 0.095 | 0.037 | 0.013 | 0.004 | 4.4 | 1.7 | 0.6 | 0.2 |
| September | 2.98 | 0.130 | 0.043 | 0.012 | 0.003 | 0.002 | 3.3 | 0.9 | 0.3 | 0.1 |
| October | 5.43 | 0.150 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 0.0 | 0.0 |
| November | 9.53 | 0.090 | 0.014 | 0.000 | 0.000 | 0.000 | 1.5 | 0.0 | 0.0 | 0.0 |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | 0.686 | 3.276 | 2.352 | 0.016 | 0.005 | 47.8 | 34.3 | 0.2 | 0.1 |
| 1989 (soybean) | | | | | | | | | | |
| January | 5.36 | 0.182 | 0.025 | .000 | 0.001 | 0.019 | 1.4 | .0 | .0 | 1.0 |
| February | 1.40 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 6.43 | 0.068 | 0.007 | 0.000 | 0.000 | 0.000 | 1.0 | 0.0 | 0.0 | 0.0 |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | 0.119 | 0.019 | 0.012 | 0.000 | 0.000 | 1.6 | 1.0 | 0.0 | 0.0 |
| June | 10.87 | 0.026 | 0.004 | 0.000 | 0.000 | 0.000 | 1.6 | 0.0 | 0.0 | 0.0 |
| July | 6.17 | 0.065 | 0.006 | 0.016 | 2.699 | 0.693 | 0.9 | 2.5 | 415.2 | 106.6 |
| Total | 52.15 | 0.460 | 0.061 | 0.029 | 2.700 | 0.712 | 1.3 | 0.6 | 58.7 | 15.5 |

Table 12. Pesticides in runoff (Plot 5, CONV)

| Period | Ppt (cm) | Flow (cm) | Load (g/ha) | | | | Flow Weighted Mean (ug/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Atrazine | Alachlor | Metalochlor | Metribuzin | Atrazine | Alachlor | Metalochlor | Metribuzin |
| **1987 (corn)** | | | | | | | | | | |
| May | 7.80 | 0.070 | 0.031 | 0.044 | 0.012 | 0.000 | 4.4 | 6.3 | 1.7 | 0.0 |
| June | 8.51 | 0.330 | 1.213 | 0.667 | 0.114 | 0.008 | 36.8 | 20.2 | 3.5 | 2.3 |
| July | 4.34 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | 0.050 | 0.001 | 0.000 | 0.000 | 0.000 | 0.3 | 0.0 | 0.0 | 0.0 |
| October | 3.76 | 0.130 | 0.003 | 0.000 | 0.000 | 0.000 | 0.2 | 0.0 | 0.0 | 0.0 |
| November | 4.75 | 0.140 | 0.019 | 0.000 | 0.000 | 0.000 | 0.1 | 0.0 | 0.0 | 0.0 |
| December | 6.07 | 0.210 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 46.15 | 0.930 | 1.268 | 0.711 | 0.126 | 0.008 | 13.6 | 7.6 | 1.4 | 0.1 |
| **1988 (soybean)** | | | | | | | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | 0.040 | 0.004 | 0.001 | 0.000 | 0.000 | 1.1 | 0.3 | 0.0 | 0.0 |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | 0.060 | 0.000 | 0.000 | 4.197 | 0.614 | 0.0 | 0.0 | 699.5 | 102.3 |
| August | 4.68 | 0.140 | 0.012 | 0.042 | 1.081 | 0.099 | 0.9 | 3.0 | 77.2 | 7.1 |
| September | 2.98 | 0.050 | 0.001 | 0.003 | 0.119 | 0.010 | 0.2 | 0.6 | 23.8 | 1.9 |
| October | 5.43 | 0.120 | 0.001 | 0.000 | 0.058 | 0.004 | 0.1 | 0.0 | 4.9 | 0.4 |
| November | 9.53 | 0.080 | 0.001 | 0.000 | 0.037 | 0.003 | 0.1 | 0.0 | 4.6 | 0.3 |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | 0.490 | 0.019 | 0.046 | 5.492 | 0.730 | 0.4 | 0.9 | 112.1 | 14.9 |
| **1989 (corn)** | | | | | | | | | | |
| January | 5.36 | 0.250 | 0.077 | 0.003 | 0.109 | 0.005 | 3.1 | 0.1 | 4.4 | 0.2 |
| February | 1.40 | 0.053 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 0.0 | 0.0 |
| March | 6.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | 0.122 | 0.009 | 0.006 | 0.021 | 0.000 | 0.2 | 0.5 | 1.8 | 0.0 |
| June | 10.87 | 0.023 | 0.002 | 0.003 | 0.010 | 0.000 | 0.8 | 1.1 | 4.3 | 0.0 |
| July | 6.17 | 0.119 | 2.967 | 1.436 | 0.048 | 0.000 | 249.3 | 120.7 | 4.0 | 0.0 |
| Total | 52.15 | 0.567 | 3.055 | 1.448 | 0.188 | 0.005 | 53.9 | 25.5 | 3.3 | 0.1 |

Table 13. Pesticides in runoff (Plot 8, CONV)

| Period | Ppt (cm) | Flow (cm) | Load (g/ha) | | | | Flow Weighted Mean (ug/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Atrazine | Alachlor | Metalochlor | Metribuzin | Atrazine | Alachlor | Metalochlor | Metribuzin |
| | | | | | | 1987 (corn) | | | | |
| May | 7.80 | 0.140 | 0.372 | 0.357 | 0.005 | 0.000 | 26.6 | 25.5 | 0.3 | 0.0 |
| June | 8.51 | 0.340 | 1.008 | 0.534 | 0.000 | 0.000 | 29.6 | 15.7 | 0.0 | 0.0 |
| July | 4.34 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | 0.050 | 0.001 | 0.000 | 0.004 | 0.000 | 0.2 | 0.0 | 0.7 | 0.0 |
| October | 3.76 | 0.040 | 0.001 | 0.000 | 0.000 | 0.000 | 0.3 | 0.0 | 0.0 | 0.0 |
| November | 4.75 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.15 | 0.570 | 1.382 | 0.891 | 0.008 | 0.000 | 24.2 | 15.6 | 0.1 | 0.0 |
| | | | | | | 1988 (soybean) | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | 0.693 | 0.109 | 0.000 | 0.000 | 0.000 | 1.6 | 0.0 | 0.0 | 0.0 |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | 0.040 | 0.002 | 0.003 | 0.008 | 0.000 | 0.6 | 0.7 | 2.1 | 0.0 |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 4.68 | 0.100 | 0.002 | 0.001 | 0.047 | 0.007 | 0.2 | 0.1 | 4.7 | 0.7 |
| September | 2.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 5.43 | 11.690 | 0.106 | 0.000 | 2.536 | 0.249 | 0.1 | 0.0 | 2.2 | 0.2 |
| November | 9.53 | 0.080 | 0.000 | 0.000 | 0.010 | 0.000 | 0.0 | 0.0 | 1.2 | 0.0 |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | 12.603 | 0.219 | 0.004 | 2.602 | 0.255 | 0.2 | .0 | 2.1 | 0.2 |
| | | | | | | 1989 (corn) | | | | |
| January | 5.36 | 0.340 | 0.015 | 0.000 | 0.036 | 0.000 | 0.4 | 0.0 | 1.1 | 0.0 |
| February | 1.40 | 0.075 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 0.0 | 0.0 |
| March | 6.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 10.87 | 0.018 | 0.002 | 0.003 | 0.005 | 0.000 | 0.9 | 1.5 | 2.6 | 0.0 |
| July | 6.17 | 0.120 | 3.486 | 2.034 | 0.139 | 0.055 | 290.5 | 169.5 | 11.6 | 4.6 |
| Total | 52.15 | 0.553 | 3.502 | 2.037 | 0.179 | 0.055 | 63.3 | 36.8 | 3.2 | 1.0 |

Table 14. Pesticides in tile drainage (Plot 1, NT)

| Period | Ppt (cm) | Flow (cm) | Load (g/ha) Atrazine | Load (g/ha) Alachlor | Load (g/ha) Metalochlor | Load (g/ha) Metribuzin | Flow Weighted Mean (ug/L) Atrazine | Flow Weighted Mean (ug/L) Alachlor | Flow Weighted Mean (ug/L) Metalochlor | Flow Weighted Mean (ug/L) Metribuzin |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1987 (soybean) | | | | |
| May | 7.80 | 0.030 | 0.028 | 0.000 | 0.290 | 0.016 | 0.9 | 0.0 | 9.7 | 5.5 |
| June | 8.51 | 0.600 | 0.040 | 0.000 | 0.111 | 0.062 | 0.7 | 0.0 | 1.8 | 1.0 |
| July | 4.34 | 0.100 | 0.006 | 0.000 | 0.020 | 0.007 | 0.6 | 0.0 | 2.0 | 0.7 |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 3.76 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 4.75 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.15 | 0.730 | 0.074 | 0.000 | 0.421 | 0.085 | 1.0 | 0.0 | 5.8 | 1.2 |
| | | | | | | 1988 (corn) | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | 1.360 | 0.027 | 0.000 | 0.000 | 0.000 | 0.2 | 0.0 | 0.0 | 0.0 |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 4.68 | 0.030 | 0.001 | 0.000 | 0.000 | .000 | 0.3 | 0.0 | 0.0 | .0 |
| September | 2.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 5.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 9.53 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | 1.390 | 0.028 | 0.000 | 0.000 | .000 | 0.2 | 0.0 | 0.0 | .0 |
| | | | | | | 1989 (soybean) | | | | |
| January | 5.36 | 2.890 | 0.875 | 0.000 | 0.000 | 0.000 | 3.0 | 0.0 | 0.0 | 0.0 |
| February | 1.40 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 6.43 | 1.339 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 0.0 | 0.0 |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | 0.623 | 0.036 | 0.000 | 0.000 | 0.000 | 0.6 | 0.0 | 0.0 | 0.0 |
| June | 10.87 | 1.137 | 0.123 | 0.000 | 0.000 | 0.000 | 1.1 | 0.0 | 0.0 | 0.0 |
| July | 6.17 | 0.465 | 0.051 | 0.000 | 0.105 | 0.026 | 1.1 | 0.0 | 2.3 | 0.6 |
| Total | 52.15 | 6.454 | 1.085 | 0.000 | 0.105 | 0.026 | 1.7 | 0.0 | 0.2 | .0 |

Table 15. Pesticides in tile drainage (Plot 2, NT)

| Period | Ppt (cm) | Flow (cm) | Load (g/ha) | | | | Flow Weighted Mean (ug/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Atrazine | Alachlor | Metalochlor | Metribuzin | Atrazine | Alachlor | Metalochlor | Metribuzin |
| | | | | | | 1987 (soybean) | | | | |
| May | 7.80 | 0.250 | 0.007 | 0.000 | 0.023 | 0.028 | 0.3 | 0.0 | 0.9 | 1.1 |
| June | 8.51 | 1.240 | 0.080 | 0.000 | 0.585 | 0.219 | 0.6 | 0.0 | 4.7 | 1.8 |
| July | 4.34 | 0.180 | 0.006 | 0.000 | 0.000 | 0.007 | 0.3 | 0.0 | 0.0 | 0.4 |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 3.76 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 4.75 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.15 | 1.670 | 0.093 | 0.000 | 0.608 | 0.253 | 0.6 | 0.0 | 3.6 | 1.5 |
| | | | | | | 1988 (corn) | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | 1.070 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 0.0 | 0.0 |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 4.68 | 0.070 | 0.002 | 0.000 | 0.036 | 0.000 | 0.3 | 0.0 | 5.1 | 0.0 |
| September | 2.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 5.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 9.53 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | 1.140 | 0.002 | 0.000 | 0.036 | 0.000 | .0 | 0.0 | 0.3 | 0.0 |
| | | | | | | 1989 (soybean) | | | | |
| January | 5.36 | 3.400 | 0.047 | 0.000 | 0.000 | 0.000 | 0.1 | 0.0 | 0.0 | 0.0 |
| February | 1.40 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 6.43 | 1.168 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 0.0 | 0.0 |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | 0.699 | 0.015 | 0.000 | 0.000 | 0.000 | 0.2 | 0.0 | 0.0 | 0.0 |
| June | 10.87 | 1.840 | 0.061 | 0.000 | 0.000 | 0.000 | 0.5 | 0.0 | 0.0 | 0.0 |
| July | 6.17 | 0.715 | 0.033 | 0.000 | 0.041 | 0.022 | 0.5 | 0.0 | 0.6 | 0.3 |
| Total | 52.15 | 7.822 | 0.156 | 0.000 | 0.041 | 0.022 | 0.2 | 0.0 | 0.1 | .0 |

Table 16. Pesticides in tile drainage (Plot 6, NT)

| Period | Ppt (cm) | Flow (cm) | Load (g/ha) | | | | Flow Weighted Mean (ug/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Atrazine | Alachlor | Metalochlor | Metribuzin | Atrazine | Alachlor | Metalochlor | Metribuzin |
| 1987 (corn) | | | | | | | | | | |
| May | 7.80 | 0.020 | 0.022 | 0.004 | 0.000 | 0.000 | 10.9 | 1.9 | 0.0 | 0.0 |
| June | 8.51 | 0.030 | 0.195 | 0.017 | 0.002 | 0.000 | 65.1 | 5.6 | 0.7 | 0.0 |
| July | 4.34 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 3.76 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 4.75 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 6.07 | 0.120 | 0.044 | 0.000 | 0.000 | 0.000 | 3.7 | 0.0 | 0.0 | 0.0 |
| Total | 46.15 | 0.170 | 0.261 | 0.021 | 0.002 | 0.000 | 15.4 | 1.2 | 0.1 | 0.0 |
| 1988 (soybean) | | | | | | | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | 0.220 | 0.020 | 0.000 | 0.000 | 0.000 | 0.9 | 0.0 | 0.0 | 0.0 |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 4.68 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 5.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 9.53 | 0.240 | 0.036 | 0.013 | 0.067 | 0.032 | 1.5 | 0.6 | 2.8 | 1.4 |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | 0.460 | 0.056 | 0.013 | 0.067 | 0.032 | 1.2 | 0.3 | 1.4 | 0.7 |
| 1989 (corn) | | | | | | | | | | |
| January | 5.36 | 0.710 | 0.107 | 0.033 | 0.226 | 0.075 | 1.5 | 0.5 | 3.2 | 1.1 |
| February | 1.40 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 6.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 10.87 | 0.068 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 0.0 | 0.0 |
| July | 6.17 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 52.15 | 0.778 | 0.107 | 0.033 | 0.226 | 0.075 | 1.4 | 0.4 | 2.9 | 1.0 |

Table 17. Pesticides in tile drainage (Plot 7, NT)

| Period | Ppt (cm) | Flow (cm) | Load (g/ha) | | | | Flow Weighted Mean (ug/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Atrazine | Alachlor | Metalochlor | Metribuzin | Atrazine | Alachlor | Metalochlor | Metribuzin |
| **1987 (corn)** | | | | | | | | | | |
| May | 7.80 | 0.020 | 0.022 | 0.023 | 0.000 | 0.000 | 54.4 | 11.5 | 0.0 | 0.0 |
| June | 8.51 | 0.550 | 1.918 | 0.137 | 0.000 | 0.000 | 34.9 | 2.5 | 0.0 | 0.0 |
| July | 4.34 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 3.76 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 4.75 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.15 | 0.570 | 1.940 | 0.160 | 0.000 | 0.000 | 34.0 | 2.8 | 0.0 | 0.0 |
| **1988 (soybean)** | | | | | | | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | 0.070 | 0.009 | 0.000 | 0.000 | 0.000 | 1.3 | 0.0 | 0.0 | 0.0 |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 4.68 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 5.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 9.53 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | 0.070 | 0.009 | 0.000 | 0.000 | 0.000 | 1.3 | 0.0 | 0.0 | 0.0 |
| **1989 (corn)** | | | | | | | | | | |
| January | 5.36 | 0.610 | 0.072 | 0.029 | 0.060 | 0.034 | 1.2 | 0.5 | 1.0 | 0.6 |
| February | 1.40 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 6.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 10.87 | 0.065 | 0.007 | 0.000 | 0.000 | 0.000 | 1.0 | 0.0 | 0.0 | 0.0 |
| July | 6.17 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 52.15 | 0.675 | 0.079 | 0.029 | 0.060 | 0.034 | 1.2 | 0.4 | 0.9 | 0.5 |

Table 18. Pesticides in tile drainage (Plot 3, CONV)

| Period | Ppt (cm) | Flow (cm) | Load (g/ha) | | | | Flow Weighted Mean (ug/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Atrazine | Alachlor | Metalochlor | Metribuzin | Atrazine | Alachlor | Metalochlor | Metribuzin |
| | | | | | | 1987 (soybean) | | | | |
| May | 7.80 | 0.040 | 0.001 | 0.000 | 0.015 | 0.004 | 0.4 | 0.0 | 3.8 | 0.9 |
| June | 8.51 | 0.250 | 0.017 | 0.000 | 0.179 | 0.066 | 0.7 | 0.0 | 7.1 | 2.6 |
| July | 4.34 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 3.76 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 4.75 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.15 | 0.290 | 0.019 | 0.000 | 0.194 | 0.069 | 0.6 | 0.0 | 6.7 | 2.4 |
| | | | | | | 1988 (corn) | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 4.68 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 5.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 9.53 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | | | | | 1989 (soybean) | | | | |
| January | 5.36 | 2.710 | 0.215 | 0.000 | 0.000 | 0.001 | 0.8 | 0.0 | 0.0 | .0 |
| February | 1.40 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 6.43 | 2.766 | 0.000 | 0.000 | 0.000 | 0.000 | 0.0 | 0.0 | 0.0 | 0.0 |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | 0.053 | 0.003 | 0.000 | 0.000 | 0.000 | 0.5 | 0.0 | 0.0 | 0.0 |
| June | 10.87 | 0.826 | 0.060 | 0.000 | 0.000 | 0.000 | 0.7 | 0.0 | 0.0 | 0.0 |
| July | 6.17 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 52.15 | 6.355 | 0.278 | 0.000 | 0.000 | 0.001 | 0.4 | 0.0 | 0.0 | .0 |

Table 19. Pesticides in tile drainage (Plot 4, CONV)

| Period | Ppt (cm) | Flow (cm) | Load (g/ha) | | | | Flow Weighted Mean (ug/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Atrazine | Alachlor | Metalochlor | Metribuzin | Atrazine | Alachlor | Metalochlor | Metribuzin |
| 1987 (soybean) | | | | | | | | | | |
| May | 7.80 | 0.030 | 0.003 | 0.000 | 0.015 | 0.006 | 1.1 | 0.0 | 4.8 | 2.0 |
| June | 8.51 | 0.340 | 0.042 | 0.000 | 0.224 | 0.097 | 1.2 | 0.0 | 6.6 | 2.9 |
| July | 4.34 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 3.76 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 4.75 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.15 | 0.370 | 0.045 | 0.000 | 0.238 | 0.103 | 1.2 | 0.0 | 6.4 | 2.8 |
| 1988 (corn) | | | | | | | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 4.68 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 5.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 9.53 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1989 (soybean) | | | | | | | | | | |
| January | 5.36 | 2.860 | 0.748 | 0.000 | 0.000 | 0.000 | 2.6 | 0.0 | 0.0 | 0.0 |
| February | 1.40 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 6.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 10.87 | 0.310 | 0.026 | 0.044 | 0.134 | 0.000 | 0.8 | 1.4 | 4.3 | 0.0 |
| July | 6.17 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 52.15 | 3.170 | 0.774 | 0.044 | 0.134 | 0.000 | 2.4 | 0.1 | 0.4 | 0.0 |

Table 20. Pesticides in tile drainage (Plot 5, CONV)

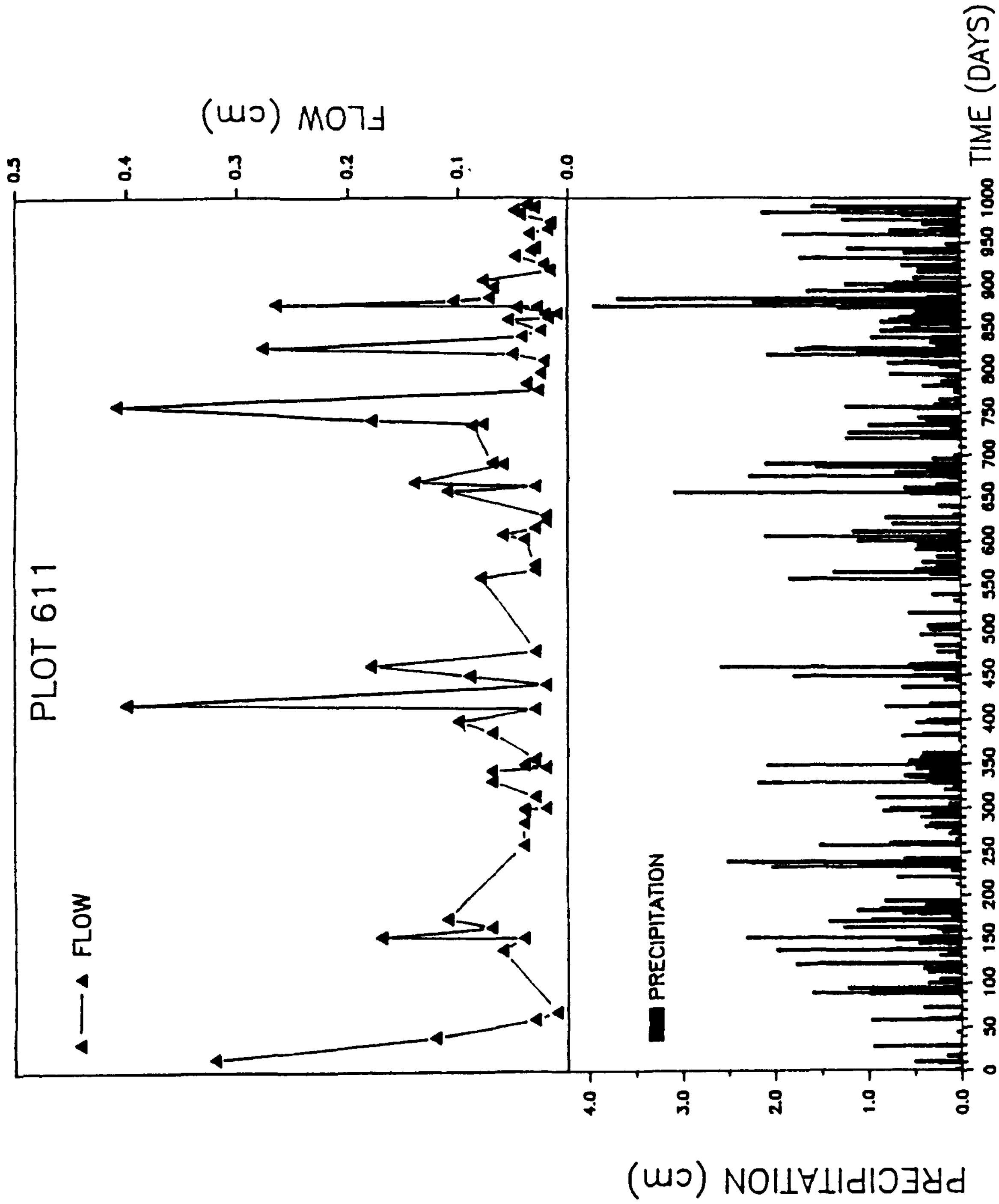
| Period | Ppt (cm) | Flow (cm) | Load (g/ha) | | | | Flow Weighted Mean (ug/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Atrazine | Alachlor | Metalochlor | Metribuzin | Atrazine | Alachlor | Metalochlor | Metribuzin |
| | | | | | | 1987 (corn) | | | | |
| May | 7.80 | 0.010 | 0.009 | 0.002 | 0.000 | 0.000 | 9.4 | 2.0 | 0.0 | 0.0 |
| June | 8.51 | 0.160 | 0.408 | 0.060 | 0.000 | 0.000 | 25.5 | 3.7 | 0.0 | 0.0 |
| July | 4.34 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 3.76 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 4.75 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.15 | 0.170 | 0.417 | 0.062 | 0.000 | 0.000 | 24.6 | 3.6 | 0.0 | 0.0 |
| | | | | | | 1988 (soybean) | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | 0.200 | 0.019 | 0.000 | 0.000 | 0.000 | 1.0 | 0.0 | 0.0 | 0.0 |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 4.68 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 5.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 9.53 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | 0.200 | 0.019 | 0.000 | 0.000 | 0.000 | 1.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | 1989 (corn) | | | | |
| January | 5.36 | 0.510 | 0.002 | 0.002 | 0.000 | 0.001 | .0 | .0 | 0.0 | .0 |
| February | 1.40 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| March | 6.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 10.87 | 0.174 | 0.010 | 0.000 | 0.000 | 0.000 | 0.6 | 0.0 | 0.0 | 0.0 |
| July | 6.17 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 52.15 | 0.684 | 0.013 | 0.002 | 0.000 | 0.001 | 0.2 | .0 | 0.0 | .0 |

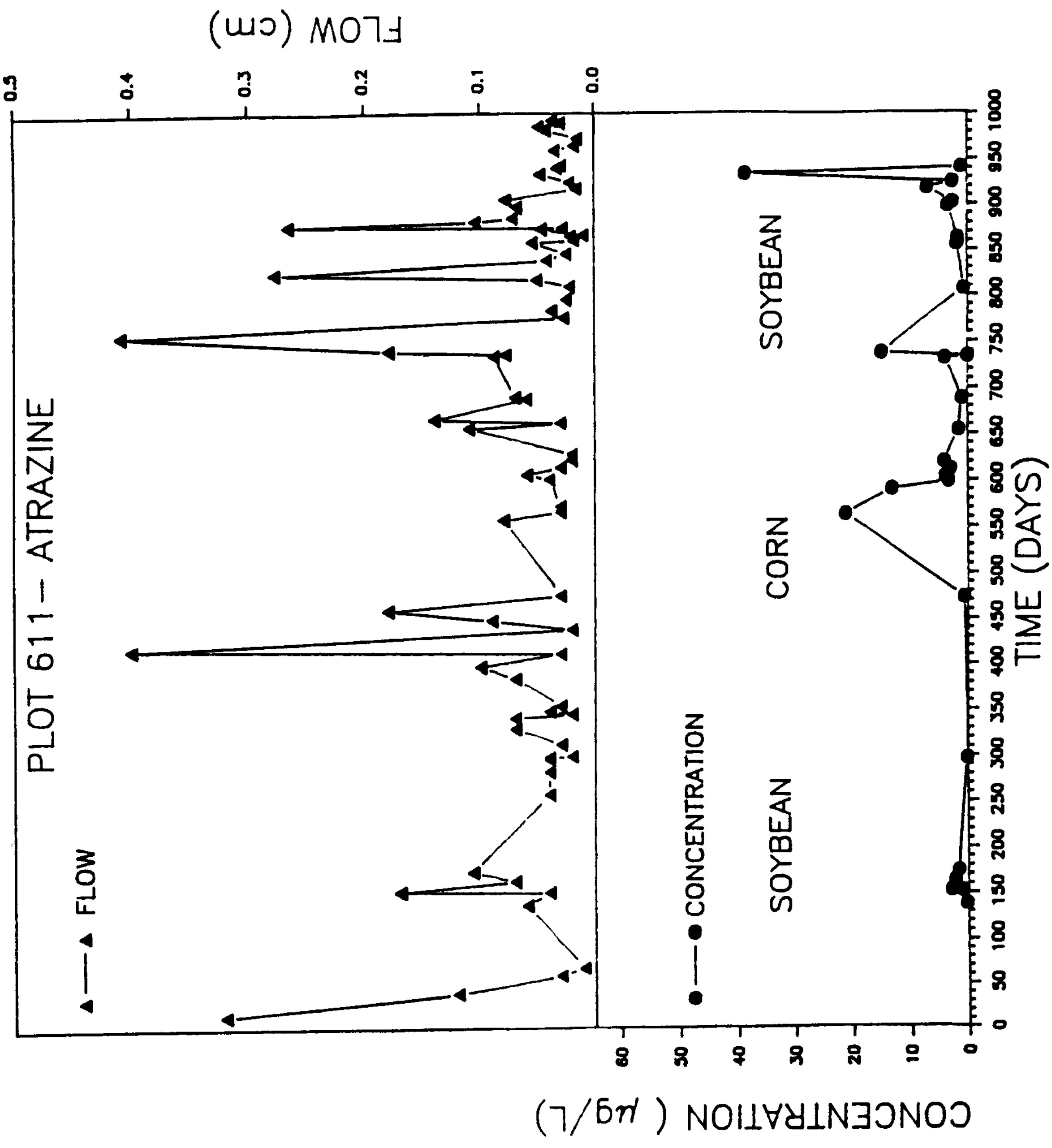
Table 21. Pesticides in tile drainage (Plot 8, CONV)

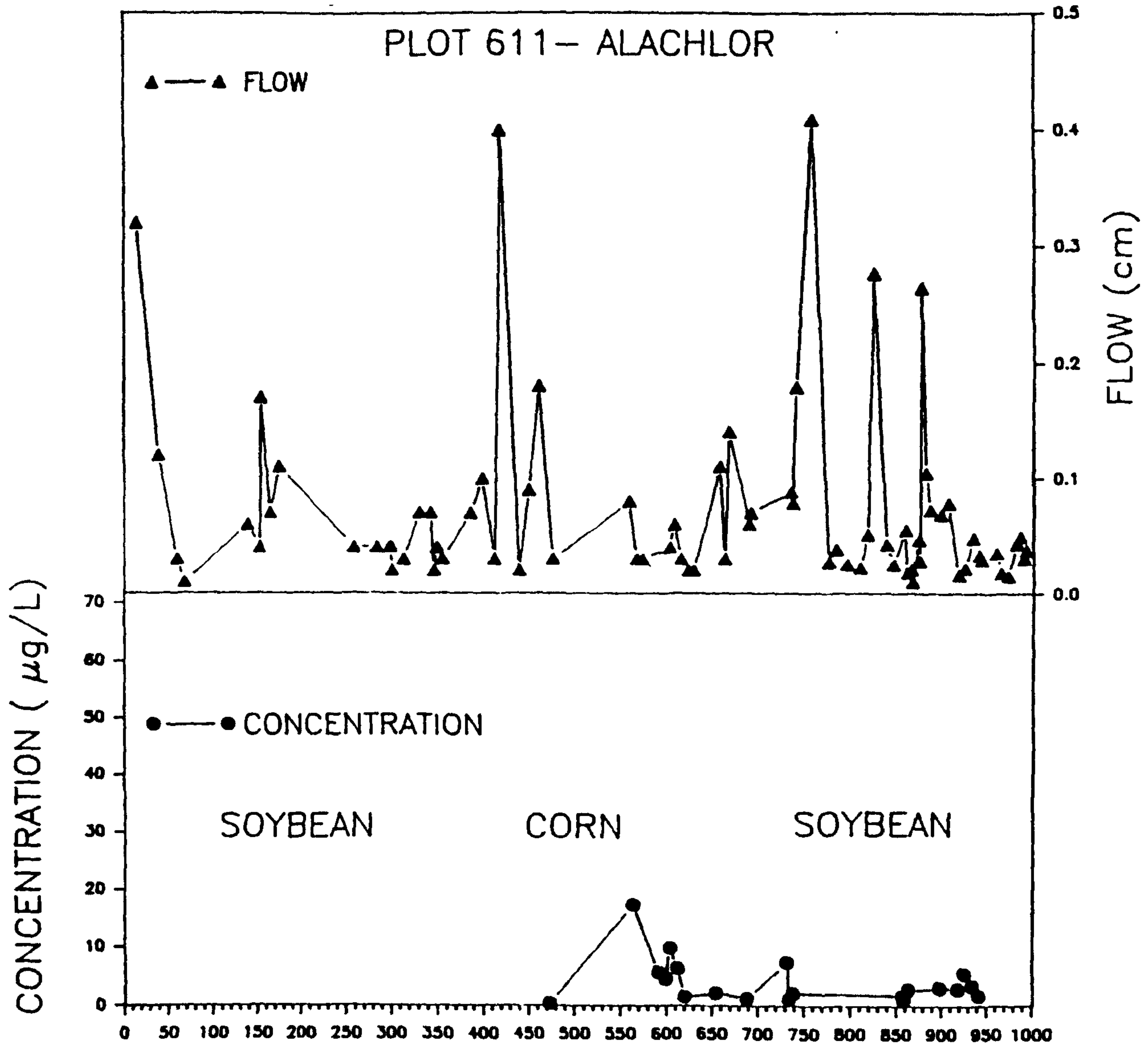
| Period | Ppt (cm) | Flow (cm) | Load (g/ha) Atrazine | Load (g/ha) Alachlor | Load (g/ha) Metalochlor | Load (g/ha) Metribuzin | Flow Weighted Mean (ug/L) Atrazine | Flow Weighted Mean (ug/L) Alachlor | Flow Weighted Mean (ug/L) Metalochlor | Flow Weighted Mean (ug/L) Metribuzin |
|---|---|---|---|---|---|---|---|---|---|---|
| **1987 (corn)** | | | | | | | | | | |
| May | 7.80 | 0.120 | 0.231 | 0.097 | 0.000 | 0.000 | 19.2 | 8.0 | 0.0 | 0.0 |
| June | 8.51 | 5.000 | 9.896 | 0.000 | 0.000 | 0.000 | 39.6 | 0.0 | .0 | 0.0 |
| July | 4.34 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 8.08 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.84 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 3.76 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 4.75 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.15 | 5.120 | 10.127 | 0.097 | 0.000 | 0.000 | 19.8 | 0.2 | 0.0 | 0.0 |
| **1988 (soybean)** | | | | | | | | | | |
| January | 1.24 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| February | 2.06 | 0.490 | 0.045 | 0.000 | 0.000 | 0.000 | 0.9 | 0.0 | 0.0 | 0.0 |
| March | 3.30 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 4.78 | 0.560 | 0.040 | 0.000 | 0.000 | 0.000 | 0.7 | 0.0 | 0.0 | 0.0 |
| May | 1.22 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| June | 0.94 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| July | 6.07 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| August | 4.68 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| September | 2.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| October | 5.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| November | 9.53 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| December | 3.98 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Total | 46.21 | 1.050 | 0.085 | 0.000 | 0.000 | 0.000 | 0.8 | 0.0 | 0.0 | 0.0 |
| **1989 (corn)** | | | | | | | | | | |
| January | 5.36 | 2.813 | 0.100 | 0.076 | 0.001 | 0.000 | 0.4 | 0.3 | .0 | 0.0 |
| February | 1.40 | 0.574 | 0.017 | 0.000 | 0.000 | 0.000 | 0.3 | 0.0 | 0.0 | 0.0 |
| March | 6.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| April | 8.43 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| May | 13.49 | 11.081 | 0.218 | 0.007 | 0.007 | 0.007 | 0.2 | .0 | .0 | .0 |
| June | 10.87 | 0.141 | 0.006 | 0.000 | 0.000 | 0.000 | 0.4 | 0.0 | 0.0 | 0.0 |
| July | 6.17 | 0.088 | 0.005 | 0.000 | 0.000 | 0.000 | 0.6 | 0.0 | 0.0 | 0.0 |
| Total | 52.15 | 14.697 | 0.346 | 0.083 | 0.008 | 0.007 | 0.2 | 0.1 | .0 | .0 |

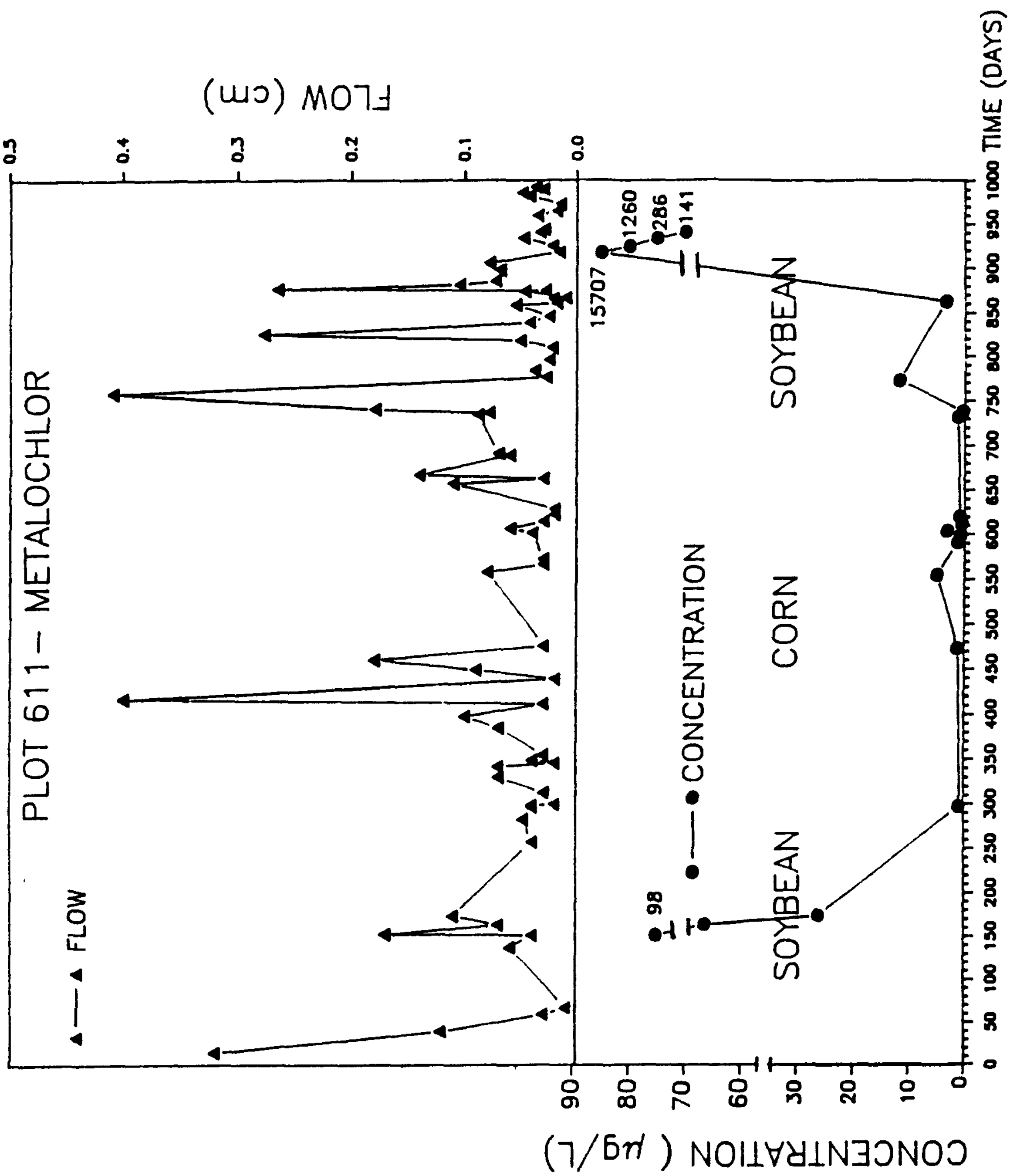
Figures 3-11.

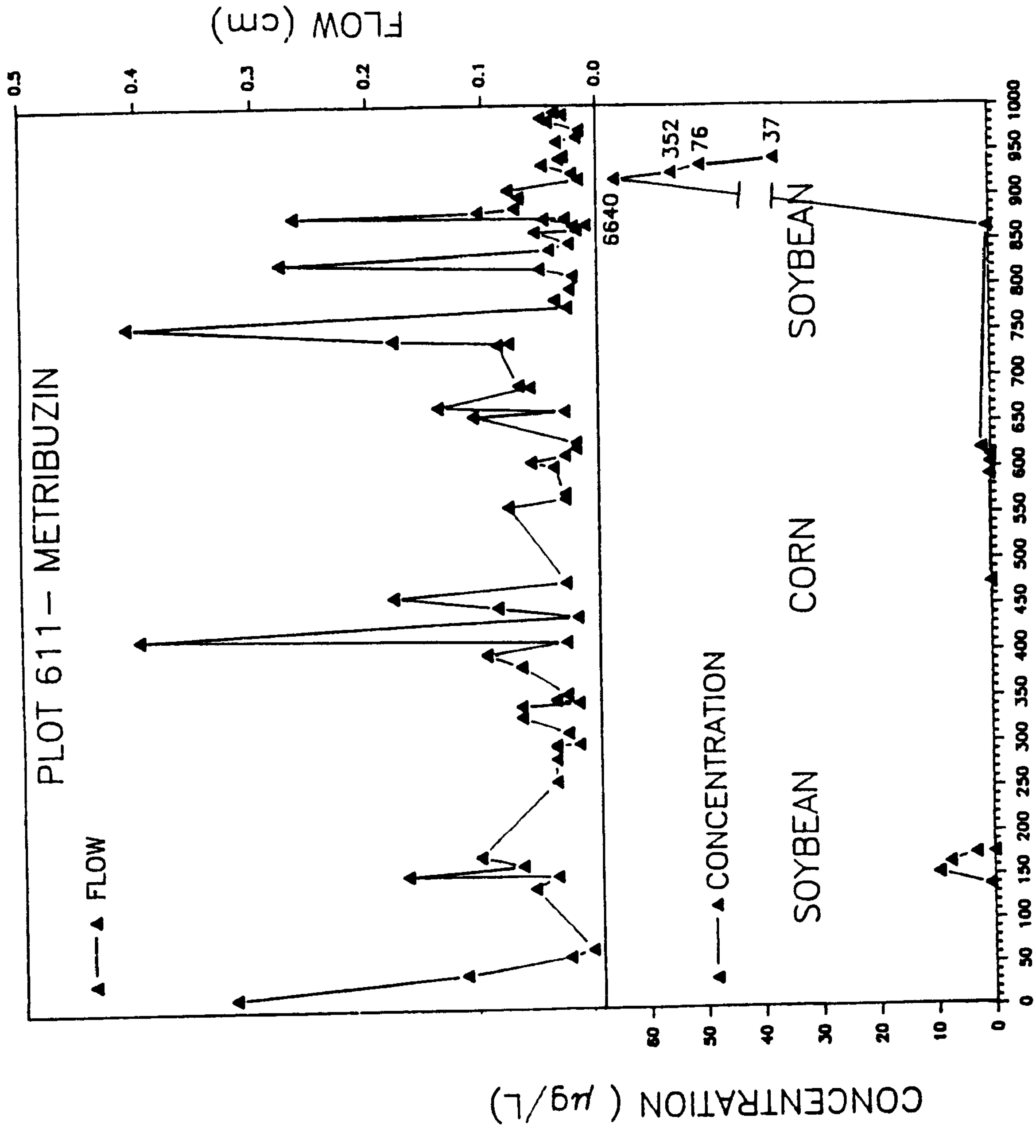
Precipitation, runoff, and runoff concentrations and loads in individual events for the four monitored herbicides. No-till in corn-soybean-corn rotation (Plot 611).

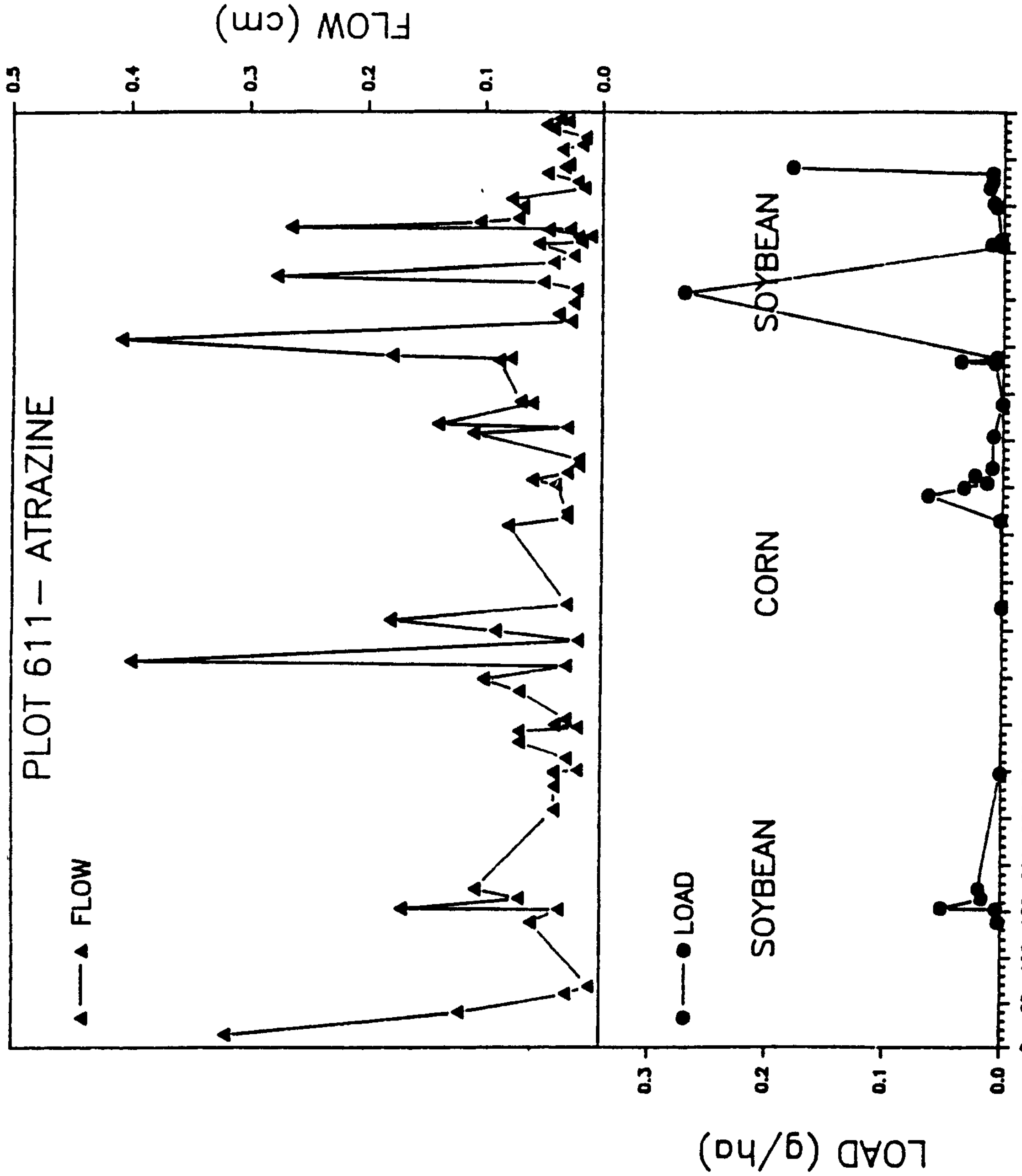

PLOT 611
FLOW
PRECIPITATION
FLOW (cm)
0.0
0.1
0.2
0.3
0.4
0.5
PRECIPITATION (cm)
0.0
1.0
2.0
3.0
4.0
TIME (DAYS)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000


PLOT 611 — ATRAZINE
FLOW
CONCENTRATION
SOYBEAN
CORN
SOYBEAN
FLOW (cm)
0.5
0.4
0.3
0.2
0.1
0.0
CONCENTRATION ( µg/L)
60
50
40
30
20
10
0
TIME (DAYS)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000

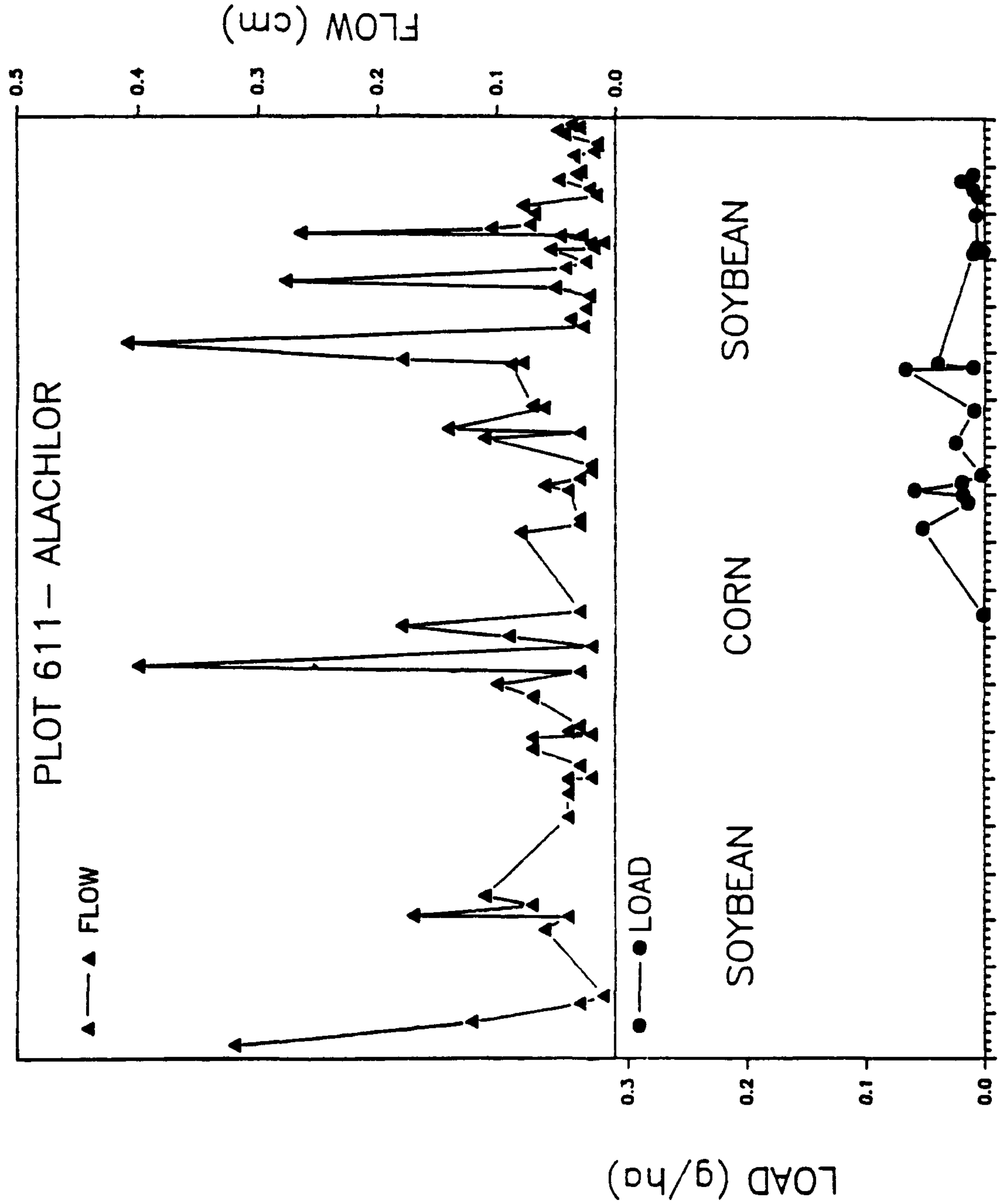

PLOT 611– ALACHLOR
FLOW
CONCENTRATION
SOYBEAN
CORN
SOYBEAN
CONCENTRATION ( µg/L)
FLOW (cm)
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000
0 10 20 30 40 50 60 70
0.0 0.1 0.2 0.3 0.4 0.5

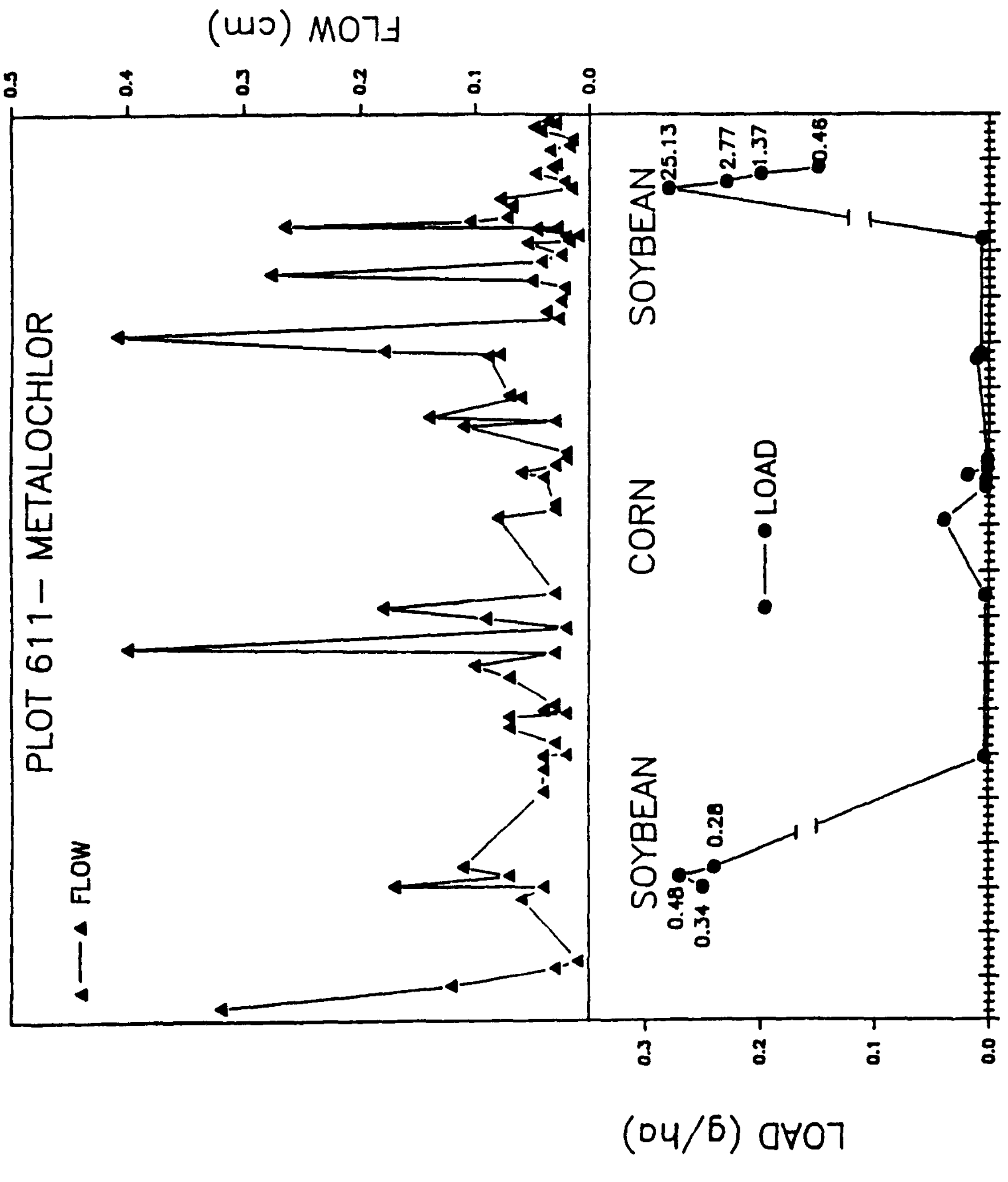

PLOT 611 — METALOCHLOR
FLOW
CONCENTRATION
SOYBEAN
CORN
SOYBEAN
98
15707
1260
286
141
FLOW (cm)
CONCENTRATION ( µg/L)
TIME (DAYS)

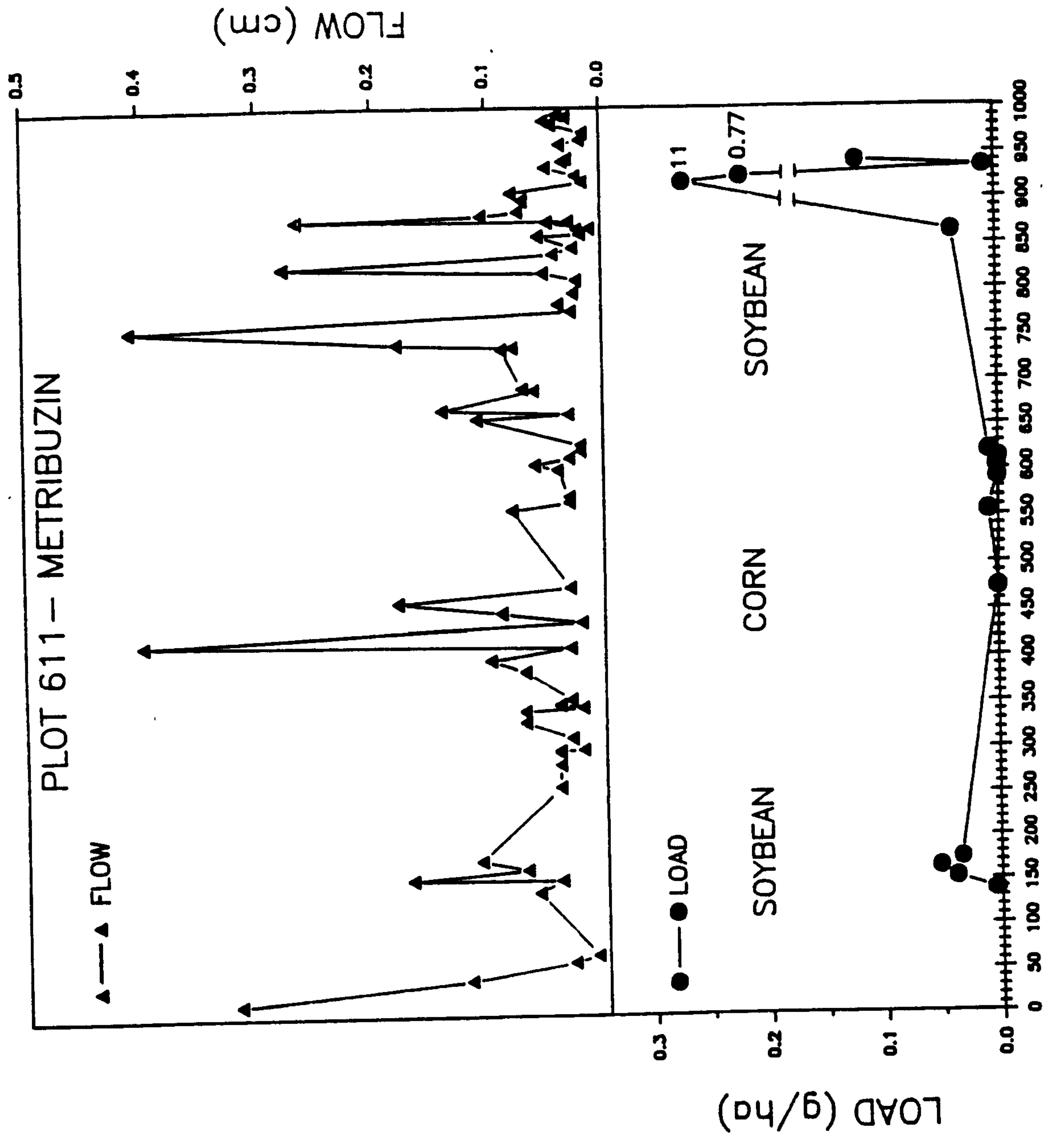

PLOT 611 — METRIBUZIN
FLOW
CONCENTRATION
SOYBEAN
CORN
SOYBEAN
6640
352
76
37
FLOW (cm)
CONCENTRATION ( µg/L)
0.0
0.1
0.2
0.3
0.4
0.5
0
10
20
30
40
50
60
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000



PLOT 611 — ATRAZINE
FLOW
LOAD
SOYBEAN
CORN
SOYBEAN
FLOW (cm)
0.0
0.1
0.2
0.3
0.4
0.5
LOAD (g/ha)
0.0
0.1
0.2
0.3
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000

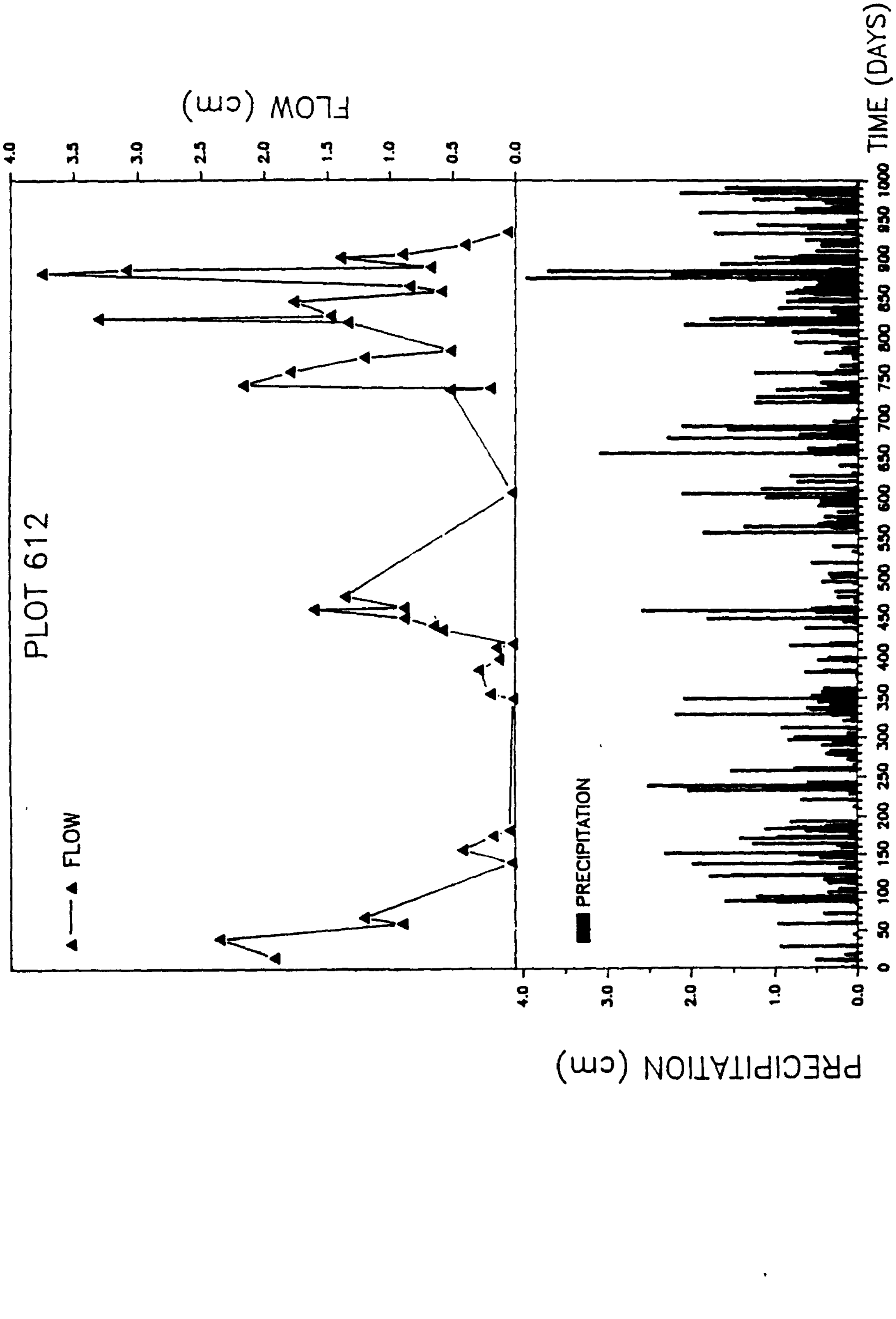

PLOT 611 – ALACHLOR
FLOW
LOAD
SOYBEAN
CORN
SOYBEAN
FLOW (cm)
LOAD (g/ha)
0.0
0.1
0.2
0.3
0.4
0.5
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000

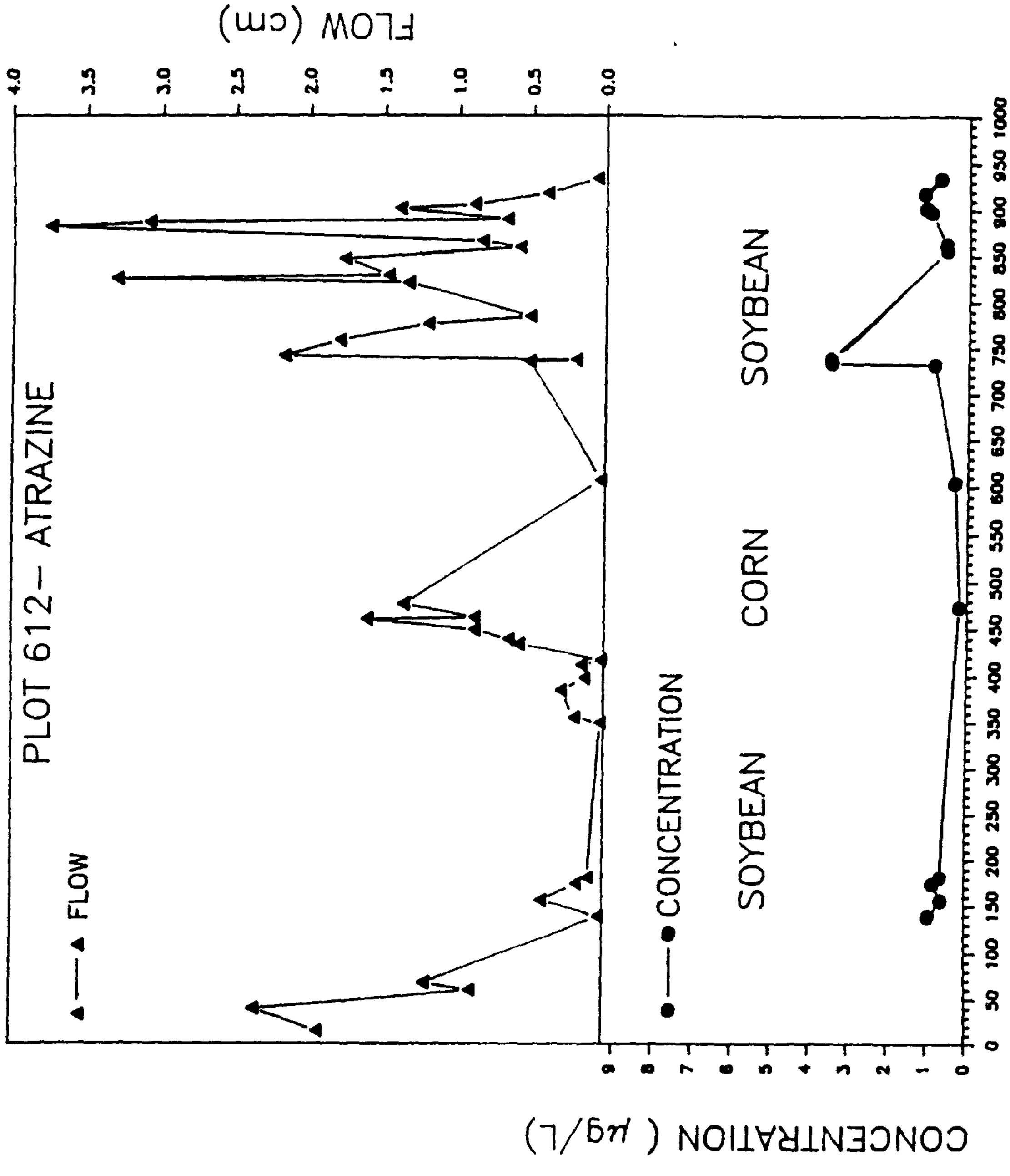

PLOT 611 — METALOCHLOR
FLOW
LOAD
SOYBEAN
CORN
SOYBEAN
0.48
0.34
0.28
25.13
2.77
1.37
0.48
FLOW (cm)
LOAD (g/ha)
0.0
0.1
0.2
0.3
0.4
0.5
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000

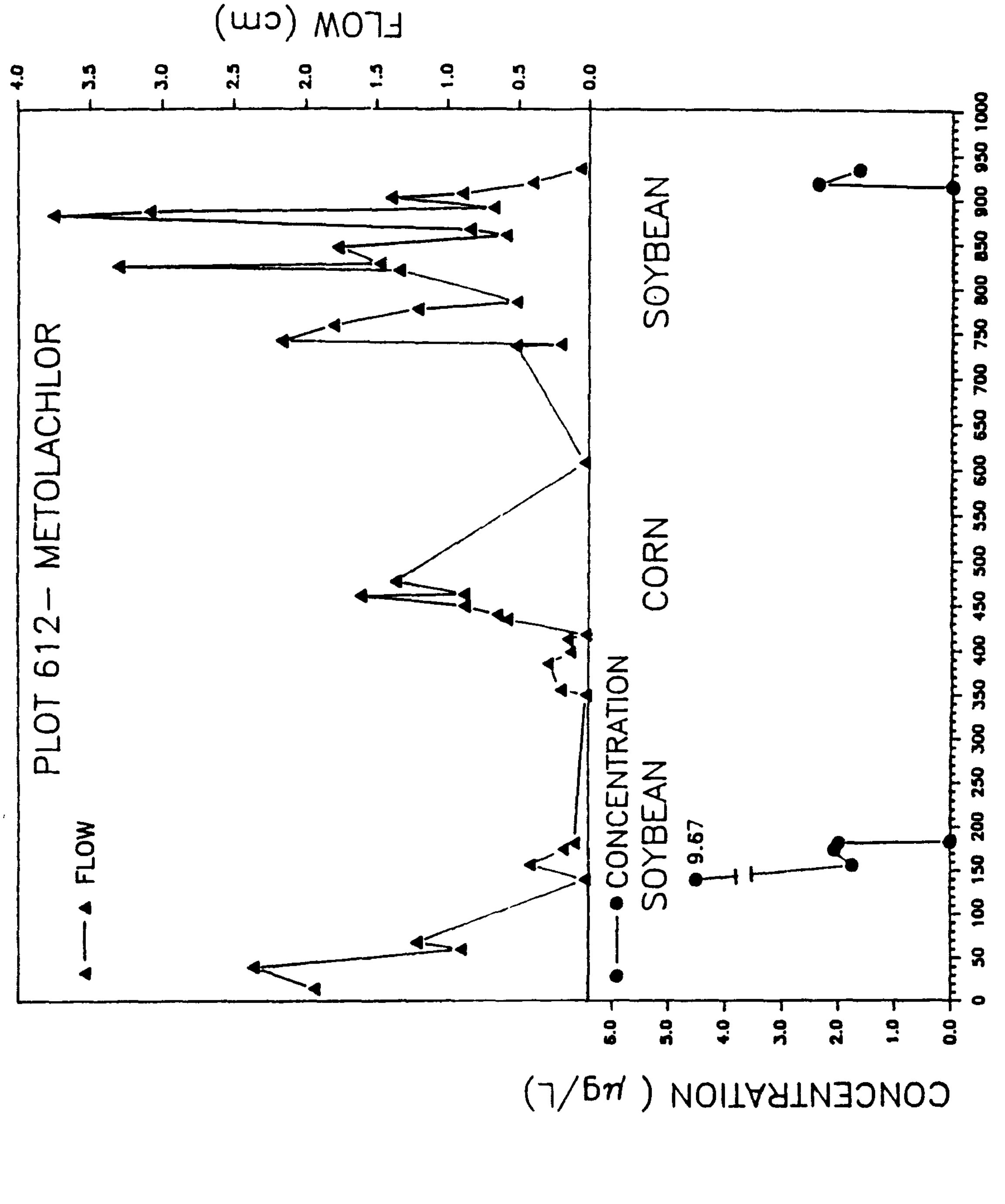

PLOT 611 — METRIBUZIN
FLOW
LOAD
SOYBEAN
CORN
SOYBEAN
FLOW (cm)
LOAD (g/ha)
0.77
11
0.0
0.1
0.2
0.3
0.4
0.5
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000

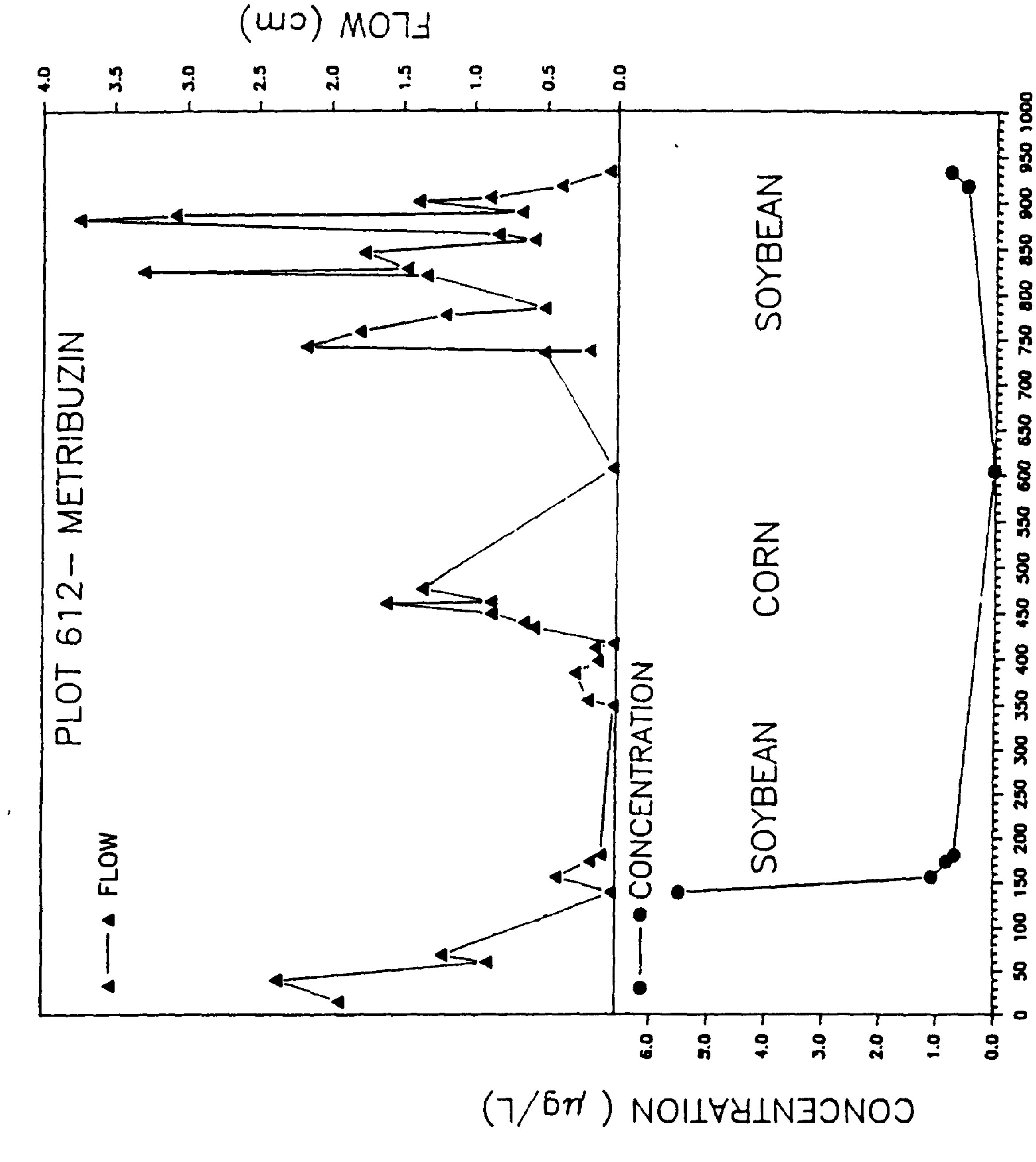
Figures 12-18.

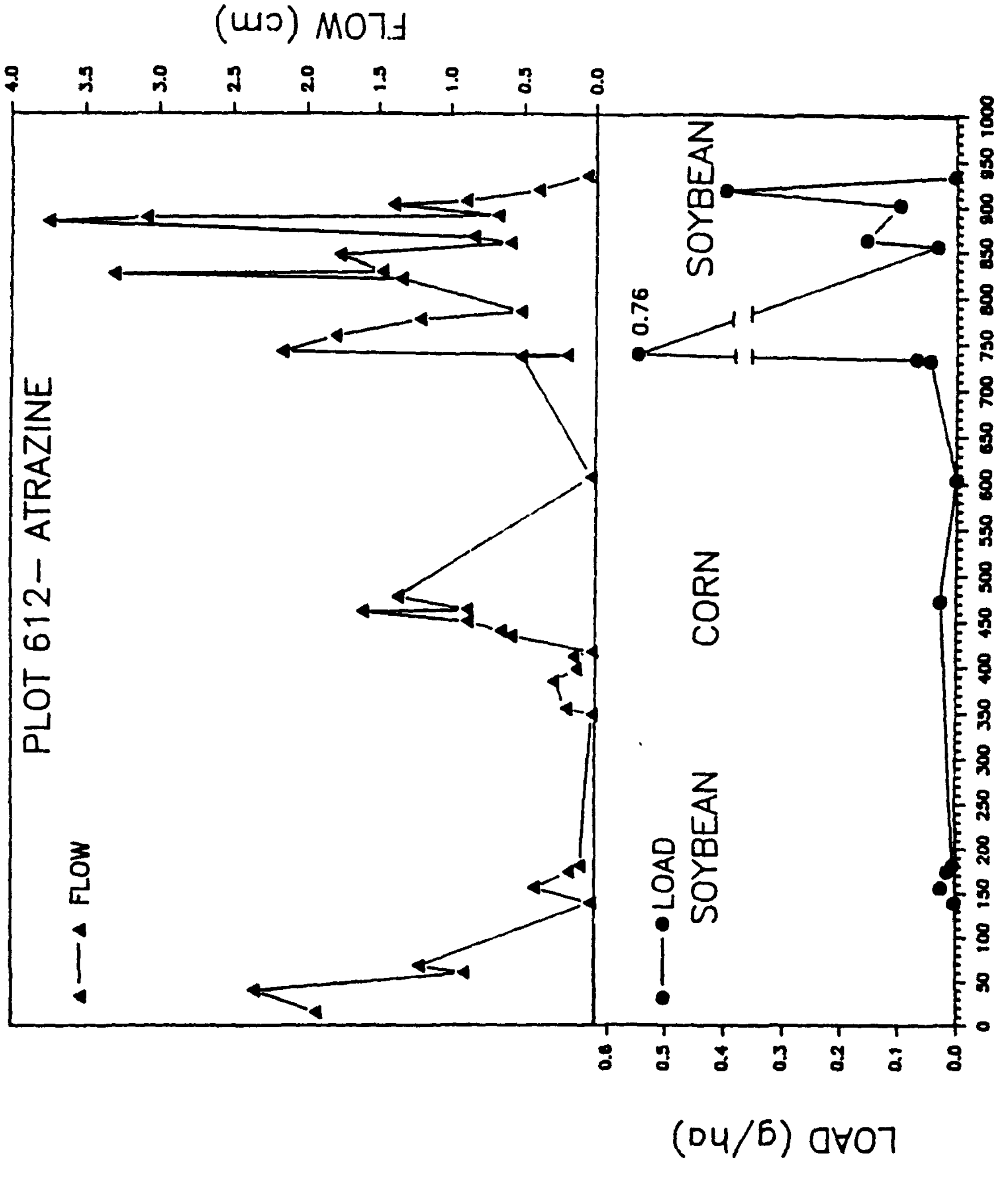
Precipitation, tile drainage, and tile drainage concentrations and loads in individual events for the four monitored herbicides. No-till in corn-soybean-corn rotation (Plot 612).

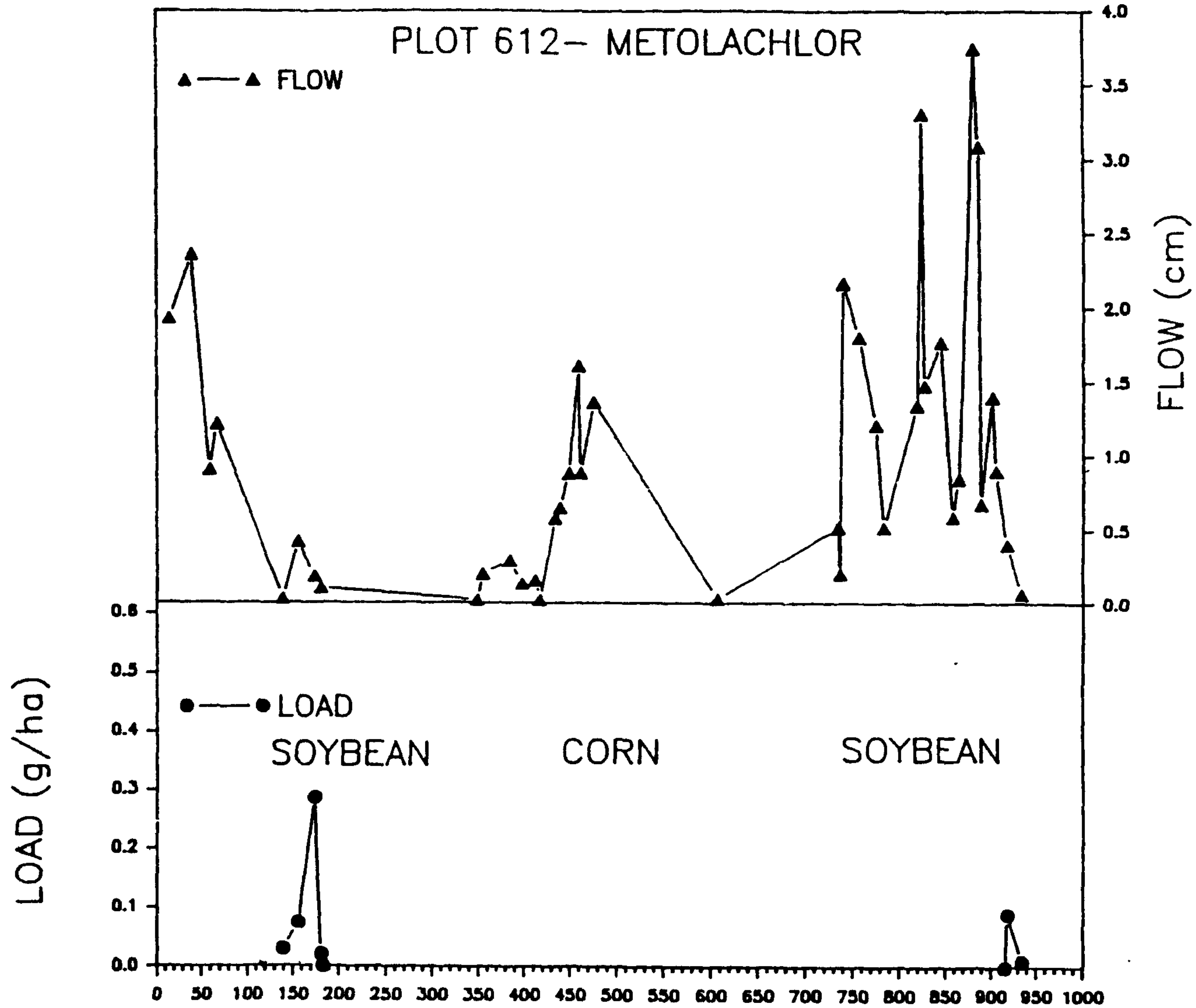

PLOT 612
FLOW
PRECIPITATION
FLOW (cm)
PRECIPITATION (cm)
TIME (DAYS)

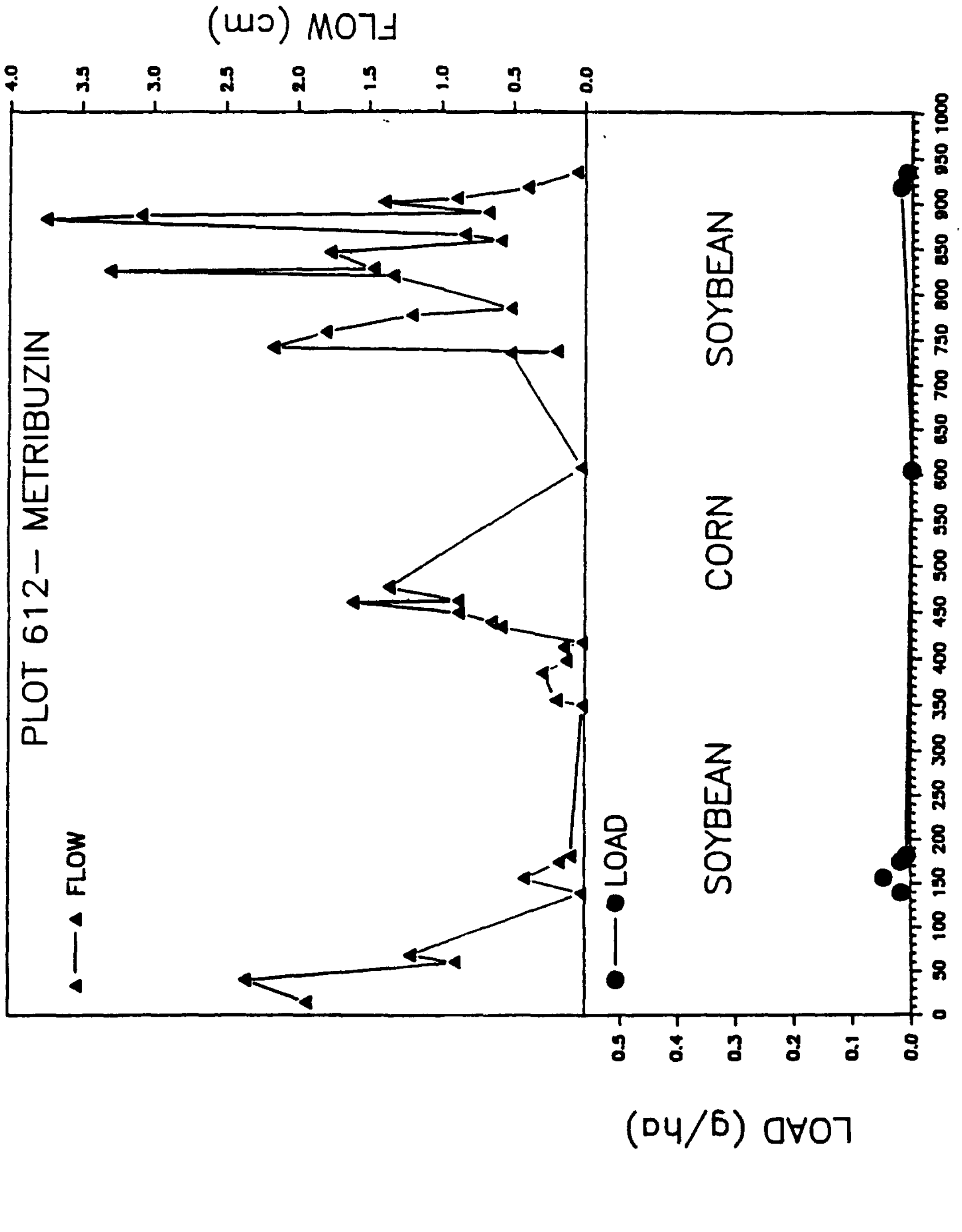

PLOT 612– ATRAZINE
FLOW
CONCENTRATION
SOYBEAN
CORN
SOYBEAN
FLOW (cm)
CONCENTRATION ( μg/L)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
9
8
7
6
5
4
3
2
1
0
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000


PLOT 612— METOLACHLOR
FLOW
CONCENTRATION
SOYBEAN
CORN
SOYBEAN
9.67
FLOW (cm)
CONCENTRATION ( µg/L)
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
0.0 1.0 2.0 3.0 4.0 5.0 6.0
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000


PLOT 612— METRIBUZIN
FLOW
CONCENTRATION
SOYBEAN
CORN
SOYBEAN
FLOW (cm)
CONCENTRATION ( µg/L)


PLOT 612– ATRAZINE
FLOW
LOAD
SOYBEAN
CORN
SOYBEAN
0.76
FLOW (cm)
LOAD (g/ha)

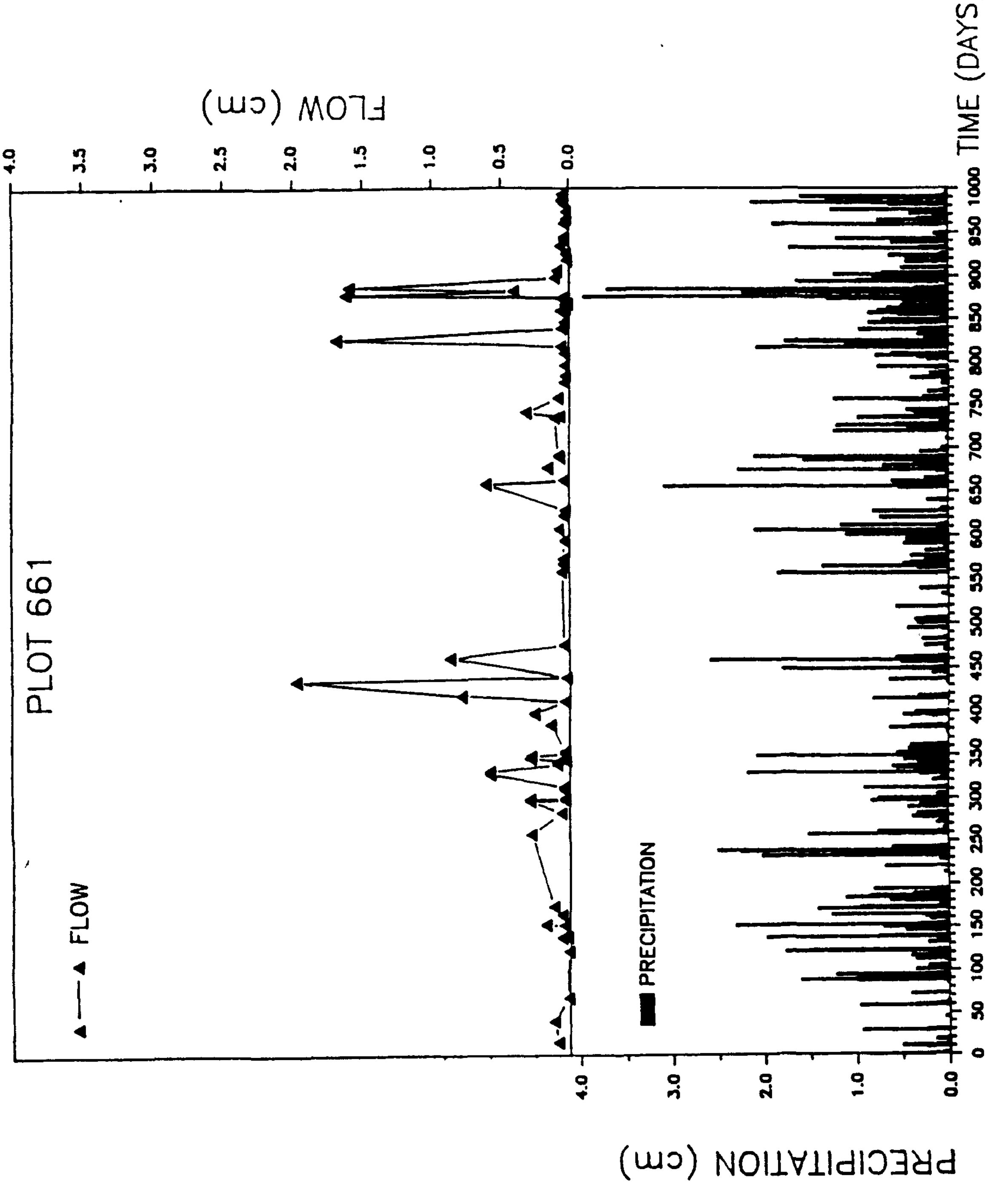

PLOT 612— METOLACHLOR
FLOW
LOAD
SOYBEAN
CORN
SOYBEAN
FLOW (cm)
LOAD (g/ha)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.1
0.2
0.3
0.4
0.6
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000

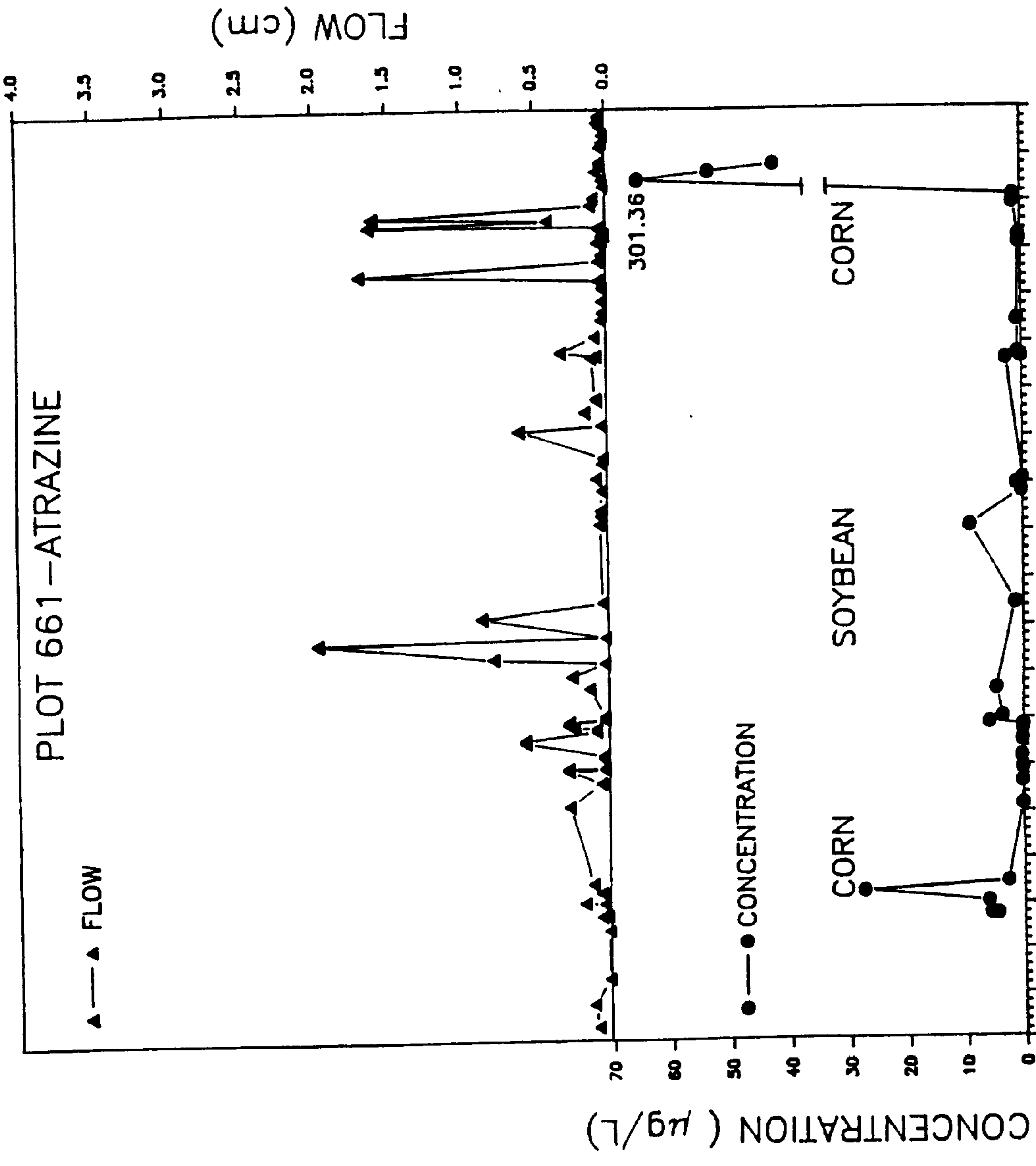


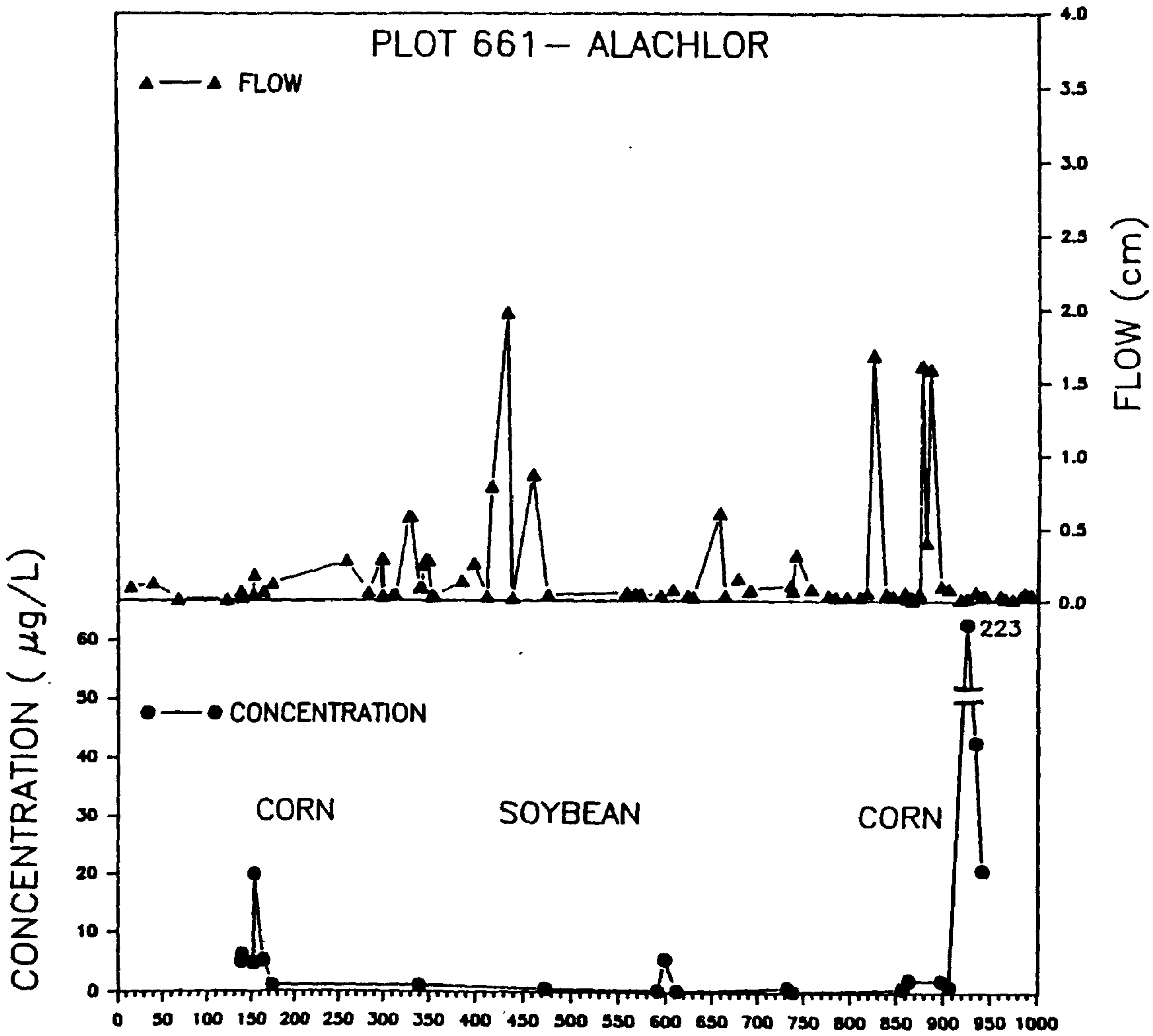
PLOT 612— METRIBUZIN
FLOW
LOAD
SOYBEAN
CORN
SOYBEAN
FLOW (cm)
LOAD (g/ha)
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
0.0 0.1 0.2 0.3 0.4 0.5
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000

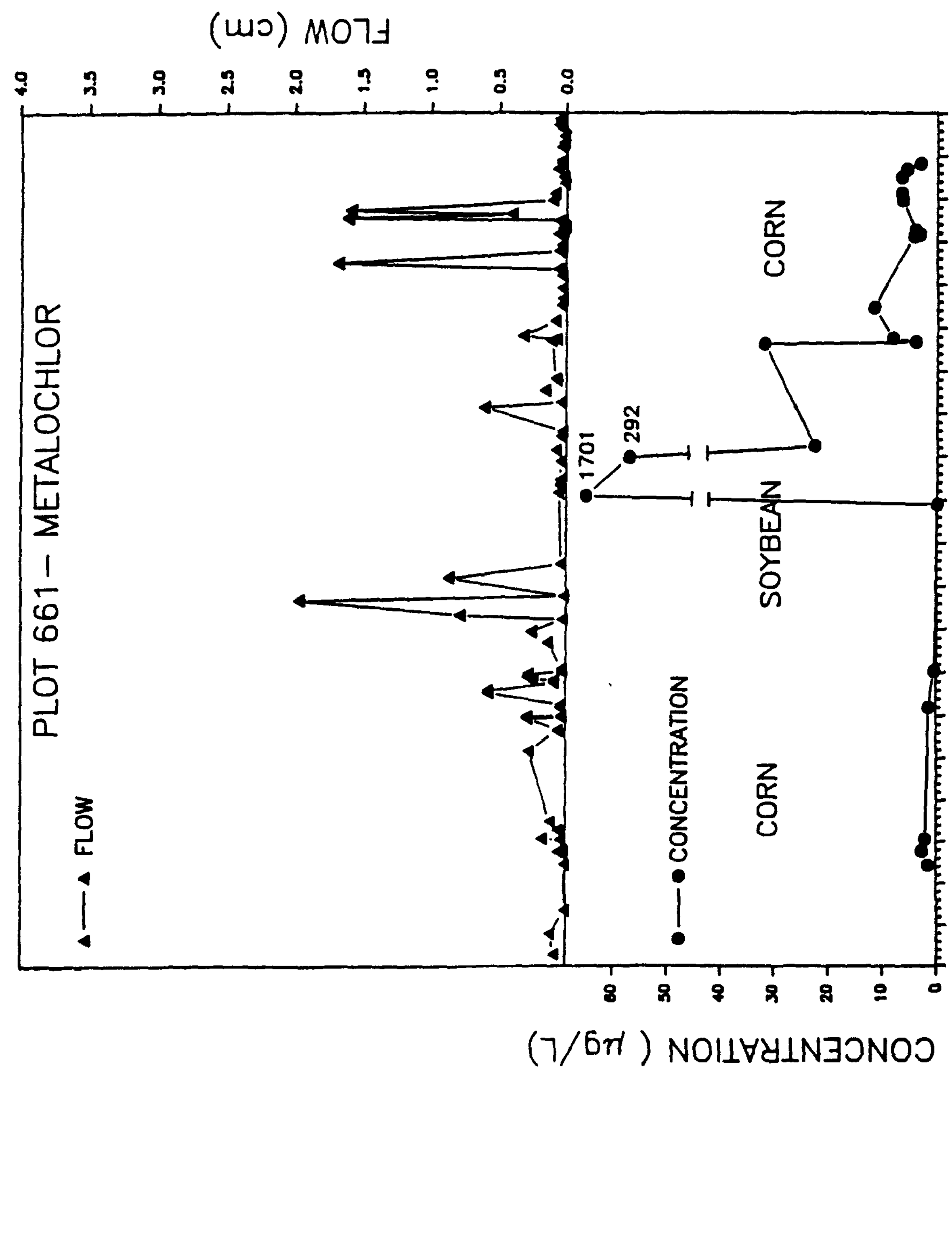
Figures 19-27.

Precipitation, runoff, and runoff concentrations and loads in individual events for the four monitored herbicides. No-till in soybean-corn-soybean rotation (Plot 661).

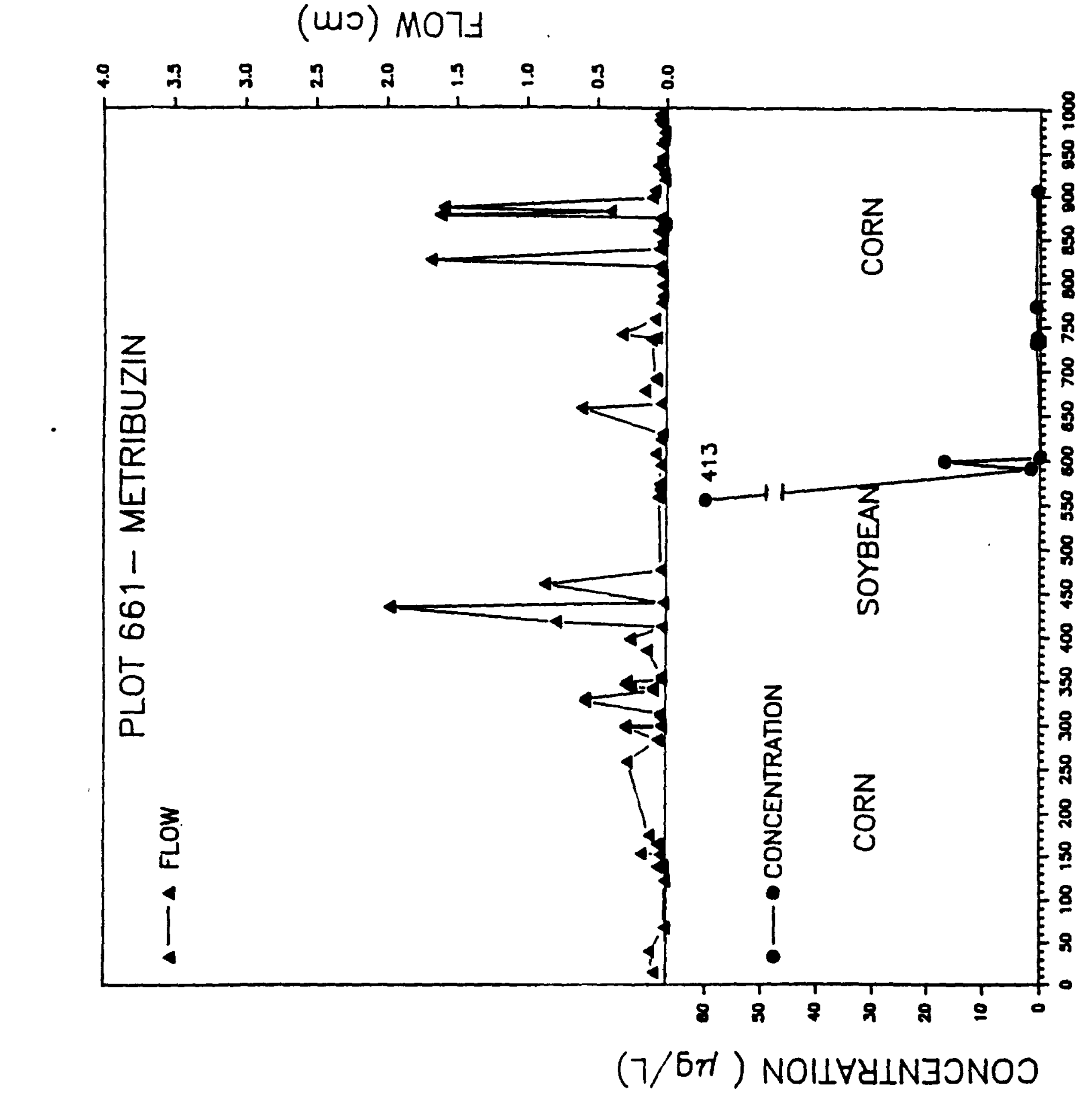

PLOT 661
FLOW
PRECIPITATION
FLOW (cm)
4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
PRECIPITATION (cm)
4.0 3.0 2.0 1.0 0.0
TIME (DAYS)
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000

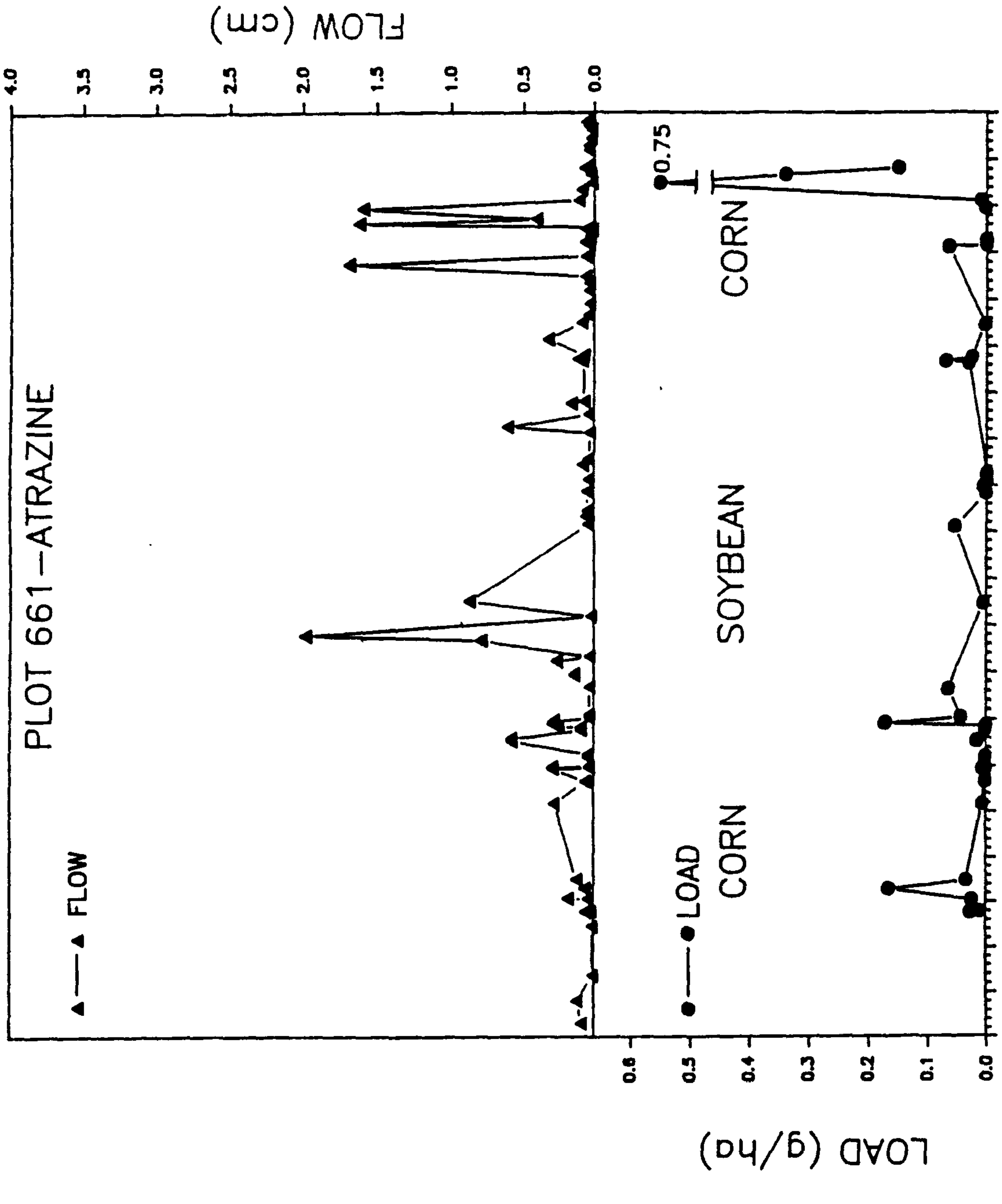

PLOT 661—ATRAZINE
FLOW
CONCENTRATION
FLOW (cm)
CONCENTRATION ( µg/L)
CORN
SOYBEAN
CORN
301.36
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
10
20
30
40
50
60
70
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000

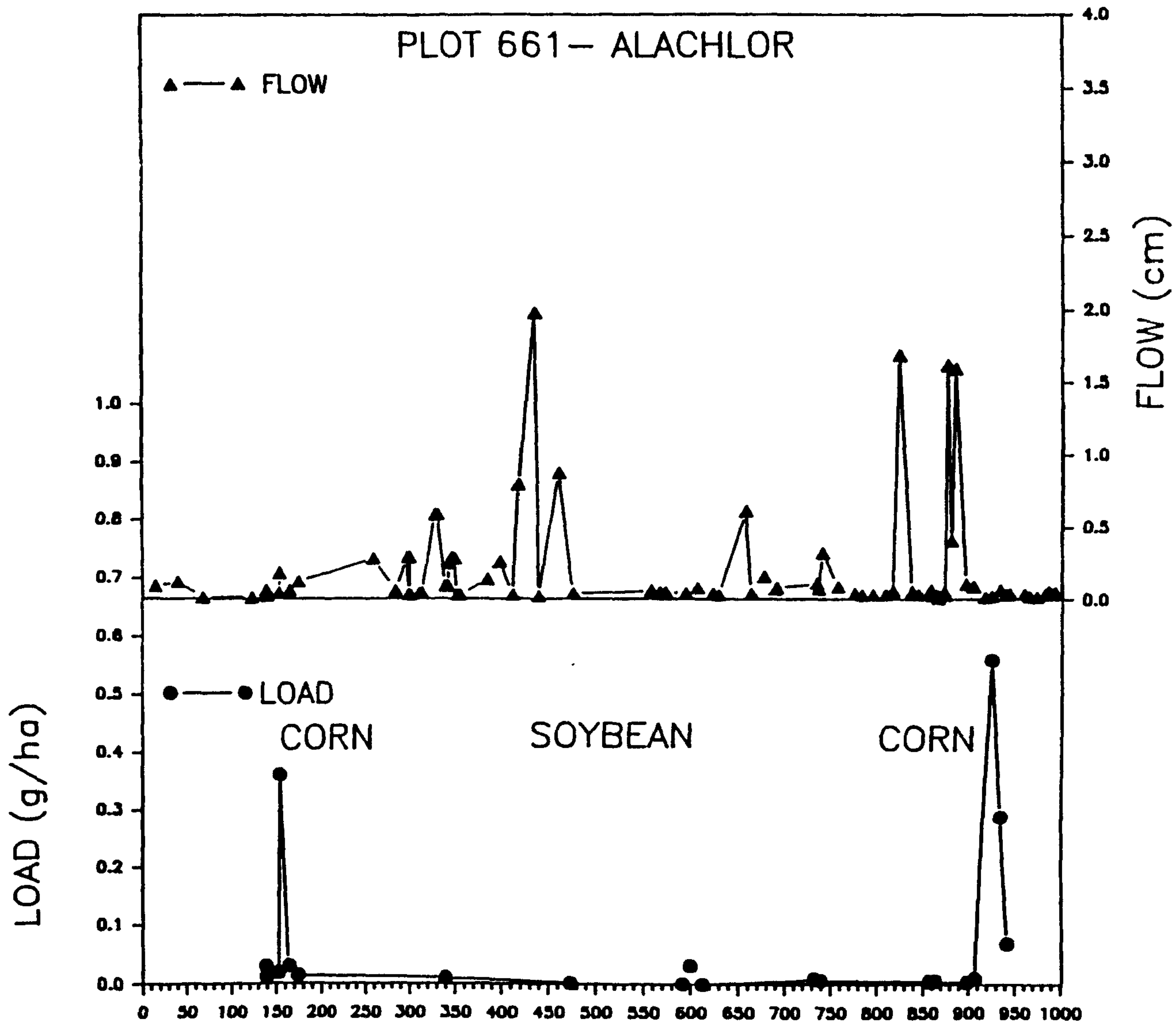

PLOT 661— ALACHLOR
FLOW
CONCENTRATION
CORN
SOYBEAN
CORN
223
FLOW (cm)
CONCENTRATION ( μg/L)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
10
20
30
40
50
60
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000

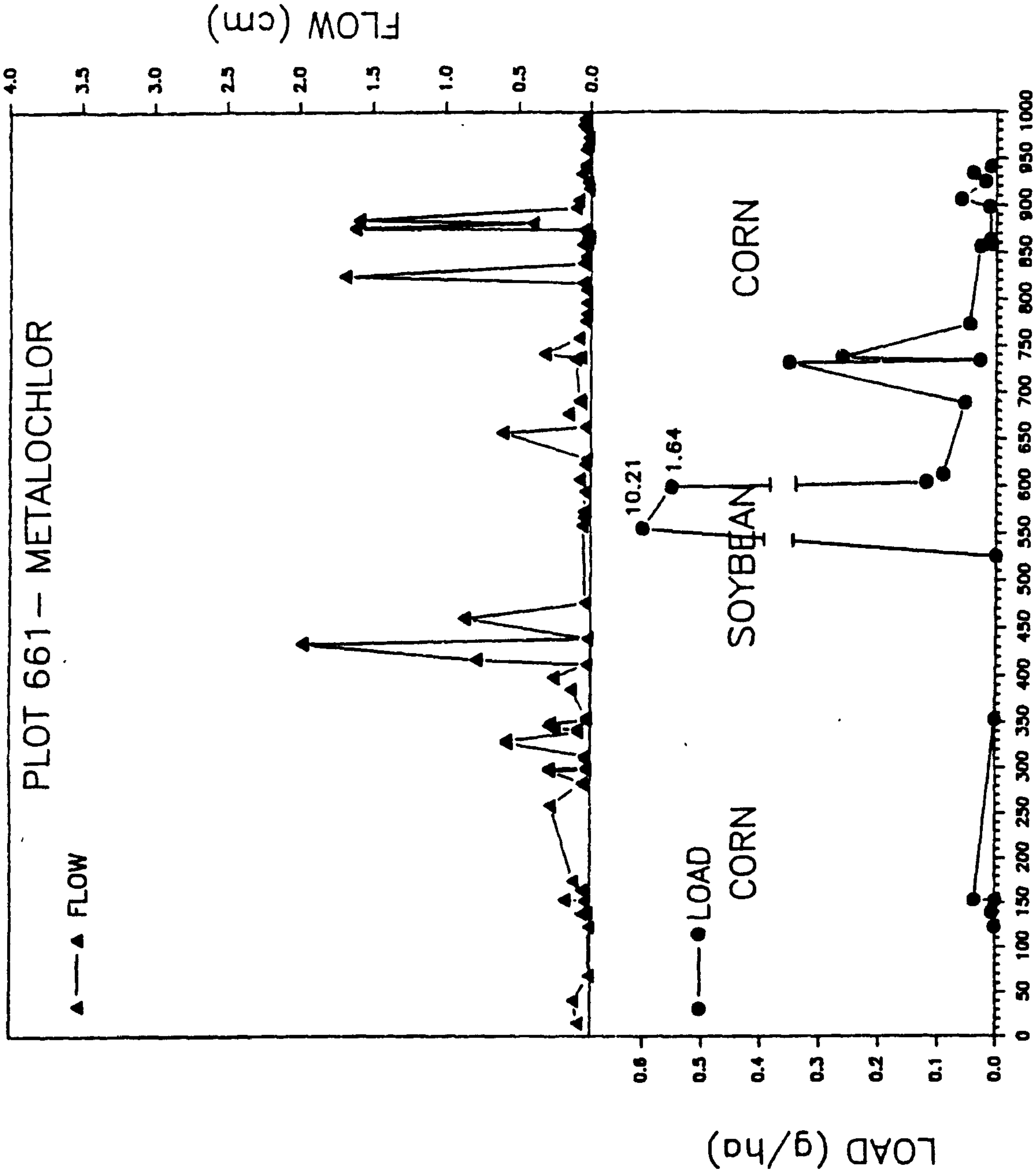


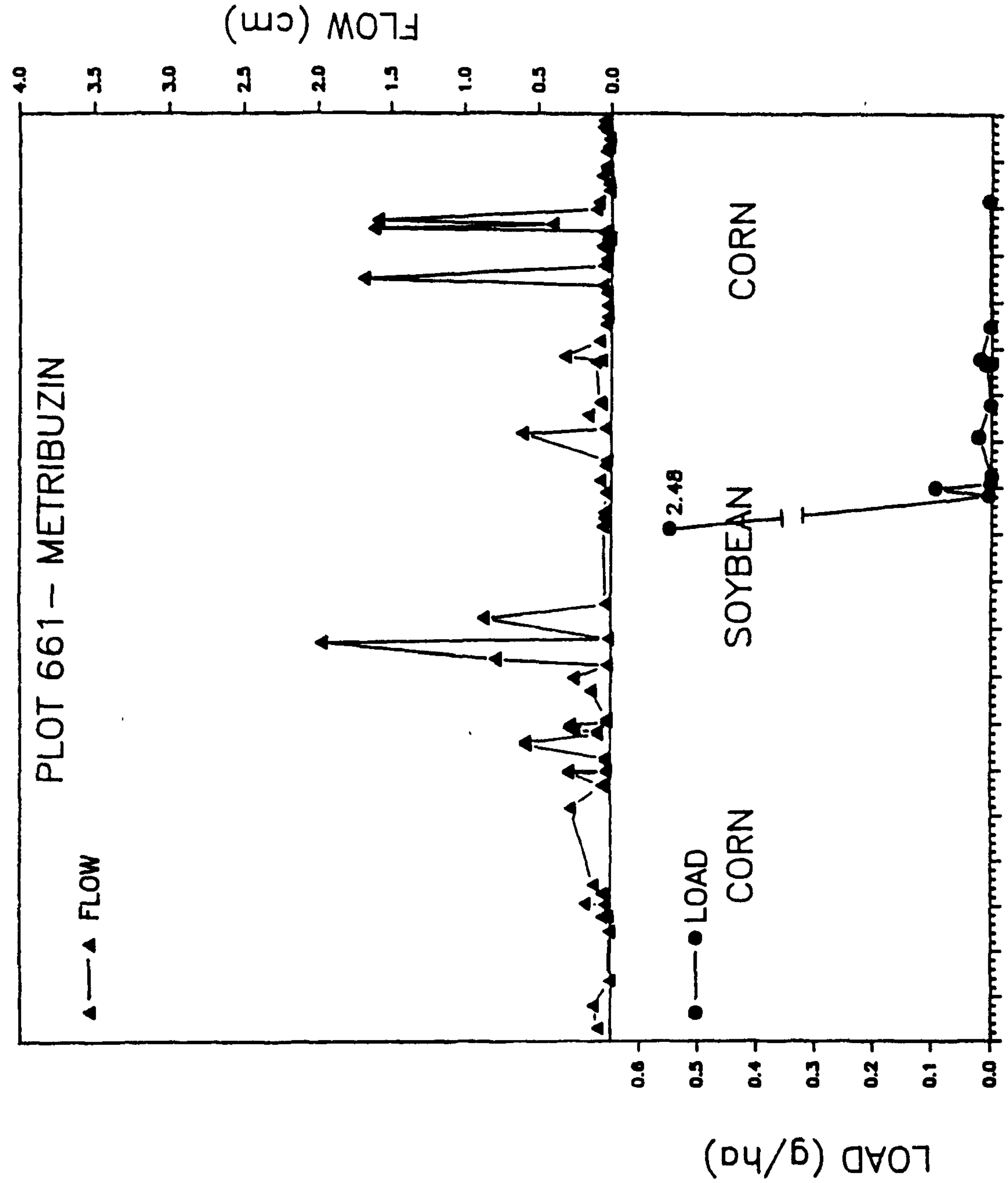
PLOT 661 — METALOCHLOR
FLOW
CONCENTRATION
CORN
SOYBEAN
CORN
1701
292
FLOW (cm)
CONCENTRATION ( µg/L)


PLOT 661 — METRIBUZIN
FLOW
CONCENTRATION
CORN
SOYBEAN
CORN
413
FLOW (cm)
CONCENTRATION ( µg/L)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
10
20
30
40
50
60
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000


PLOT 661—ATRAZINE
FLOW
LOAD
CORN
SOYBEAN
CORN
0.75
FLOW (cm)
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
LOAD (g/ha)
0.0 0.1 0.2 0.3 0.4 0.5 0.6
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000

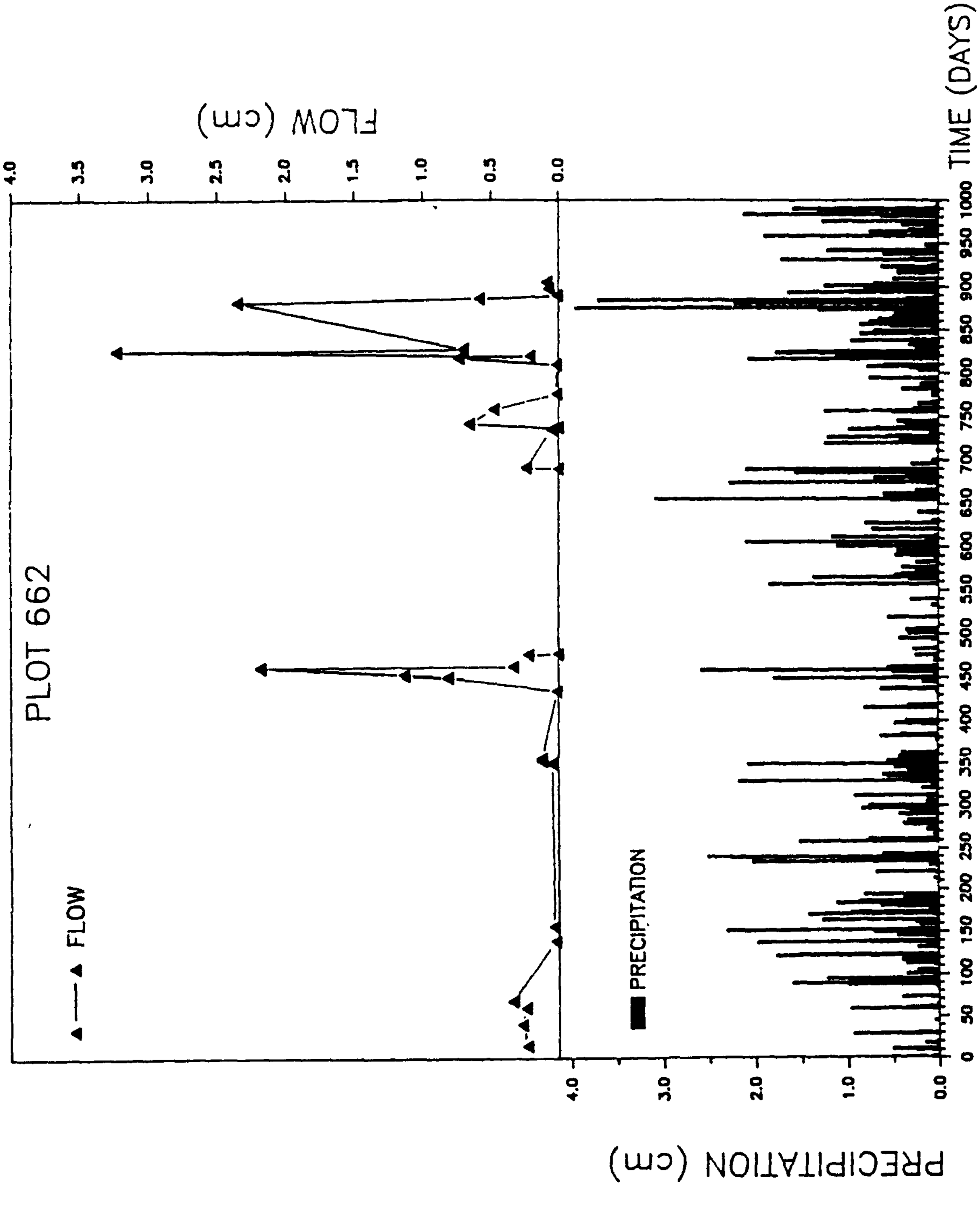

PLOT 661— ALACHLOR
FLOW
LOAD
CORN
SOYBEAN
CORN
FLOW (cm)
LOAD (g/ha)
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000


PLOT 661 — METALOCHLOR
FLOW
LOAD
CORN
SOYBEAN
CORN
10.21
1.64
FLOW (cm)
LOAD (g/ha)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000

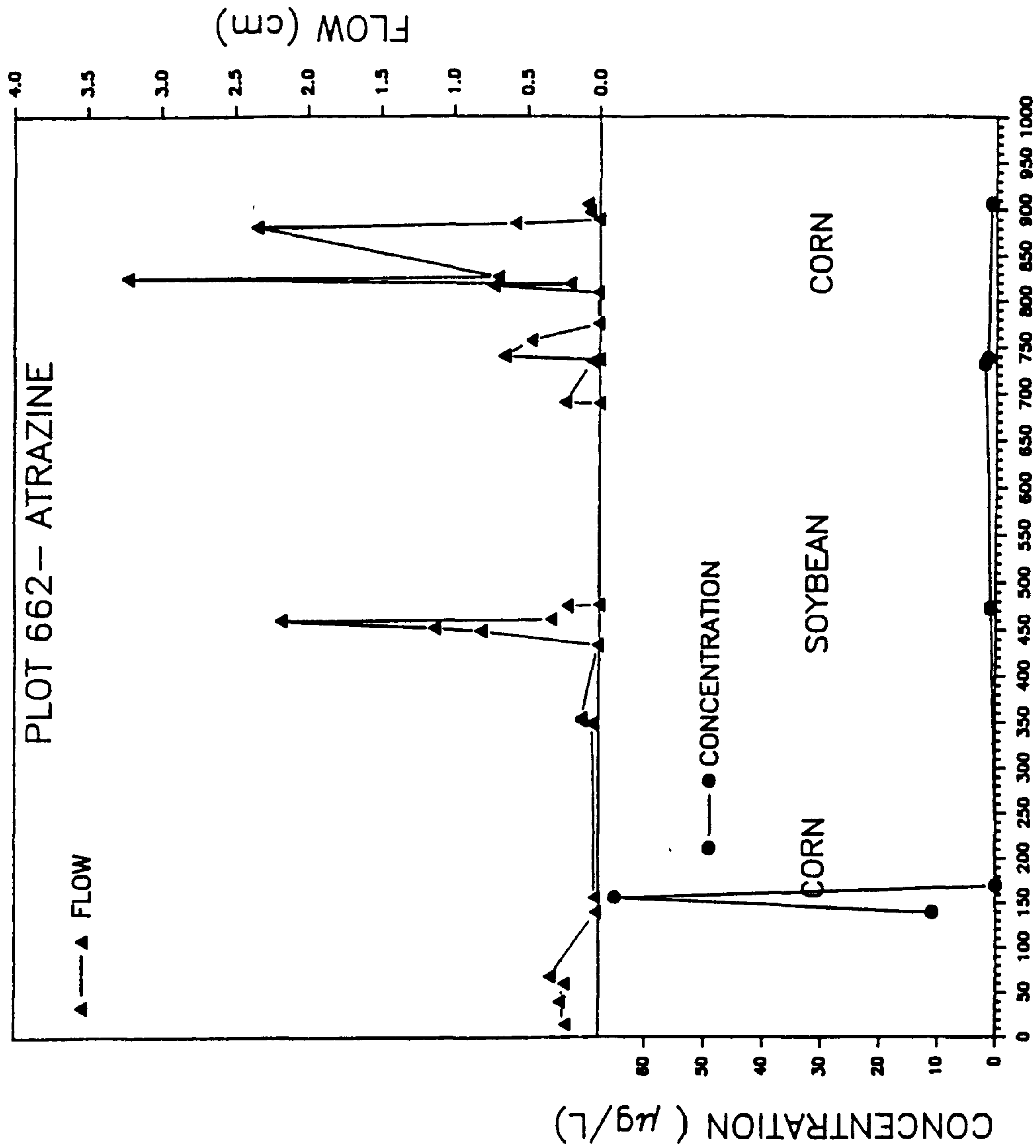

PLOT 661 — METRIBUZIN
FLOW
LOAD
CORN
SOYBEAN
CORN
2.48
FLOW (cm)
LOAD (g/ha)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.1
0.2
0.3
0.4
0.5
0.6
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000

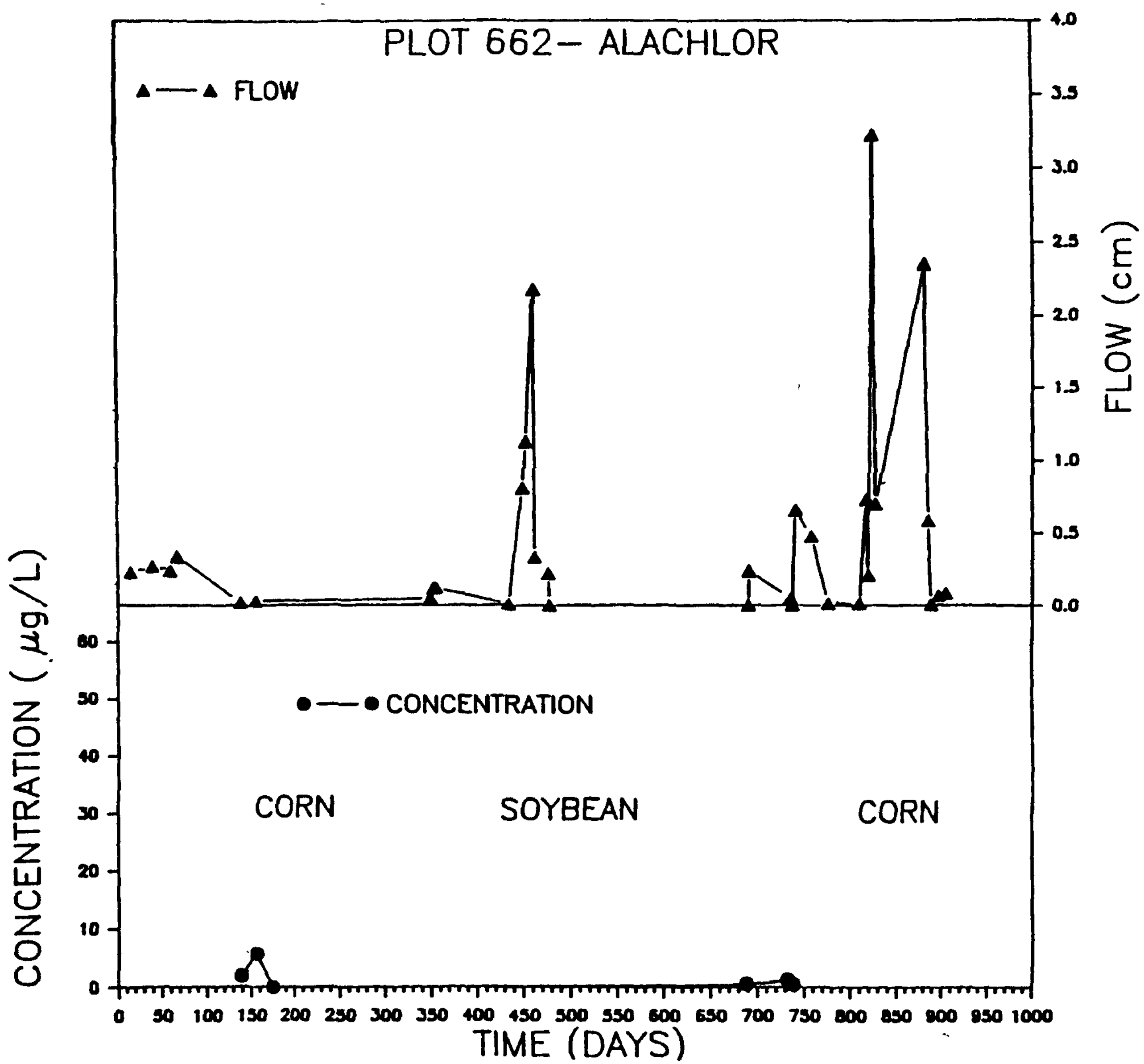
Figures 28-36.

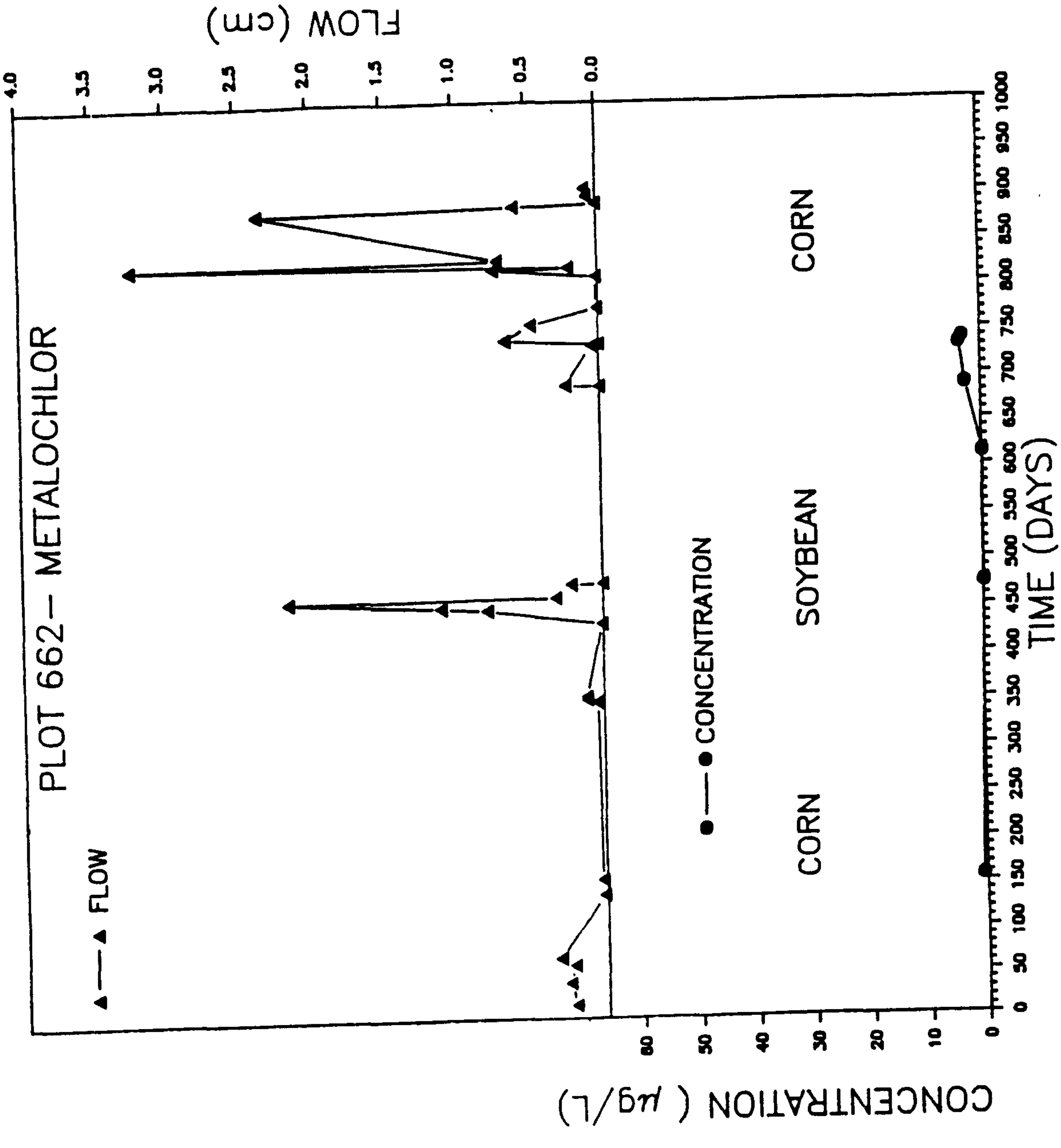
Precipitation, tile drainage, and tile drainage concentrations and loads in individual events for the four monitored herbicides. No-till in soybean-corn-soybean rotation (Plot 662).

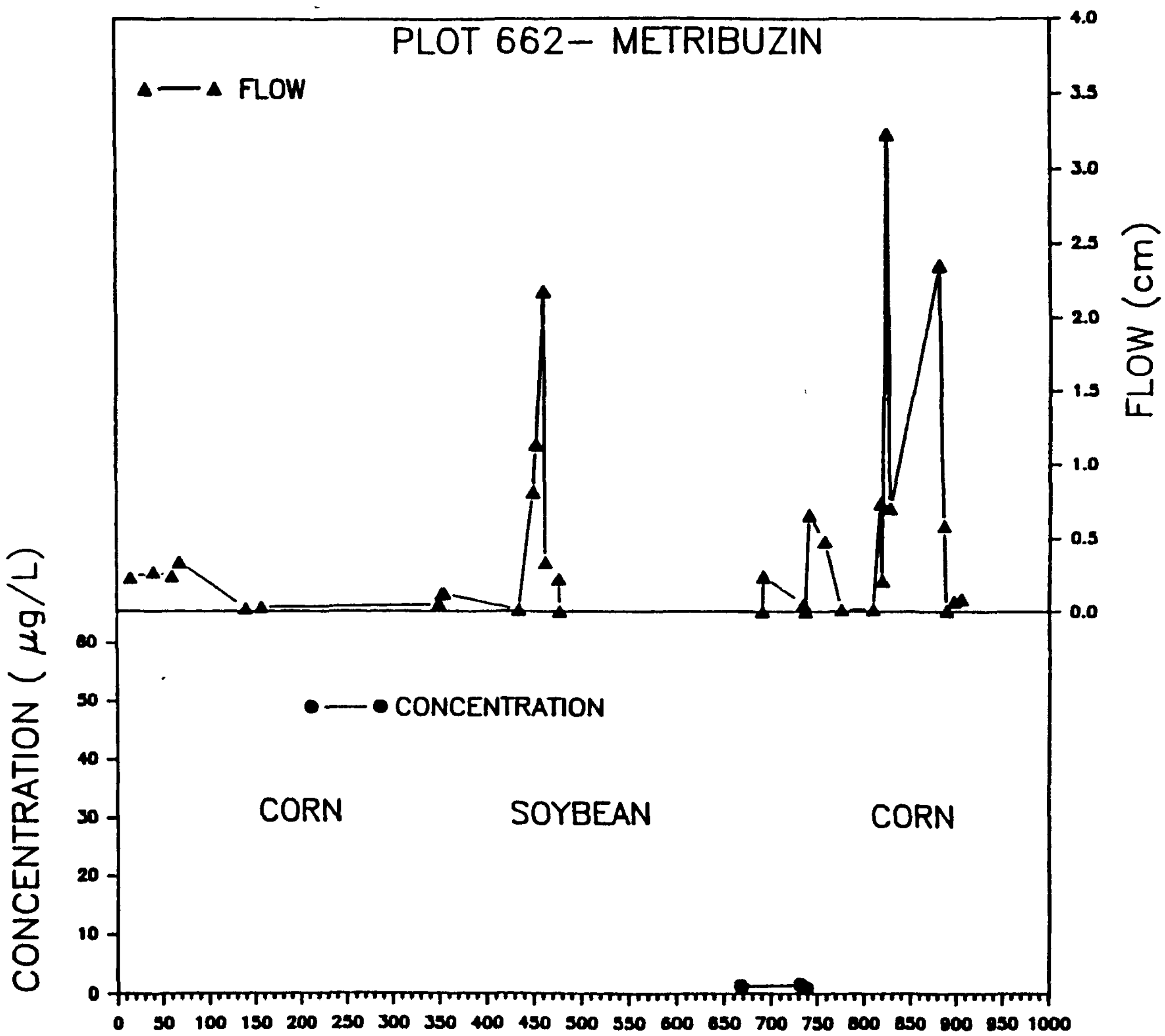


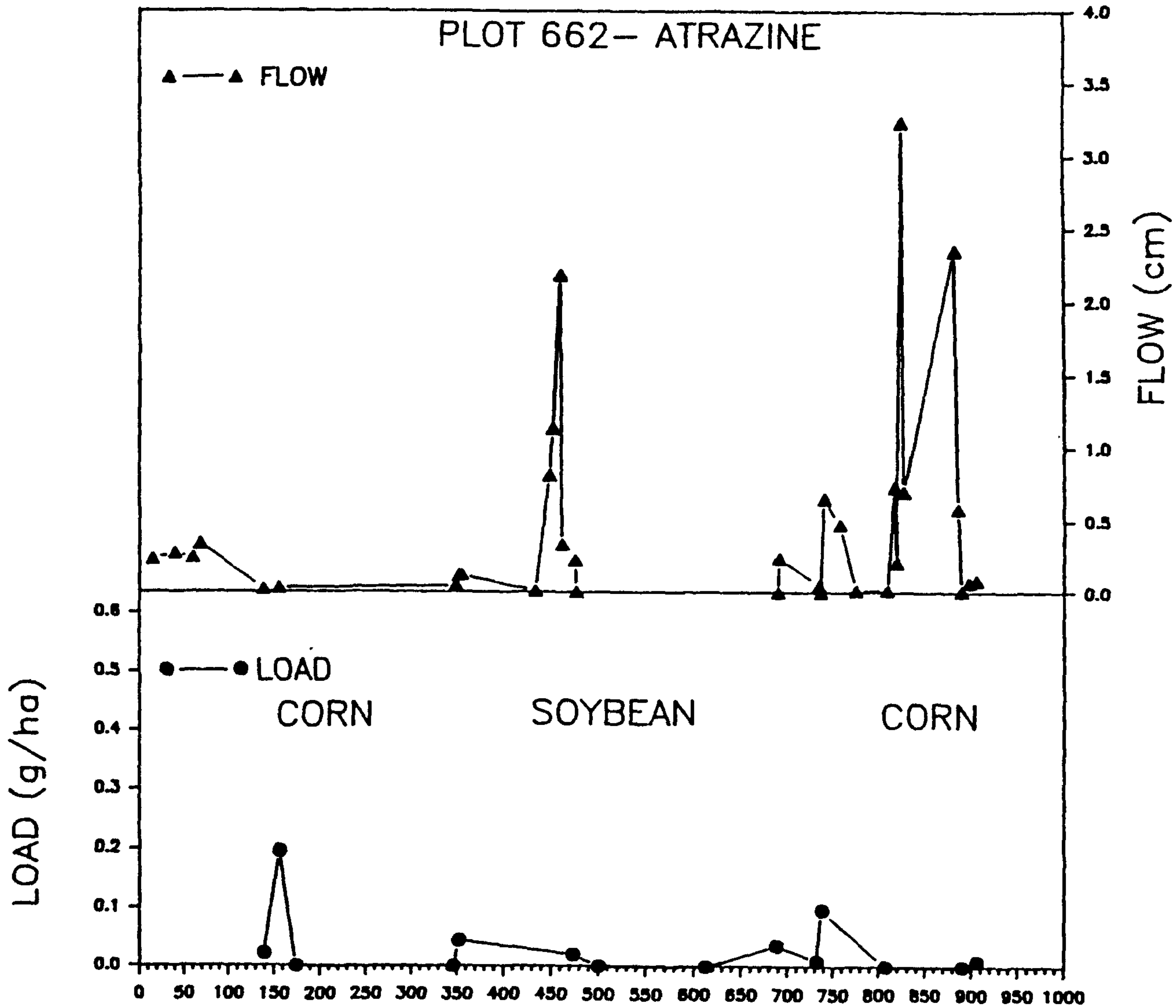
PLOT 662
FLOW
PRECIPITATION
FLOW (cm)
PRECIPITATION (cm)
TIME (DAYS)
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
0.0 1.0 2.0 3.0 4.0
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000

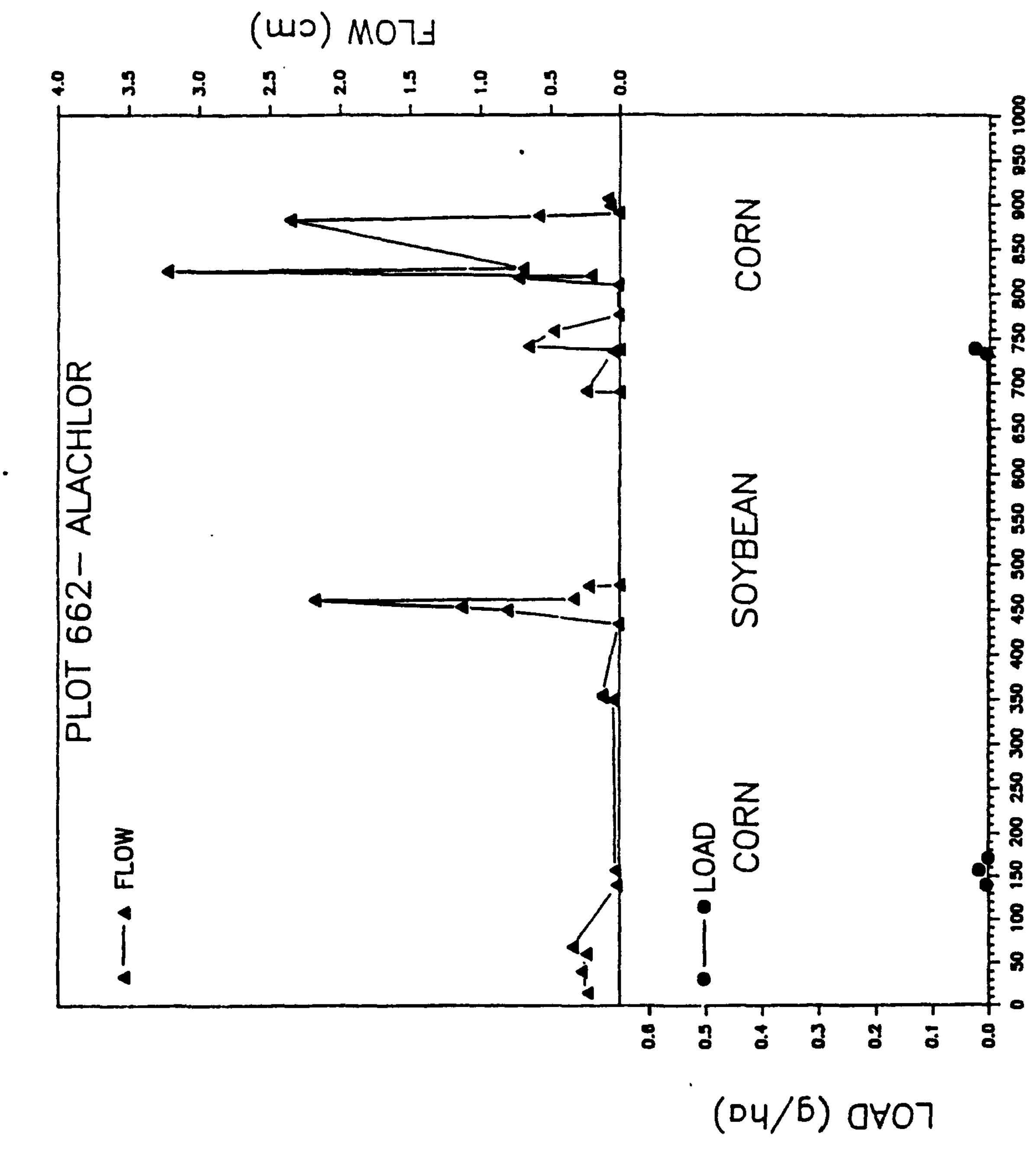

PLOT 662– ATRAZINE
FLOW (cm)
CONCENTRATION ( μg/L)
FLOW
CONCENTRATION
CORN
SOYBEAN
CORN
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000

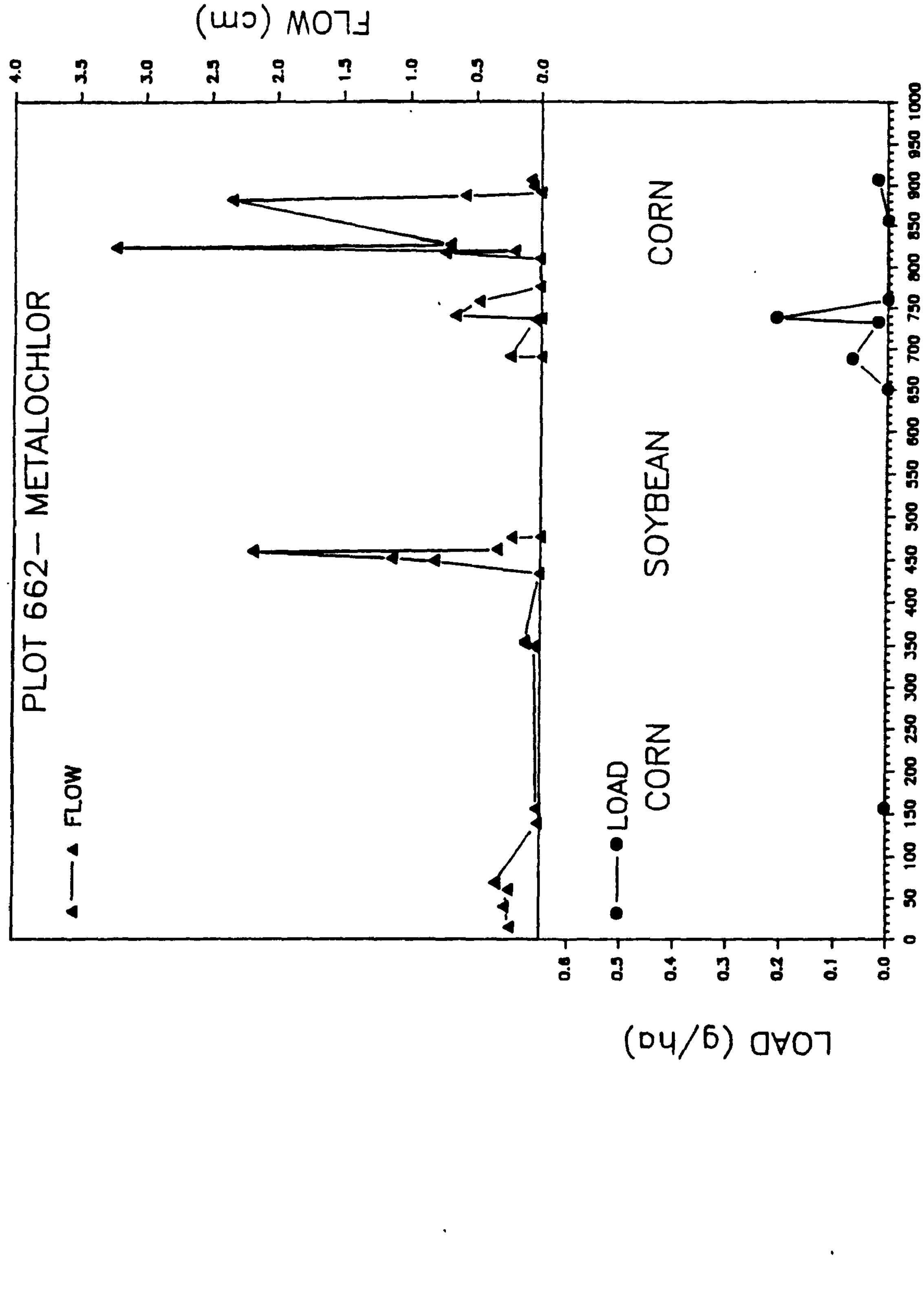

PLOT 662– ALACHLOR
FLOW
CONCENTRATION
CORN
SOYBEAN
CORN
FLOW (cm)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
CONCENTRATION ( μg/L)
60
50
40
30
20
10
0
TIME (DAYS)
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000

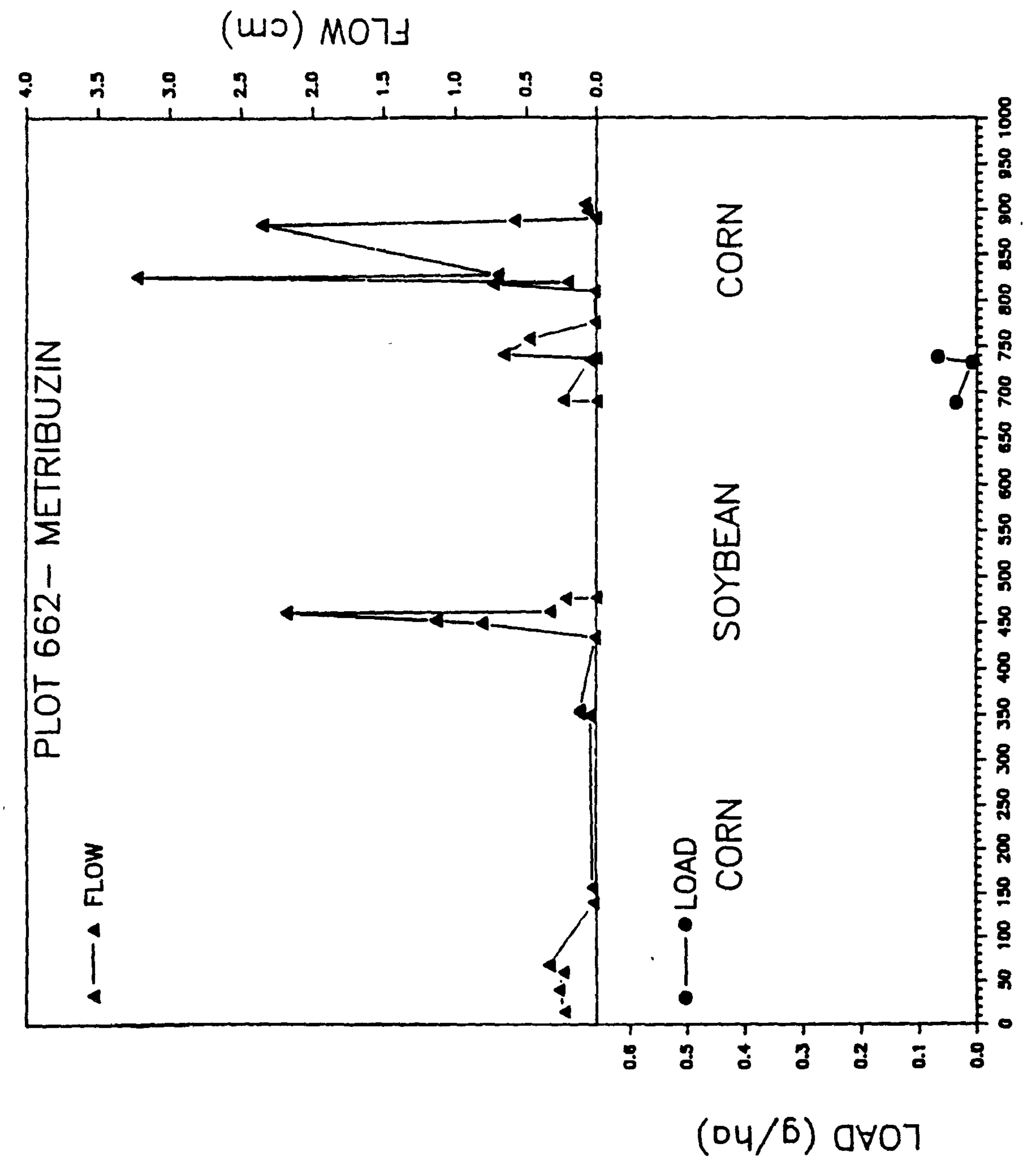

PLOT 662– METALOCHLOR
FLOW
CONCENTRATION
CORN
SOYBEAN
CORN
FLOW (cm)
CONCENTRATION ( µg/L)
TIME (DAYS)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
10
20
30
40
50
60
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000


PLOT 662— METRIBUZIN
FLOW
CONCENTRATION
CORN
SOYBEAN
CORN
CONCENTRATION ( μg/L)
FLOW (cm)
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000
0 10 20 30 40 50 60
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0


PLOT 662– ATRAZINE
FLOW
LOAD
CORN
SOYBEAN
CORN
FLOW (cm)
LOAD (g/ha)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000


PLOT 662— ALACHLOR
FLOW
LOAD
CORN
SOYBEAN
CORN
FLOW (cm)
LOAD (g/ha)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000


PLOT 662— METALOCHLOR
FLOW
LOAD
CORN
SOYBEAN
CORN
FLOW (cm)
LOAD (g/ha)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.1
0.2
0.3
0.4
0.5
0.6
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000


PLOT 662— METRIBUZIN
FLOW (cm)
LOAD (g/ha)
FLOW
LOAD
CORN
SOYBEAN
CORN
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000

concentration and loads for the four herbicides. Data for two plots (one with no-till and the other with fall-plowing) are presented.

Atrazine

Runoff: Atrazine concentrations were generally less than 15 ug/L in runoff with the exception of one event in July, 1988 when concentrations were 695 ug/L on one of the no-till corn plots (Table 7) and 669 and 520 ug/L on the two plowed corn plots (Tables 10 and 11), respectively. This was about 75 days after pesticides were applied. In July, 1989, following pesticide application at the end of June, concentrations were 99 and 262 ug/L for no-till (Tables 8 and 9), and 249 and 290 ug/L for the plowed plots (Tables 12 and 13). Concentrations of between 27 and 37 ug/L were observed on the two plowed plots in corn in May and June 1987 (Tables 12 and 13). No atrazine was detected in runoff in the year after application at concentrations greater than 12 ug/L. Atrazine loads were not primarily associated with the few high concentration events in July, 1988, but with the higher flows (Tables 7, 10 and 13).

Tile Drainage: The only significant observations of atrazine in tile drainage were in May and June, 1987 on the no-till and plowed corn plots (Tables 16, 17, 20 and 21). Concentrations ranged from 11 to 65 ug/L on the no-till plots and from 9 to 40 ug/L on the plowed plots. These low levels (and those of the other compounds, as discussed below) were primarily due to the low rainfall that occurred after application of the materials in 1987 and 1988. Only a few events from 1989 have been analyzed. The U.S. EPA health advisory for atrazine is 3 ug/L (EPA, 1989). This number was exceeded by only 9 of 53 monthly average concentrations for the plots monitored in 1987-1989.

Alachlor

Runoff: The highest alachlor concentrations correlated exactly with the high atrazine concentrations (Tables 7-13). Alachlor values were consistently lower than those of atrazine. Since alachlor was applied at rates equal to or greater than atrazine (Table 1), the lower concentration in runoff may be due to the more rapid degradation of alachlor than atrazine. Alachlor loads paralelled those of atrazine but were somewhat smaller.

Tile Drainage: Concentrations of alachlor in tile drainage were very low, below or near the limit of detection in most cases. Alachlor appears to be much less leachable than atrazine. This is probably due to the shorter residence time of alachlor rather than any difference in partition coefficients which is small. The EPA health advisory for alachlor is 0.4 ug/L (EPA, 1989), a number exceeded in only 11 of 53 monthly means of the plots sampled in 1987-1989.

Metolachlor

Runoff: The highest metolachlor concentrations were recorded in July, 1989 on the no-till and fall plow soybean plots Tables 6, 7, 10, and 11). Concentrations ranged from 415 to 2500 ug/L. These levels correspond to pesticide application in late June. Highest loads were also associated with these events. The next highest levels occurred in July, 1988 (Tables 8, 9, 12 and 13). Concentrations ranged from 597 to 1748 ug/L. The next highest concentrations occurred in June, 1987 on the no-till and fall plow soybean plots where concentrations ranged from 17 to 74 ug/L (Tables 6, 7, 10 and 11).

Tile Drainage: Metolachlor concentrations never exceeded 10 ug/L in any of the samples in which it was detected. Highest levels were associated with the May and June, 1987 events on the no-till and fall plow soybean plots. The EPA health advisory for metolachlor is 100 ug/L (EPA, 1989), ten times higher than the higest value recorded in this study.

Metribuzin

Runoff: As with metolachlor, the highest metribuzin concentrations occurred in July, 1989 on the no-till and plowed plots (Tables 6, 7, 10 and 11). High concentrations were also found in July, 1988 on the no-till and fall plow soybean plots (Tables 8, 9 and 12), with lower levels in June, 1987 on the soybean plots (Tables 6, 10, and 11). Metribuzin concentrations were always several times lower than the corresponding metolachlor concentrations. This is attributable, in part to the fact that metribuzin is applied at a fourth the rate of metalochlor (Table 1).

Tile Drainage: Metribuzin was never detected in tile drainage at concentrations greater than 5.5 ug/L. The highest values corresponded to the high values for metolachlor on the no-till and fall-plow soybean plots in May and June, 1987 (Tables 6, 7, 10 and 11). The EPA health advisory for metribuzin is 200 ug/L (EPA, 1989), a value 40 times higher than the highest value seen in tile drainage.

Overall Summary of Pesticide Losses

Table 22 summarizes losses of the four herbicides in runoff and tile drainage by crop and tillage treatment for the three years studied. Average annual runoff concentrations were highest for atrazine and metolachlor, while loads were greatest for metolachlor. These occurred in July, 1988 and 1989 and correspond to applications of these compounds in May, 1988 and late June, 1989. The very dry conditions in

Table 22. Summary of pesticide losses in runoff and tile drainage in 1987-1989.

| Tillage | Crop | Atrazine FYM (ug/L) | Atrazine Load (g/ha) | Alachlor FYM (ug/L) | Alachlor Load (g/ha) | Metolachlor FYM (ug/L) | Metolachlor Load (g/ha) | Metribuzin FYM (ug/L) | Metribuzin Load (g/ha) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1987 Runoff | | | | |
| No-till | corn | 3.75 | 0.413 | 2.35 | 0.327 | 0.55 | 0.053 | 0.00 | 0.000 |
| No-till | soybeans | 3.00 | 0.184 | 0.00 | 0.005 | 19.35 | 3.309 | 13.45 | 1.287 |
| Plow | corn | 18.90 | 1.325 | 11.60 | 0.801 | 0.75 | 0.067 | 0.05 | 0.004 |
| Plow | soybeans | 1.20 | 0.093 | 0.600 | 0.058 | 23.05 | 1.539 | 3.35 | 0.311 |
| | | | | | 1987 Tile | | | | |
| No-till | corn | 24.70 | 1.101 | 2.00 | 0.091 | 0.05 | 0.001 | 0.00 | 0.000 |
| No-till | soybeans | 0.800 | 0.084 | 0.00 | 0.000 | 4.70 | 0.515 | 1.35 | 0.169 |
| Plow | corn | 22.20 | 5.272 | 1.90 | 0.080 | 0.00 | 0.000 | 0.00 | 0.000 |
| Plow | soybeans | 0.90 | 0.032 | 0.00 | 0.000 | 6.55 | 0.216 | 2.60 | 0.086 |
| | | | | | 1988 Runoff | | | | |
| No-till | corn | 29.00 | 7.488 | 11.65 | 2.730 | 0.85 | 0.079 | 0.15 | 0.009 |
| No-till | soybeans | 0.75 | 0.077 | 0.55 | 0.037 | 137.45 | 13.589 | 21.90 | 2.257 |
| Plow | corn | 28.25 | 4.185 | 20.10 | 2.910 | 0.15 | 0.026 | 0.05 | 0.005 |
| Plow | soybeans | 0.30 | 0.119 | 0.45 | 0.025 | 57.10 | 4.047 | 7.55 | 0.493 |
| | | | | | 1988 Tile | | | | |
| No-till | corn | 0.10 | 0.015 | 0.00 | 0.000 | 0.15 | 0.018 | 0.00 | 0.000 |
| No-till | soybeans | 1.25 | 0.033 | 0.15 | 0.007 | 0.70 | 0.034 | 0.35 | 0.016 |
| Plow | corn | --- | --- | --- | --- | --- | --- | --- | --- |
| Plow | soybeans | 0.90 | 0.052 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| | | | | 1989 (Through July) Runoff | | | | | |
| No-till | corn | 34.80 | 2.386 | 17.70 | 1.220 | 7.65 | 0.569 | 0.60 | 0.067 |
| No-till | soybeans | 2.80 | 0.510 | 1.90 | 0.406 | 7.46 | 17.424 | 42.15 | 6.697 |
| Plow | corn | 58.60 | 3.279 | 31.15 | 1.743 | 3.25 | 0.184 | 0.55 | 0.030 |
| Plow | soybeans | 1.80 | 0.094 | 1.05 | 0.056 | 73.05 | 3.775 | 17.20 | 0.881 |
| | | | | 1989 (Through July) Tile | | | | | |
| No-till | corn | 1.30 | 0.093 | 0.40 | 0.031 | 1.90 | 0.143 | 0.75 | 0.055 |
| No-till | soybeans | 0.95 | 0.621 | 0.00 | 0.000 | 0.15 | 0.073 | 0.00 | 0.048 |
| Plow | corn | 0.20 | 0.180 | 0.05 | 0.043 | 0.00 | 0.004 | 0.00 | 0.004 |
| Plow | soybeans | 1.40 | 0.526 | 0.05 | 0.022 | 0.20 | 0.067 | 0.00 | 0.001 |

the summer of 1988 delayed activation of the materials applied in May and resulted in runoff levels in July that were similar to those in July, 1989 which occurred much closer to time of pesticide application.

Annual tile losses in the three years studied were very low with the exception of atrazine in 1987. Carryover losses in 1989, when precipitation and tile flow were more normal, have been low. This suggests that the greatest threat to water contamination is runoff in the first two months after pesticide application.

## Multiresidue Soil Pesticide Extraction

Tables 23 to 26 show pesticide recovery in each solvent and solvent mixture with each extraction method. Methylene chloride with wrist-action shaker was the most effective combination for extracting atrazine, alachlor, metolachlor and metribuzin. However, since methanol was the only solvent that best extracted all eight pesticides we examined, and the iso-octane-methanol mixture performed better than the other two solvent mixtures, further evaluations of methylene chloride, methanol and iso-octane-methanol are scheduled. Core samples taken from the plots after fall harvest will be extracted and analyzed by these extractants.

## Analysis of Pesticides in Precipitation

Table 27 shows the recovery of atrazine, alachlor, metolachlor and metribuzin from the SPE column by a variety of solvents to be in the order: 2-propanol > ethyl acetate > methanol > hexane. No pesticide was extracted by hexane (data not shown) but the added pesticide was later recovered in the column wash solution. From the results of the single solvents, 1:1 2-propanol-ethyl acetate mixture was tested to increase recovery of all the compounds, and that of metribuzin in particular. Results indicate that 2-propanol and ethyl acetate singly give better recovery than a 1:1 mixture of the two solvents.

We determined that complete recovery was obtained with 3 mL of each solvent used. However, we adopted 4 mL for routine use to provide a safety factor. The experiment also indicated that a solid-phase extraction column can be safely used for eight times without the column losing its integrity. However, the column must be properly washed between use.

## Quality Assurance-Quality Control (QA/QC)

### Recovery of Spiked Samples

Tables 28 and 29 give concentrations of spiked and unspiked (10 mg/L) water samples for the four applied herbicides for

Table 23. Pesticide recovery from single solvent extractions: Wrist-action shaker.

| Compound | Class | Methylene Chloride | Iso-octane | Methanol | Acetone | Hexane |
|---|---|---|---|---|---|---|
| | | | | % | | |
| Trifluralin | Dinitroaniline | 11.6 | 3.13 | 54.1 | 30.9 | 11.4 |
| Carbofuran | Carbamate | 91.8 | 56.4 | 63.7 | 91.1 | 76.2 |
| Atrazine | s-Triazine | 81.8 | 58.5 | 67.9 | 61.4 | 55.6 |
| Fonofos | Urea | 21.1 | 13.9 | 59.8 | 34.3 | 30.9 |
| Metribuzin | as-Triazinone | 64.6 | 49 | 54.4 | 51.8 | 49.4 |
| Alachlor | Anilide | 73.9 | 59.4 | 68.5 | 59.7 | 53.7 |
| Linuron | Urea | 18.7 | 7.25 | 62 | 59.7 | 17.4 |
| Metolachlor | Anilide | 79 | 62.3 | 70.1 | 75.8 | 66.3 |

Table 24. Pesticide recovery from single solvent extractions: Utrasonic bath.

| Compound | Class | Methylene Chloride | Iso-octane | Methanol | Acetone | Hexane |
|---|---|---|---|---|---|---|
| | | % | | | | |
| Trifluralin | Dinitroaniline | 2.37 | 3.08 | 6.03 | 14.9 | 1.44 |
| Carbofuran | Carbamate | 66.3 | 35.5 | 57.5 | 99.3 | 30.6 |
| Atrazine | s-Triazine | 88.5 | 32.5 | 34.7 | 44.4 | 20.1 |
| Fonofos | Urea | 7.29 | 7.25 | 5.6 | 18 | 15.4 |
| Metribuzin | as-Triazinone | 87 | 30.9 | 30.2 | 38.4 | 22.2 |
| Alachlor | Anilide | 53.6 | 24.9 | 26.9 | 42.8 | 13.2 |
| Linuron | Urea | 12.7 | 5.67 | 38.5 | 7.02 | 3.96 |
| Metolachlor | Anilide | 61.2 | 29.1 | 36.9 | 54 | 14.9 |

Table 25. Pesticide recovery from single solvent extractions: Rotary-action shaker.

| Compound | Class | Methylene Chloride | Iso-octane | Methanol | Acetone | Hexane |
|---|---|---|---|---|---|---|
| | | % | | | | |
| Trifluralin | Dinitroaniline | 1.68 | 1.05 | 5.65 | 5.8 | 2.15 |
| Carbofuran | Carbamate | 50.6 | 16.4 | 65.2 | 11.3 | 13.2 |
| Atrazine | s-Triazine | 30.7 | 7.3 | 45.2 | 26.3 | 11.4 |
| Fonofos | Urea | 5.25 | 3.2 | 7.65 | 8.6 | 6.4 |
| Metribuzin | as-Triazinone | 36.7 | 14.8 | 36 | 19.8 | 17.9 |
| Alachlor | Anilide | 12.1 | 8.5 | 30.1 | 20.5 | 11.3 |
| Linuron | Urea | 15.4 | 4.6 | 38.6 | 24.5 | 9.8 |
| Metolachlor | Anilide | 18.3 | 13 | 45.1 | 27.6 | 13.2 |

Table 26. Pesticide recovery from mixed solvent systems.

| Compound | Class | Methylene chloride-methanol | | | Iso-octane-methylene chloride | | | Iso-octane-methanol | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | WAS | RAS | USB# | WAS | RAS | USB | WAS | RAS | USB |
| | | -------------------- | | | % | | | -------------------- | | |
| Trifluralin | Dinitroaniline | 26.0 | 27.8 | 23.6 | 2.38 | 0.85 | 1.46 | 0.88 | 0.94 | 16.9 |
| Carbofuran | Carbamate | 87.3 | 47.1 | 53.3 | 58.3 | 64.3 | 49.9 | ---- * | ----- * | 103 |
| Atrazine | s-Triazine | 52.6 | 42.9 | 47.3 | 40.0 | 12.7 | 16.3 | 64.4 | 72.8 | 43.8 |
| Fonofos | Urea | 32.2 | 27.1 | 23.3 | 11.6 | 4.02 | 5.42 | 4.89 | 3.17 | 23.8 |
| Metribuzin | as-Triazinone | 44.6 | 40.4 | 42.3 | 41.9 | 19.2 | 22.2 | 73.7 | 73.6 | 43.0 |
| Alachlor | Anilide | 49.0 | 44.1 | 48.3 | 21.7 | 3.46 | 4.15 | 45.0 | 32.7 | 76.6 |
| Linuron | Urea | 14.0 | 9.27 | 26.1 | 14.2 | 4.42 | 6.00 | 38.0 | 40.1 | 24.6 |
| Metolachlor | Anilide | 57.9 | 46.5 | 55.2 | 33.1 | 4.85 | 12.3 | 60.0 | 90.3 | 45.7 |

# WAS ------ Wrist -action shaker
RAS ------ Rotary-action shaker
USB ------ Ultrasonic bath
* not determined

Table 27. Pesticide recovery from solid phase extraction column used to trap pesticides in precipitation.

| Compound | Concentration in each 1 mL eluate | | | | | Total | Recovery | Conc. in column wash |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | | |
| | mg/L | | | | | | % | mg/L |
| | | | Ethyl acetate | | | | | |
| Atrazine | 0.434 | 0.229 | 0.073 | 0.000 | 0.000 | 0.736 | 73.6 | 0.000 |
| Metribuzin | 0.192 | 0.189 | 0.044 | 0.000 | 0.000 | 0.425 | 42.5 | 0.000 |
| Alachlor | 0.449 | 0.180 | 0.085 | 0.000 | 0.000 | 0.714 | 71.4 | 0.000 |
| Metolachlor | 0.462 | 0.189 | 0.081 | 0.000 | 0.000 | 0.732 | 73.2 | 0.000 |
| | | | Methanol | | | | | |
| Atrazine | 0.382 | 0.298 | 0.022 | 0.000 | 0.000 | 0.702 | 70.2 | 0.014 |
| Metribuzin | 0.151 | 0.143 | 0.000 | 0.000 | 0.000 | 0.294 | 29.4 | 0.000 |
| Alachlor | 0.371 | 0.342 | 0.000 | 0.000 | 0.000 | 0.713 | 71.3 | 0.000 |
| Metolachlor | 0.346 | 0.341 | 0.000 | 0.000 | 0.000 | 0.687 | 68.7 | 0.000 |
| | | | 2-Propanol | | | | | |
| Atrazine | 0.642 | 0.218 | 0.025 | 0.000 | 0.000 | 0.885 | 88.5 | 0.015 |
| Metribuzin | 0.419 | 0.098 | 0.000 | 0.000 | 0.000 | 0.517 | 51.7 | 0.000 |
| Alachlor | 0.584 | 0.292 | 0.000 | 0.000 | 0.000 | 0.876 | 87.6 | 0.000 |
| Metolachlor | 0.550 | 0.303 | 0.000 | 0.000 | 0.000 | 0.853 | 85.3 | 0.000 |
| | | | 1:1 2-Propanol - Ethyl Acetate | | | | | |
| Atrazine | 0.549 | 0.082 | 0.015 | 0.000 | 0.000 | 0.646 | 64.6 | 0.000 |
| Metribuzin | 0.194 | 0.037 | 0.000 | 0.000 | 0.000 | 0.231 | 23.1 | 0.000 |
| Alachlor | 0.600 | 0.108 | 0.024 | 0.000 | 0.000 | 0.732 | 73.2 | 0.000 |
| Metolachlor | 0.621 | 0.106 | 0.000 | 0.000 | 0.000 | 0.727 | 72.7 | 0.000 |

TABLE 28. QA/QC summaries for liquid-liquid extraction procedure.

| QA/QC SAMPLE | ATRAZINE | | | METRIBUZIN | | | ALACHLOR | | | METALOCHLOR | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | NS* (mg/L) | S** (mg/L) | REC (%) | NS* (mg/L) | S** (mg/L) | REC (%) | NS* (mg/L) | S** (mg/L) | REC (%) | NS* (mg/L) | S** (mg/L) | REC (%) |
| 04/14/88 | BDL | 8.688 | 86.88 | BDL | 8.449 | 84.49 | BDL | 8.103 | 81.03 | 0.237 | 8.224 | 79.87 |
| 05/10/88 | BDL | 8.640 | 86.40 | BDL | 8.056 | 80.56 | BDL | 5.977 | 59.77 | 0.789 | 4.605 | 38.16 |
| 05/24/88 | 0.238 | 7.051 | 70.51 | BDL | 8.029 | 80.29 | BDL | 8.550 | 85.50 | 0.219 | 6.078 | 58.59 |
| 07/25/88 | 0.742 | 12.254 | 115.12 | 0.168 | 10.742 | 105.75 | BDL | 8.166 | 81.67 | BDL | 6.329 | 63.29 |
| 08/09/88 | 0.758 | 9.822 | 90.64 | BDL | 10.448 | 104.48 | BDL | 11.876 | 118.76 | BDL | 8.985 | 89.85 |
| 08/16/88 | 2.905 | 13.191 | 102.86 | BDL | 12.834 | 128.34 | BDL | 14.847 | 148.47 | BDL | 14.653 | 146.53 |
| 08/16/88 | 0.758 | 12.788 | 120.30 | BDL | 12.905 | 129.05 | BDL | 14.024 | 140.24 | BDL | 14.257 | 142.57 |
| 08/29/88 | 0.648 | 12.868 | 122.20 | BDL | 13.459 | 134.59 | BDL | 13.967 | 139.67 | BDL | 14.744 | 147.44 |
| 09/06/88 | 0.959 | 13.643 | 126.84 | 0.065 | 13.240 | 131.75 | 0.492 | 14.637 | 141.45 | 1.063 | 16.152 | 150.89 |
| 09/06/88 | 0.751 | 11.746 | 109.94 | BDL | 11.594 | 115.94 | BDL | 10.434 | 104.34 | BDL | 9.212 | 92.12 |
| 09/08/88 | 0.751 | 12.038 | 112.87 | BDL | 12.460 | 124.60 | BDL | 12.853 | 128.53 | BDL | 12.414 | 124.14 |
| 09/29/88 | 0.648 | 14.607 | 139.59 | BDL | 14.554 | 145.54 | BDL | 15.526 | 155.26 | BDL | 8.466 | 84.66 |
| 09/30/88 | 0.648 | 12.241 | 115.93 | BDL | 11.572 | 115.72 | BDL | 12.794 | 127.94 | BDL | 12.754 | 127.54 |
| 11/01/88 | 0.648 | 9.902 | 92.54 | BDL | 11.547 | 115.47 | BDL | 11.377 | 113.77 | BDL | 11.135 | 111.35 |
| 12/13/88 | 0.796 | 11.672 | 108.76 | 0.110 | 13.256 | 131.46 | 0.560 | 16.999 | 164.39 | 1.793 | 16.351 | 145.58 |
| 12/15/88 | 0.796 | 12.078 | 119.68 | 0.110 | 12.078 | 129.58 | 0.560 | 13.518 | 129.58 | 1.793 | 17.484 | 156.91 |
| 01/06/89 | 0.722 | 11.057 | 103.35 | 0.050 | 13.420 | 133.70 | 0.334 | 11.966 | 116.32 | 1.405 | 13.401 | 119.96 |
| 01/07/89 | 1.009 | 12.605 | 115.96 | 0.142 | 13.144 | 130.02 | 0.452 | 13.762 | 133.10 | 2.007 | 15.043 | 130.36 |
| MEAN | | | 107.80 | | | 117.85 | | | 120.54 | | | 111.66 |
| SD | | | 16.59 | | | 19.00 | | | 27.67 | | | 35.10 |
| MIN | | | 70.51 | | | 80.29 | | | 59.77 | | | 38.16 |
| MAX | | | 139.59 | | | 145.54 | | | 164.39 | | | 156.91 |

* NS= Non-spiked Composite
** S= Spiked Composite (10 mg/L of Atrazine, Metribuzin, Alachlor, Metalochlor)

TABLE 29. QA/QC summaries for solid phase extraction procedure.

| QA/QC SAMPLE | ATRAZINE | | | METRIBUZIN | | | ALACHLOR | | | METALOCHLOR | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | NS* (mg/L) | S* (mg/L) | % REC. (%) | NS* (mg/L) | S* (mg/L) | % REC. (%) | NS* (mg/L) | S* (mg/L) | % REC. (%) | NS* (mg/L) | S* (mg/L) | % REC. (%) |
| 05/23/89 | 0.337 | 6.594 | 125.14 | BDL | 7.175 | 143.50 | BDL | 7.075 | 141.50 | 0.676 | 7.916 | 144.80 |
| 06/13/89 | 0.452 | 5.595 | 102.86 | BDL | 6.108 | 118.02 | BDL | 5.901 | 118.02 | 0.877 | 6.836 | 119.18 |
| 06/14/89 | 0.378 | 6.065 | 113.74 | 0.086 | 6.254 | 123.36 | 0.112 | 6.564 | 129.04 | 0.262 | 7.329 | 141.34 |
| 06/15/89 | 0.370 | 3.948 | 71.56 | 0.081 | 3.941 | 77.20 | 0.011 | 4.017 | 78.22 | 0.260 | 4.182 | 78.44 |
| 06/16/89 | 0.264 | 4.560 | 85.92 | BDL | 5.326 | 106.52 | BDL | 4.947 | 98.94 | BDL | 5.746 | 114.92 |
| 06/16/89 | 0.257 | 4.931 | 93.48 | BDL | 5.628 | 112.56 | BDL | 5.222 | 104.44 | BDL | 5.376 | 107.52 |
| 06/19/89 | 0.072 | 5.139 | 101.34 | BDL | 5.866 | 117.32 | BDL | 5.496 | 109.92 | BDL | 5.586 | 111.72 |
| 06/20/89 | 0.464 | 9.550 | 181.72 | BDL | 5.999 | 119.98 | BDL | 5.658 | 113.16 | BDL | 5.754 | 115.08 |
| 06/27/89 | 0.166 | 6.615 | 128.98 | BDL | 6.566 | 131.32 | BDL | 7.091 | 141.82 | BDL | 3.589 | 71.78 |
| 06/30/89 | 0.052 | 5.355 | 106.06 | BDL | 6.077 | 121.54 | BDL | 6.411 | 128.22 | 0.805 | 5.957 | 103.04 |
| 07/06/89 | 0.140 | 3.687 | 70.94 | BDL | 4.195 | 83.90 | BDL | 3.979 | 79.58 | BDL | 3.990 | 79.80 |
| 07/06/89 | 0.153 | 4.942 | 95.78 | BDL | 5.701 | 114.02 | BDL | 5.320 | 106.40 | BDL | 5.906 | 118.12 |
| 07/07/89 | 0.171 | 5.919 | 114.96 | BDL | 6.771 | 135.42 | BDL | 7.047 | 140.94 | BDL | 6.207 | 124.14 |
| 07/11/89 | 0.118 | 4.184 | 81.32 | BDL | 4.329 | 86.58 | BDL | 4.448 | 88.96 | BDL | 4.366 | 87.32 |
| 07/12/89 | 0.158 | 6.820 | 133.24 | BDL | 7.645 | 152.90 | BDL | 7.404 | 148.08 | BDL | 7.578 | 151.56 |
| 07/12/89 | 0.146 | 7.187 | 140.82 | BDL | 6.807 | 136.14 | BDL | 7.767 | 155.34 | BDL | 7.413 | 148.26 |
| 07/13/89 | 0.169 | 6.742 | 131.46 | BDL | 7.699 | 153.98 | BDL | 7.461 | 149.22 | BDL | 7.301 | 146.02 |
| 07/14/89 | 0.316 | 6.894 | 131.56 | BDL | 5.903 | 118.06 | BDL | 7.629 | 152.58 | BDL | 8.012 | 160.24 |
| 07/14/89 | 0.307 | 8.068 | 155.22 | BDL | 5.966 | 119.32 | BDL | 8.356 | 167.12 | BDL | 9.367 | 187.34 |
| 07/17/89 | 0.250 | 4.944 | 93.88 | BDL | 5.305 | 106.10 | 0.262 | 6.164 | 118.04 | BDL | 5.790 | 115.80 |
| 07/18/89 | 0.251 | 4.882 | 92.62 | BDL | 5.323 | 106.46 | 0.000 | 5.237 | 104.74 | BDL | 5.043 | 100.86 |
| 08/08/89 | 6.645 | 10.950 | 86.10 | 32.130 | 37.380 | 105.00 | 4.785 | 10.380 | 111.90 | 97.305 | 103.875 | 131.40 |
| 08/08/89 | 8.310 | 13.050 | 94.80 | 39.630 | 45.780 | 123.00 | 6.045 | 10.635 | 91.80 | 122.085 | 126.840 | 95.10 |
| MEAN | | | 110.1521 | | | 117.9217 | | | 120.7817 | | | 119.7295 |
| SD | | | 26.87972 | | | 19.20221 | | | 24.80211 | | | 28.08997 |
| MIN | | | 70.94 | | | 77.2 | | | 78.22 | | | 71.78 |
| MAX | | | 181.72 | | | 153.98 | | | 167.12 | | | 187.34 |

* NS= Non-spiked Composite

** S= Spiked Composite (10 mg/L of Atrazine, Metribuzin, Alachlor, Metalochlor) liquid-liquid and SPE extraction, respectively. Pesticide concentrations are at the GC level and reflect a 500:1 concentration of the sample levels. Figures 37 and 38 present the percent recovery data in graphical form. Recoveries of all four compounds increased over the first six QC samples and then have leveled off. Recoveries have generally been somewhat greater than 100% for all compounds with means of 108 to 120% (Table 28). Part of the increase seen in 1988 QA samples was the shift to a 50 m column from a shorter column. We also shifted from a Perkin-Elmer GC to our present instrument.

The SPE QA data show fewer trends with time (Figure 38). Mean values are in the range of 110 to 120% recovery.

Precision of Field Replicates

Figure 39 gives the percent deviation of field replicate data. With the exception of one atrazine value (one replicate value was below the detection limit, causing the percent deviation to be 100%), field replicate values were within 10% in most cases. More importantly, the precision of the field replicates has improved with time.

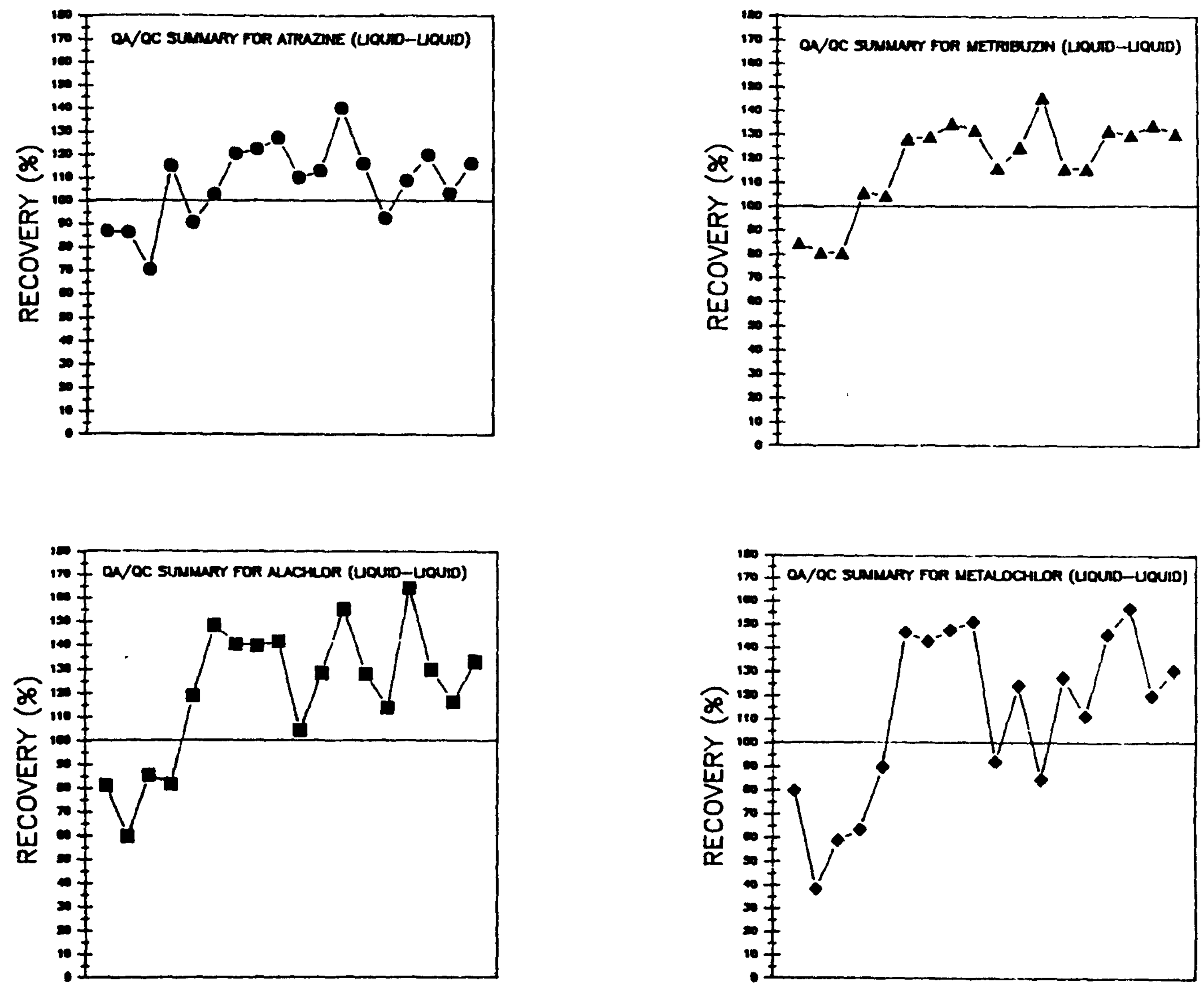



Figure 37. Percent recovery of spiked samples for liquid-liquid extraction.

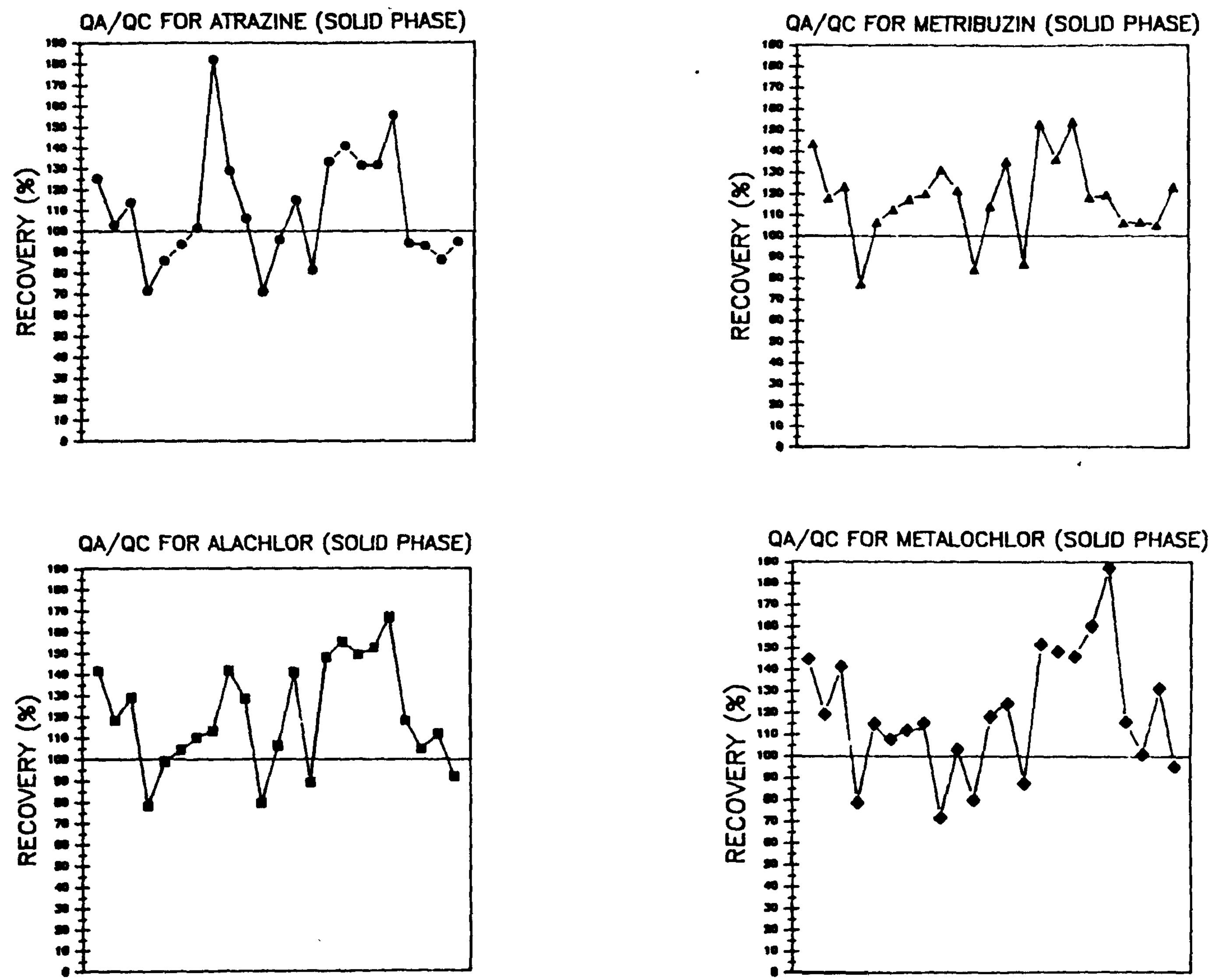



Figure 38. Percent recovery of spiked samples for solid phase extraction.

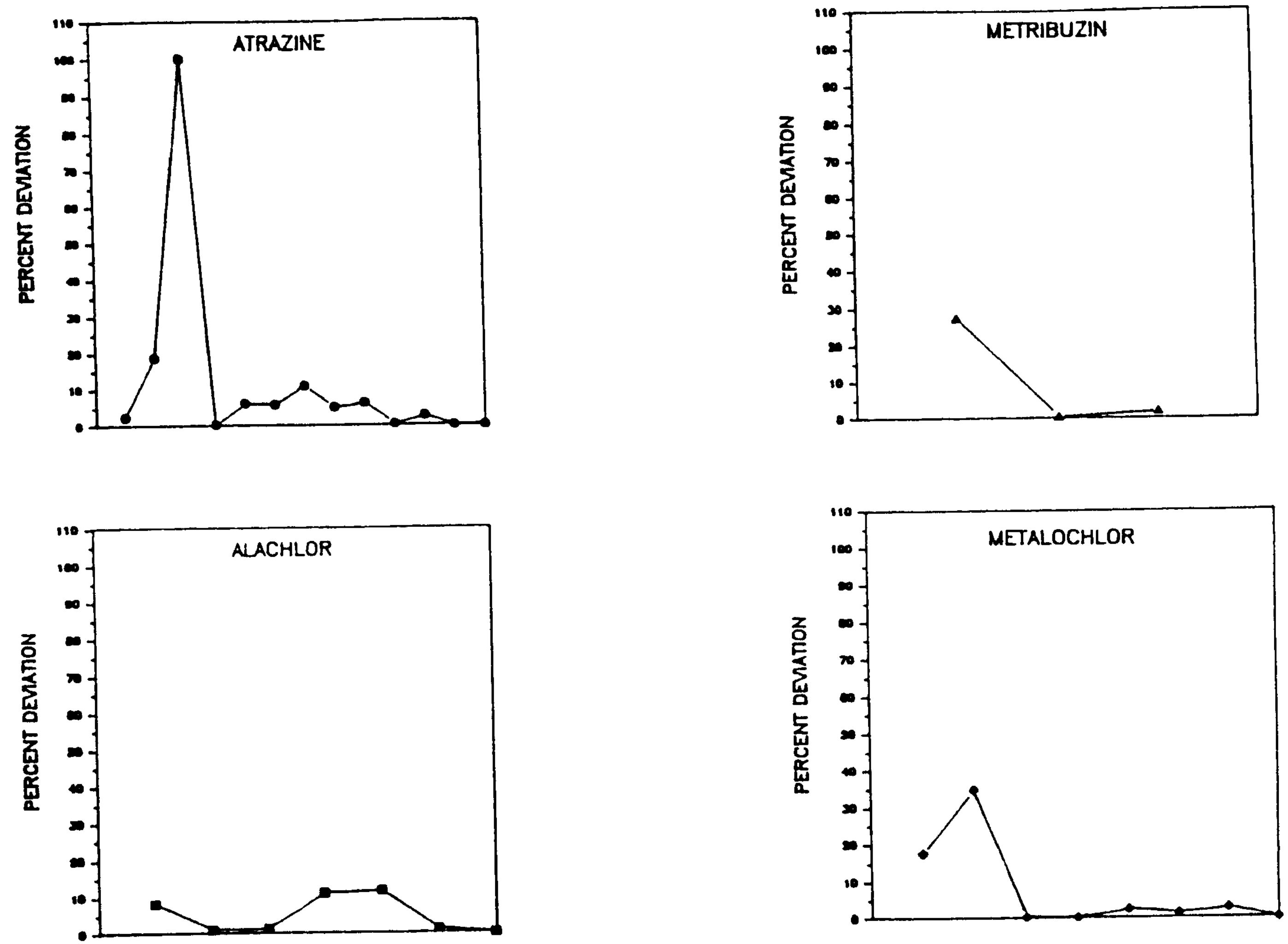



Figure 39. Deviation of field duplicate samples for detected herbicides.

## SUMMARY AND CONCLUSIONS

We have been studying for three years the effects of no-till versus fall moldboard plowing in a corn-soybean rotation on the losses of four commonly used herbicides in runoff and tile drainage. Atrazine and alachlor are the two most widely used corn herbicides in Ohio, while metolachlor and metribuzin are among the most widely used soybean herbicides.

Rainfall in 1987 and 1988 were well below normal and resulted in few runoff and tile drainage events. In contrast, 1989 was one of the wettest years on record. There were no significant differences in runoff and tile drainage in the three years studied, and this is consistent with the long-term trends for this site which shows that the hydrology of this heavy-textured soil is little affected by tillage.

Losses of the four herbicides were greater in runoff than in tile drainage and runoff losses were associated with events occurring just after pesticide application.

Losses of the four herbicides in both runoff and tile drainage were in the order: atrazine > alachlor > metolachlor > metribuzin. This relationship is consistent with the higher rates of alachlor and metolachlor used, and with the longer residence time of atrazine in soil.

In very few instances did concentrations of any of the four compounds exceed the EPA health advisories for these compounds in drinking water.

Because of the very dry years in 1987 and 1988, followed by a very wet year in 1989, we had the opportunity to determine the extent to which pesticides are carried over from one year to another. The data for both runoff and tile drainage in 1989 prior to application of pesticides on June 27 show very little carryover of any of the compounds. This suggests that the greatest threat to surface water from these materials is from runoff associated with storms occurring shortly after pesticide application.

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