

1988 GLYPHOSATE IMPROVED-USE TRIAL

- Status Report -

File Report No. 98

April 6, 1989

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Last summer, FPMI worked cooperatively with the New Brunswick Department of Natural Resources and Energy and the Canadian Forestry Service, Maritimes, to establish a trial designed to develop an improved-use strategy for VISION (glyphosate). The following status report is designed to outline exactly what has taken place in terms of data generation and analysis to date and what work is planned for completion of this project. I am inviting comments on the work thus far as well as on future plans. This write-up will also serve as guidance for Rich Fleming, who will be taking the analysis of this data beyond its current state.

For the above purposes, this report contains a lot of detail and potentially extraneous information. Any final publication will certainly contain only pertinent data and the most appropriate presentations thereof. These results, therefore, are not to be considered final in any way and this report is not for publication.

a) Executive Summary :

A randomized complete block design was used to evaluate potential differences in the biological efficacies produced by two different delivery systems and, for each system, derive dose response curves for glyphosate on raspberry. Analysis of variance of pre-treatment raspberry cover reveals adequate within-block homogeneity on the four blocks chosen for the study.

AU5000 micronairs, mounted on a BELL 206b, were calibrated to deliver a total volume of 37.4 l/ha, with a droplet VMD of 300 μ m and a maximum diameter of 677 μ m. Conventional D10-45/46 nozzles, mounted on a similar aircraft, were calibrated to deliver the same volume, with a droplet VMD of 425 μ m and a maximum diameter of 1085 μ m. Chemical deposit from these two delivery systems appears to be comparable under relatively calm wind conditions (0-2 kph), but notably superior for the D10 under increased wind speeds (> 3 kph). Under conditions of increasing swath displacement, AU5000 deposit (produced in a finer drop spectrum) may have been compromised to a greater extent than D10 deposit on the experimental plot sizes used (2 ha). A recommendation has been made, to the New Brunswick Department of Natural Resources, that several of this season's operational blocks be treated with AU5000s (as calibrated in this study) in order to provide additional support to the final conclusions produced in this study.

Current expenditures are slightly lower than budget figures at this point in the study. Field data collection will continue this July with the measurement of post-treatment raspberry cover and crop tolerance. Additional data will be collected in terms of plot hardwood densities. This data will be correlated with deposit, with the intention of providing additional explanation for deposit variability.

b) Study Objectives :

Before going on to the details, I would like to briefly recall the objectives of the study.

The problem that the trial addresses is the fact that forestry herbicide application technology has generally remained unchanged during the last decade, while application technology in forest insect-control operations has progressed considerably. Concerns have been expressed by the forestry community that the delivery systems being used for herbicide application, largely adopted from agricultural operations, may not provide optimum biological efficacy at minimum cost.

At the time of conception, there were several approaches that could have been taken toward filling this herbicide application technology gap, including optimization of such factors as active ingredient rate, carrier volume, droplet-size spectrum, and application timing. It was obvious that all of these factors could not be considered in a single experiment, so it was decided that the first cut should deal with the factors that have the greatest potential for increasing efficiency: droplet size spectrum and active ingredient rate.

Recent lab research suggests that glyphosate efficacy may be improved through the use of small (200 to 350 μ m) droplets (Bode and Butler, 1982; Prasad and Cadogan, 1987; Prasad and Cadogan, 1988). The question being asked by the forestry community is 'will the Micronair, capable of producing a relatively small, uniform-sized droplet, provide greater biological efficacy than the conventionally used TeeJet nozzle system?'. Further, there appears to be a large range of operational glyphosate application rates for similar targets within a region (i.e., 1.0 to 1.6 kg ai/ha on raspberry and grass in New Brunswick). The obvious question being asked is 'what is the optimum rate for acceptable weed control?'. In light of these questions, the objectives of this trial are defined as follows:

- 1) to compare the biological efficacy produced by the currently-used operational delivery system (D10-45/46 nozzles) to that produced by the AU5000 micronair system (both systems mounted on similar aircraft and calibrated to deliver comparable active rates in identical application volumes), and
- 2) to derive dose-response curves, for each delivery system, that will allow definition of an optimum active ingredient rate for the achievement of a specified level of weed control.

It is hoped that, through the fulfillment of these two objectives, the groundwork will be laid to conduct further experiments aimed at investigation of other improved-use factors like carrier volume, spray timing, adjuvants, and various interactions thereof. In the interim, forest managers should be provided with some insight into how well their existing delivery system is performing and what rate of active ingredient they should be using to control their major weed competition.

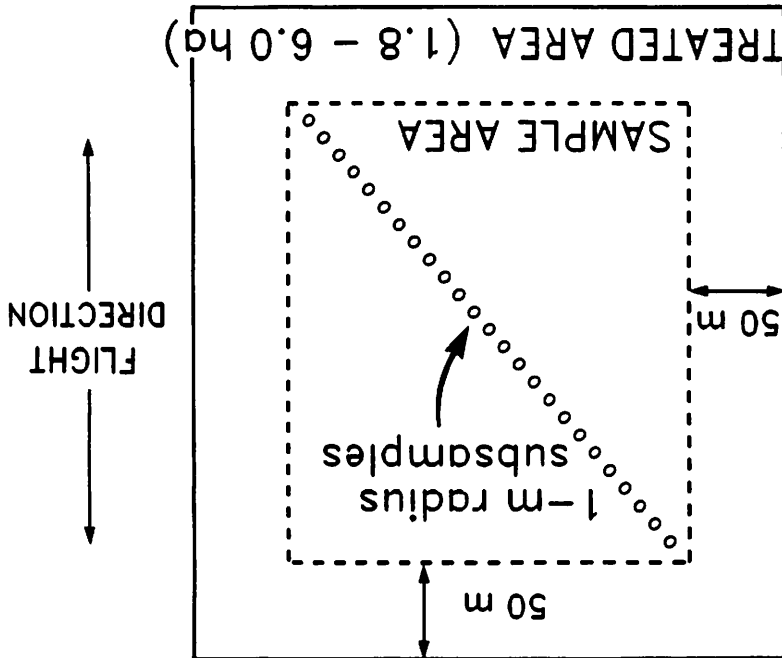
c) Site Selection and Plot Establishment :

In order to fulfill the above objectives, a randomized complete block design with four replicates was chosen for the experiment. Raspberry, the major weed competitor in New Brunswick, was chosen for the measure of efficacy in the study (specifically, the relative change in pre- and post-treatment cover of this species). Black spruce, being the main crop species, was chosen for the measure of crop tolerance (specifically, the relative change in pre- and post-treatment health of crop trees). A total of 9 plots were required in each block in order to accommodate the following treatments :

- | | | | | | |
|---|---|-------------------------|----|---|---|
| 1) AU5000 micronair @ 0.25 kg ai/ha (M0.25) | " | @ 0.50 kg ai/ha (M0.50) | 2) | " | " |
| " | " | @ 0.75 kg ai/ha (M0.75) | 3) | " | " |
| " | " | @ 1.00 kg ai/ha (M1.00) | 4) | " | " |
| D10-45/46 Teejet @ 0.25 kg ai/ha (D0.25) | " | @ 0.50 kg ai/ha (D0.50) | 5) | " | " |
| " | " | @ 0.75 kg ai/ha (D0.75) | 6) | " | " |
| " | " | @ 1.00 kg ai/ha (D1.00) | 7) | " | " |
| " | " | @ 0.25 kg ai/ha (D0.25) | 8) | " | " |
| " | " | @ 0.50 kg ai/ha (D0.50) | 9) | " | " |
- (CONT)

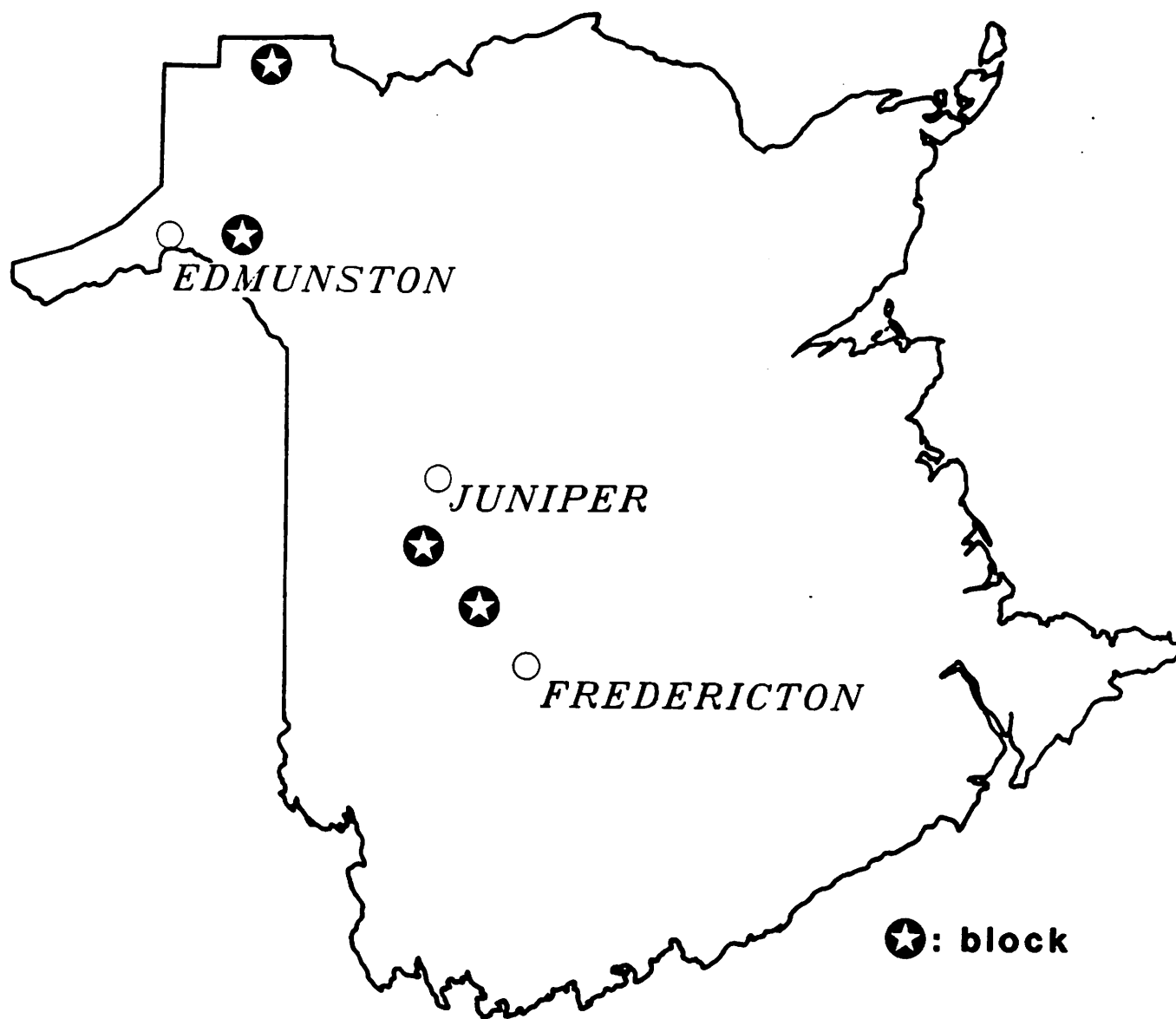
During July 1988, a total of 17 blocks, scheduled for operational herbicide treatment in August 1988, were examined for study potential. Only 7 of these blocks met the study criterion of having uniform raspberry cover, black spruce crops, uniform topography and site conditions, and adequate size. At least 9 plots, a minimum of 140 m wide and as deep as each block would allow, were laid out in each of these 7 blocks. Within the inner 40 m of each plot, at least 50 m from each end, a sample transect of 25 subsamples was then ribboned off, at uniform spacing, on the diagonal. Individual crop trees formed the center point of each of these subsamples and the percent cover of raspberry was subsequently measured within a 1-m radius of each center point:

EACH PLOT :





Crop trees were numbered and the health of each tree was assessed and recorded on a scale of 1 to 5 (1 being perfectly healthy, 5 dead). Data were then analyzed for each block and 4 blocks with the 9 plots of most uniform raspberry cover were then selected for the study (Map 1). All are on Crown Lands.

For each of the blocks selected, plots and subsamples were then permanently marked and numbered (Maps 2-5). Colour coded flag lines were placed between each plot in order to allow easy identification and navigation from the air.

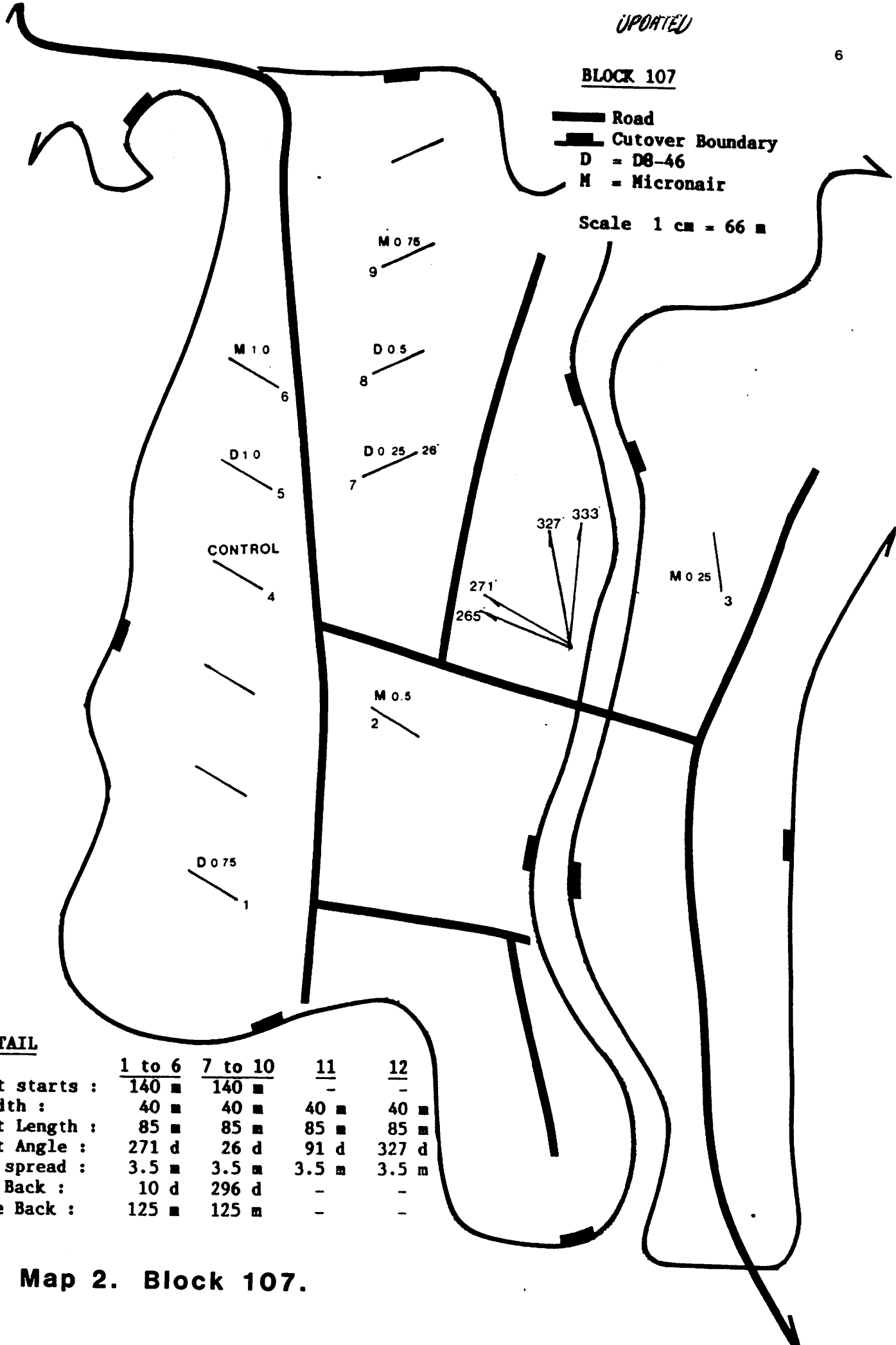


Map 1. Location of improved-use trial blocks.

BLOCK 107

 Road
 Cutover Boundary
 D = D8-46
 M = Micronair

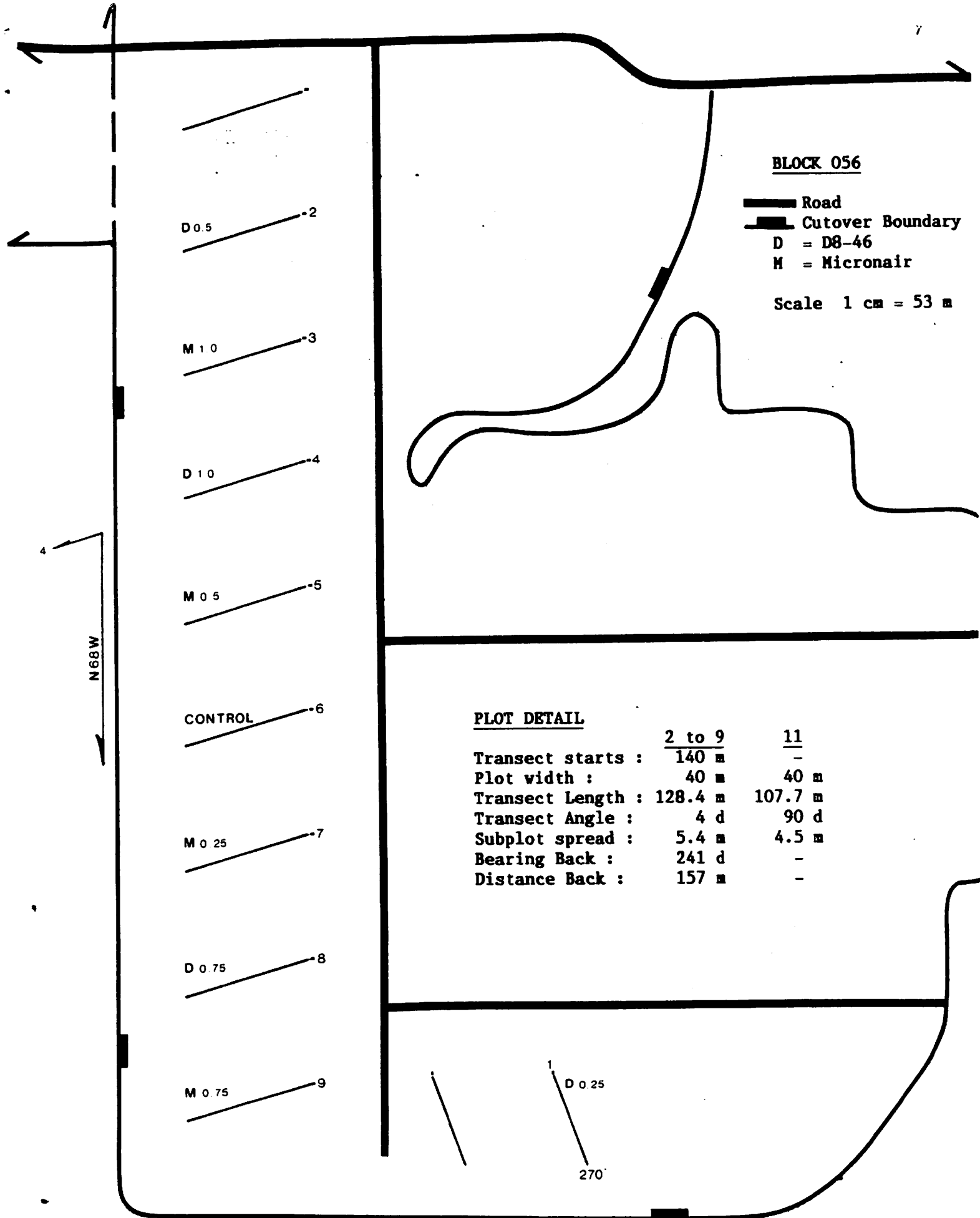
Scale 1 cm = 66 m



PLOT DETAIL



	<u>1 to 6</u>	<u>7 to 10</u>	<u>11</u>	<u>12</u>
Transect starts :	140 ■	140 ■	-	-
Plot width :	40 ■	40 ■	40 ■	40 ■
Transect Length :	85 ■	85 ■	85 ■	85 ■
Transect Angle :	271 d	26 d	91 d	327 d
Subplot spread :	3.5 ■	3.5 ■	3.5 ■	3.5 m
Bearing Back :	10 d	296 d	-	-
Distance Back :	125 ■	125 ■	-	-

Map 2. Block 107.

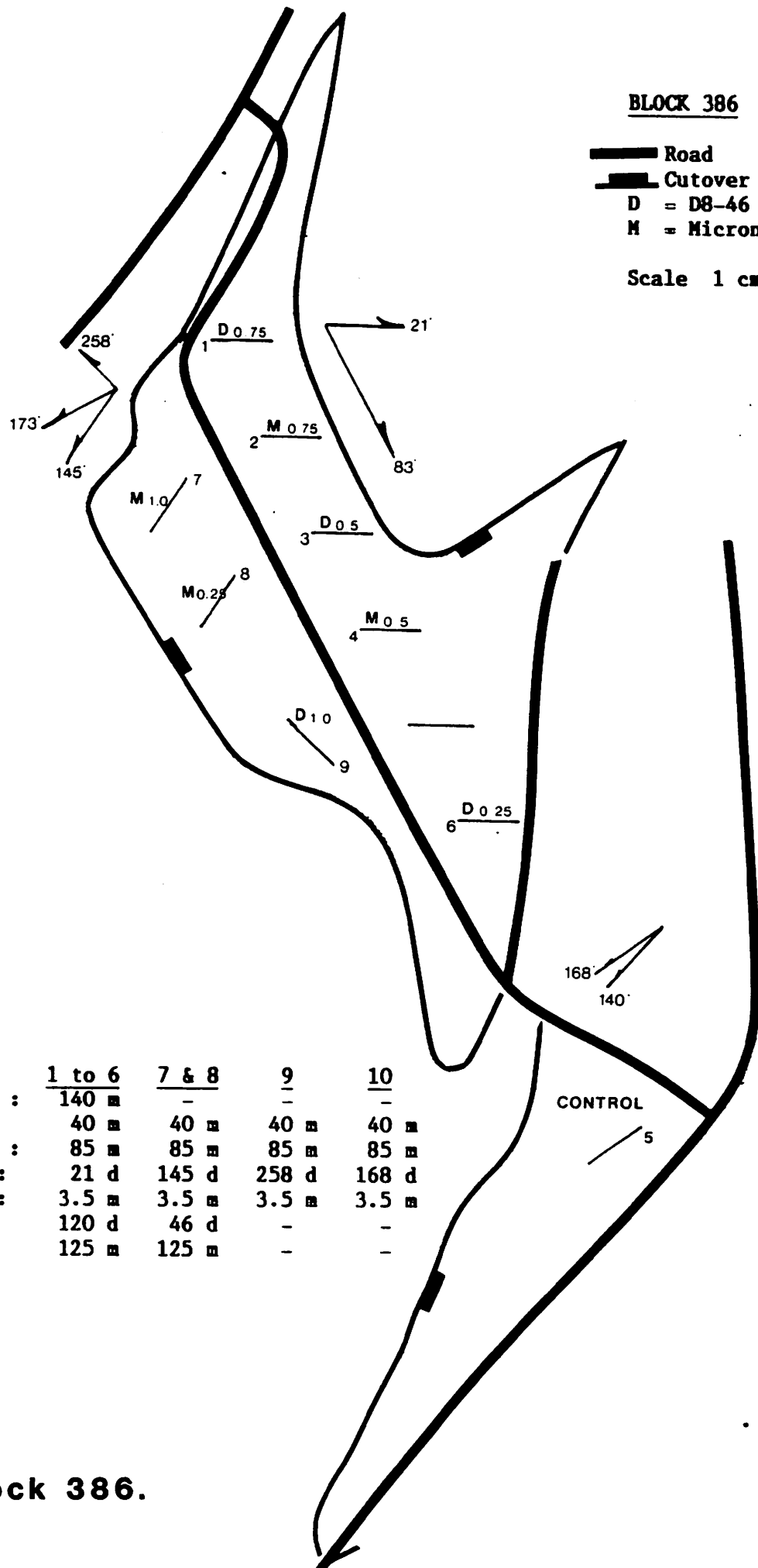


Map 3. Block 056.

BLOCK 386

 Road
 Cutover Boundary
 D = D8-46
 M = Micronair

Scale 1 cm = 75 m

**PLOT DETAIL**

	<u>1 to 6</u>	<u>7 & 8</u>	<u>9</u>	<u>10</u>
Transect starts :	140 m	-	-	-
Plot width :	40 m	40 m	40 m	40 m
Transect Length :	85 m	85 m	85 m	85 m
Transect Angle :	21 d	145 d	258 d	168 d
Subplot spread :	3.5 m	3.5 m	3.5 m	3.5 m
Bearing Back :	120 d	46 d	-	-
Distance Back :	125 m	125 m	-	-

Map 4. Block 386.

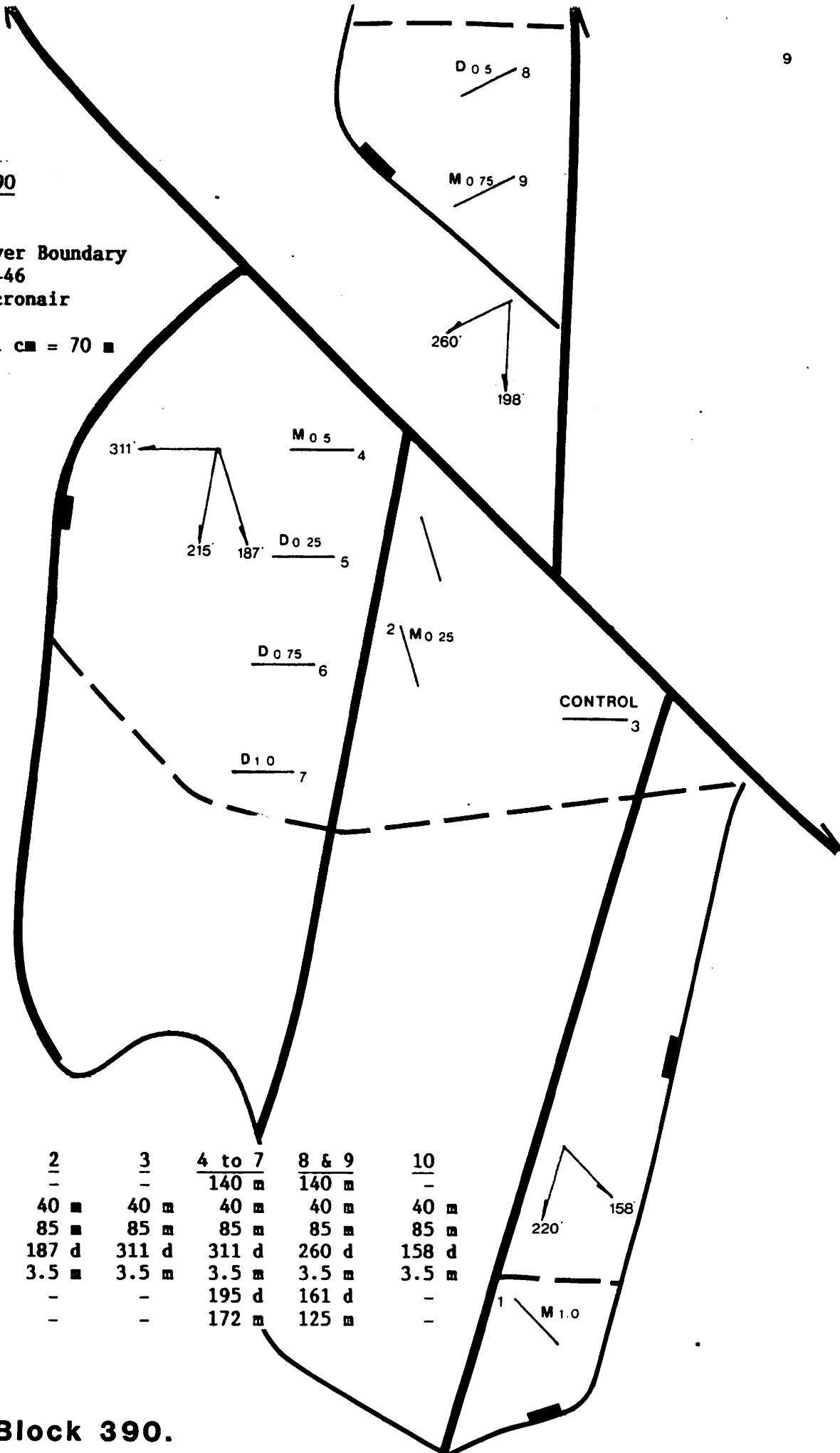
BLOCK 390

 Road
 Cutover Boundary

D = D8-46

M = Micronair

Scale 1 cm = 70 m

**PLOT DETAIL**

	<u>2</u>	<u>3</u>	<u>4 to 7</u>	<u>8 & 9</u>	<u>10</u>
Transect starts :	-	-	140 m	140 m	-
Plot width :	40 m	40 m	40 m	40 m	40 m
Transect Length :	85 m	85 m	85 m	85 m	85 m
Transect Angle :	187 d	311 d	311 d	260 d	158 d
Subplot spread :	3.5 m	3.5 m	3.5 m	3.5 m	3.5 m
Bearing Back :	-	-	195 d	161 d	-
Distance Back :	-	-	172 m	125 m	-

Map 5. Block 390.

d) Pre-treatment Weed Efficacy Data :

In order to insure adequate interspersions, the 9 plots within each block were ranked by percent cover of raspberry (1 = highest, 9 = lowest), and treatments assigned according to the following criterion :

- 1) CONTROL was always assigned the median cover in each block.
- 2) the middle rates (0.50 and 0.75 kg) were always assigned the highest or the lowest covers, alternating the two rates in the high/low positions between blocks.
- 3) the extreme rates (0.25 and 1.00 kg) were always assigned the middle covers, alternating the two rates above and below the CONTROL between blocks.
- 4) MICRONAIR and D10 treatments, within a given rate, were always assigned plots of adjacent rank, within the criteria set out in 1-3) above. The two systems were alternated in these positions between blocks.
- 5) The four blocks were then randomly assigned to the regimes set out in 1-4) above.

Table 1 outlines the result of the above randomization for the four blocks chosen in the study.

Table 1. Key to the assignment of treatments in the improved-use trial.

rank	BLOCK 386			BLOCK 107			BLOCK 056			BLOCK 390		
	PCR	Plot	TRT	PCR	Plot	TRT	PCR	Plot	TRT	PCR	Plot	TRT
1	72.4	2	M0.75	54.8	11	M0.50	54.8	2	D0.50	56.0	6	D0.75
2	70.2	1	D0.75	52.8	8	D0.50	51.2	5	M0.50	48.4	9	M0.75
3	69.8	6	D0.25	50.6	5	D1.00	50.8	3	M1.00	45.6	2	M0.25
4	67.4	8	M0.25	49.0	6	M1.00	50.4	4	D1.00	44.6	5	D0.25
5	65.8	10	CONT	49.0	4	CONT	49.6	6	CONT	43.0	3	CONT
6	62.0	9	D1.00	48.6	7	D0.25	49.0	7	M0.25	36.0	10	M1.00
7	61.4	7	M1.00	48.6	12	M0.25	46.8	11	D0.25	35.4	7	D1.00
8	56.2	4	M0.50	39.8	9	M0.75	41.0	8	D0.75	35.8	8	D0.50
9	56.0	3	D0.50	39.2	1	D0.75	34.8	9	M0.75	33.6	4	M0.50

- PCR = percent cover of raspberry.

- TRT = treatment designation; M = micronair, D = D8-46.

For the comparison of these treatments to be a fair one, it was essential that the treatments within a block be applied to comparable weed cover values. In the analyses of variance of pre-treatment percent cover of raspberry (Table 2), the F value for TREATMENTS is very low (0.20), indicating adequate uniformity of cover across each of the four blocks. The orthogonal contrasts

provide additional assurance that there are no pre-treatment differences in raspberry cover between plots assigned CONTROL, MICRONAIR, and D10 treatments ($F = 0.15$), or between MICRONAIR and D10 within each of the rates ($F < 0.31$). A blocks design is appropriate, as indicated by the large component of variation attributable to blocking.

Table 2. ANOVA table for pre-treatment raspberry cover.

SOURCE OF VARIATION	DF	SS	F	P > F
TREATMENTS	8	79.4600	0.20	.9878
(CONT vs AU5000 vs D10)	(2)	(14.4625)	0.15	>.7500
(" " - 0.25 kg)	(1)	(0.0800)	0.00	.9682
(" " - 0.59 kg)	(1)	(1.2800)	0.03	.8733
(" " - 0.75 kg)	(1)	(15.1250)	0.31	.5847
(" " - 1.00 kg)	(1)	(0.1800)	0.00	.9523
BLOCKS	3	2572.6222		
TREATMENT*BLOCKS (error)	24	1182.3978		
TOTAL	35	3834.4800		

In summary then, there are no significant pre-treatment differences between plots within blocks with respect to raspberry cover. This aspect is illustrated by Figure 1.

e) Application Details :

Treatment of the four blocks took place between September 4th and 10th, 1988, all during early morning sessions. All 8 treatments were applied to each individual block during a single 2-hr spray session. Each session began with the lowest rate and ended with the highest rate to avoid time-consuming tank rinses and potential for cross-rate contamination. Table 3 outlines the weather conditions during the application of each block.

Table 3. Application weather conditions by block.

TIME	BLOCK	DATE	WIND :			TEMP	RH	FOLIAGE	CLOUD	PRECIPITATION	
			(kph)	Var.	DIR.	°C	%	MOIST.%	COV.%	before	after
0718	107	Se 4	< 1	steady	NW	1.7	100	100	0	>24h	18h
0919		Se 4	1-3	steady	W	9.4	89	20	25		~10mm
0705	056	Se 8	1-3	variab	?	7.7	86	10	0	>24h	>24h
0828		Se 8	10-20	gusty	W	12.8	77	0	0		
0706	386	Se 9	< 1	steady	W	2.2	100	100	5	>24h	>24h
0914		Se 9	2-3	steady	W	8.9	88	5	0		
0648	390	Se10	2	steady	W	10.5	98	70	20	>24h	>24h
0830		Se10	1	steady	W	11.1	90	15	0		

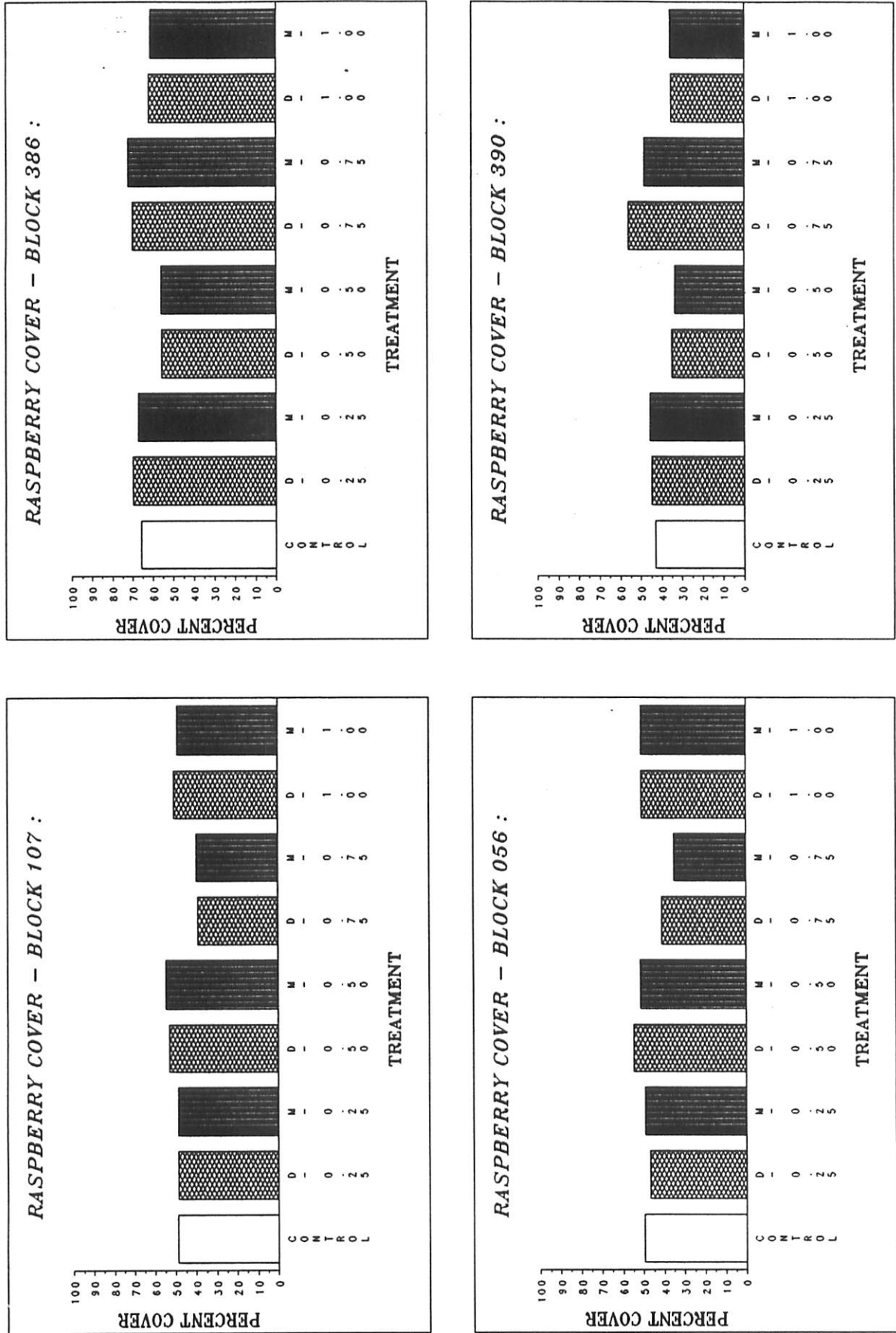


Figure 1. Mean pre-treatment cover of raspberry

Swath centers were marked out for each plot with ribbons placed along roadsides. A large flag, mounted in the back of a half-ton truck, served as guidance for the pilot so that accurate track spacing could be maintained. The number of spray swaths placed in each plot varied with plot size and calibrated track spacing; 8 swaths were typical.

f) Calibration Data :

Two BELL 206B helicopters were used to apply these treatments, one equipped with AU5000 micronaires, the other with conventional TeeJet D10-45/46 nozzles. Both helicopters were flown by the same pilot, fitted with the same SIMPLEX spray system, and calibrated to deliver a total volume of 37.4 l/ha. Table 4 outlines the calibration specifications in detail.

Table 4. Delivery system specifications.

<u>Parameter</u>	<u>Micronair</u>	<u>Nozzle</u>
- aircraft	BELL 206B	BELL 206B
air speed (kph)	112	128
altitude (m above canopy)	~6-8	~6-8
pilot	Barry Grant	same
- spray system	SIMPLEX	SIMPLEX
nozzle type (number)	AU5000 (6)	D10-46 (6) D10-45 (42)
orientation	180° (back)	90° (down)
RPMs (wet)	4410	-
VRU setting	13	-
flow rate (l/min)	134.1	195.8
boom pressure (psi)	50	29
track spacing (m)	19.05	24.38
total calibrated volume (l/ha)	37.4	37.4
- droplet characteristics: VMD (µm)	300	425
NMD (µm)	73	100
Dmax (µm)	677	1085
Mean volume deposited in swath (l/ha)	8.1 ± 1.7	14.8 ± 2.6
Diameter of drop of mean volume (µm)	167	241
Mean density within swath (drops/cm ²)	34.8 ± 3.1	20.8 ± 2.0

Final calibration and swath checks took place just prior to sunset, the evening of September 3rd. Each aircraft made a single spray pass over a set of 17 Kromekote® cards placed at 3.05-m intervals along a road within a cutover portion of block 107. The droplet densities and volume estimations for each of these passes are given in Figure 2. Erio acid red dye was used, along with an appropriate spread-factor of 2.4 (Reilley, 1988).

Figure 3 presents the deposit for the calibrated portions of each swath, expressed as cumulative percent of the volume and number of drops in each diameter class. The VMDs (300 µm-AU5000 and 425 µm-D10) and the NMDs (73 µm-AU5000 and 100 µm-D10) are shown. Figure 4 plots the same parameters as Figure 3, for each captured swath, and shows very little change in result. The

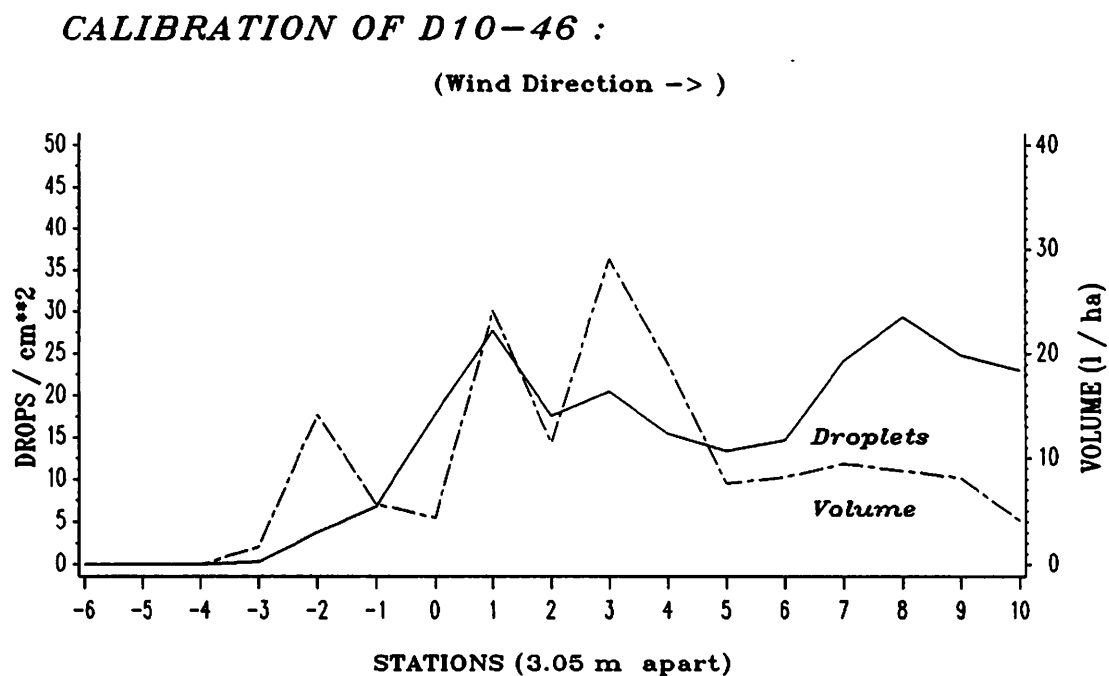
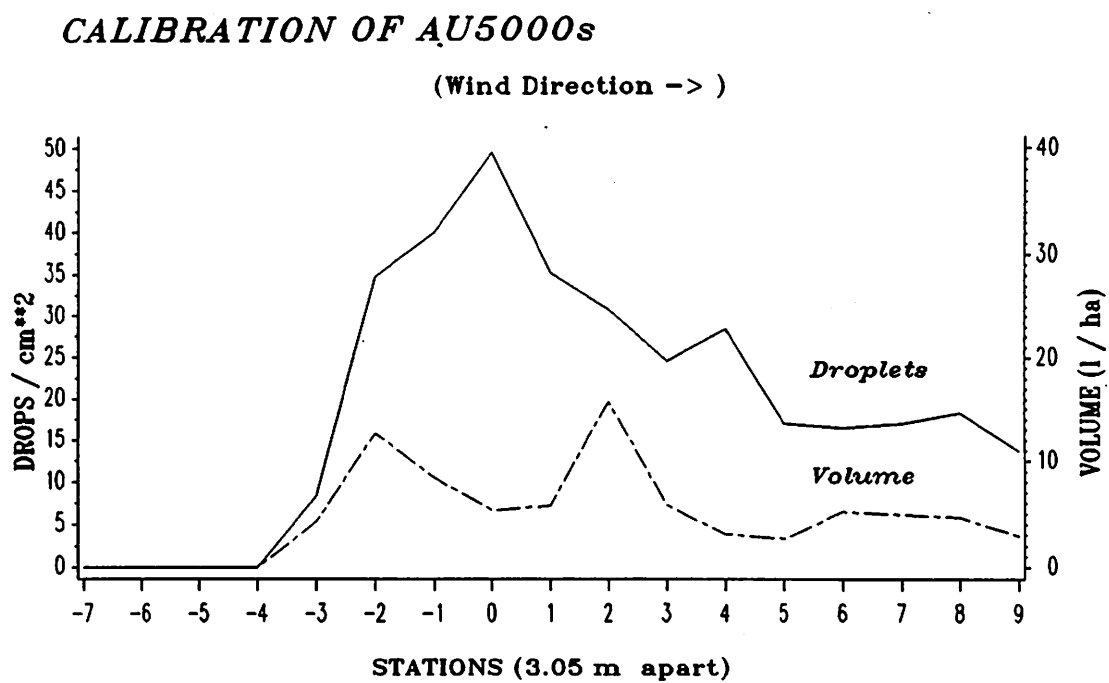
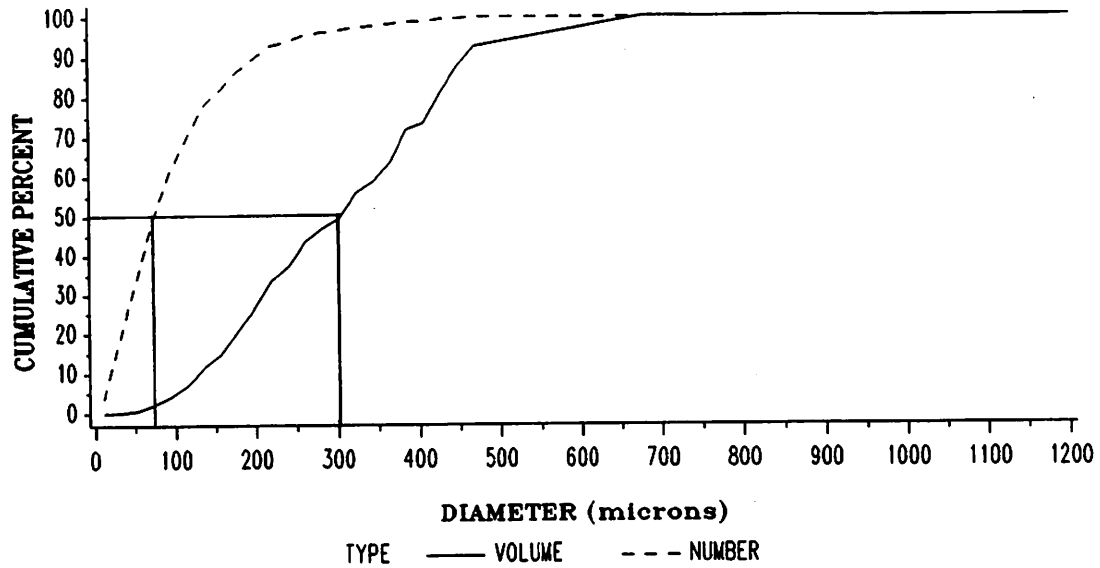


Figure 2. Droplet density and volume within swath widths.

CALIBRATION OF AU5000s :

(calibrated swath only - stations -2 through 4)



CALIBRATION OF D10-46 :

(calibrated swath only - stations 1 through 9)

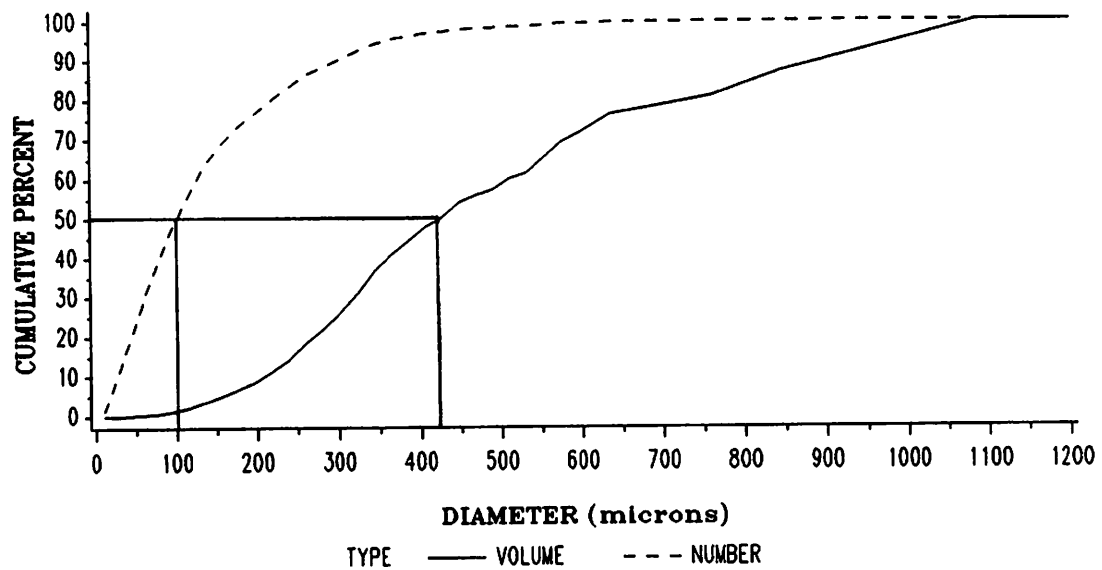
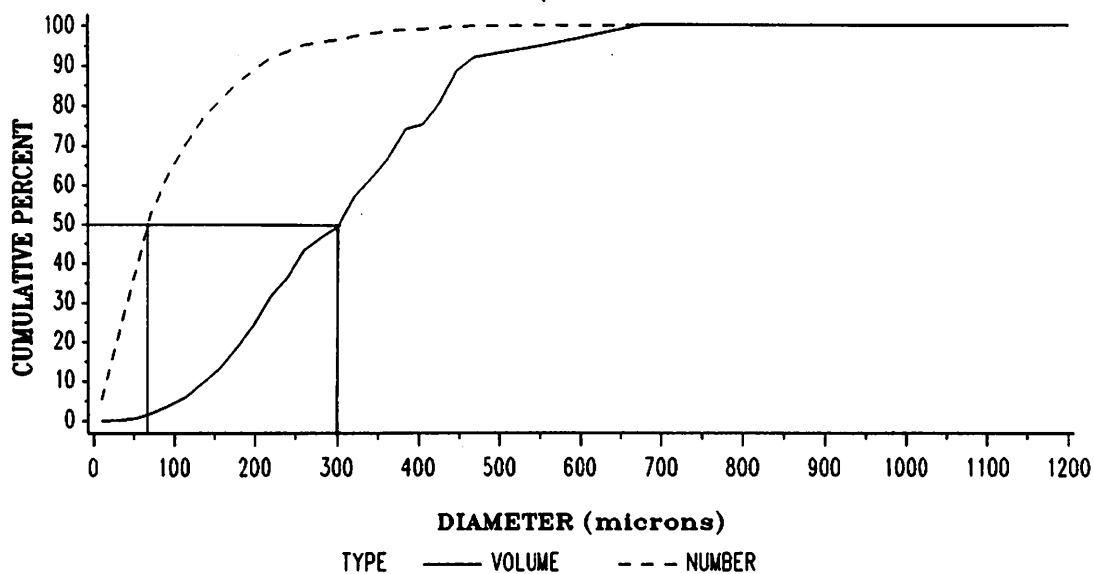


Figure 3. Deposit for calibrated swath widths.

CALIBRATION OF AU5000s :

(over entire captured swath)



CALIBRATION OF D10-46 :

(over entire captured swath)

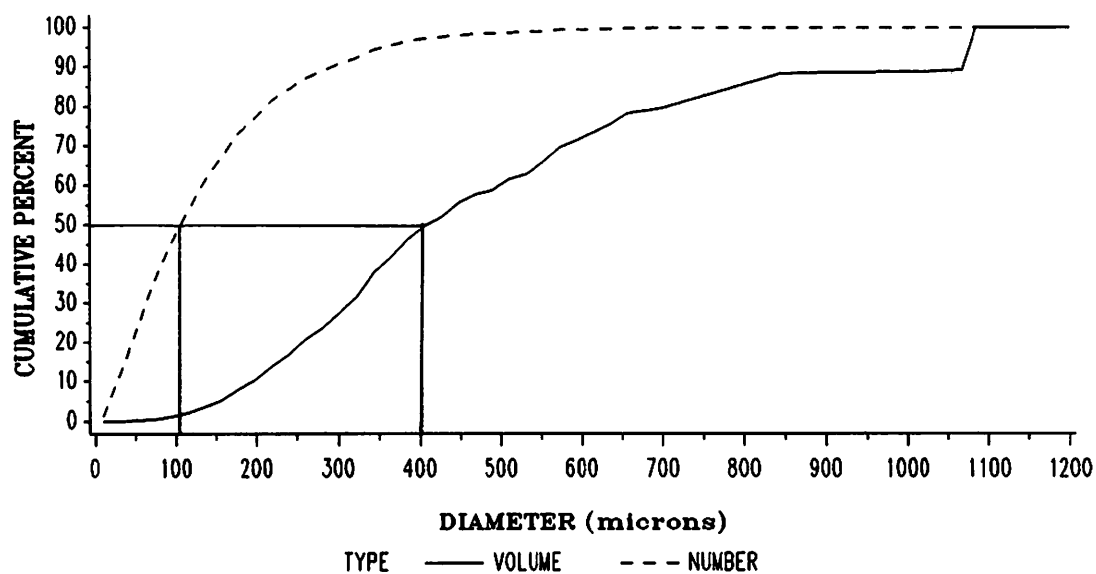


Figure 4. Deposit for captured swath widths.

portion of each swath captured on the 17 stations is, therefore, well represented by the calibrated swaths themselves.

Figures 5-7 plot frequency, percent of total number, and percent of total volume in each diameter class for each system.

There are clearly differences between the two systems in terms of droplet spectrum. The AU5000s are producing smaller, more uniform-sized droplets than the D10 TeeJets. The question one asks though, is 'are the differences that exist between the two systems enough to lead one to expect corresponding differences in biological efficacy?'.
 .

g) Formulation Analysis :

In order to determine whether or not the product used in the trial was up to par in terms of concentration, samples were taken from each container used. Chemical analysis of these samples revealed no significant differences between the manufacturer's guarantee (356 g ai/l) and the concentration of the product used (difference between observed and expected = 0.1433 g ai/l, standard error = 6.35 g ai/l, $t = 0.02$, $p > |t| = 0.9829$).

h) Chemical Deposit Data :

To help verify the results obtained in this trial, residue and deposit sampling was conducted. Petri dishes (dia. = 17.7cm), containing glass-fibre filter paper were placed within every fifth subsample area in each plot (5 per plot) in order to estimate impingement of active ingredient on target foliage at the time of application. A second set of petri dishes, placed in the same locations as the first, were used to detect potential contamination from adjacent treatments. All petri dishes were randomly placed within the 1-m weed sampling radius of the subplot centers, at the height of the surrounding raspberry foliage. (Note : Brush cover in subplots was ignored in the random placement of the dishes. Brush density data will be collected this August and correlated with deposit data. Please keep this in mind when interpreting the following data). 3M paper (#729) was also placed beside the residue sample locations in order to provide droplet density data for each of the treatments.

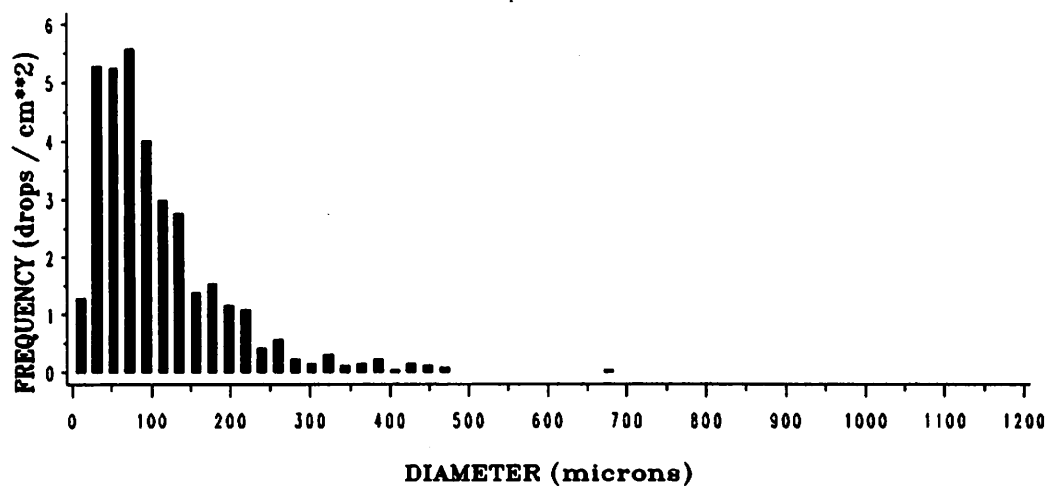
As well, samples of each helicopter spray mixture were taken and analyzed for active ingredient concentration.

Figure 8 summarizes the extent of contamination that occurred in each plot of the four blocks. In general, contamination was negligible (less than 10 % of the lowest calibrated rate). None of the 36 plots in the trial received a contaminating dose that was near the 'no-effect level' for aspen (Hofstra and Payne, 1988), a species that is particularly sensitive to glyphosate. As a result, contamination from adjacent plots is assumed to be non-existent in subsequent analyses.

Figures 9a-9d present the deposit values for each of the five subsamples in each plot, by block. The subsamples are arranged in the diagrams by cross-wind direction (upwind subplot = 1, downwind subplot = 5). I expected to see a trend of increasing deposit on downwind collectors, but this did not materialize. As expected, the deposit across each plot is quite variable. The most notable observation is the relatively low deposit on blocks 107, 056,

CALIBRATION OF AU5000s :

(calibrated swath only - stations -2 through 4)

***CALIBRATION OF D10-46 :***

(calibrated swath only - stations 1 through 9)

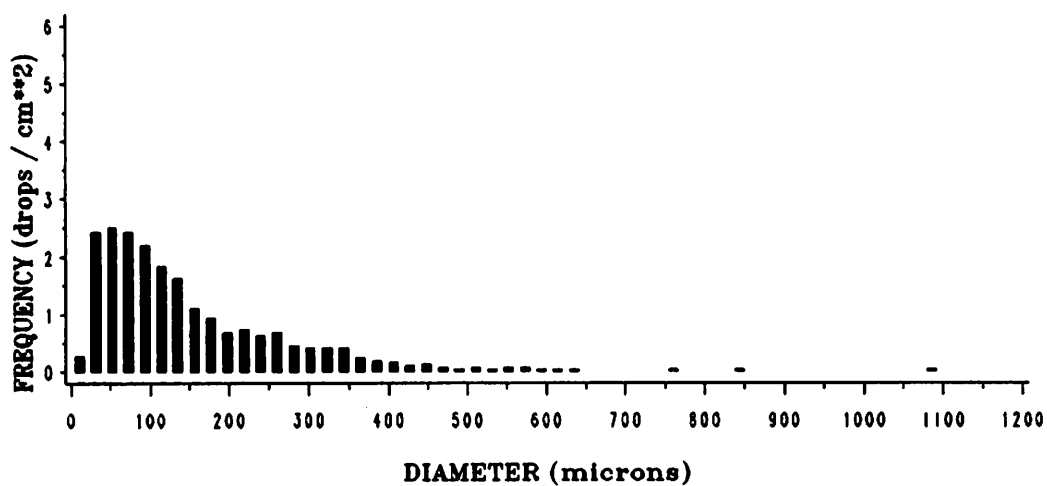
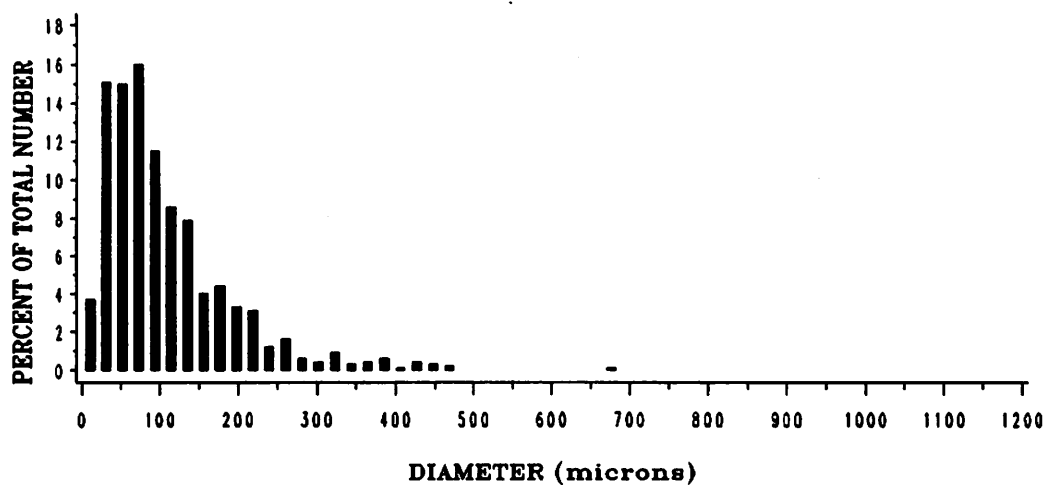


Figure 5. Frequency of drops in each diameter class.

CALIBRATION OF AU5000s :

(calibrated swath only - stations -2 through 4)

***CALIBRATION OF D10-46 :***

(calibrated swath only - stations 1 through 9)

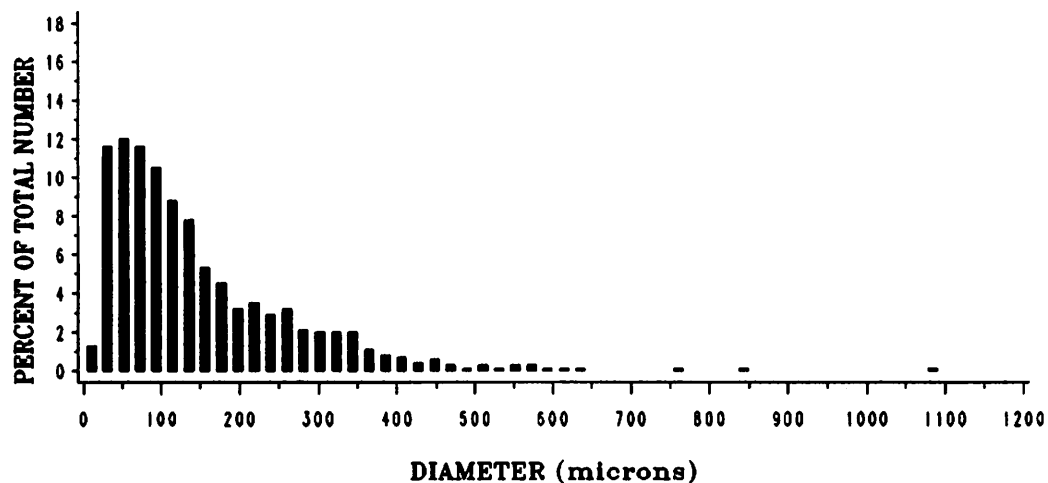
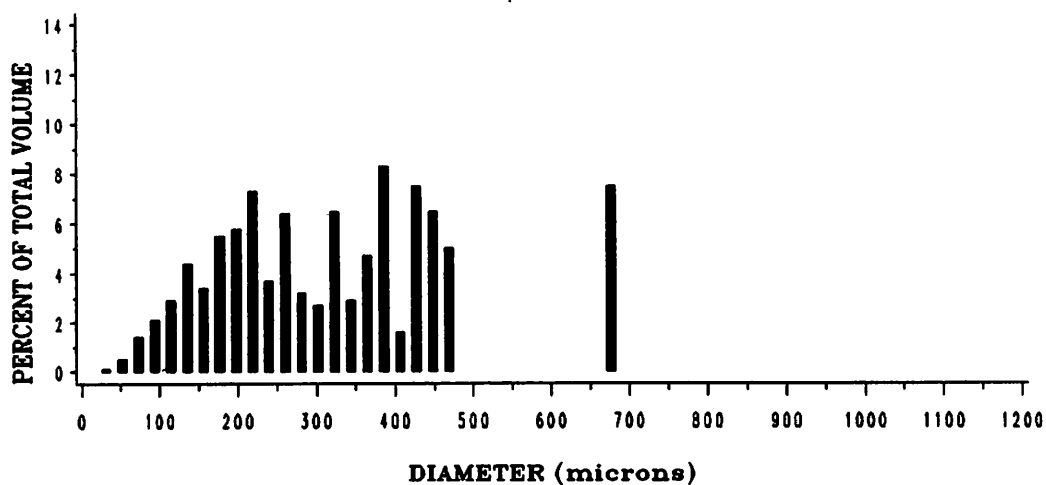


Figure 6. Percent of total number of drops in each diameter class.

CALIBRATION OF AU5000s :

(calibrated swath only - stations -2 through 4)

***CALIBRATION OF D10-46 :***

(calibrated swath only - stations 1 through 9)

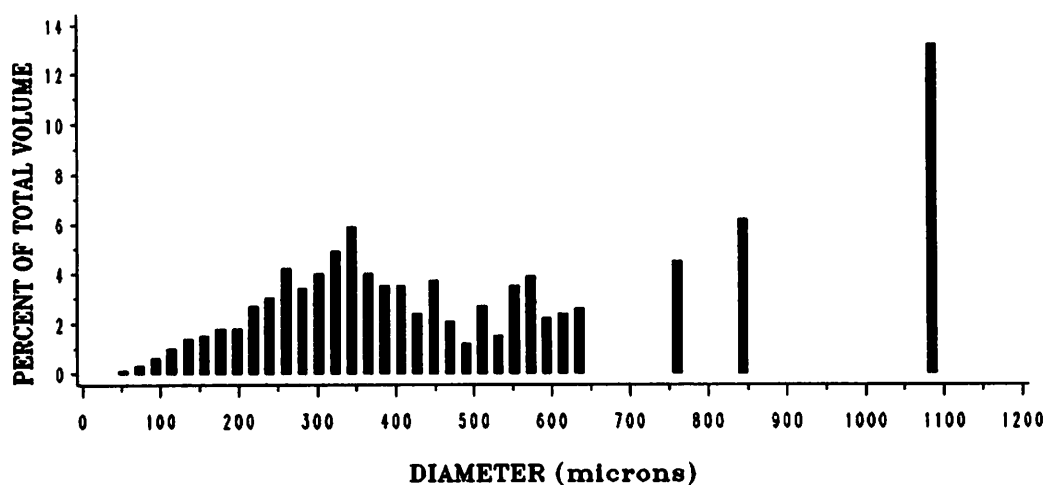


Figure 7. Percent of total volume in each diameter class.

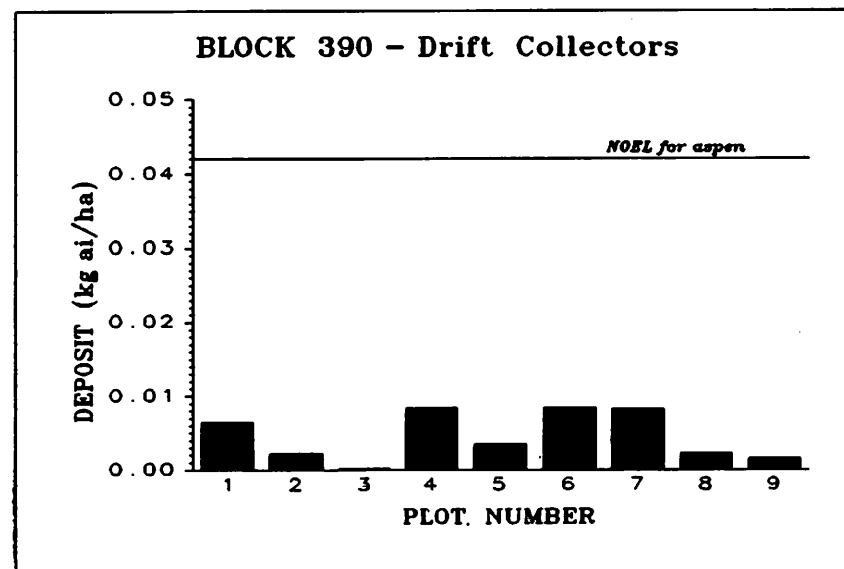
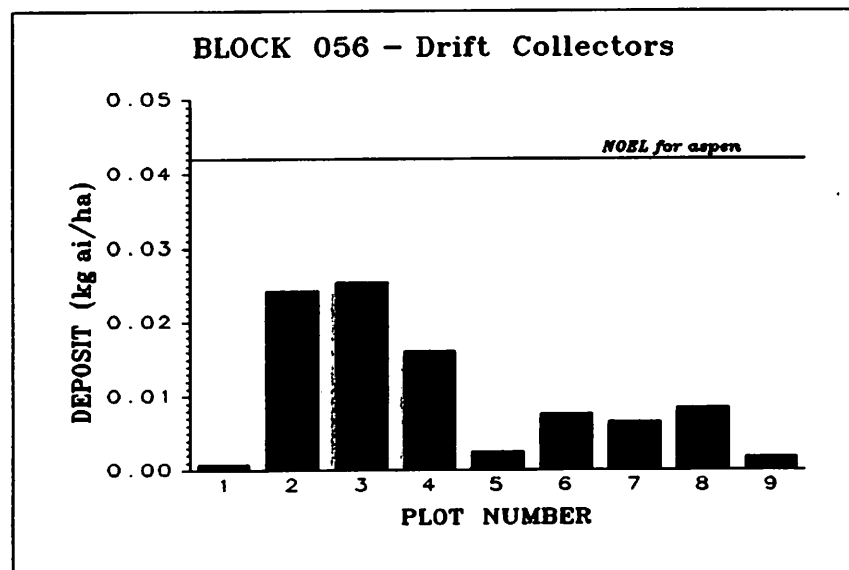
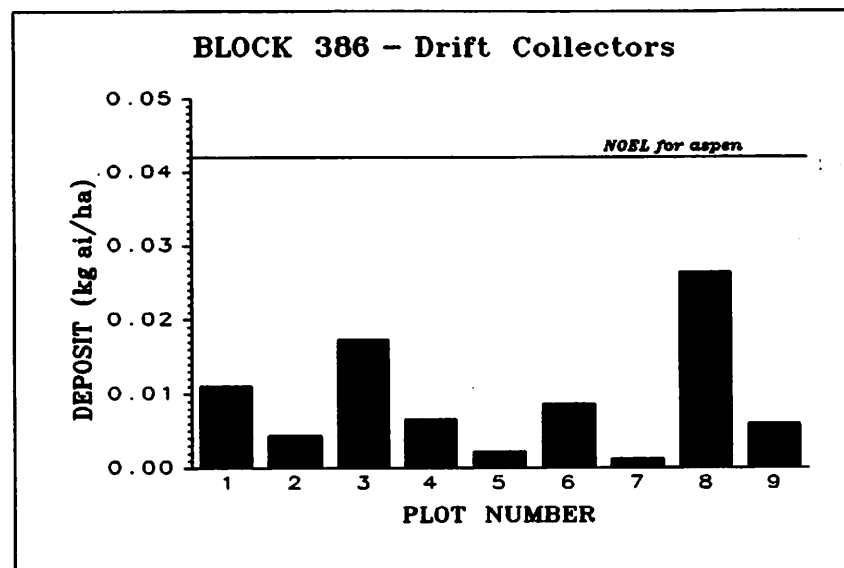
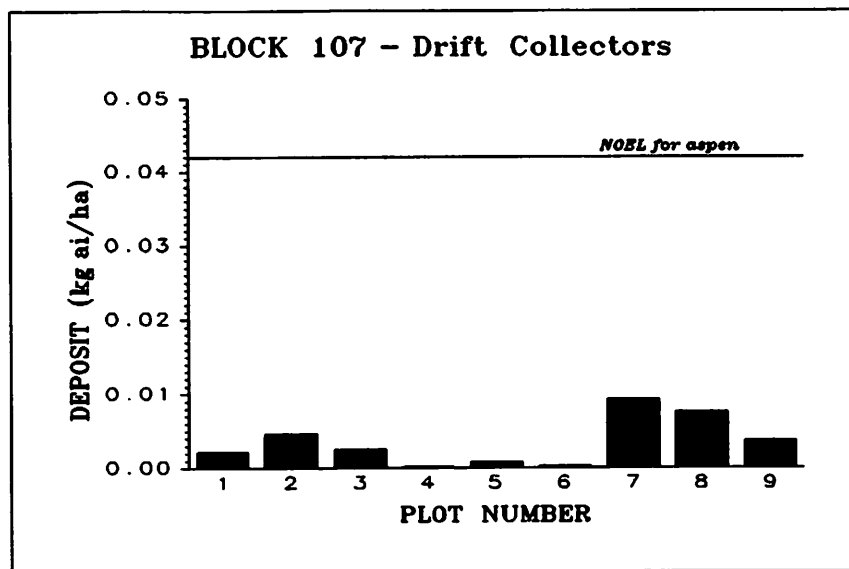


Figure 8. Plot contamination.

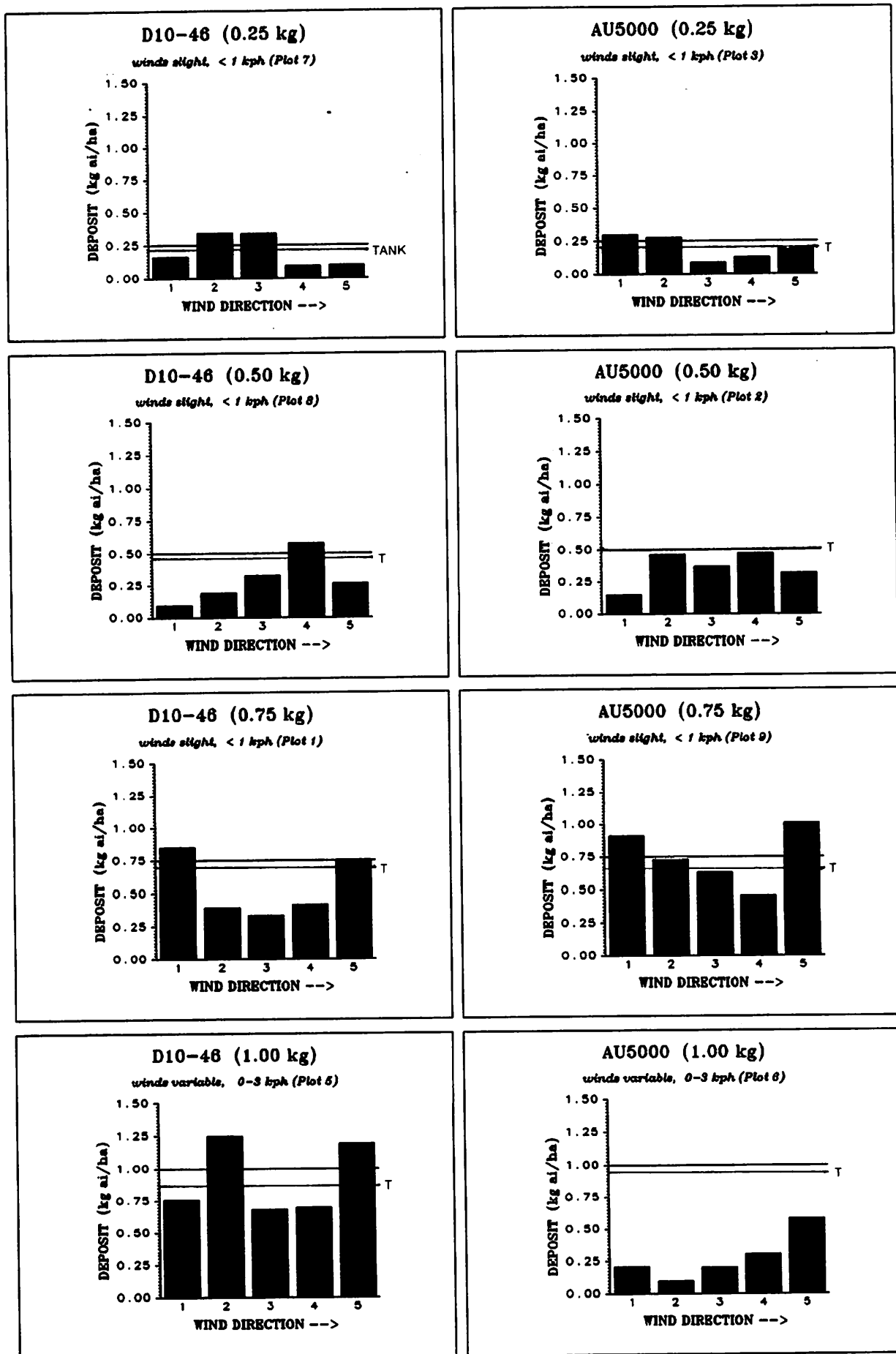


Figure 9a. Deposit by subsample -block 107.

DEPOSIT - 107 - 100, 500, 500

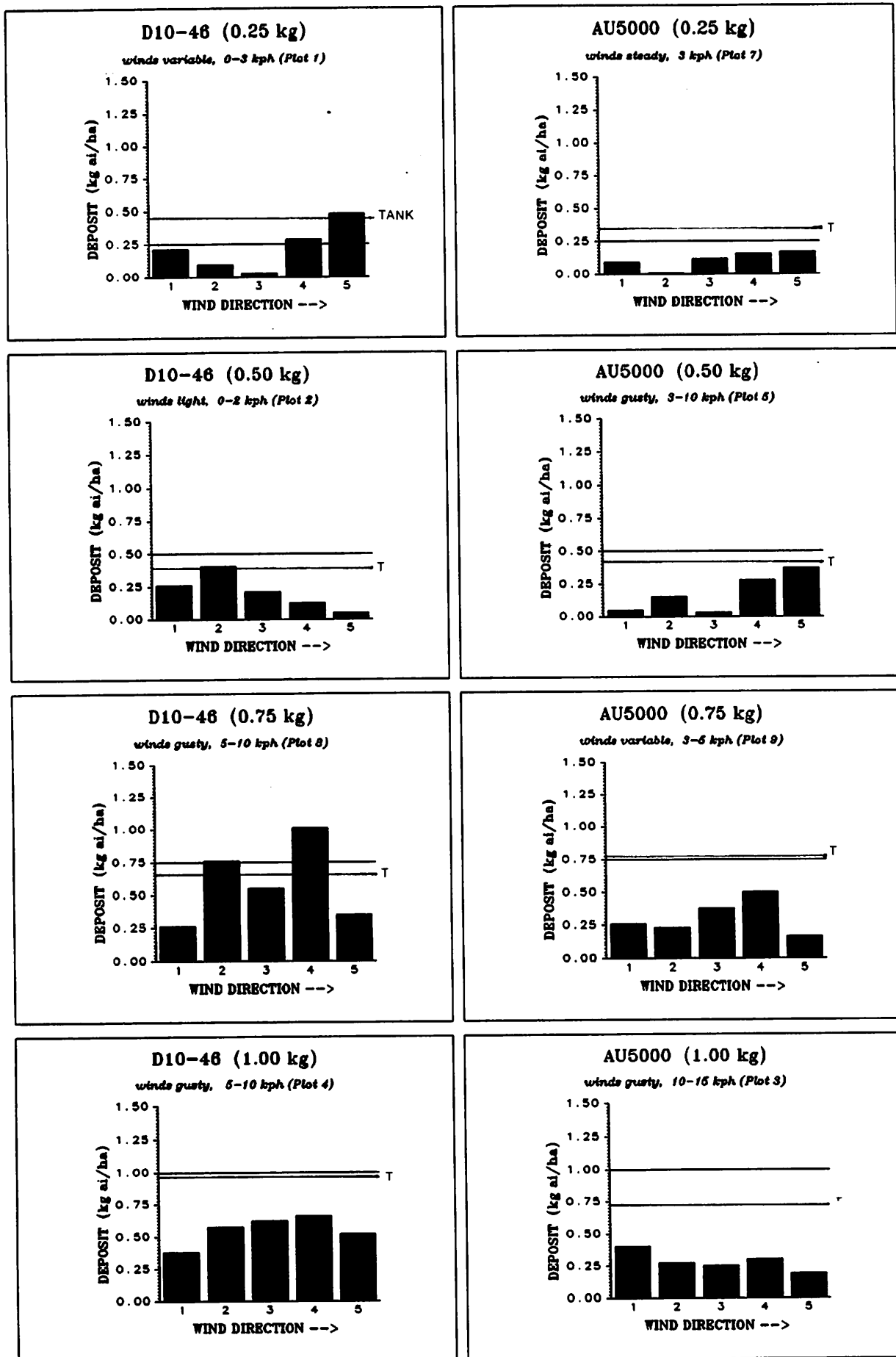


Figure 9b. Deposit by subsample -block 056.

DEPOSIT 0.50 kg ai/ha

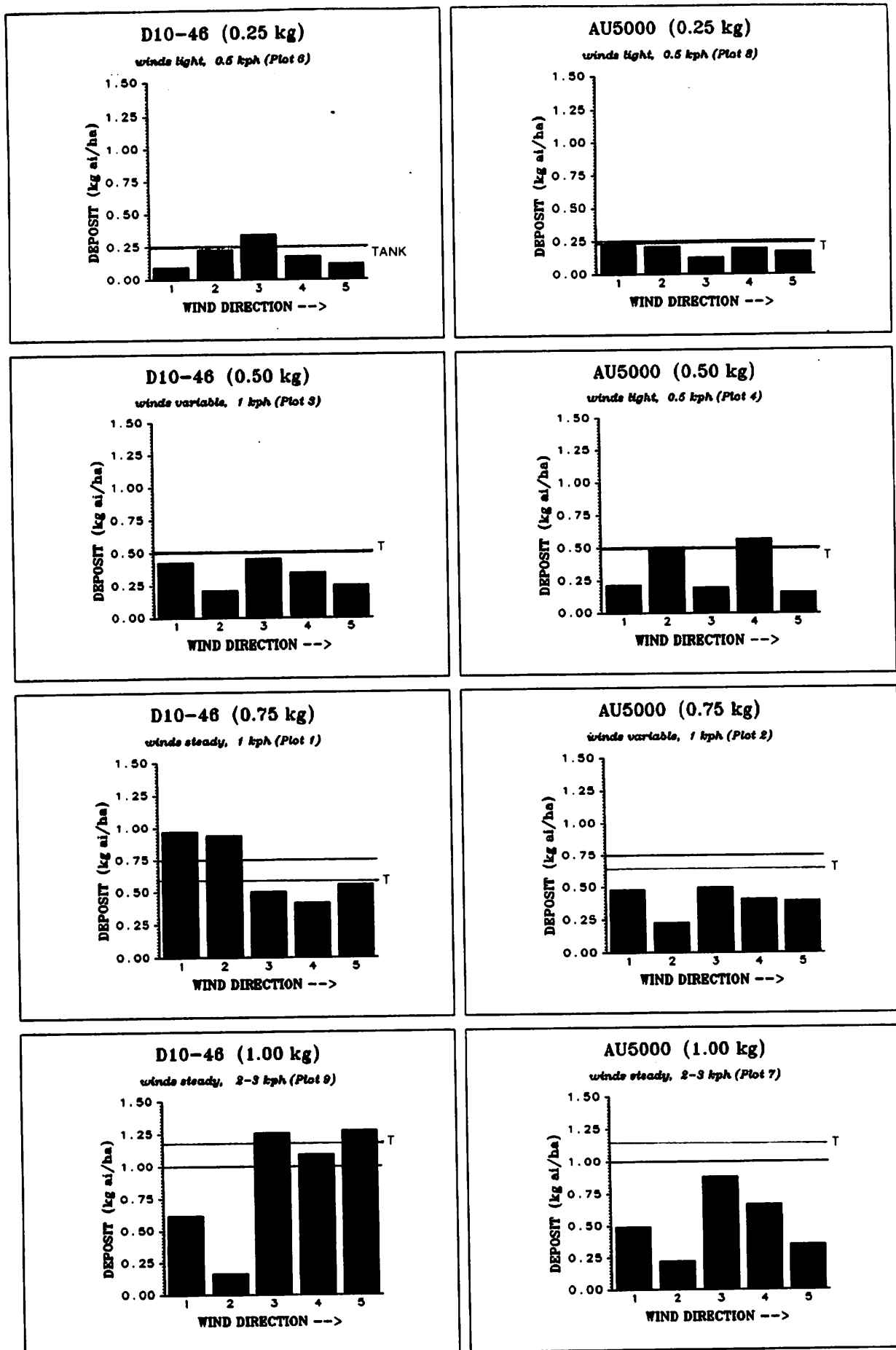


Figure 9c. Deposit by subsample -block 386

DEPOSIT - 350-200-000

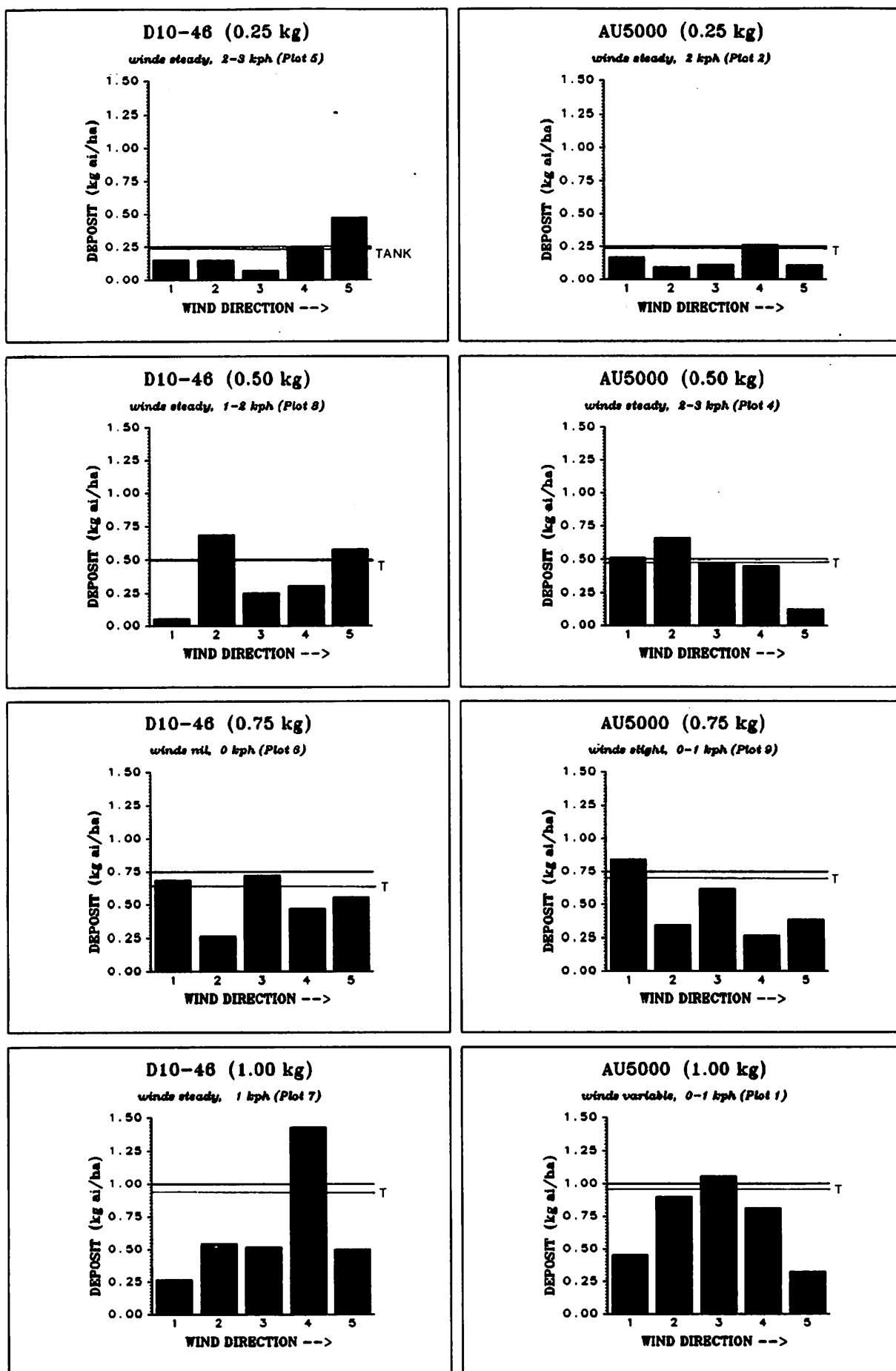


Figure 9d. Deposit by subsample -block 390.

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and 386 by the AU5000, 1.00kg treatments. More will be said about this shortly.

Figures 10a-10d present the mean deposit values and tank-mix concentrations for each treatment, by block. Figure 11 presents the overall block means for the data given in Figures 10a-10d. In general, the mix concentrations were very close to the targeted values and there were only small differences in the concentrations delivered to the two systems. Deposit recovered was slightly lower than the concentration of the mix, as expected. Again, the most notable observation is the low deposit in the 1.00kg, AU5000 treatments of blocks 107, 056, and 386. Consider the following points:

- 1) The 1.00kg plots were the last to be treated on all the blocks. With the exception of block 390, the last treatments were made under the most turbulent conditions. The AU5000 was the last system to be used on blocks 107 and 386.
- 2) Block 056 was treated under extremely high wind conditions. D10 deposit at 1.00kg was also suppressed, having been applied in 10 to 20 kph gusts. In all four rates applied, AU5000 deposit was lower than D10 deposit in the high wind conditions.

Figures 10a-10d suggest that, under low wind conditions, the two systems provide comparable deposit (all blocks, 0.25 and 0.50kg rates). Under turbulent conditions, it appears that AU5000 deposit is compromised to a greater extent than the D10 deposit (block 107, 1.00kg, and blocks 056, 386, and 390, 0.75 and 1.00kg). This situation may have been different, had we been able to use larger plots which would better accommodate swath displacement.

This trend is reflected in the analysis of variance of the deposit data (Table 5). Most of the variation in deposit results from the four different rates tested, as one might expect, but there is a significant difference between the deposits generated by the two systems ($F = 7.47$). The orthogonal contrast of the 1.00kg treatments confirms that the low AU5000 deposits are a major reason for this difference ($F = 14.59$).

Table 5. ANOVA table for chemical deposit.

SOURCE OF VARIATION	DF	SS	F	P > F
TREATMENTS	8	8.4320	16.90	.0001
(AU5000 vs D10)	(1)	(0.4658)	7.47	.0116
(" " - 0.25 kg)	(1)	(0.0259)	0.42	.5255
(" " - 0.50 kg)	(1)	(0.0050)	0.08	.7803
(" " - 0.75 kg)	(1)	(0.1027)	1.65	.2116
(" " - 1.00 kg)	(1)	(0.9102)	14.59	.0008
BLOCKS	3	0.4968		
TREATMENT*BLOCKS (error)	24	1.4970	1.55	.0617
SUBSAMPLES v. TREATMENTS & BLOCKS	144	5.8059		
TOTAL	179	16.2317		

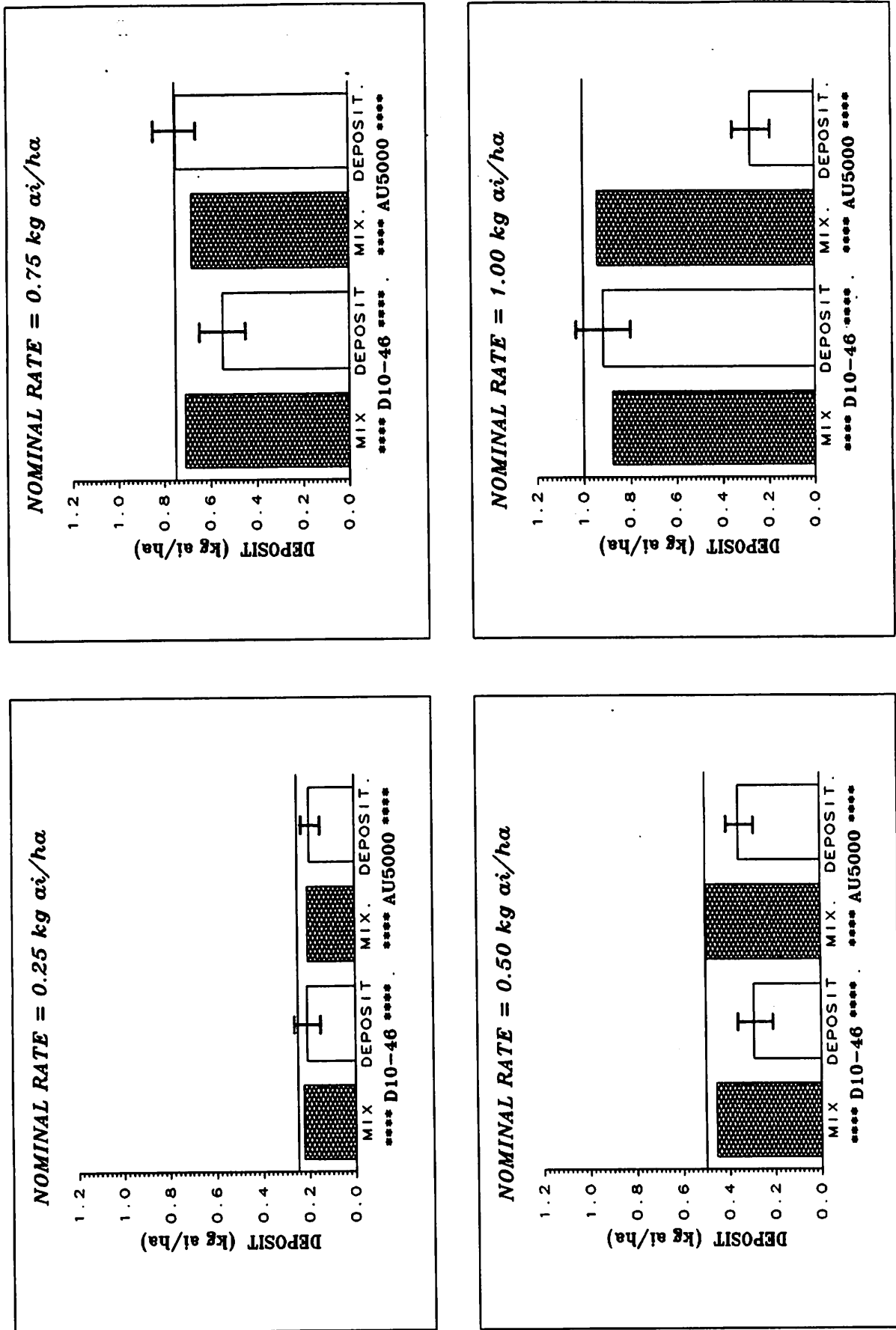


Figure 10a. Mean deposit and tank mix -block 107.

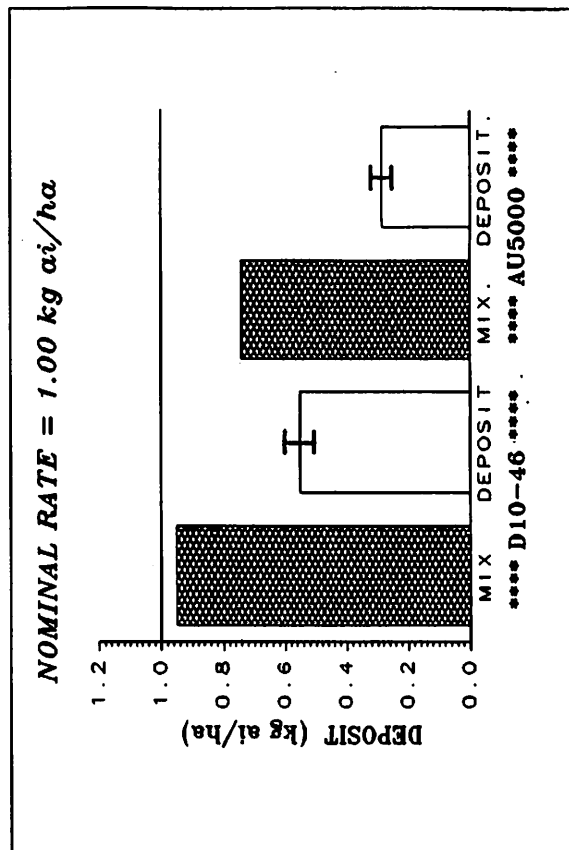
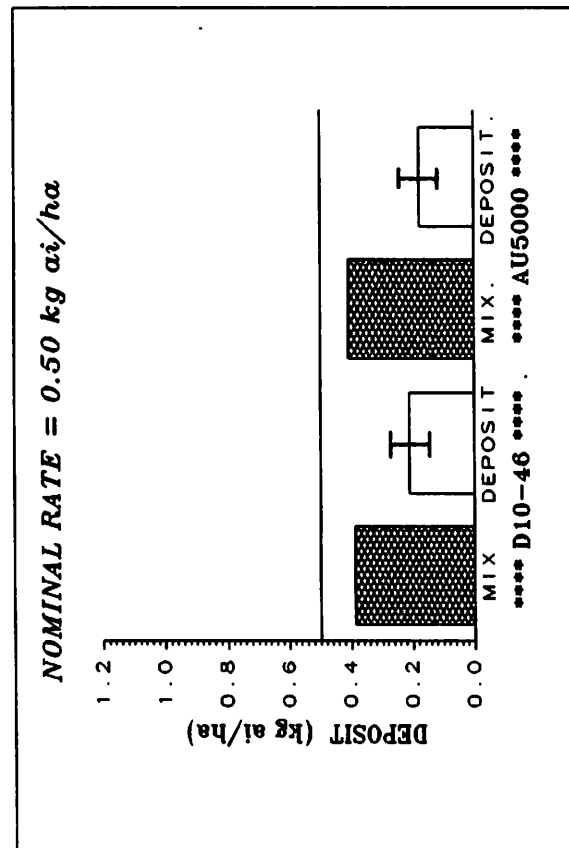
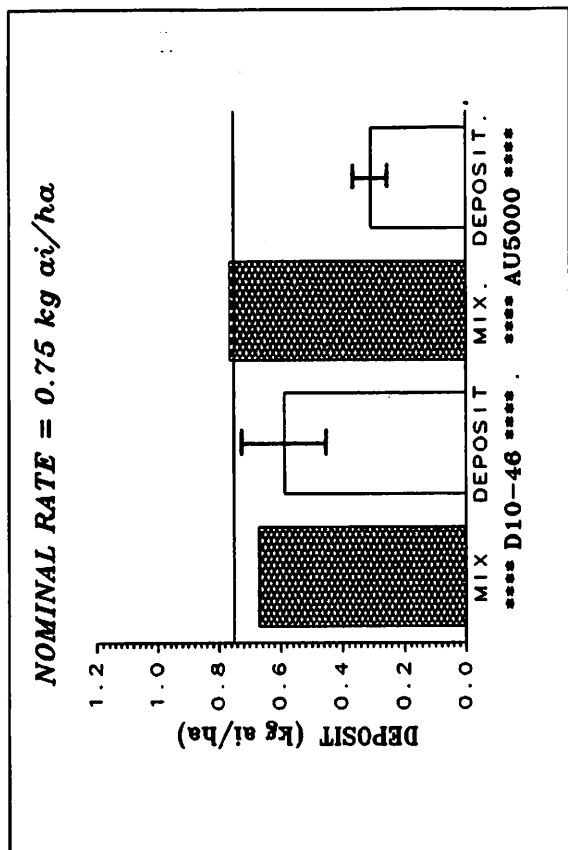
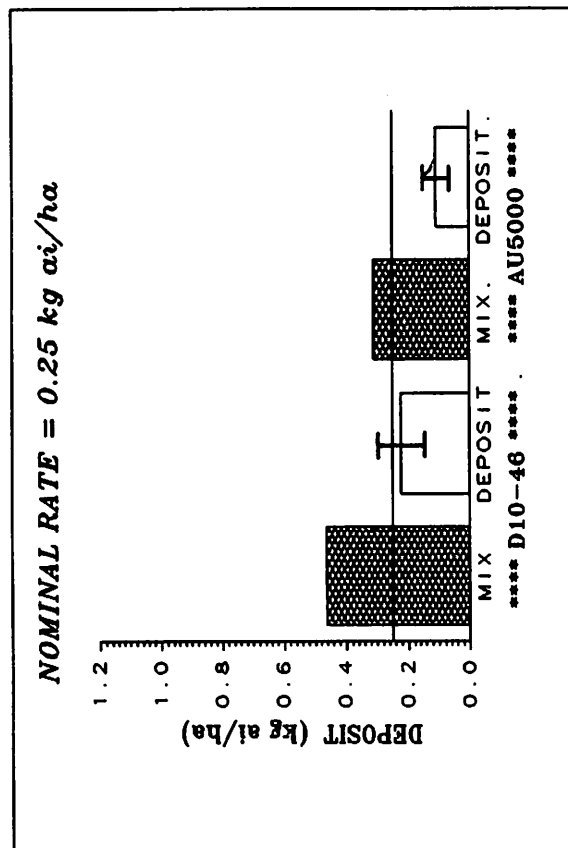


Figure 10b. Mean deposit and tank mix -block 056.

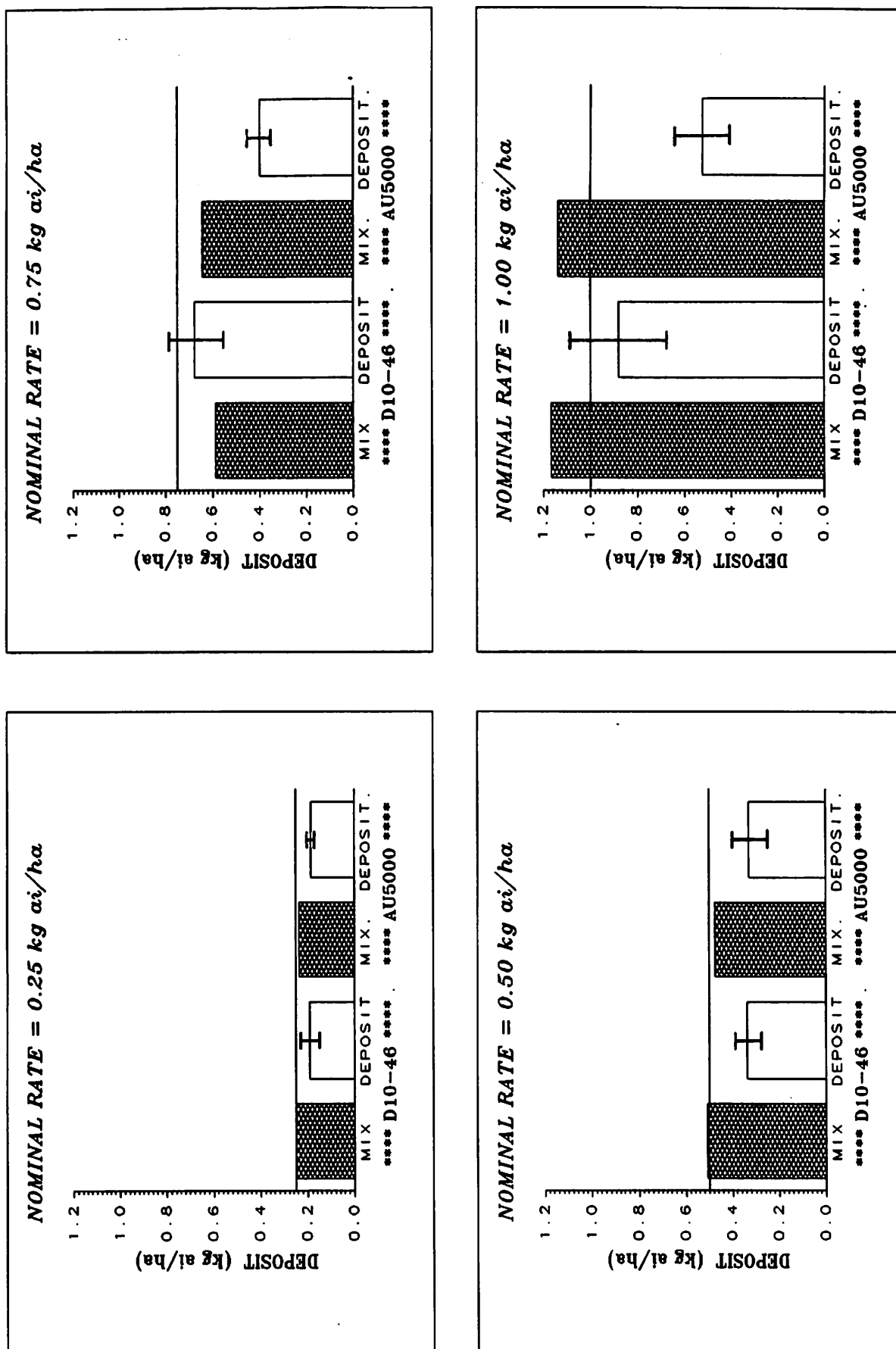


Figure 10c. Mean deposit and tank mix -block 386.

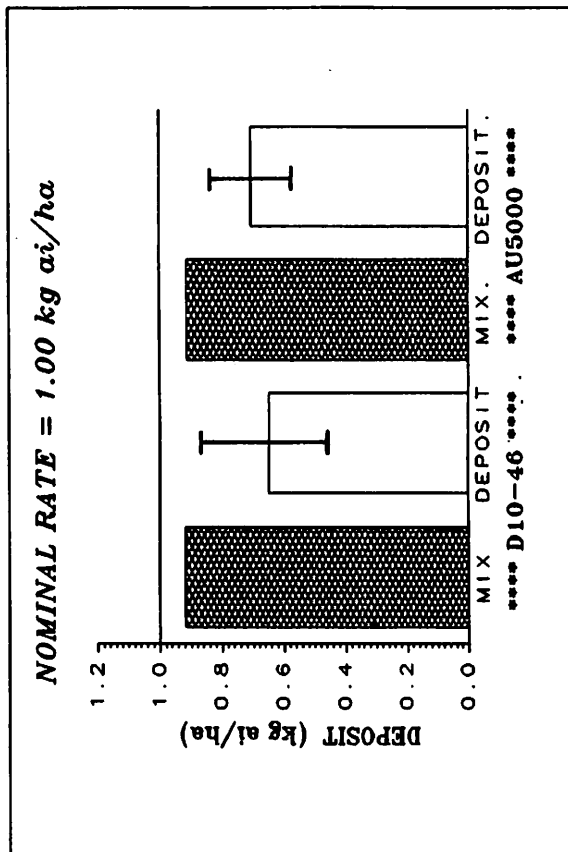
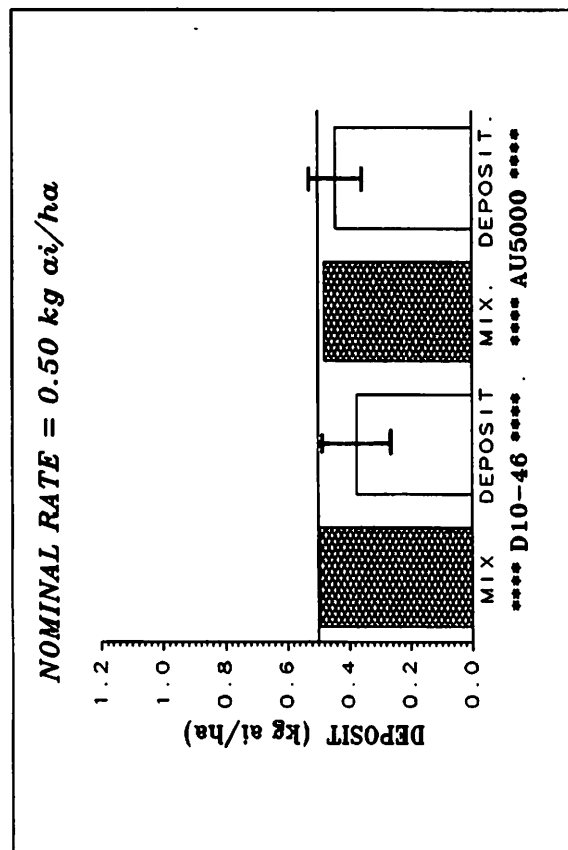
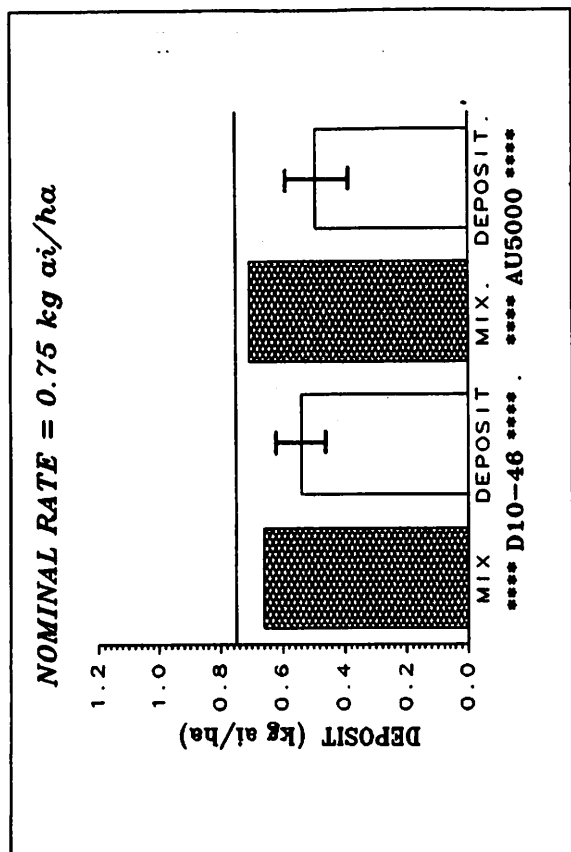
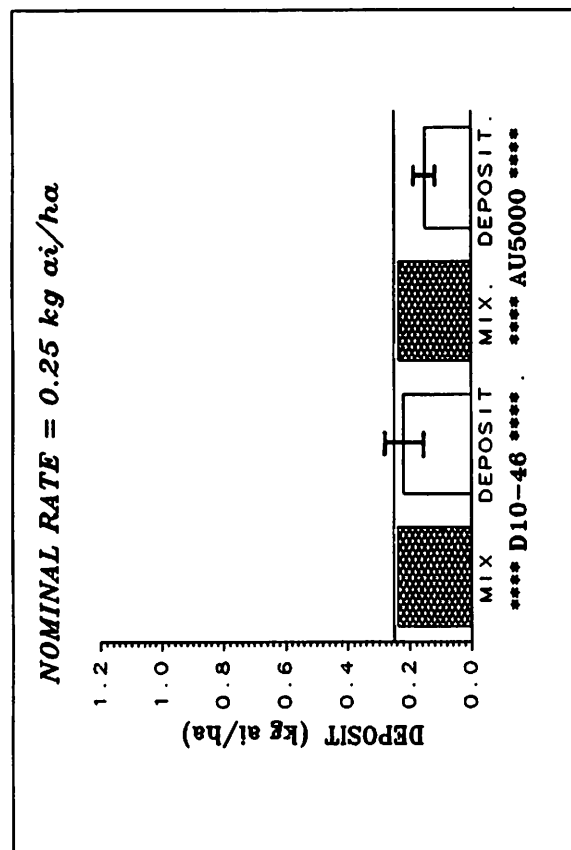


Figure 10d. Mean deposit and tank mix -block 390.

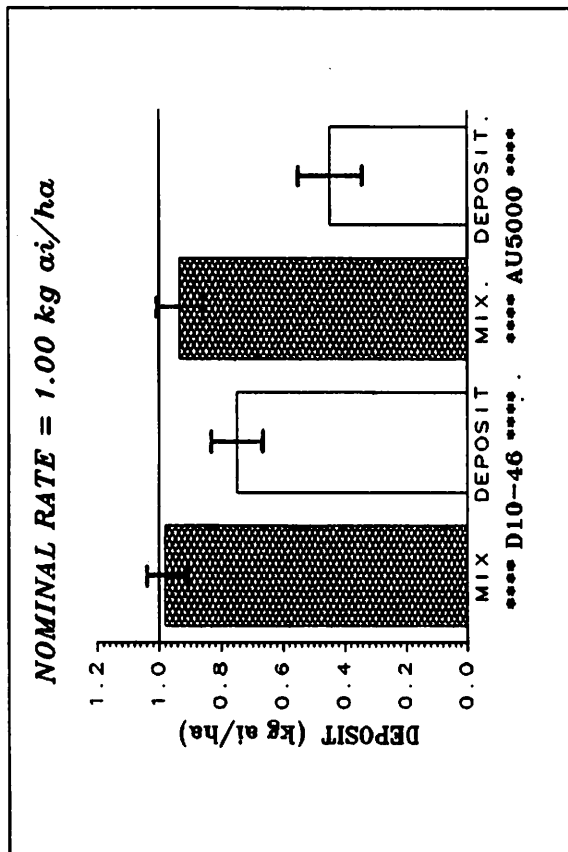
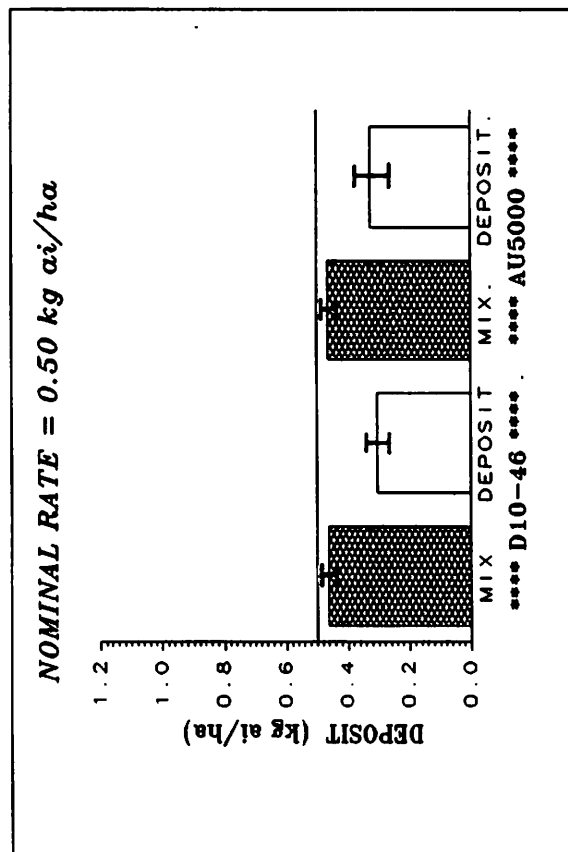
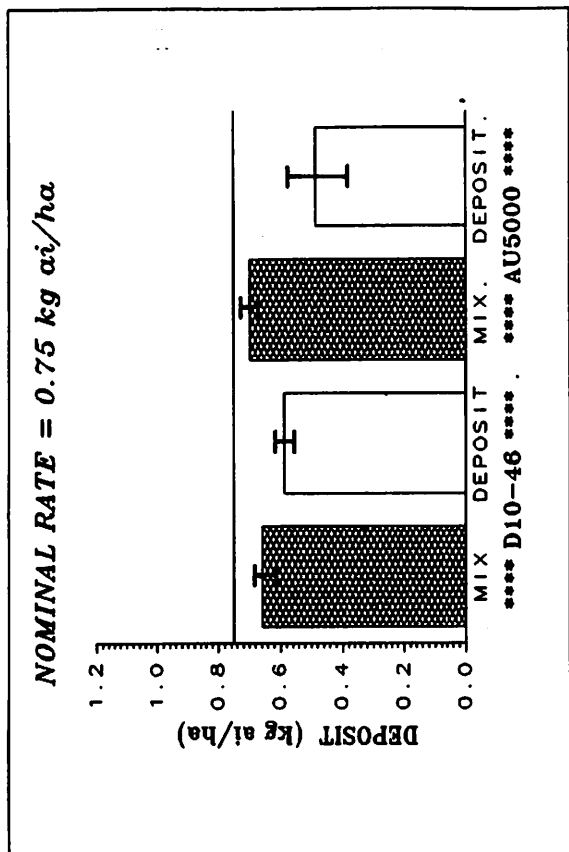
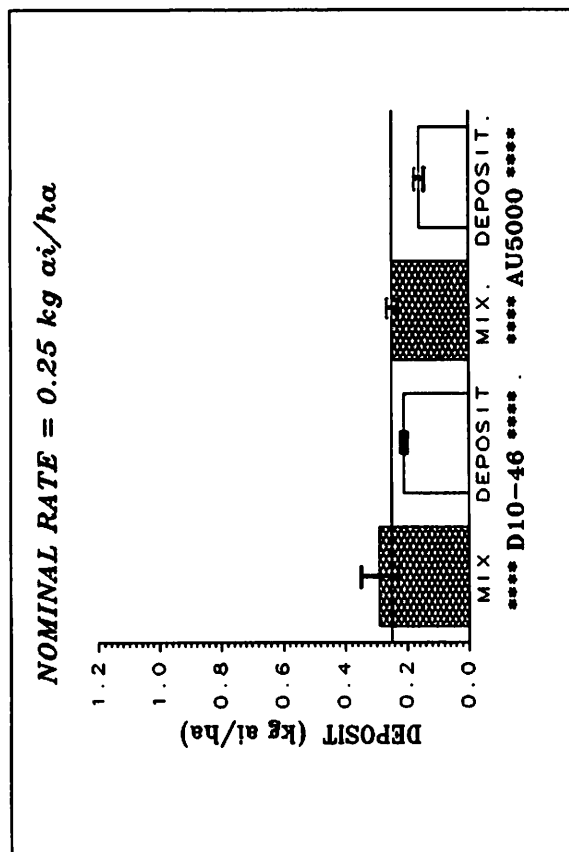


Figure 11. Mean deposit and tank mix - all blocks averaged.

A recommendation has been made, to the New Brunswick Department of Natural Resources, that several of this season's operational blocks be treated with AU5000s (as calibrated in this study) in order to provide additional support to the final conclusions produced in this study.

Figure 12 illustrates the regression of deposit on mix concentration for the two delivery systems. If 100% of the active ingredient in the mix were deposited, then the slopes of these regression lines would equal 1. While both regressions are significant, it is clear that the deposit of the D10 ($r^2 = 0.8683$) is somewhat more consistent than that of the AU5000 ($r^2 = 0.6107$). The 95 % confidence intervals for slope are:

$$0.3003 < \mu < 0.7151 \text{ (AU5000), and}$$

$$0.6173 < \mu < 0.9245 \text{ (D10).}$$

Since these intervals overlap, we really cannot conclude that the regression lines are different.

Figure 13 differs from Figure 12 only in that the 1.00kg, AU5000 treatments of blocks 107 and 386 have been removed (assuming we had a valid reason for doing so). This improves the AU5000 regression somewhat ($r^2 = 0.7229$).

Figure 14 illustrates the regression of deposit on calibrated rate for the two delivery systems. Both regressions are significant and the D10 ($r^2 = 0.9055$) still exhibits more consistent deposit than the AU5000 ($r^2 = 0.6343$). The 95 % confidence intervals for slope are:

$$0.3039 < \mu < 0.6695 \text{ (AU5000), and}$$

$$0.6284 < \mu < 0.8680 \text{ (D10).}$$

Again, since these intervals overlap, we have insufficient evidence to conclude that the regression lines are different.

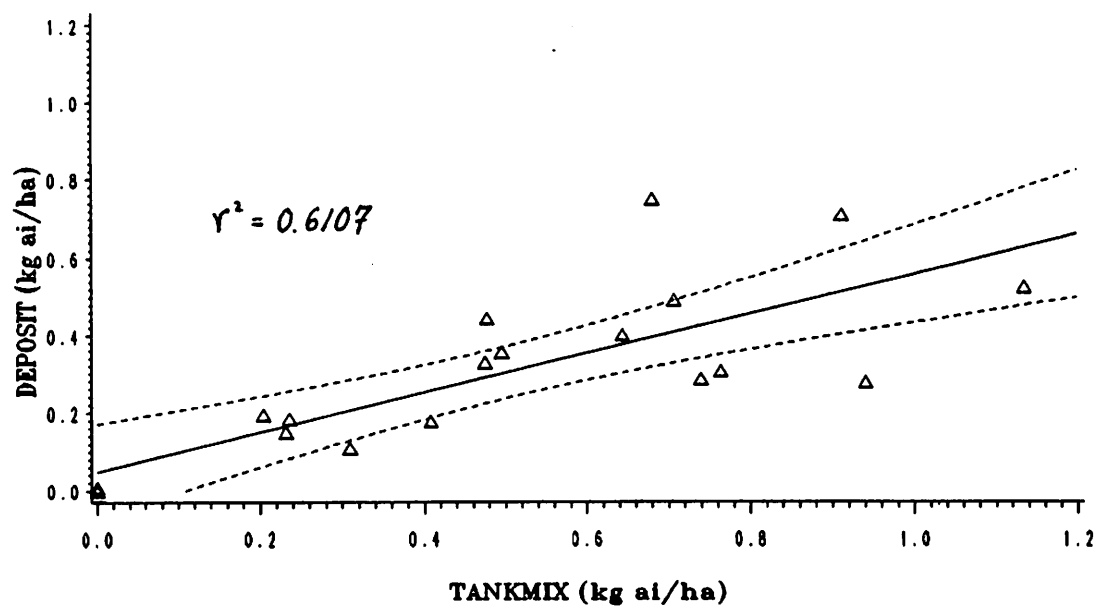
Figure 15 differs from Figure 14 only in that the 1.00kg, AU5000 treatments of blocks 107 and 386 have been removed (again, assuming we had a valid reason for doing so). This improves the AU5000 regression slightly ($r^2 = 0.6970$).

i) Droplet Density Data :

Figures 16a-16d plot deposit and droplet density over calibrated rate for each delivery system, by block. For each delivery system, droplet density should be constant through the range of rates tested (total volume was maintained at 37.4 l/ha). This rule holds true, in general, for all treatments except the 1.00kg, AU5000 treatment in plot 107. There, the factor(s) that functioned to suppress deposit also appears to have depressed density.

Analysis of variance of this data reflects this observation (Table 6). There is a highly significant amount of variation due to the different treatments ($F = 11.21$) and it is clear from the orthogonal contrasts that the majority of this variation is due to differences between the drop densities of the two delivery systems ($F = 7.06$) (recall that it was established in calibration that the AU5000 was producing about 1.7 times the number of droplets that the D10 was producing). While D10 density remains constant through the range of rates tested ($F = 0.42$), this does not hold true for the AU5000 ($F = 2.55$).

REGRESSION OF DEPOSIT ON TANKMIX – AU5000s :



REGRESSION OF DEPOSIT ON TANKMIX – D10-46s :

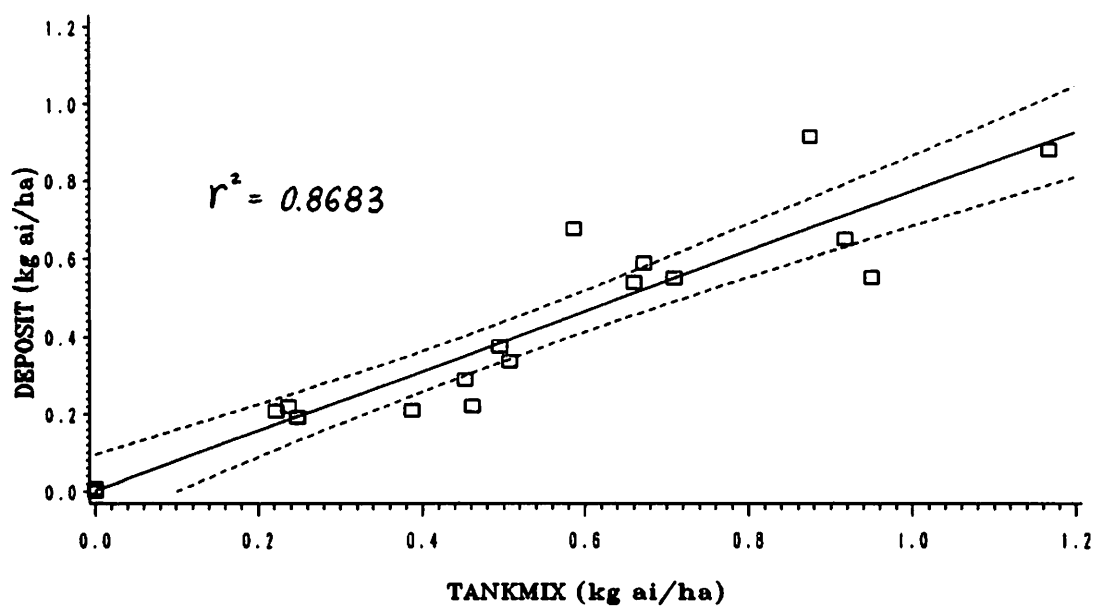
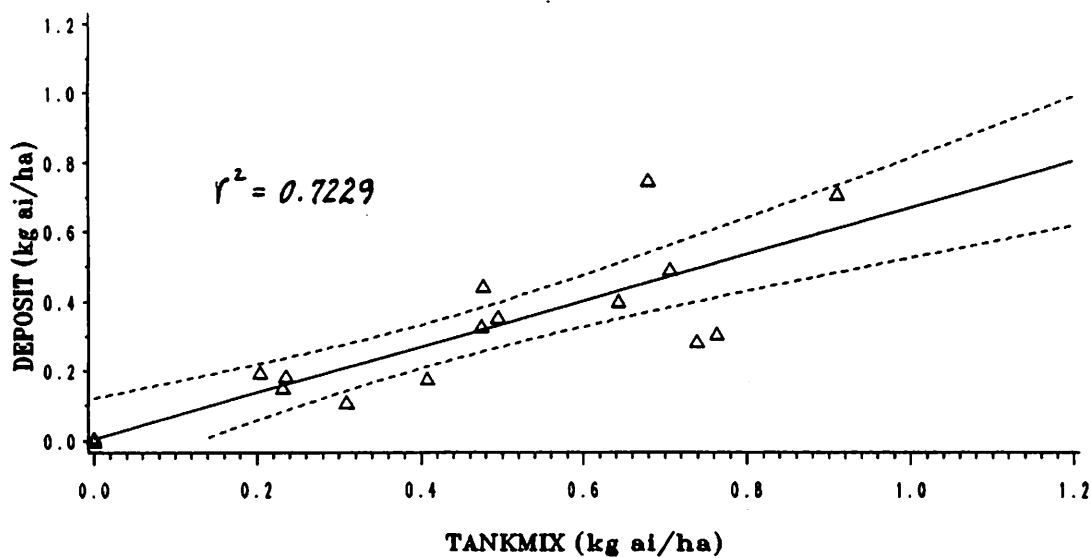


Figure 12. Deposit on mix concentration.

REGRESSION OF DEPOSIT ON TANKMIX - AU5000s :

(1 kg in plots 107 & 386 removed)



REGRESSION OF DEPOSIT ON TANKMIX - D10-46s :

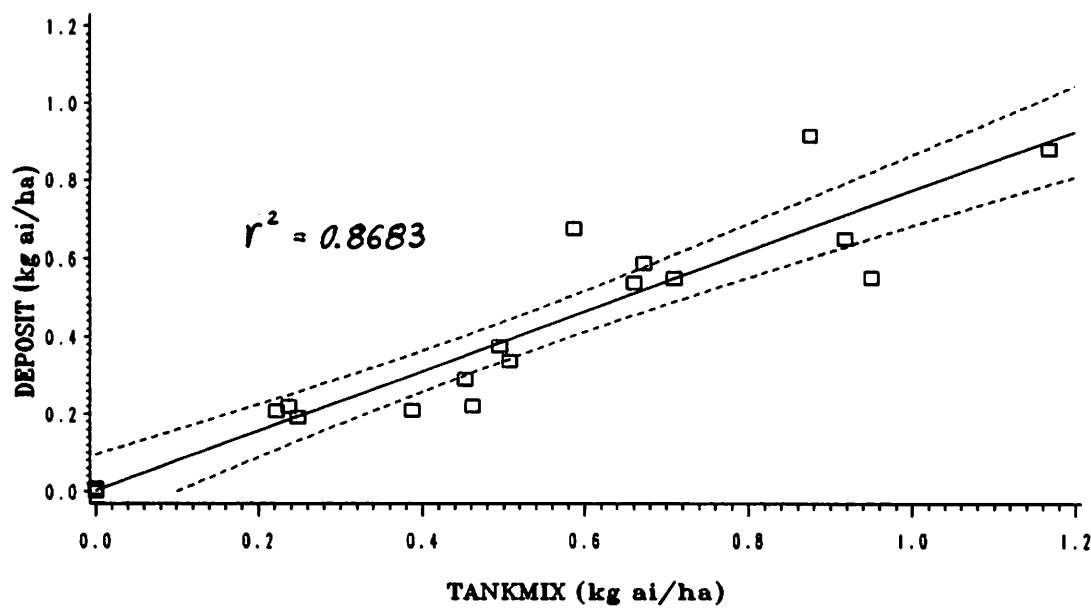
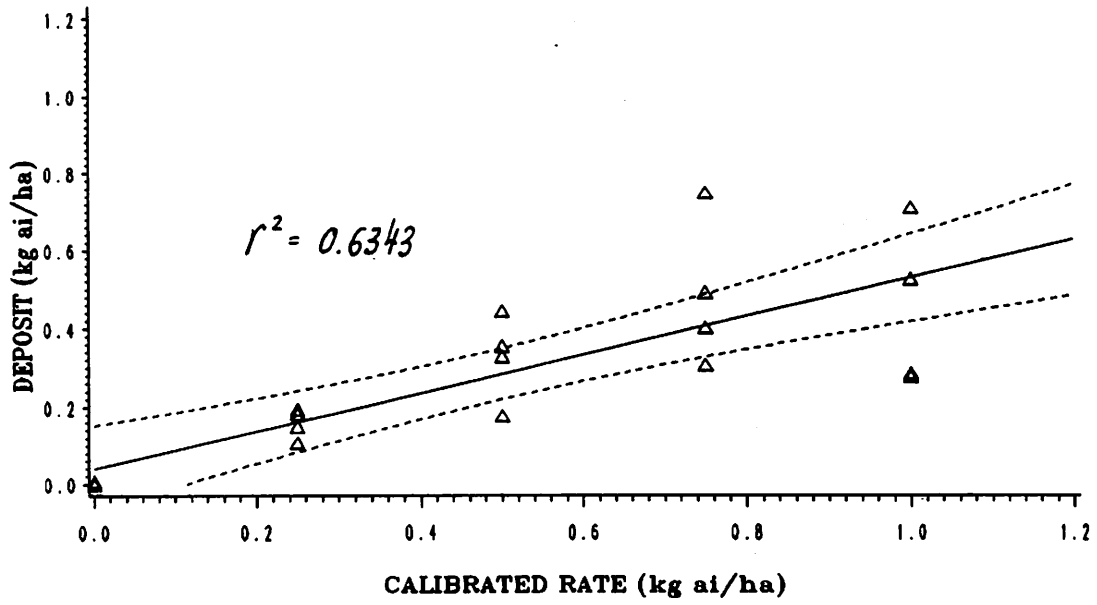


Figure 13. Deposit on mix concentration (outliers removed).

REGRESSION OF DEPOSIT ON RATE - AU5000s :



REGRESSION OF DEPOSIT ON RATE - D10-46s :

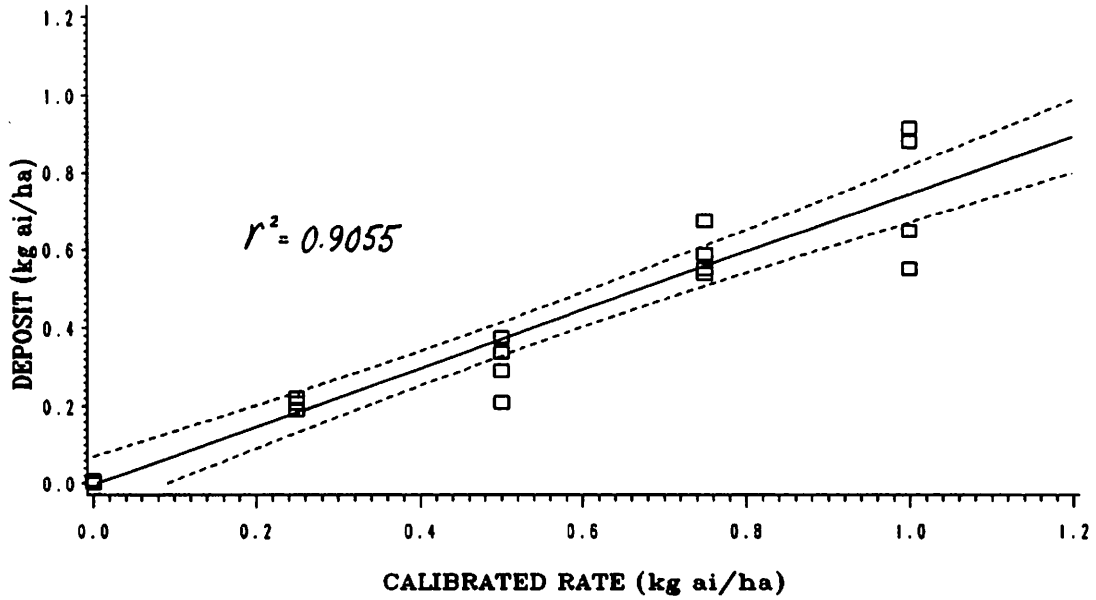
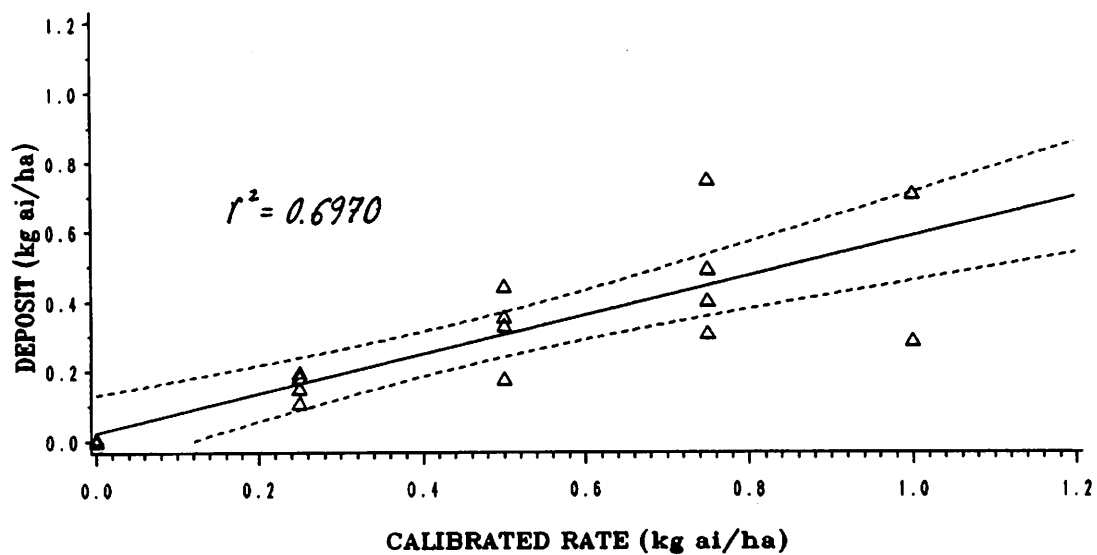


Figure 14. deposit on calibrated rate.

REGRESSION OF DEPOSIT ON RATE – AU5000s :

(1 kg in plots 107 & 388 removed)



REGRESSION OF DEPOSIT ON RATE – D10-46s :

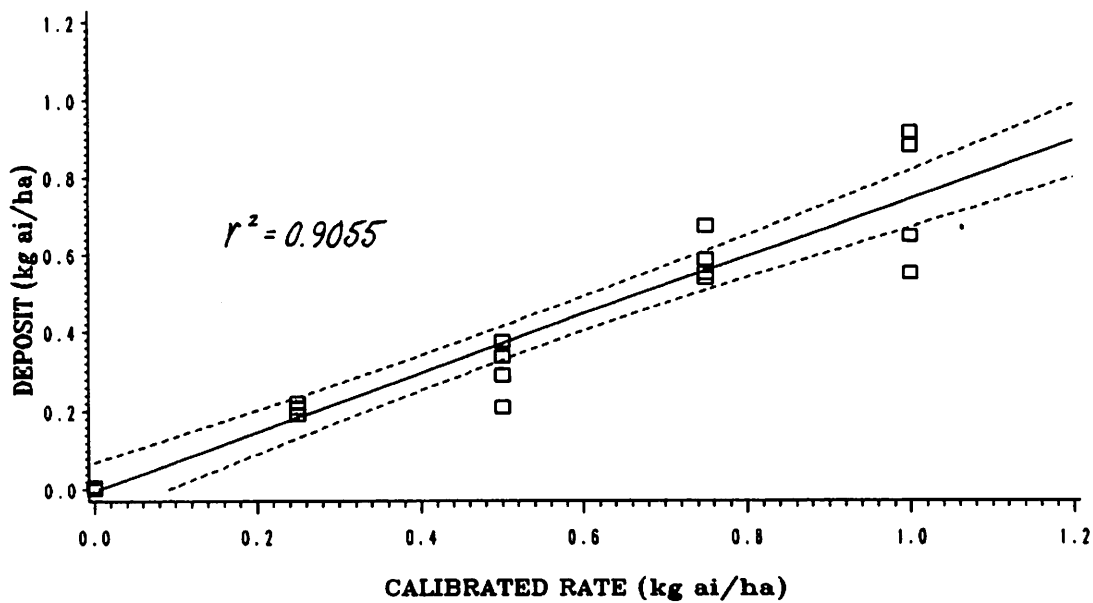
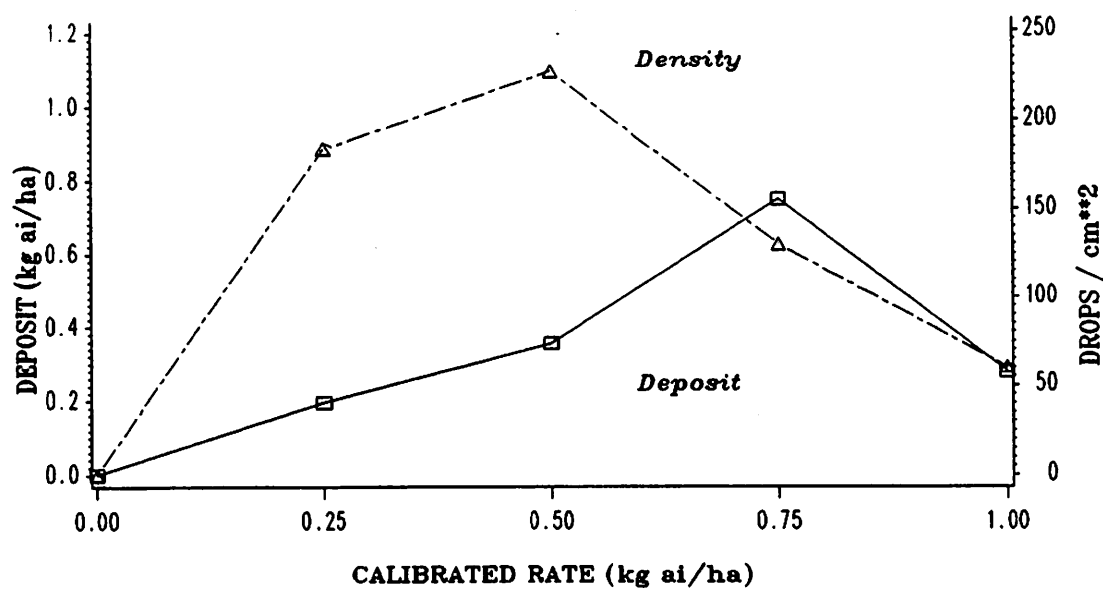
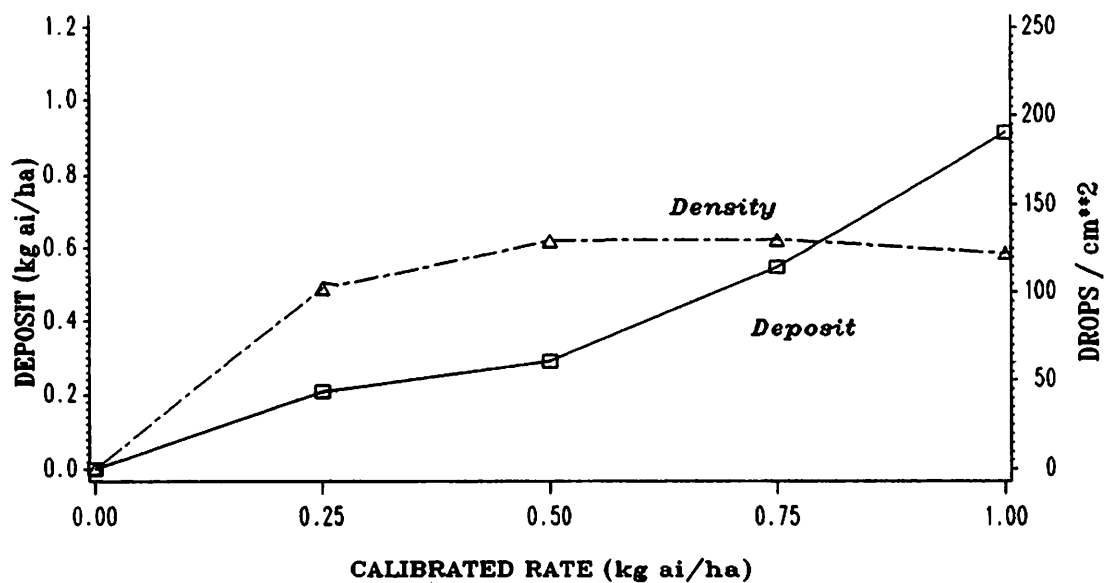


Figure 15. Deposit on calibrated rate (outliers removed).

BLOCK.107 - AU5000s:

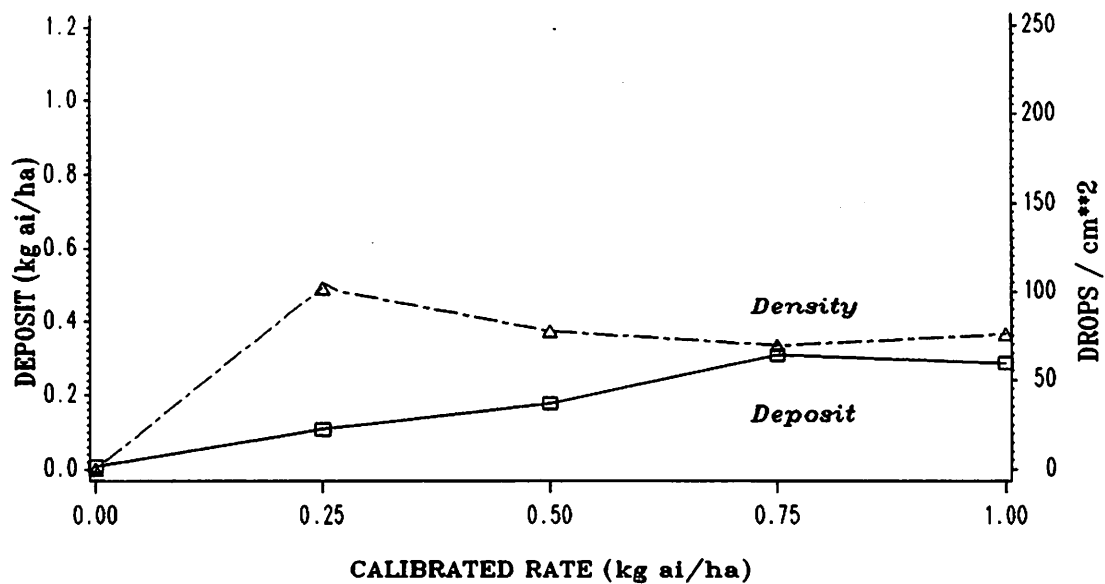


BLOCK 107 - D10-46:

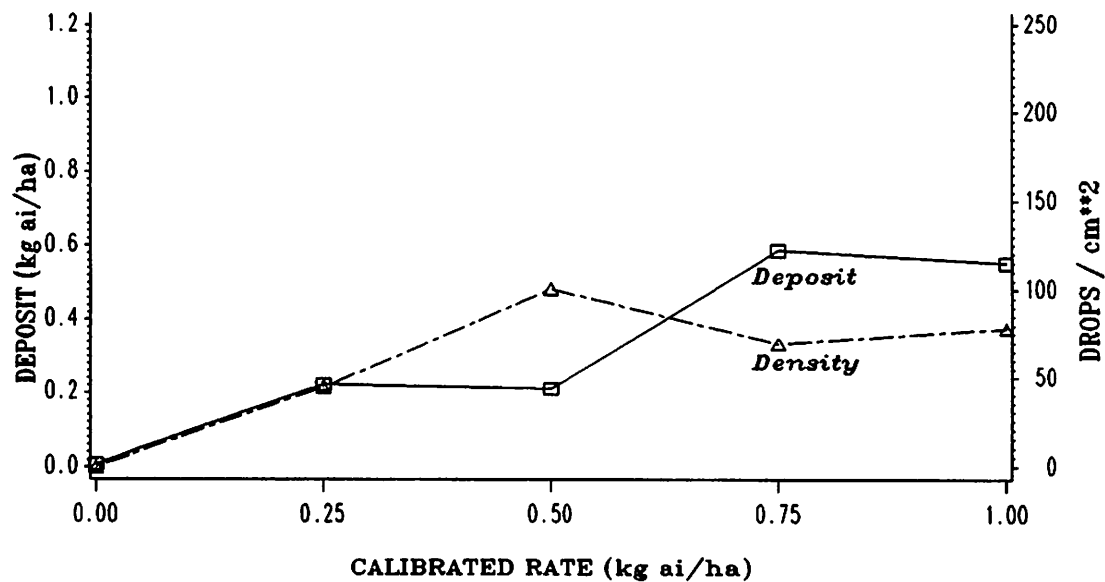


**Figure 16a. Density and deposit over rate
-block 107.**

BLOCK.056 - AU5000s:

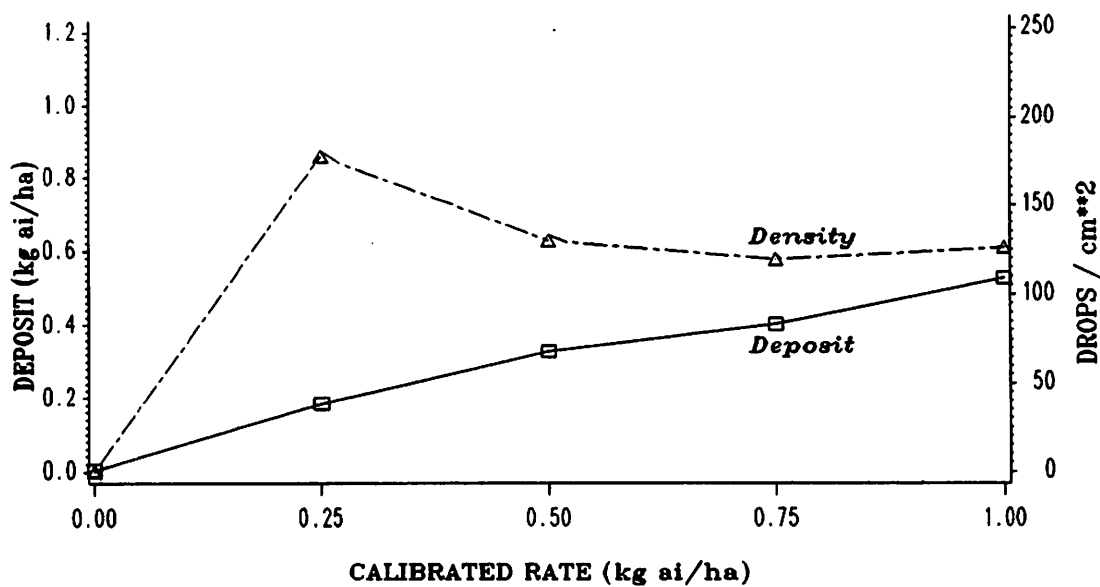


BLOCK 056 - D10-46:



**Figure 16b. Density and deposit over rate
-block 056.**

BLOCK.386 - AU5000s:



BLOCK 386 - D10-46:

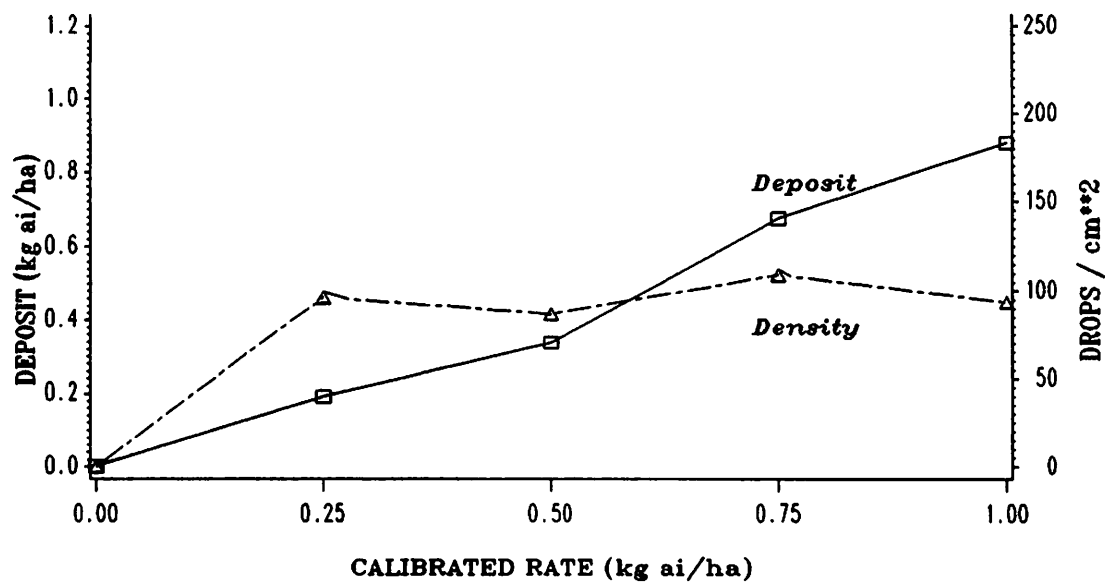
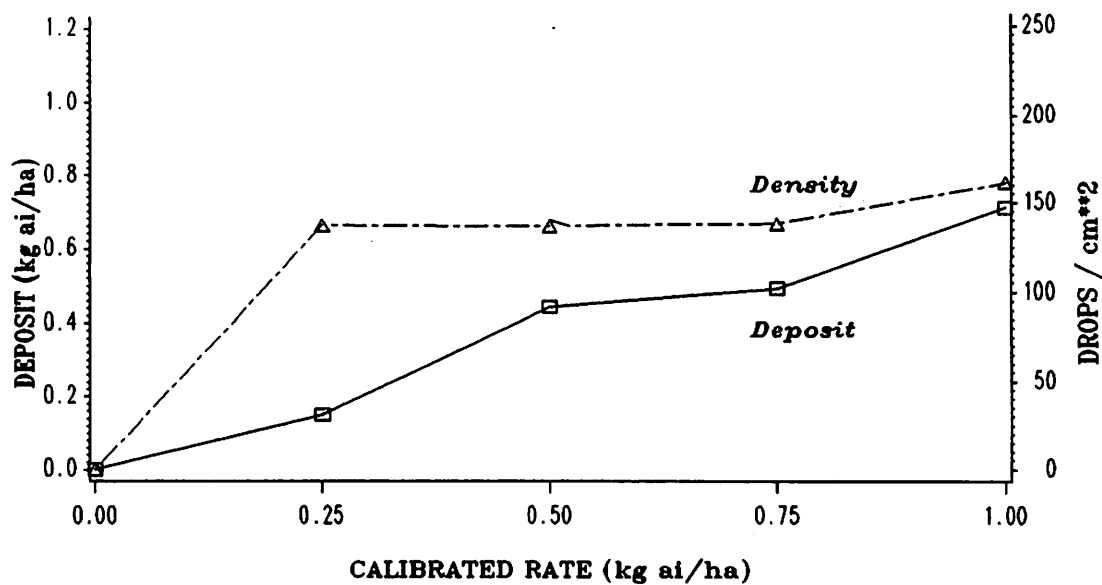
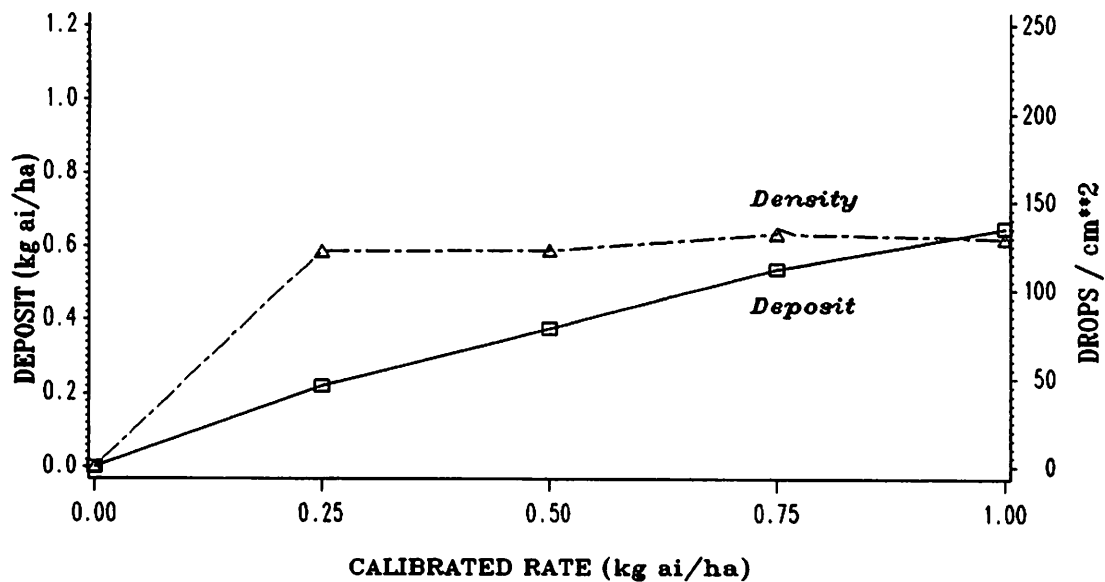


Figure 16c. Density and deposit over calibrated rate -block 386.

BLOCK 390 - AU5000s:



BLOCK 390 - D10-46:



**Figure 16d. density and deposit over rate
-block 390.**

Table 6. ANOVA table for droplet density.

<u>SOURCE OF VARIATION</u>	<u>DF</u>	<u>SS</u>	<u>F</u>	<u>P > F</u>
TREATMENTS	8	282707.7382	11.21	.0001
(AU5000 vs D10)	(1)	(22261.4657)	7.06	~.0154
(within AU5000s)	(3)	(24115.1836)	2.55	~.0838
(within D10s)	(3)	(3999.1041)	0.42	~.7414
(CONTROL vs TREATED)	(1)	(232331.9848)	73.67	<.001
BLOCKS	3	71818.3642		
TREATMENT*BLOCKS (error)	24	75687.6417	2.06	.0054
SUBSAMPLES w. TREATMENTS & BLOCKS	132	202530.9167		
TOTAL	167	632744.6608		

j) Budget Status :

Table 7 summarizes expenditures to date.

Table 7. Improved-use trial expenditures as of 06/04/89.

a) Summary of field expenditures to date :

1414.98	(Pitt, July site selection)
3499.62	(Roden, " ")
1921.23	(Studens, Aug application)
1507.80	(Buscarini, " ")
1780.65	(Robinson, " ")
4278.78	(Pitt, plot est. & application))
1135.90	(Flemming, N.B. tour)
318.77	(DNR, motel accom. for helpers))
100.11	(Pitt, film processing)
31.60	(Pitt, film processing)
811.10	(Pitt, pest control forum)
418.50	(Pitt, help from RPC)
78.12	(Pitt, 3M paper for deposit)
<u>37.68</u>	(Pitt, film)

17334.84 ----> 21465 Budgeted = 4130.16 remaining

- expected additional expenses : unknown

b) Summary of lab expenditures :

708.46	(Thompson, Canlab - petri dishes)
609.53	(Thompson, Fisher - lab materials)
263.59	(Thompson, Supelco - lab materials))
<u>1166.30</u>	(Thompson, - lab materials))

2747.88 ----> 9500 Budgeted = 6752.12 remaining

- expected additional expenses : 6752.12
(replacement costs of resins & HPLC columns)

c) Summary of total expenditures to date:

20082.72 ----> 30965 Budgeted = 10882.28 remaining

- expected free balance : 4000.00

An additional \$ 6400.00 is tentatively secured for 1989 work on this trial (pending a new FRDA for New Brunswick).

k) Plans For Subsequent Data Collection :

Post-treatment raspberry cover and crop health data collection will conform to the procedures followed in the pre-treatment assessment. The plots and subplots are permanently marked and numbered, so it is simply a matter of locating and remeasuring them.

Last summer, there was some concern that pre-treatment disturbance of raspberry cover would impair the uptake of glyphosate, thereby biasing the post-treatment data (activity around the subplots may have resulted in some trampling of raspberry bushes). As a contingency plan, in the event that this concern becomes reality, I plan to do as follows. I will be taking large-scale (1:200) colour aerial photographs of all of the plots this summer, as a means of 'illustrating' treatment differences (if there are any). Percent cover of raspberry could be measured directly from such photography with a degree of accuracy that is at least as good as that of ground measurements. Ground-measured percent cover could then be correlated with photo-measured percent cover (based on the remaining untreated plots) and, from the resulting equation, photo-measured cover in the damaged plots could be translated to 'ground-measured' values. This would eliminate the time-consuming task of relocating the subplots and the potential for error in doing so.

There was also concern last summer, that young hardwood brush (particularly pin cherry) on some of the blocks would have an effect on chemical deposit. In order to account for this potential source of variation in deposit, I plan to collect the following data from each subplot:

- 1) Brush density, by species. The proposed sampling method for this procedure is illustrated in Figure 17. Plots of fixed radius may not provide density data that correlates closely with on-target deposit because brush height and distance from plot center are not considered. For example, we may arbitrarily choose a sample unit with a 2-m radius. There will be instances where there are 3m bushes, 2.5m away from the crop tree at plot center, that could easily have intercepted a portion of the active ingredient destined for the plot. Similarly, there will be instances where there are shorter stems, near but inside, the fixed plot boundary that really would have had little effect on deposit. The proposed sample method involves the projection of a sample boundary at a 45° angle from the base of the crop tree or sample center. As such, any brush stem that is greater in height than its distance from plot center will be considered in the sample. This method should provide better data for correlation with chemical deposit.
- 2) Brush condition, by species. This will provide a measure of the impact that the herbicide had on the brush itself and may help to elucidate differences between treatments. Of particular interest will be the comparison of pre- and post-treatment density (live stems before vs. live stems after. The 5 Condition Classes used for crop evaluation will be applied here.
- 3) Average height of the brush included in each sample. This may provide an additional variable that may help to explain variation in deposit.

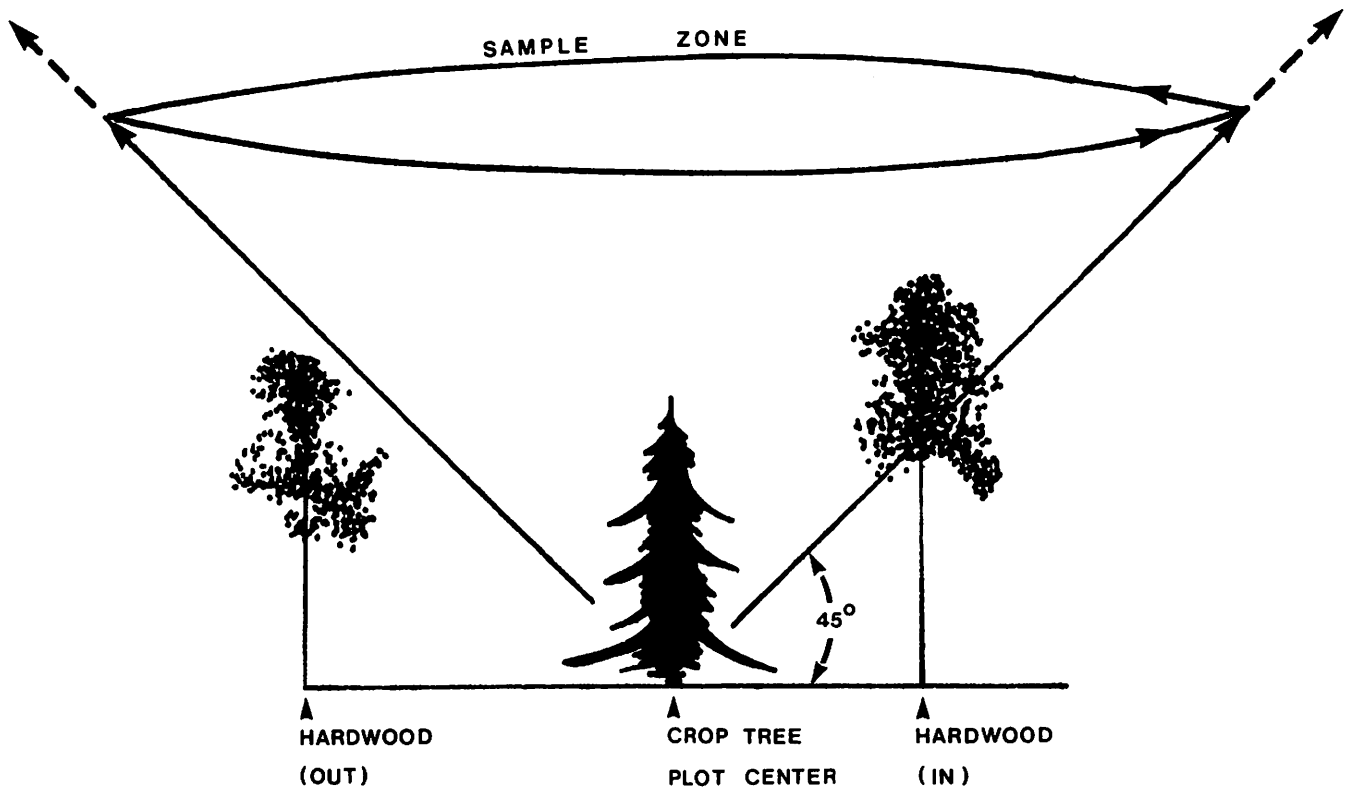


Figure 17. Proposed brush sampling method.

1) References :

- Bode, L.E. and B.J. Butler.. 1982. The three Ds of droplet size: diameter, drift, and deposit. World Agric. Aviation. May. p. 37-39.
- Hofstra, G. and N. Payne. 1988. Personal communication, Nov.15, 1988; Dr. Hofstra is a Professor at Guelph University, Dept. of Environmental Biology, Dr. Payne is Study Leader, Pesticide Atomization and Dispersal, Forest Pest Management Institute.
- Prasad, R. and B.L. Cadogan. 1987. Influence of small droplets on herbicide efficacy. Proc. A.C.A.F.A. Symposium, Oct. 23-25, Ottawa. p.1-12.
- Prasad, R. and B.L. Cadogan. 1988. Role of droplet size and density on phytotoxicity of three herbicides. Weed Technology (in press) M.S. 25pp.
- Reilley, C. 1988. Personal communication Sept. 2, 1988; Researcher in Spray Technology, Research and Productivity Council, Fredericton, New Brunswick.

Doug Pitt