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THIS IS A PROGRESS REPORT ON AEROJET'S STUDIES OF EXPERIMENTS CURRENTLY UNDERWAY (E.G., PLANT GROWTH & DIMP DCPD LYSIMETER TESTS). THE TWO GROUPS OF FULL SCALE LYSIMETER TESTS ARE STILL IN PROGRESS. GROUP I HAS BEEN TERMED "CHRONIC" EXPOSURE AND GROUP 2 "SINGLE CHARGE," EXPOSURE. THE FULL SCALE SOIL CULTURE EXPERIMENTS HAVE REACHED A STAGE WHERE ANALYSIS OF THE PLANT TISSUE HAS BEGUN.





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AEROJET ORDNANCE AND MANUFACTURING COMPANY

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# DETERMINATION OF DECONTAMINATION CRITERIA

DIMP AND DCPD (U)

Report No. 1953-01(13)MP

Contract DAMD-17-75-C5069

to

U.S. ARMY, Ft. Detrick

Fredrick, Maryland 21701





Prepared by: P. A. O'Donovan
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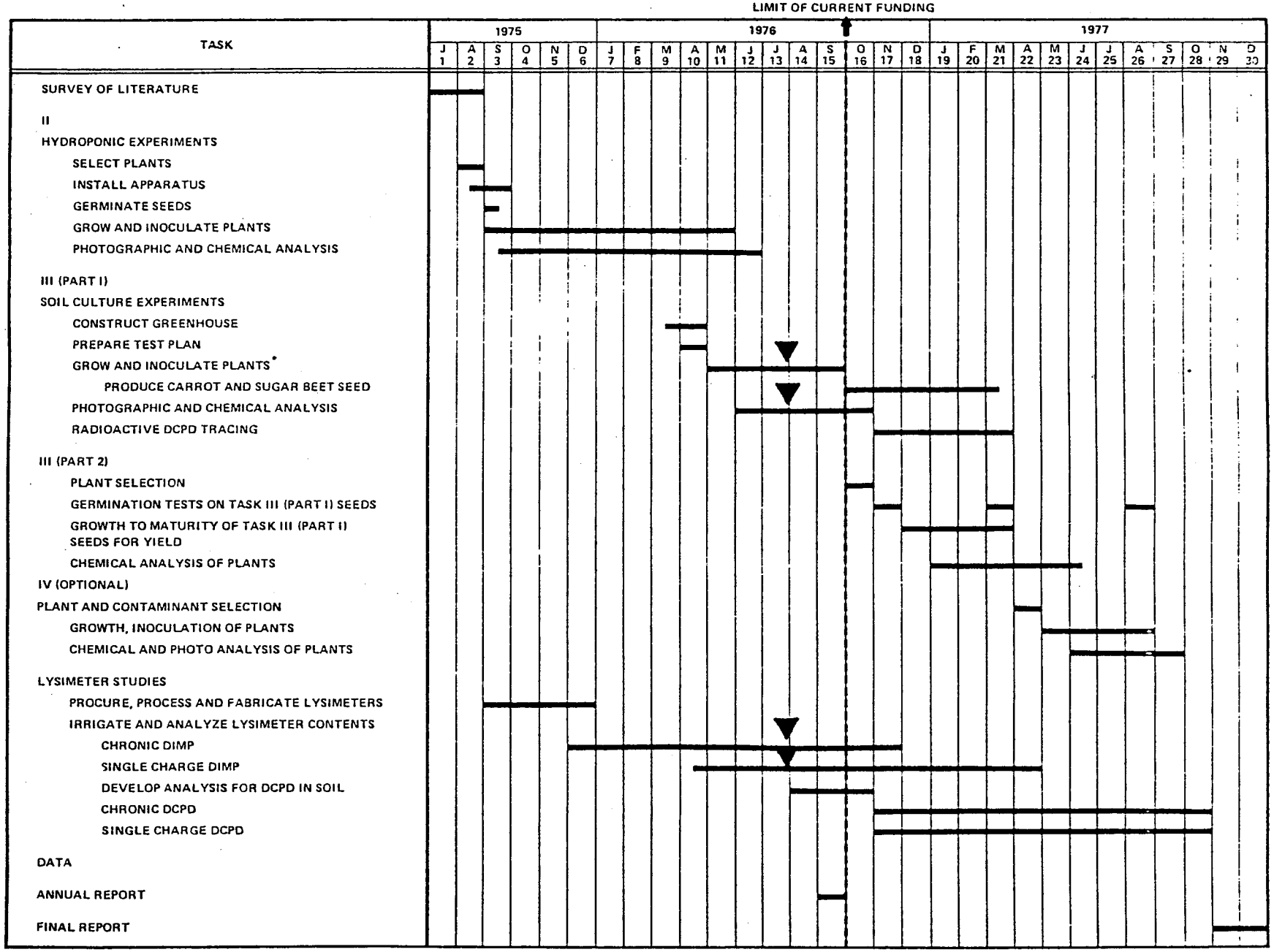
Date: 7 August 1976

No. of Pages 25

# DETERMINATION OF DECONTAMINATION CRITERIA DIMP AND DCPD RESEARCH TASK SCHEDULE




*POSSIBLE SLIPPAGE POINT. ADJUSTMENT OF CONTAMINANT AT THIS POINT SHIFTS ALL FOLLOWING PLANT WORK TO THE RIGHT.

▼ Satisfactory Progress - on Schedule

Progress on items proposed for action during july, 1976 is discussed in the following paragraphs.

## FULL SCALE LYSIMETER TESTS

The two groups of full scale lysimeter tests are still in progress. The five types of soil used in these tests are:

| | | |
|---|---|---|
| Chino | - | Sandy clay loam |
| Brawley | - | Silty Clay |
| Ventura | - | Clay loam |
| Fullerton | - | Sandy loam |
| Walnut | - | Clay loam |

The two groups of lysimeters contain one each of the above soil types. In Group 1 the lysimeters are subjected to an irrigation flow of two inches of distilled water (12, 887 ml) contaminated with 20 ppm (parts per million) DIMP (diisopropyl methyl phosphonate) applied once every two weeks. In Group 2 the top one foot depth of soil was intimately mixed (dry) with DIMP to result in a concentration of 20 ppm and has been subjected to irrigation with distilled water at the rate of 12, 887 ml every two weeks. Group 1 has been termed "chronic" exposure and Group 2 "single charge" exposure.

The water volume drained from the lysimeter in two weeks, divided by the volume applied (12, 887 ml), results in a ratio which has been designated drainage efficiency. This ratio appeared to be approaching an equilibrium value (i.e. 0.4 - 0.6) after an initial period of irregular values. During the most recent report period, however, the ratio has dropped considerably. Table 1 lists the drainage efficiencies from the Group 1 lysimeters. To reduce the number of points plotted the data in Table 1 consists of the average values for each successive pair of data points. Figure 1 is a plot of the data in Table 1.

Table 2 lists the drainage efficiencies of the Group 2 lysimeters. This data is plotted in Figure 2. Figure 3 shows the average drainage efficiencies for all the members of each group.

Table 1

Lysimeter Drainage Efficiencies (Group 1)

| Lysimeter Age - Days | Chino | Brawley | Ventura | Fullerton | Walnut | Average |
|---|---|---|---|---|---|---|
| 10.5 | 1.04 | 0.93 | 0.91 | 1.00 | 0.88 | .95 |
| 26 | 0.59 | 0.62 | 0.57 | 0.49 | 0.64 | .58 |
| 38.5 | 0.58 | 0.57 | 0.54 | 0.55 | 0.58 | .57 |
| 52.5 | 0.47 | 0.60 | 0.60 | 0.60 | 0.60 | .58 |
| 66.5 | 0.73 | 0.86 | 0.90 | ** | 0.83 | .79 |
| 80.5 | 0.75 | 0.81 | 0.74 | ** | 0.73 | .78 |
| 93.5 | 0.57 | 0.78 | 0.61 | ** | 0.66 | .67 |
| 112 | 0.64 | 0.65 | 0.62 | 0.43 | 0.54 | .58 |
| 140 | 0.52 | 0.75 | 0.62 | 0.42 | 0.41 | .55 |
| 168 | 0.54 | 0.42 | 0.55 | 0.40 | 0.40 | .46 |
| 195 | 0.41 | 0.57 | 0.63 | 0.51 | 0.49 | .52 |
| 216* | 0.26* | 0.07* | 0.43* | 0.28* | 0.33* | .27 |

*Single value, not average.

**Do not fit sampling sequence.

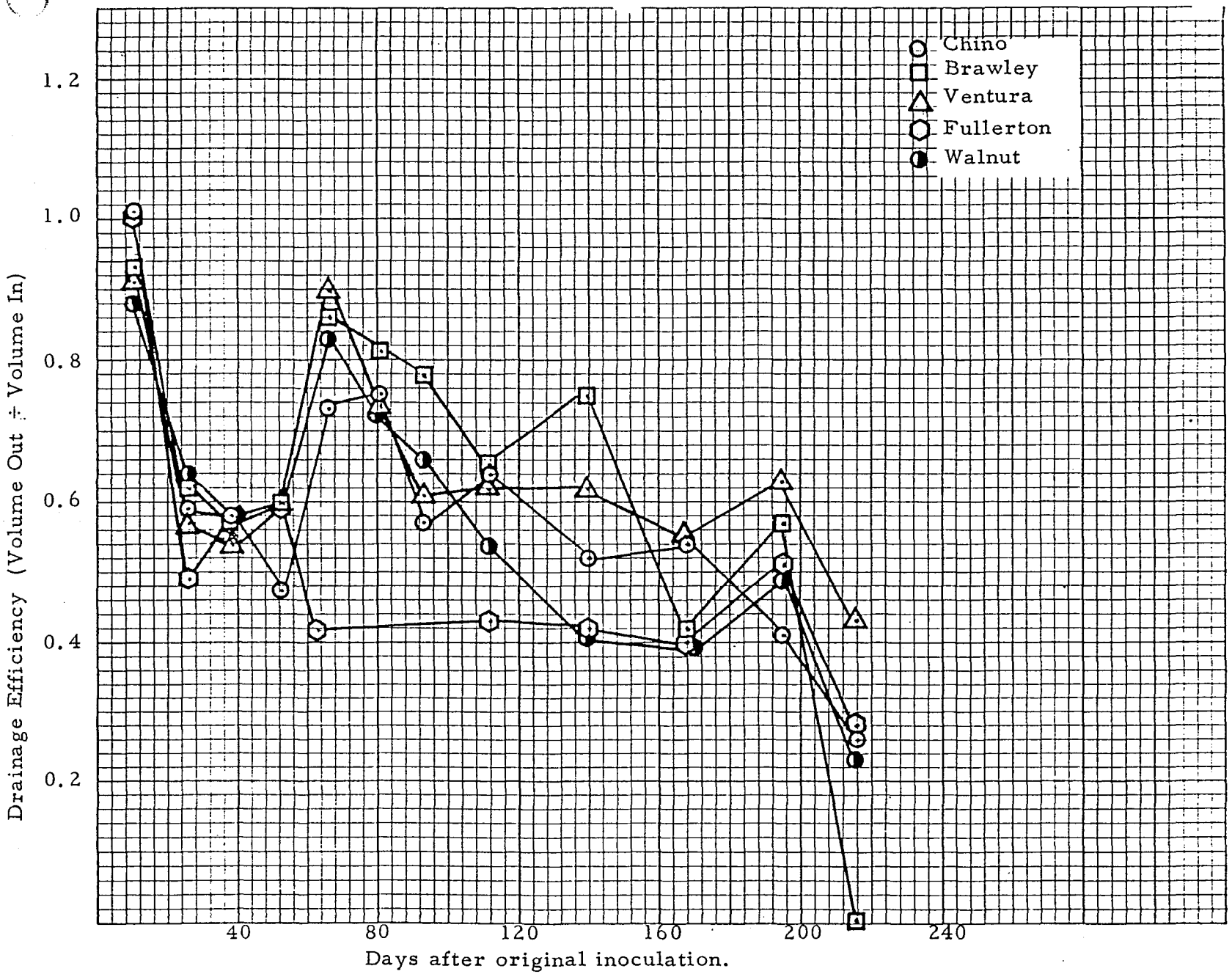



Figure 1. Drainage efficiencies of various soils in full scale lysimeters (Group 1).

Table 2

Drainage Efficiencies (Group 2)

| Lysimeter Age - Days | Chino | Brawley | Ventura | Fullerton | Walnut | Average |
|---|---|---|---|---|---|---|
| 7 | 0.03 | 0.12 | 0.13 | 0.07 | 0.09 | 0.09 |
| 14 | 0.01 | 0.04 | 0.11 | 0.03 | 0.00 | 0.04 |
| 21 | 0.02 | 0.00 | 0.00 | 0.13 | 0.08 | 0.05 |
| 28 | 0.20 | 0.02 | 0.11 | 0.35 | 0.47 | 0.23 |
| 35 | 0.30 | 0.18 | 0.32 | 0.44 | 0.48 | 0.34 |
| 42 | 0.31 | 0.33 | 0.41 | 0.41 | 0.56 | 0.40 |
| 56 | 0.72 | 0.70 | 1.03 | 0.90 | 0.91 | 0.85 |
| 70 | 0.35 | 0.34 | 0.47 | 0.63 | 0.44 | 0.45 |
| 84 | 0.10 | 0.05 | 0.21 | 0.30 | 0.24 | 0.18 |
| 98 | 0.11 | 0.10 | 0.23 | 0.34 | 0.35 | 0.23 |

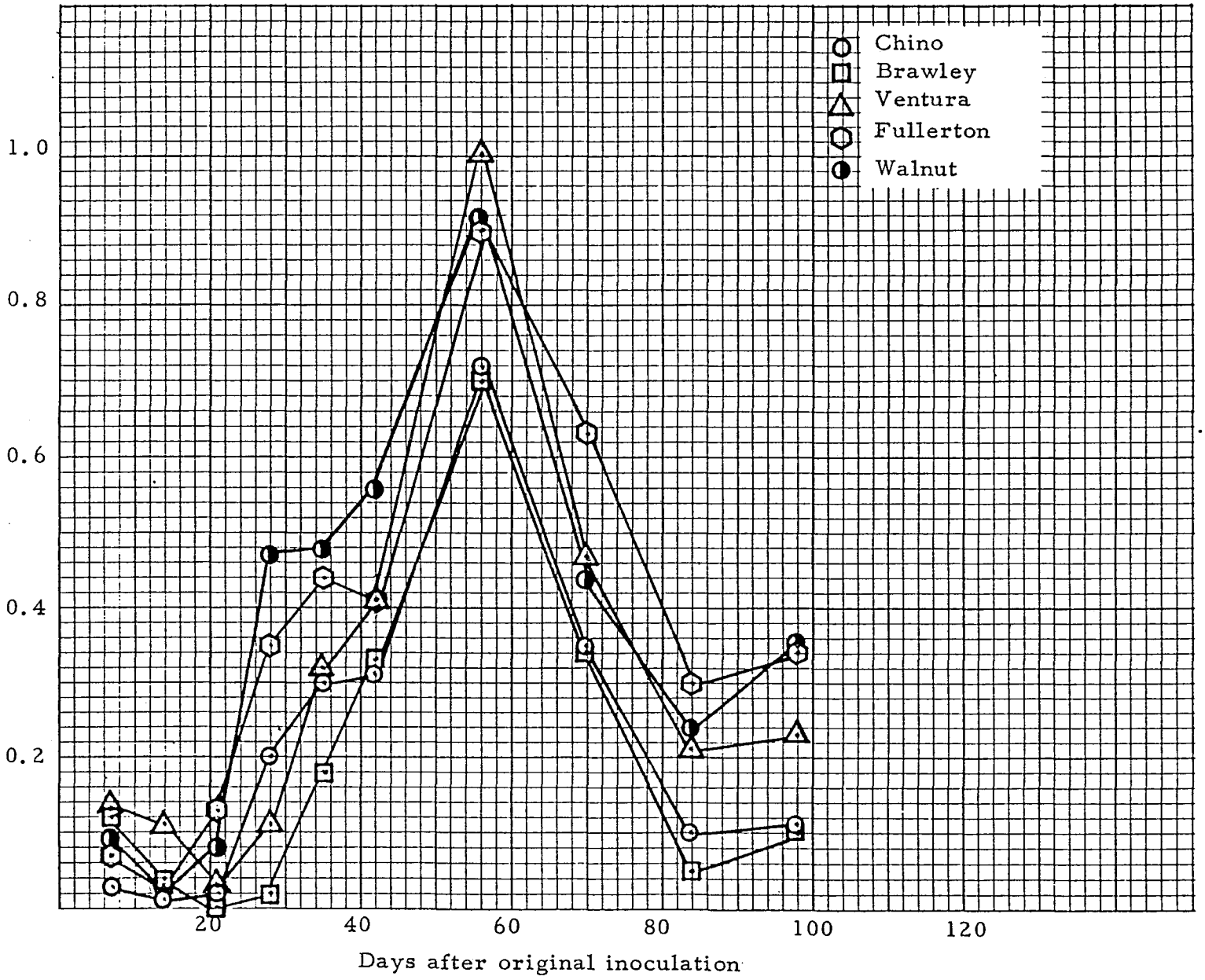



Figure 2. Drainage efficiencies of various soils in full scale lysimeters (Group 2).

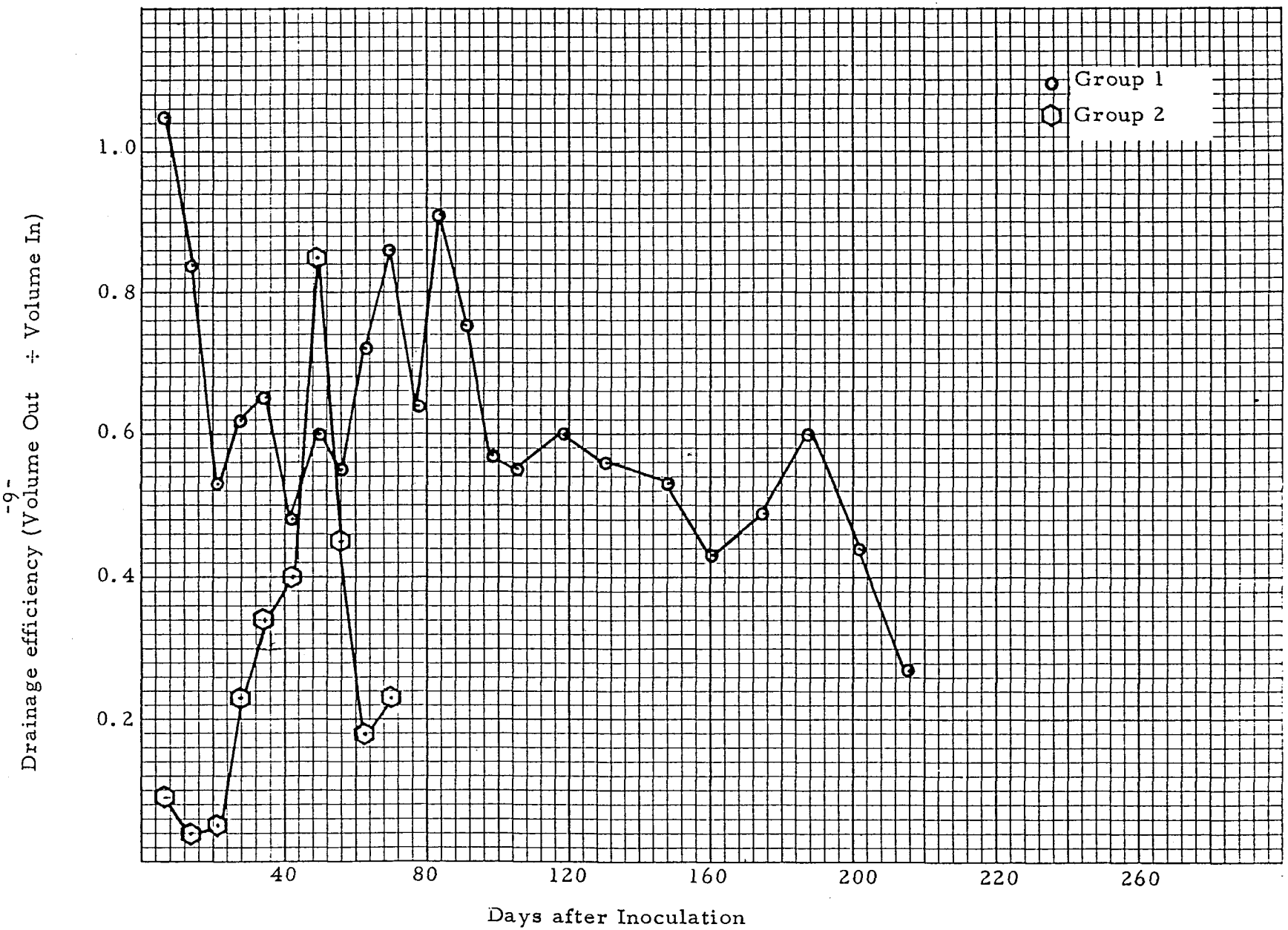



Figure 3. Drainage efficiencies of various soils in full scale lysimeter, Average of all samples within the groups.

It is during this period that the ambient temperature has been unusually high and an attempt will be made to correlate temperature with drainage efficiency.

Data related to the evaluation of the drainage efficiency of the soils is the moisture content of the soils at various depths. Tables 3 and 4 show the moisture content of the various soils after 2 week drainage periods from the most recent water addition. These values are plotted as points in Figure 4. The lines in Figure 4 are fitted to the data points from the previous month's moisture evaluations. This plot shows that the soil moisture values have also appeared essentially to reach an equilibrium value.

Water added to the lysimeters is sampled at various depths as it percolates down through the soil. This sampling is done by means of a tensiometer tube which is subjected to a vacuum prior to the sampling time to attempt to assure that there will be samples in the tubes. These tensiometer samples are subjected to GLC (gas-liquid chromatographic) analysis for DIMP content. Tables 5 and 6 show the values determined by these analyses during the current period. Figures 5a, b, c, d and e are plots of the tensiometer data from the last several sampling periods for Group 1 samples. The general trend can be seen as the most concentrated sample at the top of the lysimeter progressing downward to greater depths. There is a trend also toward lower concentrations in the older samples progressing upward as the age of the lysimeter increases. The data in Table 6 indicates that the DIMP which was applied to the lysimeters in a single charge is still moving very slowly down into the lysimeter. The DIMP has reached the second to third level of tensiometers (18-30 inches) in all of the lysimeters.

The soil in the lysimeters has also been sampled and analyzed for DIMP content. Table 7 shows the values obtained for the samples from Group 2.

Table 3

% Loss on Drying of Soil from East Lysimeters - Group 1
(after 2 week drainage) (207 days from original inoculation)

| Sample Depth | Ventura | Chino | Fullerton | Walnut | Brawley | Mean |
|---|---|---|---|---|---|---|
| 1/8-6" | 10.25 | 9.63 | 10.31 | 11.75 | 12.18 | 10.82 |
| 6 - 12" | 12.04 | 14.45 | 11.72 | 13.58 | 16.49 | 13.66 |
| 12 - 18" | 5.47* | 14.84 | 12.89 | 15.12 | 17.56 | 15.10 |
| 18 - 24" | 2.68* | 14.21 | 11.52 | 17.04 | 18.79 | 15.39 |
| 24 - 30" | 13.07 | 14.73 | 11.17 | 17.79 | 17.82 | 14.92 |
| 30 - 36" | 14.32 | 15.16 | 12.42 | 16.50 | 12.88 | 14.26 |
| 36 - 42" | 15.52 | 15.73 | 15.96 | 14.43 | 19.70 | 16.27 |
| 42 - 48" | 17.01 | 15.47 | 16.97 | 13.01 | 14.08 | 15.31 |
| 48 - 54" | 16.23 | 15.37 | 17.99 | 17.17 | 21.97 | 17.75 |
| 54 - 60" | 15.24 | 17.88 | 19.97 | 19.32 | 22.98 | 19.08 |

*Sample left open.

Table 4

% Loss on Drying of Soil from West Lysimeters - Group 2
(after 2 week drainage) ( 84 days from original inoculation)

| Sample Depth | Ventura | Chino | Fullerton | Walnut | Brawley | Mean |
|---|---|---|---|---|---|---|
| 1/8"-6" | 5.95 | 13.05 | 11.93 | 14.00 | 14.51 | 11.89 |
| 6 - 12" | 7.28 | 15.30 | 14.02 | 15.88 | 17.99 | 14.09 |
| 12 - 18" | 16.40 | 17.00 | 12.53 | 17.30 | 19.96 | 16.64 |
| 18 - 24" | 16.52 | 16.79 | 14.28 | 19.30 | 19.01 | 17.18 |
| 24 - 30" | 17.36 | 16.79 | 15.68 | 17.42 | 20.55 | 17.56 |
| 30 - 36" | 17.84 | 17.17 | 17.03 | 20.76 | 22.36 | 19.03 |
| 36 - 42" | 18.70 | 17.77 | 18.59 | 21.76 | 21.97 | 19.76 |
| 42 - 48" | 20.09 | 18.35 | 20.10 | 24.64 | 21.97 | 21.03 |
| 48 - 54" | 21.24 | 19.15 | 19.80 | 25.60 | 21.60 | 21.48 |
| 54 - 60" | 19.12 | 19.87 | 20.75 | 20.70 | 21.41 | 20.37 |

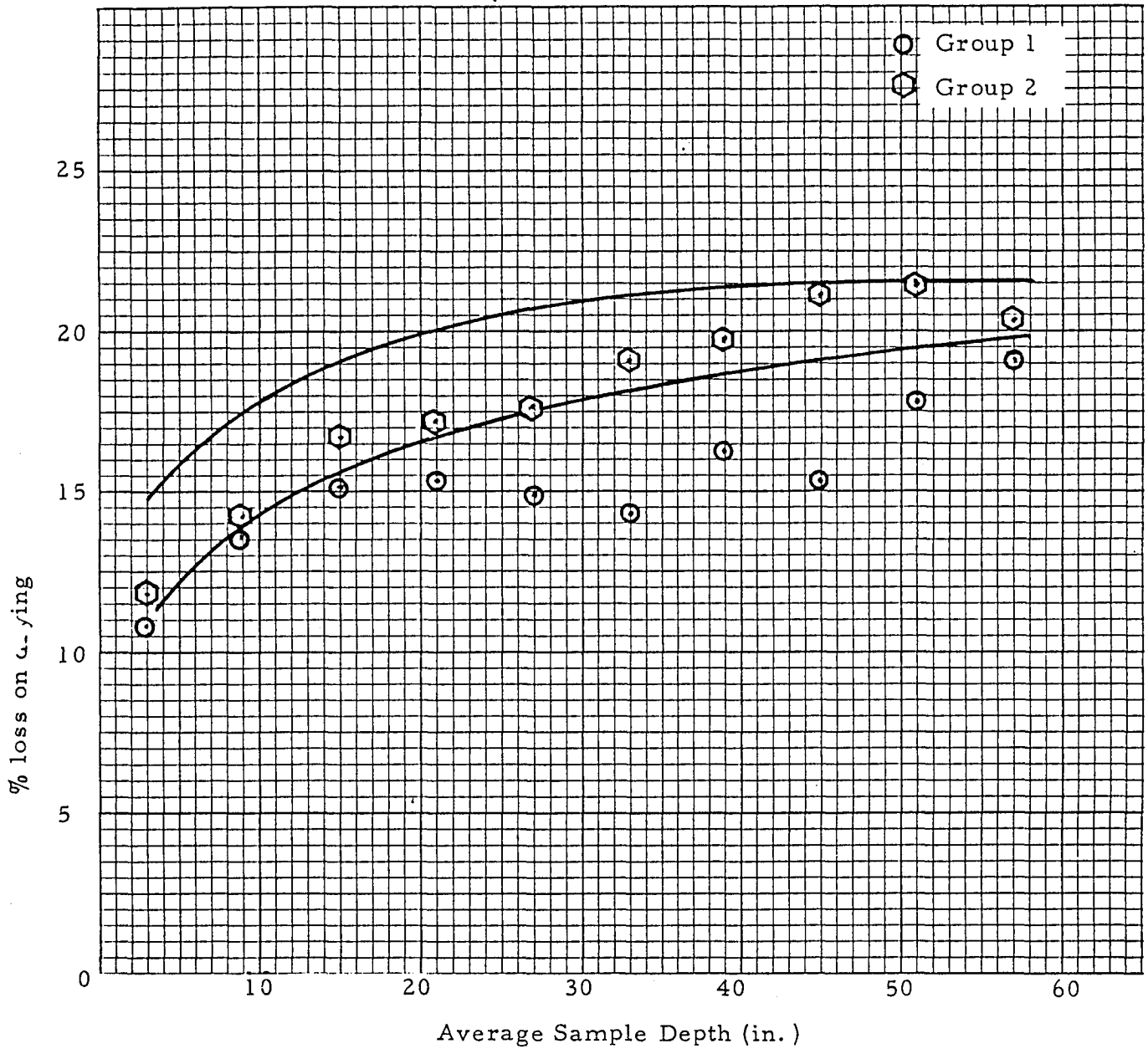



Figure 4. Average moisture content of lysimeters (after 2 week drainage).

Table 5

DIMP Content of Tensiometer Water Samples (Group I East)

| Depth | Ventura | Chino | Fullerton | Walnut | Brawley |
|---|---|---|---|---|---|
| | | (ppm @ 213 days) | | | |
| 6" | * | 10.00 | 8.76 | 7.80 | 17.42 |
| 18" | * | 9.47 | 7.38 | 9.43 | * |
| 30" | <0.1 | 12.97 | 10.77 | 11.65 | 7.47 |
| 42" | 5.20 | 15.27 | 5.83 | 8.60 | 4.33 |
| 54" | 3.08 | 6.58 | 1.92 | 8.33 | 7.00 |
| 60" | 9.58 | 3.41 | 6.92 | 5.30 | 8.42 |
| | | (ppm @ 227 days) | | | |
| 6" | <0.1 | 25.39 | 23.33 | 23.31 | <0.1 |
| 18" | 4.29 | 21.85 | 16.25 | 21.76 | 19.93 |
| 30" | 4.06 | 24.16 | 11.02 | 17.79 | <0.1 |
| 42" | 8.21 | 22.02 | 10.31 | 25.75 | 7.98 |
| 54" | 9.80 | 17.94 | 10.46 | 10.72 | 15.33 |
| 60" | 21.54 | 15.06 | 7.85 | 8.44 | 18.28 |

* No sample obtained.

Table 6

DIMP Content of Tensiometer Water Samples (Group 2 - West)

| Depth | Ventura | Chino | Fullerton | Walnut | Brawley |
|---|---|---|---|---|---|
| | | (ppm @ 63 days) | | | |
| 6" | * | * | * | * | * |
| 18" | 292.83 | 85.41 | 182.82 | 28.20 | 59.49 |
| 30" | 6.47 | 1.83 | 6.85 | 142.89 | * |
| 42" | * | * | * | * | * |
| 54" | * | * | * | * | * |
| 60" | * | * | * | * | * |
| | | (ppm @ 70 days) | | | |
| 6" | * | 2.36 | * | * | 0.99 |
| 18" | 14.17 | 64.67 | ** | 12.09 | 16.18 |
| 30" | 21.85 | 33.46 | ** | ** | * |
| 42" | ** | * | ** | * | * |
| 54" | ** | * | ** | * | * |
| 60" | * | * | * | * | * |
| | | (ppm @ 77 days) | | | |
| 6" | * | * | * | * | * |
| 18" | 49.40 | 77.86 | 113.04 | 9.68 | 69.17 |
| 30" | 24.17 | 30.93 | ** | ** | * |
| 42" | ** | ** | ** | ** | * |
| 54" | ** | ** | ** | ** | * |
| 60" | * | * | * | * | * |
| | | (ppm @ 91 days) | | | |
| 6" | 0.8 | * | 0.9 | * | 1.11 |
| 18" | 14.9 | 180.0 | 11.8 | 7.9 | 20.8 |
| 30" | 11.1 | 13.6 | ** | 114.2 | 1.3 |
| 42" | 9.5 | ** | ** | * | 0.5 |
| 54" | ** | ** | ** | * | * |
| 60" | * | * | * | * | * |

* < 0.1 ppm.

**No sample obtained.

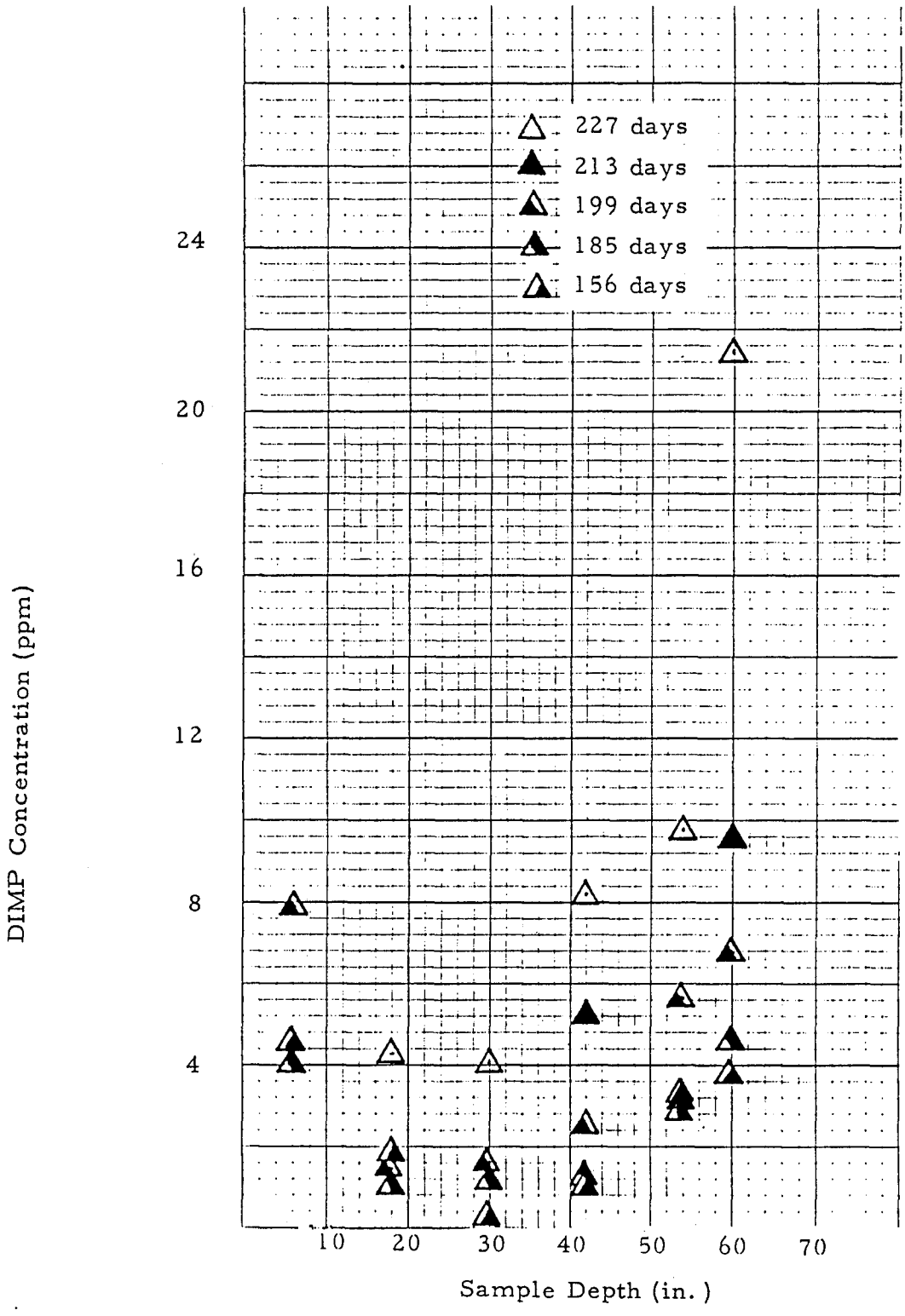



Figure 5a. DIMP Concentration vs sample depth, Group 1, Ventura (Tensiometer)

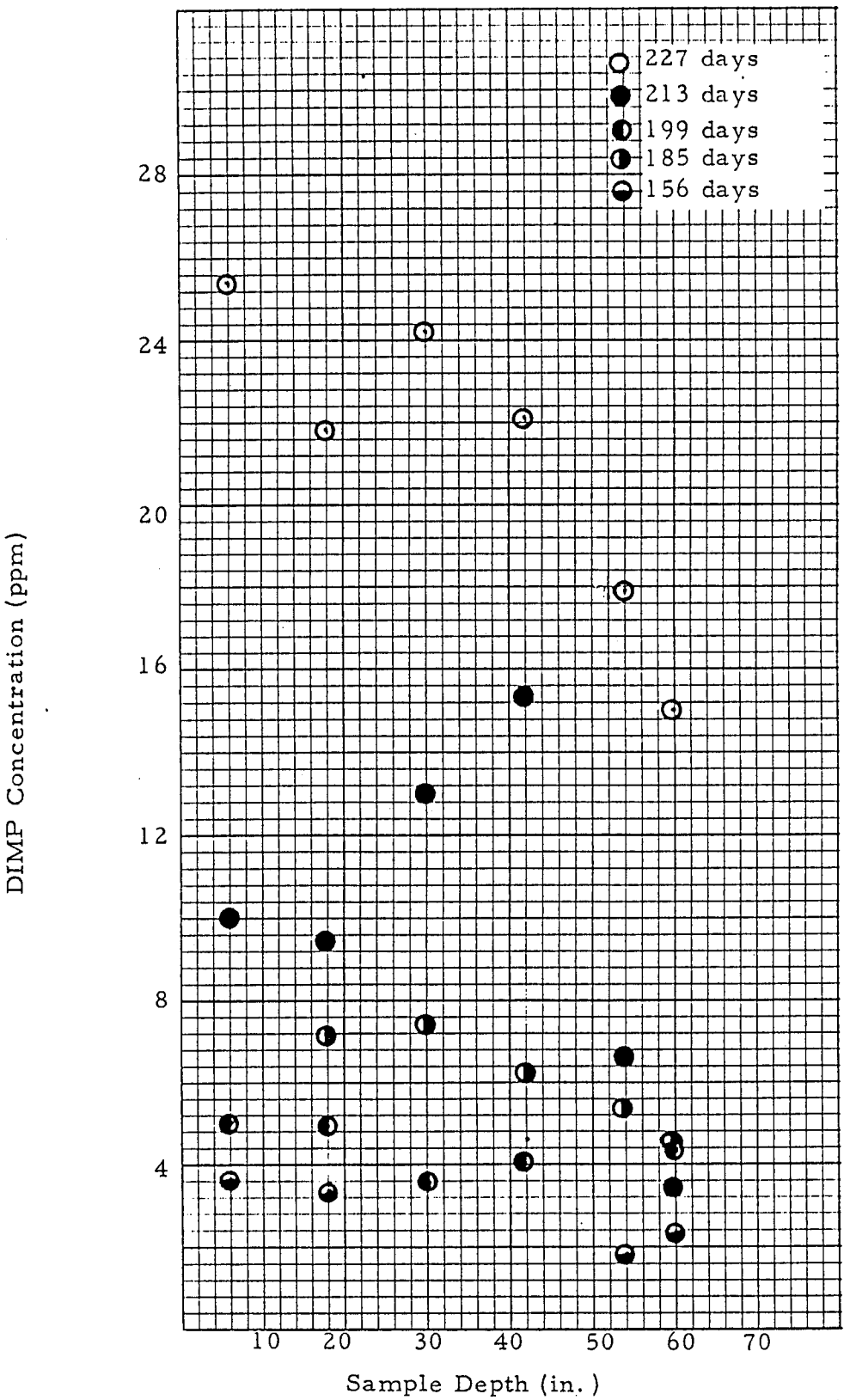



Figure 5b. DIMP Concentration vs Sample Depth, Group 1, Chino (Tensiometers)

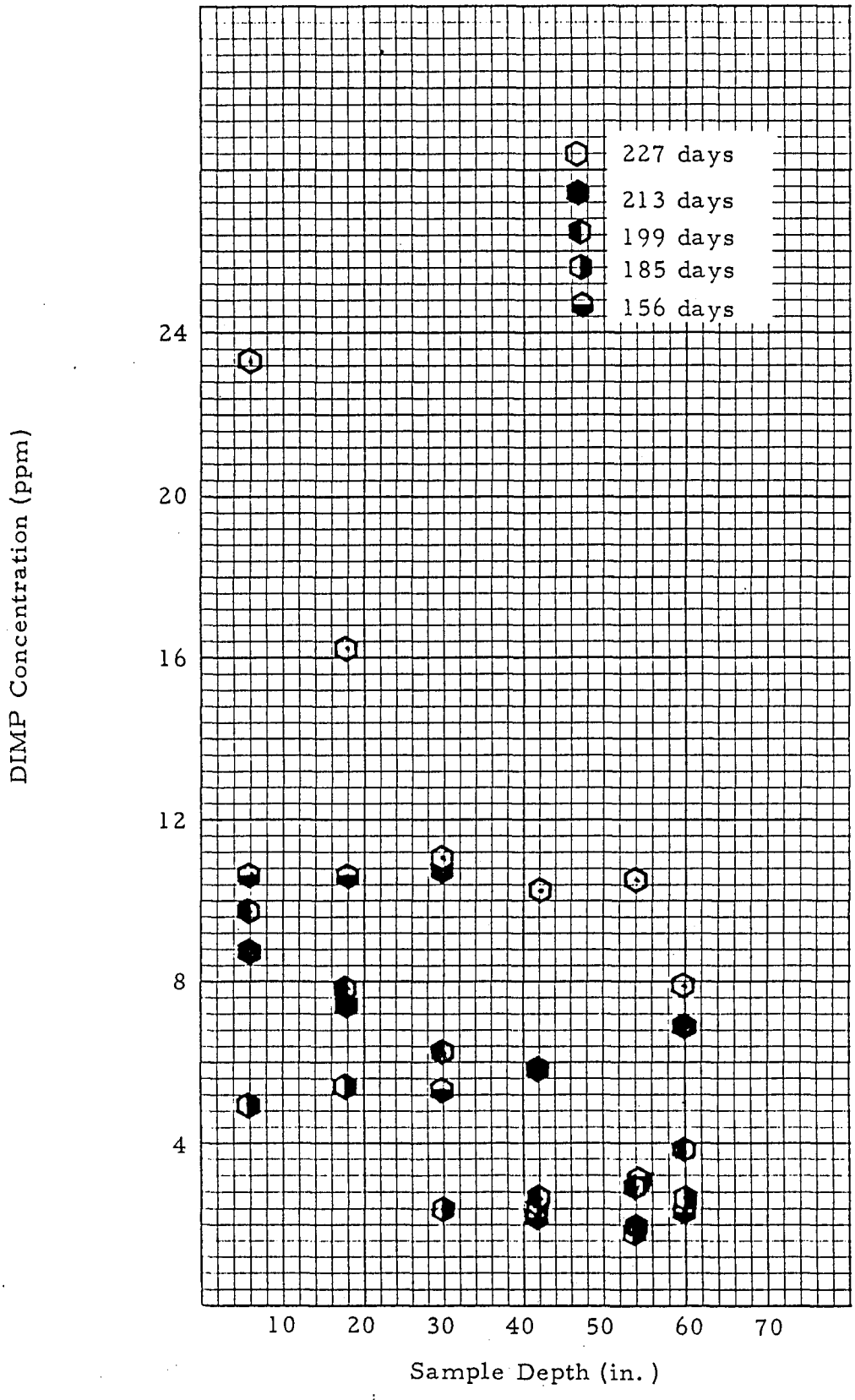



Figure 5c. DIMP Concentration vs Sample Depth, Group 1, Fullerton (Tensiometers)

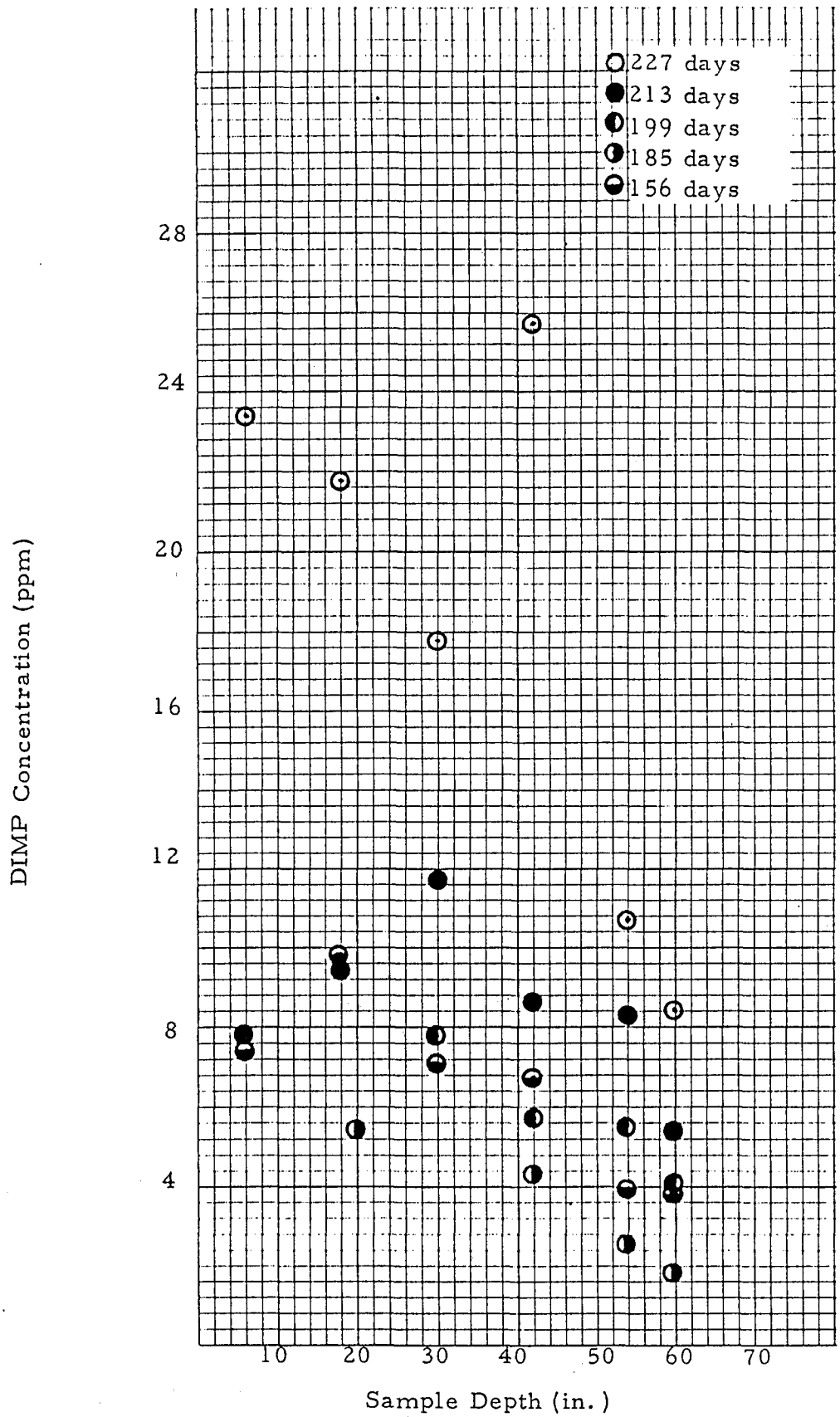



Figure 5d. DIMP Concentration vs Sample Depth, Group 1, Walnut (Tensiometers)

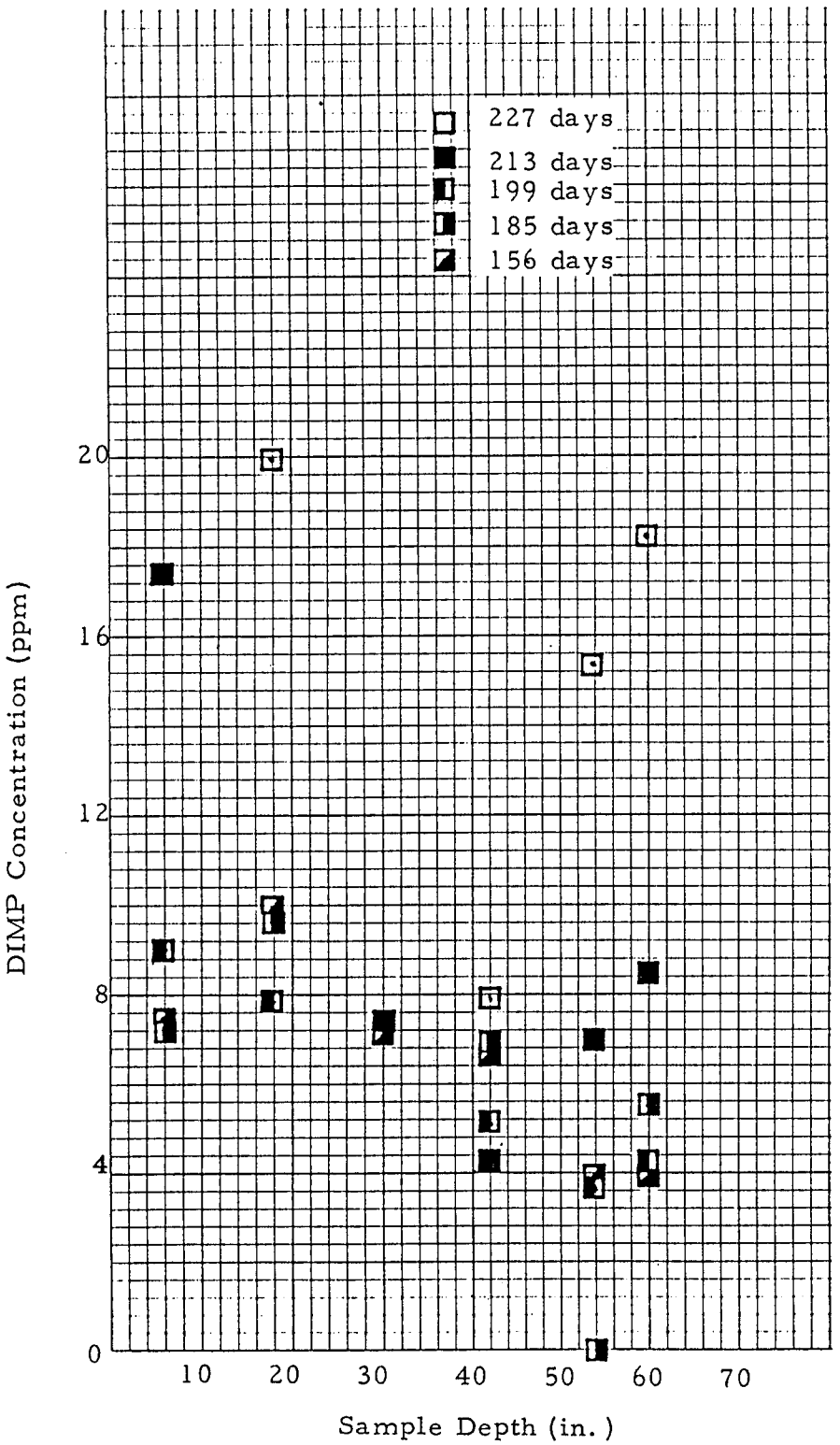



Figure 5e. DIMP Concentration vs Sample Depth, Group 1, Brawley (Tensiometers)

Table 7

DIMP Content of Soil Samples Group 2 (ppm) (84 days)

| Depth | Ventura | Chino | Fullerton | Walnut | Brawley |
|---|---|---|---|---|---|
| 0(surface) | * | * | * | * | * |
| 0 - 6" | * | * | * | * | * |
| 6 - 12" | * | * | * | * | * |
| 12 - 18" | * | 24.5 | * | 1.5 | * |
| 18 - 24" | 32.5 | 22.8 | 20.9 | 8.3 | 5.0 |
| 24 - 30" | 28.1 | 16.7 | 13.8 | 27.4 | 42.7 |
| 30 - 36" | 25.5 | 21.0 | 15.3 | 35.2 | 12.9 |
| 36 - 42" | 10.3 | 2.9 | 9.2 | 23.5 | * |
| 42 - 48" | 6.5 | * | 7.3 | * | * |
| 48 - 54" | * | * | * | * | * |
| 54 - 60" | * | * | * | * | * |

* <0.1 ppm

These data indicate that the DIMP is very slowly being washed downward in the lysimeter. The Brawley samples which previously showed a very narrow band of DIMP seems to have become somewhat broadened.

Figure 6 shows the concentration of DIMP in the Group 2 soils 84 days after addition of the DIMP to the lysimeters. The upper boundary of the DIMP layer appears to be quite sharp while the lower or leading edge appears slightly irregular. The plotted depths are the mid-points of the six-inch sampling depths. The dotted line indicates the original concentration of DIMP in the lysimeters.

Table 8 shows the most recent data for DIMP content of the soil samples from Group 1 lysimeters. The Ventura and Brawley groups are significantly lower than their analysis last month. Reasons for this are not immediately apparent and will be considered during the next reporting period.

## Soil Culture Experiments

The full scale soil culture experiments reported in June (1953-01(11)MP) have reached a stage where analysis of the plant tissue has begun. In brief the analysis for DIMP consists of harvesting the desired plant part (root, stem or leaf) washing any residual DIMP off the exterior surface, homogenizing a weighed portion of the tissue with a known volume methyl alcohol, centrifuging the mixture and chromatographing the supernatant alcohol. The analysis for DCPD is similar up to the point of homogenizing in methanol. Following this a volume of distilled water equal to the volume of methanol is mixed therein and a similar volume of ($CS_2$) carbon disulfide is added to the mixture, agitated and centrifuged. At this point the DCPD is in the lower or $CS_2$ layer and this is chromatographed.

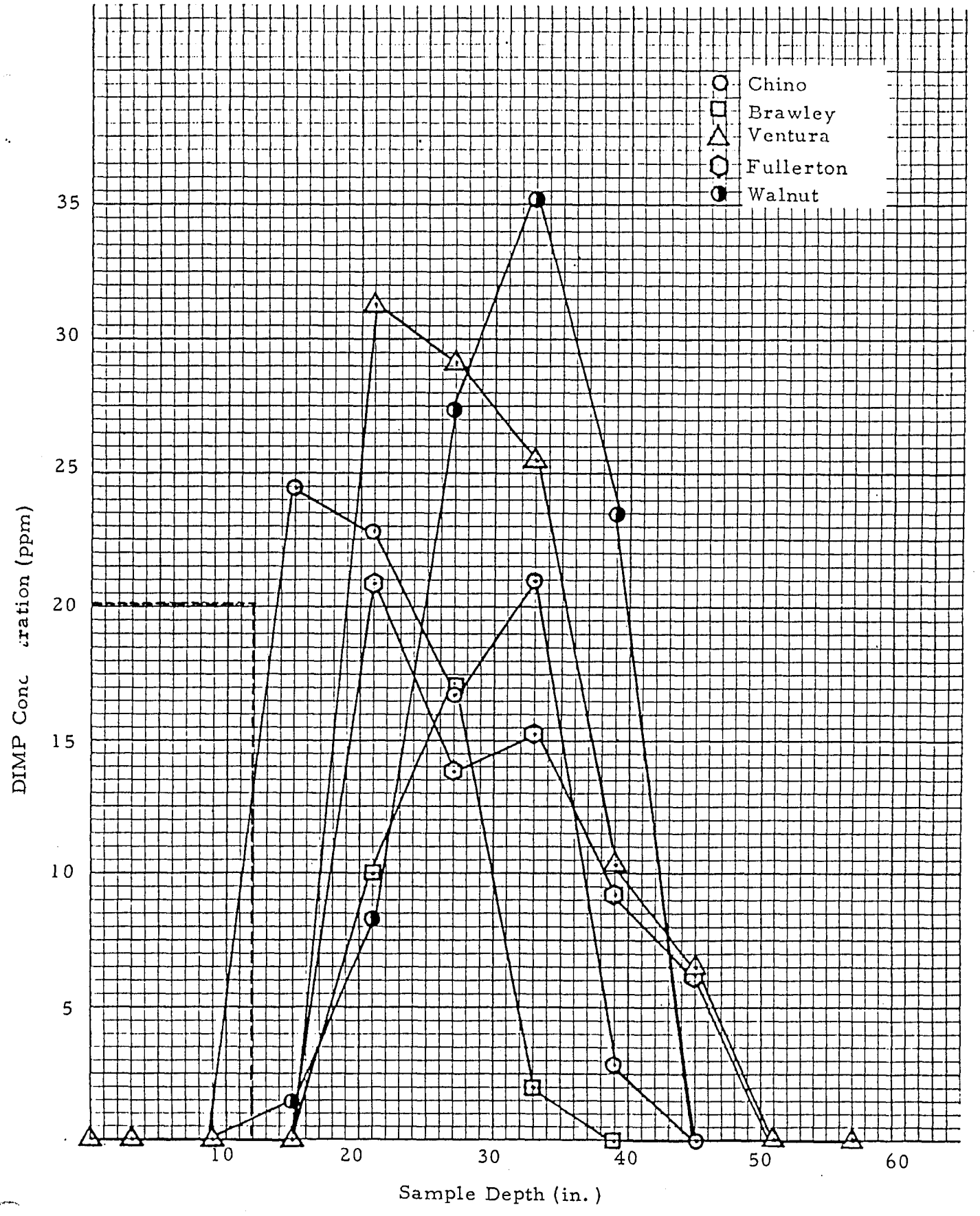



Figure 6. DIMP Content of soil, Group 2 (84 days)

Table 8

DIMP Content of Soil Samples Group 1 (ppm) (217 days)

| Depth | Ventura | Chino | Fullerton | Walnut | Brawley |
|---|---|---|---|---|---|
| 0(surface) | 30.7 | 24.4 | 26.9 | 41.9 | 35.9 |
| 0 - 6" | 3.8 | 12.7 | 9.5 | 9.5 | 13.5 |
| 6 - 12" | 1.5 | 8.0 | 7.0 | 6.5 | 5.0 |
| 12 - 18" | * | 6.4 | 5.6 | 5.5 | 8.3 |
| 18 - 24" | * | 15.0 | 7.6 | 7.4 | 8.4 |
| 24 - 30" | * | 5.7 | 8.3 | 6.1 | 6.7 |
| 30 - 36" | 1.1 | 6.5 | 9.8 | 4.7 | 7.3 |
| 36 - 42" | 1.3 | 6.9 | 7.7 | 6.4 | 9.1 |
| 42 - 48" | 1.3 | 4.0 | 7.0 | 7.9 | 6.5 |
| 48 - 54" | 2.7 | 5.7 | 5.7 | 2.2 | 6.6 |
| 54 - 60" | 3.7 | 2.4 | 6.0 | 5.1 | 6.6 |

* <0.1 ppm

Table 9 shows data on DIMP uptake for the plants subjected to irrigation with water containing 20 ppm DIMP. The bioaccumulation factor is again defined as the concentration of DIMP in the plant tissue divided by the concentration in the irrigation water.

For those plants for which data is available at this writing a pattern of uptake similar to that of the hydroponically grown plants is evident, namely that the leaves accumulate the greatest amount of DIMP followed in order by the roots and the stems. Figure 7 is a graphical representation of this data. Further analyses will be made on these plants as they age as well as on plants from the other concentration levels. Assays of the DIMP content of the pot soil are also being run. One available figure for a 4 inch deep x 1 inch diameter core from a 20 ppm carrot pot yielded a concentration of 11.2 ppm DIMP in soil.

There is no direct correlation between the pot soils and the lysimeters but it may be possible to evaluate, broadly, the expected plant exposures and soil concentrations by calculations such as below. Lysimeter data comes from a previous report (1953-01(07)MP).

Lysimeter

Area of lysimeter surface = 2508.5 $cm^2$.

Amount of DIMP added to Fullerton soil prior to 30 day sample = 1030.8 mg.

$$\frac{1030.8 \text{ mg}}{2508.5 \text{ cm}^2} = 0.411 \text{ mg. DIMP/cm}^2$$

Pot

Area of pot surface = 530.9 $cm^2$

Amount of DIMP added to Fullerton soil in pot prior to 37 day sample = 184 mg

$$\frac{184 \text{ mg}}{530.9 \text{cm}^2} = 0.347 \text{ mg/cm}^2$$

Table 9

Bioaccumulation of DIMP by Plant Parts in

20 ppm Irrigation (37 days from Original Inoculation)

| Plant Part | Total DIMP added to Pot | | DIMP Conc. In Tissue (ppm) | Bio-Accumulation Factor |
|---|---|---|---|---|
| | Vol of 20ppm Irr. (cc) | Wt. of DIMP (mg) | | |
| Sugar Beet - | 9500 | 190 | | |
| Root | | | 45.6 | 2.28 |
| Stem | | | 37.1 | 1.86 |
| Leaf | | | 129.2 | 6.46 |
| Carrot - | 9200 | 184 | | |
| Root | | | 12.4 | 0.62 |
| Stem | | | 6.6 | 0.33 |
| Leaf | | | 36.9 | 1.85 |
| Bean - | 9200 | 184 | | |
| Root | | | 45.4 | 2.27 |
| Stem | | | 28.9 | 1.45 |
| Leaf | | | 150.0 | 7.50 |
| Wheat - | 9200 | 184 | | |
| Root | | | 31.5 | 1.58 |
| Stem | | | 14.2 | 0.71 |
| Leaf | | | 105.5 | 5.28 |

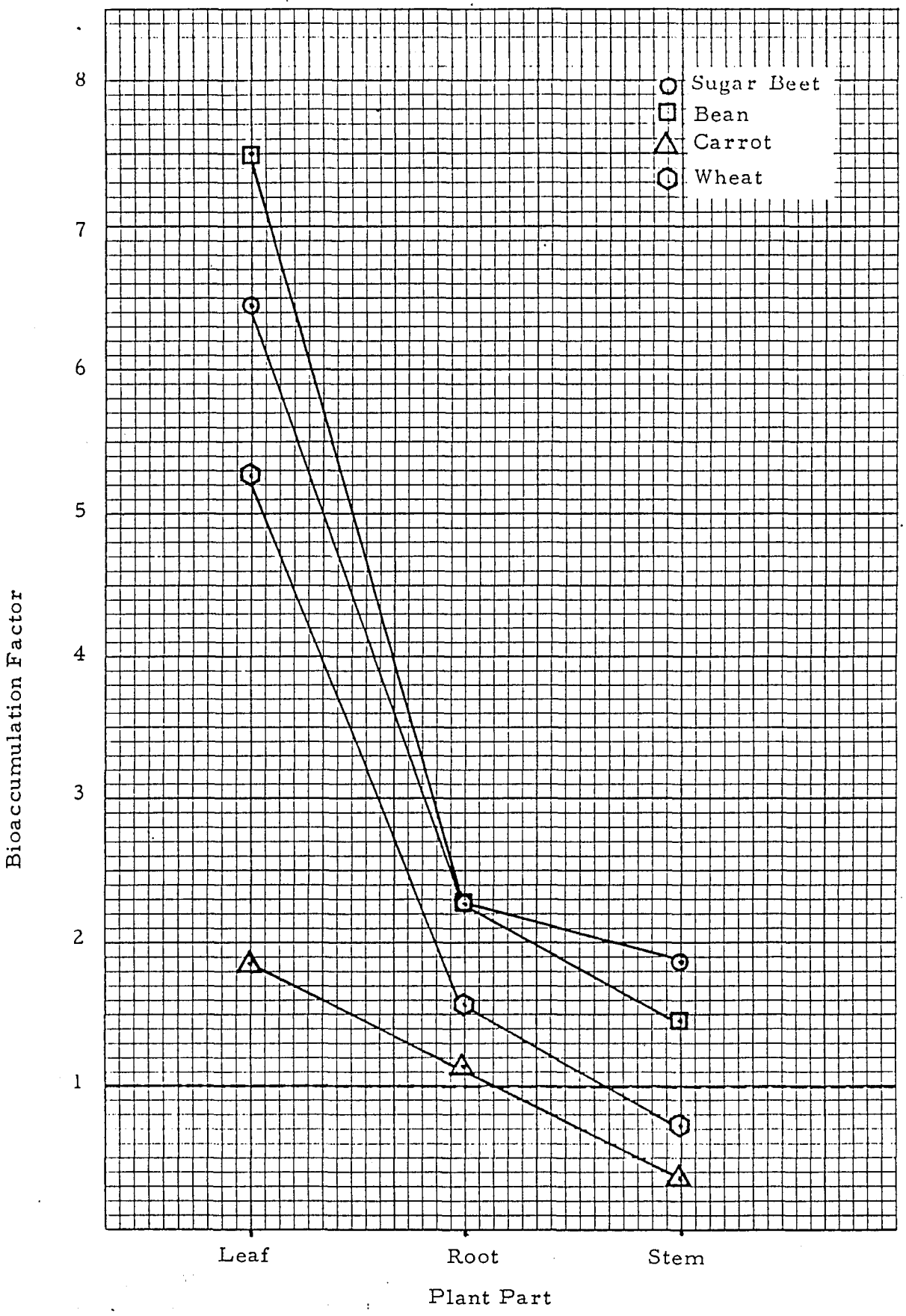



Figure 7. Bioaccumulation of DIMP by plant parts.
Soil culture, 37 days exposure to 20 ppm DIMP in irrigation water.

Concentration of DIMP in top 6" layer of Fullerton lysimeter at 30 days = 13.6 ppm.

Concentration of DIMP in top 4" layer of Fullerton carrot pot at 37 days = 11.2 ppm.

Ratio of lysimeter values to pot values:

$$\frac{\text{DIMP Added}}{\frac{0.411 \text{ mg/cm}^2}{0.347 \text{ mg/cm}^2}} = 1.18 \qquad \frac{\text{DIMP Found}}{\frac{13.6 \text{ mg/cm}^2}{11.2 \text{ mg/cm}^2}} = 1.21$$

Although it is too early in the experiment to attach great significance to these ratios they do show that the analytical techniques as related to DIMP movement in soil appear to be quite consistent.

Samples of plant tissues from all of the concentration levels of DCPD in soil have been analyzed. No DCPD (<1ppm) has been found in any of these tissues.

## PROPOSED ACTIVITY DURING JULY, 1976

- Continue soil culture growth experiments including plant tissue analysis for contaminants.
- Continue treatment and analysis of lysimeter soil and water samples.
- Develop procedures for analysis of DCPD in soils.
- Run germination tests on seeds in contaminated seed beds at several concentration levels of contaminants DIMP and DCPD.
- Run a toxicity range finding test on wheat and bean seedlings using several levels of DIMP and DCOD concentrations in their irrigation water.