FINAL REPORT TO THE CALIFORNIA AIR RESOURCES BOARD

UNDER AGREEMENT ARB-3-690

DEVELOPMENT OF A SYSTEM FOR EVALUATING AND REPORTING ECONOMIC CROP LOSSES CAUSED BY AIR POLLUTION IN CALIFORNIA

III. OZONE DOSAGE-CROP LOSS CONVERSION FUNCTION -- ALFALFA, SWEET CORN

IIIA. PROCEDURES FOR PRODUCTION, OZONE EFFECTS ON ALFALFA AND SWEET CORN, AND EVALUATION OF THESE SYSTEMS

by

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ABSTRACT

Ozone dosage-crop loss conversion functions were developed for Moapa 69 alfalfa yields and percent leaf reduction. The calculations of the conversion functions were based on the functional relationships observed in field plots within an ambient ozone gradient in the South Coast Air Basin. Seasonal ozone dosage proved to be the only significant monitored variable influencing alfalfa yields and percent leaf reductions when tested in multiple regression correlations with average seasonal maximum temperature, average seasonal minimum temperature and average daily relative humidity. A comparison of the plotted monitored variables at each location revealed that the seasonal ozone dosage was the most divergent of any variable. The pattern of daily fluctuations of climatological variables at all test plots was very uniform and differences between test plots generally related to modest variations in their range of values. Problem areas relative to vandalism, vertebrate predation, irrigation and wind pollination of sweet corn reduced the data input to an unacceptable level. These problems have been remedied but no conversion function could be produced for Golden Jubilee sweet corn.

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CONCLUSIONS

The conversion function system for assessing economic crop losses from air pollutants has progressed to the stage where an evaluation of its potential was undertaken and the following conclusions made:

1. Production of conversion functions for the major field and row crops in California is feasible as demonstrated by the two alfalfa ozone dosage-crop loss conversion functions. Conversion functions for tree crops would take a much longer period of time to develop and would cost considerably more per function.

2. The conversion functions are representative of field effects and do not rely on extrapolated fumigation data. Their production is based on the ambient ozone dosage-response functions of commercial varieties.

3. Environmental variables did not appear to have a significant influence on the ozone dosage yield response of Moapa 69 alfalfa within the tested parameters. Environmental factors did influence the foliar sensitivity and growth of Golden Jubilee sweet corn but no determination of the yield response was possible. However, the analyses of the 1973 sweet corn results used in the calculations of the prototype conversion function indicated that ozone dosage was the most significant factor influencing yields.

RECOMMENDATIONS

The effect of different soils on the ozone sensitivity and overall growth of a test crop should be analyzed. Soil type remains the only major environmental variable left untested relative to the ozone dosage-crop response function used in the calculations of conversion functions. If a commercial crop proved to be equally adapted to the existing range of soils, test plots could be established without the restriction of 15-gallon containers and a uniform soil mix. The production potential for a conversion function would then increase dramatically to be limited only by available space and labor requirements.

A production program geared to construct conversion functions for several crops per year should be implemented. A maximum of six conversion functions could be produced each year on the existing test plots if funding were available. Maximum production would reduce the cost per conversion function and quickly build up an inventory of operational units.

INTRODUCTION

This phase of the three-year air pollution methodology study was designed to construct the network of field plot locations necessary for the production of ozone dosage-crop loss conversion functions and to produce the first conversion functions for sweet corn and alfalfa.

The first two years in the development of this method concentrated on:

1. The isolation of ozone effects on the crop quality of seven varied species (1),

2. the isolation of ozone effects on the crop yield of the same seven species (2),

3. the selection of a single species (Golden Jubilee corn) to construct a prototype ozone dosage-crop loss conversion function and the development of the statistical procedures for calculation of the conversion function (2).

Several related studies were incorporated into the program and included in the final reports.

1. Development of an Air Monitoring Biological Indicator (AMBI) system utilizing sensitive indicator plants to monitor oxidant levels in agricultural areas (1).

2. Development of a photo-reference system for oxidant leaf injury evaluation (1).

3. Study of oxidant effects on the nutritional levels in harvested produce (2).

The present production phase of the study required the use of a network of field locations with varying ambient ozone dosages, temperatures and relative humidities. The selected test crop was grown at all locations under standardized cultural conditions. The crops' response to the ozone dosages and climatological variables at test plot locations yielded the data necessary for the identification of their relationships. Climatological variables were monitored to identify differences among locations and to provide data for the analysis of their effect on the crop under study. The functional relationship between ozone dosage and crop loss could then be utilized to calculate the ozone dosage-crop loss conversion function. A specific crop would require one season's data in order to produce its conversion function. Conversion functions for several crops could be produced simultaneously provided the manpower and required space were available.

Summarized, this development would utilize a network of locations to produce data and a series of calculations to construct the conversion function. The completed ozone dosage-crop loss conversion function could then be utilized by any agency to provide accurate crop loss estimates.

DESIGN

The production of ozone dosage-crop loss conversion functions utilizes the input from several different components. Figure 1 indicates the relationship of each to the production system. A more detailed description of the components is included in this chapter.

Field Plots

Fourteen field locations within the South Coast Air Basin were selected to represent a range of ambient ozone concentrations and meteorological variables (Map 1, Table 1). Each location consisted of 16 5-gallon cans (alfalfa) and 16 15-gallon cans (corn) filled with a uniform soil mix (1) and buried in the ground. Sites were selected in open areas away from shading and uniformly oriented. Each field plot was protected by a 2 ft. rabbit fence and screened from public view.

Four Moapa 69 alfalfa seedlings were transplanted in each 5-gallon can at field plots on 1 April 1974. The plants were thinned to one per can after six weeks. All plants were watered uniformly during growth and sprayed with Diazinon or Malathion to control insects. Plants at each location were harvested at 1/10 bloom, weighed, and evaluated.

Six Golden Jubilee sweet corn plants were started from seed in each 15-gallon can. Seeds were planted on the 2nd and 3rd of April 1974 and thinned to a single individual after three weeks of growth. A strict watering and fertilization schedule (the equivalent of 200 lbs N/acre) was administered throughout growth. Most insects were controlled by spraying with Diazinon but Gardona was used to control corn earworm during silking. Plants were harvested 25 days after silking.

Variety Plots

Alfalfa and corn variety plots were established at the University of California at Riverside (UCR), the Moreno and the South Coast Field Station to provide data for a varietal injury bias. The following varieties were selected because of popularity among commercial growers:

<u>Corn</u>: Golden Jubilee, Valley Market, FM Cross, and GH 66.

<u>Alfalfa</u>: Moapa 69, El Camino, El Dorado, Hayden, Mesa Sirsa, Bonanza, Caliente, Joaquin, Old Sonora, and AS 13.

Corn variety cultivars were grown under uniform cultural conditions at UCR, the Moreno Field Station, and the South Coast Field Station. Plantings were made in 150 ft. rows utilizing 40 inch widths and 8 inch spacing between seeds. Fertilizer was applied at the rate of 200 lbs N/acre at all sites. Fifty plants in each cultivar were randomly selected for growth data and harvest. Plants were harvested 25 days after silking.

Alfalfa variety plots were established at UCR, the Moreno Field Station and the South Coast Field Station. Each of the 10 varieties were planted in four 5 ft. x 5 ft. replicate plots in a randomized design. No fertilization was applied and all plots were sprinkler irrigated. Harvests were initiated at 1/10 bloom.

Fumigations

A long-term ozone fumigation of Moapa 69 alfalfa was undertaken to isolate fumigant effects and provide information necessary for field operations. Three treatments (0 pphm ozone, 20 pphm ozone, 30 pphm ozone) of 10 replicates per treatment were utilized in the fumigations.

Ozone fumigations of the 10 alfalfa varieties used in the variety plots were undertaken to determine their relative susceptibility under controlled conditions. Three treatments (0 pphm ozone, 20 pphm ozone, 30 pphm ozone) of five replicates per treatment were utilized.

The sweet corn fumigation study was completed in the 1973 quality phase.

Ozone and Climatological Data

Ambient ozone and climatological data were collected and processed in the same manner discussed in the two preceding final reports (1, 2). The ozone monitoring stations (Table 2) and climatological stations (Table 3) were chosen for their proximity to field plots (Maps 2, 3). Field plots located outside a five-mile radius from an instrument station were assigned interpolated values calculated from the following formula:

$$I = \frac{\left(\frac{O_1}{d_1} + \frac{O_2}{d_2} + \frac{O_3}{d_3}\right)}{\left(\frac{1}{d_1} + \frac{1}{d_2} + \frac{1}{d_3}\right)}$$

where I = interpolated dosage

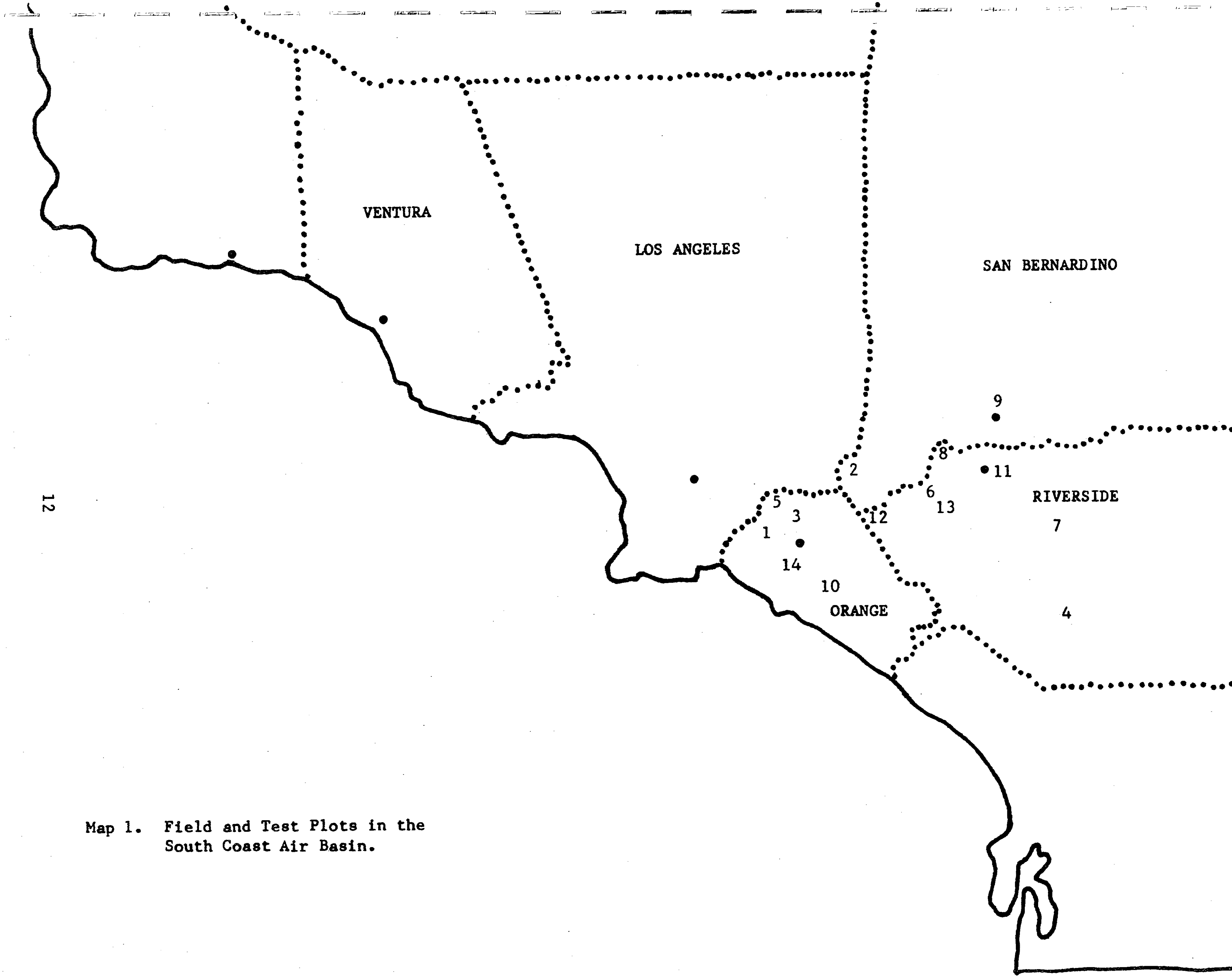
O = ozone dosage

d = distance from instrument

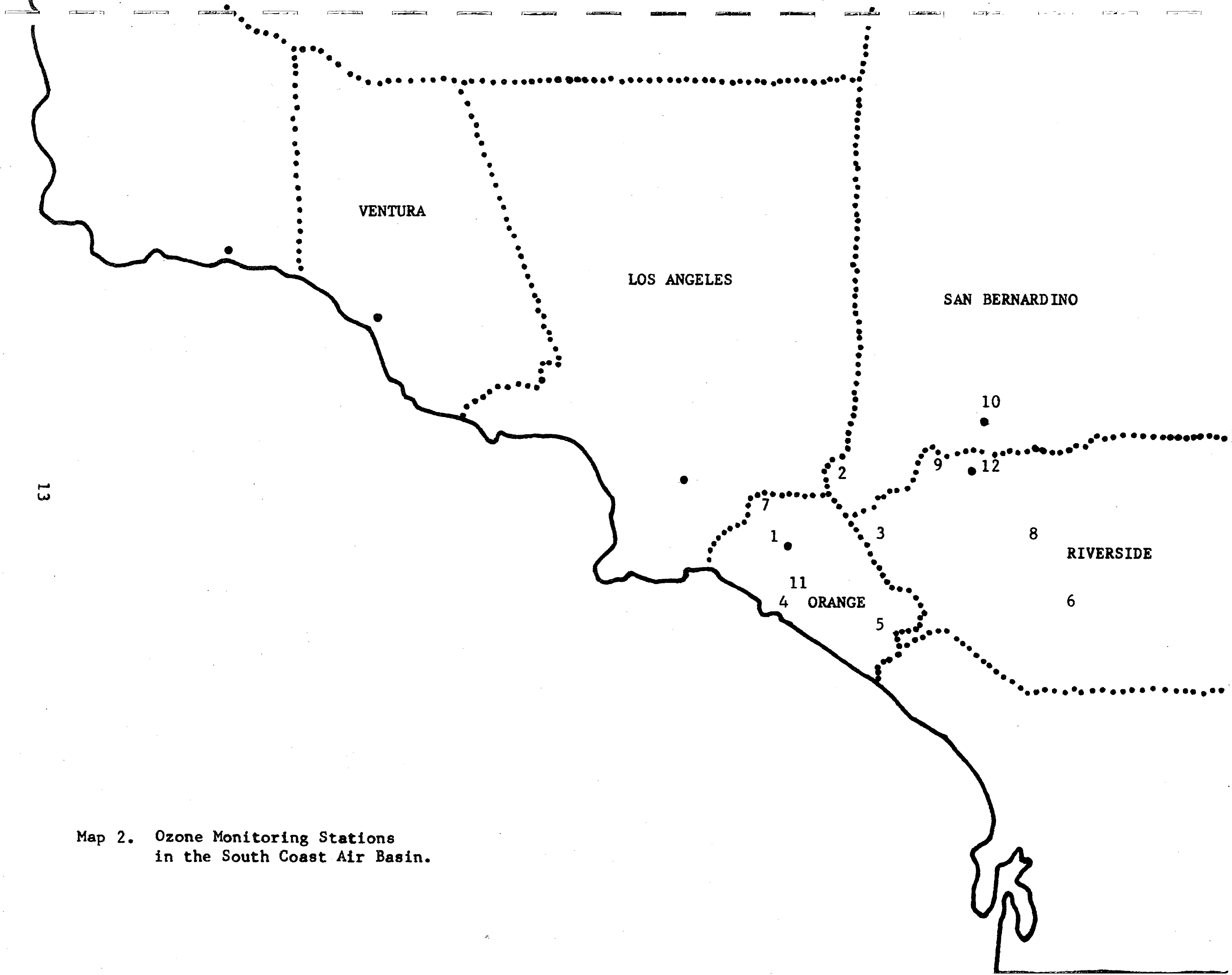
Statistical Evaluation and Analysis

Data from fumigations and field plots was analyzed statistically utilizing analysis of variance and Duncan's Multiple Range Test. Linear regression correlations were used to determine significant associations between measured characteristics and seasonal ambient ozone dosage. A multiple regression correlation was run to test the effect of monitored variables on the productivity of the test crop. Seasonal ambient ozone dosage, average daily relative humidity, average seasonal maximum temperature and average seasonal minimum temperature were correlated with crop productivity to determine the significant effects of each. The following notations of significance are presented if applicable:

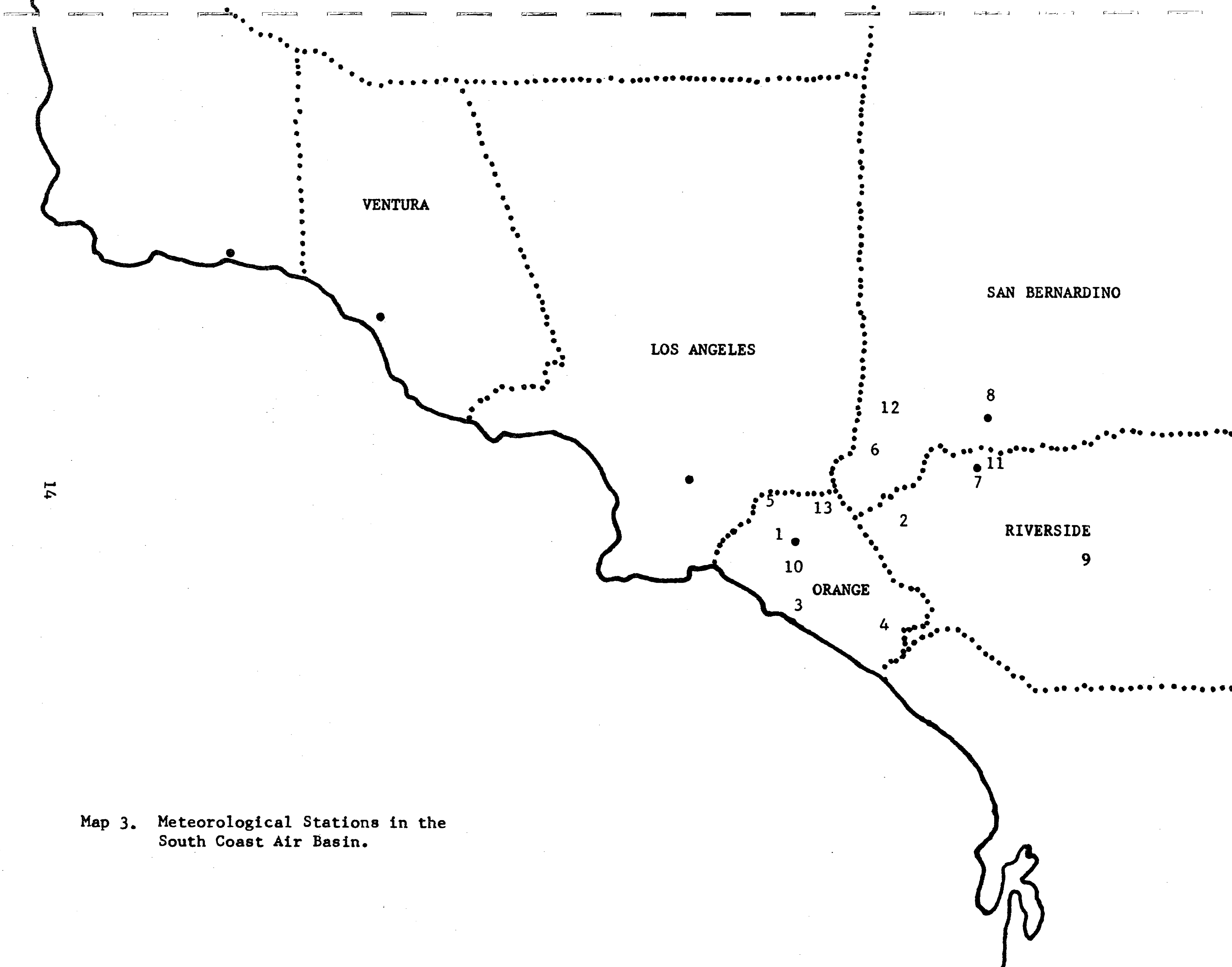
* = .05 level of significance
** = .01 level of significance.



Map 1. Field and Test Plots in the South Coast Air Basin.



Map 2. Ozone Monitoring Stations in the South Coast Air Basin.



Map 3. Meteorological Stations in the South Coast Air Basin.

Table 1. Identification key of field and variety plots in the South Coast Air Basin.

Location	Identification No.
Anaheim	1
Chino	2
Fullerton	3
Hemet	4
La Habra	5
Mira Loma	6
Moreno	7
Rubidoux	8
San Bernardino	9
South Coast Field Station	10
UCR	11
Green River	12
Norco	13
Santa Ana	14

Table 2. Identification key of ozone monitoring stations utilized in the South Coast Air Basin.

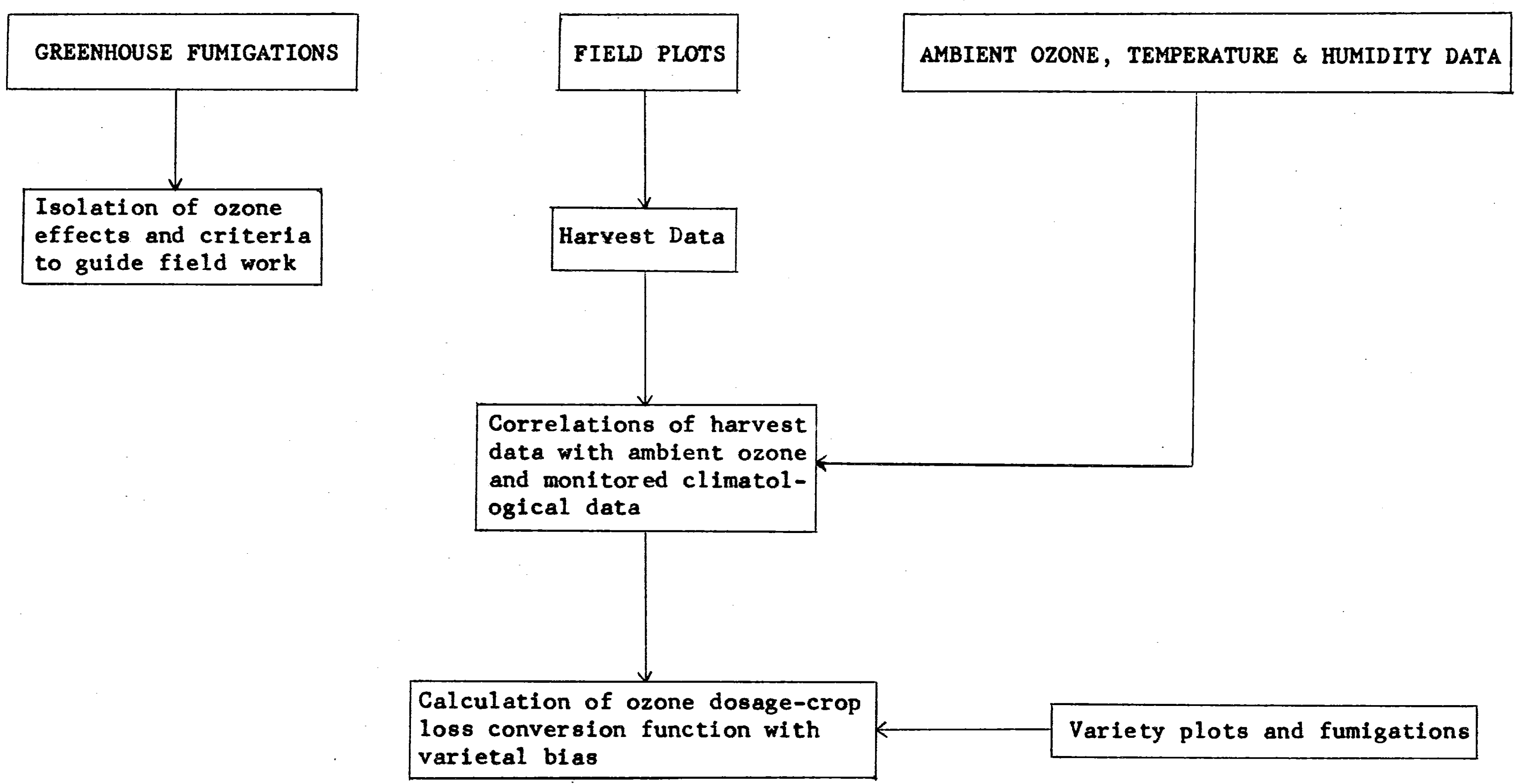
Location	Identification No.
Anaheim	1
Chino	2
Corona	3
Costa Mesa	4
El Toro	5
Hemet	6
La Habra	7
Moreno	8
Rubidoux	9
San Bernardino	10
South Coast Field Station[1]	11
UCR	12

1. Instrument station run by the Air Pollution Methodology Program.

Table 3. Identification key of meteorological stations in the South Coast Air Basin.

Location	Identification No.
Anaheim	1
Corona	2
Costa Mesa	3
El Toro	4
La Habra	4
Ontario	6
Riverside	7
San Bernardino	8
San Jacinto	9
Santa Ana	10
UCR	11
Upland	12
Yorba Linda	13

Figure 1. Outline of Ozone Dosage-Crop Loss Production Procedure



OZONE DOSAGE-ALFALFA LOSS CONVERSION FUNCTIONS

Ozone dosage-crop loss conversion functions are presented for two criteria used in the marketing of alfalfa. Table 4 represents the conversion function for estimating alfalfa yield loss given the seasonal ozone dosage. Table 5 represents the conversion function for estimating the reduction of leaves in the yield (indication of protein content) given the seasonal ozone dosage.

Direction for use:

1. Calculate the ozone dosage for the season (1 April to 30 October) in pphm-hrs greater than 10 pphm and locate the corresponding value in the ozone dose column.

2. Find the percent reduction by locating the value in the predicted percent reduction column and the 95% confidence range of reduction.

3. Final selection of the best value within the 95% confidence range should take the amount of visible injury (if available) into account. If heavy injury was observed during the season, a value between the predicted percent reduction and the highest percent reduction given in the 95% confidence range might be used. If little visible injury was observed during the season, a value between the predicted percent reduction and the lowest percent reduction in the 95% confidence range might be used.

4. The conversion function values for different varieties would change with their relative susceptibility to ozone. In lieu of constructing a separate conversion function for each variety, estimates of their predicted percent reductions can be made using the Moapa 69 conversion function values as a reference. The following list of varieties were tested for ozone sensitivity and ranked for susceptibility relative to Moapa 69:

   Ozone sensitive

   Moapa 69, Mesa Sirsa, Hayden, Joaquin

   Moderate ozone sensitivity

   Old Sonora, Caliente, Bonanza

   Ozone resistant

   El Camino, El Dorado, AS-13

   Estimates of the reduction in yield and percentage of leaf material for these varieties should be made using their sensitivity ranking relative to Moapa 69.

No conversion function was calculated for Golden Jubilee sweet corn because of the lack of sufficient data. Vandalism, vertebrate predation, and problems associated with wind pollination and irrigation on small plots reduced the data input to an unacceptable level.

The ozone dosage-crop loss conversion functions presented in this chapter represent the final phase of development in the production of a standardized method for assessing crop losses. The conversion function approach was originally selected over injury survey methods and mathematical models because of its accuracy and uniformity. Moreover, the initial 1972-1973 phase of the program indicated that the extremely divergent characteristics of the seven test crops and the lack of uniformity in marketing criteria would further increase error using the two older methods.

Conversion functions incorporate the key parameters characteristic of a given crop in their construction. They are calculated using data taken from field conditions and account for varying climatological variables. The conversion function concept is adaptable to refinement or modification as more data becomes available and is not a rigid uncompromising method. Initially, conversion functions should be produced for the major economic crops to provide the basis for statewide assessments. The assessments would improve in accuracy and scope as more conversion functions were produced and incorporated.

Production procedures:

The production procedures necessary for construction of pollutant dosage-crop loss conversion functions are listed in order of implementation.

1. Establish 10-20 field plots within an ambient ozone gradient. These plots should be located as close to climatological and pollutant monitoring stations as possible and maintained uniformly with respect to cultural conditions, pest control, frequency of maintenance and harvest intervals.

2. Run linear regression correlations of selected harvest data with the seasonal pollutant dosages to determine whether a significant functional relationship is discernible.

3. Run a multiple regression correlation of the selected harvest criterion and pollutant dosage, average seasonal maximum temperature, average seasonal minimum temperature and average daily relative humidity for the season. Significant functional relationships and interactions should be analyzed to determine the relative effect of climatological variables. Plots of the daily values of each monitored variable for the season should be made to further aid in the evaluation of the crop's performance. The pollutant must be isolated as the single most significant variable influencing the harvest characteristic before proceeding to step 4.

4. The conversion function can be calculated utilizing the pollutant dosage-crop reduction function initially calculated in step 2. The original calculations for the prototype pollutant dosage-crop loss conversion function for sweet corn presented in the June 1974 Final Report have been altered to provide a more direct loss calculation. The following calculations should now be used:

   x_i = pollutant dose (independent variable) for the ith observation

   y_i = value of crop characteristic (dependent variable) for the ith observation

   $\bar{x}$ = mean of observed dosages

   $\bar{y}$ = mean of observed characteristic values

t = Student's t value at 95% confidence

z_u = upper 95% confidence value of % reduction at x

z_l = lower 95% confidence value of % reduction at x

n = number of observations

$\hat{y}$ = predicted value of characteristic according to linear regression equation

x = any oxidant dosage at which one wants to calculate $\hat{y}$ or t

Equation 1. $\hat{y} = mx + b$ (linear regression equation)

Equation 2.

$$m = \frac{\left[\sum(x_i y_i)^2 - \frac{\left(\sum x_i y_i\right)^2}{n}\right]}{\left[\sum x_i^2 - \frac{\left(\sum x_i\right)^2}{n}\right]}$$ = slope or coefficient of regression line

Equation 3. $\hat{y} = m(x-\bar{x}) + \bar{y} = mx + b$

$b = \bar{y} - m\bar{x}$ = intercept of regression line

Converting to percent reduction where:

$\bar{z}$ = mean of % reduction values

$z = \frac{b-y}{b} \times 100$ = % reduction of yield

$\hat{z}$ = predicted % reduction

Equation 4.

$$S_{\hat{z}} = \sqrt{S^2_{z.x}\left[\frac{1}{n} + \frac{(x-\bar{x})^2}{\sum(x_i-\bar{x})^2}\right]}$$ = estimated standard error of $\hat{z}$

Equation 5.

$$S^2_{z.x} = \frac{\sum(z_i - \hat{z})^2}{n-2}$$ = mean square deviation from regression

Equation 6. $z_u = mx + b + t\,S_{\hat{z}}$ = upper 95% confidence value

Equation 7. $z_l = mx + b - t\,S_{\hat{z}}$ = lower 95% confidence value

The alfalfa conversion function uses dosage increments of 250 pphm-hrs >10 pphm in the calculation of the predicted value (regression line) and the range of reduction at 95% confidence (95% confidence belts) but the selection of increment size is arbitrary.

The four production procedures are discussed in greater detail in the Experimental Results - Alfalfa chapter.

Table 4. Ozone dosage-alfalfa (Moapa 69) yield reduction conversion function.

Ozone Dose[1]	Predicted % Reduction	Range of % Reduction at 95% Confidence		
0.	0.000	0.0	-	17.209
250.	1.252	0.0	-	17.798
500.	2.504	0.0	-	18.401
750.	3.755	0.0	-	19.020
1000.	5.007	0.0	-	19.656
1250.	6.259	0.0	-	20.313
1500.	7.511	0.0	-	20.992
1750.	8.762	0.0	-	21.697
2000.	10.014	0.0	-	22.431
2250.	11.266	0.0	-	23.198
2500.	12.518	1.034	-	24.002
2750.	13.770	2.691	-	24.848
3000.	15.021	4.303	-	25.740
3250.	16.273	5.863	-	26.683
3500.	17.525	7.368	-	27.682
3750.	18.777	8.813	-	28.741
4000.	20.029	10.194	-	29.863
4250.	21.280	11.509	-	31.052
4500.	22.532	12.756	-	32.308
4750.	23.784	13.937	-	33.631
5000.	25.036	15.051	-	35.020
5250.	26.288	16.103	-	36.473
5500.	27.539	17.094	-	37.984
5750.	28.791	18.031	-	39.551
6000.	30.043	18.917	-	41.169
6250.	31.295	19.757	-	42.832
6500.	32.546	20.557	-	44.536
6750.	33.798	21.319	-	46.277
7000.	35.050	22.050	-	48.050
7250.	36.302	22.751	-	49.852
7500.	37.554	23.427	-	51.680
7750.	38.805	24.081	-	53.529
8000.	40.057	24.716	-	55.399
8250.	41.309	25.332	-	57.286
8500.	42.561	25.934	-	59.188
8750.	43.813	26.521	-	61.104
9000.	45.064	27.096	-	63.032
9250.	46.316	27.661	-	64.971

1. Sum of pphm hrs > 10 pphm between 1 April to 30 October of any given year.

Table 5. Ozone dosage-alfalfa (Moapa 69) leaf reduction conversion function.

Ozone Dose[1]	Predicted % Reduction	Range of % Reduction at 95% Confidence		
0.	0.000	0.0	-	5.945
250.	0.407	0.0	-	6.123
500.	0.813	0.0	-	6.306
750.	1.220	0.0	-	6.494
1000.	1.627	0.0	-	6.688
1250.	2.034	0.0	-	6.889
1500.	2.441	0.0	-	7.098
1750.	2.847	0.0	-	7.316
2000.	3.254	0.0	-	7.544
2250.	3.661	0.0	-	7.783
2500.	4.068	0.100	-	8.035
2750.	4.475	0.647	-	8.302
3000.	4.881	1.178	-	8.584
3250.	5.288	1.692	-	8.885
3500.	5.695	2.186	-	9.204
3750.	6.102	2.659	-	9.544
4000.	6.508	3.111	-	9.906
4250.	6.915	3.539	-	10.291
4500.	7.322	3.945	-	10.700
4750.	7.729	4.327	-	11.131
5000.	8.136	4.686	-	11.585
5250.	8.542	5.024	-	12.061
5500.	8.949	5.341	-	12.558
5750.	9.356	5,638	-	13.074
6000.	9.763	5.919	-	13.607
6250.	10.170	6.183	-	14.156
6500.	10.576	6.434	-	14.719
6750.	10.983	6.672	-	15.295
7000.	11.390	6.898	-	15.881
7250.	11.797	7.115	-	16.478
7500.	12.203	7.323	-	17.084
7750.	12.610	7.523	-	17.697
8000.	13.017	7.717	-	18.317
8250.	13.424	7.904	-	18.944
8500.	13.831	8.086	-	19.575
8750.	14.237	8.263	-	20.211
9000.	14.644	8.436	-	20.852
9250.	15.051	8.606	-	21.496

1. Sum of pphm-hrs > 10 pphm between 1 April to 30 October for a given year.

Moapa 69 alfalfa was selected as the test variety because of its popularity and widespread use. Long-term fumigations and variety plots were designed to provide data for the delineation of ozone effects and varietal ozone sensitivity ranking; field plots were designed to provide data for the calculation of an ozone dosage-response function.

Field Plots

Alfalfa field plot harvests were summed to give seasonal yields. Five harvests were taken at each location for the 1974 season. Each harvest was also analyzed for the percentage of leaf material expressed as a leaf to total weight ratio. The average weight harvested per plant per location for the season and the average leaf to total weight ratio for the season were calculated and utilized in linear regression correlations with seasonal ozone dosage (Figures 2, 3). Both characteristics proved to have a significant correlation with dosage.

Multiple regression correlations indicated that ozone dosage was the only significant variable affecting the seasonal yield and the amount of leaf material in harvests (Tables 6, 7). Average seasonal maximum temperature, average seasonal minimum temperature, and average daily relative humidity for the season were found to be insignificant. An analysis of the multiple regression correlations indicated that the t-values calculated for ozone dosage were primarily responsible for each significant interaction. The t-values for the other measured variables were not significant in any interaction involving the harvest characteristics.

The seasonal ozone dosages, average seasonal temperatures, and average daily relative humidity values were tested for reliability as indicative measurements of climatology during the season. Daily values of each of the four measured variables were plotted for each location and compared.

1. Temperatures: A comparison of the daily maximum and minimum temperatures for the alfalfa season revealed a strikingly uniform pattern of fluctuation among field plots. The maximum temperatures were generally higher in inland areas and lower on the coastal plain but the pattern of daily fluctuation was similar at each location. The range of temperature variation in both daily maximum temperatures and daily minimum temperatures was smaller at coastal locations (Figures 4, 5, 10). The wider ranges of temperature variation at inland locations (Figures 6, 7, 8, 9, 11) can be partially explained by the spring and fall downslope winds (Santa Ana condition) which elevate temperatures and reduce relative humidity. In general, the maximum and minimum temperatures remained well within a tolerable growing range for Moapa 69 alfalfa. Hemet was possibly the only location which bordered on restrictive temperatures as the average minimum and maximum temperatures were observed to vary by 40° F.

2. Relative humidity: The average daily relative humidities for a season ranged from a high of 58.8% to a low of 41.7%, a difference of 17.1%. As expected, the locations on the coastal plain exhibited more uniform values at a higher overall range (Figures 12, 14, 19). Inland locations were observed to have a greater range of variation at lower overall values, especially in the spring and fall during Santa Ana wind conditions (Figures 13, 15, 16, 17, 18, 20). The average daily relative humidity values for the season appeared to be a reasonable appraisal of differences among locations.

3. <u>Ozone dosage</u>: The ozone dosages were the most divergent of all the monitored variables. Total dosage, the distribution of dosage over the season and the distribution of dosage during an average day varied immensely from location to location. Figures 12, 13, 14, 15, 16, 17, 18, 19, and 20 indicate the incidence and distribution of ozone dosage for each location during the season. No discernible pattern among locations was obvious. The daily pattern of ozone exposure peculiar to given locations varied in the time of peak levels and duration of exposure (Figures 21, 22, 23, 24, 25, 26, 27, 28, 29). A pattern of early peak levels and shorter ozone exposure emerged for the plot locations on the coastal plain. Longer exposures, peaking later in the afternoon characterized inland location with the exception of Hemet (Figure 24). The Hemet plot was observed to have a double peak at low dosage levels.

The seasonal averages for maximum temperature, minimum temperature and relative humidity appeared to be representative of locations. The fluctuation patterns of climatological variables were similar at all locations varying only in their value range. This variation generally corresponded with the seasonal average values used in the multiple regression correlation.

Ozone dosage was effectively isolated as the only significant monitored variable affecting the harvest characteristics. The evaluation of the dosage variable (time of peak levels and duration of exposure) pointed out factors which may possibly be more definitive than total dosage but cannot be utilized at this time. Further research into this area would be outside the immediate goals of this program.

Ozone dosage must be established as the dominant factor causing the reduction of the harvest characteristic before a conversion function can be calculated. This relationship is clear in the analyses of alfalfa yield reduction and the reduction of percent of leaf material in harvested alfalfa.

Calculation of the conversion functions for ozone dosage-alfalfa yield reduction and ozone dosage-alfalfa leaf reduction first required the utilization of the linear functions developed in the initial linear regression correlations (Figures 30, 31). The intercepts were calculated and used to translate yield values into percent reduction values. The linear regression function was then recalculated for percent reduction and ozone dosage (Figures 32, 33). Predicted percent reduction and the range of reduction (95% confidence belts) were then calculated at specific ozone dosages and tabulated to make up the conversion functions (Tables 8, 9). The equations needed for this series of calculations are presented in the Ozone Dosage-Alfalfa Loss Conversion Functions chapter.

<u>Fumigation Studies</u>

A long-term fumigation study of Moapa 69 alfalfa was undertaken to delineate ozone effects and to establish criteria needed for field work. A total of five harvests were taken at 1/10 bloom before terminating the experiment.

<u>Treatments</u>: 0 pphm ozone, 20 pphm ozone, 30 pphm ozone

<u>Exposure</u>: Treatments were exposed to their respective concentrations of ozone for 6 hours weekly over a period of 17 weeks.

<u>Results</u>: Ozone was observed to cause dramatic reductions in yield as measured by fresh and dry weights (Table 10). Reductions of 63.6% fresh weight and 64.5% dry weight were recorded for plants in the 30 pphm ozone

treatment. The 20 pphm treatment plants were observed to have yield reductions of around 31% measured as fresh and dry weights.

The ratio of leaves to total plant weight decreased in the 30 pphm treatment when measured as fresh weight but increased when measured as dry weight. This reversal cannot be explained at this time.

A fumigation study of 10 commercial varieties of alfalfa was undertaken to rank their respective ozone susceptibilities relative to Moapa 69.

Treatments: 0 pphm ozone, 20 pphm ozone, 30 pphm ozone

Exposure: Treatments were exposed to their respective ozone concentrations for 6 hours weekly over a period of 11 weeks.

Results: Each of the 10 varieties was evaluated for yield reductions within variety treatments (Table 11). The 10 varieties were then ranked for each treatment using seasonal yield as the basis for comparison (Table 12). The intra-varietal analysis and inter-varietal ranking were the basis for the sensitivity rankings given in the Ozone Dosage-Alfalfa Loss Conversion Functions chapter.

Variety Plots

The alfalfa variety plots established at the UCR Agricultural Station, Moreno Field Station and South Coast Field Station were not definitive as varietal yield data taken over a five harvest season could not be statistically separated (Tables 13, 14, 15). Dr. W. H. Isom, Extension Agronomist at UCR, has indicated tremendous variability exists during the first year's harvests in all alfalfa varieties because of the competition among seedlings and self thinning mechanism inherent in alfalfa. The seasonal harvests for the field variety plots tended to bear this out. The variability among replicate plots of the same variety was so great that no statistical differentiation was possible.

Table 6. Summary of results from the regression correlations with average seasonal yield of Moapa 69 alfalfa from field plots, ozone dosage, average seasonal maximum temperature and average daily relative humidity for a season.

Linear Correlations	Correlation Coefficients
total wt vs dose	-0.802**
total wt vs T max	-0.644
total wt vs T min	0.5356
total wt vs RH	0.6924

Regression Matrix	T-values of Regression Coefficient			f-values
	dose	character	character	
total wt vs dose & T max	-3.3411*	-2.1127		11.6641*
total wt vs dose & T min	-3.6257**	1.8918		10.4243*
total wt vs dose & RH	-3.1827*	-0.1		12.0318*
total wt vs T max & T min				2.3017
total wt vs T max & RH				3.3716
total wt vs T min & RH				3.1229
total wt vs dose & T max & T min	-3.2341*	-1.0513	0.7676	7.44*
total wt vs dose & T max & RH	-2.5653*	-0.5246	-0.4979	6.9502*
total wt vs dose & T min & RH	-2.6422*	0.499	-0.1604	6.8993*
total wt vs T max & T min & RH				2.2138
total wt vs dose & T max & T min & RH				4.1682

* Denotes significance at the .05 level.
** Denotes significance at the .01 level.

Table 7. Summary of results from the regression correlations with the average leaf to total weight of yield ratios for Moapa 69 alfalfa from field plots, ozone dosage, average seasonal maximum temperature, average seasonal minimum temperature, and average daily relative humidity for a season.

Linear Correlations	Correlation Coefficients
avg lvs/wt ratio vs dose	-0.78*
avg lvs/wt ratio vs T max	-0.4135
avg lvs/wt ratio vs T min	0.1096
avg lvs/wt ratio vs RH	0.5889

Regression Matrix	T-values of Regression Coefficient: dose	character	character	f-values
avg ratio vs dose & T max	-2.7391*	-0.6154		5.1439*
avg ratio vs dose & T min				4.7493
avg ratio vs dose & RH				4.3454
avg ratio vs T max & T min				0.8585
avg ratio vs T max & RH				1.7057
avg ratio vs T min & RH				1.3714
avg ratio vs dose & T max & T min				3.5312
avg ratio vs dose & T max & RH				2.3487
avg ratio vs dose & T min & RH				3.1647
avg ratio vs T max & T min & RH				0.9779
avg ratio vs dose & T max & T Min & RH				1.8325

* Denotes significance at the .05 level.

Table 8. Ozone dosage-alfalfa (Moapa 69) yield reduction conversion function.

Ozone Dose[1]	Predicted % Reduction	Range of % Reduction at 95% Confidence		
0.	0.000	0.0	-	17.209
250.	1.252	0.0	-	17.798
500.	2.504	0.0	-	18.401
750.	3.755	0.0	-	19.020
1000.	5.007	0.0	-	19.656
1250.	6.259	0.0	-	20.313
1500.	7.511	0.0	-	20.992
1750.	8.762	0.0	-	21.697
2000.	10.014	0.0	-	22.431
2250.	11.266	0.0	-	23.198
2500.	12.518	1.034	-	24.002
2750.	13.770	2.691	-	24.848
3000.	15.021	4.303	-	25.740
3250.	16.273	5.863	-	26.683
3500.	17.525	7.368	-	27.682
3750.	18.777	8.813	-	28.741
4000.	20.029	10.194	-	29.863
4250.	21.280	11.509	-	31.052
4500.	22.532	12.756	-	32.308
4750.	23.784	13.937	-	33.631
5000.	25.036	15.051	-	35.020
5250.	26.288	16.103	-	36.473
5500.	27.539	17.094	-	37.984
5750.	28.791	18.031	-	39.551
6000.	30.043	18.917	-	41.169
6250.	31.295	19.757	-	42.832
6500.	32.546	20.557	-	44.536
6750.	33.798	21.319	-	46.277
7000.	35.050	22.050	-	48.050
7250.	36.302	22.751	-	49.852
7500.	37.554	23.427	-	51.680
7750.	38.805	24.081	-	53.529
8000.	40.057	24.716	-	55.399
8250.	41.309	25.332	-	57.286
8500.	42.561	25.934	-	59.188
8750.	43.813	26.521	-	61.104
9000.	45.064	27.096	-	63.032
9250.	46.316	27.661	-	64.971

1. Sum of pphm hrs > 10 pphm between 1 April to 30 October of any given year.

Table 9. Ozone dosage-alfalfa (Moapa 69) leaf reduction conversion function.

Ozone Dose[1]	Predicted % Reduction	Range of % Reduction at 95% Confidence
0.	0.000	0.0 - 5.945
250.	0.407	0.0 - 6.123
500.	0.813	0.0 - 6.306
750.	1.220	0.0 - 6.494
1000.	1.627	0.0 - 6.688
1250.	2.034	0.0 - 6.889
1500.	2.441	0.0 - 7.098
1750.	2.847	0.0 - 7.316
2000.	3.254	0.0 - 7.544
2250.	3.661	0.0 - 7.783
2500.	4.068	0.100 - 8.035
2750.	4.475	0.647 - 8.302
3000.	4.881	1.178 - 8.584
3250.	5.288	1.692 - 8.885
3500.	5.695	2.186 - 9.204
3750.	6.102	2.659 - 9.544
4000.	6.508	3.111 - 9.906
4250.	6.915	3.539 - 10.291
4500.	7.322	3.945 - 10.700
4750.	7.729	4.327 - 11.131
5000.	8.136	4.686 - 11.585
5250.	8.542	5.024 - 12.061
5500.	8.949	5.341 - 12.558
5750.	9.356	5,638 - 13.074
6000.	9.763	5.919 - 13.607
6250.	10.170	6.183 - 14.156
6500.	10.576	6.434 - 14.719
6750.	10.983	6.672 - 15.295
7000.	11.390	6.898 - 15.881
7250.	11.797	7.115 - 16.478
7500.	12.203	7.323 - 17.084
7750.	12.610	7.523 - 17.697
8000.	13.017	7.717 - 18.317
8250.	13.424	7.904 - 18.944
8500.	13.831	8.086 - 19.575
8750.	14.237	8.263 - 20.211
9000.	14.644	8.436 - 20.852
9250.	15.051	8.606 - 21.496

1. Sum of pphm-hrs > 10 pphm between 1 April to 30 October for a given year.

Table 10. Effects of ozone on fumigated Moapa 69 alfalfa.

Ozone Treatments (pphm)	Season	Harvest 1	Harvest 2	Harvest 3	Harvest 4	Harvest 5
RATIO LEAVES/TOTAL FRESH WTS.						
0	.577 a[1]	.648 a	.561 a	.573 a	.566 a	.535 a
20	.565 a	.629 a	.554 a	.552 a	.550 a	.526 a
30	.531 b	.580 b	.558 a	.495 b	.425 b	.505 a
RATIO LEAVES/TOTAL DRY WTS.						
0	.582 a	.655 a	.570 a	.573 a	.571 a	.542 a
20	.621 b	.675 a	.623 b	.604 a	.620 a	.571 a
30	.641 b	.679 a	.622 b	.612 a	.602 a	.642 b
TOTAL FRESH WTS (GMS)						
0	132.5 a	28.7 a	25.4 a	25.0 a	24.3 a	29.1 a
20	89.4 b	21.7 b	16.2 b	17.1 b	14.7 b	19.5 b
30	48.2 c	15.3 c	9.6 c	9.9 c	5.9 c	7.4 c
TOTAL DRY WTS (GMS)						
0	25.1 a	5.6 a	4.4 a	4.4 a	4.8 a	5.9 a
20	17.2 b	4.4 b	3.0 b	2.8 b	3.0 b	3.8 b
30	8.9 c	3.1 c	1.6 c	1.7 c	1.0 c	1.3 c

1. Treatment means followed by the same letter are not significantly different at the .05 level.

Table 11. Ozone effects on fumigated alfalfa variety yields.

Variety	Ozone Treatments (pphm)	Fresh Wts (GMS) Season	Fresh Wts (GMS) Harvest 1	Fresh Wts (GMS) Harvest 2	Fresh Wts (GMS) Harvest 3	Dry Wts (GMS) Season	Dry Wts (GMS) Harvest 1	Dry Wts (GMS) Harvest 2	Dry Wts (GMS) Harvest 3
AS 13	0	195.6 a[1]	58.0 a	74.2 a	63.4 a	34.4 a	9.1 a	14.0 a	11.3 a
	20	163.2 a	34.4 b	60.0 a	68.8 a	29.7 a	6.1 a	11.1 a	12.4 a
	30	122.6 a	27.6 b	43.6 a	51.4 a	23.5 a	5.3 a	8.3 a	9.9 a
BONANZA	0	185.2 a	60.4 a	64.0 a	60.8 a	36.4 a	10.1 a	14.8 a	11.6 a
	20	161.4 a	51.2 a	55.2 a	55.0 a	29.7 a	8.5 a	11.3 a	9.9 ab
	30	94.0 b	30.8 a	29.6 b	33.6 a	18.2 b	5.9 b	6.4 b	5.9 b
CALIENTE	0	232.4 a	59.8 a	87.6 a	85.0 a	41.9 a	9.6 a	16.7 a	15.7 a
	20	204.7 a	44.2 ab	88.5 a	74.5 a	36.6 a	7.9 a	16.0 a	12.7 a
	30	133.0 b	32.2 b	54.0 b	44.8 b	23.4 b	6.0 a	9.8 b	7.6 b
EL CAMINO	0	163.6 a	61.6 a	52.2 a	49.8 a	32.1 a	10.1 a	11.9 a	10.1 a
	20	159.4 a	49.2 ab	56.0 a	54.2 a	30.6 a	7.7 b	11.8 a	11.1 a
	30	143.2 a	38.8 b	56.4 a	48.0 a	27.4 a	7.1 b	10.9 a	9.4 a

1. Treatment means followed by the same letter are not significantly different at the .05 level.

Table 11. Ozone effects on fumigated alfalfa variety yields.

Ozone Treatments (pphm)	Fresh Wts (GMS) Season	Fresh Harvest 1	Fresh Harvest 2	Fresh Harvest 3	Dry Wts (GMS) Season	Dry Harvest 1	Dry Harvest 2	Dry Harvest 3
EL DORADO								
0	193.0 a[1]	54.2 a	71.8 a	67.0 a	35.6 a	8.7 a	14.4 a	12.5 a
20	170.2 a	39.6 b	65.0 a	65.6 a	32.2 a	7.0 b	12.6 ab	12.6 a
30	136.8 b	37.8 b	53.4 a	45.6 b	24.9 b	6.9 b	9.9 a	8.1 b
HAYDEN								
0	205.7 a	77.0 a	74.8 a	68.6 a	37.5 a	12.6 a	16.3 a	12.7 a
20	133.8 b	39.4 b	52.6 a	41.8 b	25.2 b	6.8 b	10.8 a	7.6 b
30	133.8 b	42.0 c	52.4 a	39.4 b	24.2 b	7.1 b	10.3 a	6.9 c
JOAQUIN								
0	226.4 a	57.6 a	84.6 a	83.8 a	38.1 a	8.6 a	15.3 a	14.2 a
20	160.6 b	36.6 b	61.0 b	63.0 b	29.4 b	6.1 b	11.7 ab	11.6 a
30	115.4 c	27.6 b	41.8 b	46.0 c	20.4 c	5.0 c	7.5 b	7.8 b
MOAPA								
0	260.6 a	73.0 a	100.4 a	87.2 a	47.1 a	11.9 a	19.2 a	16.0 a
20	176.2 b	49.6 b	72.8 b	54.0 b	33.1 b	8.5 b	14.6 b	10.1 b
30	116.2 c	29.0 c	52.0 b	35.2 c	21.4 c	5.5 c	9.4 c	6.4 c

1. Treatment means followed by the same letter are not significantly different at the .05 level.

Table 11. Ozone effects on fumigated alfalfa variety yields.

MESA SIRSA

Ozone Treatments (pphm)	Fresh Wts (GMS) Season	Fresh Wts (GMS) Harvest 1	Fresh Wts (GMS) Harvest 2	Fresh Wts (GMS) Harvest 3	Dry Wts (GMS) Season	Dry Wts (GMS) Harvest 1	Dry Wts (GMS) Harvest 2	Dry Wts (GMS) Harvest 3
0	259.8 a[1]	68.8 a	103.8 a	79.6 a	45.8 a	10.7 a	18.1 a	15.8 a
20	170.4 b	50.6 b	65.8 b	57.8 b	29.8 b	7.9 b	10.8 b	9.9 b
30	108.8 c	31.4 c	42.2 c	35.4 c	18.2 c	5.3 c	7.9 b	5.2 c

OLD SONORA

Ozone Treatments (pphm)	Fresh Wts (GMS) Season	Fresh Wts (GMS) Harvest 1	Fresh Wts (GMS) Harvest 2	Fresh Wts (GMS) Harvest 3	Dry Wts (GMS) Season	Dry Wts (GMS) Harvest 1	Dry Wts (GMS) Harvest 2	Dry Wts (GMS) Harvest 3
0	202.6 a	62.6 a	74.6 a	65.4 a	37.9 a	10.3 a	11.8 a	12.2 a
20	146.0 b	45.6 b	69.4 a	51.0 a	30.4 a	8.0 b	13.8 a	8.6 ab
30	119.8 b	32.8 c	45.0 b	42.0 a	21.2 b	5.5 c	8.6 a	7.1 b

1. Treatment means followed by the same letter are not significantly different at the .05 level.

Table 12. Ranked seasonal yields within fumigated treatments.

0 PPHM OZONE

	Variety	Yield (gms)		Variety	Yield (gms)
1.	Moapa 69	260.6	6.	Old Sonora	202.6
2.	Mesa Sirsa	259.8	7.	AS 13	195.6
3.	Caliente	232.4	8.	El Dorado	193.0
4.	Joaquin	226.4	9.	Bonanza	185.2
5.	Hayden	205.7	10.	El Camino	163.6

20 PPHM OZONE

	Variety	Yield (gms)		Variety	Yield (gms)
1.	Caliente	204.7	6.	Bonanza	161.4
2.	Moapa 69	176.2	7.	Joaquin	160.6
3.	Mesa Sirsa	170.4	8.	El Camino	159.4
4.	El Dorado	170.2	9.	Old Sonora	146.0
5.	AS 13	163.2	10.	Hayden	133.8

30 PPHM OZONE

	Variety	Yield (gms)		Variety	Yield (gms)
1.	El Camino	143.2	6.	Old Sonora	119.8
2.	El Dorado	136.8	7.	Moapa 69	116.2
3.	Hayden	133.8	8.	Joaquin	115.4
4.	Caliente	133.0	9.	Mesa Sirsa	108.8
5.	AS 13	122.6	10.	Bonanza	94.0

Table 13. UCR alfalfa variety harvests.

AVG FRESH WTS. (GMS)

	Season	Harvest 1	Harvest 2	Harvest 3	Harvest 4	Harvest 5
AS 13	4536.5 a[1]	518.7 a	933.2 a	794.7 a	947.7 a	1342.0 cd
Bonanza	5395.7 a	709.5 a	963.5 a	954.7 a	1250.7 a	1517.2 abc
Caliente	4832.5 a	533.5 a	744.5 a	773.5 a	1176.0 a	1605.0 ab
El Camino	4966.0 a	446.7 a	777.5 a	1010.7 a	1122.7 a	1608.2 ab
El Dorado	4295.0 a	456.5 a	692.0 a	755.5 a	987.7 a	1403.2 bcd
Hayden	4456.2 a	581.7 a	858.7 a	731.5 a	856.0 a	1428.2 bcd
Joaquin	4344.0 a	504.0 a	846.0 a	801.5 a	930.5 a	1262.0 d
Moapa 69	4750.7 a	475.5 a	809.5 a	823.2 a	1062.5 a	1580.0 ab
Mesa Sirsa	4969.7 a	574.7 a	805.5 a	910.7 a	1128.7 a	1550.0 abc
Old Sonora	4883.2 a	436.7 a	690.5 a	987.5 a	1062.5 a	1706.0 a

RATIO OF LEAVES TO TOTAL WTS.

	Season	Harvest 1	Harvest 2	Harvest 3	Harvest 4	Harvest 5
AS 13	.590 ab	.686 a	.551 a	.534 a	.587 a	.599 b
Bonanza	.563 cd	.684 a	.536 a	.503 a	.568 a	.550 a
Caliente	.574 bc	.673 a	.590 a	.507 a	.566 a	.567 ab
El Camino	.602 a	.723 a	.576 a	.574 a	.584 a	.585 b
El Dorado	.596 a	.683 a	.572 a	.533 a	.609 a	.595 b
Hayden	.555 cd	.682 a	.521 a	.470 a	.582 a	.540 a
Joaquin	.591 ab	.678 a	.557 a	.527 a	.612 a	.591 b
Moapa 69	.555 cd	.679 a	.497 a	.504 a	.580 a	.551 a
Mesa Sirsa	.551 d	.651. a	.544 a	.487 a	.568 a	.538 a
Old Sonora	.564 cd	.678 a	.544 a	.535 a	.573 a	.541 a

1. Treatment means followed by the same letter are not significantly different at the .05 level.

Table 14. South Coast Field Station alfalfa variety harvests.

AVG FRESH WTS. (GMS)

	Season	Harvest 1	Harvest 2	Harvest 3	Harvest 4	Harvest 5
AS 13	6071.2 a[1]	1192.5 a	1124.7 a	1275.2 a	1349.0 a	1129.7 a
Bonanza	6128.5 a	1163.0 a	916.2 a	1388.0 a	1364.2 a	1297.0 a
Caliente	5946.7 a	1280.0 a	1138.0 a	1166.5 a	1308.0 a	1304.2 a
El Camino	6646.2 a	1310.0 a	1200.5 a	1318.5 a	1504.2 a	1338.0 a
El Dorado	5671.0 a	1173.2 a	968.5 a	1149.5 a	1213.0 a	1166.7 a
Hayden	5897.5 a	1139.2 a	1273.5 a	1178.2 a	1134.2 a	1172.2 a
Joaquin	5960.7 a	1102.0 a	1073.0 a	1273.0 a	1421.5 a	1091.2 a
Moapa 69	6433.5 a	1224.7 a	1232.7 a	1243.7 a	1400.5 a	1199.5 a
Mesa Sirsa	6289.7 a	1289.7 a	1242.7 a	1203.7 a	1401.5 a	1152.0 a
Old Sonora	6260.0 a	1181.2 a	977.2 a	1303.2 a	1297.7 a	1500.5 a

RATIO OF LEAVES TO TOTAL WTS.

	Season	Harvest 1	Harvest 2	Harvest 3	Harvest 4	Harvest 5
AS 13	.591 ab	.620 abc	.617 a	.557 a	.583 a	.599 a
Bonanza	.541 c	.626 abc	.657 a	.507 a	.491 a	.519 a
Caliente	.561 bc	.628 abc	.643 a	.485 a	.540 a	.549 a
El Camino	.614 a	.674 d	.683 a	.559 a	.601 a	.590 a
El Dorado	.546 c	.610 abc	.643 a	.536 a	.564 a	.557 a
Hayden	.551 c	.598 a	.609 a	.516 a	.520 a	.557 a
Joaquin	.592 ab	.648 cd	.641 a	.533 a	.571 a	.590 a
Moapa 69	.566 bc	.645 bcd	.627 a	.510 a	.523 a	.553 a
Mesa Sirsa	.559 bc	.602 ab	.601 a	.537 a	.521 a	.556 a
Old Sonora	.547 c	.617 abc	.674 a	.463 a	.535 a	.519 a

1. Treatment means followed by the same letter are not significantly different at the .05 level.

Table 15. Moreno alfalfa variety harvests.

AVG FRESH WTS. (GMS)

	Season	Harvest 1	Harvest 2	Harvest 3	Harvest 4	Harvest 5
AS 13	5038.7 a[1]	882.5 a	1374.5 a	1127.7 a	866.2 a	787.7 a
Bonanza	5219.5 a	929.5 a	1316.2 a	1090.5 a	1041.0 a	842.2 a
Caliente	5026.7 a	963.7 a	1346.7 a	1093.5 a	891.2 a	731.5 a
El Camino	5258.0 a	990.0 a	1264.5 a	1166.0 a	984.5 a	853.0 a
El Dorado	4888.7 a	890.0 a	1354.5 a	1059.2 a	836.7 a	748.2 a
Hayden	4553.7 a	839.7 a	1078.0 a	1036.7 a	880.2 a	719.0 a
Joaquin	5177.0 a	986.2 a	1272.5 a	1218.2 a	915.7 a	784.2 a
Moapa 69	4394.7 a	760.5 a	1058.5 a	980.2 a	870.0 a	725.5 a
Mesa Sirsa	4808.2 a	956.7 a	1151.0 a	1026.5 a	909.2 a	764.7 a
Old Sonora	5272.0 a	996.0 a	1345.5 a	1131.2 a	976.0 a	823.2 a

RATIO OF LEAVES TO TOTAL WTS.

	Season	Harvest 1	Harvest 2	Harvest 3	Harvest 4	Harvest 5
AS 13	.586 ab	.612 a	.549 abc	.559 a	.608 bc	.638 a
Bonanza	.569 b	.607 a	.504 a	.525 a	.557 a	.642 a
Caliente	.594 ab	.598 a	.553 bcd	.580 a	.594 b	.642 a
El Camino	.628 c	.659 a	.598 cd	.594 a	.639 c	.661 a
El Dorado	.591 ab	.594 a	.557 bcd	.589 a	.586 ab	.623 a
Hayden	.595 ab	.599 a	.568 bcd	.547 a	.599 b	.657 a
Joaquin	.612 ac	.616 a	.601 d	.565 a	.611 bc	.673 a
Moapa 69	.594 ab	.577 a	.572 bcd	.600 a	.583 ab	.634 a
Mesa Sirsa	.577 b	.626 a	.540 ab	.540 a	.594 b	.605 a
Old Sonora	.589 ab	.612 a	.566 bcd	.536 a	.577 ab	.631 a

1. Treatment means followed by the same letter are not significantly different at the .05 level.

Figure 2. Correlation of the average lvs/wt ratio of field plot Moapa 69 alfalfa with the total ambient ozone dosage present during growth.

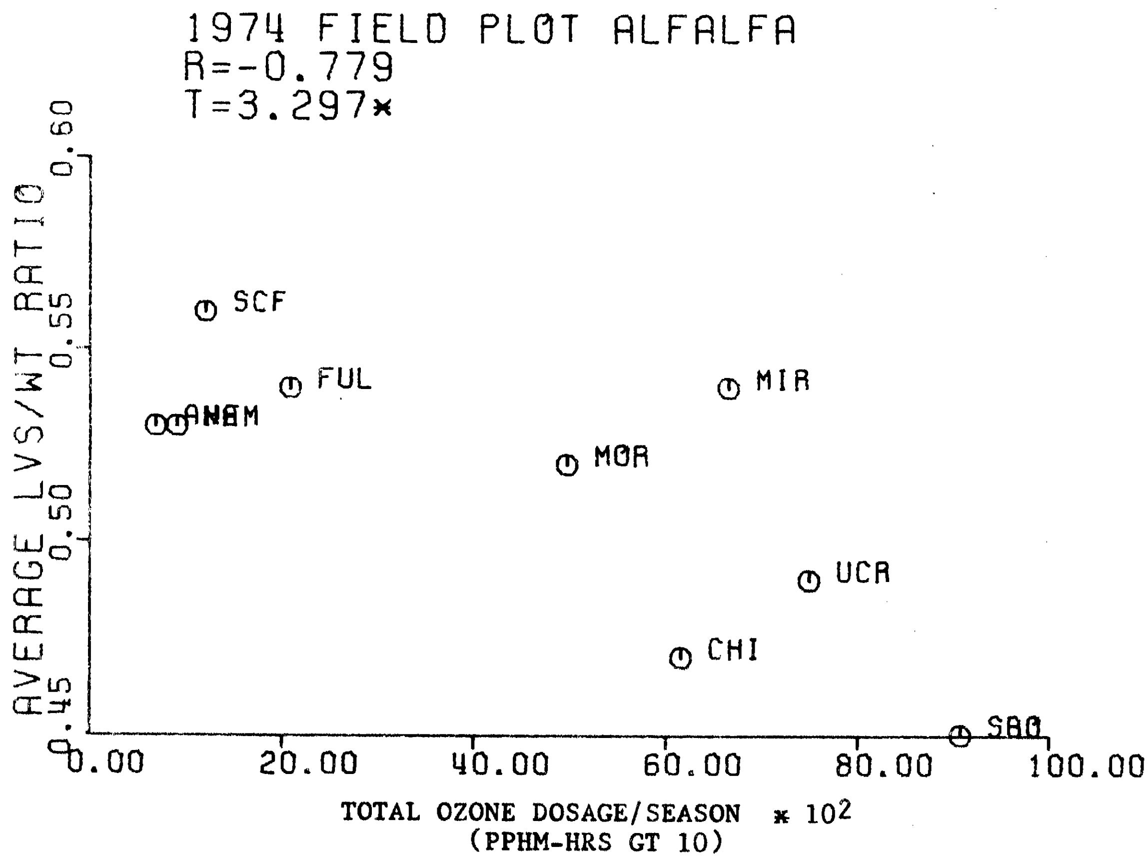


Figure 3. Correlation of average wt per plant harvested with the total ambient ozone dosage present during growth.

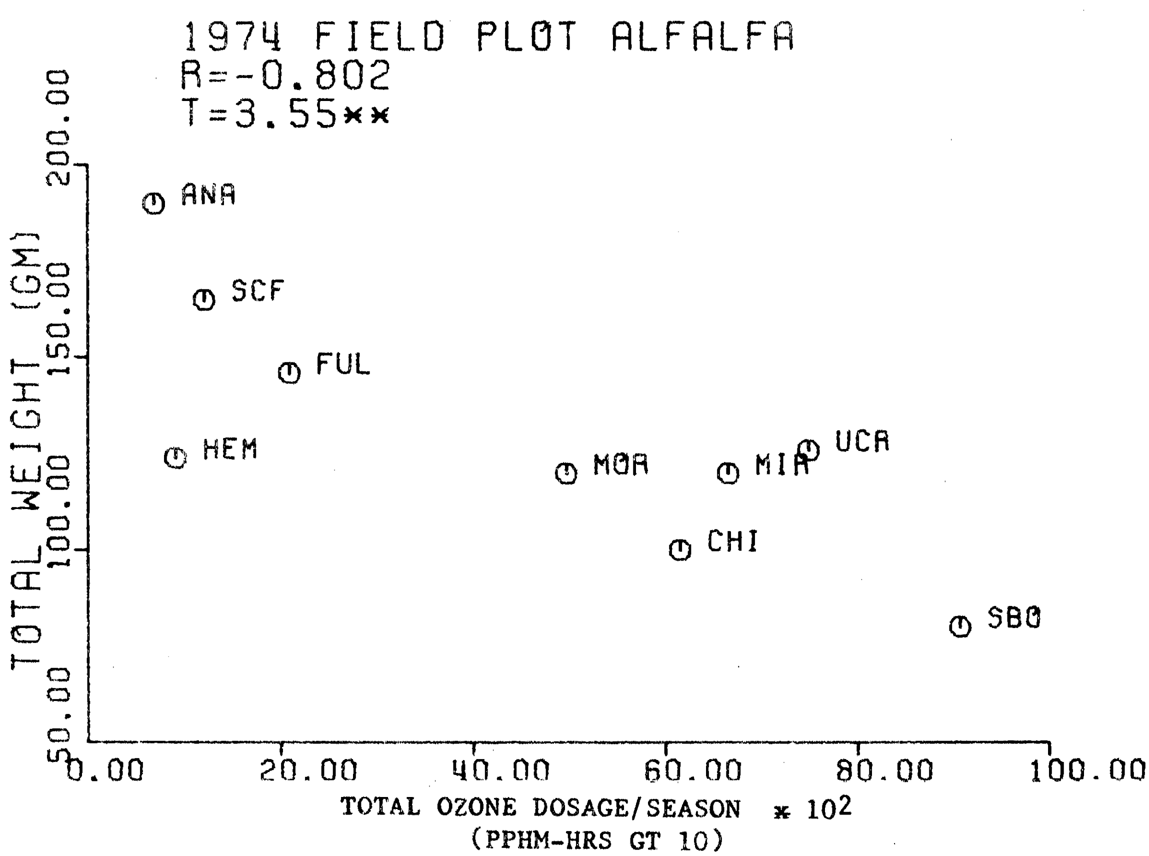


Figure 4. Anaheim field plot maximum and minimum temperatures during the growth of Moapa 69 alfalfa starting 1 April 1974

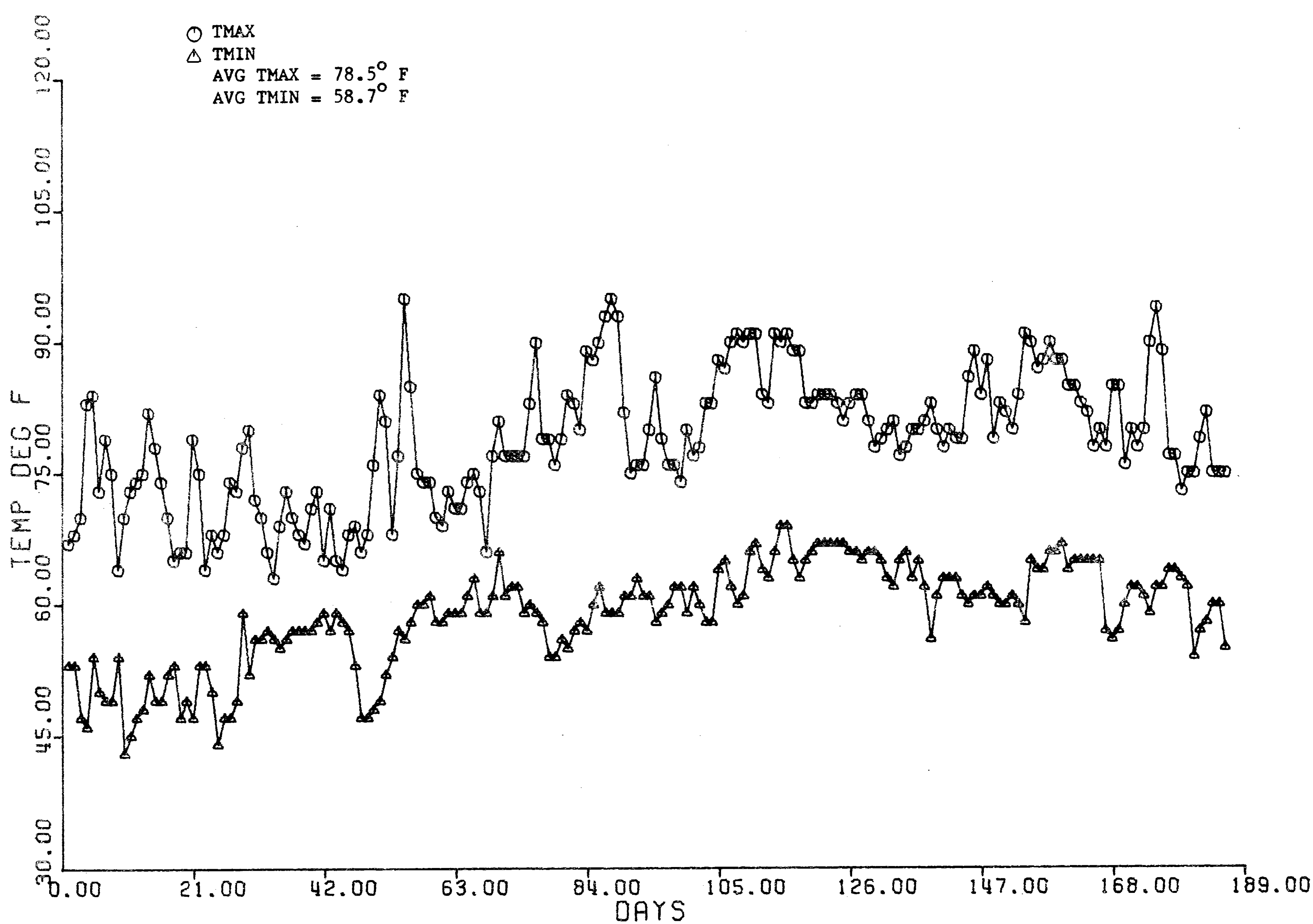


Figure 5. Fullerton field plot maximum and minimum temperatures during the growth of Moapa 69 alfalfa starting 1 April 1974.

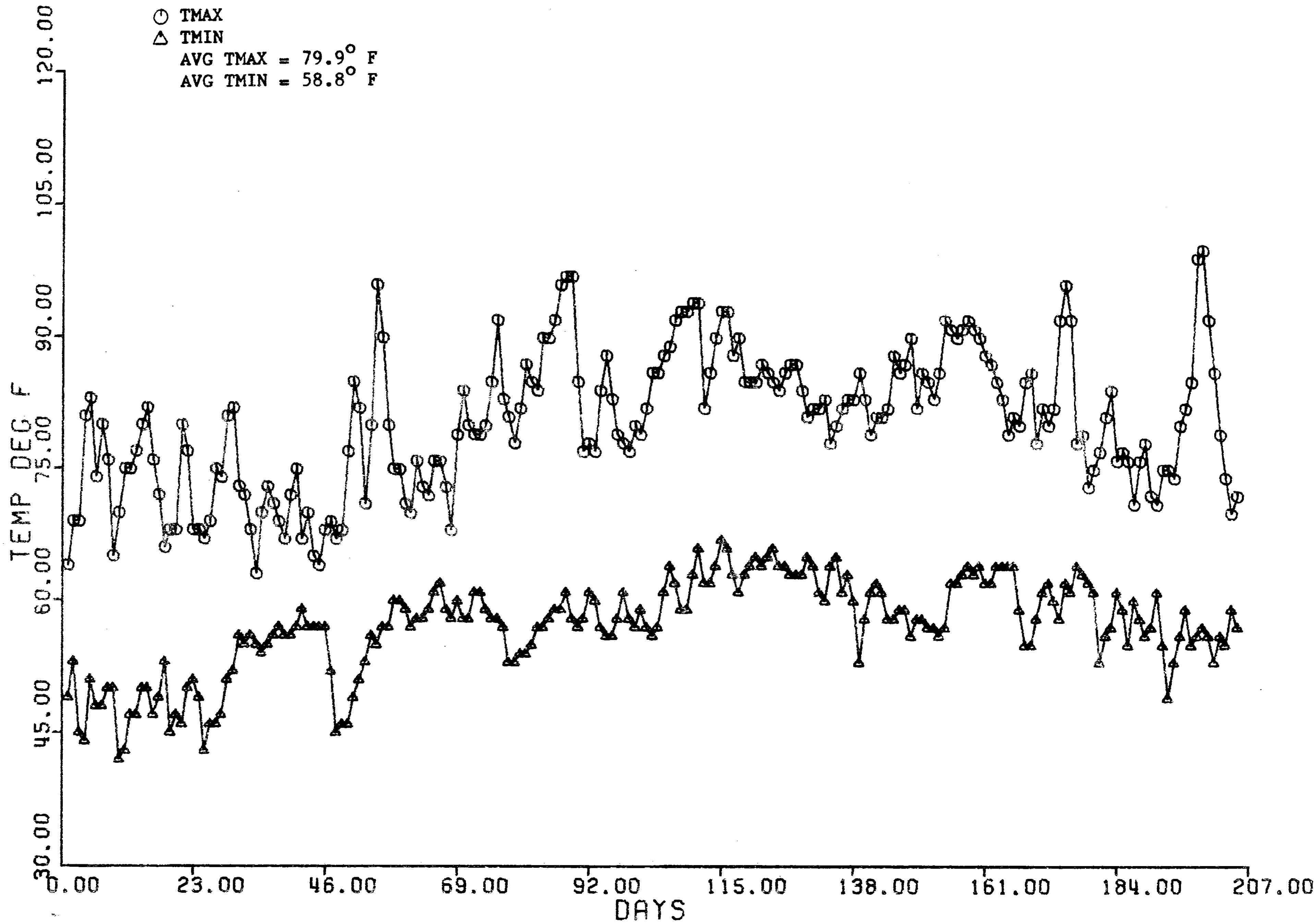


Figure 6. Hemet field plot maximum and minimum temperatures during the growth of Moapa 69 alfalfa starting 1 April 1974.

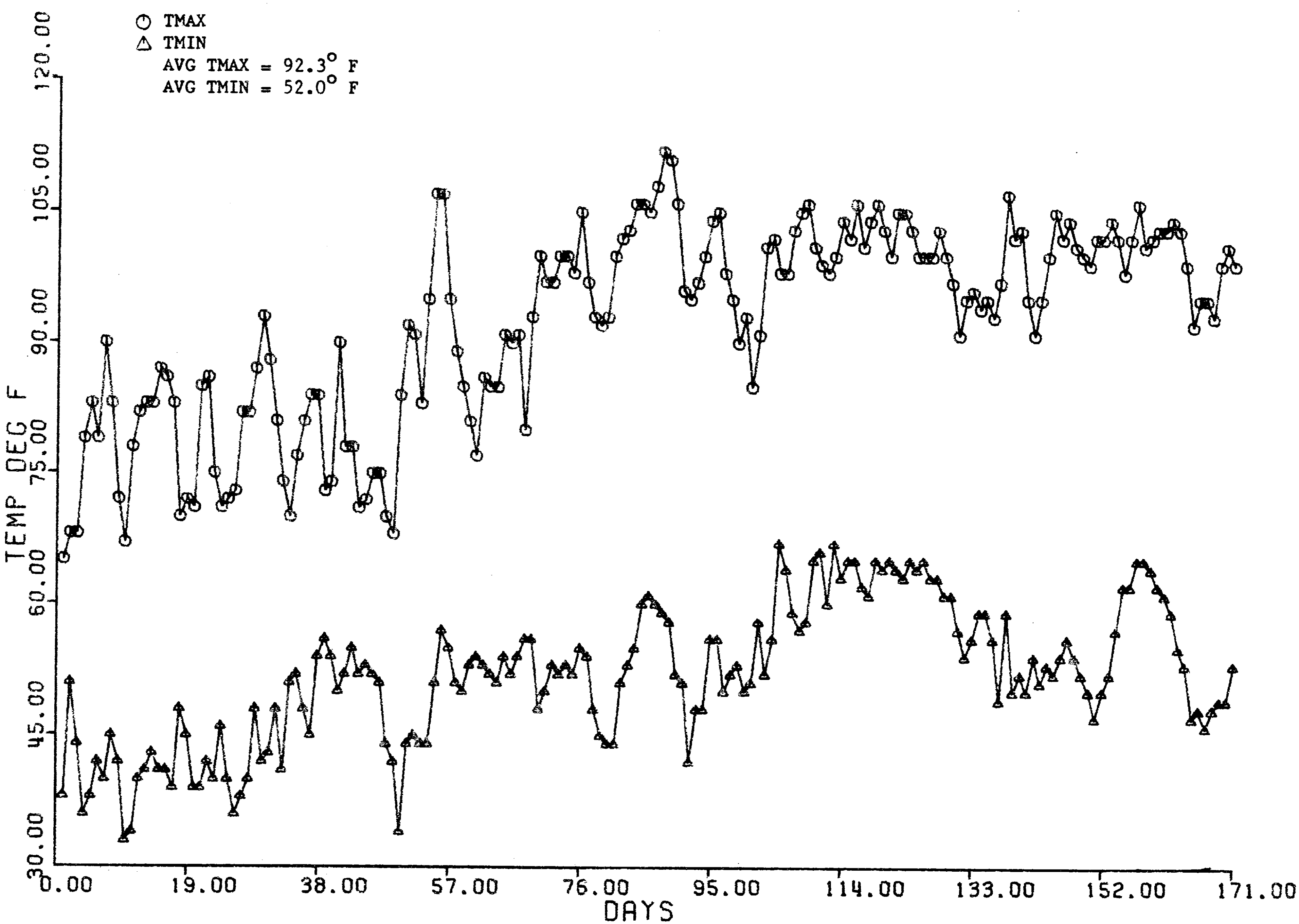


Figure 7. Mira Loma and Chino field plot maximum and minimum temperatures during the growth of Moapa 69 alfalfa starting 1 April 1974.

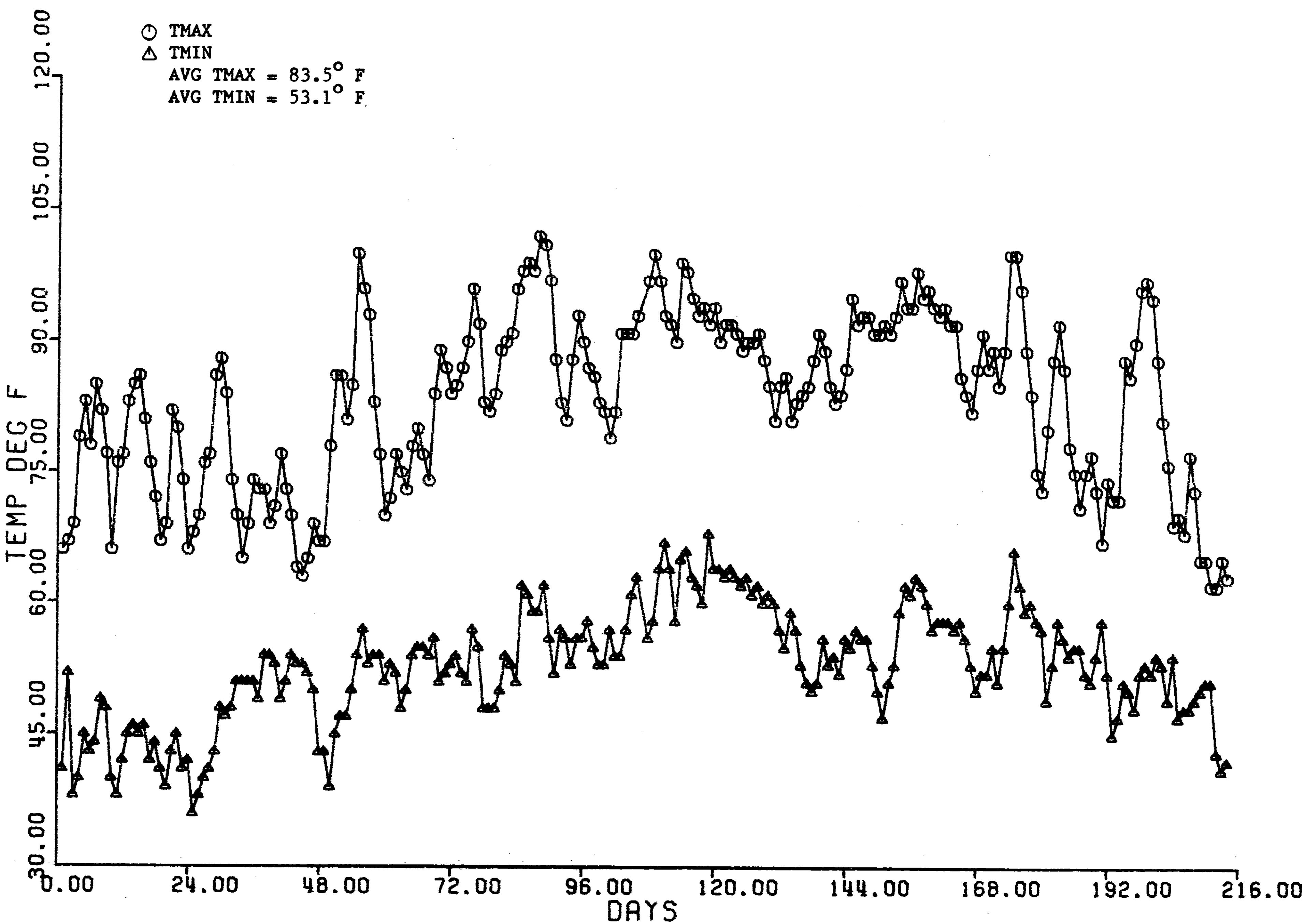


Figure 8. Moreno field plot maximum and minimum temperatures during the growth of Moapa 69 alfalfa starting 1 April 1974

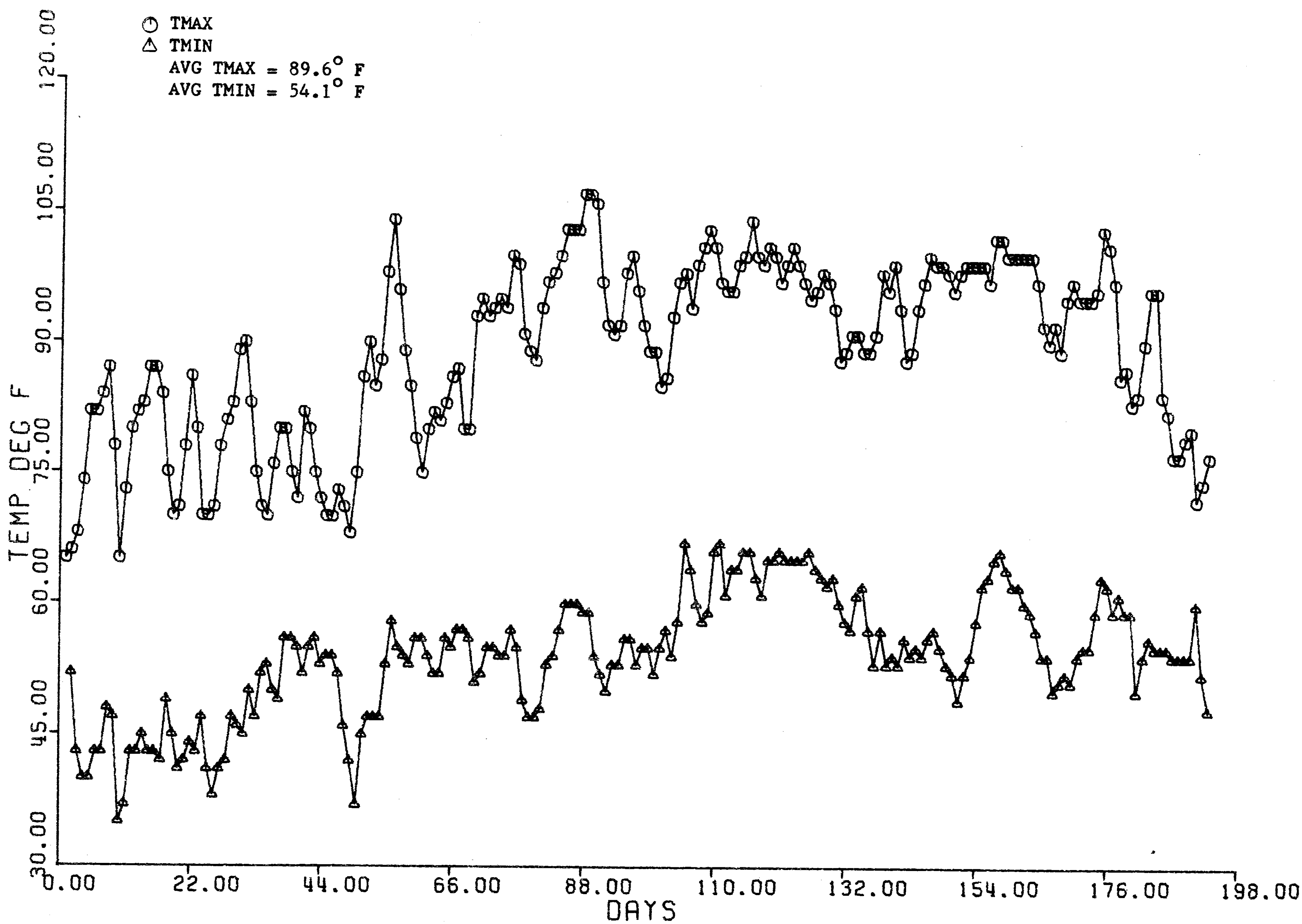


Figure 9. San Bernardino field plot maximum and minimum temperatures during the growth of Moapa 69 alfalfa starting 1 April 1974.

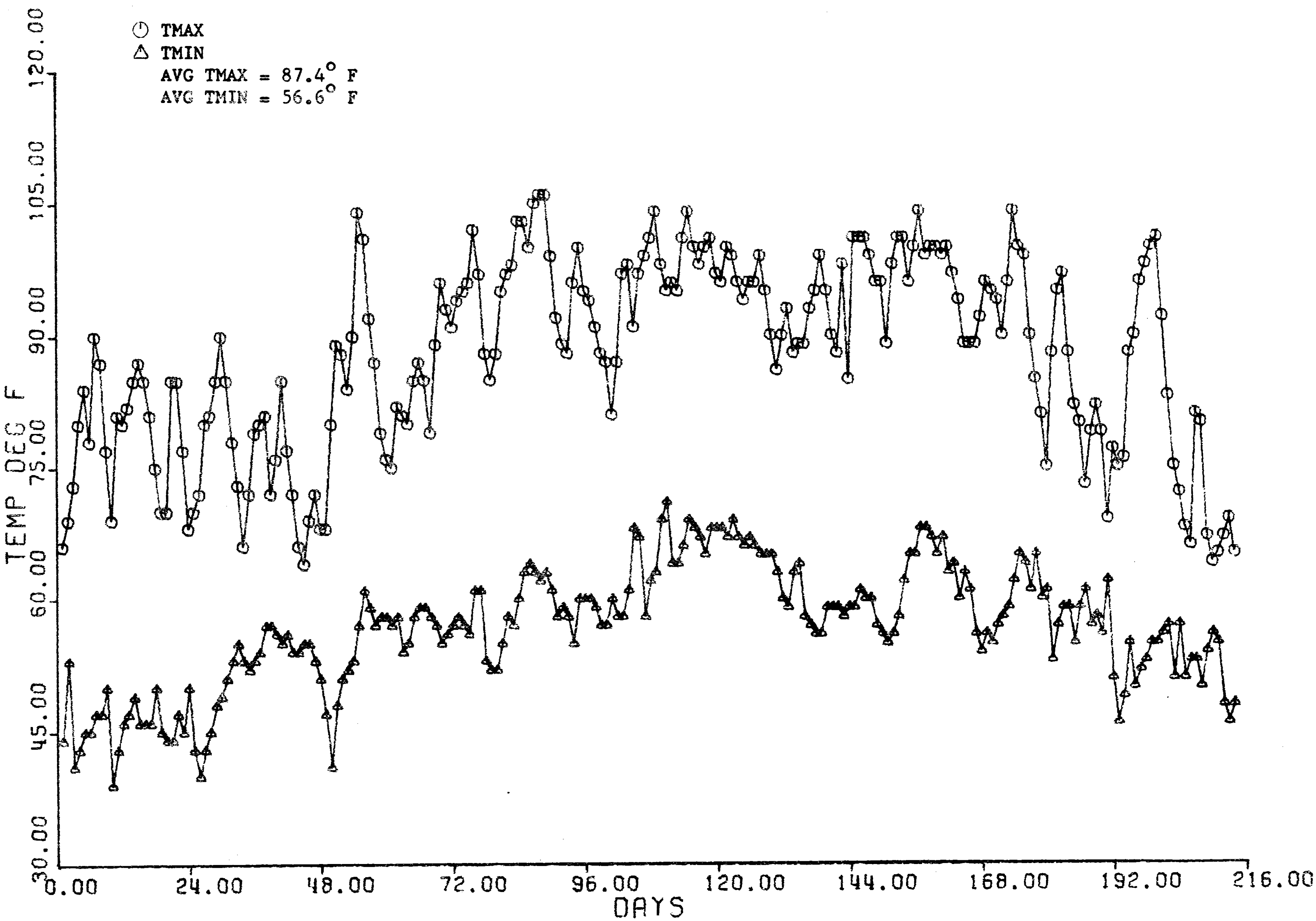


Figure 10. South Coast Field plot maximum and minimum temperatures during the growth of Moapa 69 alfalfa starting 1 April 1974.

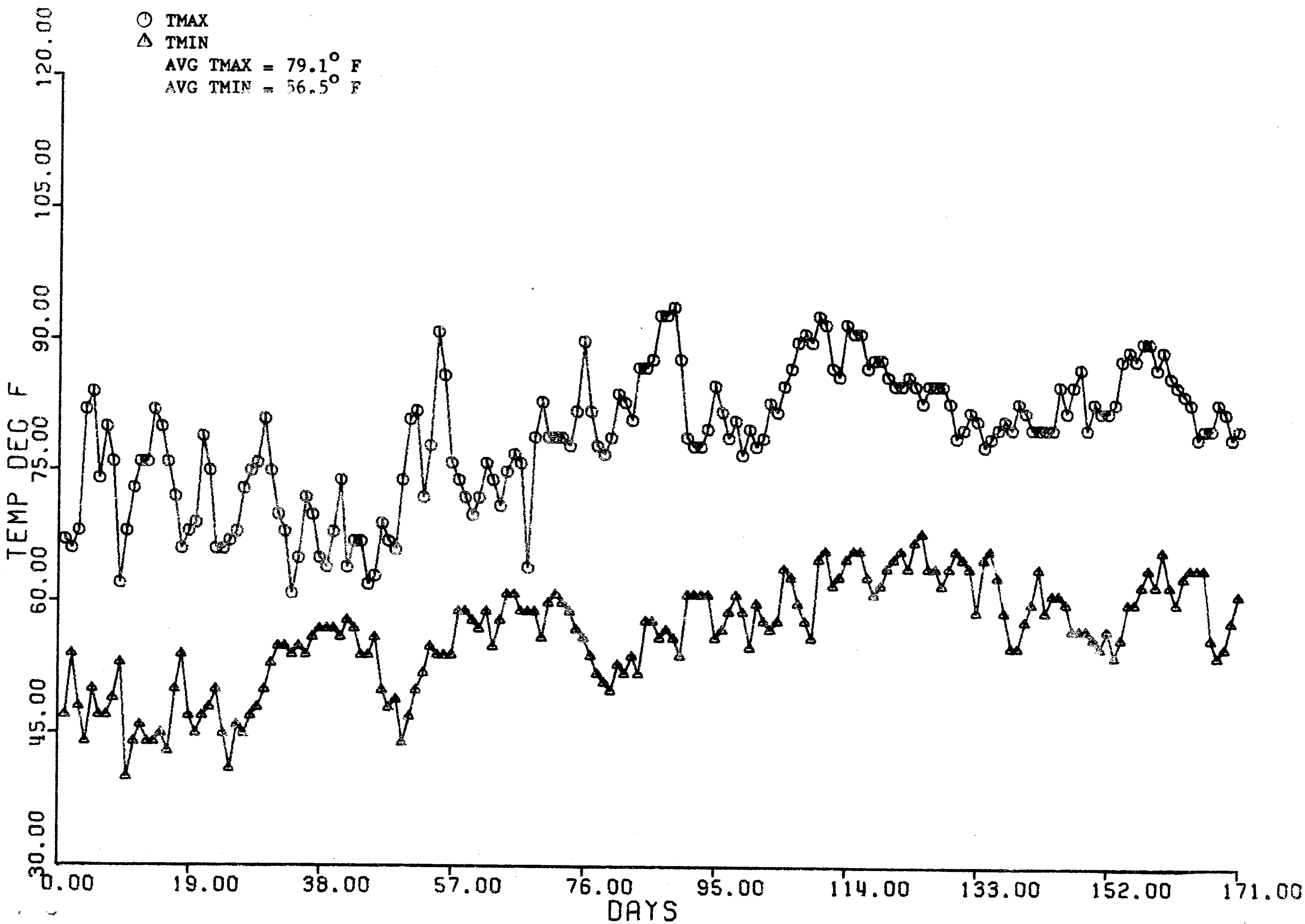


Figure 11. UCR field plot maximum and minimum temperatures during the growth of Moapa 69 alfalfa starting 1 April 1974.

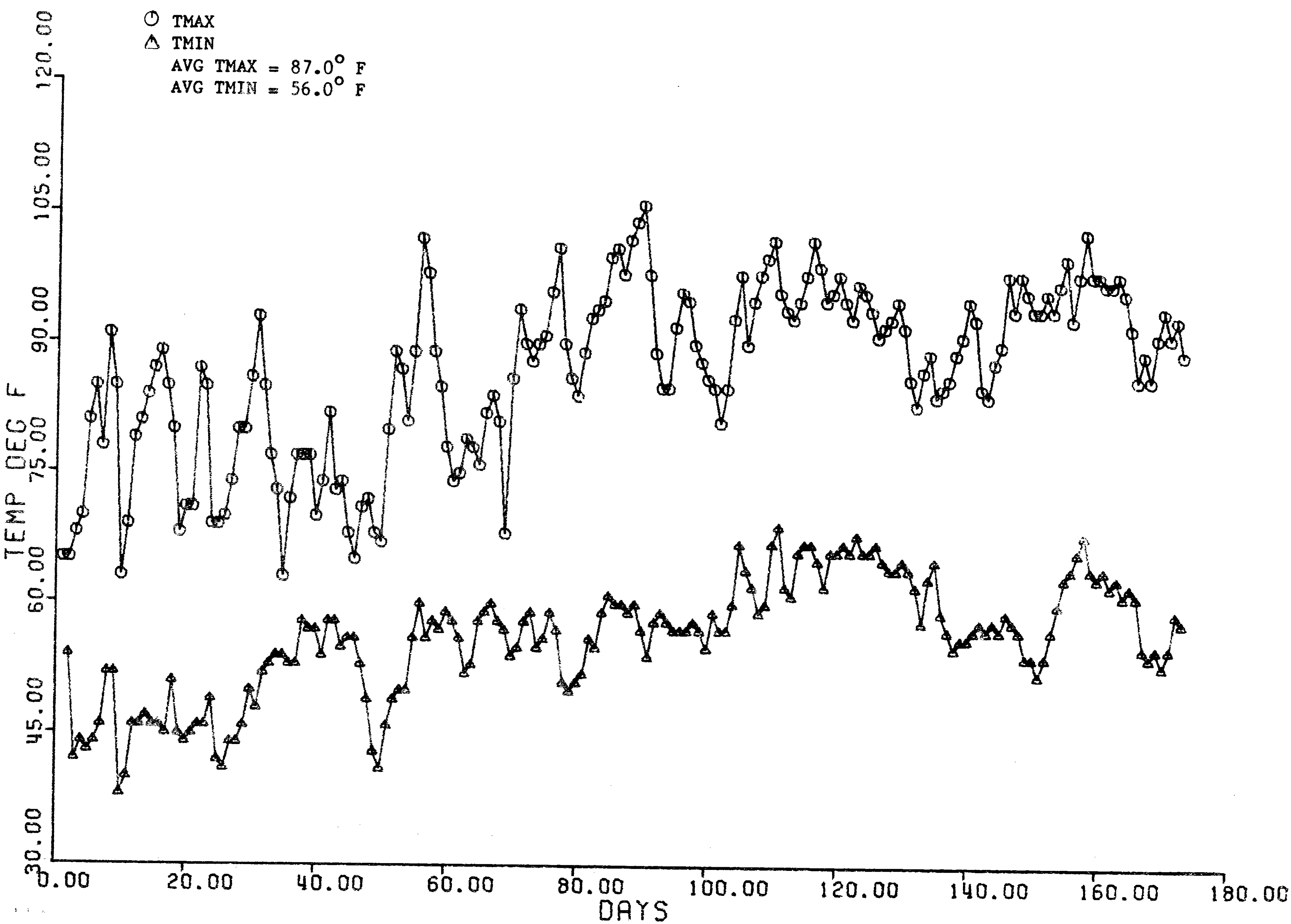


Figure 12. Anaheim field plot average daily relative humidity and daily ozone dosage during the growth of Moapa 69 alfalfa starting 1 April 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

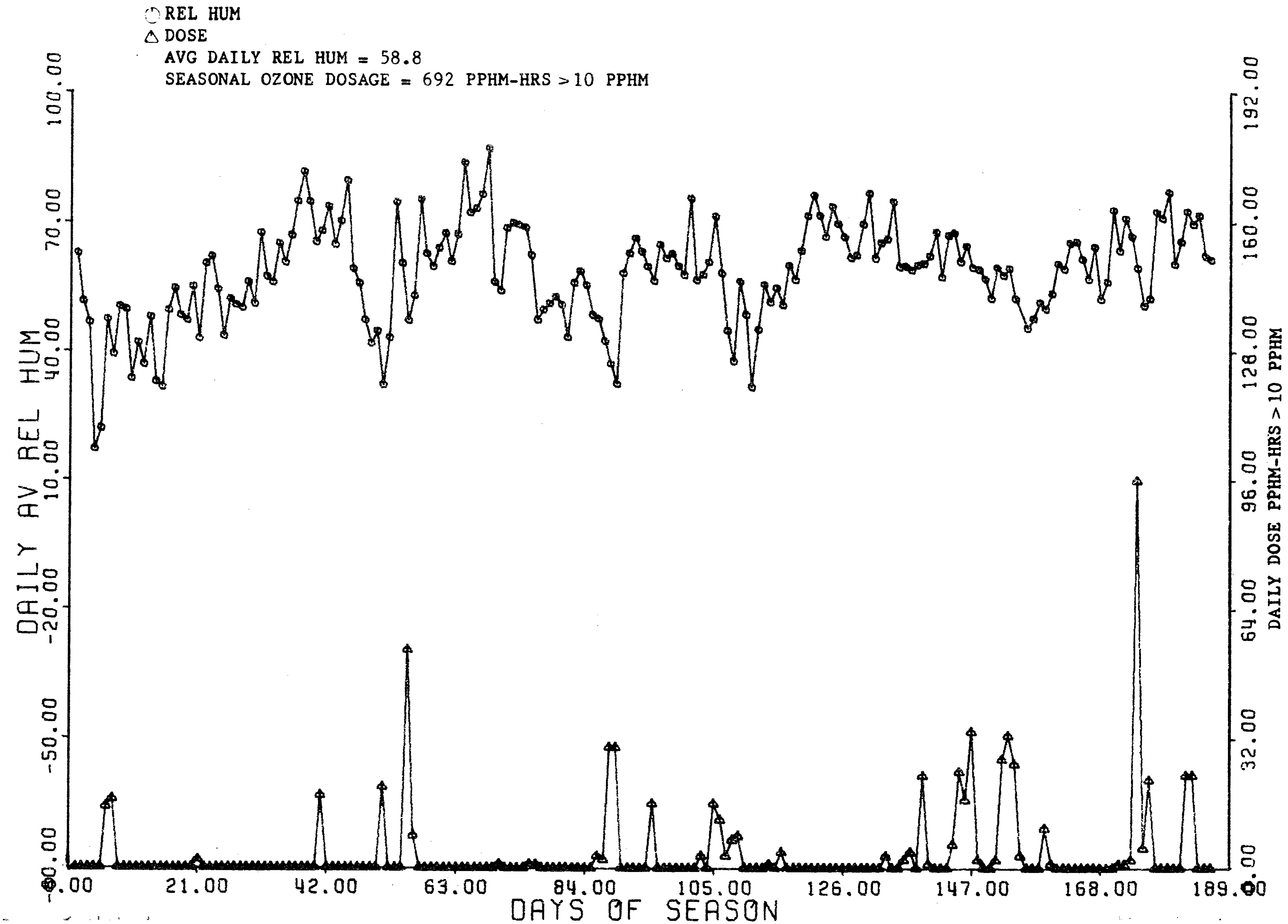


Figure 13. Chino field plot average daily relative humidity and daily ozone dosage during the growth of Moapa 69 alfalfa starting 1 April 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

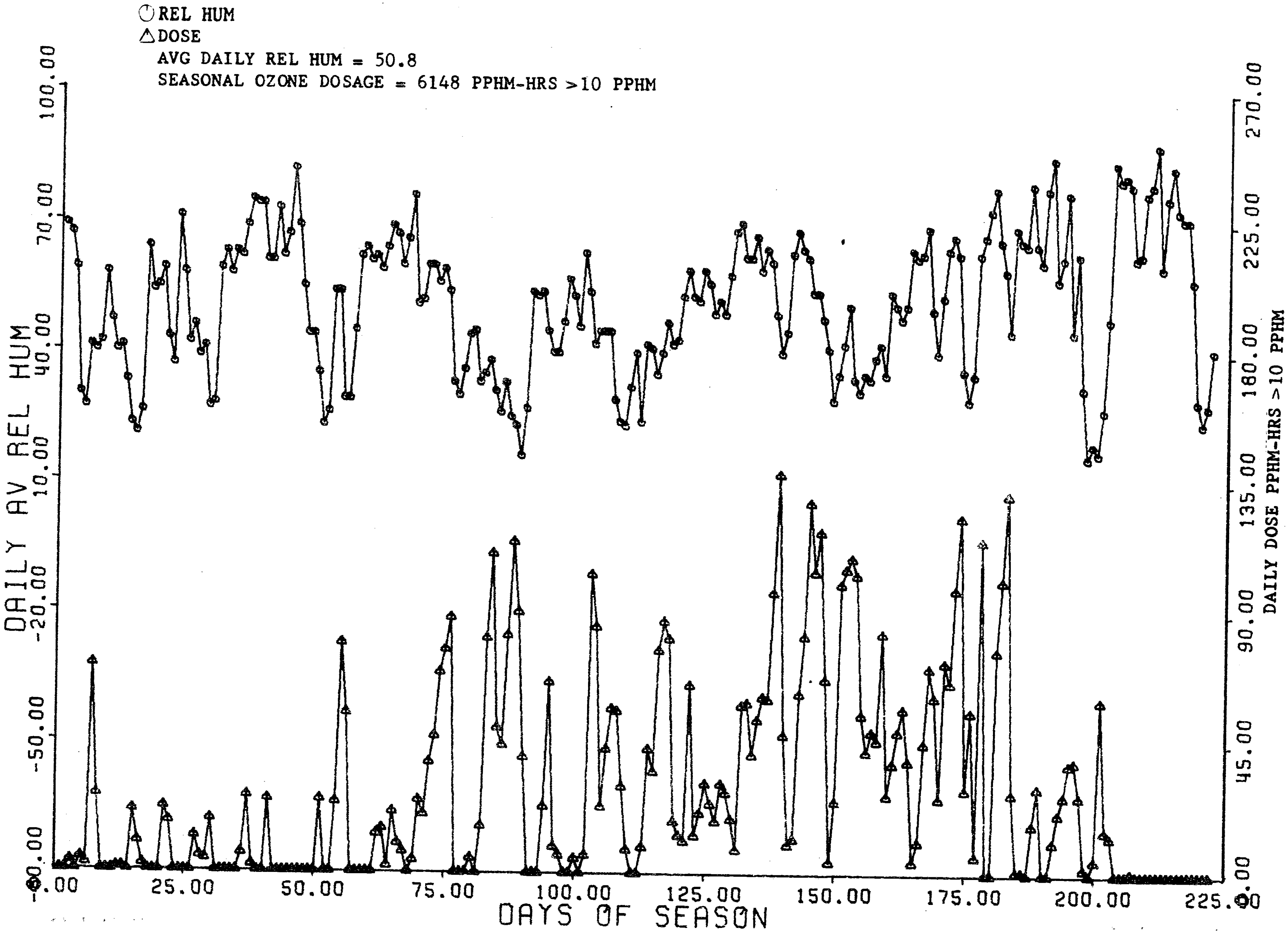


Figure 14. Fullerton field plot average daily relative humidity and daily ozone dosage during the growth of Moapa 69 alfalfa starting 1 April 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

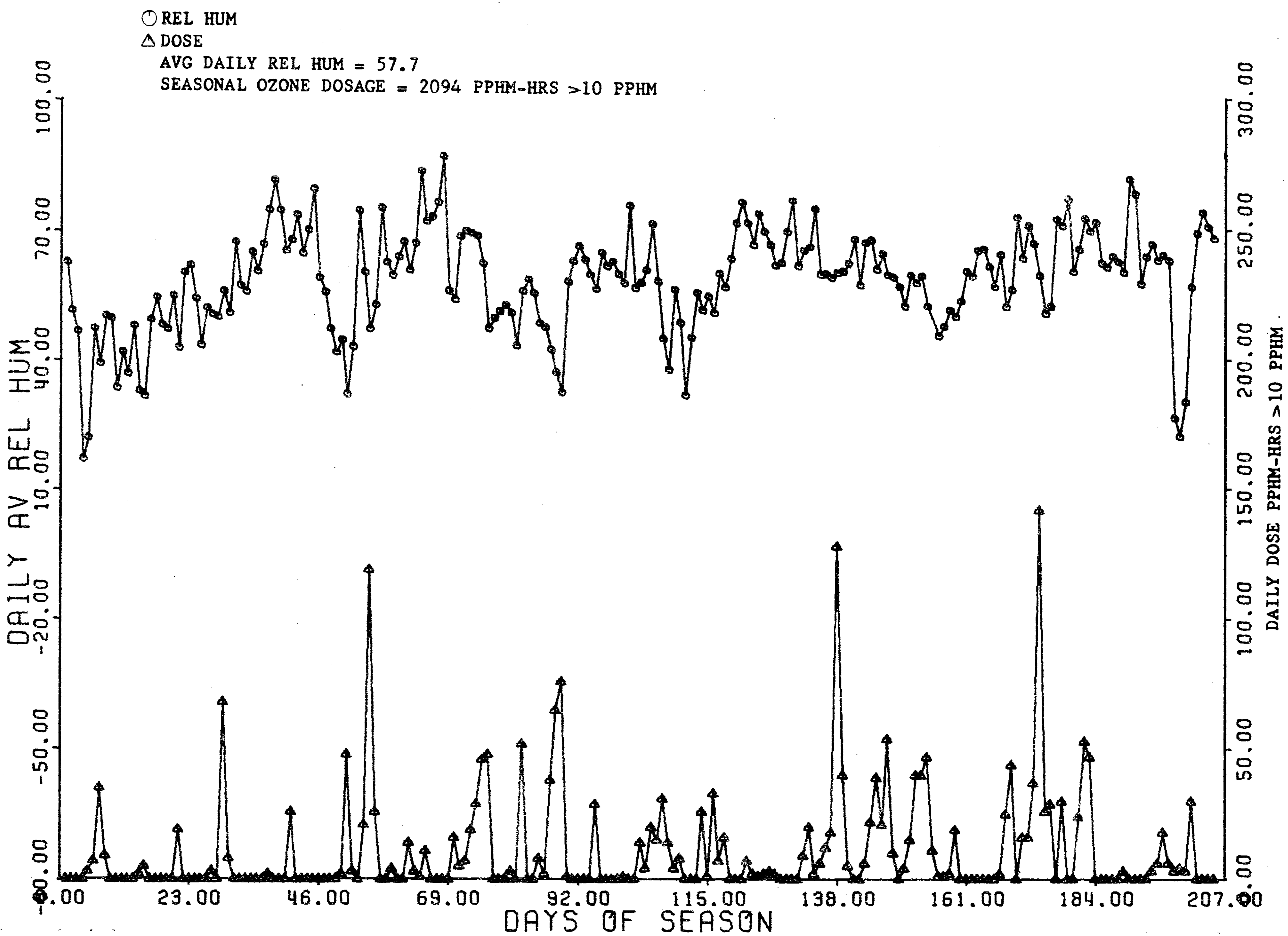


Figure 15. Hemet field plot average daily relative humidity and daily ozone dosage during the growth of Moapa 69 alfalfa starting 1 April 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

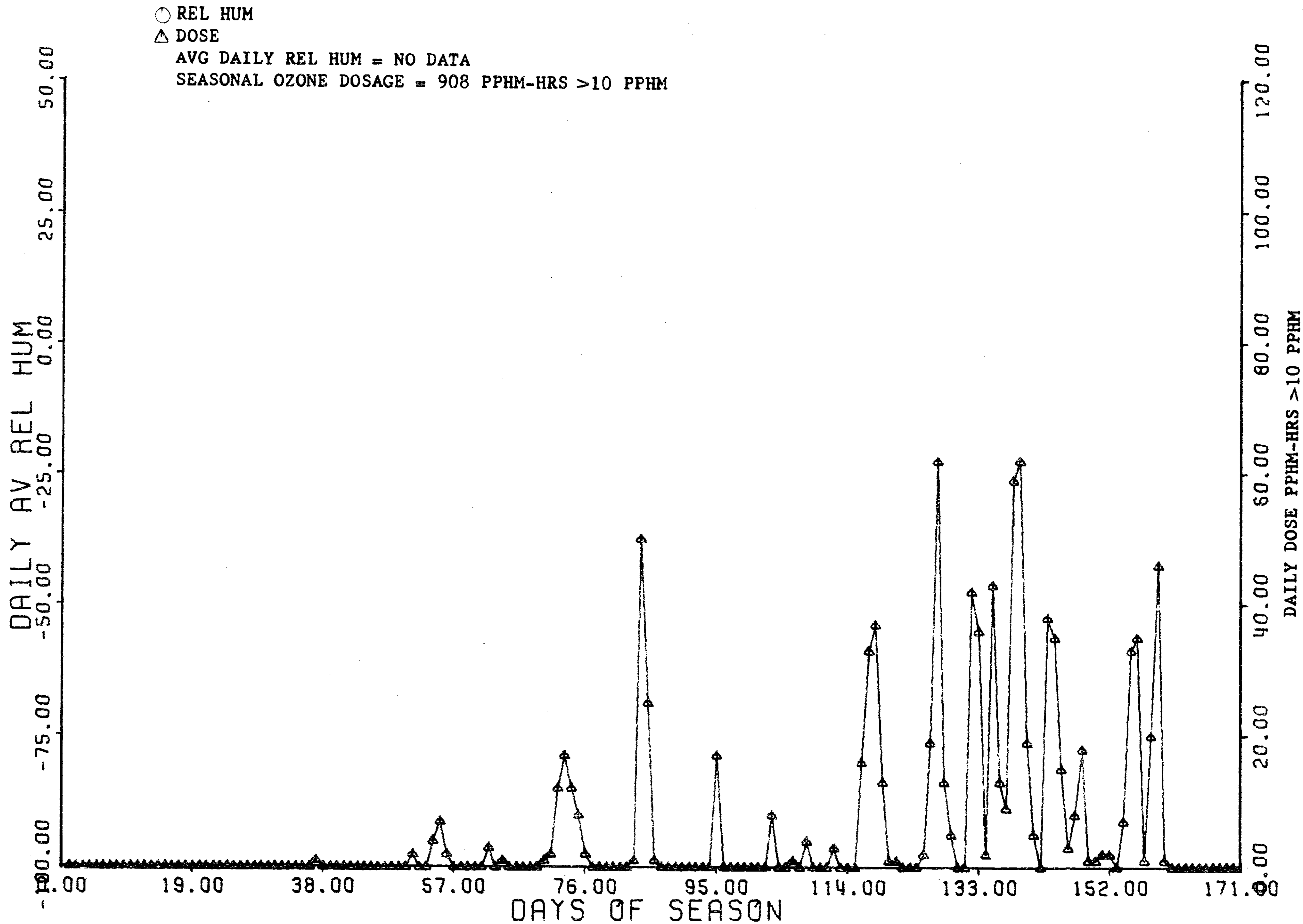


Figure 16. Mira Loma field plot average daily relative humidity and daily ozone dosage during the growth of Moapa 69 alfalfa starting 1 April 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

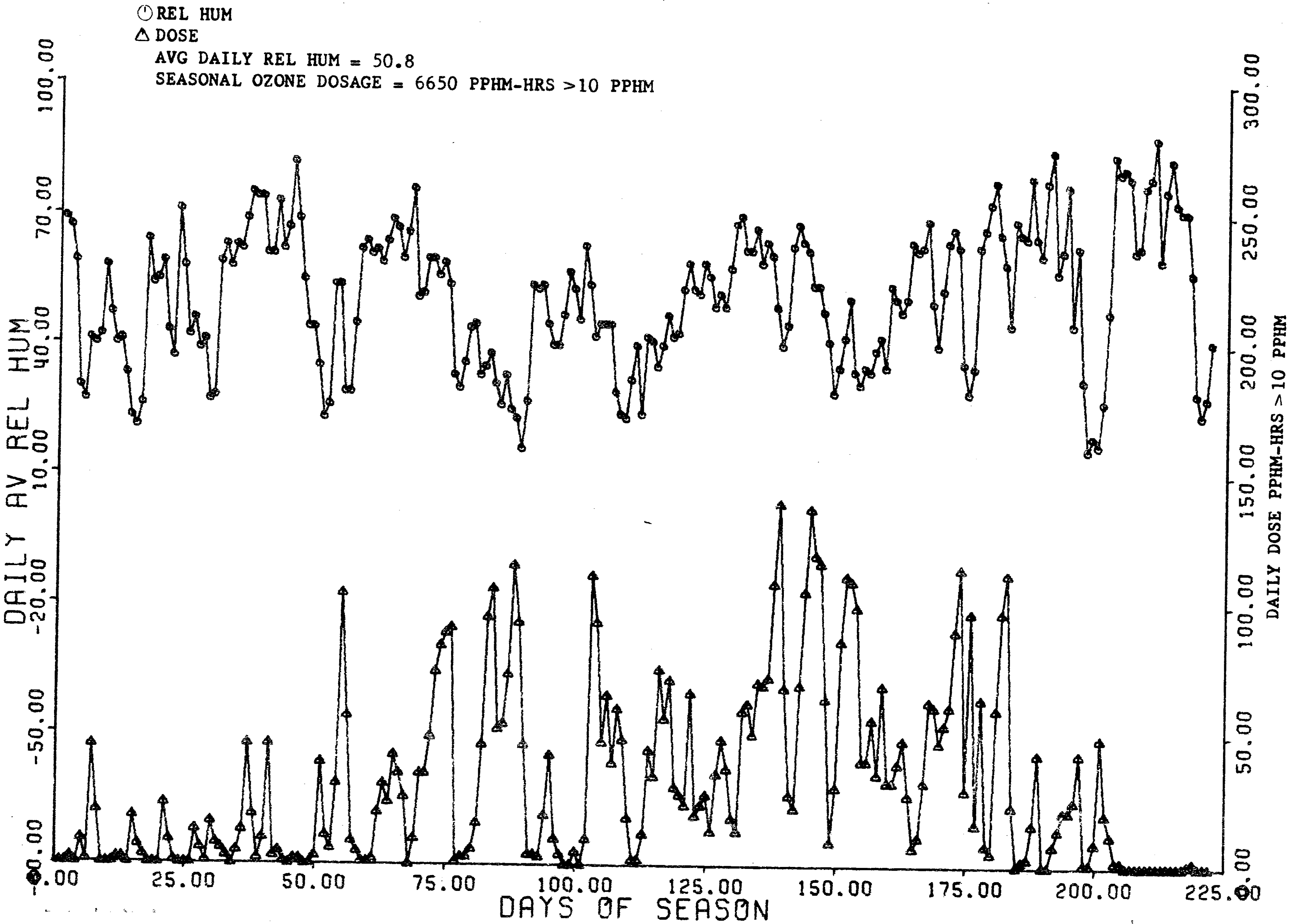


Figure 17. Moreno field plot average daily relative humidity and daily ozone dosage during the growth of Moapa 69 alfalfa starting 1 April 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

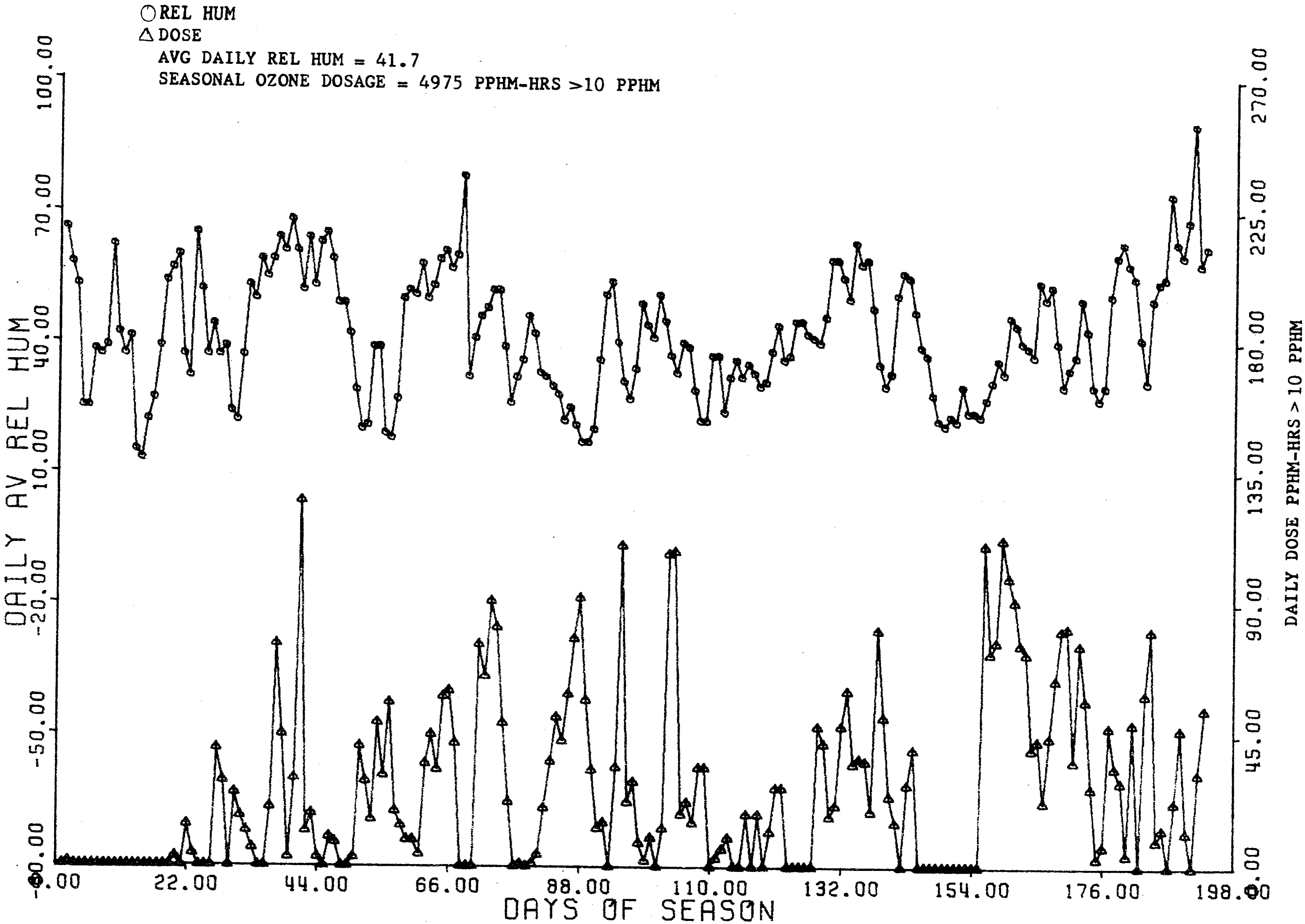


Figure 18. San Bernardino field plot average daily relative humidity and daily ozone dosage during the growth of Moapa 69 alfalfa starting 1 April 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

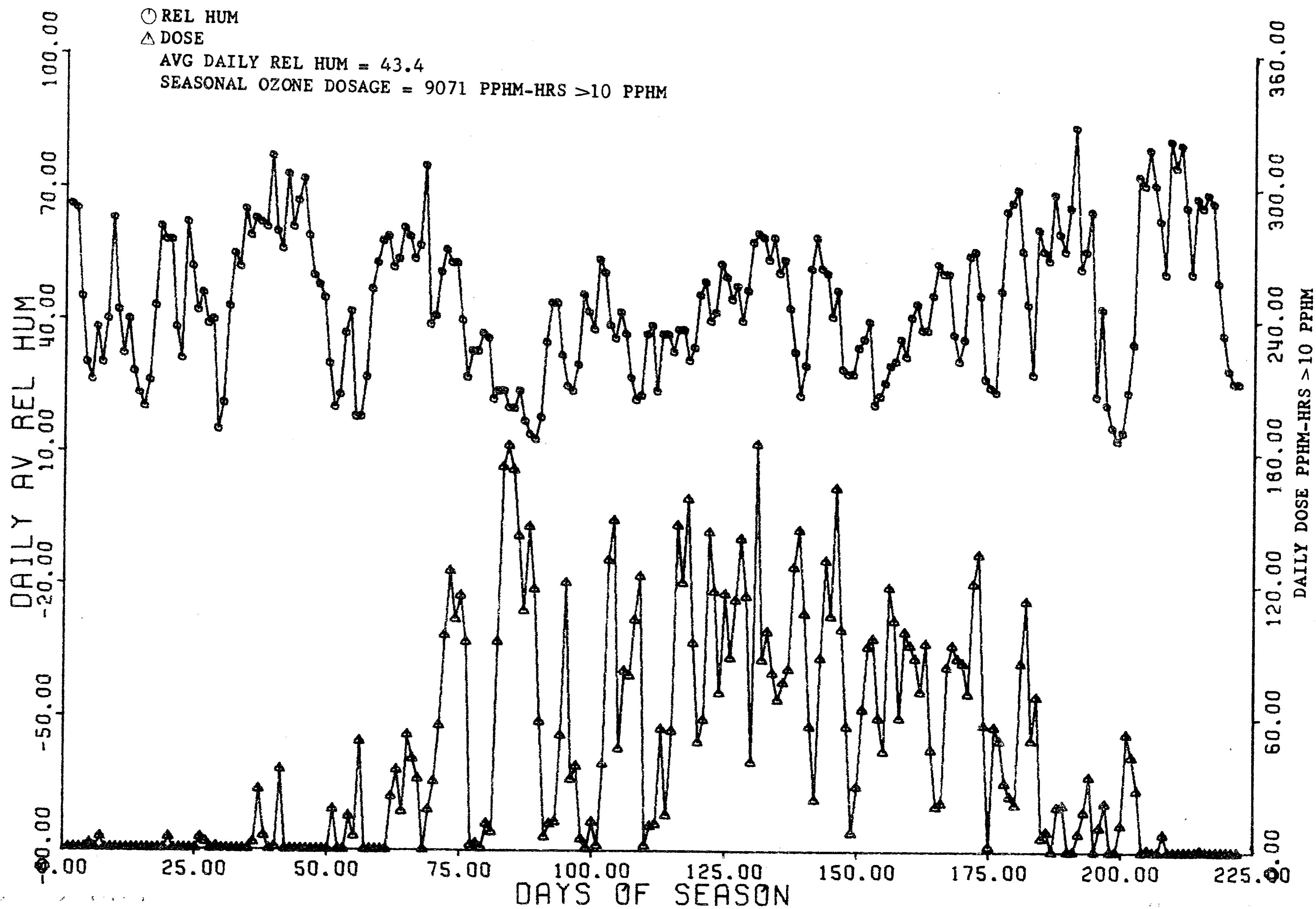


Figure 19. South Coast Field plot average daily relative humidity and daily ozone dosage during the growth of Moapa 69 alfalfa starting 1 April 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

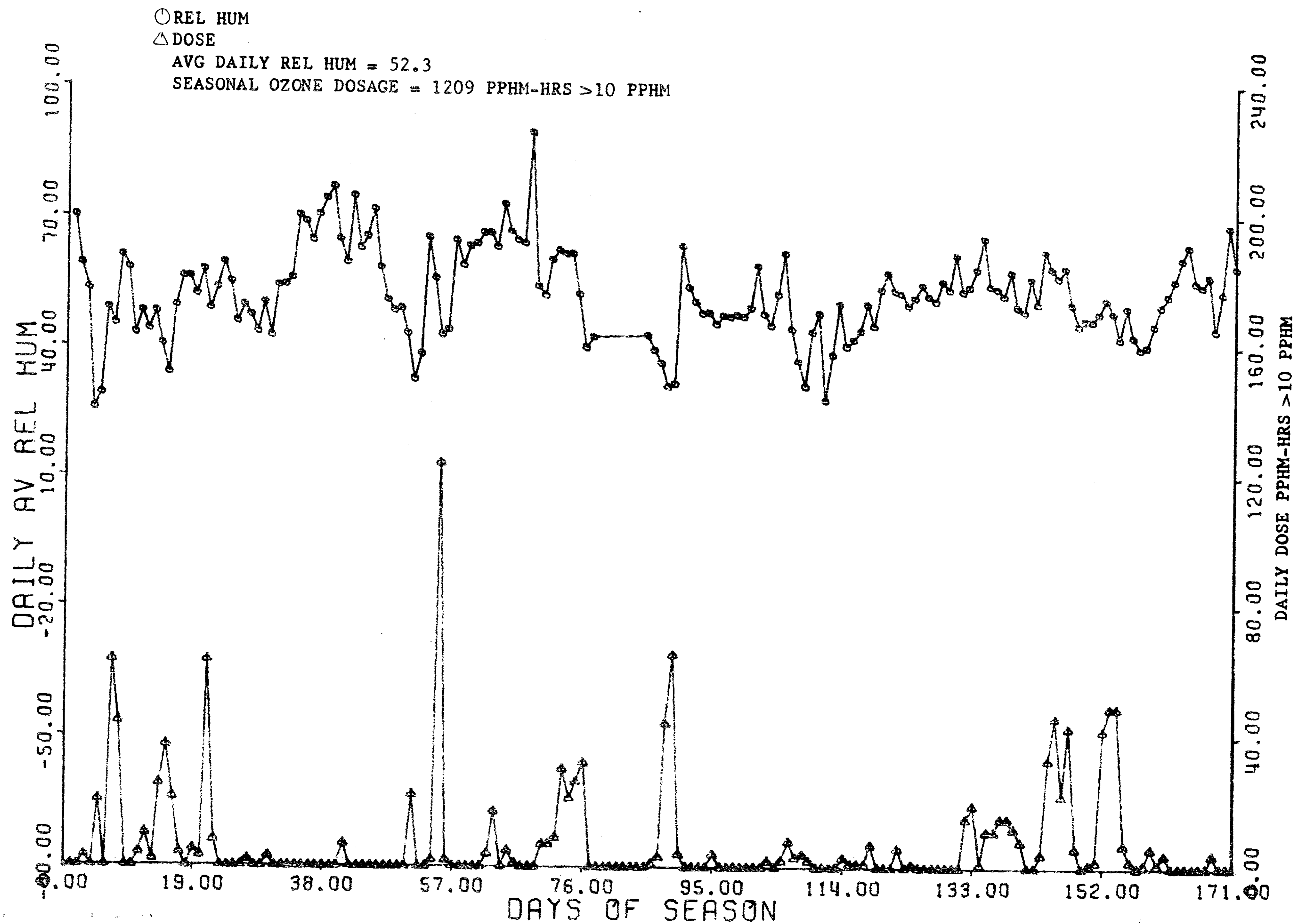


Figure 20. UCR field plot average daily relative humidity and daily ozone dosage during the growth of Moapa 69 alfalfa starting 1 April 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

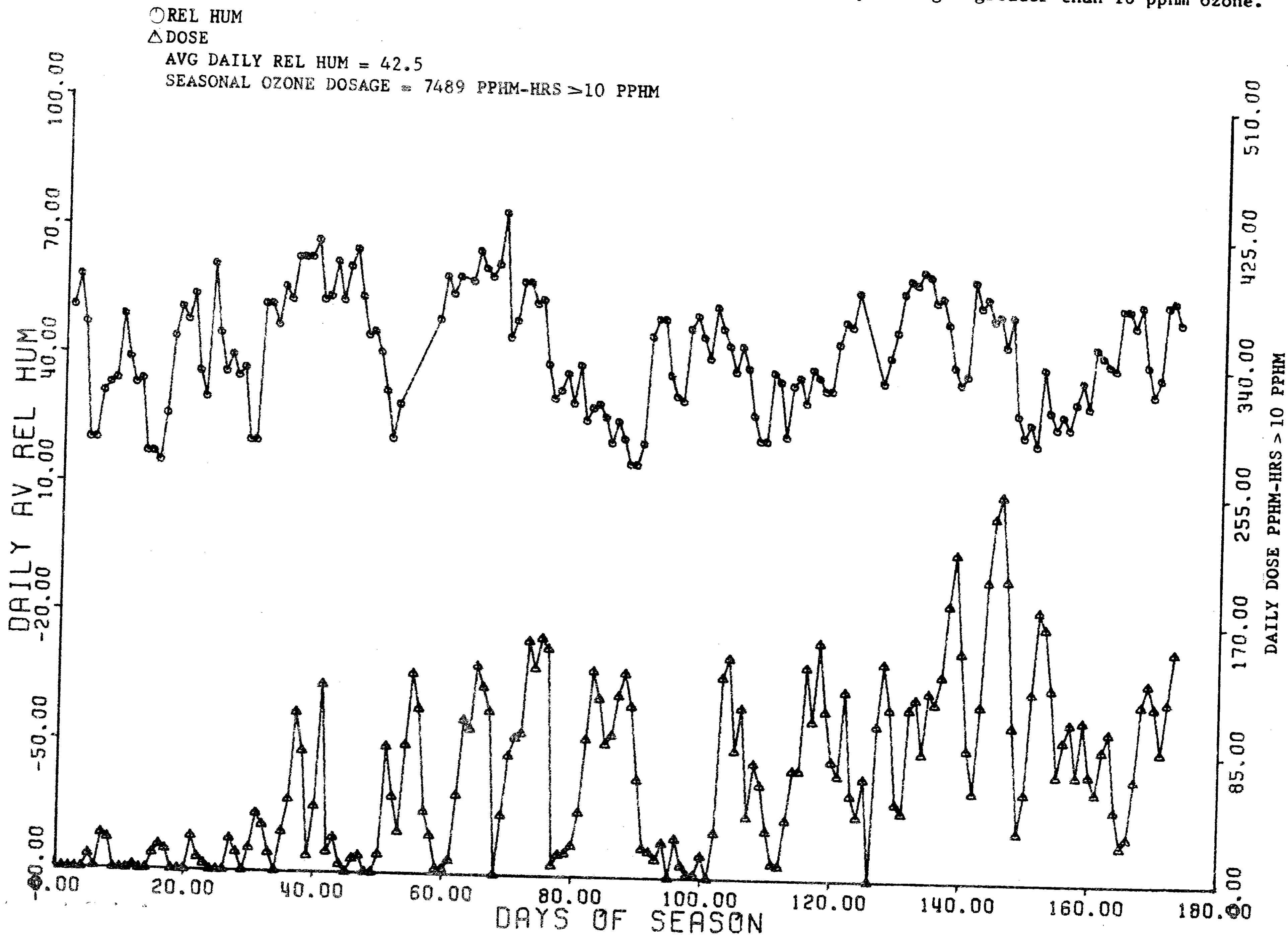


Figure 21. Anaheim average ozone dosage per hour of the day for the Moapa 69 alfalfa growing period.

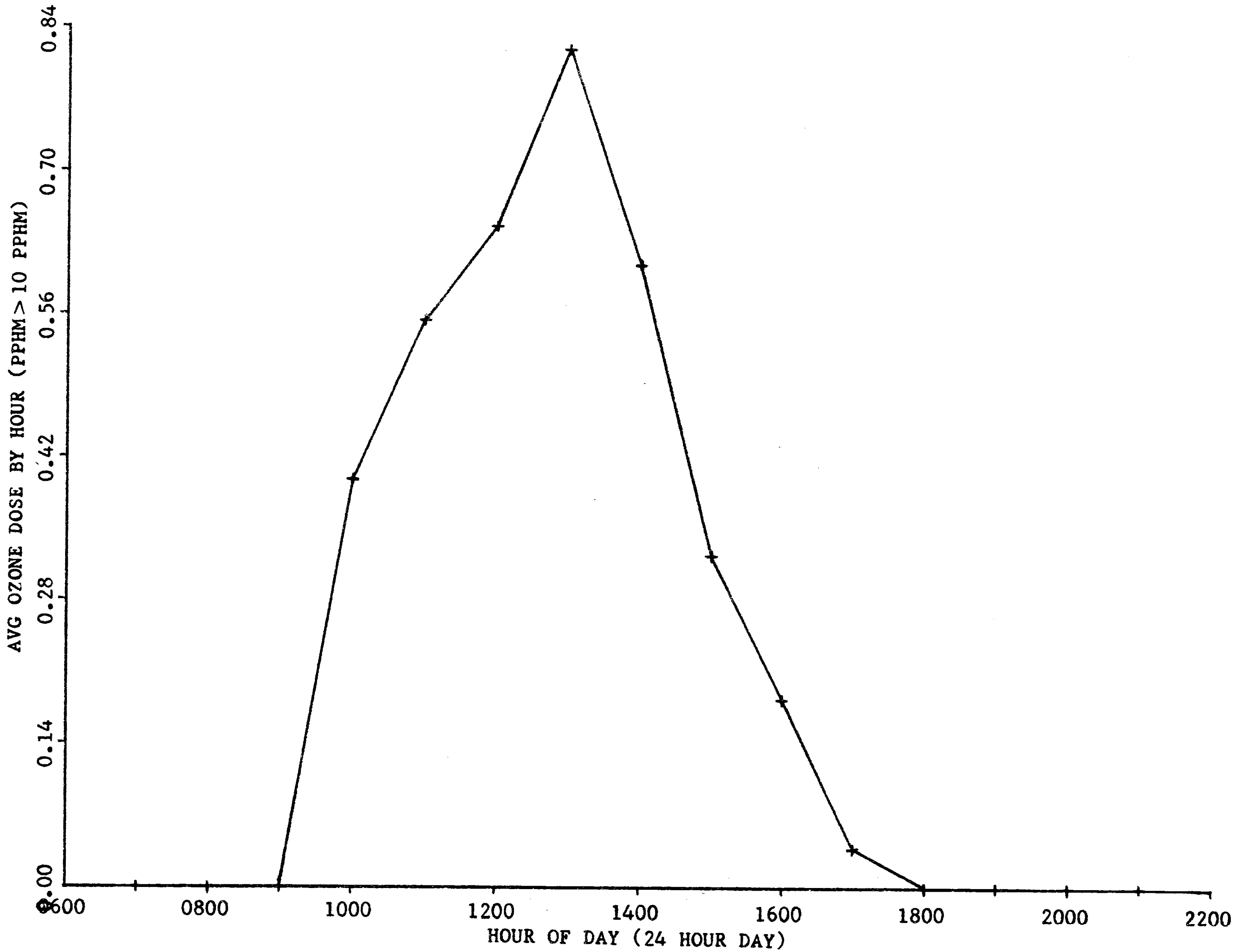


Figure 22. Chino average ozone dosage per hour of the day for the Moapa 69 alfalfa growing period.

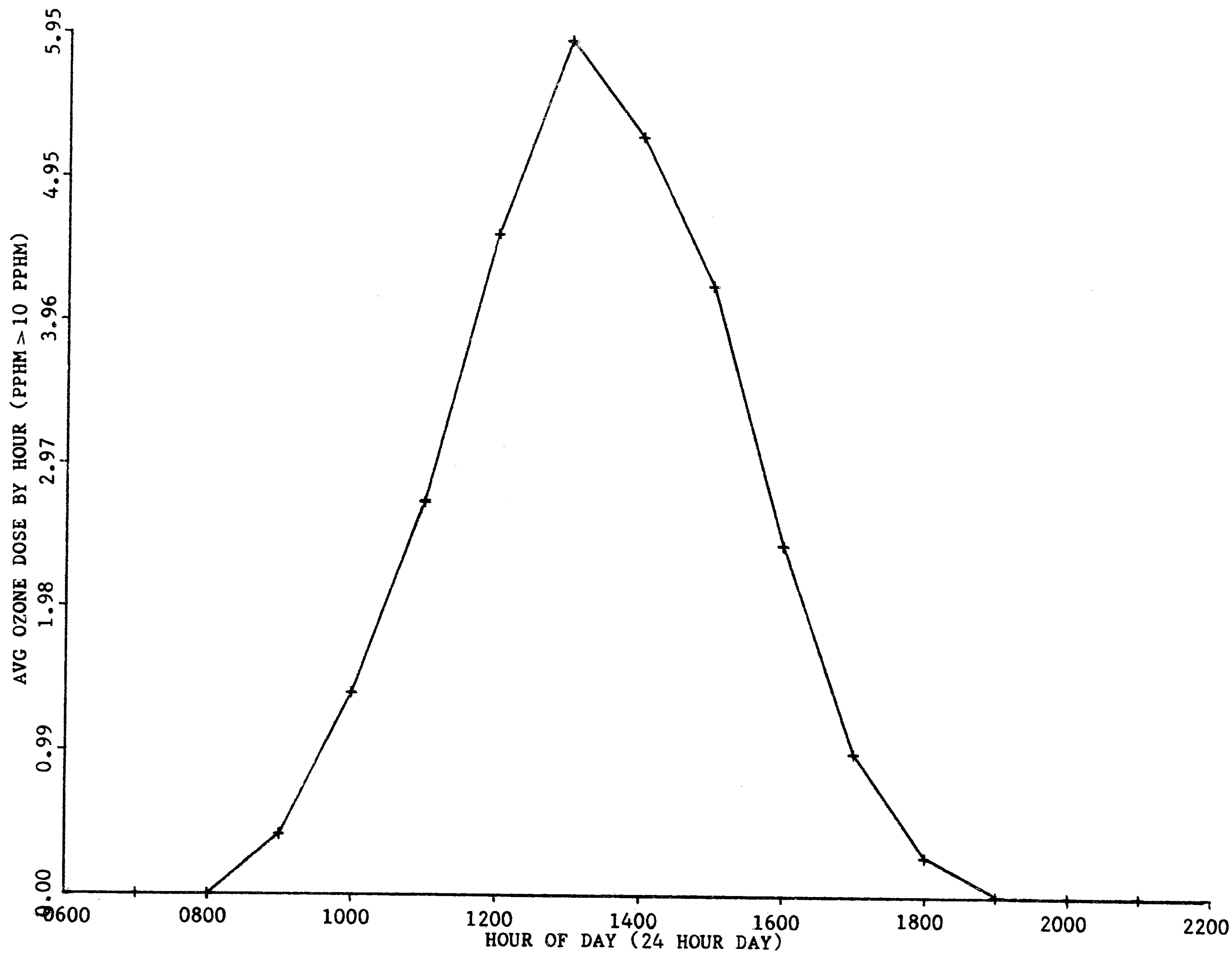


Figure 23. Fullerton average ozone dosage per hour of the day for the Moapa 69 alfalfa growing period.

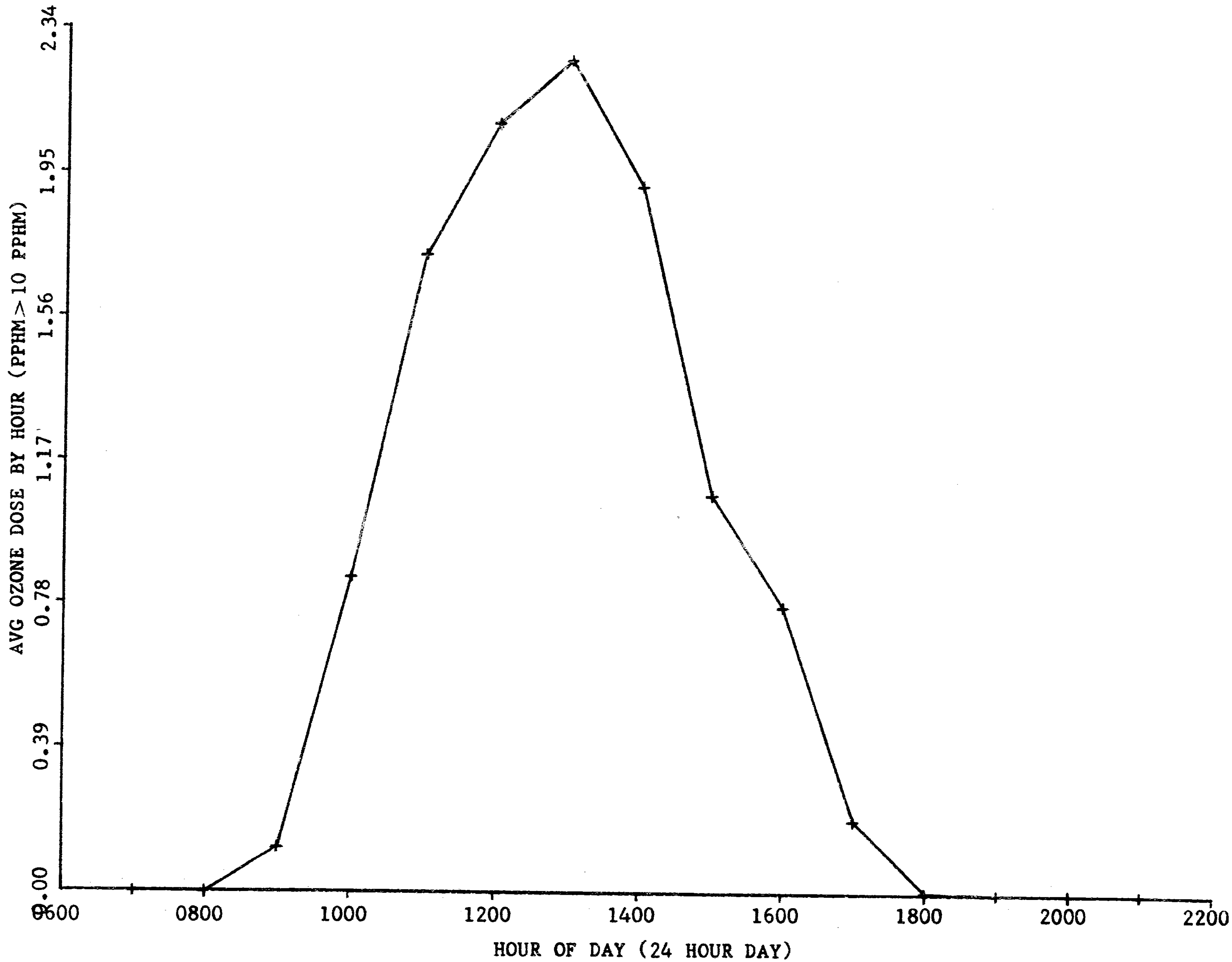


Figure 24. **Hemet average ozone dosage per hour of the day for the Moapa 69 alfalfa growing period.**

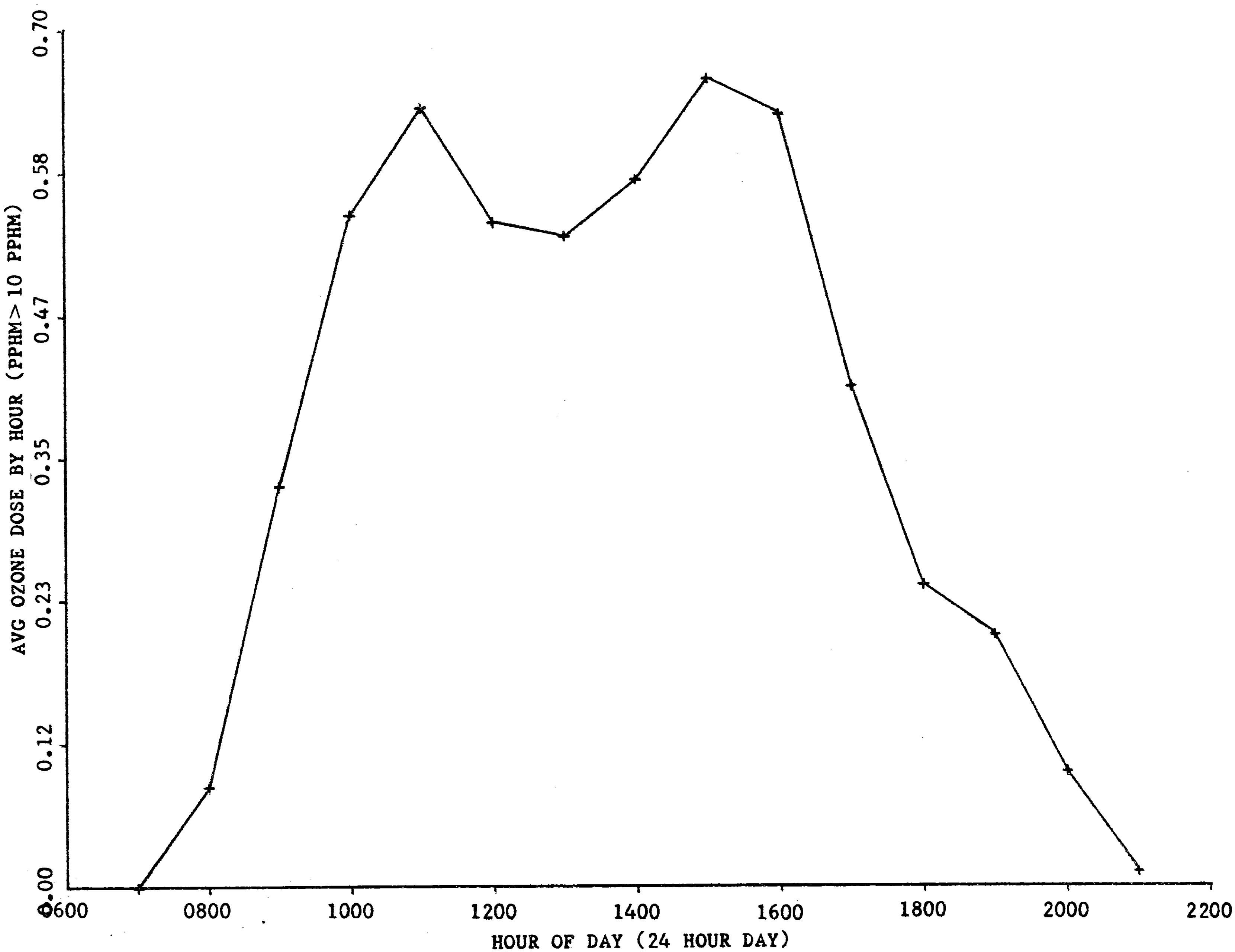


Figure 25. Mira Loma average ozone dosage per hour of the day for the Moapa 69 alfalfa growing period.

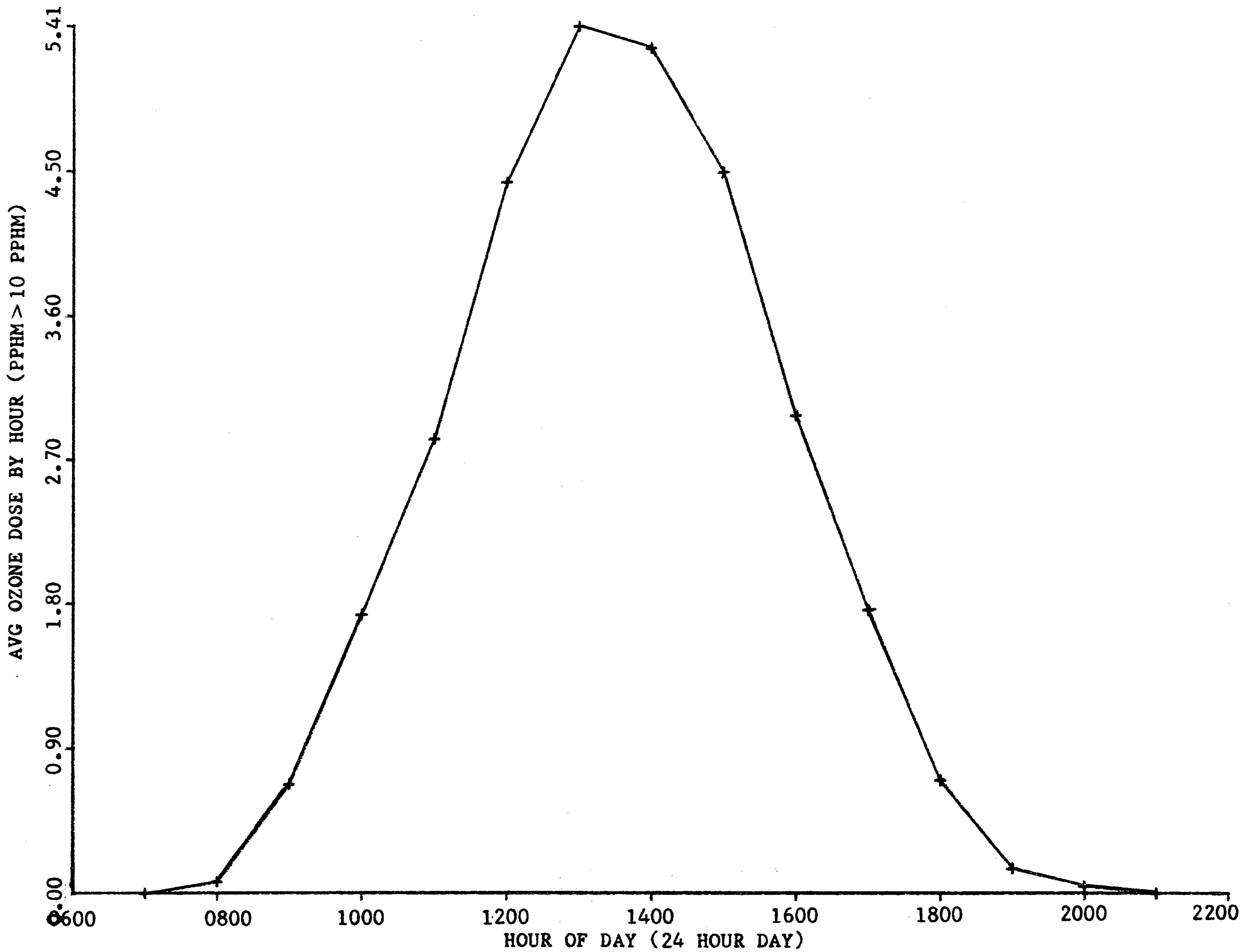


Figure 26. Moreno average ozone dosage per hour of the day for the Moapa 69 alfalfa growing period.

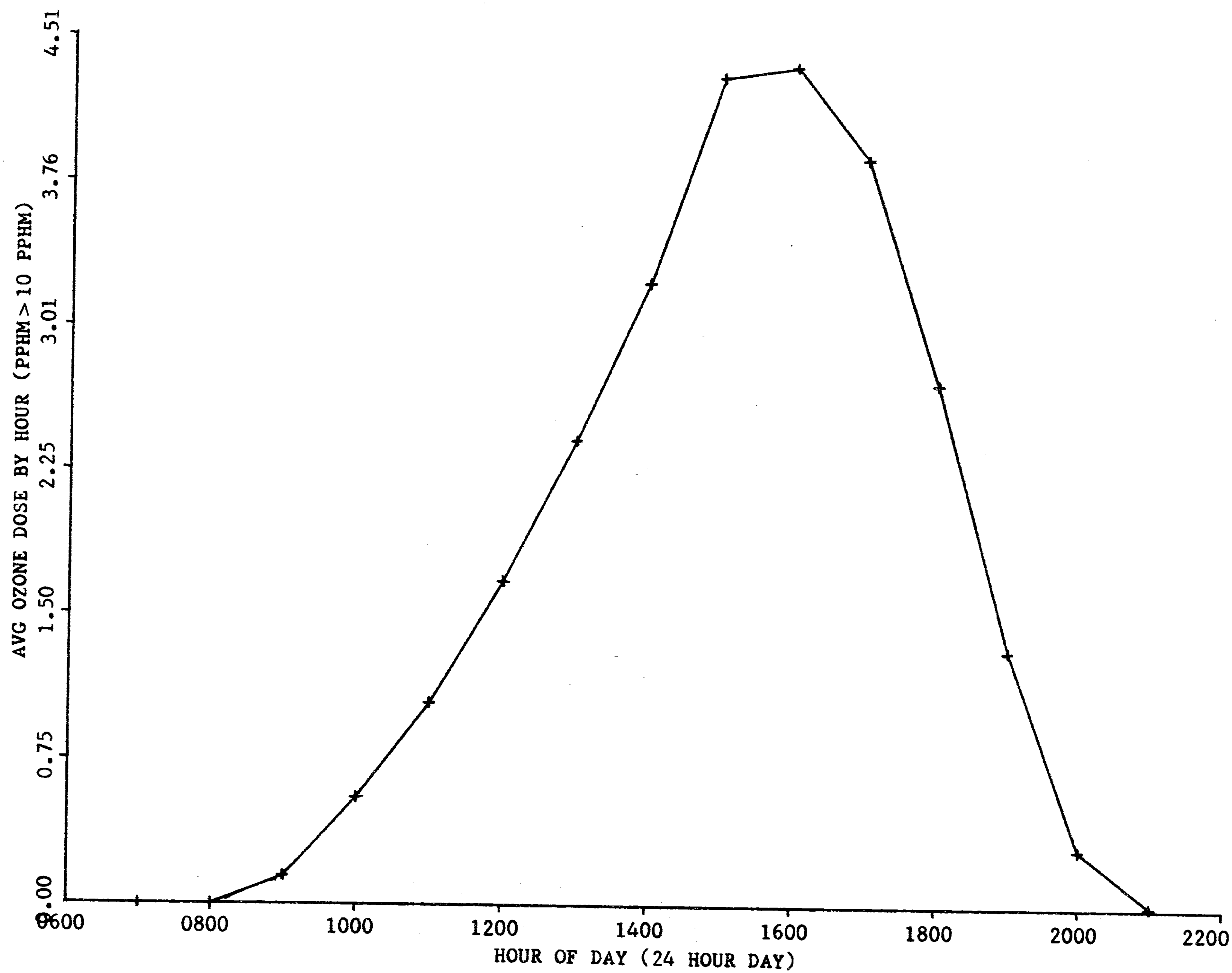


Figure 27. San Bernardino average ozone dosage per hour of the day for the Moapa 69 alfalfa growing period.

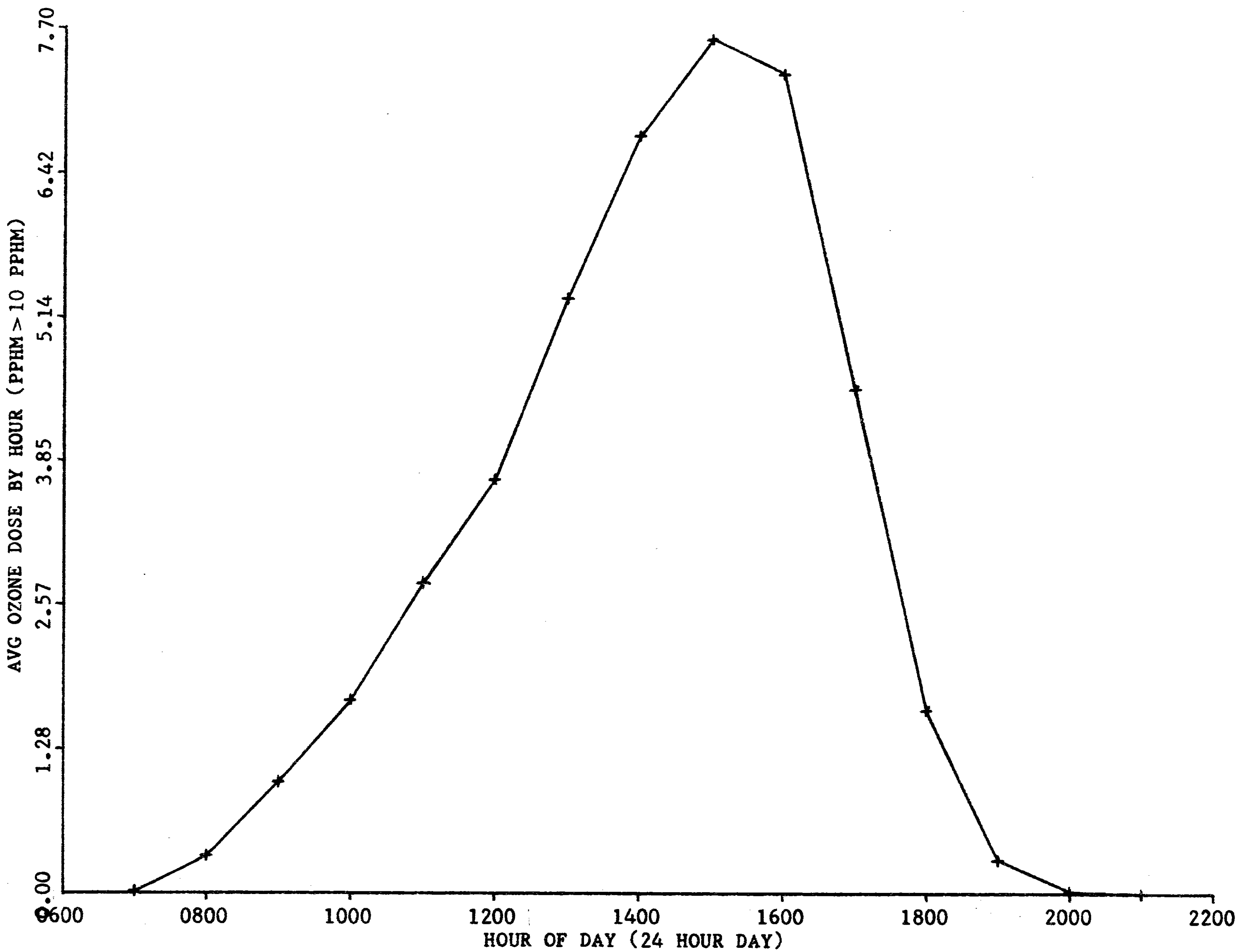


Figure 28. South Coast Field average ozone dosage per hour of the day for the Moapa 69 alfalfa growing period.

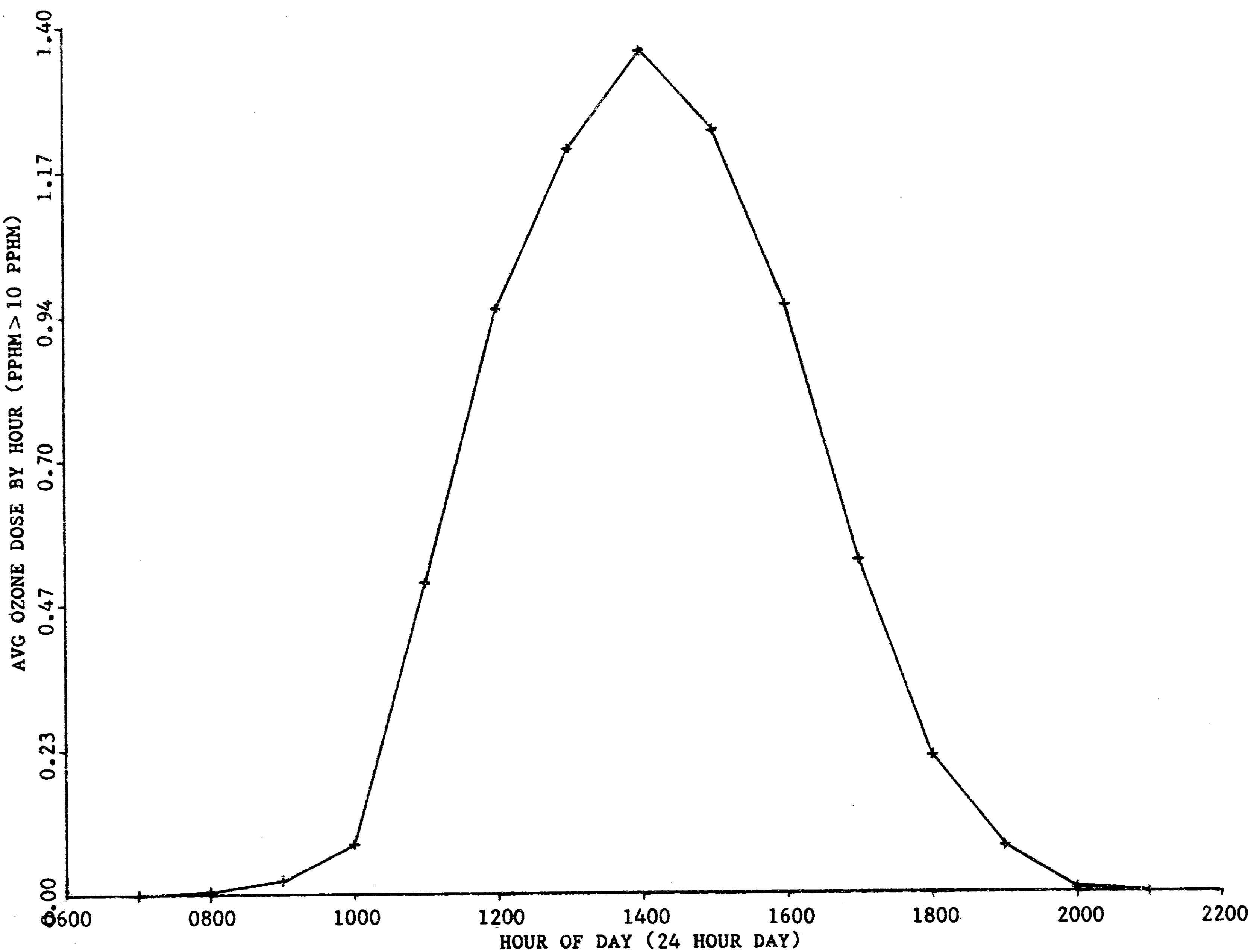


Figure 29. UCR average ozone dosage per hour of the day for the Moapa 69 alfalfa growing period.

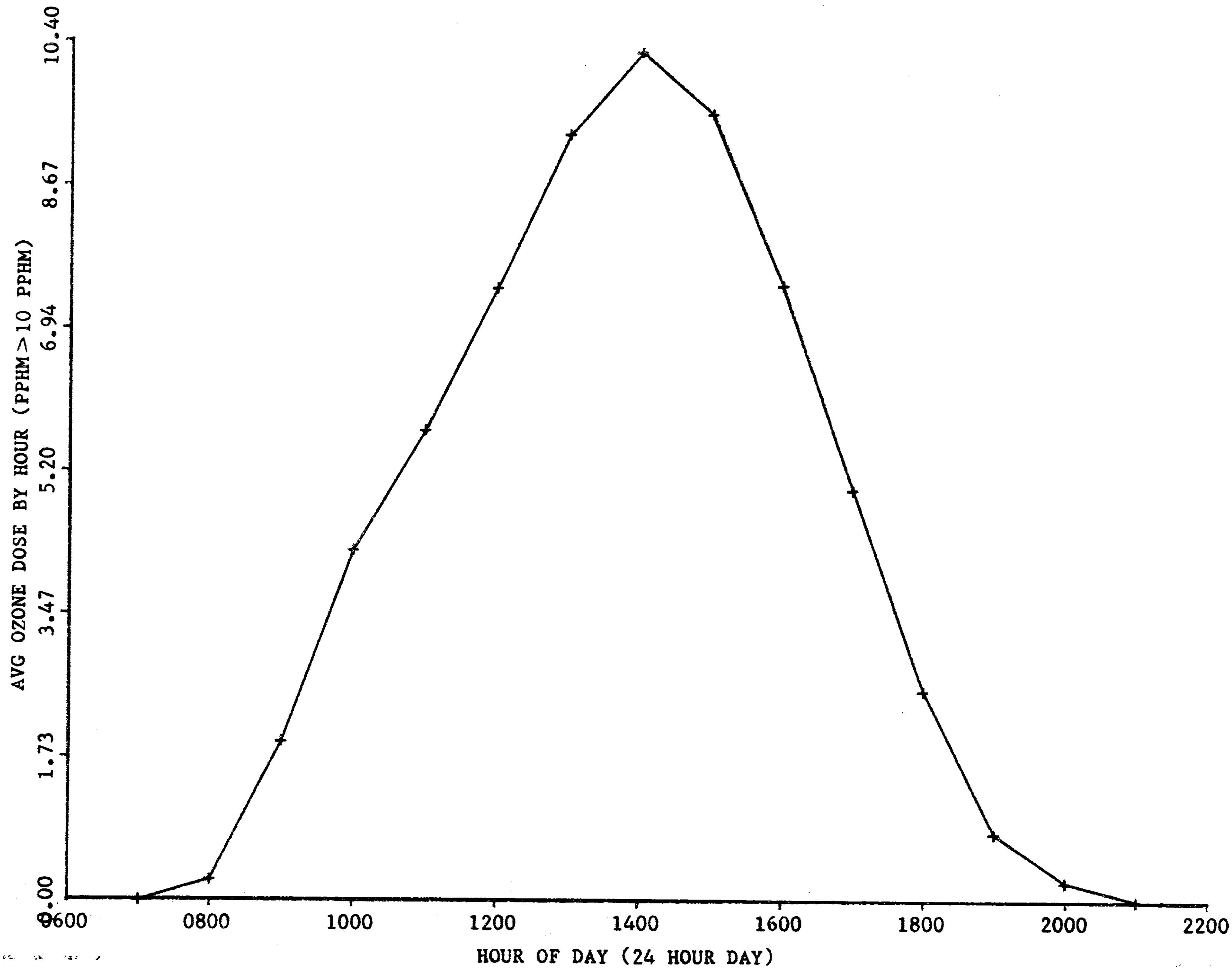


Figure 30. Correlation of seasonal yield per plant with ozone dosage for Moapa 69 alfalfa.

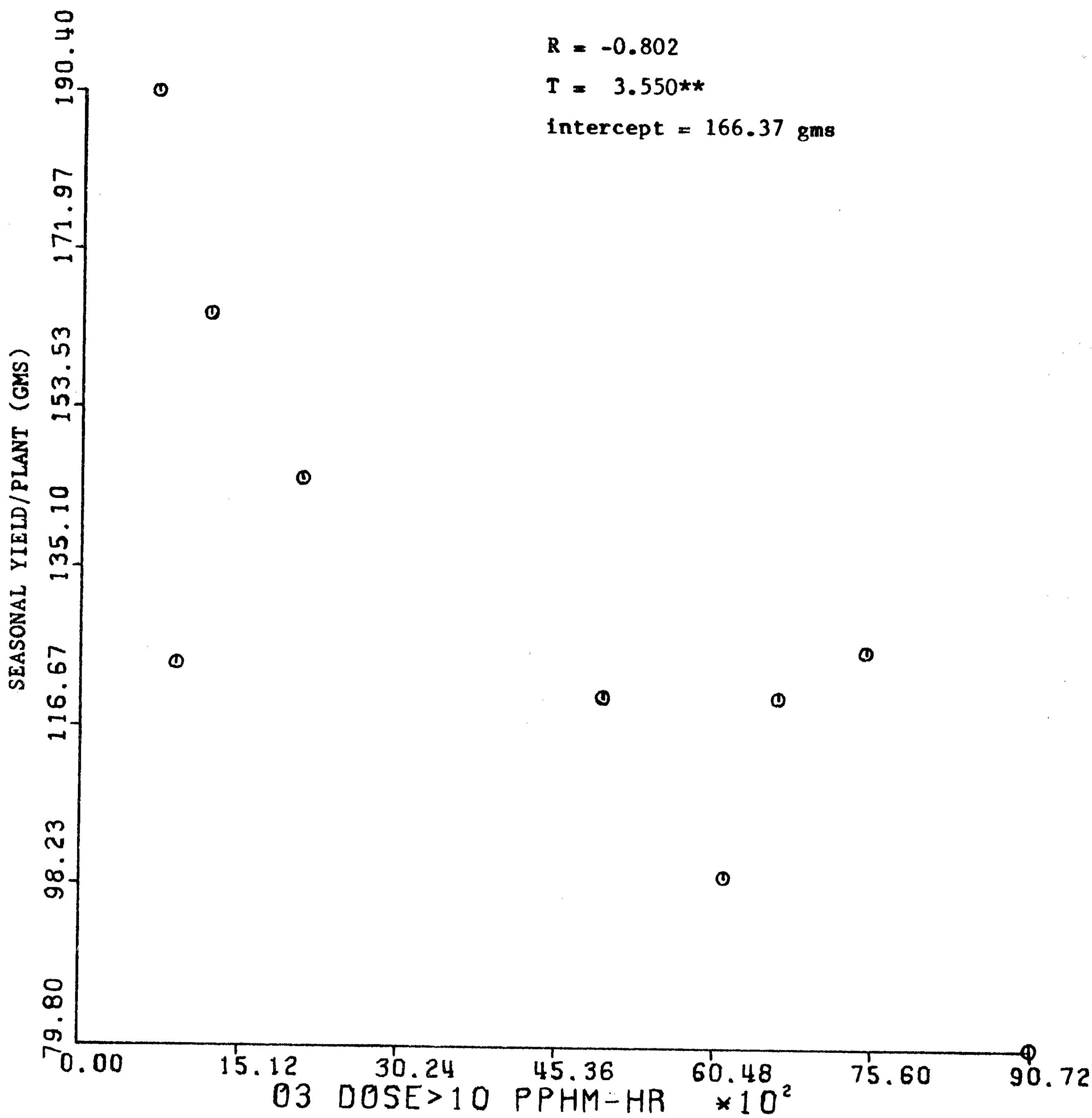


Figure 31. Correlation of average leaf to total weight ratios with seasonal ozone dosages for Moapa 69 alfalfa.

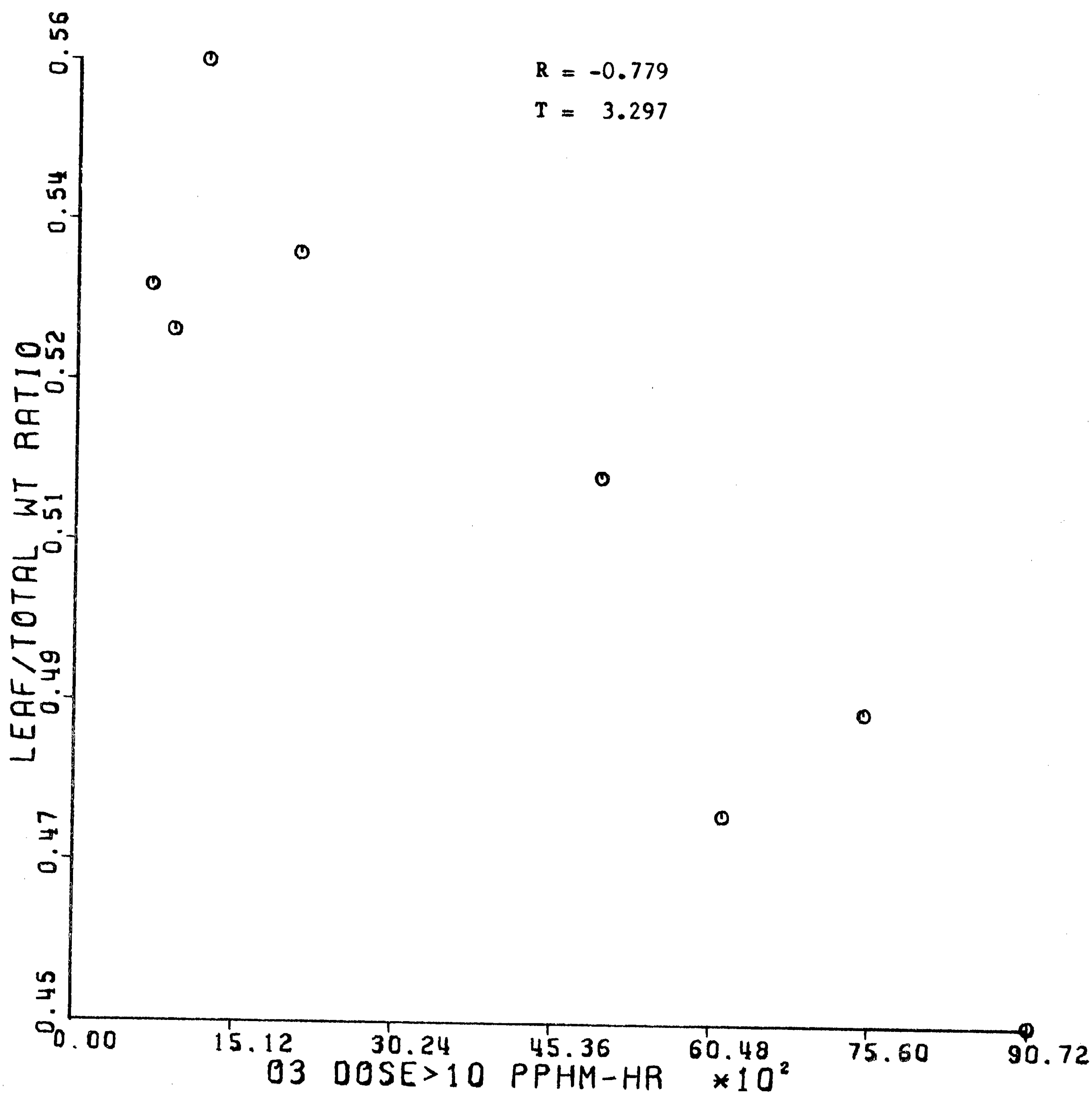


Figure 32. Calculated linear regression and 95% confidence belts for the yield reduction and seasonal ozone dosage correlation for Moapa 69 alfalfa.

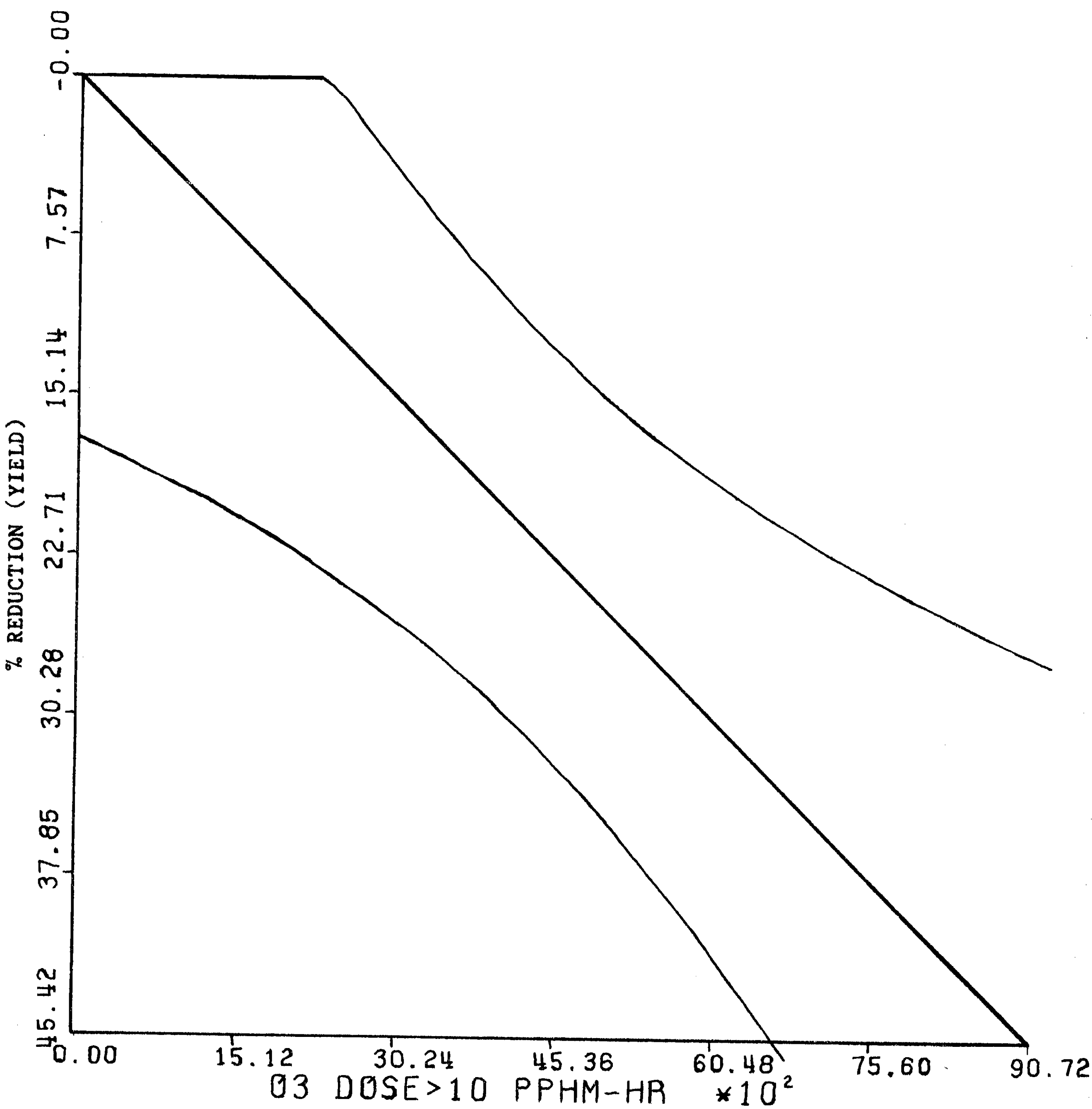
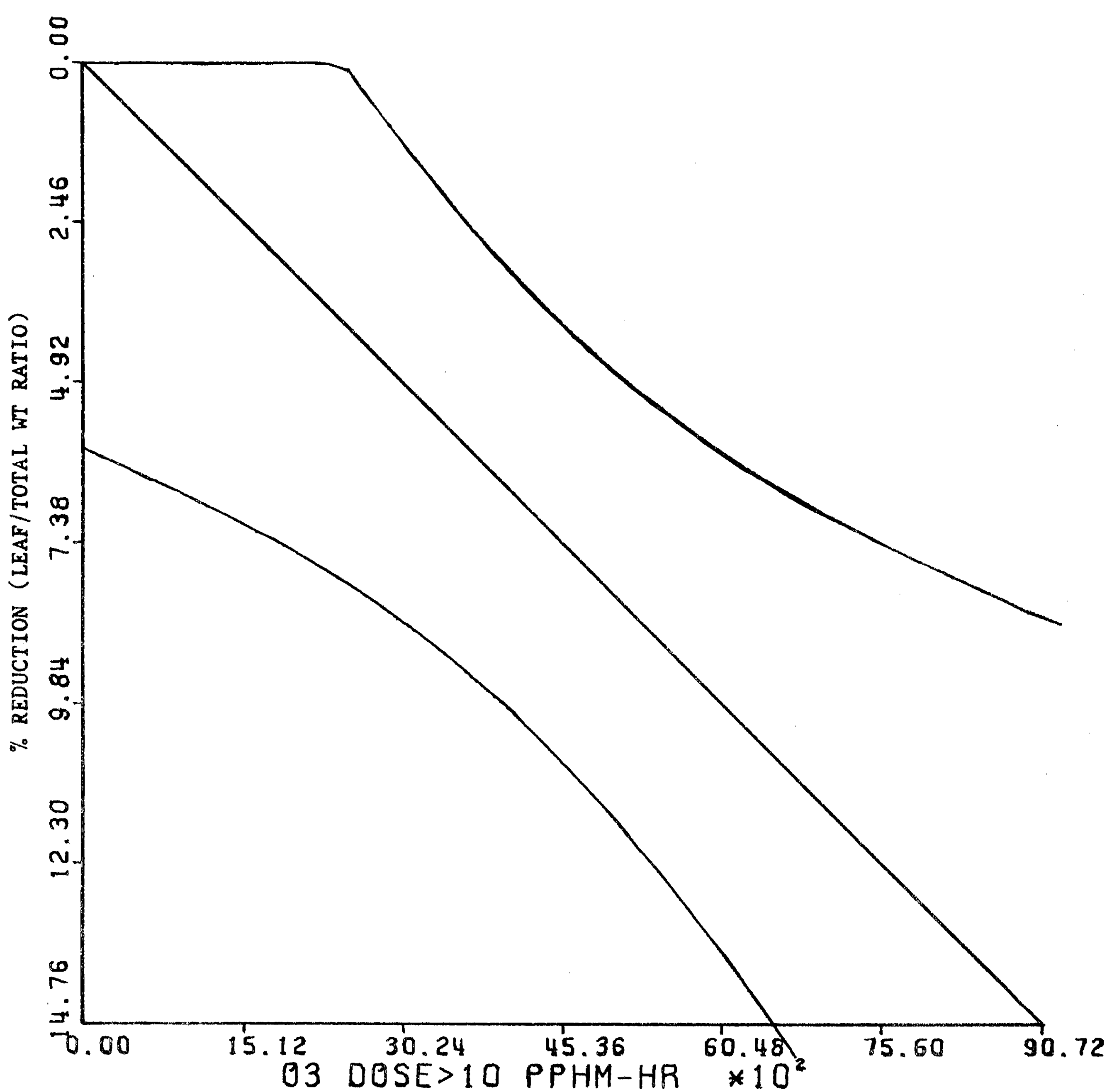


Figure 33. Calculated linear regression and 95% confidence belts for reduction of leaf to total weight ratios and seasonal ozone dosage correlation for Moapa 69 alfalfa.



EXPERIMENTAL RESULTS - SWEET CORN

Golden Jubilee sweet corn was selected as the field plot test variety to develop a dosage-response function for ozone. Variety plots, consisting of Golden Jubilee, Valley Market, FM Cross and G.H. 66 sweet corn were established at the University of California, Riverside Agricultural Station, the Moreno Field Station and the South Coast Field Station to develop a varietal ozone sensitivity ranking. The fumigation studies delineating ozone effects on Golden Jubilee sweet corn had already been completed in the 1973 program.

Field Plots

Only 8 of the 13 sweet corn field plots produced usable data in 1974 because of vandalism, vertebrate predation, and problems associated with irrigation and wind pollination. These problems do not normally influence large fields because of the buffering effect of perimeter rows, but are critical when working with 16-plant field plots. Steps were taken to prevent similar occurrences in the future but five 1974 plots were unsalvable. Yield data from the remaining 8 plots was not significantly correlated with ozone dosage. The needed dosage-response function was therefore unattainable.

Two other plant characteristics, plant height and number of ozone injured leaves, were found to have a significant correlation with ozone dosage (Figures 34, 35). These values are not directly associated with yield but were analyzed further because of scientific interest. The multiple regression correlation revealed the relationship between ozone dosage and the two plant characteristics was much more complex than that of ozone dosage and alfalfa yield. The average daily relative humidity for a season, the average seasonal maximum temperature and the seasonal ozone dosage were all significantly correlated to the mean number of ozone injured leaves per plant (Table 16). Nine interactions in the regression matrix were significant. Seasonal ozone dosage and average daily relative humidity were also significantly correlated with plant height (Table 17) but no interactions were found to be significant.

The monitored climatological variables and ozone dosage for each location were plotted for the growing season.

1. Temperature: The average seasonal maximum temperatures varied within 10^{o} F. A comparison of the plotted daily maximum temperatures (Figures 36, 37, 38, 39, 40, 41, 42) indicated the same similarity in the pattern of temperature fluctuations previously described for alfalfa.

   The average seasonal minimum temperatures were found to have a range of only 5^{o} F and the plotted daily values demonstrated the same uniformity in their fluctuations as the daily maximum temperatures.

2. Relative humidity: The average daily relative humidity values for a season varied within 19% relative humidity and the pattern of daily fluctuations at each location was very uniform (Figures 43, 44, 45, 46, 47, 48, 49, 50).

3. Ozone dosage: The seasonal ozone dosage was the most divergent variable among locations. The distribution of ozone dosage over a season and the pattern of the average daily exposure also varied among locations. Field plots on the coastal plain generally received peak ozone levels earlier in the day than the inland plots and were of shorter duration (Figures 51, 52, 53, 54, 55, 56, 57, 58).

Variety Plots

Harvest data from the three sweet corn variety plots is presented in Tables 18, 19, and 20. Harvests were taken 25 days after silking. The following yield ranking was developed based on unhusked ear weights harvested at all three locations:

Low ozone dosage (463 pphm-hrs SCF)	1.	G. Jubilee
	2.	G.H. 66
		FM Cross
	3.	V. Market
High ozone dosage (4070 pphm-hrs Moreno)	1.	FM Cross
		G.H. 66
	2.	G. Jubilee
	3.	V. Market
High ozone dosage (4548 pphm-hrs UCR)	1.	FM Cross
	2.	G. Jubilee
		V. Market
	3.	G.H. 66

FM Cross appeared to be the most ozone resistant variety at high dosages as harvested primary ears were larger at both UCR and Moreno. Separation of the other three varieties was not as clear cut. No significant differences were found among varietal secondary ear weights or evaluated ear quality at each location. This data was produced to compare varieties at each location and is not valid for inter-location comparisons.

Table 16. Summary of results from the regression correlations with average number of injured leaves on Golden Jubilee corn in the field, ozone dosage, average seasonal maximum temperature, average seasonal minimum temperature and average daily relative humidity for a season.

Linear Correlations	Correlation Coefficients
# inj lvs vs dose	.7871*
# inj lvs vs T max	.8602**
# inj lvs vs T min	-.455
# inj lvs vs RH	-.9415***

Regression Matrix	T-values of Regression Coefficient				f-values
	dose	character	character	character	
# inj lvs vs dose & T max	- .5021	1.6466			7.6337*
# inj lvs vs dose & T min					5.5117
# inj lvs vs dose & RH	-3.5767	-7.3888***	1.6503		7.5815*
# inj lvs vs T max & T min	3.633*	-0.8796			8.6402*
# inj lvs vs RH & T max	-3.1628*	-1.2558			26.4483*
# inj lvs vs RH & T min	-5.6506**	-0.3689			20.1062*
# inj lvs vs dose & T max & T min					4.7658
# inj lvs vs dose & RH & T max	-2.6288*	-5.2122**	-.1815		40.7784*
# inj lvs vs dose & RH & T min	-4.0908**	-7.3828***	1.409		61.1639*
# inj lvs vs RH & T max & T min	-2.5307*	-1.0617	0.0625		14.1209*
# inj lvs vs dose & RH & T max & T min	-3.1284*	-5.4221**	-.4024	1.301	36.3019*

* Denotes significance at the .05 level.
** Denotes significance at the .01 level.
*** Denotes significance at the .001 level.

Table 17. Summary of results from the regression correlations with field plant heights from Golden Jubilee corn, ozone dosage, average seasonal maximum temperature, average seasonal minimum temperature and average daily relative humidity for a season.

Linear Correlations	Correlation Coefficients
ht vs dose	-0.7274*
ht vs T max	-0.6729
ht vs T min	-0.0003
ht vs RH	0.7404*

Regression Matrix	T-values of Regression Coefficient			f-values
	dose	character	character	
ht vs dose & T max				2.8638
ht vs dose & T min				3.1316
ht vs dose & RH				3.1399
ht vs T max & T min				2.4457
ht vs RH & T max				3.3
ht vs RH & T min				4.7154
ht vs dose & T max & T min				1.6743
ht vs dose & RH & T max				2.0741
ht vs dose & RH & T min				2.5906
ht vs RH & T max & T min				3.7622
ht vs dose & RH & T max & T min				2.1388

* Denotes significance at the .05 level.

Table 18. Harvest data from Moreno corn variety plot. Treatment means were tested with the analysis of variance coupled with Duncan's Multiple Range Test.

	NUMBER			WTS (GMS)			
	Internodes	Leaves	Inj. Leaves	Unhusked Ear Primary	Husked Ear Primary	Unhusked Ear Secondary	Husked Ear Secondary
G. Jubilee	8.9 a[1]	8.2 a	6.8 a	391.0 a	279.3 a	307.1 a	206.0 a
V. Market	10.3 b	9.6 bc	4.3 b	354.6 b	221.3 c	303.6 a	203.3 a
FM Cross	9.7 c	9.5 cd	3.3 c	437.3 c	296.2 b	298.3 a	201.1 a
G.H. 66	9.4 d	9.2 d	8.2 d	425.1 c	288.9 ab	331.0 a	234.6 b

	MEASUREMENTS (CM)				
	Ht. Plant	Ear Length Primary	Ear Length Secondary	Ear Dia. Primary	Ear Dia. Secondary
G. Jubilee	166.8 a	23.8 a	20.8 a	4.8 ac	4.4 a
V. Market	164.3 a	22.1 b	20.5 a	4.3 b	4.5 a
FM Cross	178.8 b	22.7 c	19.2 b	4.9 a	4.6 a
G.H. 66	142.3 c	25.0 d	22.9 c	4.8 c	4.6 a

	MEASUREMENTS (CM)					
	Ear Blemish Primary	Ear Blemish Secondary	Ear Blanking Primary	Ear Blanking Secondary	Ear Shrivel Primary	Ear Shrivel Secondary
G. Jubilee	1.9 a	1.5 a	0.3 a	1.6 a	0.1 a	0.9 ab
V. Market	2.6 a	1.3 a	0.4 a	0.6 a	0.2 a	0.1 a
FM Cross	2.5 a	2.8 a	0.2 a	2.5 a	0.0 a	4.2 c
G.H. 66	3.1 a	2.2 a	0.4 a	1.8 a	0.1 a	2.2 bc

1. Treatment means followed by the same letter are not significantly different at the .05 level.

Table 19. Harvest data from South Coast Field Station corn variety plot. Treatment means were tested with the analysis of variance coupled with Duncan's Multiple Range Test.

	NUMBER			WTS (GMS)			
	Internodes	Leaves	Inj. Leaves	Unhusked Ear Primary	Husked Ear Primary	Unhusked Ear Secondary	Husked Ear Secondary
G. Jubilee	10.5 a[1]	9.8 a	6.4 a	389.5 a	222.9 a	284.8 a	171.1 ab
V. Market	12.7 b	12.1 b	0.9 b	303.3 b	166.6 b	279.6 a	167.2 ab
FM Cross	11.3 c	10.6 c	1.4 c	349.6 c	239.5 c	272.3 a	153.7 b
G.H. 66	11.1 c	10.2 d	4.4 d	363.4 c	210.0 a	296.9 a	179.8 a

	MEASUREMENTS (CM)				
	Ht. Plant	Ear Length Primary	Ear Length Secondary	Ear Dia. Primary	Ear Dia. Secondary
G. Jubilee	220.8 a	21.0 a	19.7 a	4.7 ab	4.3 a
V. Market	232.5 b	20.2 b	19.5 a	4.2 c	4.3 a
FM Cross	236.6 b	19.3 c	16.9 b	4.7 a	4.5 b
G.H. 66	203.3 c	20.5 b	19.8 a	4.6 b	4.2 a

	MEASUREMENTS (CM)					
	Ear Blemish Primary	Ear Blemish Secondary	Ear Blanking Primary	Ear Blanking Secondary	Ear Shrivel Primary	Ear Shrivel Secondary
G. Jubilee	0.2 a	0.1 a	0.6 a	1.2 a	0.0 a	0.0 a
V. Market	0.0 a	0.5 a	0.0 a	0.8 a	0.0 a	1.2 ab
FM Cross	0.1 a	0.0 a	1.9 b	2.3 a	0.0 a	2.3 b
G.H. 66	0.3 a	0.2 a	0.6 a	1.0 a	0.0 a	0.6 a

1. Treatment means followed by the same letter are not significantly different at the .05 level.

Table 20. Harvest data from UCR corn variety plot. Treatment means were tested with the analysis of variance coupled with Duncan's Multiple Range Test.

	NUMBER			WTS (GMS)			
	Internodes	Leaves	Inj. Leaves	Unhusked Ear Primary	Husked Ear Primary	Unhusked Ear Secondary	Husked Ear Secondary
G. Jubilee	10.2 ab[1]	9.3 a	3.5 a	329.9 a	209.9 a	279.9 a	190.8 a
V. Market	11.2 d	10.7 a	1.8 c	311.2 a	161.3 b	268.2 a	162.5 b
FM Cross	10.0 bc	9.3 a	3.0 b	378.2 b	239.5 c	298.8 a	198.0 a
G.H. 66	9.8 c	9.3 a	3.1 ab	287.9 c	171.1 b	275.4 a	179.8 ab

	MEASUREMENTS (CM)				
	Ht. Plant	Ear Length Primary	Ear Length Secondary	Ear Dia. Primary	Ear Dia. Secondary
G. Jubilee	143.5 a	21.9 a	21.1 a	4.4 a	4.3 ab
V. Market	152.8 b	22.4 b	20.9 a	4.2 b	4.1 b
FM Cross	159.0 c	22.9 c	21.0 a	4.7 c	4.6 a
G.H. 66	113.7 d	21.8 a	22.0 b	4.1 b	4.2 b

	MEASUREMENTS (CM)					
	Ear Blemish Primary	Ear Blemish Secondary	Ear Blanking Primary	Ear Blanking Secondary	Ear Shrivel Primary	Ear Shrivel Secondary
G. Jubilee	0.1 ab	0.1 a	0.2 a	1.3 a	0.0 a	0.0 a
V. Market	0.2 ab	0.0 a	0.4 a	0.0 a	0.0 a	0.0 a
FM Cross	0.4 a	0.8 a	1.0 a	4.5 b	0.0 a	0.0 a
G.H. 66	0.0 b	0.4 a	0.7 a	1.2 a	0.0 a	0.0 a

1. Treatment means followed by the same letter are not significantly different at the .05 level.
2. Only acute injury was rated. These values are not comparable to SCF and Moreno ratings where both chronic and acute injury was evaluated.

Figure 34. Correlation of the plant heights of field plot Golden Jubilee sweet corn with the total ambient oxidant dosage present during growth.

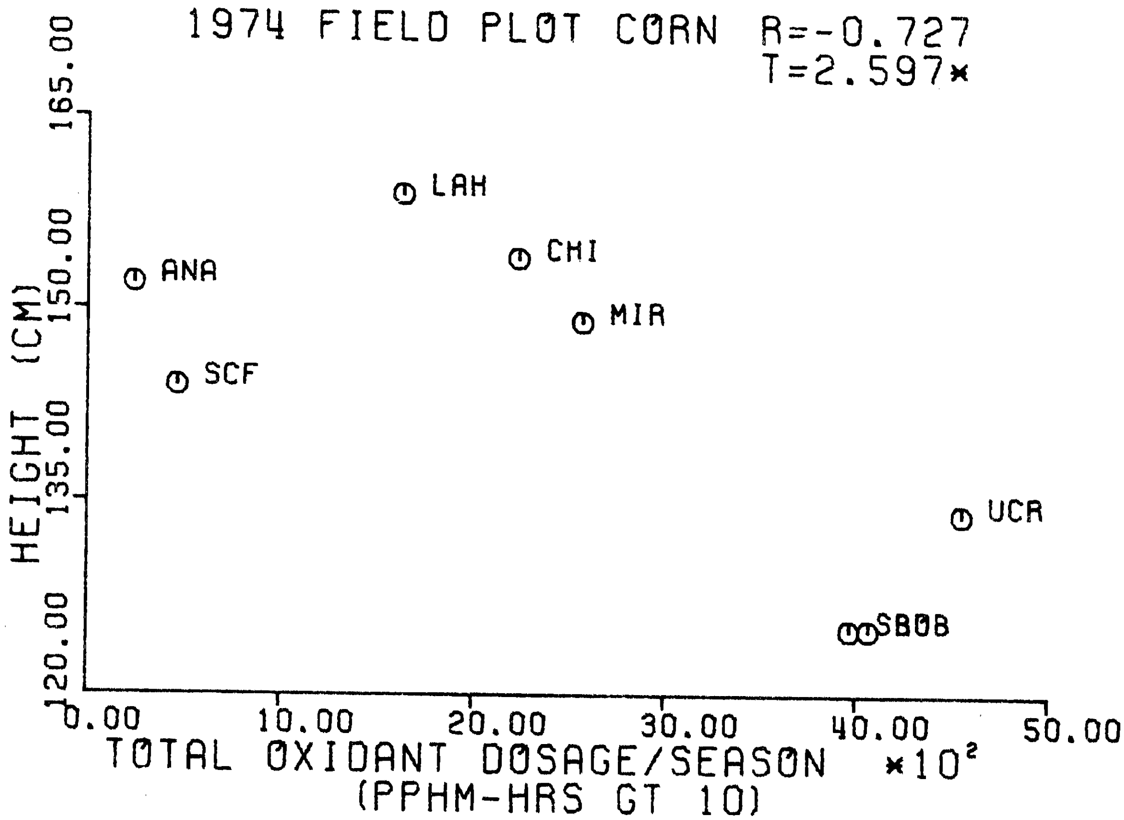


Figure 35. Correlation of the number of injured leaves with the total ambient oxidant dosage present during growth.

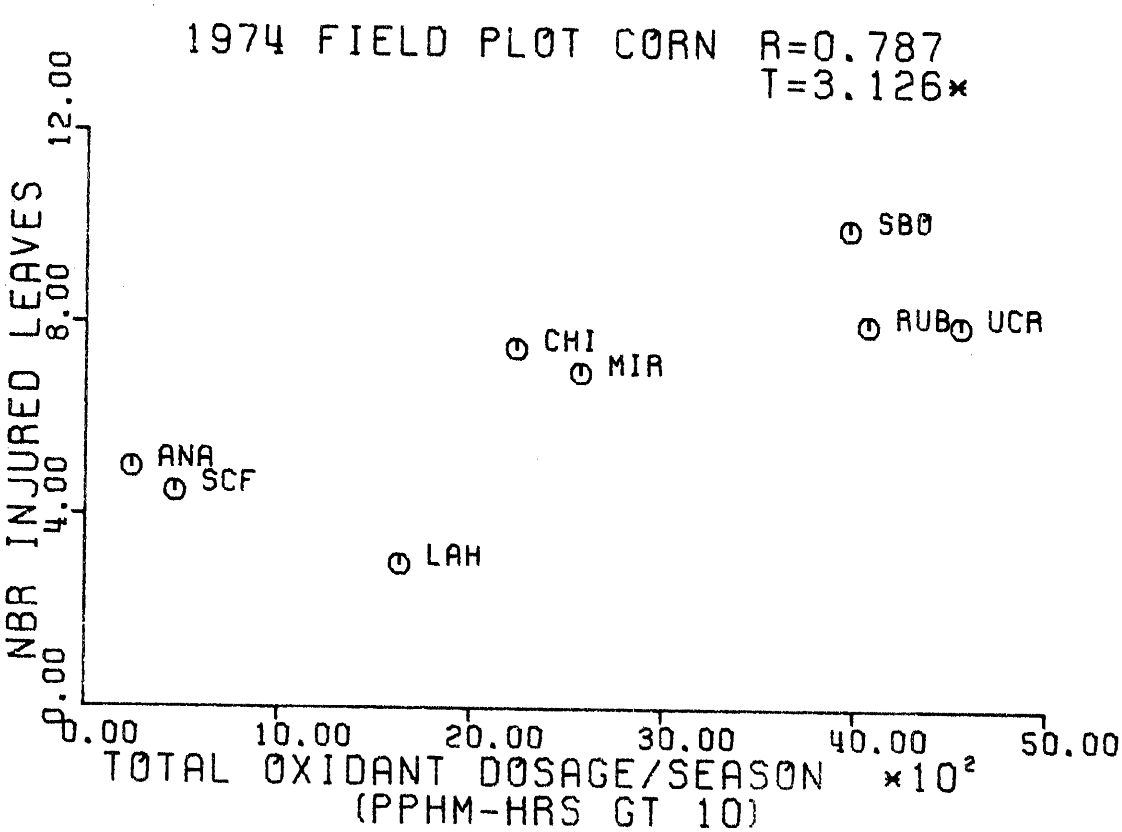


Figure 36. Anaheim field plot maximum and minimum temperatures for a 90-day period starting 2 May 1974.

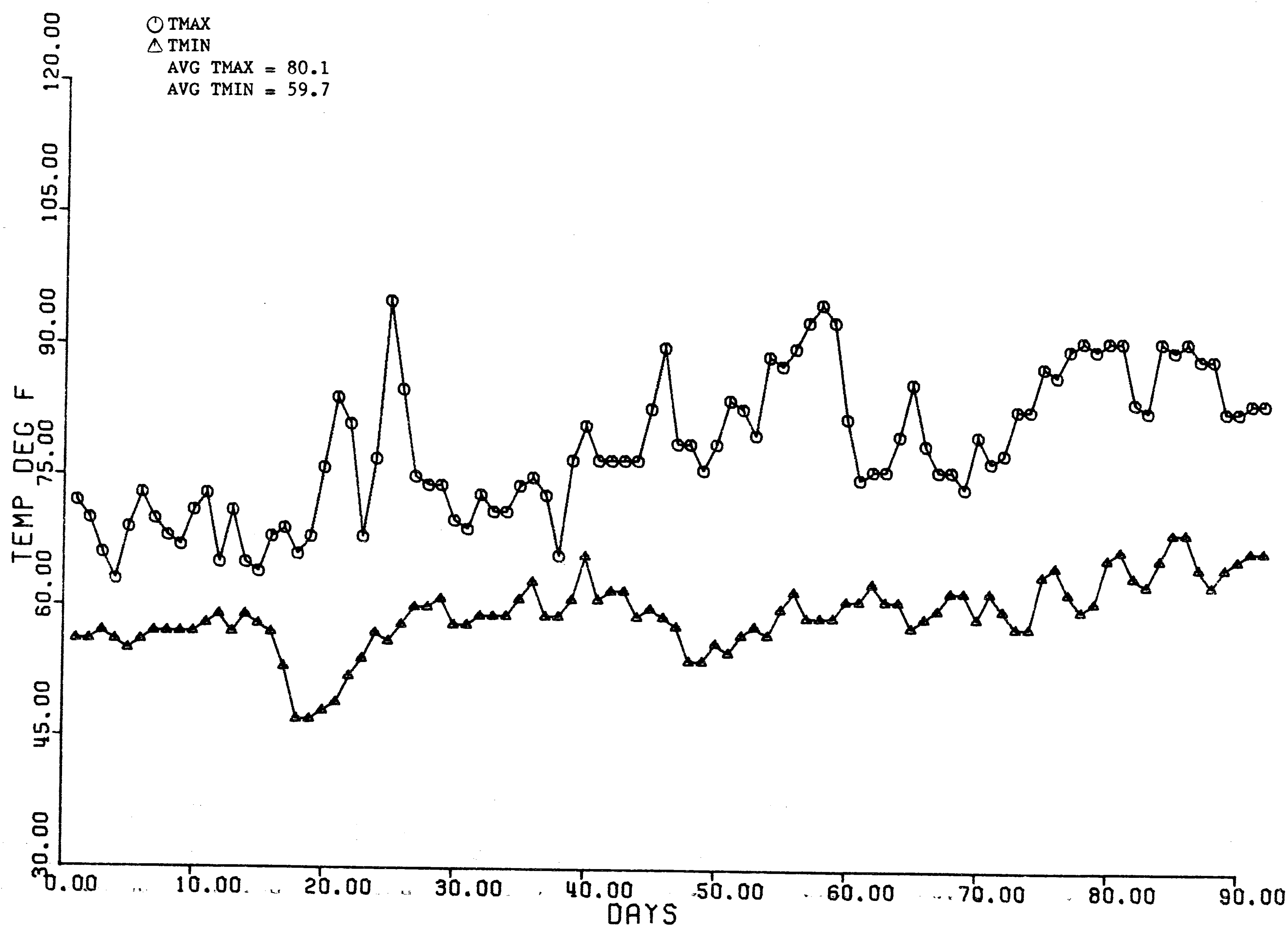


Figure 37. Chino field plot maximum and minimum temperatures for a 90-day period starting 2 May 1974.

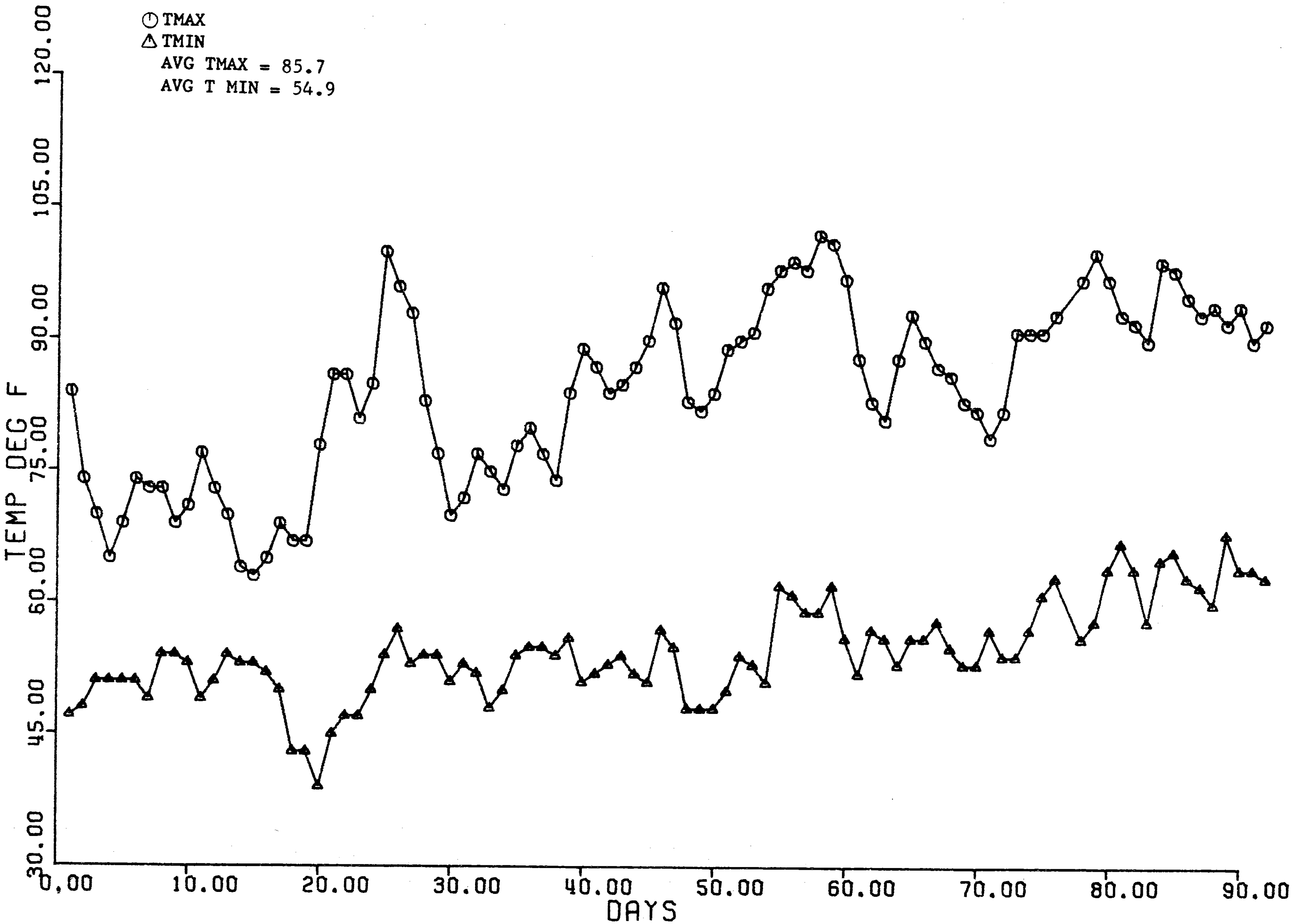


Figure 38. Mira Loma field plot maximum and minimum temperatures for a 90-day period starting 2 May 1974.

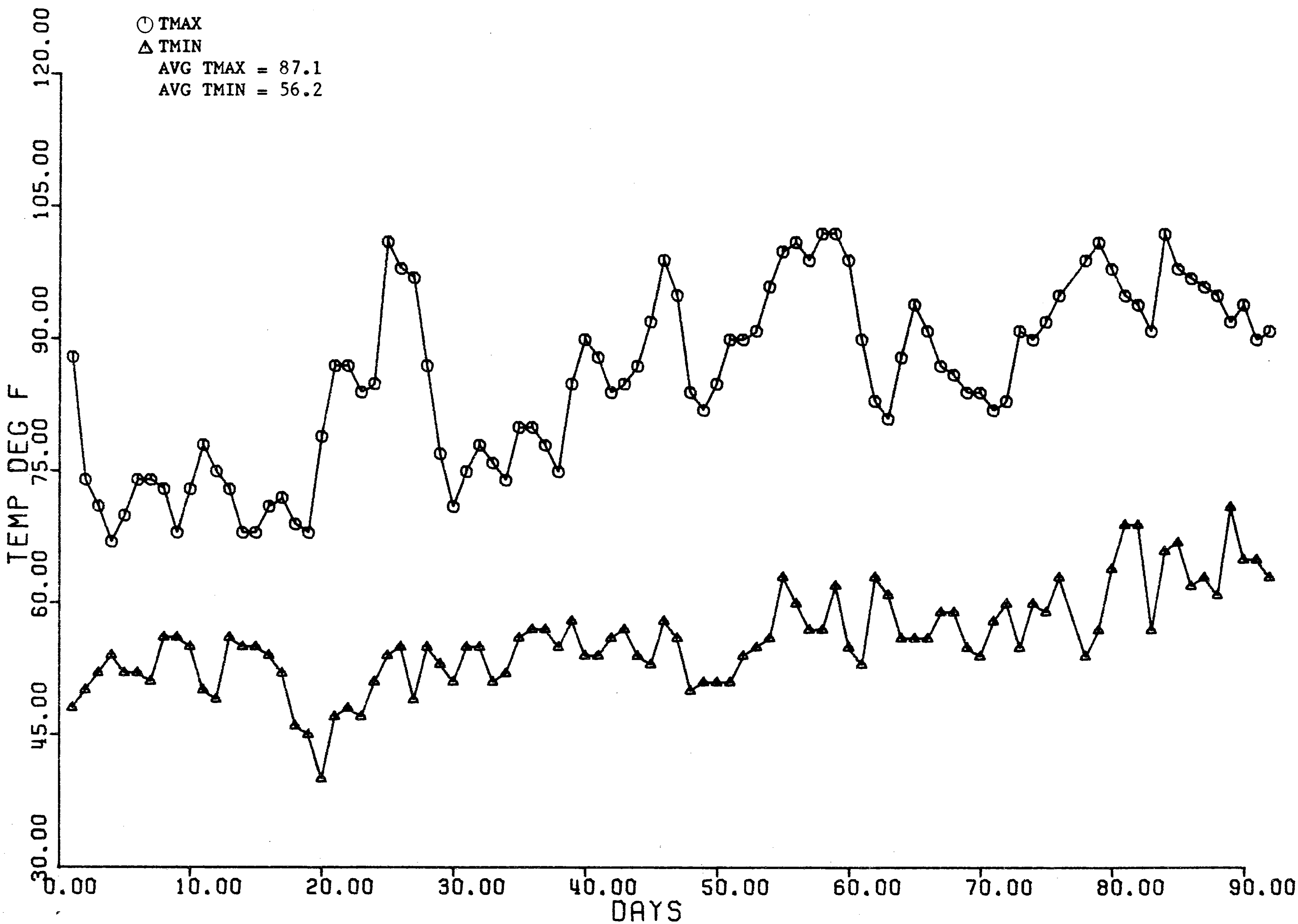


Figure 39. La Habra field plot maximum and minimum temperatures for a 90-day period starting 2 May 1974.

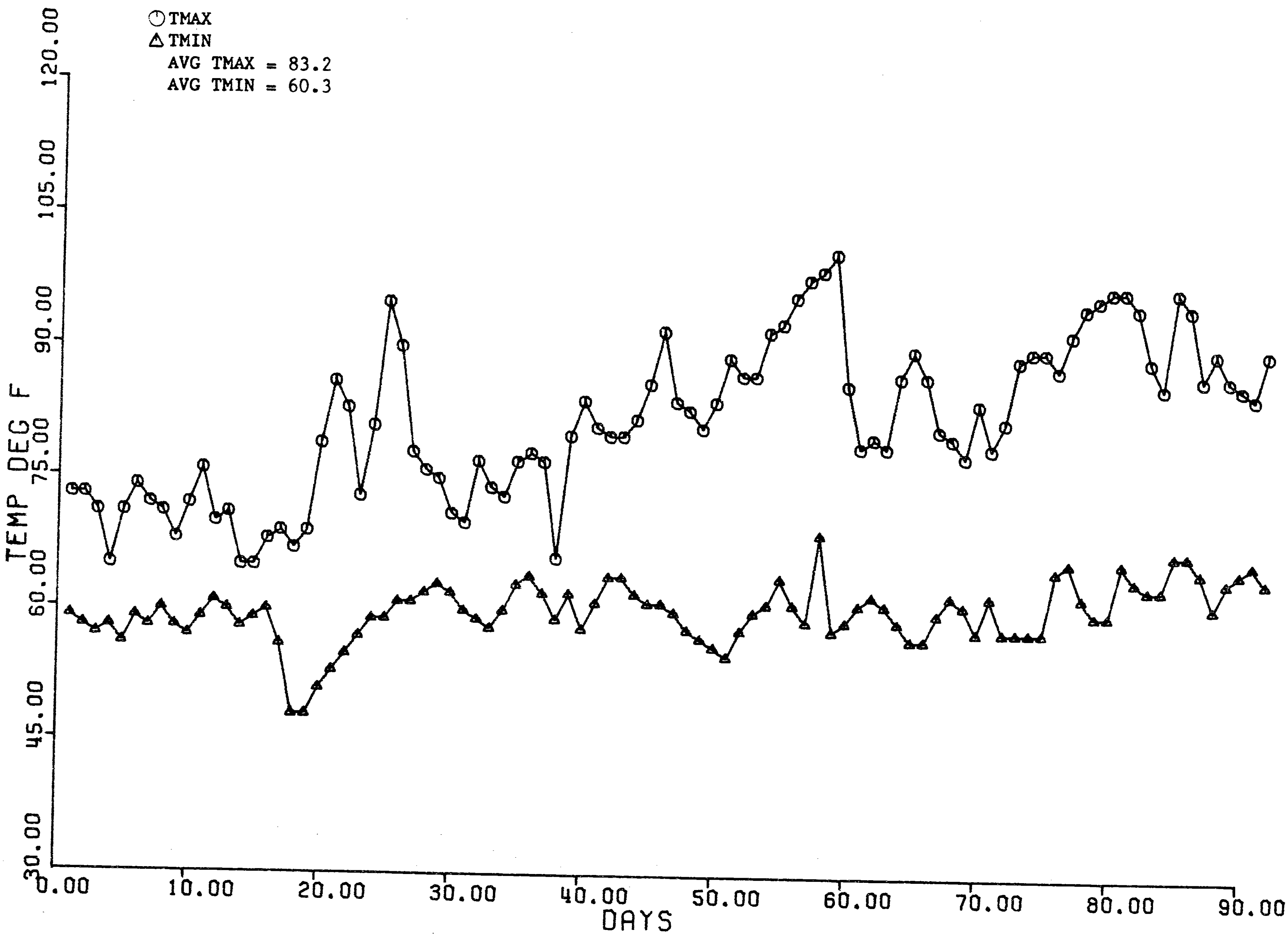


Figure 40. San Bernardino field plot maximum and minimum temperatures for a 90-day period starting 2 May 1974.

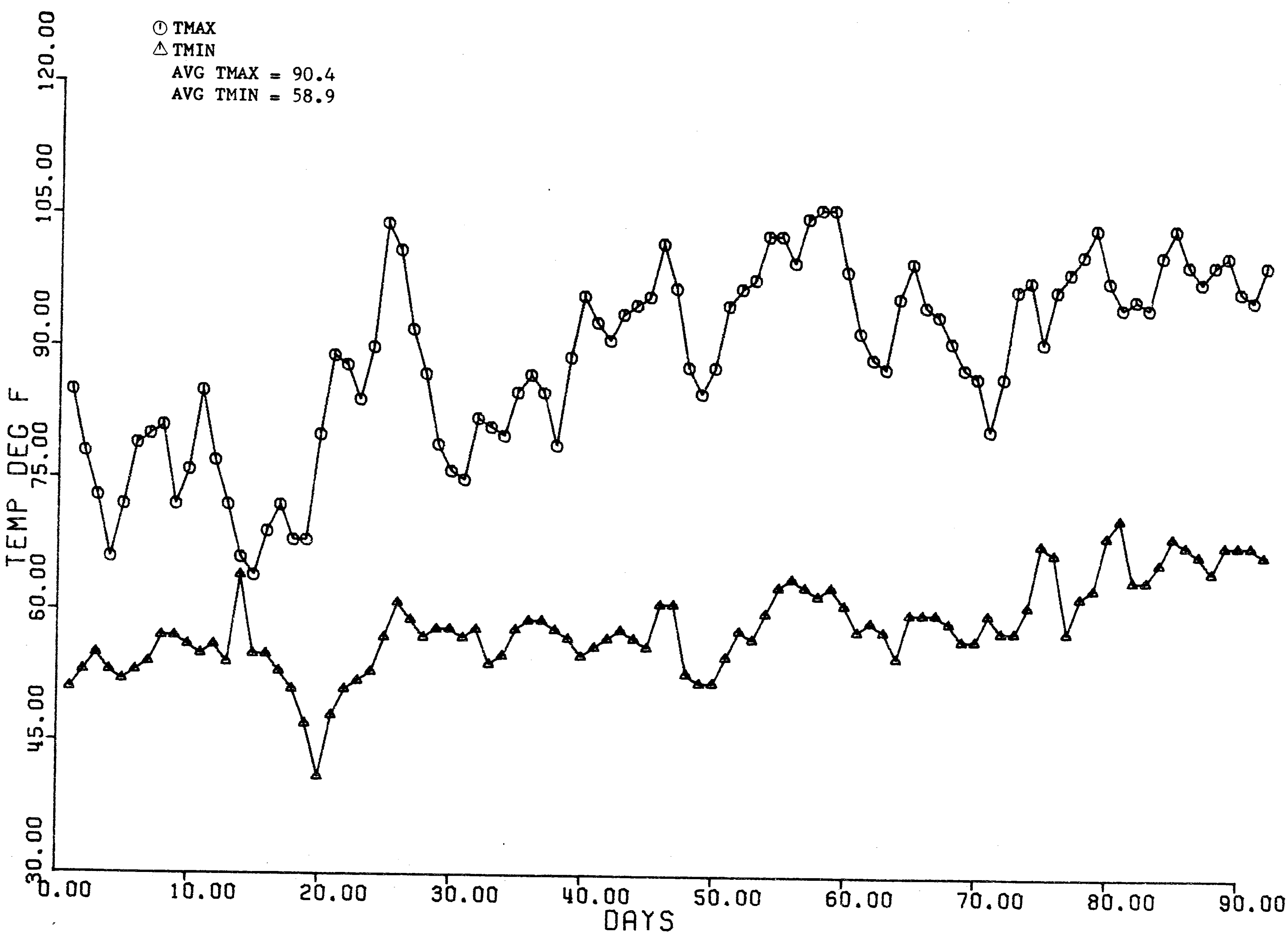


Figure 41. South Coast field plot maximum and minimum temperatures for a 90-day period starting 2 May 1974.

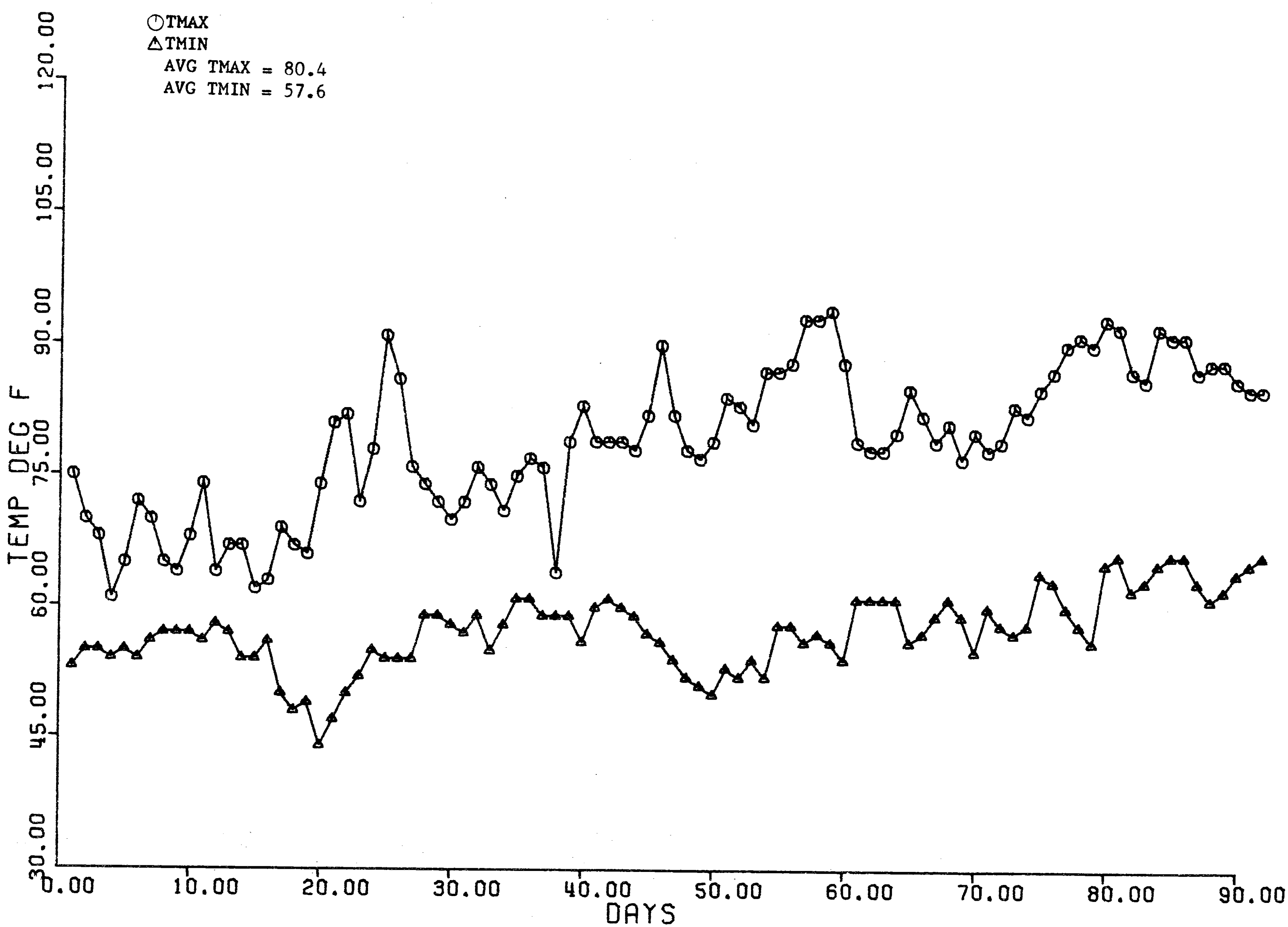


Figure 42. UCR and Rubidoux field plot maximum and minimum temperatures for a 90-day period starting 2 May 1974.

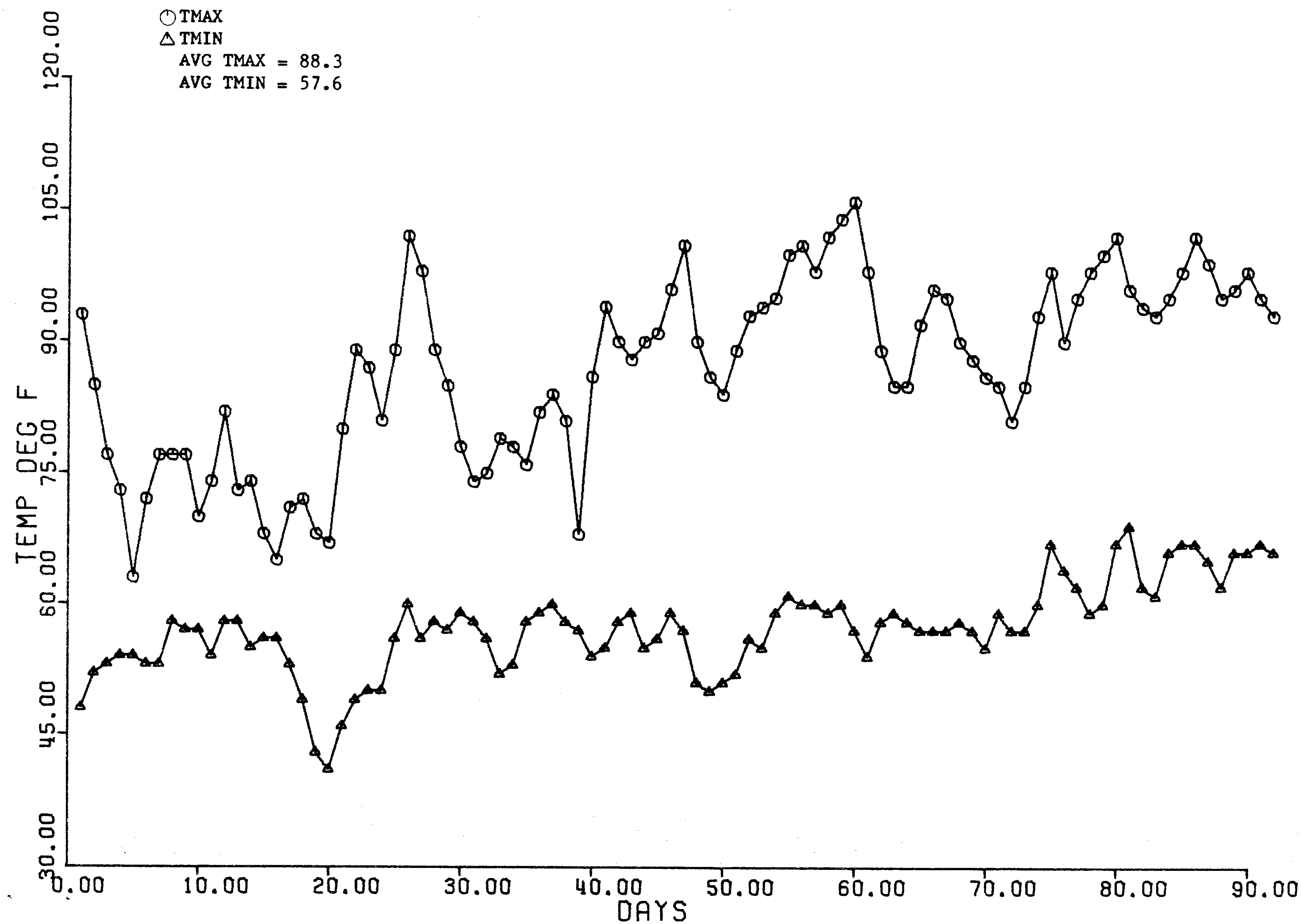


Figure 43. Anaheim field plot average daily relative humidity and daily ozone dosage during the growth of Golden Jubilee corn starting 2 May 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

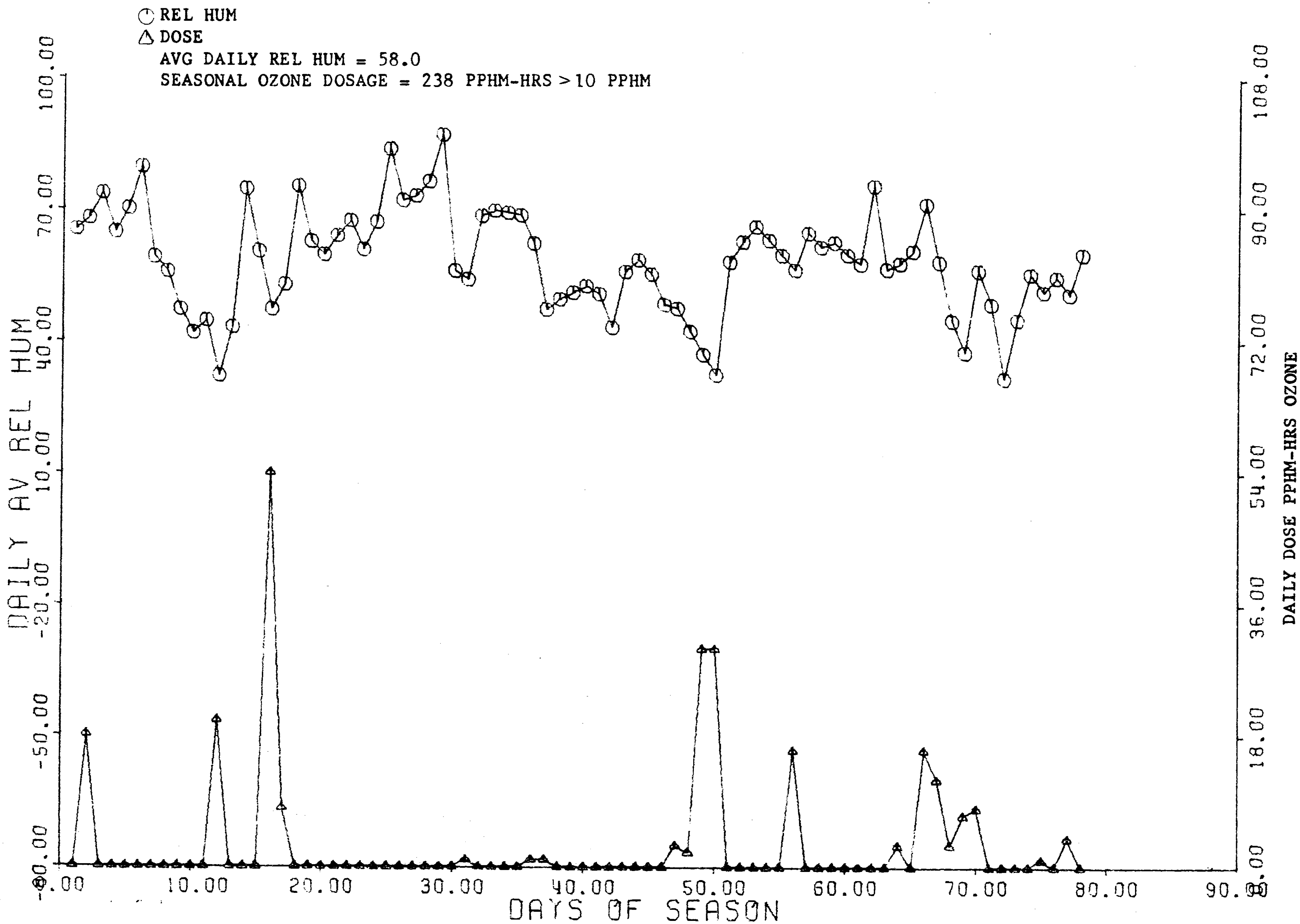


Figure 44. Chino field plot average daily relative humidity and daily ozone dosage during the growth of Golden Jubilee corn starting 2 May 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

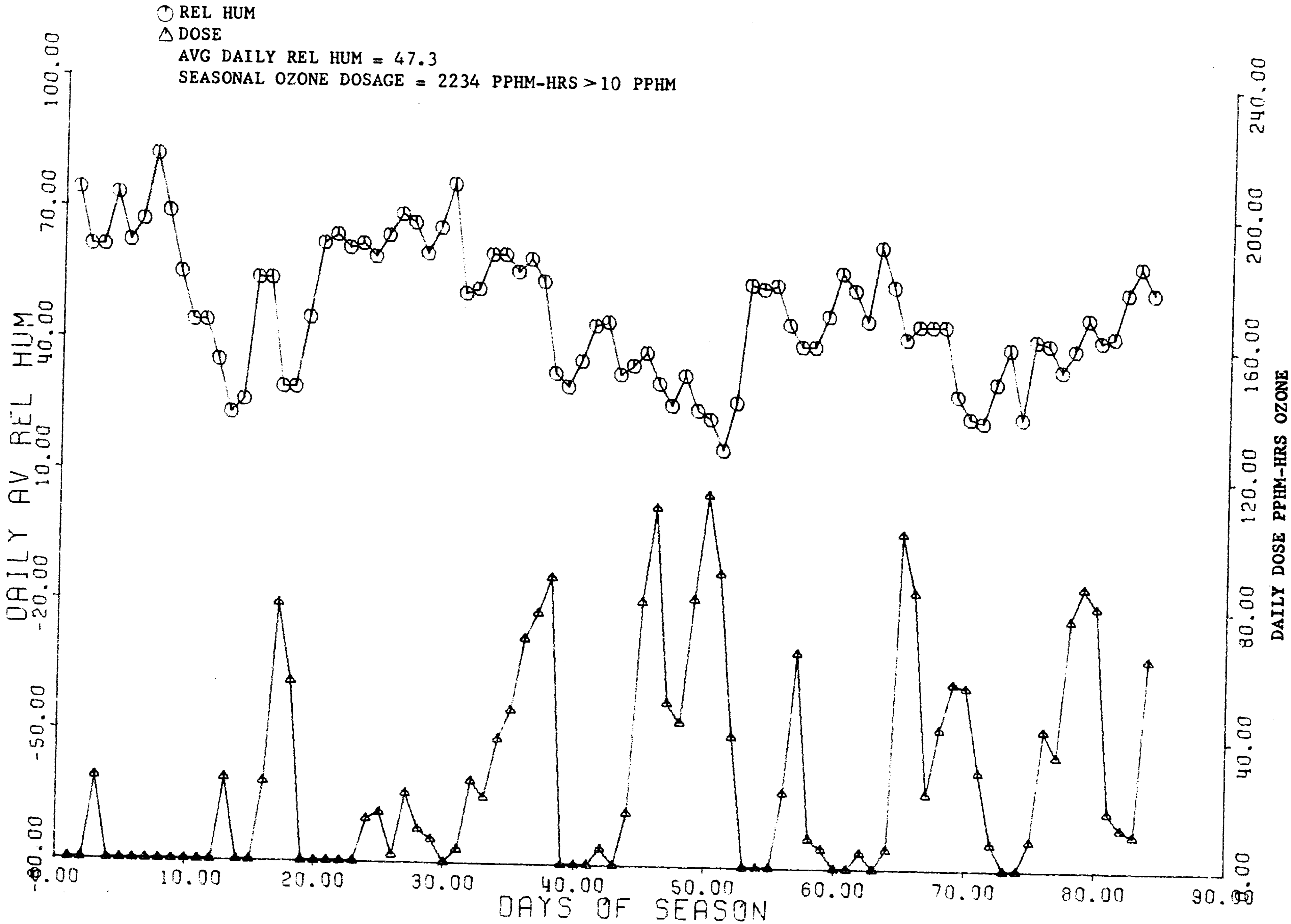


Figure 45. La Habra field plot average daily relative humidity and daily ozone dosage during the growth of Golden Jubilee corn starting 2 May 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

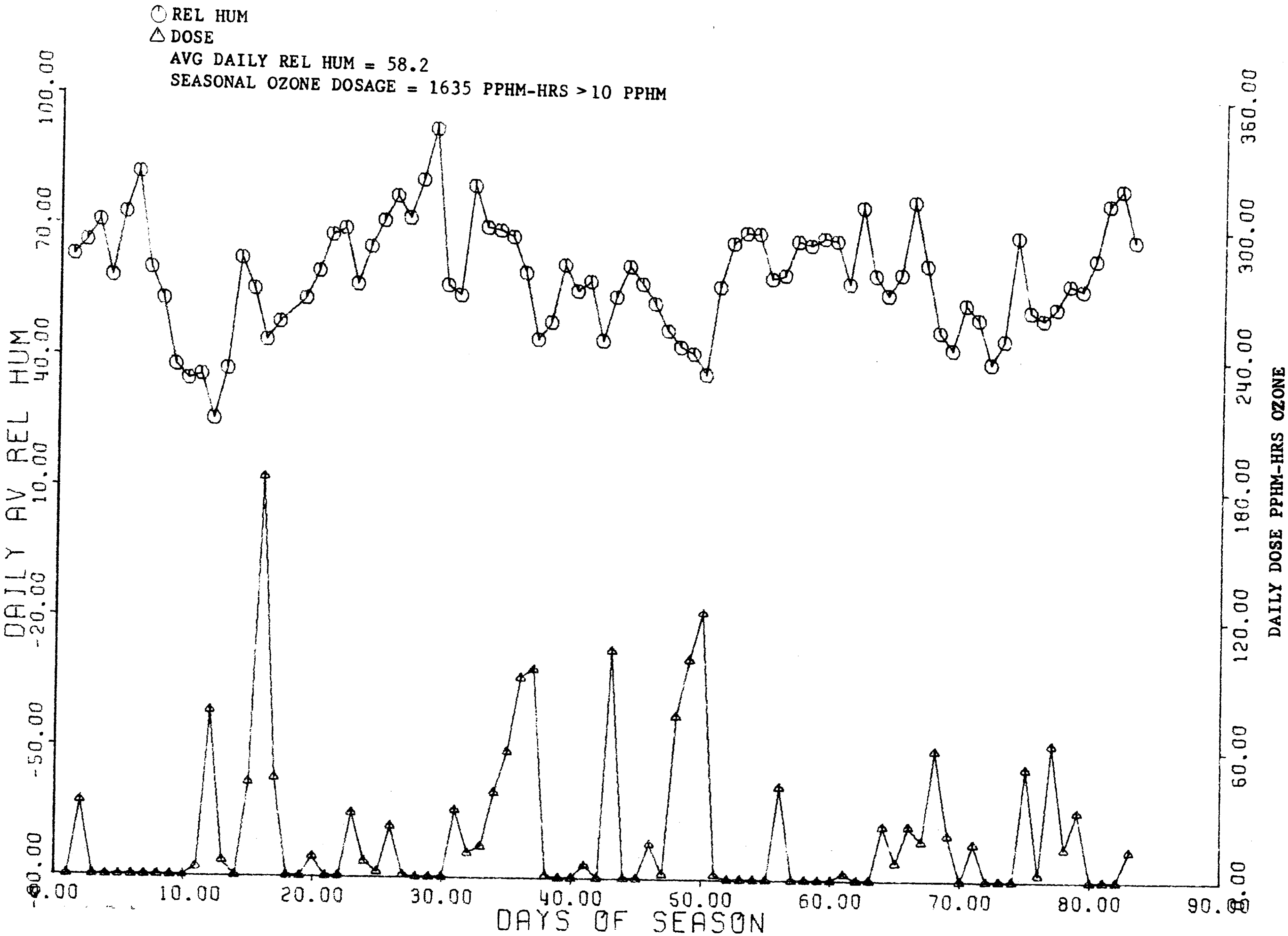


Figure 46. Mira Loma field plot average daily relative humidity and daily ozone dosage during the growth of Golden Jubilee corn starting 2 May 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

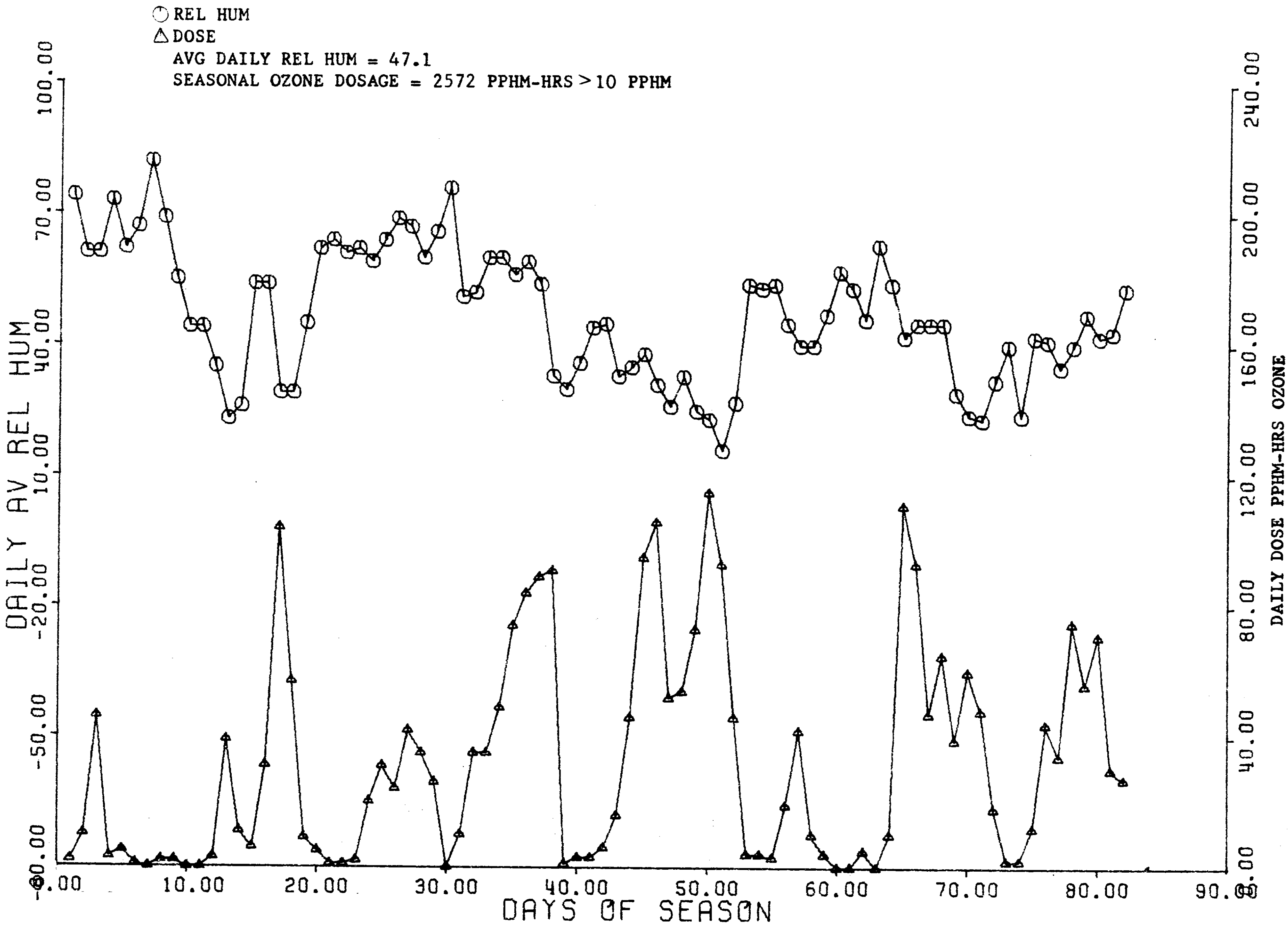


Figure 47. Rubidoux field plot average daily relative humidity and daily ozone dosage during the growth of Golden Jubilee corn starting 2 May 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

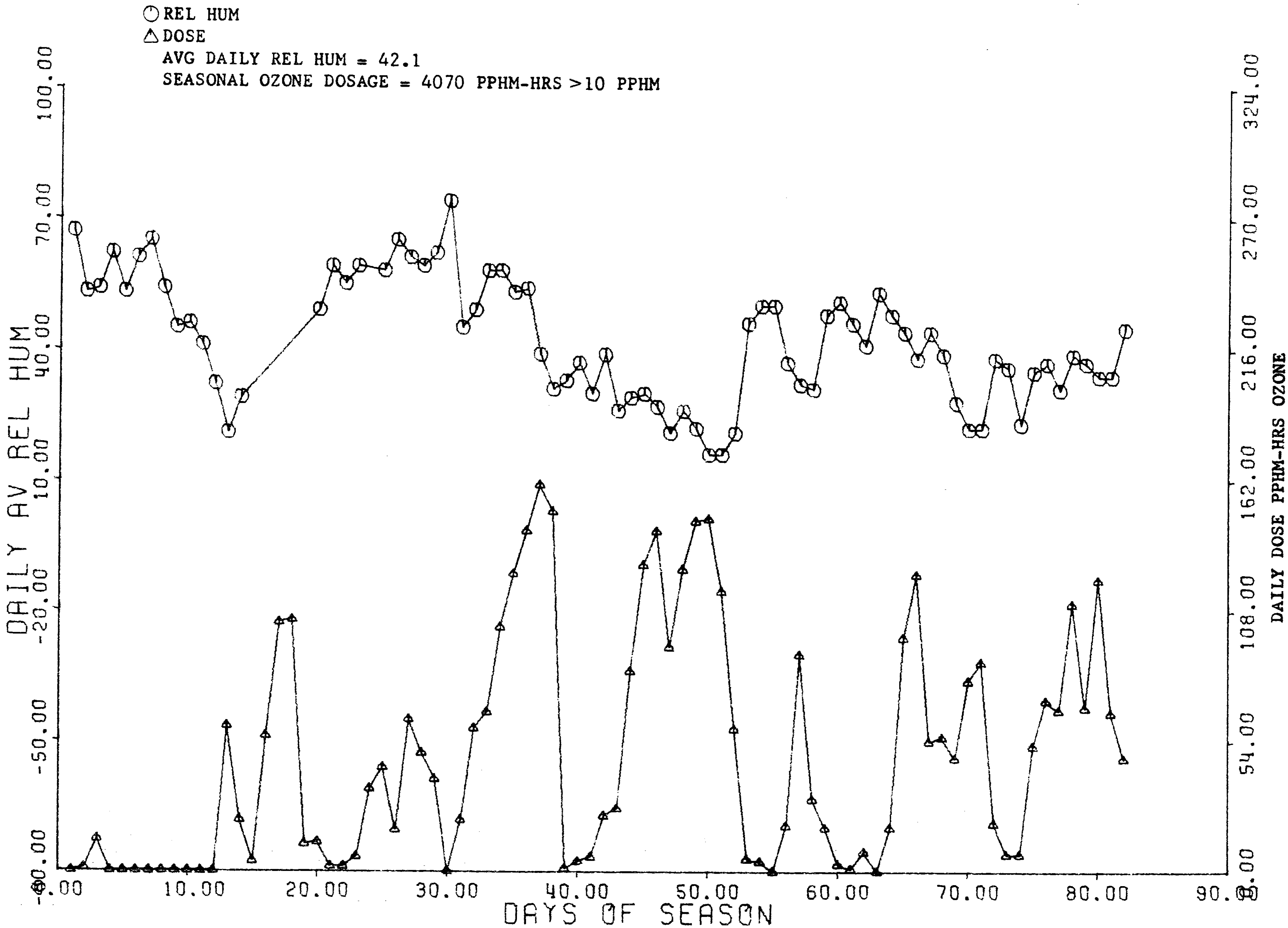


Figure 48. San Bernardino field plot average daily relative humidity and daily ozone dosage during the growth of Golden Jubilee corn starting 2 May 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

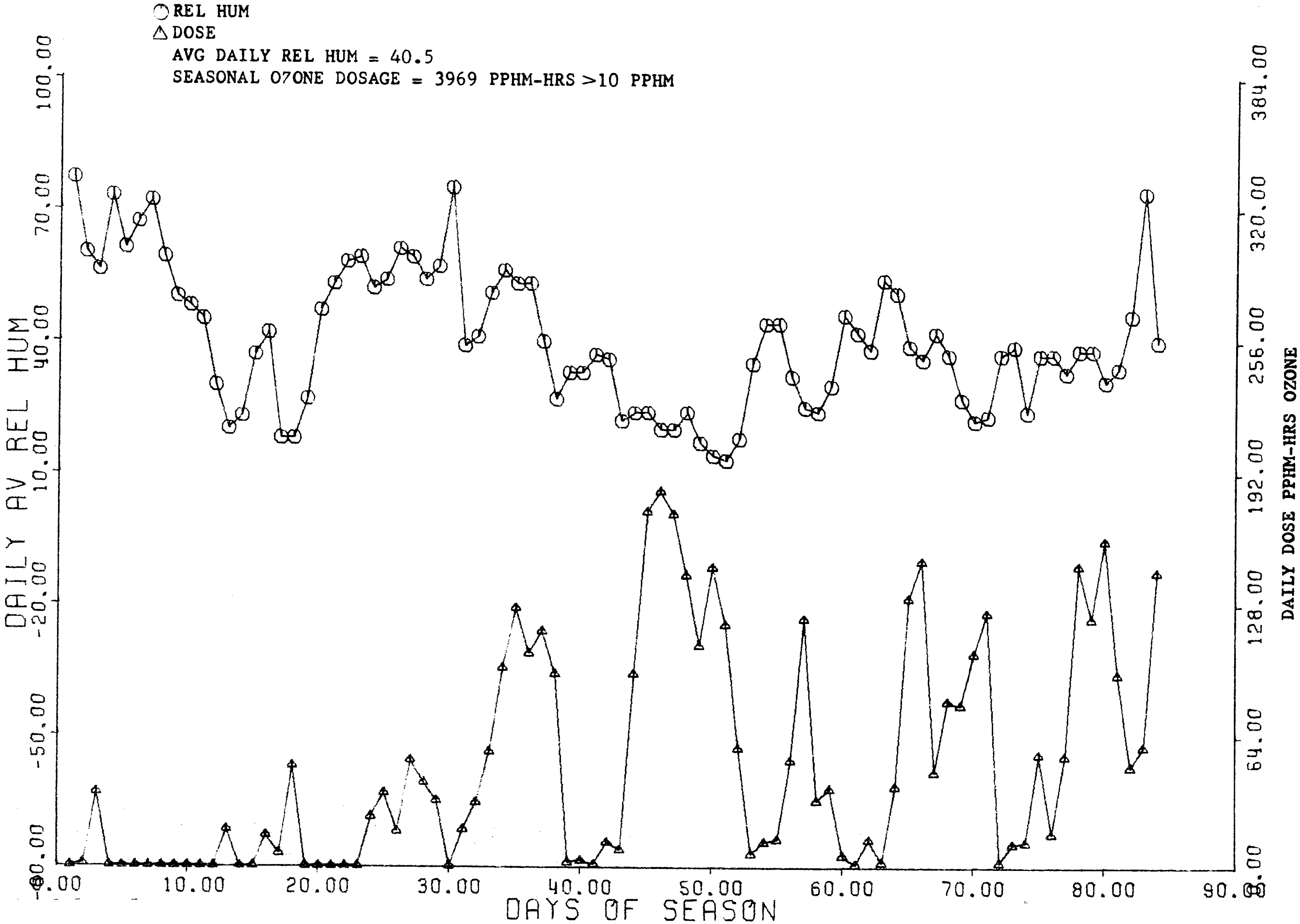


Figure 49. South Coast field plot average daily relative humidity and daily ozone dosage during the growth of Golden Jubilee corn starting 2 May 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

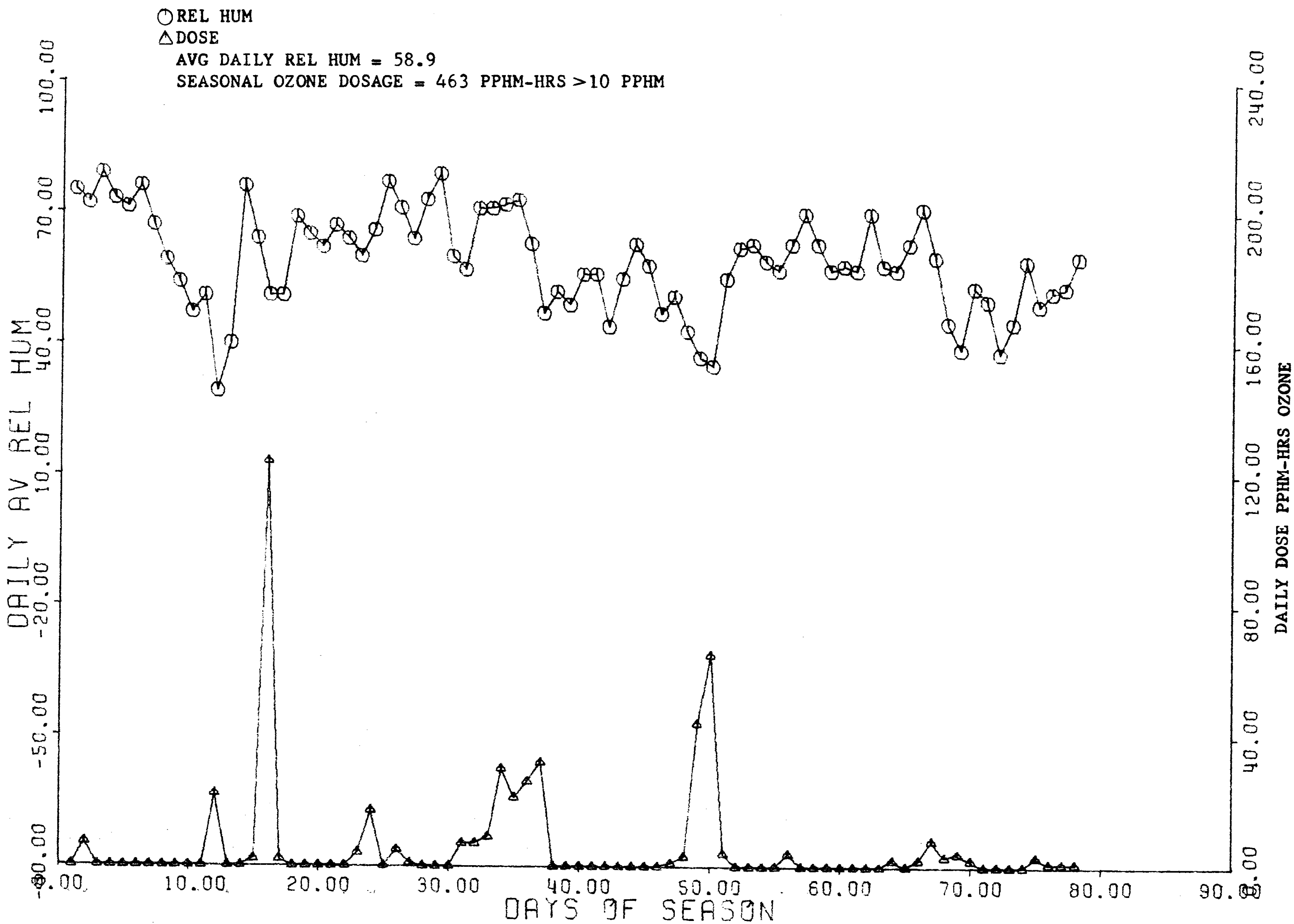


Figure 50. UCR field plot average daily relative humidity and daily ozone dosage during the growth of Golden Jubilee corn starting 2 May 1974. Dosages were calculated from hourly averages greater than 10 pphm ozone.

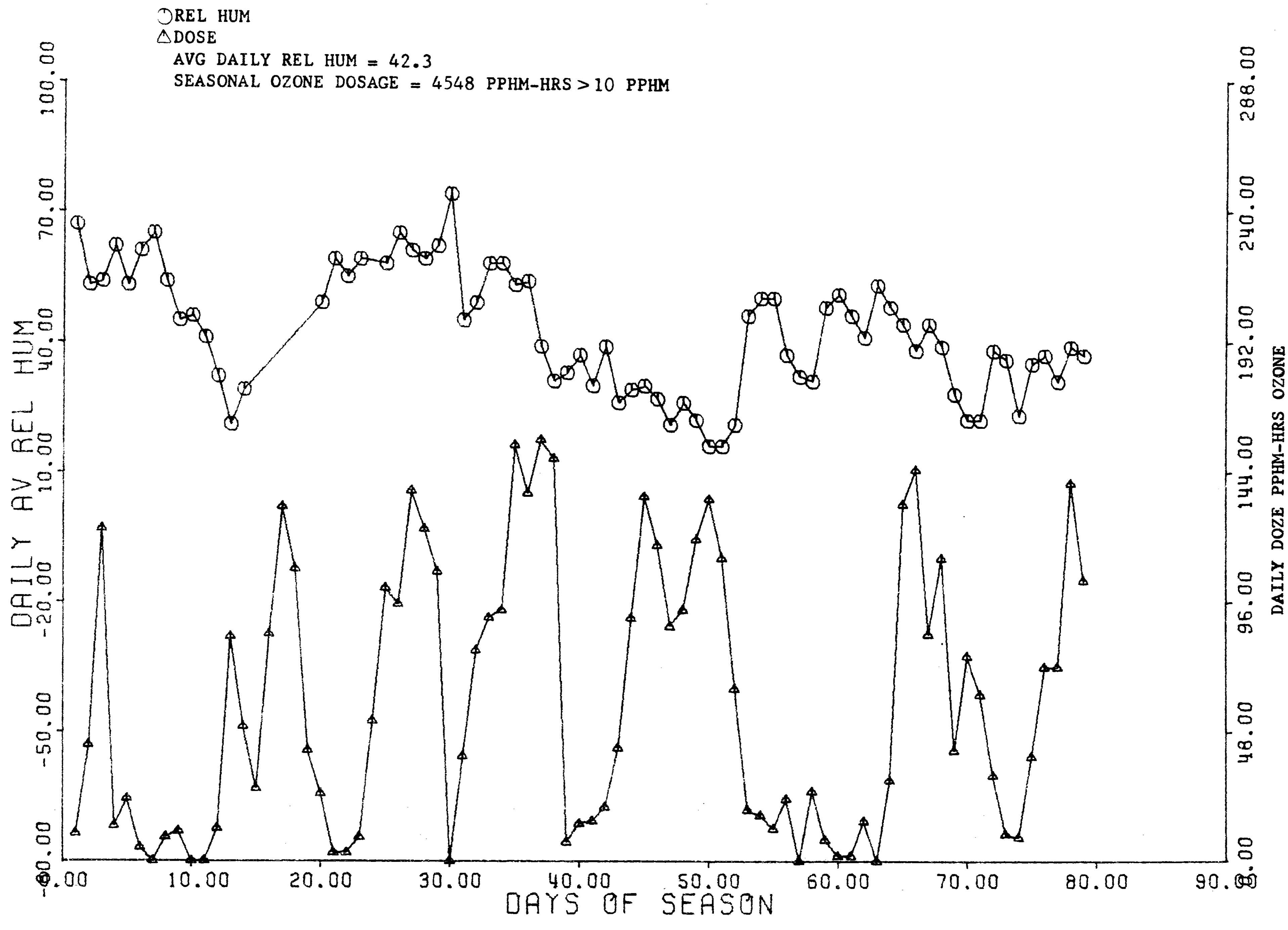


Figure 51. Anaheim average ozone dosage per hour of the day for the Golden Jubilee corn growing period.

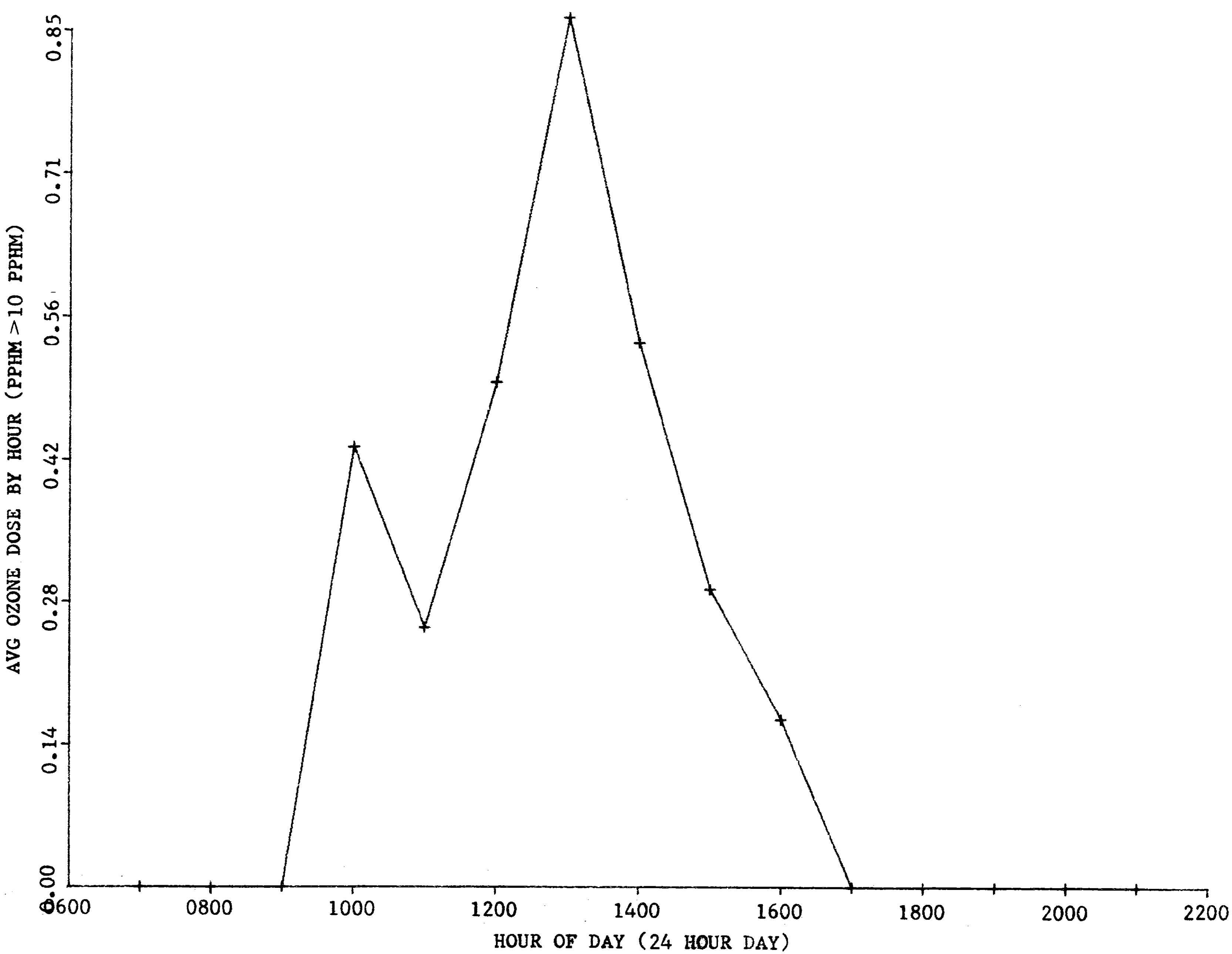


Figure 52. Chino average ozone dosage per hour of the day for the Golden Jubilee corn growing period.

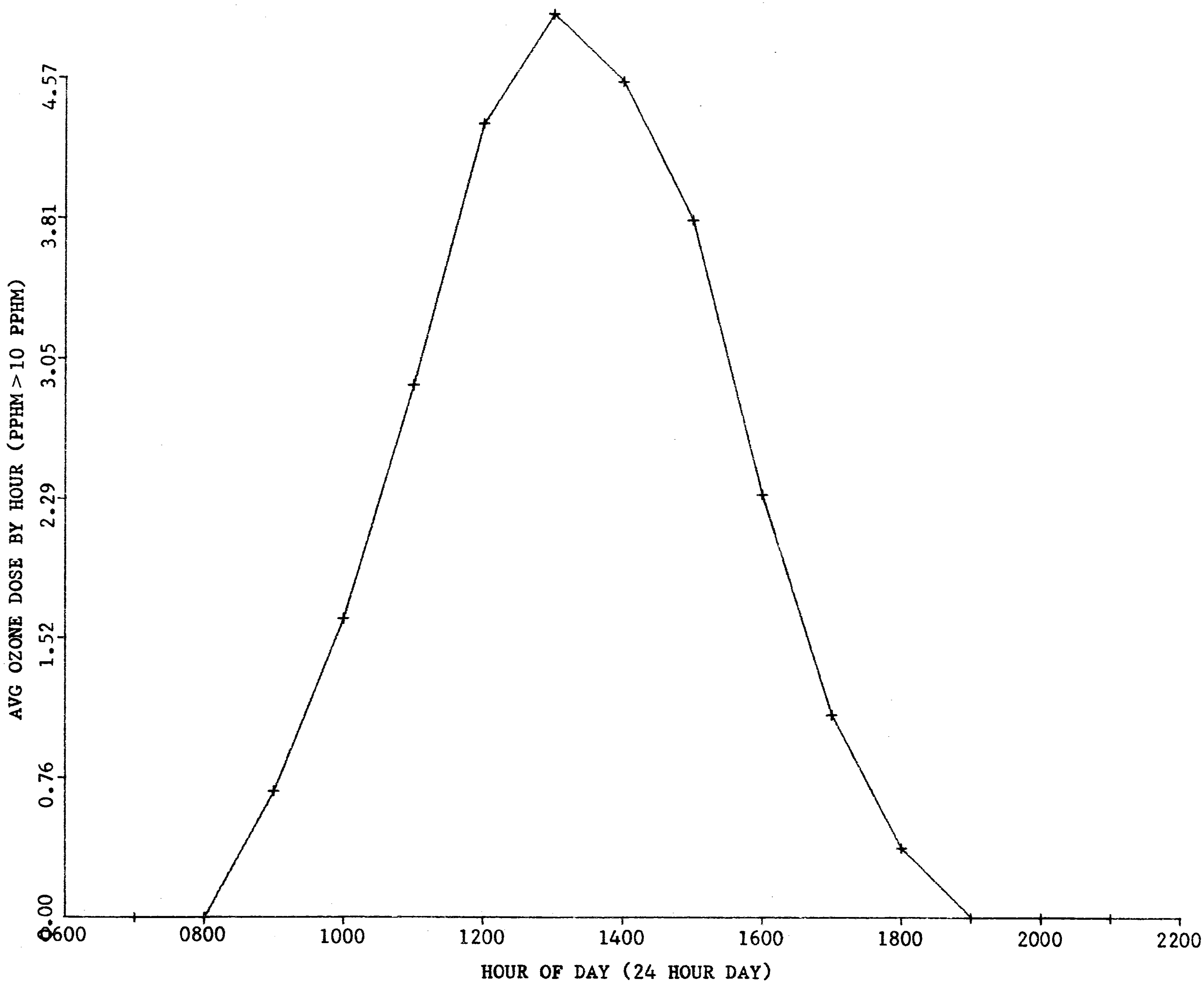


Figure 53. **La Habra average ozone dosage per hour of the day for the Golden Jubilee corn growing period.**

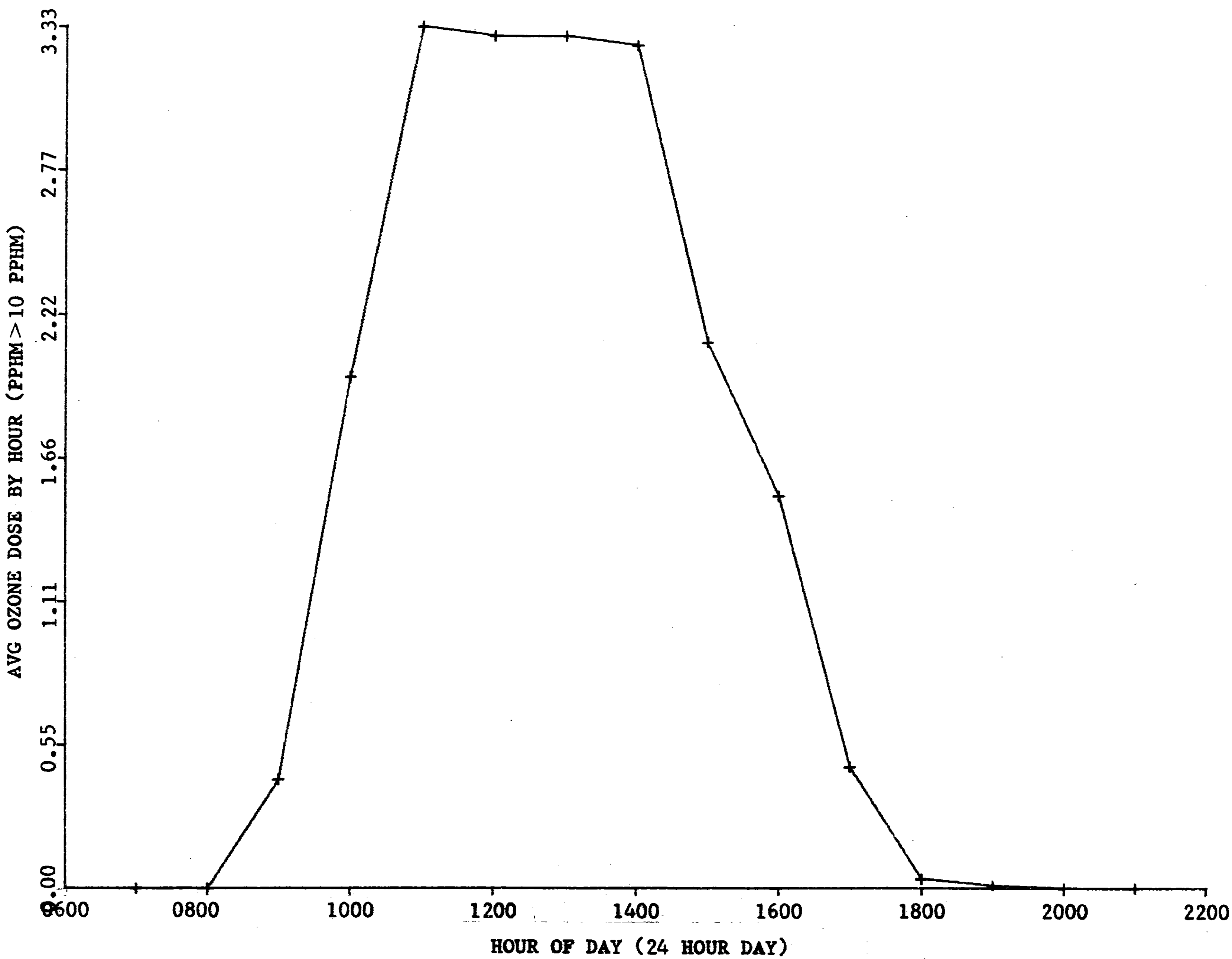


Figure 54. Mira Loma average ozone dosage per hour of the day for the Golden Jubilee corn growing period.

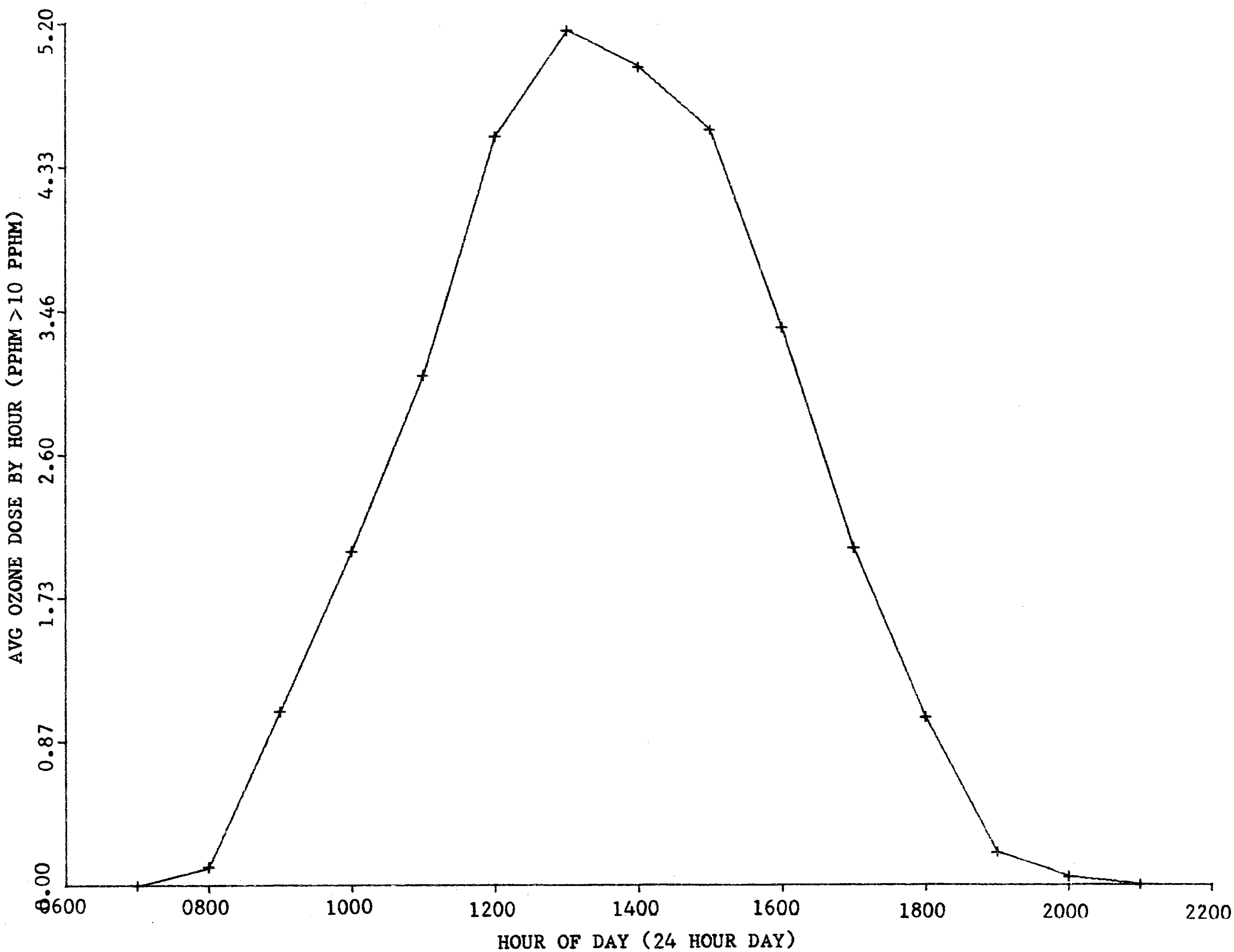


Figure 55. Rubidoux average ozone dosage per hour of the day for the Golden Jubilee corn growing period.

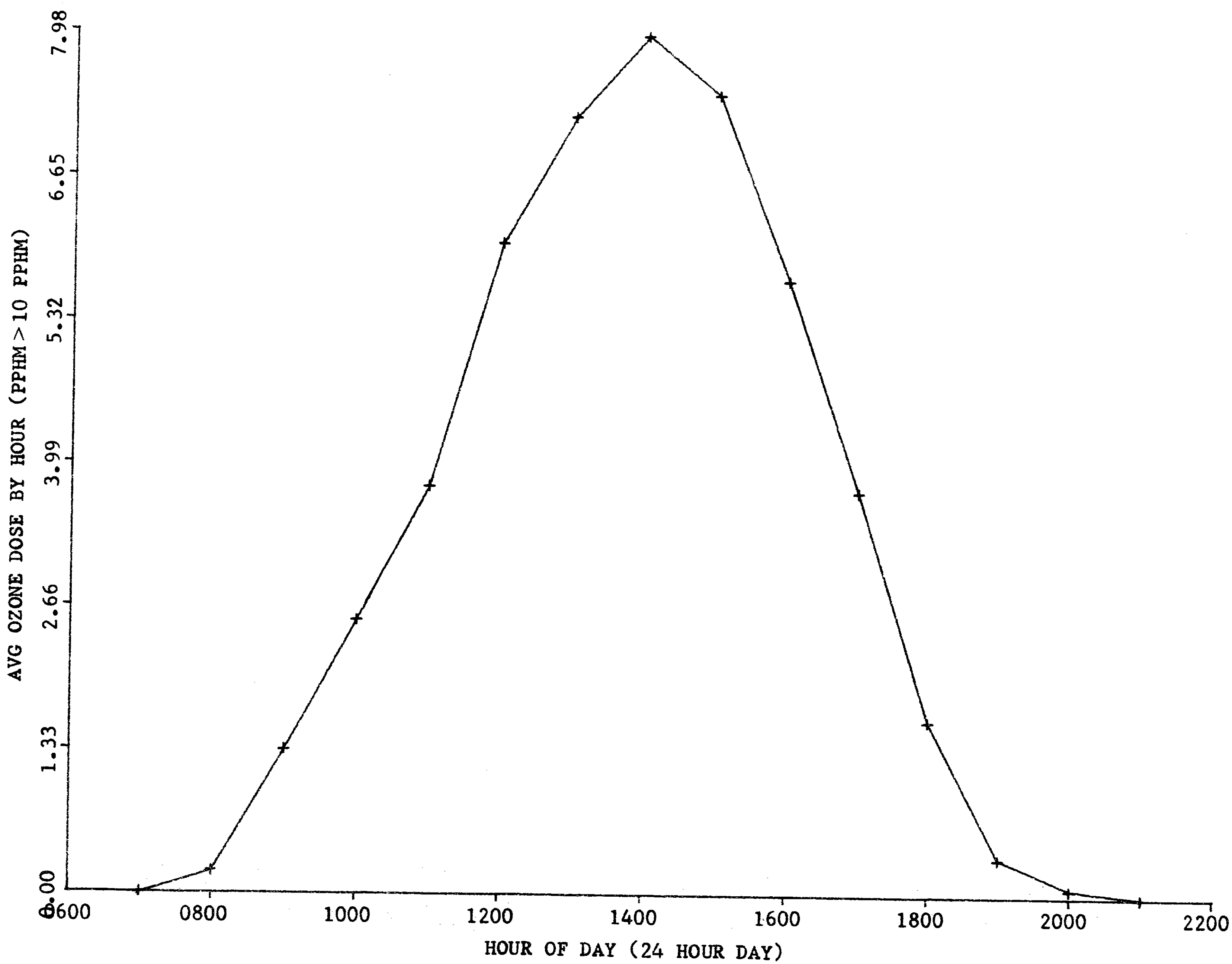


Figure 56. San Bernardino average ozone dosage per hour of the day for the Golden Jubilee corn growing period.

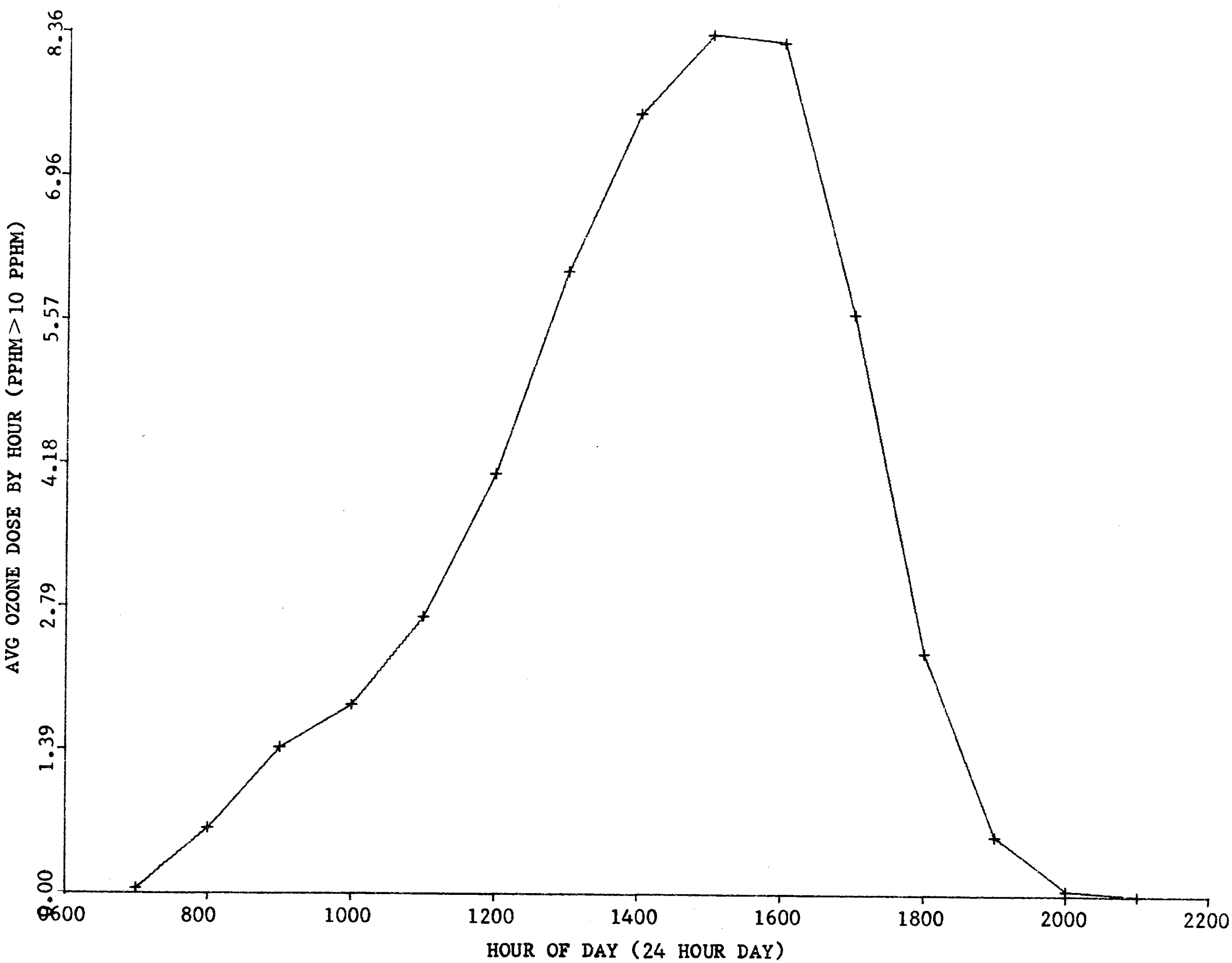


Figure 57. South Coast Field average ozone dosage per hour of the day for the Golden Jubilee corn growing period.

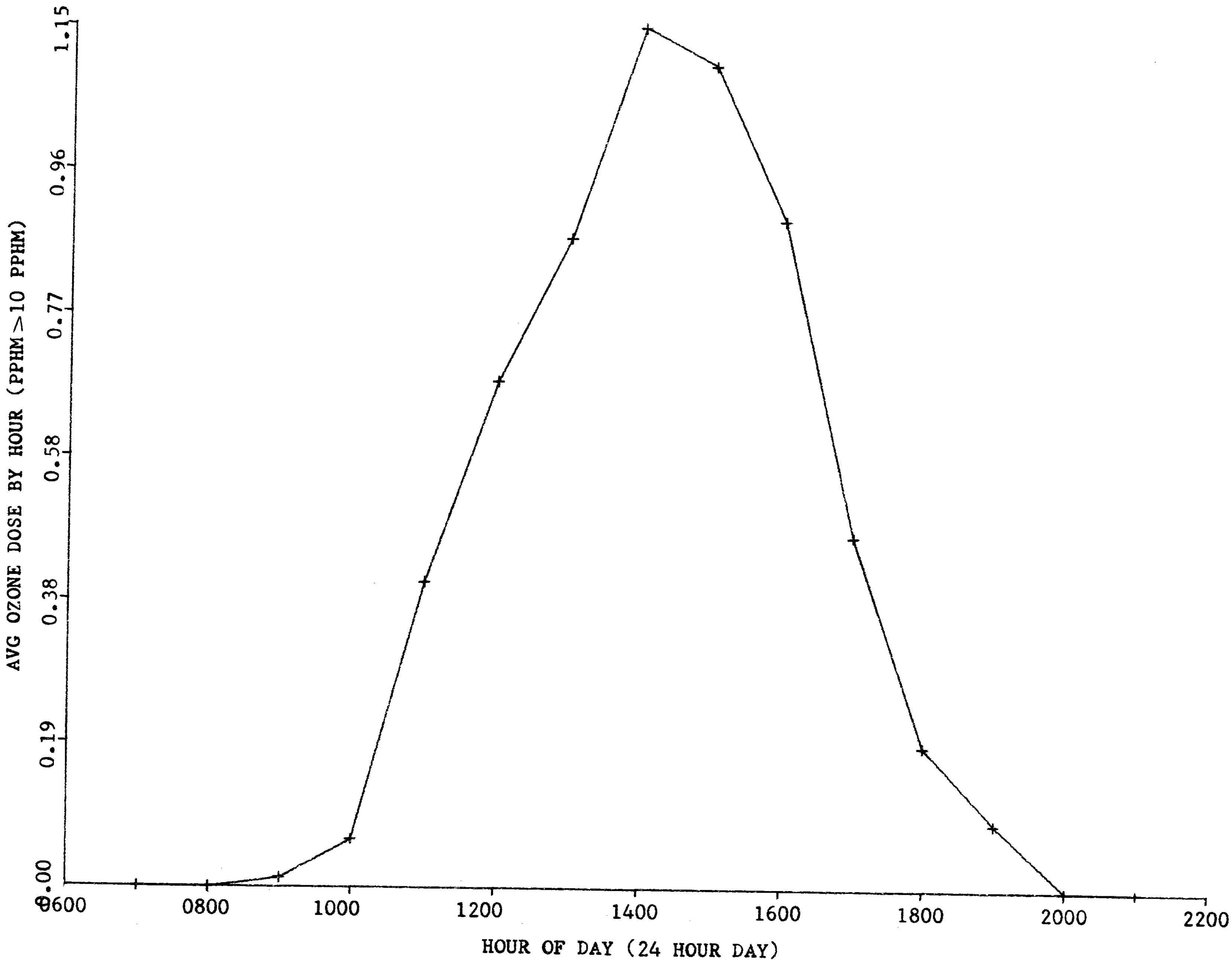
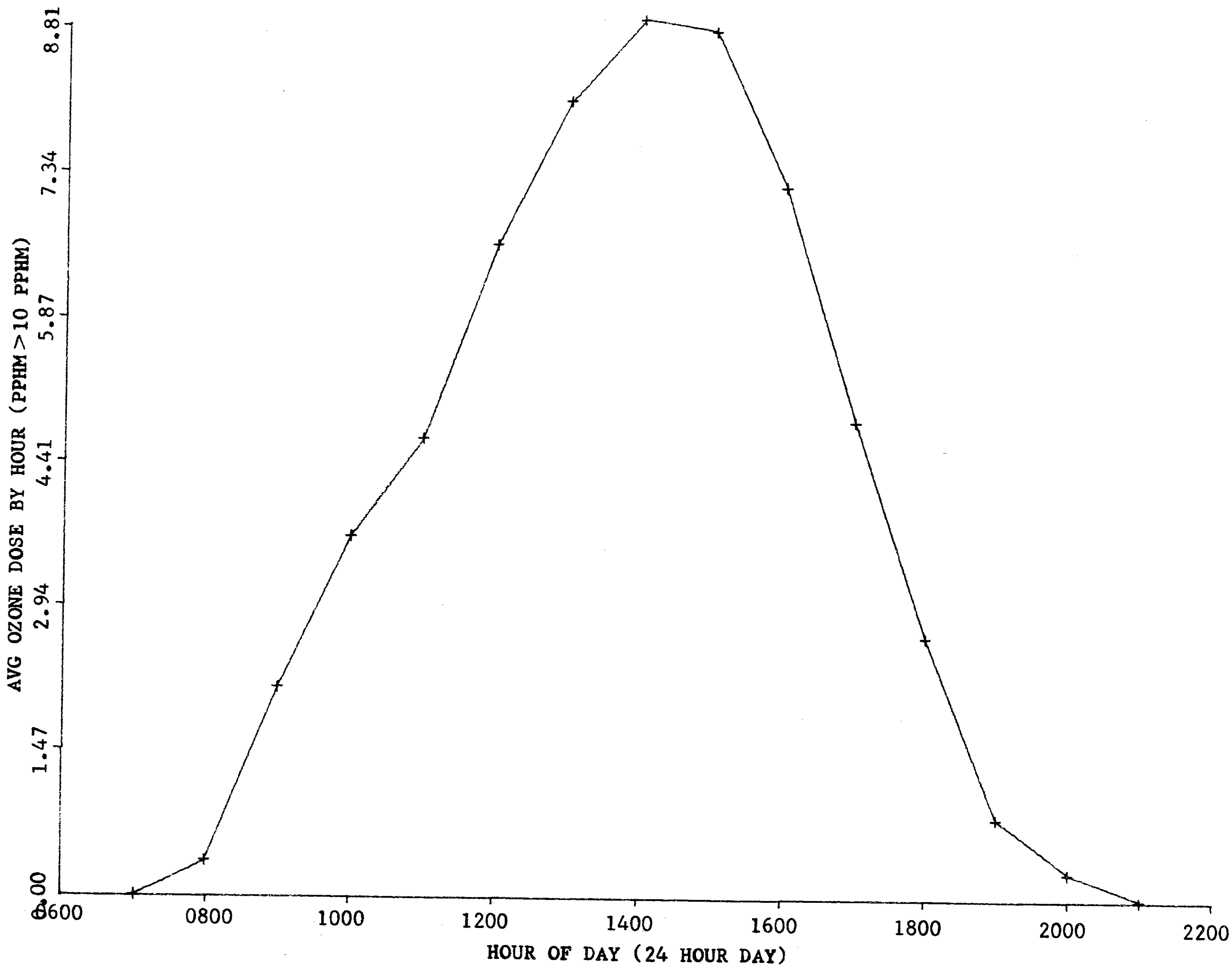


Figure 58. UCR average ozone dosage per hour of the day for the Golden Jubilee corn growing period.



DISCUSSION

The completed conversion functions are designed to be utilized by any agency interested in making economic assessments of air pollution losses to agriculture. The data necessary to compile ozone dosage values is public information available from local Air Pollution Control Districts or the California Air Resources Board. The seasonal dosage value is simply the sum of hourly averages greater than 10 pphm ozone for the daylight hours. Given the seasonal dosage for a specific area, one can find the corresponding predicted percent reduction on the conversion function.

The conversion functions should be used in conjunction with field observations of ozone injury to maximize accuracy. However, the conversion function would still give viable assessment ranges if injury observations are not available.

The production of the ozone dosage-yield reduction conversion function for alfalfa was based on a single year's growth. The highest production levels for alfalfa are usually visible during the second and third years and are closely associated with crown size or the nutrient storage potential of the plant. It is conceivable that alfalfa plants exposed to significant level of ozone may not have sufficient stored nutrients in the crowns to produce maximum second and third year harvests. The cumulative ozone injury over a period of years may have a greater effect on the lifetime yield of alfalfa than the predicted percent reduction value in the conversion function. This type of effect has been documented with a variety of grapes (3) and may affect many ozone sensitive perennials.

The production of ozone dosage-crop loss conversion function for woody perennials (tree crops) would require several years. Most tree crops require an extended period of growth before bearing fruit. After test plots are established, several years of growth would be required before any usable yield data would be available. Moreover, several years of yield would be necessary to establish production curves to eliminate inherent variations like the alternate year bearing cycle characteristic of some citrus. A program to construct conversion functions for tree crops would require a much greater expenditure per conversion function. Test plots would require a significantly larger area than current locations afford in order to accommodate space requirements. The possibility of locating the required number of already established groves of uniform age within an oxidant gradient would be remote. A further consideration of variables like rootstock, cultural conditions, and grower cooperation would make the task impossible. Only standardized test plots located in a predetermined oxidant gradient would be realistic.

The 1974 program was the initial production season using standardized field plots. The field plots consisted of 16 individual plants grown under uniform conditions; a highly vulnerable population in terms of number of observations. A 2 ft. rabbit fence was constructed around each field plot and a vertebrate trapping and poisoning program established in areas where rodents had been observed. Each field plot was situated in an isolated area out of public view or within a fenced enclosure with a locking gate to further ensure against vandalism. Despite these precautions, five corn plots and four alfalfa plots were lost.

Those field plots vulnerable to vandalism have since been relocated to more secure areas or are now patrolled by security force. Individual wire mesh coverings were constructed to protect test crops from predation at the remaining field plots and are now incorporated as standard field plot equipment. This type of security measure should eliminate the problem of vertebrate predation in the future.

REFERENCES

1. Oshima, R. J. 1973. Final Report -- Development of a system for evaluating and reporting economic crop losses caused by air pollution in California: I. Quality study. State of Calif., Dept. Food and Agr., Sacramento, California. 131 pp.

2. Oshima, R. J. 1974. Final Report -- Development of a system for evaluating and reporting economic crop losses caused by air pollution in California: II. Yield study. IIA. Prototype ozone dosage-crop loss conversion function. State of Calif., Dept. Food and Agr., Sacramento. 148 pp.

3. Thompson, C.R., et al. 1969. Effect of photochemical air pollutants on Zinfandel grapes. HortScience 4:222.

Figure 2. Correlation of the average lvs/wt ratio of field plot Moapa 69 alfalfa with the total ambient ozone dosage present during growth.

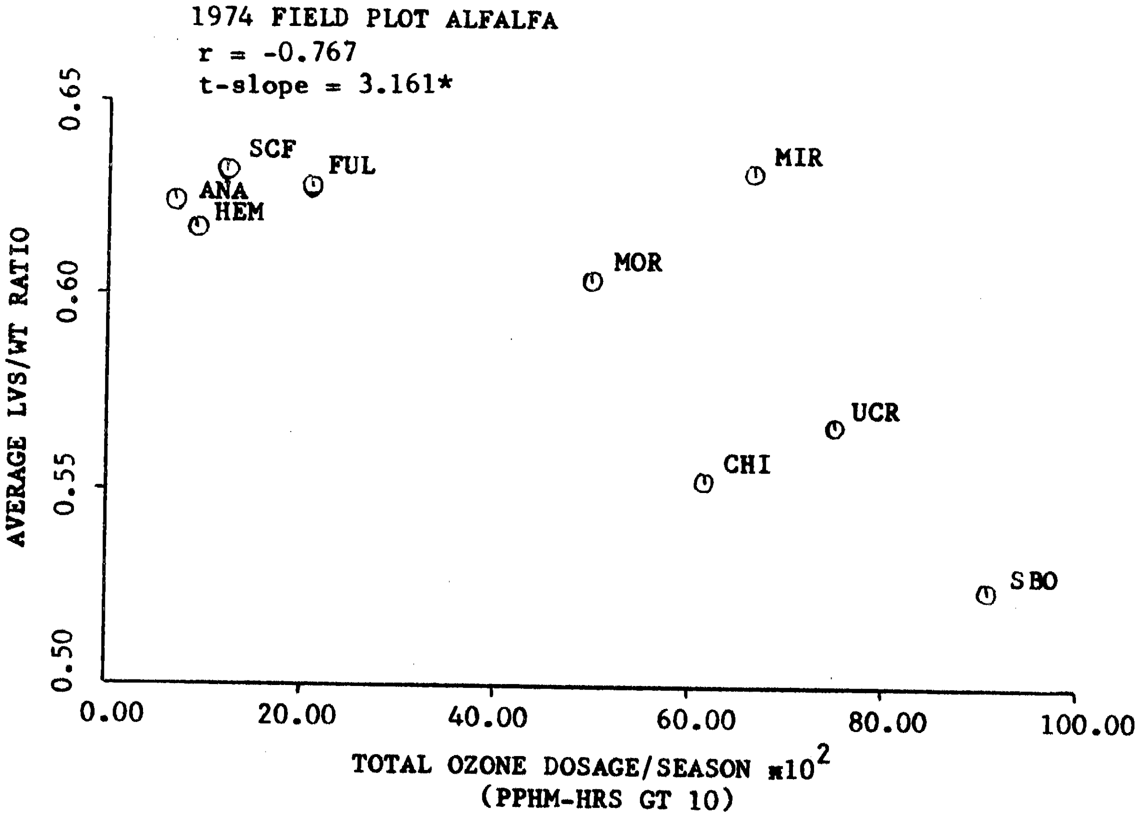


Figure 31. Correlation of average leaf to total weight ratios with seasonal ozone dosages for Moapa 69 alfalfa.

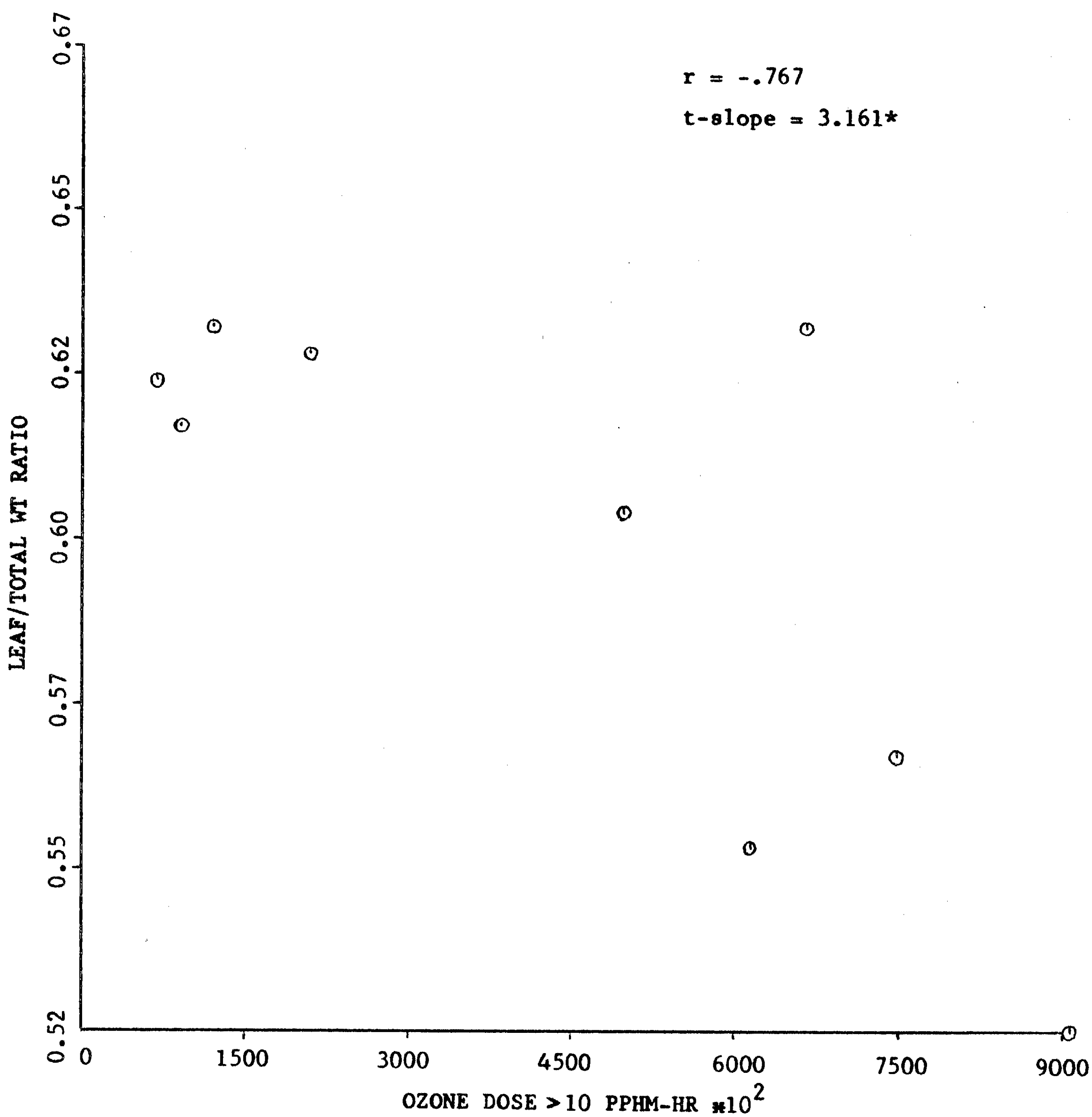


Figure 33. Calculated linear regression and 95% confidence belts for reduction of leaf to total weight ratios and seasonal ozone dosage correlation for Moapa 69 alfalfa.

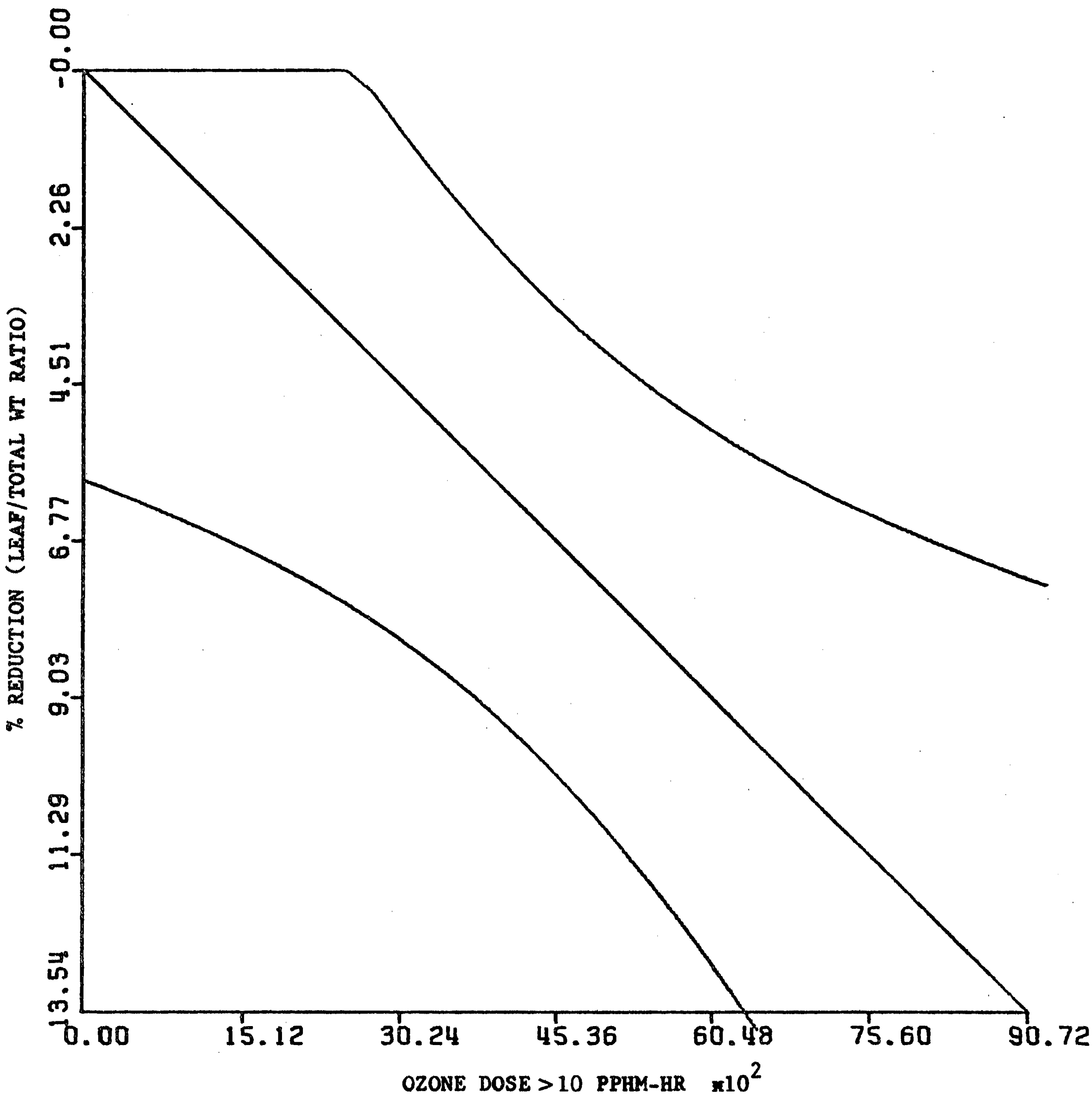


Table 5. Ozone dosage-alfalfa (Moapa 69 leaf reduction conversion function.

Ozone Dose[1]	Predicted % Reduction	Range of % Reduction at 95% Confidence		
0.	0.000	0.0	-	5.914
250.	0.373	0.0	-	6.059
500.	0.746	0.0	-	6.210
750.	1.120	0.0	-	6.365
1000.	1.493	0.0	-	6.527
1250.	1.866	0.0	-	6.696
1500.	2.240	0.0	-	6.873
1750.	2.613	0.0	-	7.058
2000.	2.986	0.0	-	7.253
2250.	3.360	0.0	-	7.460
2500.	3.733	0.0	-	7.679
2750.	4.106	0.299	-	7.913
3000.	4.479	0.796	-	8.163
3250.	4.853	1.275	-	8.430
3500.	5.226	1.735	-	8.716
3750.	5.599	2.175	-	9.023
4000.	5.973	2.593	-	9.352
4250.	6.346	2.988	-	9.704
4500.	6.719	3.360	-	10.079
4750.	7.092	3.708	-	10.476
5000.	7.466	4.034	-	10.897
5250.	7.839	4.339	-	11.339
5500.	8.212	4.623	-	11.802
5750.	8.586	4.888	-	12.283
6000.	8.959	5.135	-	12.782
6250.	9.332	5.367	-	13.297
6500.	9.705	5.585	-	13.826
6750.	10.079	5.790	-	14.367
7000.	10.452	5.984	-	14.920
7250.	10.825	6.169	-	15.482
7500.	11.199	6.344	-	16.053
7750.	11.572	6.512	-	16.632
8000.	11.945	6.673	-	17.217
8250.	12.318	6.828	-	17.809
8500.	12.692	6.978	-	18.406
8750.	13.065	7.123	-	19.007
9000.	13.438	7.264	-	19.613
9250.	13.812	7.401	-	20.223

1. Sum of pphm-hrs $>$10 pphm between 1 April to 30 October for a given year.

Table 7. Summary of results from the regression correlations with the average leaf to total weight of yield ratios for Moapa 69 alfalfa from field plots, ozone dosage, average seasonal maximum temperature, average seasonal minimum temperature, and average daily relative humidity for a season.

Linear Correlations	Correlation Coefficients
avg lvs/wt ratio vs dose	.767*
avg lvs/wt ratio vs T max	.373
avg lvs/wt ratio vs T min	.089
avg lvs/wt ratio vs RH	.610

Regression Matrix	T-values of Regression Coefficient				f-values
	dose	character	character	character	
avg ratio vs dose & T max					4.521
avg ratio vs dose & T min					4.406
avg ratio vs dose & RH					3.693
avg ratio vs T max & T min					0.683
avg ratio vs T max & RH					1.545
avg ratio vs T min & RH					1.549
avg ratio vs dose & T max & T min					3.012
avg ratio vs dose & T max & RH					2.014
avg ratio vs dose & T min & RH					2.626
avg ratio vs T max & T min & RH					0.877
avg ratio vs dose & T max & T Min & RH					1.495

* Denotes significance at the .05 level.

Table 9. Ozone dosage-alfalfa (Moapa 69 leaf reduction conversion function.

Ozone Dose[1]	Predicted % Reduction	Range of % Reduction at 95% Confidence		
0.	0.000	0.0	-	5.914
250.	0.373	0.0	-	6.059
500.	0.746	0.0	-	6.210
750.	1.120	0.0	-	6.365
1000.	1.493	0.0	-	6.527
1250.	1.866	0.0	-	6.696
1500.	2.240	0.0	-	6.873
1750.	2.613	0.0	-	7.058
2000.	2.986	0.0	-	7.253
2250.	3.360	0.0	-	7.460
2500.	3.733	0.0	-	7.679
2750.	4.106	0.299	-	7.913
3000.	4.479	0.796	-	8.163
3250.	4.853	1.275	-	8.430
3500.	5.226	1.735	-	8.716
3750.	5.599	2.175	-	9.023
4000.	5.973	2.593	-	9.352
4250.	6.346	2.988	-	9.704
4500.	6.719	3.360	-	10.079
4750.	7.092	3.708	-	10.476
5000.	7.466	4.034	-	10.897
5250.	7.839	4.339	-	11.339
5500.	8.212	4.623	-	11.802
5750.	8.586	4.888	-	12.283
6000.	8.959	5.135	-	12.782
6250.	9.332	5.367	-	13.297
6500.	9.705	5.585	-	13.826
6750.	10.079	5.790	-	14.367
7000.	10.452	5.984	-	14.920
7250.	10.825	6.169	-	15.482
7500.	11.199	6.344	-	16.053
7750.	11.572	6.512	-	16.632
8000.	11.945	6.673	-	17.217
8250.	12.318	6.828	-	17.809
8500.	12.692	6.978	-	18.406
8750.	13.065	7.123	-	19.007
9000.	13.438	7.264	-	19.613
9250.	13.812	7.401	-	20.223

1. Sum of pphm-hrs > 10 pphm between 1 April to 30 October for a given year.