ANALYSIS of HAWAII GREENHOUSE TOMATO DATA

Hawaii Agricultural Reporting Service

Hawaii Department of Agriculture
U.S. Department of Agriculture

ANALYSIS OF HAWAII GREENHOUSE TOMATO DATA

Prepared By:

Fred B. Warren, Senior Math Statistician
United States Department of Agriculture
Statistical Reporting Service, U. S. D. A.
Statistical Research Division
Yield Research Branch

for

Hawaii Agricultural Reporting Service
A cooperative function of

Hawaii
Department of Agriculture
Marketing & Consumer Services Division

United States
Department of Agriculture
Statistical Reporting Service

ANALYSIS OF HAWAII GREENHOUSE TOMATO DATA. By Fred B. Warren, Statistical Research Division, Economics and Statistics Service, U. S. Department of Agriculture, June 1981.

ABSTRACT

One hundred seventeen weeks of temperature and greenhouse tomato condition data were evaluated to identify factors which might be related to weekly sales and fruit set. Prototype models were developed from the given data both to determine the types of variables which would be most useful and to determine the possible gains in precision which might be obtained. The principal findings of this evaluation are that: data of the type evaluated can be used to develop reasonable forecast and estimation models for numbers of fruit set, for the amount of saleable fruit, and for the average weight per fruit, and that the numbers of fruit set and average weight of fruit at maturity responded differently to different levels of maximum and minimum temperatures at different stages of development.

Key words: Yield modeling, linear regression, tomatoes, temperature.

TABLE OF CONTENTS

ANALYSIS OF HAWAII GREENHOUSE TOMATO DATA

INTRODUCTION

The data used in this analysis was compiled by a commercial greenhouse tomato grower in Hawaii. It was then passed to the Hawaii State Statistical Office (ESS-Statistics) for analysis, particularly to define those factors which related specifically to production. This task, and the data, was then referred to the Yield Research Branch, Statistical Research Division.

Difficulties with the data included the following: (1) Estimates of the number of fruit set and of sales were recorded by weeks for the entire operation, even though the actual area in production varied widely over the 117 week period; (2) Estimates of the numbers of fruit set were obtained by counts on `representative' plants, rather than a random sample of plants; (3) Temperatures generally were recorded only on weekdays; and (4) while the reported conditions were computed by some formula which included the effects of sunlight, wind, temperature and humidity, the actual weights used were not recorded.

ANALYSIS

The analysis was directed both towards determining the possibility of using the observed temperature and "condition" data to predict the components of production, i.e., the number of fruit set and the average weight per fruit at harvest, and towards direct predictions of the pounds of saleable fruit.(1)

---

(1) "Condition" was reported daily, on a scale of 1 to 10. Factors considered in determining daily condition values were (1) the amount and duration of sunlight, (2) the presence and duration of wind, and (3) temperature "duration" and humidity. These factors were not given specific weights.

Assumptions required by this analysis are that:

1. The "representative plant" procedure used for obtaining the numbers of fruit set did produce estimates of the actual numbers which, if not unbiased, at least had a constant bias throughout the entire period.
2. The number of fruit sold as a proportion of fruit set was constant throughout the entire period.
3. The amount of time required for the fruit to mature was constant throughout the entire period.
4. All plantings were of the same size and stayed in production for the same amount of time.
5. The reported condition figures were based upon some unchanging objective criteria.
6. The reported temperatures were uniform for all greenhouses in the complex.

Because the reported numbers of fruit set are estimates derived from counts on "representative" plants, any correlation or regression analyses involving the number of fruit set will not be as good as if the actual counts, even for small units, could have been compared with saleable produce from the same units.

Initial Analysis

The initial analysis of the data was limited to:

(a) Plotting weekly totals of fruit set, and of the pounds of fruit sold, over time.

(b) Correlating daily reports of condition, and of maximum and minimum temperatures over time.

Weekly Plots of Fruit Set and Sales

Because the actual number of plantings in production at any time was not given, plots of the weekly fruit set and sales data were used to determine the period of time during which the number of plantings, as indicated by the data for fruit set and sales, would be comparatively stable. As shown in Figure 1, there was a rapid increase in the number of fruit set each week from week 1 until about week 24. This resulted from a rapid increase in total plantings during this period. Then, aside from irregularities in fruit set and sales which may be related to the weather, the number of plantings in production appeared to be somewhat constant from week 25 through 109. However the number of fruit set was not reported after week 109. Also, sales during weeks 110-117 were considerably below the period just preceding. These events were taken to indicate that there was a drastic reduction in the number of plantings in production during weeks 110-117. Therefore, the analysis to relate the observed values of condition and of temperature to the number of fruit set was limited to the data for weeks 25 through 109. Also, since there appears to be about an 8 to 10 week lag between fruit set and sales, the analysis to relate condition and temperature data to actual sales was limited to weeks 34 through 109.

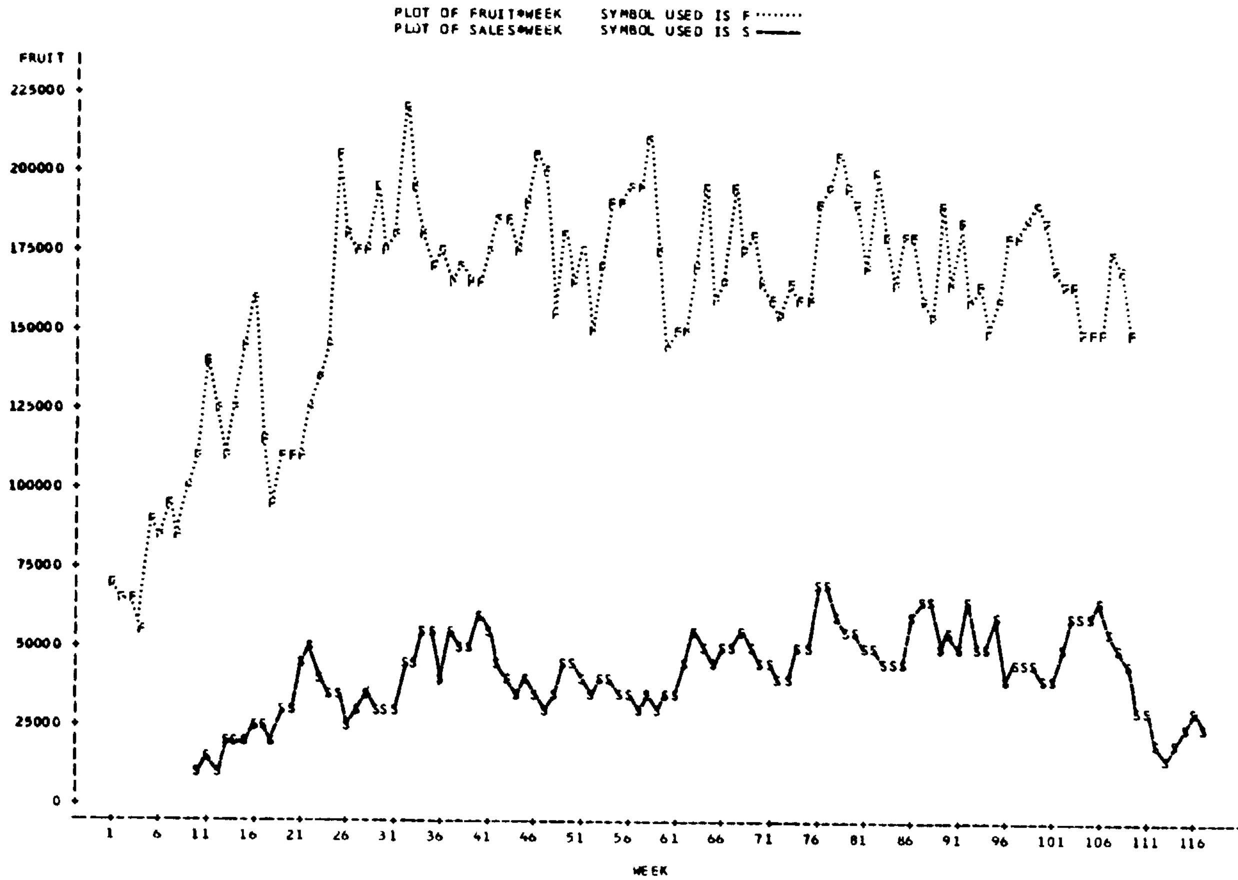

Figure 1: Numbers of fruit set and pounds of tomatoes sold, by weeks.

Daily Condition and Temperature Data:

Daily maximum and minimum temperatures were grouped by and correlated with condition codes. This was to determine how well they were related (See Table 1). Both daily and weekly average data were also plotted and regressed over time to determine if there appeared to be any long term factors in the data. (The effects of any seasonal cycles in the data would appear to be minimal, since the first and last 14 weeks of the study period overlap the months of November through February.)

The principal findings from this stage of the analysis were the highly significant downward trends over time for (1) reported daily conditions, (2) daily ranges in temperatures, and (3) reported maximum daily temperatures. There was also a very high positive correlation between the daily reports of condition and the maximum daily temperatures. That is, high daily maximum temperatures tended to be associated with high condition values.

Table 1: Coefficients of correlation (r) between reported daily condition codes, daily maximum and minimum temperatures and time, and probabilities (p) that the computed values of r are not significantly different from zero, Hawaii Greenhouse Tomato data, 11-7-76 to 2-3-79. (n=569)

				Temperature		
Variable		Time	Condition	Maximum	Minimum	Max-Min
Time	r	1.000	-0.296	-0.112	0.156	-0.174
	p(r=0)	0.000	<0.001	0.007	<0.001	<0.001
Condition	r	-0.296	1.000	0.638	-0.249	0.638
	p(r=0)	<0.001	0.000	<0.001	<0.001	<0.001
Maximum temperature	r	-0.112	0.638	1.000	-0.092	0.638
	p(r=0)	0.007	<0.001	0.000	0.028	<0.001
Minimum temperature	r	0.156	-0.249	-0.092	1.000	-0.621
	p(r=0)	<0.001	<0.001	0.028	0.000	<0.001

Although still highly significant, the correlation between the reported daily conditions and the minimum daily temperatures was smaller than for condition versus maximum temperature. Also the correlation of condition with minimum temperatures was negative rather than positive. This implies that low minimum temperatures tended to result in high condition values. The negative correlation between minimum temperatures, and both the maximum and daily range of temperature may be associated with periods of clear skies. Clear skies would be associated with a greater degree of nighttime cooling and more sunlight during the day--hence higher maximum temperatures and higher daily condition values.

Normalized weekly average condition and temperature values were plotted over weeks. These plots (Figures 2a and 2b) indicate that (1) there was no significant seasonal pattern in the fluctuations of the daily maximum temperatures, 2) the weekly average condition values did follow the pattern established by the weekly average high temperatures, but (3) that there was a significant seasonal pattern in the daily minimum temperatures. Means, standard deviations, and maximum and minimum values of the reported daily values are in Table 2.

Table 2: Simple statistics for daily reports of condition and of maximum and of minimum temperatures, and for weekly values of numbers of fruit set, of total sales, and of derived average weights per fruit, Hawaii greenhouse tomato data, 11-7-76 to 2-3-79.

Variables	Mean	Standard Error	C.V. (%)	Minimum	Maximum
Condition	5.277	2.07	25.9	1	9
Temperature:*					
High	29.44	3.52	11.9	16	41
Low	12.95	2.45	19.0	4	19
Range	16.49	4.48	27.3	4	31
Fruit set per week, (000) weeks 24 to 101	176.9	15.67	8.9	146.58	220.54
Sales per week, (000) weeks 34-109	47.81	9.77	20.4	29.18	69.31
Average weight per fruit sold** weeks 34-109	0.271	0.056	20.6	0.163	0.392

* Degrees Celsius
** Weight per fruit computed as pounds sold that week divided by the average number of fruit set 8 and 9 weeks earlier.

Number of Fruit Set:

This portion of the analysis was limited to the data from weeks 25 through 109. This was because the first 24 weeks apparently represent a period of buildup in production, and there were no observations for numbers of fruit set during the last 8 weeks. Factors considered in attempting to model the number of fruit set each week were the average and extreme temperatures, and the condition values both for that week and for the previous week.

The first portion of this analysis was to determine if the same trends observed over the entire period for reported daily condition and temperatures also held for the abbreviated subset of weekly averages. After adjusting the regression coefficients for differences in the numbers of observations, the data in Table 3 indicates that there were essentially no differences between the two sets of trends.

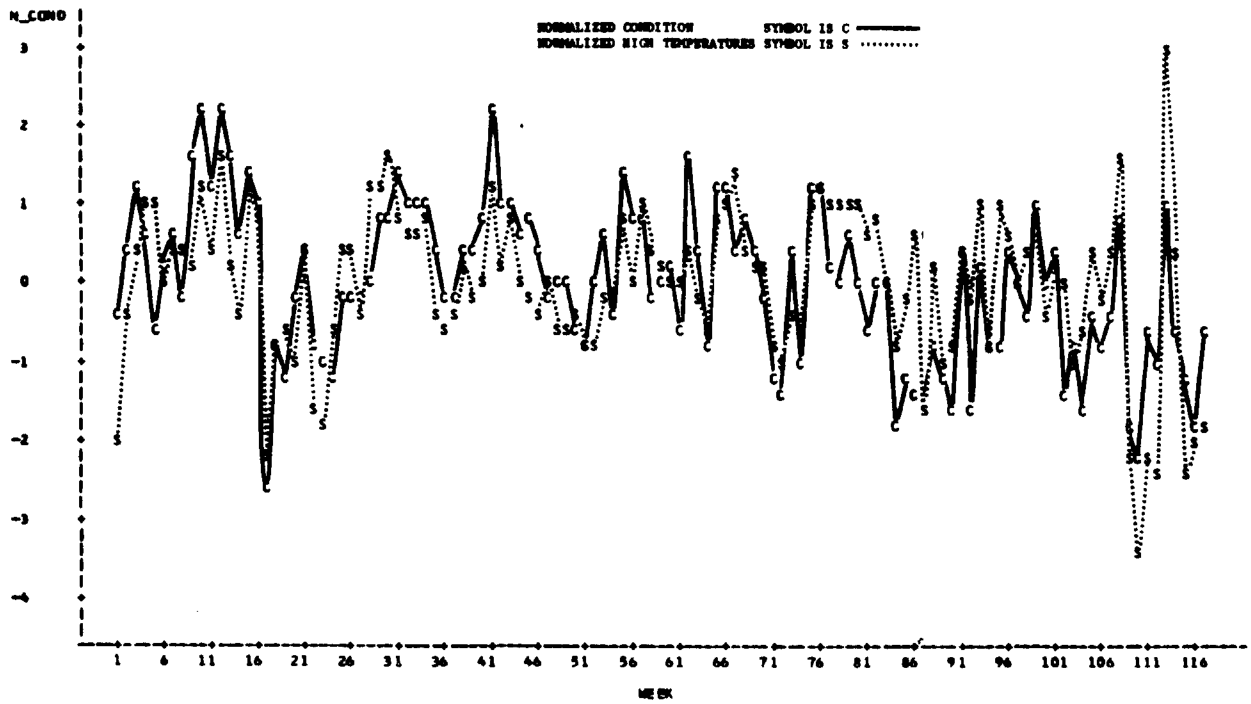

Figure 2A: Normalized weekly average conditions and maximum temperatures, by weeks.

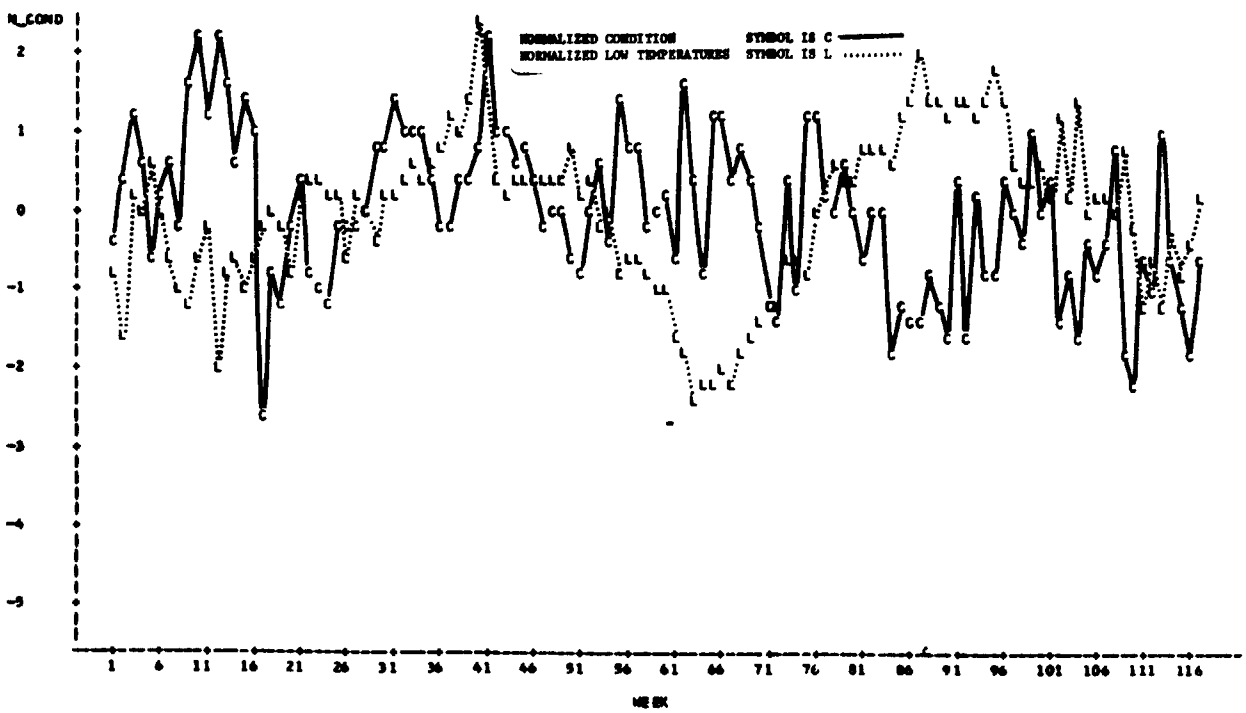

Figure 2B: Normalized average reported conditions and minimum temperatures, by weeks.

Table 3: Coefficients of correlation (r), probabilities of nonsignificance (p), and regression coefficients for daily condition and temperature observations over time for 117 weeks vs. weekly averages for only weeks 25 through 109, Hawaii Greenhouse Tomato data, 11-7-76 to 2-3-79.

Variables		Type of Observation: Daily (117 weeks)	Weekly Averages (weeks 25-109)
Observations		569	85
Condition	r	-0.296	-0.471
	p	<0.001	<0.001
	b	-0.003	-0.025
Maximum temperature	r	-0.112	-0.131
	p	0.007	0.235
	b	-0.0016	-0.0090
Minimum temperature	r	0.156	0.153
	p	<0.001	0.161
	b	0.0016	0.015

Given that there were no differences in the trends for either condition or for weather, the next step in the analysis was to use a stepwise 'max r-sq' regression procedure to identify the variables which would be most useful in modeling the number of fruit to be set in any particular week. Variables evaluated in this analysis included both the linear and quadratic effects of maximum, minimum and average high and low daily temperatures and condition reports for both the current and for the preceding week as well as the number of fruit set the previous week. For the range of temperature values observed, the best model (best in terms of having the smallest residual mean square error) for this purpose would contain the variables listed in Table 4. This model has a coefficient of correlation (r) of 0.64 and the standard deviation of the residuals is 12,538. Given the overall weekly average number of fruit set of 175,838, this implies that about two out of every three predictions from this model would have been within 7.2 percent of the actual number. With respect to the overall mean, this model would have a relative precision of about 0.65.(2)

---

(2) The relative precision of one model with respect to another

Table 4: Variables for estimating weekly numbers of fruit set, with regression coefficients and F-values, Hawaii greenhouse tomato data, weeks 25 through 109.

Variable	b	F(b=0)
Intercept	-144909.3	
Average condition last week		
--squared	340.11	10.45
Highest minimum daily temperature (Celsius) observed this week	1503.23	7.63
Highest maximum daily temperature (Celsius) observed this week	1275.30	2.85
Number of fruit set last week		
-- linear	2.256	1.85
-- squared	- 0.000005	1.34

The functional relationships represented by this group of variables could be defined as follows. First, there is a very strong positive and non-linear relationship between growing conditions the previous week and the number of fruit set during the current week. Second, and within the range of temperature values observed, there is a strong positive and linear relationship between high minimum temperatures and the number of fruit set during a particular week. Also, the regression procedure rejected weekly average minimum temperatures in favor of the highest daily minimum temperature. High maximum daily temperatures are also desirable but not as much as high daily minimum temperatures. Finally, there is an overall positive non-linear relationship between the number of fruit set during the previous week and the number of fruit set during the current week.

Sales

The second stage of the analysis was to cumulate weekly averages of indicated conditions and of maximum and minimum temperatures. These were lagged over both weekly and three week intervals. The lagged three-week cumulations were also squared. Therefore, the augmented set of observations for a particular week included the sales for that week, the linear effects of the weekly temperature and condition values, and both the linear and quadratic effects of the cumulated three-week values. The

---

is expressed as the ratio of the variances of the errors of the two models. In this case, the variance of the differences between the reported numbers of tomatoes set and the number estimated by the model would be divided by the variance of the weekly deviations from the overall mean.

augmented data set also included the average weekly number of fruit set 8, 9, and 10 weeks previously. In order to eliminate the variability which resulted from both the initial startup and the tail off in production during the final 8 weeks, this analysis was limited to the sales from weeks 34 through 109.

Principal findings from this phase of the analysis include:

1. The variables most highly correlated with the sales during a particular week were the average high temperature during the tenth week before harvest (r= 0.444), the average condition 4 to 6 weeks before harvest (r= -0.384), the range of average daily temperatures during the tenth week before harvest (r= 0.382), the week itself (r= 0.378), and the square of the average condition during the fourth to sixth weeks before harvest (r= -0.377).(3) With 76 observations, all of these correlations are statistically different from zero at the .001 level of probability. However the coefficient of correlation for the linear component of the average condition 4 to 6 weeks before harvest is only slightly larger than the coefficient for the quadratic component. This indicates that the quadratic component really is not important.

2. Although the individual correlations are highly significant, statistically, individually they are not large enough to support a forecast model. Therefore the analysis was taken into a stepwise "Max-R-sq" multiple regression to sort out the variables which would interact to form the most efficient model. (The best model is defined here as being the one for which the sum of squares of the differences from the regression surface is least.)

The best multiple regression (Table 5) had a R-sq of 0.73 and a standard deviation of the differences between actual and predicted weekly sales of about 5,540 pounds. This computes to a relative standard error (CV) of about 11.6 percent. This error is only about one-half as large as the 20.4 percent CV computed for the weekly deviations of weekly sales from their own mean. The relative precision of the model with respect to the overall mean was 0.32.

An apparent weakness of this model lies in the small contribution to the estimated sales which comes from the number of fruit set. This may only indicate that the tomato plant tends to compensate for small fruit sets with larger tomatoes.

---

(3) The rationale for the negative correlation between weekly sales and the average 'condition' 4 to 6 weeks earlier could be that, since there was a high positive correlation between the daily condition reports and the maximum daily temperatures, the negative correlation would indicate that tomatoes at that stage of maturity develop better with relatively lower temperatures.

Table 5: Variables for estimating weekly sales of tomatoes, with regression coefficients and F-tests of their significance, Hawaii tomato greenhouse data, weeks 34 through 109.

Variable	b	F(b=0)
Intercept	-1878077.224	
Number of fruit set eight weeks before harvest	0.0589	1.26
Sum of average weekly conditions for - 7 to 9 weeks before harvest	-1653.529	16.12
Sum of weekly average maximum temperatures for -		
1 to 3 weeks before harvest	1910.637	23.11
4 to 6 weeks before harvest	-1285.699	12.22
7 to 9 weeks before harvest	41103.464	19.79
Squares of sums of --		
weekly average conditions for -		
1 to 3 weeks before harvest	-41.388	9.44
4 to 6 weeks before harvest	33.300	4.97
weekly high average temperatures for-		
7 to 9 weeks before harvest	-220.625	16.69
weekly low average temperature for -		
1 to 3 weeks before harvest	9.129	21.90
7 to 9 weeks before harvest	-12.641	13.43
Weekly average high temperature for the		
eighth week before harvest	1033.110	2.65
tenth week before harvest	1323.894	6.85
Weekly average low temperature for the tenth week before harvest	839.901	1.70

It should be noted that the most important variables in the multiple regression equation, as defined by the "F"-values, are not the same variables which had the highest linear correlation. Also, one variable could be said to appear three times in that the weekly average high temperature for the eighth week is also included in the linear and quadratic effects for the sum of average maximum temperatures of weeks 7 to 9 before harvest.

The model coefficients (b's) listed in Table 5 indicate that maximum production would result from the following combination of factors.

1. A maximum number of fruit were set. Within the range of temperatures reported, both maximum and minimum temperatures

during the eighth and tenth weeks before harvest should be high.

2. For the first three week period (7 to 9 weeks before harvest), maximum daily temperatures should be high but minimum daily temperatures and the observed conditions should be low.

3. For the second three week period (4 to 6 weeks before harvest), the daily maximum temperatures should be low but the observed conditions should be high.

4. For the final three week period (1 to 3 weeks before harvest), daily maximum and minimum temperatures again should be high and the observed conditions should be low.(4)

Because the above model requires condition and temperature data up to the week of harvest, it can be used only to estimate production for the current week. However, marketing specialists, etc., could reasonably want to predict production in advance of actual harvest. Therefore a similar analysis which excluded all data not available within three weeks of harvest was conducted. This was both to illustrate what might be done and to point out the loss of precision which should be expected when using a less than full season model. The variables and regression coefficients for such a model are listed in Table 6. As expected, the R-sq for this model is smaller (0.61 vs. 0.73) and the standard deviation of the errors is larger (6510 vs. 5541). However, it may be of sufficient accuracy for some purposes.

Weight per Fruit

Since no actual weights per fruit sold were included with the data, weekly average weights per fruit sold were computed from the reported weekly sales for weeks 11 through 117 and from the reported numbers of fruit set 8, 9, and 10 weeks earlier. Factors considered in attempting to model the average weight of fruit at harvest included the lagged three-week cumulations of condition and of temperature plus the reported numbers of fruit set 8, 9, and 10 weeks before harvest.

A stepwise 'max r-sq' regression analysis of the above data showed that the highest correlations were obtained when the dependent variable was weekly sales divided by the reported number of fruit set 8 weeks earlier. The best model (again, best from the standpoint of having the smallest residual mean square) used thirteen variables and resulted in a R-sq of 0.77. The standard deviation of the residuals was 0.031 pounds. Variables and regression coefficients for the 'best' model are listed in Table 7.

---

(4) Considering the overall high positive correlation between maximum daily temperatures and condition, the indication that temperatures should be high but that condition should be low hints at some type of complex interaction.

Table 6: Variables for predicting weekly sales of tomatoes three weeks before harvest, with regression coefficients and F values, Hawaii tomato greenhouse data, weeks 34 through 109.

Variable	b	F(b=0)
Intercept	-2050694.760	
Number of fruit set eight weeks before harvest	-0.0639	1.32
Weekly average high temperature for the tenth week before harvest	2071.507	15.51
Weekly average low temperature for the eighth week before harvest	-3268.936	26.07
Sum of average weekly conditions for 7 to 9 weeks before harvest	-7691.265	10.38
Sum of weekly average maximum temperatures for 7 to 9 weeks before harvest	44751.807	17.47
Sum of weekly average minimum temperatures for 4 to 6 weeks before harvest	4365.578	11.67
Squares of sums of --		
weekly average conditions for 7 to 9 weeks before harvest	168.865	5.29
weekly high average temperatures for 7 to 9 weeks before harvest	-240.503	16.54
weekly low average temperature for 4 to 6 weeks before harvest	-48.768	8.82

The model coefficients (b's) listed in Table 7 would imply that the largest (heaviest) tomatoes would result from the following combination of factors.

1. The number of fruit set 8 weeks earlier is relatively small. In fact, the fewer fruit set, the larger they will be.

2. Within the range of temperatures reported, high temperatures, both minimum and maximum, from 8 to 10 weeks before harvest are desirable.(5)

3. For the first 3 weeks after fruit set (7 to 9 weeks before harvest), high daytime temperatures and low nighttime temperatures are desirable. The response to higher daytime

---

(5) Interestingly, the data presented in Table 5 indicates that higher temperatures during this period are conducive to larger numbers of fruit being set. This would appear to be at variance with 1.

Table 7: Variables for predicting average weight of tomatoes (pounds per fruit) at harvest, with regression coefficients and F-tests of their significance, Hawaii tomato greenhouse data, weeks 34 through 109.

Variable	b	F(b=0)
Intercept	-10.47702	
Number of fruit set eight weeks earlier	-0.00000099	11.35
Sum of average weekly conditions for - 7 to 9 weeks before harvest	-0.009385	16.50
Sum of weekly average high temperatures for -		
1 to 3 weeks before harvest	0.011880	29.03
4 to 6 weeks before harvest	-0.007391	12.73
7 to 9 weeks before harvest	0.222322	18.17
Sum of weekly average low temperatures for -		
7 to 9 weeks before harvest	-0.005900	14.69
Squares of -		
sums of weekly average conditions for		
1 to 3 weeks before harvest	-0.000238	9.85
4 to 6 weeks before harvest	0.000189	5.05
sums of weekly average high temperatures		
7 to 9 weeks before harvest	-0.001192	17.13
sums of weekly average low temperatures		
1 to 3 weeks before harvest	0.000053	22.44
Weekly average high temperatures -		
8 weeks before harvest	0.005822	2.65
10 weeks before harvest	0.008181	8.29
Weekly average low temperatures -		
10 weeks before harvest	0.006056	2.42

temperatures is non-linear, tapering off as temperatures increase.

4. For the second three week period (4 to 6 weeks before harvest), desirable factors are low daytime temperatures and high condition values.(6)

(6) Considering the high positive correlation between reported condition figures and the daily maximum temperatures (Table 3), this particular combination appears odd.

5. For the final three week period (1 to 3 weeks before harvest), desirable factors are a combination of high maximum and minimum temperatures with low condition values.

While the above analysis did include both the linear and quadratic effects of the observed and derived variables, there was no attempt to examine the possible "threshold" effects of extreme daily and/or weekly temperature values.(7) (The data does not suggest that any "threshold" temperatures were observed.)

The variables listed in Table 7 are virtually the same ones which appear in Table 5. Also the relative importance, as measured by the computed "F" statistics, of the seven highest ranking variables in each model is identical. Therefore, considering that the the multiple R-sq's of the two models are very close (0.77 for weight per fruit vs. 0.73 for total sales), there would seem to be little advantage in computing probable sales as the product of separate estimates of the number of fruit set and the average weight per fruit.

---

(7) "Threshold is defined here as being a level at which the plant's response to its environment becomes asymptotic. For example, the temperature may become too high or too low for any blooms to develop.

APPENDIX

DATA

The data set obtained from the Hawaii State Statistical Office contained the following information for 117 consecutive weeks of greenhouse operation.

1. Month, day and year for the FRIDAY of the calendar week in which the observations were taken. The dates given range from 11-7-76 to 2-3-79.
2. The total number of fruit set that week.(8)
3. The number of pounds of tomatoes sold that week.
4. Daily(9) observations of maximum and minimum temperatures plus appraisals (on a scale of 1 to 10) of growing conditions(10) in the greenhouses. Daily observations were recorded Monday through Saturday.

Plantings reportedly were made at two week intervals. It is not known how long a particular planting stayed in production or how many plantings were made. The data also did not indicate if all the plantings were the same size.

The basic data, as received from the Hawaii State Statistical Office, is resident on the USDA Washington Computer Center (WCC) as an OS file, DSN=RAD14.TOMATO.DATA. There is also a three member SAS dataset (edited) on WCC, DSN=RAD14.SASD.TOMATO.DATA. The member names are "TOMATO" , "FRUIT" and "LAGS". "TOMATO" contains the basic data but with the following editing changes:(11)

---

(8) 'Numbers of fruit set' were extrapolated from counts of 'pea-size' fruit on ten 'representative' plants in each greenhouse.

(9) No observations were taken on Sunday, any time the week of 12-23-77, most Saturdays, nor most holidays.

(10) Factors considered in determining the daily condition values included (1) the amount and duration of sunlight, (2) the presence and duration of wind, and (3) temperature 'duration' and humidity. These factors were not given specific weights.

1. All "0" values were converted to "missing".

2. A reported minimum temperature of 82 degree F. for Wednesday of the week of 9-1-78 was changed to 62 degrees.

3. All temperatures were converted from degrees Fahrenheit to degrees Celsius.(12)

4. Weekly averages of nonmissing condition values and of maximum and minimum temperatures, as well as counts of the number of nonmissing values in each weekly average.

"FRUIT" contains the following data for weeks 26 through 109:

1. Number of fruit set.

2. Average weekly condition and average maximum and minimum temperatures.

3. Extreme condition and temperature values for the week.

4. All of the above for the previous week.

"LAGS" contains the following data for weeks 34 through 109 of the observation period:

1. Weekly sales, in pounds of tomatoes.

2. The number of fruit set 8, 9, and 10 weeks earlier.

3. Three week cumulations of weekly average conditions, average maximum temperatures, average minimum temperatures, and of the weekly differences between average maximum and minimum temperatures. The periods of cumulations were:

   (a) The first three weeks before harvest,

   (b) The three week period before that, and

   (c) the three week period before the second period (i.e. 7-9 weeks before harvest).

4. "Average weights of fruit sold" computed by dividing the sales for the week by the numbers of fruit set 8, 9, and 10 weeks earlier.

5. Averages of the minimum and maximum daily temperatures for the current week and for each of the nine preceding weeks.

---

(11) See Table 1, Appendix for a complete listing of the edited data.

(12) Aside from the above, all values were accepted as received.

APPENDIX TABLE 1: HAWAII GREENHOUSE TOMATO DATA

WEEK ENDING (FRIDAY) MO-DA-YR	MONDAY C UND	MONDAY TEMP MIN	MONDAY TEMP MAX	TUESDAY C UND	TUESDAY TEMP MIN	TUESDAY TEMP MAX	WEDNESDAY C UND	WEDNESDAY TEMP MIN	WEDNESDAY TEMP MAX	THURSDAY C UND	THURSDAY TEMP MIN	THURSDAY TEMP MAX	FRIDAY C UND	FRIDAY TEMP MIN	FRIDAY TEMP MAX	SATURDAY C UND	SATURDAY TEMP MIN	SATURDAY TEMP MAX	WEEKLY C UND	WEEKLY TEMP MIN	WEEKLY TEMP MAX	WEEKLY NUMBER FRUIT SET
11- 7-7	4	10	22	4	11	22	3	10	23	6	12	28	6	12	30	.	.	.	4.6	11.0	24.9	71,220
11-15-7	7	10	29	4	9	27	3	10	27	9	9	29	6	10	30	.	.	.	5.8	9.7	28.2	64,240
11-22-7	6	12	28	7	15	32	9	14	30	.	.	.	6	13	32	.	.	.	7.0	13.6	30.6	62,920
11-29-7	7	12	32	6	13	33	6	13	29	6	13	32	6	13	32	.	.	.	6.2	12.8	31.6	57,020
12-10-7	4	10	33	4	15	30	6	15	31	4	16	33	4	16	33	.	.	.	4.4	14.3	32.2	92,440
12-17-7	4	12	32	7	14	32	9	12	31	4	13	29	4	14	24	.	.	.	5.6	13.3	29.8	82,940
12-23-7	5	10	32	5	14	27	9	11	30	6	12	33	.	.	.	.	.	.	6.3	11.9	30.6	95,020
12-31-7	5	10	31	4	11	31	5	12	30	6	10	30	.	.	.	.	.	.	5.0	10.8	30.6	87,080
1- 7-7	8	10	32	6	.	.	9	12	29	7	10	27	8	9	32	.	.	.	7.6	10.3	30.0	99,800
1-14-7	8	13	32	8	12	31	9	12	32	9	11	32	9	10	34	.	.	.	8.6	11.6	32.4	108,160
1-21-7	9	11	34	8	14	32	7	13	34	6	14	27	6	10	24	.	.	.	7.2	12.7	30.2	138,300
1-28-7	9	4	34	9	9	32	9	8	33	9	11	34	7	10	33	.	.	.	8.6	8.4	33.6	123,320
2- 4-7	9	12	30	9	11	32	9	10	32	5	14	32	7	9	24	.	.	.	7.8	11.4	30.1	108,500
2-11-7	5	10	29	6	12	30	7	13	30	6	12	27	7	12	27	.	.	.	6.2	12.0	28.4	125,080
2-18-7	6	10	32	6	12	30	8	12	31	8	11	34	9	9	34	.	.	.	7.4	10.9	32.3	144,800
2-25-7	8	7	37	7	14	32	8	11	29	6	12	29	5	14	30	.	.	.	6.8	11.7	31.4	160,300
3- 4-7	2	13	27	2	13	27	1	12	24	1	13	22	2	12	23	.	.	.	1.6	12.8	24.6	113,680
3-11-7	2	12	29	4	13	26	5	13	29	5	12	29	4	14	25	.	.	.	4.0	12.8	27.8	96,300
3-18-7	1	13	27	4	13	28	4	12	26	4	12	30	4	12	30	.	.	.	3.4	12.1	28.0	107,740
3-25-7	5	11	29	4	10	23	4	11	26	4	12	27	8	11	32	.	.	.	5.0	11.1	27.4	112,440
4- 1-7	7	10	36	5	14	32	5	15	24	6	14	27	.	.	.	.	.	.	5.8	13.3	30.3	109,840
4- 8-7	7	12	34	4	16	26	3	14	22	3	14	24	3	14	24	.	.	.	4.0	14.1	26.0	122,840
4-15-7	3	14	27	3	14	23	5	14	26	4	14	25	4	14	26	.	.	.	3.8	14.2	25.3	136,700
4-22-7	3	.	.	5	12	32	3	15	31	3	14	27	3	13	22	.	.	.	3.4	13.6	28.1	144,460
4-29-7	7	11	32	7	11	34	5	18	31	3	13	29	3	14	27	.	.	.	5.0	13.6	30.7	205,120
5- 6-7	3	12	26	8	10	27	6	14	37	5	14	31	3	8	32	.	.	.	5.0	11.7	30.4	181,480
5-13-7	7	12	34	3	13	27	2	14	21	6	12	31	7	16	29	.	.	.	5.0	13.4	28.7	175,600
5-20-7	7	12	35	7	.	.	4	13	36	5	13	30	4	14	28	.	.	.	5.4	13.2	32.1	173,600
5-27-7	6	.	.	7	13	32	7	13	31	7	11	34	6	11	33	.	.	.	6.6	12.2	32.8	196,600
6- 3-7	7	.	.	7	12	34	7	14	34	5	14	33	7	13	32	.	.	.	6.6	13.5	33.6	176,140
6-10-7	7	14	32	7	14	33	7	12	33	8	14	32	8	13	27	.	.	.	7.4	13.8	31.6	181,880

APPENDIX TABLE 1: HAWAII GREENHOUSE TOMATO DATA

WEEK ENDING (FRIDAY)	MONDAY			TUESDAY			WEDNESDAY			THURSDAY			FRIDAY			SATURDAY			WEEKLY			WEEKLY NUMBER
		TEMP			TEMP			TEMP			TEMP			TEMP			TEMP			TEMP		
MO-DA-YR	CLOUD	MIN	MAX	CLOUD	MIN	MAX	CLOUD	MIN	MAX	CLOUD	MIN	MAX	CLOUD	MIN	MAX	CLOUD	MIN	MAX	CLOUD	MIN	MAX	FRUIT SET
6-17-7	7	13	30	7	14	31	7	13	31	7	13	32	6	15	30	.	.	.	6.8	13.7	30.8	220,540
6-24-7	7	14	31	6	14	31	8	14	31	7	15	31	6	14	30	.	.	.	6.8	14.4	30.8	193,280
7- 1-7	7	14	31	6	13	31	7	14	31	7	14	31	7	14	32	.	.	.	6.8	14.1	30.9	178,240
7- 8-7	.	.	.	5	14	30	7	15	28	5	14	29	6	14	27	.	.	.	5.8	14.6	28.6	169,780
7-15-7	4	.	.	4	15	29	4	14	26	4	16	28	9	14	26	.	.	.	5.0	14.9	28.1	175,720
7-22-7	4	17	29	5	14	29	6	16	29	5	14	27	5	16	28	.	.	.	5.0	15.3	28.2	166,040
7-29-7	7	16	32	7	15	29	6	14	31	6	16	32	4	14	26	.	.	.	6.0	15.1	30.0	170,900
8- 5-7	6	16	28	5	14	27	5	16	28	7	17	31	7	17	31	.	.	.	6.0	15.8	28.9	164,940
8-12-7	6	17	30	9	18	32	6	19	31	6	18	30	3	18	24	.	.	.	6.4	17.8	29.6	167,120
8-19-7	9	17	28	9	17	33	8	19	32	8	16	34	9	17	32	.	.	.	8.6	16.9	32.3	176,700
8-26-7	6	14	32	6	14	26	7	14	28	9	14	33	6	14	28	.	.	.	6.8	14.2	29.7	186,680
9- 2-7	7	13	31	7	13	31	6	14	31	7	13	32	7	14	31	.	.	.	6.8	13.6	31.0	184,880
9- 9-7	6	14	31	6	14	30	5	14	28	8	13	30	6	14	29	.	.	.	6.2	14.0	29.8	176,500
9-16-7	9	14	31	6	14	29	6	14	29	7	14	29	4	14	27	.	.	.	6.4	14.2	29.1	192,480
9-23-7	5	14	30	7	14	29	7	14	29	5	14	27	6	14	27	.	.	.	6.0	14.1	28.7	207,420
9-30-7	6	14	31	5	14	30	5	14	29	4	14	29	5	13	29	.	.	.	5.0	14.0	29.7	200,420
10- 7-7	5	13	29	5	14	28	7	14	28	5	14	26	5	14	27	.	.	.	5.4	14.0	28.1	156,480
10-14-7	6	14	29	5	14	29	5	14	28	6	14	28	5	14	27	.	.	.	5.4	14.1	28.3	178,760
10-21-7	3	15	30	4	15	26	5	14	28	6	15	29	4	15	26	.	.	.	4.4	14.9	28.4	164,760
10-28-7	4	13	29	5	13	26	2	14	26	7	14	29	2	13	26	.	.	.	4.0	13.7	27.6	175,340
11- 4-7	5	14	29	7	14	29	5	14	26	2	14	24	7	14	29	.	.	.	5.2	14.1	27.9	149,820
11-11-7	5	9	29	6	13	26	7	13	29	7	13	30	6	14	30	.	.	.	6.2	12.4	29.3	171,600
11-18-7	6	12	31	2	14	27	3	14	27	5	13	29	8	12	31	.	.	.	4.8	12.9	29.0	188,500
11-25-7	8	11	31	8	11	32	6	12	31	.	.	.	.	.	.	.	.	.	7.3	11.3	31.3	191,380
12- 2-7	6	11	32	7	11	30	8	12	32	7	11	31	4	13	23	.	.	.	6.4	11.7	29.7	193,940
12- 9-7	7	11	33	6	11	33	4	13	29	6	11	32	7	11	31	.	.	.	6.4	11.1	31.7	195,100
12-16-7	6	11	33	7	11	32	5	11	31	5	12	31	2	11	25	.	.	.	5.0	11.2	30.3	209,000
12-23-7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	172,940
12-30-7	.	6	32	6	12	26	4	12	27	5	13	29	7	8	31	.	.	.	5.5	10.3	29.3	146,580
1- 6-7	.	.	.	3	12	31	3	10	30	4	7	26	7	8	31	.	.	.	4.3	9.3	29.4	149,600
1-13-7	8	6	31	8	13	32	6	13	33	6	7	27	8	5	30	.	.	.	7.6	8.9	30.7	149,880

APPENDIX TABLE 1: HAWAII GREENHOUSE TOMATO DATA

WEEK ENDING (FRIDAY)	MONDAY	TEMP C		TUESDAY	TEMP C		WEDNESDAY	TEMP C		THURSDAY	TEMP C		FRIDAY	TEMP C		SATURDAY	TEMP C		WEEKLY	TEMP C		WEEKLY NUMBER FRUIT SET
MO-DA-YR	UND	MIN	MAX	UND	MIN	MAX	UND	MIN	MAX	UND	MIN	MAX	UND	MIN	MAX	UND	MIN	MAX	UND	MIN	MAX	
1-20-7	8	6	32	7	8	29	6	8	27	7	8	29	2	9	28	.	.	.	6.0	7.7	29.1	171,460
1-27-7	7	8	29	2	8	25	3	8	27	2	8	27	7	8	29	.	.	.	4.2	8.2	28.1	195,220
2- 3-7	7	8	31	7	9	29	7	8	32	8	8	33	7	8	32	.	.	.	7.2	8.4	31.3	160,420
2-10-7	8	8	33	8	8	33	6	9	33	7	9	33	7	8	27	.	.	.	7.2	8.6	31.8	164,660
2-17-7	4	8	33	5	6	32	6	8	32	7	6	33	6	6	33	.	.	.	6.0	8.3	32.6	197,040
2-24-7	7	10	32	7	9	32	7	9	32	3	9	24	8	8	33	.	.	.	6.4	9.2	30.8	174,250
3- 3-7	3	9	22	7	9	32	7	9	32	7	10	32	6	9	32	.	.	.	6.0	9.2	30.0	179,000
3-10-7	6	9	33	5	9	28	2	10	27	5	11	31	5	11	30	.	.	.	5.0	9.9	29.7	163,300
3-17-7	4	11	28	3	11	26	4	10	28	2	10	26	4	10	28	.	.	.	3.4	10.2	27.7	161,640
3-24-7	2	10	32	4	10	27	3	10	26	4	11	26	3	10	26	.	.	.	3.2	10.1	27.2	157,080
3-31-7	9	11	32	5	12	26	6	12	29	5	11	28	4	11	26	.	.	.	5.8	11.0	26.6	165,600
4- 7-7	5	11	32	5	12	28	5	12	28	2	12	26	2	12	26	.	.	.	3.8	11.8	27.9	161,260
4-14-7	7	10	32	8	11	32	8	11	32	8	11	32	5	12	31	.	.	.	7.2	11.0	31.9	162,480
4-21-7	6	11	32	7	13	32	8	14	33	6	13	33	7	13	32	.	.	.	7.2	13.0	32.4	190,160
4-28-7	3	12	32	5	14	31	7	14	32	6	14	32	7	14	32	.	.	.	5.6	13.7	31.8	192,680
5- 5-7	3	14	33	7	15	32	6	13	32	6	15	32	4	14	31	.	.	.	5.2	14.2	32.1	203,160
5-12-7	7	14	33	7	14	32	5	13	31	4	15	30	6	14	33	.	.	.	6.2	14.1	31.9	196,900
5-19-7	2	14	33	6	14	32	5	14	31	7	14	32	6	14	31	.	.	.	5.2	14.0	31.7	190,500
5-26-7	6	13	33	6	14	32	2	16	29	2	16	29	6	14	32	.	.	.	4.4	14.7	31.0	171,640
6- 2-7	6	14	33	2	15	29	7	15	32	7	15	32	5	14	31	.	.	.	5.4	14.7	31.4	197,680
6- 9-7	9	13	32	9	14	31	2	16	28	3	16	28	3	15	29	.	.	.	5.2	14.7	29.7	180,740
6-16-7	3	15	29	2	15	27	2	14	28	3	14	27	3	14	28	.	.	.	2.6	14.7	27.8	166,200
6-23-7	2	16	33	6	15	31	4	16	29	2	16	26	3	15	26	.	.	.	3.4	15.3	26.8	180,160
6-30-7	2	15	32	3	16	30	3	16	30	5	16	32	3	16	31	.	.	.	3.2	15.8	31.0	181,840
7- 7-7	3	16	29	4	17	27	4	19	27	2	18	26	3	17	21	.	.	.	3.2	17.2	25.9	160,360
7-14-7	2	16	31	5	15	31	5	16	29	3	16	29	5	16	30	.	.	.	4.0	15.7	30.0	156,820
7-21-7	7	15	31	4	16	27	2	16	27	2	16	26	2	17	26	.	.	.	3.4	15.9	27.4	190,820
7-28-7	4	14	29	2	15	27	3	17	27	4	16	28	2	16	27	.	.	.	3.0	15.3	27.3	163,600
8- 4-7	4	15	30	5	15	29	8	16	32	6	16	31	6	16	31	.	.	.	5.8	15.4	30.4	165,560
8-11-7	2	16	31	2	17	26	4	16	29	3	16	28	4	16	28	.	.	.	3.0	16.0	29.0	161,980
8-18-7	5	16	32	5	16	31	8	14	33	4	16	31	6	16	31	.	.	.	5.6	15.4	31.6	166,900

APPENDIX TABLE 1: HAWAII GREENHOUSE TOMATO DATA

WEEK ENDING (FRIDAY)	MONDAY TEMP C			TUESDAY TEMP C			WEDNESDAY TEMP C			THURSDAY TEMP C			FRIDAY TEMP C			SATURDAY TEMP C			WEEKLY TEMP C			WEEKLY NUMBER
MO-DA-YR	COND	MIN	MAX	COND	MIN	MAX	COND	MIN	MAX	COND	MIN	MAX	COND	MIN	MAX	COND	MIN	MAX	COND	MIN	MAX	FRUIT SET
8-25-7	5	16	30	5	16	28	2	16	26	5	16	28	4	16	27	.	.	.	4.2	15.9	26.0	150,000
9- 1-7	4	17	34	6	16	31	5	28	36	3	17	29	3	17	29	.	.	.	4.2	18.9	31.7	160,740
9- 8-7	7	.	.	6	16	31	8	15	33	5	16	30	4	16	30	.	.	.	6.0	15.6	31.1	178,200
9-15-7	6	13	36	4	14	24	4	14	28	6	14	31	6	16	29	.	.	.	5.2	14.2	29.7	181,500
9-22-7	4	16	28	5	15	31	5	13	31	5	13	30	4	13	31	.	.	.	4.6	14.0	30.2	183,700
9-29-7	7	15	30	8	12	32	7	13	34	6	15	32	6	14	29	.	.	.	6.8	13.9	31.6	189,200
10- 6-7	6	15	26	7	14	32	2	14	23	4	15	29	7	13	31	.	.	.	5.2	14.2	28.4	183,700
10-13-7	2	13	22	6	14	35	6	13	30	6	13	32	7	14	33	.	.	.	5.8	13.3	29.9	170,400
10-20-7	2	14	32	3	14	31	4	16	29	3	16	27	4	17	29	.	.	.	3.2	15.3	29.4	167,400
10-27-7	1	13	27	2	14	22	5	13	27	5	13	27	7	14	34	.	.	.	4.0	13.7	27.4	165,000
11- 3-7	3	14	30	3	14	26	3	17	29	2	17	27	3	17	27	.	.	.	2.8	16.0	28.3	151,800
11-10-7	2	16	29	2	16	29	7	11	31	6	11	32	6	11	31	.	.	.	4.6	12.9	30.3	150,700
11-17-7	3	13	30	3	13	29	4	15	29	4	13	29	7	12	29	.	.	.	4.2	13.3	29.4	151,600
11-24-7	2	13	28	4	13	29	4	15	28	8	13	33	6	13	33	.	.	.	4.8	13.2	30.2	173,800
12- 1-7	7	12	34	8	12	35	8	13	35	7	13	34	2	14	28	.	.	.	6.4	13.0	33.2	169,400
12- 8-7	7	14	29	2	16	25	1	15	22	2	13	22	2	13	27	1	16	21	2.5	14.5	24.3	151,800
12-16-7	2	13	23	2	13	22	2	13	22	2	12	21	2	12	21	.	.	.	2.0	12.6	21.9	.
12-23-7	2	12	22	2	12	19	2	12	18	6	11	25	8	8	26	7	8	36	4.5	10.4	24.4	.
12-30-7	3	11	21	4	11	27	4	13	22	3	13	22	6	11	31	3	12	19	3.8	11.7	23.8	.
1- 6-7	4	10	27	6	12	35	6	9	36	8	13	41	8	9	40	8	9	40	6.7	10.6	36.5	.
1-13-7	8	11	41	8	12	41	4	12	28	5	16	38	1	12	17	1	11	16	4.5	12.2	30.0	.
1-20-7	1	11	16	1	11	16	4	12	27	6	11	31	5	11	29	.	.	.	3.4	10.9	23.9	.
1-27-7	1	13	23	1	13	21	1	12	24	3	11	28	7	12	29	.	.	.	2.6	12.3	25.1	.
2- 3-7	1	16	21	5	14	24	7	13	32	6	11	26	3	13	23	.	.	.	4.4	13.6	25.3	.