PR-ET Version 1.0

Puerto Rico EvapoTranspiration Estimation Computer Program

USER'S MANUAL

University of Puerto Rico-Mayagüez Campus
Department of Agricultural and Biosystems Engineering
and
University of Puerto Rico Experiment Station-Rio Piedras

July 2002

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Disclaimer of Warranty

The PR-ET (Version 1.0) computer code is provided without any warranty. We make no warranties, express or implied, that the PR-ET code is free of errors or whether it will meet your need for solving a particular problem. You use the code at your own risk. The authors disclaim all liability for direct or consequential damage resulting from the use of the code.

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ABSTRACT

Puerto Rico EvapoTranspiration (PR-ET) Estimation Computer Program calculates the mean monthly average crop evapotranspiration at any location in Puerto Rico. With only the site latitude and elevation, and specification of the Climate Division, the program calculates all the climate data necessary as input to the Penman Monteith reference evapotranspiration method. Alternatively, the user can enter monthly average climate data manually into the Windows-based computer program. In this mode the program can be used anywhere in the world. The program currently included crop coefficient data for fifteen vegetable crops.

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1. INTRODUCTION

This document provides information about the PR-ET computer program. The purpose of the program is to estimate mean daily values of evapotranspiration for fifteen vegetable crops in Puerto Rico. The program utilizes the Penman Monteith method for estimating reference evapotranspiration (ETo). Crop coefficients (K_c) are provided internally for the fifteen vegetable crops. Additional crops can be evaluated if the user provides values of the crop coefficient.

Estimates of crop evapotranspiration are useful for planning irrigation systems and scheduling irrigation applications. In Puerto Rico, irrigation is needed to supplement rainfall during certain months of the year. This is especially true in the southwest Puerto Rico where the climate is considered to be semi-arid and evapotranspiration greatly exceeds rainfall. Estimation of the evapotranspiration is also important for hydrologic and environmental studies.

PR-ET provides estimates of potential evapotranspiration. Potential evapotranspiration is the estimated evapotranspiration for a crop that does not experience water stress at any time during the crop season. Allen et al. (1998) provide a method for incorporating the effects of crop water stress that could be used in combination with estimates of crop evapotranspiration derived from the PR-ET computer program.

The program operates in two modes: manual climate data input and automatic estimation of the climate input data. In the first case the user enters average monthly data. In the second case the program estimated long-term average monthly climate data based on procedures described in Harmsen et al. (2002). The procedures are described in the following section.

2. THEORY AND CALCULATIONS

2.1 Evapotranspiration

Evapotranspiration (ET_c) is defined as the combination of evaporation from soil and plant surfaces, and transpiration from plant leaves. Evaporation is the process whereby liquid water is converted to water vapor and removed from the evaporating surface (Allen et al., 1998). Transpiration is the vaporization of liquid water contained in plant tissues and its subsequent removal to the atmosphere. Crops predominately loss water through small openings in their leaves called stomata. Evapotranspiration estimates from PR-ET are expressed in units of mm/day.

Crop evapotranspiration (ET_c) can be defined as the product of a reference evapotranspiration (ET_o) and crop coefficient (K_c):

$$ET_c = K_c\, ET_o \tag{1}$$

The crop coefficient (K_c) accounts for the effects of characteristics that distinguish the field crop from the grass reference crop (Allen et al., 1998). The reference evapotranspiration is defined as the evapotranspiration from an extended surface of 0.08 to 0.15 m tall, green grass cover of uniform height, actively growing, completely shading the ground and not short of water (Doorenbos and Pruitt, 1977). Numerous mathematical expressions have been developed for ET_o. One such expression, which has been shown to have global validity and is recommended by the United Nations Food and Agriculture Organization (FAO) is the Penman-Monteith equation (Allen et al., 1998):

$$ET_o = \frac{0.408 \cdot \Delta \cdot (R_n - G) + \gamma \cdot \left(\frac{900}{T + 273}\right) \cdot u_2 \cdot (e_s - e_a)}{\Delta + \gamma \cdot (1 + 0.34 \cdot u_2)} \tag{2}$$

where Δ = slope of the vapor pressure curve, R_n = net radiation, G= soil heat flux density, γ = psychrometric constant, T = mean daily air temperature at 2 m height, u_2 = wind speed at 2 m height, e_s is the saturated vapor pressure and e_a is the actual vapor pressure. Equation 4 applies specifically to a hypothetical reference crop with an assumed crop height of 0.12 m, a fixed surface resistance of 70 sec/m and an albedo of 0.23. PR-ET uses equation 2 to estimate reference evapotranspiration.

2.2 Climate Parameter Estimation

Estimation procedures are presented below for long-term average daily climate parameters on a monthly basis for Puerto Rico. Climate data include: minimum air temperature (T_{min}), maximum air temperature (T_{max}) , dew point temperature (T_{dew}), solar radiation (R_s) and wind speed (U). A more detailed description of the method background and a validation of the methodology can be found in Harmsen and Torres Justiniano (2001).

2.2.1 Minimum and Maximum Air Temperature

Goyal et al. (1988) developed regression equations for minimum and maximum long-term average daily air temperatures for Puerto Rico based on surface elevation. Table 1 lists the regression coefficients for the daily average minimum and maximum air temperatures in Puerto Rico by month. The regression equations have the following general form:

$$T = A - (B \cdot 10^{-5}) \cdot Z \qquad (3)$$

where T is temperature (°C), A and B are regression coefficients and Z is elevation (m) above mean sea level.

Table 1. Relationships among temperatures (T) and elevations (Z) for Puerto Rico (Goyal et al., 1988)[1]

	Mean Daily Maximum Temperatures, °C			Mean Daily Minimum Temperatures, °C		
Month	A	B	r^2	A	B	r^2
Jan.	29.24	770	0.73	18.58	544	0.44
Feb.	29.37	752	0.72	18.37	558	0.46
Mar.	30.08	711	0.71	18.71	590	0.48
Apr.	30.59	687	0.71	19.9	686	0.63
May	31.16	707	0.76	21.23	608	0.63
Jun.	31.76	686	0.73	21.92	577	0.59
Jul.	32.07	717	0.64	22.14	591	0.58
Aug.	32.12	682	0.75	22.21	585	0.58
Sep.	32.12	696	0.79	21.95	586	0.62
Oct.	31.84	705	0.79	21.48	553	0.59
Nov.	30.89	706	0.75	20.68	562	0.55
Dec.	29.83	744	0.73	19.52	547	0.47

[1] $T = A - (B \cdot 10^{-5})\, Z$, where T = temperature, °C; Z = elevation above mean sea level, m; and A and B are regression coefficients and r^2 is the coefficient of determination.

2.2.2 Dew Point Temperature

The FAO (Allen et al., 1998) has reported that T_{dew} can be estimated on the basis of the daily minimum air temperature. A correction factor based on local conditions should be added to the minimum temperature as follows:

$$T_{dew} = T_{min} + K_{corr} \qquad (4)$$

where K_{corr} is a temperature correction factor in degrees °C, listed in Table 2. Correction factors (K_{corr}) were calibrated for three of the six Climate Divisions of Puerto Rico as defined by the U.S. National Oceanic and Atmospheric Administration (NOAA), and are presented in Table 2. Figure 1 shows the Climate Divisions for Puerto Rico. A climate division is defined as region possessing similar climatic characteristics. Long-term average T_{dew} data were not available for Climate Divisions 3, 5 and 6, therefore, these Divisions were assigned a value of 0 ^{o}C similar to that of Division 4 (humid conditions).

Table 2. Temperature correction Factor K_{corr} used in Equation 2 for Climate Divisions[1] within Puerto Rico.

Climate Division[1]	**1**	**2**	**3,4,5,6**
K_{corr} (^{o}C)	1.0	-2.9	0

1 See Figure 1 for Climate Divisions

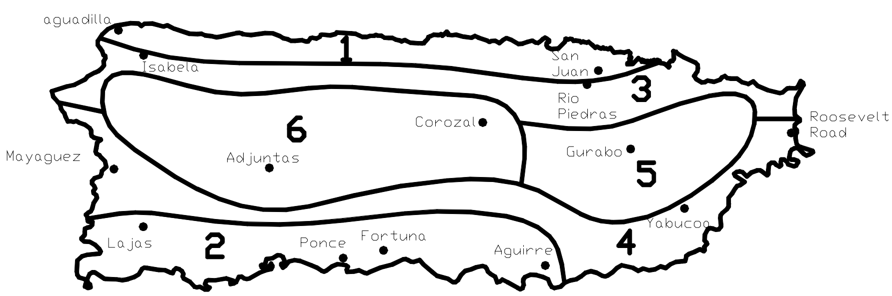


Figure 1. Climate Divisions of Puerto Rico: 1, North Coastal; 2, South Coastal; 3, Northern Slopes; 4, Southern Slopes; 5, Eastern Interior; and 6, Western Interior.

2.2.3 Wind Speed

The Penman-Monteith method is based on a wind speed measured 2 m above the ground and is referred to as U_2. Wind speeds that are collected at heights other than 2 m above the ground were adjusted to the U_2 value using an exponential relationship. Table 3 presents U_2 values for Puerto Rico. These wind speeds were estimated by averaging station data within the Climate Divisions established by the NOAA.

Table 3. Average Daily Wind Speeds (U_2) by Month and Climate Division[1] within Puerto Rico.

	Average Daily Wind Speeds at 2 m Above the Ground (m/s)[2]											
Climate Division[1]	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
1	2.7	2.8	3.0	2.9	2.6	2.6	2.9	2.7	2.1	1.9	2.2	2.6
2	1.8	2.0	2.2	2.1	2.2	2.4	2.4	2.1	1.7	1.5	1.4	1.5
3	2.2	2.4	2.6	2.4	2.2	2.4	2.7	2.5	2.0	1.8	2.0	2.3
4	1.8	2.0	2.1	2.1	2.0	2.0	2.0	1.8	1.6	1.6	1.6	1.6
5	1.1	1.3	1.4	1.5	1.6	1.7	1.6	1.3	1.1	0.9	0.9	0.9
6	1.3	1.5	1.5	1.5	1.6	1.8	1.8	1.5	1.2	1.1	1.0	1.0

[1] See Figure 1 for Climate Divisions

[2] Averages are based on San Juan and Aguadilla for Div. 1; Ponce, Aguirre, Fortuna and Lajas, for Div. 2; Isabela and Río Piedras for Div. 3; Mayagüez, Roosevelt Rd. and Yabucoa for Div. 4; Gurabo for Div. 5; and Corozal and Adjuntas for Div. 6. Measured wind speeds were adjusted to the wind speed 2 m above the ground (U_2) using the following equation: $U_2 = (4.87U_z)/[\ln(67.8z-5.42)]$, where U_z in m/sec is the wind speed at height z in meters above the ground.

2.2.4 Solar Radiation

The FAO recommends that solar radiation be estimated by using the following equation for islands:

$$R_s = (0.7\ R_a - b) \qquad (5)$$

where R_s is solar radiation, b is an empirical constant equal to 4 mega-joules per meter squared per day (MJ m^{-2} day^{-1}) and R_a is the incoming extraterrestrial radiation given by the following equation:

$$R_a = (24*60/\pi)\ G_{sc}\ d_r\ [\omega_s \sin(\varphi) \sin(\delta) + \cos(\varphi) \cos(\delta) \sin(\omega_s)] \qquad (6)$$

where G_{sc} is a solar constant equal to 0.0820 MJ m^{-1} min^{-1}, and d_r is the inverse relative distance Earth-Sun equal to

$$d_r = 1 + 0.033 \cos(2\pi\ J / 365) \qquad (7)$$

where J is a number of the day in the year between 1 (1 January) and 365 or 366 (31 December). For estimating the long-term average daily reference evapotranspiration by month, J is equal to 15 for January, 45 for February, 75 for March, and so on. The sunset hour angle ω_s is give by

$$\omega_s = \arccos[-\tan(\varphi)\tan(\delta)] \qquad (8)$$

The solar declination (radians) is given by

$$\delta = 0.409 \sin[(2\pi\ J / 365) - 1.39] \qquad (9)$$

In the above equations, the latitude φ must be in radians. The conversion from decimal degrees to radians is

$$[\text{Radians}] = (\pi/180)\ [\text{decimal degrees}] \qquad (10)$$

It should be noted that the only input required to use equation 6 is the day of the year (J) and the site latitude (φ). For a more detailed discussion of the calculation of R_a, the reader is referred to Allen et al. (1998).

Equation 5 is limited to elevations of less than 100 m above sea level. Therefore, for higher elevations, in the interior areas of Puerto Rico, where the ocean does not moderate air temperatures as much as along the low altitude coastal areas, the Hargreaves radiation formula should be used:

$$R_s = k_{Rs}\,(T_{max} - T_{min})^{1/2}\,R_a \qquad (11)$$

where k_{Rs} is an adjustment factor equal to 0.19.

2.3 Crop Coefficients

Crop coefficients for fifteen vegetable crops are provided within the PR-ET computer program. Table 1 shows the K_c values used for the initial, mid and end crop growth stages ($K_{c,ini}$, $K_{c,mid}$ and $K_{c,end}$, respectively). The crop coefficients in Table 1 were obtained from the United Nations Food and Agriculture Organization (FAO) Paper No. 56 (Allen et al., 1998).

In the program, the value of $K_{c,ini}$ is adjusted to account for type of irrigation used, soil type and depth of irrigation applied. A description of this adjustment is provided in Allen et al. (1998). If drip irrigation is used, 40 percent of the surface is assumed to be wet. With flood and sprinkler irrigation, 100% of the surface is assumed to be wet. Values of $K_{c,mid}$ and $K_{c,end}$ are adjusted for the monthly minimum relative humidity and wind speed as described in Allen et al. (1998).

2.4 Crop Evapotranspiration

PR-ET calculates the crop evapotranspiration using equation 1. Monthly average values of ET_o are interpolated to obtain the daily values throughout the crop season. The adjusted values of $K_{c,ini}$ and $K_{c,mid}$ are used during the initial and mid crop growth stages, respectively. The K_c values used between the last day of the initial stage and the first day of the mid stage is a linear interpolation between the $K_{c,ini}$ and $K_{c,mid}$ values. The K_c values used between the last day of the mid stage and the last day of the crop season is a linear interpolation between the $K_{c,mid}$ and $K_{c,end}$ values. Daily values of K_c and ET_o are multiplied to obtain daily values of ET_c throughout the crop season.

3. INPUTTING DATA

The program can be started by double clicking on the program icon (PR-ET.EXE). After the program is started the introductory page will appear on the screen (Figure 2).

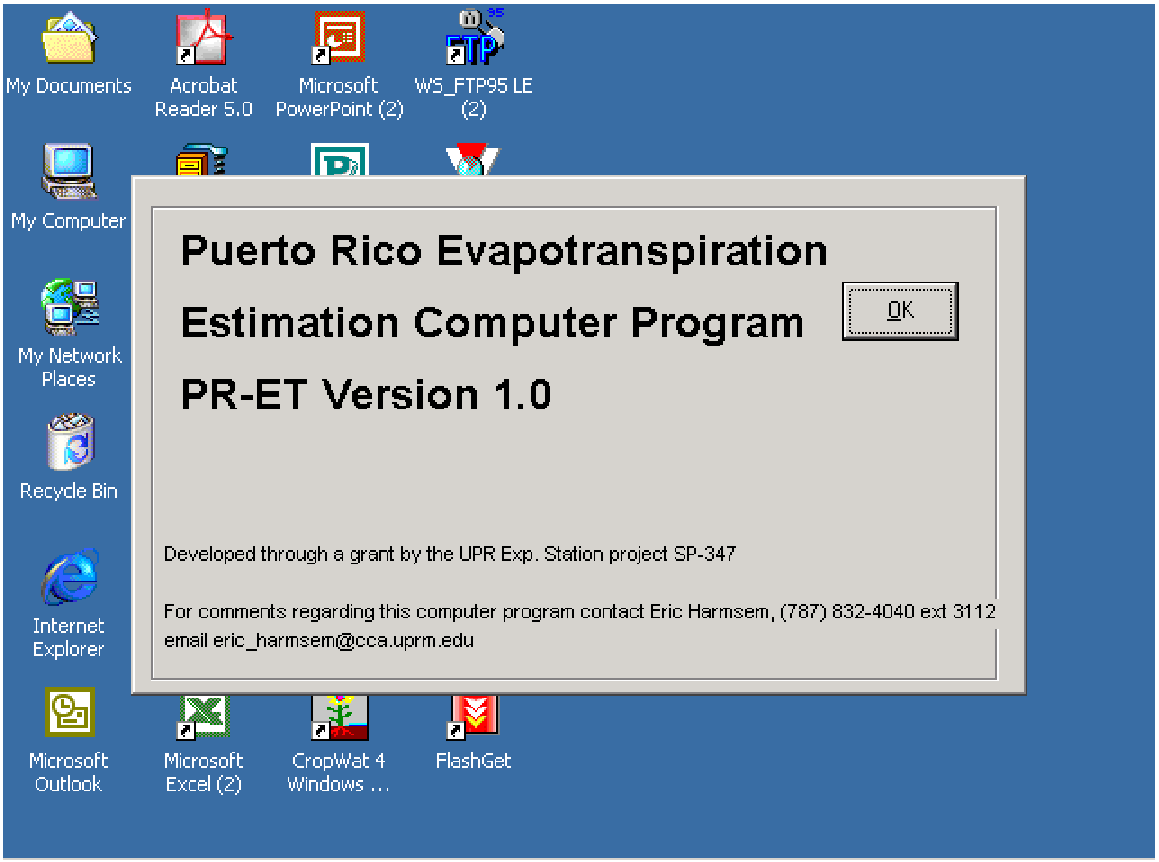


Figure 2. The PR-ET computer program introductory page.

By clicking on the **OK** button on the introductory page, the first input page will appear.

Crop: In this menu you can select from fifteen vegetable crops. If your crop is not shown in the list select Other.

Location: Enter the location of your site (e.g., Juana Diaz)

Latitude: Enter the site latitude in decimal format. The value of site latitude can be obtained from maps commonly available (e.g., topographical map). To convert a latitude from degrees and minutes to degrees decimal, divide the minutes part by 60 and add to the degree part. For example $18^{o}30'$ is $18 + 30/60 = 18.5^{o}$.

Elevation: Enter the average site elevation in meters above mean sea level.

Interval Between Irrigations: This is the average number of days between irrigation applications. For example if you typically irrigate once every four days you would enter 4. This number is used in determining the amount of water that evaporates from the soil early in the season before the crop fully shades the soil.

Depth of Irrigation: The is the equal to the total volume of irrigation water divided by the field area.

Type of Soil: Select either fine or course textured soil.

Planting Date: Enter the date that the crop will be planted.

Type of Irrigation: Select drip, spray or surface irrigation.

Length of Initial Crop Stage: Enter the length of initial crop stage in days. The initial crop stage starts at planting and ends as soon as the crop enters the development crop stage. The initial crop stage is characterized by little to no crop growth.

Length of Development Crop Stage: Enter the length of development crop stage in days. The development crop stage is characterized by rapid growth. This stage terminates when the mid crop stage is reached.

Length of Mid Crop Stage: Enter the length of mid crop stage in days. The mid crop stage is occurs when the plants are at maximum height and transpiration is maximum. This stage terminates when the end crop stage is reached.

Length of End Crop Stage: Enter the length of end crop stage in days. The end crop stage is characterized by a reduction in plant area as the plant. This stage terminates at the end of the crop season.

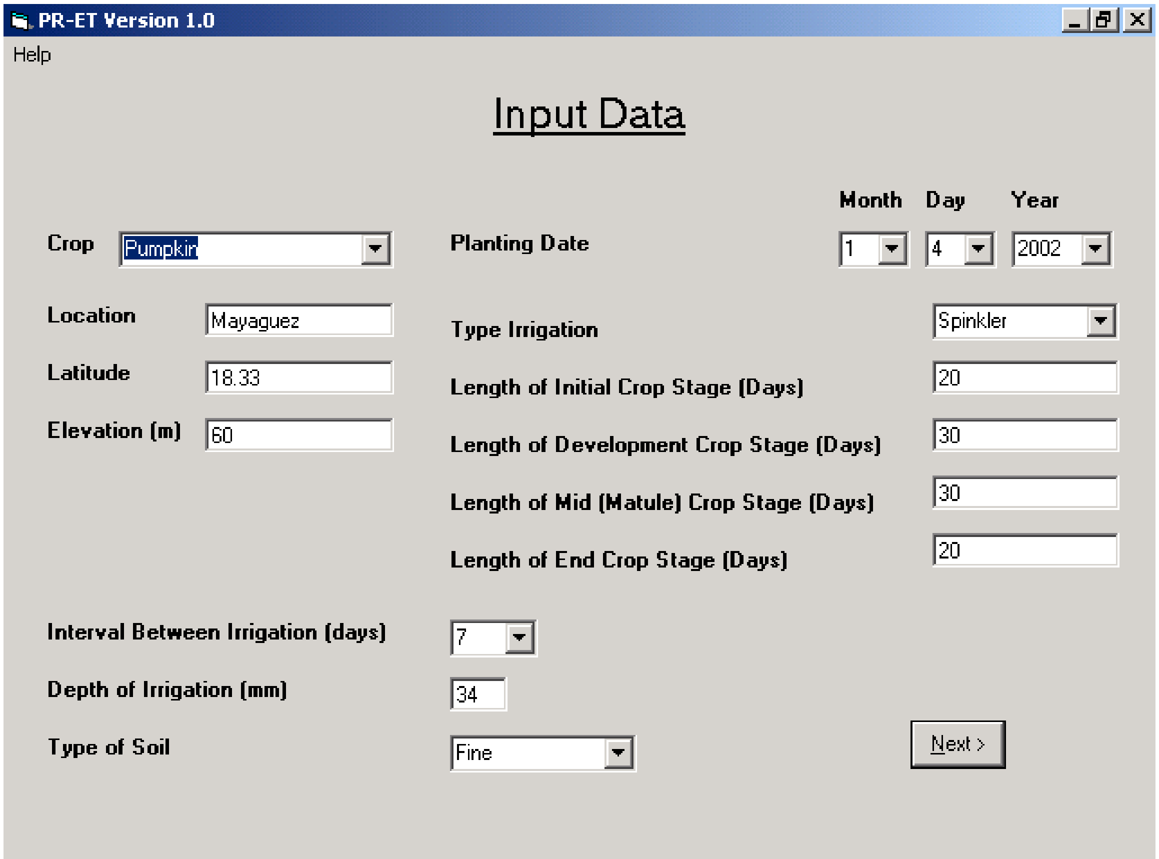


Figure 3. Introductory data input page.

After entering the data shown in Figure 3 and clicking on the **Next** button, the screen shown in Figure 4 will appear. By selecting **Enter Climate Data** it will be necessary to enter the monthly values for minimum and maximum air temperature, relative humidity, wind speed and solar radiation. Figure 5 shows the manual input screen for the Minimum Air Temperature. Input for other climate parameters are similar to Figure 5.

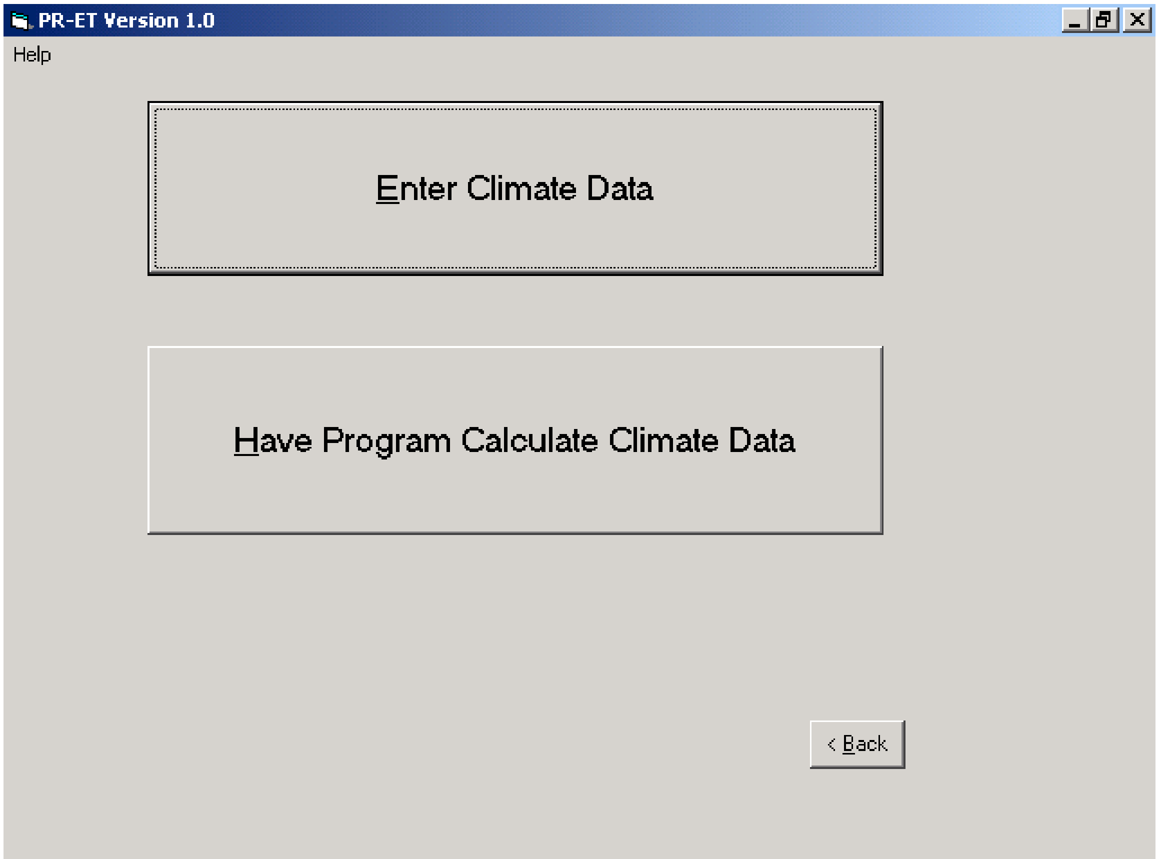


Figure 4. Selection of data input method.

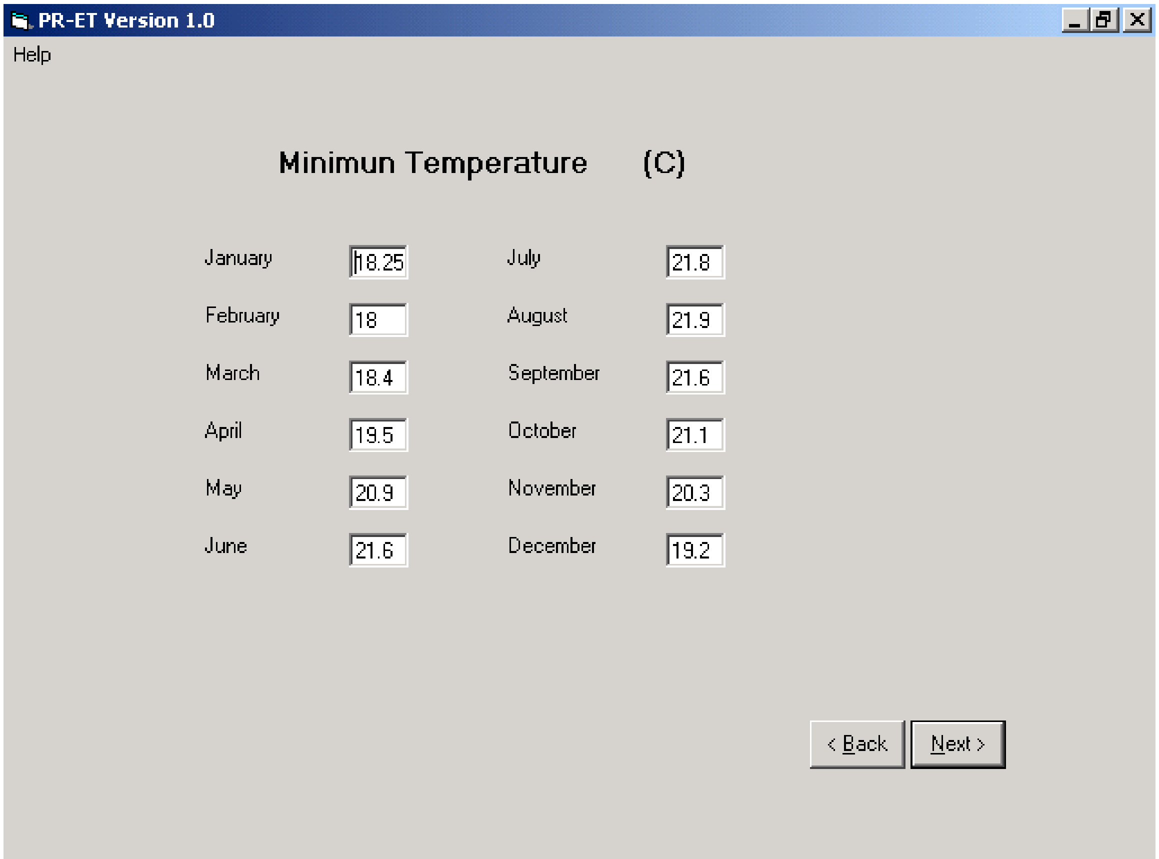


Figure 5. Manual input table for minimum air temperature.

It is possible to have the program estimate all of the climate input data by selecting **Have Program Calculate Climate Data** (Figure 4). If this approach is selected the user must specify the Climate Division in Puerto Rico where the site is located. This screen is shown in Figure 7.

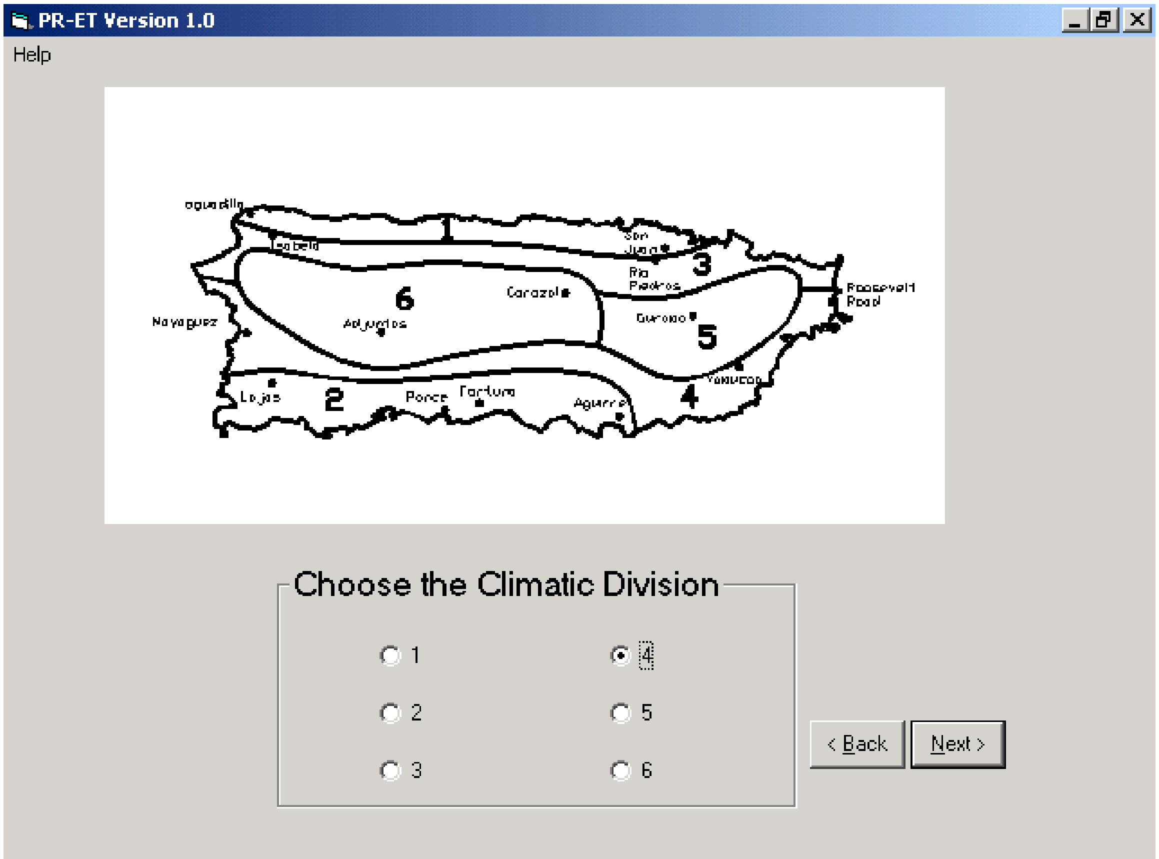
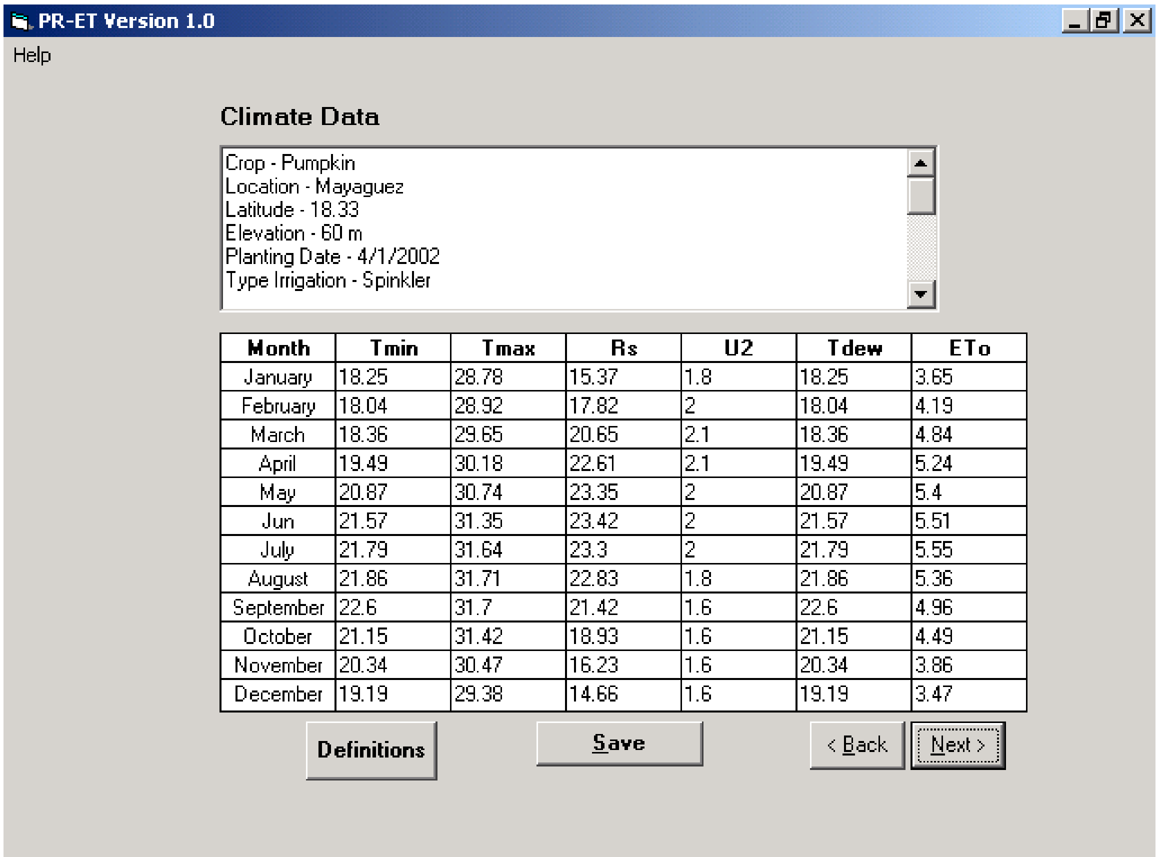


Figure 7. Climate Division selection screen.

After clicking the **Next** button on the screen shown in Figure 7, the program will calculate the daily crop coefficient, reference evapotranspiration and crop evapotranspiration.

4. OUTPUTTING DATA

Figure 8 shows the first output screen, which includes the average monthly minimum air temperature, maximum air temperature, relative humidity, wind speed, solar radiation and the estimated reference evapotranspiration. If desired the data can be saved to a text file for post-processing in another program (e.g., Microsoft Excel).



Month	Tmin	Tmax	Rs	U2	Tdew	ETo
January	18.25	28.78	15.37	1.8	18.25	3.65
February	18.04	28.92	17.82	2	18.04	4.19
March	18.36	29.65	20.65	2.1	18.36	4.84
April	19.49	30.18	22.61	2.1	19.49	5.24
May	20.87	30.74	23.35	2	20.87	5.4
Jun	21.57	31.35	23.42	2	21.57	5.51
July	21.79	31.64	23.3	2	21.79	5.55
August	21.86	31.71	22.83	1.8	21.86	5.36
September	22.6	31.7	21.42	1.6	22.6	4.96
October	21.15	31.42	18.93	1.6	21.15	4.49
November	20.34	30.47	16.23	1.6	20.34	3.86
December	19.19	29.38	14.66	1.6	19.19	3.47

Figure 8. Screen printout of monthly average climate data and reference evapotranspiration.

The next screen gives the estimated crop coefficient, reference evapotranspiration and crop evapotranspiration. The data can be saved to a file if desired. Note that these data, unlike those shown in Figure 8, are daily average values. By clicking on the **Graph** button a graph will appear on the screen showing crop coefficient, reference evapotranspiration and crop evapotranspiration versus time. From this screen the user may terminate the program by clicking on the **End Program** button or perform another analysis by clicking on the **Restart Program** button.

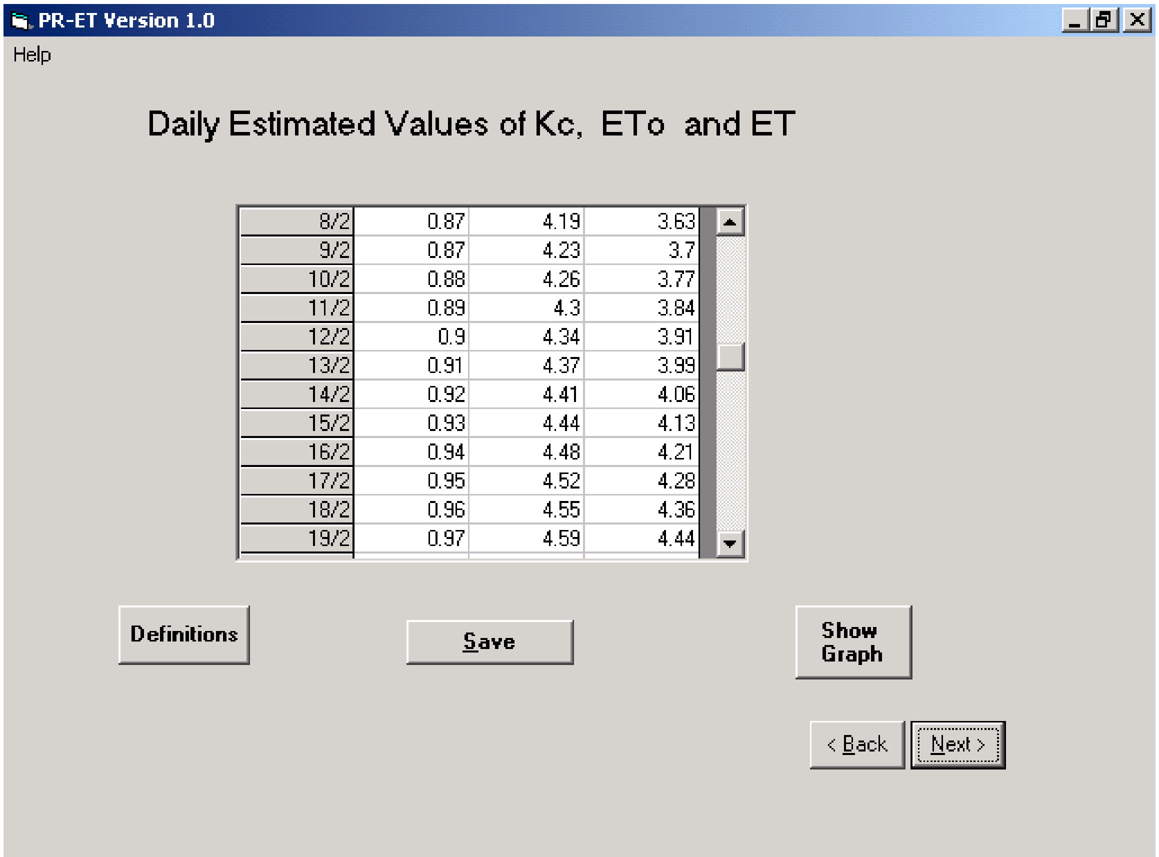


Figure 9. Output screen for daily average crop coefficient, reference evapotranspiration, and crop evapotranspiration.

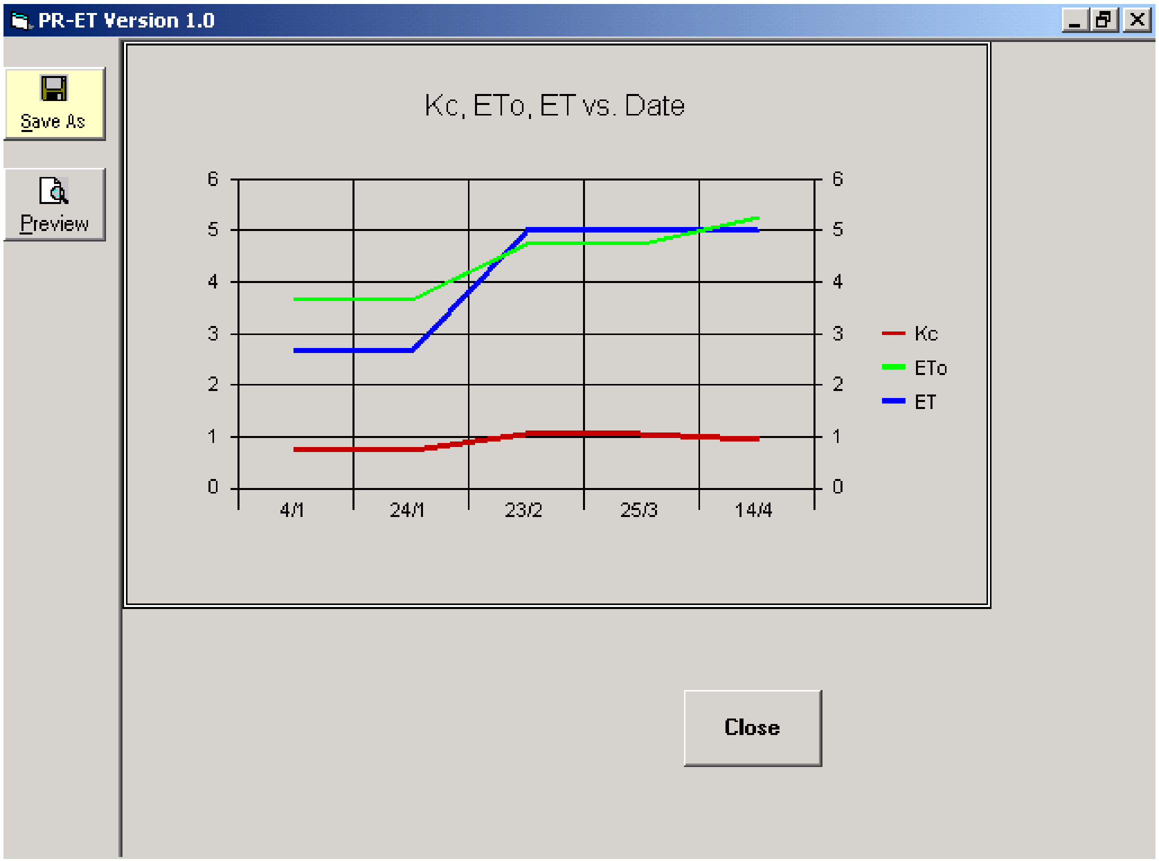
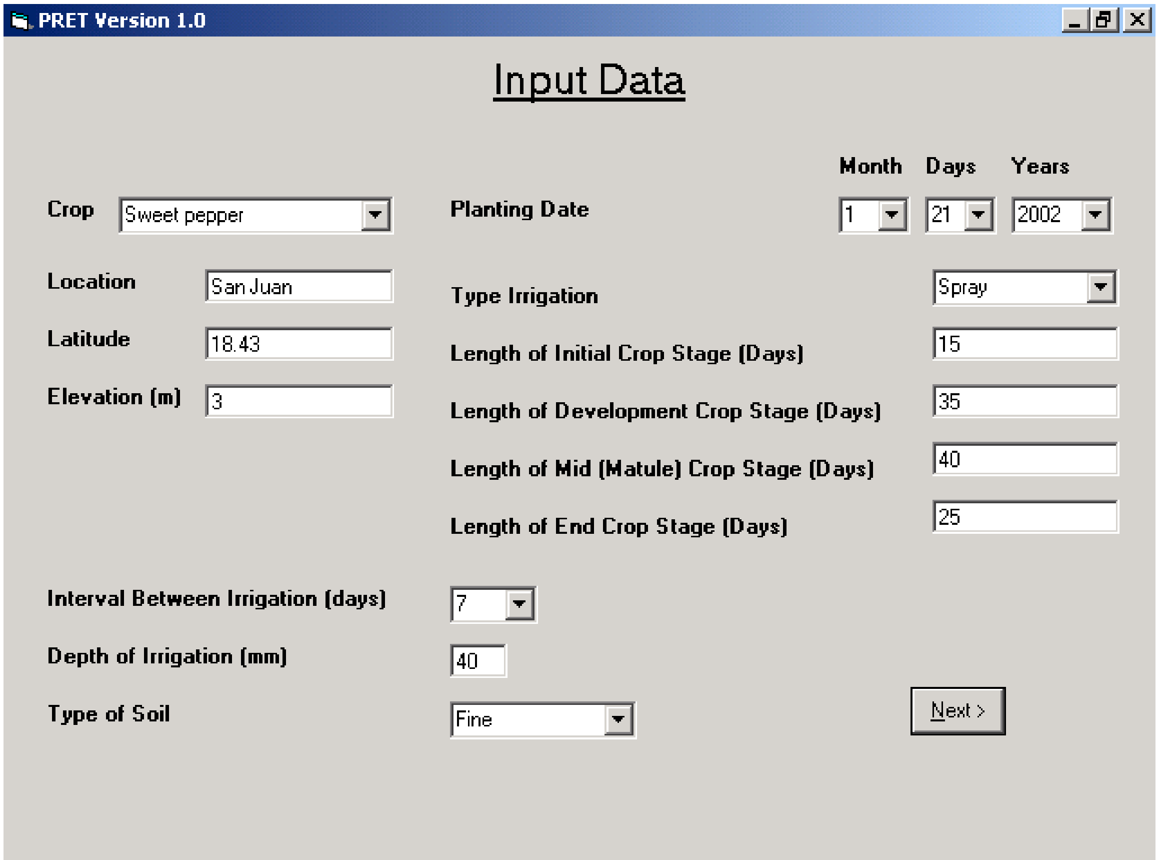
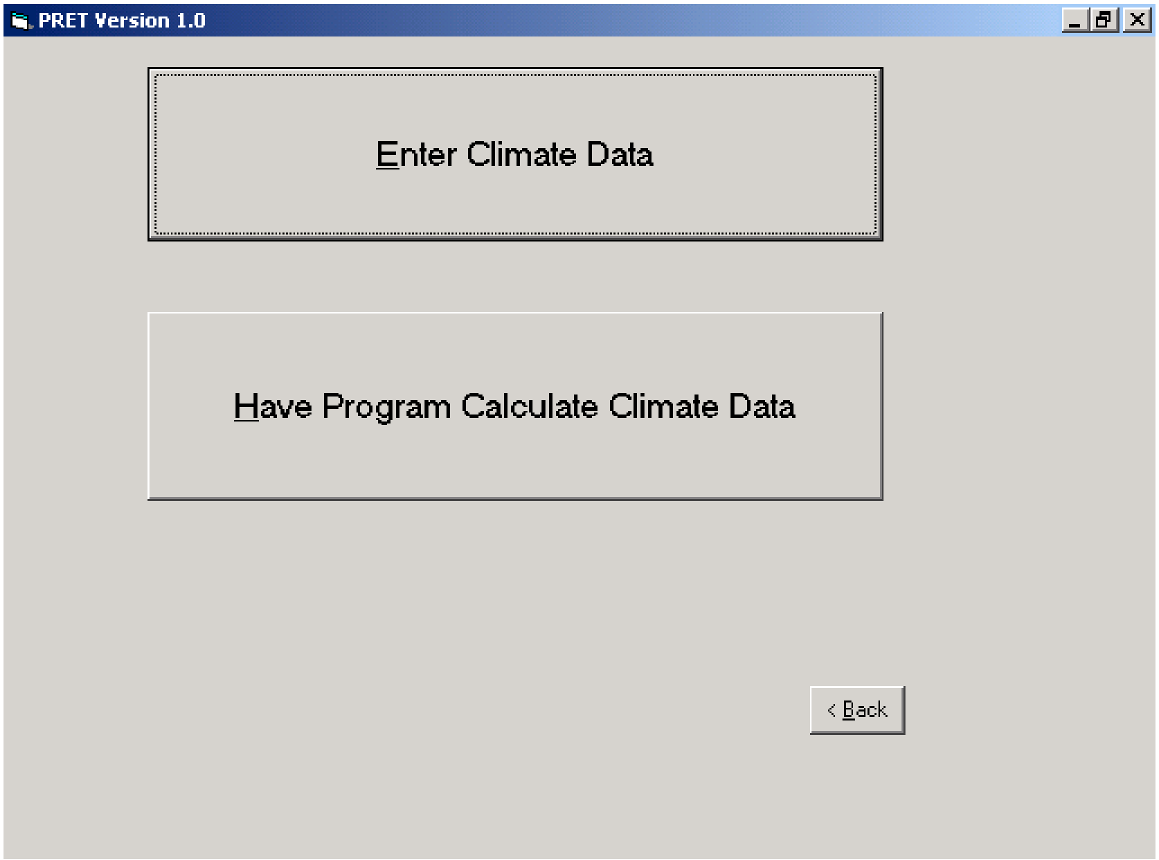


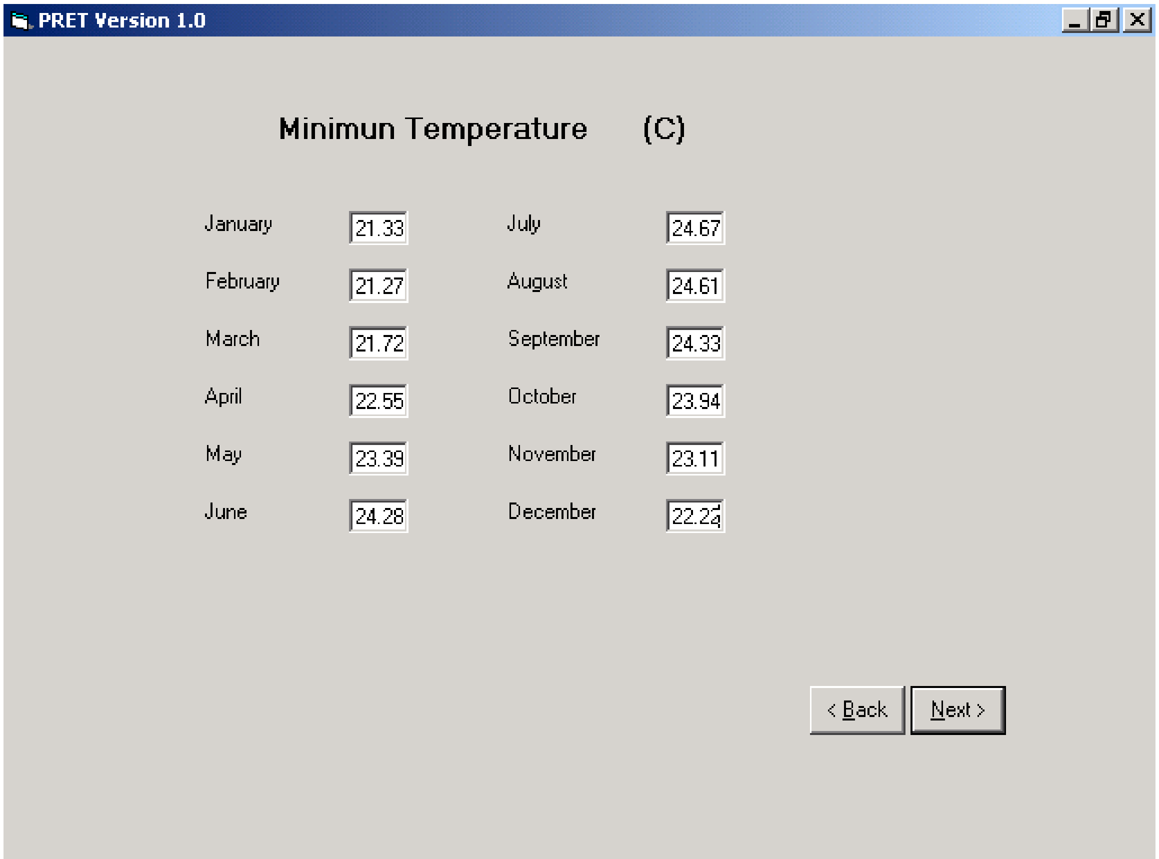
Figure 10. Graph of crop coefficient, reference evapotranspiration, and crop evapotranspiration versus time.

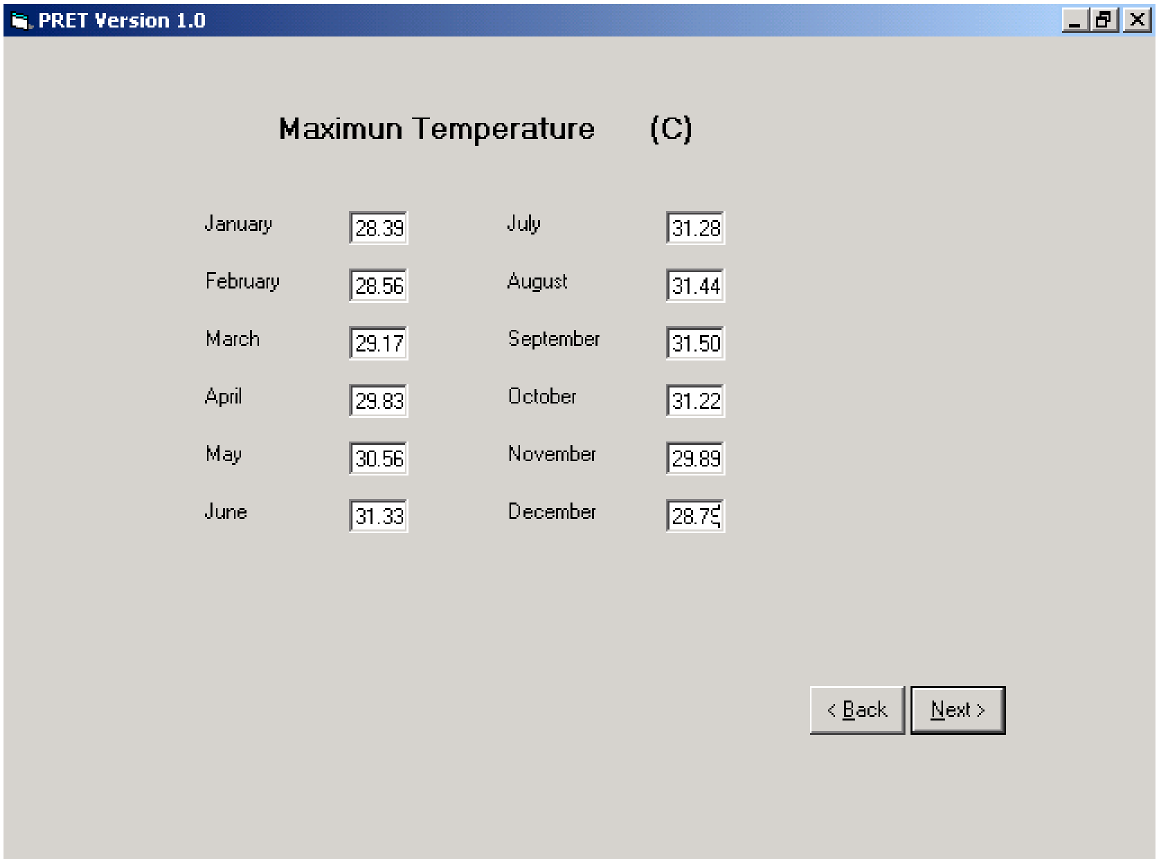
5. EXAMPLE PROBLEMS

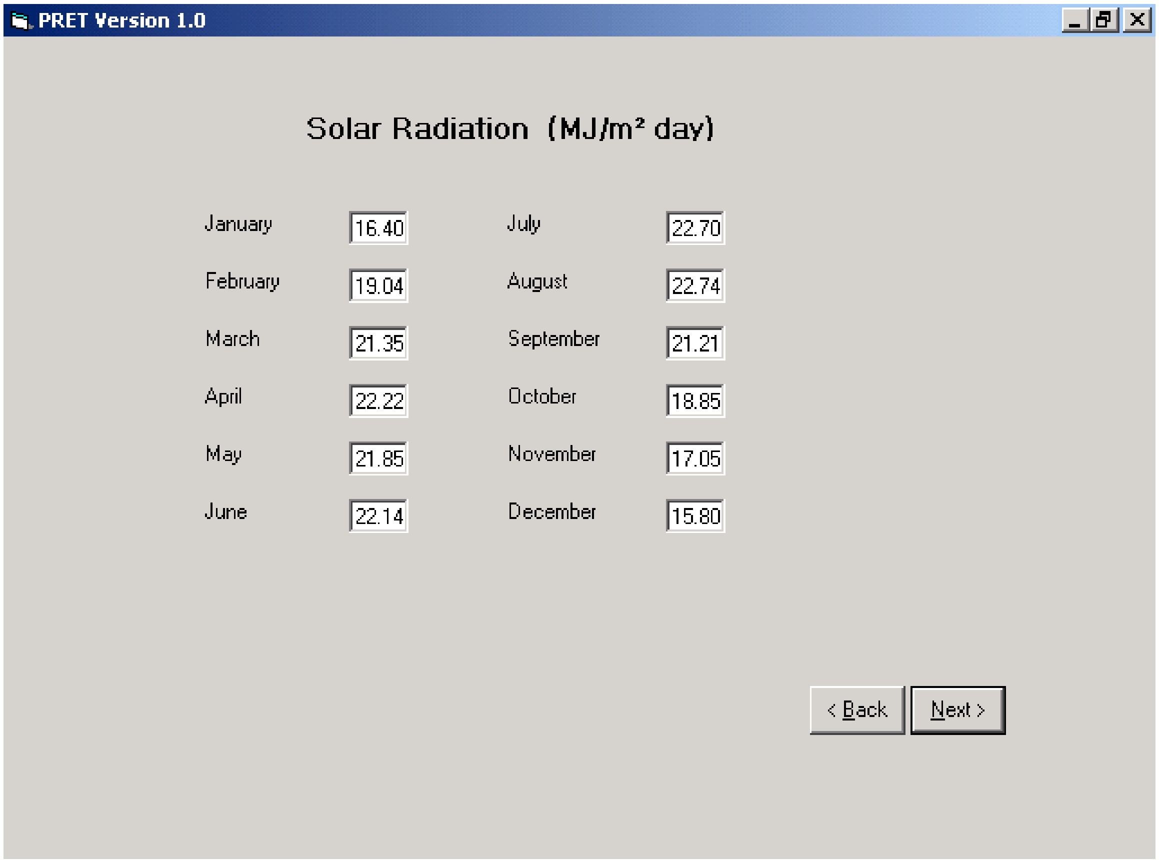
5.1 Manual Entry of Climate Data

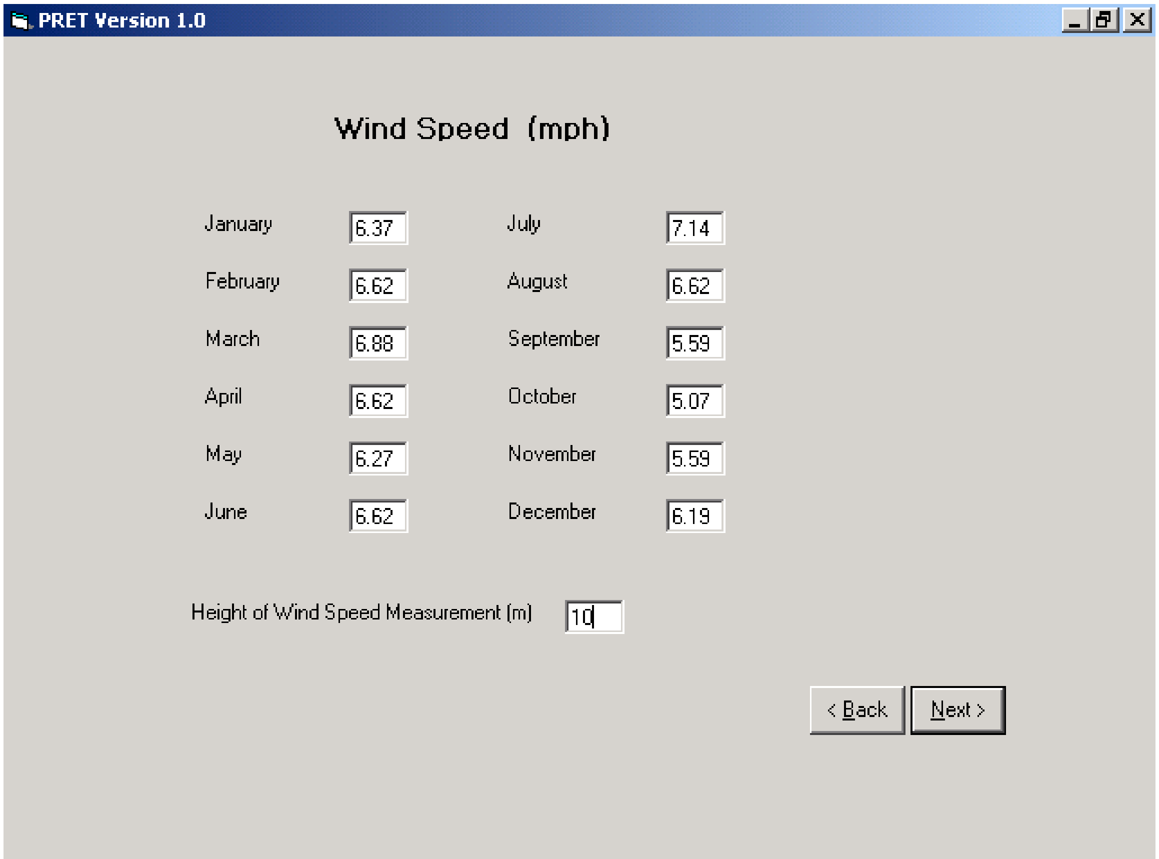


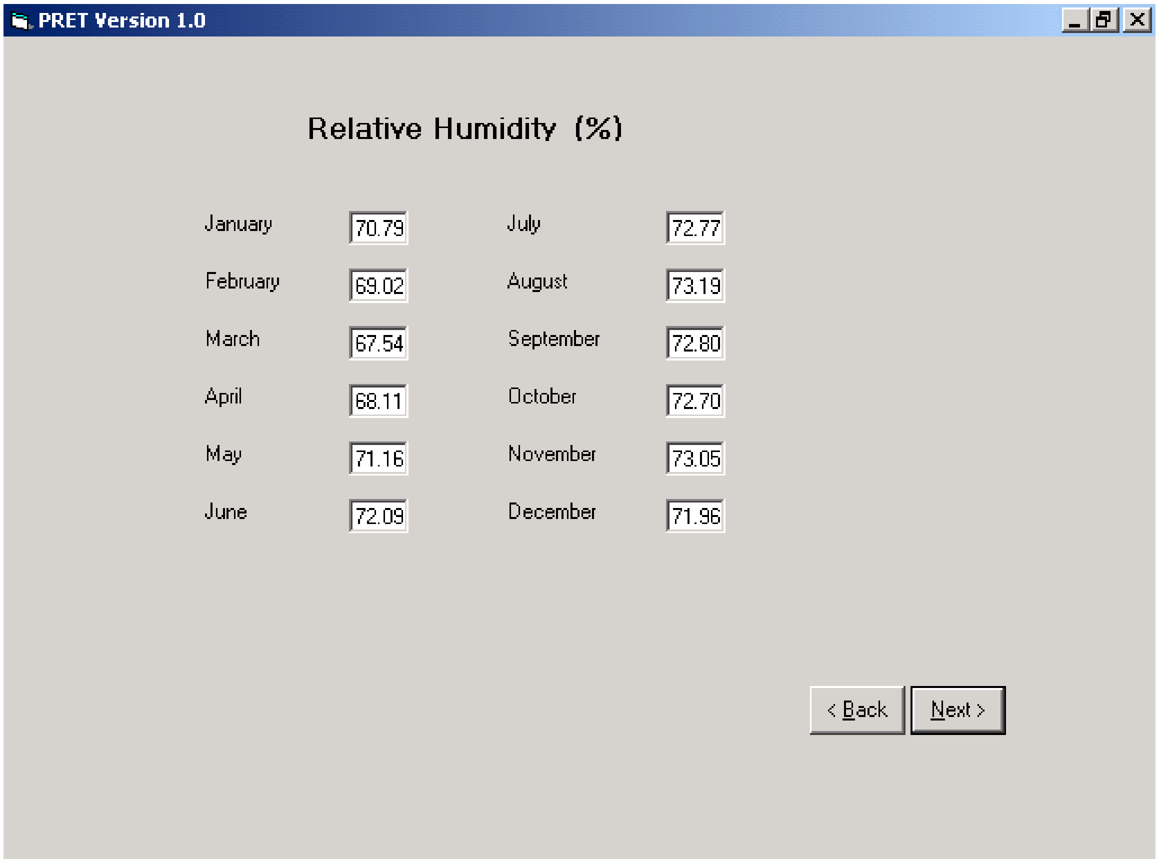

PRET Version 1.0
Enter Climate Data
Have Program Calculate Climate Data
< Back

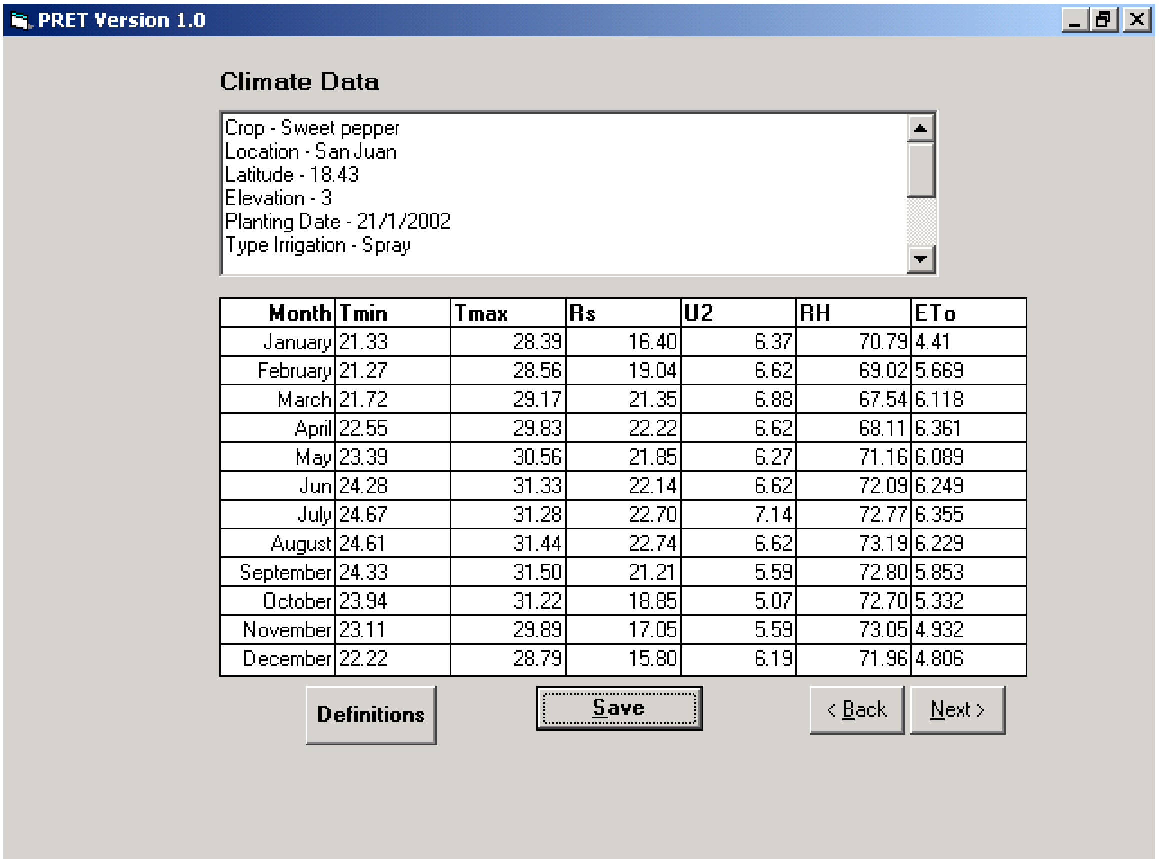

PRET Version 1.0
Minimun Temperature (C)
January 21.33
February 21.27
March 21.72
April 22.55
May 23.39
June 24.28
July 24.67
August 24.61
September 24.33
October 23.94
November 23.11
December 22.24
< Back
Next >


PRET Version 1.0
Maximun Temperature (C)
January 28.39
February 28.56
March 29.17
April 29.83
May 30.56
June 31.33
July 31.28
August 31.44
September 31.50
October 31.22
November 29.89
December 28.7
< Back
Next >


PRET Version 1.0
Solar Radiation (MJ/m² day)
January 16.40
February 19.04
March 21.35
April 22.22
May 21.85
June 22.14
July 22.70
August 22.74
September 21.21
October 18.85
November 17.05
December 15.80
< Back
Next >


PRET Version 1.0
Wind Speed (mph)
January
6.37
February
6.62
March
6.88
April
6.62
May
6.27
June
6.62
July
7.14
August
6.62
September
5.59
October
5.07
November
5.59
December
6.19
Height of Wind Speed Measurement (m)
10
< Back
Next >


PRET Version 1.0
Relative Humidity (%)
January
70.79
February
69.02
March
67.54
April
68.11
May
71.16
June
72.09
July
72.77
August
73.19
September
72.80
October
72.70
November
73.05
December
71.96
< Back
Next >



PRET Version 1.0

Climate Data

Crop - Sweet pepper
Location - San Juan
Latitude - 18.43
Elevation - 3
Planting Date - 21/1/2002
Type Irrigation - Spray

Month	Tmin	Tmax	Rs	U2	RH	ETo
January	21.33	28.39	16.40	6.37	70.79	4.41
February	21.27	28.56	19.04	6.62	69.02	5.669
March	21.72	29.17	21.35	6.88	67.54	6.118
April	22.55	29.83	22.22	6.62	68.11	6.361
May	23.39	30.56	21.85	6.27	71.16	6.089
Jun	24.28	31.33	22.14	6.62	72.09	6.249
July	24.67	31.28	22.70	7.14	72.77	6.355
August	24.61	31.44	22.74	6.62	73.19	6.229
September	24.33	31.50	21.21	5.59	72.80	5.853
October	23.94	31.22	18.85	5.07	72.70	5.332
November	23.11	29.89	17.05	5.59	73.05	4.932
December	22.22	28.79	15.80	6.19	71.96	4.806

Definitions Save < Back Next >

PRET Version 1.0

Daily Estimated Values of Kc, ETo and ET

Day	Kc	ETo	ET
21/1	0.6997	4.8297	3.3792
22/1	0.6997	4.8297	3.3792
23/1	0.6997	4.8297	3.3792
24/1	0.6997	4.8297	3.3792
25/1	0.6997	4.8297	3.3792
26/1	0.6997	4.8297	3.3792
27/1	0.6997	4.8297	3.3792
28/1	0.6997	4.8297	3.3792
29/1	0.6997	4.8297	3.3792
30/1	0.6997	4.8297	3.3792
31/1	0.6997	4.8297	3.3792

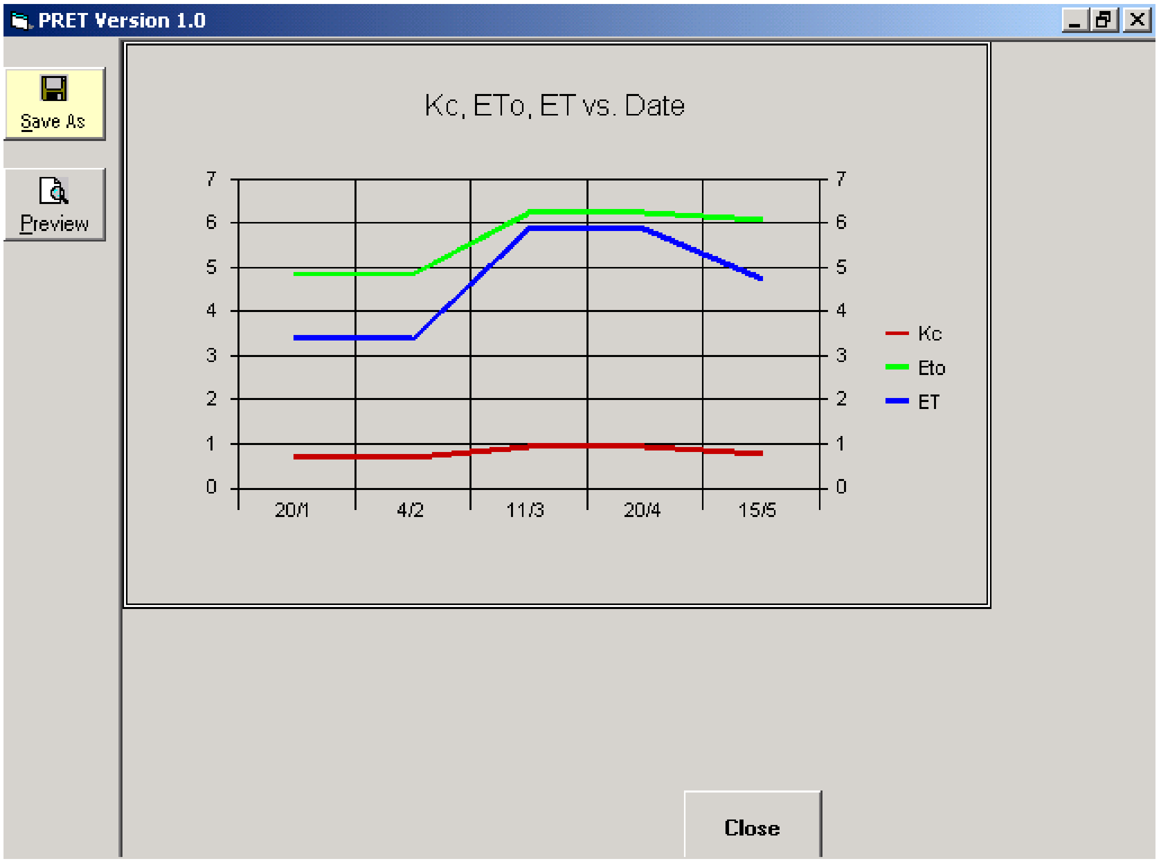
Definitions

Save

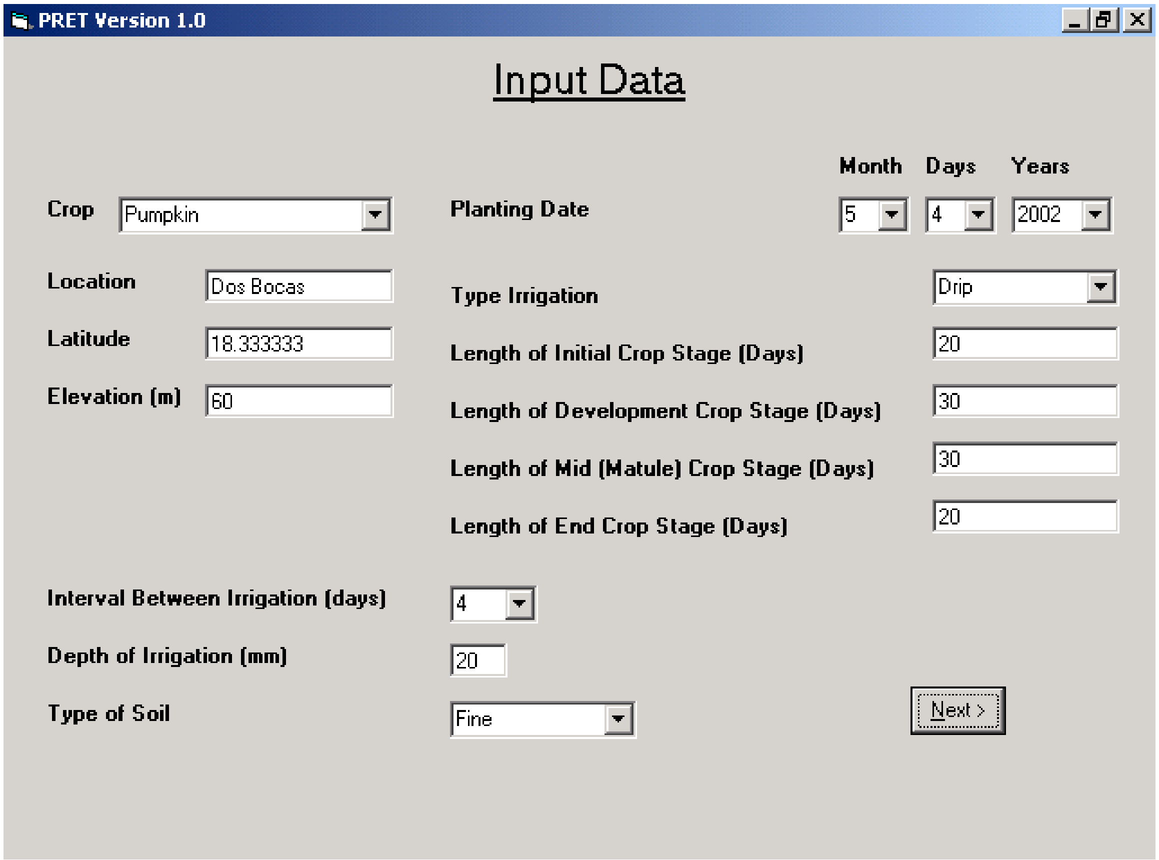
Show Graph

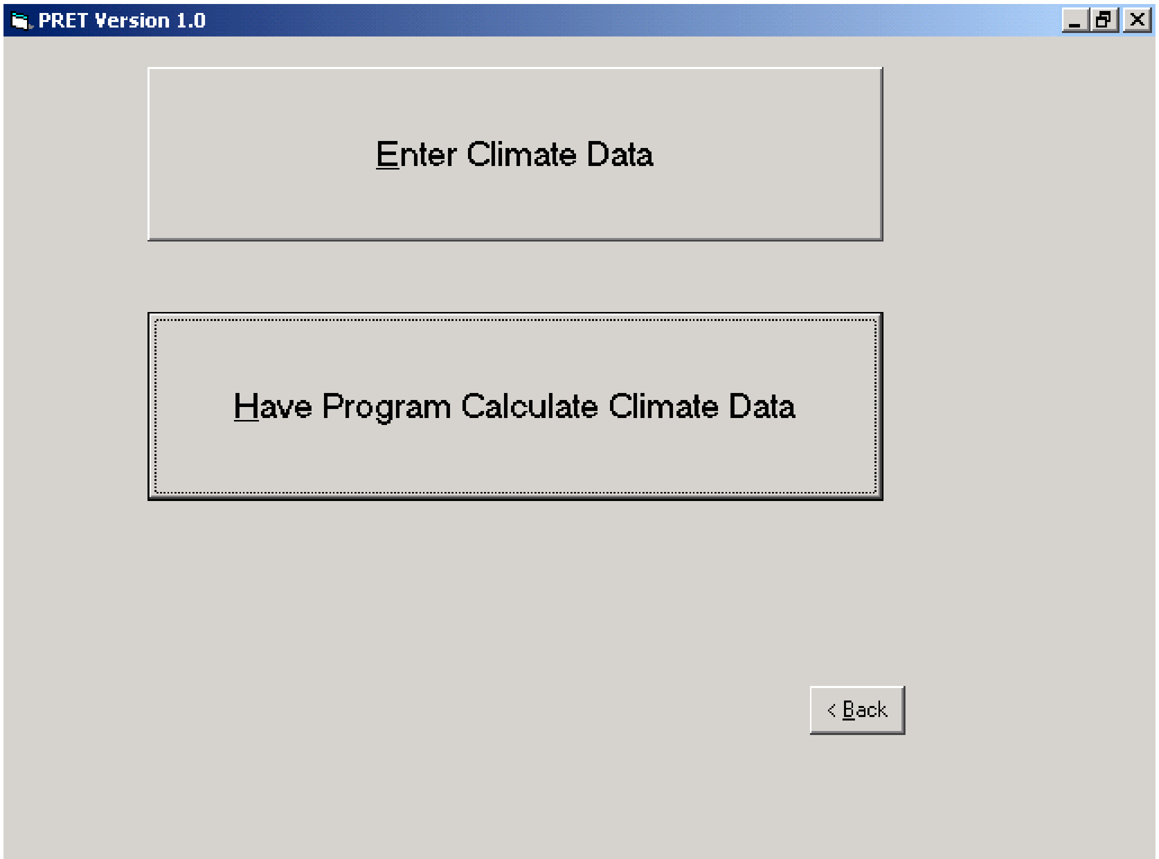
< Back

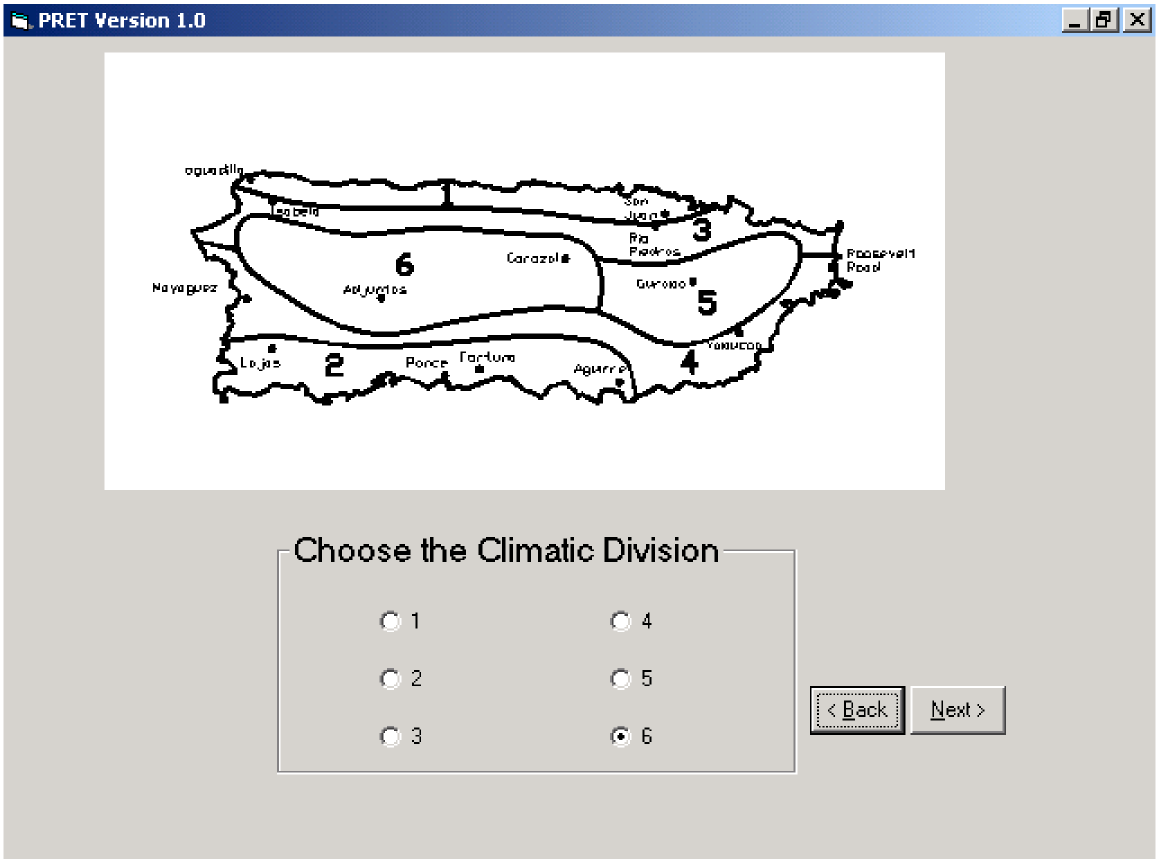
Next >


PRET Version 1.0
Save As
Preview
Kc, ETo, ET vs. Date
7
6
5
4
3
2
1
0
20/1
4/2
11/3
20/4
15/5
Kc
Eto
ET
Close

5.2 Automatic Calculation of Climate Data




PRET Version 1.0
Enter Climate Data
Have Program Calculate Climate Data
< Back


PRET Version 1.0
Choose the Climatic Division
1
2
3
4
5
6
< Back
Next >

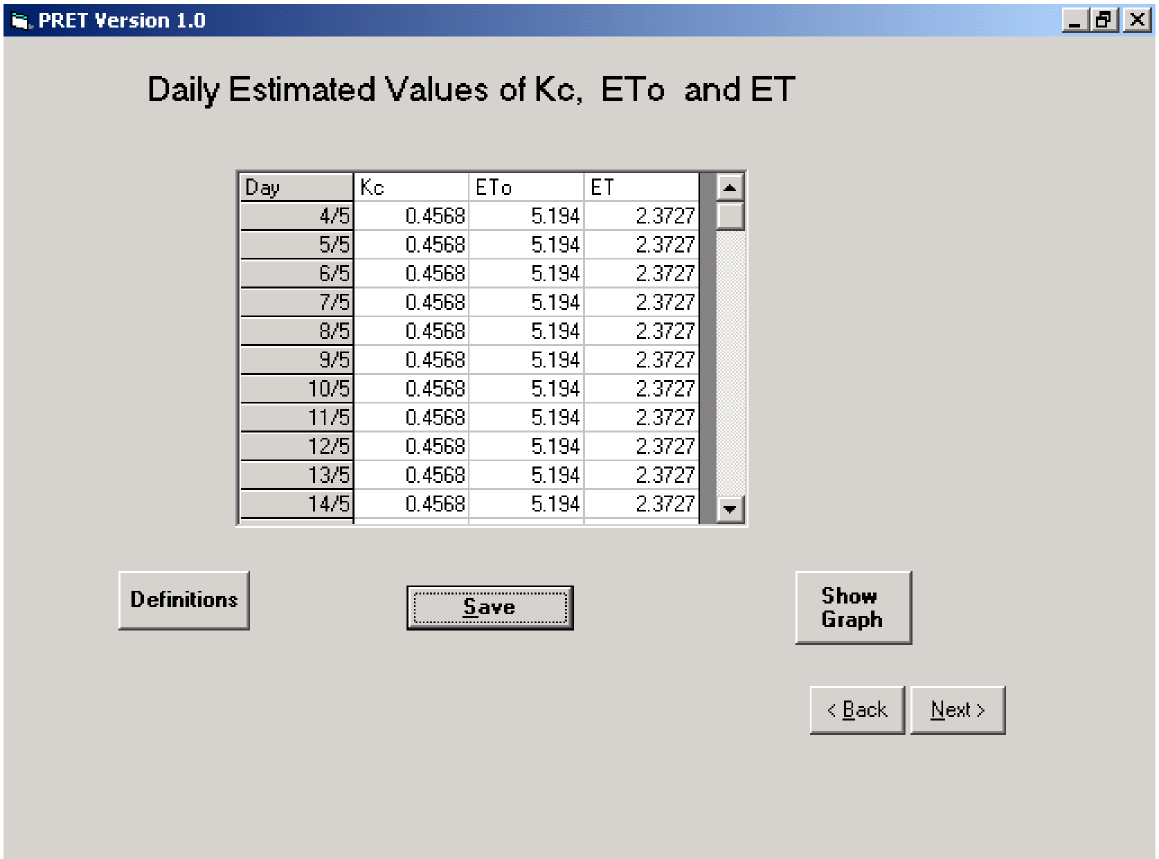
PRET Version 1.0

Climate Data

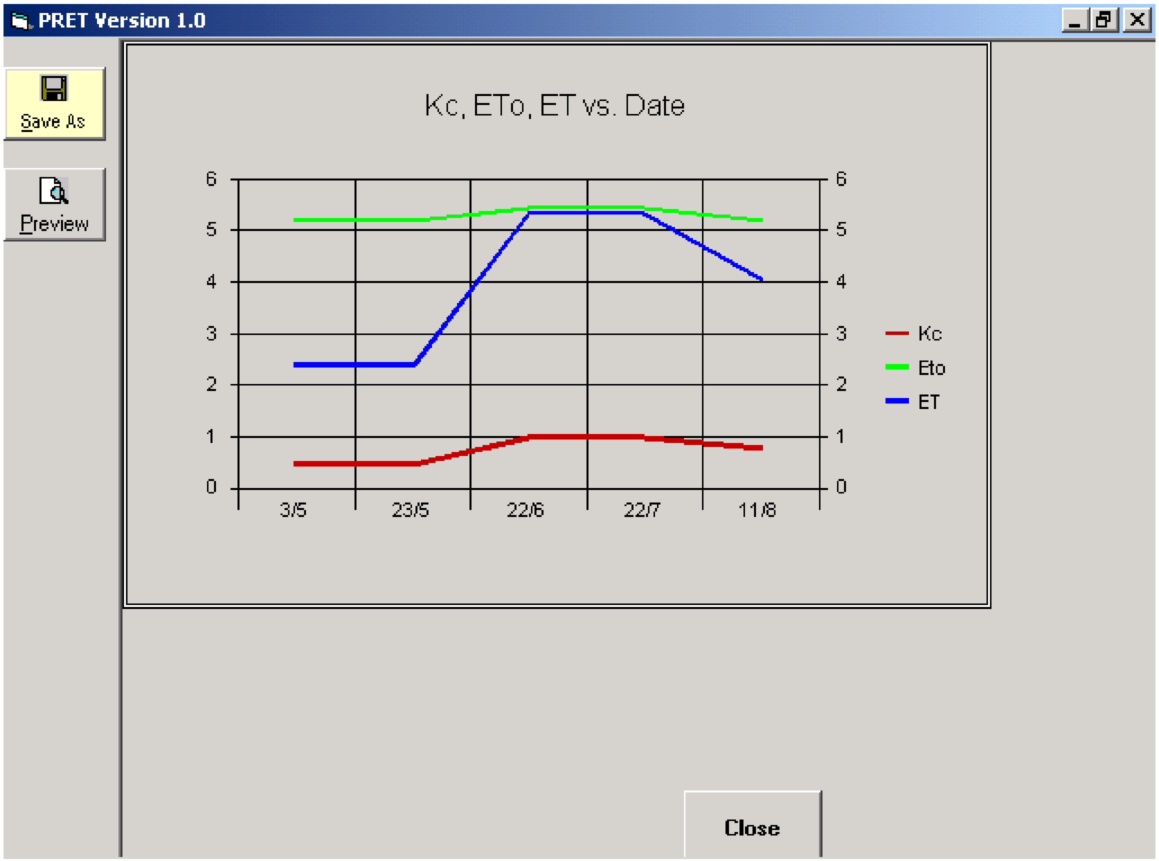
Crop - Pumpkin
Location - Dos Bocas
Latitude - 18.333333
Elevation - 60
Planting Date - 4/5/2002
Type Irrigation - Drip

Month	Tmin	Tmax	Rs	U2	Tdew	ETo
January	18.254	28.778	15.371	1.3	18.254	3.346
February	18.035	28.919	17.821	1.5	18.035	3.907
March	18.356	29.653	20.654	1.5	18.356	4.5
April	19.488	30.178	22.608	1.5	19.488	4.926
May	20.865	30.736	23.354	1.6	20.865	5.194
Jun	21.574	31.348	23.42	1.8	21.574	5.407
July	21.785	31.64	23.299	1.8	21.785	5.44
August	21.859	31.711	22.828	1.5	21.859	5.198
September	22.598	31.702	21.421	1.2	22.598	4.734
October	21.148	31.417	18.934	1.1	21.148	4.167
November	20.343	30.466	16.224	1	20.343	3.47
December	19.192	29.384	14.656	1	19.192	3.082

Definitions Save < Back Next >



Day	Kc	ETo	ET
4/5	0.4568	5.194	2.3727
5/5	0.4568	5.194	2.3727
6/5	0.4568	5.194	2.3727
7/5	0.4568	5.194	2.3727
8/5	0.4568	5.194	2.3727
9/5	0.4568	5.194	2.3727
10/5	0.4568	5.194	2.3727
11/5	0.4568	5.194	2.3727
12/5	0.4568	5.194	2.3727
13/5	0.4568	5.194	2.3727
14/5	0.4568	5.194	2.3727



6. LIMITATIONS

The climate estimation procedure presented in Section 2.2 should be considered only approximate for estimating reference evapotranspiration. Some potential limitations include:

- The data presented in Tables 1, 2 and 3 are valid only for Puerto Rico.
- The coefficient of determination (r^2) values for the regression equations relating elevation and temperature in some cases were quite low, especially for minimum air temperature. Capiel and Calvesbert (1976) showed, for example, that Utuado at elevation 130 m, located within an interior valley, had higher average temperatures during every month of the year than did Manati at elevation 75 m. The average temperature data for Utuado even exceeded average temperatures for Ponce (elevation 12 m) for nine months of the year. Therefore, within interior valleys, measured temperature data should be used if possible, rather than the temperature regression equations.
- The approach has not yet been validated using measured T_{dew} data from Climate Divisions 3, 5 and 6.

- Equation 4 has not yet been validated for areas within Puerto Rico where elevations exceed 100 m.

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