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THE CROP WEATHER ANALYZER: A PROGRAM TO EVALUATE REAL-TIME AND HISTORICAL IMPLICATIONS OF TEMPERATURE AND RAINFALL ON CROP DEVELOPMENT

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Abstract

Crop Weather Analyzer is a software program that makes it possible for the producer to assess the rate of crop development and the growing season rainfall in order to make informed crop management decisions. The software enables the crop consultant and/or manager to download real-time daily weather from the web or from the user's weather station(s), to calculate and compare cumulative growing-degree units for most major crops and cumulative precipitation for the current year-to-date with any two previous years and the long-term historical average through a graphic interface. The user may edit the daily data to reflect his/her site-specific observations and create his/her own weather files for future use with Crop Weather Analyzer and CroPMan. Crop growth stages can be overlayed on graphs to reference and/or anticipate the timing of key phenological growth stages. A graphic interface displays the results, which can be saved as windows metafiles (*.wmf) or ASCII text (*.txt) and can be directly incorporated into reports, emailed to clients, or imported into other software/programs. The software operates under Microsoft Windows 98, 2000, and XP operating systems.

Introduction

Growing season temperature and precipitation play a large role in the development of a crop. Air temperature is the principal controlling factor that defines the appearance rate of plant organs (leave, nodes, & reproductive structures). The progression of crop growth from one developmental stage to another is related to the accumulation of growing-degree units (GDU). The number of growing-degree units needed for a crop to progress to the next growth stage or for the next plant organ to appear is genetically programmed characteristics associated with the crop. Each crop (and in some cases variety) has a pre-determined base temperature where growth and development commences, an optimum temperature where crop metabolic functions are at their peak and a maximum temperature where growth and development cease. Theoretically, if the growing-degree units are properly accounted, the crop development rate should be the same, regardless of planting date or location (Hodges, 1991). However, the timing and amount of growing season precipitation also affect the growth processes of the crop. Some researchers have suggested that crop development depends too on the level of water stress, with mild water stress accelerating crop development and severe water stress decreasing or even stopping development (Hodges, 1991)

Anticipating key stages of crop development is important in managing cotton and other crops and addressing issues associated with pests, irrigation, and harvest. Crop Weather Analyzer enables the crop advisor and/or manager to assess the crop development and anticipate the occurrence of key growth stages with regard to the air temperature and precipitation that occurs when the crop is growing. Cumulative growing degree units (GDUs) and precipitation for the current year can be compared with that from previous years and the historical average. Since year-to-year differences in crop yield are related to air temperatures and precipitation during the growing season, the Crop Weather Analyzer can help producers make more informed decisions for management practices that are strongly influenced by weather and involve pests, irrigation timing, and/or harvest. Crop Weather Analyzer uses up-to-date and historical weather to calculate the cumulative GDUs and precipitation. Crop Weather Analyzer also provides the means to create and update daily weather files for the Crop Production and Management Model (CroPMan) (see: http://cropman.brc.tamus.edu).

The Crop Weather Analyzer can be downloaded and installed from the CroPMan website (http://cropman.brc.tamus.edu). It operates under Windows® 98, 2000, and XP and operates independently of the CroPMan program.

Features

Crop Weather Analyzer contains a web-based interface to download up-to-date weather to create and update weather files and CroPMan weather stations. The user can obtain weather from seven pre-set weather websites. Pre-selected weather websites include:

- U.S. Forage Condition Weather Data System
  http://cnrit.tamu.edu/usweather/weather.cgi
  Weather data is geo-referenced and covers the continental U.S.
- National Climatic Data Center
  http://lwf.ncdc.noaa.gov/servlets/DLY

http://lwf.ncdc.noaa.gov/servlets/DLYP (preliminary data)
Consists of 2000+ National Weather Service, COOP, U.S. weather stations.

- Texas ET Network
  http://texaset.tamu.edu
  Consists of approximately 25 stations from the Texas Panhandle to Central and South Texas.
- The Crop Weather Program
  http://cwp.tamu.edu/cgi-bin/start.cgi/content/home.html
  Consists of approximately 20 stations from the Texas Upper Coastal Bend.
- Texas Weather Connection
  http://webgis.tamu.edu/metar.aspx (Texas FAA stations)
  http://webgis.tamu.edu/plains.aspx (Texas North and South Plains)
  Consists collectively of approximately 100 stations from across Texas.

All the abovementioned stations with the exception of the U.S. Forage Condition Weather Data System website contain measured weather data from actual stations. The U.S. Forage Condition Weather Data System website contains geo-referenced weather data from the NOAA-Climate Prediction Center. Daily weather is interpolated from surrounding weather stations to the location of interest (based on longitude and latitude) and distance from nearest reporting stations. Weather data including, maximum and minimum temperature, precipitation, solar radiation, relative humidity, and wind speed, are available for a 12 x 12 square mile area. The precipitation from 1948 through 1998 is interpolated, as are the other weather variables, but from January 1999 to the current day precipitation is derived from corrected NEXRAD Doppler radar with similar resolution. Efforts are underway, however, to improve the precision of NEXRAD Doppler to a 2.5 x 2.5 square mile area. Tiger maps available through the U.S. Gazetteer website (http://tiger.census.gov/cgi-bin/mapbrowse-tbl) are available to identify coordinates for fields and locations of interest. The user enters the name or zip code of a town near the location of interest. A map is displayed for that area. By adding streets and other features, and using the zoom feature the user can manipulate the map and locate the farm, field, or location of interest. Clicking the cursor on the site of interest will re-center the map and compute and display the latitude and longitude coordinates required to obtain the daily weather information at the bottom of the map. These numbers are entered on the U.S. Forage Condition Weather Data System website along with the time period of interest to obtain weather information (Figure 1). The weather data is then displayed, and the user can save and convert the data to the "*.dly" format used by the Crop Weather Analyzer and CroPMan via the filter provided (Figure 2).

Users can also use weather data from his/her weather station or data source by constructing a tab-delimited text file with the daily weather data in the following format: year, month, day, radiation (MJ m-2), maximum temperature, minimum temperature (C or F), precipitation (inches or millimeters), relative humidity (fraction), and wind speed (m/s). The tab-delimited text data is converted to *.dly format through the weather filter and once converted, it can be scanned for missing days/data and edited using the built-in weather data editor. The user can modify, add, or delete days/data (Figure 3). Using the Weather Filter/File Maintenance feature, the user can combine any two previously created weather files, delete user-created weather files, or create, delete, and update weather stations (Figure 4). Weather stations created within Crop Weather Analyzer are compatible with CroPMan and can be used in the creation of runs.

Crop Weather Analyzer also contains a feature, which calculates cumulative GDUs and cumulative precipitation using data for a selected time frame contained in standard CroPMan weather stations, user-created weather stations, or weather files (*.dly) created through filters provided in Crop Weather Analyzer. This feature also calculates the total yearly precipitation, average yearly temperature, and the average maximum and minimum temperatures for the entire duration of the weather file/station. The program is also capable of substituting any missing data with average long-term data derived by calculating the daily average for each of the weather parameters across all years in the weather file. Weather output is based on a selected weather file/station, crop, base temperature, upper limit temperature, and time frame (start/stop date) (Figure 5).

Applications

Calculation of GDUs is dependent on the base temperature. Within Crop Weather Analyzer the user can select crop base temperatures from three sources: those used by the CroPMan model, the Standard crop base temperatures (e.g., those typically used by agronomists to calculate growing degree units for crop development (phenology)), or "User-Defined" bases temperatures (e.g., those supplied by the user for crops not covered).

NOTE: Cumulative Growing Degree Units (GDUs) are estimated as follows:

GDU = ((Daily Maximum Temperature + Daily Minimum Temperature)/2) – Base Temperature.

Cumulative GDUs are the daily GDUs summed over a specified time interval.

The graphic and/or text file output enables the user to compare cumulative GDUs and precipitation for up to two years of data with that of the long-term average over all years in the selected weather file (Figure 6 and 7). By clicking on any point on any line graph, point data (cumulative GDUs or precipitation) is displayed for the selected day. Cumulative and total precipitation, average temperature, and maximum and minimum temperature can also be displayed on a yearly/monthly basis (Figure 8). This lets the user see the precipitation distribution for any year/month combination. The crop growth stage overlay feature enables the user to overlay growth stages for major crops (corn, grain sorghum, and cotton) on cumulative GDU graphs and compare the crop development for the current year with that experienced in any previous year and the historical average (Figure 9). This feature helps growers anticipate/predict the timing of key phenological events and improve their ability to make pest and/or crop management decisions. The graphic information displayed can be saved as a windows metafile (*.wmf) and incorporated into documents or reports to growers, while text output information can be saved and used in other analyses and programs.

Crop Weather Analyzer is a versatile tool for assessing the rate of crop development and for anticipating the occurrence of key crop growth stages critical for management. It puts current weather data at the user's finger providing a means to make informative crop management decisions.

References

Hodges, T. 1991. Predicting Crop Phenology. CRC Press, Boca Raton, FL.

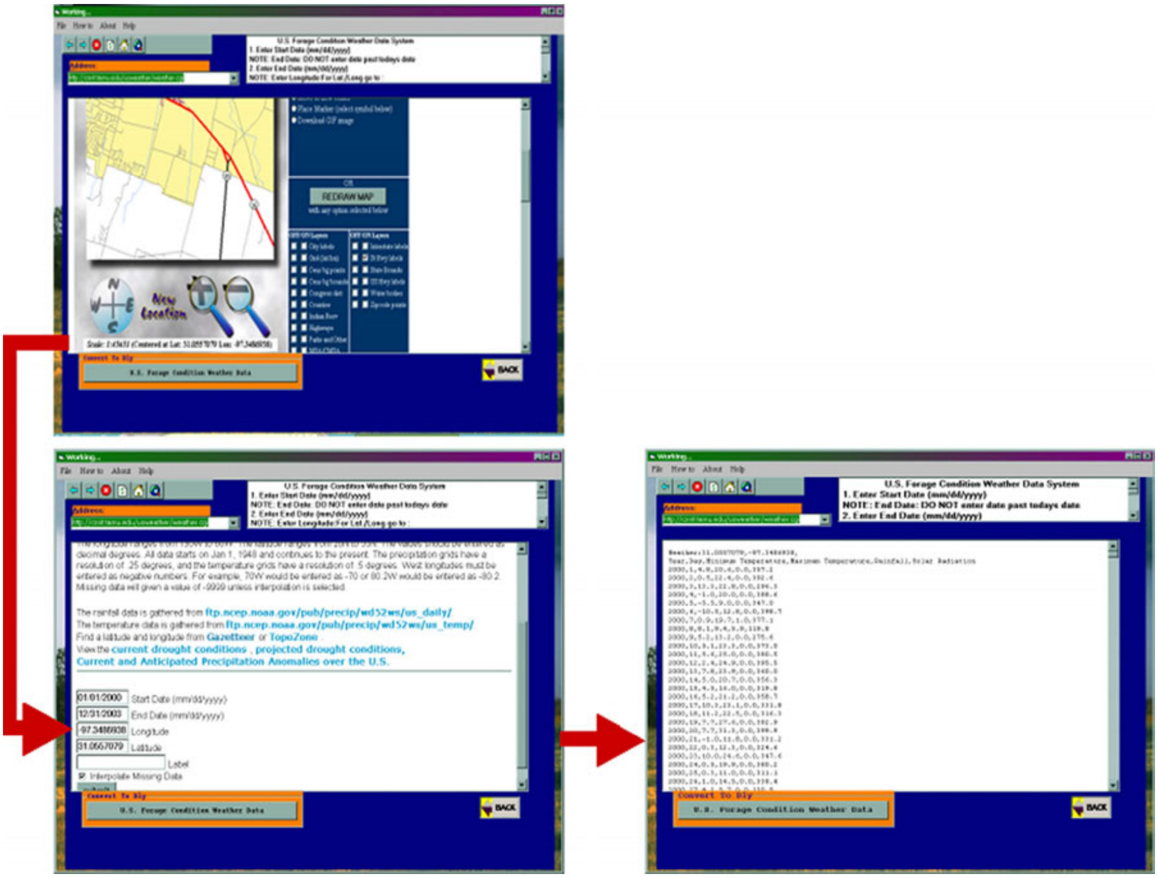


Figure 1. Using Tiger maps to find latitude and longitude values for use with the U.S. Forage Condition Weather Data System website to obtain weather data for a specific site.

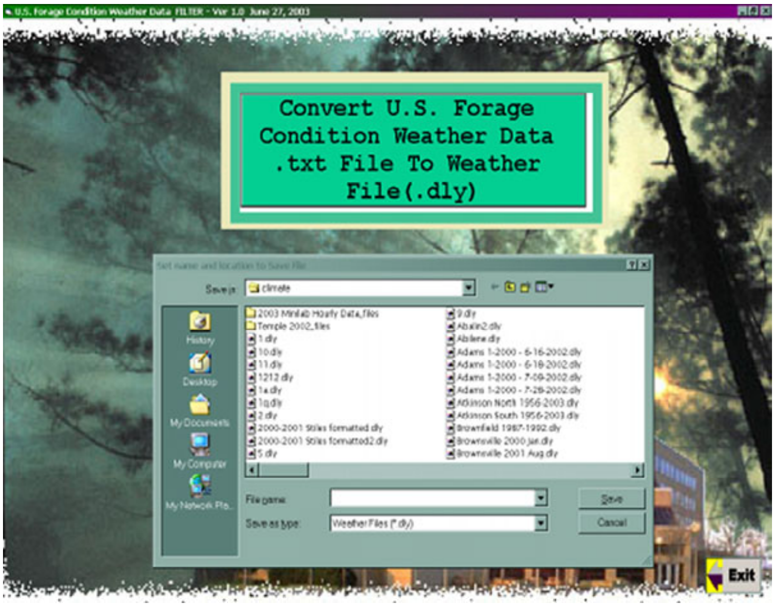
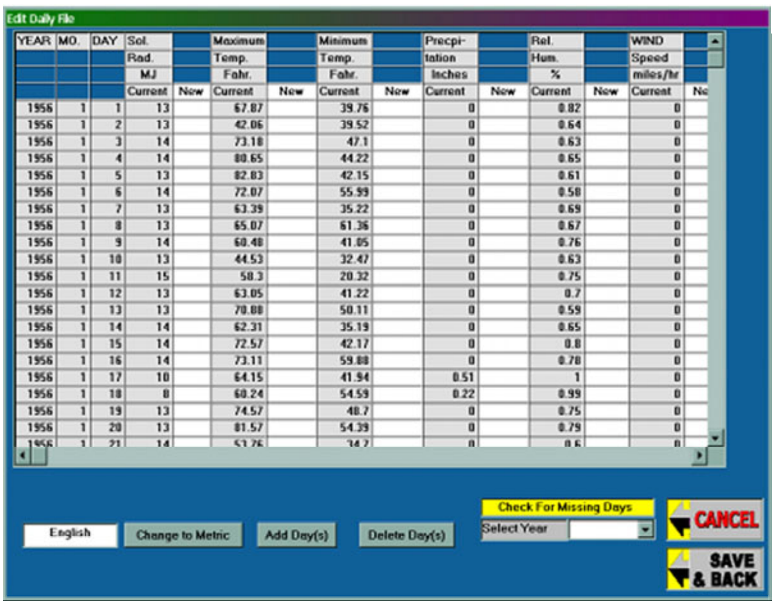


Figure 2. Conversion of weather data obtained from the U.S. Forage Condition Weather Data System website into a Crop Weather Analyzer *.dly file.



YEAR	MO.	DAY	Sol. Rad. MJ Current	New	Maximum Temp. Fahr. Current	New	Minimum Temp. Fahr. Current	New	Precpi-tation Inches Current	New	Rel. Hum. % Current	New	WIND Speed miles/hr Current
1956	1	1	13		67.87		39.76		0		0.82		0
1956	1	2	13		42.06		39.52		0		0.64		0
1956	1	3	14		73.18		47.1		0		0.63		0
1956	1	4	14		80.65		44.22		0		0.65		0
1956	1	5	13		82.83		42.15		0		0.61		0
1956	1	6	14		72.07		55.99		0		0.58		0
1956	1	7	13		63.39		35.22		0		0.69		0
1956	1	8	13		65.07		61.36		0		0.67		0
1956	1	9	14		60.48		41.05		0		0.76		0
1956	1	10	13		44.53		32.47		0		0.63		0
1956	1	11	15		58.3		20.32		0		0.75		0
1956	1	12	13		63.05		41.22		0		0.7		0
1956	1	13	13		70.88		50.11		0		0.59		0
1956	1	14	14		62.31		35.19		0		0.65		0
1956	1	15	14		72.57		42.17		0		0.8		0
1956	1	16	14		73.11		59.88		0		0.78		0
1956	1	17	10		64.15		41.94		0.51		1		0
1956	1	18	8		60.24		54.59		0.22		0.99		0
1956	1	19	13		74.57		48.7		0		0.75		0
1956	1	20	13		81.57		54.39		0		0.79		0

Figure 3. Using the weather editor to edit weather data.

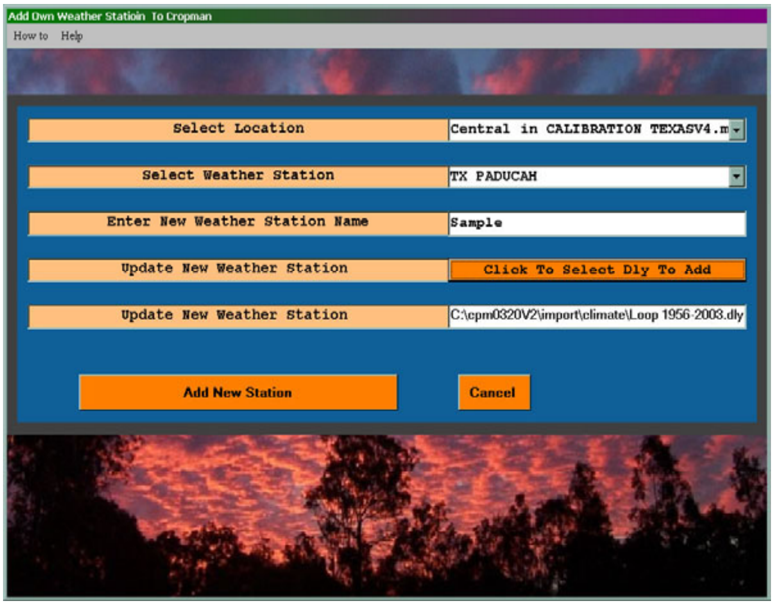


Figure 4. Creating a new weather station within Crop Weather Analyzer.

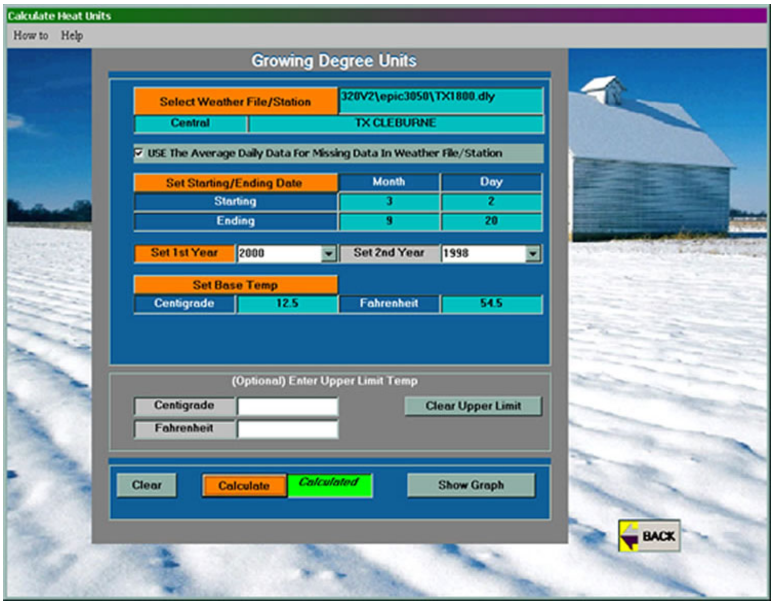


Figure 5. Setup screen for calculation of growing degree units.

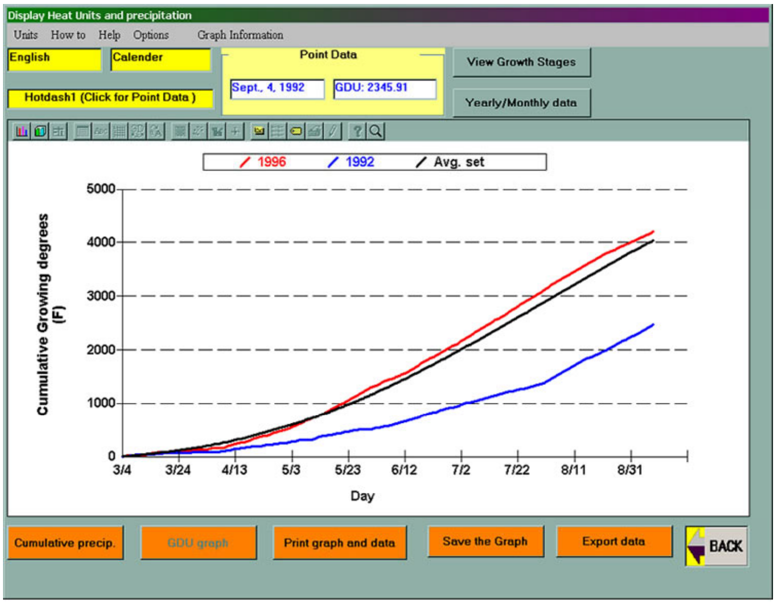


Figure 6. Comparison of GDUs for 1992, 1996, and historical long-term average.

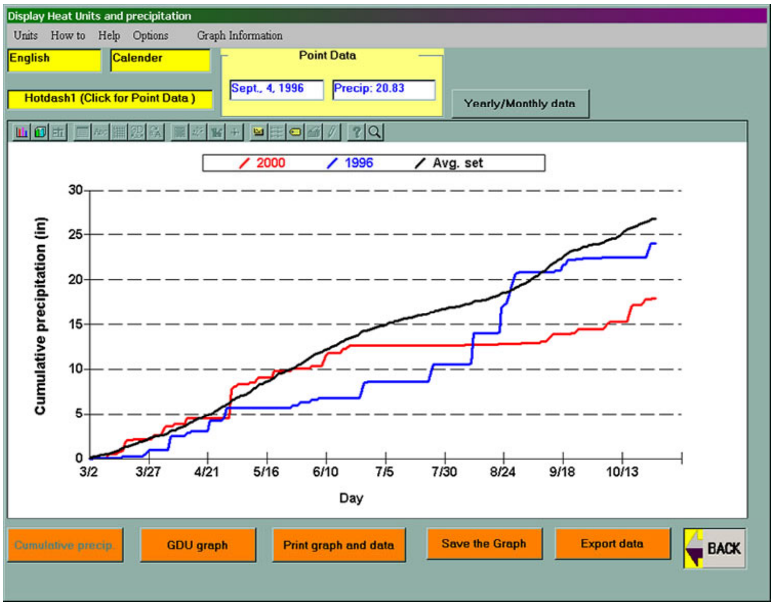


Figure 7. Comparison of cumulative precipitation for 1996, 2000 and historical long-term average.

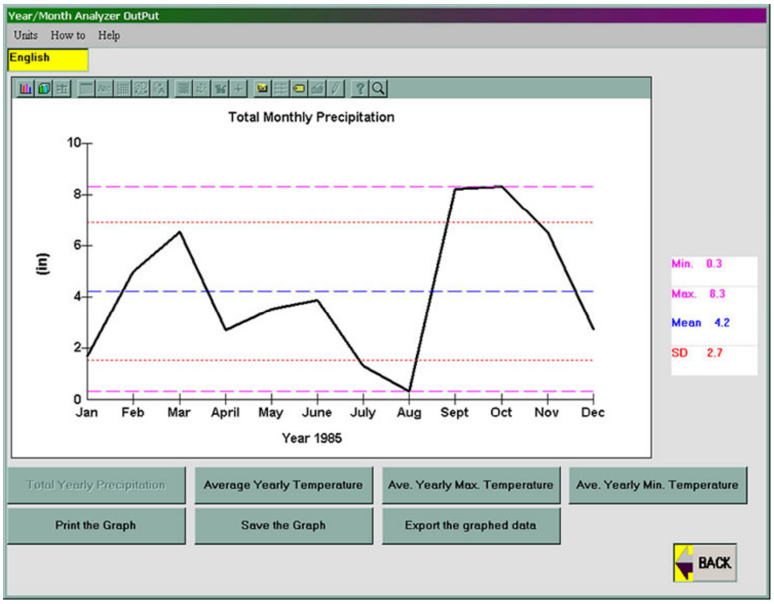


Figure 8. Monthly precipitation distribution graph.

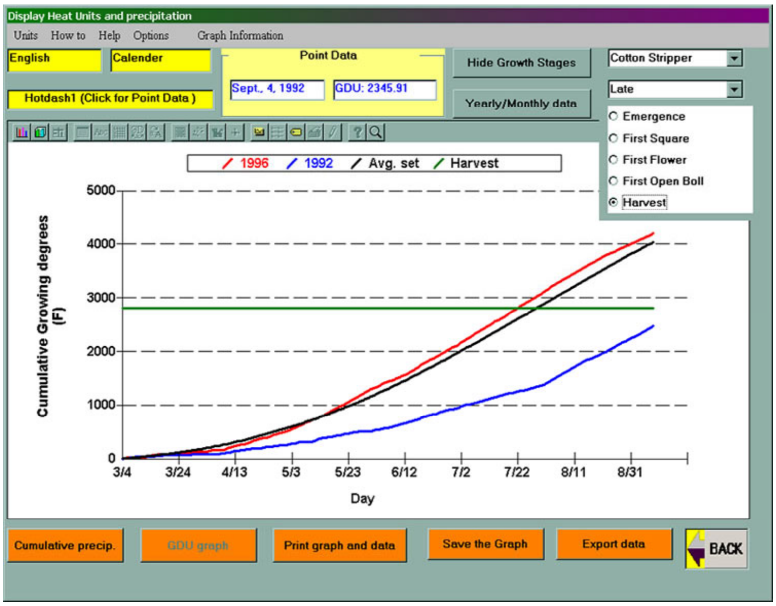


Figure 9. Crop growth stage overlay on GDU graph.