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WATER USE AND IRRIGATION SCHEDULING OF YOUNG BLUEBERRIES

Final Research Report
(Three-Year Project)

presented to

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
and
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

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WATER USE AND IRRIGATION SCHEDULING OF YOUNG BLUEBERRIES

INTRODUCTION

Blueberries show great promise as a Florida fruit crop. Although blueberries are grown in many other states, Florida's climate allows blueberries grown here to reach maturity earlier, avoiding competition with growers in other states, thus commanding high prices. This advantage has been increased by the recent introduction of earlier-yielding Highbush varieties.

The recent Task Force on Microirrigation in Florida at the Institute of Food and Agricultural Sciences (IFAS) at the University of Florida reported that 2,100 acres of blueberries are grown in Florida (Smajstrla et al., 1993). This acreage is expected to expand as more growers take advantage of Florida's unique market window and new early-yielding blueberry varieties, and as existing growers expand their acreage.

The importance of irrigating young blueberry plants has been recognized for some time and is apparent throughout the literature. In dry years, irrigation is very important during fruit formation. In Florida, Buchanan et al. (1978) reported that yield and berry size were increased by 20 to 25 percent with drip irrigation in a dry year, and that a drip irrigation system would pay for itself in one year at the market prices at that time. Irrigation is critical to successful production in Florida because rainfall is typically low during the time of blueberry bud formation. Adequate irrigation during bud formation is critical for the next year's crop (Lyrene and Crocker, 1991).

Microirrigation allows precise water application directly to the root zone of the crop. The amount and placement of water can be precisely controlled to minimize application losses. In Florida, blueberries are grown on sandy soils with low waterholding capacities and large pore spaces. Thus, water applications must be frequent and relatively small to avoid water losses from the root zone. This requires precise irrigation scheduling.

Earlier research at IFAS, University of Florida, demonstrated the importance of an organic mulch ground cover and precise irrigation scheduling on the growth of young Rabbiteye and Highbush blueberry plants (Haman et al., 1988). The control of a microirrigation system using magnetic switching tensiometers was also demonstrated to be an effective means of scheduling irrigations for blueberries (Smajstrla et al., 1988).

Prior to this research, evapotranspiration and irrigation water requirements of blueberries had not been studied under Florida conditions. The objectives of this research were:

(1) to determine evapotranspiration and irrigation requirements of Florida blueberries,

(2) to develop crop water use coefficients that can be used to schedule irrigations and to estimate crop water use from climate factors, and

(3) to evaluate three irrigation scheduling methods in order to optimize production with respect to irrigation.

This research evaluated three different threshold levels of soil water tension for scheduling irrigations using tensiometers. This levels were set at 10 centibars (cb), 15 cb, and 20 cb. Both native Rabbiteye and newly developed early-yielding Highbush varieties were studied for three years. Two-year old, container-grown plants, were transplanted to the field at the beginning of 1991. The experiment ended in December 1993. Total water use (evapotranspiration) of the plants, irrigation requirements, crop water use coefficients, crop yield, and the vegetative plant growth were evaluated during the three years after transplanting.

MATERIALS AND METHODS

This research was conducted in a field lysimeter system at the IFAS Irrigation Research and Education Park in Gainesville, Florida. Details of the lysimeter construction were given by Smajstrla (1985). Two-year-old container-grown Highbush (Sharpblue variety) and Rabbiteye (Powderblue and Premier varieties) blueberry plants were transplented into the lysimeters at the begining of the experiment. Two plants were grown in each of 24 drainage-type lysimeters, for a total of 48 plants (Figure 1). Blueberries were grown following typical Florida production practices (Lyrene and Crocker, 1986, 1991). The experiment was conducted for three years.

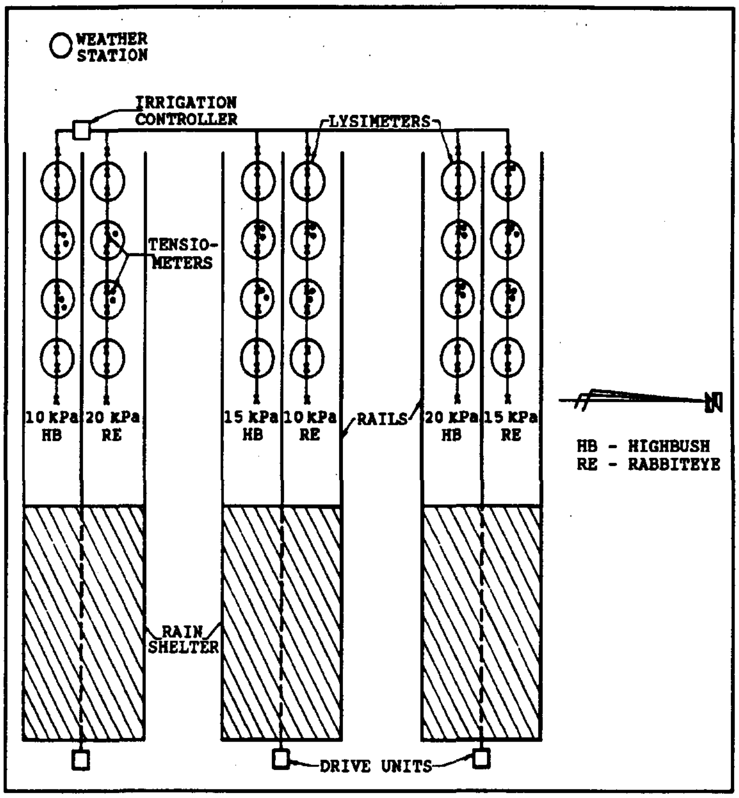

Figure 1. The experimental site in the IFAS Irrigation Research and Education Park in Gainesville.

A spray-jet microirrigation system was used in this study. Treatments consisted of irrigation at soil water tensions of 10 cb, 15 cb, and 20 cb. This project was designed so that irrigations would be scheduled using an automatic control system. Pressure-transducer tensiometers were used to send voltage signals to a microprocessor-based controller. The controller was designed to open an irrigation solenoid valve for any treatment when the transducer signal indicated that the threshold soil tension had been exceeded. During the first year of this project, numerous problems were encountered with the operation of the pressure transducers in this automated control system. Because of those problems irrigations, after the first year, were scheduled based on the combination of sensor readings and manual readings which were used to override the automated control system when necessary. During the second year, magnetic switching tensiometers were installed and used to schedule irrigation events for the remainder of the project.

Crop evapotranspiration (ET) was determined for each lysimeter by measuring water applied by irrigation and rainfall, water drained from the lysimeter, and water stored in the soil. Reference evapotranspiration (grass reference, ETo) was calculated using the Penman method. The weather data required for these calculations were continuously recorded by an automated weather station at the research site.

Because field data collections of soil water content necessary to calculate the water budget for the lysimeters were not always measured on the last day of each month, water budgets were calculated for the intervals between field data collections. Monthly average data were calculated by linearly interpolating between data collection periods.

Monthly crop water use coefficients were calculated for the Penman, Blaney-Criddle (daylength-based, Soil Conservation Service (SCS)) and modified Blaney-Criddle (solar radiation based) evapotranspiration equations. Crop coefficients were calculated by dividing the monthly crop ET by the calculated ETo for the Penman method, and by dividing the crop ET by the Blaney-Criddle climate factors for the Blaney-Criddle methods.

Vegetative growth of blueberry plants was measured monthly. The volume of each plant canopy was calculated from three measurements: the height, the width along the plant row and the width perpendicular to the row. Fruit production data were collected during the last two years of the research. Fruit yields were measured by manually harvesting ripe berries as required (at least weekly) during the production season. Fruit were counted and weighed to determine fruit size at each harvest.

RESULTS AND DISCUSSION

This report presents the research results for three years of the experiment, from 1991 through 1993. The actual data collection at the site started in April 1991, when all instruments were installed, and continued until December 1993. Results are shown in graphical form in the body of the report and they are tabulated in the Appendix B.

WEATHER DATA

Weather data at the research site were monitored during the three years of the experiment. Long-term average weather data, based on a 30-year information (1961-1990) from the University of Florida Agronomy Farm Weather Station, are also presented in this report for the reference.

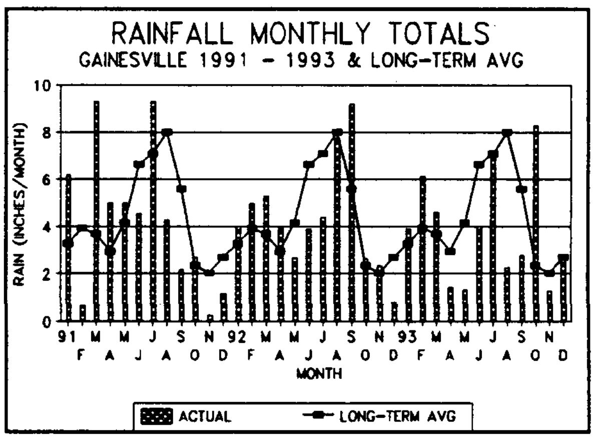

Figure 2. Actual 1991-1993 and long-term (1961-1990) average rainfall.

The distribution of monthly rainfall at the research site during three years of the experiment is shown in Figure 2. Long-term average data from the University of Florida Agronomy Farm Weather Station are also shown for reference. The totals for all three years of the experiment (50.5 inches in 1991, 51.7 inches in 1992, and 45.5 inches in 1993) were a little lower than the long-term average of 52.3 inches. The monthly distributions were also different from the typical distribution in this area. In 1991 the monthly average rainfall exceeded the long-term average in April, May, and July, but was significantly lower in June, August, September, November, and December. The 1992 rain exceeded the long-term monthly average from January through April and in September. August, October and November values were very close to long-term averages. The 1992 rainfall was less than the long-term average in May, June, July, and December. 1993 was the driest year out of the three experimental years, with more than ten inches below the average annual rainfall. The rainfall monthly averages exceeded the long term averages only in February, March and October with much less rainfall than average during the months of high evapotranspirational demand.

Figures 3, 4, and 5 show respectively the 1991, 1992, and 1993 distributions of daily rain events at the research site during three years of the experiment. It should be noted that large individual rain events were not highly effective for the shallow-rooted blueberries.

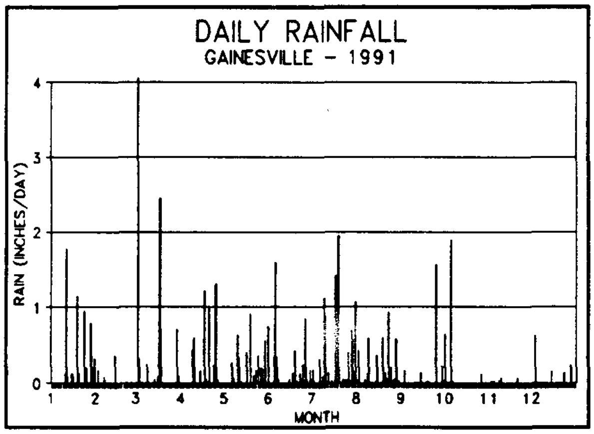

Figure 3. 1991 distribution of daily rainfall at the research project site.

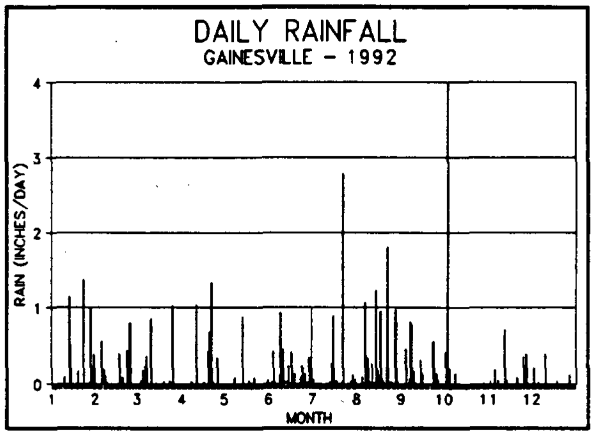

Figure 4. 1992 distribution of daily rainfall at the research project site.

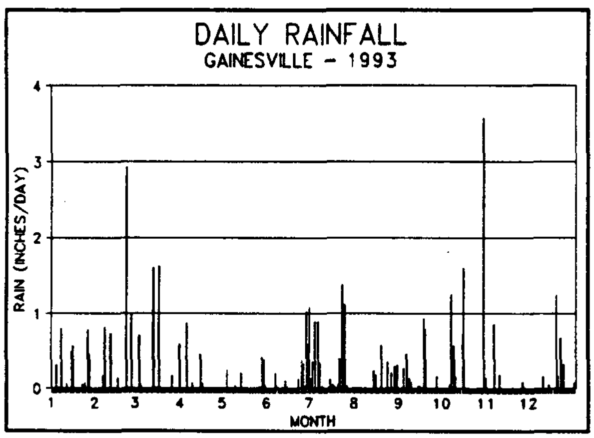

Figure 5. 1993 distribution of daily rainfall at the research project site.

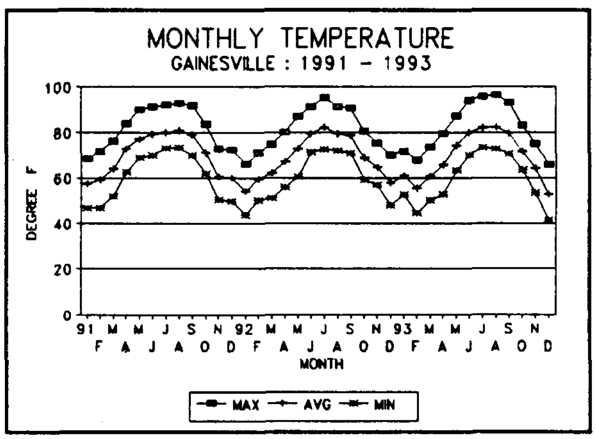

Figure 6. Distribution of mean monthly maximum, average, and minimum temperatures at the research site, 1991-1993.

Figure 6 shows the three-year distribution of monthly maximum, minimum, and average temperatures. Figure 7 shows long-term maximum, minimum, and average temperatures. An overlay of these figures shows that in all three years temperature data were very representative of the long-term temperatures. Figures 8, 9, and 10 show the daily maximum, minimum, and average temperatures in 1991, 1992, and 1993 respectively.

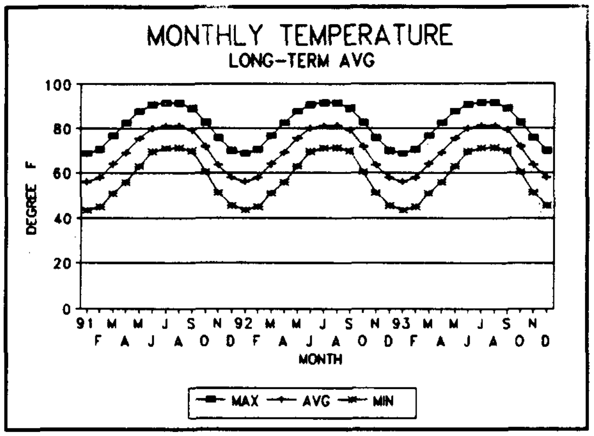

Figure 7. Distribution of long-term (1961-1990) mean monthly maximum, average, and minimum temperatures at the research site.

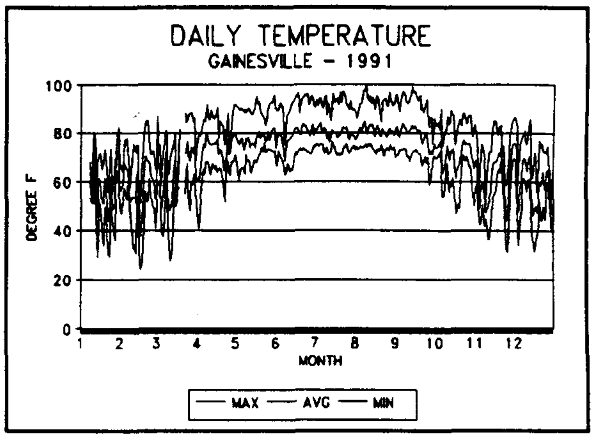

Figure 8. Annual distribution of daily maximum, average, and minimum temperatures at the research site, 1991.

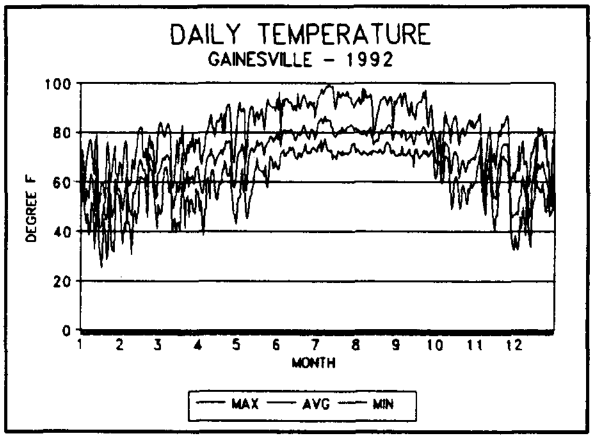

Figure 9. Annual distribution of daily maximum, average, and minimum temperatures at the research site, 1992.

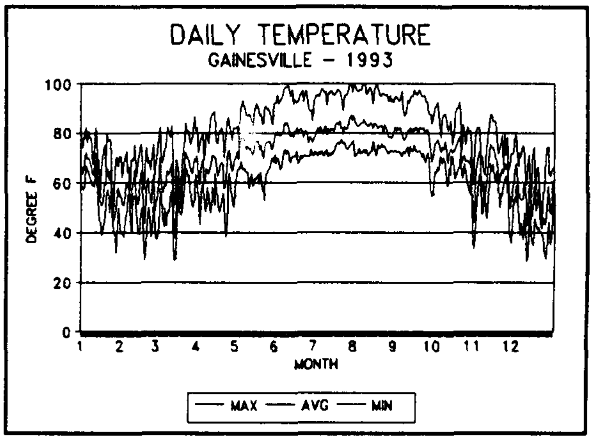

Figure 10. Annual distribution of daily maximum, average, and minimum temperatures at the research site, 1993.

In Figures 6 and 7, average daily temperatures were calculated from the average of 24 hourly values, rather than the arithmetic average of the maximum and minimum values. In the version of the Penman ETo equation used in this work, the minimum temperature was used as an estimate of the dewpoint temperature. Thus it was an index of the daily vapor pressure deficit (or humidity) at the research site.

Figure 11 shows the actual and long-term average distribution of daily wind speeds at the research site in 1991-93. Wind speeds at the 2 meters (6 feet (ft)) height were recorded. Wind speeds were lower and less variable during the summer months as compared to the other seasons. However, daily wind speeds were almost always low and only occasionally exceeded 150 miles per day. This figure also shows the comparison of the annual distribution of monthly average wind speeds at the research site and the long-term average values. For all three years, wind speeds were slightly greater than the long-term average values. The daily wind run at the site for 1991, 1992, and 1993 is presented in Figures 12, 13, and 14.

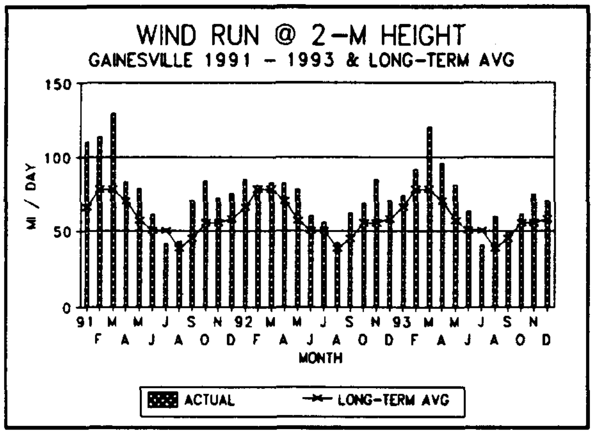

Figure 11. Annual distribution of daily actual and long-term (1961-1990) average wind speeds at the research site, 1991-1993.

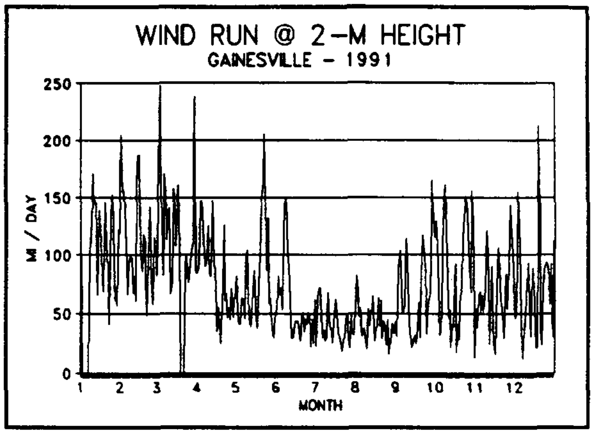

Figure 12. Annual distribution of daily wind speed at the research site, 1991.

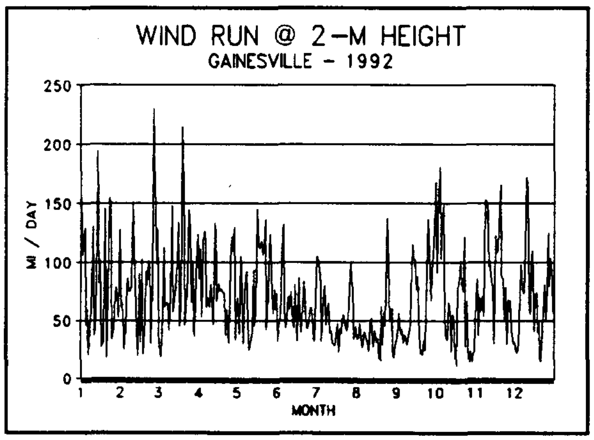

Figure 13. Annual distribution of daily wind speed at the research site, 1992.

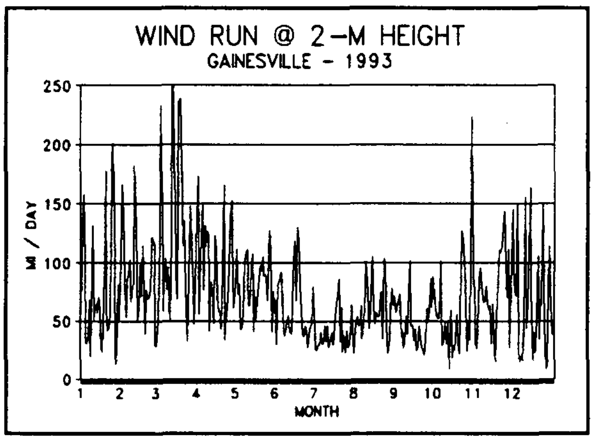

Figure 14. Annual distribution of daily wind speed at the research site, 1993.

The annual distribution of daily solar radiation at the research site for 1991-93 is presented in Figures 15-17 respectively. The day-to-day variation in solar radiation was high at this location due to frequent and variable cloud cover.

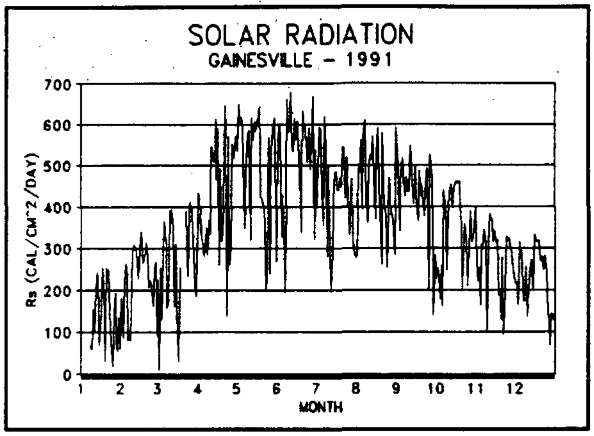

Figure 15. Annual distribution of daily solar radiation at the research site, 1991.

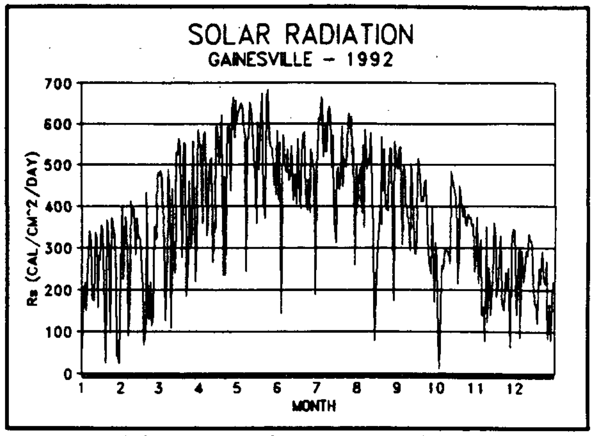

Figure 16. Annual distribution of daily solar radiation at the research site, 1992.

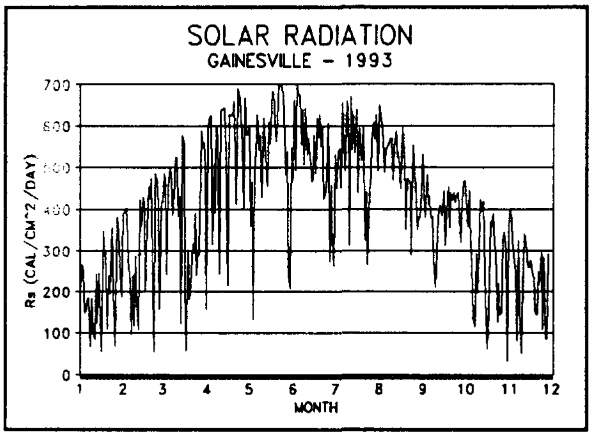

Figure 17. Annual distribution of daily solar radiation at the research site, 1993.

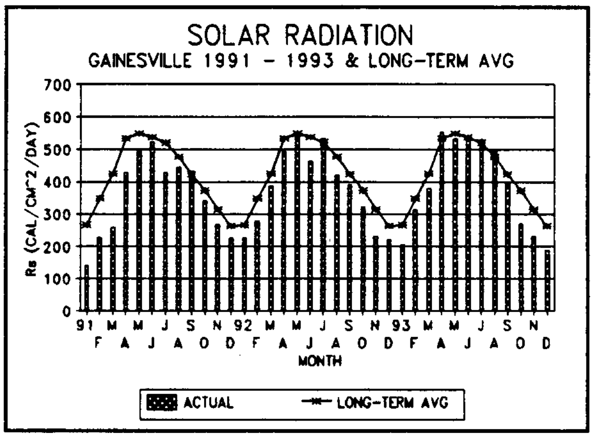

Figure 18. Long-term and monthly average solar radiation at the research site, 1991-1993.

The monthly average for these three years and long-term average solar radiation data are shown in Figure 18. In 1991 the radiation was lower than the long-term average every month except September. The 1992 radiation data were slightly lower than the long-term average data every month except May and July. This pattern indicates greater cloud cover than average and therefore less available energy for ET every month except the relatively clear, dry months of May and July in 1992. In 1993 the actual recorded data closely followed the long-term average for this area during the summer months (May, June, July, August, and September) with slightly lower radiation levels during the remaining months.

REFERENCE EVAPOTRANSPIRATION, ETo

Daily solar radiation, temperature, and wind speed data from the automatic weather station at the research site were used to calculate daily reference evapotranspiration (grass reference, ETo) using the Penman method. This is an index of climate demand which correlates directly with crop evapotranspiration.

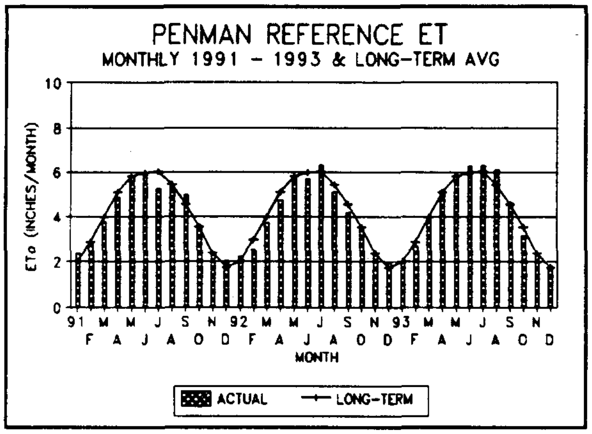

Figure 19. Long-term (1961-1990) and actual monthly average Penman reference ET at the research site.

Figure 19 shows the three-year distribution of monthly average Penman ETo during 1991-1993. This pattern closely tracks the annual distributions of solar radiation (Figure 18), with peaks in June 1991, May and July in 1992, and June and July 1993. This agreement is typical because solar radiation provides the energy required to convert water from the liquid to vapor form during evaporation.

The 1991-1993 monthly average ETo data closely followed the long-term average ETo data throughout the year (Figure 19). The ETo data were slightly lower during the spring and summer months in 1991. They were also slightly lower during that time in 1992 with the exception of July, when the radiation values were slightly higher. In 1993, the ETo data followed the long-term average very closely with the slightly higher values for June, July, and August. Overall, the 1991, 1992, and 1993 climate demand values were 49.2 inches, 48.1 inches, and 50.5 inches respectively which is very similar to the long-term average (ETo = 49.4 inches) for this location.

IRRIGATION

The monthly amounts of irrigation water applied in all treatments during three years for Rabbiteye and Highbush blueberries are presented in Figures 20-22 and 23-25. The irrigation applications generally matched the annual distributions of climate and crop growth factors, with smaller applications during low climate-demand months and larger applications during high demand months when rains were low or nonuniform. For example, in 1991 irrigation was clearly reduced in the month of July due to the large monthly rainfall and its uniform distribution (see Figures 2 and 3). Similar reduction can be observed in August of 1992 for the same reasons (Figures 2 and 4).

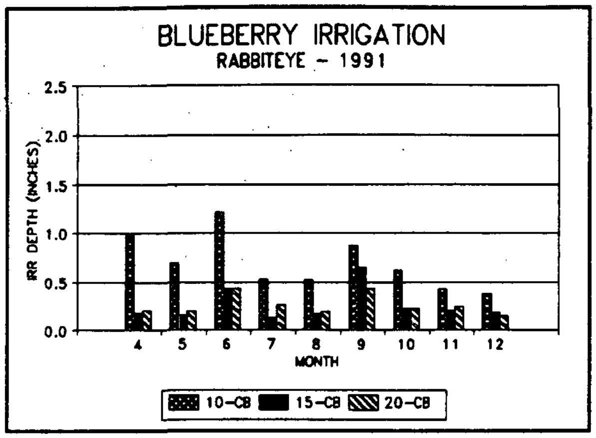

Figure 20. Distribution of monthly irrigation applications as a function of irrigation treatment for rabbiteye blueberries, 1991.

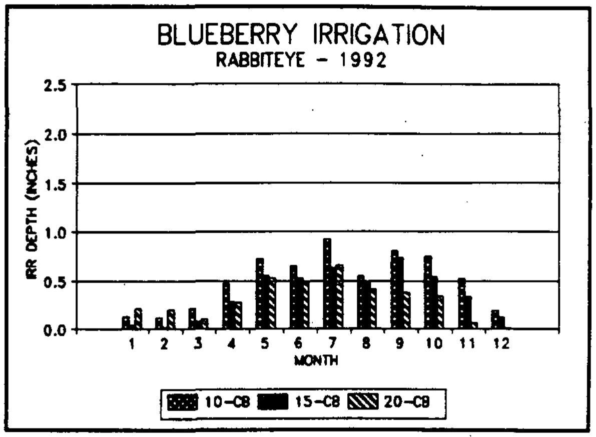

Figure 21. Distribution of monthly irrigation applications as a function of irrigation treatment for Rabbiteye blueberries, 1992.

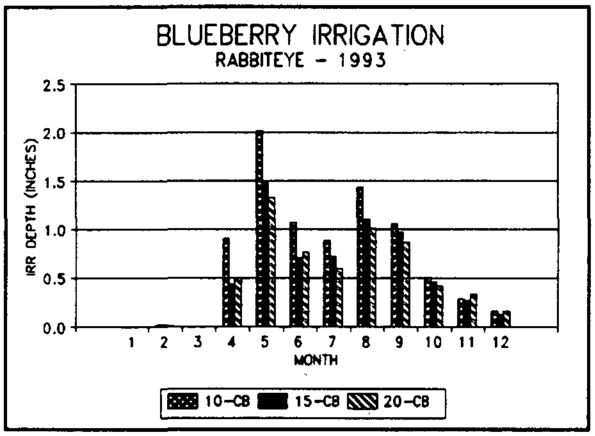

Figure 22. Distribution of monthly irrigation applications as a function of irrigation treatment for Rabbiteye blueberries, 1993.

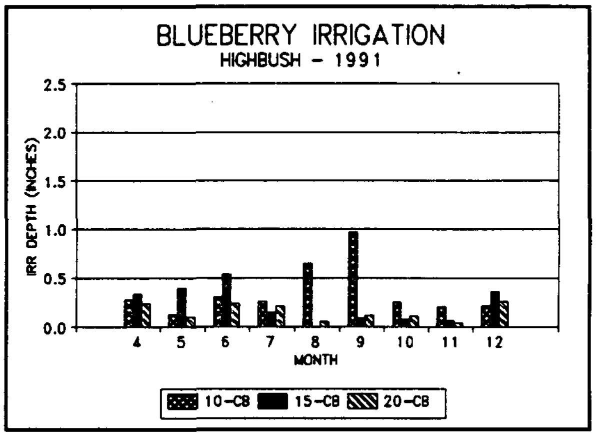

Figure 23. Distribution of monthly irrigation applications as a function of irrigation treatment for Highbush blueberries, 1991.

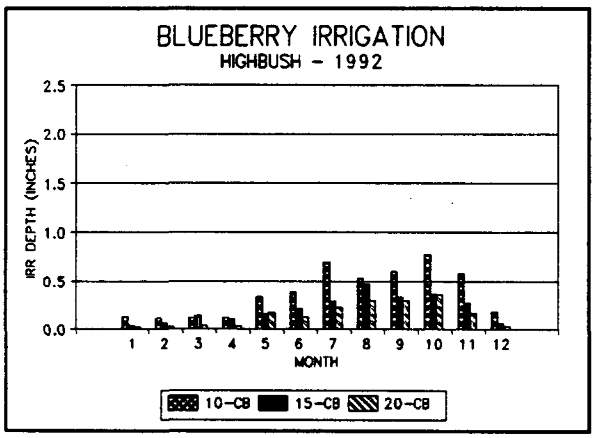

Figure 24. Distribution of monthly irrigation applications as a function of irrigation treatment for Highbush blueberries, 1992.

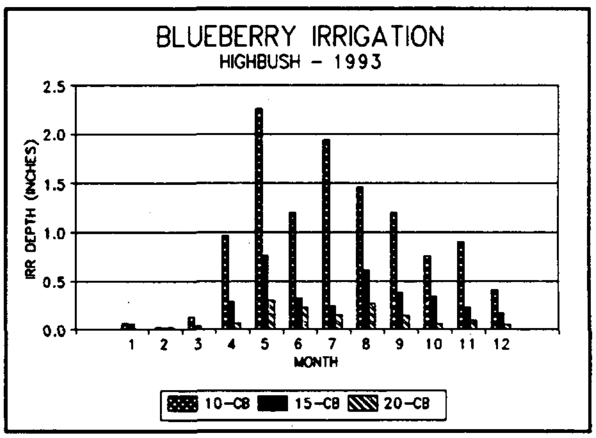

Figure 25. Distribution of monthly irrigation applications as a function of irrigation treatment for Highbush blueberries, 1993.

Figures 26 and 27 present the cumulative irrigation for both varieties of blueberry during three years of the experiment. The significant increase in the slope of the lines during 1993 for all treatments (with exception of 20-cb Highbush) reflects the higher water requirement of the larger plants and the lower rain contribution during that year.

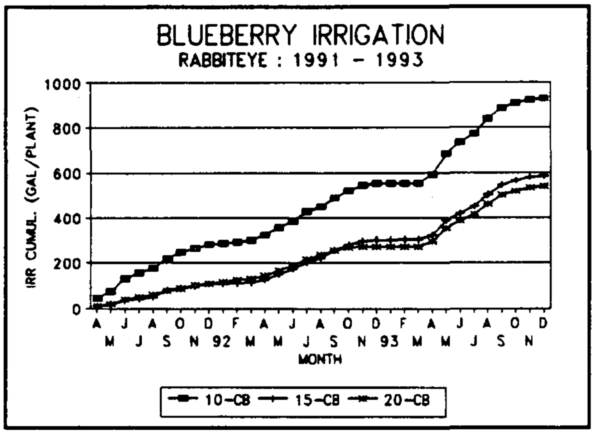

Figure 26. Cumulative irrigation for Rabbiteye variety, 1991-1993.

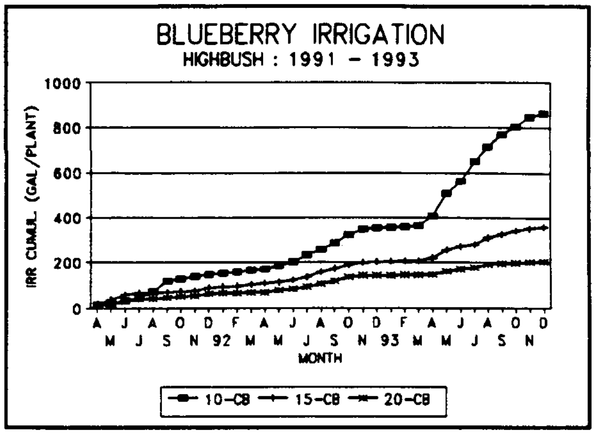

Figure 27. Cumulative irrigation for Highbush variety, 1991-1993.

An exception to the expected irrigation pattern occurred in January through early March of 1992 when excessive irrigation applications were made to the Rabbiteye 20-cb treatment. These applications were due to instrumentation problems and should not have occurred. However, the water applied during these irrigations was relatively ineffective and was recovered as drainage (see Figure 38 in the following section of this report). These applications had little effect on the annual blueberry water use in 1992. They occurred during the months when water use was low and the rainfall alone was nearly adequate to provide for the ET.

Annual irrigation summaries for all treatments are shown in Figures 28-30. Over the first two years of the experiment (1991 and 1992) the 10-cb treatment consistently required the most irrigation, followed by the 15-cb, and then the 20-cb treatments. During the first two years of the experiment, the Highbush variety required less irrigation than the Rabbiteye varieties for all treatments. This was due to the less vigorous growth and smaller plant size of the Highbush variety. In 1993, the Highbush 10-cb treatment required the highest amount of irrigation, due largely to the low efficiency of irrigation in this treatment. The Highbush variety has a very shallow root system which makes irrigation scheduling difficult, especially for large plants with higher ET demands, since water must be applied frequently and in small amounts. In this research, irrigations were started by tensiometers when the soil tension reached the threshold level for a given treatment. Timers were used to stop irrigations after 15-minute water applications. Even these very short, water applications often provided too much water for the shallow root zone. The lag-time in the movement of water in the soil does not allow for the use of tensiometers for stopping the irrigation cycle. In addition, durations of water applications less than 15 minutes are not practical for field-scale systems. From the drainage data (see later section on drainage) it is clear that a significant portion of the irrigation water in this treatment was lost to deep percolation.

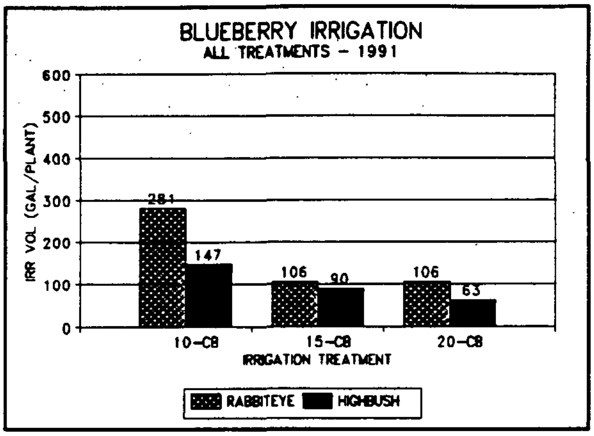

Figure 28. Annual irrigation volumes applied as a function of irrigation treatment and blueberry variety, 1991.

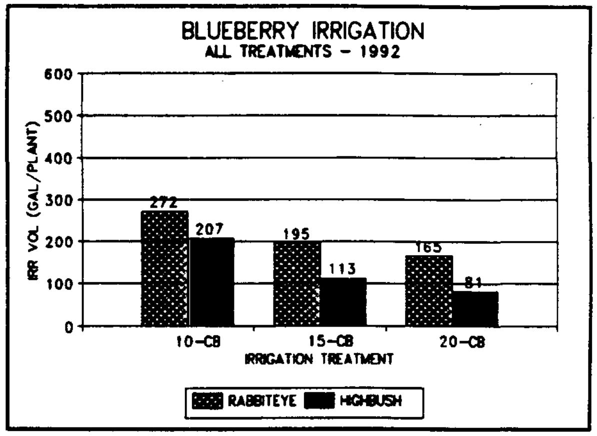

Figure 29. Annual irrigation volumes applied as a function of irrigation treatment and blueberry variety, 1992.

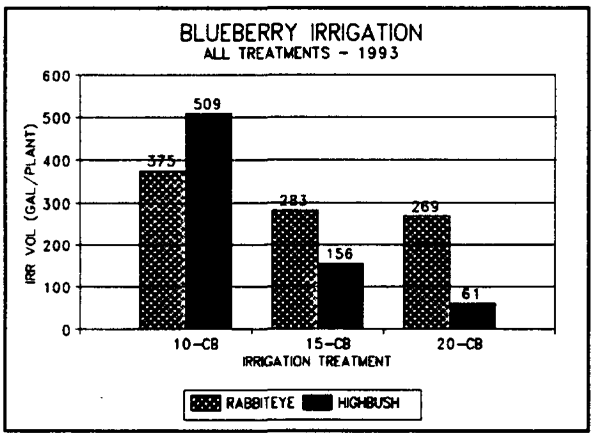

Figure 30. Annual irrigation volumes applied as a function of irrigation treatment and blueberry variety, 1993.

Because water was applied directly to individual lysimeters using a microirrigation system, irrigation data are presented as gallons per plant in Figures 28 - 30. In 1991, the annual irrigation applications ranged from 281 to 106 gallons per plant for the Rabbiteye plants and from 147 to 63 gallons per plant for the Highbush plants. The annual irrigation applications ranged from 272 to 165 gallons per plant for the Rabbiteye plants and from 207 to 81 gallons per plant for the Highbush plants in 1992 and from 375 to 269 gallons per plant for the Rabbiteye and from 509 to 61 gallons per plant for the Highbush in 1993. The increase in irrigation demand for all Rabbiteye treatments and for the 10- and 15-cb Highbush treatments reflects primarily the difference in plant size and to some extent, the lower rainfall in 1993. The only exception to this pattern was the Highbush 20-cb treatment where the establishment and growth of plants was very poor.

Irrigation depths per acre were calculated from the above volumes assuming a plant density of 604 plants per acre (6 ft x 12 ft plant spacing) and are presented in Figures 31-33. In 1991, depths ranged from 6.25 to 2.35 inches for Rabbiteye plants and from 3.28 to 1.39 inches for Highbush plants. Depths ranged from 6.06 to 3.68 inches for the Rabbiteye plants and from 4.61 to 1.80 inches for the Highbush plants in 1992. In 1993 these ranges were from 8.34 to 5.99 inches for Rabbiteye and from 11.32 to 1.37 inches for Highbush plants. These depths are relatively small because they are specific for the relatively small microirrigated blueberry plants studied in this research, and rainfall was relatively high and uniformly distributed. Under this type of irrigation system water was not applied to the grass alleyways. Also, the blueberries in this study were mulched with pine bark, which minimized evaporation losses from the soil surface near the plants.

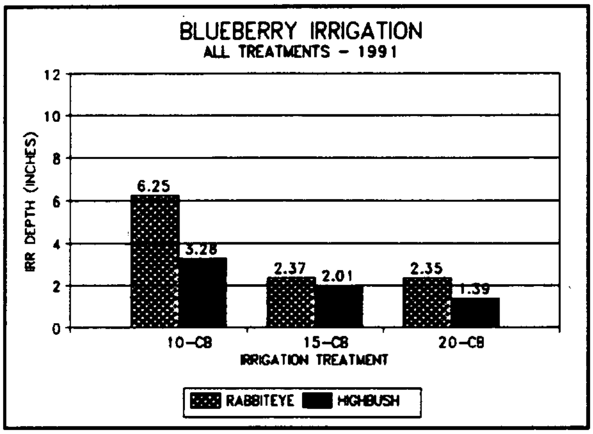

Figure 31. Annual irrigation depths applied as a function of irrigation treatment and blueberry variety, 1991.

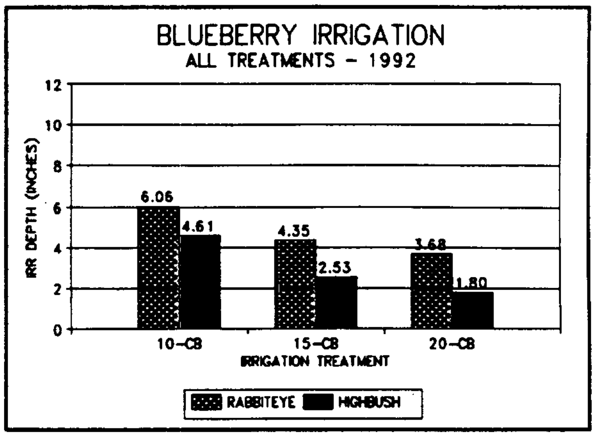

Figure 32. Annual irrigation depths applied as a function of irrigation treatment and blueberry variety, 1992.

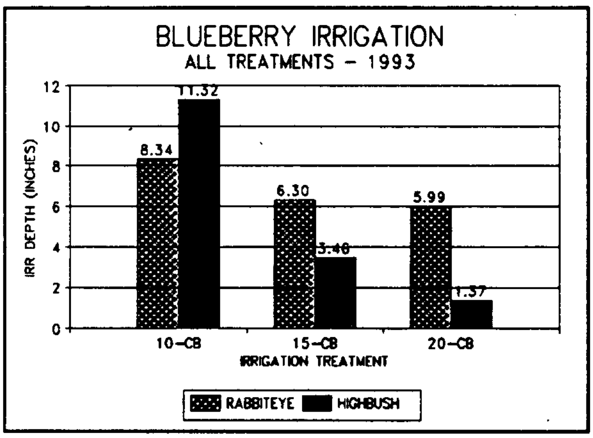

Figure 33. Annual irrigation depths applied as a function of irrigation treatment and blueberry variety, 1993.

Irrigation requirements would need to be adjusted for other plant sizes, plant densities or production practices. For example, increasing plant density increases irrigation requirements because water is applied directly to each plant using a microirrigation system. Likewise, a greater volume of water would be required with a sprinkler irrigation system because water would be applied to the entire soil surface rather than being limited to the mulched area near each plant.

DRAINAGE

Drainage data are summarized in Figures 34-36. In general, drainage was highest for the high-irrigation (10-cb) treatments and lowest for the low-irrigation (20-cb) treatments with the exception of the 1993 Rabbiteye varieties where 20-cb treatment exceeded the 15-cb by 20 gallons. As compared to the

Highbush variety treatments, drainage was lower for the 10- and 15-cb Rabbiteye variety treatments even though larger amounts of irrigation were applied in 1991 and 1992. Drainage would also have been lower for the 20-cb Rabbiteye plants in 1992 except for the excessive irrigation applications in January through early March, as discussed in the previous section of this report. The large amount of drainage in the Highbush variety 10-cb treatment in 1993 can be explained by difficulties in achieving high irrigation efficiency for the large plants with shallow root system. The irrigation application for this treatment was the highest but a significant portion of the water applied was not effective and was lost to drainage. Clearly, the extensive root systems of the larger, more vigorous Rabbiteye plants were more effective in intercepting and extracting water from irrigations and rain.

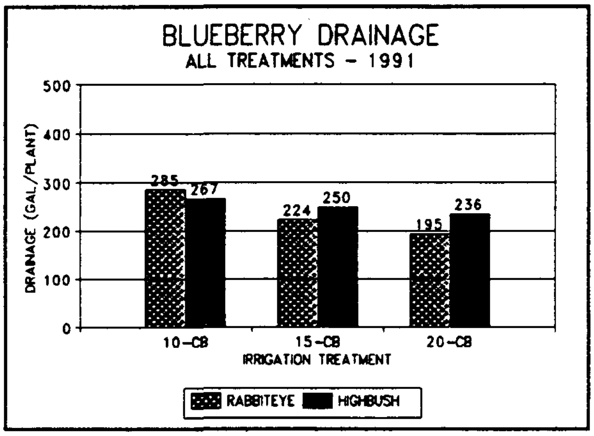

Figure 34. Annual drainage volumes extracted from lysimeters as a function of irrigation treatment and blueberry variety, 1991.

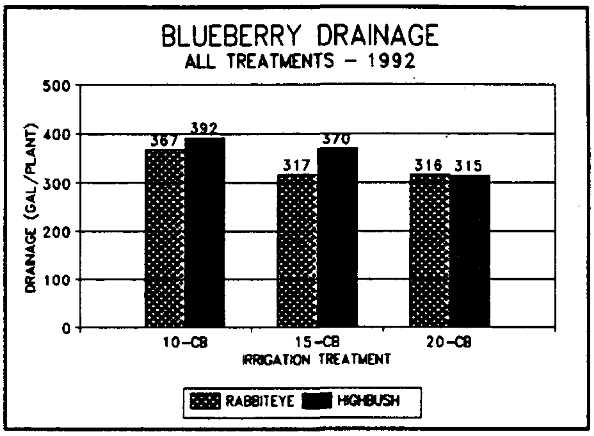

Figure 35. Annual drainage volumes extracted from lysimeters as a function of irrigation treatment and blueberry variety, 1992.

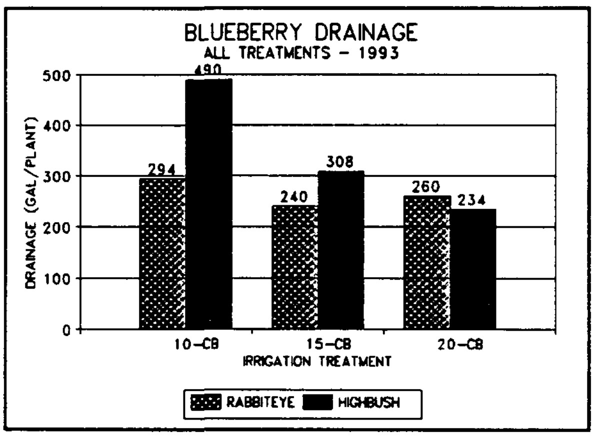

Figure 36. Annual drainage volumes extracted from lysimeters as a function of irrigation treatment and blueberry variety, 1993.

Figures 37-39 and 40-42 show the annual distributions of monthly average drainage data for the Rabbiteye and Highbush plants, respectively. Drainage patterns followed the combined patterns of rain, irrigation and crop water use. In 1991, most drainage occurred in May, June, and August following heavy, frequent storms. Monthly drainage for the Rabbiteye variety in 1991 was generally highest for the 10-cb treatment, intermediate for the 15-cb treatment, and lowest for the 20-cb treatment. This pattern did not follow for the Highbush variety until August 1991. As discussed above, the Highbush root system was much less efficient in utilizing water, and it took much longer for this variety to initially establish the plant root system under lower water treatments. In 1992, most drainage occurred following the large rains in August and September, while the least occurred in the relatively dry, high ET months of May and June. Monthly drainage was generally largest for the 10-cb treatments, intermediate for the 15-cb treatments, and lowest for the 20-cb treatments. An exception to this pattern occurred in the Rabbiteye treatments from January through March, as previously discussed. In 1993, the monthly drainage followed a pattern similar to that in 1992 for all treatments. The difference in drainage between varieties was more pronounced. The drainage for Rabbiteye was much lower than for Highbush. February, July, and October were the months with the largest amount of drainage. These correspond to the months of highest rainfall in 1993 (see Figure 2).

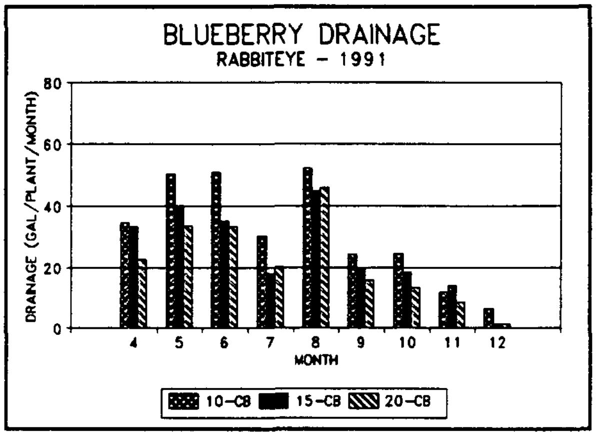

Figure 37. Distributions of monthly drainage volumes as a function of irrigation treatment for Rabbiteye blueberries, 1991.

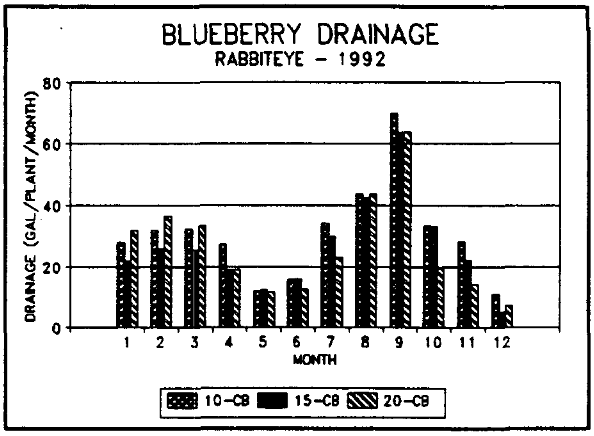

Figure 38. Distributions of monthly drainage volumes as a function of irrigation treatment for Rabbiteye blueberries, 1992.

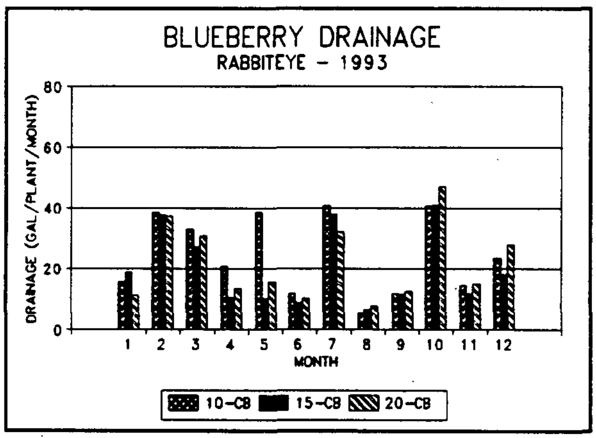

Figure 39. Distributions of monthly drainage volumes as a function of irrigation treatment for Rabbiteye blueberries, 1993.

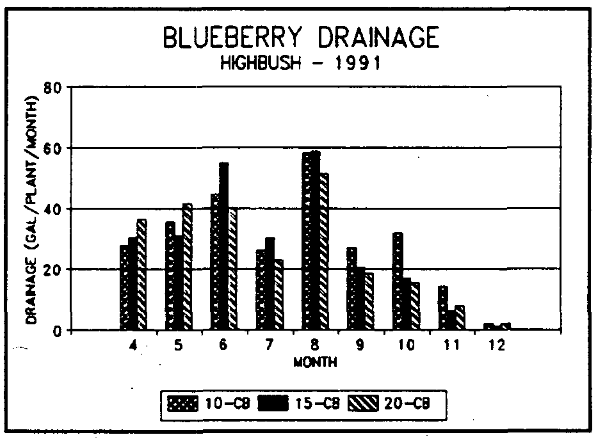

Figure 40. Distributions of monthly drainage volumes as a function of irrigation treatment for Highbush blueberries, 1991.

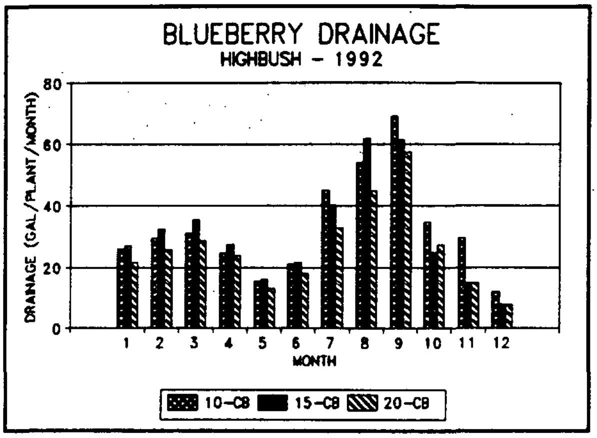

Figure 41. Distributions of monthly drainage volumes as a function of irrigation treatment for Highbush blueberries, 1992.

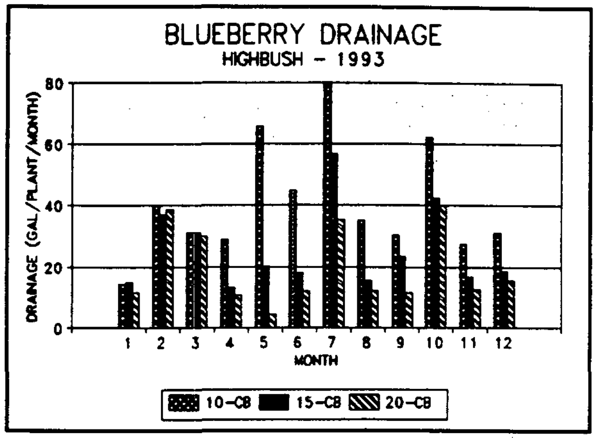

Figure 42. Distributions of monthly drainage volumes as a function of irrigation treatment for Highbush blueberries, 1993.

PLANT GROWTH

The annual distributions of blueberry plant size, for three years of the experiment, are shown in Figures 43-51. The index that is commonly used to measure growth is plant volume (Figures 43-45). Plant volumes were calculated from the measurement of plant height and two measurements of width - along the plant rows and perpendicular to the plant rows. Plant volume is a good indicator of water use because volume correlates well with the leaf area of the plant.

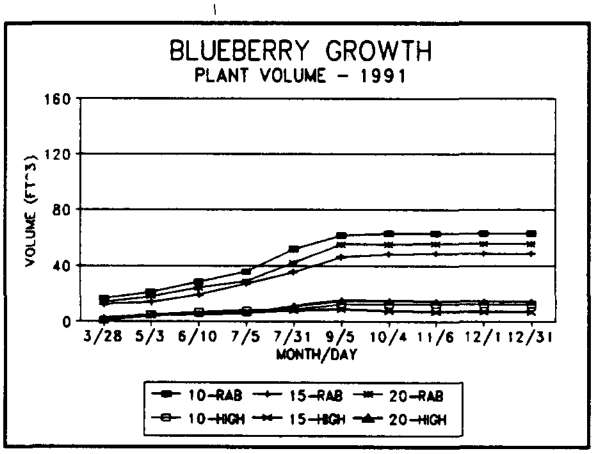

Figure 43. Blueberry growth: plant volume as a function of irrigation treatment and time of year, 1991.

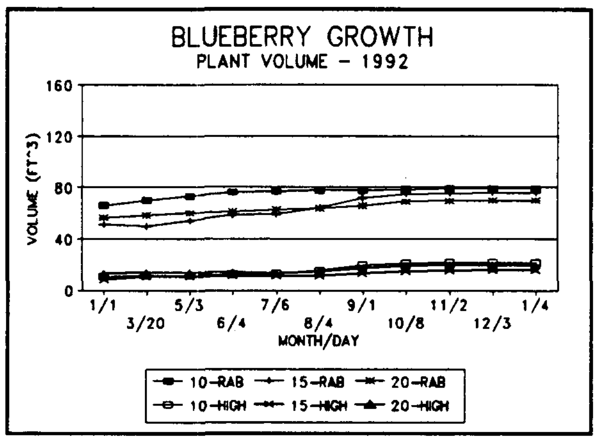

Figure 44. Blueberry growth: plant volume as a function of irrigation treatment and time of year, 1992.

Plant volumes increased during each year for all treatments. Both plant size and rate of increase were greater for the vigorous, rapidly growing Rabbiteye plants as compared to the smaller Highbush plants. Among Highbush plants only the 10-cb treatment showed significant growth in the last year of the experiment. Overall, the 10-cb treatment had the highest growth for both

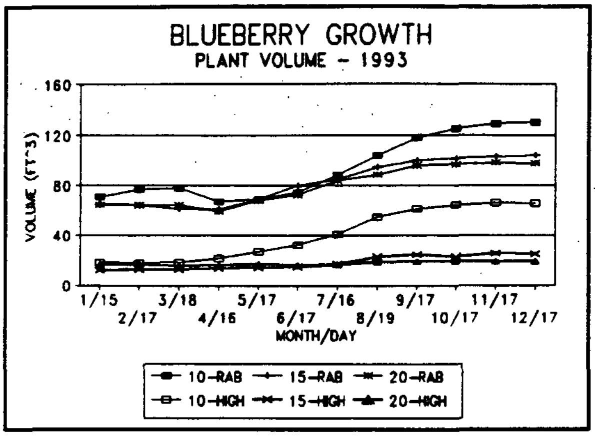

Figure 45. Blueberry growth: plant volume as a function of irrigation treatment and time of year, 1993.

varieties. In 1993, the rate of growth for the 15-cb and 20-cb treatments was very small and significantly lower than 10-cb treatment (Figure 45).

For the Highbush variety, in 1991 and 1992, the 10-cb treatment plants were largest, followed by the 20 cb plants, while the 15-cb plants were smallest. This pattern continued until July 1993 because the 20-cb plants were largest when they were transplanted at the beginning of the project. However, by the end of the experiment in 1993 the Highbush 20-cb plants were smaller and not as well established as other treatments. This poor establishment was also reflected in the very low irrigation requirement in 1993 for this treatment (as discussed above).

Plant height is shown in Figures 46-48. Rabbiteye plant heights increased mainly in the first year of experiment (1991), especially in the 10-cb treatment. During that year, the 10-cb plants reached approximately 5 ft. The 15-cb and 20-cb treatments were slightly shorter and reached 5 ft at the end of the second year. By the end of 1993, the 10-cb Rabbiteye treatment plants were approximately 6 ft tall with 15-cb slightly shorter at 5.6 ft and 20 cb at 5.3 ft.

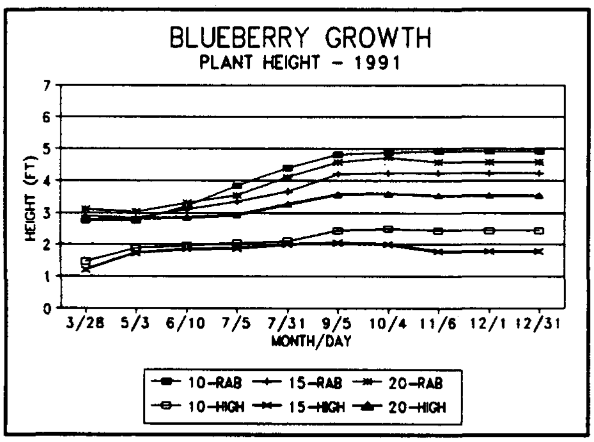

Figure 46. Blueberry growth: plant height as a function of irrigation treatment and time of year, 1991.

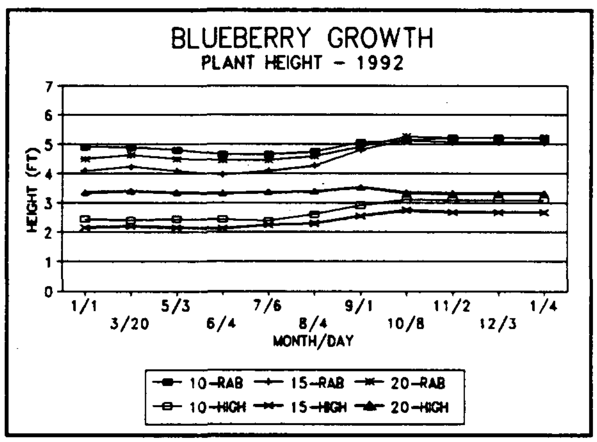

Figure 47. Blueberry growth: plant height as a function of irrigation treatment and time of year, 1992.

All Highbush plants grew much slower than the Rabbiteye plants, with the 10-cb treatment showing the largest increase over the years. A sudden change in the growth rate for the 10-cb Highbush treatment occurred in 1993. During 1993, the 10-cb plants grew almost 2 ft, while the 15-cb and 20-cb Highbush plants

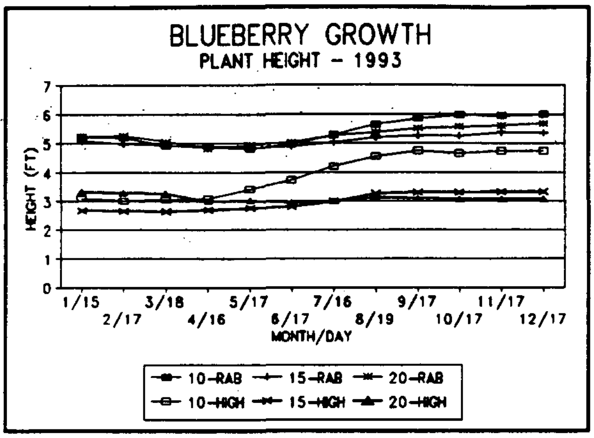

Figure 48. Blueberry growth: plant height as a function of irrigation treatment and time of year, 1993.

showed very little increase in height in all three years due to water stress and poor establishment of the root system. The irrigation requirements and ET measured in this work should be referenced to these plant sizes as these data are interpreted.

Plant widths are shown in Figures 49-51. In 1991 all the plants in all treatments showed some increases in widths, with 10-cb treatments resulting in the highest values. Rabbiteye plant widths increased only slightly in 1992, with Highbush showing a little more growth in width than Rabbiteye. In 1993, the sudden increase in volume of plants in the 10 cb Rabbiteye and Highbush treatment was due to the increase in both plant width and plant height.

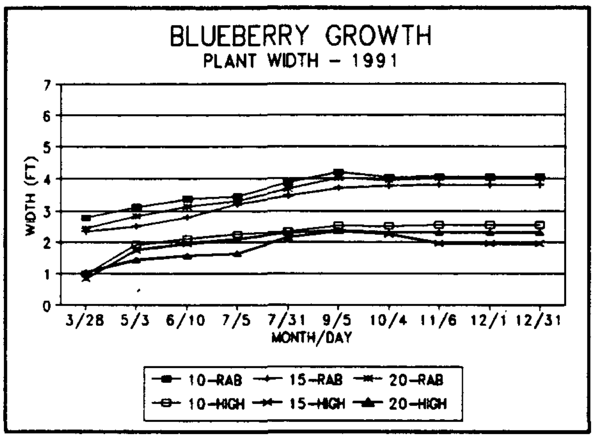

Figure 49. Blueberry growth: plant width as a function of irrigation treatment and time of year, 1991.

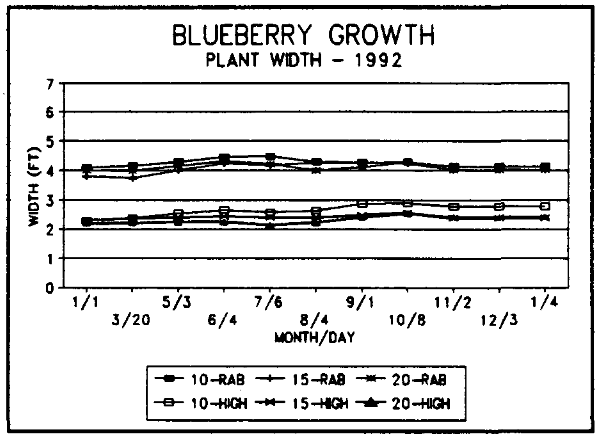

Figure 50. Blueberry growth: plant width as a function of irrigation treatment and time of year, 1992.

In 1991, following common practice for young plants to stimulate vegetative growth, the flowers were removed from the plants and the fruit did not set. This is reflected in the 1991 vegetative plant growth pattern. Most of the plants showed an increase in volume in all months until September. In 1992 and 1993, most of the increase in plant size occurred during the three months after fruit harvest. Little change in plant size occurred during the spring months as fruit was set and had grown to maturity. An apparent decrease in plant height and increase in plant width occurred during the spring months of these years. However, these changes were due to the fruit load which weighted the plant stems, causing the plants to appear shorter and wider. Heights were quickly recovered immediately after fruit harvest.

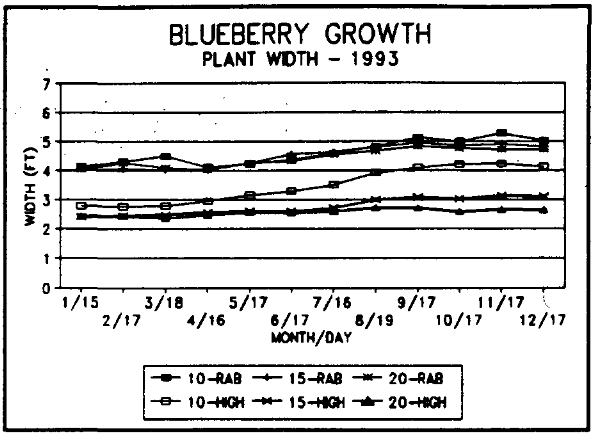

Figure 51. Blueberry growth: plant width as a function of irrigation treatment and time of year, 1993.

YIELDS

Yield data were collected in 1992 and 1993. In the first year of the experiment (1991), only vegetative plant growth was evaluated.

Fruit Weight: Blueberry yields varied as a function of irrigation treatment and variety. Figures 52 and 53 summarize yields as a function of these factors for 1992 and 1993 respectively. Yields are presented in pounds of fruit per plant.

These varieties were alternated along the plant row so that adequate pollination would occur. Only one variety of Highbush plants was grown in the lysimeters: Sharpblue. However, Mistyblue plants (a Highbush variety) were grown as buffer plants around the lysimeters to provide for pollination of fruit. Two varieties of Rabbiteye blueberries were grown in this research: Powderblue and Premier.

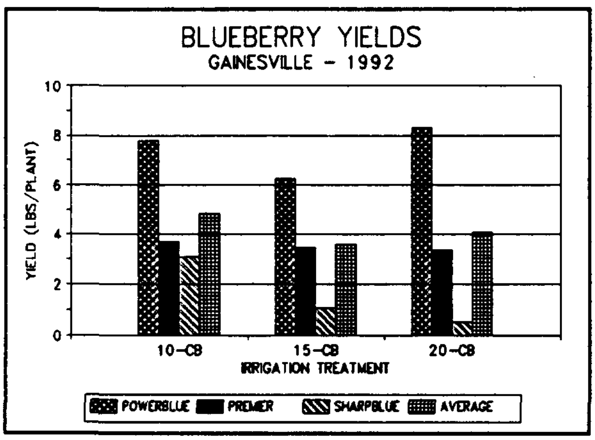

Figure 52. Annual blueberry yields as a function of irrigation treatment and variety, 1992.

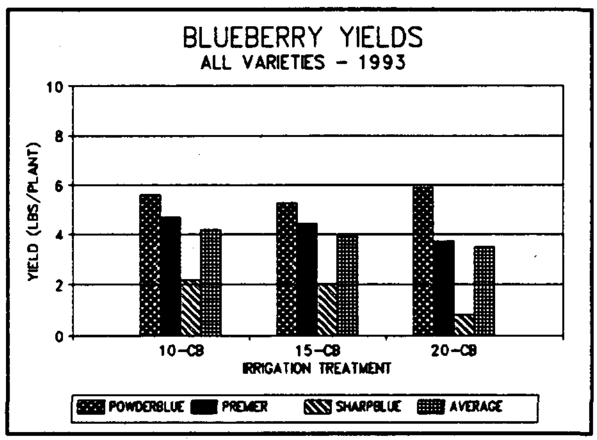

Figure 53. Annual blueberry yields as a function of irrigation treatment and variety, 1993.

Figures 52 and 53 show that in 1992 and 1993, both the Powderblue and Premier Rabbiteye varieties out-yielded the Sharpblue Highbush variety. Also, in both years, with the exception of the Powderblue variety, yields increased with increasing irrigation. The Premier Rabbiteye variety was only slightly sensitive to the irrigation treatments imposed. Yields declined only slightly as soil water tensions were increased from 10 to 20 cb. The Sharpblue plants were very sensitive to water stress during both years. Yields declined sharply as soil water tensions were increased from 10 to 20 cb. The average yield of all varieties was greatest for the largest irrigation applications (10 cb treatment).

In 1992 and 1993, the 20-cb Powderblue plants out-yielded all other treatments. The reason for this is not definitely known. We speculated in 1992 that the water stress imposed on these plants may have caused them to set more fruit than the treatments with less water stress. Yield was directly related to the number of fruit set, and more fruit may have been set on these plants because of water stress during the flowering and bud-formation stages of growth. We expected that this treatment would suffer a reduction in growth and yield in 1993 due to the additional stress of high yield. The yield of Powderblue plants in 1993 was significantly lower than in 1992, however, still higher than that of the other varieties. For all three varieties, the yield was lower in 1993 as compared to 1992. This is believed to be the result of some frost damage in late March of 1993 combined with insect damage which was quite significant in the Gainesville area that year. The insects attack flower buds and the damage is not apparent until fruit set. It is likely that this damage resulted in lower fruit setting.

Time of Harvest: Figures 54-57 show the annual distributions of berries harvested in both years for the Rabbiteye and Highbush varieties, respectively. The three varieties matured at different times of the year, and yields varied as a function of time of harvest. In both years, yields were lowest for the early-producing Sharpblue (Highbush) variety, largest for the late-producing Powderblue (Rabbiteye) variety, and intermediate for the intermediate-producing Premier (Rabbiteye) variety. Timing of harvest is critical to blueberry growers. Early-producing varieties are in great demand because early yields command much higher market prices.

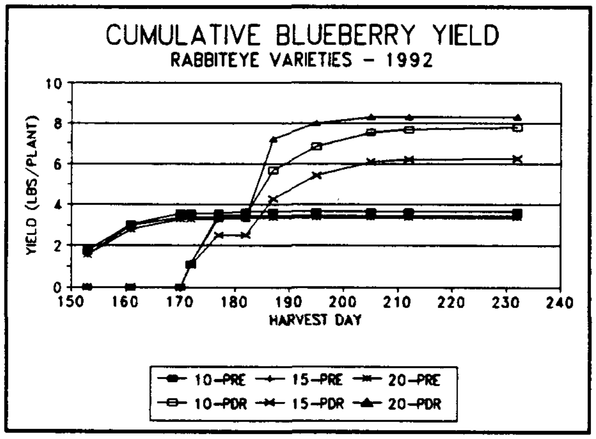

Figure 54. Cumulative blueberry yields as a function of harvest date and irrigation treatment for Rabbiteye variety, 1992.

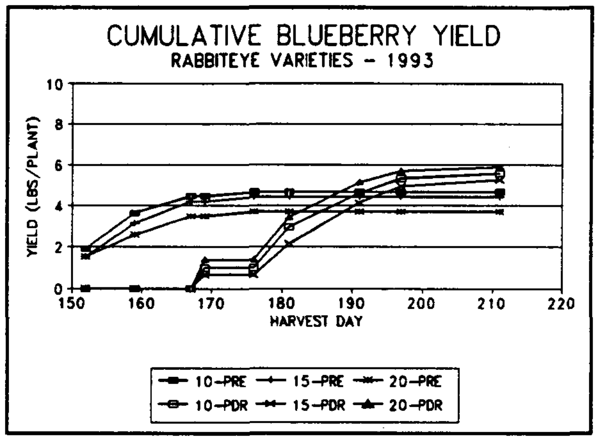

Figure 55. Cumulative blueberry yields as a function of harvest date and irrigation treatment for Rabbiteye variety, 1993.

Figures 54 and 55 show the cumulative yield functions for the Rabbiteye varieties in 1992 and 1993, respectively. In both years, the Premier fruit matured and was harvested in early June (calendar days 153-170 in 1992 and 152-176 in 1993). The Powderblue fruit did not begin to mature until the end of June and harvest continued until the end of July (calendar days 172-232 in 1992 and 169-211 in 1993). Figures 56 and 57 show the cumulative yield functions for the Highbush (Sharpblue) plants. This variety was bred for its early-producing characteristic. In both years, berries began to mature and were harvested from early May through early June (calendar days 110-157 in 1992 and 120-159 in 1993).

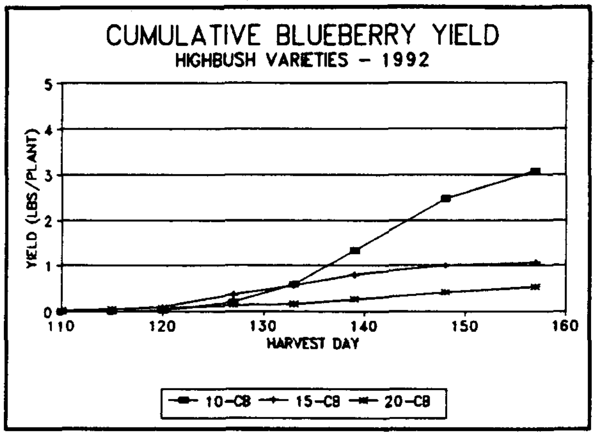

Figure 56. Cumulative blueberry yields as a function of harvest date and irrigation treatment for Highbush variety, 1992.

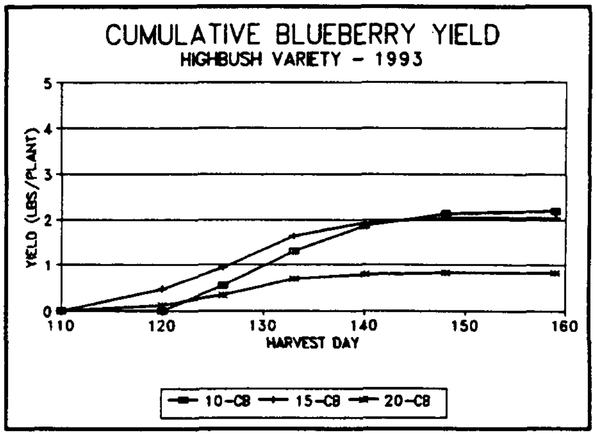

Figure 57. Cumulative blueberry yields as a function of harvest date and irrigation treatment for Highbush variety, 1993.

Fruit Number: Figures 58 and 59 show the number of berries collected per plant as a function of irrigation treatment and variety for 1992 and 1993. The pattern is different from the yield expressed in pounds per plant. In both years, the 10-cb Sharpblue plants produced more berries than the Premier (Rabbiteye) plants, however, these berries were much smaller and the total pounds collected from the Sharpblue variety was lowest. It is clear that within each variety, blueberry yields were directly correlated with the number of fruit set per plant. Thus, in order to achieve high yields, irrigation systems must be managed to ensure that a large number of fruit are set.

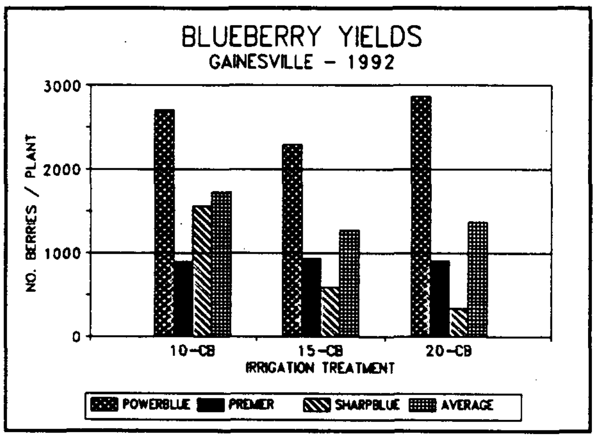

Figure 58. Annual number of blueberries havested per plant as a function of irrigation treatment and variety, 1992.

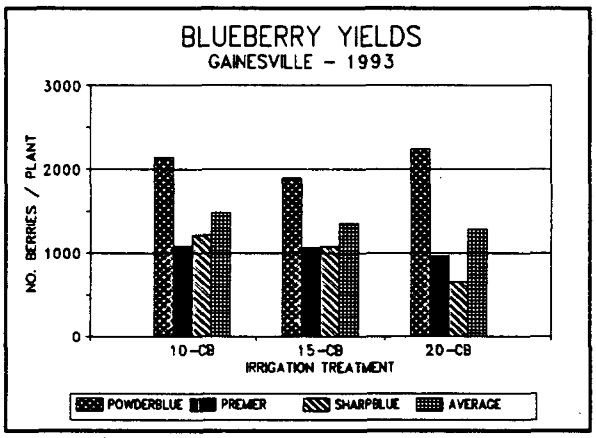

Figure 59. Annual number of blueberries havested per plant as a function of irrigation treatment and variety, 1993.

Fruit Size: The effect of variety and irrigation treatment on fruit size is shown in Figures 60 and 61. The effect of variety was greater than the effect of irrigation treatment. Premier berries were largest, and Sharpblue berries were smallest. Berry size decreased slightly as soil water tension increased from 10 to 20 cb.

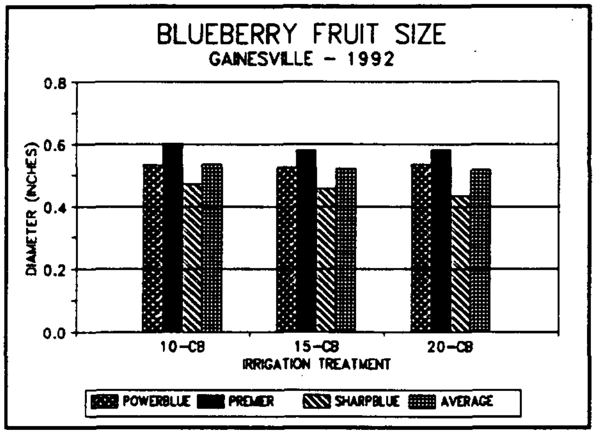

Figure 60. Blueberry size as a function of irrigation treatment and variety, 1992.

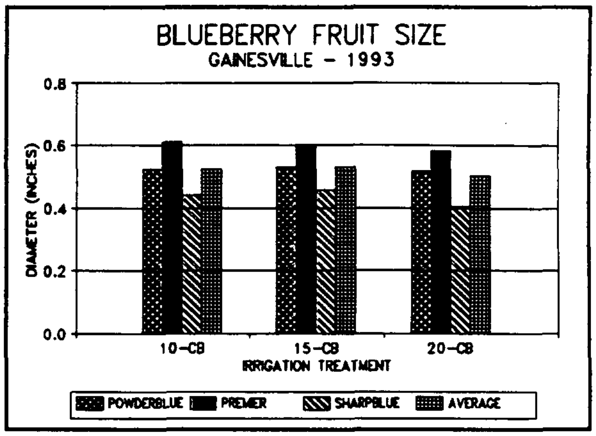

Figure 61. Blueberry size as a function of irrigation treatment and variety, 1993.

Figures 62-65 show the effects of irrigation treatment and harvest date on fruit size in both years for Rabbiteye and Highbush blueberries. The effect of harvest date was greater than the effect of irrigation treatment. Berry size decreased with harvest date for both varieties. Thus, fruit harvested early in the season were larger than fruit harvested at the end of the growing season. As discussed earlier, berry size decreased only slightly as soil water tension increased from 10 to 20 cb.

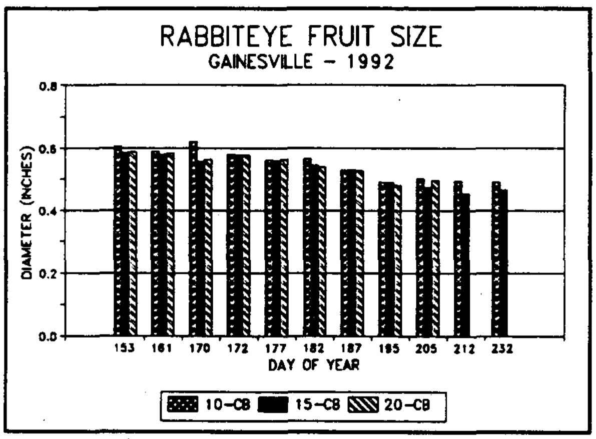

Figure 62. Rabbiteye fruit size as a function of irrigation treatment and harvest date, 1992.

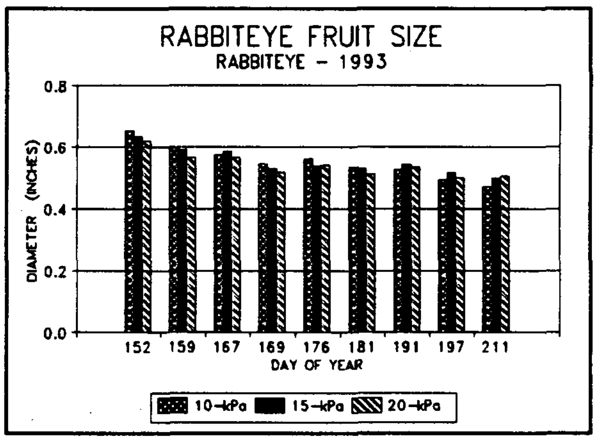

Figure 63. Rabbiteye fruit size as a function of irrigation treatment and harvest date, 1993.

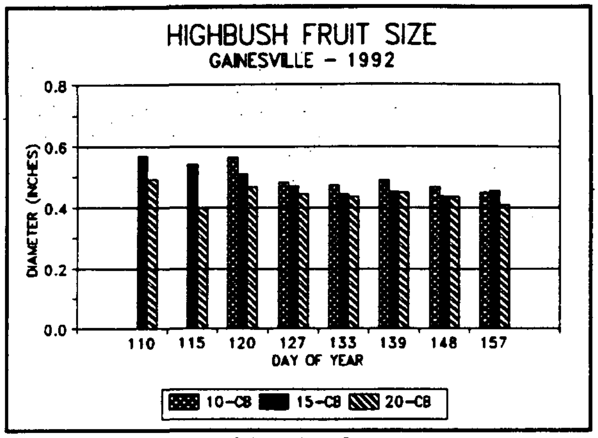

Figure 64. Highbush fruit size as a function of irrigation treatment and harvest date, 1992.

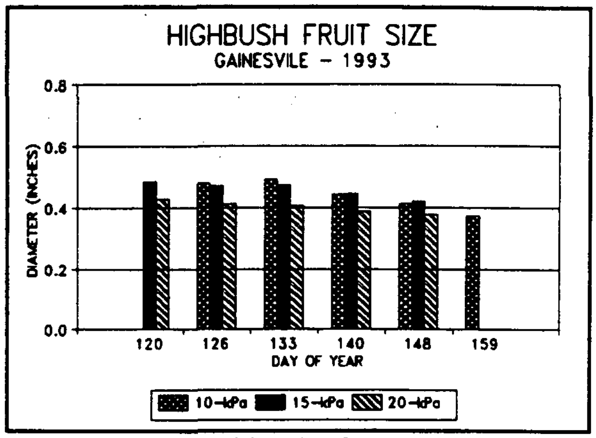

Figure 65. Highbush fruit size as a function of irrigation treatment and harvest date, 1993.

EVAPOTRANSPIRATION

Figures 66, 67, and 68 summarize, respectively, the total 1991, 1992 and 1993 evapotranspiration (ET) measured in the lysimeters for all treatments. ET data are reported for pine-bark mulched blueberry plants. Units are inches of water, assuming 605 plants per acre. ET was largest for the 10-cb irrigation treatment for both the Rabbiteye and Highbush varieties. Because of the much larger size of the Rabbiteye plants, the Rabbiteye ET was larger than the Highbush ET for all irrigation treatments.

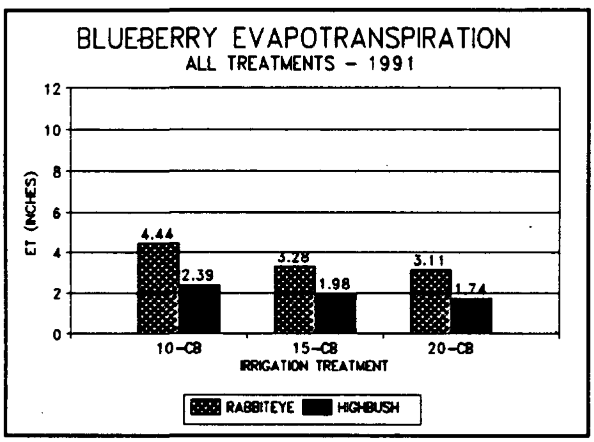

Figure 66. Annual blueberry evapotranspiration as a function of irrigation treatment and variety, 1991.

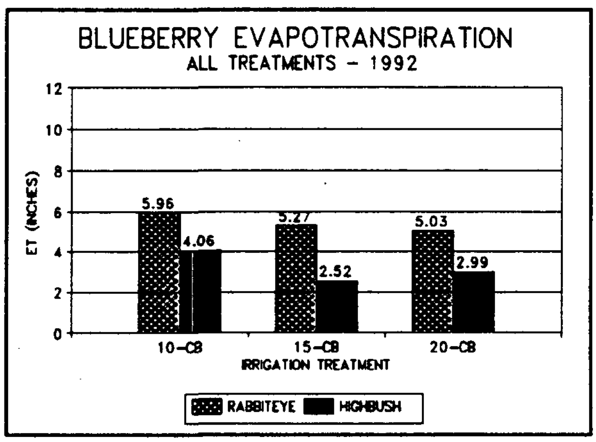

Figure 67. Annual blueberry evapotranspiration as a function of irrigation treatment and variety, 1992.

In 1991, ET ranged from 4.44 to 3.11 inches for the Rabbiteye plants as soil water tensions increased from 10 to 20 cb. The range was 5.96 to 5.03 in 1992 and 9.41 to 7.28 in 1993. This is the cumulative effect of both irrigation treatment and plant size (see Figures 53-55 for plant size comparisons). As expected, evapotranspiration increased in all treatments as the plants increased

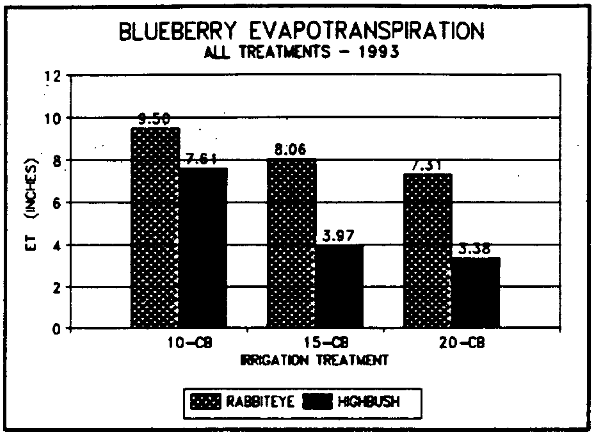

Figure 68. Annual blueberry evapotranspiration as a function of irrigation treatment and variety, 1993.

in size from 1991 to 1993. For the Highbush plants, ET was largest (2.39, 4.06, and 7.50 inches in 1991, 1992, and 1993, respectively) for the 10-cb treatment. In 1991 this was followed by 1.98 inches for the 15-cb treatment and 1.74 inches for the 20-cb treatment. In 1992 the 20-cb treatment (2.99 inches) resulted in a little higher ET than the 15-cb treatment (2.52 inches). This pattern was the result of the smaller size of the 15-cb plants (see Figure 44). However, by the end of 1993, the 15-cb treatment water use (3.95 inches) exceeded that of the 10-cb treatment (3.38 inches). This was due to the size of the plants in the 15-cb treatment. They grew faster in 1993 and were larger than the 20-cb treatment plants at the end of 1993 (see Figure 45). A rapid increase in size of the Highbush 10-cb plants is reflected in the large increase in total ET from 1992 to 1993 for (from 4.06 to 7.50 inches).

Figures 69-71 show the annual distributions of monthly ET for the Rabbiteye plants as a function of irrigation treatment for 1991, 1992 and 1993, respectively. The ET pattern is consistent with the patterns of climate demand as measured by Penman ETo for all three years (Figure 19) and increased plant size during the later part of each year. Except for early spring months, when there is very little difference among ET for all treatments, the 10-cb treatment had the highest ET each month. This indicates that more water stress (and ET reduction) occurred in the other treatments as compared to the 10-cb treatment.

For all three years, the peak monthly ET for the Rabbiteye variety occurred in July. This corresponds with the peak climate demand, and it is a result of the large number of clear days and the resulting high levels of solar radiation and high temperatures.

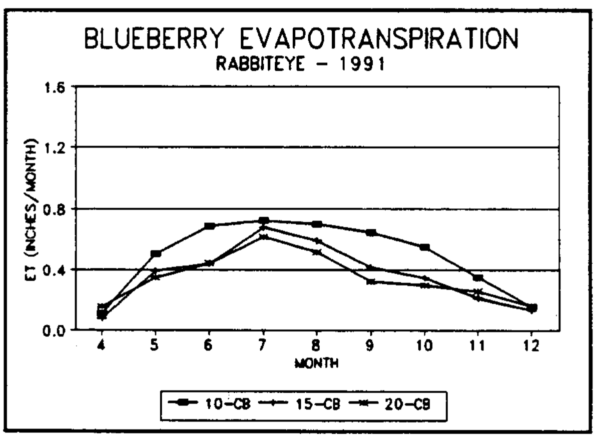

Figure 69. Distribution of monthly evapotranspiration as a function of irrigation treatment for Rabbiteye variety, 1991.

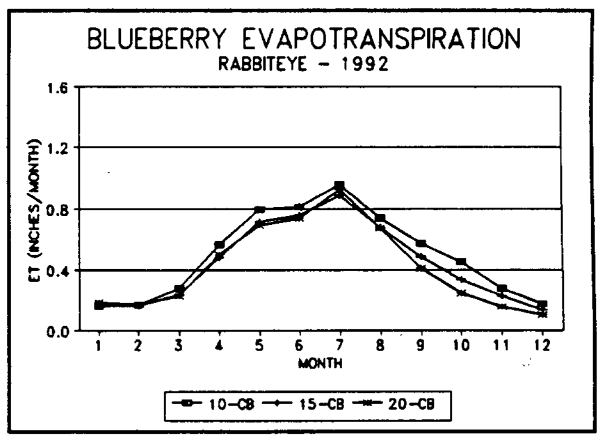

Figure 70. Distribution of monthly evapotranspiration as a function of irrigation treatment for Rabbiteye variety, 1992.

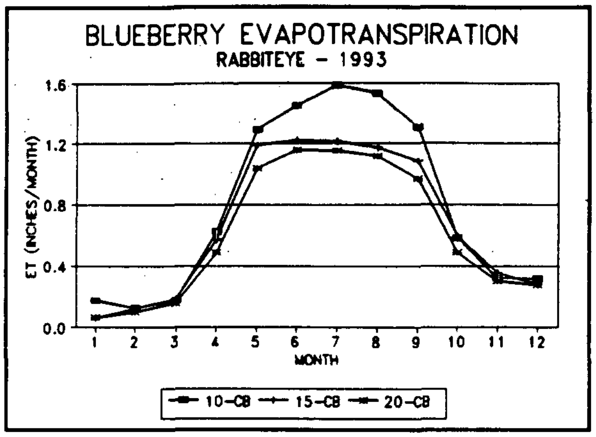

Figure 71. Distribution of monthly evapotranspiration as a function of irrigation treatment for Rabbiteye variety, 1993.

Figures 72, 73, and 74 show the annual distribution of monthly ET for the Highbush plants as a function of irrigation treatment for 1991, 1992, and 1993 respectively. The ET pattern is consistent with the patterns of Penman ETo (Figure 19) and plant growth. The 10-cb treatment had the highest ET. This indicates that more water stress (and ET reduction) occurred in the other treatments as compared to the 10-cb treatment. ET was relatively low during the spring and early summer months while the plants were bearing fruit.

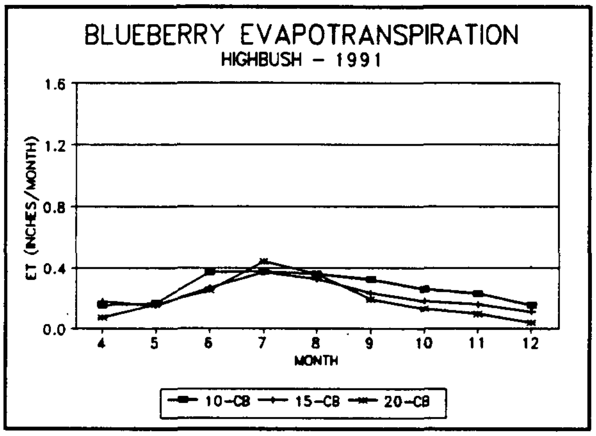

Figure 72. Distribution of monthly evapotranspiration as a function of irrigation treatment for Highbush variety, 1991.

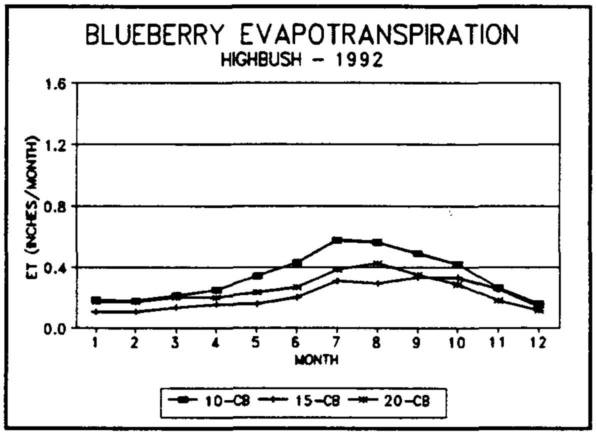

Figure 73. Distribution of monthly evapotranspiration as a function of irrigation treatment for Highbush variety, 1992.

The peak monthly ET for the well-watered (10-cb treatment) Highbush plants corresponded to peak climate demand in July during all three years of the experiment. In 1992 the 20-cb treatment ET was slightly higher in August than in July. A similar peak can be observed for the 15-cb treatment in August, 1993. The actual ET is a function of climatic demand, plant size, and water availability in the soil. If more water were available to the plants in dryer treatments in August (due to rain) or water was more uniformly distributed throughout the month, the actual ET could increase under slightly lower climatic demand.

CROP COEFFICIENTS

Crop water use coefficients are used to estimate crop ET from climate demand and crop growth stage. Coefficients are unique for the specific crop

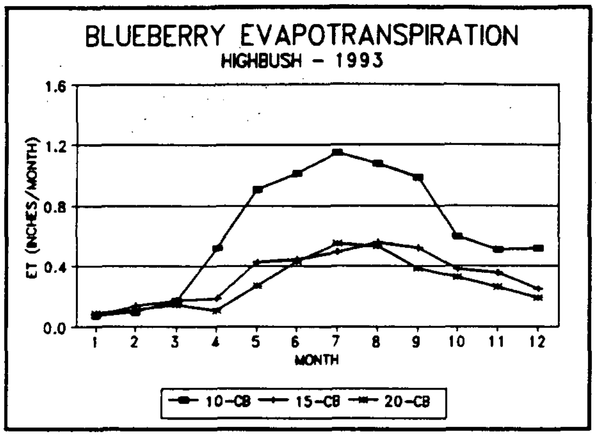

Figure 74. Distribution of monthly evapotranspiration as a function of irrigation treatment for Highbush variety, 1993.

type, method of estimating climate demand, and crop production system used. In this work, crop water use coefficients were calculated for two types of blueberries: Rabbiteye and Highbush; for three methods of calculating climate demand: Penman, Blaney-Criddle (SCS) and Modified Blaney-Criddle (Solar Radiation method); and for the pine-bark mulched, micro-irrigated production system used.

Evapotranspiration rates were largest when blueberries were irrigated at the 10 cb soil water tension as compared to the 15 and 20 cb tensions (Figures 69-74). Growth and yields were also generally greatest for the 10-cb treatment plants. This demonstrates that the 10-cb data should be used to calculate crop water use coefficients, since by definition, water use coefficients allow ET to be estimated for growth conditions where water is not a limiting factor.

ET rates were considerably larger for the Rabbiteye plants as compared to the Highbush plants. This difference was due to plant size and growth characteristics. The Rabbiteye plants are more vigorous and rapid-growing than the Highbush plants. Also, the Highbush plants are earlier-yielding and thus active earlier in the year, beginning in winter months, whereas Rabbiteye plants remain dormant until early spring months.

Figure 75 provides direct comparisons of the 10 cb treatment ET rates in gallons/plant per month for both varieties for the three years of experiment. Figure 76 presents these data in inches per month, assuming a plant density of 605 plants per acre, as previously discussed.

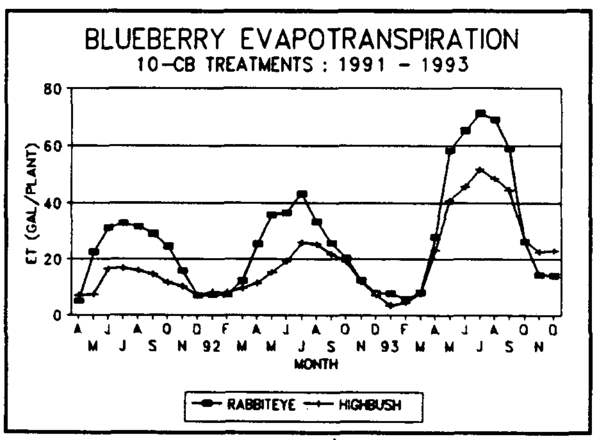

Figure 75. Distribution of monthly evapotranspiration volume as a function of variety when water is not a limiting factor.

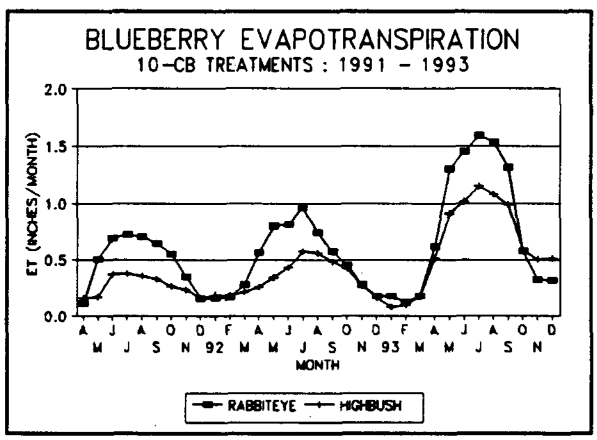

Figure 76. Distribution of monthly evapotranspiration depth as a function of variety when water is not a limiting factor.

In 1993, the blueberry ET in October, November, and December did not drop to the low levels of 1991 and 1992. This was due to the mild winter in 1993. The plants did not lose leaves through December, and the Highbush variety was blooming in January 1994. This is reflected in plant coefficients for these months in 1993 (discussed below).

Because of their great differences in size and ET rates, crop coefficients were separately calculated for Rabbiteye and Highbush blueberries. Coefficients for Rabbiteye and Highbush blueberries for the three methods of ET estimation are shown in Figures 77 and 78, respectively. Coefficients are different for the three ET estimation methods. The Penman equation coefficients are largest throughout the year. Both Blaney-Criddle method coefficients were similar from June through December, however, the daylength (SCS) method coefficients were consistently larger than the modified (solar radiation) coefficients from January through May.

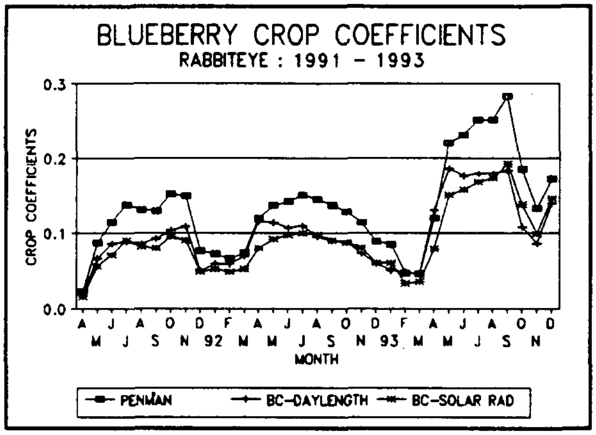

Figure 77. Monthly distribution of Rabbiteye crop water use coefficients for three methods of ET estimation, 1991-1993.

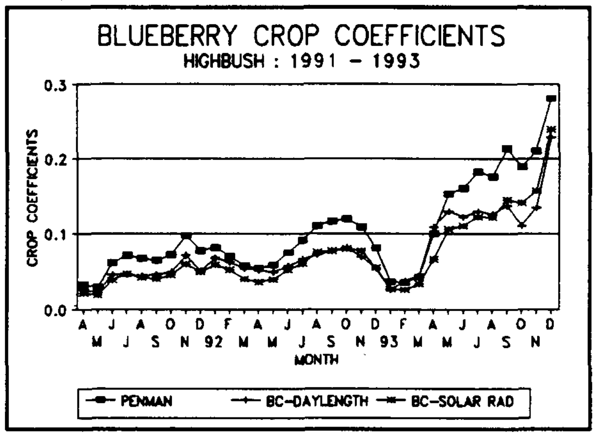

Figure 78. Monthly distribution of Highbush crop water use coefficients for three methods of ET estimation, 1991-1993.

Crop coefficients were larger for the Rabbiteye (Figure 77) as compared to the Highbush (Figure 78) variety. The shapes of the curves are also different, reflecting differences in the growth patterns observed. The Rabbiteye coefficients were small in winter, increased to a peak in summer, then decreased again toward the winter months. This pattern reflects the dormancy of this variety in winter and peak activity during summer months. The effects of plant growth are also seen as the coefficients remained relatively high throughout the fall until the plants became dormant during winter.

The Highbush coefficients (Figure 78) were relatively larger in winter because these plants were active earlier than the Rabbiteye varieties. Coefficients were lower during spring months when the rate of water use did not increase as rapidly as climate demand increased. Then coefficients increased rapidly after fruit harvest as plants grew rapidly through summer and until late fall.

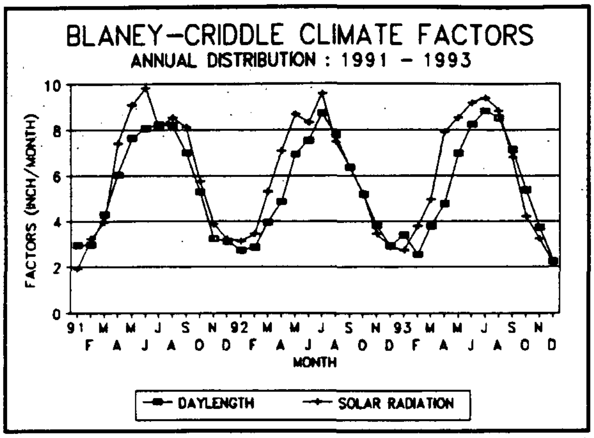

Figure 79. Monthly distribution of Blaney-Criddle climate factors for the daylength and solar radiation based equations used, 1991-1993.

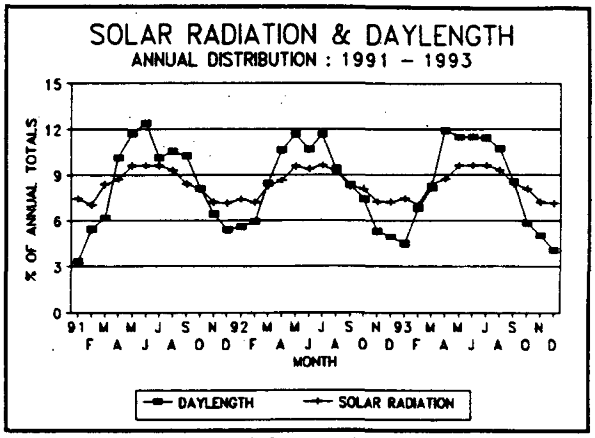

Figure 80. Monthly distribution of percentages of solar radiation and daylength used in the Blaney-Criddle ET estimation equations, 1991-1993.

The reason for the differences in crop coefficients as a function of the method of ET estimation is that the climate factor is different for each of the equations used. Penman coefficients were consistently higher because the Penman reference ET (Figure 19) was less than the climate factors calculated by either of the Blaney-Criddle methods (Figure 79).

The relative distribution of solar radiation used in the modified Blaney-Criddle method was considerably different than the distribution of daylength used in the Blaney-Criddle (SCS) method (Figure 80). A larger fraction of solar radiation occurred in the spring months (and July in 1992) than in the summer months because of cloud cover that occurred during the summer rainy season. Because of these fundamental differences in the methods used to estimate climate demand, crop water use coefficients will be unique for the different methods used to calculate the coefficients.

CONCLUSIONS AND RECOMMENDATIONS

During the three years of the experiment we studied ET and irrigation requirements for the establishment of young blueberry plants under Florida conditions. Several specific conclusions and recommendations have resulted from this research.

The establishment and water requirements of plants are strongly dependent on the blueberry variety. Two typical varieties of blueberry plants were evaluated in this research: Rabbiteye, which is native to Florida, and Highbush, which is an introduced variety. There is significant interest among growers in Highbush plants due to their early ripening and the high prices which blueberries bring early in the year.

The Rabbiteye variety is easier to establish and easier to grow successfully under Florida conditions. Plants showed rapid vegetative growth (see Tables below) after transplanting and were less sensitive to imposed water stresses up to 20 cb than the Highbush variety. Plant size was largest for the well-watered 10 cb treatment and smallest for the 20 cb treatment plants. At the end of the third year experiment, the establishment of plants was good under all treatments. The Rabbiteye plants have a deeper root system which allows them to uptake water from a larger volume of soil and makes irrigation scheduling more efficient with reduced losses to deep percolation. Vegetative growth was the best under 10-cb treatment. Also, Premier-Rabbiteye variety produced the highest yield under 10-cb treatment in both years. It can be concluded that irrigation has a beneficial effect on establishment of Rabbiteye Blueberries in Florida.

Rabbiteye Variety

	Treatment	Plant volume at the begining of each year (ft^3)	Plant yield (lbs/plant)
Year 1 - 1991	10cb	16.4	0
2 year old plants	15cb	12.1	0
	20cb	13.6	0
Year 2 - 1992	10cb	69.8	5.72
3 year old plants	15cb	49.8	4.85
	20cb	58.2	5.83
Year 3 - 1993	10cb	70.9	5.14
4 year old plants	15cb	64.8	4.84
	20cb	64.6	4.95
Year 4 - 1994	10cb	130.0	Not applicable
5 year old plants	15cb	104.0	
	20cb	97.6	

The Highbush variety is much more difficult to establish and requires more precise water management under Florida conditions. Plants exhibit high sensitivity to water stress and require systematic irrigation for good establishment. It takes longer for Highbush plants to develop a root system. Most of the roots in this variety are located relatively near the soil surface, which makes efficient irrigation scheduling more difficult. As a result, more water is lost to deep percolation. The well-watered plants (10-cb treatment) were very well established at the end of the experiment, and the yield of these plants was very high. However, two drier treatments showed much less vegetative growth and much lower yields than well- watered plants. It can be concluded that the establishment of Highbush blueberries under Florida conditions will not be successful without irrigation.

The crop coefficients for three methods of estimating blueberry evapotranspiration were developed in this research project. They can be used to estimate the water use of young Highbush and/or Rabbiteye plants during the first three years after transplanting. The methods used in this research were: Penman, Blaney-Criddle (SCS), and Modified Blaney-Criddle (Solar Radiation Method).

Irrigation amounts are presented in this report in two forms: volume of water per plant and depth of water over an area assuming 604 plants per acre (6 ft x 12 ft plant spacing). It is important to notice that in the last few years, Florida growers are increasing the plant density, and it is quite common to find plantations with 800 to 1,000 plants per acre. In these cases, the volume per plant should be used to calculate the amount of water required. This number then can be easily converted to depth over the entire production area.

Highbush Variety

	Treatment	Plant volume at the begining of each year (ft^3)	Plant yield (lbs/plant)
Year 1 - 1991	10cb	1.1	0
2 year old plants	15cb	0.7	0
	20cb	2.4	0
Year 2 - 1992	10cb	11.4	3.08
3 year old plants	15cb	10.8	1.06
	20cb	13.7	0.52
Year 3 - 1993	10cb	18.3	2.20
4 year old plants	15cb	12.0	2.04
	20cb	16.4	0.82
Year 4 - 1994	10cb	66.0	Not applicable
5 year old plants	15cb	25.0	
	20cb	19.0	

REFERENCES

Buchanan, D.W., F.S. Davies, and A.H. Teramura. 1978. Yield responses of three rabbiteye cultivars to drip irrigation and vapor gard. Proc. Fla. State Hort. Soc. 91:162-163.

Haman, D.Z., A.G. Smajstrla, and P.M. Lyrene. 1988. Blueberry response to irrigation and ground cover. Proc. Fla. State Hort. Soc. 101:235-238.

Lyrene, P.M., and T.E. Crocker. 1986. Florida blueberry handbook. Circular 564. Univ. of Fla. Coop. Ext. Ser., Gainesville, FL. 15 pg.

Lyrene, P.M., and T.E. Crocker. 1991. Commercial blueberry production in Florida. SS-FRC-002. Univ. of Fla. Coop. Ext. Ser., Gainesville Fl. 49 pg.

Smajstrla, A.G. 1985. A field lysimeter system for crop water use and water stress studies in humid regions. Soil and Crop Science Soc. of Fla. Proc. Vol. 44:53-59.

Smajstrla, A.G., D.Z. Haman, and P.M. Lyrene. 1988. Use of tensiometers for blueberry irrigation scheduling. Proc. Fla. State Hort. Soc. 101:232-235.

Smajstrla, A.G., W.G. Boggess, B.J. Boman, G.A. Clark, D.Z. Haman, G.W. Knox, S.J. Locascio, T.A. Obreza, L.R. Parsons, F.M. Rhoads, T. Yeager, and F.S. Zazueta. 1993. Microirrigation in Florida: Systems, acreage, and costs. Univ. of Fla. Coop. Ext. Ser. Bulletin. In press.

APPENDIX A

CONVERSION FACTORS

Lysimeter Size:

Lysimeter diameter = 64 inches = 5.33 ft

Lysimeter surface area = 3217 $inch^2$ = 22.34 ft^2 = 2.075 m^2

Volumes:

1 gallon = 231 $inch^3$

1 gallon = 3.785 liters

1 ft^3 = 7.48 gallons

Conversion <u>from</u> Water Volumes Applied in Lysimeters <u>to</u> Depths of Water Over Lysimeter Area:

1 gallon = 0.0718 inches = 1.824 mm

1 liter = 0.0190 inches = 0.482 mm

Conversion <u>from</u> Depths of Water Applied Over Lysimeter Area <u>to</u> Water Volumes in Lysimeters:

1 inch = 3217 $inch^3$ = 13.93 gallons = 52.71 liters
1mm = 0.548 gallons = 2.075 liters

Plant Density and Land Area per Plant:

2 plants/lysimeter = 11.17 ft^2/plant

Field spacing is typically 6 ft x 12 ft = 72 ft^2/plant

Field plant density is typically 605 plants/acre at 6 ft x 12 ft spacing

Ratio of Lysimeter Area to Total Land Area:

Ratio of lysimeter area/total land area = 11.17 ft^2/72.0 ft^2 = 0.155

Ratio of total land area/lysimeter area = 72.0 ft^2/11.17 ft^2 = 6.45

APPENDIX B

Tables of Results

TABLE 1a. 1991 AVERAGE CLIMATE DATA.

MONTH	DAYS /MO.	RAIN INCH	SOLAR RADIATION CAL/CM^2 /DAY	AIR TEMPERATURE MAX F	MIN F	AVG F	WIND MI/DAY	PENMAN ETo IN/MO.
1 JAN	31	6.22	139.8	68.5	46.7	57.6	109.3	2.35
2 FEB	28	0.63	228.5	71.8	46.8	59.3	112.4	2.89
3 MAR	31	9.29	258.5	76.2	51.9	64.1	128.7	3.76
4 APR	30	5.00	428.1	84.1	62.6	72.9	82.9	4.85
5 MAY	31	4.99	494.6	89.9	69.1	77.3	78.4	5.81
6 JUN	30	4.55	522.7	91.3	69.9	79.2	60.7	6.00
7 JUL	31	9.31	427.3	92.1	73.1	79.9	41.3	5.25
8 AUG	31	4.27	444.9	92.9	73.3	80.9	42.7	5.32
9 SEP	30	2.15	432.5	91.8	69.9	79.1	70.6	4.97
10 OCT	31	2.69	341.1	83.7	61.7	71.2	83.4	3.58
11 NOV	30	0.24	269.5	73.0	50.4	60.5	72.1	2.34
12 DEC	31	1.15	226.2	72.5	49.7	60.1	75.0	2.02
ANNUAL:	365	50.49	4213.7				957.5	49.15

TABLE 1b. 1992 AVERAGE CLIMATE DATA.

MONTH	DAYS /MO.	RAIN INCH	SOLAR RADIATION CAL/CM^2 /DAY	AIR TEMPERATURE MAX F	MIN F	AVG F	WIND MI/DAY	PENMAN ETo IN/MO.
1 JAN	31	3.98	228.8	66.0	54.3	43.7	84.3	2.24
2 FEB	29	4.97	279.0	71.1	59.5	50.3	80.0	2.52
3 MAR	31	5.29	385.8	75.0	62.4	51.4	82.0	3.69
4 APR	30	3.91	494.3	80.2	67.4	56.0	81.7	4.69
5 MAY	31	2.65	542.9	87.1	72.8	60.6	77.6	5.80
6 JUN	30	3.88	462.8	91.3	79.4	71.4	59.8	5.71
7 JUL	31	4.39	532.3	95.2	82.4	72.6	56.0	6.32
8 AUG	31	7.74	421.3	91.4	79.6	72.2	42.0	5.09
9 SEP	30	9.18	391.3	90.5	78.6	71.0	62.1	4.19
10 OCT	31	2.61	322.5	80.7	68.8	59.3	68.7	3.52
11 NOV	30	2.34	232.6	75.5	64.8	57.2	84.3	2.41
12 DEC	31	0.80	221.4	70.2	57.9	48.0	70.4	1.94
ANNUAL:	366	51.74	4514.9				849.0	48.12

TABLE 1c. 1993 CLIMATE DATA

MONTH	DAYS /MO.	RAIN INCH	SOLAR RADIATION CAL/CM^2 /DAY	AIR TEMPERATURE MAX F	MIN F	AVG F	WIND MI/DAY	PENMAN ETo IN/MO.
1 JAN	31	3.76	206.8	72.0	61.0	52.8	73.8	2.06
2 FEB	28	6.14	314.2	67.9	55.5	44.4	91.1	2.69
3 MAR	31	4.62	377.8	73.6	60.8	50.3	119.3	3.91
4 APR	30	1.43	554.6	79.7	65.9	52.8	95.3	5.16
5 MAY	31	1.32	533.0	87.4	74.4	63.2	80.8	5.91
6 JUN	30	5.11	532.2	94.1	80.0	70.2	62.7	6.30
7 JUL	31	5.87	529.0	95.9	82.3	73.5	40.4	6.32
8 AUG	31	2.25	497.1	96.4	82.3	72.8	59.4	6.11
9 SEP	30	2.76	395.8	93.0	79.7	70.7	49.0	4.63
10 OCT	31	8.24	271.2	83.2	71.8	63.6	61.0	3.14
11 NOV	30	1.25	231.5	75.2	63.6	54.2	74.4	2.40
12 DEC	31	2.77	188.8	65.9	52.8	41.5	69.7	1.83
ANNUAL:	365	45.52	4631.9				876.9	50.45

TABLE 1d. LONG-TERM AVERAGE CLIMATE DATA

MONTH	DAYS /MO.	RAIN INCH	SOLAR RADIATION CAL/CM^2 /DAY	AIR TEMPERATURE MAX F	MIN F	AVG F	WIND MI/DAY	PENMAN ETo IN/MO.
1 JAN	31	3.27	267.5	68.6	43.5	56.1	66.0	2.03
2 FEB	28	3.91	349.1	70.5	44.9	57.7	77.9	2.87
3 MAR	31	3.67	424.8	76.7	51.0	63.8	77.9	3.96
4 APR	30	2.94	533.8	82.4	55.8	69.1	70.0	5.11
5 MAY	31	4.18	548.9	87.9	62.8	75.4	56.8	5.82
6 JUN	30	6.63	537.8	90.7	69.3	80.0	50.2	5.98
7 JUL	31	7.09	520.4	91.6	71.0	81.3	50.2	6.03
8 AUG	31	7.99	477.2	91.5	71.2	81.3	38.3	5.43
9 SEP	30	5.60	422.2	89.1	69.6	79.3	44.9	4.54
10 OCT	31	2.33	372.4	82.7	60.4	71.6	55.4	3.50
11 NOV	30	2.04	317.1	75.6	51.2	63.4	55.4	2.37
12 DEC	31	2.68	264.4	70.0	45.5	57.8	58.1	1.76
ANNUAL:	365	52.33	5035.6				700.9	49.40

TABLE 2. MONTHLY AND ANNUAL IRRIGATION 1991-1993.

IRRIGATION (INCHES/MONTH)

1991 MONTH		RABBITEYE 10-CB	RABBITEYE 15-CB	RABBITEYE 20-CB	HIGHBUSH 10-CB	HIGHBUSH 15-CB	HIGHBUSH 20-CB
4	APR	0.98	0.18	0.21	0.28	0.34	0.24
5	MAY	0.70	0.16	0.20	0.13	0.40	0.10
6	JUN	1.22	0.44	0.43	0.31	0.53	0.24
7	JUL	0.53	0.13	0.27	0.26	0.15	0.21
8	AUG	0.52	0.18	0.19	0.64	0.00	0.05
9	SEP	0.88	0.65	0.43	0.97	0.09	0.12
10	OCT	0.62	0.23	0.23	0.26	0.08	0.11
11	NOV	0.42	0.21	0.25	0.21	0.06	0.05
12	DEC	0.38	0.19	0.15	0.22	0.37	0.26
ANNUAL (INCHES):		6.25	2.37	2.35	3.28	2.01	1.39
(GAL/PLANT):		281	106	106	147	90	63

1992 MONTH		RABBITEYE 10-CB	RABBITEYE 15-CB	RABBITEYE 20-CB	HIGHBUSH 10-CB	HIGHBUSH 15-CB	HIGHBUSH 20-CB
1	JAN	0.13	0.04	0.21	0.13	0.04	0.02
2	FEB	0.12	0.02	0.20	0.12	0.07	0.03
3	MAR	0.21	0.08	0.10	0.12	0.14	0.04
4	APR	0.47	0.29	0.28	0.12	0.10	0.03
5	MAY	0.72	0.56	0.53	0.34	0.16	0.17
6	JUN	0.65	0.53	0.48	0.39	0.22	0.12
7	JUL	0.93	0.63	0.66	0.70	0.29	0.22
8	AUG	0.54	0.48	0.42	0.53	0.47	0.29
9	SEP	0.81	0.74	0.38	0.60	0.34	0.30
10	OCT	0.75	0.54	0.34	0.79	0.37	0.36
11	NOV	0.52	0.33	0.07	0.58	0.27	0.17
12	DEC	0.19	0.13	0.01	0.18	0.06	0.03
ANNUAL (INCHES):		6.06	4.35	3.68	4.61	2.53	1.80
(GAL/PLANT):		272	195	165	207	113	81

1993 MONTH		RABBITEYE 10-CB	RABBITEYE 15-CB	RABBITEYE 20-CB	HIGHBUSH 10-CB	HIGHBUSH 15-CB	HIGHBUSH 20-CB
1	JAN	0.00	0.00	0.00	0.07	0.06	0.00
2	FEB	0.02	0.02	0.01	0.02	0.02	0.02
3	MAR	0.00	0.00	0.00	0.13	0.04	0.00
4	APR	0.90	0.43	0.50	0.97	0.28	0.06
5	MAY	2.02	1.48	1.33	2.26	0.77	0.30
6	JUN	1.07	0.70	0.76	1.20	0.33	0.23
7	JUL	0.88	0.71	0.60	1.93	0.24	0.15
8	AUG	1.43	1.10	1.01	1.46	0.61	0.26
9	SEP	1.06	0.98	0.86	1.20	0.38	0.14
10	OCT	0.50	0.46	0.42	0.76	0.34	0.06
11	NOV	0.29	0.27	0.34	0.90	0.23	0.09
12	DEC	0.16	0.13	0.16	0.40	0.17	0.05
ANNUAL (INCHES):		8.34	6.30	5.99	11.32	3.46	1.37
(GAL/PLANT):		375	283	269	509	156	61

TABLE 3. MONTHLY AND ANNUAL DRAINAGE 1991-1993.

DRAINAGE (GALLONS/PLANT/MONTH)

1991 MONTH		---- RABBITEYE ----			---- HIGHBUSH ----		
		10-CB	15-CB	20-CB	10-CB	15-CB	20-CB
4	APR	35	33	23	28	30	36
5	MAY	50	40	34	36	31	42
6	JUN	51	35	33	44	55	40
7	JUL	30	18	20	26	30	23
8	AUG	52	45	46	58	59	51
9	SEP	24	19	16	27	20	18
10	OCT	24	18	13	32	17	15
11	NOV	12	14	9	14	6	8
12	DEC	6	1	1	2	1	2
ANNUAL (GAL/PLANT):		285	224	195	267	250	236

1992 MONTH		---- RABBITEYE ----			---- HIGHBUSH ----		
		10-CB	15-CB	20-CB	10-CB	15-CB	20-CB
1	JAN	28	22	32	26	27	22
2	FEB	32	26	37	29	32	26
3	MAR	32	26	33	31	35	29
4	APR	27	19	19	25	27	24
5	MAY	12	12	11	15	16	13
6	JUN	16	16	13	21	22	18
7	JUL	34	30	23	45	40	33
8	AUG	44	42	44	54	62	45
9	SEP	70	64	64	69	61	57
10	OCT	33	33	19	35	25	27
11	NOV	28	22	14	30	15	15
12	DEC	11	5	7	12	8	8
ANNUAL (GAL/PLANT):		367	317	316	392	370	315

1993 MONTH		---- RABBITEYE ----			---- HIGHBUSH ----		
		10-CB	15-CB	20-CB	10-CB	15-CB	20-CB
1	JAN	16	19	11	14	15	11
2	FEB	38	38	37	40	37	39
3	MAR	33	27	31	31	31	30
4	APR	21	11	13	29	13	11
5	MAY	39	10	16	66	20	4
6	JUN	12	9	10	45	18	12
7	JUL	41	38	32	80	57	35
8	AUG	5	7	8	35	16	12
9	SEP	12	12	12	30	24	12
10	OCT	41	41	47	62	42	40
11	NOV	14	12	15	27	17	13
12	DEC	23	18	28	31	19	16
ANNUAL (GAL/PLANT):		294	240	260	490	308	234

TABLE 4a. 1991 BLUEBERRY GROWTH DATA

PLANT VOLUME (CUBIC FEET)

1991	DAY OF	---- RABBITEYE ----			----- HIGHBUSH -----		
DATE	YEAR	10-CB	15-CB	20-CB	10-CB	15-CB	20-CB
3/28	87	16.4	12.1	13.6	1.1	0.7	2.4
5/3	123	20.8	13.8	18.0	5.3	4.2	4.6
6/10	161	28.3	19.2	24.2	6.6	5.6	5.4
7/5	186	35.8	26.9	28.9	8.1	6.3	6.0
7/31	212	51.9	35.3	42.1	9.1	8.1	11.6
9/5	248	62.0	46.1	55.0	12.0	8.7	15.1
10/4	277	62.8	48.1	55.4	12.2	7.8	14.6
11/6	310	63.1	48.7	55.8	12.3	6.9	14.2
12/1	335	63.1	48.7	55.8	12.3	6.9	14.2
12/31	365	63.1	48.7	55.8	12.3	6.9	14.2

PLANT HEIGHT (FEET)

1991	DAY OF	---- RABBITEYE ----			----- HIGHBUSH -----		
DATE	YEAR	10-CB	15-CB	20-CB	10-CB	15-CB	20-CB
3/28	87	2.7	2.9	3.1	1.5	1.2	2.8
5/3	123	2.7	2.8	3.0	1.9	1.7	2.8
6/10	161	3.2	3.1	3.3	2.0	1.9	2.8
7/5	186	3.8	3.3	3.5	2.0	1.9	2.9
7/31	212	4.4	3.7	4.1	2.1	2.0	3.3
9/5	248	4.8	4.2	4.6	2.4	2.1	3.6
10/4	277	4.9	4.2	4.7	2.5	2.0	3.6
11/6	310	4.9	4.2	4.6	2.4	1.8	3.5
12/1	335	4.9	4.2	4.6	2.4	1.8	3.5
12/31	365	4.9	4.2	4.6	2.4	1.8	3.5

PLANT WIDTH (FEET)

1991	DAY OF	---- RABBITEYE ----			----- HIGHBUSH -----		
DATE	YEAR	10-CB	15-CB	20-CB	10-CB	15-CB	20-CB
3/28	87	2.8	2.3	2.4	1.0	0.8	1.0
5/3	123	3.1	2.5	2.8	1.9	1.8	1.4
6/10	161	3.4	2.8	3.1	2.1	2.0	1.6
7/5	186	3.4	3.2	3.3	2.3	2.1	1.6
7/31	212	3.9	3.5	3.7	2.3	2.3	2.1
9/5	248	4.2	3.7	4.0	2.5	2.4	2.4
10/4	277	4.0	3.8	4.0	2.5	2.3	2.3
11/6	310	4.1	3.8	4.0	2.5	2.0	2.3
12/1	335	4.1	3.8	4.0	2.5	2.0	2.3
12/31	365	4.1	3.8	4.0	2.5	2.0	2.3

TABLE 4b. 1992 BLUEBERRY GROWTH DATA

PLANT VOLUME (CUBIC FEET)

1992	DAY OF	---- RABBITEYE ----			----- HIGHBUSH -----		
DATE	YEAR	10-CB	15-CB	20-CB	10-CB	15-CB	20-CB
3/20	80	69.8	49.8	58.2	11.4	10.8	13.7
5/3	124	73.1	54.0	60.0	11.6	10.6	13.8
6/4	156	76.3	58.8	61.4	12.4	10.8	14.2
7/6	188	76.8	59.0	62.8	12.9	11.2	13.3
8/4	217	77.3	64.3	63.5	14.9	11.2	14.5
9/1	245	77.7	71.7	66.0	19.5	13.1	17.2
10/8	282	78.3	74.8	69.2	21.1	14.8	19.0
11/2	307	78.7	75.2	69.5	21.5	15.2	19.4
12/3	338	79.1	75.5	69.9	21.5	15.5	19.8
1/4	370	79.1	75.5	69.9	21.5	15.5	19.8

PLANT HEIGHT (FEET)

1992	DAY OF	---- RABBITEYE ----			----- HIGHBUSH -----		
DATE	YEAR	10-CB	15-CB	20-CB	10-CB	15-CB	20-CB
3/20	80	4.9	4.2	4.6	2.4	2.2	3.4
5/3	124	4.8	4.1	4.5	2.5	2.2	3.4
6/4	156	4.6	4.0	4.4	2.5	2.1	3.3
7/6	188	4.6	4.1	4.5	2.4	2.3	3.4
8/4	217	4.8	4.3	4.6	2.6	2.3	3.4
9/1	245	5.1	4.8	4.9	2.9	2.5	3.5
10/8	282	5.1	5.1	5.3	3.1	2.7	3.4
11/2	307	5.2	5.1	5.2	3.1	2.7	3.3
12/3	338	5.2	5.1	5.2	3.1	2.7	3.3
1/4	370	5.2	5.1	5.2	3.1	2.7	3.3

PLANT WIDTH (FEET)

1992	DAY OF	---- RABBITEYE ----			----- HIGHBUSH -----		
DATE	YEAR	10-CB	15-CB	20-CB	10-CB	15-CB	20-CB
3/20	80	4.2	3.7	4.0	2.4	2.4	2.2
5/3	124	4.3	4.0	4.2	2.6	2.4	2.3
6/4	156	4.5	4.2	4.3	2.7	2.4	2.3
7/6	188	4.5	4.2	4.2	2.6	2.4	2.1
8/4	217	4.3	4.3	4.0	2.6	2.4	2.2
9/1	245	4.3	4.3	4.1	2.9	2.5	2.4
10/8	282	4.3	4.2	4.3	2.9	2.6	2.5
11/2	307	4.1	4.0	4.0	2.8	2.4	2.4
12/3	338	4.1	4.0	4.0	2.8	2.4	2.4
1/4	370	4.1	4.0	4.0	2.8	2.4	2.4

TABLE 4c. 1993 BLUEBERRY GROWTH DATA

PLANT VOLUME (CUBIC FEET)

1993 DATE	DAY OF YEAR	---- RABBITEYE ---- 10-CB	15-CB	20-CB	----- HIGHBUSH ----- 10-CB	15-CB	20-CB
1/15	15	70.9	64.8	64.6	18.3	12.0	16.4
2/17	48	76.6	64.2	64.0	17.7	12.6	16.3
3/18	77	78.2	61.5	64.0	18.2	12.7	15.3
4/16	106	67.2	60.7	58.9	21.2	13.7	16.1
5/17	137	68.9	69.0	68.1	26.6	14.3	17.0
6/17	168	74.3	80.0	72.6	32.2	14.7	16.0
7/16	197	88.5	85.3	83.7	40.9	16.9	16.6
8/19	231	103.9	94.6	88.8	54.5	22.6	18.6
9/17	260	118.0	100.0	96.0	61.5	24.4	19.0
10/17	290	125.0	102.0	96.9	64.5	22.7	19.0
11/17	321	129.0	103.0	98.0	66.1	25.3	19.0
12/17	351	130.0	104.0	97.6	66.0	25.0	19.0

PLANT HEIGHT (FEET)

1993 DATE	DAY OF YEAR	---- RABBITEYE ---- 10-CB	15-CB	20-CB	----- HIGHBUSH ----- 10-CB	15-CB	20-CB
1/15	15	5.2	5.1	5.2	3.1	2.7	3.3
2/17	48	5.2	5.0	5.3	3.0	2.7	3.3
3/18	77	4.9	4.9	5.1	3.1	2.6	3.3
4/16	106	4.9	4.8	4.8	3.1	2.7	3.0
5/17	137	4.8	4.8	4.9	3.4	2.8	3.0
6/17	168	5.0	4.9	5.0	3.7	2.8	3.0
7/16	197	5.3	5.0	5.3	4.2	3.0	3.0
8/19	231	5.6	5.2	5.4	4.6	3.3	3.1
9/17	260	5.9	5.3	5.5	4.7	3.3	3.1
10/17	290	6.0	5.3	5.6	4.7	3.3	3.1
11/17	321	6.0	5.4	5.6	4.7	3.3	3.1
12/17	351	6.0	5.4	5.7	4.8	3.3	3.1

PLANT WIDTH (FEET)

1993 DATE	DAY OF YEAR	---- RABBITEYE ---- 10-CB	15-CB	20-CB	----- HIGHBUSH ----- 10-CB	15-CB	20-CB
1/15	15	4.1	4.0	4.0	2.8	2.4	2.4
2/17	48	4.3	4.1	4.3	2.8	2.5	2.4
3/18	77	4.5	4.0	4.1	2.8	2.5	2.4
4/16	106	4.1	4.0	4.0	3.0	2.6	2.5
5/17	137	4.2	4.3	4.3	3.2	2.6	2.6
6/17	168	4.4	4.6	4.3	3.3	2.6	2.5
7/16	197	4.6	4.6	4.6	3.5	2.7	2.6
8/19	231	4.8	4.8	4.7	3.9	3.0	2.7
9/17	260	5.1	5.0	4.8	4.1	3.1	2.7
10/17	290	5.0	4.8	4.8	4.2	3.0	2.6
11/17	321	5.3	4.9	4.7	4.2	3.1	2.7
12/17	351	5.0	4.8	4.7	4.1	3.1	2.6

TABLE 5a. BLUEBERRY YIELDS: RABBITEYE VARIETIES

RABBITEYE 10-CB AVERAGES / PLANT

DAY	DATE	- POWDERBLUE -- CUML LBS	AVG COUNT	DIAM INCH	--- PREMIER --- CUML LBS	AVG COUNT	DIAM INCH	---- ALL PLANTS ----- CUML LBS	AVG COUNT	CUML COUNT	DIAM INCH
153	6/1	0.00	0	---	1.78	423	0.61	0.89	212	212	0.61
161	6/9	0.00	0	---	3.04	324	0.59	1.52	162	374	0.59
170	6/18	0.00	0	---	3.59	122	0.62	1.79	61	435	0.62
172	6/20	1.10	301	0.58	3.59	0	---	2.35	150	585	0.58
177	6/25	3.49	712	0.56	3.59	0	---	3.54	356	941	0.56
182	6/30	3.49	0	---	3.68	27	0.56	3.58	14	954	0.56
187	7/05	5.69	786	0.53	3.68	0		4.69	393	1347	0.53
195	7/13	6.83	517	0.49	3.68	0	---	5.25	259	1606	0.49
205	7/23	7.54	296	0.50	3.68	0	---	5.61	148	1754	0.50
212	7/30	7.67	56	0.50	3.68	0	---	5.67	28	1782	0.50
232	8/15	7.76	40	0.49	3.68	0	---	5.72	20	1802	0.49
TOTAL/AVERAGE:			2708	0.52		896	0.60		1803		0.55

RABBITEYE 15-CB AVERAGES / PLANT

153	6/1	0.00	0	---	1.58	414	0.59	0.79	207	207	0.59
161	6/9	0.00	0	---	2.97	375	0.58	1.48	188	395	0.58
170	6/18	0.00	0	---	3.38	126	0.56	1.69	63	458	0.56
172	6/20	1.06	292	0.58	3.38	0	---	2.22	146	604	0.58
177	6/25	2.51	441	0.56	3.38	0	---	2.94	220	824	0.56
182	6/30	2.51	0	---	3.45	24	0.54	2.98	12	836	0.54
187	7/05	4.29	628	0.53	3.45	0	---	3.87	314	1150	0.53
195	7/13	5.44	520	0.49	3.45	0	---	4.45	260	1410	0.49
205	7/23	6.11	334	0.47	3.45	0	---	4.78	167	1577	0.47
212	7/30	6.22	62	0.45	3.45	0	---	4.83	31	1608	0.45
232	8/15	6.25	18	0.47	3.45	0	---	4.85	9	1617	0.47
TOTAL/AVERAGE:			2295	0.51		939	0.57		1617		0.53

RABBITEYE 20-CB AVERAGES / PLANT

153	6/1	0.00	0	---	1.55	402	0.59	0.78	201	201	0.59
161	6/9	0.00	0	---	2.79	330	0.58	1.40	165	366	0.58
170	6/18	0.00	0	---	3.29	146	0.56	1.64	73	439	0.56
172	6/20	1.16	318	0.58	3.29	0	---	2.22	159	598	0.58
177	6/25	3.32	641	0.56	3.29	0	---	3.30	321	19	0.56
182	6/30	3.32	0	---	3.36	26	0.54	3.34	13	932	0.54
187	7/05	7.20	1391	0.53	3.36	0	---	5.28	695	1627	0.53
195	7/13	7.98	373	0.48	3.36	0	---	5.67	186	1813	0.48
205	7/23	8.31	142	0.50	3.36	0	---	5.83	71	1884	0.50
212	7/30	8.31	0	---	3.36	0	---	5.83	0	1884	---
232	8/15	8.31	0	---	3.36	0	---	5.83	0	1884	---
TOTAL/AVERAGE:			2865	0.53		904	0.57		1884		0.55

TABLE 5b. 1992 BLUEBERRY YIELDS: HIGHBUSH VARIETY.

DAY	DATE	AVERAGES/PLANT CUML LBS	AVERAGES/PLANT AVG COUNT	ALL PLANTS CUML COUNT	ALL PLANTS DIA INCH
		10-CB	HIGHBUSH (SHARPBLUE)		
110	4/19	0.00	0	0	---
115	4/24	0.00	0	0	---
120	4/29	0.02	5	5	0.57
127	5/6	0.20	83	88	0.49
133	5/12	0.58	193	281	0.47
139	5/18	1.33	334	615	0.49
148	5/27	2.47	595	1210	0.47
157	6/5	3.08	350	1561	0.45
TOTAL/AVERAGE:			1561		0.47
		15-CB	HIGHBUSH (SHARPBLUE)		
110	4/19	0.01	2	2	0.57
115	4/24	0.04	10	11	0.54
120	4/29	0.09	22	33	0.51
127	5/6	0.36	137	170	0.47
133	5/12	0.56	116	287	0.45
139	5/18	0.79	133	419	0.45
148	5/27	1.00	134	553	0.44
157	6/5	1.06	32	585	0.46
TOTAL/AVERAGE:			585		0.46
		20-CB	HIGHBUSH (SHARPBLUE)		
110	4/19	0.02	10	10	0.49
115	4/24	0.05	21	31	0.40
120	4/29	0.07	13	45	0.47
127	5/6	0.13	34	78	0.45
133	5/12	0.16	20	99	0.44
139	5/18	0.25	53	152	0.45
148	5/27	0.41	101	253	0.43
157	6/5	0.52	85	337	0.41
TOTAL/AVERAGE:			337		0.43

TABLE 5c. BLUEBERRY YIELDS: RABBITEYE VARIETIES

		RABBITEYE 10-CB					AVERAGES / PLANT				
		- POWDERBLUE --			--- PREMIER ---			---- ALL PLANTS -----			
DAY	DATE	CUML LBS	AVG COUNT	DIAM INCH	CUML LBS	AVG COUNT	DIAM INCH	CUML LBS	AVG COUNT	CUML COUNT	DIAM INCH
152	6/1	0.00	0	---	1.93	367	0.65	0.97	184	184	0.65
159	6/8	0.00	0	---	3.63	420	0.60	1.82	210	393	0.60
167	6/16	0.00	0	---	4.48	238	0.58	2.24	119	512	0.58
169	6/18	1.01	328	0.55	4.48	0	---	2.74	164	676	0.55
176	6/25	1.01	0	---	4.69	61	0.56	2.85	31	707	0.56
181	6/30	2.97	673	0.54	4.69	0	---	3.83	337	1043	0.54
191	7/10	4.61	587	0.53	4.69	0	---	4.65	293	1337	0.53
197	7/16	5.35	396	0.49	4.69	0	---	5.02	198	1535	0.49
211	7/30	5.59	163	0.47	4.69	0	---	5.14	81	1616	0.47
TOTAL/AVERAGE:			2146	0.52		1085	0.60		1616		0.55

		RABBITEYE 15-CB					AVERAGES / PLANT				
152	6/1	0.00	0	---	1.53	314	0.63	0.76	157	157	0.63
159	6/8	0.00	0	---	3.16	410	0.59	1.58	205	362	0.59
167	6/16	0.00	0	---	4.22	273	0.59	2.11	137	499	0.59
169	6/18	0.65	242	0.53	4.22	0	---	2.44	121	619	0.53
176	6/25	0.65	0	---	4.43	68	0.54	2.54	34	653	0.54
181	6/30	2.15	552	0.53	4.43	0	---	3.29	276	929	0.53
191	7/10	4.15	660	0.54	4.43	0	---	4.29	330	1259	0.54
197	7/16	4.96	306	0.52	4.43	0	---	4.69	153	1412	0.52
211	7/30	5.26	129	0.50	4.43	0	---	4.84	65	1477	0.50
TOTAL/AVERAGE:			1888	0.53		1064	0.59		1476		0.55

		RABBITEYE 20-CB					AVERAGES / PLANT				
152	6/1	0.00	0	---	1.54	337	0.46	0.66	144	144	0.62
159	6/8	0.00	0	---	2.59	300	0.43	1.11	129	273	0.57
167	6/16	0.00	0	---	3.49	258	0.43	1.49	111	384	0.57
169	6/18	1.40	529	0.52	3.49	0	0.53	2.29	302	686	0.52
176	6/25	1.40	0	---	3.71	73	0.54	2.39	31	717	0.54
181	6/30	3.45	800	0.51	3.71	0	---	3.56	457	1174	0.51
191	7/10	5.15	595	0.53	3.71	0	0.54	4.53	340	1514	0.53
197	7/16	5.73	244	0.50	3.71	0	0.47	4.86	140	1654	0.50
211	7/30	5.89	70	0.50	3.71	0	---	4.95	40	1694	0.50
TOTAL/AVERAGE:			2238	0.51		967.	0.49		1693		0.54

TABLE 5d. 1993 BLUEBERRY YIELDS: HIGHBUSH VARIETY

JULIAN DAY	DATE	AVERAGES/PLANT CUML LBS	AVERAGES/PLANT AVG COUNT	ALL PLANTS CUML COUNT	ALL PLANTS DIAM INCH
		10-CB	HIGHBUSH (SHARPBLUE)		
120	4/30	0.00	0	0	---
126	5/6	0.55	263	263	0.48
133	5/13	1.31	337	600	0.49
140	5/20	1.86	335	935	0.44
148	5/28	2.14	213	1148	0.41
159	6/8	2.20	65	1213	0.37
TOTAL/AVERAGE:			1213		0.44
		15-CB	HIGHBUSH (SHARPBLUE)		
120	4/30	0.47	212	212	0.49
126	5/6	0.94	239	451	0.47
133	5/13	1.64	357	809	0.47
140	5/20	1.94	193	1002	0.44
148	5/28	2.04	74	1076	0.42
159	6/8	0.00	0	1076	---
TOTAL/AVERAGE:			1076		0.46
		20-CB	HIGHBUSH (SHARPBLUE)		
120	4/30	0.12	81	81	0.43
126	5/6	0.33	165	247	0.41
133	5/13	0.68	298	544	0.40
140	5/20	0.79	87	631	0.39
148	5/28	0.82	23	654	0.38
159	6/8	0.00	0	654	---
TOTAL/AVERAGE:					0.40

TABLE 6. BLUEBERRY EVAPOTRANSPIRATION 1991-1993.

		EVAPOTRANSPIRATION (INCHES/MONTH)					
1991		---- RABBITEYE ----			---- HIGHBUSH ----		
	MONTH	10-CB	15-CB	20-CB	10-CB	15-CB	20-CB
4	APR	0.11	0.08	0.15	0.15	0.18	0.07
5	MAY	0.51	0.39	0.35	0.16	0.15	0.16
6	JUN	0.69	0.44	0.44	0.37	0.27	0.25
7	JUL	0.73	0.68	0.62	0.37	0.37	0.44
8	AUG	0.70	0.59	0.52	0.36	0.33	0.36
9	SEP	0.65	0.42	0.32	0.32	0.23	0.19
10	OCT	0.55	0.35	0.30	0.26	0.18	0.13
11	NOV	0.35	0.21	0.25	0.23	0.16	0.10
12	DEC	0.15	0.13	0.16	0.16	0.11	0.04
ANNUAL:		4.44	3.28	3.11	2.39	1.98	1.74
1992		---- RABBITEYE ----			---- HIGHBUSH ----		
	MONTH	10-CB	15-CB	20-CB	10-CB	15-CB	20-CB
1	JAN	0.16	0.17	0.19	0.18	0.11	0.17
2	FEB	0.17	0.16	0.17	0.18	0.11	0.17
3	MAR	0.27	0.23	0.23	0.21	0.13	0.20
4	APR	0.57	0.48	0.50	0.25	0.16	0.20
5	MAY	0.80	0.71	0.69	0.34	0.16	0.23
6	JUN	0.81	0.76	0.74	0.43	0.20	0.27
7	JUL	0.96	0.89	0.92	0.57	0.31	0.38
8	AUG	0.74	0.68	0.67	0.56	0.29	0.42
9	SEP	0.58	0.49	0.41	0.49	0.33	0.35
10	OCT	0.45	0.33	0.24	0.42	0.33	0.28
11	NOV	0.28	0.23	0.15	0.26	0.25	0.18
12	DEC	0.17	0.14	0.10	0.16	0.14	0.11
ANNUAL:		5.96	5.27	5.03	4.06	2.52	2.99
1993		---- RABBITEYE ----			---- HIGHBUSH ----		
	MONTH	10-CB	15-CB	20-CB	10-CB	15-CB	20-CB
1	JAN	0.17	0.06	0.07	0.07	0.07	0.09
2	FEB	0.12	0.12	0.10	0.10	0.14	0.11
3	MAR	0.18	0.19	0.16	0.17	0.17	0.14
4	APR	0.62	0.57	0.48	0.52	0.19	0.11
5	MAY	1.30	1.19	1.04	0.91	0.43	0.27
6	JUN	1.45	1.22	1.16	1.02	0.44	0.43
7	JUL	1.59	1.22	1.16	1.15	0.49	0.55
8	AUG	1.53	1.18	1.12	1.08	0.55	0.53
9	SEP	1.31	1.09	0.97	0.99	0.52	0.38
10	OCT	0.58	0.59	0.48	0.59	0.38	0.33
11	NOV	0.32	0.35	0.30	0.51	0.35	0.26
12	DEC	0.32	0.28	0.28	0.51	0.25	0.19
ANNUAL:		9.50	8.06	7.31	7.61	3.97	3.38

TABLE 7. REFERENCE ET 1991-1993.

REFERENCE ET (ETo) AND BLANEY-CRIDDLE (B-C) CLIMATE FACTORS (INCHES/MONTH)

1991	PENMAN	B-C (DAYLENGTH)		B-C (RADIATION)	
MONTH	ETo	%DAY	Kt*F	%Rs	F*Rs
1 JAN	2.4	7.44	2.93	3.32	1.91
2 FEB	2.9	7.00	2.96	5.42	3.21
3 MAR	3.8	8.37	4.27	6.13	3.93
4 APR	4.9	8.70	6.03	10.16	7.41
5 MAY	5.8	9.61	7.63	11.74	9.08
6 JUN	6.0	9.60	8.07	12.40	9.83
7 JUL	5.3	9.61	8.24	10.14	8.10
8 AUG	5.3	9.30	8.20	10.56	8.54
9 SEP	5.0	8.40	7.03	10.26	8.11
10 OCT	3.6	8.06	5.28	8.09	5.76
11 NOV	2.3	7.20	3.20	6.40	3.87
12 DEC	2.0	7.13	3.11	5.37	3.22
ANNUAL:	49.2	100.00	66.95	100.00	72.98

1992	PENMAN	B-C (DAYLENGTH)		B-C (RADIATION)	
MONTH	ETo	%DAY	Kt*F	%Rs	F*Rs
1 JAN	2.2	7.40	2.73	5.56	3.12
2 FEB	2.5	7.14	2.85	5.91	3.44
3 MAR	3.7	8.27	3.95	8.46	5.29
4 APR	4.7	8.63	4.86	10.62	7.10
5 MAY	5.8	9.57	6.95	11.68	8.68
6 JUN	5.7	9.40	7.55	10.69	8.32
7 JUL	6.3	9.64	8.74	11.70	9.60
8 AUG	5.1	9.20	7.79	9.42	7.51
9 SEP	4.2	8.22	6.37	8.34	6.38
10 OCT	3.5	8.07	5.18	7.38	5.22
11 NOV	2.4	7.25	3.78	5.30	3.43
12 DEC	1.9	7.20	2.92	4.94	2.88
ANNUAL:	48.1	100.00	63.66	100.00	70.98

1993	PENMAN	B-C (DAYLENGTH)		B-C (RADIATION)	
MONTH	ETo	%DAY	Kt*F	%Rs	F*Rs
1 JAN	2.1	7.44	3.38	4.46	2.72
2 FEB	2.7	7.00	2.52	6.79	3.77
3 MAR	3.9	8.37	3.77	8.16	4.96
4 APR	5.2	8.70	4.74	11.98	7.89
5 MAY	5.9	9.61	6.98	11.51	8.56
6 JUN	6.3	9.60	8.25	11.49	9.19
7 JUL	6.3	9.61	8.84	11.42	9.41
8 AUG	6.1	9.30	8.55	10.73	8.84
9 SEP	4.6	8.40	7.16	8.55	6.82
10 OCT	3.1	8.06	5.39	5.85	4.20
11 NOV	2.4	7.20	3.72	4.99	3.21
12 DEC	1.8	7.13	2.25	4.08	2.15
ANNUAL:	50.5	100.00	65.55	100.00	71.72

TABLE 8. CROP WATER USE COEFFICIENTS 1991 - 1993.

	1991 MONTH	RABBITEYE PENMAN Kp	RABBITEYE BLANEY-CRIDDLE Ktf	RABBITEYE BLANEY-CRIDDLE Krs	HIGHBUSH PENMAN Kp	HIGHBUSH BLANEY-CRIDDLE Ktf	HIGHBUSH BLANEY-CRIDDLE Krs
4	APR	0.023	0.018	0.015	0.032	0.026	0.021
5	MAY	0.087	0.066	0.056	0.028	0.022	0.018
6	JUN	0.115	0.086	0.070	0.062	0.046	0.038
7	JUL	0.139	0.088	0.090	0.071	0.045	0.046
8	AUG	0.132	0.086	0.082	0.067	0.044	0.042
9	SEP	0.130	0.092	0.080	0.065	0.046	0.040
10	OCT	0.153	0.104	0.095	0.072	0.049	0.045
11	NOV	0.150	0.110	0.091	0.098	0.071	0.059
12	DEC	0.076	0.050	0.048	0.077	0.050	0.048

	1992 MONTH	RABBITEYE PENMAN Kp	RABBITEYE BLANEY-CRIDDLE Ktf	RABBITEYE BLANEY-CRIDDLE Krs	HIGHBUSH PENMAN Kp	HIGHBUSH BLANEY-CRIDDLE Ktf	HIGHBUSH BLANEY-CRIDDLE Krs
1	JAN	0.072	0.059	0.051	0.082	0.067	0.059
2	FEB	0.066	0.058	0.048	0.070	0.062	0.052
3	MAR	0.074	0.069	0.052	0.057	0.053	0.040
4	APR	0.121	0.116	0.080	0.054	0.052	0.036
5	MAY	0.137	0.115	0.092	0.059	0.049	0.039
6	JUN	0.142	0.107	0.098	0.075	0.057	0.052
7	JUL	0.152	0.110	0.100	0.091	0.066	0.060
8	AUG	0.146	0.095	0.099	0.111	0.072	0.075
9	SEP	0.138	0.091	0.090	0.117	0.077	0.076
10	OCT	0.129	0.088	0.087	0.120	0.081	0.081
11	NOV	0.114	0.073	0.080	0.109	0.069	0.076
12	DEC	0.089	0.059	0.060	0.081	0.054	0.055

	1993 MONTH	RABBITEYE PENMAN Kp	RABBITEYE BLANEY-CRIDDLE Ktf	RABBITEYE BLANEY-CRIDDLE Krs	HIGHBUSH PENMAN Kp	HIGHBUSH BLANEY-CRIDDLE Ktf	HIGHBUSH BLANEY-CRIDDLE Krs
1	JAN	0.085	0.050	0.060	0.036	0.022	0.027
2	FEB	0.046	0.049	0.033	0.035	0.038	0.025
3	MAR	0.046	0.046	0.035	0.043	0.044	0.034
4	APR	0.120	0.131	0.079	0.101	0.109	0.066
5	MAY	0.220	0.186	0.152	0.154	0.130	0.106
6	JUN	0.231	0.176	0.158	0.161	0.123	0.111
7	JUL	0.251	0.180	0.169	0.182	0.130	0.122
8	AUG	0.251	0.180	0.174	0.177	0.126	0.122
9	SEP	0.283	0.183	0.193	0.214	0.138	0.145
10	OCT	0.186	0.108	0.139	0.189	0.110	0.141
11	NOV	0.133	0.086	0.099	0.211	0.136	0.157
12	DEC	0.173	0.141	0.147	0.281	0.228	0.239