Irrigation practices during long-term drought in the Southeast

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Abstract

Georgia, like much of the Southeast, experienced prolonged drought between summer 1998, and fall, 2002. During this time, UGA scientists and researchers had a program in place to monitor monthly irrigation practices on 800 randomly selected permitted irrigation systems. The coincidence of the monitoring program, called Ag Water Pumping, and the drought gave us the opportunity to see what strategies and how much water farmers would use to survive the drought. On average farmers in Southwest Georgia used 9.5 in./y while those in the Coastal Zone used 7.7 in./y. Those who had to rely upon streams or ponds used 2 to 4 in./y less than those who had well water supplies. Many farmers reported that their surface supplies dried up during the drought. Individual use varied broadly with up to 25 in. or more applied to some crops, but the distribution was skewed toward those who used lesser amounts. When compared with deficits between ET and rainfall, mean monthly applications closely mirrored that deficit.

Introduction

Agricultural irrigation systems used on Georgia farms, orchards, nurseries, and certain golf courses are supplied with water from ground and surface water resources that fall under permitting requirements of the Georgia Environmental Protection Division (EPD). Most of the wells, surface water pumping stations and ponds used in these systems were built and purchased by individual land owners. Each individual water source usually supplies only one or two of the estimated 16,500 irrigation systems in the State. In the 1988 statutes that required permits for agricultural withdrawals, these privately owned pumping and delivery systems were specifically exempted from water metering, record keeping, and reporting to EPD. Consequently, Georgia water planners have lacked systematic enumeration of water quantities used in agricultural production. In 1998, EPD requested that the Georgia Cooperative Extension Service (CES) establish a statewide system for measurement of water use by farmers and conduct a multi-year study of those water withdrawals.

During the course of the measurement program, Georgia experienced a prolonged hydrologic drought that had begun by mid-1998 and that continued through fall 2002. Considered one of the worst droughts in Georgia's history, farmers and other water users across the state had to adjust their water use in response to increased water demand and limited water supplies.

Georgia had few tools to regulate water use by farmers. Permits placed no restriction on seasonal or annual amounts used as long as pumping rates and irrigated areas did not increase. A newly created drought management program in the Flint River basin[2] was used to idle 30,000 to 40,000 acres (2 to 3%) of potentially irrigated land during 2001 and 2002. Permitting for new agricultural water withdrawals was also suspended in the Flint River basin and along the coast. Other areas of the state were allowed to obtain new withdrawal permits throughout the drought period.

With independent water supplies for most irrigation systems, farmers had to make independent decisions on how to manage their irrigation during the drought. Squeezed between low prices for many of their crop commodities and rising prices for fuel needed for pumps, farmers had to manage water and other inputs

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[2] Flint River Drought Protection Act of 2000. Official Code of Ga. 12-5-540. Defined in Chapter 391-3-28 of the Ga. Dept. of Natural Resources EPD.

carefully to achieve profitability and repay production loans. This paper summarizes the observations of irrigation on farms in Georgia during three consecutive drought years.

Methodology

Engineers, researchers and statisticians at the University of Georgia (UGA) designed a statewide irrigation monitoring program that met the dual needs of rapid startup and modest budget. The basic design included repeated monthly visits to selected irrigation sites by UGA personnel. Water use was calculated from equipment use time and calibrated flow rates for most irrigation systems. Electric timers were installed on irrigation application equipment when possible or on pumps or generators that supplied unique irrigation systems and had uniform flow rates. When flow rates varied over time, flow meters were used. At each monthly visit, crops that were in the irrigated fields were noted, and the proportion of water that was used on each was estimated.

A stratified, random sampling was used to identify potential participants for a voluntary monitoring program. A statewide 2% random sample was taken of the Agricultural Water Withdrawal Permits issued by EPD between 1988 and 1998. The sample was stratified to assure proportionality of sampling by county and water source. A secondary stratification was made in an attempt to represent types of irrigation systems and choices of crops as identified by separate CES surveys. The randomly selected permit holders were asked to participate in the monitoring program that became known as Ag Water Pumping (AWP). A large majority of farmers agreed. When a farmer could not or would not participate, a potential replacement was randomly selected from among others who used the selected water source type in that county.

Once a withdrawal site was selected, all wells, surface water sources, pumps and irrigation systems connected to that site were characterized. Multiple water sources and multiple irrigation systems were common. Flow points in the system that supplied fixed "wetted" field areas with water were selected as metering sites. Flow rates were measured with the pumps and application system operating under normal conditions and under control of the farmer. Portable "strap-on" digital flow meters provided flow rates. These did not require modification of the irrigation system for the measurement and follow-up flow checks could easily be made. A systematic follow-up of flow rates was made during the 2001 to evaluate changes in farmers systems over time.

The state was divided into four reporting areas based on special water planning needs (Fig. 1). The 24-county Coastal Zone had been previously identified by EPD as a special area based on salt water intrusion concerns for the Upper Floridan aquifer. Similarly, a 26-county area in Southwest Georgia had been described because of agriculture's unique role in water use in the tri-state water planning talks. Setup and monitoring of AWP sites was initiated during 1999 for both of these reporting regions. On average, 93 irrigation systems were monitored in the Coastal zone; 221 in Southwest Georgia. The 34 remaining Coastal Plain counties were grouped into a third reporting area. Likewise all 75 counties that lay north of the fall line were grouped into a fourth. Setup and monitoring of AWP sites was initiated in 2000 for these last two regions. On average, 249 irrigation systems were monitored in the central Coastal Plain, while 15 were monitored in north Georgia. A total of approximately 43,000 acres of irrigated land was included in these sampled systems statewide. Monthly monitoring was continued through 2004. This report details water use for the period 2000 to 2003.

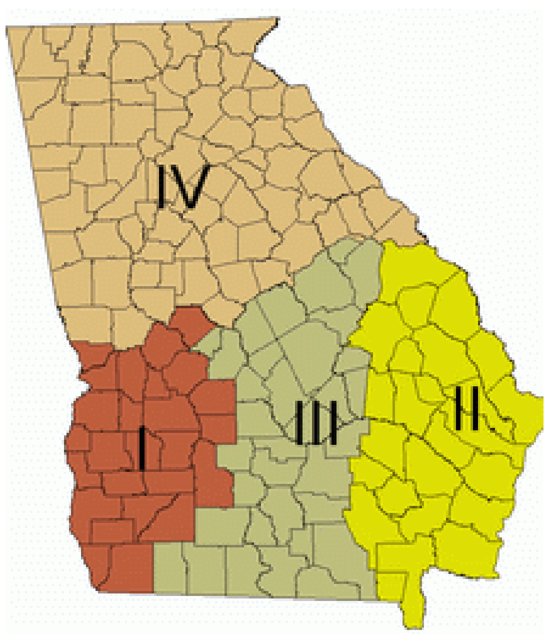

Fig. 1. Irrigation reporting regions in Georgia - I = Southwest or Flint Basin; II = Coastal Zone; III = Central Coastal Plain; IV = North GA.

Results

Statewide mean annual application depths were 9.4, 7.8, and 8.7 in. for the 2000, 2001, and 2002 drought years. Irrigation depths were weighted by field sizes to minimize the influence of small fields of specialty crops that received high irrigation depths. When applied on a statewide basis, area weighting made little difference among the 585 monitoring sites. Weighted mean annual application depths were 9.6, 7.5, and 8.4 in. for 2000 through 2002, respectively. However, when weighting was applied to smaller areas or when comparing irrigation among water sources or system types, it provides for a more reasonable value for use in water use planning. Withdrawal amounts could be computed directly from area weighted means, and this value will be used in the remaining comparisons in this summary.

In each year, farmers at some of the metered systems made the decision not to irrigate. These varied from 5 to 7% of metered systems during the drought years and increased to 17% during 2003. At times the decision to withhold irrigation was based upon limited water supplies; at others it reflected rotation of more valuable crops among a farmer's irrigation systems.

Farmers who used ground-water sources for irrigation used more water than those who relied upon surface water sources. Statewide mean application was 11.4 in. when irrigation was from ground-water sources, and 7.2 when it was from surface water sources in 2000. Similarly comparisons for 2001 and 2002 were 8.6 vs. 6.1 and 9.9 vs. 7.1 in., respectively. Explaining these differences presents a "chicken vs. egg" dilemma. Farmers who produce higher value, more water intensive crops might drill wells to obtain a reliable water source; farmers with wells might choose to grow higher value crops. During the 1998 through 2002 drought, farmers often found that their surface water supplies had dried up. While they might have planned to use more water, dry ponds and streams prevented that. Since this was a significant drought period, their surface water supply may have been adequate in most other years. In still other explanations from farmers in our study, surface water supplies were often connected to irrigation systems like travelers that are used less frequently because of increased labor requirements. Thus for a variety of reasons, surface water users applied less irrigation during our study.

Faced with inadequate runoff to refill ponds just when it was needed for irrigation, many farmers drilled wells adjacent to the ponds to supplement them during peak use periods. In some cases, the choice of a well-to-pond system was made because wells of sufficient pumping capacity to directly supply the irrigation system were too expensive or impossible given the local geology. Wells of smaller capacity could be drilled and run longer, while water would be pumped out at higher rates with separate pumps while the irrigation system was used. In other cases the choice of well to refill the pond was only to provide insurance in times of inadequate runoff and stream flow to maintain pond water levels. The higher costs associated with pumping from ground-water and again from the pond made this a less desired option than using surface water whenever it was available.

EPD issued permits by water source and recognized well-to-pond systems as a separate category in its permitting. It was included among our random selections in proportion to those permits and counties. On a statewide basis, mean annual application depths for well-to-pond systems were 8.7, 7.3, and 6.9 in. for 2000 to 2002, respectively. These values were in between amounts used with ground-water and surface supplies.

Farmers differed in their irrigation practices creating a wide distribution in annual application amounts, and those distributions differed by regions (Figs. 2 and 3). Differences among individual users could be attributed to many factors – rainfall differences among individual fields, type and value of crop, length and specific period of the crop's growing season, different yield expectations, reliability and capacity of water source, capacity and type of irrigation system, scheduling automation, and farmer's risk aversion.

Means for irrigation depths are useful in planning for water withdrawals, but it is important to recognize that means were computed from fields whose individual application depths varied from 0 to over 300 in./y. In drought years, these application depths were normally distributed over much of the range of observed irrigations. However, irrigation application depths that exceeded 20 in./y occurred with a greater frequency than would be expected for a normally distributed population.

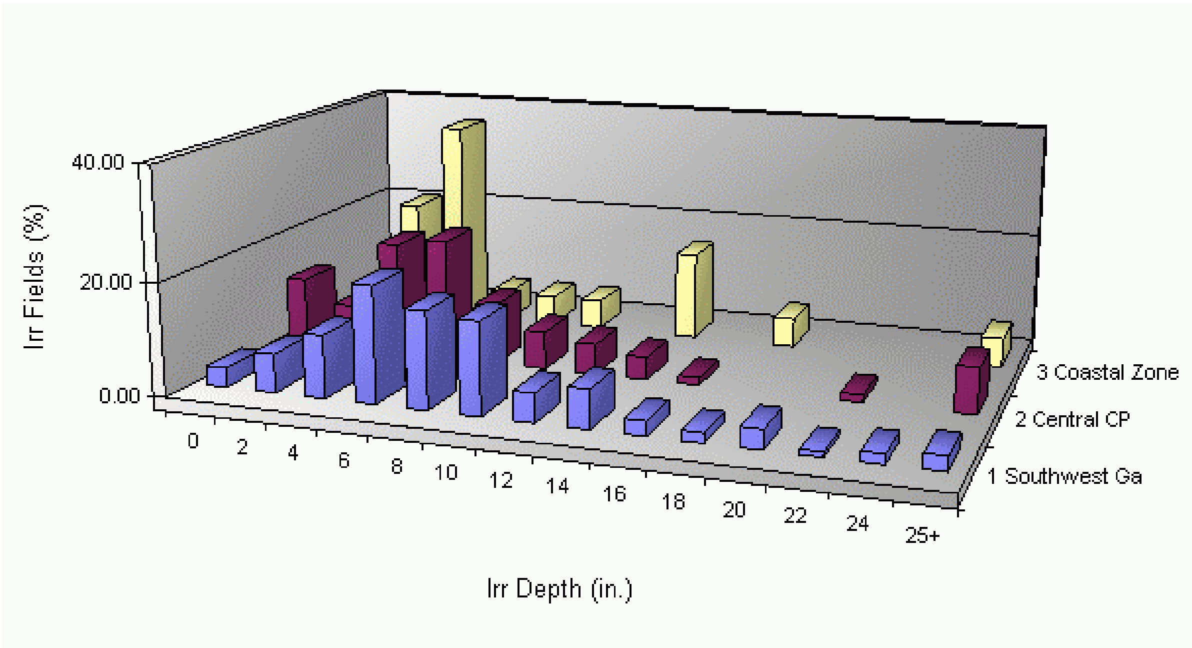

Fig. 2. Distribution (as a % of all users) of annual irrigation amounts for ground-water users during 2001. There were no ground-water users among monitored fields in North Georgia.

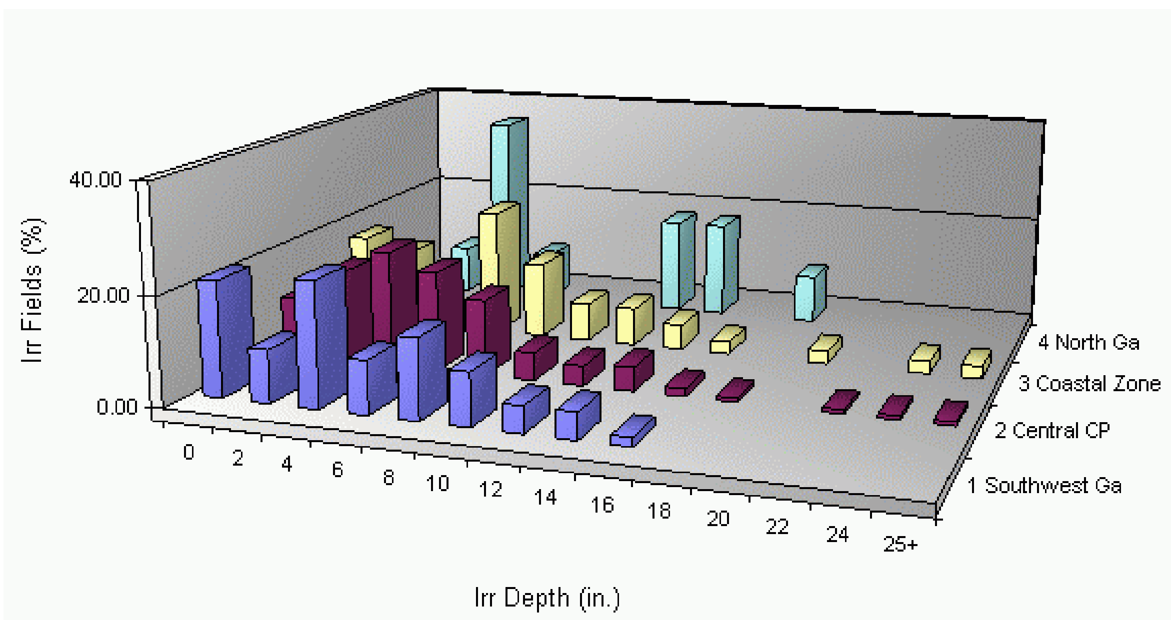

Fig. 3. Distribution (as a % of all users) of annual irrigation amounts for surface water users during 2001.

When the full range of observations were ranked, application depths associated with the 50th (median), 75th, 90th and 95th percentiles were determined. Median irrigation application depth was 8.3, 6.2, and 6.7 in. for 2000, 2001, and 2002, respectively. Less than 25% of farmers used more than 12 in./y; only 10 percent used more than 16 in./y, and 5 percent more than 20 in./y between 2000 and 2002.

When averaged over all users, more water was applied to fields in Southwest Georgia than in other regions in each of the drought years. For ground-water users, these area-weighted mean application depths varied from 9.1 to 12.0 in. in Southwest Ga., 6.8 to 8.4 in. in the Coastal Zone, and 9.0 to 10.6 in. in the central Coastal Plain. For surface water users, they varied from 5.2 to 7.3 in. in Southwest Ga., 5.6 to 6.8 in. in the Coastal Zone, 6.0 to 7.3 in. in the central Coastal Plain, and 7.2 to 7.6 in. in North Ga. Few irrigators in North Georgia have access to adequate ground-water for irrigation, and none were included in our randomly selected sample.

Irrigation systems in Georgia include center pivots, traveler systems like hose reel and cable tow, solid set sprinklers, and micro-irrigation including surface drip, drip under plastic and subsurface drip. Irrigation depths for center pivot systems were very close to overall statewide means. This was expected since 80% of the state’s systems were center pivots. Of these 40% were supplied by ground-water. Almost 97% of these were in use in each year. In contrast, only 6% of systems were travelers, and of those only 9% used ground-water. Even during drought only 40 to 75% were in use. Irrigation depths with travelers were generally less than 4 in./y.

Farmers used solid set systems primarily for pecan and other orchards, nurseries, and athletic fields. These uses resulted in mean annual application depths of 29 to 57 in./y between 2000 and 2003 when supplied from ground-water. When supplied from surface sources, solid set systems had much lower annual application depths, 7.5 to 11.2 in./y.

Drip systems were also in use on specialty crops, including pecan orchards and vegetables. About 87% of these were supplied with ground-water. Mean annual application depths varied from 8.0 to 13.7 in./y in this period. These drip systems were almost always used each year.

Irrigation does not occur uniformly throughout the year. Farmers apply water in response to plant needs, and those plants have different growing periods. Patterns of monthly withdrawals were prepared for each region and source, but common to all were peak use periods of May through September (Figs. 4 and 5). In the Southwest region, little water was applied outside of this peak use area. In the Coastal Zone and central Coastal Plain, a diversity of vegetables and pastures resulted in proportionally higher application depths in winter months than seen in the Southwest Georgia region.

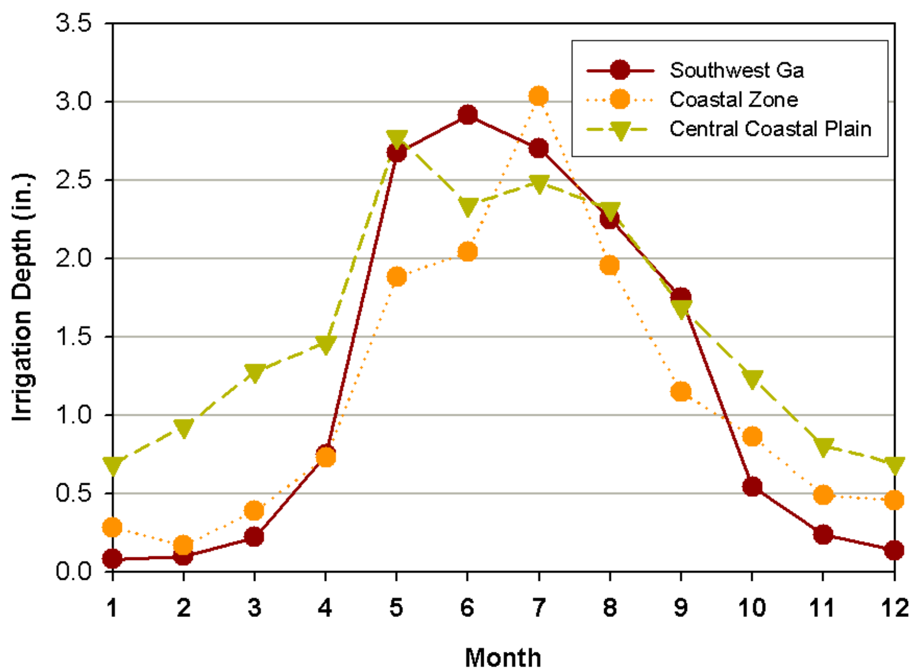

Fig. 4. Maximum of mean monthly application depths applied during the drought years 2000 to 2002 by ground-water users in three areas of Georgia.

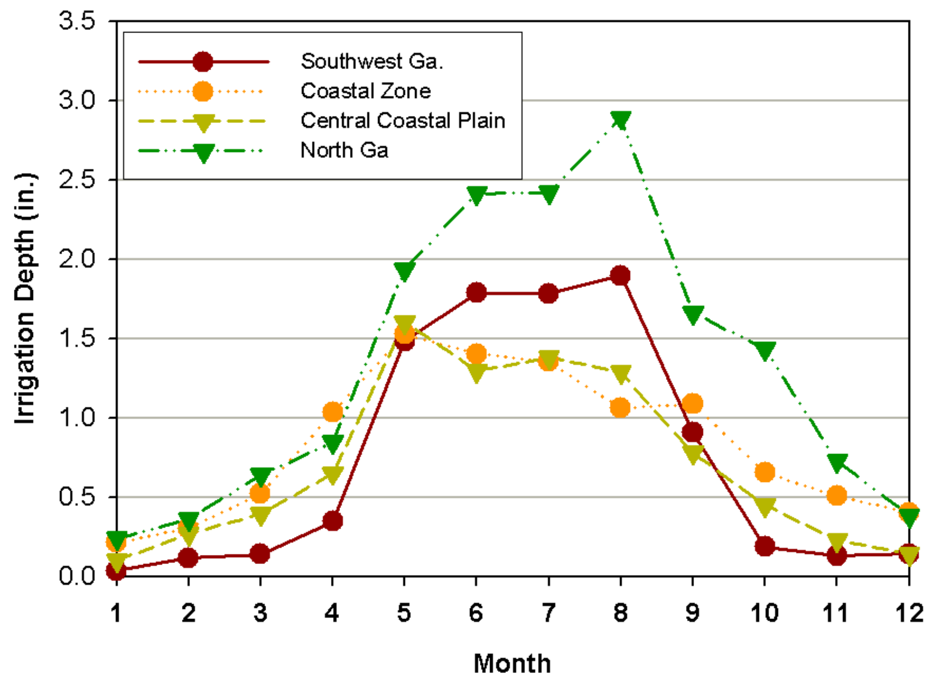

Fig. 5. Maximum of mean monthly application depths applied during the drought years 2000 to 2002 by surface water users in four areas of Georgia.

Irrigation demand is also related to net difference between evapotranspiration and effective rainfall. In effect farmers in the humid region are using irrigation to fill the gaps between effective rainfall and crop ET. Because most of the soils in Georgia's crop production region are sandy, soil water storage provides little of a crop's seasonal water needs, and it is ineffective in storing significant quantities of irrigation water. It is largely for this reason that very few surface application systems are found in the state. In Fig. 6, an example of rainfall and predicted ET is shown for the Southwest region. Total rainfall is shown rather than effective rainfall, so differences between ETp and rainfall are actually greater indicated.

When the monthly deficit was plotted with the mean monthly irrigation, the relationship between deficits and irrigation became more evident (Figs. 7 to 9). An April deficit occurred each year, but at that time a significant portion of Southwest Georgia's irrigated acreage had not been planted. Many of those who irrigate field corn and sweet corn in the region initiated their irrigation in April as initial soil water supplies failed. By May, the deficit grew in these drought years. Irrigation was needed to supply most of that month's water for spring crops, and in some cases was needed to establish stands of peanut and cotton, the region's primary crops by irrigated area. From June through August, water use mirrored the monthly deficits. September irrigation exceeded the deficit, although most of the rainfall in September came in tropical storms after irrigation that completed maturation of peanut and cotton.

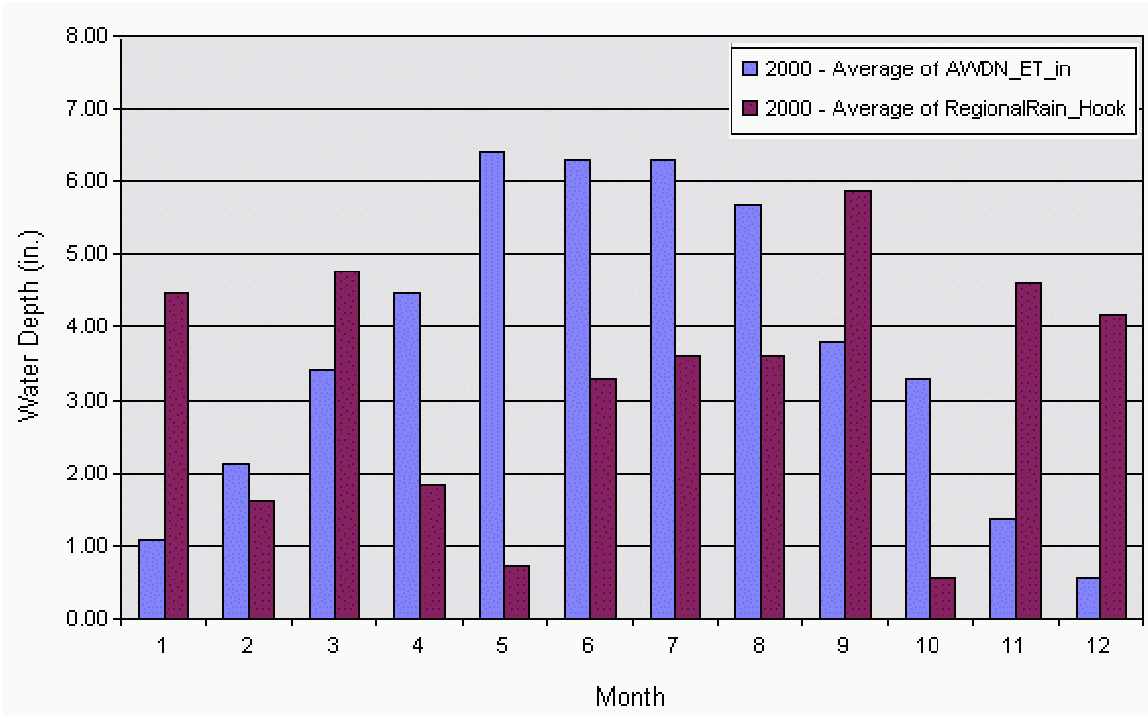

Fig. 6. Regional mean rainfall and predicted evapotranspiration (ETp) derived from Georgia's Automated Weather Data Network (AWDN) for sites in and around the Southwest Ga. region during 2000.

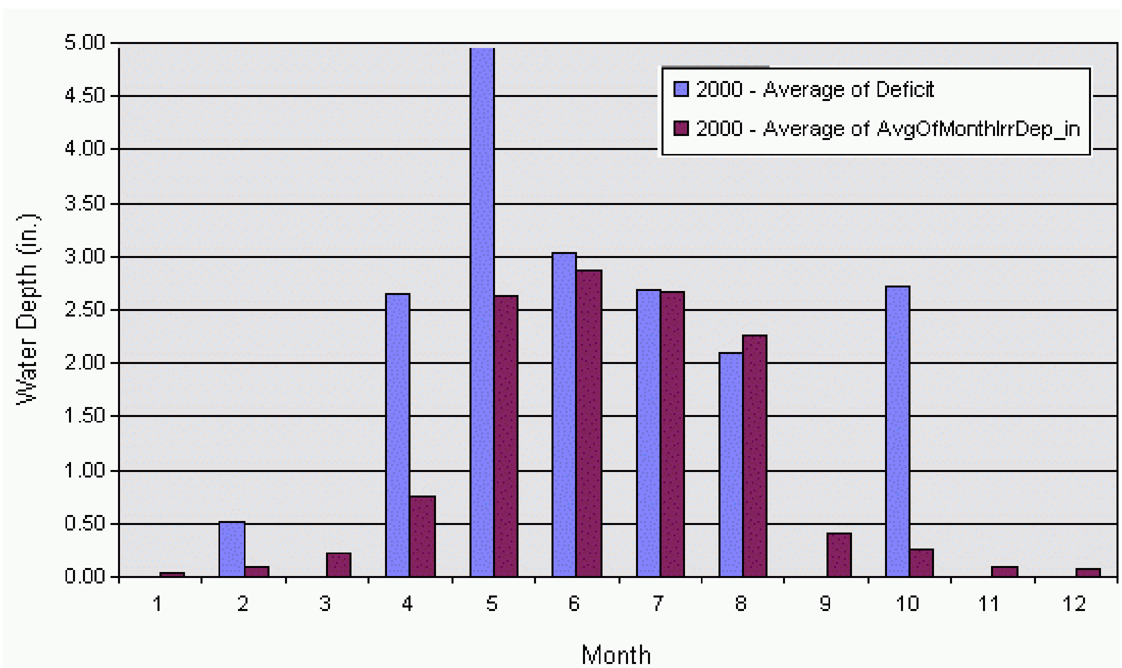

Fig. 7. Regional deficit (ETp - rain) and area-weighted mean monthly irrigation depths for ground-water users in Southwest Ga. in 2000.

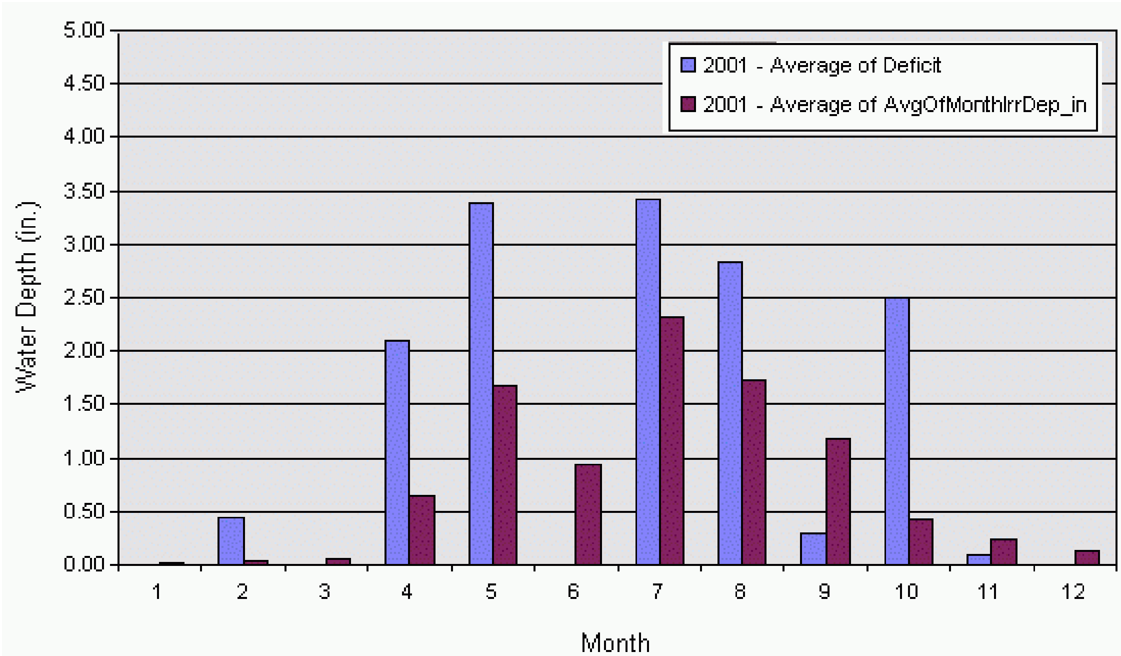

Fig. 8. Regional deficit (ETp - rain) and area-weighted mean monthly irrigation depths for ground-water users in Southwest Ga. in 2001.

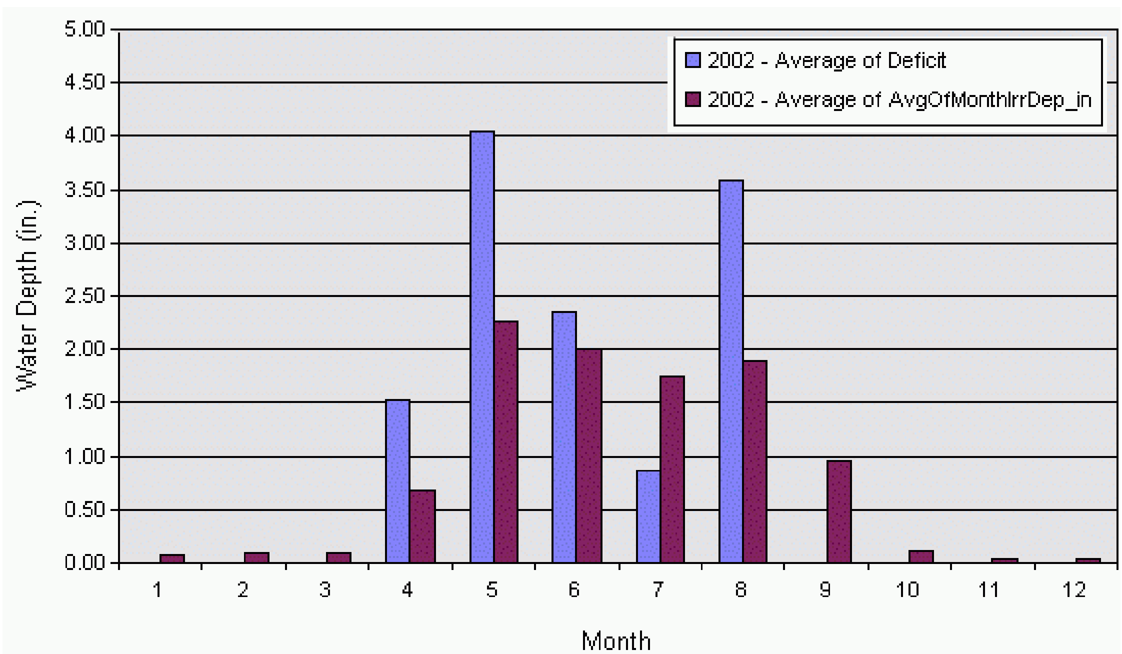

Fig. 9. Regional deficit (ETp - rain) and area-weighted mean monthly irrigation depths for ground-water users in Southwest Ga. in 2002.

Summary

The Agricultural Water Pumping program provided Georgia with a comprehensive examination of water use amounts by Georgia farmers during the severe drought years of 2000 to 2002. Irrigation amounts were seen to vary by year, region, water source, irrigation system, and month of the year. Many of these variations were related to the type of crop produced with various systems and water sources. On average, farmers used less than 12 in./y even in these drought years.