Status of Georgia's Irrigation System Infrastructure

Kerry A. Harrison and James Hook[1]

Introduction

For many years, the Georgia Cooperative Extension Service (CES) has worked to track Georgia's irrigation infrastructure so that it could provide education, service and research programs for farmers who irrigate. The Georgia Irrigation Survey has been conducted at intervals of one to three years since 1970, most recently in 2000. The Extension unit of the Biological & Agricultural Engineering Department sends this survey to the Extension agent in each of Georgia's 159 counties who is responsible for agriculture and natural resources programs. This individual fills out the survey form based on his knowledge of agricultural practices in his/her county. The forms are then returned to the Extension engineering unit where the data is compiled and distributed. Basic information from the survey has included irrigated area and irrigation amounts for each major crop in the latest year. Types of irrigation systems, water sources, and pumping plant power sources have also been enumerated, but little to no information was collected about repairs, changes, or upgrades made to the irrigation systems. Summaries of these surveys have been shared with the irrigation industry by means of the Irrigation Journal's annual survey of irrigation in each state.

A new opportunity to define the state's irrigation systems was created when the state began to regulate water withdrawals for irrigation. In 1988 Georgia's Groundwater Protection Act and Surface Water Quality Control Act were amended to require those who made withdrawals for agricultural irrigation to obtain permits from the Georgia Environmental Protection Division (EPD). During the next 10 years nearly 20,000 permits were issued. Farmers were asked to supply information about their pumps and wells, but they were not asked to describe their application systems. Unlike municipal and industrial users, agricultural users were exempt from water metering and reporting. This left EPD with names of permitted irrigators, general locations of their withdrawals but little to no information about how and when the water was used. They did stipulate limits on pumping rates (described in gallons per minute) and maximum irrigated area (acres), but no field verification was conducted. As water planning issues grew in importance, EPD turned to the CES for assistance in obtaining more specific answers to the questions "How much, when, and with what equipment?"

A statewide irrigation monitoring program was established for Georgia by UGA scientists and CES. A two percent sample of existing EPD-issued irrigation permits were randomly selected for monitoring of agricultural irrigation withdrawals. That total number was based upon estimates of monitoring costs versus available resources, but in a large population a 2% randomly selected sample would not be considered unreasonable. Selected participants were asked to participate voluntarily and most agreed. The monitoring program was conducted over a 6-year period (1999-2004) to make certain that drought years would be encountered and that crop rotation would also be "cycled through the sample population".

[1] Authors are Kerry A. Harrison, Extension Engineer, P.O. Box 1209, Tifton, GA 31793 and James Hook, Professor, Univ. of Ga. Campus at Tifton, PO Box 748, Tifton, GA 31793-0748,

The approach for the monitoring program, which became known as Ag Water Pumping (AWP), included monthly field visits to each of more than 800 irrigated fields. Project personnel recorded crops grown, systems in use, and accumulated hours of operation. Since flow rates were measured on each system under normal operating conditions, they were able to determine volumes of water removed from surface and ground-water sources. This timer approach eliminated the need for expensive up-front meter installation and allowed AWP to get accurate answers in a short time period. Current water use was recorded by type of irrigation system, source of water, type of crop and time of year in both severe drought years and in moderately wet years. Using the random sample of existing water users in combination with the survey information should allow projections for future water needs to be made with computer models. In addition to water use data, wells, pumps, and irrigation systems were documented. These descriptions detail the status of irrigation system infrastructure in Georgia - the subject of this paper.

CES Survey of Irrigation Systems

Georgia is among the top ten states nationally in area under irrigation by sprinkler systems (Table 1). Triennial CES surveys in Georgia show the total irrigated area in the state has gone through two growth periods (Fig. 1). From 1975 to 1980, there was a very rapid increase in irrigation as high commodity prices and competition led to a rapid increase in irrigation even though the period was not marked with significant droughts. The ability to install center pivots that required little field labor encouraged this trend. In the early 1980, farm prices collapsed, and little new irrigation was installed. By the mid 1980's summer droughts became more common and more serious. Bankers began to demand better protection for crop loans, and labor became less available in rural areas of the state. Since that time a second, steady annual increase in irrigated area has occurred in Georgia.

Table 1. Sprinkler-irrigated area in those U.S. states with the greatest sprinkler area.

State	Irrigated Area (ac)*
Nebraska	5,150,000
Texas	4,050,000
California	2,792,000
Idaho	2,584,300
Kansas	2,402,287
Washington	1,625,000
Georgia	1,362,835
Colorado	1,351,000
Montana	1,215,500
Missouri	671,400
Florida	667,000

* Irrigation Journal, January/February 2001

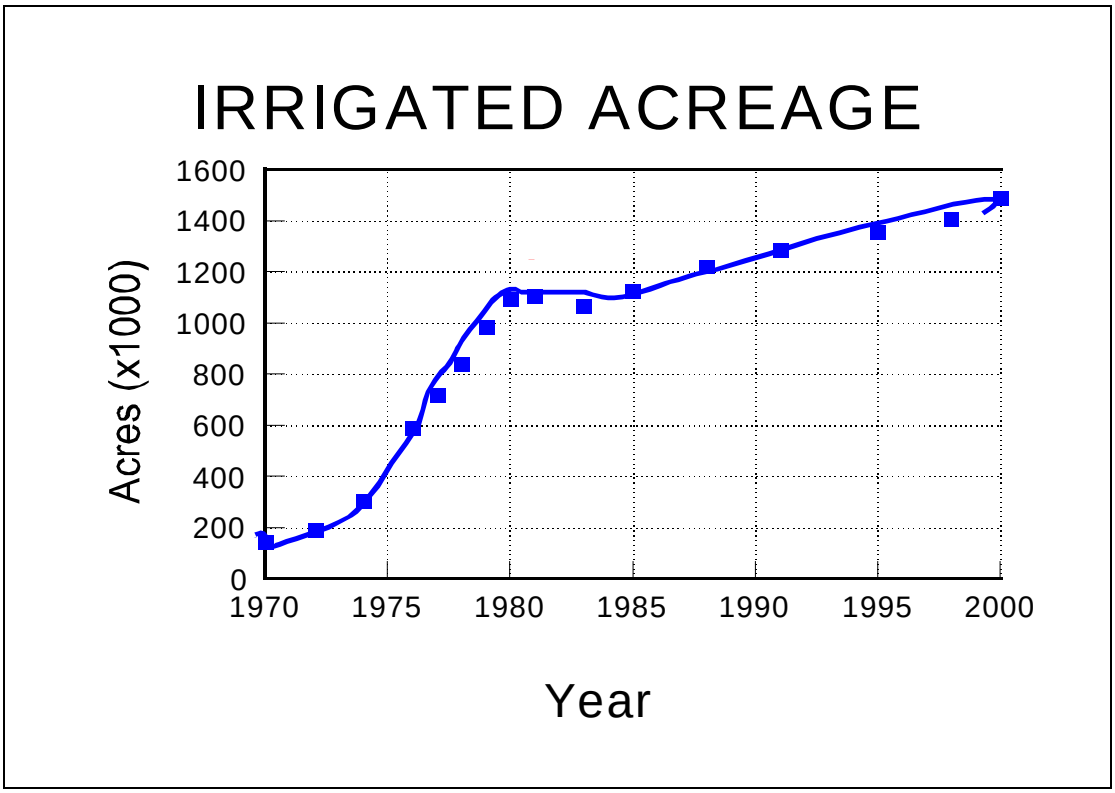

Fig. 1. Total irrigated area in Georgia as reported in CES Irrigation Surveys. Figures include drip and microirrigation, as well as sprinkler irrigation.

The CES surveys have also documented shifts over time in the preferred irrigation systems (Fig. 2). During the rapid growth period of the late 1970's both center pivots and travelers were being purchased. Since the 1980's relatively few travelers have been purchased, most of those as replacements. These systems required too much time and labor to set up, and labor has remained scarce on Georgia farms. As we observed during the Ag Water Pumping study, many of those traveler systems remained unused much of the time. Center pivot systems, however, continued to increase in numbers. Solid set systems made up the remainder of Georgia's sprinkler-irrigated land. Most were used in pecans and other permanent orchard crops or in athletic fields and golf courses that are considered agricultural water use by EPD in most of the state.

Besides the sprinkler systems, a slow and continuing growth has occurred in drip and other micro-irrigation systems. Many of the drip systems have been installed as alternatives to solid-set sprinklers in pecans; others are new vegetable production systems with drip under plastic mulch. In recent years, we've observed drip irrigation being installed under center pivot systems or in replacement for them as vegetable production continued to increase in South Georgia. Maintaining the center pivot in these fields may permit growers to rotate among non-vegetable crops in order to suppress weed and disease problems, or farmers may be hedging their bets and maintaining future options as they retire the units in favor of drip irrigation.

The CES Survey showed that by 2000 about 75% of the irrigated area in Georgia (1,120,000 ac) was being irrigated by 10,100 center pivots. Other sprinkler irrigated acres (methods) included 3,350 travelers irrigating 242,000 ac and 460 solid set systems providing irrigation on 31,000 acres.

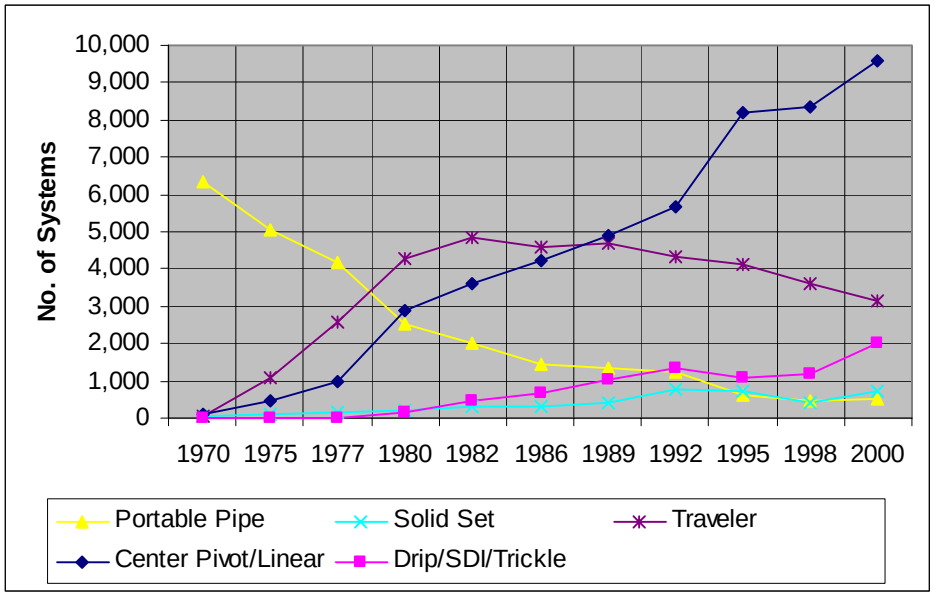

Fig. 2. Number of irrigation systems by type as reported in CES Surveys.

AWP Monitored Irrigation Systems

While the CES surveys provided valuable insight to the irrigation infrastructure, the Georgia EPD wanted detailed information on annual water use from a selection of its agriculture permit holders. In the process of selecting and describing the irrigation systems used with these permits and in our monthly return visits to each system over the past 5 to 6 years, we have gained considerable understanding of Georgia's irrigation infrastructure. The infrastructure is both complex and dynamic.

Center Pivot Systems

As noted in the CES survey, the vast majority of irrigation systems in the state were center pivots (Table 2). Of the 604 systems connected to 448 permitted withdrawal points, 86% were permanent or towable center pivots.

Table 2. Average number of irrigation systems by type in the random sample monitored during statewide sampling 2001 to 2003, and the percent of those monitored systems or fields that were not used during each year.

Irrigation System Type	Ave. No. in sample	2000	2001	2002	2003
		%	%	%	%
Permanent Center Pivot	474	2	4	8	11
Towable Center Pivot	48	11	9	6	19
Traveler	38	25	54	60	75
Surface & Subsurface Drip	18	0	11	16	20
Solid Set Sprinklers	26	6	4	3	13

Market share among sampled pivots in Georgia was as follows: Valley, 44.7%; Lindsay (Zimmatic), 30.5%; Lockwood, 10%; Reinke, 8.0%; Rainbow, 2.3%; Gifford Hill, 1.4%; TL, 1.2%; Raincat, Pierce, and unknown made up 2.1%. Georgia's center pivots are aging. Almost 45% are 15 years or older; 32% more than 20 years; 17% are over 25 years old. Almost all of these systems were operated each year (Table 2), indicating the remarkable durability of the pivots and their ability to be maintained and upgraded. About 10% of the pivots were (still) towable units at the time that the statewide sampling

was started. Because of work involved in moving the units, there was a greater tendency not to use some of the fields irrigated by towable pivots each year (Table 2). In some cases the pivots themselves were not used at all in some years.

Throughout the 6 years of the study, farmers continued to modify and upgrade their irrigation systems. When permanent center pivots were replaced, it was usually in conjunction with property changes, land clearing, or smaller pivots being replaced by large units. Towable pivots were also changing. Usually a farmer chose one of the multiple riser points and permanently locked down the towable pivot. A new pivot was installed for the other riser point.

Despite the added aggravation for operation of part-circle center pivots and the higher per acre cost of these systems, 34% of Georgia's pivots could not be operated full circle. Additionally, 23% of towable pivots could not operate in full circle on at least one riser point. Fence rows, property boundaries, ponds, wetlands, utility poles, roads and buildings, as well as other pivots, created obstructions that prevented the full circle operation. Forests were also common in the non-irrigated section, but usually they were in conjunction with some other obstacle. Clearing of forests and sometimes riparian areas and drainage ways were common in pivot areas, even when these could not be planted with crops.

About 12% of systems were still equipped with high pressure, high angle impact sprinklers. Of these, almost a third have been installed on systems younger than 15 years. Low pressure, low angle nozzles are more common; 34% of pivots were equipped with them. About 38% of systems in our sample were equipped with sprays on top, while only 16% were equipped with sprays on drops.

Water Application Information

The interaction of the type of irrigation system and its water source on irrigation amounts must be understood if future water demands are estimated. Throughout the period of this study, irrigation systems were changed. Traveler-irrigated fields were reconfigured and drip systems were installed as vegetable production began on previous row-crop fields. Towable center pivots were locked in one position and a new permanent center pivot was added at the second riser. Older, often smaller, pivots were replaced by new pivots, and wooded borders were cleared to expand the coverage of pivots that had been operated in a part circle mode previously. In one case a center pivot was idled and drip irrigation installed in its field. The tendency of these changes was to increase water use by shifting to systems that have higher average water use or to increase areas irrigated by the monitored withdrawal source.

A comparison of the water amounts obtained is shown in Table 3 for crops grown in Georgia. Not all crops were statistically represented by the monitoring project in 2000. The amounts are in agreement for most crops that had representation in the monitoring project.

Table 3: Water Applied in 2000

Crop	Inches Applied* (# sites)	Inches Applied**
Corn	13.6 (33)	14.1
Cotton	8.6 (148)	11.6
Peanuts	8.6 (104)	11.2
Tobacco		7.4
Soybeans	6.2 (24)	6.0
Small Grains		4.4
Vegetables - Sprinkler		10.5
- Drip	***	12.6
Pastures		7.5
Apples		6.0
Blueberries		8.9
Peaches	***	7.2
Pecan - Sprinkler	12.4 (9)	13.8
- Drip	4.2 (11)	12.8
Field Nursery	***	35.5
Vineyards	***	13.0
Turfgrass		18.3
Greenhouses	***	14.2
Golf Courses	***	31.6
Athletic Fields		
All Other Crops		7.6
Statewide Average	9.4 (385)	9.7

* Information was obtained from Ag Water Pumping program sample monitoring on 32,416 acres.

**Information was compiled from estimates supplied by county Extension agents.

***Not listed since small sample size would reveal individual data.

Summary Discussion

Even though Georgia receives a relatively abundant amount of annual rainfall, the patterns of rainfall are very inconsistent, particularly during the summer growing season. Consequently, irrigation is increasingly being viewed as a necessary input for profitable agricultural production in Georgia.

Irrigated acreage in the state has increased more than ten-fold since 1970, but indications are (Fig. 1) that future growth will occur at a much slower pace. Increasingly, farmers are using more efficient methods of irrigation which should help improve the effectiveness of the irrigation water applied.

The amount of irrigation water applied will vary tremendously from year to year and from crop to crop depending on the amount of rain received in the agricultural areas during the growing season. Estimates of yearly average water applications agree with monitored results and indicate that annual irrigation water use fluctuates between 100 and 300 billion gallons. Higher irrigation use will generally occur during periods of lower than normal rainfall. Since this typically coincides with periods when water tables are

naturally low, this may present an interesting challenge in managing the states water resources. A second problem that arises is the unit of measurement for agricultural water use. In some areas of the nation agricultural water use is expressed in area-depth units (i.e. acre-feet) but in Georgia the units of water measurement have traditionally been volume per unit of time (i.e. million gallons per day-MGD). This has slowed communication efforts between agencies and commodity groups but should improve in time. Thus far, relatively few conflicts have occurred, and have typically been isolated incidences during extremely dry years.

The project had 644 permits monitored with 854 fields (sites). Or, on average, about 1.33 fields per permit. The total monitored acres were 75,448. These numbers more than satisfy the 2% target stated earlier. The number of center pivots monitored was 726 or 84% of the sites monitored. This number agrees with the survey information presented earlier and gives confidence to the survey information.

Other summary information obtained about the monitored center pivots was:

- The average pivot age is 13 years with 45% older than 15 years.
- Only 66% of those were able to make a full circle.
- 99% of pivots used end guns;
- 40% with operational end gun shut-off.
- 8% of pivots are towed among fields
- **88%** of all pivots had improved energy and application efficiency sprinkler packages.
- **80%** of the old pivots have been converted
- **38%** had spray nozzles on top of pivot
- **16%** had sprays on drop tubes

From the monitored sites we determined that most Georgia pivots have already been converted to low angle impact, low pressure sprays on the pivot pipe, or sprays on drop tubes.

Sprinkler irrigation systems, in particular, center pivots; are aging. Most owners have made improvements related to sprinkler packages but more expensive and in depth changes will be needed in the future as the basic infrastructure (pivot pipe and towers) ages.

Related Literature/Publications

Blood, E.R., J.E. Hook, and K.A. Harrison. 1999. Agricultural Water Consumption in the ACT/ACF River Basins: Approaches for Projecting Irrigated Acreage and Amounts. In K. J. Hatcher (ed.) *Proceedings of the 1999 Georgia Water Resources Conference.* Univ. of Georgia Institute of Ecology, Athens, Ga.

Harrison, K.A. 2001. Agricultural Water Use trends In Georgia. In K. J. Hatcher (ed.) *Proceedings of the 2001 Georgia Water Resources Conference.* Univ. of Georgia Institute of Ecology, Athens, Ga.

Hook, J. E., K.A. Harrison, G. Hoogenboom. 2004. Ag Water Pumping – Statewide Irrigation Monitoring. Final Report to Georgia Environmental Protection Division. Project Report 52. Atlanta, GA.

Hook, J.E., K.A. Harrison, and D.L. Thomas. 1998. Analysis of water-use by growers in Southwest Georgia. Report to SW Ga. Agribusiness Assoc. and Ga. Dept. of Nat. Resources. NESPAL Rep. 98-01, Univ. of Georgia NESPAL, Tifton, GA.

Hook, J.E., E.R. Blood, D.L. Thomas, K.A. Harrison, and R. Powell. 1999. Agricultural water consumption in the ACT/ACF River Basins: Current approaches for quantifying irrigation in Georgia. In K.J. Hatcher (ed.) *Proceedings of the 1999 Georgia Water Resources Conference.* Univ. of Georgia Institute of Ecology, Athens, Ga.

National Environmentally Sound Production Agricultural Laboratory (NESPAL). The University of Georgia College of Agricultural and Environmental Sciences. Http://nespal.cpes.peachnet.edu/resources

Thomas, D.L. Cathy Myers-Roche, K.A. Harrison, J.E. Hook, A.W. Tyson, G. Hoogenboom, and W.I. Segars. 1999. Ag Water Pumping: A New Program to Evaluate Agricultural Water-use in Georgia. In K.J. Hatcher (ed.) *Proceedings of the 1999 Georgia Water Resources Conference.* Univ. of Georgia Institute of Ecology, Athens, Ga.

USDA-NASS. 2000. *Agricultural Statistics 2000-2001*. US Government Printing Office. Washington, DC.

Table 3. Compilation of Georgia Irrigation Surveys conducted by the Georgia Cooperative Extension Service between 1970 and 2000 (Harrison, 2001).

	1970	1975	1977	1980	1986	1989	1992	1995	1998	2000
Acres of irrigationsystems	144,629.00	307,416	592,088	988,356	1,128,584	1,223,835	1,286,707	1,356,726	1,430,235	1,507,929
Number of irrigation systems	6,572	7,038	8,343	10,599	11,886	13,283	14,159	14,584	12,833	17,428
Irrigated acreage by crop:										
Corn	30,418	76,996	250,227	410,241	341,296	281,135	290,505	143,611	216,496	195,006
Cotton	2,627	1,116	9,270	17,655	69,554	109,868	178,818	543,308	569,507	645,690
Peanuts	38,227	91,334	19,544	271,323	375,160	374,398	365,221	313,064	312,905	305,582
Tobacco	42,402	54,518	46,081	46,522	31,605	33,725	36,926	37,885	33,831	30,890
Soybeans	795	4,725	21,728	133,695	94,349	105,240	63,504	20,637	26,615	21,733
Winter & Small Grains	-	-	-	-	12,758	36,006	21,933	7,283	7,008	32,894
Vegetables - Sprinkler	20,061	26,223	39,727	49,005	97,890	124,737	123,053*	106,563	107,486	108,745
- Drip	-	-	-	-	-	-	9,596*	12,497	13,130	22,452
Pastures	5,440	4,613	10,668	13,991	24,216	18,442	29,617	26,172	34,820	26,267
Apples	-	152	1,100	1,378	677	514	365	54	225	178
Blueberries	-	-	-	-	1,130	1,936	2,201	2,669	3,230	4,644
Peaches	1,542	721	1,995	4,594	5,343	5,083	3,807	5,347	4,186	3,444
Pecan - Sprinkler	485	1,356	4,662	16,266	48,538	69,335	22,269*	22,774	19,823	23,172
- Drip	-	-	-	-	-	-	45,668*	48,213	44,696	57,181
Field Nursery	1,453	424	602	1,115	3,013	4,567	4,307	4,484	5,285	5,369
Vineyards	-	145	240	1,581	517	604	561	665	752	953
Turfgrass	-	1,557	1,764	2,252	5,409	9,195	11,411	15,389	34,007	32,711
All Other Crops	1,179	2,121	7,411	7,665	10,163	5,014	9,507	1,728	3,965	192
Golf Courses	-	-	6,069	7,638	**-	**-	**-	**-	**-	
Athletic Fields	-	-	-	614	6,966	15,111	18,795	21,015	24,649	22,951
Number of irrigation systems by type:										
								***	***	***
Portable pipe (hand-move)	6,365	5,026	4,179	2,517	1,452	1,352	1,250	599/32	454/37	497/31
Cable-tow	69	1,090	2,585	3,825	3,618	3,554	3,135	2,851/73	2,049/70	1,705/66
Hose Reel (hose pull)	-	-	-	429	955	1,132	1,198	1,276/93	1,608/82	1,642/78
Center Pivot	87	478	983	2,858	4,191	4,855	5,660	8,167/108	8,410/121	10,059/111
Lateral Move (linear)	-	-	-	7	28	29	23	21/120	19/84	27/81
Drip-Trickle	-	-	21	159	687	1,040	1,356	1,083/67	1,167/57	2,014/37
Solid Set Sprinkler	32	122	135	211	288	429	764	709/37	427/68	720/43
Golf Courses	-	291	229	250	257	-	-	-	-	-
Athletic Fields	-	120	175	256	405	892	766	579/37	650/37	748/33
Number of irrigation systems by type of power:										
Gasoline Engine	2,985	2,009	1,936	885	658	617	506	347	254	208
L.P. Gas Engine	1,116	1,377	1,033	822	788	781	876	684	738	553
Diesel Engine	2,292	3,434	4,180	6,794	7,485	7,950	7,769	9,366	7,779	8,076
Electric Motor	179	329	441	919	2,420	3,014	4,206	4,187	5,018	6,653
Undesignated Sources	-	-	-	1,179	5	3	4	-	-	-
Number of systems by source of water:										
Ground water	582	1,118	1,771	3,387	4,628	7,260	7,876	8,391	8,881	10,101
Surface water	5,990	6,258	6,211	6,378	6,666	6,018	6,283	6,165	5,998	6,328
Waste water	-	-	-	-	-	-	11	177	140	197
Number of acres under chemigation:										
Fertilizer	-	-	-	-	136,618	133,285	155,749	106,164	118,725	103,842
Herbicide	-	-	-	-	31,958	20,077	15,810	16,870	13,918	10,200
Fungicide	-	-	-	-	6,617	9,200	12,026	6,975	7,385	1,764
Nematicide	-	-	-	-	1,200	700	1,587	1,500	2,545	402
Insecticide	-	-	-	-	4,819	7,615	4,112	3,003	5,355	1,170

*Drip and Sprinkler acreage separated beginning 1992.
**Golf courses and athletic fields combined for these years.
***Number of systems/average, system size in acres rounded to nearest acre.
This information was compiled from estimates supplied by county Extension agents for educational purposes only.