CROP WATER USE IN THE MISSISSIPPI DELTA

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INTRODUCTION

Water can no longer be considered the unlimited resource in the Mississippi Delta that it once was. Irrigation has become the rule rather than the exception. Economics has caused a change in cropping patterns from dryland crops to those which are water dependent. Heavy pumpage of the Mississippi River Alluvial Aquifer has produced both declining water levels and rising concerns for the future of local industries that depend on a reliable source of inexpensive water. Proper management of these groundwater supplies is essential. The need to search for alternative water supplies is vital if the Delta is to remain a major agricultural region. Determining how water is currently being used is the first step in formulating a plan to ensure continued water availability.

Agriculture is the major consumer of water pumped from the shallow alluvial aquifer. Considerable effort has been put into directly measuring the volume of water used in rice, catfish, and row crop production over the past five years. The critical need for crop water use information is emphasized by the fact that the areas of the Delta where irrigation is most intensive are also the areas experiencing the greatest declines in groundwater levels over the past twenty-five years based on historic water-level measurements initiated by the U.S. Geologic Survey. The alternative water supply study currently undertaken by USDA's Natural Resource Conservation Service (NRCS) and sponsored by YMD Joint Water Management District (YMD) is vitally dependent on accurate water usage figures in order to develop a water supply system capable of providing enough water to meet the present and future needs of the Delta area. This need for water use information prompted the Mississippi Agricultural and Forestry Experiment Station (MAFES) with the assistance of the YMD Joint Water Management District to begin a survey of rice water use as the District's first major field project in 1990. The need for dependable water use information was anticipated even before the inception of the joint water supply project with NRCS. In ensuing years, YMD collected information on catfish water use. YMD and NRCS have collected a limited amount of row crop water use data. Information presented in this paper is the compilation of results from three separate studies of agricultural water use on catfish, row crops, and rice.

PURPOSE AND SCOPE

Historically, agricultural water use information has been collected indirectly through producer interviews. Producers themselves seemed unaware of the actual volumes of water they required for crop or fish production. Water budgets developed for catfish ponds in Alabama in the early 1980s considered annual requirements to be as high as 80 inches (Boyd 1983). Interviews with catfish producers led the Mississippi Department of Environmental Quality to establish a permitted volume of 60 inches per year for catfish production. In contrast, computer modeling indicated that it was possible for established ponds in Mississippi to use as little as 15 inches per year (Pote et al. 1988).

A survey of rice producers in 1987 sought information on their water use. These survey results indicated approximately 76 inches annual consumption. This number was considered to be excessive due to what was thought to be producer overestimates of well flow rates and hours pumped. Concerns about actual water use estimated by the survey helped generate further interest in directly measuring actual rice water use. A 1990 study carried out by MAFES to investigate differences in water use by contour and straight levee rice fields yielded the incidental verification that the 1987 survey figure appeared to be in error. Work specifically designed to quantify rice water use was begun in 1991 (Cooke, Caillavet, and Walker 1996).

Cotton, soybeans, and corn are farmed on several hundred thousand acres in the Delta. The irrigation of a great percentage of this extensive area is another significant area requiring investigation. The alternative water supply study currently undertaken by NRCS expanded water use studies to include row crop irrigation.

The wide range of initial speculation on water use requirements for rice and catfish production exposed a critical information deficit and a crucial need for accurate water use information for all major irrigated crops. The objective of the studies reported on in this paper was to fill that gap by directly measuring the volumes of groundwater pumped at a number of randomly selected production sites located throughout the Delta. This paper presents a summation of the results obtained by those efforts.

METHODS

The same basic procedure used to measure water use was employed in all three studies. The following formula was used:

XY/Z = Water Used/ Acre
Where X = Well operation time
Y = Flow rate of well
Z = Number of irrigated acres

The well operation times were obtained using running-time totalizers. These small, simple timers measure total operating time of a well. Depending on the totalizer type, either vibration or induced current causes a counter to trip every 1/100th of an hour (45 seconds) of well operation. An LED display shows the accumulated run time in hours. Time totalizers typically are no larger than 3x5x2 inches in dimension and are battery powered. This small size allows for placement in unobtrusive locations on wells and causes little or no interference with well operation for the study participants. Vibration-activated totalizers were used on well sites with diesel or large direct drive electric power units. Installation of these units involved tightly fastening the device to a solid portion of the well-motor system. Vibrations from the operating motor were detected by the sensor. The induction-activated totalizers were used on wells with smaller electric motors and on submersible pumps. Installation of the induction units entailed wrapping an iron sensor wire 6-8 times tightly around a current-carrying line to the well motor. The attached unit was placed in a corner of the well's fuse box.

Flow rates on farm wells were acquired with the use of portable electronic flowmeters. This device is central to much of the water-use investigation carried out by YMD. Rather than physically invading the water stream as traditional methods of well flow determination do, electronic flowmeters have sensors that attach to the outside of a pipe carrying liquid, in this case water, and send an ultrasonic signal through the pipe wall and moving fluid. Changes in the return signal are interpreted by the machine to determine the speed of flow of the water through the pipe. The flowmeter compares that velocity with operator-entered information on pipe diameter and wall thickness to calculate the well output.

The Cross-correlation flowmeter was used in both the rice study and in the catfish work in 1991. This machine performed well on a wide range of wells and was theoretically accurate to within 10% under good conditions (Arvin 1991; Cordez 1992). Flow readings could normally be made in 45 to 90 minutes including setup time for the equipment. In subsequent years, a Tyme-Flyte meter was used for most flow rate determinations. This Tyme-Flyte has a narrower range of applications than the Cross-correlation meter but has a much higher accuracy rate of from 1-3% under ideal conditions (Arvin 1991) and is much easier to install and operate. Flow readings performed with the Tyme-Flyte equipment could be taken in approximately half the time required by the Cross-correlation flowmeter. On wells where more than one flow reading was taken in the same year, the average of those readings was used in water use calculations.

Irrigated acreages were determined by one or more of three methods. These were: operator-supplied information, examination of Farm Services Agency (FSA, formerly ASCS) county office records and maps, and direct ground measurement. Acreage figures supplied by operators and C.F.S.A. records were generally within 5% of measured values and were considered adequate for study purposes. Catfish ponds water acreages as a rule were 85% of measured or documented land area with the remaining 15% in levees and support. This assumption was used to determine water acreages on newer ponds where there was no acreage documentation.

Study sites were randomly selected by computer from the list of permitted production wells in the well permit database held by YMD. Field inspections were made on each site to determine suitability and compatibility of each location with the equipment to be used. Wells had to serve a static, identifiable land area with only a single crop being irrigated by that well. Well discharge pipes were examined for compatibility with the equipment being used. The electronic flowmeter requires a minimum straight run of pipe of 14 inches for the ultrasonic sensors to be attached. Power sources for the wells had to be dedicated or provide a dedicated line for operating the well. Some locations visited had power sources that supplied both well and aerator power use. These wells could not be included in the studies. Producers were contacted directly and asked to participate. Participating producers were questioned about acreage figures. No other action by the producers was required, and response was generally positive regarding study participation.

Initial totalizer placements were made during early spring of all years. Periodic visits were made to each study well at roughly two to three weeks' intervals to check totalizer function, to record hours of operation, and to make flow rate measurements if the well was pumping. Final hours of operation were recorded at the conclusion of the pumping season. Proximity of the locations played a factor in determining the frequency of visits to each site. Locations in counties at the extreme north and south of the Delta were not measured as often as those in the central counties due to time and distance constraints. Daily travel requirements for visiting sites often exceeded 200 miles per day.

One to three flow measurements were made on each well checked in the water use studies. Flow rates obtained for each well were considered to apply for all hours of operation. Flow readings were taken from April to November in all years. Flow measurements were made during site visits where the well was operating for normal water additions and had been in continuous operation for at least one hour. This allows for stabilization of well flows following initial drawdowns in the aquifer when the well begins pumping.

RESULTS AND CONCLUSIONS

Average water volumes pumped for all years of the catfish study are listed in Table 1. Average summer water use values measured ranged from 9.7 to 32.2 inches with a five year average of 22.7 inches of water. Adjusted average values ranged from 17.3 inches to 36.4 inches. Summaries of the average measured water use on rice from 1991 through 1994 (Cooke 1996) and YMD's 1995 data are given in Table 2. Averages ranged from a low of 27.0 inches in 1992 to a high of 38.0 inches in 1995. Row crop water use for 1995, the initial year of study, was measured to be 8 inches and is shown in Table 3 (Rodrigue 1995). Average corn water use is assumed at this time to be about the same value. A summary of average annual water use figures for all study years is given in Table 4.

The information gathered by this study places average measured seasonal water use for catfish culture ponds in the range of 10 to 32 inches, with a five-year average of 22.7 inches (See Table 1). This value is for the time of March through November and does not reflect water use for winter pond maintenance. This figure is consistent with theoretical models (Boyd 1983). Too little information is available at this time to make a definitive statement concerning winter water consumption. On the basis of interviews with producers early in this study, a rough estimate of winter pond maintenance is approximately 8 inches, which, when combined with the range of summer water use figures reported here, would place the average annual water use in the range of 18 - 37 inches. This is exclusive of the water required to refill drained ponds. Many producers no longer drain or lower their ponds annually, with the exception of fingerling ponds. Most ponds are drained for levee maintenance and/or control of fish inventory at intervals of 5-7 years (Pote 1988; Steeby 1996). Assuming an average pond depth of 60 inches and 15% of pond acreage being devoted to fingerling ponds (Steeby 1996), this practice would add approximately 9-12 inches of water per year to average annual per acre water use, placing it in about 36 inches. Table 1 shows both measured water use and the figure adjusted to reflect additional drainage and winter maintenance needs.

Results from the studies described in this paper demonstrate that it is possible to directly measure average agricultural water use in the Delta in order to gain useful water use information. Efforts of this type are not without their own difficulties. The major problem identified in all water use studies was site loss due to equipment failure. The induction-type time totalizers were not resistant to field conditions and had a failure rate approaching 50%. Vibration-type totalizers fared somewhat better. Sites were also lost due to lightning, well failure, and one rice study location was struck by a car. Future work of this nature should take into account that about half of the initial site placements will not yield measurable results.

Plans for the future of YMD's investigation of catfish water use will target how pond management styles and localized climatic conditions affect water use and ways in which pond drainage and refilling practices impact water use. Continued efforts will be made in 1996 to measure row crop water use. Plans are underway for measuring the impact of corn irrigation and flood irrigation of soybeans. The results of these studies should be available in the spring of 1997.

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Table 1
Catfish Water Use

Year	Measured Average Water Use	Adjusted Average Water Use
1991.00	24.70	38.00
1992.00	22.00	35.70
1993.00	24.80	38.10
1994.00	9.70	25.30
1995.00	32.20	42.9.

Table 2
Rice Water Use

Year	Average Water Use
1991.00	31.60
1992.00	27.00
1993.00	32.40
1994.00	28.30
1995.00	38.00

Table 3
Row Crop Water Use

Year	Average Water Use
1995.00	8 inches

Table 4
Crop Water Use Summary

Crop	Average Water Use
Catfish	36.0 Inches
Rice	31.5 Inches
Row Crop	8.0 Inches