WATER CONSERVATION PRACTICES FOR RICE PRODUCTION IN THE MID-SOUTH

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Demands placed on finite water resources will increase as the human population grows during the 21st century. Because irrigation is often the single largest consumer of water and because most sources of freshwater have already been developed, increased urban, thermoelectric, industrial and recreational water needs will largely be met through conservation and/or reallocation of existing irrigation water supplies (Gollehon and Quinby, 2000; Gollehon et al., 2002). As the amount of water dedicated to irrigation declines, *agriculture will have to use less water to meet increased global demands for food and fiber* (Gardner, 1996). Thus, water savings through improved irrigation practices are essential to meeting the future water needs of both agriculture and other stakeholders (CAST, 1996).

Rice is unique among agronomic crops because it is typically grown in flooded paddies where floodwaters are maintained at a constant depth of ca. 8 to 15 cm. Flooding is done to meet rice's relatively high water demand and to control broadleaf and grass weeds (Smith and Fox, 1973; Gealy, 1998). Each of the roughly 1.26 million ha of rice harvested in the United States requires, on average, about 75 cm of water during the growing season, representing over 940 million m^3 of water. The majority of this water demand was met through irrigation drawn from underground aquifers (Gollehon et al., 2002).

Approximately 80% of the U.S.'s rice crop is grown in an 11,200 square kilometer area of intense agricultural activity along the lower Mississippi River known as the Mississippi River Alluvial Flood Plain (also referred to as the Mississippi River delta). Underlying this region is a series of six aquifers collectively known as the Mississippi Embayment aquifer system (USGS, 1998). The most intense rice production occurs in the Grand Prairie region of Mississippi River delta in Arkansas (Figure 1) where irrigation water is primarily derived from the Alluvial aquifer (ASWCC, 2010). However, due to groundwater overdraft, the Alluvial aquifer in the Grand Prairie is not expected to sustain current extraction rates beyond 2015 (U.S. Corps of Army Engineers, 2000). Mississippi has also experience aquifer decline, but not to the extent seen in Arkansas. If groundwater depletion continues in this highly important region, agricultural productivity will be reduced over time.

Rice producers are working to reduce groundwater consumption. Recently, some growers began building surface water containment systems that collect and store rainfall and runoff from fields for reuse as irrigation water. These systems use a combination of surface and groundwater with the goal of using surface water. An example tailwater recovery system is shown in Figure 2. Irrigation and rainfall runoff from fields is collected in a large canal (Fig.2-A). This water is pumped into a reservoir (Fig2.-B) for reuse. These systems reduce groundwater consumption by allowing irrigation water to be recycled rather than leaving the farm. However, these systems are expensive because they often require extensive earthwork and networks of underground pipes. Average construction costs in Mississippi have been approximately one million dollars (US) per 260 hectares of land served by system (USDA NRCS, 2011). Another disadvantage of the system is that the collection and storage systems often take valuable farmland out of production. Moreover, managing these systems for optimal performance requires time.

Rice producers have long been using a number of in-field practices that reduce water use. For example in the 1980's, Mississippi producers began using earthmoving equipment to level their fields to have uniform slopes with minimal cross slopes. To date, approximately 65% of the rice land in Mississippi has been leveled to have a 0.1 to 0.15% slope. Beginning in the 1990s, an additional 5% of Mississippi's rice fields were leveled to have zero (0%) slope. These fields are referred to as 'zero-grade' and require no levees as

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flood depths are uniform across the fields. Zero-grade rice fields require less than half the amount of water used on a typical contour-levee field while those with 0.1 to 0.15% slopes allow for the use of straight- (Fig.3-A) rather than the traditional contour-levees (Fig.3-B), resulting in water savings of ~15% as compared to contour systems (YMD, 2009). In the mid-1990's, producers began using plastic tubing with multiple gates (Fig.4-A) to simultaneously distribute water to all paddies in the straight-levee rice field rather than irrigating from a single point in the field (Fig4-B). This results in a water savings of ~20% (YMD, 2009). Thus, over the past 30 years, rice producers in the mid-South have steadily worked to reduce water consumption by up to one-half that required by traditional (contour levee) flooding methods.

More recently, a small number of producers have begun to intentionally manage their rice floods so as to maximize rainfall capture and reduce over-pumping. This approach, known as intermittent or less-than-full flooding, works best with the multiples-inlet, straight-levee systems common to the Mississippi Delta. By allowing the rice flood to naturally subside and refilling the paddies in a cyclical pattern every 5 to 8 days, rainfall capture is increased by up to 60% relative to traditional continuous-flood practices (Fig. 5). Also, a small number of rice producers are investigating the utility of sprinkler irrigation systems to reduce water use (Fig. 6). While these lower water input systems may work particularly well with the more stress-tolerant rice hybrids, research conducted in Mississippi indicates that 14 rice varieties available in the Mississippi delta require significantly less water than has been traditionally used in the past. The use of simple rice flood depth gauges (Figure 7) helps producers more carefully manage their rice flood in a variety of irrigation systems and can be easily seen while driving past a rice field.

As demands placed on finite water resources increase during the 21st century, agriculture will have to produce 'more crop per drop' to meet increased demands for food and fiber. The techniques briefly described in this paper represent several approaches mid-South rice producers are using to optimize their operations to meet these challenges.

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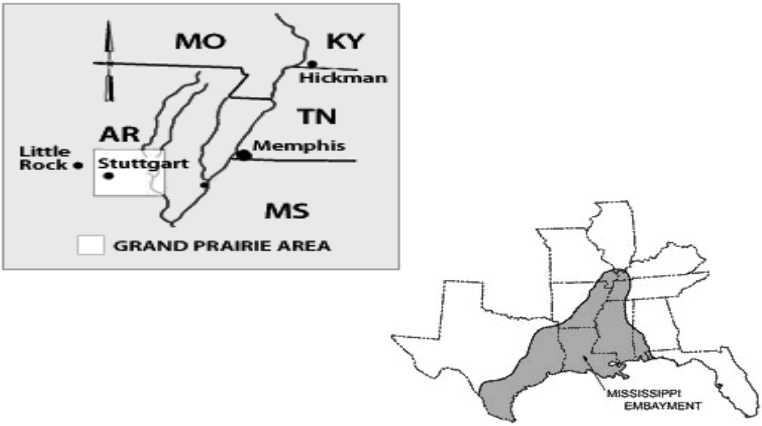


Figure 1. Nearly 80% of the nation's rice is grown using groundwater from the Mississippi Embayment aquifer system. Depletion of the Alluvial aquifer in the Grand Prairie is a concern for rice producers, municipalities, and industries alike.

Figure 2. Tail-water recovery ditch (A) collects irrigation and rainfall runoff from fields. This water is pumped to a 15-ha reservoir (B) for future use.

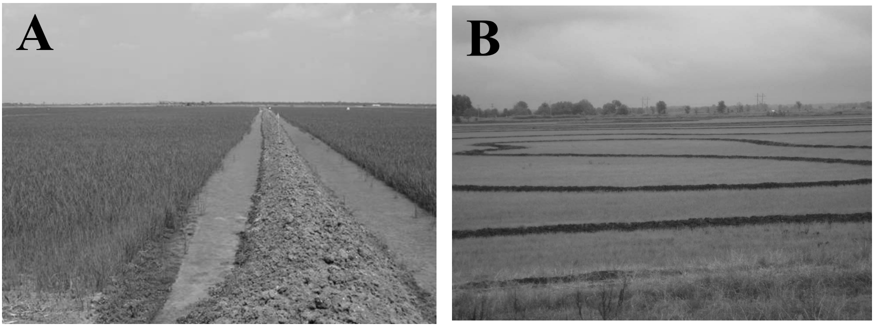
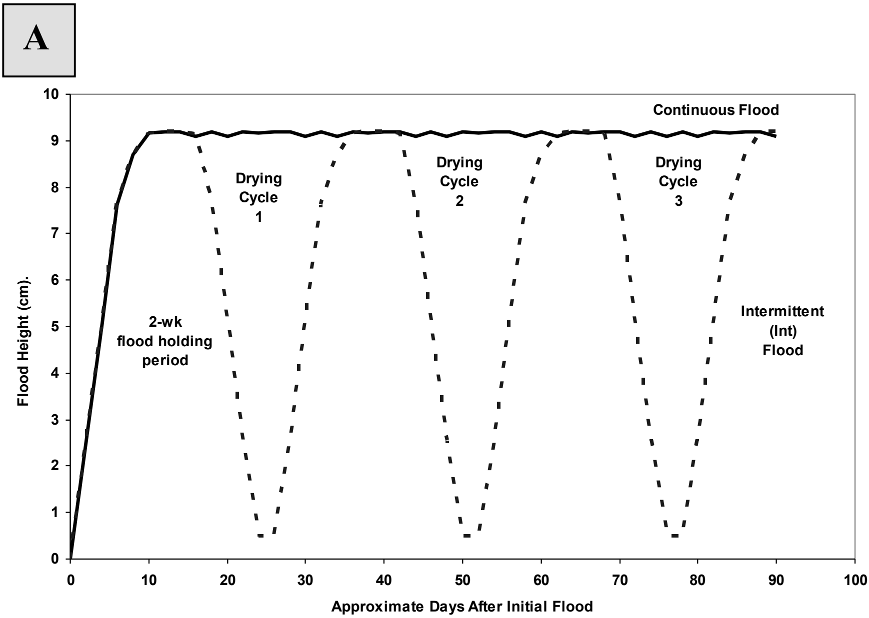


Figure 3. Straight-levee (A) and traditional contour-levee (B) rice production systems used in the mid-South.

Figure 4. Reduced water use and greater control of the rice flood is obtained using multiple-inlets and straight levees (A) as compared to traditional single-point irrigation and contour levees (B).



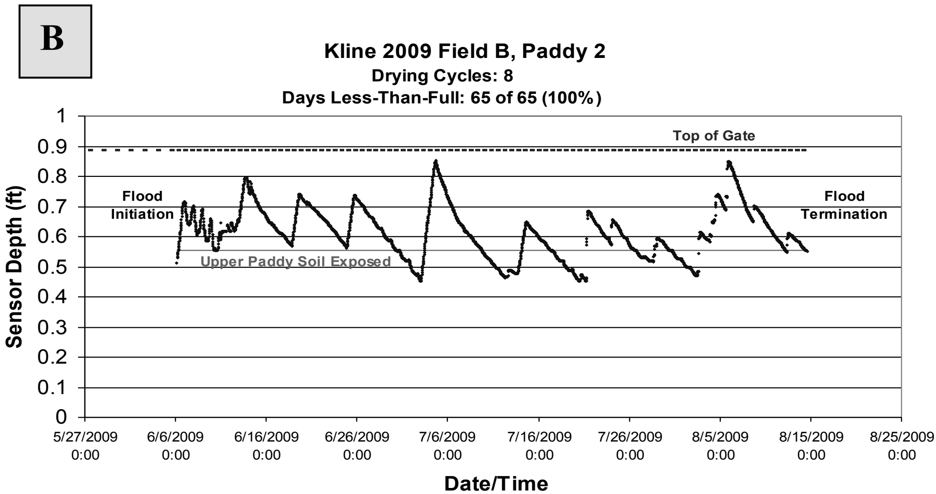


Figure 5. Diagram demonstrating flood depths in rice paddies maintained using continuous or intermittent flooding (A), and an actual flood management that resulted in 8 drying cycles and 100% of days where rice paddy was maintained at a 'less-than-full' status (B). The 2009 seasonal water use in Rice Field B was 1.22 Ac-ft/A (609 m^3/ha) and rough rice yield was ~190 bu/A (9600 kg/ha).

Figure 6. Overhead sprinkler irrigation of rice in Arkansas (A). Simple depth gauge consisting of seine float attached to PVC pipe being used to help manage rice flood (B). (Sprinkler rice photo credit: Dr. Brian Ottis, RiceTec.)