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An Economic Evaluation:

Straight Versus Contour Levee Rice Production Practices in Mississippi

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Introduction

During the past 30 years, rice production has increased in importance to the Mississippi agricultural economy. During the period 1974-1995, Mississippi rice acreage increased from 108,000 to 288,000 harvested acres, some 167% During the same period, average yields increased from 4,180 to 5,400 pounds per acre, or 29%. Total value of rice production increased from about $46 million to more than $110 million. Record acreage, yield, and total value of production occurred in 1994 with 315,000 acres, 5,900 pounds per acre average yield, and more than $118 million in value. Average price received by Mississippi farmers decreased, however, from $4.59 to $3.38 per dry bushel -- a 36% drop (1). Prices have, however, become relatively stable since 1985 in the $3.10 to $3.25 per bushel range.

Available data indicate that cost of production per acre (including all costs except return to land and management) for the years 1980 to 1995 increased on a per acre basis by 24% but decreased by 12% on a per bushel basis because of increased yield per acre (2). However, more recent estimates suggest that cost of production per bushel in Mississippi has started an upward trend once again. Per bushel cost of production increased from $3.04 in 1985 to $3.26 in 1995, a change of 7% (3). Semidwarf varieties were introduced on a commercial basis in 1985 and yields jumped dramatically. Accordingly, cost of production per bushel fell. These trends indicate that while yields reached a new plateau after 1985, costs of production per acre and per bushel have continued to climb as the price received by farmers has remained stable. With revenues stabilizing and costs increasing, profit margins are narrowing for the average producer.

In 1994, the authors approached the study of rice production practices in Mississippi from the standpoint of investigating the impact of new technology, particularly landforming for straight levees, on the potential for profits and increased rice acreage in the state (4). Schnepf and Just suggest that the Delta Region of Mississippi is one of the primary areas with potential acreage expansion. In fact, in 1994, Mississippi planted only 46.67% of its calculated sustainable rice acreage, the lowest of any of the six reporting states. Mississippi also has the greatest total number of acres available to increase sustained rice production, some 360,000 acres (5). Furthermore, Schnepf and Just indicate that because of high costs structures in the Gulf Coast and California areas, maintaining or reducing current government support levels will continue a shift of acreage to the Delta region of Arkansas, Mississippi, Louisiana, and Missouri.

U.S. and Mississippi producers respond rapidly to changes in world market indicators as was demonstrated in the periods 1973-75, 1977-78, and again in 1993-94. In each case, when tight supplies moved rice prices markedly higher, rice producers increased planted acres generating record crops. Figure 1 illustrates acreage response to expected price moves. Prices are lagged one year, correlating producers' response in terms of harvested acres to the previous year's price change. This simple response is due to a combination of government policy changes in ARP requirements and producer choice and responsiveness. In the most recent case, world market prices leaped in late 1993 only to move quickly downward to pre-1993 levels after large increases in 1994 planting and reduced world demand.

Schnepf and Just suggest that the Mississippi Delta States may be the only U.S. region that can sustain long-term viability without government support payments. Mississippi rice farms are larger than the average U.S. rice farm and are increasing in size (7). Economies of size have tended to improve profitability among Mississippi rice producers; however, the pattern has not been consistent throughout the previous 10 years. It would seem obvious that in years with low yields the producer has a reduction of net income.

One measure of producer perception of rice profitability is participation in acreage reduction programs. A clear inverse correlation can be seen in Figure 2 between participation of Mississippi farmers in the 50/85 program and the average price of rice received by farmers between the years 1986-87 and 1994-95 with prices lagged one year. Participation in Mississippi reached a high of 49% in 1991-92.

The high rate of participation reflects the perception of producers that higher net returns were achieved from the 92% government payment guarantee than from actually planting the rice. In other words, acres were idled because producers could not receive an adequate return on resources used without the government payment. As a result, dependency on government payments increased during the period to the point that per acre payment benefits were higher to rice farmers than to producers of any other program crop.

Changes in national agricultural policy forewarn of a reduction and probable termination of direct government support payments to rice producers. The Government Accounting Office (GAO) estimates that more than 34% of revenue from rice operations comes from direct government payments and as much as 50% if all government benefits are included (6). The loss of this revenue source, the decoupling of payments from bases, and the increased planting flexibility produce a combined re-emphasis on production for the market, production efficiency, budgeting and marketing skills, and improved profitability and risk management.

The narrowing gap between costs and revenues indicates the need for research concerning methods of improving rice farming profitability. In addition, Mississippi rice producers must not only be low-cost producers relative to other U.S. regions, but also must compete in world markets. Improved world market prices in 1994-95 and 1995-96 encourage foreign production. U.S. high-quality long grain rice is likely to find its foreign markets highly competitive in 1996-97.

Determining actual costs of production must be a fundamental goal of each producer. Implementing methods to lower costs and/or increase revenues thereby increasing net income from each enterprise will continue to be necessary to remain in business and competitive in today's era of government budget problems and international competition.

One method that addresses the need to improve net income from rice production involves changing the production regimen based on levee pattern. Two prominent levee schemes have been identified in Mississippi. They are (**1**) the contour levee pattern in which levees are constructed following the contour of natural grade, and (**2**) the straight levee pattern in which the field is precision formed with zero side slope and constant downslope permitting levees to be constructed more or less straight across the field.

A third scheme, termed furrow-irrigated, has been observed. Although considered to have no levees, in reality, furrow-irrigated systems have border levees and perhaps some spur levees to contain and control water flow within the field. It is reasonable to assume that costs of production are different for each scheme and that costs may be shifted among input categories. It is also reasonable to assume that yields may vary among the schemes and that one levee pattern may consistently produce higher yields than another.

A central question as to the feasibility of investing in precision landforming regards the payback period of the investment. In answering this question, the investor must consider rice as a rotation crop. Payback must include net returns from rice and the alternate crops. Therefore, soybeans production practices were included in this study and data collected in a similar fashion as with rice. For purposes of this study, the rotation to be considered was the one recommended by the Mississippi Cooperative Extension Service a nd most commonly practiced in the Delta of Mississippi: 1 year in rice and 2 years in soybeans. Soybean fields were considered as unformed (for contour rice system) and formed (for straight levee rice system).

Much of the rice grown in the Mississippi Delta region is produced on land owned by absentee landowners. Department of Agriculture data indicate that as much as 82% of rice/soybean farm acreage in Mississippi was rented land in 1991. Accurate costs and returns of the various management schemes are needed for producers to make informed production decisions. Landowners and tenants need more information to make informed investment decisions. Lenders also require better information to make appropriate financing decisions.

Economic evaluation of current technologies in rice production may also lead researchers to focus on and solve economically important problems in rice production that will make Mississippi producers more efficient and more competitive. The survival of the rice industry in Mississippi may well hinge on the ability of producers, landowners, lenders, educators, and researchers to work together to make the kinds of decisions that will keep the industry healthy in an open, competitive, unsupported, international marketplace. The major objective of this study was to evaluate the costs and returns of the predominant rice production systems in the Mississippi Delta region and to provide information to landlords, tenants, and lenders for management, investment, and financial decision-making.

Methods and Procedures

Producers use many tools and techniques in producing rice on Mississippi farms. Characteristics and needs of each field and preferences of the producer play a role in this diversity. Some growers use a variation of "no-till" or minimum tillage seedbed preparation and planting. Some growers water seed. However, three distinct patterns of production practices were observed that could be categorized. The three management systems are distinguished by levee pattern and are identified as contour levees, straight levees, and furrow-irrigated.

Contour levee fields have minimal land improvements so that levees are surveyed and constructed annually in order to manage water across uneven terrain. Straight levee fields have been precision landformed with zero side slope, generally constant slope downgrade, and often have permanent pads around the perimeter. Furrow-irrigated fields also have been landformed, often in previous years with other row crop production in mind, but with a slope thought too steep for leveed rice production. Furrow-irrigated fields have minimal levees with perhaps one around the field perimeter and short spurs to reroute water within the field to the lower end.

Thirty-nine producers were selected in 10 counties representing the major rice-producing areas of the Delta region of Mississippi. All fields included in this study were of heavy clay soils. Nearly 88% of the fields were planted to the Lemont semidwarf variety. Data were collected on 93 fields detailing the production practices and yields for each and the management system employed over a 2-year period. It should be noted that the number of fields of furrow- irrigated rice was not sufficient from which to draw conclusions; however, descriptive results are included in this study.

In 1994, 21 fields were determined to be contour systems, 21 fields had straight levees, and 4 fields were furrow-irrigated. In 1995, 25 fields were determined to be contour systems, 19 fields had straight levees, and 3 fields were furrow-irrigated. The data were collected and incorporated into the "Mississippi State Budget Generator" (MSBG) (14) for computations and analysis. Producers were requested to keep detailed records of their practices on fields included in this study. The decision-makers were interviewed repeatedly throughout the growing season. Production practices were identified including machinery (with horsepower) and equipment (with sizes), custom operations, purchased inputs (seeds, fertilizers, pesticides, growth regulators), labor, and water management. Rice production was assumed to begin with the first operation after the field was returned to conditions suitable to begin preparation for the rice crop following the previous crop and ended with the last operation needed to enable preparation for the succeeding crop. The rice crop was assumed to have been stored on the day of harvest, dried, and sold from storage 7 days after harvest.

Prices of purchased inputs used in this study are found in *MAFES Rice 1995 Planning Budgets* (8) for the 1994 crop year and in *MAFES Rice 1996 Planning Budgets* (9) for the 1995 crop year and do not necessarily reflect those paid by the individual producers in the study. They do reflect typical prices paid by farmers during the respective growing seasons. The price assumed paid to producers for rice sold in 1994 was $3.15 per bushel, which is the weighted average price received by farmers in Mississippi in calendar year 1994. The market price assumed paid to producers in 1995 was $3.92 per bushel, which was the preliminary reported weighted average price received by farmers in Mississippi in calendar year 1995 (13).

Returns estimates do not reflect government support payments to producers. Likewise, returns estimates herein **do not** include land rents or land costs, nor do they include management and general farm overhead costs. Since product and input prices are the same for all fields and producers, the emphasis in this study is focused on variation of costs and net returns based on the practices observed, quantities of inputs used, and resulting yields. The study does not examine any economies of size or business perspectives that may be associated with certain technologies.

Since some of the expected major differences among the management systems regarded levee pattern, those practices involving levee construction, destruction, planting, and water control gate placement were given careful consideration with respect to equipment used and time required to perform the operation. Similarly, different performance rates for harvest machinery were developed for each management scenario. Many practices are common to all production systems and do not vary in performance rates. Although prices changed from 1994 to 1995, performance rates for machinery and water usage for each levee system were considered the same for each year. These performance rates were updated in 1995 and may be found in the *MAFES Rice 1996 Planning Budgets* (9).

Producers were requested to note labor required for water management. Labor was recorded for flushing, maintenance, and draining operations. Unallocated labor was specified as 0.9 hour per hour of hired labor and reflects overhead labor not directly attributable to the rice crop on a field-by-field basis. Pumping costs were determined by an independent survey conducted by MAFES workers during the period 1991-1994 (10). That report suggests that producers pumped on average 36 inches of water on contour levee fields and 30 inches on straight levee fields. No furrow-irrigated fields were included in the water use study. For purposes of this study, 30 inches were assumed applied to furrow-irrigated fields.

For purposes of this study, it was assumed that contour levee systems contain 15% of the land area of the field in perimeter and interior levees while straight levee fields contain 5% of the land area in levees. Furrow-irrigated fields in all observations except one required a bottom-of-field levee and often some minor cross-slope spur levees to assist in water management. It was assumed that 1% of the land area in furrow-irrigated fields was in levees. One percent of the field was assumed in border mowing operations for straight levee and furrow-irrigated fields. These percentages were used in calculating amounts of inputs used in levee-related operations.

Interest computations began with the first operation recorded and continued on a monthly cash expense basis. Interest calculations ended with the last operation recorded. The rice crop was assumed sold 7 days after harvest and the revenue credited against the costs incurred.

Fixed costs associated with machinery and equipment were calculated using the methods incorporated within MSBG and do not necessarily reflect the actual fixed costs experienced by growers in an accounting sense. Costs for landforming for straight levee and furrow-irrigated fields were not included in the budgets. This study focused on production costs assuming that the land was formed prior to the decision as to which management system to employ; therefore, costs associated with landforming are sunk costs. The producer considering changing from a contour to a straight levee or furrow-irrigated system should include annualized costs of land forming in budget preparation while information generated in this study should be useful in making the investment decision.

In considering the economic feasibility of precision landforming, crop rotation practices should be included in determining the annualized return. In Mississippi, rice is most often rotated with soybeans. The most highly recommended rotation pattern is 1 year in rice and 2 years in soybeans (11), especially if red rice is a problem. Since red rice is an increasing problem in Mississippi rice production, the one-in, two-out rotation was assumed in this study. As an adjunct to this study, a similar one was conducted regarding soybean production practices on fields that were not precision formed compared to practices on fields that were precision formed. Twenty-nine soybean fields were sampled in nine counties. Only one year's data were collected; therefore, the data set is insufficient from which to draw reliable conclusions. However, the results are included and the expenses are comparable to those evident in *MAFES Soybeans 1996 Planning Budgets* (12).

A payback table was generated using the discounting method of computing annual returns in a matrix of various increases in net returns and a range of landforming costs. A second table generates a series of financial indices from the same matrix of annual returns and range of landforming costs. The tables present the reader with methods and sample results for determining the feasibility of precision landforming. It is the intention of the authors to provide information useful in making the investment decision.

Summary Description of Production Practices

Some general differences in production practices were observed among the three production systems included in this study. Preplant land preparation varied more by producer preference and pre-existing field conditions than by levee type. However, some practices were used in particular management systems only. The time and money spent in the construction and destruction of levees obviously varied with the levee pattern of the field.

Contour levees were surveyed for each rice crop. More diesel fuel, labor, and repair and maintenance for tractor, grain cart, and combine operation, more seed for levee planting, and more chemicals for levee spraying were necessary in contour leveed fields than for straight leveed fields.

Historically, the contour levee system has been the most common system. A general description of production practices for contour leveed fields includes most practices used by all rice producers. In this report, the contour levee system will be described first and the straight levee and furrow-irrigated practices compared to the contour levee scenario. Production practices for each system are summarized into four categories: water management, application of other production inputs, harvesting, and post-harvest tillage.

Contour Levee System

Historically, "a continuous flood culture" has been recommended for rice production. Water is maintained on the field in order to control weeds and grasses (11). Controlling the depth of water over the field necessitates levee construction. Producers in this study using the contour levee system constructed levees every 0.1- to 0.3-foot of drop in field elevation. Levees were surveyed and marked with laser equipment, either by the producer or by custom surveyors. Levees were hipped with a dike plow and packed in four to seven operations, depending on producer preference and field conditions. Seed was applied on the last pass with a seeder mounted on the dike plow or a roller-packer. Levees were butted to the perimeter levee with a backhoe or other tool to enclose the paddy.

Gates were installed to control the water within the paddy at a depth of 6 inches on the lower side and 2 inches on the upper side. Most producers used purchased plastic gates and inserted a 2-foot x 2-foot wooden board to create a level, stable flow control structure capable of being raised or lowered by water management personnel. Metal gates as well as other materials were often used. A gate installer tool mounted on a tractor often decreased installation time required by one to three laborers.

When rain failed to follow planting in a timely fashion, producers often flushed (wet the field from paddy to paddy) one or two times to provide sufficient moisture for seed germination, to prevent soil crusting, and to promote emergence. After a permanent flood was established, the water level was checked frequently, often requiring walking along each levee to look for breaks or at least viewing the level of water at the gate site. Upon crop maturity, gates were pulled out and perimeter levees cut to drain the field.

One of the problems reported by producers was levee weakness found in the curved portions because of either poor construction or levee placement. Weaknesses increased water seepage as well as repairs and attention required by labor.

Producers preferred a weed-free field in which to plant. This was accomplished by the use of preplant and/or preemergence herbicides often in addition to preplant tillage. The construction of levees effectively terminated the use of ground equipment by the producer. Aerial application of herbicides, fertilizers, fungicides, and insecticides was normally the method used in contour levee fields. Aerial application of propanil provided early grass and broadleaf weed control. Many producers used a preflood residual herbicide, which required that moist topsoil conditions be maintained for effective weed control, and a postflood granular material, which required that a flood be maintained for effective grass control. Weed control on levees was most often accomplished at midseason by the use of operator-owned or custom applicator ATV mounted sprayers. Helicopter-applied 2,4-D amine was sometimes used to control weeds over substantial portions of the field under certain limited conditions.

Nitrogen was applied at the rate of 170-180 pounds per acre. Producers split nitrogen fertilizer applications with, most commonly, 50% of total nitrogen requirements being applied prior to first permanent flood and the remainder being applied in two equal amounts at midseason about 7 days apart. The most common form of nitrogen fertilizer used was granular urea (46% N); however, substantial amounts of 41-0-4 and ammonium sulfate were applied to add sulfur as needed. The latter fertilizers were often applied to boost the early crop and, as such, were not considered in calculating total N requirements for the crop. Nitrogen generally was applied aerially to contour leveed fields in this study.

Harvesting in contour leveed fields generally involved following the curvature of the levee. Producers reported the difficulty of maintaining a full swath of rice in the header because of the curvature of the lanes. Turning was increased as the unharvested portion became smaller. Because of the temporary perimeter levee and difficult field conditions encountered, the trucks and trailers used to haul the rice from the field were often a long distance from the combine in the field. The varying length and width of the lanes, in addition to the distance required to travel to unload, created the need for grain carts to be pulled through the field to speed the combine unloading process. The grain carts unloaded on trucks or trailers at the end of the field.

Producers either hauled the grain to on-farm drying and storage facilities or to commercial driers. Sufficient documentation of on-farm drying costs in the Mississippi Delta region was not available at the time of this writing; therefore, for expensing purposes, all rice was assumed to be hauled to commercial facilities for drying and storing. The drying charge included in MSBG accounts for drying, initial storage, and sales commissions.

After harvest, producers concentrated on returning the field to conditions suitable for preparing for the next crop. Commonly, the next crop was not rice; therefore, the levees were flattened by one or two passes with the dike plow or a levee splitter. One to three diskings followed to incorporate the crop residue into the soil. One or two trips with a land plane often finished the process.

Straight Levee System

The practice of precision leveling fields so as to have constant grade downslope and zero grade sideslope to promote a straight levee pattern is gaining in popularity. A rice field with zero sideslope affords the operator alternatives not available on contour leveed fields. The impact is felt in each of the four input categories previously discussed.

Along with the forming of the interior of the field, many producers constructed perimeter pads, which (1) served to conserve water by virtually eliminating seepage from the field, (2) served as perimeter roads decreasing time and effort spent in water monitoring, (3) eliminated the need for butting levees subsequent to their construction, and (4) allowed for timely placement of hauling vehicles at harvest to increase combine efficiency. Since the field had been precision leveled with known slopes, some producers simply measured one side of the field and marked the levees, thus eliminating the need to survey and mark levees. Water management was minimal and consisted of primarily riding in a truck or ATV around the perimeter pad to visually inspect the water levels at the levee gates.

Producers frequently used ground equipment to apply fertilizers and herbicides in straight leveed fields. Operators reported that ground equipment was used for these applications since, unlike the varying paddy shapes of contour leveed fields, paddies are straight and ground equipment can be used in straight lanes. Producers report that ground application permits application under more varied conditions than does aerial application. Furthermore, producers suggested that timeliness and effectiveness of application were improved and costs reduced. Most ground work was terminated at first flood; however, one producer applied fertilizer and herbicides in the flood with his ground equipment. Postflood inputs were generally applied by airplane.

Harvesting efficiency was impacted by the regular pattern of straight levees. Combines were consistently able to cut a full header swath and moved from paddy to paddy on perimeter pads. Combines generally dumped directly onto trucks or trailers on the perimeter pads as they progressed through the field. Grain carts were generally not used in the straight levee system.

Postharvest practices were similar to those in the contour levee scenario. Producers flattened the levees using a dike plow or levee splitter and disked and/or landplaned the fields. However, producers reported that because of precision grading, fields drained and dried more quickly allowing field work to be accomplished earlier than on contour fields.

Furrow-Irrigated System

For various reasons, some producers used the furrow-irrigated production management system. Two producers reported that they wanted to rotate rice with cotton in order to increase acreage available for rice production. The steeply sloped cotton land was not conducive to levee irrigation. Other producers wanted to find alternatives to levees as a means of improving production efficiency and, hopefully, net returns. In both cases, recent developments in weed control chemistry and water management technology made furrow irrigation more feasible than in the past. Facet® herbicide uses a different mode of action than previous residual chemicals. With moisture available, Facet is able to kill grasses and weeds through uptake by the roots, thus permitting weed control through frequent flushes of water over a long period of time.

Fields were bedded prior to planting with a middle-buster or ridge-hipper on 30- to 60-inch centers. A grain drill was used to plant as in the other management systems. In one case, the field was planted and then small furrows created with a row-crop cultivator. Polypipe was used to transport water from the well to the field. The tubing was laid across the higher end of the field as well as any ridges that were not reached by gravity flow in order to release water down the furrow. Valves were often installed to aid in water control through the polypipe. One producer used a timer to control the hours during which water was being applied. Producers generally flushed fields five to nine times to maintain moist conditions as needed. In 1994, frequent rains in July reduced the number of flushes required. In 1995, the absence of rainfall during the growing season after July 5 necessitated frequent waterings. During both years, flushes were timed and applied at regular intervals in order to minimize water management labor and water use.

The goal of the water manager was to moisten completely across the bed by flushing water down the middles. Levees were not always eliminated completely. Often a perimeter levee, a bottom levee, spur levees, and combinations of each were used to effectively manage water, but levees were minimized. Fertilizers and pesticides were generally applied with the producer's ground equipment. At times, rains prevented use of ground equipment but, generally, producers avoided aerial applications in furrow-irrigated fields. One area that needs more research is in the use of fungicides. Producers in this study did not use fungicides in furrow-irrigated systems. This may be of particular interest to those growers with sheath blight problems.

In terms of harvesting efficiency, one producer estimated that his furrow-irrigated field was harvested twice as fast as his contour fields. Minimal turning and consistent cutting were reported by all producers using the furrow-irrigated system. Grain carts were eliminated and combines dumped directly onto trucks and trailers.

The flattening of levees was minimal in the furrow-irrigated fields. Disking of the rice stubble was reported for all fields. One producer bedded his field during the fall in preparation for cotton in 1995.

The decision of which management scheme is best for each producer and each field ultimately involves considerations of costs and returns. More land is being precision graded every year to allow for straight levee rice. More producers will be considering furrow irrigation in the future. While advantages and disadvantages are apparent for each management system, in the next section, the production practices highlighted and compared above will be reviewed in the context of average costs per bushel and average net returns to the producer.

Comparison of Costs and Returns

Many producers cooperating in this study believe that the straight levee rice production management system provides significant returns over traditional contour levee management systems. The primary purpose for this study was to determine and compare the differences both from a physical and an economic standpoint. Returns above direct expenses and returns above total specified expenses provide the basis for the evaluation. However, all aspects of differences need to be examined in order to establish reasons for differential net returns.

Four tables are included to present the results. Tables 1-4 are averages for the 2-year period of the study. Table 1 summarizes budget results for the contour levee system. High, low, and average values are presented for each major category of cost items as well as the budgeted yields and net returns estimates. A distribution of average total expenses per bushel is also included for break-even analysis.

Tables 2 and 3 summarize the same information for straight levee management and furrow-irrigated systems, respectively. An expected range of values found in the individual field observations can be obtained by inspecting the high and low values for each category. Of course, no individual field would have all high or low values in each category hence the returns estimates are not numerically consistent with the usual summation calculations.

Finally, Table 4 presents the averages for the three systems so as to allow an easier comparison of the average values. It should be noted, however, that the limited number of observations for furrow-irrigated systems depreciates the value of any conclusion that might be made concerning this system. The information concerning furrow-irrigated systems is presented for the reader's review, with the caveat that this method of rice production is still very new and results can be ambiguous.

Table 5 is included for information only and provides the average costs and returns for 1994 and 1995 and the respective percentage changes from 1994 to 1995 for the straight and contour levee systems.

Finally, it must be noted that the results presented herein are from 2 crop years very different in nature. In the Mississippi Delta region, the 1994 season had unusually high rainfall in mid and late July and concurrently moderate heat units (measured in rice as DD50's) during both July and August. Pumping costs were reduced because of the timely rainfall, and yields responded well to the favorable temperatures. The 1995 season had above-normal heat units in July and August and, although there were record rainfalls July 5 and 6, unusually little rainfall occurred prior to late harvest. Pumping costs increased to keep pace with evaporation, and some producers speculated that yields were decreased because of high temperatures resulting in poor pollination and water management. The disparities, however, present a good representation of the data collected in that the average of 2 years may represent typical yield and cost response to climatic variables for budgeting purposes. Table 6 contains the temperature and rainfall data for July and August, 1994 and 1995 at Stoneville, Mississippi (15). Inspection of Tables 1-4 indicates a significant difference in both costs and returns between contour and straight levee systems. Average yield reported was 8.24 bushels higher for straight levee systems than for contour systems. Average direct costs were $30.00 per acre lower for the straight levee system than for the contour system.

In the straight levee system, costs savings were most apparent in those operations relating to field work, primarily levee contruction and destruction, and labor, primarily water management. The system allowed a more efficient use of labor and machinery, lower water use, and, hence, lowered pumping costs. The reduced costs, along with a more than 8-bushel yield increase, on the average, combined to give the straight levee system an average $59.07 advantage in returns above direct expenses over the contour system.

Fixed expenses are calculated using methods included in MSBG. Those methods produce fixed costs on a per acre basis that are reflective of full equipment utilization. Hence, performance rate improvements determined for straight levee production provide lower fixed expenses since full utilization implies that the fixed cost can be spread over more acres or life of equipment can be spread over more years. The average fixed cost for straight levee production was $22.33 lower than for the contour system. The combination of lower fixed and direct costs and increased yield provided a total $81.40 larger average return above total specified expenses for the average straight levee system over the average contour system.

Once again, the prices used in the income calculation were average prices received by Mississippi farmers during the 2-year period of the study, costs **do not** include overhead or returns to land or management, and income estimates do not include any government payments.

Rather than present raw data within this report, yet in an effort to better understand the differences represented by the data, the authors have chosen to present the relevant data in graphic form. Figures 3, 4, 5, 6, 7, 8, and 9 present, a cumulative distribution of yield, total direct expenses, total direct expenses per bushel, total specified expenses, returns above direct expenses, total specified expenses per bushel, and returns above total specified expenses. Data in each case are arranged from low to high reading from left to right on the horizontal or field axis. Since there were uneven numbers of field observations in both the straight levee and contour levee fields in the two different years of the study, a simulation technique utilizing the individual years was used to develop cumulative distributions for each category of items.

The points on each of the distributions shown in Figures 3, 4, 5, 6, 7, 8, and 9 represent the mean of the values of the two individual years' cumulative distribution function at each probability percentile level. It is relatively easy to pick meaningful points on the various graphs that represent approximate frequency distribution levels, i.e., 25%, 50%, 75% probability percentile and their corresponding cumulative value.

In general, each category of data indicates a dominance of the straight levee system over the contour system. For example, total specified expenses per bushel in Figure 7 are indicative of the results. At probability peercentile levels of 90% and below, the data show at least a $0.60 per bushel lower cost of production for the straight levee system than for the contour levee system. Figure 9 indicates a dominance of straight levees over contour levees in terms of returns above total specified expenses at all positive percentile levels.

Finally, it may be of interest to note the pattern of cost allocation by levee pattern. Figure 10 illustrates selected 2-year average costs per acre. Note the apparent higher costs allocated to custom applications, fertilizer, herbicide, and other (mostly polypipe) in the furrow-irrigated system. The contour expenditures on diesel, repair and maintenance, and operator and unallocated labor are clearly higher than the other systems. The conclusion may be that expenditure allocation changes as technology changes. These items become more important as producers prepare budgets and machinery and labor complements.

Costs and Returns: Soybeans

Data were collected for soybean production in the Delta Region of Mississippi for the year 1995 using the same method as used in the rice portion of the study. The purpose of collecting information on soybean production was to provide an accurate assessment of a payment schedule for the analysis of the precision landforming investment. Data was collected on 30 soybean fields. Every attempt was made to collect data on soybean fields that were in rice in the 1994 study. This was not possible in every case, however. Of the 30 fields, 15 were planted on precision-graded fields appropriate for straight levees and 15 were planted on unimproved fields appropriate for contour levees.

Table 7 presents the high, low, and mean for yield, income, costs items, returns, and expenses per bushel for each levee system. Because only one year's data have been collected, the results from the soybean study are offered with reservations and are to be used as a guide to assist in investment planning only. These results may or may not reflect real differences in the two levee systems that would be more apparent over a number of years.

The 15 straight levee soybean fields averaged 8.12 bushels and $47.80 total income per acre or 25% more than the 15 contour levee soybean fields. Direct expenses were $16.28 or 16% percent higher per acre for the straight le vee system. Herbicide costs were lower for the straight levee system but other costs were higher, particularly labor, diesel, and repair and maintenance -- items specifically impacted by irrigation. All of the straight levee fields were irrigated to some extent. Only four (27%) of the contour fields were irrigated.

Total specified expenses per acre, which include the fixed expenses of depeciation of irrigation equipment, were also higher for the straight levee system. Although irrigation increased costs considerably for the straight levee fields, increased yields at $5.89 per bushel reduced the direct cost per bushel $0.57, or 16% below the per bushel direct cost for contour production. Furthermore, total specified costs per bushel for straight levee fields were $0.75 below the total specified expenses for contour levee fields, a 15% percent advantage. Significantly, of the straight levee fields, using prices in MSBG, 93% had positive returns over specified expenses. Only 73% of the contour soybean fields had positive net returns.

Contour to Straight Levees

The producer considering the straight levee system should perform analysis of landforming costs and returns to determine the economic consequences of switching systems. Each field to be developed for straight levee rice production will have a different cost associated with the landforming. The major cost difference is simply in the amount of soil that must be moved. Most landforming contractors negotiate a price based on the amount of soil to be moved. Hence, each field will have a unique investment cost associated with landforming.

One way to evaluate the decision about whether to landform is to do a traditional investment analysis comparing the present value of the discounted increase in net income stream with the present cost of the investment. Since the investment in landforming can be considered a permanent improvement that has virtually infinite life, one might be more interested in determining the number of years it would take to repay the initial investment plus interest on investment. One would certainly not want to exclude interest, since all funds have some alternative use. The appropriate income stream for landforming would therefore be the additional net returns that would be generated as a result of the investment.

Evidence and data presented herein suggest that increased income could come from increased production and decreased costs. The accuracy of the analysis is of course dependent on the accuracy of the estimate of net income increase, the accuracy of the investment cost estimate, and the discount rate chosen. The investment cost is usually the easiest of the three to determine.

Tables 8, 9, and 10 give the number of years it would take to repay an initial investment plus interest at an 8% annual interest rate with alternative income streams for rice. This table was developed specifically for investment in landforming, assuming alternative landforming costs and alternative income gains from landforming. This analysis assumes the land to be taken out of production and landformed the first year. The income stream begins the second year, with rice being planted the second and third years, soybeans the fourth and fifth years, and afterwards following a one-year rice and two-year soybean rotation.

Table 8 shows the crop rotation sequence, the income stream as the increases in rice and soybean returns above specified expenses (net increases) resulting from investing in precision grading to the straight levee system, and the net present value of the investment for each of the succeeding 50 years using an 8% discount rate. For example, it would take a minimum of 7 years to repay an investment of $225 per acre in landforming if the annual increased net returns from straight leveed rice were $ 81.40 per acre and from soybeans were $20.06 per acre, with an 8% discount rate. Similarly, if the investment cost $300.00, it would take a minimum of 12 years for repayment. The discrete nature of the incomes and hence the calculations cause the same discounted income stream to repay as much as $327.58 per acre within 12 years. Using the table in another way, if one wanted repayment in 10 years, the investor could spend as much as $286.65 per acre in improvements to precision grade the field.

Table 9 illustrates the investment decision from the producer/investor viewpoint. For instance, if the producer can generate an average increase in net income of $60.00 per acre, it would take 10 years to repay a $225.00 investment given that an 8% discount rate is used and a crop is not planted the year of the initial invesment. Conversely, if the investment required is $225.00 per acre, the producer/investor must generate $60.00 of increased income annually to repay the investment in 10 years. Nothing in this table suggests anything about the crops grown. The only necessary bits of infomation are the annual net income generated, the amount of the investment, and the discount rate.

Table 10 views the same decision from a landowner/investor viewpoint. Assuming the landowner leases the improved land for a constant amount per acre per year, the table shows the amount of increased rent necessary to repay various levels of inititial investment within 10, 15, and 20 years. For instance, if the landowner/investor wished to increase the rent so that an initial investment of $225.00 per acre would be repaid within 15 years, the annual rent must be increased by $29.50 per acre for the improved acres. If the landowner/investor were willing to extend the investment horizon to 20 years, the increased rent would be $25.50 per acre. Certainly this investment analysis would change if the discount rate changed, if there were some measurable increase in returns to either crop, or if the crop rotation were changed. Nevertheless, the initial cost, anticipated increased net returns, and the time value of money should be considered in the decision to form land. Other considerations may also come into play if money is borrowed to make the initial investment. Cash flow considerations of increased incomes along with principle and interest payments must be recognized. Furthermore, longer planning horizons and lower discount rates will increase the attractiveness of an investment.

Conclusions and Implications

In 1994 and 1995, rice producers in this study employing the straight levee management system produced an average of 8.24 bushels more rice per acre than did those using the contour management system. Both direct and fixed expenses were lower for the straight levee system. As a result, returns above total specified expenses averaged $81.40 per acre higher for the straight levee system than for the contour system.

On average, significant benefits were determined in yield, cost of production, and net returns for the straight levee management system over the contour levee management system. Significant cost savings were apparent in custom applications, operator labor, fuel, repair and maintenance, and fixed expenses. All of these items are particularly impacted by levee contruction and destruction. Moderate cost savings were found in irrigation and unallocated labor expenses. Only the straight levee cost of production per bushel produced was below the loan rate of $2.92. Furthermore, over the 2 years of the study, 95.62% of the straight levee producers generated positive returns above specified expenses compared to 75.44% and 50% for the contour levee and furrow-irrigated producers, respectively. However, the average cost of production for each of the systems was below the average market price of rice ($3.92) received by farmers in 1995.

Finally, investment analysis demonstrates the feasibility of precision landforming for the production of rice in straight levee fields in the deltal region of Mississippi depending on the options available to the investor. If the cost of the investment, the discount rate, and expected payback period are reasonable to the producer, the straight levee system can generate net returns above the contour system to justify the investment.

Limitations and Areas for Future Study

The results from this study are based on data from interviews with rice growers in the Mississippi Delta region during the 1994 and 1995 cropping seasons. Conclusions derived from these results must be considered in light of several points that limit the accuracy of the data.

First, data from two crop seasons are subject to the vagarities of environmental conditions that may affect yields, field practices, and input applications. Data over multiple years need to be collected to make stronger conclusions. This is especially true with regard to the furrow-irrigated system since the number of fields available for study was very limited.

Second, many of the equipment complements observed and used by growers are not available within the data sets available at this time. Consequently, calculations of this study may not accurately reflect all the information gathered in the field. Very often the tractors, coupled with various implements, were of lower horsepower than those actually used by producers. In other cases, the size implement used by the producer was not listed in the budget information. At times, implements not found in the budget were added by the investigators with performance rates suggested by the producer and prices gathered from dealers and other sources in the area. Most important are the performance rates of those items, which in turn reflect on economic efficiency and costs. Producers reported that harvesting efficiencies varied greatly, with furrow-irrigated having a distinct advantage over both straight levee and contour systems. Performance rates in all areas need review.

Third, water use studies have not included furrow-irrigated fields. It would seem that water use in the furrow-irrigated system should vary even more, on average, than water use for the other management systems because the other systems maintain water throughout most of the growing season. Water use studies including furrow-irrigated fields would aid in this determination.

Fourth, every attempt has been made to precisely detail management practices. However, often producers tend to overlook seemingly insignificant activities that may go unrecorded. Such activities eventually are included in general overhead charges, in operating expenses, and not allocated to a specific enterprise. Data collected over a longer period would aid in capturing these costs.

Fifth, the adoption of new technology is generally an interactive process. For instance, the development and use of Facet has given promise for the furrow-irrigated system, which in turn implies surge valves and timers for improved water management. Improvements in burndown chemicals (such as Roundup® and Gramoxone®) and grain drills have given greater flexibility to producers considering fall tillage and/or minimum and no-till practices. The advent of laser equipment for landforming purposes often increases the ability of the producer to lower costs of landforming by performing the operation with farm-owned equipment. Increased use of track equipment may well change timeliness factors of production. The subject for investigation may involve determining which technologies and practices may be more attributable to each system and how might technology adoption impact net returns within each system.

Sixth, data regarding the economies of soybean production were obtained for only one cropping season. The differences were not great and further research could well change the results. However, the data is consistent with that contained in more traditional sources, such as *1996 MAFES Soybean Planning Budgets*, as well as information from growers in the study who suggested increased yields, timeliness of input application, and decreased costs from soybean production on straight levee fields.

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