THE POTENTIAL OF NO-TILL RICE PRODUCTION IN ARKANSAS

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ABSTRACT

Increasing production costs combined with recent and pending environmental legislation are forcing Arkansas' rice producers to find new ways to maintain their productivity without degrading the natural resource base on which they depend. The objective of this work was to evaluate the potential for shifting to no-till rice production using current and novel crop rotations. A series of plots were established in 1999 that contain two and three phase rotations using rice, soybeans, corn, and wheat. All rotations have a conventional and no-till comparison along with fertility and variety comparisons. On average, no-till grain yields in 2000 from the conventional rotations were 957 kg ha^{-1} lower than those from conventional tillage plots. This yield difference was more than cost savings from no-till production, thus there was an average reduction in net income of \$166.57 ha^{-1} in the no-till treatments when compared to the conventional till treatments. In 2001 grain yields were similar for both tillage treatments. This resulted in a \$146.45 ha^{-1} increase in net returns from the no-till treatment when compared to the conventional till treatment. Rice grain yields in plots grown after wheat were low in 2000 with all treatments resulting in negative net returns. Improved management in the wheat rotations in 2001 resulted in an average net return of \$82.60 ha^{-1} for the no-till treatments. This was lower than net returns for the conventional tillage treatment. No-till rice has potential in the crop rotations currently used in the rice production areas of Arkansas

KEYWORDS

Crop rotation, wheat, economic analysis, crop budgets, returns

INTRODUCTION

Rice, as it is grown in the Mississippi Delta area of Arkansas, ranks as one of the most tillage intensive row crops in the United States. In order to maintain a 'flood' through much of the growing season, farmers have cut or leveled their fields to slopes between 0 and 0.15%. To move water smoothly across a field it has been the tradition to 'smooth' a field numerous times with a land plane prior to planting. To effectively use the land plane, it is necessary to disc and harrow the field numerous times. Oftentimes these field operations are carried out in the autumn and spring. Rice is harvested when grain moisture is between 18 and 20%, a time when the soil is wet from the flood. Field operations at this time can result in extensive rutting which leads to a need for more tillage. Years of intensive cultivation have resulted in an appreciable decline in soil organic matter (Scott and Wood 1989; Scott *et al*. 1994). Government regulation and support payments that as a percentage of profits, were as high as 120% have not provided farmers with incentives to reduce production costs, a scenario that might stimulate interest in no-till rice production (Cramer *et al*., 1990; Greenwalt 1997). The Federal Agriculture Improvement Act of 1996 removed controls on the amount of rice produced but did not guarantee high payments if market prices were low. There is speculation that the farm bill under negotiation may place more emphasis on conservation and restrictions on supplemental payments. This, along with growing pressures to improve air and water quality, makes the introduction of conservation tillage a key feature to future rice production in the Arkansas delta area. More recently there has been a move by some farmers to what is termed a "stale seedbed" approach to rice production. In this system the ground is tilled and floated in the fall. In spring a burn-down herbicide is applied and the rice is planted. While reducing the amount of tillage, this system leaves the soil bare at the beginning of the winter when rainfall increases. This greatly increases the potential for water erosion. This system is attractive to growers in that it can decrease production costs. However, it is unlikely to pass the land stewardship test. With no guidelines on how rice might fit

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into the conservation tillage framework, it is unlikely farmers will make a change to conservation tillage. It is one goal of this project to provide rice farmers with information that will allow them to move to conservation tillage without compromising their profitability.

MATERIALS AND METHODS

The following two and three phase rotations were selected for use in this study: 1) continuous rice, 2) rice-soybean, 3) soybean-rice, 4) rice-corn, 5) corn-rice, 6) rice (wheat) rice (wheat), 7) rice (wheat)-soybeans (wheat), 8) soybeans (wheat)-rice (wheat), 9) rice-corn-soybeans, and 10) rice-corn (wheat)-soybeans. The two-phase rotations are commonly used in Arkansas rice producing areas, while the rotations containing wheat are not currently used. Wheat is grown as a winter crop. In all the rotations where rice is grown after wheat, it was necessary to begin the study with experimental varieties because commercial varieties available at that time were of too long a duration to allow harvest in time to plant the following rice crop. In February 1999 a site was selected for this study at the University of Arkansas Rice Research and Extension Center and the field cut to a 0.15% slope. The soil at this site is a fine, montmorillonitic, thermic Typic Albaqualf of the DeWitt soil series. Main or rotation plots measuring 76 m x 12 m were laid out in a north-south direction. Each of the four replications was then divided in half with each side randomized as conventional or no-till tillage treatments. Each tillage treatment was then split into a standard and high fertility treatment. Two varieties of each crop species were planted in a continuous strip across the conventional-and no-till treatments. As a result of field leveling all plots were tilled in 1999 and the no-till treatments started in 2000. Fertility treatments consisted of a 'standard' recommendation that a farmer would receive from the analysis of soil samples collected from the field. The 'enhanced' fertility level consisted of elevated levels of nitrogen, phosphorus, and potassium. Care was taken to select popular commercial varieties that would be available for a number of years. All rice and wheat plots were sown with an Almaco no-till drill at a 190mm row width. At harvest a 1 m boarder was removed from the outside of each fertility plot with the remainder of the plot harvested. Grain yields were calculated at 13% moisture. Plot levees were replaced on all plots not planted into wheat by November in order to impound winter rainfall. In March of the following year the levees were removed and the plots either tilled or sprayed with Roundup to control the winter weeds.

Detailed notes were kept on all field operations and inputs for each treatment. These data were used to estimate net returns for each treatment using the procedure outlined in the Mississippi State Budget Generator User Guide, version 3.0 (Spurlocka and Laughlin, 1992). All economic returns were estimated using a rice price of $153.74 t^{1}, a land cost of 25%, and input costs comparable to those on a 405 ha rice farm. Yield and economic returns have been collected and calculated for all crops and phases. Only those results for rice will be presented in this paper.

RESULTS

Full season rice

Rice grain yields pooled over all treatments were 10,080 kg ha^{-1} in 1999 (Table 1). These are considered high yields and are attributed to the field being fallowed for a number of years prior to initiating the study. Analysis of soil samples from the site support this conclusion along with differences observed when comparing fertility treatments (Table 1). Variety differences were significant in 1999 with the newer variety Wells higher than LaGrue.

Overall dry grain yield dropped by 1,109 kg ha^{-1} in 2000 when compared to the previous year (Table 1). Grain yields for the no-till plots were on average 957 kg ha^{-1} lower than for the conventional till plots. Plant stands were lower in the no-till plots (data not presented), while these plots were slower emerging. Problems in achieving acceptable plant stands in the no-till plots was attributed to difficulties in adjusting the seed drill to not 'hairpin' when there was litter on the soil surface. The biggest impact on grain yield came from rotation, where dry grain yield in the continuous rice rotation was 1,764 kg ha^{-1} less than from the rice following either soybeans or corn. As in the previous year, dry grain yield from the 'standard' fertility treatment was higher than that from the enhanced fertility treatment. However, that difference was only 353 kg ha^{-1}. There was little difference between the two varieties in dry grain yield with Wells dry grain yield 555 kg ha^{-1} higher than LaGrue.

Mean dry grain yield over all treatments was 7,963 kg ha^{-1} for the 2001 season, a decrease of 1,008 kg ha^{-1} from the previous year. Dry grain yields for rice have declined each year since this study was initiated. We have no specific data that identifies the cause of this decline but feel that it might be attributed to fertilizer rates that are less than is needed and/or a decline in soil quality that is the result of cropping an area that was previously fallowed for a long period of time. Unlike the previous year, dry grain yields for the no-till treatments averaged 202 kg ha^{-1} more than the conventional till treatments. Stand counts indicated there were no differences in plant stand between the two tillage treatments. We attribute this to modifications we made on the grain drill, in particular changing coulters and adding 'close till' closing wheels. As in the previous year, dry grain yields for the continuous rice rotation were lower than rice following either soybeans or corn. Unlike the two previous years, there was a 302 kg ha^{-1} increase in dry grain yield

Table 1. Summary of 1999, 2000 and 2001 full-season rice grain yields for the long-term cropping systems study at Stuttgart, Arkansas.

Effect	Treatment	1999 yield Kg ha^{-1}	2000 yield kg ha^{-1}	2001 yield kg ha^{-1}
All	All	10,080	8,971	7,963
Tillage	Conventional	NA	9,475	7,862
	No-till	NA	8,518	8,064
Rotation	Continuous rice	NA	7,812	7,308
	Following soybeans	NA	9,576	8,266
	Following corn	NA	9,576	8,316
Fertility	Standard	10,282	9,173	7,812
	Enhanced	9,878	8,820	8,114
Variety	Wells	10,786	9,274	7,913
	LaGrue	9,374	8,719	8,014

with the enhanced fertility treatment when compared to the standard fertility treatment. This result suggests that we are probably equilibrating to the two fertility levels used. Declining grain yields was accompanied by a change in variety rankings with the variety LaGrue yielding 101 kg ha^{-1} more than Wells. Nutrient uptake data (not shown) indicate Wells consistently removed more nutrients than LaGrue to achieve the same yield. LaGrue consistently partitions a higher percentage of above-ground dry matter to grain than does Wells.

Overall high grain yields in 1999 resulted in an average net return for all treatments of \$330.50 (Table 2). The cost of land leveling was not included in this budget. Increasing fertilizer rates resulted in lower yields and a \$35.02 ha^{-1} drop in net profits. The biggest impact in net profit was variety with average net profits for Wells \$73.28 ha^{-1} higher than for LaGrue.

Lower grain yields in the year 2000 did not result in lower net returns (Table 2). This result is attributed to the fact that the field was not disturbed once it was leveled in 1999; thus, there was not a need for extensive tillage, particularly with the conventional till plots. Highest net returns (\$620.61 ha^{-1}) were from the conventional till plots. Lowest net returns (\$349.48) were from the continuous rice rotation. Net returns for rice following corn were lower than for rice following soybeans because of the field operations required to deal with corn stalks and stubble remaining after harvest. Lower grain yields from the enhanced fertility treatment compared to the 'standard' fertility treatment resulted in a \$104.13 decrease in net returns from the enhanced fertility plots. Higher overall yields from the variety Wells resulted in a \$73.41 ha^{-1} advantage over LaGrue.

Mean net return over all treatments in 2001 decreased from the year 2000 but was higher than in 1999 (Table 2). With nearly equal grain yields in the two tillage treatments, the advantage of no-till in reducing production costs was evident in its \$146.45 ha^{-1} higher net returns. Net returns for the continuous rice rotation were \$88.68 and \$100.34 ha^{-1} less than rice following soybeans or corn, respectively. Despite these lower net returns continuous rice had higher returns than either corn or soybeans, the other two crops tested in these rotations (data not presented). The increase in grain yield resulting from higher fertility levels (Table 1) was not sufficiently high to offset the cost of fertilizer and thus resulted in a \$8.11 ha^{-1} decrease in net returns (Table 2). This was the third consecutive year that there was a net loss from the enhanced fertility treatment. Unlike the previous two years, the variety LaGrue had the highest net returns when averaged across all treatments.

Table 2. Net returns (\$ ha^{-1}) for each main effect from rotations containing full-season rice varieties. Rice was priced at \$153.74 t^{-1} and a 25% land cost included.

Effect	Treatment	1999 net Returns \$ ha^{-1}	2000 net Returns \$ ha^{-1}	2001 net Returns \$ ha^{-1}
All	All	\$330.50	\$499.38	\$410.46
Tillage	Conventional	NA	\$620.61	\$337.23
	No-till	NA	\$454.04	\$483.68
Rotation	Continuous rice	NA	\$349.48	\$347.45
	Following soybeans	NA	\$579.81	\$436.13
	Following corn	NA	\$568.89	\$447.79
Fertility	Standard	\$348.00	\$551.35	\$414.52
	Enhanced	\$312.98	\$447.22	\$406.41
Variety	Wells	\$367.14	\$535.99	\$404.02
	LaGrue	\$293.86	\$462.58	\$416.89

Table 3. Summary of 1999, 2000 and 2001 short-season rice grain yields for the long-term cropping systems study at Stuttgart, Arkansas.

Effect	Treatment	1999 yield kg ha^{-1}	2000 yield kg ha^{-1}	2001 yield kg ha^{-1}
All	All	NA	6,250	6,300
Tillage	Conventional	NA	6,451	6,703
	No-till	NA	5,393	5,846
Rotation	Following wheat	NA	6,250	6,300
Fertility	Standard	NA	6,199	6,048
	Enhanced	NA	6,300	6,552
Variety	STG95L-28-045	NA	6,300	5,040
	Early LaGrue	NA	5,544	dropped
	XL-6	NA	7,963†	7,459

† Average value of standard and enhanced fertility only on conventional till plots

Short-season rice

Initial plantings of short-season rice were made in the year 2000 (Table 3). Overall grain yields (6,250 kg ha^{-1}) were much lower than those for the full season treatments (Table 1). Wheat harvest and subsequent sowing of these varieties was in July when the temperatures were high. A large number of 'blank heads' resulting from high temperatures were observed in all treatments. No-till grain yields were 1,058 kg ha^{-1} lower than those for conventional tillage. There were severe weed problems in all no-till plots, even though they were treated with the same herbicide program as the conventional till plots. There was a small (101 kg ha-1) advantage in grain yield from the enhanced fertility treatment. There was insufficient seed of the two experimental varieties, and the commercial variety XL-6 was used to complete the sowing of all plots. Grain yield for XL-6 was highest at 7,963 kg ha^{-1}.

Mean dry grain yield of all treatments in the year 2001 was 6,300 kg ha^{-1} (Table 3). As in the previous year, grain yields were lower in the no-till treatment. Weed control in the no-till treatment was good early in the season but became a problem later. There was a 504 kg ha^{-1} advantage for the enhanced fertility treatment compared to the standard fertility treatment. The variety STG95L-28-045 yielded very lowly and will be dropped in 2002.

None of the treatment combinations resulted in a positive net return in 2000 (Table 3). This is the result of very low yields and high input costs for weed and insect control. This situation improved in 2001 when the average net returns over all treatments was \$190.54 ha^{-1}. Lower grain yields from the no-till plots when compared to the conventional till plots resulted in lower net returns. The increase in grain yields from increasing fertility was more than sufficient to result in increased net returns in the 'enhanced' fertility treatments when compared to the 'standard' fertility treatment. Averaged over all plots, the variety STG95L-28-045 had a negative net return. This is in contrast with the variety XL-6 that had an average net return over all plots of \$294.37. Currently farmers plant soybeans after wheat. Net returns from plots

Table 4. Summary of net returns for short-duration rice varieties grown after wheat in a long-term cropping systems study conducted at the University of Arkansas Rice Research and Extension Center. Rice was priced at \$153.74 t^{-1} and a 25% land cost included

Effect	Treatment	1999 net Returns \$ ha^{-1}	2000 net returns \$ ha^{-1}	2001 net returns \$ ha^{-1}
All	All	NA	(\$217.41)	\$190.54
Tillage	Conventional	NA	(\$115.40)	\$189.52
	No-till	NA	(\$317.42)	\$82.60
Rotation	Following wheat	NA	(\$217.41)	\$190.54
Fertility	Standard	NA	(\$230.18	\$125.18
	Enhanced	NA	(\$149.16)	\$146.96
Variety	STG95L-28-045	NA	(\$224.50)	(\$22.25)
	Early LaGrue	NA	(\$227.43)	dropped
	XL-6	NA	(\$78.18)	\$294.37

where soybeans were planted after wheat were all lower than those for the rice variety XL-6, indicating a good potential for planting rice after wheat.

DISCUSSION

Two years of comparing no-till to conventional till rice production indicate there is potential for no-till rice production in Arkansas. Results indicate that in the currently used two phase rotations it is possible to achieve the same yield levels using no-till as is possible with conventional tillage. When grain yield levels from no-till plots were equal to those of conventional tillage plots, there were significant reductions in production costs and subsequent gains in net return for the no-till treatments. Achieving equal levels of rice production in a no-till environment involves a number of changes in production practices. We were not able to obtain acceptable plant stands in the no-till plots without retrofitting the grain drill with appropriate disc openers and a “close till” packing system. Impounding water on the field during the winter months to facilitate straw decomposition was a useful way to manage the nearly 10 t ha^{-1} of stubble and straw remaining after a rice crop is harvested. This practice reduced problems of ‘hair pinning’ when planting into rice stubble. Data collected on nutrient uptake showed no differences between tillage treatments. This finding indicates that the practice of aerial fertilizer application will not need to be modified in a no-till setting. We have found that crusting does not occur in our no-till plots and thus eliminates the need to ‘flush’ fields after planting. Flushing is a standard practice of applying sufficient water to bring the soil to field capacity and then removing the excess water. Eliminating this step represents a water savings of 102.8 – 205.6 m^3. With a number of the rice producing areas of Arkansas having been declared critical water areas, this savings will be important for future rice production in the state.

The potential for no-till rice in rotations after wheat is currently not as high as it is for standard rotations. Temporal considerations dictate the planting of rice as soon as possible after wheat harvest and the subsequent wheat planting immediately after rice harvest. For both scenarios there is a large volume of plant material in the field, thus sowing is difficult. We have also encountered weed problems with no-till rice following wheat. Growing rice after wheat in our conventional tillage plots resulted in higher net returns than growing soybeans, the current practice. We believe there is potential for this system by need to identify better rice varieties and weed control practices.

Net returns for no-till rice were not always as high as they were for conventional till rice, but in all cases they were higher than the net returns for other crops used in rotations with rice. This was expected and highlights the need to keep rice as a component in the rotations. With water issues and possible environmental restrictions, interest in no-till rice is expected to increase. Our results indicate shifting to no-till rice in the current rotations will not result in decreased yields and potentially can increase profits.

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