

YIELDS AND ECONOMICS OF CONSERVATION SYSTEMS FOR COTTON PRODUCTION**Donald J. Boquet****LSU AgCenter****Winnsboro, LA****Kenneth W. Paxton****LSU AgCenter Dep. of Agric. Economics and AgriBusiness****Baton Rouge, Louisiana****Abstract**

Year-long long cropping practices with no-till can be an efficient way to build organic matter in southern soils and, along with residue from winter crops, provides a system with unparalleled benefits for improving soil and water quality. In the 1980s and 90s, the NRCS in cooperation with farm groups and land grant universities established practices called best management practices (BMPs) farmers could implement to protect surface water bodies from non-point source pollution originating from agricultural lands. An experiment was initiated in 2001 at the LSU AgCenter Macon Ridge Research Station to evaluate some of these BMPs. No-till cropping systems that included cotton, corn, soybean, grain sorghum, wheat and winter cover crops were compared with traditional monocrop practices for annual yield and net returns above variable expenses. The studies include evaluation of doublecropping wheat and cotton; and doublecropping wheat with cotton in various rotations with soybean, corn and grain sorghum. The annual yields of the doublecrop systems have been higher than monocrop systems because of the added yield of wheat grain that averaged 63 bu/acre. Cotton usually sustained yield reductions of about 10% in double crop systems. This yield reduction is a significant economic penalty because it represents a loss directly from the net returns. However, it also represents a direct exchange for 63 bu of wheat per acre. Using enterprise budgets based on the yields and inputs for each system and annual prices, doublecropping was more profitable than monocropping. From 2001 through 2007, doublecrop cotton/wheat produced annual net returns that ranged from \$164.00 to \$340.00 per acre from average yields of 63 bu wheat per acre and 1030 lb cotton lint per acre. The system of producing three crops in two years of corn-wheat-cotton, soybean-wheat-cotton, and sorghum-wheat-cotton averaged annual net returns that ranged from \$261 to \$320.00 per acre. In comparison, monocrop cotton averaged much lower net returns of \$112.00 to \$167.00 per acre from average yields of 1152 lb lint per acre.

Introduction

Multi-crop year-round systems with summer crops of corn, cotton, soybean or grain sorghum, combined with winter crops of grass or legume green-manures or wheat grain crops can help to protect the soil and may reduce soil, nutrient and pesticide losses into water bodies and are therefore considered Best Management Practices (BMPs) for surface water quality protection. (Boquet et al., 1997a, 1997b; Dabney, 1998; Daniel et al. 1999; Nyakatawa and Reddy, 2000; Unger and Vigil, 1998). No-till planting of summer crops into wheat cover crop residue has been shown to increase cotton yield (Bauer, 1996, 2002; Hutchinson et al., 1994; Nyakatawa; Scott et al., 1990) and may increase the yield of other crops. With this practice, growth of the wheat is terminated before grain fill (Zodaks Growth Stage 40-59) and not harvested for grain, so the cotton crop can be planted in a timely manner. Crop rotation, increasingly popular in the mid-South for yield enhancement and diversification, is also recognized as a beneficial BMP. Rotation of cotton, soybean and corn increases the yield of all three crops (Boquet and Hutchinson, 1993; Ebelhar et al., 2005). Doublecropping of wheat and soybean has been a common practice throughout the mid-South for 30 years. Acreage in doublecropping is greatly reliant on the perceived profitability versus the increased risk for the summer crop. Doublecropping of wheat with soybean or cotton, when combined with no-till, is considered a promising BMP for water quality enhancement (Dabney, 1998, Dabney et al., 2001). The objectives of this research were to: 1) Evaluate BMP/no-till systems in which two crops are grown in one year or three crops are produced in two years, and 2) Compare yields and returns from BMP systems to mono-crop cotton, corn, soybean and grain sorghum.

Materials and Methods**Cropping systems**

Field experiments were performed from 2000 through 2005 on Gigger silt loam to evaluate eight BMP cropping systems in comparison with monocropping. The study was conducted at the LSU AgCenter Macon Ridge Research Station near Winnsboro, LA. Continuous monocropping of cotton, corn, soybean and grain sorghum was compared

with selected year-round crop sequences of cotton, corn, soybean or grain sorghum doublecropped with wheat or with cotton/corn or cotton/soybean rotations doublecropped with wheat. The cropping systems are listed in Table 1. All cropping systems were produced using conservation tillage practices, essentially no tillage,

Table 1. Cropping sequences evaluated for yield and net returns with conservation tillage on Gigger silt loam at the LSU AgCenter Macon Ridge Research Station, Winnsboro, LA from 2001 through 2007.				
2001-2002			2002-2003	
2003-2004			2004-2005	
2005-2006			2006-2007	
Crop Sequence				
Fall-Winter	Spring-Summer		Fall-Winter	Spring-Summer
Wheat grain crop	Cotton		Wheat grain crop	Cotton
Wheat green manure	Cotton		Wheat green manure	Cotton
Wheat grain crop	Soybean		Wheat grain crop	Soybean
Wheat grain crop	Grain Sorghum		Wheat grain crop	Grain Sorghum
Wheat grain crop	Soybean		Wheat grain crop	Cotton
Wheat grain crop	Grain Sorghum		Wheat grain crop	Cotton
Fallow	Corn		Fallow	Cotton
Fallow	Cotton		Fallow	Cotton
Fallow	Corn		Fallow	Corn
Fallow	Soybean		Fallow	Soybean
Fallow	Sorghum		Fallow	Sorghum
Fallow	Soybean		Fallow	Cotton
Fallow	Grain Sorghum		Fallow	Cotton
Rye green manure	Cotton		Rye green manure	Cotton
Oat green manure	Cotton		Oat green manure	Cotton

Land preparation, fertilizers and irrigation

In the fall of 2001, the field was disked and then bedded into 102-cm-wide beds with a moldboard plow. The beds were smoothed with a rolling cultivator and harrow before planting the initial wheat crop. No other tillage was used during the experiment except beds were reshaped in the fall after 2003 and 2006 harvest. The field was uniformly limed and fertilized with P and K in spring 2001, 2003 and 2006 according to soil tests and recommended practices. Applications of fertilizer N were made to corn and cotton each yr within 20 days of planting. Corn received 150 lb N per acre and cotton received 80 lb N acre each year. Cotton following wheat received a higher rate of N, 100 lb N acre. The wheat grain crop was fertilized with 80 lb N acre each year in mid February. The wheat cover crop was not fertilized. The summer crops were furrow irrigated as needed to maintain adequate soil water for optimal crop development.

Planting procedures and varieties

Wheat was planted in early to mid November each year with a Marliss grain drill (Model No. 14, Marliss Industries, Inc. Jonesboro, AR.). Corn was planted each year in mid March, monocrop cotton, soybean and grain sorghum were planted in late April to early May. Doublecrop cotton, soybean and grain sorghum were planted immediately following wheat harvest in mid May. Summer crops were planted with a John Deere Model 7300 planter (Deere and Co. Moline, IL) that was equipped with ripple coulters when planting in wheat stubble. The varieties and hybrids varied across years but were always selected from among the best adapted on the LSU AgCenter recommendation lists. The wheat variety was 'Terral LA481' for all years. The corn hybrid was 'Terral TV2140RR' in 2002 and 2003, 'Terral TV25BR23' in 2004 and 2005 and DeKalb DK67-87 in 2006 and 2007. The soybean variety was Delta Gro 'DG3600NRR' in 2002 and 2003 and Delta King 'DK 4866' in 2004 and 2005. The sorghum hybrid was Pioneer 'B8282' in 2002 and 2003 and Pioneer 'B84G62' in 2004 and 2005 and DeKalb DKS53-67 in 2006 and 2007. The cotton variety was Stoneville 'ST5599BR' throughout.

Weed and insect control

Winter fallow plots were sprayed with paraquat dichloride, 0.70 lb a.i. per acre, in March each year. Cotton, corn and soybean were glyphosate resistant varieties and glyphosate was the primary post emerge weed control chemical used for these crops. Two broadcast glyphosate applications of 1.0 lb a.i. per acre were applied each year, one 15 days after planting and a second application 15 days later. In addition to the post emerge glyphosate applications, all summer crops received pre emerge applications of one or more herbicides that are typically used and recommended by the LSU AgCenter Extension Service. Wheat did not need herbicides from 2001 through 2003. In 2004 through 2007, wheat received a post emerge 2.5 oz broadcast application of metribuzin (Sencor) and diclofop-methyl (Hoelon), 0.60 lb a.i. per acre.

Cotton received an infurrow at-planting application of aldicarb (Temik). 0.3 lb a.i. per acre. Corn received an infurrow at-planting application of Aztec. Foliar applications of insecticides were applied as needed to all summer crops to maintain insect populations below economic thresholds.

Harvesting

Wheat for cover crop/green manure was desiccated in early April with an application of glyphosate, 1.3 lb a.i. per acre. Grain yield was determined for each crop by harvesting four center rows of the 12-row plots. All grain crops were harvested with a plot combine with an automated weighing system. Cotton was harvested with a spindle picker with an automated weighing system. Seedcotton samples (4.5 lb) were collected from each plot during harvest to determine lint percentage and fiber properties. Cotton samples were ginned on a 20-saw gin without a cleaner. The lint percentage was used to calculate lint yields. Fiber properties were determined by HVI in the LSU AgCenter Cotton Fiber Lab. Wheat was harvested in early to mid May and corn was harvested in mid August each year. Monocrop soybean and sorghum were harvested in late August or early September. Doublecrop soybean and sorghum were harvested between late September and early October. Monocrop cotton was defoliated in mid September and harvested two to three weeks afterwards. Double crop cotton was defoliated in early October and harvested between late October and early November. The harvest aid each year was a tank mix of thidiazuron (Dropp), 0.27 lb a.i. per acre and tribufos (Folex), 0.75 lb a.i. per acre.

Design, data collection and analyses

The experiment was in a randomized complete block design with four blocks. Plots were 12 bedded rows with a 40-in spacing between rows 65 ft. long. Each cropping system remained on the same plot for the initial three years. In 2005, the experiment location was changed and treatments remained on the same plots until 2007. The yield data were analyzed by ANOVA. LSD values ($P=0.05$) were calculated for mean comparisons within crops across systems.

Economic analyses

Physical input-output data from the experiment was used to develop an enterprise budget for each cropping system. Input levels used in the experiment were incorporated into the enterprise budgets. Input prices were current input prices used by the LSU Department of Agricultural Economics and Agribusiness to estimate 2005 enterprise budgets for Louisiana. Equipment sizes representative of commercial farming operations were used to estimate costs on an acre basis. Yields were estimated for each system at the mean over the life of the experiment. Output prices were essentially current loan rates under the 2002 farm bill. Constant prices and average yields were used to compare the relative profitability of the various systems.

Results and Discussion

Wheat

Wheat yields ranged from a low of 43 bu per acre in 2001-2002 to a high of 83 bu per acre in 2004-2005 with an average yield of 63 bu per acre in most systems (Table 2). Year to year variation in yield was attributed to variations in abiotic conditions. Within years, there was no effect of cropping system on wheat yield. There was an increase in weed competition in wheat plots after the third year of continuous wheat, especially from ryegrass, which necessitated increased use of herbicides for weed control. There is little information available on the effects of continuous cropping of wheat in the mid South but, in other wheat growing regions, continuous cropping often results in increased diseases and lower yields (Cook et al., 2000; Gutteridge and Hornby, 2003). The variety grown in the current study had high levels of resistance to leaf rust and stripe rust, the two diseases that negatively impact wheat yields the most in the mid South.

Cotton

Cotton grown in continuous monocrop with winter fallow, the traditional cropping system in the mid South, produced similar yields to the year-round BMP systems (Table 2). There was only one instance in which monocrop cotton produced higher yields than another system. In 2002, monocrop cotton was higher yielding than cotton doublecropped with wheat. In all other years and cropping systems, the cotton crops produced equivalent yields. Although not out yielding monocrop cotton, cotton in the year-round BMP systems yielded as well, demonstrating there was no yield penalty associated with the BMP systems. For example, total lint production over four years for monocrop cotton was 4, 440 lb lint per acre, while doublecrop cotton produced 4, 155 lb lint per acre. The year-round BMP system thus reduced cotton yield only 70 lb per acre per year, or 6%. Bordovsky et al. (1994) and Hulugalle et al. (1999) obtained yield increases with cotton rotated with a wheat grain crop compared with continuous cotton, which were attributed to reduced soil compaction and increased mycorrhizal colonization of cotton roots. The small reduction in doublecrop cotton yield in the present study was more than compensated for by average annual production of 63 bu wheat grain per acre, or total production of 253 bu of wheat grain over four years.

Cotton yields in doublecrop systems were not increased by rotating the cotton with other summer crops of soybean, corn or sorghum. In other studies researches have concluded that rotations of cotton and grain crops usually increased yield of cotton, and the grain crops as well, but the summer crops in those studies were not doublecropped (Boquet et al. 1994; Wesley et al., 2001; Ebelhar et al., 2005). The present results suggest that growing summer crops in rotations as a doublecrop following wheat may limit the yield increases that would normally be expected with rotations of summer crops vs. continuous monocropping.

Cotton following the wheat cover crop also did not exhibit any increase in yield compared with cotton following winter fallow, probably because the summer crops were furrow irrigated (Table 2). Earlier research had demonstrated variable yield benefits of winter cover crops to a following cotton crop. Bauer and Busscher (1996), Boquet et al. (2004), Dabney et al. (2001) and Nyakatawa and Reddy 2000 all reported yield increases for cotton following a wheat cover crop, whereas Bloodworth and Johnson (1995) found no yield differences for cotton following wheat or winter fallow. One factor contributing to differences from earlier studies is that the present study was irrigated and previous studies were with rain fed cotton. Some studies have demonstrated a greater yield benefit for rain fed cotton than irrigated cotton following a wheat cover crop (Boquet et al., 2004; 1997a; 1997b). Therefore the lack of yield differences between cotton following the wheat cover crop and cotton following winter fallow is not surprising.

In one of six years, cotton following the wheat cover crop yielded higher than cotton following the wheat grain crop but, on average, there was no difference between cover crop and grain crop effect on cotton yield. With the likelihood of little difference in cotton yield between the two BMP systems, it may be better in some years to mature

Table 2. Yield and net returns for selected cropping systems.

Crop sequence	Average annual crop yield Bu of grain or lb of lint/acre	Average annual net returns Dollars/acre
Wheat grain crop + cotton	63 + 1030	271
Wheat green manure + cotton	00 + 1127	101
Wheat grain crop + soybean	63 + 44	233
Wheat grain crop + sorghum	57 + 109	221
Wheat grain + soybean/cotton	61 + 51/1083	271
Wheat grain + sorghum/cotton	60 + 119/1191	313
Wheat grain + corn/cotton	52 + 159/1175	284
Winter fallow + cotton	00 + 1152	124
Winter fallow + soybean	00 + 51	94
Winter fallow + sorghum	00 + 111	119
Winter fallow + corn	00 + 151	251

the wheat crop for grain harvest than to terminate growth at GS 40 as a cover crop. Terminating the wheat as a cover crop does allow earlier planting of the summer crop, which reduces risk for the summer crop.

Corn

Monocrop corn with winter fallow averaged a yield of 151 bu per acre during the seven years of the study (Table 2). In each of the years in which monocrop corn and corn doublecropped with cotton occurred together, the rotated corn yielded significantly higher than continuous corn. Cotton did not exhibit yield increases in the corn/cotton rotation. Previous research has shown a cotton/corn rotation to have significant yield benefits for cotton and corn (Boquet et al. 2004; Ebelhar et al., 2005). However, in the present study, the cotton was planted following harvest of a wheat grain crop, and the later planting may have had an effect on the cotton yield. As with the other doublecrop sequences, the yield reduction in cotton yield in this system was offset by two years of wheat grain production, which averaged 52 bu per acre each year.

Soybean

In four of the six years, monocrop soybean with winter fallow yielded higher than doublecrop soybean following a wheat grain crop (Table 2). In the other two years, the two systems produced similar yields and there was no yield penalty for the doublecrop system. The annual yield reduction for using the BMP system was only 7 bu per acre or a total penalty over six years of 42 bu of soybean grain. Wheat grain production in the soybean/wheat doublecrop system averaged 63 bu per acre. Thus the tradeoff for the annual loss of 7 bu of soybean was a gain of 63 bu of wheat grain. The average yield of soybean in the doublecrop system in which soybean was rotated with cotton was similar to continuous monocrop soybean. However, in 2005, continuous monocrop soybean yield was lower than doublecrop soybean rotated with cotton, which may represent the initial indication of expected yield reductions for non-rotated continuous monocrop soybean (Boquet et al., 2004; Wesley et al. 2001).

Grain sorghum

Results with sorghum were variable because of yield reductions of the 2004 and 2006 crops due to glyphosate drift. During the other years continuous monocrop sorghum averaged 111 bu per acre. Sorghum doublecropped with wheat produced similar yields of 109 bu per acre. Sorghum doublecropped with wheat in rotation with cotton produced yields similar to continuous monocrop sorghum. There was no yield reduction from using sorghum in BMP systems compared with monocropping but there was no increase in sorghum yield from rotating with doublecrop cotton. Rotation with sorghum has been proven to be beneficial to cotton yield in other studies (Boquet et al., 1994, 2004) but did not affect yield in the present study.

Economics - Net returns

Although seldom increasing yield of summer crops, most of the BMP systems were more profitable than growing monocrop grain crops and two BMP systems were as profitable as growing monocrop cotton (Table 2). Annual net returns from continuous monocrop cotton averaged 124 dollars per acre. All cotton BMP systems except wheat green manure + cotton averaged higher net returns per acre. The BMP rotation of wheat/sorghum/cotton had the highest net returns of 313 dollars per acre. Wheat contributed to increases in net returns, and in most systems, the increases were large enough to offset yield reductions of the summer crops. Paxton et al. (2001) has previously reported BMP systems were as profitable for producers as non-BMP systems but Bullen et al. (2004) reported higher net returns for monocrop cotton than for cotton/wheat systems.

Summary

The various cropping systems of year-long cropping with wheat, cotton, soybean, corn and grain sorghum were highly productive for yield and net returns. These systems have potential to improve soil and water quality and therefore qualify as BMPs. The studies were conducted with no till, a viable economic practice because of the associated savings in fuel, equipment and labor costs. Production risk is an important consideration for BMP systems. Probably the greatest risk factor is the possibility of soil water deficient, especially at planting time. Irrigation capability eliminates this risk by ensuring a stand of cotton and rapid crop development. Other risks are related to the later-maturity of the cotton and include insects and tropical systems that bring extensive rain and high winds. Production risks for double crop cotton in the six years of the current study were minimized because these were irrigated studies. In 2008, however, Hurricane Gustav and Ike caused severe crop damage to all crops except soybean and corn.

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