YIELD AND ECONOMIC SUSTAINABILITY OF REDUCED IRRIGATION CAPACITY ON THREE TILLAGE SYSTEMS IN THE SOUTHEASTERN COASTAL PLAIN

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ABSTRACT

The interaction between reduced irrigation capacity and tillage, including the possible conservation of water with reduced tillage systems, is of vital interest to growers. A field study was initiated in the fall of 2001 to determine crop response under a simulated reduction in irrigation. Three tillage systems were replicated three times each under one of four irrigation levels (100% of a recommended amount, 66%, 33%, and 0% or dryland). Tillage systems were conventional tillage, wide-strip tillage and narrow-strip tillage. The test area was planted in triplicate, in a peanut-cotton-corn rotation, with each crop being present each year. Tillage was significant for peanut yield and net return at the 0% irrigation level only. No trend in yield was evident, however, net return was consistently high with narrow-strip tillage in all years. Irrigation, at any level greater than 0%, masked tillage effects in both yield and net return. These data confirm the suitability of peanut to conservation tillage practices, including both wide- and narrow-strip tillage.

INTRODUCTION

Crop production in the Southeastern Coastal Plain is generally water-limiting. Because these highly-weathered soil systems tend to be drought-prone and susceptible to compaction and erosion, they present water management challenges. To complicate this, abundant rainfall is poorly distributed, and producers commonly utilize supplemental irrigation to sustain crops during extended dry periods. A major problem facing producers in the region is maintaining crop yield, while maximizing current water resources through efficient water use. Lamb et al. (1997) reported significant increases in yield, quality, net returns, and a reduction in aflatoxin contamination for peanuts produced under irrigation compared to dryland peanut production systems. These findings illustrate the importance of irrigation and demonstrate the potential negative impacts future water restrictions may have on growers in the region. Interstate litigation regarding water rights has focused much attention on agricultural water use in the Southeast in recent years. Moratoria on agricultural withdrawal permits in certain watersheds and voluntary auctioning of agricultural water rights have occurred in Georgia; thus the future expansion of irrigated acreage may be limited unless alternative methods of irrigation are adopted or current practices are made more efficient.

Surface residue management coupled with conservation tillage is a viable management tool for producers (Brown et al. 1985). The positive impact of conservation tillage, strip-tillage in particular, on infiltration, runoff and soil quality has been well-researched (Bosch et al. 2002; Lascano et al. 1994; Truman et al. 2005a and 2005b). It is also suspected that conservation tillage increases the amount of plant available water, thus increasing the efficiency of rainfall or irrigation (Sullivan et al. 2005). Conservation tillage systems for peanut have been successful, although not always increasing yield when compared with conventional tillage systems (Baldwin and Jones 2003; Hartzog and Adams 1989; Wright and Porter 1995). Objectives of this field study were to quantify the yield effect of reduced irrigation amounts on three tillage systems and ultimately, to understand how reductions in irrigation water may affect the economic sustainability of crop production in the southeast.

MATERIALS AND METHODS

An experimental site was established on a Greenville fine sandy loam (fine, kaolinitic, thermic Rhodic Kandiudults) at the Hooks-Hanner Environmental Resource Center, near Dawson, GA in the fall of 2001. The site was fallow the previous 5 yr with an occasional disking or mowing to limit weed growth.

The following three tillage systems were implemented: conventional tillage, wide-strip tillage, and narrow-strip tillage. Conventional tillage consisted of multiple diskings, subsoiling (year one only) and moldboard plowing, field cultivation, and bedding prior to planting. Wide-strip tillage consisted of a single-pass tillage operation with an implement consisting of a coulter ahead of a subsoil shank, followed by two sets of fluted coulters ahead of a rolling basket and a drag chain assembly. An area approximately 18 in. wide was tilled over the row. Narrow-strip tillage consisted of a coulter ahead of a subsoil shank followed by two parallel press wheels that firm the disturbed area in one pass. An area approximately 12 in. wide was tilled over the row.

The three tillage systems were replicated three times each under one of four irrigation levels (100% of a recommended amount, 66%, 33%, and 0% or dryland) in a randomized block design. Plot dimensions were 6-36 in. rows wide by 120 ft. long. Irrigation timing was based on plant evapotranspiration (ET) measurements (2002) and on Irrigator Pro®, an irrigation decision support system that uses atmospheric ET and plant growth stage (2003-2004). Irrigation levels were obtained using a lateral move overhead sprinkler irrigation system with three spans, each span nozzled for the appropriate reduction in volume. The dryland area lay just beyond the third span of the lateral.

The study was planted in triplicate with each of the following three crops present and in rotation: peanut (*Arachis hypogea* L. var. 'Georgia Green'), followed by cotton (*Gossypium hirsutum* L. var. 'DPL 555RR'), followed by corn (*Zea mays* L. var. 'DK 6760RR'). Best management practices for each crop were followed with regards to seeding rates, fertility, pest management, growth regulation, and harvest timings. Peanut only was planted in a twin row pattern, with the center of each twin row spaced 36 in. apart. A wheat (*Triticum aestivum* L. var. 'AGS 1000') cover crop was drill-seeded each fall on conservation tillage plots. Cover crop termination was performed approximately three weeks prior to planting of each crop species.

The center two rows by 100 ft. were machined harvested in each crop to determine yield. Peanut plots were subjected to soilborne and foliar disease evaluations, aflatoxin analysis, FSIS grade, and digging loss analysis. Net returns were calculated using enterprise budgets with the following adjustments: variable cost of irrigation, \$6.50 acre^{-1} inch^{-1}; irrigated land rent, \$100 acre^{-1}; dryland rent, \$50 acre^{-1}; cost (variable plus fixed costs) of machinery and fuel for conventional tillage, \$83.67 acre^{-1}; cost of machinery and fuel for strip tillage, \$28.45 acre^{-1}; selling price, \$380 ton^{-1} (2002, 2004) and \$390 ton^{-1} (2003). Yield and net returns for tillage systems were analyzed within a given irrigation level using Mixed Models analysis. Orthogonal contrasts were performed to further distinguish between tillage systems. Peanut yield response and net returns from 2002-2004 are presented.

RESULTS AND DISCUSSION

ANOVA revealed that tillage was a significant effect at the 0% irrigation level, and then only by year (Table 1). All remaining irrigation levels showed no differences between tillage systems, only differences by year. Accordingly, both yield and net return data will be presented by year only for the 33-100% irrigation levels. Yield and net return are presented by tillage and year for the 0% (dryland) irrigation level.

Although a statistical comparison may not be made, yield increased numerically with an increase in irrigation level in two of three years (Table 2). Rainfall in 2002 was very near the 30-yr average for the research site (Table 3). Both 2003 and 2004 had approximately four more inches of rainfall than the 30-yr average. Yield in 2003 showed no trend with irrigation and is likely due to the even distribution of rainfall during that growing season (Figure 1). Compared with 2004, rainfall recorded during a 9 week period starting at week 9 was three-fold greater during 2003. This time period, from 63 to 119 days after planting corresponds to the pegging and pod fill stages of peanut development, when crop water use is at its greatest. A similar drought occurred in 2002 beginning at week 11 and continuing through week 17. This corresponds to a four-fold increase in rainfall during that time. Irrigated yields in 2003 were less than both 2002 and 2004 due to excessive vine growth which caused digging problems (data not shown).

Tillage effects were evident at the 0% irrigation level only (Table 4). Yields ranged from 2700 to 3350 lb acre^{-1} in 2002, with maximum yield in the narrow-strip tillage system. Net return corresponded closely with yield, with the highest return (\$102.00 acre^{-1}) found also in the narrow-strip tillage. Contrasts revealed no significant difference between the narrow-strip tillage system and the conventional tillage system. However, a significant decrease in both yield and net return was found for the wide-strip tillage system. This decrease cannot be attributed to any certain factor. No significant differences were determined for 2003, with maximum yield of 3810 lb acre^{-1} and net return of \$203.00 acre^{-1}. Both strip tillage systems had greater yield and net return compared to the conventional tillage system in 2004. Highest yield and net returns were with wide-strip tillage (3940 lb acre^{-1} and \$214.33 acre^{-1}), but these were not significantly greater than those for narrow-strip tillage. With the exception of wide-strip tillage in 2002, all treatments had positive net returns for dryland production.

These initial findings indicate that dryland fields may be more responsive to choices in tillage system compared to irrigated fields. No clear trend in yield can be related to tillage at this time. Conservation tillage adoption in peanut has lagged compared with other crops such as corn and cotton, due to producer reluctance and concern for digging problems. Our data further indicate that either wide- or narrow-strip tillage can be used successfully in the southeast in both favorable (2003-2004) and marginal production years (2002). Narrow-strip tillage production was among the highest in net return per acre regardless of year. No significant differences in tillage were determined at any level of irrigated peanut production for either yield or net returns, indicating that water continues to influence peanut production in the southeastern coastal plain. The interaction between tillage and irrigation level will continue to be monitored, with special emphasis on the temporal effects of conservation tillage.

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Table 1. ANOVA results for peanut yield and net return within irrigation level[†].

Effect	0% (dryland)		33%		66%		100%	
	Yield	Net return	Yield	Net return	Yield	Net return	Yield	Net return
	----------	----------	----------	----------	*P > F*	----------	----------	----------
Year	0.0011	0.0021	0.0293	0.0265	0.0252	0.0142	0.0328	0.0201
Tillage	0.0207	0.0031	0.9961	0.9957	0.8501	0.8039	0.9674	0.9547
Year * tillage	0.0207	0.0031	0.9961	0.9957	0.8502	0.8038	0.9673	0.9545

[†] Main effects considered significant if $P \leq 0.05$. Interactions considered significant if $P \leq 0.10$.

Table 2. Mean peanut yield and net return by year (across tillage systems) at three irrigation levels.

Irrigation level	2002		2003		2004	
	Yield	Net return	Yield	Net return	Yield	Net return
	--lb/A--	*--$/A--*	*--lb/A--*	*--$/A--*	*--lb/A--*	*--$/A--*
0%[†]	3100	33.67	3680	161.22	3700	146.89
33%	4250	183.56	3710	112.33	3780	96.00
66%	4760	262.33	3460	59.44	4040	130.78
100%	4820	254.00	3660	94.89	4140	135.44

[†] 0% (dryland) means presented for comparison purposes only.

Table 3. Total rainfall and supplemental irrigation applied to the 2002-2004 peanut crops at the Hooks-Hanner Environmental Research Center, Dawson, GA.

Source	2002	2003	2004	30-yr average
	---------- *inches* ----------			
Rainfall	24.01	27.83	28.06	24.82
Irrigation†	8.4	1.76	7	--
Total water	32.41	29.59	35.06	--

† Irrigation amounts are those in the 100% irrigation level.

Table 4. Mean peanut yield and net return of three tillage systems at the 0% (dryland) irrigation level†.

	2002		2003		2004	
Tillage system	Yield	Net return	Yield	Net return	Yield	Net return
	--lb/A--	*--$/A--*	*--lb/A--*	*--$/A--*	*--lb/A--*	*--$/A--*
Conventional	3260	19.67	3810	141.33	3340	33.33
Wide-strip	2700	-20.67	3460	139.33	3940	214.33
Narrow-strip	3350	102.00	3780	203.00	3830	193.00
Contrast	---------- *P > F* ----------					
Conventional vs. strip	0.1536	0.6973	0.2670	0.3560	0.0435	0.0059
Wide-strip vs. narrow-strip	0.0021	0.0845	0.1136	0.1141	0.6682	0.6676
Wide-strip vs. conventional	0.0104	0.5225	0.0943	0.9556	0.0052	0.0087
Narrow-strip vs. conventional	0.7970	0.2151	0.8979	0.1237	0.0427	0.0149

† Contrasts considered significant if $P \leq 0.05$.

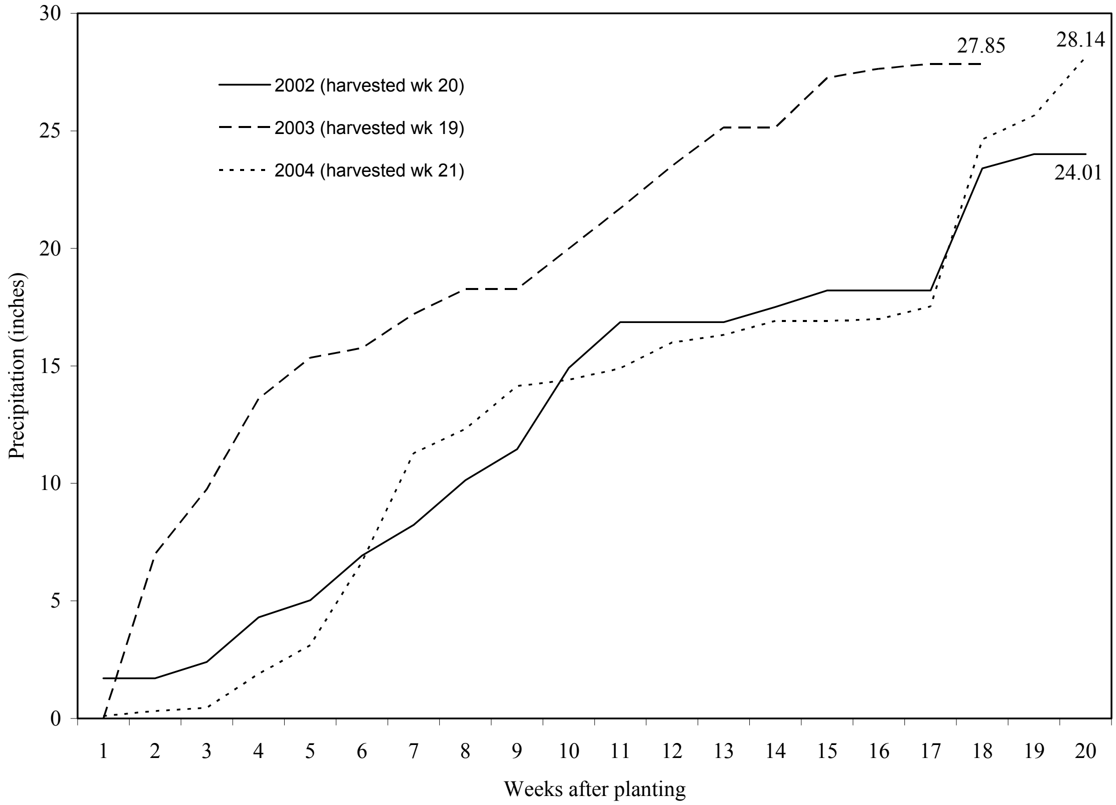

Figure 1. Rainfall distribution with cumulative totals during the 2002-2004 cropping seasons, Dawson, GA.