A Comparison of Three Cotton Tillage Systems

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Abstract

Two reduced cotton tillage systems, both of which utilize controlled traffic farming techniques, are being compared to a conventional tillage system in terms of energy requirements, field work time requirements, crop yield, and operating costs. Four seasons of testing show the Sundance system to have the lowest energy requirement of 28.2 HpHr/Ac, the Uprooter-Shredder-Mulcher (USM) the second lowest at 40.5 HpHr/Ac, and conventional tillage the highest at 54.4 HpHr/Ac. Field work times of the two reduced tillage systems are about one-half that of conventional tillage. Costs of the two reduced tillage systems are lower than for conventional tillage. We have never measured a significantly lower lint yield with either of the two reduced tillage systems, relative to conventional tillage.

Introduction

With a conventional tillage system, the farmer spends more than one-half of the annual fuel budget before the crop emerges (Cannon and Stapleton, 1977).

From 1965 to 1973, Cannon and Stapleton (1975) evaluated chisel-list systems for minimum tillage in cotton. These systems saved almost 75% of the fuel and labor costs of plowing down and preparing a new seedbed. They never measured significantly lower cotton yields with these systems; however the main drawback was that chisel-listing resulted in a rough and trashy seedbed that was difficult to plant.

Newer reduced cotton tillage systems are now available which offer savings in energy, time and cost. We are conducting this study to measure differences in energy requirements, field work times, cost, and lint yields.

Both of these alternative systems utilize controlled traffic farming techniques. They re-work the existing beds, while confining all wheel traffic to certain furrows. The concept is to confine wheel traffic to "traffic lanes", while maintaining uncompacted "production zones". An article in this volume (4) explains the concept of controlled traffic tillage.

Materials and Methods

We began this study with the plowdown of a 1988 cotton crop in field D-1 of the University of Arizona's Marana Agricultural Center. The soil is a Pima Clay Loam. The conventional, Uprooter-Shredder-Mulcher (USM), and Sundance systems are replicated in the field four times in a complete randomized plot design. All data are from the center four rows of each plot.

We now have four cotton seasons of data from the study. Throughout the study we have maintained a controlled traffic pattern in the USM and Sundance plots, even while we rotated to durum wheat in 1991 to alleviate problems with verticillium wilt. We have made no attempt to control wheel traffic patterns in the conventional plots.

We measured the input power of each implement by recording implement draft, tractor speed, and PTO torque and speed as required. We estimated field capacities based on travel speeds, effective implement widths, and an assumed 85% field efficiency. Cost estimates are based on these data, and per hour machinery cost data by Daugherty and Wade (1991). To estimate costs for a grower, we assumed six-row equipment would be used where possible.

We measured lint yields by picking the center four rows of each plot with a spindle picker and dumping into a trailer on scales.

The following presents the sequence of tillage operations used to plow down cotton and prepare a new seedbed for each system:

Conventional:

1. Shred stalks.
2. Disk parallel to the rows.
3. Subsoil on a diagonal to the rows at 18-inches deep with shanks spaced 40-inches apart.
4. Disk on the other diagonal.
5. Apply herbicide and incorporate by disking.
6. List.
7. Pre-irrigate.
8. Mulch the seedbed with a power mulcher.

Uprooter-Shredder-Mulcher (USM):

The main implement used in this system is the Uprooter-Shredder-Mulcher (USM). It was developed by S. Ben-Dor Automotive Industries Ltd. of Israel. It is a two-row machine which uses sweeps to cut the tap roots about 6-inches below the soil line, then counter-rotating wheels grip and uproot the stalks. The stalks are fed into a shear bar chopper, and then discharged down a chute behind an opener which passes along the furrow between the two cotton rows.

The sequence of operations is as follows, except that in two of the years we had to re-list the plots.

1. Uproot, shred, and bury the stalks with the USM.
2. Rip/List (subsoil down the centerlines of the beds at 18-inches deep).
3. Pre-irrigate.
4. Mulch the seedbed with a power mulcher (herbicide applied at the same time).

Sundance:

This system was developed by Sundance Farms of Coolidge, AZ for tilling cotton with subsurface trickle irrigation. The subsurface trickle irrigation laterals are left in place for several years, hence the beds and furrows must be maintained from season to season. This requires a tillage system which will meet Arizona's plowdown requirements without destroying the irrigation system. The unique implement used in this system is the uprooter, which uses two converging disk blades per row to grip and lift the tap roots out of the soil.

There are two ways to utilize the uprooter. One method is to adjust the implement so that it completely pulls the roots out of the soil. A disadvantage to this is that the long tap roots can interfere with planting and cultivation later on. A second method of using the uprooter is to adjust the machine so that it lifts the roots free from the soil and leaves them standing upright. Then another pass with a stalk shredder cuts the roots below the first node, ensuring that they can't regrow and reduces the size of the residue. We have used both methods.

The sequence of operations for this system is as follows, except that in two of the years we had to re-list the plots.

1. Shred stalks.
2. Uproot with the Sundance uprooter.
3. Shred stalks again to reduce the size of the taproot (we skipped this in two of the years).
4. Rip/List (subsoil down the centerlines of the beds at 18-inches deep).
5. Pre-irrigate.
6. Mulch the seedbed with a power mulcher (herbicide applied at the same time).

Results and Discussion

Energy Requirements:

The mean energy requirements for each field operation, and total average energy use are presented in Table 1.

Energy requirements varied relatively little from year to year, with the majority of the differences due to operating the equipment at slightly different field speeds or depths. On average, the energy required by the USM and Sundance systems was 74 and 52 percent, respectively, of that required by the conventional system. The USM operation itself required the greatest energy of any single operation, with ripping in the conventional system being second.

Field Work Times:

A major concern of Arizona cotton growers is to comply with the legal plowdown deadlines. To meet the deadline with a conventional tillage system requires 1.20 hours of tractor work per acre (Table 2). The USM will meet the legal requirement with 0.50 hours of tractor work per acre, and the Sundance system requires 0.76 hours per acre.

The total hours of tractor work per acre to plow down the cotton and prepare a new seedbed with the USM or Sundance systems is about one-half that required with conventional tillage (Table 2).

Costs:

We calculated the per acre operating costs of each system, assuming that six-row equipment would be used where possible (Table 3). The conventional system costs $64.63 per acre, the USM system costs $56.42 per acre, and the Sundance system costs $40.35 per acre.

Lint Yields:

We never measured a significantly lower lint yield with either of the reduced tillage systems, relative to conventional tillage (Table 4). Overall yields in the study have been lower than the county average due to problems unrelated to tillage; namely a devastating infestation of lygus and pink bollworm in 1990, a hailstorm in 1992, and verticillium wilt in all years.

Conclusions

Both of the reduced tillage systems offer significant energy savings over conventional tillage. The total tractor work time required for either reduced tillage systems is about one-half that of conventional tillage. Costs are also lower than with conventional tillage. We never measured a significantly lower lint yield with either of the reduced tillage systems, relative to conventional tillage.

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Table 1. Tillage energy requirements of conventional, USM, and Sundance tillage systems.

Conventional		**USM**		**Sundance**	
Operation	Energy (average HpHr/Ac)	Operation	Energy (average HpHr/Ac)	Operation	Energy (average HpHr/Ac)
Shred	5.2	USM	22.6	Shred 1	4.3
Disk 1	6.8	Rip/List	9.6	Uproot	3.2
Rip	19.9	Relist	2.7	Shred 2	1.6
Disk 2	6.2	Mulch	5.6	Rip/List	11.0
Disk 3	6.2			Relist	2.9
List	4.5			Mulch	5.2
Mulch	5.6				
Total Average 1987-'92 Energy Use (HpHr/Ac)					
54.4		40.5		28.2	
Percent Energy Use of Conventional					
100		74		52	

Table 2. Field work time requirements to meet Arizona plowdown compliance and to prepare a new seedbed with conventional, USM, and Sundance tillage systems.

CONVENTIONAL Operation	Hours per Acre	USM Operation	Hours per Acre	SUNDANCE Operation	Hours per Acre
Shred Stalks	0.20	USM	0.50	Shred Stalks	0.20
Disk	0.25			Uproot	0.11
Rip	0.50			Reshred Roots	0.20
Disk	0.25			Rip/List	0.25
Subtotal	1.20	Subtotal	0.50	Subtotal	0.76
PLOWDOWN COMPLIANCE					
Disk	0.25	Rip/List	0.25	Mulch	0.33
List	0.20	Mulch	0.33		
Mulch	0.33				
TOTAL	1.98	TOTAL	1.08	TOTAL	1.09

Table 3. Per acre operating costs of conventional, USM, and Sundance tillage systems.

CONVENTIONAL Operation	Dollars per Acre	USM Operation	Dollars per Acre	SUNDANCE Operation	Dollars per Acre
Shred Stalks	6.18	USM	31.97	Shred Stalks	6.18
Disk	8.14	Rip/List	13.81	Uproot	3.54
Rip	16.67	Mulch	10.64	Reshred Roots	6.18
Disk	8.14			Rip/List	13.81
Disk	8.14			Mulch	10.64
List	6.72				
Mulch	10.64				
TOTAL	64.63	TOTAL	56.42	TOTAL	40.35
Savings Over Conventional			8.21		24.28

Table 4. Lint yields with Sundance, USM, and conventional tillage systems.

Tillage System	Lint Yield, lbs/Ac 1988	1989	1990	1992	Average
Sundance	891 a*	970 a*	423 a*	651 a*	734
USM	735 a	1030 a	367 ab	623 a	689
Conventional	782 a	929 a	325 b	627 a	666

*Means followed by the same letter within a column are not significantly different at the 95% confidence level.