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DRYLAND CROPPING SYSTEMS TO ENHANCE SOIL MOISTURE CAPTURE AND WATER-USE EFFICIENCY IN COTTON

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Abstract

Rainfall is the most limiting factor in dryland cotton production in the Texas Rolling Plains. Cropping systems that enhance rainfall capture and storage during the season offer the most promise for increased dryland cotton yield. This project was initiated in 2001 to study cropping systems that offer a means to capture limited rainfall other than furrow-diking and at the same time offer seedling cotton protection from blowing sand. This research (in its second year) was conducted at the Chillicothe Research Station on a Abilene clay loam. The objectives were to (1) compare rainfall capture and soil moisture profiles in five cropping systems that include conventional tillage, reduced-till, reduced-till with dikes, strip-till with interseeded rye, and no-till with interseeded rye, (2) determine the effects of different cropping systems on plant yield response and lint quality, and (3) develop educational programs to disseminate information obtained from this research.

The test contained three replications of each cropping system. In the strip-till and no-till plots, two rows of rye (7.5-inch spacing) were planted each fall between the future cotton rows. Rye was terminated at 50% heading the following April with Roundup Ultra. Paymaster 2280 RR/BG was planted mid-May of each year at 4 seeds per foot of row on 40-inch rows. Shortly after emergence soil moisture probes were placed at 1-foot and 3-foot depths within plots to determine soil moisture extraction profiles over the season. Soil moisture readings were taken weekly until cotton matured. A runoff collection system was installed mid-May to collect rainfall runoff from three systems: conventional, strip-till with inter-seeded rye, and reduced-till with furrow dikes. Sediment load in the runoff was also determined.

The 2001 growing season was extremely dry and hot, whereas the 2002 growing season was more normal with respect to rainfall amount and temperature. Dryland yields in 2002 were nearly double those of 2001. In 2001, the furrow-diked and the strip-tilled with rye systems were numerically the last to dry out at the 3-ft depth. In 2002, the no-till with rye, strip-till with rye, and furrow-diked systems contained more soil moisture at the 3-ft depth at the end of the growing season than the conventional-till and reduced-till systems.

Surface water runoff was recorded following each rainfall event that produced runoff. No rainfall event in either year resulted in substantial runoff. Nevertheless, there were differences in runoff amounts even though not all differences were significant. The conventional-till system resulted in the greatest amount of runoff and sediment displacement. In 2002, the strip-till with interseeded rye resulted in the least runoff and greatest reduction in sediment load. This system appeared to be even superior to the diked system. The runoff results are encouraging in that the strip-till with rye system approached, and may exceed, that of furrow-diking with respect to rainfall capture.

Lint yields were not significantly affected by any system. This is encouraging as the strip-till with rye and no-till with rye systems require fewer field operations than conventional or diked systems and may result in greater economic returns while providing seedling protection from wind as well as conservation of soil resources.

Introduction

Dryland cotton production (nearly 400,000 acres) in the Rolling Plains means low input and marginal returns compared with other cotton production regions of the state. Producers are dependent on subsoil moisture going into the cropping season and seasonal rainfall. Since rainfall is sporadic and limited, any cropping system that captures rainfall offers cotton producers a means to increase cotton yields and improve profitability. Previous studies from the Vernon Research Center (Clark, et. al, 1991 and 1996) have shown that furrow-diking and reduced tillage offered a means to capture rainfall and increase lint yield. Generally, this resulted in economic yield increases up to 21% over conventional tillage. Clark and Barnett (1995) recognized that a furrow-diked system did not, however, provide a satisfactory means of reducing crusting and blowing soil. They used cover crops in an attempt to protect cotton seedlings and compared results to continuous cotton in a reduced-tillage system with furrow-diking. Their results showed that terminated Austrian winter pea and wheat cover crops did not result in a significant yield increase over continuous cotton in a reduced system with furrow-diking. Water-use efficiency also was not altered. The authors indicated that wheat was allowed to grow too long before it was terminated. Perhaps late-terminated wheat extracted too much moisture prior to planting cotton.

Although furrow-diking has the potential to reduce runoff and subsequent soil erosion, furrow-diking has never been widely adopted by producers for a number of reasons: (1) new equipment had to be purchased, (2) the equipment would not hold up and needed constant repair, (3) putting in dikes slowed field preparation operations, (4) the dikes had to be plowed out and re-established after cultivating and spraying, (5) dikes had to be removed prior to harvest, and (6) crusting and wind erosion were still present.. Although furrowing-diking resulted in increased yields, producers did not make the investment in equipment, time, and labor. With the advent of transgenic crops and new tillage equipment, new and/or novel production systems may offer producers a means to efficiently capture rainfall while protecting the soil from erosion by water and wind as well as cotton seedlings from blowing sand. The goal is to identify a cropping system that will equal or exceed lint yield observed in a furrow-diked system but without the drawbacks of furrow-diking. Specific objectives include: (1) compare rainfall capture and soil moisture profiles in cropping systems that include furrow-diking, conventional tillage, minimum-till, no-till with interseeded rye, and strip-till with interseeded rye that is terminated prior to cotton planting, (2) determine the effects of different cropping systems on plant response and yield parameters in each of the above systems, and (3) develop educational programs to disseminate information obtained from this research.

Materials and Methods

The study was conducted at the Chillicothe Research Station on an Abilene clay loam. Paymaster 2280BG/RR was planted in May of both years at 4 seeds per foot of row. Plots consisted of eight rows wide and 310-feet long. Row width was 40 inches. Five cropping systems were arranged in a randomized complete design with three replications. Rainfall runoff was determined from one of the two middle rows of conventional, strip-tilled with interseeded rye, and furrow-diked systems. Runoff was limited to 50 feet of row so as not to overwhelm the collection system during heavy rainfall events.

The runoff collection system is shown in Figure 1. Runoff is directed into a sunken collection tube fitted with a sump pump and float switch. Runoff water is pumped into a 2-foot -high by 6-foot-diameter stock tank. Water level depth is measured and volume of water calculated. Runoff is then converted into gallons per acre. Tank water is thoroughly stirred to suspend solids and a water sample taken for sediment analysis.

Gypsum blocks (Irrometer Co., Inc., Riverside CA) were used to measure soil moisture at the 1-foot and 3-foot depths, and data were taken weekly. Two center rows were machine harvested in October for lint yield. Data were subjected to analysis of variance and means separated using protected LSD (P=0.10). Table 1 provides additional experimental design information in an abbreviated form.

Results and Discussion

Figure 2 visually shows the degree of soil erosion among three tillage systems. Conventional tillage results in the greatest amount of soil movement. No attempt was made to quantify this soil displacement.

Figure 3 shows seasonal soil moisture profiles in all tillage systems at the 1-foot for 2001 and 2002. Virtually all soil moisture was extracted in the top foot of soil by mid-July in 2001 and by August 15 in 2002.

Figure 4 shows seasonal moisture profiles at the 3-foot depth for 2001 and 2002. There were few significant differences among tillage systems in 2001 due to extreme drought. In 2002, differences in soil moisture were much more apparent among tillage treatments with the no-till and strip-till systems resulting in numerically more moisture late in the season. Numerically, both systems that included rye had more stored soil moisture at the 3-foot depth than the other systems by late August.

Table 2 shows runoff data from three tillage systems. Only two rainfall periods provided runoff in 2001. No rainfall event in June, July, or August resulted in runoff in 2001. Nevertheless, furrow diking reduced total runoff by 60% and strip-till with interseeded rye reduced seasonal runoff by 40%. Even though 8.66 inches of rain were received from May through September in 2002, this was still 40% below the 20-year average of 14.65 inches for the same period. The runoff results are encouraging in that the strip-tilled system approached, and may exceed, that of furrow-diking with respect to rainfall capture.

Figure 5 shows lint yields for 2000 and 2001. Yields in 2001 were well below average due to extreme drought. By contrast, lint yields in 2002 were more normal, averaging about 280 lbs/acre.

No dryland cropping system resulted in significant yield differences over conventional tillage in either year. However, this is encouraging as the no-till and strip-till systems with rye require fewer field operations than conventional or diked systems and may result in greater net economic returns while providing seedling protection from wind as well as conservation of soil resources. Furthermore, these systems are more likely to be adopted by producers than diking systems to capture rainfall.

References

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Clark, L. E., H. T. Wiedemann, C. J. Gerard, and J. R. Martin. 1991. A Reduced Tillage System with Furrow Diking for Cottton Production. Soil Sci. Soc. Am. J. 34:1597-1603.

Table 1. Agronomic information for dryland cropping systems at Chillicothe, Tx during the 2001 and 2002 growing seasons**.**

	2001	2002
Planting Date		
Bates Rye	Nov. 15; 90 lb/ac; 2 rows / furrow	Nov. 27; 90 lb/ac; 2 rows / furrow
Paymaster 2280 BtRR	May 9; 4 plants/ft	May 13; 4 plants/ft
Fertilizer Date		
65-30-0	Mar. 23	June 20
Herbicide Date		
	Mar 23; Prowl 2.4 pts/ac 3.3 EC	Mar 27; Prowl 2.4 pts/ac 3.3 EC
	Apr. 9; 1 qt/ac Roundup Ultra for rye	Apr. 17; 1 qt/ac Roundup Ultra for rye
	May 25; 0.6 oz Staple	June 10; 0.6 oz Staple
	with 1 qt/ac Roundup Ultra	with 1 qt/ac Roundup Ultra
Harvest Date		
	Oct. 9	Sep. 24

Table 2. Surface water runoff and sediment from three tillage systems, Chillicothe, Texas during the 2001 and 2002 growing seasons.

	Tillage System				
Year	**Conventional**	**Strip-till**	**Reduced-till with dikes**	**Prob (F)**	**Total Rainfall (in)**
	----------------Runoff (gal/ac)----------------				
2001	12173	4603	6985	$P<0.01$	3.48
2002	16629	9238	6151	$P=0.33$	8.66
	--------------Sediment (lb/acre)--------------				
2001	1431	284	227	$P<0.01$	3.48
2002	876	507	97	$P=0.40$	8.66

Figure 1. Runoff collection system. Runoff is channeled into a sunken tube from approximately 50 feet of row and pumped into a 6-foot diameter stock tank.

Figure 2. Visual comparison of soil erosion differences among three tillage systems: strip-till interseeded (left), conventional-till (center), furrow-diked (right).

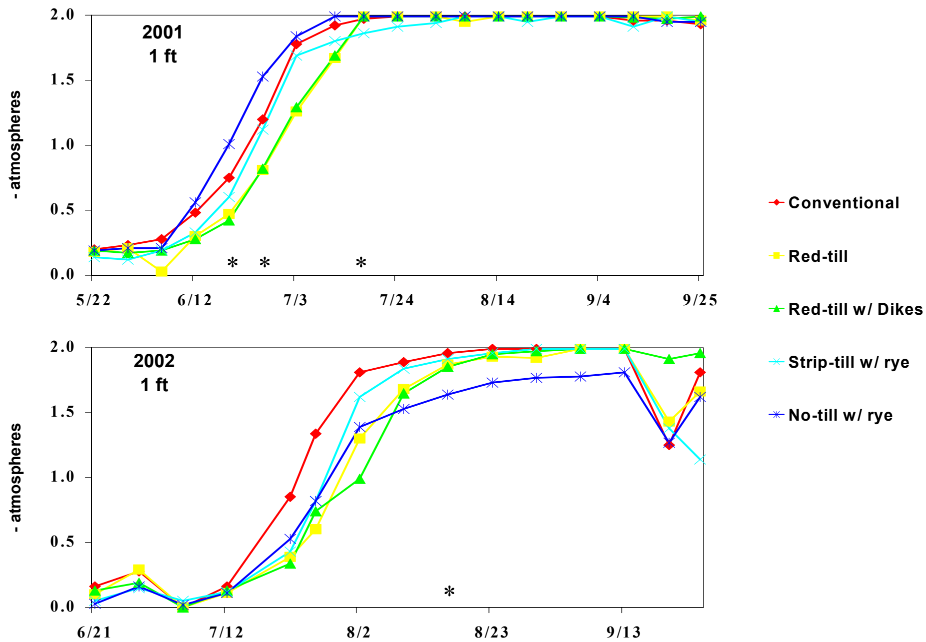

Figure 3. 2001 and 2002 seasonal soil moisture profile at the 1-foot depth. A reading of -2 indicates most available soil moisture has been extracted. * Signifies weeks where soil moisture significantly differed between tillage types (*P*<0.05).

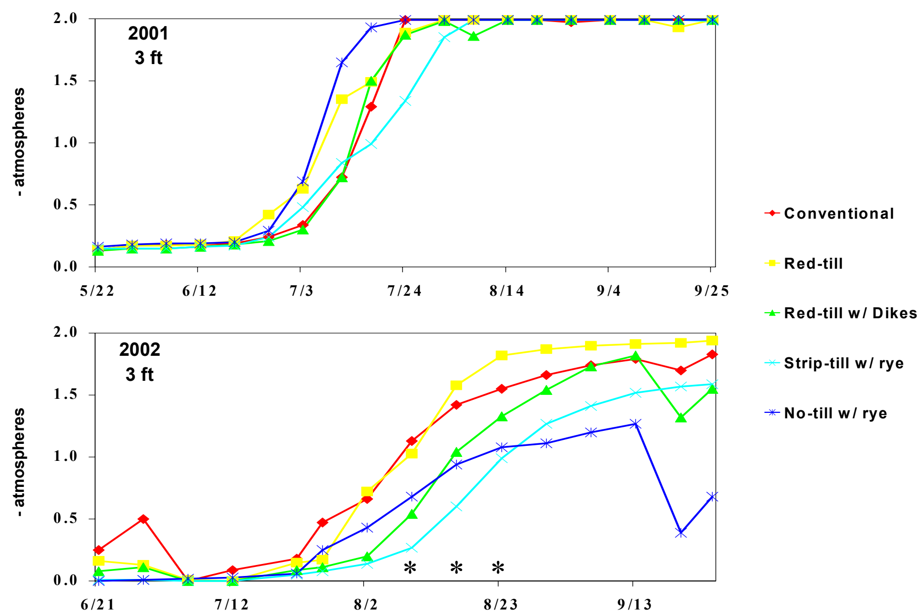

Figure 4. 2001 and 2002 seasonal soil moisture profile at the 3-foot depth. A reading of -2 indicates most available soil moisture has been extracted. * Signifies weeks where soil moisture significantly differed between tillage types (*P*<0.05).

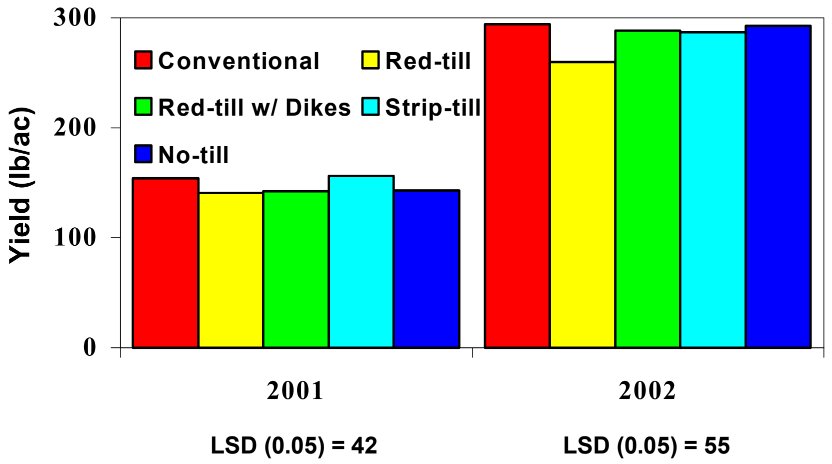

Figure 5. Cotton lint yields from five tillage systems.