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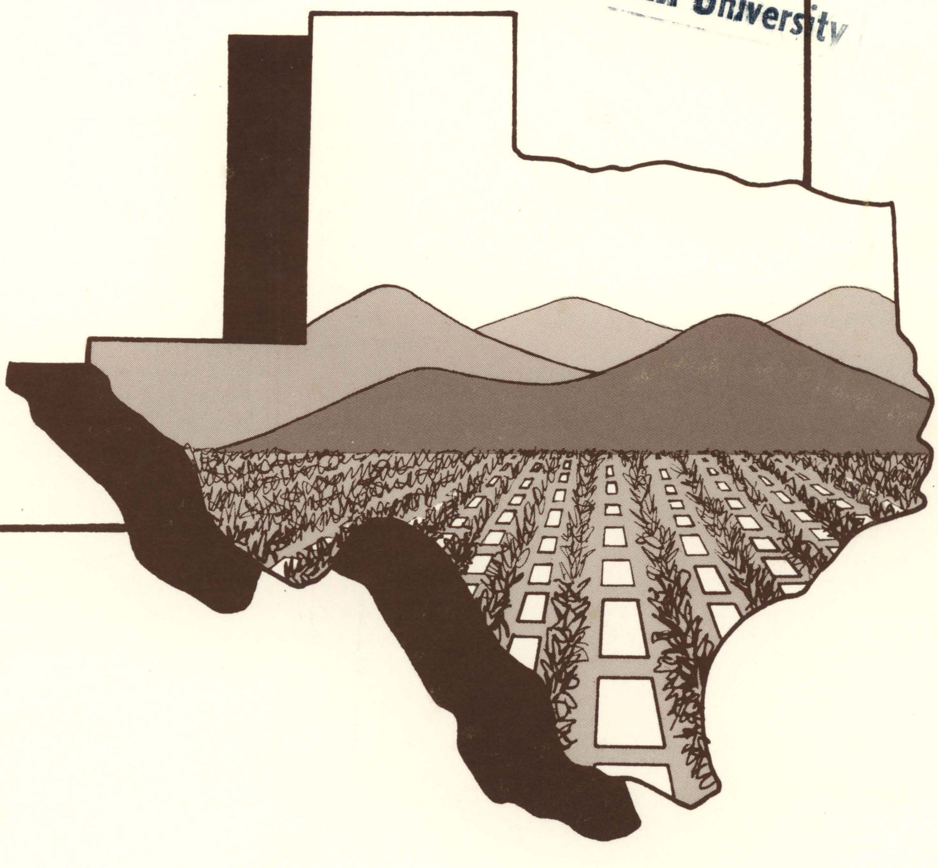
Furrow Diking and Subsoiling Studies in the Rolling Plains



THE TEXAS AGRICULTURAL EXPERIMENT STATION/Neville P. Clarke, Director/The Texas A&M University System/College Station, Texas

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Furrow Diking and Subsoiling Studies in the Rolling Plains[1]

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Introduction

Research has demonstrated that water is the dominant factor for yields in the Rolling Plains of Texas (5). This area is plagued by periods of drought during the growing season. The soils in the Rolling Plains are low in organic matter and have a weak or fragile structure that contributes to significant loss of water and soil following even moderate rainfall. Furrow diking or basin tillage is the practice of putting small dams in the furrow to obstruct water flow, reduce runoff, and increase moisture storage for crop production. The idea of furrow diking or basin tillage is not recent. Luebs (12) reported on research with furrow dikes at Hays, Kansas, between 1937 and 1953. He stated that holding rain with dikes on nearly level land appeared to have merit for increasing yields, particularly for continuous sorghum.

In the High Plains of Texas, Bilbro and Hudspeth (1), Hudspeth (10), and Lyle and Dixon (13) used basin tillage or diking to reduce runoff and increase cotton yields. Similarly, Jones and Clark (11) reported that diking conserved water and increased sorghum yields. Gerard et al. (7) found that diking every 50 ft in the furrow increased sorghum yields by 11 percent to 17 percent in 1979 in the Rolling Plains of Texas. Furrow diking increased cotton yields by about 35 percent in the Rolling Plains in 1981, according to Clark (4) and Gerard et al. (6). Diking alternate rows increased cotton yields from 10.5 percent to 15 percent, according to Bordovsky (2) and Gerard et al. (8).

Gerard et al. (8) summarized studies on sorghum and cotton in 1981 and 1982. They noted that furrow dikes seem to be effective in reducing runoff and increasing moisture storage on gently sloping land, and that position on the slope has an important effect on yields. Hanna et al. (9) found that in Nebraska, landscape position on the slope can influence the amount of water retained by soils for dryland crop production. To evaluate the effectiveness of diking in capturing rainfall or reducing runoff, according to Gerard et al. (8), it is necessary that response be measured on a substantial part of the slope. For example, in these studies, diking increased sorghum yields an average of 302 percent, 140 percent, and 42 percent more than the check treatments on the upper, middle, and lower parts of the slope, respectively, and diked cotton produced 57 percent, 37 percent, and 12 percent more than the check on the upper, middle, and lower parts of the slope, respectively.

This publication summarizes furrow diking and subsoiling studies on sorghum during 1979-85, and cotton during 1980-82 and 1984-85 in the Rolling Plains.

Methods and Materials

Sorghum

The effects of subsoiling and diking on yields of sorghum were evaluated from 1979 to 1985 at the Texas A&M Research Center at Chillicothe-Vernon. Rainfall data during 1979-1985 are reported in Table 1. This experiment, conducted on an Abilene loam soil, was a randomized block design with three replications. Moisture retention curve for the Abilene soil is shown in Figure 1. Selected properties of this soil are reported in Table 2. All treatments described in Table 3 were 12 rows 200 ft long. The locations of all treatments were the same throughout the experiment. The slope of the field down the rows ranged from 0.1 percent on the lower half to 0.4 percent in the upper half. The lower 50 ft of the field had a low place that tended during significant rainfall to accumulate water from the upper side of the field. The entire field except the lower part was bordered to intercept runoff water from adjacent fields and keep it out of the experimental area.

To test the feasibility of diking, dikes were installed by hand 50 ft apart in 1979 (Table 3). In 1980, dikes were installed with dikers manufactured in Lockney, Texas. These were mounted behind lister sweeps and adjusted to establish dikes about 4- to 6-in. high on 4- or 8-ft intervals in the furrows. The tripping mechanism that determined intervals between dikes was a 3-ft-diameter wheel. In 1981, dikers were modified to trip by means of a hydraulic motor-driven mechanism described by Lyle and Dixon (13). This replaced the 3-ft-diameter wheel used in 1980 and provided more uniform diking intervals. Removing the wheel shortened the dikers by about 3 ft, which allowed easier handling of less weight. As noted in Table 3, a diking interval of 6 ft in the furrow was used from 1981 to 1985.

Treatment 2 was a check treatment in 1979 (Table 3). In 1980, this treatment was changed to evaluate diking interval (8 ft apart), and from 1981 to 1985 it was changed to evaluate diking alternate middles (half-diked).

Typical cultural operations for all treatments including the check or conventional-tilled sorghum consisted of the following: (1) bedding and applying 1.2 lbs/A of propazine in early spring; (2) rod weeding if needed in April and/or early June; (3) fertilizing land with 40 to 60 lbs of N/A and 20 to 25 lbs of P/A; (4) planting and applying 1.2 lbs/A of propazine in late June or early July, and (5) cultivating for reshaping beds and controlling weeds in late July. Pioneer 8501 sorghum hybrid was planted on dates given in Table 4 at a rate of about 3 seeds/ft of row (3 lbs/A). As reported in Table 4, diked and subsoiling operations for specific treatments in Table 3 were done on indicated dates and years. Dikes were installed, sometimes in conjunction with bedding or cultivation on treatments 2, 4, and 5, at the time of bedding and herbicide applications in early spring and again after stand establishment in July or August (Table 4). Subsoiling in treatments 3 and 5 was usually done when land was bedded. After the sorghum was harvested, stubble remained standing until land was bedded and diked in early spring. During this fallow period dikes, even though reduced in size, were still functional on appropriate treatments.

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TABLE 1. RAINFALL DATA FROM 1979 TO 1985 AT CHILLICOTHE, TEXAS

Months	1979	1980	1981	1982	1983	1984	1985
				inches			
January	1.49	2.14	0.04	1.24	2.47	0.09	0.33
February	0.43	0.71	0.80	0.34	0.22	0.75	1.77
March	2.37	0.42	1.55	2.17	2.25	1.94	2.71
April	2.10	0.72	3.19	1.53	1.56	0.88	1.93
May	6.23	7.43	5.20	7.82	4.49	0.91	2.51
June	4.16	1.17	3.87	4.20	3.51	1.15	8.31
July	3.03	0.00	0.69	2.66	1.43	1.58	2.02
August	5.31	0.44	0.83	3.11	0.23	1.96	2.56
September	0.01	2.42	0.74	1.99	0.59	0.23	2.73
October	1.97	0.78	2.28	0.11	13.74	6.29	5.35
November	1.36	0.60	0.66	1.87	1.76	2.23	1.36
December	1.21	1.18	0.28	1.12	0.61	4.30	1.95
Total	29.67	18.01	20.13	28.16	32.86	22.31	33.53

TABLE 2. THE pH, PERCENT ORGANIC MATTER, AND PARTICLE SIZE DISTRIBUTION OF ABILENE LOAM AND MILES FINE SANDY LOAM

	Soils									
	Abilene loam					Miles fine sandy loam				
Soil depth (inches)	pH	organic matter	sand	silt	clay	pH	organic matter	sand	silt	clay
		%					%			
0-6	7.1	0.88	47	36	17	6.1	0.40	70	21	9
6-12	7.2	0.87	47	36	17	6.1	0.41	72	18	10

TABLE 3. DESCRIPTION OF TILLAGE TREATMENTS ON SORGHUM IN 1979, 1980, AND 1981-85.

Treatment*	Description of treatments
	1979
1. Check	Conventional
2. Check	Conventional
3. Subsoiled**	Land was subsoiled 16 in. below beds and furrows
4. Diked	Rows were diked 50 ft apart
5. Subsoiled and diked	Rows were subsoiled and diked as described under treatments 3 and 4
	1980
1. Check	Conventional
2. Diked	Rows were diked 8 ft apart
3. Subsoiled**	Land was subsoiled 16 in. below beds and furrows
4. Diked	Rows were diked 4 ft apart
5. Subsoiled and diked	Rows were subsoiled and diked as described under treatments 3 and 4
	1981-1985
1. Check	Conventional
2. Half-diked	Diked every other row about 6 ft apart
3. Subsoiled**	Subsoiled 16 in. below beds and furrows
4. Diked	Rows were diked 6 ft apart
5. Subsoiled and diked	Rows were subsoiled and diked as described under treatments 3 and 4

*Treatments were 12 rows wide and about 200 ft long and replicated three times.

**Time of subsoiling operation is given in Table 4.

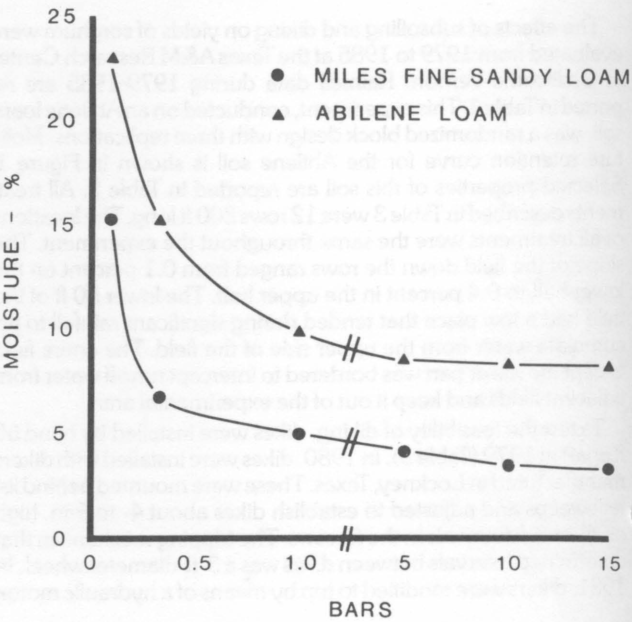

Figure 1. Moisture retention curves for Miles fine sandy loam and Abilene loam soils.

Soil moisture of the top foot was determined gravimetrically; soil moisture at 1 to 4 or 5 ft at 6-in. increments was determined using neutron scattering techniques. Moisture in top foot and neutron readings were converted to inches. In 1979, moisture use was determined about 75 ft from the upper part of the slope. From 1980 to 1985, moisture use was measured on the upper, middle, and lower parts of slope. Distances of neutron access pipes with respect to slope for monitoring soil moisture were about 30, 90, and 150 ft down the slope for upper, middle, and lower parts of slope, respectively.

Yield determinations were made by combine-harvesting three center rows. Fifty feet were harvested from each section of the slope in 1979, and 60 ft were harvested in remaining years. Grain yields were corrected to 13 percent moisture. Yield data were subjected to appropriate analysis of variance as explained in a previous publication (8).

Soil particle size distribution shown in Table 2 was determined by the hydrometer method (3). Organic matter was determined according to the method described by Walkley (14). Strength of soil as affected by subsoiling furrows and beds was evaluated using a recording soil penetrometer. The penetrometer, which is about 0.5-in. diameter with a 60° cone-shaped tip, is mounted on a 300- or 500-lb force transducer with an output of ± 5V. The shaft behind the tip is about 0.4 in. in diameter. The output from the transducer was a linear function of mechanical resistance of the soil. Strength measurements were made at 2-in. depth increments to a depth of 20–22 in., and data were recorded with a Omnidata polycorder. The output was converted to mechanical impedance in bars (0.99 atmosphere or 14.5 lbs/in.^{2}). Runoff from the check, half-diked, and diked treatments was measured in 1985 using level stage recorders.

Cotton

The effects of subsoiling and furrow diking on cotton yields were evaluated in 1980-82, 1984, and 1985. Cotton failed to emerge to satisfactory stands in 1983. Because it was too late to replant cotton, mungbeans were planted on the site but failed to produce marketable yields. Chemical and physical properties of this Miles fine sandy loam are given in Table 2. Water retention characteristic of this soil is shown in Figure 1. This deep and uniformly coarse-textured soil frequently develops compacted zones that severely restrict water infiltration and root growth. The test site is in a flat area between two parallel terraces. The slope down the row is 0.1 percent to 0.2 percent. Tillage treatments that remained at the same location during 1980-85 are described in Table 5. Plot included eight 40-in. rows, 650–750 ft long. Treatments were randomized in three complete blocks.

Typical cultural operations for all treatments including the check or conventional-tilled cotton were as follows: (1) shredding stalks, bedding, and applying 1½ pt/A of Treflan in early spring; (2) fertilizing with 20 to 40 lbs/A of N, cultivating, and planting in late May or early June; (3) cultivating or reshaping beds after stand establishment, and (4) if needed, cultivating for weed control in July. Diking and subsoiling operations for specific treatments were done on indicated dates and years (Table 6). Dikes were installed, sometimes in conjunction with bedding or cultivation on treatments 2, 3, and 4, at time of bedding in early spring and again after stand establishment in June or July (Table 6). Subsoiling of land in treatment 2 was done at time of early bedding.

Dates of main cultural operations are given in Table 6. Bedding and diking as reported in Table 6 were performed before spring rains. Rainfall at the site is reported in Table 7.

In 1980, Tamcot SP-37 was planted at a rate of about 4 seeds/ft (12 lbs/A), and from 1981 to 1985 a similar variety, G&P3774, was planted in these experiments. Cotton was harvested with a two-row brush stripper. The effects of slope and treatments were measured by harvesting 100-ft sections of two rows in the upper,

TABLE 4. DATES OF CULTURAL OPERATIONS FOR SORGHUM

Years	Diking	Subsoiling	Planting
1979	Mar. 9*-July 1**	Mar. 8***	June 21
1980	Apr. 8*-July 18**	—	June 18
1981	Jan. 28*-Aug. 3**	—	July 6
1982	Jan. 16*-July 26**	Nov. 15, 1981***	June 28
1983	Apr. 18*-July 25**	—	June 27
1984	Feb. 1*-Aug. 7**	Feb. 1****	July 5
1985	May 7*-July 3**	—	June 25

*Appropriate treatments were diked before planting and undiked at planting.

**Appropriate treatments were rediked after stand establishment.

***Beds and furrows were deep-plowed 14–16 in.

****Furrows were deep-plowed 14–16 in.

TABLE 5. DESCRIPTION OF TILLAGE TREATMENTS FOR COTTON ON MILES FINE SANDY LOAM IN 1980, 1981, 1982, 1984, AND 1985

Treatment	Description of treatments
1. Check	Conventional
2. Half-diked	Diked every other row about 6 ft apart
3. Diked	Diked every row about 6 ft apart
4. Subsoiled and diked	Diked every row as in treatment 3 and subsoiled furrows 14 in. deep

TABLE 6. DATES OF MAJOR CULTURAL OPERATIONS FOR COTTON

Years	Diking	Subsoiling	Planting
1980	Apr. 15*-July 14**	Apr. 15***	June 5
1981	Mar. 24*-July 22**	Mar. 23***	June 24
1982	Jan. 25*-July 27**	Jan. 25****	June 16
1984	Feb. 6*-June 14**	Feb. 6***	May 25
1985	Apr. 10*-June 17**	—	May 30

*Appropriate treatments were diked before planting and undiked at planting.

**Appropriate treatments were rediked after stand establishment.

***Furrows were deep-plowed 14–16 in.

****Beds and furrows were deep-plowed 14–16 in.

TABLE 7. RAINFALL DURING 1980-82 AND 1984-85 AT VERNON

Months	1980	1981	1982	1984	1985
			inches		
January	—*	0.05	1.33	0.10	0.28
February	—*	0.83	0.25	0.88	2.10
March	—*	1.34	1.66	2.33	6.82
April	1.00	2.45	1.70	0.95	4.05
May	3.52	4.97	8.94	1.55	1.54
June	1.70	4.73	4.18	0.43	5.57
July	0.00	1.73	2.46	0.74	0.05
August	1.15	3.03	1.47	1.95	2.54
September	2.06	1.40	0.77	0.52	3.11
October	0.28	3.21	0.14	3.25	5.80
November	0.76	0.44	2.31	3.01	0.81
December	1.35	—*	1.04	4.72	0.07
Total	11.82	24.18	26.25	20.43	32.74

*Rainfall not recorded.

middle, and lower parts of the slope. Fiber quality analyses for each harvested plot were determined in 1981, 1982, and 1984. Analyses of variance of yield data by location on slope and total yields were performed as outlined in a previous publication (8).

Runoff on undiked and half-diked treatments was measured in 1985 with level stage recorders.

The effect of subsoiling was measured using a recording soil penetrometer as previously described. Average soil strength was calculated at intervals of 2 in. to a depth of 22 in. The effects of time and moisture on changes in strength were evaluated. Implications of these results on root growth and moisture use are discussed.

Results and Discussion

Sorghum

Yields of sorghum grown under different tillage practices in 1979 are reported in Table 8. High rainfall from May through August (Table 1) was responsible for high yields in 1979 that ranged from about 2,900 to almost 5,400 lbs/A. The average increases due to diking, subsoiling, and diking plus subsoiling ranged from 11 percent to 17 percent. Average yields for diked or subsoiled treatments were about 1,215 to 1,960 lbs/A higher than the check on the upper side of the slope, but there was no difference among the treatments at the lower position of the slope. Even though the handmade dikes were 50 ft apart, their effects were highly significant. Plants close to the dikes on the upper part of the slope (5) were 36 percent taller and appeared more productive than plants 25 to 50 ft from the dikes. These results indicated the need for shorter intervals between dikes and the need for determining plant response and moisture use with respect to location down the slope.

Because of the low yields, sorghum was not harvested with respect to the slope in 1980. Sorghum yields were very low and ranged from 550 to almost 800 lbs/A (Table 9). Low rainfall (Table 1) and high evaporative conditions contributed to the lower grain yields. However, as shown in Table 9, diked sorghum produced about 250 lbs/A or about 35 percent more than the sorghum on the check treatments.

Yields as affected by treatments, position on the slope, and years 1981-1985 are reported in Table 10. As shown in Table 10, yield increases due to diking were very high in 1981 and 1982. In 1981, yields of the diked treatments were four and six times higher than yields of the check and subsoiled treatments on the upper part of the slope (Table 10) and slightly more than two times the average yields of the check and subsoiled treatments. Yields of the diked treatments in 1982 were more than four times the yields of the check on the upper part of the slope and averaged more than two times the average yield of the check treatment.

Results in 1983 indicated diking increased yields an average of 43 percent over the check treatment. Average yields in 1983 were slightly more than 1,000 lbs/A on the check and subsoiled treatments and about 1,450 to 1,620 lbs/A on diked and diked-subsoiled treatments, respectively.

Yield increases caused by diking treatments in 1984 and 1985 as shown in Table 10 were small compared with previous years. The greatest effects of diking in 1984 and 1985 were found on the upper part of the slope.

Average yields for treatments and position on the slope for 1981-1985 are reported in Table 11 and shown in Figure 2. The data presented in Tables 8, 9, and 10 illustrate that diking significantly affected yields every year during 1979-1985. Yields of diked sorghum shown in Table 11 were 88 percent, 48 percent, and 30 percent higher than the yields of the check treatments on the upper, middle, and lower parts of the slope, respectively. Diking increased the average yield of sorghum 50 percent over the check for 1981-1985. Half-diking increased sorghum yields an average of about 62 percent, 21 percent, and 17 percent on the upper, middle, and lower parts of the slope, respectively, and an overall average of 29 percent higher than the average check yield.

The yields of the check in the upper and middle parts of the slope reported in Table 10 and Figure 2 are probably indicative of the expected yields of sorghum on undiked large fields. This assumption is based on the fact that most of the productive land area on large, gently sloping fields would be composed of the upper and middle parts of the slope. The lower part of the slope often includes a drainage ditch or an area that conducts runoff to drainage waterways or to low areas where water accumulates. These areas are often not productive because excessive runoff prevents planting or waterlogging conditions prevent plant growth. However, the sorghum yields from undiked land would probably vary with factors such as soils, location, rainfall, and degree of slope.

The effects of subsoiling on yields varied with years. Yield increases from subsoiling were greatest the same year the tillage operation was performed. Data presented in Table 8 show a marked increase in yields from subsoiling on the upper part of the slope in 1979. Subsoiling significantly increased yields in 1982, but residual effects of subsoiling in prior years, which were measured in 1980, 1981, and 1983, were small or insignifant. The only possible exception was the response of sor-

TABLE 8. EFFECT OF SUBSOILING AND DIKING TREATMENTS OF SORGHUM HYBRID (PIONEER 8501) IN 1979

		Distance down slope in feet									
		0-50		50-100		100-150		150-200		Average	
Treatments		lbs/A	% of diked	lbs/A	% of diked	lbs/A	% of diked	lbs/A	% of diked	lbs/A[4]	% of diked
1,2	Conventional (check)	2939[4]	69	4184a	86	4973a	100	5298a	101	4349a	89
3	Subsoiled[1]	4153	95	5237a	108	5244a	106	5111a	97	4936ab	102
4	Diked[2]	4384	100	4855a	100	4947a	100	5256a	100	4861ab	100
5	Subsoiled and diked	4898	112	4999a	103	5255a	106	5372a	102	5131b	106
	Average[3]	3863c		4692b		5078ab		5267a			

[1]Land was subsoiled 16 in. below the beds and furrows.

[2]Dikes were 50 ft apart (put in manually).

[3]Average values for distance down slope followed by same letter are not significantly different at 5% probability level.

[4]Average yields of treatments 3, 4, and 5 were significantly higher yielding than check at 5% probability level.

TABLE 9. GRAIN YIELDS OF GRAIN SORGHUM HYBRID (PIONEER 8501) UNDER DIFFERENT CULTURAL TREATMENTS OF SUBSOILING AND DIKING IN 1980

Treatments	lbs/A	% of Diked
Conventional (check)	547a[1]	73
Subsoiled[2]	580ab	77
Diked[3]	747ab	99
Diked[4]	751ab	100
Subsoiled and diked[4]	791b	105

[1]Average values for treatment followed by same letter are not significantly different at 5% probability level. Yields from diking were significantly higher yielding than the check and subsoiling treatments at 5% level of probability.

[2]Land was subsoiled 16 in. below furrows and beds in 1979.

[3]Land was machine-diked 8 ft apart.

[4]Land was machine-diked 4 ft apart.

ghum to subsoiling and diking in 1983, which averaged 17 percent more than the yield of diked sorghum (Table 10). As shown in Table 11, average yields from subsoiling were 5 percent, 4 percent, and 22 percent higher than the check on the upper, middle, and lower parts of the slope, respectively. These results suggest that runoff water from the upper and middle parts of the slope was captured on the lower part of the slope. Subsoiling may prove to be most effective on gently sloping land with long rows. Surface sealing during and after rainfall probably reduces effectiveness of subsoiling in capturing rainfall for increased yields.

Regression equations for sorghum yield on rainfall for the check and diked treatments shown in Table 12 indicate the increase in efficiency of rainfall achieved by diking. Total rainfall from April through September accounted for only 18 percent of the variability in yield of the check on the upper part of the slope and 40 percent of the variability of average yield. In contrast, rainfall during the same period accounted for 51 percent and 58 percent of the variability of yield for the diked treatments. Rains during August accounted for 57 percent and 83 percent of the variability of yield of the check on the upper part of the slope and of the average yield. These percentages compare to 89 percent and 91 percent of the variability of yield for the diked treatment. For both periods of rainfall, diking substantially increased the effect of rainfall on yield. The relative low contribution of rainfall to variability of yield on the upper part of the slope for the check can be attributed to high runoff. Diking was particularly effective in increasing the yield response to rainfall on the upper part of the slope as evidenced by the slopes of the regression lines. The contribution of rainfall to variability of yield on diked treatments was similar for yield on the upper part of the slope and the average yield.

Water use for years with no runoff and where runoff was measured in 1985 are reported in Table 13. Previous studies showed that water was the dominant factor for yields in the Rolling Plains (5) (7). High temperatures and lack of timely and adequate rainfall are often responsible for severe stress on growing plants in the Rolling Plains. The severity of this stress in any year determines the amount of water required to produce acceptable yields.

For example, according to regression analyses, 4.5 to 5 in. of water were required before any grain was produced in the dry years of 1977 (5) and 1981 (8). Previous results and data presented in Table 13 indicate that under typical years the diked sorghum produced about 300 lbs of grain/inch of water. The production/inch of water in 1980, an extremely dry year, was only about 100 lbs/in. of water.

Measured runoff in inches from check, half-diked, and diked treatments during the 1985 crop year was 1.64, 0.75, and 0 in., respectively. Factors such as residue cover, soils, antecedent moisture, and tillage affect the surface permeability of soils and runoff.

TABLE 10. SORGHUM GRAIN YIELDS UNDER DIFFERENT TREATMENTS AND LOCATIONS ON THE SLOPE IN 1981-1985

	Position on slope			
Treatments	Upper	Middle	Lower	Average
	1981 lbs/A			
Check	478a*	949a	1681a	1036a
Subsoiled	312a	527a	2499a	1113a
Half-diked	1439b	1778b	2355a	1857b
Diked	1806b	2298bc	2559a	2221b
Subsoiled and diked	1939b	2559c	2234a	2243b
Average	1195	1622	2266	
	1982 lbs/A			
Check	655a	1509a	2817a	1661a
Subsoiled	1282b	2279a	3385a	2315b
Half-diked	2036c	2147a	2916a	2366b
Diked	2747d	3596b	3853a	3399c
Subsoiled and diked	3410e	3715b	3237a	3454c
Average	2026	2649	3242	
	1983 lbs/A			
Check	760a	1112a	1195a	1022a
Subsoiled	587a	900a	1602a	1030a
Half-diked	1002ab	1556a	1847a	1468b
Diked	1103ab	1481a	1778a	1454b
Subsoiled and diked	1347b	1585a	1936a	1623b
Average	960	1327	1672	
	1984 lbs/A			
Check	1549a	2266a	2056a	1957a
Subsoiled	1457a	2500a	2323a	2093a
Half-diked	2423b	2649a	2568a	2547b
Diked	2363b	2682a	2408a	2484b
Subsoiled and diked	2408b	2675a	2380a	2488b
Average	2040	2554	2347	
	1985 lbs/A			
Check	2661**	3342	3202	3068***
Subsoiled	2756	3344	3578	3226
Half-diked	2991	2934	3079	3001
Diked	3479	3555	3646	3560
Subsoiled and diked	3183	3147	3638	3323
Average	3014	3264	3429	

*Values within each location on slope or averages followed by same letter are not significantly different at 5% level according to Duncan's multiple range test.

**Half-diked, diked, and subsoiled-diked treatments significantly higher yielding than check and subsoiled treatments at 0.08 level of probability.

***Diked and subsoiled-diked treatments produced significantly more grain than other treatments (sign = 0.05).

The land in this study has been in sorghum since 1979. The residue from preceding sorghum crops probably reduced the amount of runoff on the check and half-diked treatments.

Penetrometer resistance measurements of the soil profile in 1985 below beds and furrows are shown in Figures 3 and 4, respectively. The beds were deep-plowed in November 1981; however, the effects of deep tillage are still apparent in 1985. There was a greater difference in strength of soil between the check and the subsoiled-diked treatment in the furrows than in the beds, particularly in the zone of 8- to 12-in. depth. This difference likely can be attributed to the furrows having been subsoiled in February 1984 compared to the beds having been subsoiled in November 1981.

Cotton

Cotton yields from various tillage treatments and slope positions are given in Table 14. Yields of cotton, like sorghum, were very low in 1980, which was a year with extremely high summer temperatures and low rainfall. Cotton in the lower parts of the field produced higher yields than cotton on the upper and middle parts of the slope, but yields were not significantly affected by tillage treatments.

Diking significantly increased yields in 1981 and 1982. The diked treatments averaged from 87 to 125 lbs/A of cotton more than the check treatments. Position on the slope significantly affected yields, especially the yields of the check treatments. For example, in 1981 and 1982 average cotton yields of the check treatments on the upper and middle parts of the slope averaged 70 percent and 88 percent, respectively, of the yields of the check on the lower part of the slope. Yields of half-diked cotton were higher in comparison to the check in 1982 than in 1981. Since the tillage treatments were in the same location throughout the experiment, diking could have caused residual effects on soil moisture from one year to the next. Soil moisture profiles of conventional beds are often only partially replenished by late fall and early spring rains. Cotton continues to extract water from the soil profile until the first killing frost, and valuable water also is lost to runoff.

Treatments and locations on the slope did not affect cotton yields in 1984. Yields in 1985 were lower than in 1981, 1982, and 1984, and treatment effects were small but significant. As shown in Table 15, cotton on diked treatments produced about 25 lbs/A more lint than the cotton on the check treatments.

A summary of diking studies on cotton (Table 15 and Figure 5) shows half-diking increased yield about 28 lbs/A and full-diking increased yields almost 50 lbs/A. Diking treatments increased yields by an average of 22 percent, 21 percent, and 11 percent on the upper, middle, and lower parts of the slope, respectively, and an average of 18 percent during the 5 years of investigation. Half-diking increased yields over the check by 10 percent from 1980 to 1985. Factors such as years, percent slope, and soils probably affect the response of cotton to diking. However, diking of the soil at this location with slopes of 0.1 percent to 0.2 percent increased soil moisture storage and yields in 3 of the 5 years. The benefits of diking cotton would probably be greater on soils with steeper slopes. However, the slope of some fields may be such that furrow dikes alone could not effectively prevent runoff and severe erosion.

The effects of treatments on fiber length and micronaire for 1981, 1982, and 1984 are reported in Table 16. The main effect of diking is reduction of drought stress. In dry years such as 1981, diking significantly increased fiber length and micronaire. In 1981, cotton from the diked and diked-subsoiled treatments had a higher grade and was estimated to be worth 4¢/lb more than the cotton from the check (6). Half-diked cotton in 1981 was worth about 2¢/lb more than cotton from the check. As shown in Table 16, the half-diked and diked cotton was about 1/32 in. longer than cotton from the check treatment. These data indicate diking could increase fiber length and micronaire of certain cotton varieties. Estimates of runoff using yield data on this site were made in 1981. The average runoff on the check, half-diked, and diked treatments were estimated at 35 percent, 18 percent, and 0 percent, respectively (6). Water-use estimates for years or treatments free of

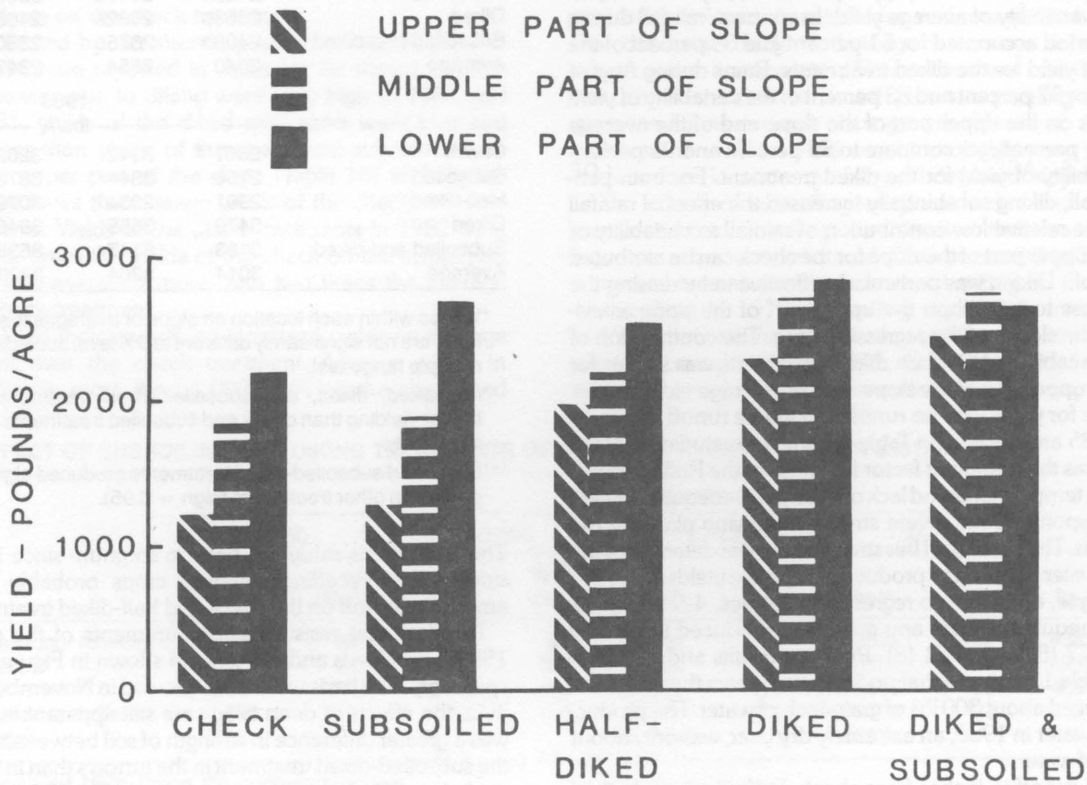

Figure 2. Average sorghum yields under different tillage treatments and parts of slope from 1981 to 1985.

TABLE 11. AVERAGE SORGHUM GRAIN YIELD UNDER DIFFERENT TREATMENTS AND LOCATIONS ON THE SLOPE FOR 1981 THROUGH 1985

	Position on slope			
Treatments	Upper	Middle	Lower	Average
	lbs/A			
Check	1221	1836	2190	1749
Subsoiled	1279	1910	2677	1955
Half-diked	1978	2213	2553	2248
Diked	2300	2722	2849	2624
Subsoiled and diked	2457	2736	2685	2626
Average	1847	2283	2591	2240

TABLE 12. REGRESSION OF SORGHUM YIELD ON RAINFALL FOR CHECK AND DIKED TREATMENTS DURING 1979-85

Treatment	Time of rainfall	Slope position	Equation*	R^2
Check	April–September	upper	$\hat{y} = 331.6 + 72.4x$	0.18
Check	April–September	average**	$\hat{y} = -276.4 + 142.2x$	0.40
Check	August	upper	$\hat{y} = 464.1 + 439.1x$	0.57
Check	August	average**	$\hat{y} = 550.7 + 678.0x$	0.83
Diked	April–September	upper	$\hat{y} = -44.5 + 154.6x$	0.51
Diked	April–September	average**	$\hat{y} = -87.1 + 176.5x$	0.58
Diked	August	upper	$\hat{y} = 980.6 + 676.5x$	0.89
Diked	August	average**	$\hat{y} = 1162.0 + 734.1x$	0.91

*$\hat{y}$ is estimated yields in lbs/A; x refers to rainfall in inches.

**Average yield refers to an average for upper, middle, and lower parts of slope.

TABLE 13. AVERAGE WATER USE AND GRAIN YIELD/INCH OF WATER FROM 1979-1985*

Treatment	1980 water use	Grain lbs/in. of H_2O
Check	6.5	84
Subsoiled	7.3	80
Diked	7.3	103
Subsoiled and diked	7.2	110

Treatment	1981 water use	Grain lbs/in. of H_2O
Check	6.1	170
Subsoiled	6.5	171
Half-diked	6.5	285
Diked	7.3	306
Subsoiled and diked	7.2	312

Treatment	1982 water use	Grain lbs/in. of H_2O
Diked	11.0	310
Subsoiled and diked	11.0	311

Treatment	1983 water use	Grain lbs/in. of H_2O
Check	3.8	269
Subsoiled	4.6	224
Half-diked	4.4	336
Diked	5.0	297
Subsoiled and diked	4.9	299

Treatment	1984 water use	Grain lbs/in. of H_2O
Half-diked	8.1	314
Diked	8.5	291

Treatment	1985 water use	Grain lbs/in. of H_2O
Check	8.7	354
Half-diked	9.9	305
Diked	10.2	350

*Water-use data reported for treatments and years with no runoff experience during 1979-1984. In 1985, runoff was measured and subtracted from check and half-diked treatments. Runoff did not occur from diked treatment during crop year in 1985.

TABLE 14. LINT COTTON YIELDS FROM DIFFERENT TILLAGE TREATMENTS AND SLOPE LOCATIONS IN 1980-82 AND 1984-85

Treatments	Upper	Middle	Lower	Average
	Position on slope			
	1980			
	lbs lint/A			
Check	82	71	116	90
Half-diked	64	76	120	87
Diked	69	77	115	87
Subsoiled and diked	70	86	150	102
Average	71	78	125	92
	1981*			
	lbs lint/A			
Check	270a	330a	376a	325a
Half-diked	334b	361b	429a	375b
Diked	399c	459c	429a	429c
Subsoiled and diked	397c	480c	475a	451c
Average	350	408	427	395
	1982*			
	lbs lint/A			
Check	260a	339a	386a	328a
Half-diked	388b	403ab	435a	409b
Diked	437c	459b	417a	438b
Subsoiled and diked	426c	430b	390a	415b
Average	378	408	407	398
	1984**			
	lbs lint/A			
Check	411	380	350	380
Half-diked	371	390	351	371
Diked	378	383	389	383
Subsoiled and diked	347	400	396	381
Average	377	388	372	379
	1985			
	lbs lint/A			
Check	265	243	255	254***
Half-diked	301	266	274	280
Diked	289	276	296	287
Subsoiled and diked	281	257	295	278
Average	284	261	280	275

*Values within each location on slope or averages followed by same letter are not significantly different at 5% level according to Duncan's multiple range test.

**Yields not significantly affected by treatments in 1984.

***Average yields of diked treatments were significantly higher than the check in 1985.

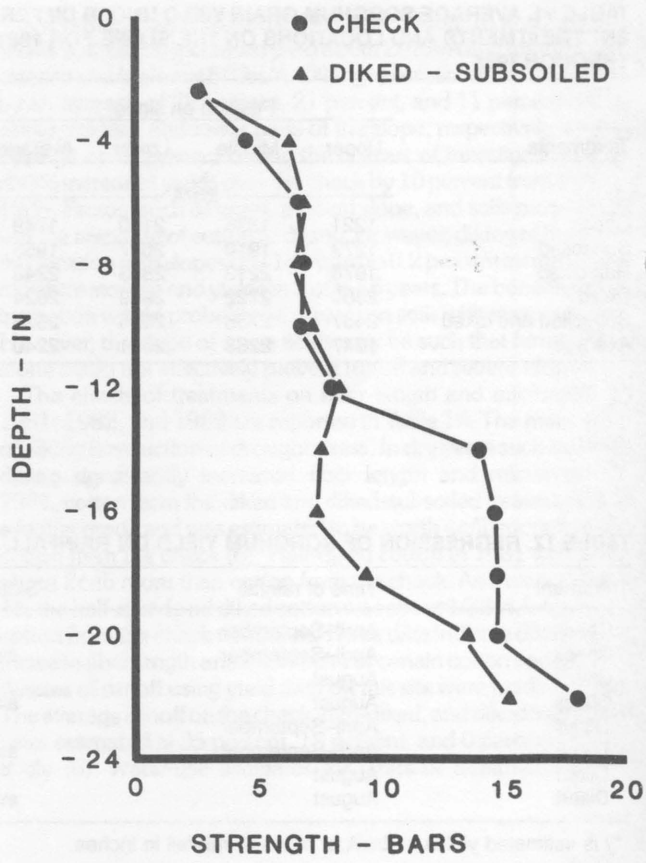

Figure 3. Average penetrometer resistance of beds of wet soil for diked and subsoiled, and check treatments in sorghum in 1985. Beds for diked and subsoiled treatment were deep-plowed in November 1981.

TABLE 15. AVERAGE COTTON YIELDS ON DIFFERENT PART OF THE SLOPE FOR VARIOUS DIKING PRACTICES FROM 1980 TO 1985

Treatments	Upper	Middle	Lower	Average
	Position of slope			
	Lint cotton—lbs/A			
Check	258	273	297	276
Half-diked	292	299	322	304
Diked	314	331	329	325
Subsoiled and diked	304	331	341	325
Average	292	309	322	

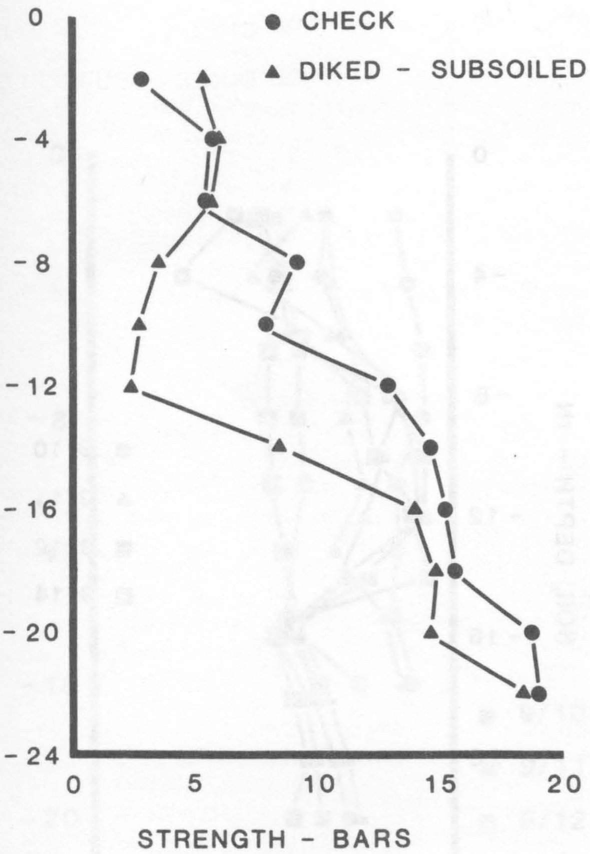

Figure 4. Penetrometer resistance of furrows when soil was wet for diked and subsoiled, and check treatments in sorghum in 1985. Furrows for diked and subsoiled treatment were deep-plowed in February 1984.

TABLE 16. FIBER LENGTH AND MICRONAIRE AS AFFECTED BY TILLAGE TREATMENTS IN 1981, 1982, AND 1984

Treatment	1981	1982	1984	Average
	Fiber length—inches			
Check	0.99a*	1.04	1.01	1.01
Half-diked	1.01b	1.05	1.04	1.03
Diked	1.03bc	1.06	1.00	1.03
Subsoiled and diked	1.04c	1.05	1.02	1.04
	Micronaire**			
Check	3.6	4.3	4.2	4.0
Half-diked	3.6	4.4	3.9	4.0
Diked	3.5	4.4	4.1	4.0
Subsoiled and diked	3.9**	4.5	4.2	4.2

*Average values for treatment followed by same letter are not significantly different at 5% probability level.

**Micronaire refers to fineness. In 1981 micronaire of diked and subsoiled treatment was significantly greater than other treatments at 5% probability level.

TABLE 17. WATER USE AND PRODUCTION OF LINT COTTON/INCH OF WATER*

Treatment	Water use (inches)	lbs/in. of water
	1980	
Check	8.4	11
Half-diked	8.5	10
Diked	8.4	10
Subsoiled and diked	8.7	11
	1981	
Diked	13.5	31.8
Subsoiled and diked	13.2	34.1
	1982	
Diked	12.0	36.7
Subsoiled and diked	10.8	38.5
	1984	
Diked	9.6	39.9
Subsoiled and diked	9.6	39.8

*Water-use data reported for treatments and years with no runoff experienced during 1980-1985.

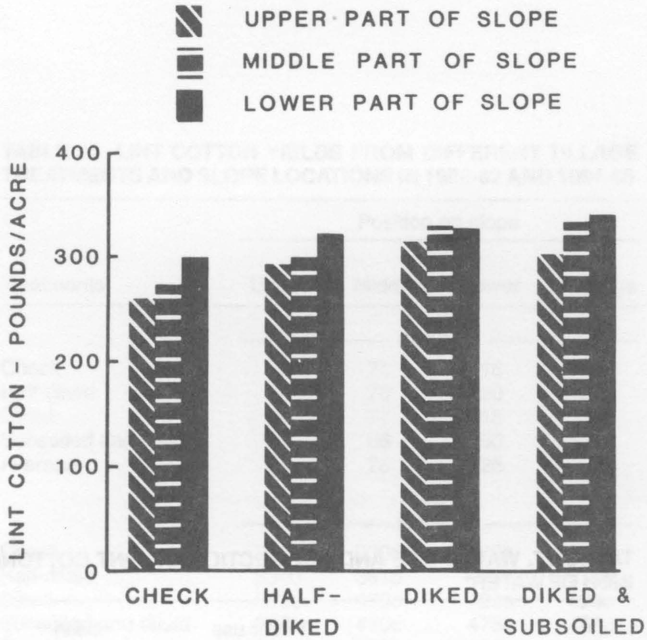

Figure 5. Average cotton yields under different tillage treatments and parts of slope from 1980 to 1985.

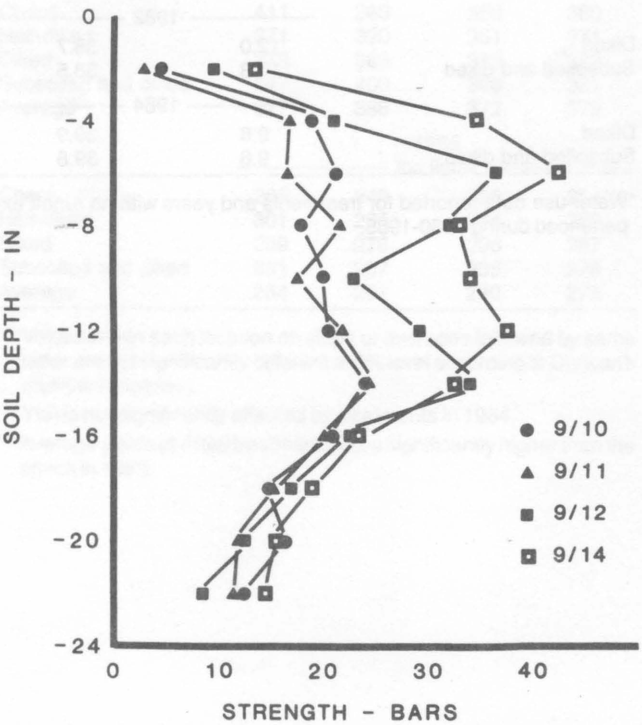

Figure 6. Penetrometer resistance of a Miles soil as a function of depth and moisture changes in cotton in September 1985. Soil moisture was at about 0.1 bars suction (field capacity) on September 10, 1985.

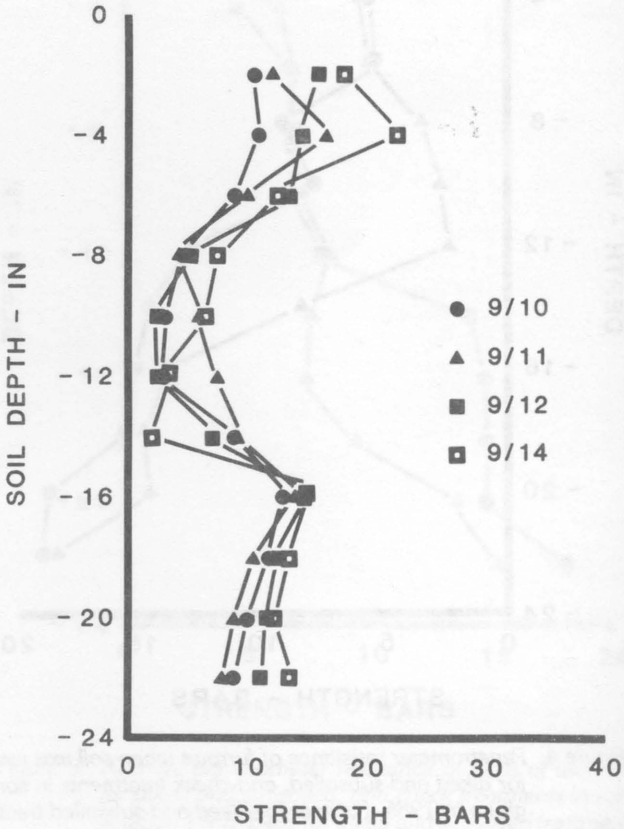

Figure 7. Penetrometer resistance of a Miles soil after subsoiling as a function of depth and moisture changes in cotton in September 1985. Soil moisture was at about 0.1 bar suction (field capacity) on September 10, 1985.

runoff were determined for 4 of the 5 years (Table 17). Production of lint per inch of water for 1980, 1981, 1982, and 1984 ranged from about 10 to 40 lbs/in. of water. Previous studies (5) indicate that climatic conditions and varieties affect the production/inch of water. Under the severe stress conditions of the Rolling Plains, cotton produced only 10 to 11 lbs/in. of water in 1980. In 1976 and 1977 (5), two varieties in irrigated experiments averaged about 50 lbs/in. of water. However, the dryland treatment produced as low as 40 lbs/in. of water.

Soil strength affects root penetration and is negatively related to infiltration rate of the soil. Soil strength of a Miles soil in cotton was measured with a penetrometer at near field capacity and on three subsequent days. Figure 6 shows soil strength at various depths for conventionally tilled cotton, and Figure 7 shows soil strength at comparable depths for subsoiled tilled cotton. Soil strength (penetrometer resistance) increased rapidly at depths of

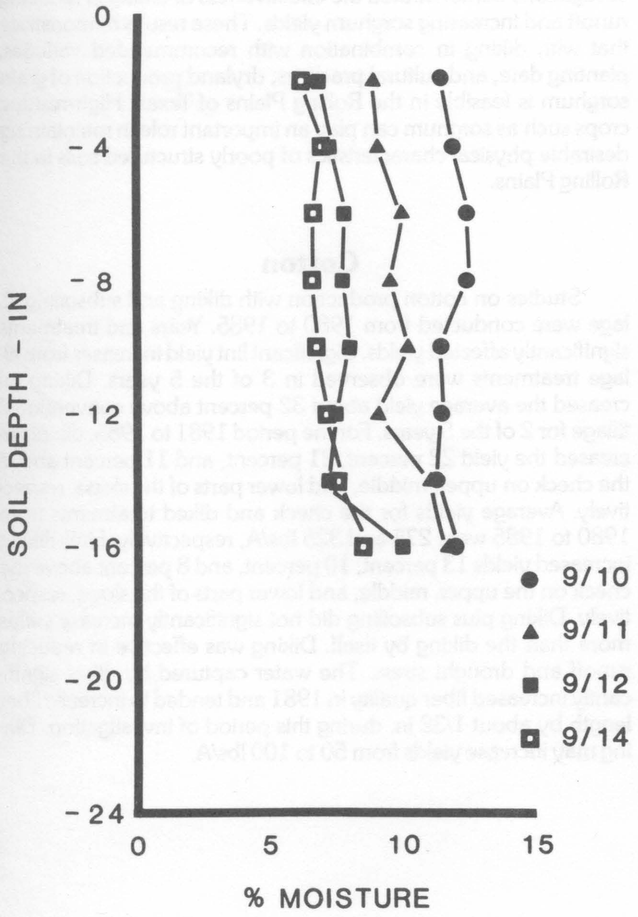

Figure 8. Moisture changes with time and depth in cotton from September 10 through September 14, 1985.

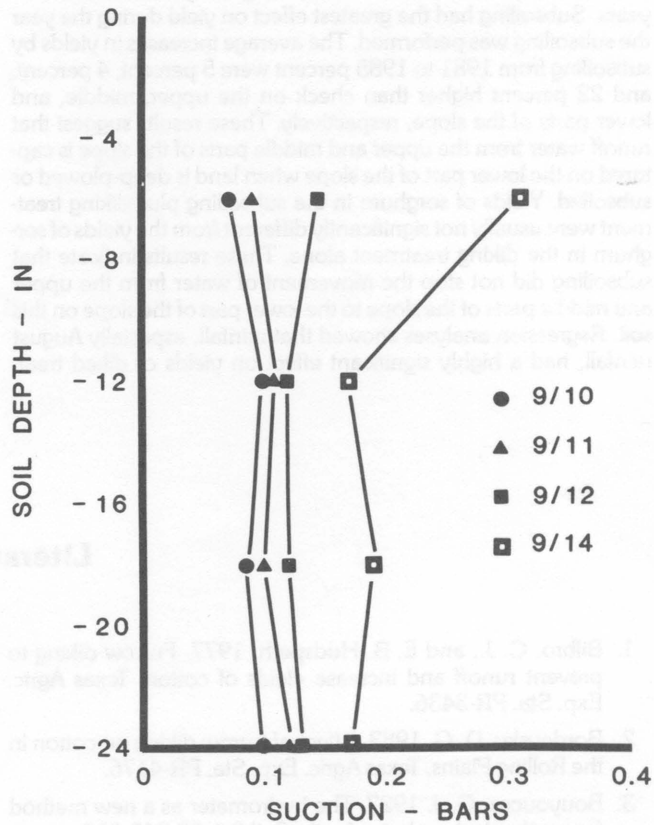

Figure 9. Soil moisture suction changes at four depths in cotton from September 10 through September 14, 1985.

from 4 to 14 in. in the conventionally tilled soil. Over the 4 days, strength increased from 20 to 35 bars at the 4-in. depth. Changes were similar to the 14-in. depth. In contrast, there was little change in soil strength below the 4-in. depth in the subsoiled treatment, and soil strength was from 10 to 20 bars less in the subsoiled treatment than in the conventionally tilled treatment. The substantial changes in soil strength of the conventionally tilled soil occurred over a 4-day period with very small changes in moisture suction. Figures 8 and 9 show the moisture suction and percent moisture of these soils over the 4-day period. The moisture suction changed from less than 0.1 bar to about 0.30 bar, and percentage moisture changed from 12 percent to 7.5 percent. These data emphasize the dynamic physical characteristics of this sandy loam soil. Cotton growing in soils such as the Miles often show deformed roots when soil strength is greater than 20 bar.

Summary

Sorghum

Studies on sorghum production with diking and subsoiling tillage practices were conducted from 1979 to 1985. Diking significantly increased yields in every year of the study. Average yields of diked treatments from 1981 to 1985 were 2,625 lbs/A, which was about 900 lbs/A more than the check treatments. During this period, yields of diked sorghum were 88 percent, 48 percent, and 30 percent higher than the check on the upper, middle, and lower parts of the slope, respectively. Half-diking during the period from 1981 to 1985 increased yields 62 percent, 21 percent, and 17 percent higher than the check on the upper, middle, and lower parts of the slope, respectively. The increase in yield from diking in some years was restricted primarily to the upper side of the slope. However, data from the upper part of the slope in these experiments may be the best estimate of potential yields for large, undiked fields. The effect of subsoiling on yields varied with years. Subsoiling had the greatest effect on yield during the year the subsoiling was performed. The average increases in yields by subsoiling from 1981 to 1985 percent were 5 percent, 4 percent, and 22 percent higher than check on the upper, middle, and lower parts of the slope, respectively. These results suggest that runoff water from the upper and middle parts of the slope is captured on the lower part of the slope when land is deep-plowed or subsoiled. Yields of sorghum in the subsoiling plus diking treatment were usually not significantly different from the yields of sorghum in the diking treatment alone. These results indicate that subsoiling did not stop the movement of water from the upper and middle parts of the slope to the lower part of the slope on this soil. Regression analyses showed that rainfall, especially August rainfall, had a highly significant effect on yields of diked treatments. Finally, yields varied with years and rainfall, but these investigations demonstrated the effectiveness of diking in reducing runoff and increasing sorghum yields. These results demonstrate that with diking in combination with recommended varieties, planting date, and cultural practices, dryland production of grain sorghum is feasible in the Rolling Plains of Texas. High-residue crops such as sorghum can play an important role in maintaining desirable physical characteristics of poorly structured soils in the Rolling Plains.

Cotton

Studies on cotton production with diking and subsoiling tillage were conducted from 1980 to 1985. Years and treatments significantly affected yields. Significant lint yield increases from tillage treatments were observed in 3 of the 5 years. Diking increased the average yield about 32 percent above conventional tillage for 2 of the 5 years. For the period 1981 to 1985, diking increased the yield 22 percent, 21 percent, and 11 percent above the check on upper, middle, and lower parts of the slope, respectively. Average yields for the check and diked treatments from 1980 to 1985 were 275 and 325 lbs/A, respectively. Half-diking increased yields 13 percent, 10 percent, and 8 percent above the check on the upper, middle, and lower parts of the slope, respectively. Diking plus subsoiling did not significantly increase yields more than the diking by itself. Diking was effective in reducing runoff and drought stress. The water captured by dikes significantly increased fiber quality in 1981 and tended to increase fiber length by about 1/32 in. during this period of investigation. Diking may increase yields from 50 to 100 lbs/A.

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