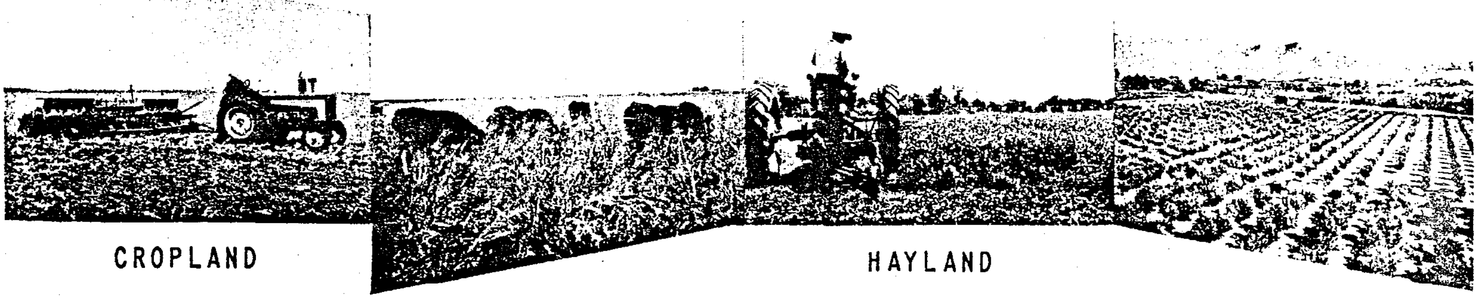
CONSERVATION AGRONOMY TECHNICAL NOTES



U. S. DEPARTMENT OF AGRICULTURE   NEW MEXICO   SOIL CONSERVATION SERVICE

AGRONOMY TECH NOTE NO. 33

February 27, 1984

RE: INFLUENCE OF REDUCED TILLAGE ON FURROW-IRRIGATION INFILTRATION

Enclosed is a paper by D. E. Eisenhauer, E. C. Dickey, P. E. Fishback, and K. D. Frank of the University of Nebraska. The paper was presented at a meeting of the American Society of Agricultural Engineers.

Since reduced tillage is becoming more prevalent throughout the state, this information may prove useful to some of your cooperators.

Attachment
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PAPER NO. 82-2587

INFLUENCE OF REDUCED TILLAGE ON FURROW IRRIGATION INFILTRATION

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SUMMARY: The effects of tillage practices on furrow irrigation advance and recession times and net infiltration were evaluated during years six and seven of a field experiment. When compared to conventional tillage practices, the reduced tillage systems increased water advance times by 62 percent and net infiltration by 74 percent.

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American Society of Agricultural Engineers

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INFLUENCE OF REDUCED TILLAGE ON FURROW IRRIGATION INFILTRATION[1/]

by
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INTRODUCTION

Soil infiltration characteristics have a large effect on the design and operation of furrow irrigation systems. Infiltration rates influence the design furrow length, stream size, and application duration or inflow time. When soils have high infiltration rates it is usually necessary that furrow lengths and inflow times be short and stream sizes be large to obtain uniform application of water and minimize deep percolation.

Reduced tillage practices result in higher surface residue conditions after planting than clean tillage systems. It is generally agreed that these surface residues reduce soil erosion and increase water infiltration. While high infiltration rates are desirable for conserving rainfall and for maximizing sprinkler irrigation efficiencies, this is not necessarily true for furrow irrigation. For slowly permeable soils, increasing infiltration rates for furrow irrigation can be advantageous. However, an increase in infiltration on more permeable soils can cause poorer water distribution and deep percolation.

Allen et al (1975) reported on a two-year tillage study of furrow irrigated grain sorghum on a Pullman clay loam soil. The forward grade of their 305 m plots was 0.3 percent. The average time for water to advance across the field was 7.0 hours for the clean-till treatment and 10.5 hours for the no-till treatment with the same stream size. The total water intake (application minus runoff) for five irrigation was 267 and 323 mm for the clean-till and no-till treatments respectively. The surface residues in the no-till treatments caused the slower water advance and increased the depth of flow in the furrows. The increase in depth of flow caused higher infiltration rates. Longer recession times after shutoff for the no-till treatment were also reported. Since the Pullman soil has a low permeability, the authors felt that the higher infiltration rates of no-till would increase water use efficiency and that the longer recession times would improve the uniformity of water application.

Aarstad and Miller (1978) studied the effect of three tillage practices on furrow erosion and infiltration rates on a fine sandy loam soil. Their tillage treatments were clean-tillage, disk, and till-plant. Furrow stream sizes had to be higher for the disk and till-plant treatments to achieve similar advance

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times for all treatments. The furrow infiltration rate at 24 hours for the till-plant system was significantly higher than the clean-till system for the first three irrigations of the season. There was no significant difference between the infiltration rates of the three tillage systems during the fourth irrigation. Total cumulative infiltration for four irrigations was 305, 414, and 511 mm for the clean-till, disk, and till-plant systems, respectively. Cumulative infiltration during the first irrigation for the till-plant system was 172 mm, which is a relatively high application of water for one irrigation on sandy soils. The higher infiltration rates of the reduced tillage systems were attributed to the greater wetted perimeter caused by the corn residues left in the furrows. The residues also significantly reduced furrow erosion rates.

OBJECTIVES

The objectives of the field study reported in this paper were to compare the long-term effects of conventional and reduced tillage practices on (1) irrigation advance times, (2) recession times, and (3) net irrigation infiltration.

EXPERIMENTAL PROCEDURE

The field research plots were established in 1976 at the University of Nebraska-Lincoln South Central Station, Clay Center. Six tillage systems for continuous corn production were evaluated. Three systems were considered conventional for south central Nebraska while three of them were considered reduced tillage systems. The operations of each system are listed in Table 1. The conventional systems have four or five tillage operations prior to the planting process; whereas, the reduced tillage systems have only the application of anhydrous ammonia. After planting, the tillage operations were the same for all systems. Four-row planting and cultivation equipment was used. The data reported below were collected during 1981 and 1982.

Anhydrous ammonia was knifed in to a depth of 15 cm at a spacing of 76 cm. In 1981 the anhydrous knife traveled in the center of the previous year's irrigation furrow for the reduced tillage treatments. This procedure was modified in 1982 for the rotary till system. The anhydrous knife was placed halfway between the furrow center and the corn row. This is a more common practice by farmers who use the rotary till system.

The study was conducted on a Hastings silt loam soil. The average forward grade of the irrigation furrows was 0.5 percent. Plot dimensions were 18.3 m wide and 366 m long. The crop row and furrow spacing was 76 cm. The experimental design is a randomized complete block with three replications. Water is delivered to the plots with 203 mm gated pipe. Every furrow was irrigated.

The experiment was irrigated four times in 1981 and 1982. The criteria for scheduling irrigations was to irrigate when 50 percent of the available moisture in the root zone was depleted. Soil moisture depletion was estimated with electrical resistance blocks placed at three depths (15, 46, and 76 cm) and two locations (upper and lower end) in the three till-plant plots.

Experimental data were collected for all four irrigations in both years. Irrigation data collected included the volume of water applied, runoff rate and volume, and rate of water advance and recession. A wheel track or hard furrow and a non-wheel track or soft furrow were monitored in each plot.

The water was metered into each furrow using a clamp-on, 31.75 mm diameter orifice meter. The pressure head on the orifice was adjusted to provide a flow rate of 113.6 L/min. The advance time was recorded at 30.5 M intervals. A 60° v-notch trapazoidal flume (Robinson and Chamberlain, 1960) was placed at the end of each furrow to measure runoff. Head readings on each flume were taken one minute after runoff commenced and at 5 and 15 minute intervals thereafter depending on how fast the head was changing

The inflow to each plot was terminated 30 minutes after the water in the furrow with the slowest advance rate reached the flume. Usually this occurred in the soft furrow. Recession time was recorded at 30.5 m and at the flume.

The photographic grid technique (Laflin et al, 1981) was used to estimate the percent cover of the soil surface by crop residues. A 7.6 cm x 7.6 cm grid board with 50 intersection points was photographed on the ground surface. The percent cover was then estimated from projected slides by counting the number of interaction points that had residue under them. Four samples were taken in each plot. Percent cover measurements were made between planting time and the first cultivation (early June) and then again after cultivation or after the furrows were made.

RESULTS AND DISCUSSION

Irrigation advance times are shown in Table 2. The results show that on the average advance rates were 40 percent slower in 1981 than 1982. This is because we had a very wet spring in 1982 which probably resulted in soil compaction due to rainfall impact and from performing tillage operations at high soil moisture conditions. The differences between years were noticeable during all four irrigations. The variation during the season was also evident. Advance rates were slow during the first irrigation. Smoothing and surface sealing of the furrows during the first irrigation caused faster advance times during subsequent irrigations. The advance rates were also 59 percent faster for the hard furrows than the soft furrows.

In 1981 the advance rates of the three conventional tillage systems were significantly faster than the rotary till and slot plant systems for both the hard and soft furrows. For the soft furrows, the conventional systems were significantly faster than all three reduced tillage systems. On the average, the times of advance of the reduced tillage systems were 70 percent longer than the conventional systems. The trends in 1982 were somewhat different than 1981 with the advance rates for the three conventional tillage systems and the rotary till system being significantly faster than the slot plant system. For the soft furrows, the conventional treatments were significantly faster than the till plant system also. This difference in results between years was probably due to the change in location of the anhydrous ammonia knife for the rotary till system in 1982.

The results of the recession measurements taken at 366 m are shown in Table 3. Tillage practices did not have any significant effect on recession times, and there was very little difference between hard and soft furrows and between years. The average recession time was 61 minutes.

Net infiltrations during irrigation given in Table 4 were calculated by subtracting the runoff volume from the inflow volume and dividing by the land area irrigated per furrow. Similar to the advance data, net infiltration was 60 percent higher in 1981 than in 1982 and higher during the first irrigation than the following three irrigations. The average net infiltration was 106, 54, 52, and 64 mm during irrigations 1, 2, 3, and 4, respectively. Seasonal variation in infiltration was also found by Linderman and Stegman (1971). Net infiltration was about 38 percent higher in the soft furrows than in the hard furrows.

The total infiltration during 1981 was significantly lower for the three conventional tillage systems than the three reduced tillage systems. Also, the till plant system was significantly lower than the slot plant system. On the average, the reduced tillage systems had a 75 and 71 percent higher net infiltration than the conventional tillage systems for 1981 and 1982, respectively. In 1982 the three conventional systems and the rotary till system had significantly lower total infiltration than the slot plant system. Again, this difference between years for the rotary till system was probably due to the change in the location of anhydrous application.

The net infiltration during irrigation has a significant effect on the efficiency of water application. For corn on a Hastings silt loam soil, the maximum desired infiltration per irrigation application is 76 mm. For the soft furrows in 1981 the net infiltration exceeded 76 mm for all three reduced tillage systems during all irrigations. The highest net infiltration was 215 mm with the slot plant system during the first irrigation. This is almost three times the desired amount. Even during the fourth irrigation, the net infiltration was 142 mm or about twice as large as necessary.

In 1982 the slot plant system had excessive net infiltration during all four irrigations for the soft furrows. However, the rotary till system had an excessive water application only during the first irrigation. This suggests that reduced tillage practices might be compatible with furrow irrigation if the right system is selected and with proper management.

The slower advance times of the reduced tillage systems were probably due to a combination of higher infiltration rates and increased hydraulic roughness of the furrows caused by surface residues. The surface residue data are shown in Table 5. After cultivation, the conventional tillage systems had a surface cover of less than 10 percent while the reduced tillage systems exceeded this amount with the slot plant being as high as 28 percent in 1981.

The correlation coefficient between advance time and percent surface cover was 0.89 and 0.73 in 1981 and 1982, respectively. Both coefficients are significant at the 10 percent level of probability.

Recession time is influenced by both hydraulic roughness and the infiltration rate. Recession time will increase if roughness is increased while an increase in the infiltration rate will cause a decrease in recession time. Since recession times were not influenced by the tillage treatments but advance times were, it seems probable that both the hydraulic roughness and infiltration rates were higher for the reduced tillage systems. Apparently the effects of these two factors were offsetting during recession.

CONCLUSIONS

1. Reduced tillage practices significantly affect furrow irrigation advance and infiltration.

2. The net infiltration of the slot and till-plant systems were greater than desired for efficient water application on a Hastings silt loam soil.

3. Tillage treatments did not affect recession times.

4. Placement of the anhydrous ammonia application knife away from the center of the furrow increased the advance rate and reduced net infiltration for the rotary till system.

REFERENCES

Aarstad, J. S. and D. E. Miller. 1978. Corn residue management to reduce erosion in irrigation furrows. J. Soil and Water Conservation. 33(6): 289-291.

Allen, R. R., J. T. Musick, and A. F. Wiese. 1975. No-till management of furrow irrigated continuous grain sorghum. Progress Report PR-3332C, Texas Agricultural Experiment Station, Texas A & M University, College Station, Lexas.

Laflin, J. J., M. Amemiya, and E. A. Hinz. 1981. Measuring crop residue cover. J. Soil and Water Conservation. 36(6): 341-343.

Linderman, C. L. and E. C. Stegman. 1971 Seasonal variation of hydraulic parameters and their influence upon surface irrigation application efficiency. Trans. ASAE. 14(5):914-918, 923.

Robinson, A. R. and A. R. Chamberlain. 1960. Trapezoidal flumes for open-channel flow measurement. Trans. ASAE. 3(1): 120-128.

Table 1. Field operations for the tillage system experiment--University of Nebraska, South Central Station

Treatment	Fall Operations	Spring Operations
Conventional Tillage Systems		
Disk and List	Shred stalks, tandem disk	Apply anhydrous, tandem disk, harrow, list, spray herbicide, cultivate, make furrows, combine
Disk and Surface Plant	Shred stalks, tandem disk	Apply anhydrous, tandem disk, harrow, surface plant, spray herbicide, cultivate, make furrows, and combine
Chisel and Surface Plant	Shred stalks, tandem disk chisel 15 cm deep with 38 cm spacing	Apply anhydrous, tandem disk, harrow, surface plant, spray herbicide, cultivate, make furrows, combine
Reduced Tillage Systems		
Till Plant	None	Shred stalks, apply anhydrous, till-plant, spray herbicide, cultivate, make furrows, combine
Rotary Till	None	Shred stalks, apply anhydrous, rotary till and plant, spray herbicide, cultivate, make furrows, combine
Slot Plant	None	Shred stalks, apply anhydrous, plant, spray herbicide, cultivate, make furrows, combine

Table 2. Irrigation advance times (minutes)[1,2]

Year	Treatment	Soft Furrows Irrigation Number					Hard Furrows Irrigation Number				
		1	2	3	4	Average	1	2	3	4	Average
1981[3]	Conventional Tillage Systems										
	Disk and List	296	116	107	102	155a[4]	178	96	58	88	105a
	Disk and Surface Plant	273	153	124	139	172a	160	105	70	106	110a
	Chisel and Surface Plant	296	146	96	183	180a	183	113	71	121	122ab
	Reduced Tillage Systems										
	Till Plant	413	192	220	295	280 b	231	137	92	144	151 b
	Rotary Till	447	199	239	349	309 bc	230	135	98	207	168 cd
	Slot Plant	515	211	294	343	341 c	256	159	148	184	187 d
1982	Conventional Tillage Systems										
	Disk and List	141	64	60	54	80a	132	62	65	56	79a
	Disk and Surface Plant	164	81	83	75	101a	159	74	83	61	94a
	Chisel and Surface Plant	168	74	82	68	98a	167	66	77	58	92a
	Reduced Tillage Systems										
	Till Plant	197	174	139	178	172 bc	142	83	86	77	97ab
	Rotary Till	182	116	99	100	124ab	133	73	71	58	84a
	Slot Plant	290	226	172	217	226 c	193	99	95	85	118 b

1 Data are averages of 3 replications

2 Furrow stream size = 113.6 L/min

3 Advance times are to 366 m in 1981 and 335 m in 1982

4 Treatment averages followed by the same letter are equal using Duncan's Multiple Range Test at a significance level of 10%.

Table 3. Irrigation recession times to 366 m (minutes) [1,2]

Year	Treatment	Soft Furrows Irrigation Number					Hard Furrows Irrigation Number				
		1	2	3	4	Average	1	2	3	4	Average
	Conventional Tillage Systems										
1981	Disk and List	50	72	49	47	54	46	74	48	50	54
	Disk and Surface Plant	65	56	53	55	57	71	61	65	56	63
	Chisel and Surface Plant	35	47	48	52	46	45	51	54	61	53
	Reduced Tillage Systems										
	Till Plant	42	59	63	61	56	44	60	68	76	62
	Rotary Till	41	47	42	47	44	53	50	50	56	52
	Slot Plant	48	78	62	66	64	64	75	73	71	71
						n.s.[3]					n.s.
	Conventional Tillage Systems										
1982	Disk and List	49	55	53	56	53	59	61	58	58	59
	Disk and Surface Plant	68	67	71	61	67	61	67	72	70	70
	Chisel and Surface Plant	53	59	66	63	60	63	70	71	87	73
	Reduced Tillage Systems										
	Till Plant	73	65	65	64	67	84	81	74	74	78
	Rotary Till	52	67	55	51	56	75	65	65	70	69
	Slot Plant	62	67	66	65	65	63	82	69	69	71
						n.s.					n.s.

1 Recession times taken at 366 m

2 Data are averages of three replications

3 n.s. = not significant

Table 4. Net irrigation infiltration (mm)[1]

Year	Treatment	Soft Furrows Irrigation Number 1	2	3	4	Total	Hard Furrows Irrigation Number 1	2	3	4	Total
	Conventional Tillage Systems										
1981	Disk and List	124	49	48	46	267a[2]	91	44	26	40	201a
	Disk and Surface Plant	110	67	52	68	297a	67	53	35	50	205a
	Chisel and Surface Plant	123	63	41	70	297a	95	52	37	61	245a
	Reduced Tillage Systems										
	Till Plant	168	78	92	123	461 b	127	54	53	80	314 b
	Rotary Till	188	84	108	145	525 bc	137	69	72	98	376 bc
	Slot Plant	215	83	123	142	563 c	140	70	95	109	414 c
	Conventional Tillage Systems										
1982	Disk and List	56	28	24	24	132a	65	20	25	23	133a
	Disk and Surface Plant	75	36	38	31	180ab	69	28	28	24	149a
	Chisel and Surface Plant	79	31	29	27	166a	75	25	30	23	153a
	Reduced Tillage Systems										
	Till Plant	87	80	64	79	310 bc	66	40	35	45	186ab
	Rotary Till	83	49	44	49	225ab	61	39	31	25	156a
	Slot Plant	132	109	81	106	428 c	105	57	45	52	259 b

1 Data are averages of three replications

2 Treatment totals followed by the same letter are equal using Duncan's Multiple Range Test at a significance level of 10%.

Table 5. Average percent ground cover by crop residue[1]

Treatment	1981 Before Cultivation[2]	1981 After Cultivation[3]	1982 Before Cultivation	1982 After Cultivation
Conventional Tillage Systems				
Disk and List	12a[4]	10 a	12a	2.7a
Disk and Surface Plant	23 bc	7.7a	22 b	0.5a
Chisel and Surface Plant	25 bc	8.0a	16ab	1.4a
Reduced Tillage Systems				
Till Plant	27 cd	24 b	22 b	14 b
Rotary Till	15ab	14 a	13a	12 b
Slot Plant	36 d	28 b	48 c	20 c

1 Data are averages of 3 replications

2 Measurements before cultivation were taken after planting and just prior to the first cultivation.

3 Measurements after cultivation were taken prior to furrowing in 1981 and immediately after furrowing in 1982.

4 Treatment means followed by the same letter are equal using Duncan's Multiple Range Test at a significance level of 10%.