SARE Project LS88-9

EFFECTS OF CROP COVER AND WHEEL TRAFFIC ON SOIL SORPTIVITY

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INTRODUCTION

Soil sorptivity is a parameter to measure vertical infiltration of a soil at the earlier stage of infiltration process. The latter stage of vertical infiltration is determined by soil hydraulic conductivity (Bouwer, 1986). Sorptivity data may be related to the degree of past accelerated erosion but there was no significant relationship between sorptivity and landscape position because of very high variability (Van Es, 1987). Water holding capacity, run-off, crop cover, soil compaction, and nutrient transport may also be related to sorptivity. The rate and magnitude of clogging of soil surface pores can also be shown from sorptivity values (Bouwer, 1986).

Philip (1969) described vertical infiltration as

$$vi = 1/2\ Si\ t^{-1/2} + A \qquad (1)$$

where Si is the sorptivity, A is a factor related to steady state hydraulic conductivity, and t is time. Cumulative infiltration can be calculated by integrating equation (1)

$$I = Si\ t^{1/2} + At \qquad (2)$$

The Si depends on soil pore distribution and configuration, initial water content, and water head above soil surface (Bouwer, 1986). Si is the slope of the plot of I versus $t^{1/2}$ for the first few minutes of the infiltration measurement while the plot shows linear relationship (Talsma, 1969).

Sorptivity measurements have been done from a crop rotation study. The objectives of this study were to quantify and compare the sorptivity for each rotation and at each measurement positions.

MATERIALS AND METHODS

The sorptivity measurement were super imposed at an on-going crop rotation study at the Unit II Experiment Station, NCSU, NC.

For the first year of measurement (1989) the treatments selected for sorptivity measurement were:

A4 = Continuous corn for four years, fallow over winter, 100 % NPK, 0 rock phosphate, chemical weed control, insecticide

D4 = Conventional corn - wheat - soybean rotation
1985-1986 (wheat - soybean); 1986-1987 (fallow corn);
1987-1988 (wheat - soybean), 1988-1989 (fallow - corn)

D5 = Conventional corn - wheat - soybean rotation
1985-1986 (fallow - corn); 1986-1987 (wheat - soybean); 1987-1988 (fallow - corn); 1988-1989 (wheat - soybean)

E1 = Low input corn - wheat - soybean rotation
1985-1986 (wheat - soybean); 1986-1987 (crimson clover - corn); 1987-1988 (wheat - soybean); 1988-1989 (crimson clover - corn). No chemical input added, no cultivation, and no insecticide

G6 = Low input corn - wheat - beans - corn - red clover
1985-1986 (fallow - corn); 1986-1987 (wheat - soybean); 1987-1988 (crimson clover - corn); 1988-1989 (red clover - red clover)

For the first date (29 March 1989), sorptivity measurements were taken from row and traffic positions. The measurements were replicated four times for each treatment and each position. For the second date (25 May 1989), measurements were only done for the row position. The measurements were replicated four times for each treatment. For the third measurement (2 August 1989), treatment G6 was not included. However, for this third treatment, three positions (row, no traffic inter row, and traffic inter row) were measured; each treatment and each position were replicated two times.

For the second year of measurement (1990) the treatments selected for sorptivity measurement were:

A4 = Continuous corn. The year 1990 is the fifth straight year for corn, fallow over winter, 100 % NPK, no till

D5 = Conventional no till, corn - wheat - soybean rotation.
1985-1986 (fallow - corn); 1986-1987 (wheat - soybean); 1987-1988 (fallow - corn); 1988-1989 (wheat - soybean); 1989-1990 (fallow - corn)

G6 = Low input corn - wheat - beans - corn - red clover rotation. 1985-1986 (red clover - corn); 1986-1987 (wheat - soybean); 1987-1988 (fallow - corn); 1988-1989 (wheat - beans); 1989-1990 (fallow - corn)

J3 = Continuous corn. 1990 is the fourth straight year for corn, fallow over winter, chisel plow and disk before planting

For the first date of the second year measurement (9 April 1990) the measurements were taken from row and traffic positions with three replications

for each treatment and each position.

These treatments were arranged in completely randomized block design (CRBD) with four blocks. The association of the treatments and positions were in a 'split block' arrangement (Steel and Torrie, 1980).

The sorptivity measurements were done with single ring infiltrometers (open ended cylinders of 11 cm inner diameter and 25 cm height). The bottom part of the cylinder was sharpen to reduce soil compaction during the driving of the cylinder into the soil and to make it easier to drive. The cylinders were driven to a depth of 15 cm at each measurement position. Four layers of cheesecloth were placed on the soil surface inside the ring. A ruler was installed in each ring to measure the level of water head. 600 ml of water was ponded on each ring to create an approximately 7.5 cm of instantaneous water head. Water-level readings were done at times *ti* (0, 5, 10, 15, 20, 30, 40, 50, 60, 80, 100, 120, 150, and 180 seconds) where *i* ranges from 1 to up to 14 taken for gravimetric water content determination right after the sorptivity measurement.

Cumulative infiltration (water level at time *t1* minus water level at time *ti*,) in millimeter, was plotted against the square root of time. The linear portion of the plotting was taken for calculating the slope (sorptivity = S) and the Y-axis intercept (INT) of the plot with the following linear regression model

$$Ii = S\ ti^{0.5} + INT + Ei \qquad (3)$$

where *Ei* is the random error. As a measure of linear relationship, coefficient of correlation (R^2) was used. Regression equations with R^2 values of 0.81 or larger were kept while those with R^2 values smaller than 0.81 were re-evaluated to reach such value. The R^2 values tend to be larger as we eliminate the non linear part of I versus $t^{1/2}$ plots.

Because of the skewness of the residual distribution of *S*, the *S* is transformed into log(0.5 +S) to approach normality. The transformation was also done to stabilize the variance (Rawlings, 1989). Analysis of variance was done for the *LNS* to compare the treatment, position, and treatment-position interaction effects. Means comparisons were done with Fisher's-protected least square difference (LSD).

RESULTS AND DISCUSSION

Log (0.5 + sorptivity) for each treatment and each positions for the measurement on 29 March 1989 is presented in Table 1. Crop rotation treatments

did not affect soil sorptivity at the row position but the effects were shown at the traffic position. At traffic position, treatment E1 has the highest sorptivity value. Its sorptivity is significantly different from that of treatments A4, D5, and G6 but not significantly different from treatment D4. The sorptivity of treatment G6 at traffic position is the lowest; it is significantly lower than the treatment E1 and D4. If the two positions were averaged, the treatment effects are not significant. Measurement positions have some effect on soil sorptivity where the sorptivity at the row positions was significantly greater than for the traffic for treatments D5 and G6 but this difference was not significant for treatments A4, D4 and E1. When all of the treatment were averaged, the sorptivity for the row position was significantly higher than the traffic position.

Log (0.5 + sorptivity) at row position for the five treatments for the second measurement (25 May 1989) is presented in Table 2. Crop rotation treatments gave significant effect on sorptivity where treatments A4, D5, and E1 had significantly higher sorptivity than treatments D4 and G6. This result has been inconsistent with the first measurement where no significant effect was observed for the row position.

Log (0.5 + sorptivity) for treatments A4, D4, D5, and E1 and positions row, no traffic inter row, and traffic inter row for the third measurement (2 August 1989) is presented in Table 3. Crop rotation treatments affected sorptivity significantly at row and non traffic inter row, but not at traffic inter row positions. Treatment D4 had the lowest sorptivity value at row position, while at no traffic inter row, treatment D5 was the lowest and D4 was the second lowest. The sorptivity of treatments A4 and E1 were consistently higher than D4 at these two positions. When the three positions were averaged, the treatment effects were not significant. Measurement positions for treatments A4, D5, and E1, but not for treatment D4, gave significant effect on sorptivity. For these three treatments, sorptivity at traffic inter row was consistently lower than at row position. When all of the treatment were averaged, the sorptivity for the traffic inter row position was significantly lower than at the other two positions.

Log (0.5 + sorptivity) for each treatment and each positions for the fourth measurement (9 April 1990) is presented in Table 4. As it was for the first measurement, crop rotation treatments did not affect soil sorptivity at the row position but the effects were shown at the traffic position. At traffic position, treatment G6 has the highest sorptivity value. Its

sorptivity is significantly different from that of treatments A4 and J3 but not significantly different from treatment D5. If the two positions were averaged, the treatment effects were not significant. Measurement positions have some effect on soil sorptivity for treatments A4, D5, and J3 where the sorptivity at the row positions was significantly greater than for the traffic position. This effect was not significant for treatment G6. When all four of the treatments were averaged, the sorptivity for the row position was significantly greater than the traffic position.

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Table 1. Log (0.5 + sorptivity) as affected by crop cover treatments and measurement positions measured on 29 March 1989 (... days after planting).

Treatment	Log(0.5+sorptivity) ($mm.sec^{-.5}$) Position			Row vs. Traffic
	Row	Traffic	Means	
A4	0.682 a[1)]	0.352 b	0.517 a	*[2)]
D4	0.663 a	0.603 ab	0.633 a	ns
D5	0.942 a	0.312 b	0.627 a	**
E1	0.891 a	0.874 a	0.883 a	ns
G6	0.669 a	0.277 b	0.473 a	*
Means	0.769	0.483	0.624	*
C.V. (%)	59	99	66	

1) Numbers followed by common letters indicate that treatment means are not significantly different at the 5 % level as tested by Fisher's LSD.

2) Contrasts between row and traffic positions are significant at the 5 % level (*), at the 1 % level (**), and not significant at the 5 % level (ns).

Table 1 b. Sorptivity as affected by crop cover treatments and measurement positions measured on 29 March 1989 (... days after planting).

Treatment	Sorptivity ($mm.sec^{-.5}$) Position			Row vs. Traffic
	Row	Traffic	Means	
A4	1.648 a[1)]	1.258 bc	1.453 a	ns[2)]
D4	1.832 a	1.991 ab	1.911 a	ns
D5	2.323 a	0.964 c	1.644 a	**
E1	2.326 a	2.197 a	2.262 a	ns
G6	1.719 a	0.934 c	1.323 a	*
Means	1.970	1.469	1.719	ns
C.V. (%)	61	86	65	

1) Numbers followed by common letters indicate that treatment means are not significantly different at the 5 % level as tested by Fisher's LSD.

2) Contrasts between row and traffic positions are significant at the 5 % level (*), at the 1 % level (**), and not significant at the 5 % level (ns).

Table 2. Log (0.5 + sorptivity) at row positions affected by crop cover treatments measured on 25 May 1989 (... days after planting).

Treatment	Log (0.5+Sorptivity) ($mm.sec^{-.5}$)
A4	0.967 a[1)]
D4	0.664 b
D5	1.088 a
E1	1.911 a
G6	0.672 b
Means	0.902
C.V. (%)	42

1) Numbers followed by common letters are not significantly different at the 5 % level as tested by Fisher's LSD.

Table 2 b. Sorptivity at row positions affected by crop cover treatments measured on 25 May 1989 (... days after planting).

Treatment	Sorptivity ($mm.sec^{-.5}$)
A4	2.489 ab[1)]
D4	1.577 b
D5	3.018 a
E1	2.713 a
G6	1.535 b
Means	2.266
C.V. (%)	68

1) Numbers followed by common letters are not significantly different at the 5 % level as tested by Fisher's LSD.

Note: All of the measurements were done at row position.

Table 3. Log (0.5 + sorptivity) as affected by crop cover treatments and measurement positions measured on 2 August 1989 (... days after planting).

Treatment	Log(0.5+sorptivity) ($mm.sec^{-.5}$) Position R	NTI	TI	Treatment means
A4	1.164 a[1)] p	1.071 a p	0.450 a q	0.895 a
D4	0.554 b p	0.731 b p	0.446 a p	0.580 a
D5	0.974 a p	0.387 c q	0.576 a q	0.646 a
E1	1.104 a p	1.112 a p	0.615 a q	0.944 a
Position means	0.949 p	0.825 p	0.524 q	0.766
C.V. (%)	49	52	90	53

1) Numbers followed by common letters are not significantly different at 5 % level as tested by Fisher's LSD (letters a, b, and c are for between treatment and letters p and q are for between position comparisons).

Table 3 b. Sorptivity as affected by crop cover treatments and measurement positions measured on 2 August 1989 (... days after planting).

Treatment	Sorptivity ($mm.sec^{-.5}$) Position R	NTI	TI	Treatment means
A4	2.937 a[1)] p	2.720 ab p	1.211 a q	2.289 a
D4	1.706 a p	1.727 bc p	1.214 a p	1.549 a
D5	2.624 a p	1.174 c q	1.569 a q	1.789 a
E1	2.615 a p	2.868 a p	1.552 a q	2.345 a
Position means	2.470 p	2.122 p	1.386 q	1.993
C.V. (%)	72	71	70	68

1) Numbers followed by common letters are not significantly different at 5 % level as tested by Fisher's LSD (letters a, b, and c are for between treatment and letters p and q are for between position comparisons).

Table 4. Log (0.5 + sorptivity as affected by crop cover treatments and measurement positions measured on 9 April 1990 (... days after planting).

Treatment	Log(0.5+Sorptivity) ($mm.sec^{-.5}$) Position: Row	Traffic	Means	Row vs. Traffic
A4	0.661 a[1)]	0.070 b	0.366 a	**[2)]
D5	0.683 a	0.306 ab	0.495 a	*
G6	0.331 a	0.578 a	0.454 a	ns
J3	0.509 a	-0.020 b	0.245 a	**
Position means	0.546	0.233	0.390	*
C.V. (%)	98	193	116	

1) Numbers followed by common letters indicate that treatment means are not significantly different at 5 % level as tested by Fisher's LSD.
2) Contrasts between row and traffic positions are significant at the 5 % level (*), at the 1 % level (**), and not significant at the 5 % level (ns).

Table 4 b. Sorptivity as affected by crop cover treatments and measurement positions measured on 9 April 1990 (... days after planting).

Treatment	Sorptivity ($mm.sec^{-.5}$) Position: Row	Traffic	Means	Row vs. Traffic
A4	1.749 a[1)]	0.716 a	1.232 a	*[2)]
D5	1.758 a	1.296 a	1.527 a	ns
G6	1.262 a	1.480 a	1.371 a	ns
J3	1.399 a	0.551 a	0.975 a	*
Position means	1.542	1.010	1.276	ns
C.V. (%)	85	117	49.61	

1) Numbers followed by common letters indicate that treatment means are not significantly different at 5 % level as tested by Fisher's LSD.
2) Contrasts between row and traffic positions are significant at the 5 % level (*), at the 1 % level (**), and not significant at the 5 % level (ns).

Table 5. Log (0.5 + sorptivity as affected by crop cover treatments and measurement positions measured on 26 June 1990 (... days after planting).

Treatment	Log(0.5+Sorptivity) ($mm.sec^{-.5}$) Position			Row vs. Traffic
	Row	Traffic	Means	
A4	1.229 a[1)]	0.912 a	1.070 a	* [2)]
D5	1.362 a	0.779 a	1.070 a	**
G6	1.076 a	0.742 a	0.909 a	**
J3	1.265 a	0.756 a	1.012 a	**
Position means	1.233	0.797	1.015	**
C.V. (%)	53	109	35	

1) Numbers followed by common letters indicate that treatment means are not significantly different at 5 % level as tested by Fisher's LSD.
2) Contrasts between row and traffic positions are significant at the 5 % level (*), at the 1 % level (**), and not significant at the 5 % level (ns).

Table 5 b. Sorptivity as affected by crop cover treatments and measurement positions measured on 26 June 1990 (... days after planting).

Treatment	Sorptivity ($mm.sec^{-.5}$) Position			Row vs. Traffic
	Row	Traffic	Means	
A4	3.213 a[1)]	2.327 a	2.770 a	ns[2)]
D5	3.822 a	1.750 a	2.784 a	**
G6	2.582 a	1.670 a	2.141 a	**
J3	3.321 a	1.877 a	2.599 a	**
Position means	3.234	1.912	2.573	**
C.V. (%)	85	117	51	

1) Numbers followed by common letters indicate that treatment means are not significantly different at 5 % level as tested by Fisher's LSD.
2) Contrasts between row and traffic positions are significant at the 5 % level (*), at the 1 % level (**), and not significant at the 5 % level (ns).

Table 6. Log (0.5 + sorptivity as affected by crop cover treatments and measurement positions measured on 30 July 1990 (... days after planting).

Treatment	Log(0.5+Sorptivity) ($mm.sec^{-.5}$) Position			Row vs. Traffic
	Row	Traffic	Means	
A4	1.247 a[1)]	0.534 b	0.891 a	**[2)]
D5	1.164 a	0.906 a	1.035 a	*
G6	1.327 a	0.960 a	1.144 a	ns
J3	1.368 a	0.840 a	1.104 a	**
Position means	1.277	0.810	1.043	*
C.V. (%)	37	47	40	

1) Numbers followed by common letters indicate that treatment means are not significantly different at 5 % level as tested by Fisher's LSD.
2) Contrasts between row and traffic positions are significant at the 5 % level (*), at the 1 % level (**), and not significant at the 5 % level (ns).

Table 6 b. Sorptivity as affected by crop cover treatments and measurement positions measured on 30 July 1990 (... days after planting).

Treatment	Sorptivity ($mm.sec^{-.5}$) Position			Row vs. Traffic
	Row	Traffic	Means	
A4	3.549 a[1)]	1.342 a	2.446 a	**[2)]
D5	3.095 a	2.076 a	2.585 a	ns
G6	3.852 a	2.614 a	3.233 a	ns
J3	3.799 a	1.887 a	2.843 a	**
Position means	3.574	1.979	2.777	ns
C.V. (%)	64	78	70	

1) Numbers followed by common letters indicate that treatment means are not significantly different at 5 % level as tested by Fisher's LSD.
2) Contrasts between row and traffic positions are significant at the 5 % level (*), at the 1 % level (**), and not significant at the 5 % level (ns).

Table 7. Ln(0.5 + sorptivity) as affected by tillage and irrigation systems measured on 10/11/1988 for SALISBURY experiment.

Treatment	Position			Means
	Row	Traffic	Untraffic	
	mm sec$^{-1/2}$			
CN1	0.904 a[1)] q	0.300 a r	1.474 a p	0.893 a
CN2	0.868 a q	-0.056 b r	1.400 a p	0.738 b
NT1	0.840 a p	-0.091 b q	0.998 b p	0.582 c
NT2	0.349 b q	-0.249 b r	0.643 c p	0.248 d
Position means	0.740 q	-0.024 r	1.129 p	0.615
C.V. (%)	38	1301	28	42

1) Numbers followed by common letters are not significantly different at 5 % level as tested by Fisher's LSD (letters a, b, and c are for between treatment and letters p, q and r are for between position comparisons).

Table 7 a. Cumulative infiltration as affected by tillage and irrigation systems measured on 10/11/1988 for SALISBURY experiment.

Treatment	Position			Means
	Row	Traffic	Untraffic	
	mm			
CN1	21 a q	10 a r	38 a p	23 a
CN2	21 a q	6 b r	37 a p	21 a
NT1	22 a p	5 b q	24 b p	17 b
NT2	14 b q	5 b r	19 b p	13 c
Position means	19 q	7 r	29 p	18
C.V. (%)	31	57	30	32

1) Numbers followed by common letters are not significantly different at 5 % level as tested by Fisher's LSD (letters a, b, and c are for between treatment and letters p, q and r are for between position comparisons).

Table 8. Ln(0.5 + sorptivity) as affected by tillage and irrigation systems measured on 9/12/1989 for SALISBURY experiment.

Treatment	Position			Means
	Row	Traffic	Untraffic	
	mm sec$^{-1/2}$			
CN1	0.505 a[1)] q	0.447 a q	1.244 a p	0.732 a
CN2	0.155 b p	0.181 b p	0.492 b p	0.276 b
NT1	0.291 ab q	-0.272 c r	0.577 b p	0.199 b
NT2	0.091 b q	-0.553 d r	0.332 b p	-0.043 c
Position means	0.261 q	-0.049 r	0.662 p	0.291
C.V. (%)	138	650	71	127

1) Numbers followed by common letters are not significantly different at 5 % level as tested by Fisher's LSD (letters **a, b, c, and d** are for between treatment and letters **p, q and r** are for between position comparisons).

Table 8 a. Cumulative infiltration as affected by tillage and irrigation systems measured on 9/12/1989 for SALISBURY experiment.

Treatment	Position			Means
	Row	Traffic	Untraffic	
	mm			
CN1	14 a q	14 a q	35 a p	21 a
CN2	9 a p	11 a p	16 b p	12 b
NT1	10 a q	3 b r	15 b p	9 bc
NT2	9 a q	4 b r	12 b p	8 c
Position means	10 pq	8 q	19 p	13
C.V. (%)	60	81	60	64

1) Numbers followed by common letters are not significantly different at 5 % level as tested by Fisher's LSD (letters **a, b, and c** are for between treatment and letters **p, q and r** are for between position comparisons).