Plant and Soil **237:** 25–35, 2001.

Soil water dynamics in row and interrow positions in soybean (*Glycine max* L.)

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Received 28 November 2000. Accepted in revised form 19 July 2001

Key words: plant canopy, stemflow, throughfall, time domain reflectometry

Abstract

Quantitative knowledge of infiltration processes and the mechanisms that control water movement in soil is necessary to properly manage water and chemical use in agricultural fields. The objective of this study was to compare the soil water content dynamics in row and interrow positions in a soybean crop (*Glycine max* L.) under conventional (plow) tillage. Two field plots (Beltsville silt loam soil, Fine-loamy mixed mesic Typic Fragiudult) were instrumented with Time Domain Reflectometry (TDR) probes at 0–10 cm, 0–25 cm and 0–40 cm depths. TDR probes were installed in the row and interrow positions. Soil water content was continuously monitored at 1 hour intervals. The distribution of infiltrated water and evapotranspiration showed strong row-interrow patterns. The row positions received significantly more water during precipitation than the interrow positions. Water loss, due to evapotranspiration, was also significantly greater in the row position than in the interrow position. Both plant and soil characteristics appeared to be important factors for infiltration and redistribution. The results of this study suggested that the presence of the crop canopy altered the surface boundary conditions of the soil and, hence, the volume of infiltrating water. Results of this study suggest that in order to model water movement in row crops, the ability to simulate canopy architecture and flow processes in two dimensions is necessary.

Introduction

The practice of planting agricultural crops in rows results in the potential for large variations in water and solute transport, and distributions with respect to distance from the plant stem. The crop canopy intercepts rainfall and changes the intensity, amount and distribution of water that reaches the ground (Haynes, 1940). McGregor and Mutchler (1982) reported that the number of raindrops per unit area under a corn plant (*Zea mays* L.) decreased with increase in canopy, but median drop sizes were larger under the canopy than in the open midrow area. Water droplets cascading from leaf to leaf at the outer boundary of the canopy grow in size due to aggregation of smaller raindrops although the velocity is decreased (Kitanosono, 1972; Morgan, 1985). Haynes (1940) reported that the amount of rain (throughfall) passing through the canopy (other than water flowing down the stem) and reaching the ground in row crops was greatest in the mid-row position. The amount of throughfall decreased toward the stem.

Armstrong and Mitchell (1987) found a linear relationship to ground rainfall as a function of distance from stem for both corn and soybean (*Glycine max* L.). Intercepted rain may also be directed toward the plant and reach the ground as stemflow in most crops (Bui and Box, 1992; Haynes, 1940; Quinn and Laflen, 1983). Up to 47% of rainfall arriving at the soil as stemflow has been reported for corn (Quinn and Laflen, 1983) and 30% for soybean (Haynes, 1940). The magnitude of stemflow and canopy throughflow depends on the stage of growth and rainfall rate. Throughflow remains fairly constant until about 50% crop cover is reached in corn and 35% in soybean

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(Morgan, 1985). After this point, interception of rainfall increases markedly. Paltineanu and Starr (2000) reported that the ratio of stemflow – throughflow was 20–30 times larger when rainfall amounts were less than 5 mm. At higher rainfall rates, the proportion of rainfall reaching the soil as stemflow decreased. The amount of stemflow has also been found to correlate with total leaf area (Bui and Box, 1992).

Throughfall and stemflow of intercepted rain may have marked effects on the soil water dynamics. Because of the higher intensity of rainfall in uncovered midrow positions before 100% crop cover is established, the soil in the interrow position may crust while the soil beneath the canopy is protected from crusting (Ben–Hur et al., 1989). Large amounts of stemflow may result in enhanced water flow around the brace roots of corn thereby increasing erosion (Bui and Box, 1992). Furthermore, the plant canopies and root systems change with time with respect to both their extent and geometry and, as a result, their effects on hydrologic processes may also vary. Differences in solute transport between row and interrow positions have also been observed in maize (Timlin et al., 1992) where it was reported that a larger amount of uniformly applied solute was recovered in the row position than in the interrow position in corn.

While there is a large amount of information for rainfall distribution under plant canopies, there have been few measurements of the water that actually infiltrates. Furthermore, most measurements have been taken only on a daily basis (Van Wesenbeek and Kachanoski, 1988). The objective of this study was to derive information about infiltration and plant water uptake from hourly soil moisture observations in row and interrow positions.

Materials and methods

Field studies were conducted in 1994 at the Beltsville Agricultural Research Center at Beltsville, MD on a Beltsville silt loam soil (Fine-loamy mixed mesic Typic Fragiudult). Maturity group III soybeans (cv. Morgan) were planted with row spacing of 0.5 m on 28 June, 1994. Plots were seeded in excess and hand-thinned at emergence to obtain the desired plant density of 40 plants m^{-2}. Rainfall was augmented by irrigation with an overhead sprinkler system. In order to study effects of soil water dry down on water uptake, irrigation was withheld during a 15-d period after the canopy was fully developed. Approved herbicides were used for weed control and no cultivation was used. Weeds that escaped chemical control were removed manually.

Water content measurements

Time Domain Reflectometry (TDR) probes having three waveguides were installed vertically into the soil to 10, 25 and 40 cm in two neighboring plots in the row and interrow positions. The 10-cm probes were made from three 0.984-mm dia threaded rods (10 cm long) fixed in a rigid plastic handle and soldered to 50 ohm coaxial cable. The spacing between the outer rods was 7 cm. The 25 and 40-cm TDR probes were made from three 0.492-mm diameter welding rod (25 and 40 cm long) and connected to 50 ohm coaxial cable via alligator clips. The welding rods were inserted using a fixed wooden template to insure that the rods were parallel. The rod spacing was 6.5 cm between the outer two rods. The soil at the measurement sites was carefully leveled to minimize surface topography effects on runoff and infiltration. The wave traces were inspected frequently to detect poor connections. The use of alligator clips did not appear to affect the quality of the wavetraces. The relationship between the apparent dielectric constant and water content was calibrated with data taken from soil cores at the site.

The TDR measurements were taken by a Tektronix 1502B cable tester (Tektronix Corp, Beaverton, OR). A Cambell Scientific CR10 (Cambell Scientific Co, Logan, Utah, USA) data logger and multiplexors were used to control the cable tester and switch among the TDR probes. Water contents were measured hourly except during the night period from 6 pm to 6 am when measurements were recorded every 3 h to conserve data logger memory. The wave traces were saved for later analysis and determination of water content.

Daily evapotranspiration rates were calculated from water contents averaged over a 4 h period between the hours of 5 and 9 am. The average water contents were differenced over a 24 h period to obtain a daily evapotranspiration rate in cm d^{-1}. The water contents were filtered to eliminate periods after rainfall where some water loss may have occurred as a result of drainage.

In order to quantify cumulative infiltration during rainfall, the rainfall events were classified into discrete periods. Times with rainfall occurring within the same 24 h period were classified into the same rainfall period. Times with rainfall that were separated by more than 24 h were classified into different periods. Cumulative soil water storage was calculated by summing positive differences in water contents during an infiltration period. The total cumulative soil water storage at the end of the rainfall period was used for comparison of total infiltration in the row and interrow periods.

Data on plant height, leaf area index (LAI) and canopy light interception were collected non-destructively at weekly intervals using a LAI-2000 Plant Canopy Analyzer (LI-Cor Inc., Lincoln, NE). Data on plant height were collected on 10 different randomly selected plants from each plot. At the end of the season (10 October, 92 days after emergence), the plants were cut at the soil surface and removed from the plot.

Weather data were collected from an automated weather station (500 m from the field plots). The data included hourly net radiation, rainfall, wind velocity, relative humidity and temperatures. Values of potential evapotranspiration were calculated using the Penman equation (Penman, 1956). The weather station is surrounded by a large (approx 150 ha) cultivated area planted to soybean, corn, turfgrass and vegetables.

The statistics for comparisons of means were carried out with Proc Means and regressions were carried out with Proc Reg of SAS (SAS Institute, 1985). We used indicator variables (Neter and Wasserman, 1975, p 279–338) in multiple linear regression to obtain parameters for regression lines in order to calculate values of the Students t-statistic to make comparisons of slopes.

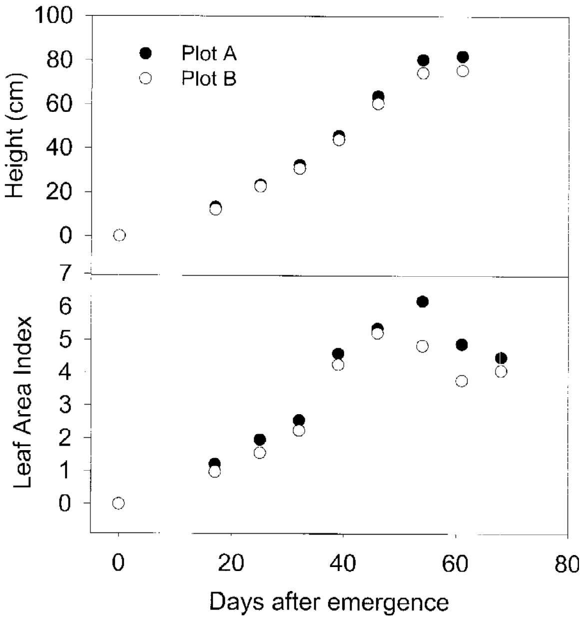

Figure 1. Leaf area index and plant height of the soybean canopies as a function of time for the two plots.

Table 1. Mean water contents in the row (R) and interrow (IR) positions for days after emergence 20–68

Plot	0–10	0–25	0–40
		$cm^3\ cm^{-3}$	
Plot A			
IR	0.227	0.260	0.276
R	0.222	0.212	0.253
Plot B			
IR	0.206	0.227	0.291
R	0.234	0.272	0.337

Results

Plant canopy development

Figure 1 shows plant height and LAI (leaf area index) as a function of time. The LAI and heights of the plants in both plots showed a similar progression with time. Peak LAI was reached at 50 days after emergence (DAE). The decline in LAI after DAE 60 was partially due to severe moisture stress.

Changes in water contents over time

The dynamics of water content changes as a function of infiltration and evapotranspiration for the 0–25 cm depth are shown in Figure 2. Rapid increases in water content occur as a function of rainfall or irrigation. The diurnal pattern of water uptake by plants and evaporation from soil is seen in the decrease in water content during the daylight period and relatively constant water content at night. The inset in Figure 2 shows that 1–2 days after rainfall, water loss during the night hours was negligible. In fact, we often saw a small increase in water content near the dawn hours. This could be due to upward movement of water from deeper in the profile, condensation of water in the soil pores during the morning hours, or exudation of water from plant roots. The latter has been reported by Song et al. (2000). The water contents reached their minimum value during the drying period beginning 50 days after emergence. Toward the end of this period, the plants were visibly wilting.

The row water content was higher than the interrow water content in plot A and the row water

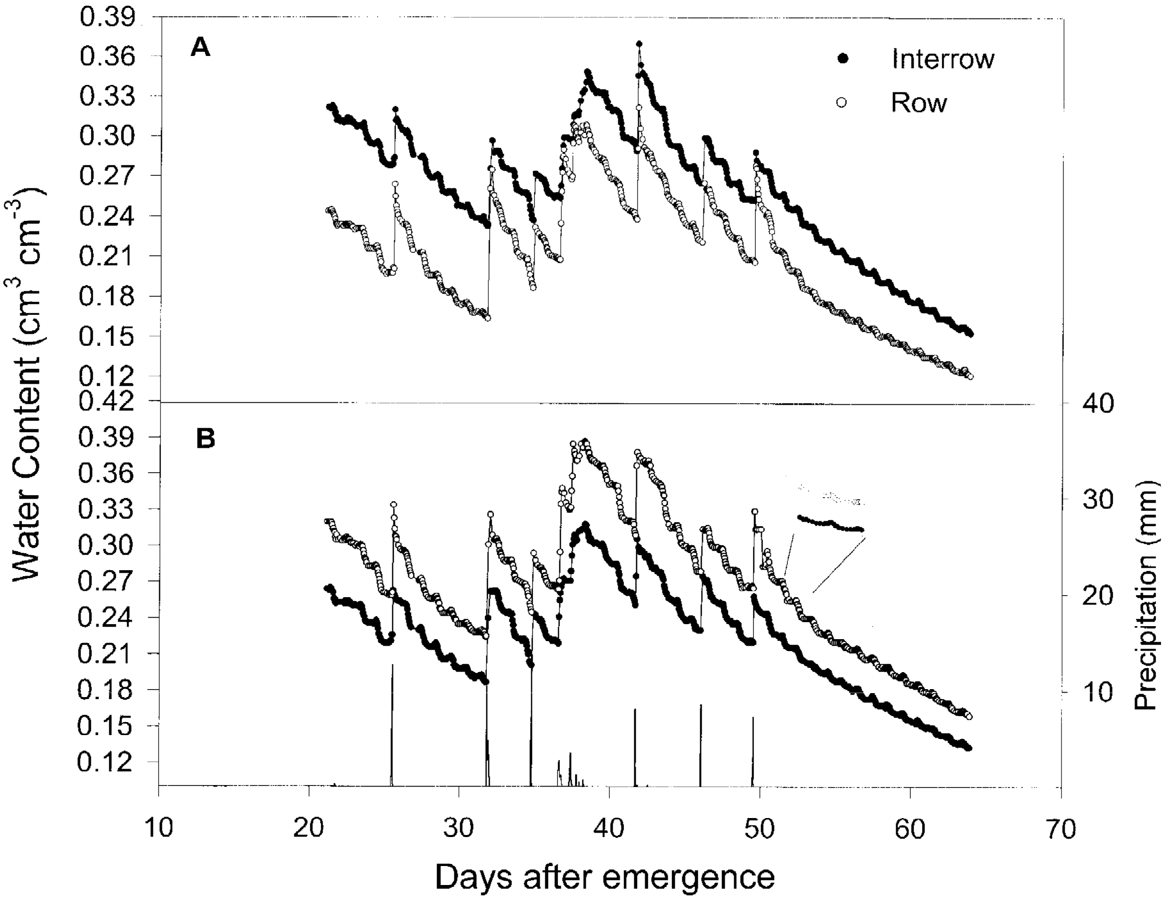

Figure 2. Water content changes due to water uptake and infiltration in the row and interrow zones of the two plots in the 0–25 cm depth.

content was lower than the interrow water content in the plot B (Table 1 and Figure 2). Van Wesenbeek and Kachanoski (1988) reported lower water contents in the row position as compared to the interrow position and attributed this to higher rates of drying in the row position. In spite of the differences in water content measured in this study, the water regimes in the row positions for the two plots were very similar. These differences in water content may have been due to spatial variability in the water content vs. matric potential relationships or soil compaction.

Water uptake and evaporation from the soil

Evapotranspiration (ET) measured by TDR in the 0–25 cm depth of Plot A vs. calculated ET is shown in Figure 3. The purpose of this comparison was to provide a check on the water content measurements. The magnitudes of the measured and calculated values are in reasonable agreement and they vary similarly from day to day. However, the maximum measured values of evapotranspiration were somewhat higher than the maximum calculated values. A component of these differences could be the result of calculating evapotranspiration by differencing noisy measured water contents.

There were small but significant differences in water loss due to evapotranspiration between the row and interrow positions for most of the probe locations (Table 2). Negative values in Table 2 indicate greater water loss from the row position. Before the plants began to lose their leaves (DAE 68), the differences for all but the 0–25 cm probe in plot A and the 0–10 cm probe in plot B show significantly more water loss from the row position than from the interrow position, although the magnitudes of the differences are small. Based on the mean difference, over a 68 day growing season, there could be a 2–3 cm difference in water uptake due to evapotranspiration between the row and

Table 2. Mean differences in water contents between the row and interrow positions over 24 hours due to evapotranspiration. Negative values indicate greater water loss from the row position since water loss is expressed as a negative value. The *t* statistic tests probability that mean is not zero. The crop began to senescence after DAE 68.

		Mean difference in water loss between the row and interrow zones					
		N	Mean	Min	Max	*t*	Prob
			cm d-1				
			Before DAE 68				
Plot A							
	0–0.10	22	−0.036	−0.173	0.023	−3.08	0.006
	0–0.25	23	−0.003	−0.283	0.142	−0.19	0.848
	0–0.40	23	−0.057	−0.440	0.040	−2.52	0.020
Plot B							
	0–0.10	23	−0.019	−0.210	0.080	−1.61	0.121
	0–0.25	23	−0.059	−0.225	0.033	−4.60	0.000
	0–0.40	18	−0.144	−0.653	0.027	−3.68	0.002
			After DAE 68				
Plot A							
	0–0.10	28	−0.025	−0.173	0.090	−2.11	0.045
	0–0.25	30	−0.012	−0.275	0.125	−0.79	0.439
	0–0.40	21	0.053	−0.307	0.667	1.09	0.287
Plot B							
	0–0.10	28	−0.011	−0.140	0.130	−0.86	0.396
	0–0.25	24	−0.013	−0.217	0.325	−0.55	0.587
	0–0.40	30	0.042	−0.347	0.347	1.48	0.149

interrow positions. After DAE 68, the differences were smaller and none were significant.

Figure 4 shows the water contents in the 0–25 cm depth for the two plots during the two week drying period that began 48 days after emergence. Visual inspection of the data suggest two distinct periods of drying. The slope of the water content values appear to be steeper at the beginning of the period as compared to the end. Slopes were calculated from regression lines fitted to the periods from 50.3 days after planting to 54 (period 1) and 60 days after planting to 63.5 (period 2) for the row and interrow positions at all the locations. The values of the slopes are given in Table 3 and the slopes for the 0–25 cm depth are plotted with the hourly measured water content data in Figure 4.

Two periods of drying are clearly distinguished in Figure 4. The apparent transition point for both plots occurs near DAE 55. Water uptake rates during period 1 were significantly larger than the uptake rates for period 2 for the 0–25 cm data in Figure 4. Water uptake from the row position was also significantly greater than from the interrow position for all the depth intervals during period 1 (Table 3). During period 2, the differences in water uptake between the row and interrow positions were not consistent. There were significant differences between the row and interrow positions for the second period only in the 0–25 cm depth in Plot A and in the 0–25 and 0–40 cm depths in Plot B. In Plot A, the interrow water uptake rate was greater than in the row.

The slopes in Table 3 show that during period 1, most of the water was taken from the 0 to 25 cm depth since the water uptake rates from the 0 to 40 cm depth were not much larger. During period 2, the 0–40 cm depth appears to contribute more toward water uptake suggesting deeper root extraction of water. The 0–10 cm depth contributed little to water uptake in the second period.

For the period from DAE 50.3 to 55, the total evapotranspiration estimated using the Penman equation was 1.88 (0.31 per day) and 2.10 (0.30 per day) cm for the period DAE 55–63.5. This indicated that the energy available for evapotranspiration was similar for both periods. The calculated water uptake, based

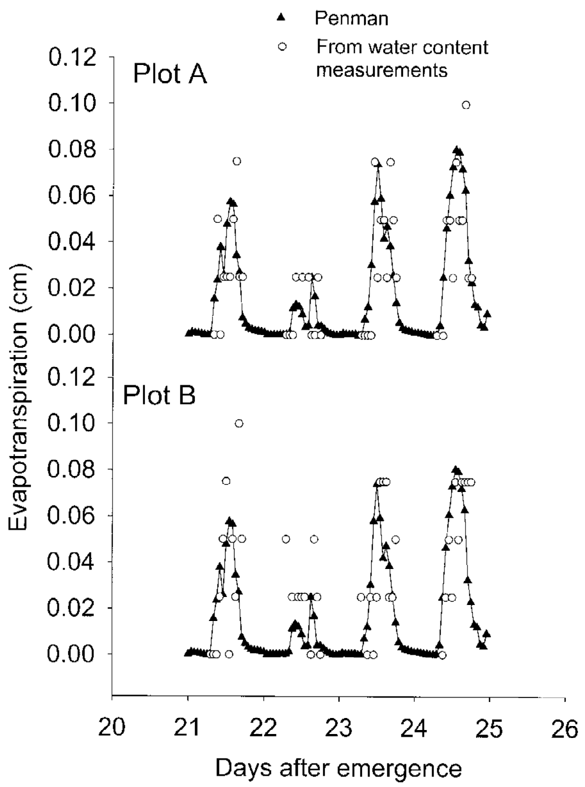

Figure 3. Evapotranspiration in Plots A and B measured by TDR in the 0–25 cm depth vs. ET calculated using the Penman equation.

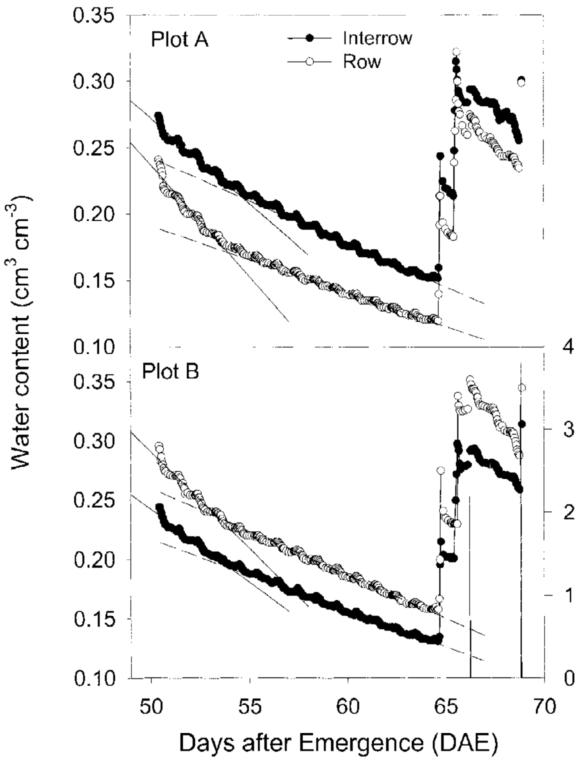

Figure 4. Water contents for the 0–25 cm depth showing a slowing of water uptake rates as the soil dries. Four regression lines are also plotted. The solid regression lines show projected changes in water content due to plant water uptake for the wetter range of soil water contents. The dashed lines show projected changes in water content for the dryer range of soil water contents. Irrigation was applied at DAE 65 and 66. Rainfall occurred on DAE 67 and 69.

on the slope values in Table 3 for the 0–25 cm depth for period 1 was approximately 2.5 cm for both plots. The calculated uptake from the row position for the second period was 0.88 for plot A and 1.29 cm for plot B from the 0 to 25 cm depth. The uptake from the row position during the second period from the 0 to 40 cm depth was 1.37 for plot A and 2.19 cm for plot B. These uptake rates were less than during period 1 and suggest the plants, especially in Plot A were not able to fully meet evaporative demand from the 0 to 40 cm depth of soil. Starr and Paltineanu (1998) noted similar transitions from large daily changes in water storage to smaller daily changes due to decreasing plant water uptake. The water uptake rates for the drier soil in Starr and Paltineanu's study (1998) was roughly half the rates when the soil was wetter.

Mean daily water uptake for the period before DAE 68 is shown in Figure 5. In Plot A, most of the water uptake appears to have been confined to the 0–25 cm depth for both row positions. Root activity in the row position of plot B appears to extend deeper than root activity for plot A according to the data in Figure 5. The 0–40 cm depth in the row position of Plot B supplied a significant portion of water. This is consistent with the observations of the drying period shown in Figure 4.

Cumulative water storage during rainfall

During irrigation or rainfall, the water contents in the row position appeared to have increased more than the water contents in the interrow. Figure 6 shows cumulative water storage as a function of time at the row and interrow positions for three time periods. The cumulative water storage increased faster in the row positions for both plots in the interrow positions. This occurred for most of the infiltration events before the canopy had senescenced. Later in the year, after senescence, the differences were not as strong and cumulative water storage in the interrow position may even have been higher than storage in the row position (Figure 6c).

The mean differences between the row and interrow positions in the total increase in soil water storage

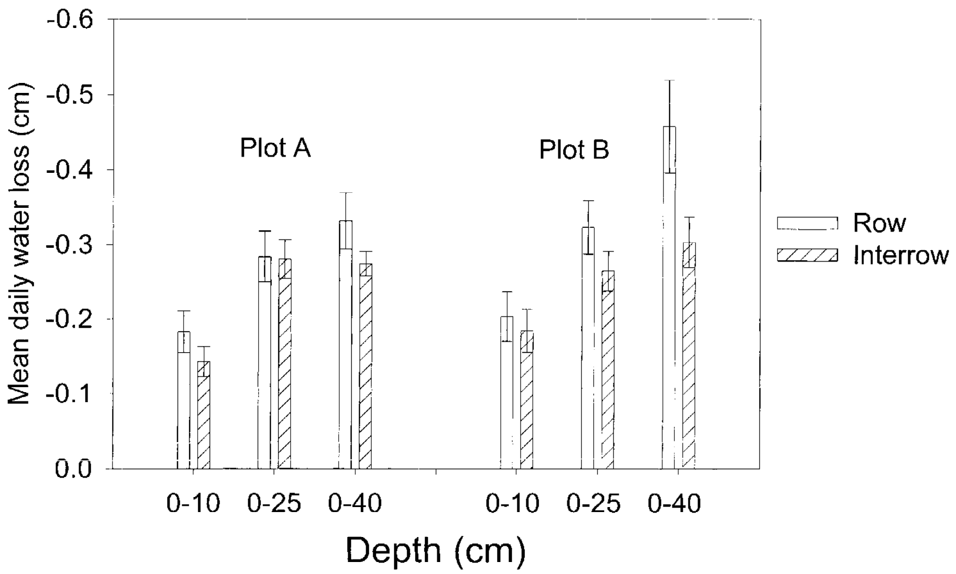

Figure 5. Mean daily water uptake (cm) from the row and interrow positions from three depth intervals from DAE 20 to 86.

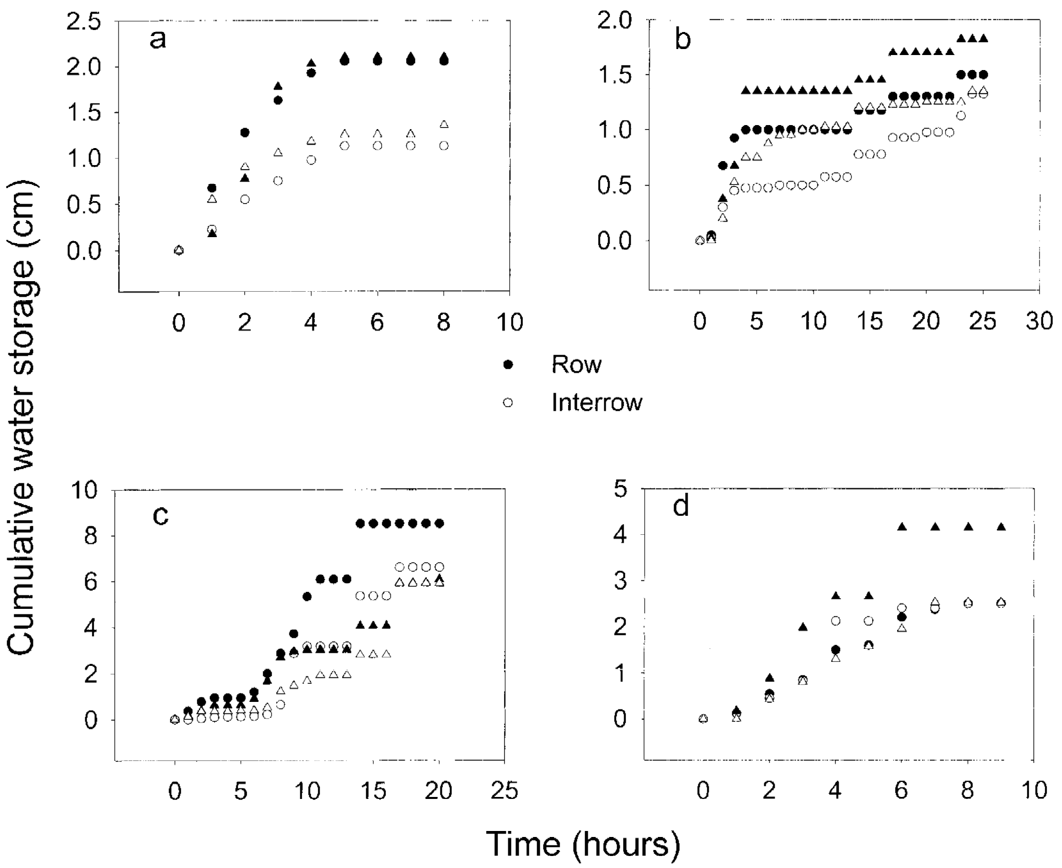

Figure 6. Increase in total water storage vs. time for the row and interrow positions for three time periods of rainfall, DAE 36 (a) DAE 37 (b), DAE 73 (c) and DAE 104 (d).

Table 3. Slope values for the regression of water content vs. time during a 14-day period of soil drying. Period 1 refers to the beginning of the period, DAE 50.3–54. Period 2 refers to the end of the period, DAE 60 – 63.45. The slope values were multiplied by probe length to obtain total water uptake from the depth indicated

	Depth	Period 1		Period 2	
		Row	IR	Row	IR
Plot A	m		cdm d^{-1}		
	0–0.10	−0.235a[a]	−0.184b	−0.064c	−0.062c
	0–0.25	−0.420a	−0.322b	−0.125c	−0.162d
	0–0.40	−0.412a	−0.324b	−0.196c	−0.22c
Plot B					
	0–0.10	−0.301a	−0.239b	−0.062c	−0.058c
	0–0.25	−0.408a	−0.307b	−0.183c	−0.150d
	0–0.40	–	–	−0.312c	−0.236d

[a] Slopes with different letters (within a row) are significantly different (p<0.001)

Table 4. Mean differences between the row and interrow positions in total water storage at the end of rainfall for all rainfall periods. Positive values indicate a greater amount of water entered the soil in the row position. The t statistic tests probability that mean difference is not zero

	Row - Interrow difference in total water storage						
	Depth	*N*	Mean	Min	Max	*t*	Prob
	m				cm		
			Before DAE 68				
Plot A							
	0–0.10	7	0.46	−0.02	1.05	2.59	0.0410
	0–0.25	7	0.56	0.10	0.95	3.92	0.0078
	0–0.40	7	0.39	−0.52	0.72	2.23	0.0673
Plot B							
	0–0.10	7	0.23	−0.44	0.56	1.58	0.1658
	0–0.25	7	0.50	0.15	0.83	5.17	0.0021
	0–0.40	7	1.10	−0.24	2.16	3.28	0.0169
			After DAE 68				
Plot A							
	0–0.10	6	−0.13	−1.37	0.43	−0.515	0.6284
	0–0.25	6	0.16	−0.53	1.90	0.449	0.6723
	0–0.40	5	0.44	−1.00	2.40	0.786	0.4759
Plot B							
	0–0.10	6	0.14	−0.19	0.44	1.353	0.2342
	0–0.25	6	0.31	−0.68	1.63	0.956	0.3829
	0–0.40	5	−0.54	−2.04	1.12	−0.951	0.3953

due to infiltration at the end of an infiltration event are given in Table 4. Positive values indicate more water entering the soil in the row position than in the interrow position. Most of the differences for the period before DAE 68 (before plant senescence) are significant at the 95% level and all the differences are positive. The difference for the 0–10 cm depth in Plot A is not significant. After DAE 68, the differences are smaller and none are significant. Overall, before DAE 68, while there was a crop canopy, rainfall or irrigation increased the water content in the row position more than it increased water content in the interrow position. Van Wesenbeek and Kachanoski (1988) reported similar results for maize.

Because these differences were not significant after plant senescence, this suggests that the presence of the plant canopy contributed to the differences in water storage accumulation between the two row positions. It has been shown that the crop canopy protects the soil from raindrop impact and therefore can reduce crusting and sealing (Ben–Hur et al., 1989). It has also been shown that the crop canopy can intercept rainfall and direct it to the interrow position and toward the plant stem (Haynes, 1940; Paltineanu and Starr, 2000). These would act to increase the amount of water available for infiltration in the row position.

Figure 7 shows the mean increase in soil water storage at the end of a rain event for DAE 20 – 68. The mean total increase in soil water storage was only slightly higher for the 0–25 and 0–40 cm depths than for the 0–10 cm depths except for the Plot B row position. Only in Plot B was the increase in water in the 0–40 cm depth in the row position much greater than in the 0–25 cm depth. These results suggest that most of the infiltrated water remained in the 0–25 cm depth interval in Plot A for both the row and interrow positions and the interrow position for Plot B.

The amount of water infiltrated into the 0–40 cm depth of the row position of Plot B was considerably greater than mean rainfall/irrigation. The relatively low error for the increase in water storage indicates that this discrepancy was not due to one or two extreme values. We can only speculate that this could possibly be due to the effects of the arrangement of the plant canopy above the row position probes that funneled a large amount of water to their location, due to a shallow perched water table or due to high microvariability in rainfall intensity. This measurement also corresponds to the larger amount of water uptake

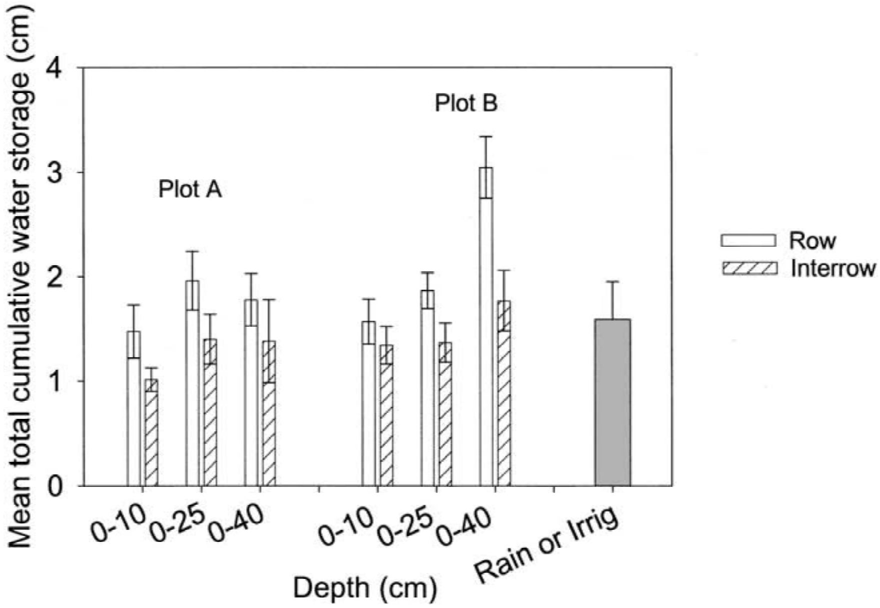

Figure 7. Mean total increase in water storage (cm) for each infiltration event into the row and interrow positions for three depth intervals from DAE 20 to 86.

measured in the 0–40 cm depth of the Plot B row position.

The differences between the two plots in terms of row-interrow comparisons could be explained on the basis of greater cumulative infiltration into the soil in Plot B. If the water entering the soil in Plot A was not sufficient to wet below 25 cm, then the differences between the row and interrow positions would be larger in the upper section of the profile since this is where most of the water uptake would occur. Similarly, if there was enough water infiltrating into Plot B to wet deeper than in Plot A, then most of the differences between the row and interrow positions would be seen deeper in the profile of Plot B. In fact, there was much more water uptake from the 0–40 cm depth of the row position of Plot B than from the row position of Plot A. This reasoning is consistent with the result that the row-interrow differences were not significantly different in either the 0–10 cm depth of plot B or the 0–40 cm depth of Plot A.

Some of the data suggested a higher rate of drainage in the row position shortly after rainfall than in the interrow position after the rain ended. An examination of the water contents in Figure 2 near DAE 25 suggests that the row water contents were decreasing faster than the interrow water contents shortly after the rainfall. This can be seen in several of the other times after rainfall as well. A faster decrease of water in the row position than in the interrow position would prevent the occurrence of an increasing difference between row and interrow water contents. This behavior could also contribute to the differences in water uptake between row and interrow positions. The effect would not dominate, however, since differences in water uptake between row and interrow positions were not calculated for periods shortly after rainfall. This observation suggests that the presence of higher root density in the row position could influence the hydraulic properties of the soil by increasing drainable porosity or hydraulic conductivity in the wet range of soil moisture. Studies have shown that bulk density decreases and porosity increases where there is an increase in soil organic matter (Ahuja et al., 1998; Hall et al., 1977).

Summary and conclusions

During a 14-d period with no rainfall or irrigation, the rate of change in stored water from the row zone was significantly greater than from the interrow zone for all the depths. The 14-d period could be divided into two subperiods where there was a transition to smaller rates of changes in stored water after approximately 4 d as the soil dried. After the transition to smaller rates of changes in stored water, the average decrease in water storage was similar for both the row and interrow periods.

There were small but consistent differences in water loss from the row and interrow zones. The mean water loss from the row zones was 0.02 cm – 0.15 cm per day greater than water loss from the interrow zones. The differences were significant for two of the six probe locations before plant senescence and not significantly different for any of the probe locations after senescence.

There were significant differences in cumulative soil water storage between the row and interrow positions during and after rain or irrigation. The differences in cumulative water storage were often larger early in the infiltration event and diminished toward the end. These differences could be attributed to the presence of the crop canopy. After rainfall, the difference between the row and interrow water contents decreased. The slopes of the row and interrow water contents vs. time relationships approached a parallel configuration after rainfall, and the difference between the row and interrow water contents decreased. We believe this could be due to the higher water uptake by roots in the row position, as well as increased drainage from the soil in row positions. There may have also been some lateral movement of water from the row position to the interrow position. When water uptake by plants decreased due to drying of the soil, differences in water uptake between the row and interrow positions were small.

We believe that the presence of the plant dominated the water regime in this study rather than soil hydraulic properties. The water regimes in the row and interrow positions were quite different within plots. The water regimes were similar between the two plots for the same row position in spite of a relatively large variation in water content between the two plots. The relative water contents were reversed between the row and interrow positions of both plots, i.e. the row water content was lower than the interrow water content in Plot A, while the interrow water content was higher in Plot B. The higher water content in the row position vs. the interrow position in one plot of our study may have been a result of different moisture release characteristics due to soil compaction. The difference did not affect the overall observed trends. The results of this study suggest that, while the plant is actively growing, boundary fluxes of evapotranspiration and infiltration and their interaction with the plant may be as important a determinant of the water regime as soil hydraulic properties.

For modeling these processes, therefore, it may be important to consider the two-dimensional distribution of surface fluxes and water uptake from the soil. Timlin et al. (1992) showed that solute transport in maize is affected by crop row position. This study and others (Van Wesenbeek and Kachanoski, 1988) have shown that more water infiltrates into the row position than into the interrow position. At the same time, because of root activity, there may also be more water loss from the row position than from the interrow position (Arya et al., 1975). The net effect on solute transport may, therefore, be dependent on the relative frequency and amount of rainfall. As a result, any attempt to manage fertilizer movement in soil by placement in various row positions should take into account the expected frequency and timing of rainfall, as well as the crop canopy geometry.

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Section editor: B.E. Clothier