Wheat Root Dynamics as Affected by Landscape Position

K.C.J. Van Rees and R. Block
Department of Soil Science
5 1 Campus Drive
University of Saskatchewan
Saskatoon, SK S7N 5A8

Introduction

Previous work investigating root distribution and activity for wheat grown on shoulder and footslope landscape positions revealed that root length density was highest for the footslope compared to the shoulder position with root densities being highest in the surface for both landscapes. Root activity, as measured by a strontium tracer, showed that roots at depth (90 cm) were more effective in absorbing the tracer per unit root length than that for roots growing in the soil surface. Although these estimates for root activity give us some indication of root function they were measured for only one point in time on the landscape. Relatively little, however, is known about the growth and senescence of roots at various depths in the soil profile and how these dynamics are altered by landscape position. Therefore, the objective of this study was to determine the dynamics of root growth for spring wheat (cv Katepwa) grown on a shoulder and footslope landscape using a minirhizotron system.

Material and Methods

Spring wheat was grown on two landscape positions (shoulder and footslope) with a northerly aspect at a farm site located 30 km east of Saskatoon, SK. The landscape positions were classified with the procedure developed by Pennock et al. (1987) and the shoulder landscape was 4.0 m higher in elevation than the footslope with the area having an 8% slope. The soil of the eroded shoulder landscape was classified as an Entic Typic Haploboroll (Rego Dark Brown Chernozem) and the soil of the footslope landscape was classified as a Typic Haploborolls (Orthic Dark Brown Chernozem) (Soil Survey Staff, 1987).

Katepwa wheat was sown (101 kg ha“) at a 4 cm depth into wheat stubble on 30 May 1996 using a double disc drill (22.5 cm spacings). Anhydrous fertilizer was applied to the soil at a rate of 60 kg ha^{-1} two weeks prior to planting. Plant biomass was 2600 and 5070 kg ha“ and grain yield was 1110 and 1890 kg ha^{-1} for the shoulder and footslope landscapes, respectively at harvest (111 DAP).

Root dynamics were measured with a minirhizotron system which measures roots nondestructively (Taylor et al. 1990). Holes were made with a punch truck at a 45” angle to 150 cm depth and clear tubes constructed of cellulose acetate butyrate (5 cm dia. X 183 cm) were inserted into each hole. A metal rod (70 cm) was inserted next to each tube and the tube attached to the rod with a nylon strap in order to keep the tube from moving. The exposed tube aboveground was first spray-painted black to exclude light and then spray-painted white to reduce heat transfers to the tube. Three replications of three tubes were installed at both the shoulder and footslope landscape positions. A BTC-2 minirhizotron colour camera (Bartz Technology Co., Santa Barbara CA) was used with lighting from four 1.2W incandescent lamps and a camcorder to record the images. An indexing handle was used to position the camera head at specific locations in the tube and the camera head was moved at 4 set intervals down the entire length of the tube. Root images were recorded at 13,22, 34,43, 55, 64,78 and 92 days after planting (DAP) which corresponds to approximately 1, 2, 4, 9, 10.1, 1 1, 11 and 1 1 for the Feekes growth stages. Root images were then captured onto a computer (Hill and Van Rees, 1997) and the images analyzed with the RooTracker program to determine root length (m m^{-2}), and daily root production and mortality. Root production (m m^{-2} d^{-1}) was defined as new roots that were observed at subsequent sampling dates while root mortality (m m^{-2} d^{-1}) was defined as all roots that disappeared from the image at subsequent sampling dates.

Soil water contents (0) were measured hourly using an automated Time Domain Reflectometry (TDR) system (Campbell Scientific, Edmonton). Wave guides (30 cm long) were inserted horizontally in pit faces at 10, 20, 50, and 100 cm depths at 7 DAP. Two pit faces were monitored on the shoulder and footslope landscape positions. The dielectric constant was measured from the TDR trace hourly and then used in the equations given by Ledieu et al. (1986) to determine the soil water content. Soil water measurements for each depth are expressed as daily averages and rainfall as daily totals. Soil temperatures were also measured with equipment from Campbell Scientific (Edmonton) at depths of 5, 10,20,50 and 100 cm. Soil temperatures were measured every 10 min and averaged hourly.

Results and Discussion

Root length densities were highest **(60-80** m m^{-2}) for the 40-60 depth at the end of the growing season for the shoulder landscape whereas the highest concentrations of roots (120- 140 m m^{-2}) was located in the upper **20** cm of the soil profile for the footslope landscape.

The highest root production rates were 5-6 m m^{-2} d^{-1} and were concentrated in the centre of the soil profile (30-60 cm depth) for the shoulder landscape; however, the highest root production rates occurred around 43 DAP which corresponded to the time of booting (Fig. 1). Root production dropped off significantly after 55 DAP which is when the head was fully emerged but there appeared to be an increase in root production again at 78 DAP for the 40-80 cm depth. For the footslope, the highest root production rates were concentrated in the 10-20 cm depth (Fig. 1). The highest rates for the footslope also corresponded to 43 DAP, which was observed for the shoulder landscape. In the upper 50 cm of the soil profile, daily root production dropped off after 55 DAP, but continued on in the subsoil till 64 DAP.

Soil water contents for the 10 cm depth were fairly consistent until 43 DAP and then began to gradually decrease for both landscapes (Fig. 2a). Daily root growth also appeared to decrease at this time until the end of the growing season. Whether root production decreased as a result of decreasing water contents or due to the life stage of the crop is uncertain. There appeared to be no relationship between soil temperature and daily root growth for the O-10 cm depth (Fig. 2b).

Root mortality ranged from 0.5 to 2.5 m m^{-2} d^{-1} but did not begin until 55 DAP for the shoulder landscape and was limited to the upper 20 cm of the soil profile. For the footslope, root mortality began earlier in the growing season (34 DAP) although rates ranged from 0.5 to 1.5 m m^{-2} d^{-1}. Root mortality was also limited to the upper 30 cm of the soil profile for the footslope landscape.

Conclusion

Root dynamics for wheat at this site were quite different between landscape position with the lower fertility shoulder having root production concentrated deeper in the soil profile while at the footslope root production was higher closer to the soil surface. Daily root production rates were highest for both landscape at 43 DAP, and rapidly decreased after that time. Further measurements of root dynamics are needed across several landscapes to validate processes affecting root dynamics. The minirhizotron technique also lends itself to studying the role that roots may have in carbon sequestration by providing reliable estimates of root production, mortality and hence turnover.

References

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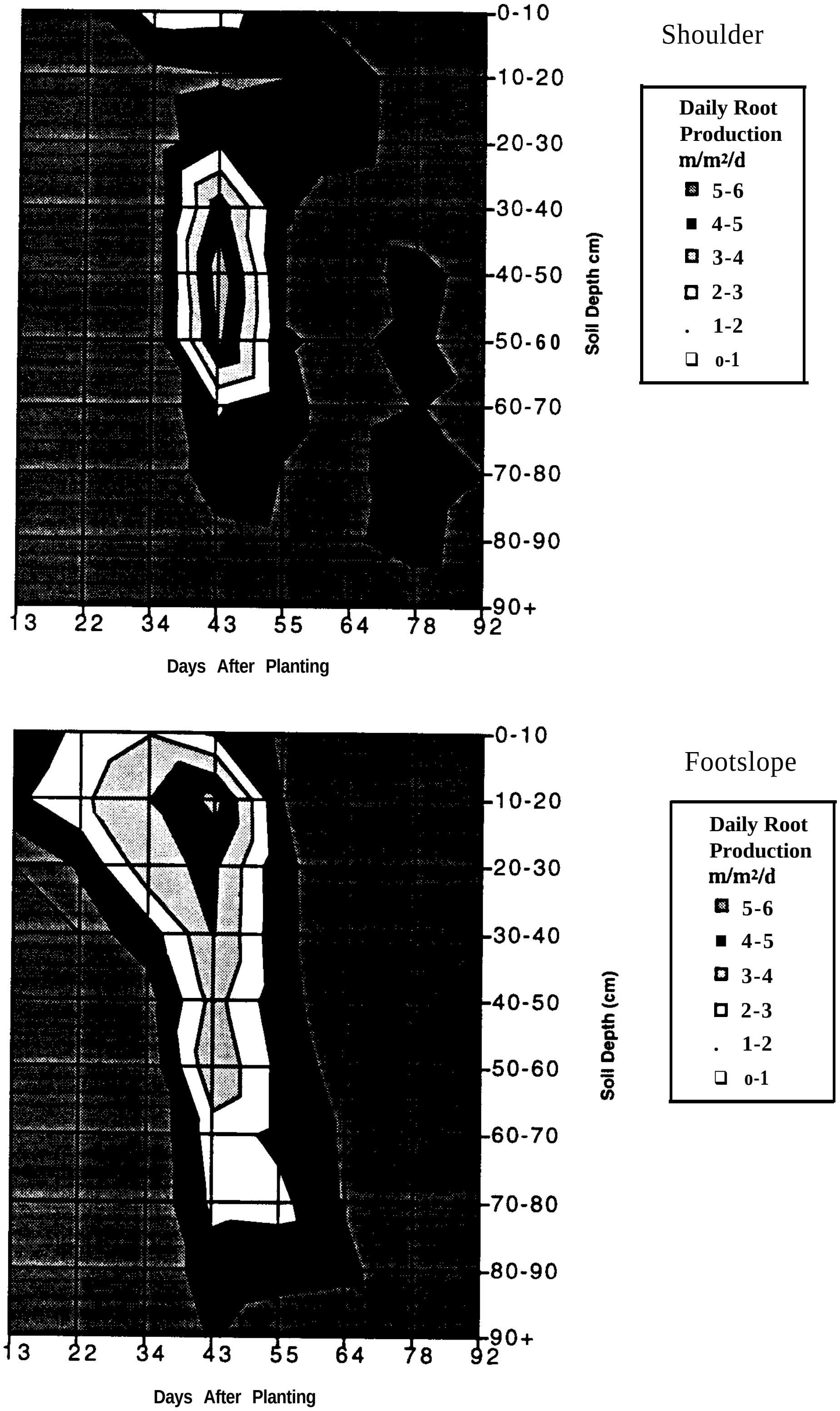

Figure 1. Daily root production for wheat grown on a shoulder and footslope landscape position.

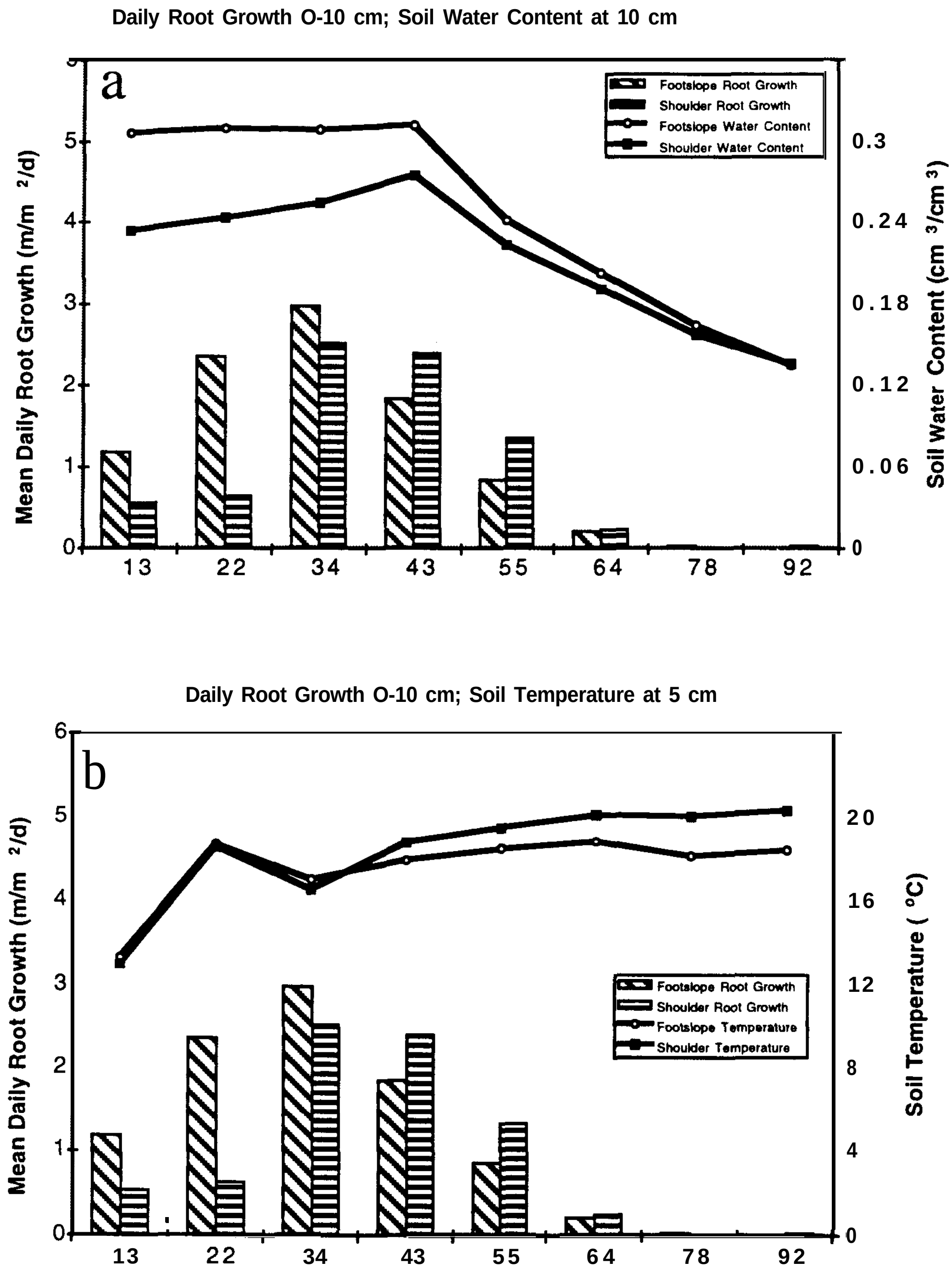

Figure 2. Comparison of soil water contents (a) and soil temperatures (b) to daily root production for the O-10 cm depth on the shoulder and footslope landscape.