# Effect of Landscape Position and Soil Depth on Wheat Root Activity Using a Stable Strontium Tracer

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## Introduction

Wheat roots are essential for supplying nutrients to the plant. However, little is known about the importance of roots at various soil depths to plant nutrition. It has been shown that surface wheat roots are most important in taking up nutrients (Tofinga and Snaydon, 1992; Bole, 1977). However, uptake of nutrients from subsoils can also be important (Williams and David, 1963). The objective of this study was to measure the activity of wheat roots (cv Katepwa) throughout the growing season at various soil depths and landscape positions using strontium chloride ($SrCl_2$) as a tracer. Stable strontium has been used successfully as a tracer for measurement of root activity and depth of penetration for other crops (Pinkerton and Simpson, 1979). Strontium uptake by the plant is similar to that of calcium (Russell and Squire, 1957; Bollard and Butler, 1966). Strontium is fairly immobile in the soil and also found in small amounts, thus making it an ideal tracer for root activity and penetration.

## Materials and Methods

The site used was an Elstow loam soil located five kilometers south of Clavet, Sask. A north-facing slope was chosen which had a length of 50 m and an elevational difference of 4 m. Three slope positions were studied: shoulder backslope and footslope positions. However, only the data from the shoulder and footslope positions will be presented.

Soils were sampled from the major horizons at each slope position and analyzed for pH, N, P, K, Ca, and Mg.

Two weeks after Katepwa wheat was planted, $SrCl_2$ was placed in plots at all three slope positions. Four treatments were used based on the depth of Sr placement: surface, 40 cm, 90 cm, and control (each treatment plot was 2 $m^2$ with 1 m between plots to avoid cross-contamination). In the surface treatment, the $SrCl_2$ was spread on the soil surface and raked in. A hand auger was used to drill holes to a depth of 40 and 90 cm for the other two treatments. A total of 72 holes were drilled in each plot and $SrCl_2$ was poured down a PVC pipe to avoid contamination of the upper horizons. Each treatment was replicated twice in a complete random block design. Each plot had 20 plants harvested at 5 different times throughout the season (33, 47, 58, 75, and 89 days after planting) and the shoot tissue was analysed for shoot weight, Sr concentration and Sr content.

Root length distrbution was determined at 77 days after planting (DAP). Soil cores were extracted to 120 cm and divided into 10 cm segments. The roots in these segments were washed and analysed for length using Image Analysis.

Soil moisture was analyzed using Time Domain Reflectometry (TDR). TDR probes (30 cm long) were inserted horizontally in a soil pit at 10, 20, 30, and

40 cm depths. Pits were located at all three landscape positions and rainfall was also recorded electronically. All readings were taken hourly and downloaded onto a computer every few weeks.

## Results

The A horizon varied in thickness from <10 cm at the shoulder to 15 cm at the footslope. The shoulder was a heavily eroded knoll as seen by the high amounts of Ca in the surface soil. There was also a buried A horizon at the footslope position indicating erosion of soil down the slope.

Organic matter levels varied at each slope position. Nutrient levels at the shoulder position were low because of the thin A horizon and low organic matter levels. The footslope had a thick A as well as a buried A horizon which were both high in organic matter, resulting in a higher fertility status (Table 1).

Bulk densities calculated for surface soils were 1.2 g/cm$^3$ while at 100 cm depths the bulk density was as high as 1.7 g/cm$^3$. The buried A horizon at the footslope was also quite dense with a bulk density of 1.5 g/cm$^3$.

Root length density was found to be highest at the surface and decreased with depth (Fig. 1). The footslope had the highest root length density while the shoulder and backslope positions had similar densities. At 77 (DAP), roots had grown to the 90 cm depth with a density of 0.5 cm/cm$^3$.

Rainfall and soil water distribution are important in understanding root activity. Data for the shoulder and footslope are shown in Figure 2. At the shoulder position, water contents at the beginning of the season were 0.25 cm$^3$/cm$^3$ and decreased slowly until a rainfall event. Precipitation increased water contents at all three depths measured. Soil moisture contents for the footslope were higher than those of the shoulder at the time of planting indicating that the footslope had a higher moisture holding capacity. The 20 cm depth showed the highest moisture content and this level corresponded to the buried A horizon which was higher in organic matter. The footslope dropped to a lower level of soil moisture than the shoulder throughout the season. This suggests that there were more roots absorbing water at this landscape position than at the shoulder position. Another important difference from the shoulder position is that lower soil depths did not show an increase in soil moisture with precipitation events.

Shoot weight distribution increased in all treatments over time (Fig. 3). The footslope showed the biggest gain in biomass followed by shoulder.

Total strontium in the wheat plant also increased throughout the growing season (Fig. 4). The plants on the footslope took up approximately three times more strontium than plants on the shoulder landscape. The surface and 40 cm treatments took up the most strontium in the shoulder postition. The similar root activity between the surface and 40 cm depth suggests that water infiltrated to this depth and was not absorbed by surface roots thus allowing the roots to function in nutrient uptake. At the footslope, the 40 cm treatment showed little activity before 47 DAP. This could be due to the inhibition of root penetration by the dense Ahb horizon. As well, precipitation did not infiltrate to the 20 cm depth possibly reducing activity of roots deeper in the profile. At the shoulder position, roots began to take up more Sr in the surface and 40 cm treatments after 47 DAP because soil moisture was increased due to precipitation. Roots did not penetrate to 90 cm until after 47 DAP because no activity was seen until after this time. Later in the season, roots at the 90 cm depth became more important in nutrient uptake as they absorbed up to 50 - 70 % of the Sr that was absorbed by surface roots.

## Conclusions

1. Wheat roots were observed to depths of 120 cm at all landscape positions.
2. Root activity varied at each slope position, mostly due to the moisture status of the soil.
3. Data suggests that subsoils are important for water and nutrient absorption, therefore absorption of nutrients and water in subsoils (>50 cm) should be included in nutrient uptake models to accurately simulate uptake processes.

## References

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**Table 1. Horizon Classification and Elemental Analysis of the Elstow Loam Soil.**

| Slope | Horizon | $NO_3$ | P | K | Ca | Mg | pH |
|---|---|---|---|---|---|---|---|
| | | ug/g | | | | | |
| Shoulder | Apk | 1.6 | 9.4 | 131 | 4366 | 198 | 8.0 |
| | Ck1 | 0.8 | 2.5 | 84 | 4368 | 374 | 8.1 |
| | Ck2 | 0.4 | 0.8 | 97 | 3752 | 529 | 8.3 |
| Backslope | Ah | 2.4 | 21.7 | 173 | 2789 | 151 | 8.0 |
| | Bm | 0.8 | 5.4 | 96 | 2054 | 357 | 7.6 |
| | Ck | 2.8 | 2.0 | 86 | 4187 | 337 | 8.2 |
| Footslope | Ah | 3.2 | 13.0 | 260 | 2850 | 232 | 7.7 |
| | Ahb | 3.0 | 9.5 | 121 | 3132 | 396 | 7.0 |
| | Ck | 0.8 | 3.1 | 145 | 2492 | 588 | 8.2 |

**Figure 1. Rainfall and Soil Water Distribution at Two Landscape Positions.**

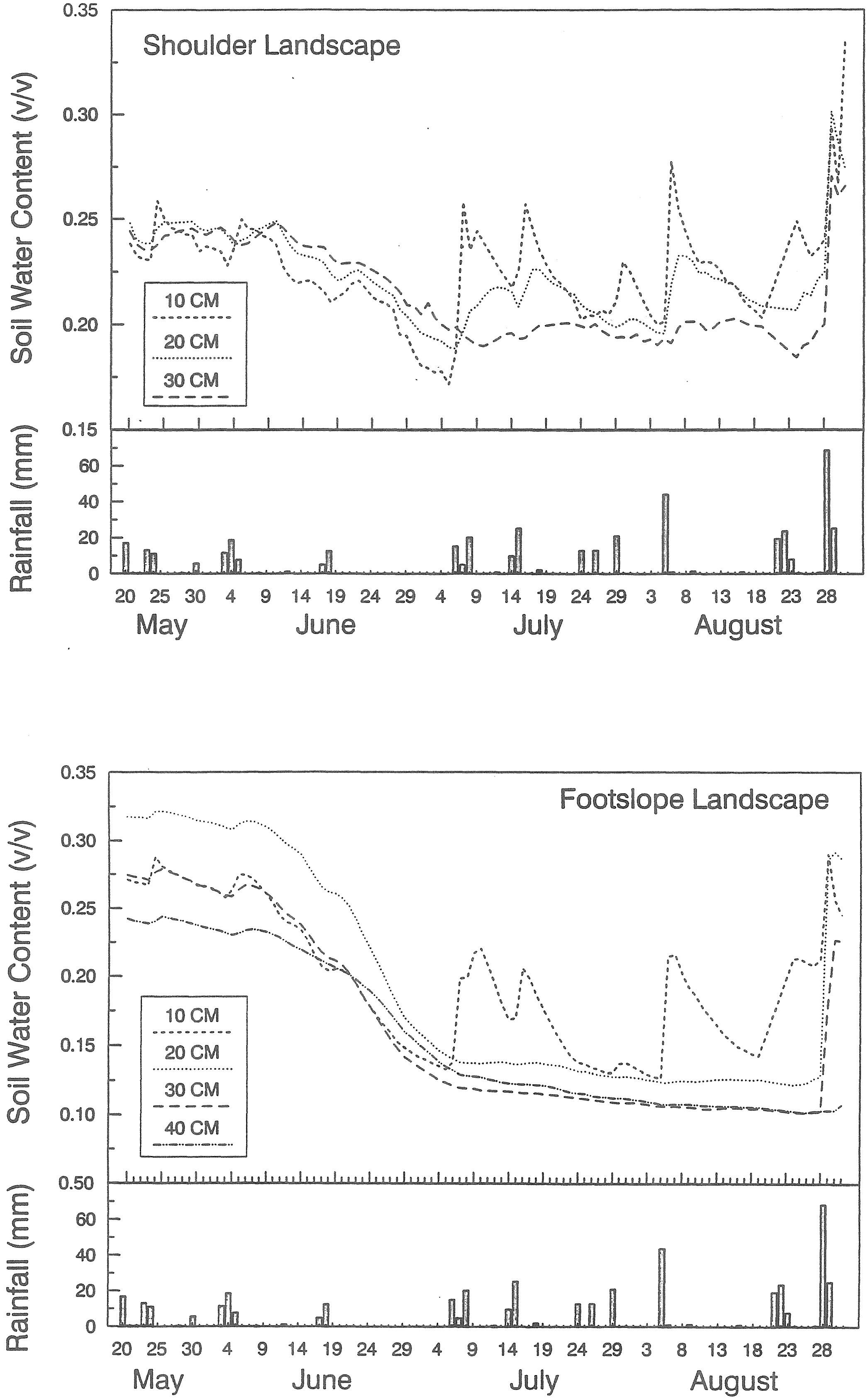

Figure 2. Wheat Shoot Distribtution at Two Landscape Positions.

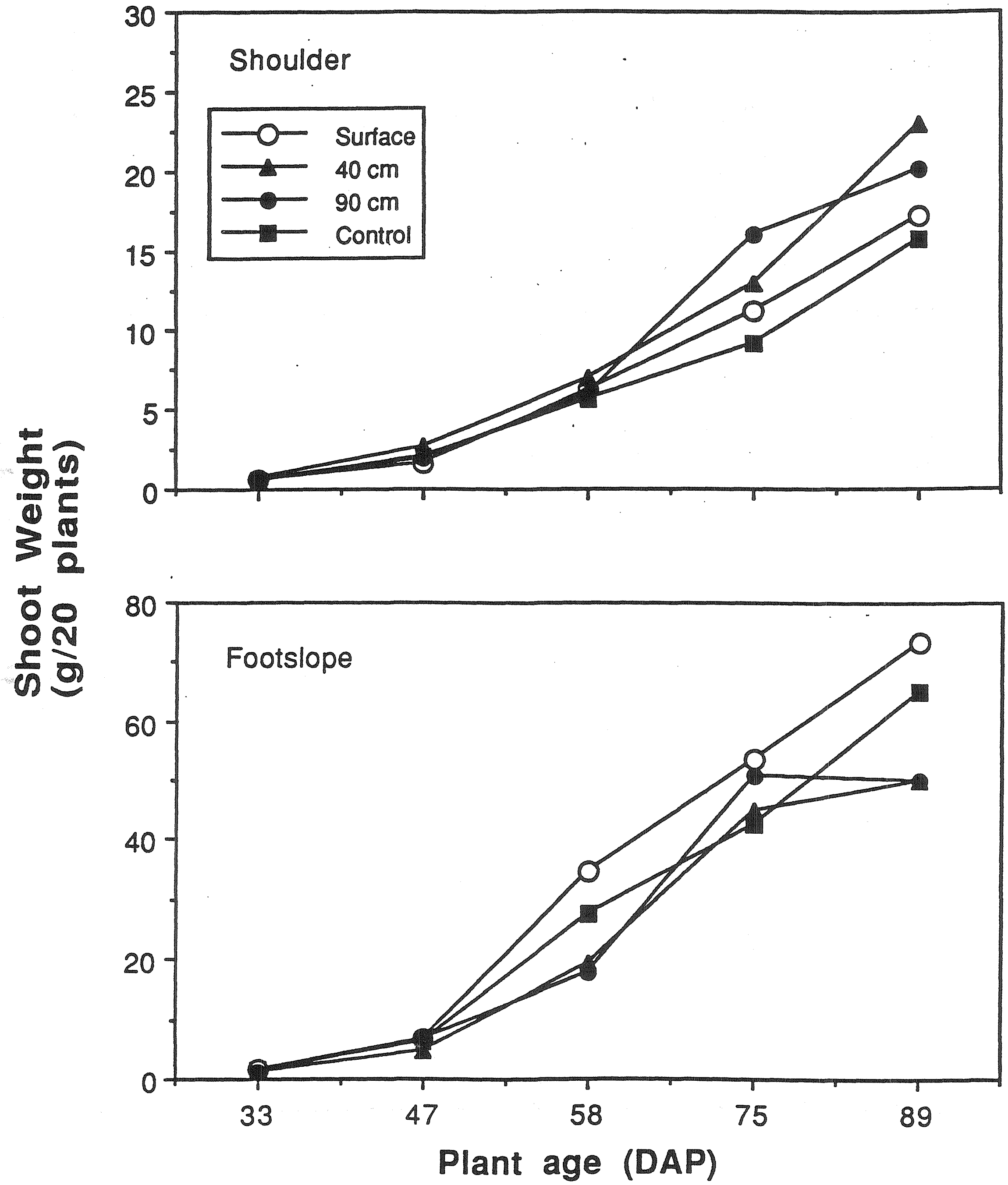

**Figure 3.** Total Strontium Content in Wheat Shoot Tissue at Two Landscape Positions.