Efficiency of Irrigation Applications in a Potato Crop in Southern Alberta

T.E. Harms and W.D. Helgason

AAFRD, Irrigation Branch, Brooks AB
University of Saskatchewan, Saskatoon SK
2004 - 2005

Efficiency of irrigation applications in a potato crop grown in southern Alberta

T.E. Harms[1] , W.D. Helgason[2]

[1]. AAFRD, Irrigation Branch, Brooks AB. [2]. University of Saskatchewan, Saskatoon SK

1. Introduction

Relative to other crops grown in southern Alberta, potato requires a very intensive irrigation management program to maximize economic returns. Potatoes have a relatively low tolerance to water stress, develop a shallow rooting system, and are typically grown on coarse textured soils with inherently low water holding capabilities. Accordingly, growers must have an advanced knowledge of soil moisture status to maintain soil moisture at prescribed levels.

It is often assumed that the infiltration of irrigation and rainfall into a potato hill is uniform. However, due to the implied topographic relief of hill-furrow tillage systems it is likely that the actual infiltration and subsequent redistribution of irrigation water is quite variable. This is supported by Saffigna et al. 1976; Stieber and Shock, 1995; Bargar et al. 1999; and Robinson, 1999 who all noticed that more water enters the soil through the furrow than through the ridge or hill. It is believed that suction exerted by the plant's root system acts to redistribute some of this water into the hill position over the next few days where it can be used by the plant. However, there is sufficient reason to believe that some of the water that collects in the furrow position will move to positions below the root zone, effectively lost for crop use.

Reservoir tillage (dammer-diking) is commonly used in commercial potato production. In many instances it has been shown to effectively reduce runoff (Mickelsen and Schweizer, 1987; Kincaid et al., 1990). However, this practice may lead to increased movement of water beneath the furrow due to localized zones of increased infiltration. The ripping effect of the tillage shank acts to shatter the soil, effectively increasing the ability of water to move into and through the soil. If rainfall or irrigation water ponds in the depression created by the reservoir tillage paddle, most of this water will infiltrate below the furrow position. Root density beneath the furrow is minimal and much of this water may be lost to deep percolation.

It is also likely that the development of the canopy of a potato crop has a marked effect on the distribution of irrigation water. Results presented by Saffigna et al. 1976 suggest that early in the season, prior to row closure infiltration into the furrow was higher than after row closure. After row closure, approximately 40% of the irrigation water applied was directed toward the plant stem by the canopy. This result suggests that irrigation efficiency may actually improve throughout the growing season.

It is important to gain a detailed understanding of the fate of the irrigation water applied so the amount of water applied to the field can be balance with the amount of water that is available to the plant. This project quantifies the movement of moisture within a standard hill-furrow potato bed, grown under typical conditions, with the intent of determining irrigation efficiency.

This information will be used as a baseline study to support the research and development of alternative management practices that could lead to higher water use efficiencies in potatoes. The objectives of this study are to:

1.Quantify the irrigation efficiency in a crop of potatoes.

2.Quantify the distribution of water within a potato crop.

3.Identify opportunities for improvements in current practices or technologies.

2. Methodology

The study was conducted at the Canada-Alberta Crop Development Initiative Demonstration Farm near Lethbridge, Alberta. An area of approximately 1.8 m wide x 2.0 m long, (an equivalent width of two beds and three furrow locations, extending for a distance of 2.0 m) was delineated within a field prepared and seeded to potatoes. Soil moisture was measured using 3 prong TDR sensors (Figure 1) and soil tension was measured using the granular matrix block (Watermark) sensors (Figure 2).

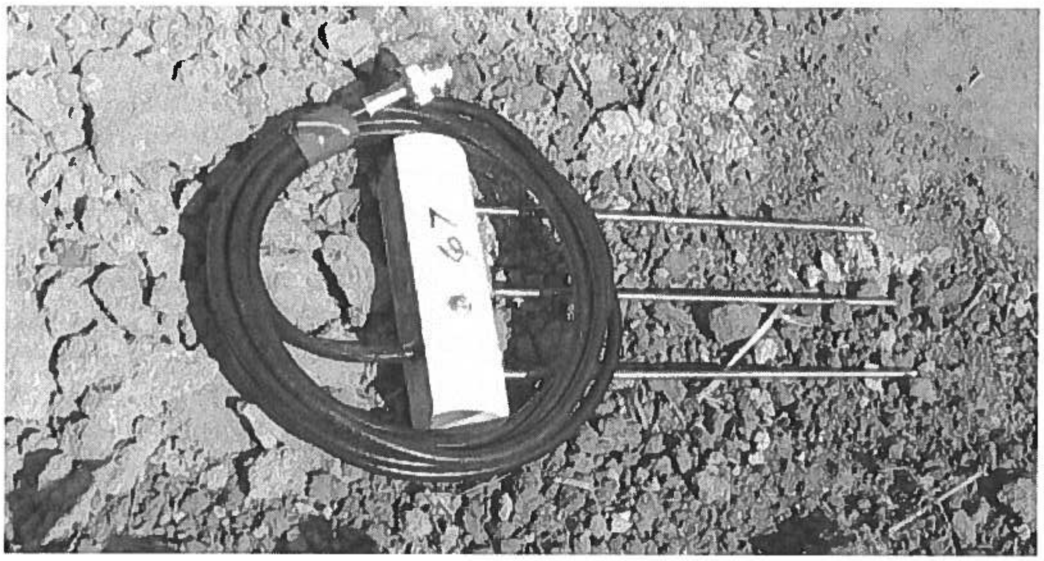

Figure 1. 3-prong TDR soil moisture probe.

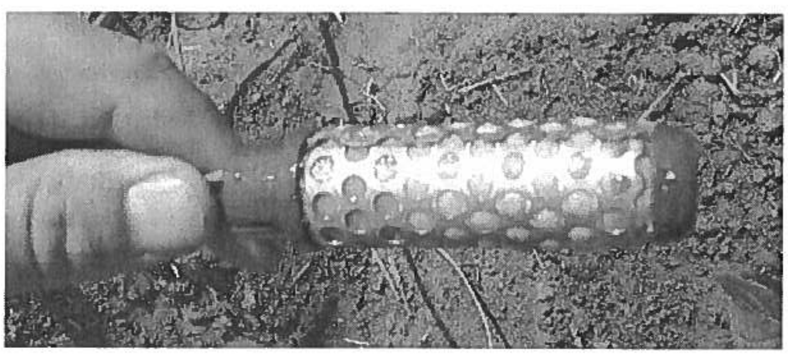

Figure 2. Watermark granular matrix block soil tension probe.

A 2.1 by 0.8 m grid with 10 cm grid nodes was designed and the distribution of TDR and Watermark sensors within the soil profile for the hill-furrow configuration was determined. TDR sensors were placed 10 cm below the surface within the hill position and 20 cm below the surface within the furrow position. Maximum vertical or horizontal distance between the probes was 10 cm within the hill position and 20 cm within the furrow (Figure 3).

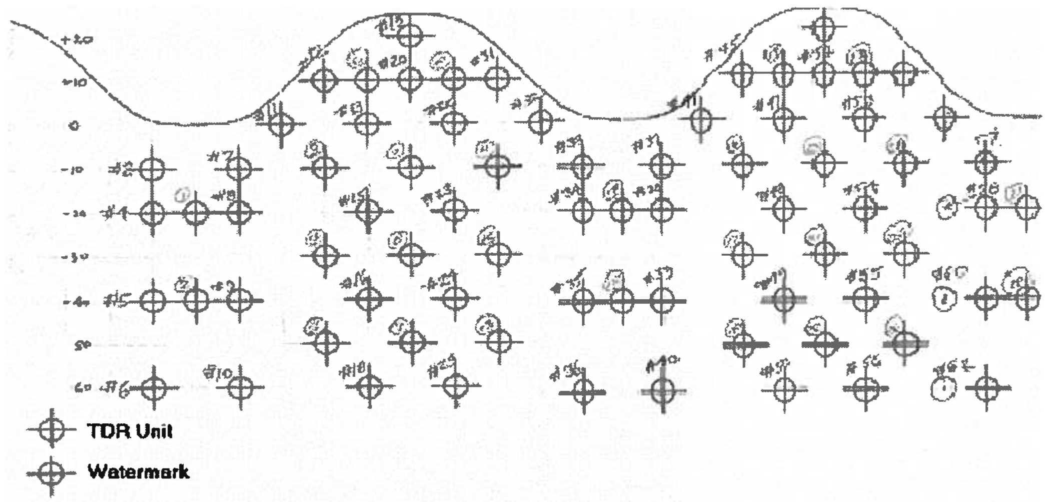

Figure 3. Schematic of soil moisture (TDR) and soil tension (Watermark) array.

A trench was excavated at one end of the plot to facilitate installation of the soil moisture and soil tension instrument array (Figure 4). A total of fifty TDR probes and twenty-seven Watermark sensors were installed.

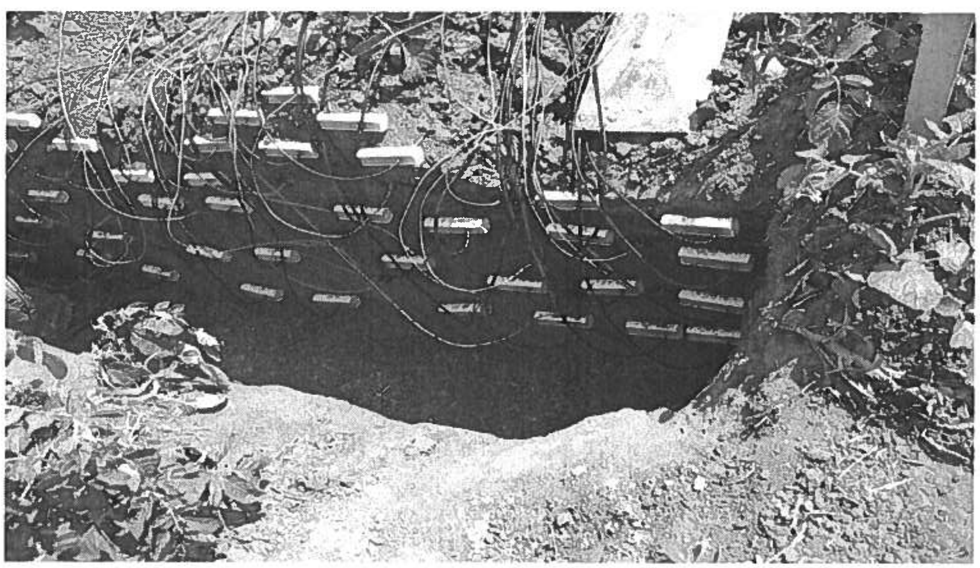

Figure 4. TDR and Watermark sensors installed in soil face.

The excavated area was hydrologically isolated from the out of plot area by installation of a 1.2 m wide by 2.4 m long by 0.23 m thick preserved wood plywood. The trench was backfilled using the excavated soil and the soil was packed in an attempt to minimize preferential infiltration into the disturbed soil (Figure 5).

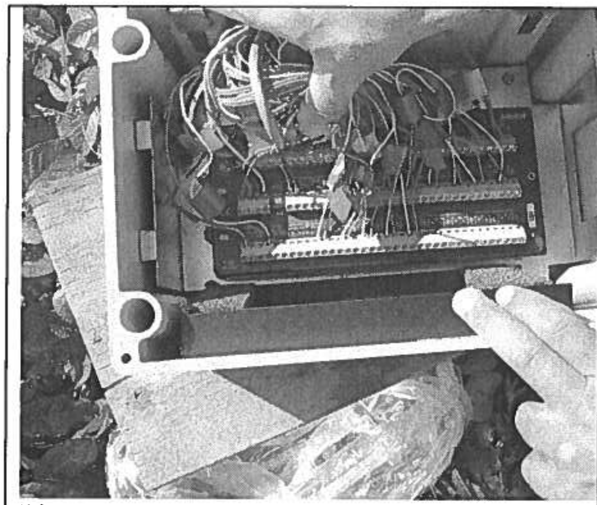

Figure 6. Watermark sensors to multiplexer.

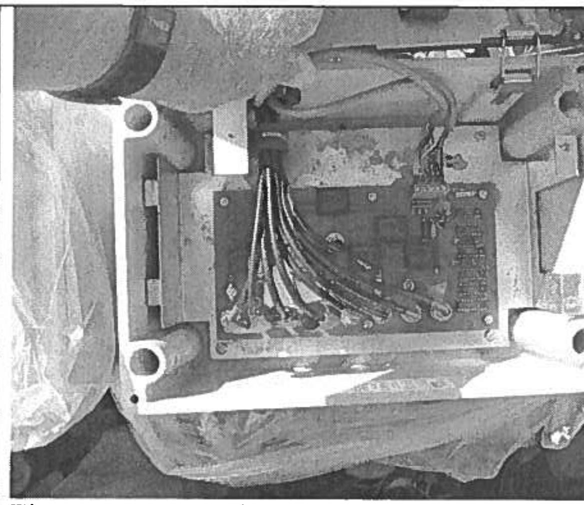

Figure 7. TDR units connected to coax multiplexer

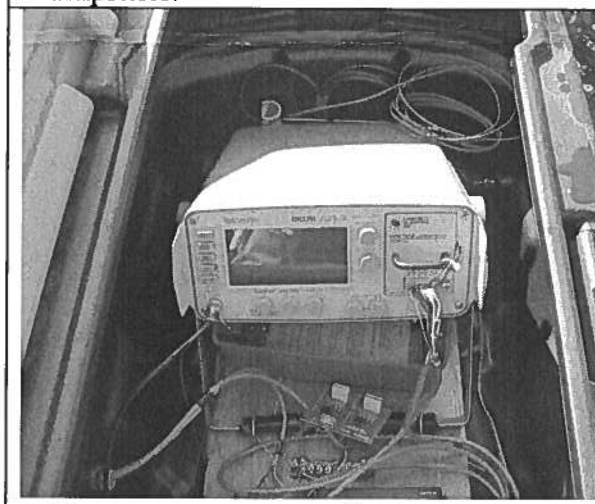

Figure 8. Tektronix 1502B cable tester.

A vadose zone fluxmeter (Figure 9) was placed 70 cm below the soil surface directly below the furrow position to record the quantity of either irrigation or rainfall that percolated below the root zone of the potato plant. The fluxmeter was also connected to the datalogger.

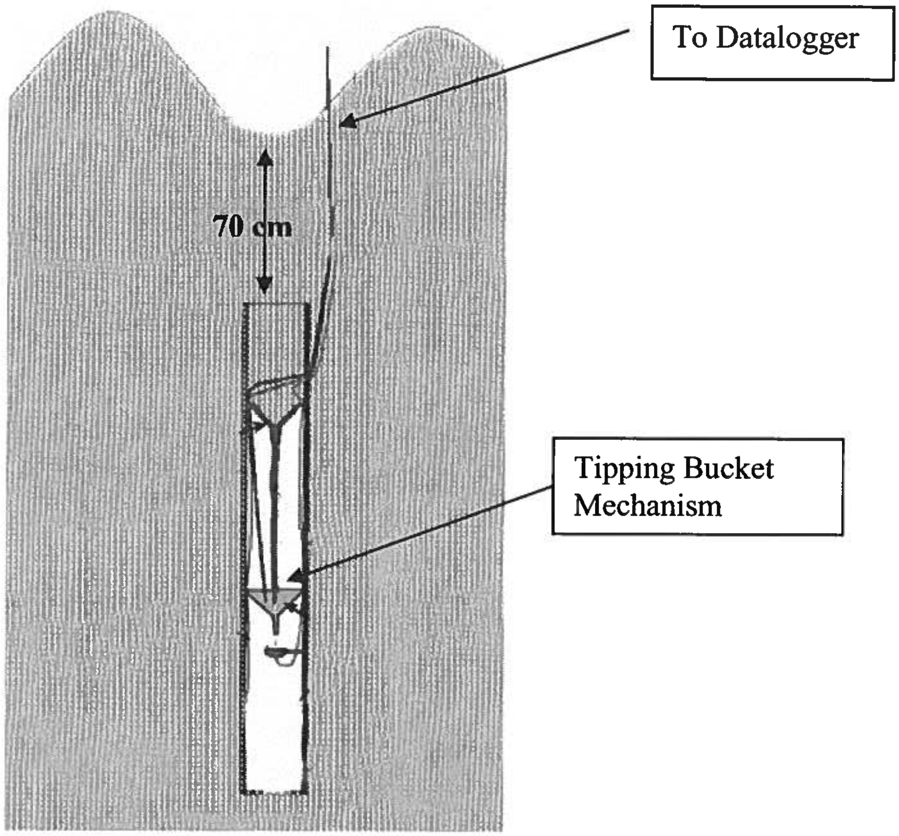

Figure 9. Flux meter installed below furrow position.

To complete the instrumentation, a tipping bucket rain gauge to record rainfall or irrigation timing and amounts and two Delta T Devices, PR1-6 soil moisture probes to record hourly soil moisture values within the plot were connected to a separate datalogger.

The agronomic management practices followed were assumed to represent the majority of potato crops grown in southern Alberta and were:

- Seed Variety: Russet Burbank
- Seeded into beds spaced 0.9m apart
- Beds constructed with power-hiller (immediately after planting operation)
- Reservoir tillage technique – ripping shank w/ dammer-diker attachment (conducted soon after hilling)
- Irrigation method – medium pressure center pivot
- Water application – equivalent depth of 20-25 mm per application

Results and Discussion

There were delays in obtaining and constructing some of the instrumentation resulting in delays in data collection. There were additional problems with programming the logger so data collection only started in early August. The soil matrix potential for August 10, 2004 is shown in Figure 7.

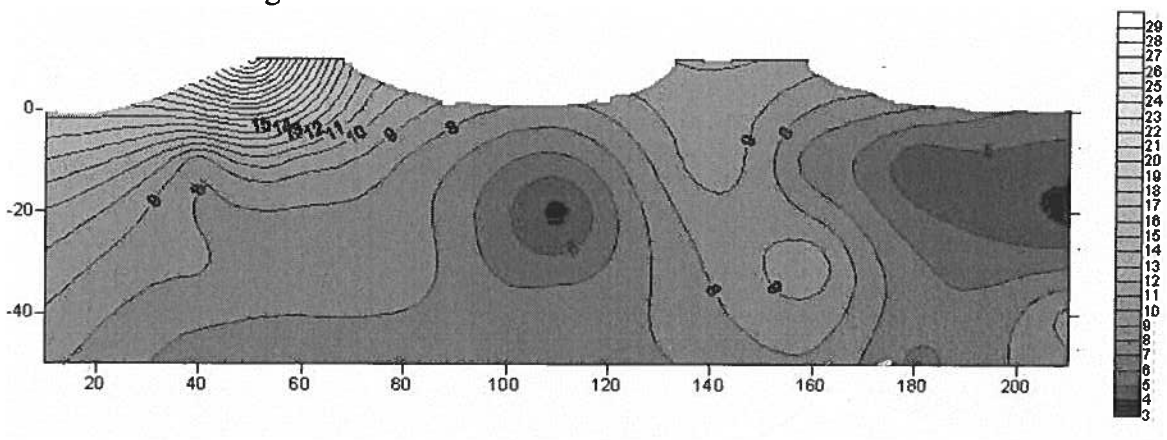

Figure 7. Soil tension profile for August 10, 2004.

Lower soil moisture was expected in the hill versus the furrow but interestingly, drier soil moisture conditions remained in the hill where the potato plants were actively growing even though there was high soil moisture in the furrows. There appears to be limited movement of soil moisture from the furrow into the hill. Similar soil moisture values near surface in the furrows are found at a 40 cm depth and greater in the hills.

Vadose Zone Flux Meter

There was no recorded flow through the vadose zone flux meter during the time of monitoring in August. Total rainfall and irrigation during August were 24 mm which appeared to be insufficient to initiate deep percolation.

Conclusions and Suggestions

Although testing was limited to August 2004, it was apparent that even in the finer textured (higher clay) soils at the CACDI site, gravity dominates the movement of water into the soil and soil suction forces in the hill are not sufficient to attract sufficient water from the furrow position into the hill.

Proper calibration and sensor integrity will be tested in the lab during the winter months of 2004-2005. The complete instrumentation and monitoring protocol should be started shortly after seeding in 2005 so a more complete picture of soil moisture distribution with the hill-furrow configuration will emerge for the entire growing season.

References

Kincaid, D.C., McCann, I., Busch, J.R., and Hasheminia, H. 1990. Low pressure center pivot irrigation and reservoir tillage. Pages 54-60 *in* Proceedings 3rd National Irrigation Symposium. Phoenix, Arizona, United States of America, October 28 to November 1, 1990.

Mickelon, R.H., and Schweizer, E.E. 1987. Till-plant systems for reducing runoff under low-pressure center-pivot irrigation. Journal of Soil and Water Conservation. 42(2): 107-111.

Robinson, D. 1999. A comparison of soil-water distribution under ridge and bed cultivated potatoes. Agricultural Water Management. 42(1999):189-204
.

Saffigna, P.G., Tanner, C.B. and Keeney, D.R. 1976. Non-uniform infiltration under potato canopies caused by interception, stemflow, and hilling. Agronomy Journal. 68:337-342.