Application of Variable-Rate Irrigation for Potato Productivity

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Abstract. Variable-rate irrigation (VRI) has the potential to increase yields and reduce water consumption and energy costs. Spatial and temporal variability of soil and field properties can impact the efficiency of irrigation and crop yield. The VRI technology allows for the precise application of irrigation to meet crop water demands in controlled amounts prescribed for specific management zones within a field. Sensitivity to over and under-irrigation and the high-water requirements of potato make the crop a good candidate for site-specific irrigation management. The use of VRI to conserve water and obtain high quality potato production was tested in Southern Alberta, Canada during the 2015 and 2016 growing seasons. Exceptionally dry weather in 2015 resulted in a total of 21 irrigation events. Overall, 43% less water was applied under the VRI, and a 12% reduction in irrigation pumping cost was achieved. The crop in plots receiving normal irrigation (361 mm per season) produced a slightly lower yield than plots receiving high irrigation (480 mm per season) but produced the best quality in terms of uniformity of size and glucose content of the tubers. In 2016, there were no significant differences between potato yield and quality within the irrigation treatments due to significant amounts of precipitation during the growing season.

Keywords. Potato productivity, water saving, energy cost, potato yield, and tuber quality.

Introduction

Site-specific management (SSM) is becoming increasingly in demand due to the limitations of conventional agricultural practices. Spatial and temporal variations are major factors that contribute to within-field crop-yield variation. Reducing or eliminating areas of excess irrigation applications within a field will reduce the potential for runoff and pond formation, creating conditions for improving crop yield and quality (Evans and Saldler, 2013). Natural spatial field variability results in uneven absorption of water (Xiang et al., 2007) due to differences in elevation, and soil properties, such as texture and electrical conductivity (EC). Redulla et al (2002) studied the effects of spatial variability of pH, nutrient availability, and soil texture on four commercial potato fields. They concluded that soil texture had the strongest correlation with yield because it was an indicator of available water holding capacity. Russet Burbank potato is a chipping variety common to the province of Alberta. Expected potato yield in Alberta is 35 t ha^{-1} (Wood, 2013). Potatoes have high water sensitivity and require an annual total of 400-550 mm of water (King and Stark, 1997).

Materials and Methods

A two-year field experiment was conducted at the Alberta Irrigation Technology Centre (AITC) located in southern Alberta with a mean elevation of 905 m above sea level. Irrigation was performed using a Valley 8000 series center pivot system spanning 295 m and covering 27 ha during the 2015 and 2016 growing seasons. The system was modified for variable rate application using a VRI zone control package from Valmont Industries Inc., (Valmont Industries Inc., Omaha, Nebraska, USA). A Real Time Kinematic (RTK) global navigation satellite system (GNSS) receiver was used to conduct a topographical survey of the field. The apparent soil electrical conductivity (ECa) was measured using a Veris® 3100 (Veris Technologies, Inc., Salina, Kansas, USA) and EM38 instrument (Geonics Limited, Mississauga, Ontario, Canada). Russet Burbank potatoes were planted in the south eastern and south western quadrants of the experimental site on April 28, 2015 and May 2, 2016 and harvested on September 3, 2015 and September 15, 2016 growing seasons, respectively. Irrigation frequency and depth were recommended by Alberta Agriculture and Forestry using the Alberta Irrigation Management Model (AIMM-version 3.1.3, Alberta Agriculture and Forestry, Calgary, 2010). In the 2015, 2016 growing seasons, three water application treatments were applied randomly in three replicates on experimental plots.

Results and Discussions

Overall, 43% less water was applied under the variable rate irrigation, and a reduction of 12% in electricity cost was achieved in the 2015 growing season. Figure 1 summarizes the results of yield and quality of the tubers. It is interesting to notice that the High Irrigation (1.5×Normal Irrigation) plots had a higher total yield and marketable yield. However, they had the largest loss of deformed or small tubers. Overall the harvest in the Normal Irrigation plots was uniform in quantity and quality.

In 2016, there were no significant differences among irrigation treatments for yield and tuber quality (Fig. 2). This is likely because the differences in the amount of irrigation applied to the three treatments were very small. The data analysis indicated that the differences between the two years were significant for all factors tested. This shows the powerful influence of weather and soil conditions. In 2016 the plant count, stem count, and deformed yield were greater than 2015. Conversely, in 2015, the marketable yield and mean tuber weight were greater than 2016.

Conclusions

Higher water application in the experimental plots resulted no significant improvement on potatoes yield. The harvest of tubers in normal irrigation plots proved to be more uniform in quality and size of tubers. The normal irrigation produced tubers of a larger size with lower specific gravity and higher glucose content. Furthermore, plots under normal irrigation had the lowest loss rate. Under-watered plots underperformed in every category, stressing the importance of water management under drought conditions.

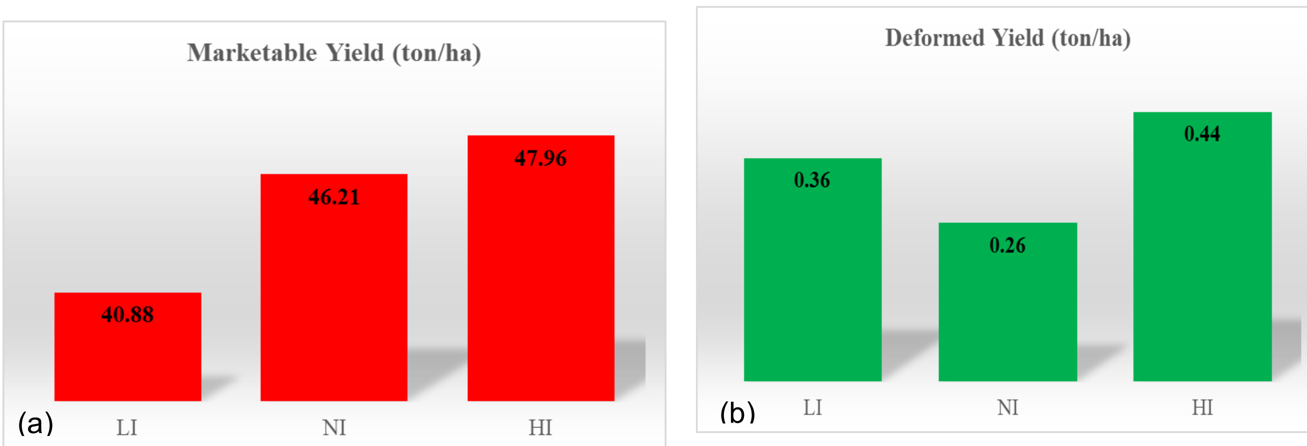

Figure 1. Mean marketable yield (a) and deform yield (b) for the three irrigation treatments in 2015, (HI: high irrigation, NI: normal irrigation, LI: low irrigation)

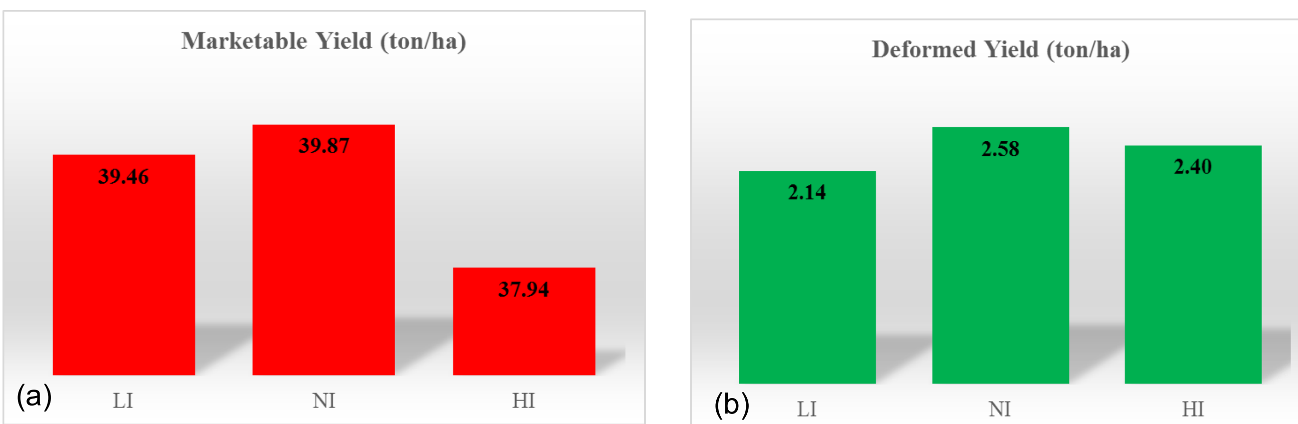

Figure 2. Mean marketable yield (a) and deform yield (b) for the three irrigation treatments in 2016, (HI: high irrigation, NI: normal irrigation, LI: low irrigation)

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