Managing deficit irrigation for potatoes

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Abstract

Inadequate water availability, particularly at certain growth stages, has negative impact on the yield and quality of potato tubers. Tuber quality is important for processing potatoes to meet the marketability standards. The Pacific Northwest (PNW) of the US is a major potato production region of premium quality processed potatoes for domestic and export markets. Due to low annual rainfall (about 150 mm), potato production is dependent on irrigation. Generally irrigation is managed to replenish full evapotranspiration (ET). This field study was conducted to evaluate the effects of deficit irrigation on tuber yield and quality of 'Ranger Russet' and 'Umatilla Russet' cultivars grown on a typical sandy soil in the PNW (96% sand) with different rates of pre-plant and in-season nitrogen applications. Total tuber yield significantly decreased (by about 7.5%) with deficit irrigation as compared with irrigation to replenish full ET. The impact of the above yield reduction associated with only 20% decrease in irrigation following row closure of the plant canopy on the net return needs to be evaluated.

Keywords: Best management practice, tuber quality, water use efficiency.

Introduction

Adequate water availability during the entire growing season is important for production of high yields of good quality potatoes. Irrigation is generally scheduled to replenish the estimated daily loss of water using ET estimates. The crop growth stage is an important factor in determining the degree of sensitivity of the crop to soil moisture deficits. Water deficit causes reduced leaf area and foliage biomass. In addition to tuber yield reductions, water stress affects tuber quality parameters including secondary growth, i.e. knobbiness and pointed ends (Hooker 1981), growth cradles (Hiller et al. 1985), physiological disorders such as brown center, hallow heart, translucent end (Rex and Mazza 1989). The tubers grown under water stress are susceptible to bruise and heat stress (Hiller et al. 1985).

Deficit irrigation is aimed to optimize the economic efficiency. Although deficit irrigation has been successful for a number of crops, its application to potato has been questionable due to the fact that short duration water stress could result in appreciable reduction in tuber yield and quality (Shock et al. 1993). High productivity of high-quality potatoes can be possible by ensuring adequate availability of soil water and N (Saffigna et al. 1977; Sanderson and White 1987; Ojala et al. 1990; Stark et al. 1993).

The objective of this study was to evaluate the response of two potato cultivars to deficit irrigation and varying rates of pre-plant and in-season N application in a production practice typical to irrigated production in the U.S. Pacific Northwest.

Materials and methods

This study was conducted in Quincy fine sand (mixed, mesic Xeric Torripsamments) in Eastern Washington, in the U.S. Pacific Northwest. This soil represents the predominant potato growing soils in the Columbia Basin production region. 'Ranger Russet' and 'Umatilla Russet' cultivars were used. To represent the commercial industry standards, potato was rotated with wheat and corn. Treatments included: I. Two irrigation regimes; i.e. (1) irrigation to replenish full evapotranspiration (ET), or (2) irrigation to replenish 80% of ET following row closure of the plant canopy, deficit irrigation (DI). II. Pre-plant N rates: either 56, 112, or 168 kg N ha^{-1} applied to soil and incorporated before planting. III. In-season N rates: either 145, 200, or 258 kg N ha^{-1} in year one. The rates were changed to either 112, 224, or 336 kg N ha^{-1} in year two. In-season N was applied with pivot irrigation water in five doses at two-week interval, beginning four weeks after the seedling emergence. There were three replications of each treatment. Petiole samples were taken on weekly intervals starting four weeks after the seedling emergence to determine the nutrient concentration in the plant (results not presented). Plot size was six rows (5.2 m) of 12.2 m each. The middle two rows of 6.1 m each were harvested to determine the tuber yield. A subsample of tubers were graded, using electronic size grading equipment, into tuber in size >340 g, 226-340 g, 113-226 g, <113 g, and US No. 2 plus culls. Tuber yields expressed as metric tonnes per hectare (Mg ha^{-1}).

Results and discussion

Total tuber yield decreased under deficit irrigation as compared with that under irrigation to replenish full ET in two years across both cultivars (Fig. 1). Yields of tubers greater than 226 g size were greater with full irrigation than deficit irrigation. The converse was true for smaller (<226 g) size tuber yields.

Pre-plant N rates (56 to 168 kg N ha^{-1}) had no significant affects on either total tuber yields or yield of different size grade tubers (Fig. 2). During year one of the study, total tuber yield was significantly lower at the highest in-season N rate (258 N kg ha^{-1}) as compared with that at the 145 and 200 kg N ha^{-1} rates, in both cultivars (Fig. 3). In-season N rates were changed during the second year, i.e. 112, 224, and 336 kg N ha^{-1}. Total tuber yield significantly increased with an increase in in-season, N rates for 'Ranger Russet', while for the 'Umatilla Russet' the tuber yield significantly increased with an increase in the in-season N rate from 112 to 224 kg ha^{-1} rate, and then leveled off at the third in-season N rate of 336 kg ha^{-1}.

Deficit irrigation resulted in tubers with greater specific gravity than those under full irrigation during year one across both cultivars (Fig. 4). However, in year two, the irrigation affect was non-significant. Pre-plant N rates did not show consistent affects on tuber specific gravity across both years and both cultivars.

An increase in in-season N rates had negative affects on the tuber specific gravity during year one. During year two, however, the in-season N rate affect was non-significant on the tuber specific gravity on 'Ranger Russet' cultivar, while there was a positive affect on the 'Umatilla Russet' cultivar.

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Figures

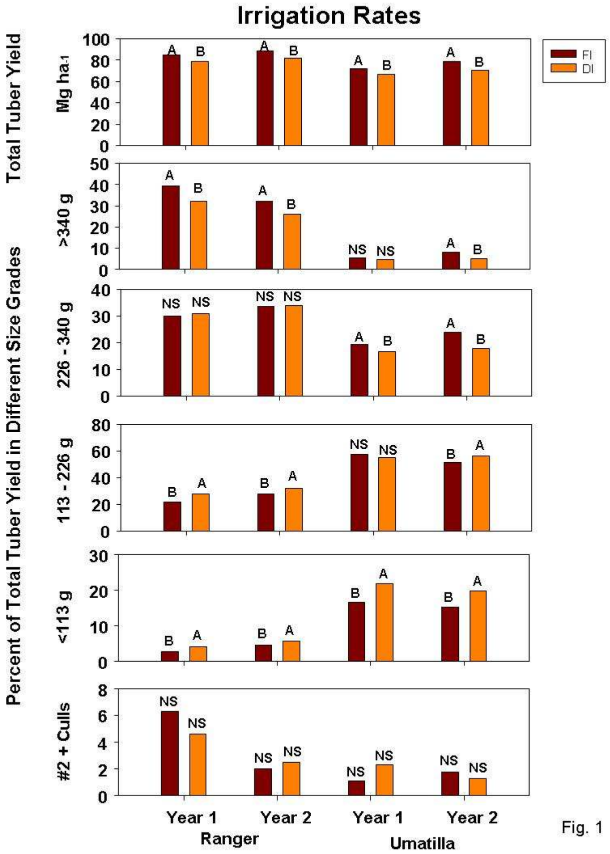

Fig. 1. Total tuber yields and percent of tubers in different size grades of ‘Russet Ranger’ and ‘Umatilla Russet’ cultivars grown under irrigation to replenish full evapotranspiration (ET) (FI) or irrigation to replenish 80% of ET (DI) in a Quincy fine sand. Means followed by similar letters are not significantly different at P=0.05, for each response variable by each cultivar and each year of the study. NS= non-significant.

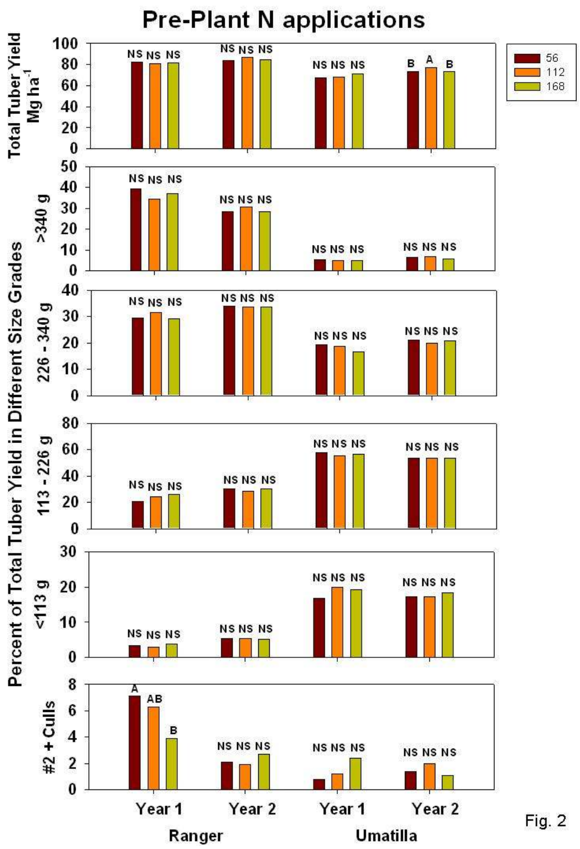

Fig. 2. Total tuber yields and percent of tubers in different size grades of ‘Russet Ranger’ and ‘Umatilla Russet’ cultivars grown under different pre-plant N rates (56, 112, 168 kg ha^{-1}) in a Quincy fine sand. Means followed by similar letters are not significantly different at P=0.05, for each response variable by each cultivar and each year of the study. NS= non-significant.

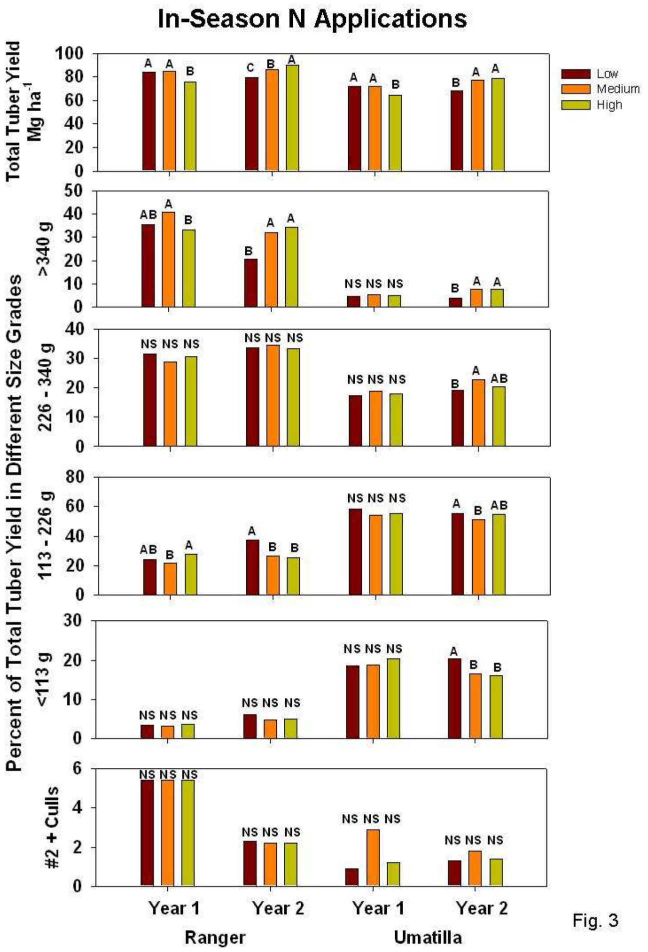

Fig. 3. Total tuber yields and percent of tubers in different size grades of 'Russet Ranger' and 'Umatilla Russet' cultivars grown under different in-season N rates (low, medium, high, 145, 200, 258 kg ha^{-1} in year one, and 112, 224, 336 kg ha^{-1} in year two) in a Quincy fine sand. Means followed by similar letters are not significantly different at P=0.05, for each response variable by each cultivar and each year of the study. NS= non-significant.

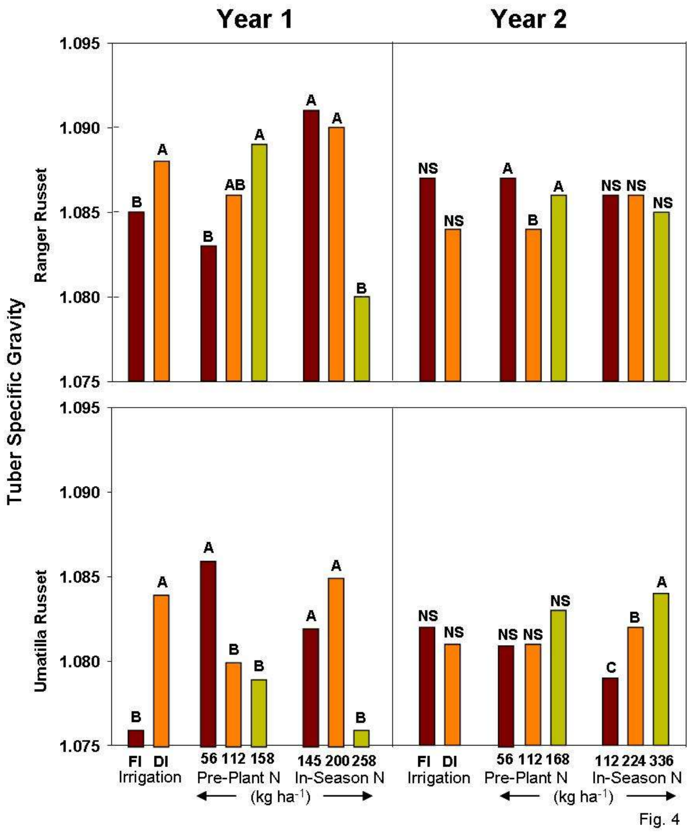

Fig. 4. Effects of different irrigation regimes (FI= irrigation to replenish full evapotranspiration (ET) or DI = irrigation to replenish 80% of ET), pre-plant and in-season N rates on tuber specific gravity. Means followed by similar letters within each cultivar and each treatment combination are not significantly different at P=0.05. NS= non-significant.