Planting Configuration and Plant Population Effects on Drip-Irrigated Umatilla Russet potato Yield and Grade

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Introduction

Drip irrigation of potato for processing in the Treasure Valley of eastern Oregon and Idaho is not a standard production practice. However, drip irrigation could provide several advantages to growers, including no tailwater runoff from the field, the ability to apply fertilizer to the crop root zone, precise irrigation application, minimal leaching of chemicals or salts to the groundwater, and reduced canopy moisture with reduced risk of fungal foliar diseases. Drip irrigation systems are costly to install and manage, and growers are reluctant to install them on fields where capital has already been spent to install furrow- or sprinkler-irrigation systems. To be profitable for potato production, drip irrigation should provide yield and quality above that obtainable with other irrigation methods. This study was conducted to test modified planting configurations on the standard 72-inch tractor wheel spacing used in Treasure Valley potato production, to test whether changes in the planting configuration could improve yield response to drip irrigation.

By placing two rows on a single bed, plants would be spread apart over the soil surface. They should not come immediately into competition with each other for sunlight during June, increasing yield potential. Spreading the plants across the bed could allow a higher plant population, which might enhance yield and reduce the number of oversize potatoes. Furthermore, the distribution of plants across the soil surface would provide better soil shading during June, a factor that might result in better tuber quality.
When potato seeds are planted directly in line with the drip tape, the roots and new tubers are directly in the most saturated part of the soil. By placing the drip tape offset from the seed, roots and tubers would develop in a less saturated part of the potato bed, favoring tuber quality.

Methods

Both Years

The treatments consisted of two populations, 18,150 and 24,200 plants per acre, with each population planted in three configurations. Drip tapes were shanked into the beds on May 6. Configuration 1 was 2 rows 36 inches apart on a nominal 72-inch bed (72 inches furrow to furrow) with a drip tape directly above each row of potatoes (Table 1). Configuration 2 was 2 rows 36 inches apart on a 72-inch bed with the drip tapes offset 7 inches to the inside of the bed from each potato row. Configuration 3 was 4 rows on a 72-inch bed with 16 inches between the pairs of rows, and the paired rows 14 inches apart, with the drip tape centered between the pairs of rows. Plants were staggered in the paired rows. Plots were 20 ft long by 2 beds (12 ft) wide, replicated 4 times.

Irrigations were controlled by a CR10 data logger (Campbell Scientific, Logan, UT) connected to a multiplexer that provided connections for two Watermark (Irrometer Co. Inc., Riverside, CA) soil

moisture sensors in each plot. The sensors were installed in a plant row at the seed piece depth. The data logger was connected through relays to a 24VAC solenoid valve for each treatment. The drip tape on each set of 4 plots of a treatment was plumbed through 0.5-inch PVC pipe to 6 solenoid valves supplied with water under constant pressure. The soil moisture sensors were read by the data logger every 3 hours. At midnight and noon the data logger calculated the average sensor readings for each treatment. If the average soil water potential for a treatment was below -30 kPa, the valve opened for 3 hours to apply a 0.2-inch irrigation. Crop evapotranspiration (ETc) was estimated by an automated AgriMet (U.S. Bureau of Reclamation, Boise, ID) station located about 0.5 mile away on the Malheur Experiment Station.

The vines were flailed from the potato plants on October 2, 2003, and on September 21, 2004. The potatoes were dug on October 9, 2003 and on September 29, 2004. The tubers from 15 ft of the center 2 rows of each 4-row plot were bagged and graded. Data were statistically analyzed using the ANOVA procedure in NCSS (Number Cruncher Statistical Systems, Kaysville, UT).

2003 Trial

The 2003 experiment was conducted on Owyhee silt loam, following winter wheat, where potato had not been planted for 3 years. In September 2002, after the wheat stubble had been chopped and irrigated, the field was disked. A soil test taken on September 9, 2002 showed 18 ppm Nitrate (NO3), 18 ppm phosphorus (P), 306 ppm potassium (K), organic matter 2.2 percent, and pH 7.6. Fall fertilizer was spread to apply 21 lb Nitrogen (N)/acre, 100 lb phosphate (P2O5)/acre, 60 lb potash (K2O)/acre, 60 lb sulfur (S)/acre, 30 lb magnesium (Mg)/acre, 4 lb zinc (Zn)/acre, 2 lb copper (Cu)/acre, 1 lb manganese (Mn)/acre, and 1 lb boron (B)/acre. The field was deep ripped, disked, and Telone II® was applied at 25 gal/acre, and the soil was bedded on 36-inch spacing. On April 4, 2003, Roundup® was applied at 1 qt/acre to control winter annual weeds and volunteer wheat.

Certified seed of 'Umatilla Russet' was cut by hand into 2-oz seed pieces and treated with Tops MZ + Gaucho® dust. On April 23 and 24, the cut seed was planted 8 inches deep using a custom-built potato plot planter. The planter used cups on chains driven by a ground wheel, with interchangeable drive sprockets providing the adjustment of seed spacing in the row. Four individual planter units could be slid to different positions on the frame so that two or four rows could be planted at various between-row spacings. On April 28, the beds were shaped using a spike bed harrow pulling wide shovels to maintain the wheel furrows and dragging a chain to pull soil into the center of the bed and smooth the top flat.

Prowl® at 1 lb/acre plus Dual® at 2 lb/acre was applied on May 1. On May 6 the drip tape was installed in each plot using a pair of drip tape injectors and spools mounted on a tool bar and moved to the correct spacing for each treatment. The drip tape was T-tape 0.22 gal/hour/100 ft, with 12-inch emitter spacing. Matrix® herbicide was applied at 1.25 oz/acre on May 28. The first irrigation was applied on June 6. Bravo® plus Ridomil Gold® was applied by aerial application on June 7 and again on June 25. Bravo fungicide plus liquid sulfur was applied by aerial applicator on July 2, and again on August 8. Sulfur dust was applied by aerial applicator on July 20 at 40 lb S/acre.

2004 Trial

The procedures were similar for the 2004 trial. The soil was Owyhee silt loam where the previous crop was winter wheat. The wheat stubble was flailed and the field was irrigated and disked. A soil test taken on September 16, 2003 showed 37 lb N/acre in the top 2 ft of soil, and 102 lb available P2O5, 851 lb soluble K2O, 29 lb sulfate (SO4), 1966 ppm Ca, 463 ppm Mg, 87 ppm Na, 1.6 ppm Zn, 18 ppm Fe, 4 ppm Mn, 0.7 ppm Cu, 0.5 ppm B, organic matter 3.5 percent, and pH 7.4 in the top foot of soil. Fall

fertilizer was spread to apply 60 lb N/acre, 50 lb P2O5/acre, 80 lb K2O/acre, 57 lb S/acre, 8 lb Zn/acre, 5 lb Cu/acre, and 1 lb B/acre. The field was ripped, Telone II soil fumigant was injected at 25 gal/acre, and the field was bedded on 36-inch row spacing.

Potato seed of Umatilla Russet was commercial certified seed from central Oregon. Seed was cut by hand into approximately 2-oz pieces, treated with Tops MZ plus Gaucho seed-treating dust. The potatoes in plots with four rows per bed were planted on April 29, and the two-row beds were planted on April 30. On May 1, the beds were formed with a spike harrow pulling wide shovels to clean the furrows and form the shoulders of the beds, and dragging a heavy chain to smooth and flatten the top of the bed. The drip tape was installed on May 5 and 6, at 2- to 3-inches depth. The drip tape was 5/8-inch diameter, with 5-mil wall thickness, 6-inch emitter spacing, 0.22 gal/min/100 ft flow rate (T-tape, T-Systems International, San Diego, CA). Irrigations began on June 16.

Prowl at 1 lb/acre plus Dual at 2 lb/acre was applied on May 7, 2004 before any potato plants had emerged, and was incorporated with the bed harrow. Matrix herbicide was applied at 1.25 oz/acre on May 17, and was incorporated by 0.41 inch of rain on the next day, followed by 0.89 inch of additional rain through the end of May. Fungicide applications to control early blight and prevent late blight infection started with an aerial application of Ridomil Gold and Bravo at 1.5 pint/acre on June 12. On June 25, Headline® fungicide was applied, on July 17, Topsin-M fungicide plus liquid sulfur with 1.5 lb P2O5/acre and 0.2 lb Zn/acre was applied by aerial applicator. On August 8, Headline plus 6 lb S/acre was applied to prevent two-spotted spider mite infestation and powdery mildew infection. No fertilizer was applied to the field in the spring. Petiole tests were taken every 2 weeks from June 11, and fertilizer was injected into the drip system during irrigation to supply the crop nutrient needs.
Fertilizer solution was injected into the drip system in response to bi-weekly petiole tests. The total fertilizer applied from June 19 to August 14, both through the drip system and by aerial application, was 108 lb N/acre, 28 lb P2O5/acre, 12 lb K2O/acre, 14 lb SO4/acre, 40 lb S/acre, 0.03 lb Ca/acre, 0.5 lb Mg/acre, 0.61 lb Zn/acre, 1.15 lb Mn/acre, 0.69 lb Cu/acre, 0.06 lb Fe/acre, and 0.01 lb B/acre.

Results and Discussion

2003 Results

In 2003, the low-population (18,150 plants/acre), 36-inch hills with drip tape configuration yielded 556 cwt/acre, significantly more than the 470 cwt/acre total yield in the high-population (24,200 plants/acre), 36-inch hills with drip tape configuration (Table 2).

For the marketable yield category, comprised of the U.S. No. 1 and No. 2 tubers over 4 oz, there was a significant difference between the high and low plant population on the hills with drip tape configuration. The average marketable yield was higher with the low plant population, and there was a significant interaction between population and configuration because the marketable yield of the standard configuration at the high plant population was 333 cwt/acre, which was significantly lower than all other treatments.

There were no significant differences in percentage of U.S. No. 1 tubers among the treatments. The overall average percentage of U.S. No. 1 tubers, 66 percent, was lower than usual for Umatilla Russet at this location. Percentage U.S. No. 1 tubers ranged from 70 percent for the staggered double row (configuration 3) at the low plant population, to 63 percent for the 2 rows

per bed with the drip tapes offset 7 inches (configuration 2) at the high population.

The high plant population produced significantly more small, 4- to 6-oz, U.S. No. 1 tubers, and undersized tubers. There were no significant differences in yield of 6- to 12-oz U.S. No. 1 tubers. The high plant population produced a lower 12- to 16-oz and over 16-oz U.S. No. 1 yield. Total U.S. No. 1 yield was significantly higher at the low plant population with configuration 1.

The yield of U.S. No. 2 tubers was significantly greater with the low plant population. The high plant population standard configuration produced the lowest U.S. No. 2 yield, but that treatment also produced the most undersize tubers of less than 4 oz.

2004 Results

In 2004, there was a significant interaction between population and configuration for percentage of U.S. No. 1 tubers. There was a higher percentage of U.S. No. 1 in the low population with 2 rows of potato plants on a 72-inch bed with 2 drip tapes offset 7 inches inside the row, compared to the 2 rows with the drip tape above the row at the low population and 4 rows in a staggered planting with tapes between pairs of rows at the high population (Table 3). This interaction in production of U.S. No. 1 tubers also was seen in the total U.S. No. 1 production in 2004.

Both Years

The averaged data from 2003 and 2004 showed significantly higher total yield for configuration 3 at the high population (Table 4). The high population produced significantly more 4- to 6-oz tubers, and there was a significant year by population interaction. The lowest yield of U.S. No. 2 tubers was produced by the high population in two rows per bed with drip tape above the row (configuration 1).

The soil water remained adequate all season, since the soil water potential remained in the ideal range for all treatments (Fig. 1).

The average water applied by the drip-irrigation systems is one of the interesting aspects of this trial. The total amount of water applied by the drip systems plus rainfall averaged only 15.76 inches, 66.3 percent of the estimated potato evapotranspiration (23.78 inches) from May 25 to September 3 of 2004 (Fig. 2). This result suggests that drip irrigation is a very efficient method for applying limited amounts of water for potato production.

Figure 1. Average soil water potential of six different drip-irrigation treatments for potato, 2004, Malheur Experiment Station, Oregon State University, Ontario, OR.

Figure 2. Cumulative irrigation water plus rainfall for six different drip-irrigation treatments for potato compared with the accumulated potato evapotranspiration from May 25 through September 3, 2004, Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 1. Relationship of planting configuration treatments in the planting configuration trial to a common potato production planting configuration, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003 and 2004.

Table 2. Yield and grade of Umatilla Russet grown at two plant populations and three planting configurations with respect to the drip tape, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Table 3. Yield and grade of Umatilla Russet grown at two plant populations and three planting configurations with respect to the drip tape, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 4. Yield and grade of Umatilla Russet grown at two plant populations and three planting configurations with respect to the drip tape, averaged over two years, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

† Not Significant at alpha = 0.05.

‡ Becomes significant at this alpha level.