Yield and Quality of Two U.S. Red Potatoes: Influence of Nitrogen Rate and Plant Population.

Samuel Y.C. Essah[1], David G. Holm[1] and Jorge A. Delgado[2]

[1]Colorado State University, San Luis Valley Research Center, 0249 East Rd. 9 N, Center, CO 81125, U.S.A.
Email sessah@lamar.colostate.edu and spudmkr@lamar.colostate.edu
[2]USDA-ARS, Soil Plant Nutrient Research Unit, 2150 Center Avenue, Building D, Suit 100, Fort Collins, CO 80526, U.S.A
Email jdelgado@lamar.colostate.edu

Abstract

Nitrogen (N) rate and seed piece spacing are important economic considerations in the production of potatoes (*Solanum tuberosum* L.). The optimum spacing and N rate vary with cultivar, geographic location, and intended market. Studies were designed to determine the influence of N rate and seed spacing on yield, tuber size distribution, and quality of two red potato cultivars, CO93037-6R and Sangre. In the seed piece spacing experiment, seed tubers were planted 15.0, 22.5, 30.0, or 37.5 cm apart. In the N rate study nitrogen was applied at 90, 157, 224, or 291 kg/ha. Total yield, tuber size distribution, external and internal defects were determined. Seed spacing did not influence total yield in either cultivar, but size distribution shifted from a predominance of small tubers (<5 cm diameter) at the narrowest (15 cm) spacing to a predominance of large tubers (>5 cm diameter and >284g) at the widest (37.5 cm) spacing. Even though seed spacing did not influence marketable (5 to 10 cm diameter) yield, fewer external and internal defects were observed when seed tubers of CO93037-6R and Sangre were planted at 15 and 30 cm apart, respectively. N rate did not influence total yield in Sangre, but higher total yields were produced in CO93037-6R at lower N (90 to 157 kg/ha) rates. Even though N rate did not influence marketable size tubers, fewer external and internal defects were observed when N was applied at 90 kg/ha in Sangre. Application of N at 157 kg/ha produced higher marketable size tubers with lower percent external and internal defects in CO93037-6R. Percent external defects showed some promise as a predictor of optimum seed piece spacing and N application rate.

Media Summary

The percentage of tuber external defects show some promise as a predictor of optimum seed piece spacing and nitrogen application rate in southwest U.S. red potatoes.

Key Words

Midsize marketable tubers, large size marketable tubers, hollow heart.

Introduction

A number of factors influence yield in potato (*Solanum tuberosum* L.) including nitrogen, seed piece spacing, cultivar, geographic location, and climatic conditions (Arsenault et al. 2001). Nitrogen is an important nutrient in potato production and much variability exists in nitrogen requirements between cultivars (Chase et al. 1990). Cultivars generally show increased yields as nitrogen rate is increased (Belanger et al. 2000; Arsenault et al. 2001). However, excessive nitrogen can lead to poor tuber quality, delayed crop maturity, and excessive nitrate leaching; while nitrogen deficiency usually results in poor growth and low yield (Harris 1992).

In-row seed piece spacing can also influence yield and optimum spacing varies by cultivar. Total yields in some cultivars increase with closer spacing (Arsenault et al. 2001), while others show no significant difference (Halderson et al. 1992). Plant population studies with potatoes are never outdated because of unique tuber characteristics of new cultivars and the changing tuber size requirements of evolving industries (Wurr et al. 1993). Potato seed piece spacing influences economically important

characteristics, including total yield, marketable yield, tuber size distribution, and tuber quality (Love and Thompson-Johns 1999). By impacting these characteristics, seed piece spacing and the resulting plant population have a direct influence on net returns.

To optimize grower returns for specific markets, careful attention must be paid to cultural management practices that influence tuber size and other quality factors (Mckeown et al.1990). Nitrogen rate and seed piece spacing are some of the most important factors under grower control. Appropriate Nitrogen application rates and seed piece spacing for standard cultivars have evolved for specific markets and geographic areas through research and grower experience. Several promising new cultivars have not been sufficiently evaluated to provide growers an adequate basis for specific market requirements. This need is widely recognized, both for new cultivars and for introduction of established cultivars in new production environments (Mckeown et al. 1990). The objective of this study was to evaluate effects of seed piece spacing and N fertilizer rate on yield, tuber size distribution and quality of two red potatoes under growing conditions in the Southwestern United States.

Materials and Methods

Two field experiments were conducted at the San Luis Valley Research Center, Colorado, U.S.A. (latitude 37? 43' N, longitude 106? 9' W, and 2,310 m altitude). The nitrogen rate study was conducted on a Norte gravelly sandy loam (loamy-skeletal mixed (calcareous), frigid *Aquic Ustorthents*). Soil pH and organic matter ranged from 7.0 to 7.3 and 1.4 to 1.6%, respectively. P_2O_5 was broadcast at the rate of 67 kg/ha pre-plant. No K_2O was applied based on soil test results.

The seed piece spacing experiment was conducted on a Dunul very gravelly sandy loam (sandy-skeletal, mixed, frigid *Typic Torriorthents*). Soil pH and organic matter were 7.8 and 2.0%, respectively. The pre-plant fertilizer applied was 90-67-45 kg/ha (N-P_2O_5-K_2O), and a split application of N (22, 11, 11 kg/ha) was done in July. The irrigation water analysis indicated a total of 33.6 and 35.8 kg/ha NO_3-N supplied from the irrigation well by the end of August, in the seed spacing and nitrogen rate experiments, respectively. Soil analysis before planting indicated a 28.0 and 17.9 kg/ha residual NO3-N in the seed spacing and nitrogen rate experiments, respectively. Cut seed pieces (56-70g) from a promising red cultivar, CO93037-6R, and a standard red cultivar, Sangre, were machine planted in the nitrogen study and hand planted in the seed piece spacing study. Each plot consisted of four rows 7.5 m long with 0.85m between rows. The experiments were arranged in a randomized complete block design for each cultivar, with three replications.

Treatments included nitrogen applied at 90, 157, 224, and 291kg/ha and a no nitrogen application treatment as check for both cultivars. In-row seed piece spacing treatments were 15.0, 22.5, 30.0, and 37.5cm for both cultivars. Vines were killed by flailing 118 and 120 days after planting in the N rate and seed piece spacing experiments, respectively. Plots were harvested 14 days after vine kill. The center two rows from each plot were mechanically harvested and tubers weighed in the field. Tubers were mechanically sized according to U.S standards for round type potatoes into <5cm diameter, 5-10cm diameter, >10cm diameter, >5cm diameter but <284g, and >5cm diameter and >284g. Analysis of variance (ANOVA) was performed for each of the measured and calculated parameters. Differences among treatment means were compared using the least significant difference test (LSD) at the 0.05 level of probability.

Results

Seed Piece Spacing

Total Yield and Tuber Size Distribution:

Seed piece spacing did not influence total yield in both cultivars, but more undersize tubers (<5 cm diameter) were produced in the narrowest (15 cm) seed piece spacing treatment (Table 1 and 2). More marketable mid-size tubers (>5 cm diameter but <284g) were produced in the narrower spacings (15.0 to

22.5 cm) while wider seed spacings (30.0 to 37.5 cm) produced more larger marketable (>5 cm diameter and >284g) tubers in Sangre (Table 1). In-row seed spacing did not influence marketable yield tubers of CO93037-6R, except for the widest spacing (37.5 cm) which produced the highest yield of larger marketable tubers (Table 2).

External and Internal Defects:

The lowest percentage (1.7 %) of external defects was observed when Sangre seed tubers were planted at 30 cm seed piece spacing, and no hollow heart was observed (Table 1). Hollow heart was observed (1.6 %) only when Sangre was planted at a 37.5 cm spacing. Fewer external defects were observed (1.2 and 3.9 %) when CO93037-6R was planted at 15 and 30 cm spacing, respectively (Table 2). No hollow heart was observed in CO93037-6R in any of the seed piece spacing treatments.

Table 1. Effect of seed piece spacing on total yield, tuber size distribution and quality of Sangre.

Seed spacing treatment (cm)	Total yield (Mg/ha)	<5 cm dia.[1] (Mg/ha)	5–10 cm dia. (Mg/ha)	>5 cm dia. but <284g (Mg/ha)	>5 cm dia. and >284g (Mg/ha)	External[2] Defects (%)	Hollow heart (%)
15	62.5	9.0	53.5	48.0	5.5	3.6	0.0
22.5	61.7	5.5	56.2	49.7	6.4	4.9	0.0
30.0	59.2	4.6	54.6	35.7	19.1	1.7	0.0
37.5	58.2	4.5	53.7	36.4	17.3	4.0	1.6
Mean	60.4	5.9	54.5	42.5	12.1	4.5	0.4
LSD (0.05)	4.9	1.8	3.2	1.9	4.8	-	-

[1] dia. = diameter
[2] External defects include misshapes, growth cracks and knobs.

Table 2. Effect of seed piece spacing on total yield, tuber size distribution and quality of CO93037-6R.

Seed spacing treatment (cm)	Total yield (Mg/ha)	<5 cm dia.[1] (Mg/ha)	5–10 cm dia. (Mg/ha)	>5 cm dia. but <284g (Mg/ha)	>5 cm dia. and >284g (Mg/ha)	External[2] Defect (%)	Hollow heart (%)
15	60.2	16.8	43.4	42.5	1.0	1.2	0.0

22.5	51.9	12.2	39.7	39.2	0.5	5.2	0.0
30.0	59.8	10.8	49.0	47.0	2.1	3.9	0.0
37.5	55.4	7.5	47.9	41.3	6.6	5.8	0.0
Mean	56.8	11.8	45.0	42.5	2.6	4.0	0.0
LSD (0.05)	9.3	4.9	10.4	9.4	2.1	-	-

[1] dia. = diameter
[2] External defects include misshapes, growth cracks and knobs.

Nitrogen Application Rate

Total Yield and Tuber Size Distribution:

Nitrogen rate did not influence total yield and tuber size distribution in Sangre (Table 3), but in CO93037-6R higher total yields were produced at the lower N rates, with the highest total yield (55.6 Mg/ha) and marketable size tubers (5 to 10 cm diameter) produced when N was applied at 157 kg/ha (Table 4).

Table 3. Effect of nitrogen application rate on total yield, tuber size distribution and quality of Sangre.

Nitrogen application rate (kg/ha)	Total yield (Mg/ha)	<5 cm dia.[1] (Mg/ha)	5–10 cm dia. (Mg/ha)	>5 cm dia. but <284g (Mg/ha)	>5 cm dia. and >284g (Mg/ha)	External[2] Defects (%)	Hollow heart (%)
0	53.8	6.0	47.8	41.6	6.1	4.8	0.0
90	55.1	5.1	50.0	42.2	7.7	2.9	0.0
157	52.1	5.1	47.0	40.7	7.3	4.1	0.0
224	56.7	5.7	51.0	44.6	6.3	9.8	0.0
291	51.6	5.6	46.0	40.0	6.0	8.2	0.0
Mean	53.9	5.5	48.4	41.8	6.7	6.0	0.0
LSD (0.05)	4.3	1.2	6.2	5.3	2.1	-	-

[1] dia. = diameter
[2] External defects include misshapes, growth cracks and knobs.

External and Internal Defects:

Very few external defects (2.9 and 4.9%) were observed when N was applied at 90 and 157 kg ha^{-1} in Sangre and CO93037-6R, respectively (Table 3 and 4). No hollow heart was observed in both cultivars at all N application rates.

Conclusion

A major reason for conducting this study was to determine the optimum seed piece spacing and nitrogen rate for optimum marketable yield and tuber quality in two U.S. red potatoes (Sangre and CO93037-6R) grown at higher altitudes in the Southwestern United States. Total yield appeared to be of little use in determining optimum spacing. Seed spacing did not influence total yield in either cultivar. In contrast, narrower spacing increased undersize tubers in both cultivars. Narrower spacing increased midsize marketable tubers, while wider spacing increased large size marketable tubers in Sangre. Low percentage of external defects were observed in the 30 cm spacing for this cultivar. Seed piece spacing did not influence marketable yields in CO93037-6R, but the lowest percentage of external defects were observed at the 30 cm spacing.

Table 4. Effect of nitrogen application rate on total yield, tuber size distribution and quality of CO93037-6R.

Nitrogen application rate (kg/ha)	Total yield (Mg/ha)	<5 cm dia.[1] (Mg/ha)	5–10 cm dia. (Mg/ha)	>5 cm dia. but <284g (Mg/ha)	>5 cm dia. and >284g (Mg/ha)	External[2] Defects (%)	Hollow heart (%)
0	50.7	7.5	43.2	40.1	3.3	7.0	0.0
90	52.1	7.1	45.0	43.4	1.6	6.9	0.0
157	55.6	8.4	47.2	42.9	4.4	4.9	0.0
224	47.1	9.5	37.6	33.1	4.0	6.6	0.0
291	49.3	8.7	40.6	37.9	2.7	4.9	0.0
Mean	50.9	8.2	42.7	39.5	3.2	6.1	0.0
LSD (0.05)	4.9	2.1	7.6	6.3	1.2	-	-

[1] dia. = diameter
[2] External defects include misshapes, growth cracks and knobs.

Nitrogen rate did not influence total yield or tuber size distribution in Sangre, but fewer external defects were observed at lower rates (90 to 157 kg/ha) of N application. In contrast, maximum total and marketable yields were produced when N was applied at 157 kg/ha in CO93037-6R, where fewer external defects were observed. The significant production of potato tubers at the 0 N rate could be due to $N0_3$-N from the irrigation water. Percentage of external defects appeared to be a good predictor of optimal seed

piece spacing and N application rate in both cultivars, since lower percentage of external defects correlated with optimum seed spacing and nitrogen application rate.

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