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Andrew Jensen, Editor. ajensen@potatoes.com; 509-760-4859

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Early "Baby" Potato Nitrogen Requirements and Effects of Nitrogen Rate on Vine Kill, Tuber Yield, and Tuber Nutrients and Phytonutrients

R. A. Boydston*, D.A. Navarre, and H. P. Collins

USDA-ARS, 24106 N. Bunn Road, Prosser, WA 99350 (first and second author).

USDA-ARS, 808 E. Blackland Road, Temple TX, 76502 (third author).

Highlights

- N rates of 35, 67, and 101 kg N ha^{-1} did not impact number of tubers and stems per plant of Bintje or Ciklamen.
- Increasing N rate tended to increase leaf area of both cultivars, and vine desiccation with diquat tended to be less effective as N rate increased.
- Total tuber yield was lower for both cultivars in 1 of 2 years at the low 35 kg N ha^{-1} rate.
- Tuber skinning injury, tuber weight loss, and tuber size distribution were not affected by N rate.
- Tuber skinning injury and tuber weight loss were greatly reduced in both cultivars by harvesting at 4 weeks after initial vine kill compared to harvesting at 2 weeks after vine kill.
- Tuber N content tended to increase with increasing N rates, while most other nutrients, vitamin C, total phenolics, and antioxidant capacity showed little response.
- It appears that 67 kg N ha^{-1} provides adequate N to produce a good tuber set and yield of small tubers while not producing excessive vine growth that may be more difficult to kill.

Introduction

Both consumer demand and production of early potatoes (also referred to as baby, little, new, petites and creamers) have increased in recent years. Baby potatoes have various traits that are in line with emerging food trends and appeal to many consumers and chefs: they can be visually striking, are perceived to have superior flavor and be a premium product, have a novelty factor, smaller portion sizes, suitable for tapas and shared plates, require less preparation, cook more quickly and tend to have higher amounts of phytonutrients.

The increased demand has led growers and processors to refine various production inputs and practices including row and plant spacing, fertility, irrigation, vine kill methods and identifying cultivars especially suited for early potato production. Potatoes intended for the early potato market are usually in the 25 to 38 mm diameter size range (C-size class) depending on the particular market and end use. In order to maximize the tubers in this smaller size range, the potato crop is usually planted at a higher density than a typical full season potato crop and terminated early when vines are still growing rapidly, and small, immature tubers are present.

Killing the vines early controls tuber sizing at harvest, induces tuber maturity, and accelerates skin set. An early potato crop may be terminated in as little as 60 to 85 days from planting, so fertility and pest management requirements of early potatoes are different from that of full season potatoes. Excess early season N can delay tuber set, delay the tuber growth period and promote excessive vine growth making vines more difficult to kill. Differences in fertility can also influence yield, quality, and nutritional content of potato tubers.

Field studies were conducted from 2013 to 2014 with the objectives to evaluate the effect of three preplant N rates on tuber yield and size distribution, vine kill, tuber skinning injury, and tuber nutrient and phytonutrient levels in Bintje and Ciklamen cultivars grown for early potatoes. Bintje (pale yellow skin and yellow flesh) and Ciklamen (red skin and white creamy flesh) cultivars were chosen based on their popularity for early potato production.

Materials and Methods

Potatoes were planted in 86 cm rows at a seeding rate of 4500 kg ha^{-1} (15 cm spacing) in early April in 2013 and 2014 at the USDA-ARS Paterson, WA research farm. The soil was a Quincy sand containing 0.6% organic matter (O.M.). Preplant soil residual N totaled 35 kg N ha^{-1} in both years. After initial soil sampling and analysis, N (46-0-0, urea) was broadcast on April 15 each year to obtain three levels of N: 35, 67, and 101 kg N ha^{-1}. Vines were desiccated with two sequential applications of diquat (Reglone) at 0.6 kg ai ha^{-1} one week apart starting in mid-June using a tractor mounted field sprayer.

Tubers were harvested at 2 and 4 weeks after initial diquat application to determine if speed of skin set was affected by N rate. Tuber skinning injury was visually rated and total tuber yield, number of tubers, and tuber size distribution were determined. Tubers were sampled directly from the field at the final harvest of each cultivar for determining nutrient and phytonutrient concentrations. Total nutrient (N, P, K, S, Ca, Fe, and Zn) concentrations and total phenolic content, antioxidant capacity (FRAP), and total Vitamin C in tubers were determined. Additional details of the studies are published in the American Journal of Potato Research (Boydston et al. 2017).

Results

Nitrogen rates of 35, 67, and 101 kg ha^{-1} did not affect the number of tubers per plant or number of stems per plant at the time of vine kill for both cultivars. Over the two years of studies and N rates, Bintje yielded from 19 to 25 tubers/plant and Ciklamen 21 to 28 tubers/plant. Both cultivars averaged 4 to 6 stems/plant.

Leaf area per plant increased with increasing N rate for both cultivars and leaf area was greater in year 1 than year 2 (Fig. 1). For Bintje, leaf area was 1.2 to 1.8 X greater with the highest rate of N than the lowest rate. For Ciklamen, leaf area was 1.5 to 2.1 X greater with the highest N rate than the lowest rate. The greater leaf area per plant and denser canopy with the higher N rate likely decreased spray coverage with the desiccant resulting in slightly lower vine kill. Vine kill of Bintje tended to decrease more with increasing N rate, whereas vine kill of Ciklamen was not responsive to N rate (Fig. 2).

Tuber skin set, measured by visually rating skinning injury, was not adequate when harvesting only 2 weeks following the initial application of diquat. Tuber skinning injury at the later harvest date (4 weeks after initial vine desiccation) was much lower for both cultivars in both years. These results support current grower practices of delaying harvest for 3 to 4 weeks following vine kill to maximize tuber skin set and minimize tuber skinning and weight loss in storage.

Nitrogen rate did not affect total tuber yield for Bintje, which averaged 21.0 and 17.3 MT ha^{-1} in 2013 and 2014, respectively (averaged over all N levels). Likewise, N rate did not affect total tuber yield of Ciklamen in 2013 which averaged 22.5 MT ha^{-1}. However, in 2014, Ciklamen total tuber yields for the two higher N rates averaged 18.2 and 17.1 MT ha^{-1} and were greater than tuber yield of the low N treatment which averaged 11.7 MT ha^{-1}.

In both years, tuber size distribution was not affected by N rate for both cultivars. Bintje averaged 56.1% and 50.1% (by weight) in the desired 2.5 to 3.8 cm diameter category in 2013 and 2014, respectively. Ciklamen, averaged 52.8% and 53.9% (by weight) in the desired size class in 2013 and 2014, respectively.

Tuber N content increased with increasing N rates for both cultivars in 2013 (Fig. 3). Similar trends were evident in 2014, but differences were not statistically significant. Overall, N levels in tubers ranged from 10 to 15 g kg^{-1} and 9 to 17 g kg^{-1} for Bintje and Ciklamen, respectively during the two years.

In Bintje, N rate had little or no effect on tuber P, K, Zn, Fe, S, or Ca content in either year. Tuber P, K, Zn, Fe, and Ca content in Ciklamen increased as N rate increased from 38 kg N ha^{-1} to 101 kg N ha^{-1} in 2013. In 2014, however, N rate had no effect on any of the tuber nutrients measured.

In both Bintje and Ciklamen, tuber phytonutrients Vitamin C, total phenolics (GA), and antioxidant capacity (FRAP) were not significantly affected by N rate in either year (Table 1).

Discussion

Compared to a full season potato crop, relatively low N fertility (< 100 kg N ha^{-1}) is adequate for baby potato production. For Bintje and Ciklamen cultivars, preplant soil N levels of 35, 67, and 101 kg N ha^{-1} resulted in similar numbers of tubers and stems per plant. Potatoes receiving the low N rate of 35 kg N ha^{-1} tended to produce less leaf area than those receiving higher N rates, and vine kill with diquat became increasingly difficult as N rate increased.

Tuber skinning injury was much less in both cultivars by harvesting at 4 weeks after initial vine kill compared to harvesting at 2 weeks. Total tuber yield tended to be lower for both cultivars in 2013 with the lowest N rate, but not in 2014. Under the conditions of these studies a preplant N rate of 67 kg ha^{-1} provided adequate N to consistently produce good tuber set and yield of small tubers of Bintje and Ciklamen potatoes while preventing excessive vine growth that may be more difficult to kill.

Tuber N content tended to increase with increasing N rates, while most other nutrients measured showed little or no response to N rate. Tuber phytonutrient (vitamin C, total phenolics, and antioxidant capacity) varied by year but were not impacted by N rates, although total phenolics showed a trend to higher concentrations at higher N rates.

Acknowledgements

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References

Boydston, R. A., D.A. Navarre, H. P. Collins, and B. Chaves-Cordoba. 2017a. The Effect of Nitrogen Rate on Vine Kill, Tuber Skinning Injury, Tuber Yield and Size Distribution, and Tuber Nutrients and Phytonutrients in Two Potato Cultivars grown for Early Potato Production. American Journal Potato Research. 94:425-436. doi: 10.1007/s12230-017-9579-z

Table 1. Tuber phytonutrient levels in Bintje and Ciklamen potatoes grown under three soil nitrogen levels and harvested for early potatoes near Paterson, WA in 2013 and 2014.

Year	N rate	Bintje			Ciklamen		
		Vitamin C	Total Phenolics	FRAP	Ascorbate	Total Phenolics	FRAP
	kg ha^{-1}	mg 100 g^{-1}	mg g^{-1}	µg g^{-1}	mg 100 g^{-1}	mg g^{-1}	µg g^{-1}
2013	38	18.0	2.1	13.7	6.0	1.1	5.4
	67	17.1	2.1	15.1	5.6	1.1	5.0
	101	16.4	1.9	13.5	4.9	1.4	5.2
	P>F	NS	NS	NS	NS	NS	NS
2014	34	19.9	2.1	12.5	22.5	2.6	13.3
	67	19.7	2.2	13.2	22.1	2.9	12.0
	101	20.8	1.9	13.7	20.9	3.0	12.5
	P>F	NS	NS	NS	NS	NS	NS
ANOVA Factor							
Year		0.048	NS	NS	<0.0001	<0.0001	<0.0001
N		NS	NS	NS	NS	0.036	NS
Year*N		NS	NS	NS	NS	NS	NS

Figure 1. Leaf area of Bintje and Ciklamen potatoes grown with three nitrogen rates for early potato production. Bars within a year containing the same letters are not significantly different at the $P = 0.05$ level. When no letters are present there were no significant differences between treatments. WAP = weeks after planting.

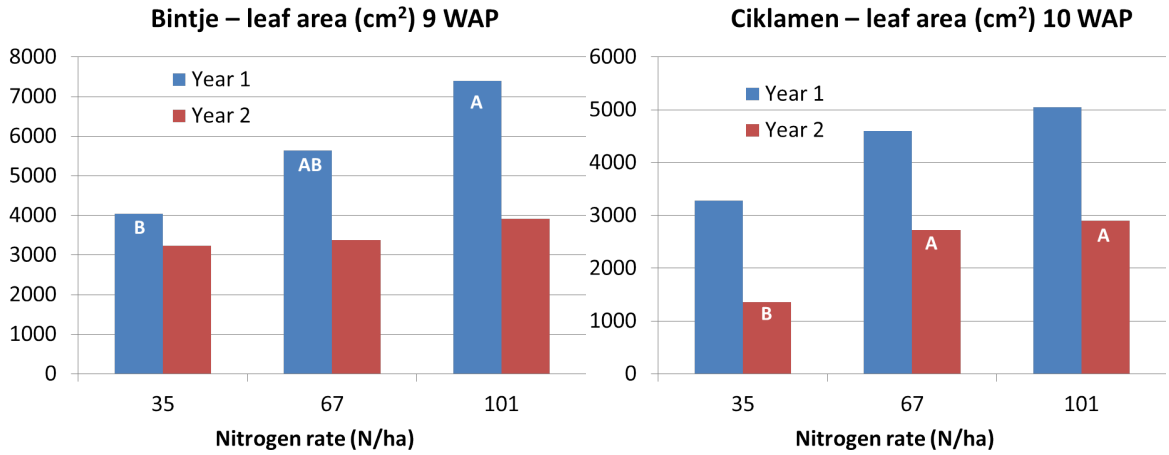

Figure 2. Percent vine kill following two sequential treatments of diquat to Bintje and Ciklamen potatoes grown with three nitrogen rates for early potato production. Bars within a year containing the same letters are not significantly different at the $P = 0.05$ level. When no letters are present there were no significant differences between treatments.

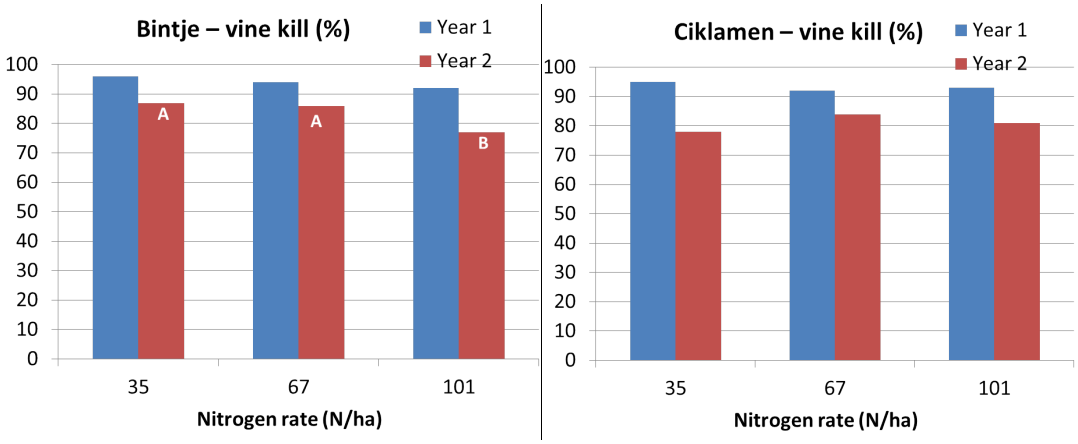

Figure 3. Tuber nitrogen content of Bintje and Ciklamen potatoes grown with three nitrogen rates for early potato production. Bars within a year containing the same letters are not significantly different at the $P = 0.05$ level. When no letters are present there were no significant differences between treatments.