Potato Nitrogen Management by Monitoring Petiole Nitrate Level

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ABSTRACT

Petiole nitrate nitrogen (NO₃-N) concentrations have been successfully used in Northwestern New Mexico to make timely nitrogen (N) recommendations for irrigated potatoes. However, a quick test and consistent sampling time is needed to precisely determine fertigation and to prevent over fertilization, especially in sandy soils. This study examined the petiole NO₃-N dynamics during the growing season for both chipping and table stock varieties. Readings from a quick in-field sap NO₃-N meter were highly correlated with NO₃-N indications using the conventional laboratory method. The sap NO₃-N meter can significantly reduce testing turnaround time and has great potential for potato N management. Results showed that most consistent NO₃-N readings could be obtained by collecting tissue samples between 1100 and 1400 hours of the day.
INTRODUCTION

Navajo Agricultural Products Industry (NAPI) in Farmington, New Mexico grows over 6,000 acres of potatoes annually. The yields and quality of the chipping and fresh pack potatoes are crucial to the company’s financial success. Nitrogen fertilizer has a significant effect on potato quality and yield (Kleinkopf and Westermann, 1987). Excess levels of soil N at or before tuberization can delay tuber growth, reduce yields and lower tuber specific gravity (McDole et al., 1992). Excess N in the late growing season can delay maturity of the tubers which can adversely affect potato storability and quality. Excessive N in some chipping varieties could result in poor chip color during processing. Poor N management also result in ground water contamination by NO$_3$-N, especially under sandy soils. A complete soil test predicts what should be applied to the soil to ensure acceptable yields; however, a series of plant tissue tests are needed to determine how well the crop is doing nutritionally during the growing season. The objectives of this study were to fine tune N fertigation by monitoring potato petiole NO$_3$-N levels weekly during peak growing stage; to calibrate the newly developed Cardy sap NO$_3$-N meter for quick NO$_3$-N results; and to identify the ideal tissue sampling time of day for consistent testing results.

MATERIAL AND METHODS

Two fields were chosen for this study. Selected soil chemical and physical properties before planting are shown in Table 1. A chipping variety, Atlantic, was planted in Field 612 on March 31, 1994. A table stock variety, Norkotah, was planted in Field 402 on April 12, 1994. The total N fertilizer recommended for both fields was 270 lbs/acre based on soil NO$_3$-N level and organic matter content, and on the yield goal of 550 hundred weight (cwt.) potatoes per acre.

<table>
<thead>
<tr>
<th>Field</th>
<th>Variety</th>
<th>pH</th>
<th>OM %</th>
<th>Texture</th>
<th>NO$_3$-N ppm</th>
<th>P$_2$O$_5$-P ppm</th>
<th>K$_2$O-K ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>612A</td>
<td>Atlantic</td>
<td>8.8</td>
<td>0.53</td>
<td>Sandy loam</td>
<td>3.7</td>
<td>10.4</td>
<td>128</td>
</tr>
<tr>
<td>402A</td>
<td>Norkotah</td>
<td>7.2</td>
<td>0.58</td>
<td>Loamy sand</td>
<td>4.4</td>
<td>13.1</td>
<td>72</td>
</tr>
</tbody>
</table>
Because of the sandy texture, the recommended N was split into several applications. Nitrogen was broadcast before planting at 50 lbs N/acre with needed phosphorus and potassium. Liquid starter fertilizer (30-30-0) was also applied at 66 lbs N/acre during planting. Rest of the N was applied through irrigation water after emergence using 32-0-0. The rate for fertigation was based on weekly petiole NO$_3$-N testing results to maintain a desired NO$_3$-N concentration at different growing stages.

Three representative tissue samples each containing 30 fully matured potato leaves (4th or 5th leaf from the growing terminal) were collected 55 to 60 days after planting from each field weekly for NO$_3$-N determination. Samples were normally collected around the 1000 HR. To determine the NO$_3$-N fluctuation during the day, additional samples were collected at the same location several times from early morning to mid afternoon. Leaflets were removed and half of the petioles were dried at 80°C and ground for NO$_3$-N measurement using ion selective electrode. The remaining petioles were cut to small pieces with scissors and mixed thoroughly in a pile. A portion of the plant material was transferred to a garlic press. The sap was squeezed into a small container. The sap NO$_3$-N was immediately read on a Cardy NO$_3$ meter (Figure 1). The meter was calibrated with a standard and checked with a slop solution. The calibration was checked after every five to six samples.

FIGURE 1. The sap nitrate meter (Cardy, from Spectrum Technologies, Inc.), plant sap press used for sap nitrate measurement.
RESULTS AND DISCUSSION

Scheduling Nitrogen Application

Petiole NO$_3$-N levels were monitored weekly during peak growing stages for both chipping and table stock varieties (Figure 2). Nitrate concentrations decreased as the crop matured and the season progressed. To maintain petiole NO$_3$-N in the sufficient ranges at each growth stage, eight to 43 lbs of nitrogen was applied through irrigation water each week based on the current petiole analysis. The amount of nitrogen applied was appropriate to maintain tissue N level within the published desirable NO$_3$-N zone. Results from a separate study indicated no significant amount of NO$_3$-N was leached out of the root zone using this practice. Information from these two fields can be used as a base for other potato fields in this region.

Optimum N application ensured high yields and good quality. The yields were 592 cwt. and 502 cwt. per acre for Atlantic and Norkotah, respectively. Both are

![Graph showing weekly petiole nitrate-N levels measured by conventional laboratory procedure for Norkotah and Atlantic potatoes.](image)
FIGURE 3. Correlation between petiole sap nitrate-N measured with the Cardy Nitrate Meter and dry-weight based nitrate-N obtained with the conventional laboratory procedures (A: linear fit, B: quadratic fit).
considered excellent yields in the industry. Tubers in both varieties had high specific gravities and low defects. The Atlantic was shipped directly to chip manufacturers from the field. Majority of the shipments were premium grade. Good N management also helped to reduce storage problems for Norkotah.
Correlation between Sap and Dry Petiole Nitrate-Nitrogen

There was a highly significant linear correlation between petiole sap NO$_3$-N measured with the Cardy NO$_3$ meter and dry-weight based NO$_3$-N obtained with the conventional laboratory procedures (Figure 3A). This finding agrees with that of a similar study conducted in Minnesota (Rosen and Errebhi, 1994), but the slopes and intercepts are different, possibly because of differences in climate and soil conditions. However, a quadratic equation (Figure 3B) better fits the data in the entire range ($r=0.98$). Since optimum ranges for petiole NO$_3$-N on a dry weight basis have been well documented, petiole sap NO$_3$-N readings can be used for guiding N fertigation using the equations in Figure 3. The sap NO$_3$-N meter reduces testing time from days to minutes. It not only saves critical time but also reduces analytical costs significantly. This finding is consistent with those on other vegetable crops (Hochmuth, 1994; Vitosh and Silva, 1994).

Ideal Time to Collect Petiole Sample for Nitrate Testing

The relationship between petiole NO$_3$-N concentration and time of day when the sample was collected is shown in Figure 4. Nitrate increased linearly with time between 0800 and 1100 HR and then stabilized at the highest level of the day for the next three hours. This may be due to the translocation of N within the potato plant in the morning as transpiration rate increased with increasing temperature and solar radiation. Figure 4 also indicates that NO$_3$-N increased with air temperature. Research has shown that transpiration rate increases as air temperature and solar radiation increases. Transpiration will concentrate NO$_3$-N in the petioles. Identical trends were found on a different variety planted on a different field (Figure 4B). Since petiole NO$_3$-N readings vary with time, care must be taken in extrapolating plant N needs from petiole NO$_3$-N analysis unless the time of sampling is considered. We recommend collecting sample between 1100 and 1400 HR to provide the most consistent NO$_3$-N results, thus enabling more precise nitrogen scheduling.

CONCLUSIONS

Split applications of N through irrigation water during potato peak growing season helped maintain petiole NO$_3$-N in the desirable ranges. Both potato yields and quality were improved by monitoring petiole NO$_3$-N levels. The time to get petiole NO$_3$-N results can be reduced from days to minutes by using a pocket size sap NO$_3$ meter. Use of this meter is particularly applicable to small farms. Consistent petiole NO$_3$-N readings can be obtained by collecting tissue samples between 1100 and 1400 HR, or when air temperature is stabilized.
REFERENCES


