DAILY NUTRIENT USE IN POTATOES

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INTRODUCTION

Potatoes have received a reputation as being a large consumer of nutrients such as nitrogen (N), phosphorus (P) and potassium (K). How much and when a nutrient is used is important for planning any fertilizer program. The advent of pivot irrigation has allowed nutrient management advances. Fertilization with pivots can be done on a daily, weekly, monthly or at whatever interval is deemed appropriate to meet crop need. Therefore, understanding how much of a nutrient is used and during what growth stage is critical for making fertilizer decisions. Uptake data should be used in conjunction with soil and petiole analysis.

This work was initiated in 1999 as a way to document the potato plant's demand for nutrients in high yielding potato systems. The objectives of the work were to: 1. measure nutrient uptake in a high yielding potato crop, 2. Model the data to fit a sigmoidal curve, and 3. Determine daily nutrient uptake rate

METHODS

Potato fields near Hermiston, OR were sampled in 1999, 2000 and 2001. Each potato field was sampled a minimum of 5 times during the growing season starting at flowering and finishing near harvest (late May or early June). Potato varieties sampled were Russet Burbank, Russet Norkota and Shepody. Five whole plant samples were harvested starting at flowering and spaced to measure uptake rate. Whole plant samples were separated into tubers and non-tuber parts once tuber weight became significant, generally starting on the third sampling. Each sample was dried, weighed and analyzed for N, P, K, calcium (Ca), magnesium (Mg), sulfur (S), chloride (Cl), boron (B), zinc (Zn), manganese (Mn), copper (Cu) and iron (Fe). Dry matter accumulation and nutrient uptake were calculated for each sampling date. Each field had three areas sampled. Data points in graphs represent the average of the three samplings. Sigma-Plot was used to fit the three point sigmoidal model. The first derivative of the model was used to calculate daily uptake rates. The 1999 sampling dates were June 8th, June 22nd, July 20th, August 20th and September 10th for the Russet Burbank field. Most of the data presented in this article is from the 1999 Russet Burbank field.

RESULTS

Dry matter produced in 1999 was just over 20,000 pounds per acre. Peak dry matter accumulation was 325 pounds per acre per day, which occurred in July (Fig.1). At

Presented at the Idaho Potato Conference, January 22, 2004.

harvest there were 15,000 lbs in dry tuber weight and 5000 lbs in top and roots. Fresh yield was 70,000 pounds of potatoes per acre or 700 cwt/a (35 t/a). Fresh yield between the July 20th and August 20th sampling date accumulated at a rate of 9.34 cwt (0.47 t) per acre per day.

Nitrogen was utilized at 413 lb/a in 1999 and just under 400 lb/a in 2000 on the Russet Burbank fields. Nitrogen uptake rate peaked at 7 lb/a-d in 1999 (figure 2) and 18 lb/a-d in 2000. During 2000 the sampling dates did not measure N uptake rate adequately. Whereas the 1999 data has three of the sampling dates during the linear phase of N uptake. During 1999 the crop followed wheat and had 328 lb N applied of which 65 lb N/a was applied pre-plant and the remaining water run.

Nitrogen concentration in the tubers was constant during the growing season in 1999, while total N in the tops decreased (Figure 3). Whole plant N started at nearly 5% in early June and decreased during the growing season to 2%. The nitrogen in the tops remained constant over the last three sampling dates at 3%, but increased tuber production and a lower tuber N concentration than the tops resulted in declining total plant N.

N uptake in potatoes increases during the growing season, while plant N concentration decreases. This is normal in agronomic crops. Nitrogen is taken up prior to dry matter production then transported and diluted into later growth.

Nutrient uptake can be influenced by fertilizer additions, such as K as shown by Figure 4. Potassium uptake was influenced by three K application rates 0, 350 and 700 lb/a K_20 applied as potassium chloride (KCl). The high K application rate had over 400 lb/a K, whereas the check had less than 200 lb/a K in the plant at harvest. Not only was K uptake rate influenced, but length of uptake and peak uptake rate were also impacted. Figure 4 shows early in the season that the check had a much shorter and less intense uptake. The impact of KCl on chloride uptake can be seen in Figure 5. K in this study increased yield and decreased solids.

Calcium uptake is represented in Figure 6. Approximately 90% of Ca utilized by potatoes is in the tops and roots at harvest and not in the tubers. Calcium uptake in 1999 showed 125 lb/a in the plant at harvest. Peak Ca uptake was just over 4 lb/a-d. Calcium, like every other nutrient, was taken up early in the growing season. Intense uptake started shortly after flowering or at the end of tuber initiation and continues through mid-bulking when demand decreases. When approximately 50% of dry matter is accumulated the plant has acquired approximately 80-90% of all of its nutrients except P, which is much more linked to dry matter accumulation.

Phosphorous uptake was 65 lb/a or 145 lb P_2O_5. Phosphorus uptake peaked in mid-July when tuber bulking also peaked. Peak P uptake was between 0.8-1.0 lb P/a-d. The P uptake rate curve is much broader than other nutrients, which tended to have narrow peaks of uptake. The amount of P in the tuber at harvest is between 80-90% of the total P in the plant, which is opposite to a nutrient such as Ca. Phosphorus is important for conversion of sugars to starch and though P is assumed to be mobile, it does not appear to move out of the tuber once the sugar to starch conversion is made. Phosphorous uptake continued later in the season than N, K, Ca or any of the other nutrients (Figure 8).

SUMMARY

Nutrient uptake and use in potatoes is a complex process that is impacted by yield, fertilization and climatic factors. Nutrient management decisions must incorporate the growth habits of the potato plant, as well as feasible farming practices.

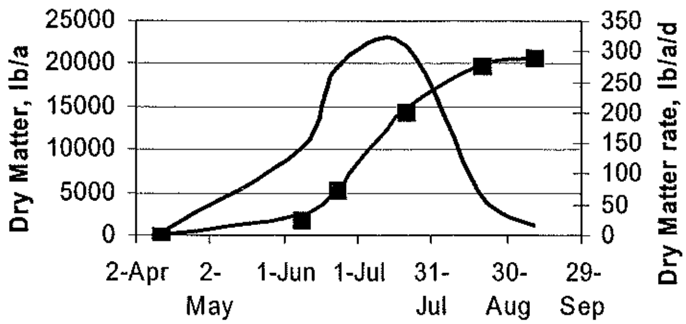

Figure 1. Dry matter production and daily dry matter rate in a 700 cwt Russet Burbank crop in 1999.

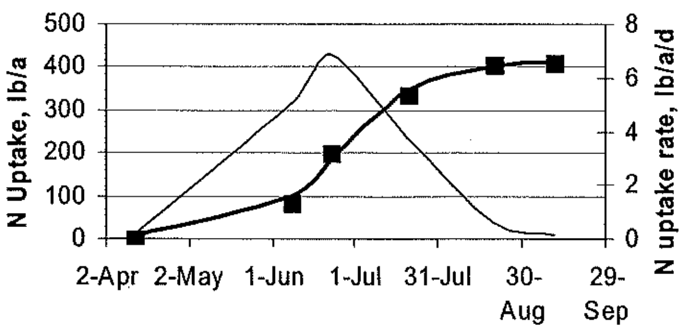

Figure 2. Nitrogen uptake in Russet Burbank in 1999.

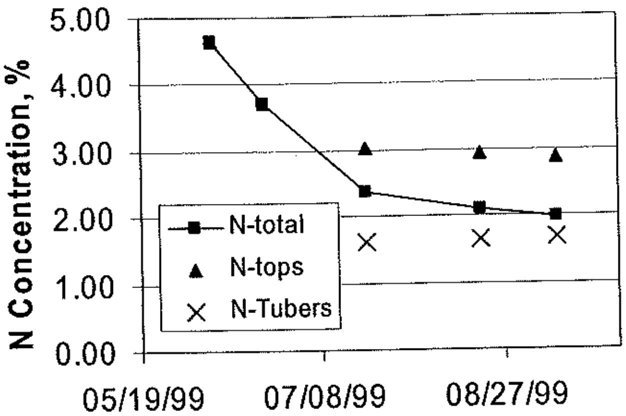

Figure 3. Nitrogen concentration in Russet Burbank in 1999.

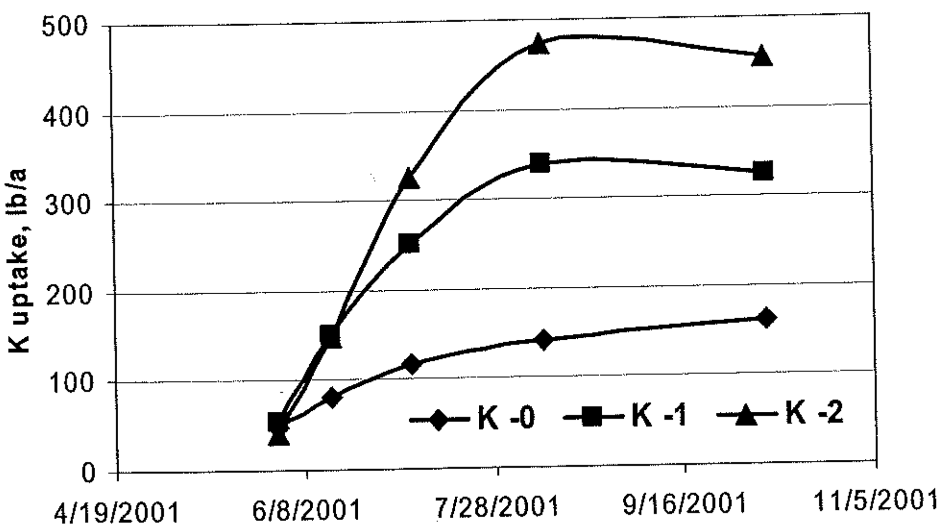

Figure 4. K uptake for 3 KCl treatments in Russet Burbank in 2001.

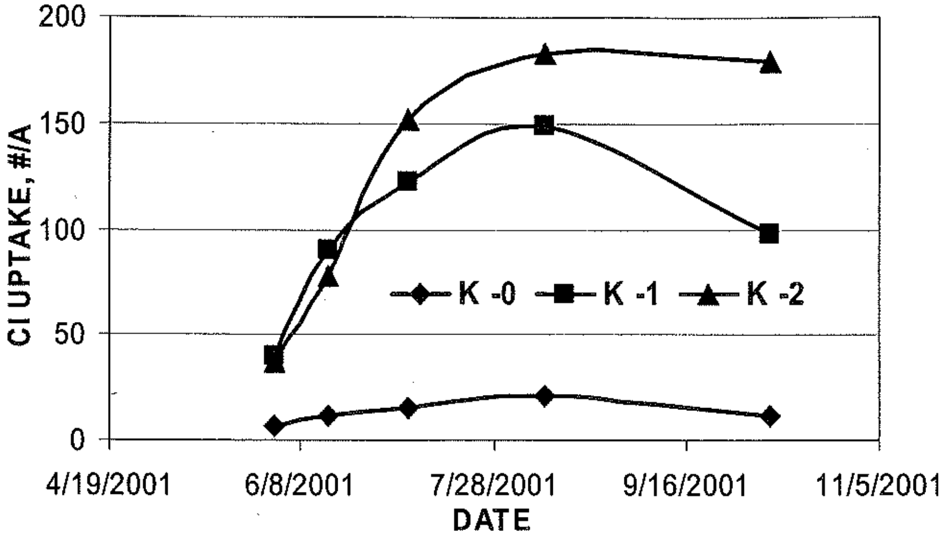

Figure 5. Chloride uptake for 3 KCl treatments in Russet Burbank in 2001.

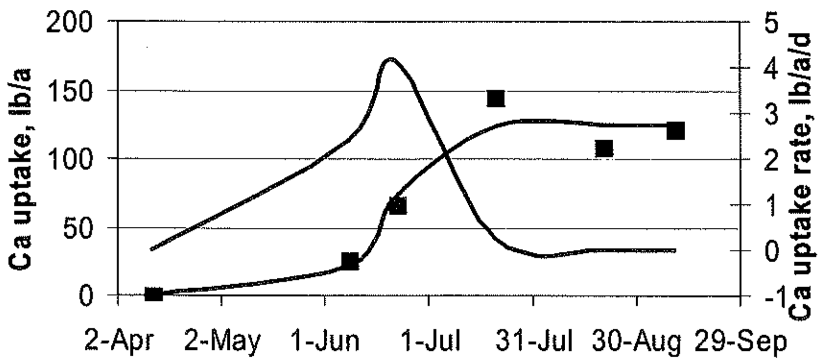

Figure 6. Calcium uptake and uptake rate for Russet Burbank in 1999.

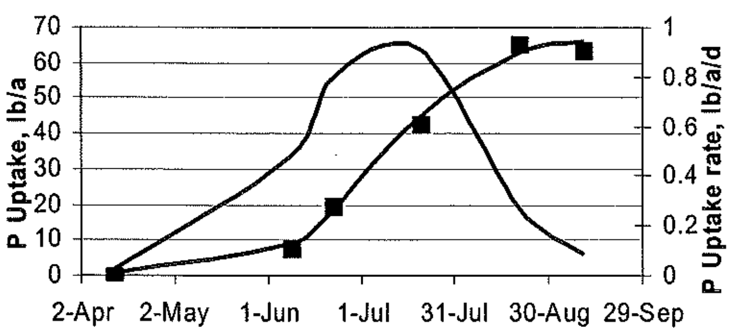

Figure 7. Phosphorus uptake and uptake rate for Russet Burbank in 1999.

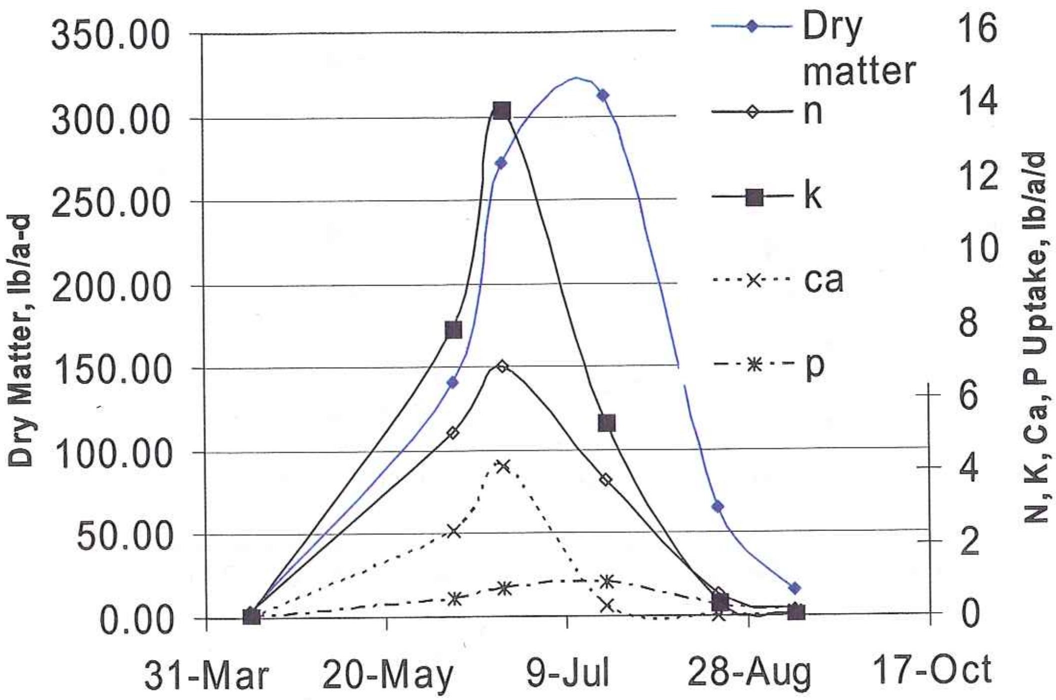

Figure 8. Dry matter, P, K, Ca, P uptake rate for Russet Burbank in 1999.