NUTRIENT ACCUMULATION AND PARTITIONING BY POTATOES IN MANITOBA

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ABSTRACT

The purpose of this study was to document nutrient uptake and partitioning in processing potatoes. Potatoes did take up and remove considerable amounts of macro and secondary nutrients. Nutrients behaved differently in uptake pattern, partitioning in the plant and translocation within the plant. More than half the N, P, K, S and Cu were found in the tuber of the plant. The nutrients Ca, Mg, Fe and Mn were found predominantly in the leaves. B and Zn had similar levels in leaf and tubers at harvest. The nutrients N, P, K, S, Cu and B showed some partitioning from leaves to tubers as maturity approached whereas Mn, Ca and Mg did not appear to translocate to the tuber from above ground material.

Plant uptake of nitrogen coincided with nitrate-N depletion of the rooting zone.

INTRODUCTION

It is recognized that high yields of potatoes require a substantial supply of nutrients. With more attention on nutrient management planning it is important to assess the degree of nutrient uptake and removal and the effect on residual soil nutrients.

MATERIALS AND METHODS

Commercial processing potatoes (variety Ranger Russet) were seeded on May 13, 2003 on the Manitoba Crop Diversification Research Centre near Carberry, Manitoba. The soil is a well-drained Ramada clay loam soil. Fertilizer was banded at seeding to supply 66 kg N/ha, 77 kg P_2O_5/ha and 33 kg K_2O/ha. Additional nitrogen at 77 kg N/ha was broadcast just prior to hilling on June 24. The crop was irrigated as required.

Whole plant samples were taken at selected growth stages during the season (Table 1) according to a randomized complete block design with 3 replicates. Plants were cut at ground level, dug, separated into plant portions (leaf, stem and tubers), dried, ground and submitted for full nutrient analysis by AgVise Laboratories. At the last sampling tubers were separated into marketable and undersize (<2" diameter) classes.

Table 1. Sampling dates and potato growth stages.

Sampling Date	Growth stage and description
June 23	Growth stage 2 = vegetative
July 7	Growth stage 3 = tuber initiation
July 23	Growth stage 4 = tuber bulking (<2" diameter)
August 18	Growth stage 4 = tuber bulking (>2" diameter)
September 18	Growth stage 5 = maturity

Nutrient concentrations were scaled according to dry matter yields and the cumulative dry matter and nutrient uptake displayed graphically. Phosphorus (P) and potassium (K) levels are converted to the oxide forms (P_2O_5 and K_2O) to equate to "fertilizer nutrient" values. The daily rate of dry matter and nutrient accumulation was determined based on the interval between samplings. Full data is presented by Heard, 2004.

Soil sampling was done at intervals during the growing season to depths of 90 cm to track nitrate-N depletion in the soil.

RESULTS AND DISCUSSION

Total dry matter accumulation at harvest was 14,656 kg/ha (Figure 1A). The tuber portion was 80% of total dry matter production, with 72% as maingrade size and 8% being undersize. The remaining biomass at maturity consisted of 11% leaves and 9% stem. The yield of maingrade potatoes was 376 cwt/ac. The pattern of dry matter partitioning in Figure 1A shows that dry matter did decline slightly in the leaves but not in the stem during final tuber bulking. Dry matter disappearance from leaves was at 21 kg/ha/day during the final month of growth. During this same period dry matter accumulated in tubers at 138 kg/ha/day.

Total nitrogen (N) accumulation in the potato was 199 kg/ha, with 67% or 134 kg/ha in the tubers. Peak accumulation in potato tops was 119 kg N/ha at early tuber bulking on July 23 (Figure 1B). During the period between tuber initiation and early bulking (July 23), the plant accumulated N at a rate of 5.2 kg N/ha/day. After this stage, nitrogen content declined in leaf and stem tissue at 0.5 to 1.4 kg N/ha/day, while N accumulated in the tuber at 1.7 to 2.1 kg N/ha/day.

Total phosphorus (P) accumulation was 77 kg P_2O_5/ha, with 86% or 67 kg P_2O_5/ha in the tubers (Figure 1C). During the period between tuber initiation and early bulking (July 23), the plant accumulated P at a rate of 1.3 kg P_2O_5/ha/day. After August 18, P content declined slightly in leaf tissue at 0.2 kg P_2O_5/ha/day, while P accumulated in the tuber at 0.9 to 1.0 kg P_2O_5/ha/day. P uptake occurs at a fairy constant rate over the growing season, indicating that a good supply of P is important throughout the season.

Total potassium (K) accumulation was 369 kg K_2O/ha, with 69% or 254 kg K_2O /ha in the tubers (Figure 1D). During the period between tuber initiation and early bulking (July 23), the plant accumulated K at a rate of 5.2 kg K_2O /ha/day. After August 18, K content declined in leaf tissue at 0.8 kg K_2O /ha/day, while K accumulated in the tuber at 3.6 kg K_2O /ha/day. Similarly to P, K accumulated throughout the growing season.

Sulphur (S) uptake by the plant was only 26 kg S/ha, with 16 kg S/ha or 62% in tubers. Peak accumulation in potato tops was 13 kg S/ha on August 18 (Figure 1E). After August 18, S content declined slightly in leaf tissue at 0.1 kg S/ha/day, while S accumulated in the tuber at 0.2 kg S/ha/day. The greatest S accumulation rate of the plant was 0.5 kg S/ha/day between tuber initiation and early bulking (July 23).

Calcium (Ca) was almost exclusively in the above ground portion, with 62% in the leaves and 32% in stems (Figure 1F) The greatest Ca accumulation rate of the plant was 1.9 kg Ca/ha/day between tuber initiation and early bulking (July 23). Apparent loss of plant Ca was observed during the last month, exclusively from leaf tissue. The magnesium (Mg) uptake pattern was similar to that of Ca, with most present in leaf (62%) and stem (24%) portions (Figure 1G).

Total accumulation of micronutrients was small; 340 g Zn/ha, 2489 g Fe/ha, 920 g Mn/ha, 66 g Cu/ha and 133 g B/ha. The high Fe content at the July 23 date probably resulted from contamination of tissue with soil. At other samplings the leaf, stem and tubers were rinsed with water to remove soil, the likely contributor to inflated Fe measurements. Zinc and copper tended to accumulate in the plant until maturity, whereas B content had plateaued and Mn and Fe content actually declined as maturity approached. Manganese was almost exclusively found in the leaf tissue (84%), whereas copper accumulated in tubers (75% of total Cu).

Soil nitrate levels actually increased between the June and late July sampling date, presumably a result of the pre-hill broadcast application of 77 kg N/ha (Table 2). Plant uptake of N depleted soils between the late July and harvest measurement.

Table 2. Soil nitrate-N levels through the growing season.

Soil depth	June 1	July 28	Sept 26
	Nitrate-N kg/ha		
0-15 cm	34	30	6
16-30 cm	19	34	1
31-60 cm	18	27	2
61-90 cm	6	19	2

REFERENCES

Heard, J. 2004. Nutrient accumulation and partitioning by potatoes in Manitoba. In Proc. of Manitoba Soil Science Society. http://www.gov.mb.ca/agriculture/msss/2004/mss600.pdf

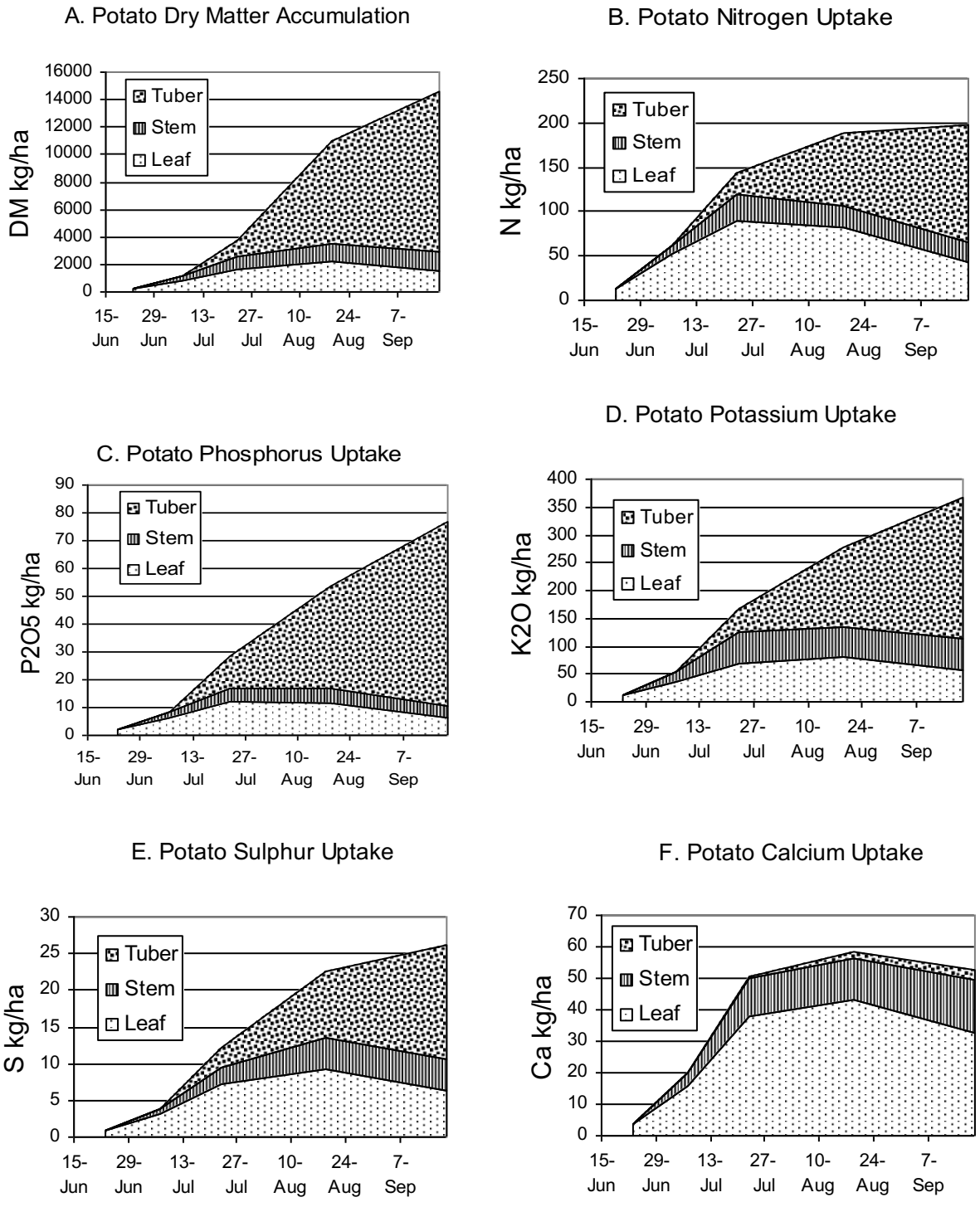

Figure 1. Dry matter and nutrient uptake and partitioning in the potato (A = dry matter, B = nitrogen, C = phosphorus, D = potassium, E = sulphur, F = calcium).

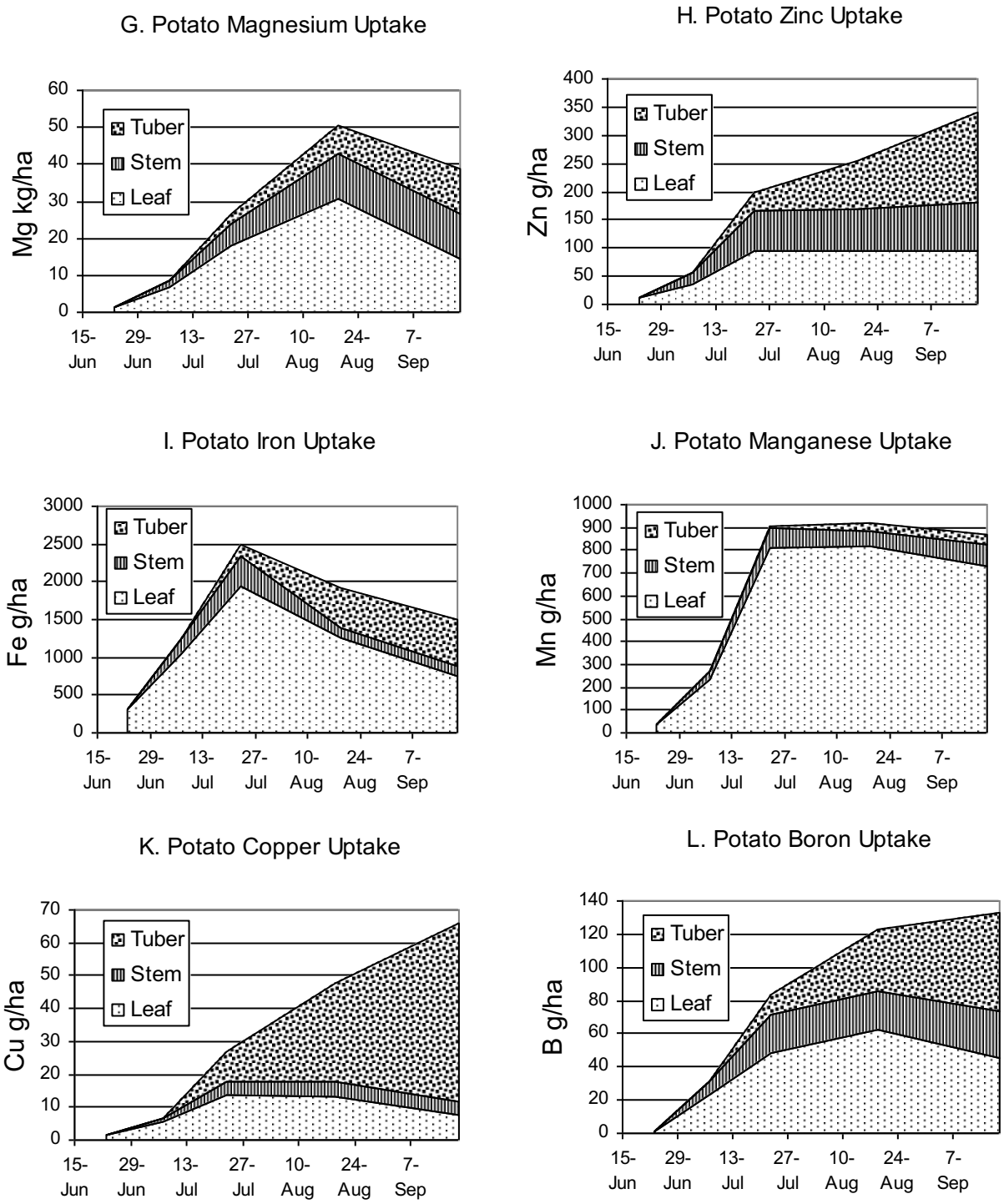

Figure 1 (cont). Nutrient uptake and partitioning in the potato (G = magnesium, H = zinc, I = iron, J = manganese, K = copper, L = boron).