CAN WE MAINTAIN A PROPER BALANCE BETWEEN GROWTH RATE AND NUTRIENT COMPOSITION TO IMPROVE TUBER YIELD AND QUALITY? [1,2]

by
B. W. Poovaiah [3]

Tuber yield and quality are major factors that determine crop value and profit to the producer. Climatic factors such as temperature and moisture extremes have a strong influence on tuber yield and quality. For example, at higher temperatures or when potato plants are subjected to moisture stress, the increased respiration rate reduces the amount of stored carbohydrates and consequently reduces yield and quality. The climate cannot be altered but we can develop cultural practices to manipulate the growth and development of potato plants for economical production of this important food crop.

Under conditions of rapid vine growth, the physiological balance of the plant is altered and excessive top growth is produced at the expense of storage organs. This altered growth rate can also induce mineral imbalance in developing tubers which predisposes them to various internal disorders. The basis for our study is that under conditions of excessive vine growth the potato plant is more susceptible to temperature and moisture stress. A management scheme which includes an overall reduction in competition for water and nutrients between developing tubers and growing shoots results in uniform, high quality tubers. Preliminary results of our trials indicate that we can reduce vein growth using growth regulators even when the plants are subjected to high nitrogen nutrition without sacrificing tuber yield and quality.

In general, in most tuberous crops the formation of storage organs is associated with the suppression of elongation growth. This is illustrated in Figure 1, where the period of tuber development is shown to coincide with a period of little or no increase in leaf area. Rapid vine growth at the time of tuber induction and while the tubers are rapidly growing can drastically alter the growth pattern and increase the incidence of physiological disorders. Tuber growth can be stimulated by the application of growth regulators to the leaves which serve to inhibit elongation growth of vines.

Calcium is needed to protect cell wall structure and membrane integrity in the tuber. Calcium follows the water paths within the plant, and accumulates primarily in the leaves where most of the transpiration takes place. Excessive vine growth and stress are known to alter calcium transport and the leaves out-compete tubers especially when plants are not getting enough calcium. Low soil pH can further complicate this problem.

Mineral analysis of plant samples collected from field plots in Othello revealed a significant difference in the distribution of major cations (Table 1). The results in Table 1

---

1 Paper presented at the 22nd Annual Washington State Potato Conference and Trade Fair, February 2-4, Moses Lake, Wa. 98837

2 I am thankful to Mr. Hari Krishnan and Ms. Janet Clancy for the technical assistance; and Mr. Bill Foeppel, Area Extension Agent, Pasco, and Dr. Robert Thornton, Extension Horticulturist, Washington State University, Pullman, for helpful discussions and for providing tuber samples from different locations.

3 Professor, Department of Horticulture and Landscape Architecture, Washington State University, Pullman, Wa. 99164-6414

This Presentation is part of the Proceedings of the 1983 Washington Potato Conference and Trade Fair.

illustrate that of all the organs of the Russet Burbank potato plants, the tubers contain the lowest amount of calcium and that in comparison to other positively charged cations, the calcium amounts to a minor fraction of the total cation concentration in the tuber. Mineral imbalance in potato tubers can lead to increased incidence of physiological disorders especially when the concentration of $K^+ + Mg^{++}$ is high in comparison to Ca^{++}. Our previous results suggest that a reduced calcium level in the tuber or an imbalance between potassium, magnesium and calcium ($K^+ + Mg^{++}:Ca^{++}$ ratio) predisposes the tubers to physiological disorders.

The results in Table 2 illustrate the composition of calcium, magnesium and potassium in potato tubers at various stages of development. Calcium content during early stages of tuber growth decreases significantly as compared to other minerals. Calcium is relatively immobile and it is rarely relocalized within the plant, whereas, potassium and other minerals are redistributed readily. Hence, there must be uninterrupted supply of calcium to the rapidly developing tubers. Under conditions of rapid vine growth past the tuber induction stage (arrow in Fig. 1) or under environmental stress, when plants are not getting enough calcium, leaves out-compete tubers for carbohydrates and minerals. This leads to mineral imbalance and less dry matter accumulation in the tuber.

Figure 1. The start of tuber growth and development in potato plants is associated with the cessation of the growth of new leaves. Arrow indicates the stage of tuber induction.

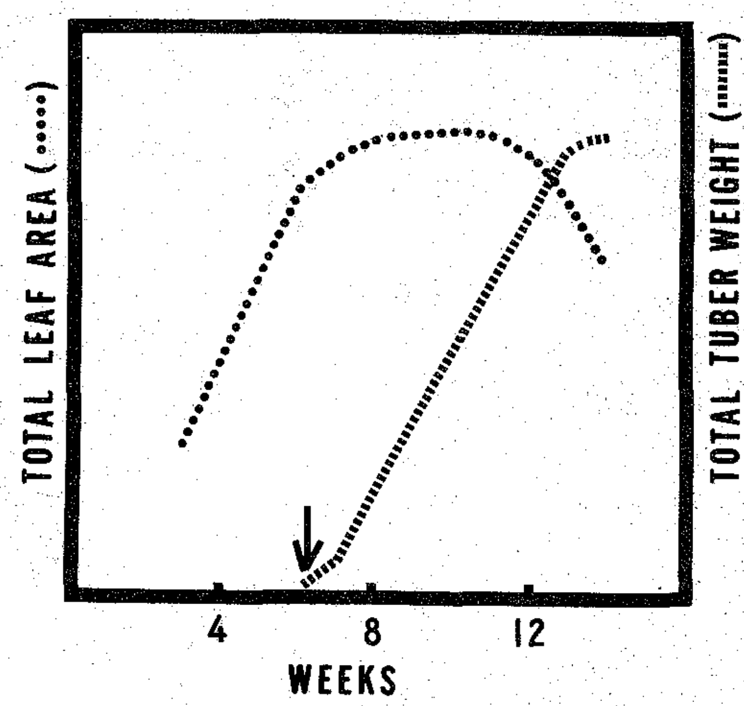

Table 1. Composition of Calcium (Ca^{++}), Magnesium (Mg^{++}) and Potassium (K^{+}) in Potato Samples Collected From Othello Field Experiments.

Plant Parts	Calcium	Magnesium	Potassium
	--------------------	mg/g dry weight	--------------------
Leaves	15.0	7.4	85.0
Stems	5.5	5.1	49.0
Roots	6.3	1.9	8.0
Tubers	0.5	1.4	45.0

Table 2. Composition of Calcium (Ca^{++}), Magnesium (Mg^{++}) and Potassium (K^{+}) in Potato Tubers at Various Stages of Development.

Harvest Date	Calcium	Magnesium	Potassium
	--------------------	mg/g dry weight	--------------------
6/29	1.94	1.25	24.50
7/13	0.95	0.95	19.00
7/27	0.55	1.00	16.75
8/10	0.45	0.85	16.50
8/24	0.53	0.95	17.90