FOLIAR NUTRIENT USE ON POTATOES[1]

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In recent years there has been renewed interest in the use of foliar fertilizers (and other foliar compounds such as antitranspirants) on potatoes. This renewed interest is largely due to the availability of new fertilizer formulations which appear to be more suitable. Limited university research information is available on the effect of this method of nutrient application to potatoes. The general aspects of foliar fertilization, factors affecting the uptake and utilization of foliar nutrients, and preliminary research results will be discussed.

Fertilizer is unquestionably one of the most important and costly inputs involved in the production of a potato crop. The objective of any fertilization program should be to provide the required plant nutrients at the right time, in the right place, and of the right kind and amount to achieve optimum yield and quality. A producer must utilize soil testing and nutrient monitoring of concentrations in the plant tissues so that fertilizer application(s) achieve these objectives.

Applying nutrients to the foliage of plants in not a "new" practice--it has been used on commercial fruit and vegetable crops for more than 50 years. Two beneficial aspects presented for the use of foliar nutrients have been to correct micronutrient deficiencies when root uptake is inadequate or impaired, and to supplement standard soil fertilization programs. As plants are pushed to their limits to achieve higher yields, there may be inadequate uptake of nutrients through the roots or soil nutrient levels that result in a deficiency in the plant. For example, phosphorus is one of the most important elements needed in a plant's early growth period, but also the most difficult for a plant to absorb from the soil when the soil is cold. In the summer, potassium and calcium may be the most difficult for the plant to absorb from the soil.

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1 Abstract of invited presentation to the Irrigated Agriculture Fertilizer Conference, January 6, 1988, Pasco, WA 99301.
The reported research was supported in part by funds provided by the Washington State Potato Commission.

Plants can experience localized periods of trace element deficiencies due to climatic factors or other adverse conditions which reduce uptake from the soil (for example, pH effects, poor aeration or other conditions affecting good root growth and nutrient uptake, unfavorable weather conditions, low exchange capacities of soils such as in sandy soils, fixation of nutrients in the soil, etc.).

The major benefits generally given for the use of foliar nutrient applications on potatoes are increased yields (prevent yield losses) and improved quality. One of the first questions pertaining to the use of foliar fertilization is: "Can fertilizer nutrients be absorbed through leaves and stems?" It has been established in various research studies that plant leaves and other above-ground parts are capable of absorbing chemicals and nutrients. Absorption of nutrients by plants is not a function limited to the roots. However, there is still a lack of information on the precise mechanism(s) of nutrient uptake and transport to other plant parts as well as the retranslocation (renewed movement) of elements from one leaf, or other plant part, to another leaf or plant part during different stages of growth.

MECHANISM OF FOLIAR UPTAKE

The leaf is the principal location of several metabolic activities in the plant. The mineral elements, which are both structural and functional, are moved to the leaf to help convert carbon from the air to carbohydrates (the photosynthesis process).

1. Permeability of the leaf cuticle: The cuticle is a waxy layer on the surface of leaves which is important in preventing water loss (Fig. 1). It is now considered to be much more permeable than previously believed. Passage of solutions through this layer is a passive process (ie, does not require energy). Light, moisture, temperatures, and certain chemicals (surfactants) bring about alterations in the permeability of the cuticle and influence the absorption through the cuticle and thus by the living cells of the leaf. Solutions may also be absorbed through the stomatal openings which are more numerous on the underside than on the upper surface of leaves.

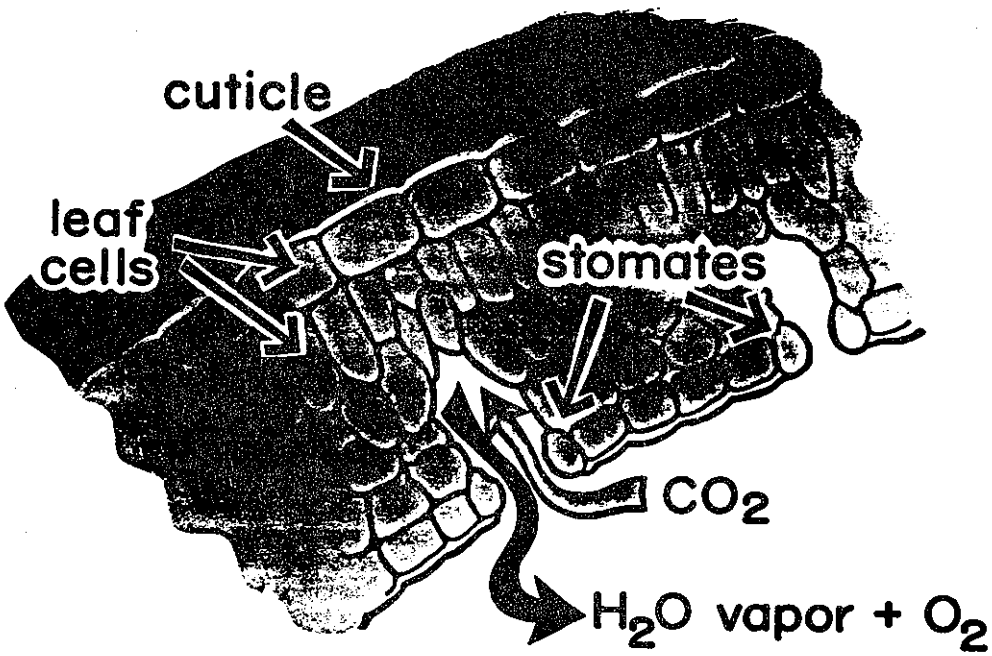
2. Nutrient element uptake by leaf cells: Foliar absorption of nutrients is a multi-step process consisting of passive (simple movement not requiring energy) and metabolically active (requires expenditure of energy) phases. This latter process is generally enhanced by light, indicating that the needed metabolic energy is supplied through photosynthesis and the respiration processes that are occurring in the plant.

3. Translocation of nutrients: Uptake and movement of materials applied to the leaves have been investigated using radioactive isotopes of the various nutrient elements. The movement of nutrients has been shown to occur bidirectionally (that is, both up and down the plant system) in the xylem to the leaf tips and in the phloem to the base of leaves and into the stems.

Table 1. The major (macro) and minor (micro) nutrient elements required for plant growth and metabolic processes in plants.

MAJOR	MINOR
Nitrogen	Boron
Phosphorus	Chlorine
Potassium	Copper
Calcium	Iron
Magnesium	Manganese
Sulfur	Molybdenum
	Zinc

Figure 1. Cross section of a leaf showing the waxy cuticle layer, leaf cells, and stomatal openings on the lower surface.



4. Remobilization of nutrients: When some nutrient elements are transported to various plant parts, they have been considered to be "fixed" fairly permanently in that location. Retranslocation of nutrient elements from older leaves (or other plant parts) is an important aspect of plant nutrition, especially for certain elements such as calcium, iron, manganese, and zinc which have not been considered to be freely retranslocated in plant tissues. New information is challenging this concept, but much more basis research needs to be done on this question.

There is ample evidence to indicate that the mechanisms of foliar absorption and translocation largely resemble those of root absorption; however, "Foliar Feeding is NOT a substitute for soil-applied fertilizers."

FACTORS AFFECTING UTILIZATION/APPLICATION OF FOLIAR NUTRIENTS

1. Rate of application -- too much of certain nutrient elements can cause leaf burn, be wasted, or be toxic.

2. Time of application -- for optimum absorption by plants, it is generally recommended that application take place early in the morning or late in the evening; it is suggested that application not be made during midday except during cool and cloudy weather.

3. Plant growth stages -- generally considered that these compounds should be applied early in the growing season, but there are now questions regarding the value of later applications during the tuber-bulking or tuber-maturing stages.

4. Size of foliar fertilizer droplet -- should be as fine as possible and achieve uniform wetting of the leaf surfaces during application.

5. Adequate soil moisture -- do not apply to plants in a moisture-stressed condition.

6. Basis of plant needs -- apply only what the plant needs; if there is not a low level of any one nutrient, a balanced formulation may be preferred.

7. Chemical composition of solution -- the solubility of nutrient elements in the solution is important to increase absorption by the foliage and to prevent injury; the pH of the solution has an effect on the solubility of the nutrient elements, but if too low or too high may be toxic to the foliage.

All of the major and minor plant nutrient elements (Table 1) contribute to plant growth and development as well as the functional and metabolic processes that go on in plants. A deficiency of any one element will adversely affect and limit the entire metabolic system. On the other hand, toxicity levels of nutrient elements can also occur in plants and cause detrimental results.

FIELD RESEARCH TRIALS

The objectives of our field research have been to (1) evaluate the effect of major and minor foliar-applied nutrient compounds on yield and quality of potato tubers (determine if there would be a positive influence), and (2) select materials with positive and negative yield responses to be further studied to determine the effect on potato growth and physiological processes.

Commercially available compounds were applied to potato plants in three growers' fields near Pasco, Quincy and Warden, Washington. These were Russet Burbank potatoes grown under center pivot and linear move irrigation systems using each grower's normal cultural practices and fertilizer programs. Thus, these treatments were in addition to the grower's normal fertilization program. Sprays were applied with a hand-held plot sprayer at the rate of 20 gallons of water per acre or the label rate. Applications were made to each field when the plants had reached tuber initiation (plants were 10 to 12 inches tall), and, in some cases, a second application was made two weeks later. Treatments included the major and minor elements separately or in various combinations. In general, treatments containing a balance of the major elements yielded better than those containing two or fewer of the major elements with some minors. Results for both yield and quality have been obtained and will be discussed.

SUMMARY

Our preliminary results would indicate that foliar nutrition has the potential for an important role in potato production. Several new considerations, for example, cost of fertilizer materials, concern for ground water quality, availability of newer formulations of compounds, newer surfactants which increase the efficiency of foliar absorption, etc., are factors which may give reason to consider this fertilization method. Additional experiments and replicated studies will be necessary to confirm these results and to further evaluate many other questions about the use of foliar nutrient applications.