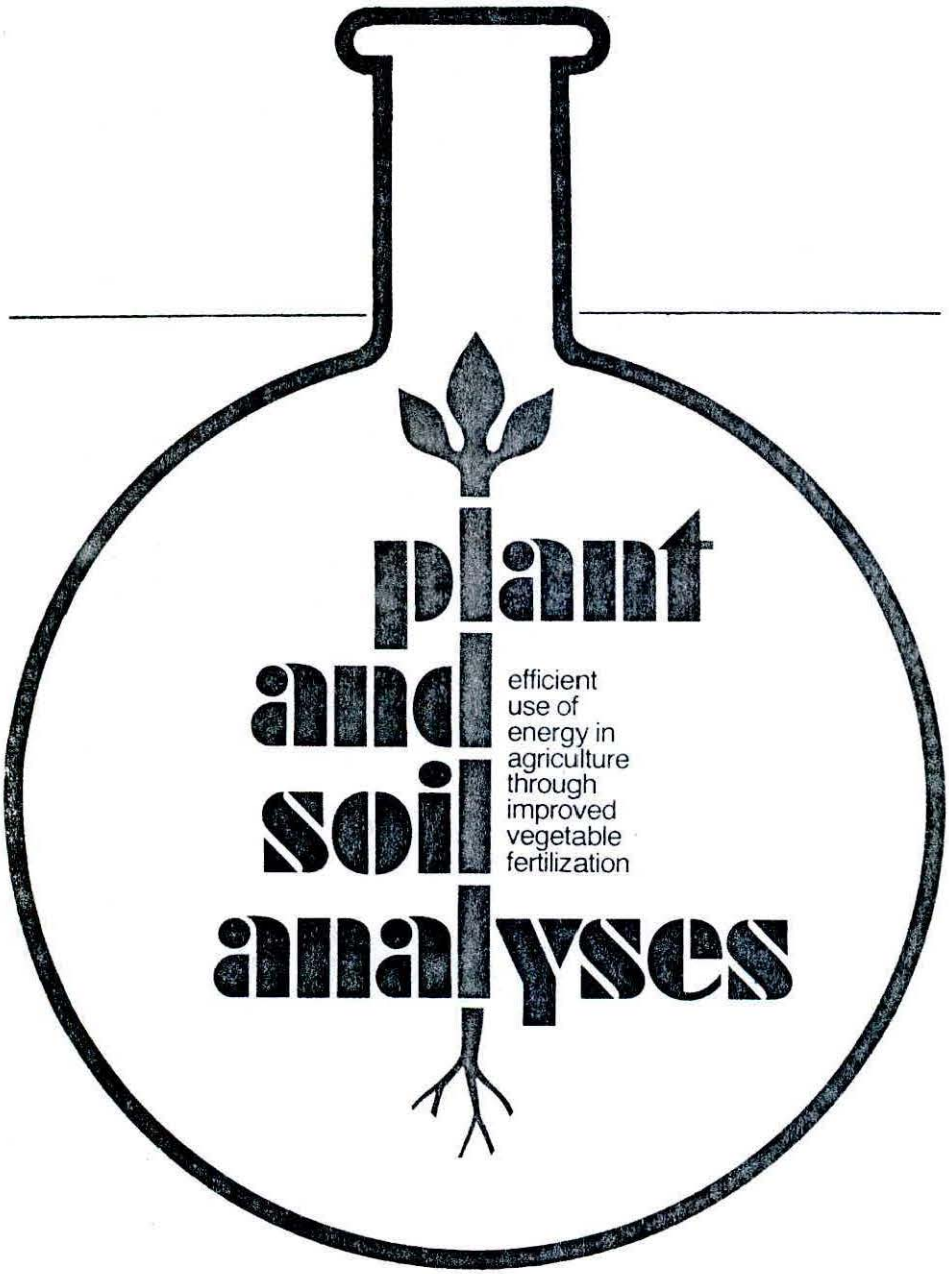
by Nathan H. Peck, *Seed and Vegetable Sciences, Geneva*



Manufacture of fertilizers requires a third of the energy used in agriculture. Optimum production from a fertilization system that also maintains a natural ecological balance is necessary. Plant and soil analyses are useful tools for improving crop fertilization systems. During the last decade, soil tests and chemical analysis of plant tissues have been used at Geneva to study the phosphorus and potassium nutrition of vegetable crops grown for processing. The present emphasis, however, is on nitrogen nutrition of vegetables.

Chemical analysis of plant tissues and soil analysis are combined to assess the nutrient status of a crop during the growing season and to measure plant responses to soil fertility and fertilizers. Chemical analysis of vegetable plant parts made at intervals of growth, development, and maturation are used to monitor uptake of nutrients and to establish reference points at optimum growth. Both plant analyses and soil analyses (soil tests) are essential to understanding the principles of inorganic nutrition of plants and for developing fertilization systems. Tests of the soil in producers' fields are necessary for practical application of the fertilization systems.

Fertilization of vegetable crops should result in optimum production and simultaneously improve the soil's production potential and maintain a natural ecological balance. A total fertilization system should be designed to control the nutrition of a crop from planting to harvest — of vegetables grown for processing, for example, during the seedling, vegetative frame, and harvest stages.

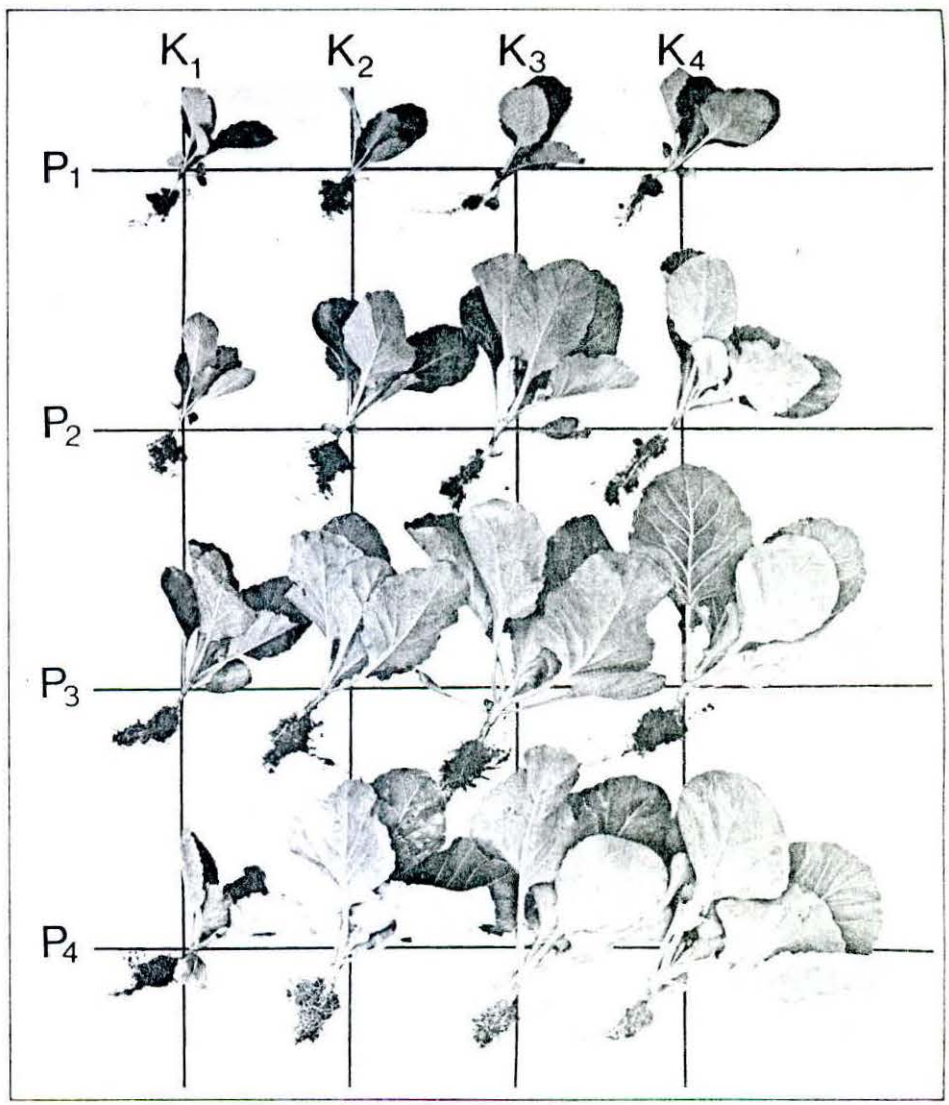
Seedling stage. (first part of the growing season) Seedlings have small rooting systems, and because the soil is often cold and wet at planting time, nutrients are not readily available and the roots take them up slowly. An adequate supply of balanced, readily available, nonphytotoxic plant nutrients for seedlings is necessary to promote vigorous, uniform growth. Seedlings are very responsive to a proper balance of nutrients but they (and germinating seeds) are also

Mechanical snap bean pod harvester. Mechanical harvesting of vegetables for processing is a once-over, plant-destructive operation. Only the pods of acceptable size and quality at harvest are usable for processing. Uniformity among plants is necessary for high, reliable yields of quality produce.

highly sensitive to injury from improper fertilization. This may be caused by applying excessive amounts of potassium chloride or other fertilizers with a high salt index or of potentially injurious materials, such as urea, too close to the seeds. Although phosphorus promotes seedling growth, it has been shown that an extremely high concentration of phosphorus without adequate potassium will reduce seedling growth and yields, especially of snap beans, table beets, and cabbage. Application at planting time of fertilizers that contain a low proportion of nitrogen, phosphorus, and potassium is usually essential to assure adequate nutrients in proper balance in the seedling rooting zone.

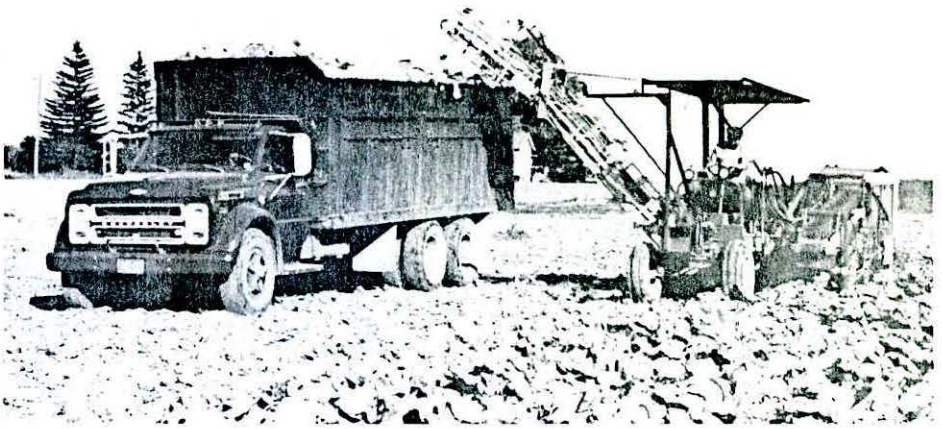
Vegetative frame stage. (middle part of the growing season) During this stage, rooting systems enlarge and extend through the entire rooting soil. Nutrients are taken up rapidly and are needed in large amounts for development of the sturdy vegetative frames that hold the plants upright for efficient mechanical harvesting.

Soil tests made before planting indicate the amount of nutrients already available in the soil. Combining the information from soil tests and plant analyses with the knowledge that soil nutrients are released more rapidly as the soil warms, the additional amounts of each fertilizer nutrient needed for optimum crop response are determined. They are added at different times. Those used at the frame stage, such as phosphorus, potassium, and some of the nitrogen, can be applied before planting.



Cabbage seedling response to superphosphate (P) and potassium chloride (K) fertilizers. Direct-seeded vegetables are very responsive to a proper balance of nutrients within their limited rooting zones.

Mechanical cabbage harvester.



Mechanical table beet harvester.

However, it is essential that most of the nitrogen be added during the growing season. Fertilizer is only a supplement to the nutrients released from the natural minerals in the soil and the residue from previous fertilizers.

Harvest stage. (last part of the growing season) As the vegetable crops approach maturity, nutrients are needed to maintain growth for reliable quality and harvest yield. By gradually removing the available nutrients from the rooting zone, the roots assure a maximum supply of nutrients for the plants and a minimum surplus in the soil after the crop is harvested. The unharvested portions of the crops return nutrients to the soil.

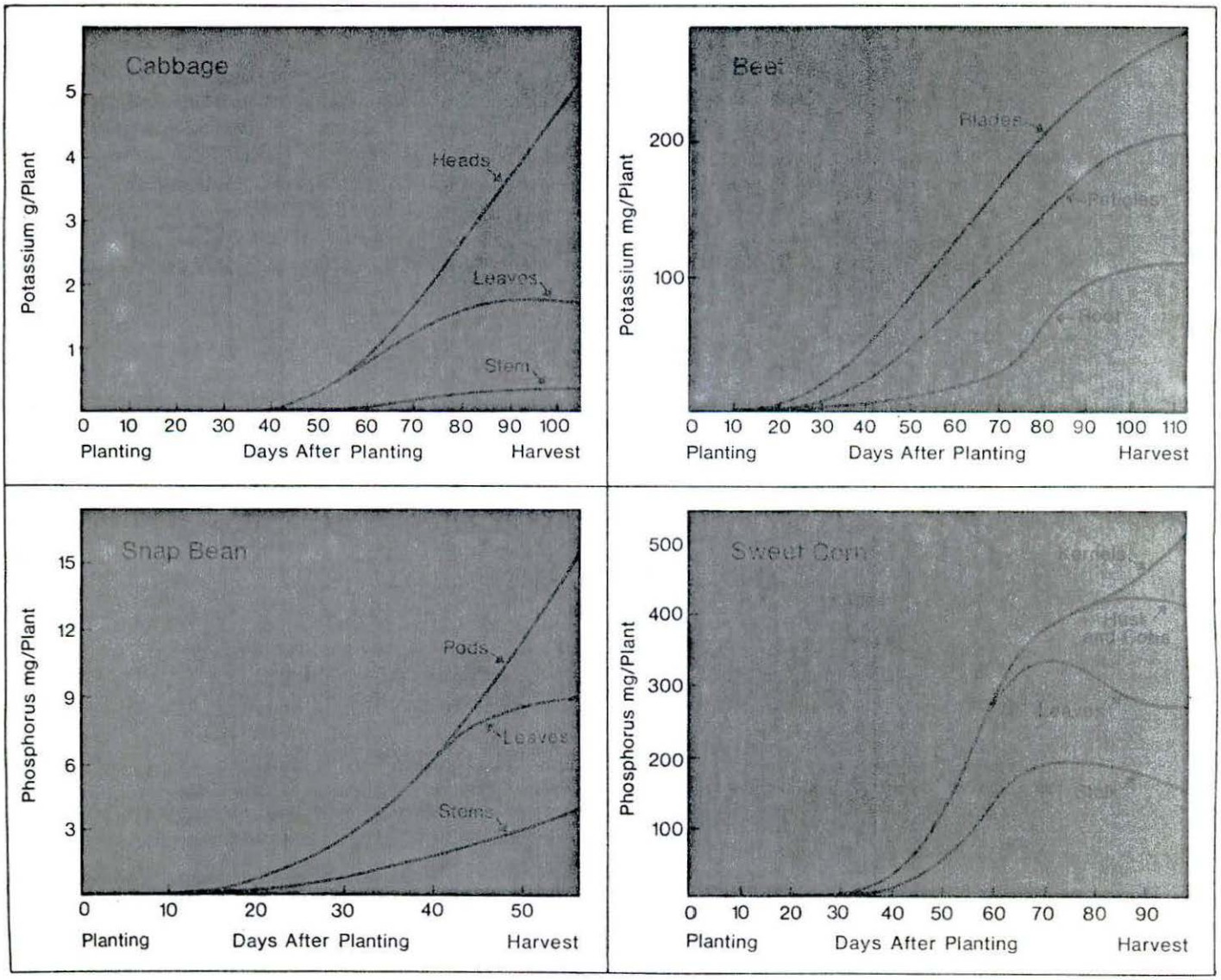
Overall fertilization system. Fertilizers should be added to supplement soil nutrients when the crop response is apt to be most intense. For example, in an experiment studying effects of nitrogen on table beets, tissue analyses showed that seedlings fertilized with nitrogen at or near planting time had a high concentration of nitrate and developed large plants which used both the fertilizer and soil nitrogen during the growing season. As harvest time approached, nitrate concentration in the roots declined to a low level. Further, the roots had a low glutamine concentration, a high sugar concentration, and yields were abundant. Since nitrate and nitrite in food are potential health hazards and glutamine may cause bitter flavor in canned beets, their levels should be low at harvest time. In this experiment, proper nitrogen management resulted in quality produce, and the soil was nearly depleted of available nitrogen at harvest time.

A properly fertilized, high-yielding crop will increase the soil production potential for future years. Interplanted crops and cover crops sown after harvest maintain actively growing roots in the soil that minimize the nutrient loss from leaching, erosion, and volatilization, and provide organic matter that improves soil structure.

Plant and soil analyses are not the only factors involved in developing a fertilization system for optimum production. The genetic yield potential of the crop variety, soil conditions, pest control, environmental factors, and other cultural practices must be adequate in order to obtain a positive response to a total fertilization system.

Quality. Nutrients affect the yield reliability and quality of processing vegetables. The effect of nitrogen on table beets has already been described. Phosphorus promotes uniformity of pod set of snap beans, whereas excessive nitrogen causes too much vegetative growth and uneven pod set. Phosphorus promotes early harvest maturity of sweet corn and prolongs the length of time that kernels maintain an acceptable processing quality. Excessive phosphorus with inadequate potassium may darken the tissue in the petioles of cabbage heads. Potassium increases cabbage yields but promotes bursting of the heads.

In summary, tissue analysis and soil tests are being used in research to develop fertilization systems that: furnish abundant nutrients for development of vigorous seedlings, supplement soil nutrients during periods of rapid uptake for development of the vegetative plant frames, and allow depletion of soil nutrients as plants approach harvest time. This assures the most efficient use of soil and fertilizer nutrients as well as the production of reliable yields of quality vegetables for the processing market.



Uptake of phosphorus and potassium during the seedling, vegetative frame, and harvest stages. At harvest time, the plants are at rapidly changing stages.