EFFECT OF SOIL ON THE MINERAL COMPOSITION OF COMMERCIALLY GROWN VEGETABLES

G. M. Volk and G. T. Sims
Florida Agricultural Experiment Station
Gainesville

Soil composition is usually the most important of the environmental factors causing variation in mineral composition of plants, with climate and season of secondary but still significant effect. The latter may possibly have a relatively greater importance in influencing organic composition under Florida conditions (1). Plant analysis has been most frequently used in the past for the purpose of increasing crop production. Such data do not represent the composition of the products found on the market. For this reason more emphasis should be placed on the composition of the products produced under commercial practices.

It was the purpose of this work to determine the ranges in mineral composition of severally commercially grown vegetables in Florida, and to correlate the composition with cultural practice, locality, soil type and soil composition. A detailed report of the data appears elsewhere (2).

Four categories of vegetables, based on the edible portions, were sampled. Cabbage and collards represented leaf-type vegetables; snap beans the pod-type; tomatoes, the fruit-type; and celery, the stem-type. Vegetables were collected from each area as near the peak of the harvest season as possible. An average of 8.6 samples were collected from each of the major areas. Only marketable samples were collected. The fields selected for sampling were chosen in a manner intended to make the data representative of the area. Crop and soil samples were taken across the rows in a line usually extended from 100 to 200 feet depending on the size of the field. Soil samples consisted of 20 plugs, 6 inches deep, taken at random. Twenty-four heads or stalks of cabbage, collards or celery; or about 10 pounds of beans or tomatoes were taken from a field.

All samples were thoroughly washed with distilled water, using a bristle brush to remove foreign matter. Cabbage heads were divided to make 2 samples, one consisting of the 6 to 8 green leaves next to the head, and the other consisting of the head, itself. Collards were prepared by stripping the thin portion of the leaves from the coarse portion of the petiole and making a sample of each portion. Celery stalks were first topped near the center of the leaf cluster, followed by cutting the roots off as close as possible without causing the stalk to fall apart. The oldest outer stems were also discarded. Beans were prepared by removing the calyx from the stem end. Tomatoes were washed and halved for drying.

All samples were dried at 70°C., and ground in a Wiley mill for macro analysis and in a porcelain mortar for the determination of iron. All chemical analyses of plant materials and soils were made by standard quantitative procedures, and reported on the oven-dry basis. Plant materials were reduced by wet combustion with perchloric acid for all analyses except iron.

Plant Composition

A statistical analysis of variance was made of the plant composition data in order to have a basis of evaluation of the variations noted between areas. Only those differences showing a significance at odds of 19 to 1 or greater will be mentioned. Analyses of individual areas are considered as above or below average for the state if they are significantly above or below the general average for the crop in question as found by this investigation.

Cabbage

Analyses of cabbage heads showed significant differences in protein, calcium, magnesium and iron percentages between areas. It was found that the average for the Belle Glade area was above the general average of all areas in protein, calcium, magnesium and iron; while samples from the Bradenton area were below the average in protein and iron; and samples from Winter Garden, below average in iron.

Analyses of cabbage leaves showed significant differences in protein, calcium, magnesium, potassium, phosporus and iron percentages between areas. Samples from Belle Glade were above average in protein, calcium, magnesium and phosphorus; while those from Hastings were above average in potassium and phosphorus; and those from Bradenton, below average in protein and phosphorus.

Beans

The composition of 25 bean samples collected from the vicinities of Belle Glade, Homestead, and the lower east coast section of Palm Beach County showed significant differences in protein, calcium and phosphorus percentages between areas. Samples from the Belle Glade area were above average in protein but below average in phosphorus; while samples from the Homestead area were above average in phosphorus; and samples from the Palm Beach area, below average in calcium.

Celery

The composition of 27 celery samples collected from the vicinities of Belle Glade, Sanford and Sarasota showed significant differences in calcium, potassium and phosphorus percentages between areas. Samples from the Belle Glade area were above average in potassium. Those from the Sarasota area were below average in calcium but above average in phosphorus.

Tomatoes

The composition of 43 tomato samples collected from Homestead, Ft. Myers, Ft. Pierce and Collier County areas showed significant differences in protein, calcium, potassium and phosphorus percentages between areas. Samples from Homestead Rockdale soils and Perrine marl soils were above average in calcium, while those from Ft. Pierce and Ft. Myers areas were below average in calcium. Samples from the Ft. Pierce area were above average in phosphorus, but those from Collier County below average in phosphorus.

Effects of Soils on Plant Composition

Certain differences in plant composition appear to be attributable to major soil characteristics. Differential response of plant varieties is not considered in this report because they appear to be of minor importance.

Moderate differences in fertilization within the same vegetable producing area on similar soil types did not appear to consistently influence plant composition. There was some indication that differences in practices between areas may have been a factor. Cabbage grown in the Hastings area received relatively more potassium in the fertilizer, and the crop was found to be relatively high in this constituent. Soil types were found to have considerable effect, but the chemical composition of the soil did not always correlate with plant analyses.

The differences in exchangeable bases and weak acid soluble phosphorus in the soils at the time of harvest appeared to be due more to soil type characteristics than to residual accumulation from differences in fertilization. Relatively higher potash concentration in the Perrine marl soils under tomato culture as compared to bean culture, indicated differential residual effect of different treatment on a given soil. There is also some indication of similar residual effect on the organic soils of the Belle Glade area.

The organic soils of the Belle Glade area contained large quantities of organic nitrogen, exchangeable or ammonium acetate soluble calcium and magnesium. This was reflected in the composition of cabbage. However, these soils were relatively low in dilute acid soluble prosphorus and exchangeable potassium, but produced cabbage which averaged second highest in these 2 elements. A higher level of organic matter apparently favored the availability of phosphorus and iron, and possibly potassium. Cabbage containing the lowest concentration of phosphorus was grown on mineral soils in the Bradenton area which contained a relatively high amount of soluble phosphorus. Potassium followed the same trend in that it was relatively high in the soils of the Bradenton area yet the cabbage was below average in potassium.

The composition of green beans did not vary as much as the composition of cabbage, although the soil types on which beans were grown represented a wider range in chemical composition. Seed bearing portions of plants are known to be more constant in composition than leaves.

The calcium and magnesium content of beans was definitely associated with soil type. Calcium was highest in beans grown on the Perrine marl soils at Homestead and second highest in those grown on the organic soils of the Belle Glade area which also contained large quantities of calcium. The highest average concentration of phosphorus was found in beans grown on calcareous soils. These soils were low in dilute acid soluble phosphorus content but measured relatively high in carbonic acid soluble phosphorus. The latter measure is the more reliable for calcareous soils. The pH of the calcareous soils was above neutral but the organic matter content of these soils was relatively high and probably aided in phosphorus assimilation by the plants. On the other hand, phosphorus was low in samples from the organic soils of the Belle Glade area, which was the reverse of the findings with respect to cabbage.

The iron concentration in beans averaged highest for those grown on acid organic soils, was next highest in beans grown on mildly acid sands and generally low in those grown on calcareous soils. This is in agreement with other investigations on calcareous soils.

There appeared to be a correlation within each area between potassium in the beans and that found in the soil. It also appears that, in organic soils, potassium was retained best in those containing the most calcium, regardless of pH or exchange capacity. Volk and Bell (3) have shown that nitrates preferentially move as $Ca(NO_3)_2$ with attendant depression of the solubility of potassium in the soil.

The analyses of celery samples and the corresponding soils showed that celery grown on the organic soils of the Sarasota area contained far less calcium and more phosphorus than celery grown on mineral soils at Sanford or the organic soils of the Belle Glade area, yet the soils of the Sarasota area were high in exchangeable calcium and soluble phosphorus. The phosphorus levels in the Belle Glade area soils were low, which apparently correlated with low phosphorus content in the celery as was found for beans, but in contrast to cabbage.

The potassium of celery grown on the organic soils of the Belle Glade area was exceptionally high. Differences in fertilization or exchangeable potassium in the soil would hardly account for this difference from the other areas. The trend is similar to that noted in cabbage analyses. The calcium uptake for the organic soils of the Sarasota area was low despite the relatively high level of exchangeable calcium in the soil.

The variation in protein content of celery is explainable on the basis of soil organic matter. Celery grown in the mineral soils of the Sanford area averaged only 14.8 percent protein while that grown on the organic soils of the Belle Glade and Sarasota areas having large quantities of organic nitrogen contained 17 and 17.1 percent protein, respectively.

There was a wide variation between the phosphorus and portein content of tomatoes grown in different areas on different soil types. The phosphorus percentage of tomatoes grown on Immokalee, Charlotte and Pompano fine sands of the Ft. Pierce and Ft. Myers areas was much higher than for tomatoes grown on the Ochopee marl of Collier County and Perrine marl of the Homestead area. Within the Ft. Pierce area, the data show that tomatoes assimilated more phosphorus from the Pompano fine sands than from the Charlotte fine sands. The latter contained less soluble phosphorus and received less fertilizer.

The protein content of tomatoes apparently did not correlate with soil factors. Season may have been the cause of recorded differences inasmuch as the high protein tomatoes grown in Collier County and at Ft. Pierce were harvested in April and May, respectively, while the other 3 areas were harvested between November and February and contained less protein.

The magnesium content of tomatoes showed little variation even though there was considerable variation in exchangeable magnesium in the soil. The calcareous soils contained much more exchangeable potassium than the sandy soils, but only in the case of marl soils was the potassium content of the tomatoes high. The calcium content of tomatoes was greater when grown on the calcareous soils than when grown on acid soils. The iron content was lowest in tomatoes grown on Perrine marl in the Homestead area. The Rockdale limestone soils at Homestead contain a high iron bearing colloid of lateritic origin which supplies adequate available iron.

There was no apparent correlation between soil and plant composition for collards grown in the Quincy area. The protein, calcium and magnesium percentages in collards were higher than in any of the other vegetables analyzed, yet the soils in which the collards were grown were comparatively low in organic matter, calcium and magnesium. The collards grown under tobacco shade on the fertilizer residue left from the tobacco crops, and those grown with fertilizer in open fields were similar in mineral quality.

The primary interrelationships that characterized soil types appeared to be between organic matter content and pH of the soil, with other factors of soil environment and moderate differences in fertilization of secondary importance.

A survey of the literature on plant composition shows that Florida vegetables are as often above as below vegetables from other areas in mineral composition.

Literature Cited

1. JANES, BYRON E. The relative effect of variety and environment in determining the variations of percent dry weight, ascorbic acid, and carotene content of cabbage and beans. *Amer. Soc. Hort. Sci. 45*: 387-390. 1944.

2. SIMS, G. T., and G. M. VOLK. Composition of Florida grown vegetables: I. Mineral composition of commercially grown vegetables as affected by treatment, soil type and locality. *Fla. Agr. Exp. Sta. Bul.* 438. In press.

3. VOLK, G. M., and C. E. BELL. Some major factors in the leaching of calcium, potassium, sulfur and nitrogen from sandy soils. *Fla. Agr. Exp. Sta. Bul.* 416. 1945.