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EFFECT OF FERTILIZERS UPON NUTRITIVE VALUE OF FOODS

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I. INTRODUCTION

Wide variations exist in the amounts of nutrients in the fruits and vegetables we eat - in all edible parts, the seed, the fruit, the leaf, and the root. Food composition tables generally reflect "average" values and seldom provide the range in variation. In Hawaii, Professor Emeritus Carey D. Miller has been the pioneer in the analyses of nutrients in foods and it has been my privilege to continue her work. The wide variation in nutrients is indicated by the sodium content of Solo Papaya - from 3.6 mg. per 100 grams to 76 mg. per 100 grams depending upon soil conditions. Also in Solo Papaya, the Vitamin C content has been found to vary from 60 mg to 122 mg per 100 grams depending upon the climate or season. In mangoes the vitamin C content varies from 15 mg per 100 grams in the Haden variety to 140 mg in the common variety. These examples illustrate the three classes of factors that have been found to affect the composition of plants--factors of soil, climate and genetics.

The first two constitute the overall environment of the plant--the root environment and the top environment. One of the most important of many variables in the soil is the supply of available mineral nutrients the plants need for growth. Some of the other variables are moisture supply aeration, microorganisms and the pH (acidity) of the soil. Some of the climatic variables are rainfall, sunlight, humidity and temperature. The sum total of these environmental components constitute a "location effect".

The influence of soil and climate on the nutritive value of foods for man has been recognized for some time and the US Department of Agriculture established the Plant, Soil and Nutrition Laboratory at Ithaca, N.Y. to study the relationships.

Today, in discussing the relationship of fertilizers and the nutritive value of foods, investigations from that laboratory as well as others will be cited.

Environmental variables:

Soil nutrients & climate ⟶ Nutrients in Plants ⟶ Nutrients for Man

Nutritionists are primarily concerned with nutrients for man. Therefore, the discussion will be directed to nutrients in plants of importance to man, and therefore, variables in the environment which affect plant nutrients. Thus, this paper will start with a brief discussion of the nutritional requirements of man.

II. NUTRITIONAL REQUIREMENTS OF MAN

Knowledge of nutrition has developed to the point where we know that the human body must get about fifty different nutrients from food. Each nutrient has specific functions and in many instances several nutrients function together. Indispensable nutrients include proteins (amino acids), fats (fatty acids) and

carbohydrates--organic substances that provide calories or fuel. In addition, many inorganic or mineral elements from calcium to zinc, and many chemically unrelated substances known as vitamins, taken in proper amounts and proportions enable the body to function normally.

The Food and Nutrition Board of the National Academy of Science - National Research Council publishes dietary allowances that say how much of each nutrient is recommended for persons differing in age, sex and physical activity. These goals can be used in planning diets as they are "designed for the maintenance of good nutrition of practically all healthy people in the USA".

The allowance for the reference man and woman is:

Sex	Age	Weight (lbs)	Activity	Calories	Protein (grams)	Vit A (IU)	Vit D (IU)	Vit E (IU)
M	22	154	normal	2800	65	5000		30
F	22	128	normal	2000	55	5000		25

Vit C (mg)	Folacin (mg)	Niacin (mg)	Riboflavin (mg)	Thianine (mg)	Vit B_6 (mg)	Vit B_{12} (µg)
60	0.4	18	1.7	1.4	2.0	5
55	0.4	13	1.5	1.0	2.0	5

Calcium (grams)	Phosphorus (grams)	Iodine (mg)	Iron (mg)	Magnesium (mg)
0.8	0.8	140	10	350
0.8	0.8	100	18	300

In addition Vitamin K, biotin, choline, panto thenic acid, copper fluoride, chromium, cobalt, manganese, molybdenum, selenium, zinc, sodium, potassium and chloride are generally considered to be essential but allowances have not been established.

III. SOIL AS A FACTOR AFFECTING PLANT NUTRIENTS

Returning to the first factor affecting nutrients in plants, the soil is the source of all the minerals the plant contains. With these and with water, carbon dioxide from the air, and energy from the sunlight, the plant synthesizes the organic components--the carbohydrates, fats, proteins, and vitamins that man needs for life.

Minerals

Regional differences in mineral content of soil may or may not be reflected in the levels of minerals in plants.

Correlation: Calcium contents of foods reflect differences in soil calcium. Copper deficiency areas in Florida is reflected in low copper level in plants. In the Great Lakes area where iodine had been leached out of the soil, the food had insufficient levels of that nutrient.

No correlation: In New Jersey no relationship was found between the manganese and iodine content of the soil and vegetables growing in it.

Antagonisms: Raising the level of one mineral in the soil may depress the uptake or movement within the plant of another. Nitrogen depresses phosphorus and calcium; magnesium depresses calcium; manganese, copper, zinc and cobalt depress iron. Calcium through its effect on soil pH also depresses uptake of cobalt, copper, iron and manganese.

Beneficial: The ability of one mineral to increase the effective concentration of another has been observed. Nitrogen spares magnesium, potassium spares iron and magnesium spares phosphorus.

The affect of sodium in the soil on sodium in Hawaii fruits and vegetables (Wenkam, Miller, Kanehiro) was studied to identify low sodium foods. The increased use of sodium restricted diets for high blood pressure, cardiovascular and renal diseases justified such as a study. Plant response to soil sodium varied with the commodity, being highest in papaya and negligible in bananas, green beans, green onions, head lettuce, long and round egg plant.

The absorption of minerals by plant roots is a complicated process. All facts needed for an adequate explanation are not yet known. This may explain why the mineral content of plants varies markedly and why apparently contradictory results occur when similar fertilizer treatments are used in different studies.

Vitamins

The effect of different fertilizer treatments on the contents of Vitamin C and carotene of tomatoes and turnip greens was studied. The vitamin levels were not altered.

Protein

A positive effect of fertilization on the protein content of corn has been demonstrated. Hybrid corn and Illinois High Protein corn were grown on an unfertilized and fertilized plots. The protein content of the hybrid corn from the unfertilized plot was 7.23% and from the fertilized 10.73%. The protein content of the Illinois High Protein corn from the same two plots was 13.47% and 20.04%, respectively. Thus fertilization increased the protein content of both varieties.

But feeding trials to test the biological value of the protein showed that the increase in protein was due to an increase in zein, a poor quality protein. So although fertilization increased protein quantity, protein quality was reduced. This points out the importance of biological assays of nutrients particularly in assessing protein.

IV. CLIMATE AND SOIL AS A FACTOR AFFECTING PLANT NUTRIENTS

Climate and soil, the overall "location effects" is perhaps a more realistic approach. It has been pointed out that a single environmental factor never varies by itself and that joint variation between two or more factors must always be expected in a natural environment. An extensive study on effects of both soil and climate on the composition of a single variety of turnip greens was made. Differences in composition were related to differences in location. Viewing the overall environmental influence on the plant, they concluded that climate played the dominant role in influencing the organic composition but that the soil was more important in affecting the inorganic composition of the plant.

V. CONCLUDING REMARKS

Scientists have made great progress in improving yield, desirable commercial characteristics and nutritional quality in plant foods. And producers have adopted cultivation practices so that scientific knowledge is put to practice.

Much progress has also been made in human nutrition. Over fifty essential nutrients have been identified and recommended dietary allowances have been established for about a third of them. But in contrast to plant nutrition, a large gap exists between human nutrition knowledge and practice. Foods carefully grown to develop high nutritive value are of little use to humans unless they are eaten! Science has succeeded in getting the crop to the kitchen but not from the plate to the palate. Bridging this gap to benefit from the agriculturists' efforts in values modifying food habits of people, people like you and me.