INTRODUCTION

Plant nutrition is a sub science of Plant Physiology. It addresses issues on elements plant needs to absorb, to grow and to live, deficiency symptoms and how to address deficiency symptoms problems in a plant. Plant nutrition also deals with the functions of nutrient elements in plants.

SCOPE OF MINERAL NUTRITION

Plant mineral nutrition has two (2) major aspects:

i) Acquisition of mineral nutrient.

ii) Functions of those minerals in the plant.

i. Acquisition of Mineral Nutrients

All living things consist of atoms of bio-chemical elements. The ultimate reservoirs of these elements on earth are the rocks, oceans and the atmosphere. Rocks are weathered into soil. Oceans and the water that is released into lakes, streams and soils as well as the atmosphere itself make up the compounds, aggregates, solution and gases which living organisms mine/ exploit for the elements, which plants absorb to form their bodies. Only green plants and certain microorganisms are capable of extracting simple ions and inorganic compounds from the environment without having to rely on complex energy rich compounds previously synthesized by other living organisms. These organisms are autotrophic. The photosynthetic plants, algae in oceans, streams and lakes and the green plants on land are by far the most important agents in the primary acquisition of elements from the external environment. Once these elements are acquired, they are translocated.

ii. Functions of Nutrients

If one of the elements essential to the plant is present in the environment in insufficient amount/unavailable forms or in difficultly available forms, the deficiencies of these elements in the cells of plant will bring about derangement or destruction in metabolism e.g. P- fruiting, rooting, flowering, N – Vegetative growth (yellowing). These metabolic disturbances will manifest in visible symptoms such as stunted growth, yellowish/purpling of leaves and other abnormalities. These symptoms of deficiency are characteristic for a given element. However, they depend also on the severity of deficiency, the particular specie of plant and many other environmental factors and state of the plant (healthy or not). All these reasons put together will make us focus attention on the functional role of elements in the metabolism of plants. The elements also constitute structural components of compounds and metabolites in the plant.

Translocation

Cells of most algae and other aquatic plants are also exposed to the aqueous medium in which they flow. They take up water and solute from it (H_2O). Terrestrial green plants have tissues that are far removed from the soil, which is the source of water and organic nutrient. In these land plants, there are elaborate structures and mechanisms, which effect a long distance translocation of water and solute within the plant bodies.

Heredity and Environment

All physiological performances of plants including the nutritional characteristics are a function of their genetic constitution and their environment. The great diversity of soil which is the main mineral medium of mineral nutrient constitute a neutral inter-place between heredity and environment in which they live. Plants are adapted genetically and physically for this soil diversity. This aspect is stressed in the ecological aspect of plant nutrition.

Three important aspects of Plant Mineral Nutrition

i. Materials and conditions that must be provided by the environment if plants are to grow normally.

ii. Movement into and distribution of the elements through the plants.

iii. Involvement of the organs of the plants in their metabolism for growth and structure.

HISTORICAL PERSPECTIVE OF PLANT NUTRITION

Early theories on how plants derive their raw materials and how these raw materials were converted within the plants to provide increase in growth, weight and size were philosophical (speculatory) in the absence of the knowledge of chemistry and experimental techniques. The advancement of science was hindered because of this situation, paricularly by the general acceptance of a speculative scheme that was advanced by the Greek national philosopher called Aristotle (384-322 B.C). He held the view that all matter consisted of four elements:

i) Earth

ii) Water

iii) Air

iv) Fire

He was a tutor of Alexander the Great.

Rationalization of Aristotle

i) Plants have no digestive tract for modifying food from the environment.

ii) Plants obtained from the soil food that was preformed (already established or made suitable for plant growth and development).

iii) Plants play passive role in nutrition.

Aristotle's opinion held sway for over 2000 years until the beginning of modern science in the 16th century. Theophrastus (371 – 285**)** the father of Botany. He studied under Aristotle and Platum. He made remarkable observations on plants especially in areas of ecology and physiology. However, his efforts were not related to Plant nutrition.

Two (2) schools of thought predominated:

i) Water theory

ii) Humus theory

Water Theory

Water theory stated that plants derive most if not all of their substances from water.

Humus Theory

It stated that plants feed only on decaying animals or vegetative matter.

The advantage of water theory is that plants in aqueous solution absorb the inorganic nutrients from aqueous solution.

The advantage of humus theory is that saprophytic plants depend entirely on decaying animals and vegetative matter. However, this is not true for all photosynthetic plants.

A. **Nicholas de Cusa** (1450BC) recognized that plants take up ash constituents in small amount from the soil and these are conveyed in the water, which forms the bulk of the plant.

B. **Job van Helmont** (1577-1644BC) was a Belgian physician. He was honoured as being the first man to conduct qualitative experiment in plant nutrition. He investigated the source of materials that plants are composed of.

Hypothesis: That all vegetable matter immediately and materially arise from elements of water alone.

i) He took a pot

ii) He put 200 pounds (lbs) of oven-dried soil.

iii) He soaked the soil with water

iv) He planted a willow shoot of 5lbs.

After five years, the willow shoot had grown to about 169lbs 3oz. the pot was constantly irrigated daily with rain or distilled water. He covered the soil to prevent dirt from entering. After five years, he dried the soil and found that the weight was still 200lbs but short of 2oz. so he concluded that, the 164 lbs of wood had arisen from the water alone.

Importance/Appraisal

i) This was one of the first controlled experiments.

i) It was a well planned, carefully executed and accurately described.

ii) It was the first qualitative attempt to gain insight into the origin of increase in fresh weight of a plant.

However, He overlooked the importance of atmosphere in plant growth. The 2oz difference in the weight of the soil was overlooked.

C. **John Woodward** (1656-1728BC) his work demonstrates the importance of mineral matter to plant growth. His experiment was the earliest recorded experiment. He grew plant in water from four different sources;

- Rain water

– Water from river Thames

– Water from Hyde Park conduit

– Water from Hyde Park and mould.

Result:

Water source	Weight of plant	Weight of plant after exp.	Mean of weight**
Rain water	285	45.75	17.5
Water from river Thames	28	54	26
Water from Hyde Park	110	249	139
Water from Hyde Park and mould	92	376	284

Appraisal

All the plants had adequate water, therefore all the plants could have made equal growth had nothing been added. However, the amount of growth increased with the impurity of water. He concluded that vegetables are not formed from water alone but from certain peculiar terrestrial matter. A great part of terrestrial matter mixed with the water passes on into the plant along with water. He therefore concluded that the earth (soil) and not water constitutes vegetable.

D. STEVEN HALES: This is the father of plant physiology. The highest award by the American Association of Physiology. He was interested in sap of plants and he made measurement of the amount of water absorbed and transpired by plants. He related this amount to the area of the root surface through which the water was absorbed and area of leave surfaces through which it was transpired and calculate relative velocity of water movement through a unit of root surface and unit area of leaf surface. He wrote a book titled 'The Vegetable Statics' in 1727. The book describes several experiments in plant physiology. He had a passion for exact measurement.

E. Ingen Housz (1730 – 1799): He discovered that light was essential for evolution of oxygen for green plants. He also observed that green plants give carbohydrate in the darkness and non-green plants give out both carbohydrate and oxygen in the darkness. His work also shows that leaves are the primary organs of food production and carbon from carbohydrate is the primary source of carbon for plants inspite of its low concentration in the air.

F. Jean Senebier (1742 – 1809): He demonstrated that only the green portion of leaves were photosynthetically active. He repeated several experiments of Ingen Housz. He was the first investigator to give a reasonable insight into photosynthesis. He found out that the amount of O_2 given out by green plants kept in water was proportional to the concentration of CO_2 dissolved in water. He also showed that it was light and not the heat from the sun, which induces giving off O_2. He also published a book called 'Physiologia Vegetale, 1800.'

DRY MATTER

When fresh plant materials are dried at 70°C for 24-48hrs, the dry matter remaining will be roughly 10-20% of the initial fresh weight. The results of chemical analysis of plant tissues are always expressed based on their dry matter rather than on their fresh weight. Fresh weight is a variable changing with time of the day, amount of water in the soil, soil temperature, wind velocity and other factors. Over 90% of dry weights of most dry matter contain carbon, hydrogen and oxygen e.g. in maize, C is about 43.5%. O is 44.3% and H is 6.2%. The bulk of the dry weight of plant is due to the cell walls, which consist mainly of cellulose and lignin. Surrounded by the cell wall is the cytoplasm i.e. the sum total of the protein and other chemical entities (lipids, amino acids, organic acids and other elements) which make up the living machinery of the cell.

Mineral composition

If only 10-20% of fresh weight of a plant is the dry matter and all of these except C, H and O, it follows that all the other elements (except C, H and O) together account for only 1.5% of the fresh weight of plants. To determine the mineral element content of the plant, the investigator ashes the dry plant material thereby removing the organic C compound and then analyzing the ash for the element for which he is interested.

Percent Elemental composition of the stem, leaves, cob and grain of maize plant

Element	% of dry matter
Carbon	43.6
Oxygen	44.4
Hydrogen	6.2
Nitrogen	1.5
Sulfur	0.16
Phosphorus	0.20
Calcium	0.22
Potassium	0.921
Magnesium	0.179
Iron	0.083
Manganese	0.035
Silicon	1.172
Aluminum	0.107
Chorine	0.143
Undetermined	0.933