CROP GROWTH

What is crop growth?

Growth can be defined as the progressive development of an organism. Crop growth is a complex process whereby different organs such as leaves, roots, stems, flower, fruits and grains develop, grow and die in overlapping sequences.

Is crop growth different from crop development?

Crop growth can be defined as the increase in size of a plant. The increase may be expressed in terms of dry weight or dimensions such as height or diameter.

Plant development is the progress of a plant from germination to maturity through a series of stages which in many crops are often well defined.

Exercise:

How is crop growth and development expressed?

Factors affecting crop growth and yield

Crop growth are affected by various factor which can be categorised into two

Genetic factors which concern primarily the inherent capability of a given crop to give high yield and desirable characteristics.

Environmental factors which concern all the external conditions that influence crop growth. It could be climatic, edaphic or human factors.

- The major environmental factors affecting crop growth are
- Sunlight/radiant energy
- Adequate supply of plant nutrients
- Adequate supply of moisture

- Availability of oxygen and carbondioxide
- Favourable temperature
- Favourable soil reaction
- Absence of toxic substances
- Soil structure and composition of soil air
- Biotic factors
- Human factors

Crop growth response to soil nutrient

Plant growth is a function of various environmental or growth factors and may be expressed as

$G = f(x_1, x_2, x_3 \ldots, x_n)$

where G = measure of growth and $x_1, x_2, x_3, \ldots\ldots x_n$ = various growth factors

Understanding Liebig's Law of the minimum

A German scientist named Liebig proposed a *law of the minimum* stating that plant growth is proportional to the amount available of the most limiting plant nutrient. It means that the addition of each successive increment of a growth factor results in an increase in growth. Maximum yield is obtained when all factors are supplied in adequate or optimum amount.

…… And Mitscherlich's Law of diminishing return

Another German scientist, Eilhart Mitscherlich concluded that plant growth response to a limiting element is not proportional as Liebig proposed but rather follow a law of diminishing return.

He developed an equation to express this law mathematically:

$dy/dx = k(Y - y)$

where *dy* is the yield increase resulting from a small addition *dx* of the limiting factor, k is a constant for a particular crop and growth factor, Y is the maximum possible yield and y is the yield under the actual condition.

The simplest interpretation of this equation is that yield improvement resulting from any additional unit of fertilizer or nutrient is proportional to the remaining possible improvement.

It means that each additional unit of fertilizer gives slightly smaller benefit than the previous unit.

Exercise

Compare Liebig's law of the minimum and Mitscherlich's law of diminishing return

Crop growth modelling

Models simulate or imitate the behaviour of a real crop by predicting the growth of its components, such as leaves, roots, stems and grains.

A crop growth simulation model not only predicts the final state of total biomass or harvestable yield, but also contains quantitative information about major processes involved in the growth and development of a plant.

Computer technology has made growth modelling easier

Some of the modern growth models like DSSAT, ORYZA, APSIM, are developed to simulate crop growth and yield responses to scenarios of field management changes

Some of these models are applied to specific crop e.g. ORYZA is used for only rice while APSIM is used mostly for legumes such as drybeans, cowpea, pigeon pea and g/nut and also sweetpotatoes.

Models are developed based on

the high-resolution sub-national agricultural statistics data

databases of region-wide field trials managed by agricultural research institutes, including CGIAR centers and FAO and NARs

Nutrient absorption for plant growth

Absorption of nutrients refers to the transfer of the nutrient ions across the soil root interfaces into the plant cell.

Crops take their nutrients in the form of inorganic ions from the solution that surrounds soil particle and roots.

Factors such as genetic make up of a plant, root morphology and the environment influence nutrient absorption and transport in plants.

The process of nutrient absorption starts from the release of nutrient ions from the soil solid phase to solution and their movement to the root surfaces. The ions move from the root surface through membranes into the root system and from the root system to the whole plant system.

Movement of ions from soil to root surfaces

Three mechanisms are recognized

Root interception (contact absorption):

Root interception occurs as the plant roots grow through the soil mass encountering ions in soil solution and adsorbed ions on soil surfaces.

Nutrient absorption through this mechanism is, however, insignificant as most of the plant nutrients occur in the soil solutions.

Mass flow

Mass flow occurs as nutrient ions are transported in the flow of water to the root surface that results from transpirational water uptake by the plant.

Mass flow prevails for nutrients that are present in relatively high concentration such as Ca and Mg, and mobile nutrients such as NO3- and SO42- .

Movement of nutrient by mass flow is reduced at low temperature and low soil moisture content.

Diffusion:

Nutrient ions diffuse toward the roots when ion concentration at the root surfaces decreases as plant absorb nutrient, creating a nutrient concentration gradient.

Diffusion functions to alleviate the nutrient depletion that has occurred in the zone next to the root.

Most P and K moves to the root by diffusion.

Diffusion acts in reverse (back diffusion) when the other two mechanisms deliver more than needed and increase the concentration near the root to a level above that of the rest of the soil.

Movement of ions into the root system

The movement of nutrient ions from root surface into the root can be described by two processes:

Passive movement/transport

Active movement/transport

Passive movement or transport of ions

Passive transport of ions occurs in the outer or free spaces in the wall of epidermal and cortical cells of roots and is controlled by ion concentration (diffusion) and electrical (ion exchange) gradient.

The concentration of ions in the apparent free space is normally less than the bulk solution concentration and therefore, diffusion occurs with concentration gradient, from high to low concentration.

Passive transport is non-selective process and does not require energy from the metabolic activities of the plant.

Active movement or transport of ions

Active transport of ions is the movement of an ion against its concentration gradient using energy i.e. when the cell uses energy to pump a solute across the membrane against a concentration gradient.

The process of nutrient entry known as ion-carrier mechanism or carrier theory involves a metabolically produced substance (carriers) that combines with free ions. The ion-carrier complex can then cross membranes and other barriers not permeable to free ions and later dissociate to release ions into the inner space of the cell.

Active ion transport is selective process such that specific ions are transported across the plasmalemma by specific carrier mechanism.

Organic manures and wastes

Organic manures are materials largely of plant and animal origin in different states of decomposition that are added to soil to supply plant nutrients and improve soil physical properties. They are made from cattle dung, excreta of other animals, rural and urban composts, other animal wastes, crop residues, green manures and industrial organic wastes such as paper and sugar industries and sewage sludge. Organic manures are rich in water and C compounds but poorer in plant nutrients than inorganic manures.

Types of organic manures

Farm yard manure: This is the wastes from mixed arable and livestock farming used to fertilise crops. It consists of animal excreta (cattle, goat and sheep dung and urine, poultry litters) mixed with bedding materials such as straw, wood chips, crop residues etc. Farm yard manure supplies both macro and micronutrients to plants. It varies in composition from location to location. However, on the average, it contains about 2% N, 0.4% P and 1.7% K.

Crop residues: These include plant parts (straw, stovers, roots) that remain on land after crop harvest.

Compost manure: This is made by accelerating the rate of humification of plant and animal residues by microorganisms in well aerated condition.

Green manure: These are green plants used in fertilizing soil. Green manuring is the practice of ploughing in a quick-growing leafy crop before maturity. Leguminous plants are largely used as green manure due to their symbiotic N fixing capacity. Some non-leguminous plants may also used due to local availability, drought tolerance, quick growth and adaptation to adverse conditions e.g *Tithonia diversifolia*

Slurry: This is a suspension of dung in the urine and washing water coming from animal houses and milking parlours.

Sewage sludge: It is an end product of wastewater treatment process, consisting of solids separated from liquid raw sewage. Sewage sludges vary in condition from sticky materials containing half their weight of water to well dried powder, easy to handle and spread. Sludges are processed and transformed into biosolids using a number of complex treatments such as digestion, thickening, dewatering, drying, and lime/alkaline stabilisation. Digested sludges are fermented anaerobically to eliminate offensive odours and lower the count of pathogens and may safely be applied to the land.

However, sustained heavy application of sludges may introduce pathogens into soil and/or raise heavy metals content such as Zn, Cu, Ni and Cd to levels that are detrimental to plants.

Benefits of organic manure to sustainable agriculture

It builds soil organic matter thus improving soil quality

It serves as nutrient reserves thus improving soil fertility

It improves soil physical properties like

Soil porosity

Water stable aggregates

Water holding capacity

Infiltration rate

Hydraulic conductivity

It buffers against rapid changes in acidity, alkalinity and salinity of soil

It improves soil structure and reduces soil crusting

It provides energy substrate for microbial transformations.

Composition of manures

Organic manures vary in composition of their nutrients. Variability in elemental and composition among and within organic fertilizer types is due to factors such as

Differences in source (whether animal or plant origin)

Animal species or breed

Population of animal

Feed ration and conversion rate of animal

Bedding material type and composition if present

Climatic condition during manure accumulation

Plant species or variety added as residues

Age of plant material

Environment of operation (industrial or domestic)