Effect of Pathogens on Plant Physiology

Host tissues show different types of responses to activities of pathogen after it has established infection and when it starts parasitic and pathogen activities. In the initial stage of penetration there may be a striking increase in protoplasmic strands and the nucleus of the cell may move to the site of penetration. Cytoplasmic particles, in Rapid Brownian movement (The random motion of microscopic particles suspended in a gas or liquid), appear followed by granulation of the cytoplasm and appearance of many more particles in Brownian movement. Later the cell contents become yellow and finally dark brown when Brownian movement ceases and cell is dead.

Normal physiological activities of the host cell are disturbed and anatomical and morphological changes appear as visible changes. In pathogenesis the first stage after infection is the manifestation of these responses of the host cells which appeared in the following forms.

Structural changes

In diseased plants usually abnormal structures are seen. Examples are overgrowth (hypertrophy), sterile flowers, phyllody (Phyllody is the abnormal development of floral parts into leafy structures), hairy root, witches broom, bunchy top, Crown gall, root knots etc. Abnormal structures on the sick plant is not due to physical but to chemical reactions occurring within the plant body and are therefore, expression of the physiological malfunctioning of the host cells.

Physiological changes

1) Disintegration of tissue by enzyme of the pathogens
2) Effect of pathogenesis on growth of the host plant due to hormonal imbalance
3) Effect on uptake and translocation of nutrient and water
4) Abnormal respiration of the host issues
5) Stomata remains impartially closed
6) Chlorophyll is reduced & photosynthesis stops, ultimately reduced the plant growth and yield.

Effect of pathogens on plant physiology:

Photosynthesis

Carbohydrates are synthesized by chloroplast in green parts of the plant to the process of photosynthesis. This is a basic function of all green plants that enables them to convert light energy (from sun) into chemical bonds of energy for utilization by the cells. This process is related to respiration but the reaction are opposite. While in respiration, carbohydrates are degraded to release carbon dioxide, water and energy, in photosynthesis carbon dioxide, water and light energy combine product as to form carbohydrates. Since photosynthesis provides the basic material for synthesis of all the organic compounds in plant tissues it is apparent that any condition that obstructs this process is pathogenic in a large number of plant diseases the symptom on leaves are clear enough to suggest that photosynthetic process impaired due to infection. Such symptom include chlorosis, necrotic lesions, reduced growth, leaf spots etc. The effect of pathogen on photosynthesis can be attributed to causes grouped under two categories

1. the destruction of chlorophyll including chloroplast and

2. decreased efficiency of the photosynthetic process for mole of chlorophyll

The effect of virus infection on Photosynthesis:

- Reduction of chloroplast numbers
- Reduction in chlorophyll content
- Chloroplast abnormalities
- Reduction in photochemical activity
- Stimulating CO_2 incorporation at early stage of infection, but declined after virus infection for several days.
- Reduction in sucrose content.

The effect of bacterial infection on Photosynthesis:

- Decrease in chloroplast stroma (chloroplast content)
- Disorientation of chloroplasts
- Destroy of chloroplast integrity
- Suppression of CO_2 fixation

The effect of fungal infection on Photosynthesis:

- Reduce chloroplast RNA content
- Loss of chlorophyll
- Inhibit photophosphorylation coupling mechanism
- Inhibit electron transport
- Suppress CO_2 fixation
- Altered translocation of organic compounds

Respiration

The increase in respiration starts soon after inoculation and rises to a maximum rate coincident with the sporulation of a fungal pathogen and then declines to normal or even sub normal level. In resistant plant the rate of increase in respiration is very rapid but declines susceptible plants respiration rises slowly but lasts for a longer time. Increased respiration has been noticed in cereals rusts, powdery mildews, blast of rice, late blight of potato and many other diseases. This increase significantly alter metabolic processes in the host. Level of many and enzyme associated with respiratory process is increased in the disease plants. Accumulation and oxidation of phenols also increase with increase in respiration. It has been suggested that increased respiration in plants is due to respiration of the host as well as the pathogen. Two main mechanisms that have been suggested are:

- Uncoupling oxidative phosphorylation that causes enhanced uptake of oxygen. Certain substances such as 2, 4 dinitrophenol (DNP) prevent formation of ATP from ADP. As a result of these uncoupling a high level of ADP accumulates in the cell and cause increased respiration.
- Stimulation of metabolism in the disease plant is a more convincing mechanism. In many plant diseases growth is first stimulated, protoplasmic streaming becomes faster, synthetic

processes such as synthesis of protein, nucleic acid and carbohydrates are stimulated and translocation of synthesized product from healthy to diseased areas occurs. All this processes require energy and therefore accelerate breakdown of ATP. With increased utilization of ATP the level of ADP and PO_4 rises in the cell. This causes increased respiration.

Permeability of Host Cell membranes

Pathogens can change the permeability of host cell membranes by mechanical injury, enzymatic degradation, or toxins. Changes in cell permeability are often the first detectable responses of cells to infection by pathogens. The most commonly observed effect of changes in cell membrane permeability is the loss of electrolytes.

Translocation of Water and Nutrients

Living cells of plants need sufficient water and nutrients (organic and mineral) for their normal activity. If there is interference with the availability of these requirements the cells fail to perform their physiological functions. Minerals and water are absorbed by roots and translocated by the xylem vessels of the stem upward towards leaves. From vascular bundles of petioles and leaf veins the water and nutrients enter the leaf cells. The minerals and a part of water is unutilized by the leaf cells for synthesis of various essential substances. However, a major portion of water reaches the intercellular spaces and diffuses into the atmosphere through stomata and lenticels in the process of transpiration. The organic nutrition of the plant is mostly synthesized in the leaf by photosynthesis and translocated through phloem vessels downward up to the roots. The excess organic nutrients, in various forms (amino acids, sugars, organic acids) are exuded out into the soil as root exudates. It is, thus, obvious that if due to effects of pathogenesis uptake and translocation of minerals and water or photosynthetic process in leaves are checked the plant tissues will starve and when due to starvation the physiological activities of these tissues are affected there will be deficiency of substances produced by these tissues for the entire plant. In this way the entire plant will be sick. For an example, if water is not absorbed by roots or there is obstruction in its translocation the leaves cease to be active and photosynthetic activities decrease or stop. The organic nutrition will not be available to roots. Thus, not only leaves but roots also will be adversely affected. The water uptake capacity of roots can be affected in three ways: root development is checked and root mass is reduced, roots are injured and permeability of root cell walls is altered. The mineral nutrient from soil enter the roots as solutions in water and are traslocated through the xylem. Therefore, the abnormalities that obstruct water uptake and translocation affect the uptake and translocation of mineral nutrients also.

Transcription and Translation:

Transcription of cellular DNA into messenger RNA & translation of messenger RNA to produce proteins are two most basic, general, and precisely controlled process in the biology of any normal cell. Disturbance of any of these process may cause drastic changes in the structure and function of the affected cells.

Effect on plant growth

The growth of plants is controlled by a group of naturally occurring compound in the plant body that are called growth regulators. In some diseases this control system is disturbed and various structural abnormalities appear on the host. The regulatory substances are of two types: growth promoting which include specific hormones and inhibitory substances which also play equally important role. Auxins, gibberellins and cytokinins are the known growth promoting compounds. Growth regulators act in very small concentration and even a slight deviation from the normal concentration induces striking difference in the pattern of plant growth. The growth promoting compounds generally continue rising in the plant body but at a particular stage the hormone-inhibitory system of the plant suppresses them so that only normal growth continues. The phenomenon of rise and suppression of regulators is genetically controlled.

In a broad sense, gibberellins and cytokinins are also auxins but in strict sense only indole acetic acid (IAA) is known as auxin. Dormin, ethylene, etc., are growth inhibitors or induce such reactions in the plant organs that lead to premature ripening of fruits and untimely formation of abscission layers leading to fall of leaves, fruits and flowers. The growth inhibitors can inhibit the action of growth promoters or the former can be rendered ineffective by the latter. This depends on the condition of the plant and its response to infection by a pathogen. The pathogens (fungi, bacteria and nematodes) also produce growth regulators. When such compound are produced during the period of infection the host cells are induced to show growth responses. These responses at wrong place and wrong time adversely affect the plant growth. Pathogens also produce metabolites that are not hormones but affect the regulatory mechanisms in the plant thereby causing unrestricted production of growth regulators by the plant. Production of growth promoting compounds in excess of normal requirements of the plant causes overgrowth of cells and tissues. In addition to their own effect the growth inhibitors produced by the pathogen can render the growth promoting substances of the plant ineffective or inhibit their production thus causing growth retardation or stunting of the organ or the entire plant. The imbalance in growth promoting and growth inhibiting substance causes appearance of symptoms known as hypertrophy and atrophy (Atrophy is the wasting away or reduction in size of some part of the body). Hypertrophy may appear as galls, tumors, knots, witches' broom etc.