Effect of Biotic Stress on Plants: Effects and Management

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Abstract

Stress can be described as the situation in which the growth and development of plants get adversely affected either due to living factor or any other environmental factors. Biotic It can be classified into two major categories i.e. disease and pest attack. There are mainly three mechanisms of disease resistance i.e. mechanical, hypersensitivity and nutritional. The insect resistance is governed by certain mechanisms i.e. non preference, antibiosis, tolerance and avoidance. Signal transduction pathway plays a major role is showing resistant response. Different breeding methods can be used to incorporate resistance for disease and insect.

Keywords: Stress, disease, antibiosis, resistance, signal transduction

Preface

Stress can be described as the situation in which the growth and development of plants get adversely affected either due to living factor or any other environmental factors. The visual appearance of a plant mainly depends on their genetic constitution, environment and an interaction between genetic constitution and environment. Environment can be said as the sum total of all the components except the individual concerned. These components can be distinguished as biotic or abiotic leaning on their living or non living nature. These stresses lead to great yield losses, poor growth and development of the plant and low quality produce (Singh 1990).

Biotic Stresses

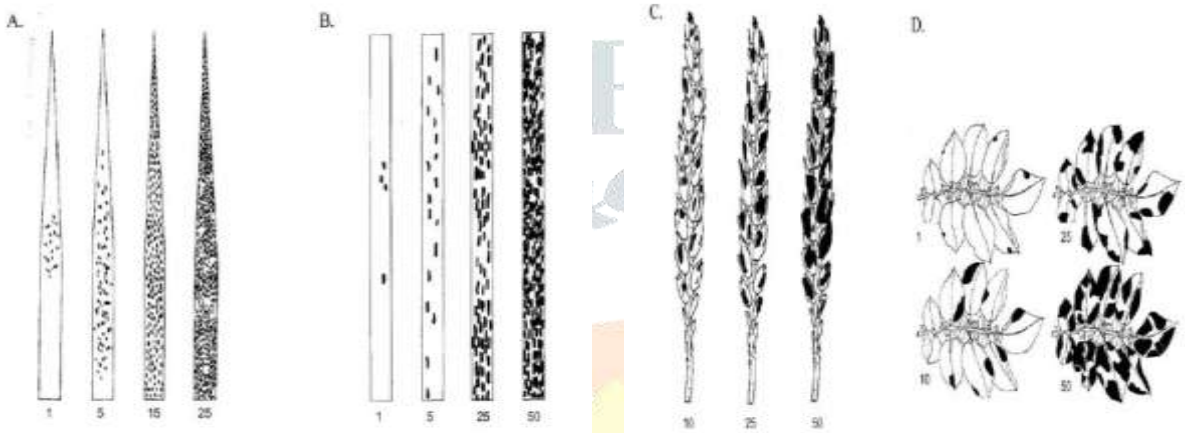
The condition in which normal growth and development of plant gets adversely affected due to biological factors is known as ‘biotic stress’. Such type of stress can be caused either due to pathogens or due to pests. These stresses generally cause great yield losses by reducing the overall biomass production via killing of plants, branches, stunting etc. It can be classified into two major categories i.e. disease and pest attack. For clear understanding of these stresses effects, symptoms and management should be studied(Singh 1990).

Disease Stress

Disease can be defined as the aberrant condition in the plant produced by an organism. The plant that is affected by the disease is known as ‘host’ and the organism causing disease is known as ‘pathogen’. The pathogen can be divided into two classes depending on the type of causing disease i.e. virulent and avirulent. The strains of a single pathogen species possessing diverse ability to attack different varieties of the same host are called as ‘pathological races’ and the host species which are used to recognise physiological races of a pathogen are called as ‘differential hosts or host testers’. Pathotypes are the strains of pathogen classified on the basis of their disease causing ability i.e. virulence. Development of disease leans on interaction between host, pathogen and environment. If we take the example of fungal diseases, the development of disease depends on four stages i.e. contact, infection, establishment and development. Landing of the pathogen on cells of host is ‘contact’. The entry of pathogen into the host is ‘infection’. Both these stages are highly depends on environment. In the ‘establishment stage’ the pathogen spreads itself in the pathogen but no symptoms are visible. In the ‘development stage’ symptoms become visible. When the pathogen attacks, the response of the varieties of host is different. On the basis of these responses of the host, reactions can be divided into four groups i.e. when the pathogen attacks the host and disease development is on high level, it fails to overcome the attack and great

losses are caused. Such reaction is said as 'susceptible'; when the host does not show any symptoms of the disease, such reaction is said as 'immune'; when the disease development in a genotype is less than susceptible genotype then such reaction is said as 'resistance' and when the genotype maintains overall biomass production at same level of pathogen attack than the susceptible genotype such type of reaction is said as 'tolerance'. There are mainly three mechanisms of disease resistance i.e. mechanical, hypersensitivity and nutritional (Singh 1990).

The screening technique for disease resistance depends on the type of disease spread. For the soil borne diseases, the test material is evaluated using 'sick plots'. Sick plots are the plots which have ample amount of inoculums of the pathogen formed by mixing different soils containing remains of diseased plants or spores of the pathogen. For the air borne diseases, the test material is evaluated by spraying spores with the help of needle or with the use of 'infector'. For seed borne diseases, test material is evaluated by dusting dry spores on the seeds of test material. Disease evaluation is done in the form of 'disease incidence' and 'disease severity'. Disease incidence is the percent of diseased leaves of the plant or diseased seedlings of the field. It is applicable to the diseases which are affecting the entire plant like smuts, rots etc and it indicates the pervasiveness of the disease in a prescribed area or field. Disease severity is the ratio of host tissue capped by the symptom or lesion of the disease.



A. Leaf rust B. Stem rust of cereals C.Septoria blotch D. Late blight of potato

Fig.1. Standard area diagram showing disease severity

It indicates the extent of damage caused by the disease like powdery mildews, leaf spots etc. Disease severity is measured using visual assessment methods such as use of standard area diagrams and use of pictorial keys. These methods consist of some pictorial diagrams already prepared for various diseases showing low and high grade of disease attack (fig.1&2).

0 1 3 5 7 9

Fig. 2. Pictorial keys showing disease severity

Stress Due to Insect-Pests

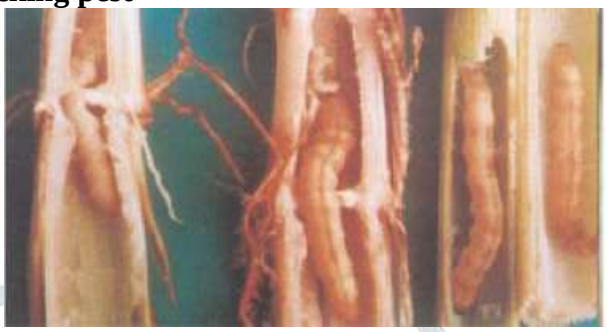
When the growth of plant is adversely affected due to insect pest attack is known as stress due to insect-pests. Insect-pests are divided into two groups depending on their mode of feeding i.e. pests which suck the cell sap (sucking pests) (fig.3) such as thrips, aphids etc and pests which feed on plant parts (tissue feeders) (fig.4) such as borer, hoppers etc. Insect infestation causes damage directly by reducing plant growth and stunting, damaging plant parts such as leaves, roots, stems, fruits and seeds, leaf defoliation and at last wilting.

Thrips

Aphids

Fig. 3. Sucking pest

Hopper



Borer

Fig. 4. Tissue feeders

Degree of insect resistance is grouped into five categories i.e. immunity, high resistance, low resistance, susceptibility, high susceptibility. The resistance can be governed by certain mechanisms i.e. non preference, antibiosis, tolerance and avoidance. Mainly the insect resistance is related to the anatomical features like hairiness, colour, thickness and toughness of tissues followed by some biochemical factors like presence of high gossypol content is not preferred by jassids in cotton, high DIMBOA content is non preferable to maize stem borer etc. Plants produce certain chemicals which are known as allelochemicals which affect the growth and development of insect-pests attacking the plant (Russel1978).

The screening of test material for insect resistance is done either in the field or in the glasshouse condition. In field screening the test material can be grown in between spreader rows of the susceptible variety for the concerned pests; material can be evaluated in an area where the attack of pest attack is severe and recurrent; in case of soil insect-pests, test material should be grown on the field containing large population of the damaging stage of the pest for resistance. In glasshouse screening the test material is evaluated using pot screening followed by spraying of larvae or eggs of the pest on the seedlings of the plant.

The sources of insect-pests and disease resistance can be found in cultivated cultivar, germplasm collection, wild relatives, and unrelated organism and through genetic engineering method. But certain problems are faced by the breeders while breeding for disease and insect-pests resistance. In case of disease resistance major problem is of boom and bust cycle which is occurring due to breakdown of vertical resistance, if the resistance is governed by polygenes then there transfer becomes a bit problematic, multilines can be used for disease resistance but they are generally poor performing and last problem is alongwith the desirable genes undesirable genes are also transferred due to linkage. In case of insect pests resistance major problem is breeding for resistance for one type of pests increases the susceptibility of the concerned genotype towards another minor pests, breeding for biochemical factors at times reduces the quality of the produce, efficient breeding for resistance require detailed knowledge of the biology, feeding and reproduction of the pests and lastly linkage drag in case of interspecific gene transfer.

Different breeding methods can be used for breeding for biotic stress i.e. selection in which the plant showing resistance can be selected from the susceptible variety; introduction in which the resistant genotype is grown in an area not cultivated earlier; hybridization methods such as pedigree and backcross method can be used and at last genetic engineering method can be used. Pedigree method is used when alongwith resistance gene other gene i.e. polygenes are to be transferred and backcross method is used in oligogene transfer. Backcross method is

applicable for both dominant as well as recessive gene transfer. Only difference is in case of recessive gene transfer after every two consecutive backcrosses F_2 generation is to be grown so that resistant gene can be identified. In case of genetic engineering method one component and two components system is used. In one component system (fig. 6) only resistant transgenic is incorporated in the host which acts as RNAse and breaks down the toxic polypeptides produced by the pathogens or pests whereas in two components system (fig. 5) both avirulent and resistant transgene is transferred in the host (Naess et al., 2000).

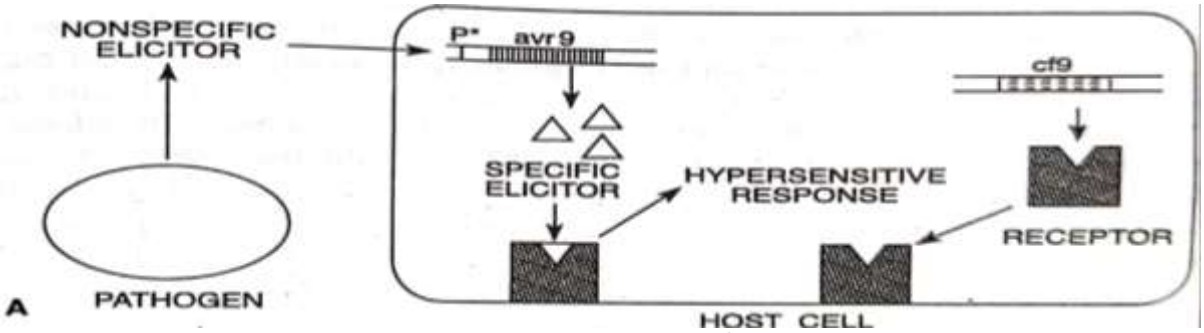


Fig.5 Two component system in genetic engineering

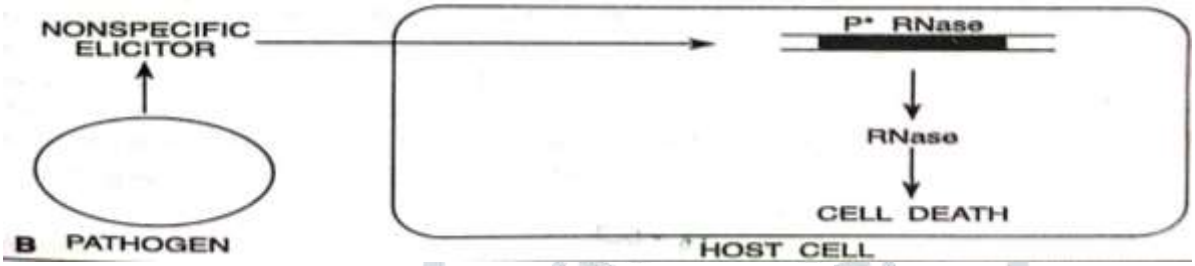


Fig.6 One component system in genetic engineering

For resistant response, certain set of signals are received and sent. Such pathway is known as 'signal transduction'. It is a phenomenon in which a cell converts a signal into a stimulus. Each signal transduction pathway has four characteristic feature i.e. specificity, amplification, adaptation and integration (fig.7) (Miklas et al., 2006).

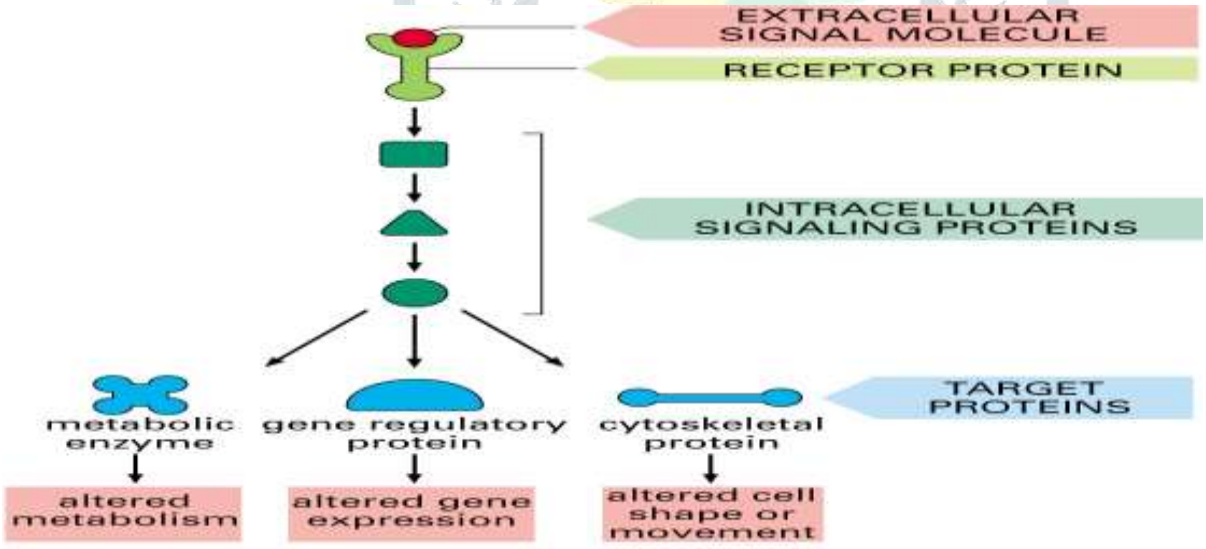


Fig. 7. Signal transduction pathways

There are two types of signalling i.e. direct contact signalling through gap junctions and through cell to cell recognition (fig.8).

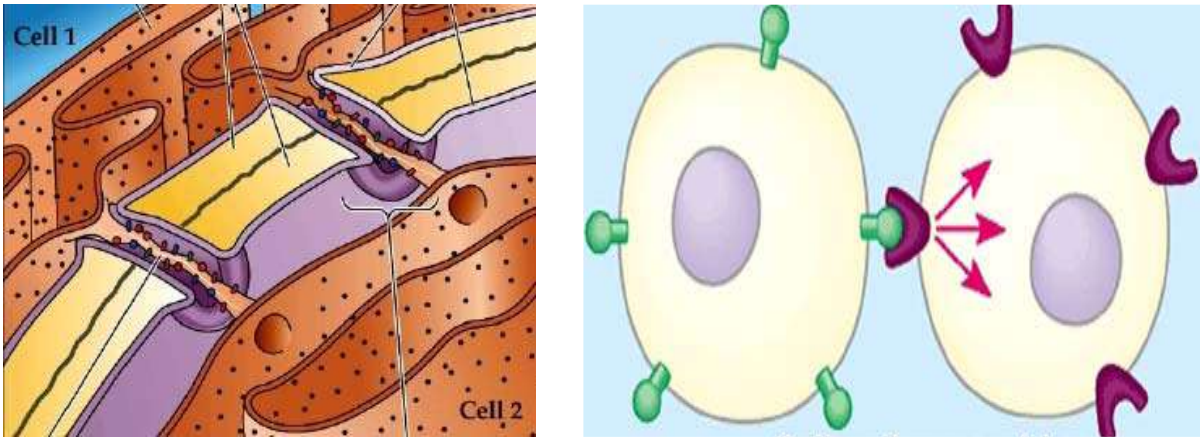


Fig. 8. Contact cell signalling through gap junction and cell to cell recognition

There are three stages of cell signalling i.e. reception, transduction and response. The signal binds to the receptor on the cell surface i.e. reception. Because of this binding the signal undergoes a conformational change i.e. transduction leading to become a intracellular signal making the cell respond to the situation i.e. response (Jegerand Viljanene-Rollinson2001).

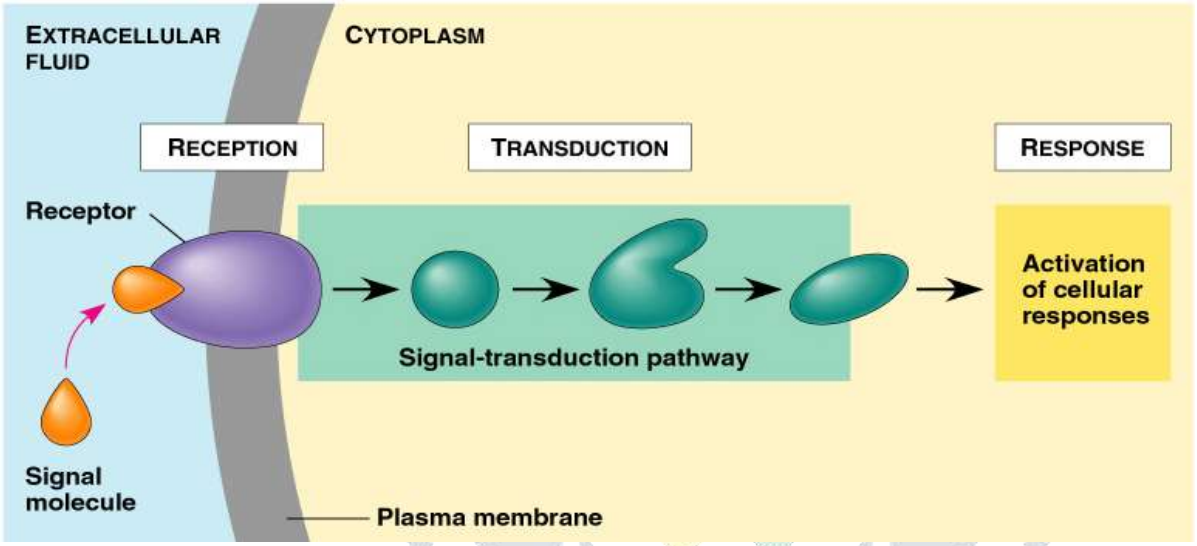


Fig. 9.

Therefore it can be concluded that the biotic stresses whether they are caused due to pathogen or due to insect pests cause great damage and huge yield losses. They can be eliminated through breeding for disease and insect resistance. For the breeding process appropriate screening techniques and breeding methods should be applied.

Reference

Jeger MJ and Viljanene-Rollinson SLH(2001).The use of area under the disease – progress curve (AUDPC)to assess quantitative disease resistance in crop cultivars.*Theor.Appl.Genet*.102,32-40.

Miklas PN, Kelly JD, Beebe SE, Blair MW (2006). Common bean breeding for resistance againstbiotic and abiotic stresses: from classical to MAS breeding. Euphytica 147:105–131.

Naess SK, Bradeen JM, Wielgus SM, Haberlach GT,Mcgrath JM, Helgeson JP (2000). Resistanceto late blight in Solanumbulbocastanum is mapped to chromosome 8. TheorAppl Genet101:697–704.

Russel GE (1978).Plant Breeding for Pest and Disease Resistance.Butterworths, London, p 486.

Singh, BD (1990). Plant breeding principle and methods. Kalyani Publ. Ludhiana.