BREEDING FOR DISEASE RESISTANCE

This is breeding for varieties / cultivars of crops that will not allow the activities of pathogens in their systems. This type of research is important for the following reasons:-

1. Diseases and pests develop on the leaf surfaces in most cases, thus reducing photosynthetic activity and hence the yield of such crops which eventually translates to economic loss to the grower
2. It is also important in order to reduce the chemical means of control to a minimum, so as to lower production costs, increase the nutritional value of agricultural products and to improve the environment.

Fungi, bacteria and viruses are the most frequent pathogens of plants. Trying to achieve higher yields and production per unit area, modern agriculture has introduced monoculture which involves growing pure varieties and the application of high doses of mineral fertilizers, especially nitrogen. This has created very favourable conditions for the development of pathogenic organisms. When a pathogen occurs in the most favorable spot in a field, it spread rapidly over the entire field and, if the same cultivar is grown in the neighbouring fields, it causes an epidemic. The consequences are reductions in yield and quality which in turn bring about large economic losses. This therefore calls for efficient measures of protection against diseases and pests.

There are four main methods of controlling pathogenic organisms:

1. Development of cultivars resistance to certain pathogens

2. Manipulation of agricultural practices (crop rotation, intercropping, avoidance of monoculture etc)

3. Biological control of parasites

The Parasite – Host Relationship

Plant growers are interested in having a healthy crop in which large economic damages cannot be inflicted by parasites. Whether a crop is healthy or diseased depends on the relationship established between the parasite and the host plant.

- Complete resistance: is an ability of the host to prevent any multiplication of the parasite. The resistant plant is considered to be hypersensitive, using the products of metabolism (toxins) to prevent the parasite from invaliding the plant and thriving on it
- Incomplete or partial resistance: has 50% resistance and 50% susceptibility.
- Tolerance: is also a kind of genetic resistance. Some cultivars are susceptible to a pathogen which develops on them, however, these cultivars tolerate the attack without suffering a significant yield reduction. The degree of tolerance of a cultivar may be calculated from the ratio between yields in an infected and an uninfected plot, the tolerance being higher as the ratio approaches unity.

Types of Resistance:

Resistance to plant diseases can be described either in functional or in genetic terms. The functional terms recognize that resistance may be both highly specific and effective against some parasite races but not others. This is <u>race-specific</u> resistance. OR <u>Non-race specific</u> and equally effective against a range of biotypes (races). These two types can also be called vertical or horizontal resistance respectively. Tolerance is sometimes described as a form of horizontal resistance. The genetic terms that describe resistance describes its mode of inheritance. Oligogenic resistance is usually determined by single genes. We have cases of single dominant genes and also single recessive genes e.g. gene HT (dominant gene) in maize confers resistance to *Helminthosporum turcicum*; rhm gene is a recessive gene also conferring resistance to *Helminthosporum maydis* race - O and race –T. Polygenic resistance is controlled by many genes of individually small effect. It is usually general; affording resistance to a wide spectrum of pathogen races.

Breeding Methods:

Breeding for resistance is usually carried out co-operatively by a plant breeder and pathologist. The possible control of disease through host resistance is an important biological principle that is well established. Breeding programmes designed to produce resistant varieties must obviously start with resistance conferring genes. Resistance most useful in plant breeding is that found in varieties of the same species. Sometimes however, adequate resistance does not appear to exist in cultivated species and then the breeder usually has two alternative sources. Firstly, he can search for resistance in related species or genera; secondly, is to attempt to induce resistance through mutagenic agents.

The best sources of resistance, nowadays, can be found in international nurseries. Most resistance genes have been transferred from wild relatives to cultivated crops, which saves breeders the trouble of having to go the long way of inter-specific hybridization. Local varieties and populations which are becoming extinct used to be more tolerant to parasites because of their genetic diversity and heterogeneity than the new high yielding cultivars, which are genetically uniform and homogeneous. The local varieties are therefore prospective sources of resistance genes, whether oligogenes or polygenes.

After resistance genes are known, they may be transferred to an adapted variety by standard hybridization procedures. Breeding for disease resistance differs in no fundamental way from breeding for other characteristics. Therefore, any of the various methods of breeding appropriate for the crop in question can be used in developing disease resistant varieties. When genes for resistance occur in existing commercial varieties, selection within these varieties will almost always promote the easiest and most satisfactory method of developing resistant strains. When adequate resistance is not found in commercial varieties, but only in types that cannot be used commercially, because of their unsuitable agronomic properties, either the backcross or pedigree method of breeding is usually used. With either method, one of the parents is select on the basis of demonstrated high level of resistance to maximum number of races and minimum number of genes controlling resistance and the other is chosen for its good agronomic or horticultural characteristics. If the resistant parent is wholly unadapted type, the backcross method is the logical option as a breeding procedure to transfer the gene for resistance unto the other parent. If, one the other hand the breeder is satisfied that the resistant parent can also contribute to improved adaptation, quality or yield, he may choose the pedigree or bulk methods of handling segregating generations. The pedigree method has been very widely used in breeding for disease resistance, and the majority of disease resistant varieties have been produced by this procedure.

In breeding for resistance, exposure to the disease, either in natural or artificially induced epiphytotics, is necessary to distinguish between the resistant and the susceptible plants. Epiphytotics is often irregular and light in natural conditions, therefore, induced epiphytotics will be more appropriate. Progeny tests of resistant plants are made to verify the inherent nature of the resistance and to ensure that uninfected plants have not merely escaped infection. The resultant strains will be selected both from the stand point of disease resistance and agronomic characters that will adapt them for agricultural use. In the final selection of varieties for the farmer to grow it is often necessary to compromise between superior disease resistance and superior adaptation when both characteristics are not found in the desired intensity in the same variety.

GERMPLASM CONSERVATION

A wide range of plant species has evolved as a result of the interactions of diverse climatic, ecological and edaphic factors and the culmination of thousand of years of natural evolution, mutation and to some extent human manipulation. These species constitute a pool of diversity from which plant scientists tap the raw materials they need for their crop improvement programmes. Plant genetic diversity is a key ingredient for sustainable agricultural development. Germplasm is a term used to describe a collection of these genetic resources for an organism. The plant germplasm consists of the reproductive structures of plants through which genes are transmitted from one generation to another and may include pollen, anthers, or ovules.

For a long time the genetic diversity of crops was naturally preserved. However, in recent decades, there has been a rapid deterioration of natural resources resulting in loss of genetic diversity. The rapid increase in population has resulted in an ever increasing pressure on the environment and the destruction of natural habitats. Also, the shift to monoculture and more uniform varieties over the last few decades as the world strive to feed its ever increasing population and frequent famine and drought, has led to erosion of genetic diversity an biological resources in general. Overgrazing of most grasslands, an increase in both the number and frequency of bush fires and the spread of soil erosion have all played a major part in the reduction of genetic resources. There is therefore an urgent need to preserve and conserve this diversity, both ex-situ and in-situ, for future use in adapting crops to new and changing environmental conditions and to sustain increase in agricultural production and development.

For many species, in-situ and on-farm conservation in protected areas may be the most appropriate method of conserving the gene pool. For a conservation effort to be sustainable, the long term security of the germplasm must be assured as well as its availability and adequate information to make it useful. Conservation without utilization could become a burden, especially for developing countries. This is what ex-situ conservation is all about because the long term conservation cannot be achieved in-situ. International plant Genetic Resources Institute (IPGRI) focuses especially on how best to conserve the genetic diversity of wild crop relatives and forest species ex-situ.

Germplasm Collection:

Before and during the 1970s, especially in Africa, very few collecting expeditions with the primary goal of conservation of germplasm took place. Most expeditions were rescue mission targeted at endangered species and the collecting of specific crop species of major priority;

mostly cereals and grain legumes. The trend in recent years is towards specialized collecting and acquisition of the wild relatives of crop species. This will continue as plant breeding techniques become more advanced and the value of these wild relatives is increasingly recognized. Also, attention is increasingly being focused on a regional or country basis rather than on emergency situations to salvage endangered species.

The work of conserving crop plant genetic resources is more than just conserving variation per se, but also has to do with the effective use of the resources conserved. A collection methodology that can make important contributions to both objectives is the <u>Core collections</u>. It has over the past decades become an increasingly important aspect of conserving and utilizing crop garmplasm effectively.

What is a Core Collection?

A core collection consists of a limited set of accessions of a crop species and its wild relative chosen to represent, with a minimum of repetitiveness, the genetic diversity and spectrum of a crop species and its wild relatives. The core should include as much as possible of its genetic diversity and provide potential users with a large amount of the available genetic variation of the crop gene pool in a workable number of accessions. It would therefore be useful to plant breeders seeking new characters which require screening techniques not possible with a large collection. Because each of the accessions in a core collection is, to some extent, representative of a number of accessions (from a particular area of the world or with some shared characters), the core can also be used as a point of entry to the active or base collections of a crop. Detailed research can be carried out on a core to obtain an effective picture of the characteristics of the gene pool as a whole.

The core collection has been able to solve two major problems militating against effective use of germplasm collection. Firstly, because of the emergency salvage mission embarked upon in the early 1970s, the volume of the collections that were assembled worldwide has far outgrown the management resources and regimes of the established gene banks. Secondly the use that has been made of these collections to bring about economically significant improvements in yield and profit has been patchy and often not up to the expectations of governments. Generally, this has been because gene bank managers have been unable to cope with the major task of evaluating their material to enable crop breeders to select from it the samples most likely to meet their needs.

Germplasm Conservation:

Conservation as defined by the United Nation (UN) means “the rational use of the earth’s resources to achieve highest quality of living for mankind”. It is the vital link between the acquisition and utilization of plant genetic resources and includes all the ways in which plant germplasm is stored and preserved. Germplasm can be conserved as seed, as vegetative materials, as tissue cultures or as living plants in- situ or ex-situ. One or more of these methods may be used for any crop. The needs of conservation and the resources devoted to it vary widely with the crop. The representative nature of the core makes it suitable for developing new methods of conservation such as ultra-dry seeds, in vitro or cryogenic storage. Curators are faced with the task of regenerating and multiplying old and neglected collections in the gene bank. They are also to monitor the viability of materials in the bank by routine seed testing.

Characterization /Evaluation:

Characterisation of the collected resources, prior to storage, is essential for further utilization. Thus, the potential of all accession needs to be assessed. Equally important is the information (passport data) that is collected during the collecting of the germplasm. The use of IPGR descriptor lists and collecting forms during collecting missions and the distribution of these forms to all collecting institutions and collectors has helped to standardize and initiate systematic characterization and documentation. The forms are designed to ensure that relevant information is collected during the collecting exercise. Characterization may be undertaken during the regeneration of old collections and sometimes during the multiplication of small-sized samples before their storage.

Use of germplasm in breeding programmes*:*

In cases where the germplasm is well characterized and documented, further evaluation leads to its use in breeding programmes:

1. Increased food production using stable, high-yielding varieties can be achieved by incorporating the useful adapted genotypes
2. High-yielding varieties of crops which are tolerate/resistance to insect attacks, diseases and various stresses such as drought or poor soil fertility can be developed by screening the germplasm collections
3. Nutritional values of various crops can also be improved
4. A rare/novel variant might be discovered through the screening of the germplasm