Biological Control

Principles of plant health care

1) Know the production limits of the agroecosystem;
2) rotate the crops;
3) maintain soil organic matter;
4) Use clean planting material;
5) plant well-adapted, pest-resistant cultivars;
6) minimize environmental and nutritional stresses;
7) maximize the effects of beneficial organisms; and
8) protect with pesticides as necessary.

Biological Control

- **Biological control refers to the purposeful utilization of introduced or resident living organisms, other than disease resistant host plants, to suppress the activities and populations of one or more plant pathogens.**
- In entomology, it has been used to describe the use of live predatory insects, entomopathogenic nematodes, or microbial pathogens to suppress populations of different pest insects.

In plant pathology, the term applies to the use of microbial antagonists to suppress diseases as well as the use of host specific pathogens to control weed populations.

The history of Biological Control may be divided into 3 periods

The preliminary efforts when living agents were released rather haphazardly with no scientific approach. Little precise information exists on successes during this time. Roughly 200 A.D. to 1887 A.D.;

B. The intermediate period of more discriminating BC which started with the introduction of the Vedalia beetle, *Rodolia cardinalis* Mulsant, for control of the cottony cushion scale in 1888. Period extended from 1888 to ca. 1955; and

C. The modern period characterized by more careful planning and more precise evaluation of natural enemies. Period from 1956 to the present.

Chinese were the first to use natural enemies to control insect pests. Nests of the ant *Oecophylla smaragdina* were sold near Canton in the 3rd century for use in control of citrus insect pests such as *Tesseratoma papillosa (Lepidoptera)*

2. Ants were used in 1200 A.D. for control of date palm pests in Yemen (south of Saudia Arabia). Nests were moved from surrounding hills and placed in trees

3. Usefulness of ladybird beetles recognized in control of aphids and scales in 1200 A.D.

The Modern Period

A. In 1959, Vern Stern *et al.* (1959) conceived the idea of economic injury level and economic threshold which would permit growers to make informed decisions on when they needed to apply control tactics in their cropping systems and therefore eliminated the need for scheduled pesticide treatments.

B. Interest developed nationwide in ecology and the environment after 1962 with the publishing of the Rachel Carson's book "Silent Spring."

C. "Silent Spring" helped stimulate the implementation of the concept of Integrated Pest Management (IPM) in the late 1960's, and biological control was seen as a core component of IPM by some. More emphasis was placed on conservation BC than classical BC.

Why Biological Control?

Early Pesticide Use

The use of chemical pesticides in agriculture has a long history. For example, the ancient Sumerians used sulphur to control insects and mites as early as 2500 BC.

The Green Revolution

It was only after World War II that chemical pesticides and other agrochemicals were widely adopted as part of the "green revolution". Chemical pesticides had many advantages, and became an integral part (along with chemical fertilizers, mechanization, and high-yielding crop varieties) of modern agriculture. A large proportion of the productivity increases seen during the "green revolution" were due to the widespread use of new pesticides. Often these agrochemicals were applied on a routine or prophylactic basis, resulting in immediate yield increases but contributing to future environmental, agricultural, and socio-political problems.

Environmental Awareness

- By 1962, when "Silent Spring" by Rachel Carson was published, serious concerns about the disadvantages of pesticide use were widely raised. Carson and others suggested that pest control methods other than chemical pesticides should be used in order to protect wildlife, human health, and the environment. Public pressure led to government legislation restricting pesticide use in many countries, causing agriculturists to reconsider the heavy use of persistent pesticides such as DDT.
- *Ecological Backlash*

- As early as the 1950's, pesticide-induced problems such as pest resurgence, pest replacement, and pesticide resistance were causing problems in agriculture. In 1959, scientists discovered that aphids could be better controlled by reducing the amount of pesticide used. This was because the pesticides were killing aphid predators as well as the aphids themselves, causing large-scale pest resurgence (Stern, et al., 1959). Reducing the amount of pesticide allowed natural predators to survive, resulting in both biological and chemical control of the aphids.

FUNGICIDE RESISTANCE

- Success in combating crop diseases, and in reducing the damage they cause to yields and produce quality, depends greatly on the timely application of fungicides.
- Sometimes, however, target fungi have acquired resistance against certain of the fungicides that normally control them well, and some serious difficulties in disease management have ensued.
- The Fungicide Resistance Action Committee (FRAC), an inter-company organization affiliated to the Global Crop Protection Federation (GCPF), has as one of its main aims the communication of information on the problems of fungicide resistance, and on counter measures, to all who are concerned professionally with crop protection, whether as researchers, advisers, teachers, students, registration officials, marketing managers or distributors.
- Therefore, FRAC has published a monograph entitled 'Fungicide Resistance in Crop Pathogens: How can it be Managed?' (Brent,1995), which gives a general overview of fungicide resistance management.
- One of the key components of fungicide resistance management is the assessment of the risk of the development of resistance.

RESISTANCE Vs. MECHANISMS OF ACTION OF FUNGICIDES

- Each chemical class is characterized by a typical resistance behaviour pattern.
- Thus certain major classes of fungicide, notably those based on copper e.g. copper oxychloride and cuprous oxide, phthalimides e.g. captan, captafol and folpet, and dithiocarbamates e.g. mancozeb, maneb, zineb and thiram, have never been known to encounter practical resistance, even after many years of use.
- By contrast, in some other classes, such as benzimidazoles e.g. benomyl, carbendazim, thiabendazole, phenylamides e.g. metalaxyl, oxadixyl, and dicarboximides e.g. iprodione, procymidone, vinclozolin, all the members met serious

resistance problems that arose in most of their target pathogens, within 2- 10 years of the commercial introduction of each class.

- Resistance to the azoles, e.g. triadimefon, flutriafol, flusilazole etc, has developed more gradually, and only in certain pathogens.

Strobilurin (*Strobilurus tenacellus*)

It inhibits electron transfer in mitochondria

- **FRAC recommendations**
  - Strobilurins should be used preventatively
  - Strobilurins should be applied at the manufacturers recommended rate
  - Strobilurins should not exceed 30% to 50% of the total fungicide sprays made to the crop per season
  - Strobilurins should be used in blocks of 1 to 3 sprays
  - Where blocks of 2 or 3 strobilurin sprays are used, the break between them should be at least 2 sprays
  - Alternation should continue between successive crops
- ***Integrated Control***

- This idea of integrating biological and chemical control of pests was termed "integrated control". It focused on conserving natural enemies of pests through the selective use of insecticides that were compatible with natural enemy conservation. This type of control was often 'supervised' by qualified entomologists who used monitoring of pest and natural enemy populations to guide spraying decisions. A key aspect of integrated control was the implication that two control methods - chemical and biological - should work in harmony, and that this combination was assumed to be better than either method by itself.

Biological control can be categorized conventionally into

1) Regulation of the pest population (the classical approach),
2) Exclusionary systems of protection (a living barrier of microorganisms on the plant or animal that deters infection or pest attack), and
3) Systems of self-defense (resistance and immunization).

The methods range from

1) conserving and making maximum use of indigenous (resident) biological control through cultural practices,
2) making one-time or occasional introductions of genes or natural enemies that are more or less self-sustaining and
3) Making repeated introductions of a biocontrol agent (e.g a microbial pesticide).

Biocontrol Tactics

- To kill the pest/pathogen directly
- To reduce the reproductive potential of a pest/pathogen population
- To modify the pest's/pathogen's behaviour to make it less troublesome

Types of interactions contributing to biological control

Diverse components of ecosystems that contribute to biocontrol

- **Mutualism** is an association between two or more species where both species derive benefit. Sometimes, it is an obligatory lifelong interaction involving close physical and biochemical contact, such as those between plants and mycorrhizal fungi. However, they are generally facultative and opportunistic. For example, bacteria in the genus *Rhizobium* can reproduce either in the soil or, to a much greater degree, through their mutualistic association with legume plants. These types of mutualism can contribute to biological control, by fortifying the plant with improved nutrition and/or by stimulating host defenses.