

## CHAPTER 1

# INTRODUCTION

### **Importance of Plants**

In the neolithic period sometimes between 12,000 and 10,000 B.C. men took to growing of plants for their subsistence from hunting and food gathering habits. Probably one of the most significant land marks in the history of civilisation that prompted men to cultivate plants was the discovery that the seeds dropped into the earth would grow into plants and give food.

The genesis of agriculture also lay on observations that seeds put into holes or dribbles or furrows specially made for the purpose by stone implements showed better germination and gave greater yield. The above observations required men to remain in one place long enough to harvest their crops and thus ancient civilisation originated in the fertile riverine tracts. Since then men have grown plants for their basic necessities of life such as food, fibre, wood and wood derivatives, edible oils, "essential" oils and related substances, beverages, narcotics, dyes, gums, latex products, drugs, masticatories etc.

The search for food producing and other useful plants led to exploration and discovery of new lands and introduction of plants from one country to the other. Most superficial study or casual survey would show increasing dependence of men on plants with increasing complexity of civilisation, in spite of the fact that rapid advances have been made in other disciplines of science. Plants are economically important in other ways, such as, checking soil erosion, improvement of soil fertility, provision of food and shelter to many animals. Apart from these utilitarian aspects, plants are grown for beautification and aesthetic pleasures.

Whenever plants are grown whether for subsistence or meeting other necessities or even for aesthetic purposes, growers are keenly interested in having an assured yield or return. Accordingly, constant attention is paid to ensure proper growth and production as successful cultivation of plants necessitates apart from suitable varieties, supply of inputs and efficient management of the same, constant care and protection from the dangers that may deter the cultivator from deriving full benefits from the economically important plants. Herein comes the question of protection from pests.

### **Importance of Pests**

Pests have been known to cause damage to plants from ancient times, though the exact causes might not then be known. References of locusts, rusts, mildews are found in the Bible and similar other ancient scriptures or literatures. They were considered to appear due to the wrath of the gods. Locusts were reported to cause ravages periodically which caused immense human misery and often migration of people from one country to another.

Late blight of potato caused by *Phytophthora infestans* in Ireland in the 1840's resulted in a potato famine and the consequent migration of half a million people from Ireland to the U.S.A. One of the major causes of the Bengal famine of 1943, which was responsible for the death of a very large number of people was due to the failure of the rice crop succumbing to the brown spot disease incited by *Helminthosporium oryzae*. Severity of rust (*Hemileia vastatrix*) disease, led to the abandonment of coffee cultivation in Sri Lanka towards the end of the nineteenth century and the adoption of tea culture. Red rot of sugar cane caused by *Glomerella tucumanensis* appeared in such a virulent form in North Bihar and Eastern Uttar Pradesh between 1939 and 1942 that the very existence of the sugar industry was threatened. Panama disease incited by *Fusarium oxysporum* f. *cubense* and the bunchy top (virus) disease often have led to the abandonment of banana cultivation and limiting areas of cultivation under this crop where they appear in a virulent form. *Tristeza* (quick decline, a virus disease) of citrus plants has brought decline in orange plantations in many

areas to such a extent that areas which once flourished in oranges are now depleted of these valuable plants. Similarly in West Africa, swollen shoot of cacao (a virus disease) has threatened the economic cultivation of this valuable crop. Instances of failure of wheat crop due to attack of rust diseases is too well known.

As far insect pests are concerned, apart from extensive damages caused by locusts, there are other instances of serious depredations. Termites or white ants, as they are popularly called are serious enemies of several agricultural crops, namely, sugar cane, wheat, maize, sorghum, groundnut, beans, chillies as well as many forest trees and timbers of farmhouses, poles, supporting roofs and other woodwork. In many parts of India, a large number of hairy caterpillars appear in certain seasons and destroy all crops that come in their way as they move from field to field. They cross roads, drywater channels on their way. They cause damage to cereals, oil seeds, pulses, and fodders to such an extent that the crop may have to be resown. In recent years, gall midge (*Orseolia oryzae*) and brown plant hopper (*Nilaparvata lugens*) are reported to cause such infestation so that to ensure proper yield definite measures are to be taken. Stem borer (*Scirpophaga incertulas*) causes much damage in major rice growing areas necessitating positive control methods to be adopted. Pink bollworm (*Pectinophora gossypiella*) is one of the most destructive insect pests of cotton not only in India, but in all cotton growing countries of the world. In sugar cane, top borer (*Scirpophaga nivella*) and Pyrilla often cause epidemics resulting in extensive reduction in yield. Rhinoceros beetle (*Oryctes rhinoceros*) in coconut palm; cottony cushion scale (*Icerya purchasi*) in citrus; hoppers (*Amritodus atkinsoni* and *Idioscopus clypealis*) in mango; fruitfly (*Dacus dorsalis*) in mango and many other fruit plants; American bollworm (*Heliothis armigera*) on cotton, pulses; etc. are some examples how destructive insect pests can be to crops.

Amongst nematodes, root knot nematodes (*Meloidogyne* spp.) and burrowing nematodes (*Radopholus similis*) are known to cause serious damage to many plants.

Damages caused by rodents are also too well known to merit special mention. Numerous such instances can be cited to

show that pests are potential threats to the successful cultivation of crops, and they can pose serious problems, if adequate steps are not taken to protect the crops. Even without taking into account extreme cases, it is estimated that under "normal" or "average" conditions, substantial loss is incurred due to attack of pests.

### **Definition of pest**

Insect and disease producing organisms are normally recognized as pests. Pest has been defined as any organism detrimental to man or his property in causing damage significant of economic importance. This organism may be insects, arachnids, nematodes, disease—producing pathogens including fungi, bacteria, viruses, mycoplasma, weeds, angiospermic parasites, rodents, birds and other animals. Pests however convey the idea or concept that they are controllable by suitable methods.

Pest control may be defined as any method or procedure employed to reduce the pest population and prevent damages caused by them. Pesticides are substances used to control pests and they include insecticides, fungicides, weedicides, nematocides, rodenticides, etc. The control of pests signifies any action taken by men to mitigate or prevent losses caused by them. Regulation of population in nature without any manipulation by man normally does not come under the purview of pest control measures. Control measures adopted for pest control may not always aim at the destruction of pests, but also amelioration of damages caused by them.

### **How do pest problems arise**

It may be recognised that out of two to three million organisms in nature, only a limited number have become pests. The situation has arisen primarily due to the efforts of men in improving and intensifying activities in agriculture to raise more crops and thus their interference with the ecosystem in nature. Cultivation of plants for deriving economic benefit is the focal point around which the interests of men and pests have clashed. One of the major causes of pest problems is the unlimited supply of food for the pests due to the intensified growing of crops. With the progress in agriculture in the

selection of suitable varieties of crops, plants with higher yield potentials are often associated with very succulent growth that the cultivated plants have now become more suitable or agreeable to pests for their food. This situation has been further aggravated by multiple cropping which has provided for an unlimited food chain. On the other hand clean cultivation aiming to increase production per unit area has eliminated or considerably reduced natural fauna or flora which act as checks and balances or barriers in the maintenance of biological equilibrium and has resulted in an unstable simple ecosystem which is often very vulnerable to fluctuations in the environment. It is well known that a complicated ecosystem existent under natural conditions is very stable.

Nature tends to scatter the plant species making it difficult for pests to spread and survive, whereas agriculture tends to concentrate millions of plants of a particular species in a limited defined area year after year. Homogenisation with one particular variety over a wide cultivated area makes the situation still more favourable for pests. Under such conditions, easy survival and multiplication of pests take place.

Many obscure pest organisms at one time restricted in their area to wild plant hosts have now become adapted to economically important plants wherever they are cultivated. Colorado beetle of potato (*Leptinotarsa decemlineata*) once a pest of wild solanaceous plants has now become pests in major potato growing areas in Europe and North America. Similarly organisms often brought inadvertently into a country along with host plants have become pests in the introduced country particularly in the absence of any suppressing organism. Examples may be given of European corn borer (*Ostrinia nubilalis*), Dutch elm disease (*Ceratocystis ulni*) introduced into the U.S.A. from Europe to mention a few cases. Wart (*Synchytrium endobioticum*) golden nematode (*Heterodera rostochiensis*) of potato was introduced into India from Europe.

Sometimes due to the introduction of new exotic varieties minor pests often assume importance. For example gall midge (*Orseolia oryzae*), brown plant hopper (*Nilaparvata lugens*), and bacterial blight (*Xanthomonas oryzae*) of rice which have

become serious pests after the introduction of high yielding dwarf indica varieties of rice.

Due to mutation in nature, or due to the development of resistance against pesticides, often new races or strains of pests appear which are more virulent and destructive and cause extensive damage. Example may be cited of black stem rust of wheat (*Puccinia graminis* f. *tritici*) where new virulent races have been reported to occur.

These are some of the relevant examples to illustrate how pest problems often arise.

### **Damages caused by pests**

Damages caused by pests may be quantitative or qualitative or both. Quantitative loss is recorded when there is an overall reduction in yield or outturn. In case of qualitative damages, the gross yield may not be affected but the presence of markings, blemishes, wart or offensive odour may fetch much less price and the net income from unit area is reduced. In case of scab infection (*Streptomyces scabies* or *Spongospora subterranea*) the yield is not adversely affected, but the presence of such markings or blemishes makes them less rapidly acceptable to consumers as a result less price is fetched, besides keeping or storage quality may also be low. Similarly banana fruits with markings caused by beetle or citrus fruits with surface damage caused by miners (*Phyllocnistis citrella*) fetch low prices. Bunt (*Tilletia* spp.) infection or infestation causes both reduction in yield and depreciation in quality. Similarly ergot (*Claviceps purpurea*) infection not only brings down the yield, but also makes infested grains unacceptable to consumers. Red rot of sugar cane (*Glomerella tucumanensis*) or damage by borer (*Chilo traxa*) causes not only reduction in yield, but affects the quality of juice of sugar cane. In case of damage by some pests in jute, not only the out-turn, but the quality of fibres also deteriorates.

Damage caused to the plants due to attack of pests may again be either direct or indirect depending on the parts affected and the resultant effect. In the case of infestation of stem borer of rice, the entire panicle becomes sterile and white and the damage is said to be direct, so also in the case of ear

cutting caterpillars (*Cirphis unipuncta*) when the entire earhead is cut off and destroyed. Whereas in the case of rice hispa, (*Hispa armigera*) leaf tissues are destroyed and the damage is indirect reflected through loss in photosynthetic area which may adversely affect total carbohydrate synthesis and grain formation. Similarly in the case of vascular wilt caused by a pathogen the entire plant is dead and the damage may be termed direct whereas in leaf spot, the effect is indirect again through loss of photosynthetic area.

The pest is said to be direct when the host is damaged by its direct action in a direct or indirect manner. If infection does not cause any damage to the host but it is affected in some other way, pest may be termed as indirect. Late blight organism (*Phytophthora infestans*) is a direct pest of potato as it affects leaves, young twigs and tubers, whereas aphid *Myzus persicae* may be called an indirect pest of potato in as much as it does not itself cause any damage to the plant, but it transmits leaf roll and other viruses from a diseased to healthy plant and thus is responsible for loss in an indirect manner. Similarly barberry plants (*Berberis vulgaris*) does not cause any direct damage to wheat plants, but they are alternate hosts of black stem rust (*Puccinia graminis* f. *tritici*) and thus may affect wheat plants by harbouring pathogen in the off season. Similarly weeds are not normally parasitic on cultivated plants, but they compete for space, light, water, and rob the cultivated plants of nutrients and thus are responsible for causing loss in an indirect manner.

A few instances may be cited in which infection apart from causing direct damage to the plant or plant parts may be responsible for further damage to many other organisms in a different manner. Grains or groundnut kernels infected with *Aspergillus flavus* show signs of positive direct damage and thus responsible for spoilage. Men or livestock consuming such spoiled grains or kernels show signs of poisoning because of production of a toxin known as "aflatoxin" in the damaged kernels or grains.

### **Usefulness of plant protection**

Some degree of protection of crops was always necessary in the past, but in recent years it is an admitted fact that

with the intensification in agriculture, a grower has to keep constant vigil against attack of pests to protect the crop and have a good harvest. Even in the recent past, a farmer could raise good crops without taking recourse to plant protection measures, when pest problems were comparatively few. But intensive agriculture is necessary to feed the increasing population and to supply raw materials for the expanding agro-business. If measures for controlling pests, diseases, rodents, weeds, etc. are not taken for the crops that are grown, they will not reach the desired level of production, as a consequence famine would likely engulf a huge chunk of population. To avoid famine, huge quantities of food would have to be imported and as a result the drain on the economy would be tremendous.

The National Council of Applied Economic Research (1967) carried out benefit cost analysis of pesticide treatment. According to the report benefit cost was, in case of insecticidal treatment 4.6 in rice, 3.2 in wheat, 2.9 in jowar 2.8 in cotton, 3.6 in sugar cane and 9.5 in potato. In the case of fungicidal treatment, it was 2.9 in paddy, 3.1 in wheat, 3.1 in cotton and 6.8 in potato. According to various research findings attempted to find out the benefit cost ratio of pesticide treatment, ratios in case of food crops were from 3 to 7.2, vegetables 2.8 to 4.7, cotton 2 to 13.5, sugar cane 3.4 to 14, oil seeds 1.4 to 44, jute 4, coconut 2. In general, savings due to plant protection measures have been estimated to vary from 5 to 15 per cent. One of the most commonly repeated 'guess' estimates of losses due to pests and weeds amount to twenty per cent, monetary value being over 1000 crores. Probably the greatest benefit of crop protection is the additional power it gives the growers to control and stabilise production without leaving the same to vagaries of nature.

### **Methods of pest control**

There have been attempts to classify different control measures that are employed for protection of crops against pests. But a rigid classification is difficult in view of the interdependence of methods upon one another. Broadly there may be two approaches, (1) method directed against the parasite to reduce population or inoculum to a very low level by chemical, biological,

autocidal and cultural methods so that damage at the economic level does not take place ; or (2) measures may be taken to the host 'or' in the environment in which the host is growing so that host plant is in a position to ward off or counteract attack of different parasites in an effective manner. Besides steps may also be taken to exclude the pest in such a manner that the pest does not have any opportunity to come in contact with the host, consequently no damage can take place. Measures may also be directed to cure the host plants of infection after it has become established. Methods may be presented as follows :

(A) PROTECTION OF THE HOST (PREVENTIVE CONTROL MEASURES)

(1) Exclusion or prevention of the parasite to come into contact with the host or reduce such contact to the minimum.

- (a) quarantine and legislative measures ;
- (b) inspection and certification ;
- (c) physical barriers (fences, fly screens ; insect-proof-packing) ;
- (d) use of repellants, attractants, antifeedants ; and
- (e) circumvention of attack by adjustment of sowing, selection of sites, crop rotation and such cultural methods.

(2) Reduction of the effects of contact between pest and host.

- (a) use of resistant varieties ; and
- (b) use of protective chemicals.

(B) DESTRUCTION OF THE PEST

(1) Cultural control.

- (a) Cultivation and other methods to destroy the organism and to reduce biotic or inoculum potential, and
- (b) sanitary measures like destruction of infected materials, etc.

(2) Ecological control—modification of the existing environment to curb the pest or to encourage natural enemies of the pest.

(3) Biological control.

- (a) introduction of suitable parasites, predators, and pathogens of the pest into the environment to reduce the pest population ; and

(b) autocidal method—use of pest species itself or some closely related species which will mate with pest species to destroy the pest population or the use of some characteristics of the pest species to destroy the population.

(4) Destruction.

(a) chemical pesticides ; and

(b) physical agencies, e.g., electromagnetic or mechanical energy.

*Chemical methods of pest control by application of pesticides.*

These methods either aim to keep the population of pests down to low level so that economic injury does not take place or eliminate pests altogether by the toxic action of chemicals. They may also be preventive in action, being applied as a prophylactic measure. There are a few instances, where chemicals act as therapeutants to get rid of an established infection in plants. Since World War II, there has been tremendous development in the field of chemical pesticides and a vast array of pesticides are now available in the market. At present chemical pesticides are used for control of insects, arachnids, molluscs, nematodes, rodents, fungi, bacteria, etc. The use of pesticides constitutes probably the most important method in spite of their limitations and adverse effect on the environment.

*Cultural methods of pest control*

Cultural methods of pest control aim in reduction of population of pests by suitable adjustment of farming practices. They also include measures which are eradivative in nature, namely destruction of crop residues, stubbles, weeds and infected plants or plant parts. These methods also include circumvention of pest attack by adjustment of sowing or planting dates and cultivation in such areas which do not have suitable climatic conditions for multiplication and dissemination of pests. They also aim at having proper and healthy growth of plants so that they can afford greater resistance to attack of pests.

*Use of resistant varieties*

Use of hosts which are not amenable to attack of pests or can resist the same is a very practical method of control. This

method has been found to be the only one which can be profitably employed in combating infections of certain categories of pathogens.

### *Biological methods*

Under this category, comes the mutual antagonism of one organism against another present in nature and is responsible for the maintenance of equilibrium in an ecosystem which is taken advantage of in the suppression of pests. In this process, specific parasites or predators either naturally occurring or exotic ones introduced into the area of infections are used. In control of pathogenic diseases, a somewhat non-specific microbial antagonism is induced in the soil for control of soil-borne pathogens inciting diseases in plants.

Use of hormones, which are of natural occurrence or their synthetic analogues also come under purview of biological methods.

### *Autocidal methods*

The control of insects by genetic manipulation which has been experimentally introduced in a few specific cases offer a promising new approach.

### *Physical and mechanical methods*

These include use of traps, barriers, physical agents like heat, light, electricity etc.

### *Legislative measures*

Quarantine regulations aim to exclude such pests which do not occur in a country from entering into the country, or preventing their spread within the country in case they have been introduced by restricting area of incidence by suitable legislative enactments. These may include certification where sale of infected material for planting purposes are prohibited or standards have been laid down regarding seeds and planting materials and same are enforced under provisions of law.

### **Integrated pest management**

Integrated pest management signifies the combination of all pertinent methods chemical, cultural, biological, use of resistant varieties, etc.

#### QUESTIONS FOR DISCUSSION

1. The statement that famine would engulf large chunk of population and economy will be adversely affected if pest controls are not adopted, may appear unrealistic. Is there any evidence to substantiate the statement ?
2. Why have more pest problems arisen in recent years as compared to the situation in the past ?
3. Why is protection of plants necessary ? How much loss is likely to be incurred due to attack of pests ?
4. Can you cite instance or instances where a minor pest has become a major one ?
5. Why is pest trouble expected when new planting materials or varieties are introduced ?
6. Why are certain measures called protective ? To whom do they give protection ?
7. What do you understand by biological control ? How can you aim at biological control ?
8. What is a direct damage ? How does it differ from indirect damage ?
9. What are quantitative and qualitative damages ?
10. Can you justify the statement that "with increasing complexity of civilisation, there has been greater dependence on plants" ?
11. Is it correct to state that populations of organisms in nature are in a state of balance with one other ? How does agriculture affect such a balance ?
12. For increasing production in agriculture, attention must be paid to crop protection. Justify the statement.
13. Are crop protection measures always economically justified ?
14. Under what conditions would it not be worthwhile to control crop pests ?