RAMA UNIVERSITY

www.ramauniversity.ac.in

FACULTY OF AGRICULTURAL SCIENCES & ALLIED INDUSTRIES

Lecture-8 Survey surveillance and forecasting of Insect pest and diseases

Pest Monitoring:

Monitoring for pests is a fundamental first step in creating a proper integrated pest management (IPM) programme. Pests are monitored through a variety of monitoring tools such as pheromone traps, light traps, coloured sticky traps, pitfall traps and suction traps.

The trap capture data serves several purposes:

(i) Ecological studies

(ii) Tracking insect migration

(iii) Timing of pest arrivals into agro-ecosystems

(iv) Initiating field scouting and sampling procedures

(v) Timing of pesticide applications

(vi) Starting date or biofix for phenology models

(vii) Prediction of later generations based on size of earlier generations (Zalucki and Furlong, 2005).

Monitoring phytophagous insects and their natural enemies is a fundamental tool in IPM - for taking management decision

Monitoring

- Estimation of changes in insect distribution and abundance
- Information about insects, life history
- Influence of biotic and abiotic factors on pest population

Pest Surveillance:

Pest surveillance refers to the constant watch on the population dynamics of pests, its incidence and damage on each crop at fixed intervals to forewarn the farmers to take up timely crop protection measures.

Three basic components of pest surveillance

Determination of

a. the level of incidence of the pest species

b. the loss caused by the incidence

c. the economic benefits, the control will provide

Objectives of Pest Surveillance:

i. To monitor, when pest population/ damage at different growth stages of crop reaches the economic threshold levels.

ii. To estimate the crop losses caused by pests.

iii. To study changing pest status from minor to major in a given crop ecosystem, this enables to determine the research priorities.

iv. To monitor the development of biotypes, resistance to insecticides, resurgence, etc.

v. To monitor the invasion of new pest species in a local ecosystem and determining the rate of spread of exotic pest that has already been established.

vi. To study the influence of weather parameters on pest by recording the changes in density of pest population throughout the year.

vii. To assess natural enemies population and their influence in a particular cropping system and in different seasons.

Pest surveys can be grouped into following categories:

(1) Qualitative Survey:

It is generally aimed at pest detection and provides list of pest species present along with reference to density like common, abundant, and rare. These are usually employed with newly introduced pests to understand the extent of infestation. These surveys are mostly adopted at international borders where agricultural commodities are inspected to avoid invasion of any new species.

(2) Quantitative Survey:

This survey defines numerally the abundance of pest population in time and space. It provides information on the damaging potential of a species and data can be used to predict future population trends. These surveys provide the basis to decision making for adopting control measures for a pest by the farmers.

Survey/surveillance can also be classified as fixed plot and roving.

(3) Fixed Plot Survey:

In fixed plot survey, the pest population or damage due to insect pests is assessed from a fixed plot selected in a field. The data are recorded regularly from sowing till harvest of the crop from the same fixed plot in a particular field. The data collected in these surveys are used to develop forecasting models.

The direct counting of population on plant, light traps, sticky trap, pheromone traps, etc., are techniques which can be used to monitor population in this survey. Counting total tillers and number of tillers affected by stem borer from 10 randomly selected plants from fixed five spots of $1m^2$ in one ha is an example of fixed plot survey.

(4) Rapid/Roving Survey:

This survey includes assessment of pest population or damage from randomly selected spots in a short period of time over a large area. It provides information on pest level which helps in determining the timing of adopting appropriate control measures. The surveys are made to monitor the initial development of pests in endemic areas in the beginning of crop season.

Based on these surveys, the farmers are instructed to monitor the pest incidence in their respective fields by the agriculture extension specialists and take interventions to manage the pests accordingly. The counting of whitefly adults from lower surface of leaf from randomly selected cotton plants on a predetermined route after a definite period of intervals is an example of roving survey.

Steps for Pest Surveillance:

1. Identification of Pest:

The first most important step for surveillance/survey is correct identification of pest. If the identification of a pest is incorrect, the decision for taking intervention for the management of pest will not be reliable. The incorrect identification may occur when one known species is confused with other or when a previously unknown species is grouped into known species.

Therefore, the person deputed for survey must have expertise on identification of all the stages of pest and their common visible morphological characters. Otherwise, the samples may be collected and reared in laboratory for all stages and specialist/expert/taxonomist may be consulted.

With the advent of molecular techniques, the data on conserved gene sequences is being generated for all the biodiversity of the world through International Barcode of Life (iBOL) project. The data will be publicly available which can be useful for identification of pest specimen.

The simple procedure includes sequencing of conserved genes amplified from total DNA of insect species and alignment of the sequence with the gene sequence databank. It would help to establish the identity of new unknown species and other species, which are generally confused with other species.

2. Determination of Pest Population:

The second basic component of surveillance is estimation of pest population. Most of the economic threshold levels for different pests depend on number of pest population present in the field. The study on pest population is helpful in pinpointing the factors that bring about numerical changes in the natural population, and also in understanding the functioning of life-system of the pest species.

For a correct and scientific understanding of a pest population, it is of fundamental importance to develop sound methods of population estimation. This involves two considerations. First, the life stage (egg, larva, pupa or adult) at which counting can be made most advantageously; and secondly, the actual process of counting.

The ideal approach to population estimation would be to count all the individuals. However, it is not possible to count most of the pest species over an area large enough to be of use in a practical study and hence some method of sampling becomes necessary.

The amount of time and effort required to obtain absolute counts even on a limited area is so large that it is often uneconomical and unproductive. Thus, although we wish to have information on the true population, we are forced to take smaller collections (samples) and use these to make inferences about the total population.

3. Estimation of Abundance of Natural Enemies:

The importance of natural enemies in regulating the populations of herbivorous insects was recognized much before the concept of IPM was developed. Unfortunately, few IPM programmes at the commercial level attempt to estimate the abundance and impact of these agents on insect pest populations.

The procedure generally employed to study the role of natural enemies, requires gathering different stages of the target organisms from the field, and subsequent emergence of parasitoids is recorded in the laboratory. Unless repeated frequently, this procedure underestimates total mortality since organisms are protected from any mortality factors while in the laboratory. Ovipositional probing and host adult parasitoid feeding is often responsible for more mortality than is caused by developing parasitoids, and is not well estimated except by detailed field observations.

For studying the impact of natural enemies on the rate of increase of pest population, it is essential to undertake field level studies so that potential for and degree of control exerted by the whole complex of parasitoids and predators can be quantified by comparing growth rates under a range of natural enemy levels.

There is an urgent need to develop efficient and cost reliable estimation procedures and forecasting models which incorporate the role of natural enemies in the decision making process; experimentation aimed at estimating functional relationships and not just significant differences. The ratios of pests to natural enemies estimated in the field could be used to predict trends in pest populations.

4. Estimation of Yield Loss:

One of the objectives of the surveys is to estimate the yield loss due to insect pest species in different areas and type of farming systems. The crop loss estimation holds significance to justify the control measures, which should be taken to manage the insect pest species. In general, surveys to assess the crop loss due to insect pests can be done directly by recording the yield or by recording infestation of pests.

Pest Forecasting

Meaning of Pest Forecasting:

Pest forecasting is the perception of future activity of biotic agents, which would adversely affect crop production. In other words, it is the prediction of severity of pest population which can cause economic damage to the crop. The systematically recorded data on pest population or damage over a long period of time along with other variable factors, which affect the development of pest, may be helpful in forecasting the pest incidence.

The prediction of a particular pest depends upon characteristics/biology of a pest and the meteorological factors. These meteorological factors may affect the pest either directly affecting their survival, development, reproduction, emergence and behaviour, or indirectly by their action on host plants or on natural enemies. These factors also determine the geographical limits of distribution and the time of appearance and abundance of pests.

The forecasting of pests guides the farmers about the timing and biology of insect incidence, and to eliminate blanket applications, reduce pesticide amounts, and achieve quality results. The farmers can take to timely action of applying various pest control measures to harvest maximum returns.

Several studies are required to generate the basic information, which is required to develop forecasting models.

Some of them are described below:

(i) Quantitative Seasonal Studies:

Using appropriate sampling techniques, the pest abundance must be studied over several years along with seasonal range, variability in number and distribution. The seasonal counts in relation to climate and topography need to be provided.

(ii) Life-History Studies:

The detailed bio-ecology of pest under a range of temperature, humidity, etc. should be known. The duration of different instars, number of generations, survival rate, amount of food eaten, overwintering, host range, number of eggs laid, etc. and other parameters can be studied in laboratory.

(iii) Ecological Studies:

Life-table studies of pest are important for better understanding of pest population build-up, natural mortality factors, intrinsic growth rate, etc. Life-table of a pest can be helpful in finding mating and emergence period which are quite useful for predicting population dynamics of the pest. The migration and immigration of pests can also be used for forecasting of pests.

(iv) Field Studies:

Climatic factors not only affect the pest abundance but also affect the natural enemy population which is an important natural factor in controlling pest population. In field situations, the natural enemy abundance under a range of temperature and humidity should be studied. The other cultural practices like fertilizer application, irrigation, plant spacing, etc., affect the crop phenology which directly influences the population build-up of a pest.

Types of Pest Forecasting:

Pest forecasting may be divided into two categories, viz., short-term forecasting and long-term forecasting.

1. Short-Term Forecasting:

The short-term forecasts are often based on current or recent past conditions that form a basis for, or an enhancement to, the forecast. These may cover a particular season or one or two successive seasons only. The pest population is sampled from a particular area within a crop using appropriate sampling technique and the relationship is established between weather data and progress in pest infestation.

The laboratory studies on the effect of temperature on emergence and egg laying can be used to forecast the pest situation in the field. The short term forecasting can be completely empirical, such as use of environmental cues reported from Japan, where the date of first blooming of cherry blossom and the mean March temperature were used to predict the peak emergence of rice stem borer.

Based on multiple regressions, short term forecasting of wheat grain aphid, *Sitobion avenae* (Fabricius), has been done. The peak population density on each field was positively correlated with the population densities at the end of ear emergence, mid-anthesis and the end of anthesis.

Based on two counts on the crop, the accuracy increased from ear emergence to the end of anthesis, however, the forecast at mid-anthesis of peak density was much more accurate.

2. Long-Term Forecasting:

These forecasts are based on possible effect of weather on the pest population and cover a large area. The data are recorded over a number of years on wide seasonal range and from different areas. Long-term forecasting is based on knowledge of the major aspects of the pest insect's life-cycle, and of how it is regulated.

The data recorded are analyzed and models are developed based on the available information. The models help in forecasting pest population in various geographical areas based on common weather parameters. Long-term population forecast based on Markov chain theory was developed for effective management strategies for *Nilaparvata lugens* (Stal) and *Sogatella furcifera* (Horvath).

This model is an effective method for long-term population forecasting of *N. lugens* and *S. furcifera*, and thus provides plant protection agencies and organizations with valuable information in implementing appropriate management strategies.

Long-term forecasting of brown and white backed plant hoppers in Japan was based on the assumption that both the hoppers overwinter as diapausing eggs on winter grasses. After it was discovered that the brown plant hopper migrates in Japan from outside, the short-term forecasting was adopted.

Methods for Pest Forecasting:

Pest forecasting has generally based on environmental factors, climatic areas and empirical observations.

1. Environmental Factors:

The population development of a particular pest mainly depends on the favourable environmental conditions available in a particular geographical region. The pest attack occurs in epidemic form only when the favourable environmental conditions for multiplication of pest prevail for longer duration. Therefore, the factors responsible for environmental conditions are the major criteria on the basis of which the forecasting can be done.

The sugarcane pyrilla, *Pyrilla perpusilta* (Walker), outbreak is predicted based on high temperature during monsoon. The population per 30 plants (Y) is predicted based on the mean maximum temperature (X) of week preceding the data of observation of field population.

Insects are exothermic (cold-blooded) and their body temperature and growth are affected by their surrounding temperature. Biological development of insects over time in correlation to accumulated degree days has been studied, discovering information on key physiological events, such as egg hatch, adult flight, etc.

There is a threshold temperature for each insect; for example, 48°F for the alfalfa weevil, *Hypera postica* (Gyllenhal). No development occurs when temperatures are below that level. Insects have an optimum temperature range in which they will grow rapidly. Then, there is maximum temperature (termed upper cutoff) above which development stops.

These values can be used in predicting insect activity and appearance of symptoms during the growing season. Therefore, the degree days would be useful in pest management programme to time the scouting of insect pests. This predictive information is known as an insect model. Models have been developed for a number of insect pests.

Degree days = Maximum temperature + Minimum temperature/2 – Development threshold

As an example, codling moth, *Cydia pomonella* (Linnaeus), pheromone monitoring traps are placed in the apple orchard at 100 degree days after March 1 in northern Utah to determine initiation of adult moth flight.

A temperature range of 50° to 85°F is most comfortable for European corn borer, *Ostrinia nubilalis* (Hubner). Below 50°F, it will not develop, and above 85°F, development will slow dramatically. A degree day for European corn borer is one of degrees above 50°F over a 24-hour period.

For example, if the average temperature for a 24-hour period was 70°F, then 20 degree-days would have accumulated (70 – 50 = 20) on that day. These accumulations can be used to predict when corn borers will pupate, emerge as adults, lay eggs, and hatch as larvae.

2. Observations of Climatic Areas:

The distribution of insects throughout the world is based on evolutionary history which includes main important factor, i.e., climate of the geographical region. There are three distinct zones of abundance of each insect species.

Zone of Natural Abundance (Endemic):

In this zone, the pest species is often in large number, regularly breeds and is a regular pest of some importance. The climate conditions are most favourable for its development and pest is seen all the time.

Zone of Occasional Abundance:

The insect species emerge in epidemic occasionally in this zone because the climatic conditions are either less suitable or the suitable conditions exist only for a short period of time followed by unsuitable conditions. Sometimes, the climatic is severe to destroy the entire population, which is then re-established by dispersal from zone of natural abundance.

Zone of Possible Abundance:

The pest species in this zone can be seen only after migration from zone of natural and occasional abundance outbreaks. The climatic conditions are drastic for their breeding and development. The population is destroyed by the severe climatic conditions within a short period of time. Three different regions Orlando, Naples and Ankara corresponding to zone of natural abundance, occasional abundance and possible abundance, respectively are known for Mediterranean fruit fly, Ceratitis capitata (Wiedemann).

The observation on the climatic areas where critical infestations are likely to occur can be predicted for some insects. Combination of climatic factors like temperature, rainfall, humidity, etc. existing in a geographical region gives an indication of possibility of establishment of pest in that region. The other factors like biotic and topography may also be used for prediction of insect pests.

3. Empirical Observations:

This type of pest forecasting is based on estimating the number of insects available during a particular time. In other words, it is nothing but the sampling of insect or monitoring of pest population. It involves forecasting the population in the next season by counting the pest in the previous seasons. In many cases, the number of pests in the early part of cropping season will give an indication as to the extent of its likely multiplication in the season.

From the counting of immature stages of insects, approximate estimations of later stages can be made. For example, in UK taking soil cores for insect eggs of carrot fly, Psila rosae (Fabricius) and cabbage root fly, Delia radicum (Linnaeus), is successful for estimating the later population of root maggots. The adult catch in the traps especially pheromone traps can be used to estimate the approximate abundance of pest population later in the season.

The sampling of insect pest on alternate host/weeds during non-availability of main crop can be quite useful to forecast the pest population development in the coming season, e.g., counting overwintering eggs of blackbean aphid, Aphis fabae Scopoli, on spindle trees helps in estimating the aphid population on peach-potato crop. In many lepidopteran species, pest forecasting is based on estimating the number of eggs and young larvae on the crop, e.g., cotton bollworms, stem borers, pulse moths, etc.

Methods of sampling

a. In situ counts - Visual observation on number of insects on plant canopy (either entire plot or randomly selected plot)

b. Knock down - Collecting insects from an area by removing from crop and (Sudden trap) counting (Jarring)

c. Netting - Use of sweep net for hoppers, odonates, grasshopper

d. Norcotised collection - Quick moving insects anaesthesised and counter

e. Trapping - Light trap

- Phototropic insects
- Pheromone trap
- Species specific Sticky trap
- Sucking insects Bait trap
- Sorghum shoot fly
- Fishmeal trap Emergence trap
- For soil insects

f. Crop samples - Plant parts removed and pest counted e.g. Bollworms

Stage of Sampling

- Usually most injurious stage counted
- Sometimes egg masses counted - Practical considerations
- Hoppers - Nymphs and adult counted

Sample Size

- Differs with nature of pest and crop
- Parger sample size gives accurate results

Decision Making

- Population or damage assessed from the crop
- Compared with ETL and EIL
- When pest level crosses ETL, control measure has to be taken to prevent pest from reducing EIL.

Economic Injury Level –

Defined as the lowest population density that will cause economic damage (Stern et al., 1959) - Also defined as a critical density where the loss caused by the pest equals the cost of control measure.

EIL can be calculated using following formula where,

EIL = C V x I x D x K (or)

C VIDK EIL = Economic injury level in insects/production (or) insects/ha

C = Cost of management activity per unit of production (Rs./ha)

V = Market value per unit of yield or product (Rs./tonne)

I = Crop injury per insect (Per cent defoliation/insect)

D = Damage or yield loss per unit of injury (Tonne loss/% defoliation)

K = Proportionate reduction in injury from pesticide use

Economic threshold level (ETL) or Action threshold - ETL is defined as the pest density at which control measures should be applied to prevent an increasing pest population from reaching Economic Injury Level (EIL)

- ETL represents pest density lower than EIL to allow time for initiation of control measure

Plant Disease Forcasting – Meaning, advantages, methods in forecasting and examples