CROP PESTS, DISEASES AND LOSSES—A DISCUSSION

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1. Introduction

There are appreciable crop losses at various stages of handling the grains. The loss at the pre-harvest stage might be due to incidence of pests and diseases, nematodes, birds and animals, floods droughts, hailstorm, etc. The crop losses at the harvest stage might be due to methods of harvesting, processing, winnowing, etc. The losses at the post-harvest stage might be mainly due to transportation and storage. However, reliable and objective estimates of such losses are hardly available in this country. The information at the same time is important, rather pre-requisite for planning effective and economic control measures and also for developing appropriate technology to reduce such losses. The United Nations has prepared a plan to reduce such losses to the tune of 50 per cent upto 1985.

An objective assessment of the losses at various stages seems to be very necessary in order to develop economic and practical methods for controlling such losses. Several attempts for assessing the losses have been made in the country in the past but these were either limited in scale or methods followed were not very scientific. The problem is very complex and its solution needs multi-disciplinary approach, The techniques of experimentation and surveys have to be employed for collection of reliable data.

For the first time, research study with the objective of evolving a suitable sampling and measurement technique for estimating the incidence of pests and diseases and assessment of loss in yield of paddy crop was taken up in 1959 in Cuttack district of Orissa, jointly by a team of statistician, micologist and entomologist. Thereafter, with a view to examining the suitability of the techniques, developed on the basis of the Cuttack surveys for different agro-climatic conditions, the survey was extended to Thanjavur district of Tamil Nadu in 1962 and West Godavari district of Andhra Pradesh in 1963 on paddy crop. The surveys in these two districts were

carried out for four years. A similar survey was also conducted in Aligarh district of U.P. on wheat and maize crops for 4 years from 1963 to 1967. In seventies the surveys on high yielding varieties (HYV) of paddy and wheat were also proposed as more serious problem of incidence of pests and diseases were expected in the high yielding varieties than in the local varieties, studied earlier.

The problem of assessing the crop losses due to pests and diseases is complex in the sense that the yield of the crop is affected by so many other factors such as variety, soil type, cultural practices, manuring, topography, irrigation, etc., and therefore the segregation of the effect of pests and diseases on the yield requires the development of appropriate statistical measurement technique. It may involve study of two components, i.e., estimation of the incidence of pests and diseases and the loss of yield thereof.

2.1 Terminologies

The terminologies, measurement and sampling techniques in regard to incidence of pests and diseases, etc,, used in these surveys are given below in brief:

2.1.1 Pests and Diseases

(*a*) *Degree of Prevalence of pests and diseases :* It is a qualitative concept for example, if in a given contiguous area, say Taluk-Tehsil or a Stratum it is found that 75 per cent of the villages are affected by pests and diseases, then the degree of prevalence of pests and diseases in that area may be considered as 75 per cent.

(*b*) *Intensity of Disease Incidence or Pest Infestation :* This is measured generally by the ratio of affected number of tillers to the total number of tillers in an ultimate unit or area.

(*c*) *Severity of Disease Incidence or Pest Infestation* : In case of diseases it is measured by assigning the score which may vary from 0 to 10, and in the case of pests it may be measured by counting the number of eggs, larva, pupa or flying insects, or by determining the percentage of leaf infested. if possible.

2.1.2 Yields

This may be defined as a measure of produce obtained from a crop (group of plants).

(*a*) *Attainable yield.* This may be defined as the resulting yield when a crop is grown under optimal conditions using fully available modern technology.

(*b*) *Economic yield:* The attainable yield is the yield obtained by using the best available production technology without consideration of economics. But when economics is taken into consideration for obtaining a higher yield it may be referred to as economic yield. This is the situation when the income in return is more than or atleast equal to the cost of improved inputs, cultural practices, etc., used for producing that yield. Hence the economic yield may be equal to or less than the attainable yield.

(*c*) *Actual yield:* This is obtained when crops are grown under farm conditions. This actual yield would obviously be less than the attainable yield.

2.1.3 Losses

Losses of food can occur during the pre-harvest, at harvest and post-harvest stages, but the discussion in this paper would be confined to the pre-harvest losses of foodgrains due to pests and diseases.

(*a*) *Crop Loss* : In simple term it is a measure of reduction in either quantity and/or quality of yield. It may be taken as the difference between the actual yield and the attainable yield.

(*b*) *Economic Loss* : It is the difference between the actual yield and the economic yield.

(*c*) *Potential Loss* : The difference of attainable yield and the economic yield may be termed as potential loss.

(*d*) *Avoidable Loss* : It is the difference between the yields obtained from the 'protected' and 'unprotected fields'. The plant protection schedule adopted in the protected fields may vary from crop to crop depending on the occurence of different pests and diseases.

2.2 Measurement Techniques

Pests: There are in general four stages of the insect pests, *viz.*, egg, larva, pupa, and then adult (flying stage). The egg and pupa (dormancy stage) stages are stationary and therefore, cannot damage the crop as such, whereas the larva and flying/adult stages of the insects are mobile and damage the crop. The larva stage is less mobile than the flying stage but it is generally reverse in terms of damage done to the crop.

Diseases: The diseases might be due to fungus, virus or bacteria. Most of the diseases observed in case of paddy crop were due to fungus and its symptoms could be seen on leaves, neck and ear.

Growth of the Plant: The growth of the plant may be divided into four main stages, *viz.*, tillering, pre-flowering, flowering and ears and at these stages the incidence of pests and diseases are measured. The first three stages are during the pre-harvest and the fourth is near the harvest stage. The measurement techniques in case of major pests and diseases of paddy are as follows:

(*i*) *Stemborer* (*Tryporyza-incertulas*)*:* The larva of stemborer bores the stem of the tiller and the infested tiller is known as 'dead heart' during the growth period, and at-harvest stage it gives rise to ear without grains and is known as white ear. The intensity of infestation of this pest is measured by the ratio of the infested tillers to the total number of tillers during growth period and by the ratio of the number of white ears to the total numbers of ears in the sampling units at the harvest time. The severity of this pest can be measured by counting its different biological stages, *viz.*, egg, larva, pupa and adult.

(*ii*) *Gall-fiy* (*Pachydiplosis oryzae*)*:* In case of this pest the larva punctures the stem and makes gall. The tillers infested are known as 'silver shoots' during the growth period. At harvest, no ears are formed but only the silver shoots are the there. The intensity of infestation of gall-fly is, therefore, measurcd by the ratio of the silver shoots to the total number of tillers during the growth period and the ratio of silver shoots to the total number of ears at the harvest time. The severity of this pest can also be measured by counting its different biological stages as in the case of the stemborer.

The major diseases (*a*) *Helminthosporiose* (*Helminthosporium oryxae*) *and* (*b*) *Blast* (*Piricularia oryzae*).

The intensity of these diseases are measured by the ratio of the tillers infected due to these diseases to the total number of tillers during the growth period. But at harvest stage, it is measured by the percentage of ears infected by the diseases. The severity of the disease is measured by assigning a score corresponding to grade of infection as per score chart prescribed for the purpose. This is done by observing five plants in the ultimate sampling unit. *i.e.*, four corner, plants and the central one and with the help of the standard score charts, supplied by Plant Pathologists, the five plants selected are assigned the score corresponding to the grade of infection by this chart. The number of grades, for example varied from 0 to 8 for blast and from 0 to 9 for helminthosporiose diseases in the studies made.

Yield : The yield is also recorded at the time of harvest of the plots of which the periodical observations of the incidence of pests and diseases are taken and recorded so that the crop loss may be worked out, by utilising the relationship between yield and incidence of pests and diseases.

2.3 Sampling Techniques

2.3.1 Survey Design

Stratified multi-stage random sampling design was adopted in the field surveys. Each district was divided into 9 or 10 homogenous zones taking into account soil, agro-climate factors, etc., by grouping adjacent thanas or blocks, and these zones were treated as strata. In each stratum, six villages, growing paddy crop were selected at random and in each selected village, four paddy fields were selected at random.

In some districts (Thanjavur/West Godavari), in addition to those four fields two more fields, in each selected village, were selected where plant protection measures (as recommended by the concerned department of agriculture) to control the incidence of pests and diseases were adopted for the purpose of assessing the avoidable loss in yield.

In each selected field, four plots of size 1 sq,m. (1m×1m) each were located at random for recording the intensity/severity of incidence of pests and diseases. In case of observing severity of certain pests and diseases, since it may not be possible to observe all the plants in a plot, only five plants (four corner and the central) were selected for recording the detailed observations.

2.3.2. Periodicity

The observations on the incidence of pests and diseases were recorded at interval of about four weeks, beginning with the first observation taken within four to six weeks after transplanting and ending with the last observation at the time of harvest. These periodical observations provided the incidence of pests and diseases at different levels of their biological/ecological stages and also at the major stage of crop growth, *viz.*, tillering, pre-flowering, flowering, ears, etc.

2.4. Investigations of The Appropriate Sampling Techniques

2.4.1. Fixed Vs. Variable Sampling Units (Plots)

Two of the plots in each selected field were kept fixed for the purpose of recording the observations for the entire season while the remaining two plots were selected afresh on each occasion of the periodical observations. In fact the observations were recorded

periodically mainly with a view to estimating the intensity/severity of pests and diseases at different stages of crop growth. The best procedure of sampling for this purpose would have been to make fresh selection of plots at each occasion of sampling. However, for such complex studies, practical difficulties in the cultivator's field force one to keep the sampling unit (plots within fields) fixed throughout the period of investigation during the crop season. In order to evaluate the loss of efficiency, if any, by keeping the sampling unit (su) fixed, observations were taken periodically on these two fixed plots (sus) and also on two other plots (sus) located afresh on each occasion of sampling. The estimates of incidence of major pests and diseases during each season were estimated separately for fixed plots and the plots selected afresh for comparison. The analysis, after suitable transformation was carried out to find out the difference in the incidence of pests and disaases in these two types of plots.

2.4.2. Efficiency of Sub-division of Fields

It is possible that the incidence of pests and diseases may vary from the edges to the centre of the field. If that is so, it would be desirable to sub-divide the field and locate plots (sus) from each such sub-division for recording the observations. In order to investigate how far the intensity/severity of incidence of pests and diseases is related to distance from the border of the field. The observations were taken in six additional plots selected in each of the largest control fields in each selected villages in only one stratum in each season. The six plots of 1 sq. m. each were located @ 2 in each of the 3 concentric sub-divisions, *viz.*, central, middle and peripheral of equal width avoiding overlapping, if any, with the other four plots already selected in the field. The incidences in these six plots were observed periodically in the same way as in the case of other plots. The analysis of data on incidence was carried out in case of each of the major pests and diseases.

2 4.3. Size of the Sample at Different Stages for Pre-assigned Degree of Precision

As mentioned earlier, startified multi-stage random sampling technique was adopted for the investigation. Village, field and plots were primary, secondary and tertiary units of sampling respectively. with zones forming the strata. For investigating the suitable sample size at each stage of sampling, it is necessary to have estimates of true variances between the sampling units at each stage. These estimates of components of variance were worked out for incidence of major pests and diseases and were utilised in working out the number of sampling units required at different stages for a pre-assigned degree of precision.

2.5. Other Techniques

Utilising the relationship of the incidence of pests and diseases and the yield of the crop techniques such as multiple regression analysis (MRA), principal component analysis (PCA) were studied to assess quantum of crop loss incurred due to incidences of pests and diseases. Since the yield is affected by many other factors such as variety, soil type, manures and fertilizers, topography, irrigation, cultural practices, agro-climate, etc., the study of data relating to incidence of pests and diseases was confined to the plots within fields. This procedure automatically eleminated the effect of the factors enumerated above. The general approach was to calculate multiple regression equation of yield of fixed plots on the measures of incidence of pests and diseases, observed periodically, at the major stages of crop growth, *i.e.*, pre-flowering, flowering, harvest etc. This was done after removing stratum, village and field variation. For the study, the observations on incidence of pests and diseases were selected on the basis of their importance in relation to biological and ecological aspects. Since the values of various observations were very low and were not highly corelated with each other, no problem was faced in their selection for the study of MRA. Thus more than one observation of the same pest/disease recorded at pre-flowering, flowering, harvest, stages, etc., were used as independant variables.

For studying the crop losses, the technique for multiple regression was preferred to the PCA technique as there were some limitations to the use of PCA. For example, difficulty was found in using the PCA for working out the crop losses in startified multi-stage sampling, *i.e.*, at the level of ultimate sampling units (sus)/plots (within fields) to avoid the effect of other factors such as variety, soil type, manures and fertilizers, topography, irrigation, cultural practices, agro-climate, etc., as PCs are constructed on single stage basis and without stratification; it also created difficulty in estimation of components of variance at different stages which are important in calculating the sample size at different stages of sampling for a given degree of precision, in the interpretation, testing and also in prediction of crop loss by using the equations/models worked on PCA basis, in the subsequent seasons/years. Since the values of incidences as well as correlations between the incidences were found to be very low, there was no problem of multi-collinearity. In such cases if a technique of PCA is applied, there is danger that a small error in such low values gets multiplied. Since the scales of measurement of incidences of pests and diseases were different, the technique of PCA could not be

applied outrightly. However, this problem could be solved by making the values standardised, but it made further very difficult in interpreting the results.

The use of PCA could however be useful in construction of an index of incidences of pests and diseases and then to relate it with yield and other soil and agro-climatic factors which could help in identification of endemic areas in different agro-climatic regions.

2.6 PROBLEMS

It is difficult to enumerate all the problems in such complicated studies where a number of disciplines, like entomology, plant pathology, statistics, etc., are involved. However, some of the problems are enumerated below, based on the past experience obtained through the conduct of pilot sample surveys, referred to above, for estimating the incidence of pests and diseases and consequent crop losses. For recording the observations on the incidence of pests and their intensity/severity, the biological and ecological behaviour of pests and diseases, and also the crop losses thereof the standardised measurement techniques were used. These problems need inter-disciplinary approach for solutions.

(*a*) *Measurement techniques.* There is a need for standardizing the measurement techniques in case of some pests and diseases where such techniques have not been evolved so far.

(*b*) *Forecasting of Incidence of pests and diseases.* There is a need of evolving of predictton equations (models) involving sampling, and multiple regression and other multi-variate techniques.

(*c*) *Demarcation of Endemic Areas.* There is a need of working out indices of pests and diseases incidence involving sampling, PCA and other multi-variate techniques, etc.

(*d*) *Individual pests/disease, incidence and assessment of consequent crop loss.* It should be studied in the laboratories and at Research Stations and in the cultivators' field. Such studies may require the application of design of experiments, statistical methods of regression analysis and also sampling of field experiments.

(*e*) *Optimum shape and size of plots for recording incidence of pests/diseases.* The optimum size and shape of plots might be worked out by conducting uniformity trials at Research Stations for different pests and diseases in different crops where such studies have not been made so far.

(*f*) *Studies of distributions of Incidence of pests and diseases over time/space.* Distributions of incidence of pests and diseases relating to different crops need to be worked out. The problem of transformation of data to approximately make it normal may also be studied.

Since the studies mentioned above involve disciplines such as entomology, plant pathology and statistics, joint efforts should be made by the coneerned specialists in tackling these problems.

The use of the findings of the above-mentioned studies, already made for improving the measurement and sampling methodology for estimation of incidence of pests and diseases and consequent crop losses will continue to be made in the conduct of pilot sample surveys and thereafter for conducting the large scale sample surveys. As such, surveys on bigger scale would provide reliable and objective informations with regard to crop pests, diseases, losses, etc. as discussed above. The Planners and Policy Makers can then chalk out their plans more effectively and economically regarding pesticides, etc., to bring the crop losses to the minimum and make the 'Plant Production and Protection', programme a great success. The International commitment of reducing such losses to atleast 50 per cent by 1985 as mentioned earlier could also be fulfilled as far as this country is concerned.

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