ESTIMATION OF POST-HARVEST FOODGRAIN LOSSES

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(Received : June, 1983)

SUMMARY

Considerable foodgrain losses are incurred at different post-harvest stages every year. The work done in this field has been reviewed in brief and observed that the reliable and objective estimates of those losses are not available in this country. Such estimates are very important rather pre-requisite for carrying out control measures more efficiently and economically and also for improving post harvest technology so as to minimise those losses.

Keeping the importance in view statistical methodology for estimating foodgrain losses at different post-harvest stages, viz., harvesting, threshing/shelling, cleaning/winnowing, drying, handling (at farm/market level), transportation, packaging, storing, etc. at farm, intermediary and warehouse level have been discussed. The methodology for working out the damage due to different causes such as temperature, relative humidity, moisture content, incidence of pests and diseases and other biological and chemical changes, etc., on the basis of the observations taken in the storage has also been discussed.

INTRODUCTION

1.1 It is a well known fact that considerable crop losses are incurred at pre-harvest and post-harvest stages which makes a great hinderence in the crop production and protection programme. The incurrence of such losses at the pre-harvest stage might be due to incidence of pests and diseases, nematodes, birds and animals, floods, droughts, hail-storm, etc. The crop losses at the harvest stage could be due to methods of harvesting, threshing/shelling, cleaning/winnowing, drying, etc. whereas the losses at the post-harvest stages might be due to

miss-handling of the foodgrain at different stages of transportation (rail, road, shipping), storage (farm storage, warehouses, cold storage), processing, packaging (local, foreign markets), handling (at farm and market level), etc. However, the reliable and objective estimates of losses of foodgrains at these stages are hardly available in this country. But, such estimates are very important rather pre-requisite for Planners, Policy Makers, Administrators, Scientists, etc. for developing and adopting efficient and economical control measures to minimise those losses.

1.2 It is observed that the losses of foodgrains especially in the developing countries where annual production of cereals per head is very low as compared to developed countries are very high. If such losses are avoided, the developing countries would not only save billion of dollors but also divert that amount to their much needed programmes. All efforts should be made to minimise these losses. The United Nations has committed to reduce such losses to the tune of 50 per cent atleast upto 1985 in its 7th special session of General Assembly in September, 1975.

1.3 Several attempts for assessing such losses have been made in the country and abroad in the past but those were either limited in scale or the methods followed were not very scientific. Keeping the importance of the problem in view this Institute has been engaged in developing the statistical methodology for estimation of those losses and on the request of the FAO two manuals, viz., "(*i*) Statistical methodology for collection and assessment of data on post-harvest foodgrain losses and (*ii*) Statistical methodology for collection and assessment of data on pre-harvest losses to foodgrains due to pests and diseases" were prepared by this Institute. The techniques for collection of reliable data and their interpretation have been discussed in those manuals.

1.4 The review of work done relating to post-harvest foodgrain losses in India was made by Singh and Khosla [11] and also the reveiew of post-harvest foodgrain losses in the developing countries made by this Institute in the FAO publication (1980). The magnitude of foodgrain losses incurred at various post-harvest stages in India is given below in brief.

1.5 The Government of India appointed a Committee in Sixties to make studies of the crop losses. The estimates of losses of important crops, viz., wheat, rice, jowar, bajra, gram, millets and pulses, made by the Committee at different stages, viz., threshing-yards, transport and storage averaged over the three years, 1962-63, 1963-64 and 1964-65. The overall percentage loss was about 9.33.

1.6 The Committee on Post-Harvest losses of Foodgrains in India [2] indicated the losses of foodgrains of wheat, paddy, jowar, bajra, maize, etc., on various stages of post-harvest. The storage losses during the period from 1963-64 to 1968-69 held in storage varied from 0.1% to 0.26%.

The percentage of losses during transportation for the period 1962 to 1967 in respect of wheat varied from 0.17% to 0.75%.

1.7 The Committee on Cost of Handling of Foodgrains set up by the Food Corporation of India [3] reported the transit and storage losses in Food Corporation of India from 1969-70 to 1972-73 as about 1.7% per year.

1.8 Supporting study 12 on Post-Harvest Grain Losses [5] of the main study "All India Grains Storage and Distribution", prepared by the Administrative Staff College of India and sponsored by the Ministry of Agriculture and Irrigation, presented a very good review of work on post-harvest grain losses and gave 170 references in this field of work. They also presented the results obtained from surveys in two regions, Punjab (Ludhiana) and Andhra Pradesh (West Godavari and Medak), on wheat and maize crop respectively. The stratified random sampling technique was adopted in these two regions. Topics such as stages of losses, grain losses with their causes and measurement, farm storage, trade and market level storage, public storage, transportation loss and loss in processing, have been dealt with in this supporting study. In supporting Study 11 on 'Farm Level Storage'[4], they have dealt with production, retention and sale, storage structures, losses and preservation practices, evaluation of structures, farm storage and public distribution and trade storage.

1.9 The Post-Harvest Grain Losses Assessment Methods published by the American Association of Cereals Chemists [6] has

dealt with assessment problems in detail, touching almost all the aspects of post-harvest foodgrain losses. The statistical approach has been mentioned in brief. In this review the concepts, definitions and measurement techniques have been dealt with very systematically and these could be adopted in the studies to be made in different countries in future with necessary modifications according to local conditions.

1.10 National Academy of Sciences, Washington published a book entitled, "Post-harvest Food Losses in Developing Countries [7]". The study is devoted to assessing both the potential of food loss reduction efforts and their limitations. It summarizes existing work and information about losses of the major food crops and fish; discusses some of the economic and social factors involved; identifies major areas of need; and suggests various policy and program options for developing countries.

1.11 The study, by adopting stratified multi-stage random sampling design, made by Directorate of Marketing and Ins pection in 1972-73 [8] in respect of rice and wheat showed that there were physical losses of the order of 4.34 and 5.00 per cent in terms of production of rice and wheat.

1.12 The Indian Agricultural Statistics Research Institute estimated, on the basis of the tentative report on the pilot study conducted in Aligarh district during 1973-74 [9] the percentage loss in storage as 2.0 and 5.2 during the year 1972-73 and 1973-74, respectively.

1.13 The Institute rendered guidance in the statistical methodology in "Research Project on the Improvement of Grain Storage", carried out in Andhra Pradesh during 1974 to 1977 jointly by the Indian Grain Storage Institute (India) and Institute of Development Studies (London). Estimates of storage loss of different type of storages was studied for the state. Since the sampling fractions was very small and was selected mainly for the purpose of making preliminary study and not for the regular survey, the results thus obtained may not be taken as reliable estimate of the state as a whole.

1.14 At the instance of FAO, the Indian Agricultural Statistics Research Insitute prepared a manual on the statistical

methodology for estimating the foodgrain losses at different post-harvest stages in 1978-1979 which was published as FAO Economic and Social Development paper 13 entitled "Assessment and Collection of data on Post-harvest Foodgrain Losses" [12]. This manual gives information regarding statistical methodology for estimating the foodgrain losses at various post-harvest stages, viz ; harvesting, threshing, or shelling, cleaning/winnowing, drying, storage, transportation, processing, packaging and handling at farm level, intermediaries level and warehouses. Schedules have also been suggested for collection of such data in the developing countries.

1.15 This article deals with the estimation of foodgrain losses at different post-harvest stages only. The statistical methodology for the estimation of foodgrain losses at different post-harvest stages has been suggested in para 2 and discussion is given in para 3 followed by a summary.

2. Statistical Methodology For The Estimation Of Foodgrain Losses At Different Post-Harvest Stages.

Effective and economic control measures can be adopted to avoid such losses in case objective and reliable estimates of the magnitude of these losses and causes thereof are known. Since at present the reliable and objective estimates based on a scientific approach of random sampling are not available in the country, it is imperative to study the appropriate statistical methodology for the estimation of those losses at different post-harvest stages in a larger area/region. It is also necessary to know the appropriate methodology for estimating the losses due to different causes collectively and individually as well as avoidable loss by adopting preventive and curative control measures in the storages. In these methodologies, it is presumed that the measurement techniques for recording the observations with respect to an ultimate sample unit (storage etc.) are already standardised. The variation in the observations collected from various sampling units in a larger area/region is therefore, the main-source of variation for working out the estimates of averages of the foodgrains losses and their standard errors.

2.1 Estimation of Overall Loss

Let y be the expected production of the crop and x the produce finally available for consumption (seeds and human food).

The total loss Z can be then expressed as :

$$Z = y - x$$

The total loss Z can be expressed as :

$$Z = Z_1 + Z_2 + \ldots\ldots\ldots + Z_k$$

where k represents the number of stages of handling the produce.

The estimation of losses at various stages, namely, harvesting, threshing or shelling, cleaning or winnowing, drying, storage, transport, processing, packaging and distribution, may be considered at three levels; (*i*) Losses at the farm level; (*ii*) Losses at the level of intermediaries; and (*iii*) Losses at the level of public agencies.

2.2 Losses at the Farm Level

The ultimate sampling unit and the mode of collection of data will differ according to the stage of the post-harvest process at which losses are being measured. These are given in brief as follows :

2.2.1 Estimation of Losses at Harvest

The area or region where the sample survey is to be conducted may be divided into a number of homogenous strata and in each stratum 'n' villages are selected at random and in each selected village 'm' household/cultivators are randomly selected.

For each selected cultivator the list of fields under cultivation is prepared and a random plot of approximate size 10 $m \times$ 5 m is located in the selected field for crop-cutting experiment. The loss at harvest can be estimated by locating a plot 10 $m \times$ 5 m in each selected field randomly. The average yield of shedded grain compared with the yield obtained by harvesting will give the loss. This part of loss assessment survey could be linked with normal crop-cutting survey in the State. The statistical methodology for estimation of losses at harvest is given below.

If P_{ij} is the estimated production per hectare of the j th cultivator based on crop-cutting experiments in sampled fields of the i th village, a_{ij} the area in hectares under the crop in the

holding, the estimate of production per hectare for the stratum will be given by :

$$\hat{\hat{P}} = \sum_{i=1}^{n} A_i \left\{ \frac{\sum_{j=1}^{m} P_{ij}\, a_{ij}}{\sum_{j=1}^{m} a_{ij}} \right\} \Bigg/ \sum_{j=1}^{n} A_i$$

where A_i is the area in hectares under the crop in the ith village.

If L_{ij} is the estimated loss per hectare of the jth holding based on crop-cutting experiments in sampled fields of the ith village, the estimate of loss per hectare can be obtained by replacing P_{ij} by L_{ij} in the above formula. The loss in the randomly selected plot is worked out after the harvested produce is removed from the plot and all grains shed or missed are carefully picked up.

The percentage loss at harvesting for the stratum will then be given by :

$$\hat{L}\% = \frac{\hat{\hat{L}}}{\hat{\hat{P}}} \times 100$$

Estimate of variance of $\hat{\hat{L}}\%$ will be given by :

$$\hat{V}(\hat{\hat{L}}\%) = \left(\frac{\hat{\hat{L}}}{\hat{\hat{P}}} x100 \right)^2 \left\{ \frac{\hat{\hat{V}}(\hat{\hat{L}})}{(\hat{\hat{L}})^2} + \frac{\hat{\hat{V}}(\hat{\hat{P}})}{(\hat{\hat{P}})^2} \right\}$$

ignoring the covariance term.

The estimate of $\hat{\hat{P}}$ and $\hat{\hat{L}}$ are easily obtained as :

$$\hat{V}(\hat{\hat{\bar{X}}}) = \frac{1}{n\bar{A}^2} \times \frac{\sum_{i=1}^{n} A_i^2 (\bar{X}_i - \hat{\hat{\bar{X}}})^2}{n-1}$$

where x is the variance (loss or production) and $\bar{x}_i$ stands for the estimate of average X for the i th village, $\bar{A}$ is the average area per village in the stratum and $\hat{\hat{\bar{X}}}$ is the estimate of average X in the stratum. The finite sampling corrections are ignored because the sampling fractions are expected to be small.

The estimate of average over strata for the region will be obtained as a weighted average of stratum-wise estimates, the estimates of production in the respective strata serving as weights. The variance of the weighted average could be calculated from stratum-wise estimates of variance.

2.2.2 Estimates of Losses in threshing/shelling

Data on grain loss in threshing/shelling are collected for the sample cultivators from a sample of his produce. It can be estimated by selecting a measured quantity of produce and hand-stripping it carefully and noting the yield and comparing it with the yield obtained by the usual practices. Alternatively, a sample of straw obtained in the process of threshing may be taken, escaped grain picked from it and the collected grain weighed, This will provide a measure of loss directly. Data on loss due to spillage and incomplete removal of grain represent quantitative losses, whereas loss due to damaged grain will be a qualitative loss. The percentage loss due to spillage and incomplete removal of grain might be calculated separately, the latter on the basis of weights converted to standard moisture content. Similarly, percentage loss of qualitative nature, viz., due to damaged grain may also be estimated for the cultivator. The statistical methodology for the estimation of the losses in threshing/shelling is given below :

If X_{ij} is the percentage loss of any kind for the jth cultivator of the ith village, the estimate of average for the stratum will be given by :

$$\hat{\bar{X}}=\sum_{i=1}^{n} P_i \frac{\sum_{j=1}^{m} P_{ij}X_{ij}}{\sum_{j=1}^{m} P_{ij}} \Bigg/ \sum_{i=1}^{n} P_i$$

where P_{ij} is the production of crop in the jth holding of the ith village, P_i is the estimated production of the grain in the ith village, the sample consists of 'm' cultivators selected in each af 'n' sample villages. Estimated variance of X will be

$$\hat{V}(\hat{\bar{X}})=\frac{1}{n\bar{P}^2}\times\frac{\sum_{i=1}^{n} P_i^2(\bar{X}_i-\hat{\bar{X}})^2}{n-1}$$

where $\bar{x}_i$ is the estimate of average percentage of loss in the ith village and $\bar{P}$ is the average production per village in the stratum.

The regional estimates and their standard errors can be worked out from the stratum-wise estimates as indicated in the first case.

2.2.3 Estimation of losses in cleaning/winnowing

The lost grain is isolated from a sample of chaff. This has to be raised to represent the total quantity of chaff obtained in the batch and then percentage taken on the basis of grain obtained by normal cleaning in the same batch of produce winnowed. If two or more samples are taken they may be averaged to obtain percentage loss in winnowing for the cult vator. The cultivator-wise observations on percentages may be used to calculate the stratum-wise and regional averages and their standard errors on the same lines as explained in the previous section.

2.2.4 Estimation of Losses in drying

In this case, as in estimation of other losses at the farm level, the design is a stratified two-stage random sampling design with cultivator or farm as the ultimate unit. Data will be available on quantity of grain spread for drying and dried grain collected. Both have to be brought to standard moisture content and the difference between the corrected values will represent the loss. The percentage loss can be calculated by dividing this difference by the original quantity subjected to drying, converted to *standard moisture content*. The qualitative type of loss will be determined by examination of grain on sample and the qualities of damaged grain and total grain which are recorded will give the percentage damage of this kind directly.

From the cultivator-wise percentage figures the stratum-wise and regional averages and their standard errors may be worked out as indicated in para 2.2.2.

2.2.5 Estimation of Losses in storage at farm level

There are some features peculiar to the estimation of storage losses at the farm level. The data are collected by inquiry at frequent intervals. Information regarding quantities put in

storage and taken out can be fairly reliable if inquiry is made at the right time so as to reduce memory errors. Losses and causes of Losses will be reported by the cultivators only when he becomes aware of them. If periodical sampling of stored grain on a sub-sample of holdings forms part of the study the cultivator will get timely warning of any deterioration and damage and preventive steps could be taken which will reduce the losses for the sub-sample, of holding which is likely to differ from the rest of the sample, as a result. The periodical sampling coupled with laboratory examination would also provide data on slow imperceptible deterioration which information may be of interest to nutritionists.

However, the principal objective of estimation will be to estimate the average loss in storage and its break-up according to reported causes of damage. For each cultivator household therefore, a figure of average quantity of grain stored, aggregate loss over the period and its break-up according to cause of damage will be calculated. Since the design for the farm level enquiry is uniform, the stratum-wise and regional estimates of average quantity stored per holding, average quantity lost due to different causes, and the aggregate loss can be worked out by the procedure described in para 2.2.1. Similarly estimates for percentage loss and their standard errors could be worked out by the procedure described in the same section. It is interesting to study variation in percentage loss according to size classes. Procedures for arriving at such estimates are also described in para 2.2.1.

The mode of storage, viz., traditional, improved and modern, is likely to be dependent on holding size. To work out the estimates for different types of storages will also be possible but the sample size available for different type of storage will differ in the different size classes and this will complicate estimation,

It may be more useful to work out for each class, the proportion of grain stored in each type of storage and relate it to percentage loss in each size class.

2.2.6. Now we discuss about the statistical methodology regarding the observations recorded on samples taken from stored grain which would not only provide percentage damage but also permit study of relation of different causes of damage

to the total damage due to major factors (such as temperature, relative humidity, moisture content, incidence of pests and diseases and other biological and chemical changes, etc.) by means of a multiple regression analysis. In such study we may adopt only those measurement techniques for recording observations which have already been standardised by the research workers of different subject specialists.

This study can easily be fitted in the above suggested stratified random sample survey technique. For example, in a stratum at least two storages of the same type in each selected household/cultivator in the selected village where observations on each of the major factors would be recorded at different times depending on the period of storage. The purpose of selecting two similar storages in each selected household would be to study the variation between storages within household and the variation due to stratum, village, household, could be removed in working out the relation of losses with these factors by multiple regression analysis between storages (within households).

This study is in addition to what has been already given in the above mentioned FAO publication. The statistical methodology in brief is given below :

The mean value of observed loss per quintal due to various causes and its variance in a stratum are given as :

$$\hat{\bar{l}} = \frac{\sum_{i=1}^{r} \sum_{j=1}^{m_i} \sum_{k=1}^{n_{ij}} l_{ijk}}{\sum_{i=1}^{r} \sum_{j=1}^{m_i} n_{ij}}$$

and $$\hat{v}(\hat{\bar{l}}) = \frac{S_v^2}{r\,\bar{m}\,\bar{n}}$$

where l_{ijk} is the measure of loss in the kth third stage unit (storage) of j th 2nd stage unit (household) in the ith 1st stage (village) unit of a stratum, r is the number of villages (1st stage units) in a stratum, m_i is the number of households (2nd stage units) in ith village, n_{ij} is the number of storages in the jth household of ith village, $\bar{m}$ is the average number of households in a village, $\bar{n}$ is the average number of storages taken in a household and s_v^2 is the mean square between villages in the analysis of variance,

Similarly, the mean value and its variance of any other observation on incidence of pests/diseases, moisture etc. are worked out by giving (say x_i) notations. These values are based on samples taken from upper, middle and lower regions of the storage by sampling probes and are suitably converted to units of number, weight, etc. The expected loss (as dependent variable) per unit of the measures of observations (as independent variables) has been worked out by multiple regression techniques as follows. The multiple regression equation of loss on the measures of factors has been worked out between storages (within households) by removing stratum, village and household variation. and is written as :

$$l=\bar{l}_o+\Sigma\, b_i\, x_i.$$

where $\bar{l}_o=\bar{l}-\Sigma\, b_i\bar{x}_i$, $\bar{l}$ is the general mean loss and $b_i s$ are the partial regression coefficients of loss on the $x_i s$ factors and $\bar{x}_i$ is the mean of x_i factor. The variances of the partial regression coefficients and $\bar{l}_o$ are obtained as :

$$\hat{v}(b_j)=\sigma^2 c_{ii}$$

and $$\hat{v}(\bar{l}_o)=\sigma^2\left\{\frac{1}{n}+\sum_i c_{ii}\bar{x}_i^2+2\sum_{i<j} c_{ij}\bar{x}_i\bar{x}_j\right\}$$

where σ^2 is the mean square deviation from regression, 'n' is the number of observations and c_{ij} is the $i.j$th element of the inverse of SS-SP matrix of the factors. For obtaining the expected loss per unit of the factor, the multiple regression equation given alone has been converted to percentage loss simply by multiplying the equation by $100/\bar{l}_o$ and is given as :

$$L=100+\Sigma\, b_i' x_i$$

where $$b_i'=\frac{b_i\times 100}{\bar{l}_o}$$ and its variance is

$$\hat{v}(b_i')=(b_i')^2\left\{\frac{\sigma^2 c_{ii}}{(b_i^2)}+\frac{\hat{V}(\bar{l}_o)}{(\bar{l}_o)^2}\right\}$$

ignoring covariance term.

The expected percentage loss due to individual mean factor x_i is given as :

$$\text{Loss}=\bar{x}_i\times b_i'$$

and its approximate variance can be given as :

$$\hat{V}(\bar{x}_i \times b_i') = \bar{x}_i^2 \hat{V}(b_i') + b_i'^2 \hat{V}(\bar{x}_i)$$

The percentage overall loss due to the mean factors is given as :

$$\text{Total loss} = \sum b_i' \bar{x}_i$$

and its approximate variance can be given as :

$$\hat{V}(\sum b_i' x_i) = \sum \bar{x}_i^2 \hat{V}(b_i') + \sum b_i'^2 \hat{V}(\bar{x}_i)$$

2.2.7. Estimation of Avoidable Loss in Storage

In each selected household a pair of similar storageis selected. Thereafter, one storage of the pair is taken at random, where control measures as recommended by the storage specialists is adopted to control the pests, diseases, etc , and is called the 'check' storage. The other storage of the pair is called 'uncheck' storage. The loss in yield is estimated by the analysis of the difference of yield of those 2 storages and termed as avoidable loss. The yield and its variance in 'check' as well as 'uncheck' storages and the difference of yield in each stratum is estimated in the usual procedure. The avoidable loss in yield is worked out as given below :

Suppose $\bar{y}$ and $\bar{y}'$ are the mean ultimate yields in kg/ha in the 'check' and 'uncheck' storages, respectively, the percentage avoidable loss in yield is worked out as :

$$\text{Avoidable Loss} = \frac{\bar{y} - \bar{y}'}{\bar{y}} \times 100$$

and its variance is given as :

$$\hat{V}\left(\frac{\bar{y} - \bar{y}'}{\bar{y}} \times 100\right) = \left(\frac{\bar{y} - \bar{y}'}{\bar{y}} + 100\right)^2 \left\{\frac{\hat{V}(\bar{y} - \bar{y}')}{(\bar{y} - \bar{y}')^2} + \frac{\hat{V}(\bar{y})}{(\bar{y})^2}\right\}$$

where $\hat{V}(\bar{y})$ is the variance of $\bar{y}$, $\hat{V}(\bar{y}')$ is the variance of $\bar{y}'$, and $\hat{V}(\bar{y} - \bar{y}') = \hat{V}(\bar{y}) + \hat{V}(\bar{y}')$ ignoring covariance terms

2.3. Estimation of Losses in Transportation :

The percentage losses at various stages can be worked out, allowance for moisture content being made where necessary.

On the basis of the data percentage loss for the region as a whole and its standard error can be worked out by procedure as indicated in para 2.2 2 above.

2.4. Estimation of Losses in Processing, Packaging and Handling :

For estimating percentage losses at these stages, at the farm level also, the approach indicated in the previous para can be followed.

2.5. Estimation of Losses at Intermediaries' Level :

In this case the design is two-stage stratified random sampling with the market at the first stage unit and the market functionary the second-stage unit. For each functionary percentage losses of various kinds can be worked out and the estimates for the region as a whole worked out by the procedure analogous to that of para 2.2.2. above, the quantities of grain handled serving as weights at the two-stages. In case of mills the selection is made only in a single stage and the procedure of estimation will be simplified in consequence.

2.6. Estimation of Losses at Government Warehouse :

Selection of warehouses is also done by single stage simple random sampling and the estimation of average and percentage loss might be done as indicated for mills in the previous para.

The estimation of losses of grain in warehouses due to different causes may be worked out by the same methodology as given in para 2.2.6. The estimates of avoidable loss in warehouses may be also be worked out by statistical methodology as given in para 2.2.7.

3. DISCUSSION

It may thus be seen that before conducting a random sample survey for estimating post-harvest foodgrain losses appropriate concepts, definitions and measurement techniques should be settled so as to have a uniform approach for adoption within a region or the country. Such survey should be linked with other agricultural surveys such as crop cutting experiments for the estimation of total food production so as to avoid setting up an independent agency for estimating foodgrain losses

thereby economising the cost involved in data collection. In each case the sampling design, the size of the samples as well as its distribution at various stages of sampling should be decided in advance on the basis of a well-designed pilot sample survey. A co-ordinated approach is very much necessary in the estimation of post-harvest losses since efforts to estimate such losses cut across various scientific disciplines such as Entomology, Plant Pathology, Agronomy, Engineering, Statistics, etc. Since the loss assessment methodology is primarily a sample survey methodology, there is no guarantee that the results obtained in a particular survey should be reproducible. Nevertheless if the standard error of the estimate of losses are properly worked out, confidence intervals within which the estimates are expected to lie can be constructed, Surveys, then repeated should give results which are expected to lie within these confidence limits. Although the loss estimates methodology, when attempted in its entirety, is a stupendous task, efforts should be made to attempt it gradually. Ultimately the entire work can be established on a permanent footing in more or less the same way as the crop cutting surveys for various cereal crops have almost attained a permanent structure in a vast country like India.

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