Assessment of pest/disease infestation on coconut and yield loss

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Abstract

One of the major limiting factors of coconut production in India is the incidence of pests and diseases. Data on incidence of pest/disease and resulting yield loss are necessary for research prioritization and technology intervention but are not collected/reported along with the official statistics on crops. The required information is therefore generated by conducting sample surveys. Results on earlier surveys conducted by CPCRI on coconut pests and disease were made use of in analyzing their usefulness for applications in similar situations. The organizational aspects of surveys such as criteria for stratification, preparation of sampling frame, selection of units, construction of estimators, organization of field work etc. were examined in relation to suitability under respective contexts.

Key words: Coconut, pest, disease infestation, yield loss

Introduction

Incidence of pests and diseases is one of the major factors adversely affecting coconut production in India. Periodic assessments of infestation level and yield loss are necessary for research prioritization and technology intervention and refinement. The major diseases of coconut in India are root(wilt), leaf rot, bud rot, stem bleeding and basal stem rot; among the 65 pests recorded on coconut the economic loss is manly due to eriophyid mite (*Eriophys guerreronis*), rhinoceros beetle (*Oryctes rhinoceros (L)*, red weevil *(Rhynchophorous ferrugineus* Fab.) and leaf eating caterpillar (*Opisina arenosella* Wlk). The economic loss due to these pests and diseases varies from region to region and also from time to time. Such data are not collected/reported along with the official statistics of crops. Therefore reports of sample surveys conducted by various agencies are the only source of information. Complexity of disease symptoms, multiple infestation by various pests and pathogens, multiple harvests of the crop thoughout the year and lack of uniformly accepted norms for measurement etc. are the major constraints in carrying out sample surveys in plantation sector in general and coconut in particular (George *et al.*, 1999).

In this paper an attempt is made to examine the procedures adopted and results obtained in selected sample surveys on crop loss due to pests and diseases in coconut conducted by CPCRI in past three decades. By examining the organizational aspects of surveys viz., criteria for stratification, preparation of sampling frame, selection of units and estimators of incidence and yield loss of pests/diseases, usefulness of the procedures for applications in similar situations was analyzed.

Materials and Methods

Data collected in six surveys conducted by CPCRI to estimate the incidence and yield loss due to pests/diseases on coconut (Table 1) were utilized for this study. Data on infestation, growth stage of palm, yield, control measures adopted and socio-economic characters of the farmers were recorded using pre-tested questionnaires. Field investigators and skilled palm climbers were engaged for data collection. Appropriate training on data collection was provided to all the personnel involved in the surveys.

Results and Discussion

Most of the surveys conducted in the coconut sector (Table 1) were confined to Kerala which accounts for nearly half the total area under the crop and production in India. During 2000-01, the state has a

Table 1. Description of important sample surveys conducted by CPCRI for estimation incidence and yield loss due to pests/disease in coconut

Sl. No.	Topic of the survey	Period	Sampling design	Reference
1	Crop loss due to root(wilt) and *Oryctes* infestation	1971-76	Administrative unit District was taken as stratum. In the first stage, 20% villages from a district were selected at random. In the second stage, four clusters of 5 survey sub divisions selected. Palms in the cluster were enumerated and grouped for different combinations of disease intensity grades and pest infestation. From each group, 2 to 3 palms were selected in the third stage.	George *et al* (1985)
2	Incidence of root(wilt) disease and yield loss	1984-85	Administrative unit Tehasil was taken as stratum. 50% villages from a Tehasil were selected at random in the first stage; in the second stage, 6 clusters of 5 survey subdivisions were selected; All the palms were examined for disease categories and two palms per category selected in the third stage for yield estimation.	CPCRI (1985)
3	Crown choke disease of coconut	1986-87	In the first stage, 25% of VLEW ELAKAS were selected from the coconut growing districts of Assam. List of homesteads was prepared and serially numbered. 20% of homesteads were selected by systematic cluster sampling. Two healthy and 2 disease affected palms were selected	CPCRI (1990)
4	Incidence and yield loss due to eriophyid mite in Alappuzha district	2000	Stratification for topography. In the first stage, following proportional allocation, 29 panchayats (40%) were selected. A total of 85 key plots (each from a separate ward) were selected as second stage unit. Yield from 20 palms in a cluster was observed for a second sample of 15 panchayats selected from the first sample of 29 panchayats.	Muralidharan *et al.*, (2001)
5	Cost of production of coconut in Kerala	2001	Stratification for agorclimatic zones. In the first stage CD blocks were selected; following proportional allocation 30 panchayats selected in the second stage; list of coconut cultivators prepared and post stratified for holding class categories; 600 holdings were selected for detailed observations on input and output cost and quantities.	Under publication
6	Yield loss due to stem bleeding disease in Kasaragod district	2004	Stratification of panchayats for low or high incidence of disease based on the perception of extension personnel; 12 panchayats were selected in the first stage; 60 contiguous holdings in 50% wards in a panchayat selected for estimating per cent incidence; a second sample 24 clusters selected and yield observed in palms selected from theses clusters.	CPCRI (2004)

share of 43.7% to India's coconut production and 50.7% to total area under the crop. The coconut palm population of Kerala is characterized for high density planting, prevalence of root(wilt) disease in almost half the coconut cultivated area in the state (7 contiguous southern districts), various kinds of inter/multiple cropping systems, non-systematic under planting and existence of large number of senile palms. The coconut productivity in the State is almost static during the past 3 decades: It was 5536 nuts/ha in 1970-71 which increased marginally to 5979 nuts/ha in 2000-01.

For administrative convenience and also for reasons of uneven incidence of pests/diseases in a region, multistage sampling designs, with or without stratification, were used in all the surveys. Besides, such a design also offers estimates at different level (i.e., at panchayat/block/district). In most of the cases, simple random sampling was followed for selection of units; cluster sampling or systematic sampling was used in a few situations to draw the sample in the final stage.

Stratification

Stratification of the region for which estimates are required under the sample survey on pests and disease incidence has to be decided based on the available information on the geographical distribution of the incidence. The published reports of the earlier studies could be used for this purpose. In the absence of such reports, the perception of experts/extension personnel on the geographical spread could be made use of.

In the survey on root (wilt), Tehasils were taken as strata, as it is required to assess the spread of the disease across districts. The estimated percent incidence revealed that the prevalence of the disease varied widely between the district: 1.52% in the district Thiruvananthapuram to 75.63% in Kottayam. The range of percentage incidence of the disease was less for Tehasils of Thiruvananthapuram and Thrissur districts (5 and 8% respectively), while it was between 30 to 40% in more severely affected districts viz., Kollam, Pathanamthitta, Alappuzha, Kottayam, Idukki and Ernakulam.

In the case of assessment of stem bleeding disease of coconut in Kasaragod district, the perception of Agricultural Development Officers functioning at Panchayat level was utilized for stratification. Panchayats were stratified based on the perception of the Officers on percentage of gardens affected, number of wards from where the disease is reported and number of farmers approached during the past three months for consultancy on management of stem bleeding disease. Based on the average score, the panchayats were classified for low- or high- disease incidence areas. An examination of the estimated percent incidence of the disease in the 12 selected panchayats revealed that the average perception scores correctly classified except for two panchayats. More refinement index based on perception scores may be attempted so as to reduce the probability of misclassification.

In the eriophyid mite-survey, the unique topographical features of the district were taken into account to stratify the panchayats. The panchayats were grouped under three topographical categories viz., Coastal, Kuttanad (below mean sea level) and Midland. The estimated percent incidence in these strata was 62.38%, 57.09% and 35.43% respectively.

Selection of units

Considerable amount of cost and time is required for preparation of list of sampling units and selection. In the earlier surveys, the land survey sub divisions (which are readily available in the village office) were used as the sampling units. Though a list of survey numbers are easy to obtain, identification of corresponding area under that survey number is often a tedious task. Other limitations of choosing villages as sample units include lack of updated cropping details against survey numbers, difficulties in identification of village boundaries etc. Subsequent to the administrative reforms, all developmental activities at present are planned and implemented at panchayat level and hence selecting panchayats instead of villages would be advantageous. The panchayat boundaries are easy to identify and its subunits (i.e. wards) are based on the population and particulars are updated periodically for various administrative purposes. Therefore in surveys conducted in the recent past in the Kerala State, panchayats were chosen as sampling units.

One disadvantage of considering the list of houses available with local bodies for sample selection is that it may contain buildings apart from house holdings. Efforts are therefore required to prepare a list of coconut holdings in certain surveys (e.g., survey to estimate cost of production of coconut). This is highly expensive (about 30% of the total expenditure for the survey) and time consuming. To overcome these difficulties, a different approach was followed in surveys on eriophyid mite and stem bleeding.

In the survey on eriophyid mite, from a selected panchayat, three wards were selected at random and a 'key plot' was identified in consultation with the Agricultural Development Officer. The criterion followed for selection of the key plot was easiness in its identification (e.g., key informant). A cluster of around 500 bearing palms in the key plot was scored visually for mite infestation. If sufficient number of palms were not available in a particular key plot, adjacent plots were augmented. The cluster size was fixed by considering the workload for a person visiting the plot. Formation of clusters in the stem-bleeding survey was slightly different: From the selected panchayat, 50% wards were selected and in each ward the concerned enumerator was asked to list 60 contiguous holdings to form a cluster. Data on total number of coconut palms in the holding and stem bleeding affected palms were collected by means of an interview schedule. Both these methods are variants of sampling with overlapping clusters.

Measures of incidence of pests/disease

The measures utilized for assessing the incidence are specific to the nature of pests and diseases. The incidence can be measured in a simple way as the presence or absence of symptom as in the case of crown choke incidence.

Apart from classification as infested or not, it may be required to analyze the severity of damage by developing suitable indices. For measuring the severity of root(wilt) disease, George and Radha (1973) proposed an index based on the three visual symptoms viz., flaccidity, yellowing and necrosis on all the leaves on the crown. Based on the index palms were classified as disease free, early and advanced. Out of the estimated 59.2 million palms in the affected region, 29.5% palms were in disease-early and 3.3% in disease-advanced stages. Number of non-bearing palms was estimated as 32.4 million, of which 13.5% were in disease-early and 3.3% in disease-advanced stages. Some of the technical terms defined in this survey (e.g., a bearing palm is one that has borne fruit at least once) were adopted in subsequent studies.

Indexing of coconut palms affected by stem bleeding disease was done in the survey conducted during 2004 by adopting the procedure suggested by Mathew *et al.*, (1989). It was observed that 60% of the disease affected palms are in the early stage with value of index less than 1. In 36% palms the index ranged from 1 to 50. Only 4% palms were having disease index more than 50. This clearly indicates that palms are lost from the population on advancement of the disease.

Under field conditions, accurate recording of incidence by observing the symptoms is not easy in many instances. Assessing the mite infestation in tall coconut palms by observing the symptoms from the ground is an example. Another situation is observing the symptoms of stem bleeding disease in the lower parts of the trunk of coconut palms of which the basin is heavily mulched or trailed by pepper. It is impractical to record observation on infestation from a large sample either by climbing or inspecting the trunk of each and every tree included in the sample. To overcome these limitations, double sampling procedure may be employed.

In the case of eriophyid mite infestation, data on percent incidence was available for a larger sample by visual scoring. However, accurate recording of observations (by climbing on the palms) were available only for a small sample. On examining the scatter plot of the data, it was found that either a regression estimator or a ratio estimator could be constructed. Since it is possible to handle the outliers in the regression approach, a regression estimator was constructed after eliminating the outliers. Details of the regression estimator were given by Muralidharan *et al.*, (2001). It was estimated that 82.4% of the bearing palms in the district was infested by mite during the year 2000.

Neither the ratio nor the regression estimator was found to be appropriate to estimate incidence of stem bleeding disease. Therefore, data collected from the larger and smaller samples were judiciously utilized to work out an admissible estimate of percent incidence. The district level estimate of palms affected by stem bleeding disease was 6.33% (408,815 palms).

The incidence of bud rot disease and red weevil infestation, many a times lead to loss of palms, if timely control measures were not adopted. Such situations are unique, as the sampling unit does not exist in the population for physical verification. Under such circumstances, we may have to rely on the recall data furnished by the cultivators. This strategy was adopted to estimate the crop loss due to bud rot disease and red weevil infestation in the survey on cost of production of coconut conducted during 2001. Number of palms lost due bud rot disease in immediate past 3 years in the selected 200 holdings was 129, 330 and 85 in Kozhikode, Ernakulam and Thiruvananthapuram districts respectively. The corresponding figures for red weevil infestation were 5, 203 and 56 respectively.

Yield loss estimation

Definition of yield in coconut in an unambiguous way in a survey is very important as it has multiple harvests around the year. This superimposed with the bienniality of yielding in certain palms makes things more complex. A direct measure of yield loss is the difference in yield between the affected and healthy palms as used in the survey on root (wilt). The limitations of this method of yield loss estimation include: (1) at least two rounds of yield observations by employing palm climbers at an interval of exactly six months and (2) the data on yield may get vitiated due to the imposition of crop protection measures practiced by the cultivators. Alternatively, the difference in predicted annual yield between the two categories of palms may be taken as the yield loss estimate. However, the yield prediction models for all the situations may not be readily available and even if it is available, the predicted yields will have different precisions.

When number of palms is less in a particular infestation category, simple random sampling could be followed for selection of palms for yield observations. However, for selection of palms from a large number of palms, the systematic sampling is easy to follow. There is always a possibility of biased selection of palms for yield observations. This is because, the investigators will avoid palms without nuts at the time of yield observation and the climbers substituting palms with less height in lieu of old and senile palms. The irregular planting of coconut in majority of the holdings also pose difficulties for selection of palms. When it is obvious that selection of palms is biased, data exploring techniques may be used to remove outliers (Muralidharan *et al.*, 2001).

The general concept that incidence of pest/disease invariably results in yield reduction need not be correct always especially at the onset of the incidence. Such a situation was observed during the surveys on eriophyid mite and stem bleeding. In the eriophyid mite survey, the average yield observed in infested palms were 51 nuts as compared to 31 nuts in mite-free palms. But it was also observed that half the number of nuts in the infested palms were damaged, of which, 50% were barren. Taking into account of these factors, it was estimated that out of the total nut production of 366 million during the year 2000, only 164 million were normal nuts, 59 millions mildly damaged nuts(less than half the portion of the nuts exhibit the symptom of mite-damage, i.e., 90 million nuts) and 53 millions moderately damaged nuts (more than half the portion is damaged but not barren nut). The Government of India production statistics for Alappuzha district for the year 2000-01 is 288 million nuts, which is very close to the forecast made by Muralidharan *et al.*, (2001) after subtracting the number of barren nuts. The regional estimate on yield loss is also expected to have less standard error compared to yield difference between palms of two categories.

Other yield loss indicators include the percent damaged nuts per palm, the difference in yield in a particular harvest between the affected and free palms, number of nuts of different maturity stages, number of bunches etc. The last two indicators were utilized in the survey on stem bleeding.

Conclusions

Assessment of infestation level and yield loss due to various pest/disease incidences is important for research prioritization in coconut to streamline appropriate technology interventions. Sample surveys on incidence of pests and diseases in coconut have to make use of appropriate strategies in assessing the geographical spread of the incidence. The measures utilized for assessing the incidence are specific to the nature of pests and diseases. Double sampling procedure could be employed in certain cases to overcome the practical difficulties in accurate recording of observations from a large number of palms. Recall data furnished by the cultivators are valuable in the estimation of crop loss due to bud rot disease and red weevil infestation. Depending on the nature of the pest/disease affecting coconut palms, appropriate yield loss indicators are to be utilized in the survey. Expressing the yield loss as difference in yield between affected and free palms may not be a true indicator in certain situations. However, the regional estimates can be constructed in all the situations which will be more useful for assessing the impact. Reducing the bias in selection, removing the outliers in the data, data scrutiny etc. are the key steps to ensure reliable estimates. Since the expression of the mean square error of many estimators is not readily available, the acceptability of estimators may be ensured by comparing the results of the survey with the authenticated information.

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