



# Assessing status of pests and diseases with cluster approach - A case of coconut in Kasaragod district in northern Kerala

K.P. Chandran\*, C. Thamban, V.H. Prathibha and P.S. Prathibha

ICAR- Central Plantation Crops Research Institute, Kasaragod- 671124, Kerala, India

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## Abstract

The main objective of integrated pest and disease management is to intervene efficiently to reduce crop damage at minimum cost and inflicting minimum damage to the environment. The basic requirement for such programmes is the availability of a cost-effective sampling method for assessing the status of incidence and intensity of the disease/pest attack wherein, accurate estimates is achieved through minimum efforts. In the present study, a sampling strategy and measures of severity and crop loss for simultaneous assessment of incidence of major pests and diseases of coconut were formulated and implemented in Kasaragod district of Kerala. The sampling methodology involved a cluster approach in which four clusters of at least 500 bearing palms from a minimum of ten coconut gardens, representing the geographical strata of the panchayath, were scored visually for the incidence of major pests and diseases. District level estimates were derived incorporating area under coconut in each panchayath as the weight. Information on geographic coordinates was recorded and utilized for preparation of thematic maps using Arc-GIS. Further, crop loss due to the major pests and diseases were also estimated under certain scenarios. The study revealed that diseases like stem bleeding and Thanjavur wilt were more prevalent in areas experiencing high temperature and low rainfall whereas, incidence of bud rot disease was significantly higher in hilly regions where low temperature and high humidity prevailed. Incidence of pests like eriophyid mite and coreid bug was higher in coastal areas of the district. The study could serve as a model for similar studies in future and the information emerging out of this study would help in formulating integrated pest and disease management programmes at grass root level.

**Keywords:** Crop loss, GIS, Kasaragod, pest and disease assessment, sampling

## Introduction

Coconut, a perennial tree, is attacked by a number of debilitating and lethal pests and diseases. Crop production losses due to the incidence of these pests and diseases are major concern in coconut cultivation. The major objective of integrated pest/disease management is to intervene efficiently, to reduce crop damage at a minimum cost and with minimum damage to the environment. Bud rot caused by the dreaded fungus, *Phytophthora palmivora*, is the most serious disease of coconut in North Kerala resulting in substantial economic loss (Sharadraj and Chandra Mohanan, 2013). The disease has been prevalent in the coconut tracts of this region since long period. During the last decades, there have been reports from various parts

of this region about huge crop losses incurred due to bud rot disease in coconut. A snapshot survey conducted by ICAR-Central Plantation Crops Research Institute (CPCRI), Kasaragod in six panchayaths; three each in Kasaragod and Kannur districts during 2013 indicated that incidence of bud rot disease in the selected panchayaths ranged from 7 to 21 per cent (CPCRI, 2014). Wide variations were observed in the disease incidence in different coconut growing tracts (Peter and Chandra Mohanan, 2009). Stem bleeding disease caused by *Thielaviopsis paradoxa* also adversely affects coconut production in this region. Recently, there were reports on the incidence of Thanjavur wilt disease from several parts of Kasaragod, Kannur and Kozhikode districts. Various insect pests also cause crop loss in coconut, of which, rhinoceros

\*Corresponding Author: [chandran.kp@gmail.com](mailto:chandran.kp@gmail.com)

beetle, red palm weevil, eriophyid mite and coreid bug are the major ones.

It is worthwhile to systematically assess the incidence and intensity of pests and diseases in different agro-ecological units of a region so that appropriate programmes to provide technical and institutional support to the farmers could be formulated for the integrated pest/disease management to prevent crop loss in coconut. The most important and basic requirement for any pest and disease management programme is the availability of a cost-effective sampling method for assessing the status on the incidence and intensity in which accurate estimates (measures like severity indices) is achieved through minimum effort (Madden and Hughes, 1999).

Further, scientific assessment of crop loss due to pests and diseases is also critical for designing appropriate need-based and location-specific interventions for their management. In the present study, a sampling strategy and measures of severity and crop loss for simultaneous assessment of major pests and diseases of coconut were formulated and implemented in Kasaragod district wherein estimates of pest and disease incidence and intensity and crop losses were derived based on the extensive field study.

### **Methodology**

Coconut is cultivated throughout Kasaragod district and it occupies 30 per cent of its geographical area and 43 per cent of net cropped area. The incidence of pests and diseases has been reported from almost all the coconut growing areas in the district, but the intensity is however expected to vary from region to region. Kasaragod district has five agro-ecological units covering 38 panchayaths and three municipalities. All the panchayaths of the district were surveyed for the study. Secondary data on panchayath and block level area, production and productivity of coconut were collected and analyzed for assessing the coconut farming scenario.

### **Sampling design**

The 38 panchayaths and three municipalities constituted first stage units in Kasaragod district. For assessing the incidence of major pests and diseases, all the 41 first stage units were selected to

collect information from each unit. Importance of sampling strategy in efficient estimation of pest/disease severity is well understood in epidemiological studies and a detailed description is available (Campbell and Nehel, 1994). A general sampling strategy employing random sampling and stratification is not feasible, as sampling frame is not available for the present study. Moreover, frequency of some of the pests/diseases are not high, necessitating a cluster approach as suggested by Hughes *et al.* (1996). Similar approaches were practiced in field surveys for yield loss assessment of coconut root (wilt) disease (George *et al.*, 1985) and eriophyid mite (Muralidharan *et al.*, 2001). Hence, instead of selecting random households, a cluster with minimum 10 contiguous holdings and a minimum of 500 palms were fixed as units for assessing pest and disease incidence. As the clusters are intended to represent geographical variations of the panchayath, clusters were selected with random starting points from each of the strata. Thus, four wards were selected representing geographical variability of the panchayath and were scored visually for pest and disease incidence.

In the second phase, 19 panchayaths were randomly selected and observations on palm-wise disease severity were recorded from infested palms in two randomly selected clusters out of four previously selected in the first round surveys. The number of palms for recording severity of a pest/disease was limited to the maximum of ten per cluster. Observations on severity were recorded following the standard indexing procedures for each of the pests and diseases.

The data were collected from selected coconut holdings by interacting with the farmers using a structured interview schedule and also by field observations to capture various dimensions of incidence and intensity of diseases such as bud rot, stem bleeding, Thanjavur wilt and insect pests such as rhinoceros beetle, red palm weevil, eriophyid mite and coreid bug.

### **Observations recorded**

In the first round survey for assessing the incidence, number of palms infested with each of the pests/diseases was recorded along with total number of palms. Incidence of diseases such as bud rot, stem bleeding, Thanjavur wilt and pests like

rhinoceros beetle, red palm weevil, coreid bug and eriophyid mite was initially identified based on characteristic symptoms of damage. In addition to the infestation related observations, data on farmer's educational background and input use status were also collected including information on fertilizers used and plant protection measures adopted. Data were collected on number of dead palms, number of dead palms removed, palms affected by the pest/disease which can be cured, *etc.*

Pest/disease severity on each palm was measured employing standard procedures, details of which are provided here under.

### ***Bud rot***

Coconut bud rot is a lethal disease and hence, only incidence was recorded and the ratio of number of palms infected to the total number of palms in the garden was taken as the severity index.

### ***Stem bleeding***

Stem bleeding incidence was calculated by considering number of palms infected to the total number of palms in the garden. Severity of the disease was computed using formula given by Jacob Mathew *et al.* (1989).

$$\text{Disease Index (DI)} = 1.8 l + 4.3 t$$

where,  $l$  = lesion size (in 1000 cm<sup>2</sup>) and  $t$  = tapering of palm ranging from 0 to 4. Severity of the disease was categorized as mild (< 10), moderate (10 – 25) and severe (> 25).

### ***Thanjavur wilt***

The disease index (Bhaskaran *et al.*, 1989) used to assess severity of the disease was

$$\text{Disease Index} = 23.6 + 17.7 h + 3.6 r - 0.6 l$$

where,  $h$  is the height (in meters) up to which bleeding symptom has spread on the stem,  $l$  is the number of functional leaves in the crown and  $r$  is the score for reduction in crown size in 0 to 4 scale. Accordingly, an index score of <15 was considered as mild, 15 to 40 as moderate and >40 as severely affected.

### ***Rhinoceros beetle***

Rhinoceros beetle mainly damages the leaf and thus, ratio of number of leaves attacked to the total number of leaves on a palm was taken as the measure of pest severity.

### ***Red palm weevil***

Red palm weevil is a lethal pest and hence, incidence was calculated as the ratio of number of palms infested to the total number of palms in the garden.

### ***Eriophyid mite***

The severity was measured in terms of index grading (Nair *et al.*, 2003). The grades ranging from 1 to 4 were fixed based on severity of infestation on nuts. Grade 1 was given for the nuts with zero per cent mite damage, grade 2 was given for the nuts showing 1 to 25 per cent damage, grade 3 was given for the nuts showing 25 to 50 per cent damage and grade 4 was given when >50 per cent mite damage was observed. To estimate mite infestation intensity index, 5 bunches of fist size nuts per tree were observed and data on total number of nuts per bunch, total number of infested nuts per bunch and score of 1 to 4 following the above index grading were recorded. The severity was calculated in terms of bunch and palm indices with the following formula:

Severity index =  $\Sigma$  grade of nuts / total number of nuts.

### ***Coreid bug***

The incidence index was calculated considering number of palms infested to the total number of palms in the garden.

### **Data analysis**

Coconut garden level data on incidence of the pests and diseases were compiled and tabulated and incidence at block and district levels were estimated using total coconut area in each panchayath as the weight. Estimates for each of the agro-ecological units were also computed. Similarly, house hold level measures of dispersion were also computed to assess the variations in each of the panchayaths. Thematic maps of Kasaragod district were developed using Arc-GIS software for each of the pests and diseases.

Severity indices were computed at district level following the standard procedures and formulae. A critical analysis of panchayath wise variation in pest/disease incidence and its association with agro-ecological characteristics was also attempted. Crop loss due to diseases/pests in Kasaragod district was also estimated under various scenarios.

## Results and discussion

Coconut is the most important crop of the district contributing substantially to the agrarian economy and provides livelihoods to lakhs of households. Coconut is having the largest area (61836 ha) among the cultivated crops in Kasaragod district followed by rubber (31740 ha) and arecanut (18039 ha) (DES, 2015). Coconut occupies about 43 per cent of the net cropped area in the district. The area under coconut showed an increasing trend during the last five years; increase in area being 10 per cent. During 2013-14, production of coconut in the district was 602 million nuts and productivity was 9735 nuts per hectare (DES, 2015). As per the survey results, only 6.6 per cent of the holdings were in the category >2 acres, while other groups were almost equal. With respect to the varieties cultivated, 94 per cent are occupied by local cultivars. Hybrids and superior varieties occupy only 0.5 per cent, whereas, holdings with both local and new varieties constitute around 6 per cent. Holdings with <0.5 acre were highest in Kasaragod and lowest in Parappa block. Similarly, large farmers were more in Parappa (13.1%) and least in Kanhangad block (2.1%). About 90 per cent of the holdings were with less than 100 palms and share of large holdings was only 0.3 per cent.

### Incidence of pests

#### *Rhinoceros beetle*

The incidence of rhinoceros beetle was assessed in terms of per cent palms showing symptoms of attack (ranged from 3.0% to 21.7%) and the district level overall incidence was assessed to be 8.5 per cent. The study revealed that incidence of rhinoceros beetle in coconut palms was the highest in coastal areas like Uduma panchayath (21.7%), followed by Pallikkara (17.7%), whereas, the incidence was the lowest in Panathady panchayath (2.2%). Within panchayath variations in rhinoceros beetle incidence was highest in Chengala and lowest in Panathady (with a range of 80 and 7%, respectively). The infestation of rhinoceros beetle in different blocks of Kasaragod district is depicted in Figure 1, which also indicates that the incidence was highest in Kanhangad block and lowest in Manjeshwar.

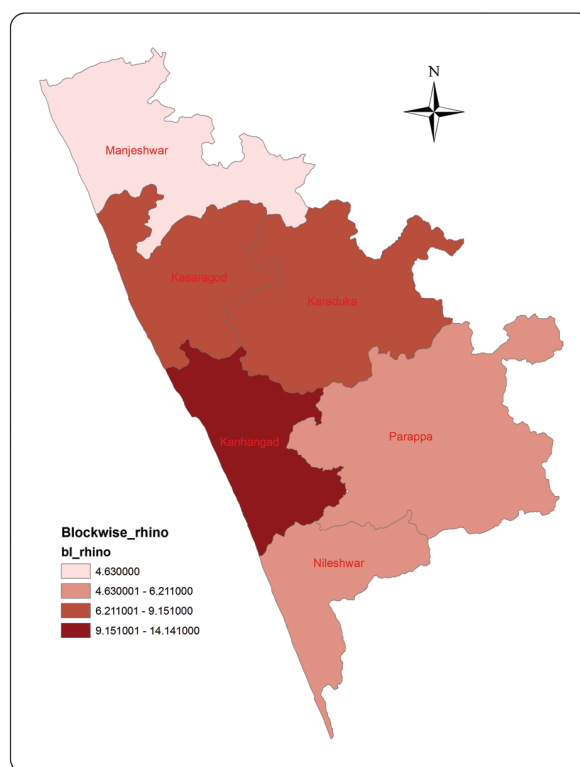


Fig. 1. Per cent incidence of rhinoceros beetle in Kasaragod district

#### *Red palm weevil*

The incidence of red palm weevil in Kasaragod district ranged to a maximum of 0.8 per cent and the district level overall incidence was assessed to be 0.2 per cent. The study showed that, the incidence of red palm weevil was the highest in Vorkady panchayath (0.8%), followed by Badiadka (0.6%). Red palm weevil was not observed in 14 panchayaths including Mangalpady, Kuttikole and Madhur. As indicated in Figure 2, Manjeshwar block was affected more whereas Parappa and Karadka blocks showed low infestation.

#### *Eriophyid mite*

Eriophyid mite infestation was observed in all the panchayaths including Ajanur, Periya and Pallikkara wherein all the fields surveyed had infestation. The incidence was highest in Ajanur (1.6%) followed by Udma (1.5%) and Madikai (1.5%). Lowest incidence was observed in Trikaripur (0.04%) and Chengala (0.05%). Blockwise analysis revealed the highest incidence in Kanhangad and lowest in Nileshwar blocks.

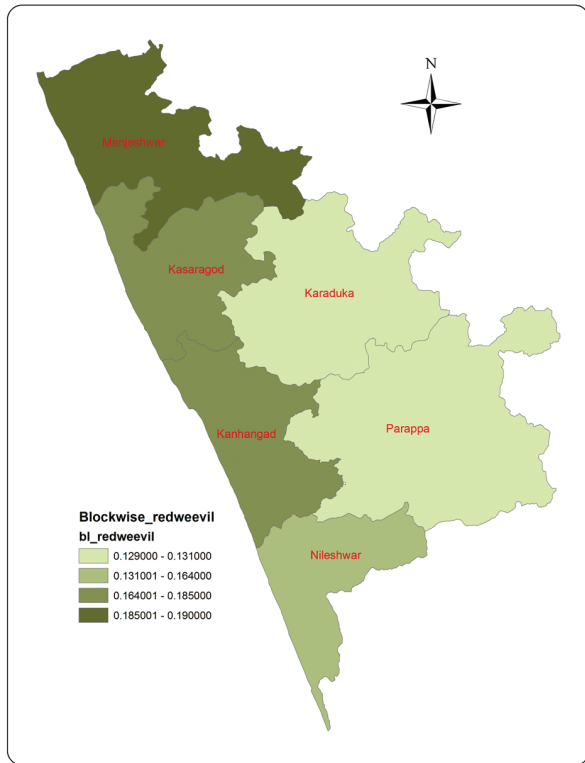


Fig. 2. Per cent incidence of red palm weevil in Kasaragod district

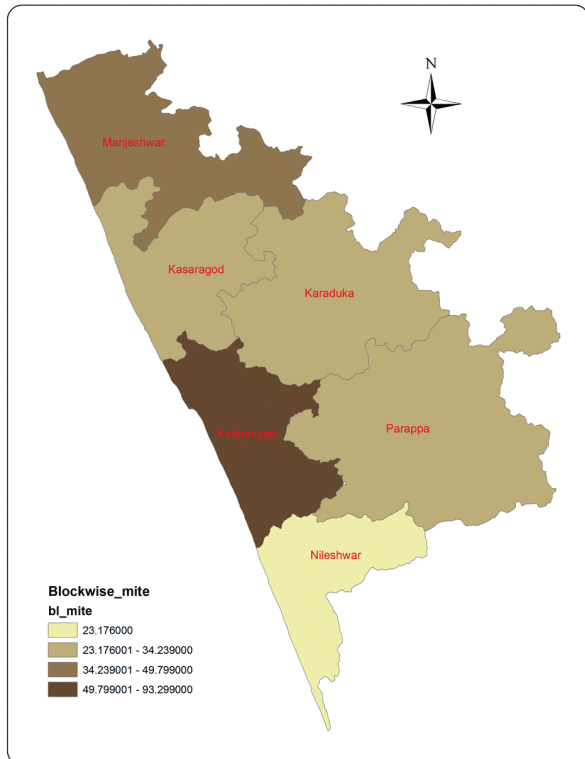


Fig. 3. Per cent incidence of eriophyid mite in Kasaragod district

### Coreid bug

Coreid bug was considered as a minor pest till recent years and has presently gained importance; and nut fall and reduction in nut quality due to the bug infestation was reported from many parts of the country. Percentage incidence was highest in coastal panchayaths viz., Kanhangad (8.3%), Pallikkara (7.2%) and Ajanur (6%) which are geographically contiguous. The lowest incidence was observed in eastern hilly tracts: Panathady (0.2%), Balal (0.3%) and Kallar (0.4%) panchayaths. Among the blocks, Kanhangad and Parappa had the highest and lowest incidences, respectively.

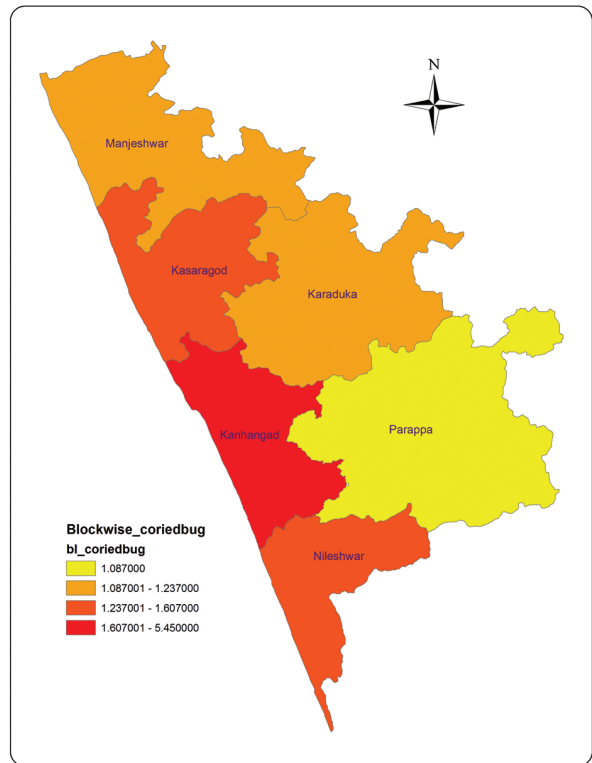


Fig. 4. Per cent incidence of coreid bug in Kasaragod district

### Incidence of diseases

#### Bud rot

The highest incidence of bud rot was recorded in East Eleri (12%) panchayath, followed by West Eleri (8%), Kallar (6%), Kayyurchemeni (5.7%) and Balal (5.4%), whereas least incidence was observed in Mangalpady and Manjeshwar (0.3%)

panchayaths. Among the blocks, highest incidence as recorded in Parappa and lowest in Manjeshwar.

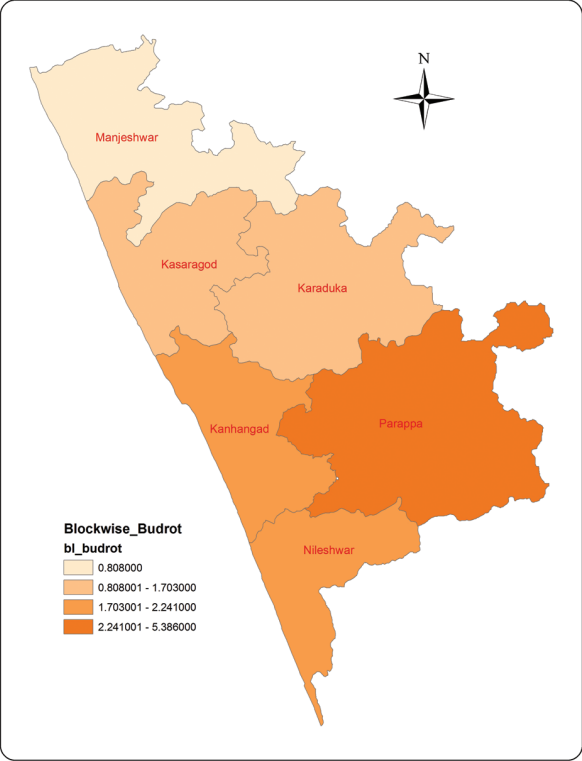


Fig. 5. Per cent incidence of bud rot disease in Kasaragod district

**Stem bleeding**

Incidence of stem bleeding was assessed in terms of per cent palms showing symptoms of disease infection. The study revealed that highest incidence was in Padanna (6.2%) followed by Delampady (5.6%) and Pilicode (4.8%) panchayaths. The incidence was lowest in Panathady (0.4%) panchayath whereas, the highest incidence was observed among blocks such as Kanhangad and Nileshwar (3% each). Only 0.01 per cent incidence of stem bleeding was observed at Parappa block.

**Thanjavur wilt**

The incidence of Thanjavur wilt was assessed in terms of per cent palms showing symptoms of disease. The highest incidence was observed in Pilicode (4%) panchayath followed by Pallikkara (1.6%) and Padanna (1.5%) while disease could not be observed in Kumbadaje panchayath. The

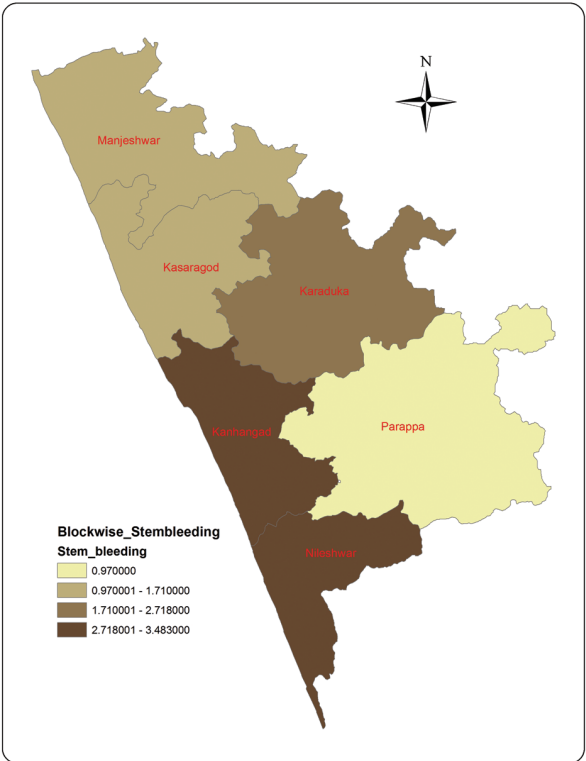


Fig. 6. Per cent incidence of stem bleeding in Kasaragod district

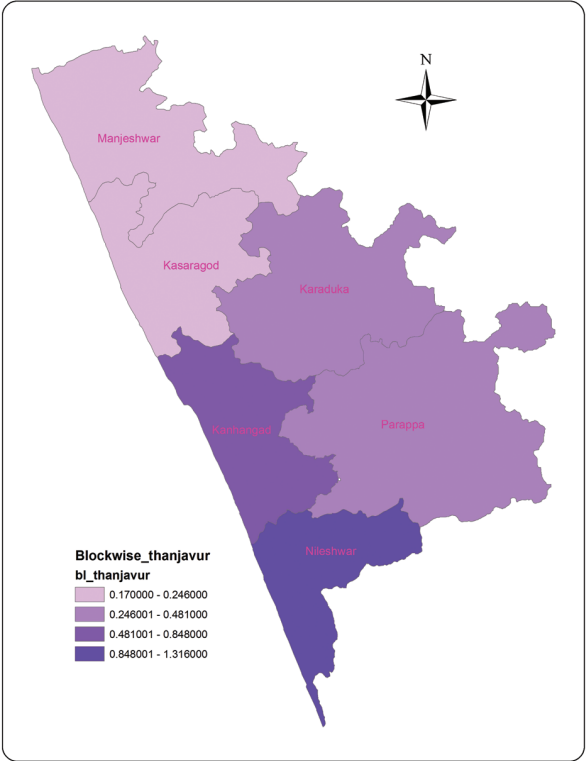


Fig. 7. Per cent incidence of Thanjavur wilt in Kasaragod district

incidence was found to be lower in Madhur, Karadka and Kallar panchayaths (0.05%). Among the blocks, Nileshwar recorded highest and Manjeshwar and Kanhangad blocks were the least affected. Within panchayath level, variation was highest in Pilicode and Padanna, whereas lowest were recorded in Enmakaje and Madhur panchayaths.

### Agro-ecological unit (AEU) wise analysis

Kasaragod district is comprised of five agro-ecological units (AEUs). Analysis on the variations in disease and pest occurrence with changes in the altitude and ecological factors was carried out. Agro-ecological unit wise pattern of the pest/disease infestation is briefly discussed here.

#### *Rhinoceros beetle*

It is evident that rhinoceros beetle is one of the major coconut pests prevalent in almost all coconut gardens irrespective of agro-ecology of the location. The infestation ranged from 5.3 per cent in eastern hilly tracts to 9.4 per cent in central lateritic region. It was observed that incidence of rhinoceros beetle was less in high altitude where rainfall is high and temperature is low.

#### *Red palm weevil*

Results in Table 1 show that Kaipad and laterite AEUs have higher infestation of red palm weevil whereas, hilly tracts (AEUs 13 and 15) were less congenial for the weevil. Earlier studies of Hashim *et al.* (2013) support this observation that weevil infestation is highly significantly and positively correlated with the mean day temperature. On the other hand, mean relative humidity during days had insignificant correlation in their study.

#### *Eriophyid mite*

Eriophyid mite infestation was more predominant in northern coastal (AEU 2) and northern laterite (AEU 11) units and lowest in eastern hill zone. Studies by Sujata and Rao (2004) suggested that temperature has a positive impact on mite infestation. Similarly, relative humidity during morning hours and rainfall had significant negative correlation with mite population. This is in confirmation with the observation that areas with high rainfall and low temperature (AEU 15) have lowest mite infestation.

#### *Coreid bug*

Coreid bug incidence was predominant in coastal plains (AEU 2) and lowest in high altitude (AEU 13 and 15) regions. However, investigations need to be undertaken further to establish possible influence of weather factors on infestation. The results highlight the importance of targeting coastal plain areas in formulating strategies for the management of coreid bug.

#### *Bud rot*

It is evident that, high altitudes with high rainfall and relative humidity coupled with low temperature are more congenial for bud rot incidence. Accordingly, as expected, the incidence was highest in AEU 13 and AEU 15. Farmers perceive that heavy wind experienced at the onset of monsoon results in spindle damage which leads to disease initiation especially when incessant spells of rain increase the relative humidity. Epidemiological studies on bud rot by Sharadraj (2013) critically analyzed the association between bud rot and weather variables. The correlation coefficient between disease incidence and number

**Table 1. Agro-ecological unit (AEU) level incidence of pests and diseases of coconut**

AEU/Disease	Disease			Pest			
	Bud rot	Stem bleeding	Thanjavur wilt	Rhinoceros beetle	Red Palm Weevil	Eriophyid mite	Coreid bug
Northern coastal plain (AEU 2)	1.9	2.5	0.5	8.2	0.1	1.0	2.7
Kaipad lands (AEU 7)	1.3	3.8	1.8	7.1	0.3	0.5	2.4
Northern laterites (AEU 11)	1.7	1.8	0.4	9.4	0.2	0.6	2.0
Northern foothills (AEU 13)	8.4	0.7	0.6	7.6	0.1	0.5	1.5
Northern highhills (AEU 15)	3.1	1.8	0.4	5.3	0.1	0.3	0.5

of rainy days, rainfall, mean relative humidity and mean maximum as well as minimum relative humidity in the coconut garden was highly significant. On contrary, there was a highly significant negative correlation between mean maximum temperature and disease incidence. This substantiates the fact that the disease incidence was high in hilly tracts with high rainfall and relative humidity and lower temperature as compared to plains.

An attempt to relate soil fertility status with the disease reveals that, there exists a negative correlation with potash (K) and positive correlation with soil nitrogen (N). The argument that potassium improves the resistance to disease substantiates the results observed.

### Stem bleeding and Thanjavur wilt

The results presented in Table 1 reveals that, stem bleeding and Thanjavur wilt incidences exhibit a similar pattern wherein the disease is more prevalent in northern lateritic region. The region is characterized by more dry spells and higher temperature as well as hard soils which favour the pathogen. The incidence was less in eastern hilly region of the district.

### District level estimates of incidence and intensity of pests in Kasaragod district

Severity was assessed in the second stage by randomly selecting the coconut gardens from those already surveyed for assessing the incidence. Summary table of the district level estimates of incidence and severity is given below:

Rhinoceros beetle was found to be the most common insect pest affecting coconut in the region.

As discussed earlier, incidence of rhinoceros beetle was assessed to be 8.5 per cent. As evident from Table 2, severity of rhinoceros beetle infestation (% of leaves attacked) is 19.8 per cent among the infested palms. The observation that, one fifth of the leaves among infested palms are infested by rhinoceros beetle clearly indicates that the incidence is severe and urgent measures for the integrated management of the pest need to be taken up to prevent crop loss. If timely IPM measures against rhinoceros beetle are not adopted, there is high possibility of crop loss due to bud rot as it is established that damage to spindle leaves by rhinoceros beetle is a predisposing factor for bud rot incidence in coconut palms.

Red palm weevil infested palms were observed in the first stage surveys and the per cent incidence at district level was estimated as 0.2 per cent. Since the measures of palm wise severity were not developed, answer to “*whether palm got infested or not*” is taken as the measure of severity which is same as per cent incidence. Overall, 23.8 per cent of nuts were infested by eriophyid mites among 0.7 per cent of the palms in Kasaragod district. The distribution of palms based on percentage of nuts infested by the pest is depicted in Table 2. It is revealed that, about half (48.2%) of the infested palms were having only less than 25 per cent nut infestation, while only an insignificant number (2.2%) of palms exhibited infestation in more than 50 per cent of the nuts. In general, the results indicated a moderate level of mite infestation in the coconut palms. Severity of incidence of coreid bug was assessed based on the percentage of nuts affected on the palms showing incidence of the pest and the results indicated that on an average,

**Table 2. Palm-wise severity of coconut pests in Kasaragod district**

Pest	Per cent incidence	Severity measure	Severity
Rhinoceros beetle	2.2	(%) leaves attacked	19.7
Red palm weevil	0.2	-	-
Eriophyid mite	0.7	<25% nuts infested	48.2
		25-50%	8.3
		>50%	2.2
		0%	40.9
		overall	23.8
Coreid bug	2.2	(%) nuts infested	19.5



**Table 3. Palm-wise severity of coconut diseases in Kasaragod district**

Disease	Per cent incidence	Severity grade		
		Mild	Moderate	Severe
Bud rot	2.4	-	-	-
Stem bleeding	2.3	8.8	24.7	66.5
Thanjavur wilt	0.6	6.1	69.5	24.4

19.5 per cent nuts were affected among the 2.2 per cent palms infested with coreid bug in Kasaragod district.

### Severity of diseases of coconut

The disease severity at palm level was assessed by randomly selecting the coconut gardens from those already surveyed for assessing the incidence. Table 3 summarizes the district level estimates of incidence and severity.

The district level estimate of bud rot incidence was found to be 2.4 per cent. Measures of palm-wise severity are not available and hence gradation of disease severity could not be made for bud rot. Assessment of severity of stem bleeding in Kasaragod district reveals that incidence was severe in two third (66.5%) of the palms affected, moderate in one fourth (24.7%) and mild in 8.8 per cent palms. The results clearly indicated that stage of stem bleeding disease infection in the district was mostly severe in nature and hence it is imperative that urgent necessary steps are taken up to implement integrated disease management strategies to prevent further crop loss. It was observed that, in many cases coconut growers did not adopt any control measures. The seriousness of disease incidence was not properly perceived by the farmers mainly because the palms affected by the disease do not perish quickly. Further, most of the farmers fail to observe the bleeding patches on the tree trunk at

the initial stages of the disease. In the coconut palms affected by Thanjavur wilt, the incidence was severe in one fourth (24.4%), moderate in two third (69.5%) and mild in 6.1 per cent of the palms. It is observed that in majority of the cases coconut growers are not able to identify the disease accurately.

### Estimation of crop losses

The assessment of economic impact of infestation of pests and diseases is a challenge due to lack of well established estimates for linking incidence or severity to yield loss. Thus, attempt to quantify the losses were carried out assuming certain probable scenarios. As the rhinoceros beetle attack does not contribute directly to crop loss, separate loss estimation was not done for it assuming that, its share as a precursor for bud rot is reflected through the loss due to bud rot disease. Economic loss due to red palm weevil was estimated by assuming that 50 per cent of the infested palms will ultimately die. Thus with a 0.15 per cent incidence, estimated loss in number of nuts was 0.45 million per annum. Assuming that the loss per palm will result in loss in nuts for ensuing seven years, the loss cumulates to 3.15 million nuts. In case of eriophyid mite attack, there is no loss in number of nuts, however the loss occurs in terms of copra and market price realized. Mite incidence in the district was 0.7 per cent and among them, percentage of palms with nuts in grade 4 was 2.2 per cent. Assuming that 50 per cent reduction in copra for the grade 4 (index >50%), annual economic loss in terms of number of nuts would be 0.05 million. Similarly, for the diseases, loss in nuts was estimated as per the criterion explained in Table 4.

Economic loss due to death of the palms was estimated assuming that a minimum of seven years

**Table 4. Estimated loss of coconut due to pests and diseases in Kasaragod district**

Pest/ Disease	Estimated loss (million nuts)	Assumptions made	No. of years affected	Cumulated loss (million nuts)
Red palm weevil	0.45	50 % of the infected palms would die	7	3.15
Eriophyid Mite	0.05	Grade 4 nuts will yield in 50% copra loss	1	0.05
Bud rot	7.16	50% of the infected palms would die	7	50.12
Stem bleeding	9.09	Severely infected palms (disease index > 25) would die	7	63.63
Thanjavur wilt	0.90	Severely infected palms (disease index > 40) would die	7	6.30
Total				123.25

is required to attain a stabilized yield after replanting with a new tree. Thus, assuming a minimum of ₹ 8 per nut, total loss could be ₹ 98 crores. In addition, by adding cost of replanting and other initial investments for the 3.17 lakh palms @ ₹ 300 per palm and adjusting with a correction factor for palms with more than one disease/pest, the loss would be ₹ 100 crores.

## Conclusions

Incidence and intensity of pests and diseases are important parameters to be assessed in order to formulate integrated management strategies. Estimation of the same requires efficient sampling strategies and technical expertise for recording the observations. Thus, studies in similar lines will help in generating accurate information on pest/disease severity and crop loss estimates which form the basis for deciding the need and feasibility of adopting control measures in specific locations. Moreover, this would help in optimizing the resources and efforts for pest and disease management by avoiding implementation of blanket schemes on unimportant problems at grass root level. This study would serve as an important initiative in developing micro-level database on pest and disease status with cost and resource effective sampling surveys which could be replicated in all the coconut growing regions of the country.

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