Research Article

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Extent of yield loss in coconut due to the infestation of coreid bug, *Paradasynus rostratus* Dist.

Ambily Paul, C. Nandakumar and Roy Stephen

Department of Entomology, College of Agriculture, Vellayani, Trivandrum - 695 522

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Abstract

Studies on quantitative and qualitative losses incurred in coconut due to the infestation of coreid bug were done in the College of Agriculture, Vellayani. Nuts with negligible damage (category II) did not show any significant difference compared to healthy (category I) nuts in nut characters, copra and oil content. Significant reduction in copra and oil was observed in moderately (category IV) and heavily (category V) damaged nuts. Length and thickness of coir fibre from heavily and severely damaged nuts and break load of coir yarn prepared from the severely damaged nuts were significantly reduced. The phenol content in young infested nuts recorded an increase compared to healthy nuts. A progressive reduction in starch and fibre content of young nuts was obtained with increase in degree of infestation. Peroxide and acid values of oil obtained from nuts with moderate, heavy and severe damage were higher compared to healthy nuts. The extent of filling of carbohydrate in parenchymatous cells decreased with increase in degree of infestation.

Keywords: Coconut, coreid bug, yield loss

Introduction

In Kerala, coconut occupies an area of 0.90 million ha with an annual production of 5,484 million nuts (Parthasarathy *et al.*, 2006). However, the productivity of 6,052 coconuts per ha is low. One of the major reasons attributed to low productivity is the infestation by pests and disease causing organisms.

The coconut palm is prone to infestation by a large number of insects like coccids, diaspidids, pseudococcids, tingids, coreids, thrips, lepidopterans, coleopterans and non-insect pests like mites, rodents etc. The control measures currently adopted against these pests are inadequate. Of late, the coreid bug has gained notoriety as a major pest of coconut in Kerala. The coreid bug was first observed on coconut in Krishnapuram, Alappuzha district of Kerala in 1959 (Kurian *et al.*, 1972). Later the pest was identified and confirmed as *Paradasynus rostratus* (Kurian *et al.*, 1976 and 1979). The damage and yield loss especially of copra and coir caused by coreid bug on coconut in the present scenario has to be studied.

Materials and Methods

Quantitative loss

The experiment was laid out in Complete Randomised Design (CRD). Four coconut palms of West Coast Tall (WCT) variety coming under the age group, 15-20 years were randomly selected and the oldest bunch was labelled. At harvest, the nuts of each observational palm were divided into six damage categories as per the method of Brown (1959) as described below.

Category I	Nuts without scars (Uninfested)
Category II	Nuts with 1 to 5 scars (Negligible damage)
Category III	Nuts with 6 to 20 scars (Mild damage)
Category IV	Nuts with greater than 20 scars in a single ring round the nut (Moderate damage)
Category V	Nuts with greater than 20 scars distributed more or less all over the nut (Heavy damage)
Category VI	Nuts heavily scarred in which the endosperm failed to develop(Severe damage)

The difference between classes IV and V depends on whether the nut has been attacked during its development only once (Class IV) or repeatedly (Class V) resulting in lesser and greater reduction of kernel, respectively.

One nut from each damage category was taken from each palm and different parameters were estimated in the laboratory. The estimation was done during four consecutive harvests and the data were pooled and analysed.

Weight of unhusked and dehusked nuts was taken using a pan balance. Coconut water was collected after splitting the dehusked nut and weighed. Weight of husk was determined by subtracting the weight of dehusked nut from unhusked whole nut. The kernel was removed from shell and the weight of shell and kernel were taken. Kernel was excised out of the shell of healthy and infested nuts, weighed and sun dried for four to five consecutive days. The moisture content was brought down from 50 - 55 per cent to six per cent and weighed. Oil was extracted from copra of nuts coming under five damage categories (endosperm is absent in category-VI nut) using Soxhlet extraction procedure of AOAC (1996) and weighed.

Qualitative loss

Quality of coir

Husks from twenty nuts in each damage category (category 1 to VI) were subjected to natural retting by submerging them in Vellayani lake. After six months, they were taken out from water, washed and the fibre extracted. Length and breadth of the fibre in each category were measured. Coir yarn was spun from fibre obtained from such nuts. The tensile strength was determined using tensile strength testing machine 'Autograph' at the Central Coir Research Institute, Kalavoor, Alappuzha, Kerala.

Bio-chemical changes

Healthy and infested young nuts were collected from the third (two months age) and fourth (three months age) bunches of WCT palms. The damaged tissues of the nuts with high (nuts showing heavy damage and splitting), medium (nuts showing medium damage) and low (nuts showing two or three spots) infestation (Visalakshi *et al.*,1989) were excised and the starch, phenol and fibre content were estimated as per the procedure of Sadasivam and Manickam (1996).

The acid value and peroxide value of the oil extracted from the nuts in the six damage categories (oil is absent in category-VI nut) were estimated as per AOAC standards (AOAC, 1996).

Histological changes

Hand sections were taken from the surface of young nuts (third bunch) of coreid bug infested tissues of different damage intensities *viz.*, high, medium and low. Sections were stained, mounted on glass slides and covered with a cover slip without any air bubble. The histological changes of the tissues were recorded.

Results and Discussion

Quantitative loss

Results on the quantitative loss of nut in different damage categories are given in Table 1. The weight of nuts in category II did not differ significantly from that of nuts in damage category I (uninfested nuts), the weight recorded being 1438.75 and 1501.25 g per nut, respectively. While the weight of nuts in categories III and IV was 1052.50 and 814.38 g per nut, respectively, it was 598.13 g per nut in category V. The lowest weight was recorded in nuts coming under damage category VI (341.25 g per nut) which was significantly lower than the weight of nuts in the other categories.

Table 1. Effect of infestation of *Paradasynus rostratus* on nut characters of coconut

Damage categories	Unhusked* nut (g)	Dehusked* nut (g)	Nut* without water (g)	Weight of nut characters (g)*					Chemical properties of oil*		
				Nut water (g/nut)	Husk	Shell	Kernel	Copra	Oil	Peroxide value(%)	Acid Value (%)
Category - I(No damage)	1501.25	817.50	435.00	240.00	812.81	166.34	243.35	185.07	153.79	0.64	0.73
Category-II(Negligible damage)	1438.75	725.00	414.69	188.44	784.69	151.93	201.03	142.73	143.25	0.65	0.80
Category-III(Mild damage)	1052.50	411.56	300.94	141.88	637.19	108.64	166.23	113.68	92.63	1.73	2.90
Category-IV(Moderate damage)	814.38	279.69	195.31	98.75	553.44	68.83	111.68	70.27	47.16	2.27	5.40
Category-V(Heavy damage)	598.13	165.63	126.25	63.69	443.75	33.87	49.13	35.39	26.10	2.17	5.60
Category-VI(Severe damage)	341.25	15.50	15.19	0.00	298.88	8.18	0.00	0.00	0.00	0.00	0.00
CD (P = 0.05)	144.03	325.31	27.31	53.22	58.51	27.97	26.40	10.14	23.42	0.26	0.42

* Values per unit

The weight of dehusked nuts in category II (725.00 g per nut) too was on par with the weight of uninfested nuts (817.50 g per nut). Lower weight was recorded for nuts in category VI (15.50 g per nut) which was on par with the weight of nuts in category V (165.63 g per nut) and IV (279.69 g per nut).

Similarly, the weight of nuts without water in category II (414.69 g per nut) did not differ significantly from that of uninfested nuts (435.00 g per nut). However, significant reduction was observed in the weight of nuts without water in damage categories III (300.94 g per nut), IV (195.31 g per nut) and V (126.25 g per nut). The nuts from damage category VI recorded the lowest weight (15.19 g per nut).

The quantity of nut water in category II (188.44 g per nut) was on par with that of the healthy nuts (240.00 g per nut). The quantity of water in nuts of category III (141.88 g per nut) and IV (98.75 g per nut) were statistically similar. The quantity of nut water in nuts of category V was 63.69 g per nut. The nuts from category VI had no water.

The weight of husk of nuts from category II (784.69 g per nut) did not differ significantly from that of healthy nuts (812.81 g per nut). However, significant difference was observed among the weight of husks in category III (637.19 g per nut), category IV (553.44 g per nut) and category V (443.75 g per nut). The lowest weight of husk was recorded from category VI nuts (298.88 g per nut).

No significant difference was observed in the weight of shells of nuts in category II (151.93 g per nut) and healthy (166.34 g per nut). Lower weight was recorded for shell of nuts in damage category V (33.87 g per nut) and VI (8.18 g per nut) and they were on par. The weight of shell from category III and IV were 108.64 and 68.83 g per nut respectively.

The weight of kernel obtained from the nuts of the different categories was significantly lower than that of the uninfested nuts (243.35 g per nut). The weight of kernel recorded from nuts of damage categories II, III and IV were 201.03, 166.23 and 111.68 g per nut respectively. The weight of kernel from nuts of category V was still lower (49.13 g per nut). The nuts in category VI were devoid of kernel.

Compared to the copra content of healthy nuts (185.07 g per nut), significant reduction was observed in the weight of copra from nuts of damage categories II to V. Among the different categories too, the weight of copra was significantly reduced, the weight of copra from nuts of categories II, III, IV and V being 142.73, 113.68, 70.27, and 35.39 g per nut respectively. The nuts from category VI were devoid of copra.

No significant difference was observed in the weight of oil from nuts of category II (143.25 g per nut) with that of uninfested nuts (153.79 g per nut). Compared to the weight of oil from nuts of category IV (47.16 g per nut) and V (26.10 g per nut), the weight of oil from nuts of category III (92.63 g per nut) was significantly higher. Since the nuts from category VI were devoid of copra, no oil was recorded from the category.

Unlike most crops wherein a mere damage by pest on the fruit results in its rejection in the market, the intensity of damage determines the economic value of coconut. Taking the fact into consideration, the harvested nuts were grouped into different damage categories and the loss in yield parameters under different categories was studied. An important finding was that only the nuts falling in the damage category IV, V and VI showed appreciable loss in the yield parameters. The reduction in weight was negligible in category II nuts (3.95 per cent). The reduction in mildly damaged category III nuts was 28.11 per cent. Whereas, the reduction was higher in severely damaged category VI nuts (76.25 per cent), heavily damaged category V nuts (59.20 per cent) and moderately damaged category IV nuts (44.10 per cent). Obviously, heavily and severely damaged nuts (category V and VI) will be rejected in the market. The nuts coming under category III (mild damage) and IV (moderate damage) will get only a lesser price compared to the healthy nuts. Category II (negligible damage) nuts will fetch the same price of a healthy nut. Thus, the economic loss to a coconut farmer due to coreid bug attack on coconut can be calculated from the total number of nuts falling under each category. Hence, an assessment of economic loss in homesteads should be made before adopting control measures. Observations on yield loss due to coreid bug were made by Brown (1959); Julia and Mariau (1978); Nair *et al.* (1997) and Mayilvaganan and Nair (2002). However, they did not conduct such category wise yield loss studies.

Qualitative loss

Quality of coir

No significant reduction was seen in the length of fibres obtained from husks under category II (23.70 cm per fibre) and III (21.50 cm per fibre) compared to that in healthy nuts (23.64 cm per fibre). When the intensity of infestation increases, the fibre length decreases. No significant difference was observed in the length of fibre

obtained from nuts in damage categories IV (18.40 cm per fibre), V (18.00 cm per fibre) and VI (15.80 cm per fibre) (Table 2).

Table 2 . Effect of infestation of *Paradasynus rostratus* on quality of fibre and coir yarn obtained from husks under different damage categories

Damage category	Quality of fibre (cm)		Coir yarn
	Length	Thickness	Break load (Kgf)
Category – I(No damage)	23.64	0.186	78.89
Category-II(Negligible damage)	23.70	0.184	79.49
Category-III(Mild damage)	21.50	0.172	75.88
Category-IV(Moderate damage)	18.40	0.148	73.84
Category-V(Heavy damage)	18.00	0.104	71.79
Category-VI(Severe damage)	15.80	0.078	17.38
CD (P = 0.05)	3.45	0.030	10.40

The thickness of fibres from category II (0.184 cm per fibre) and III (0.172 cm per fibre) had no significant difference from that of the uninfested husk (0.186 cm per fibre). Compared to fibres in these categories, the thickness of the fibres from category IV (0.148 cm per fibre) and V (0.104 cm per fibre) was reduced significantly. The least thickness (0.078 cm per fibre) was recorded from fibres obtained from category VI nuts.

The break load of coir yarn spun from husks of category II to V did not differ significantly from that of the healthy nuts (78.89 Kgf per coir yarn). The break load of coir yarn of husks of category II, category III, category IV and category V were 79.49, 75.88, 73.84 and 71.79 Kgf per coir yarn, respectively. Break load was found to be the lowest in yarn obtained from category VI nuts (17.38 Kgf per coir yarn).

The break loads of coir yarn prepared from fibres of nuts with negligible to moderate damage were not affected despite the reduction in length and thickness. Tensile elongation and modulus are the most important indications of strength in a fibre. Evidently, the yarn spun from nuts with heavy damage is neither strong nor usable. A study of similar nature was conducted by Paul and Mathew (2002) on loss of husk, quality of fibre and coir due to the infestation of coconut eriophyid mite, *Aceria guerreronis*. They reported that the coir fibre obtained from nuts coming under damage categories IV (Nuts with significant mite damage and smaller) and V (Nuts very heavily damaged and with some distortion) was very short and fragile and it was very difficult to spin the coir.

Bio-chemical changes

The results of the bio- chemical analysis of starch, phenol and fibre content of young buttons (third and fourth bunches) are presented in Table 3.

Table 3. Effect of infestation of *Paradasynus rostratus* on bio - chemical constituents of coconut buttons

Category	Starch (mg/g)		Phenol (mg/g)		Fibre (%)	
	3rd bunch	4th bunch	3rd bunch	4th bunch	3rd bunch	4th bunch
Low	1.61	2.56	6.19	6.45	8.25	13.00
Medium	0.90	1.39	6.49	6.85	5.25	9.38
High	0.65	0.71	7.75	7.78	3.25	6.13
Control	1.51	2.08	3.03	2.95	9.38	13.75
CD (P = 0.05)	0.40	0.42	0.71	0.72	0.91	2.03

Starch

The starch content in young nuts (1.61 mg/g) having low infestation was on par with those in uninfested nuts (1.51mg/g) in the third bunch. However, in medium and highly infested buttons the starch content was significantly less being 0.90 mg/g and 0.65 mg/g, respectively.

The analysis of starch content in the young nuts from fourth bunch too revealed that the starch content in nuts (2.56 mg/g) having low infestation was significantly higher to that in uninfested nuts (2.08 mg/g). While, the starch content was 1.39 mg/g in nuts having medium infestation, it was significantly lower in highly infested nuts (0.71 mg/g).

Phenol

Phenol was seen only in low quantities in uninfested nuts (3.03 mg/g). However, the content of phenol was significantly higher in the bug infested nuts. The quantity of the chemical in nuts having low (6.19 mg/g) and medium infestation (6.49 mg/g) was on par. The highest phenol content (7.75 mg/g) was recorded from nuts having high infestation.

A similar trend was observed in the nuts from the fourth bunch. The lowest phenol content (2.95 mg/g) was recorded from uninfested nuts. The phenol content in nuts having low (6.45 mg/g) and medium infestation (6.85 mg/g) did not differ significantly. The highest phenol content (7.78 mg/g) was observed from the nuts having high infestation.

Fibre

The fibre content was significantly greater in uninfested nuts of third bunch (9.38 per cent). While the fibre content of nuts having low infestation was 8.25 per cent, it was 5.25 per cent in nuts with medium infestation. The lowest fibre content (3.25 per cent) was recorded from highly infested nuts.

In the fourth bunch, the fibre content of nuts (13.00 per cent) having low infestation did not differ

significantly from that in the uninfested nuts (13.75 per cent). The fibre content of nuts with medium infestation was 9.38 per cent. Significantly lowest fibre content (6.13 per cent) was recorded from highly infested nuts.

Peroxide value of oil

The peroxide value of oil obtained from nuts in category II (0.65 per cent) was comparable to that of the oil of healthy nuts (0.64 per cent). However, a significant increase was observed in the peroxide value of oil with increase in the intensity of infestation by coreid bug (Table 1). The peroxide value of oil of nuts in category III was 1.73 per cent. Higher value was obtained for oil from category IV nuts (2.27 per cent) followed by category V (2.17 per cent) which were significantly similar. The category VI nuts were devoid of copra.

Acid value of oil

A similar trend was observed in the case of acid value of oil also. The acid value of oil was low in healthy nuts (0.73 per cent) and category II nuts (0.80 per cent), which were on par. The acid value of oil from category III was 2.90 per cent. Higher acid value was reported from category V nuts (5.60 per cent), which had no statistical difference with that of category IV nuts (5.40 per cent) (Table 1).

The biochemical constituents of coconut buttons too were affected due to the feeding of coreid bug. The phenol content in young infested nuts from third and fourth bunches registered an increase compared to the healthy ones, the increase in the infested nuts being 60 and 62 per cent, respectively. Phenolic compounds are secondary metabolites which are induced as a response to biotic stress. The accumulation of phenols in response to coreid bug infestation is one of the major reasons for the development of the symptoms on infested nuts. There was a progressive reduction in the starch content of young nuts with increase in degree of infestation. These observations indicated a feeding induced alteration in the carbohydrate metabolism of young nuts in coreid bug infested parts. Sucrose is the principal form of carbohydrate that is translocated from the source leaves to the developing young nuts and where it is converted to starch and stored. The coreid bug feeds on the translocated sucrose thus reducing the supply of carbohydrate for starch biosynthesis in young nuts.

The fibre content of young nuts was also reduced due to infestation by the pest. The feeding by coreid bug caused a reduction in the sucrose that was available for conversion to glucose for cellulose bio-synthesis. According to Taiz and Zeiger (2003) any reduction in the carbohydrate supply decreased the total fibre production in young nuts also. The observations on starch content of young nuts infested by coreid bug also supported this result. The peroxide and acid values of oil were estimated in nuts coming under five damage categories. In severely infested nuts (category VI), no endosperm was present.

The peroxide value of oil increased due to feeding of coreid bug. Biotic and abiotic pressure causes oxidative stress at the cellular level because of the accumulation of reactive oxygen species including superoxide, hydroxyl radicals and hydrogen peroxide. The peroxide value increased in response to infestation by coreid bug, which explained the intensity of oxidative stress caused by the feeding. Mayilvaganan and Nair (2002) studied the changes in chemical properties of oil due to coreid bug infestation. The result of this study is in line with their findings. However, they did not conduct category wise damage analysis. The acid value of oil was significantly higher in category IV and V nuts and the least in category II (negligible damage).

Histological changes

In the healthy young buttons, the epidermis is composed of small, compactly arranged thin walled parenchymatous cells. On the inner side of epidermis, a few layers are sclerenchymatous and this region is called the hypodermis. The region inner to the hypodermis consists of thin walled parenchymatous tissues with a large number of intercellular spaces. Vascular bundles are found irregularly scattered in the parenchymatous tissues.

The coreid bug was observed to probe in the parenchyma cells seen outside the vascular bundles. The styles were inserted intracellularly and the cellular contents were lacerated which underwent plasmolysis. When infestation was low, the discolouration of parenchymatous cells was seen just below the epidermis around the vascular bundles. The discolouration of the parenchymatous cells increased and extended downwards when infestation was medium. In highly infested nuts, the parenchyma cells disintegrated and were destroyed. The cells could not be differentiated.

The intensity of discoloration of parenchymatous cells around vascular bundles increased with increase in the level of infestation in young nuts. Feeding of coreid bug from phloem causes a reduction in the availability of carbohydrate for biosynthesis of starch, which will normally be stored in the vascular bundles. As the degree of infestation increased, the extent of filling of starch in

parenchymatous cells decreased. The feeding of coreid bug also caused accumulation of phenols, which on oxidation resulted in change in colour of parenchymatous cells (Taiz and Zeiger, 2003).

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