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Vulnerable stages of cashewnuts for pest infestation and the pest influence on kernel quality

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Abstract

Insect infestation on cashewnuts is mainly due to tea mosquito bug, thrips and apple and nut borers. Developing tender nuts are more vulnerable to the attack by these pests compared to matured nuts. Among the phenological stages, 619, 711 and 713 were highly vulnerable to TMB and ANB, where the infested tender nuts dried and fell down prematurely. Random samples of harvested raw cashewnuts collected from cashew plantations indicated that, among the three pests, thrips infestation was more followed by ANB and TMB. Varied levels of pest infestation resulted differences in physical characteristics of nuts and kernels. But, presence of shrivels, brown patches, black spots on kernels of healthy raw cashewnuts without visible signs of pest infestation indicates involvement of factors other than insects. Less damage of thrips (G1 and G2), ANB (A1 and A2) and TMB on raw cashewnuts had no much influence on the kernel physical quality and highly significant correlations were arrived with good kernel recovery. But, good kernel recovery was very less in G3, G4 and A3 nuts. Percent reduction of nut length, nut width and nut thickness up to 18.13, 8.20 and 6.97, respectively has been recorded in G4 nuts compared to healthy cashewnuts.

Keywords: Cashewnuts, kernels, pests, damage, thrips, good kernel recovery

Introduction

Insects are a major limiting factor in crop production. Farmers have to recognize insect infestation and their damage levels to decide on management measures. Cashew (*Anacardium occidentale* L.) is an important commercial tree nut grown in several parts of the world. In India, it is grown in an area of 11.05 lakh hectares with an annual production of 7.43 lakh tonnes of cashewnuts in 2018-19^[1]. Cashewnuts are globally consumed for their nutritional and sensory qualities. In general, larger sized whole cashew kernels with uniform colour especially creamy ones without any insect damage fetch high market price compared to the ones having shrivels, brown patches, dark spots, oily surface etc. Worldwide, cashew production and nut quality are severely affected by several insect pests^[2, 3, 4] at different phenological stages. Among the pests, thrips, *Scirtothrips dorsalis* (Thysanoptera: Thripidae), apple and nut borer (ANB), *Thylacoptila paurosema* (Lepidoptera: Pyralidae) and tea mosquito bug (TMB), *Helopeltis antonii* Sign. (Hemiptera: Miridae) are the important pests that damage the flowers, developing nuts and apples^[5, 6]. Pest damage can range from slight to severe and reduce the market value of the raw cashewnuts and the end produce. Severe feeding damage by the insects results in drying of immature nuts in the inflorescences itself. Most of the times, insects damaged very young nuts may abort thus reducing yield as observed for TMB, ANB, coreid bug etc.^[5, 7]. But identifying the vulnerable stages for different pests is especially important to decide upon timely management measures. However, the nuts suffering low pest infestation reach maturity, and the pest damage symptoms are often seen in the harvested cashewnuts. Harvested raw cashewnuts (RCN) often have admixtures of spoilt, void, insect infested, damaged, immature nuts etc. which reduces the market value. Sometimes, insect infestation may remain only on the external surface of nuts without any ill effects on the kernels. Thus, information on quality of kernels obtained from the nuts having pest damage symptoms will give basic information which aids in mechanization to detect and discard inferior quality RCN to conserve cost, energy and time in the line of processing. With this background, the present study attempted to find out the vulnerable stages of developing nuts to the important pests of cashew and also the influence of pest infestation in the harvested raw cashewnuts on the physical quality of its kernels.

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Materials and Methods

To identify the pest vulnerable stages of developing nuts, inflorescences of different phenological stages according to BBCH scale [8] were tagged randomly and the developing nuts were carefully examined for pest infestation levels. Cashewnuts of different phenological stages were exposed to TMB adult @ 1 / nut for 24 hours of feeding in the field using a small cage (Fig. 1.) and the resultant damage was recorded. Cashew plants severely infested by thrips and apple and nut borers were separately marked and examined for the symptoms of damage.



Fig 1: Field cage for confining TMB



Fig 2: Symptoms of pest infestation on RCN a. nuts damaged by TMB, b. apple and nut borer, c. thrips, d. Healthy nuts

In order to find out the degree of pest infestation on kernel quality, the samples of thrips infested nuts collected during 2016-17 were segregated into G1, G2, G3 and G4 based on the extent of corky layer on the nut surface (G1 - <25% corky surface; G2 - 26-50% corky surface, G3 - 51-75% corky surface and G4 - >75% corky surface and malformation). Similarly, ANB infested nuts were segregated as A1, A2 and A3, where A1 represents 25% surface damage, A2 represents 25-50% surface damage without holes and A3 represents >50% surface damage or the nuts with bore holes). The extracted kernels were segregated into healthy kernels, kernels with shrivels or brown patches or black spots or spoiled or oily patches. The proportion of each kernel type was computed, and correlation analysis was performed using MS excel to find out the influence of pest infestation on kernel quality. Correlation analysis was also done to find out relationship between nut characters and kernel weight. Thrips infested nuts of selected varieties viz., Bhaskara, VRI-3 and NRCC Sel 2 were collected separately and analyzed to record the changes in nut length, width and thickness in comparison with healthy nuts. Measurements were taken with the help of electronic balance (Sartorius BS 124S with LC 0.0001g) and Digital caliper (Model: Mitutoyo, Japan with LC 0.001m).

Results and Discussion

Cashewnuts are infested by various insect pests. at different

To understand the extent of pest infestation on raw cashew nuts and the influence of pest damage on kernel quality, random samples of freshly harvested raw cashewnuts (RCN) were collected from the cashew farms of ICAR-Directorate of Cashew Research located in Karnataka, India from the year 2015 to 2017. Nut samples were collected at three harvests viz., early (January-February), mid (March-1st fortnight of April) and late (2nd fortnight of April- May). Each sample consisted one kg of raw cashewnuts and six such samples were collected for every harvest.

Nuts were dried under sun for 2-3 days immediately after collection and packed airtight in polythene covers and stored. Physical dimension of randomly selected nuts (n=200) were measured to find out any correlation with its kernel parameters. The nut samples were segregated into healthy, pest infested and other infested ones upon visual observation and subjected for floating test. Nuts were segregated as healthy nuts if no insect infestation, as infested by tea mosquito bug (TMB) if sunken spots are seen, as infested by apple and nut borers (ANB) if surface damage showing rough shell portions with or without holes at the scar region of nuts, by thrips having corky patches with or without shrivels and malformation, other infested (malformed without pest damage, immature nuts, nut with physical damage etc.) (Fig. 2). Besides, kernels extracted from these nuts were examined for their surface quality characteristics.

development stages respond differently to pest infestation. Observations showed that developing tender nuts dry off due to infestation by thrips, apple and nut borers and tea mosquito, hence are vulnerable to pest attack compared to matured ones. Sometimes, infestation by all these three pests can be noticed on same inflorescences and the nuts. During flowering and fruiting, pest damage symptoms were much higher than the damage seen on the harvested nuts, since many tender nuts dried prematurely. Among the phenological stages, 619, 711 and 713 were highly vulnerable to TMB and ANB, where the infested tender nuts dry and fall off prematurely. Feeding by TMB resulted in development of black lesions or black sunken spots on the fed surface of the nuts. Feeding by single TMB resulted in complete drying of nuts of phenological stages of 619, 711 and 713 (Fig. 3a and 3b). Thus, the nuts that were damaged early by TMB cease to develop further leading to yield loss. This similar type of nut drop due to pest damage has also been recorded in other cashew growing regions [7, 9]. The nuts infested at 715 and 717 stages developed two to six sunken spots within one day after feeding (Fig. 3c and d) but attained maturity later. Kernels of those TMB infested matured nuts were mostly healthy or with slight brown patches without black spots, indicating that TMB damage remained only on its shell. The nuts of phenological stage of 719 (Fig. 3e) and beyond were not damaged by TMB ensuring healthy kernels.

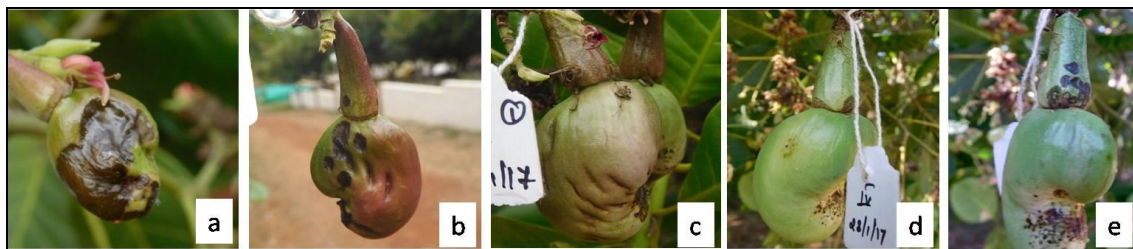


Fig 3: Vulnerable stages of cashew nuts to TMB and the damage symptoms a. 711, b. 713, c. 715, d. 717, e. 719

Degree of thrips damage depends on its population as well as the intensity of damage. Feeding by the nymphs and adults of thrips resulted in shriveling of tender nuts and development of corky layers on the surface of nuts and apples (Fig. 4). The nuts of phenological stages 619 and 711 were more vulnerable as they totally dried off (Fig 4 a, 4b and 4c). The larger nuts (715 and beyond) sustained the damage and matured with corky layers, while the severely infested nuts developed malformation (Fig. 4d and e) and sometimes, more than 75% of nut surface had corky layers. Thus, thrips may significantly affect cashew yields and/or quality as reported by Peng [10]. During certain occasions, severe damage by both thrips and apple and nut borers were seen on same nuts (Fig.

5f). Larvae of ANB preferred tender nuts and apples of all stages. Upon hatching from the eggs laid on nut surface, the larvae fed the shell initially and later entered the nuts. Nuts of the phenological stages from 619 to 715 dried and fell (Fig. 5a). Larval faecal matter with webbings can be seen protruding from the bore holes (Fig.5b and 5c). Nuts of developmental stages 717 and 719 reached maturity with or without boreholes, though feeding damage was seen on their shell (Fig. 5d and 5e). But in the nuts of phenological stages beyond 719, ANB larvae fed mostly the developing apples alone. Thus, the nuts escaping pest attack during vulnerable stages reached maturity.

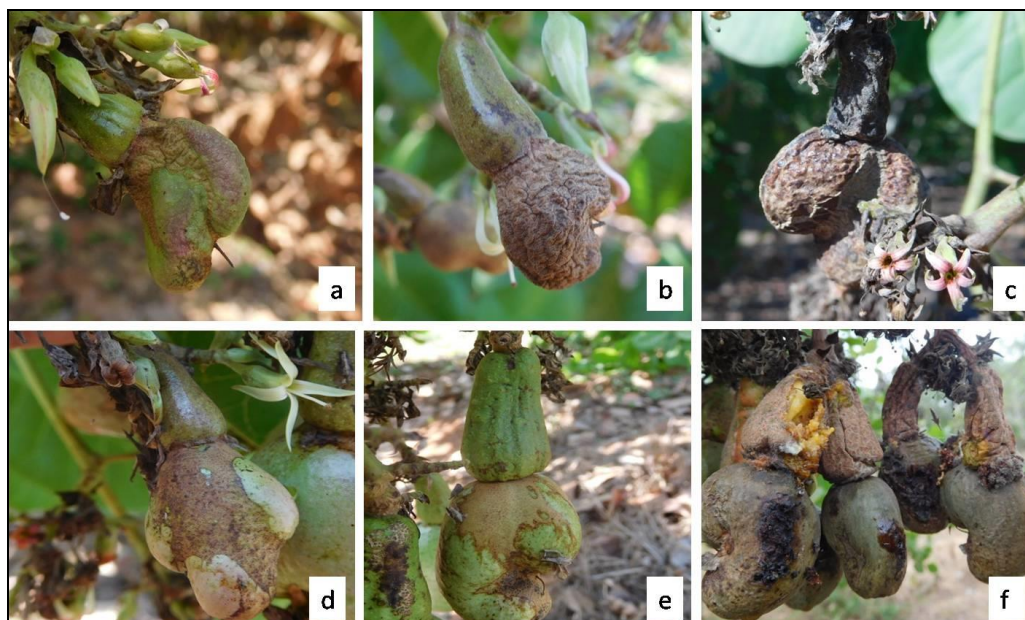


Fig 4: Vulnerable stages of cashewnuts to thrips and the damage symptoms a. 711, b. 713, c. 715, d. 717, e. 811, f. severe infestation by thrips and ANB

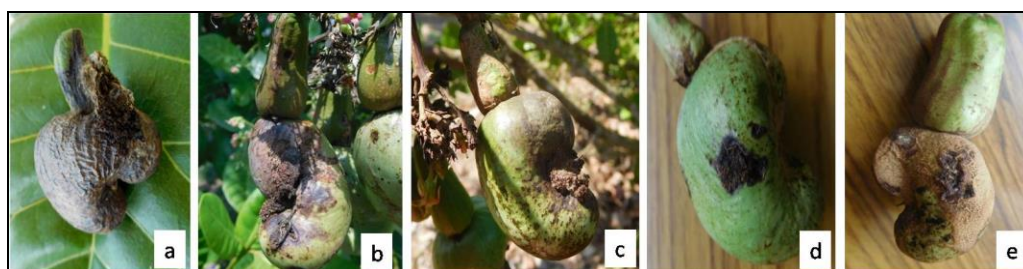


Fig 5: Vulnerable stages of cashew nuts to ANB and the damage symptoms a. 715, b. 717, c. 717, d. 719, e. 811

The cashewnut samples were subjected for processing to assess the physical quality of kernels as influenced by pests. Damage symptoms on the harvested RCN are the indicators of the degree of pest infestation. The moisture content of the RCN samples varied between 5.0

and 7.0% d.b. during both the years. During the year 2015-16, the nut samples had 25.86, 10.70 and 2.08% infestation levels of thrips, ANB and TMB, respectively and 61.07% of nuts were healthy without any damage symptoms (Table 1). In which, 47.71% of ANB infested nuts were floated nuts.

However, 17.98% of floated nuts were healthy nuts. Percent infestation levels indicated similar trend during 2016-17 also.

Table 1: Pest infestation percentage in raw cashew nuts collected during 2015-16 and 2016-17

Pooled	Nuts (2015-16)			Nuts (2016-17)		
	% to total RCN	Floated nuts (%)	Sunken nuts (%)	% to total RCN	Floated nuts (%)	Sunken nuts (%)
Healthy nuts	61.07	10.95	50.12	71.44	9.07	62.37
Thrips	25.86	6.05	19.81	21.09	3.97	17.09
ANB	10.70	5.11	5.60	5.83	1.46	4.33
TMB	2.08	1.63	0.45	1.02	0.18	0.84
Other Infested	0.29	0.04	0.25	0.62	0.40	0.22
Total	100.00	23.78	76.23	100.00	15.08	84.85

Among the three harvesting seasons, better good kernel recovery was recorded in early and mid-season nuts (75.82 and 83.62%, respectively) compared to late season nuts

(58.94%). The percentage of kernels with brown patches was more in late season nuts compared to early and mid-season, which could be due to climatic factors prevailed during the harvest season, physiological reasons etc., that needs further investigation. Similar trend was observed in 2016-17 also. Percentage of shriveled kernels was almost equal during all the three harvests that ranged between 4.09 and 5.30 during the year 2015-16 (Fig. 6). The qualities of resultant kernels are given in Table 2. Good kernel recovery was high in sunken nuts compared to floated ones. However, it is important to note that little quantity of shrivels, brown patches and black spots were also present in kernels of healthy nuts, and thus these symptoms on kernels could not be attributed to specific pest infestation. In other words, nuts with pest damage symptoms did not have clear-cut damage symptoms on its kernels, but the degree of shrivel, brown patches and black spots was more in infested nuts than healthy nuts.

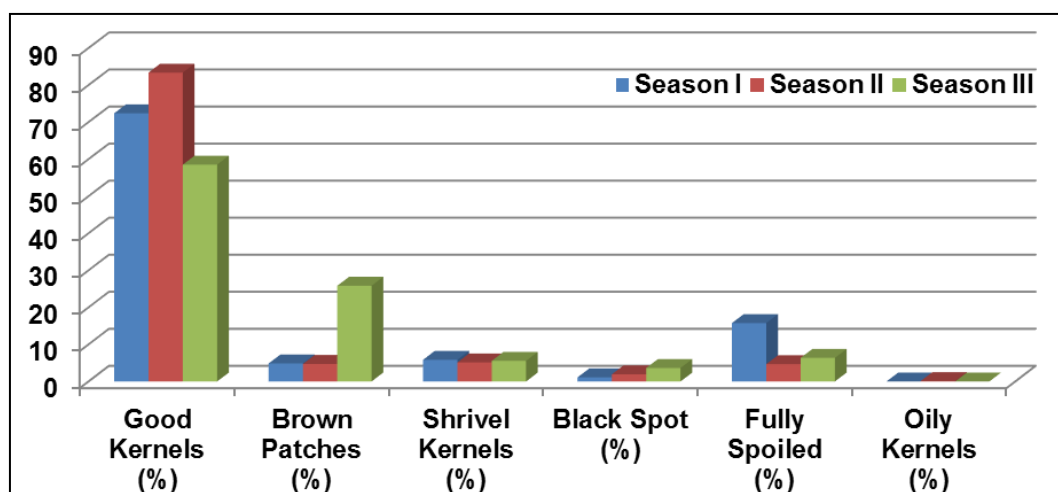


Fig 6: Kernel quality of the RCN collected during 2015-16

Table 2: Kernel quality as influenced by pest infestation during 2015-16

Kernel quality (%)	Uninfested nuts		Thrips infested		ANB infested		Other infested		TMB infested		Total Percentage
	Floated	sunken	Floated	Sunken	Floated	Sunken	Floated	Sunken	Floated	Sunken	
Good kernels	4.78	41.12	2.61	16.37	1.51	4.21	0.12	0.37	0.00	0.16	71.25
Brown patches	2.65	5.80	0.90	1.43	0.86	0.49	0.08	0.08	0.04	0.04	12.37
Shriveled kernels	1.14	1.43	0.98	0.69	0.61	0.45	0.16	0.00	0.00	0.04	5.51
Black spot	0.45	1.14	0.20	0.37	0.08	0.08	0.00	0.00	0.00	0.00	2.33
Fully spoiled	1.96	0.61	1.35	0.94	2.04	0.37	1.27	0.00	0.00	0.00	8.53
Total											100.00

During 2016-17 out of the segregated nut samples, 21.09 percent had symptoms of thrips infestation, out of which, 19.45% were G1. Percentage of G3 and G4 were very less (0.18 and 0.15%, respectively) indicating that through thrips infestation was seen in many nuts, its severity was less during the year (Table 3). The extracted kernels indicated that good kernel recovery is very less in G3 and G4 nuts (Fig. 7). This is in line with Anato [7], who reported a significant negative

correlation between the proportion of first-quality nuts and the amount of thrips damage. Similarly, good kernel recovery was very less in A3 nuts. The negative correlation between A3 nuts and good kernel recovery indicates that, nut having bore holes are spoilt, thus can be discarded. On the other hand, significant positive correlation was recorded between good kernel recovery and TMB infested (0.87), G1 (0.87), G2 (0.89) and A1 & A2 nuts (0.98) (Table 4).

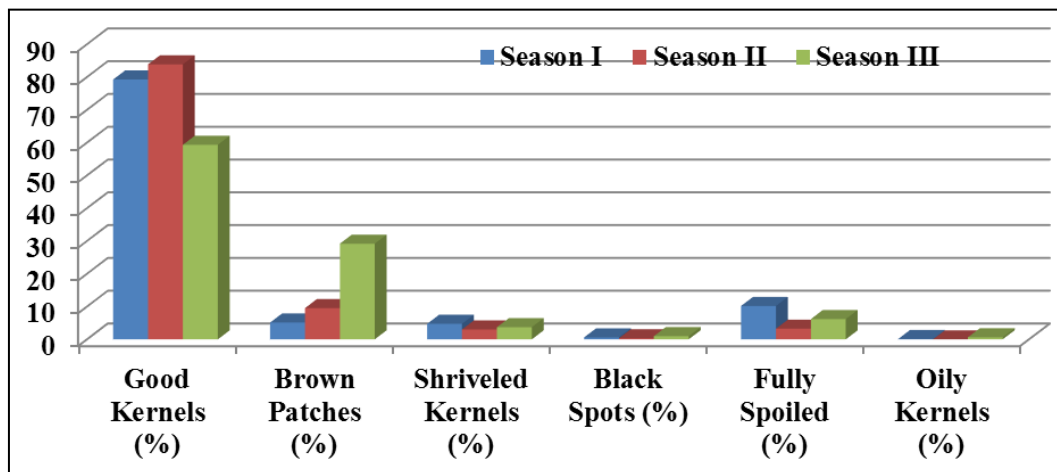


Fig 7: Kernel Quality of the RCN collected during 2016-17

Table 3: Kernel quality as influenced by pest infestation during 2016-17

RCN group	% RCN	Kernel recovery (%) - quality of kernels					
		GK	Brn P	S K	BS	FS	OK
Healthy nuts	71.44	55.59	8.67	1.79	0.44	4.81	0.15
Thrips (G1)	19.45	13.62	3.90	0.91	0.15	0.87	0.00
Thrips (G2)	1.31	0.80	0.22	0.29	0.00	0.00	0.00
Thrips (G3)	0.18	0.00	0.04	0.15	0.00	0.00	0.00
Thrips (G4)	0.15	0.07	0.00	0.07	0.00	0.00	0.00
ANB (A1)	5.03	3.61	0.66	0.36	0.00	0.40	0.00
ANB (A2)	0.26	0.18	0.00	0.04	0.00	0.00	0.04
ANB (A3)	0.55	0.15	0.00	0.15	0.04	0.22	0.00
TMB	1.02	0.66	0.22	0.11	0.00	0.00	0.04
Other Infested	0.62	0.26	0.00	0.00	0.00	0.36	0.00

GK- Good kernels, BP- Brown Patches, SK- Shriveled Kernels, BS- Black Spot, FS- Fully Spoiled

Table 4: Correlation analysis of insect infestation with good kernel recovery (2017-18)

Nuts	'Good kernel recovery (r value)
Thrips infestation G1	0.87
Thrips infestation G2	0.89
Thrips G3 & G4	0.25
ANB infestation A1 & A2	0.98
ANB infestation A3	-0.44
TMB	0.87

Highly significant positive correlation of nut characters (weight, length, width and thickness) with kernel weight was recorded (Table 5).

Analysis on thrips infested nuts indicated that reduction in nut length to a tune of 0.35-0.61% in G1 nuts and 2.6-18.13% in G4 nuts has been recorded compared to its corresponding healthy nuts of different cashew varieties.

Similarly, a reduction up to 8.20% of nut width and 6.97% of nut thickness has been recorded in G4 nuts compared to the healthy nuts (Table 6).

Table 5: Correlation between RCN parameters with corresponding kernel weight

Cashewnut parameters (N=200*)	Kernel weight (r value)
Nut weight	0.80**
Nut length	0.71**
Nut width	0.65**
Nut thickness	0.44**

Table 6: Changes in RCN parameters due to thrips infestation

Thrips infestation	Percent reduction compared to corresponding healthy nuts *		
	Nut length	Nut width	Nut thickness
G1	0.35-0.61	0.6-1.04	0.31-1.82
G2	1.22-3.62	0.25-2.76	1.12-2.50
G3	1.77-13.82	1.23-5.54	2.42-5.15
G4	2.6-18.13	3.63-8.20	3.19-6.97

** - Significant at 0.01%, * Random samples (N= 120, 50, 20 and 20 for G1, G2, G3 and G4)

This indicates that reduction in kernel weight is possible in thrips infested nuts as there is a significant positive correlation with nut characteristics and kernel weight. In Australia, compared with undamaged nuts, 17–32% reduction in the weight of the raw cashewnuts and 35–53% reduction in kernel weight have been recorded in the nuts having more than 51% of the nut surface damaged by thrips [10]. According to Raman [11], pest attack by tea mosquito bug and thrips on cashew not only caused considerable reduction in the size of nuts and kernels but also resulted in low white whole recovery, more kernel pieces and rejects. Reduction in nutritional quality and palatability in pest infested nuts has also been reported [11]. The present study emphasizes on further study on influence of these pest damages on nutritional and other biochemical quality of kernels.

Conclusion

Insect infestations on RCN were mainly due to TMB, thrips and apple and nut borers. Among the phenological stages of nuts, 619, 711 and 713 were highly vulnerable pests, and the infested tender nuts dried and fell prematurely. Higher good kernel recovery was recorded for early and mid-season harvested nuts compared to late harvest. Presence of shrivels, brown patches, black spots also on kernels of healthy raw cashewnuts indicated involvement of factors other than insects in causing those defective symptoms. Good kernel recovery was very less in G3, G4 and A3 nuts which may be segregated before processing for better cost economics. As there is reduction in nut parameters observed due to thrips infestation, influence of thrips damage on other physical and biochemical quality of kernels invites further study.

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