quarantine measures and so on might have played their role in producing the outbreak levels of coconut mite experienced slightly over ten years ago. Nevertheless, the coconut mite was first reported in India, at high population levels in the late 1990´s (Sathiamma *et al*., 1998). The degree of damage incurred and consequent economic loss in tune of several crores of rupees created by the mite during this period will remain as 'black days' in the history of coconut cultivation in Kerala, in which 80–90% of palms were seriously affected (Hameed Khan *et al*., 2003).

Mite colonization

Button/nut invasion by the coconut mite and the consequent deleterious effects favouring nut all, husk damage and reduction in nut size leading to yield loss have been studied by different authors (Mariau, 1977; Rethinam, 2003; Haq, 2007). Once a migrating mite finds a button of suitable age, it enters through the gap between tepals and button to reach the meristematic area. Development of the coconut mite from egg to adult has been estimated to take 8–10 days. Each fruit is usually colonized by more than a single mite. Symptoms of mite attack may only show up after some time of the initiation of the colonization, while the population is increasing under the tepals. During the growth phase of a nut, varying levels of mite populations can be observed, according to the age of the nut, time of initial colonization, climatic condition, presence of natural enemies and adopted control practices. The effect of continuous feeding by colony members produces the initial triangular creamy white patches extending beyond the tepals. The patched area then evolves to present longitudinal streaks, fissures and cracks while withering and becoming progressively larger.

Nature of Damage

The mites infest and develop on the meristematic tissues of growing nuts under the perianth by desapping the soft tissues. Initial symptoms appear in the form of small, pale white or yellow, inverted triangular patches just below the perianth. As the feeding activity increases, it results in physical damage leading to necrosis. In the severely damaged condition, brown patches appear. As the nuts mature, longitudinal fissures and splits occur on the outer surface of the husk. Occasionally, brownish gummy exudate oozes out from the fissures of the nuts. Severe infestation leads to malformed nuts with hardened husk, resulting in reduced copra and fibre yield. Mites occur in large number in two to six months old buttons. Palms of all ages and nut colour are affected by this mite. All the coconut varieties/germplasms are susceptible to this mite. In the severely infested nuts, the husk becomes thick and hardened, making dehusking difficult, besides drastic reduction in fibre yield. The quantity of reducing sugars and the acidity content were very low in the highly damaged nuts. The peroxidase value was found to be high in severely damaged nuts indicating that such nuts become quickly rancid. There was drastic reduction in both quality and quantity of coir.

Nut fall

Development of nuts to a minimum stage in which they can be used for human consumption requires at least 4–6 months. This duration has been found to coincide with the time when coconut mite population is near its peak. Premature nut fall is quite common, deserving special attention in terms of control strategies (Haq & Sumangala, 2001). Early nut fall irrespective of mite invasion was observed in the first few weeks, but in the case of uninfested nuts it soon ceased. However, infested nuts continued to fall up to 20–25 weeks. In extreme cases, nuts of various age groups fall at the same time from the same tree, because of water stress, mite attack or both. The result of the study on pattern of nut fall in infested and uninfested palms revealed maximum nut fall of about 47 - 70%, meaning heavy economic loss in Kerala. (*pers. comm.* from C.P.R Nair, Coconut Research Institute, Kayamkulam, Kerala).

Husk damage, nut malformation and fiber loss

For coconut growers, coconut husk is considered a precious item because of its several uses. The most important of these is coir production. Reduction of nut size, associated with nut malformation, very often lead to the need to discard husks, as they fetch no market value. In addition to this, husks of nuts attacked by the coconut mite firmly adhere to the mesocarp, requiring extra time and labour for de-husking. Thus, the husks of severely infested nuts are most often sold at very low prices, to be used as plant growing substrate, mulching or firewood. Mite feeding effects often appeared to be expressed as symptoms.

Reduction of copra weight and oil content

Nut fall and husk damage caused by the coconut mite is readily visible. However, reduction in copra weight and oil content cannot be detected until the crop is harvested and nuts are opened. The economic sustainability of the coconut plantation is largely determined by the production of kernels of good quality. In its early stage of development, the kernel is soft and fragile. On progressive development, it becomes more consistent, more nutritious and with increased oil content (Anonymous, 1950). Mite attack leading to reduced nut development, a common feature throughout Kerala, has a direct impact on copra weight and oil content. The nut shell is a hard protective structure to the soft inner kernel, which is not directly affected by the coconut mite. However, it may be morphologically and physiologically altered, deformed, smaller and of reduced quality depending on the intensity of mite attack. Copra processing and coconut oil extracting industries have reported considerable reduction in productivity due to mite attack in Kerala. Copra dealers of North Malabar estimate that copra production dropped from 18–20 to 10–12 kg per 100 nuts after the coconut mite upsurge at the end of the 1990´s. Weight loss of copra was reported by Haq & Sobha (2010).

3. Commercial Impact of the Mite

As in the case of any other fruit, the external appearance of coconut has crucial importance in the commercialization of tender nuts, but not of mature nuts, provided the external appearance does not affect other qualities of the latter. Tender coconuts and kernels are largely used as fresh food items and mite attack on tender coconuts make them not acceptable by consumers, resulting in considerable economic loss. Yield reduction of 67.2% due to intense early and late nut fall (Haq & Sumangala, 2001) has been recorded in Kerala. This has greatly discouraged marginal level farmers from following farm management practices. Such situation eventually led to the reduction of the income

of thousands of small and marginal farmers (Haq, 2007). The most crucial aspect of mite attack has been attributed to the loss in copra weight, estimated to almost reach 32% (Haq & Sobha, 2010); however, the impact on oil production has not been assessed. In addition, losses due to husk damage has been estimated at 41.74%, particularly because of the reduction of fiber length by 26–53% and the consequent extra cost for de-husking (Muralidharan *et al*., 2001; Beevi *et al*., 2003). Fibers become thin, shorter and with reduced tensile strength, hence unacceptable to coir industry. Husk malformation induces further economic loss. Normally, the husks of 100 mature un-infested nuts may yield 9–10 kg of fibers, whereas the same number of infested nuts usually yields not more than 6–7 kg. Several phases of coconut production have been greatly affected by the coconut mite. It has led to the closure of most of the coir factories and coconut based industries in Kerala. This has greatly affected the people of this state, as these industries have served for the sustenance of a considerable part of the population. India used to be a major exporter of copra, desiccated coconut, coconut oil, oil cake, shell products, coir and coir products. These activities earned around 3 to 4 billion rupees (ca. 65 to 85 million US dollars) through export of a wide range of products in 2000–2001 (Singh, 2003). Although more recent data are not available, it is believed that earning reduced drastically, due to the current attack of the coconut mite.

4. Future of Coconut Mite and Coconut in India

As the largest single market for coconut, India consumes 12.6 billion nuts per year, corresponding to about 74% of its national production (Rethinam, 2003). The upsurge of the coconut mite from the end of the 1990´s marked the beginning of a tragic era in the history of the coconut cultivation in the state of Kerala. The attack of the mite to the most vulnerable part of the coconut plant, i.e., the meristematic tissue of the nut, makes it a peculiarly relevant pest. Various chemical control measures practiced in the state were encouraging to some extent in the beginning, but soon they proved to be unsatisfactory. Limitations for such a drawback include usually the high cost involved, difficulty in the application of chemicals (because of the size of most coconut palms), potential environmental hazards and toxic effects to human beings. Attempts to reduce part of those problems, through root feeding and stem injection of synthetic pesticides, were reported by farmers to cause severe reduction in nut yield (Mallik *et al*., 2003). The use of bio-pesticides, including fungal formulations, reported as promising by some researchers (Nair *et al*., 2002; Kannaiyan *et al*., 2002), also requires repeated application. All the above would suggest that formulation of a low cost IPM programme would be more successful biological control measure, as in any other case, seems a possible means for effective and long lasting effects. Incidence and invasion of the mite is a significant happening to Kerala, where coconut is a major crop and more than 50% of the population depend on them for their livelihood.

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