Immature nutfall of coconut in India: An overview

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Immature nutfall in coconut has been observed as a serious problem in almost all parts of Kerala state and the intensity is found to increase year by year. The characteristic feature of mother palm is one of the prime reasons for button shedding in coconut. Even in well-maintained coconut gardens, there was heavy button shedding and immature nutfall.

The coconut palm is susceptible to a number of diseases and pests. Some of them are fatal while others reduce its vigour and finally resulting in economic loss. It has been reported that 830 insects and mites, 173 fungi and 38 nematodes are associated with coconut (Koshy, 1999). But only a few of them cause any serious damage to the crop. Root (wilt), leaf rot, stem bleeding, basal stem rot and bud rot are the major diseases that affect coconut palms in India. Red palm weevil, rhinoceros beetle, leaf eating caterpillar, rats and eriophyid mite are the major pests of coconut in India. Immature nutfall in coconut has been observed as a serious problem in almost all parts of Kerala state and the intensity is found to increase year by year. The research findings of last several years revealed that immature nutfall occurs due to several factors (Menon and Pandali, 1958; Sudhakara, 1990; Karunanithi, *et al.*, 2002; ChandraMohanan and Baby, 2004).

1. Genetic causes

Genetic variability is one of the causes of button shedding. Shedding of buttons varied from 55 to 95% depending on the prevailing climatic conditions and variety (Menon and Pandalai, 1958). It was reported that shedding was comparatively more severe in dwarf palms than tall ones. Shedding was high in Fiji and Cochin China varieties and less in Ceylon and Philippine varieties. Shedding in the ordinary tall variety was fairly low and almost at par with that of laccadive and Andaman varieties. There was also variation in the shedding of buttons from year to year even in the same variety. Studies conducted at Central Plantation Crops Research Institute, Kasargod during the year 1986-87 on 15 palms of Chowghat orange dwarf (COD) x West Cost Tall (WCT) and WCT showed that under rain fed condition the percentage of button shedding was 91% in the hybrid, COD x WCT as against 73% in WCT. When irrigated WCT had only 63% shedding. In all cases most of the shedding of buttons or female flowers takes place during the first three months after the opening of the inflorescence (Anonymous, 1988b).

The characteristic feature of mother palm is one of the prime reasons for button shedding in coconut. It has been reported that even in well-maintained coconut gardens, there was heavy button shedding and immature nutfall. It was found to be due to the poor nut yielding capacity or lesser setting of buttons into nuts of the mother palms. Hence, the selection of good yielding mother palms is very important for collection of seed nuts for raising coconut seedlings (Karunanithi *et al.*, 2002).

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2. Poor pollination

Preliminary investigations on this aspect were carried out long back in Sri Lanka by Petch (1913). In Tanzania, Welsford (1926) reported that button shedding was due to the failure of fertilization caused by the abortion of carpel in the female flowers. Patel (1938) observed that artificial pollination did not minimize shedding. Trials conducted at Pilicode, Kerala during 1942-47 showed that the maximum number of buttons shed were those in which all cells were distinct (Anonymous, 1947b). Shedding was low for buttons with one- celled and two – celled ovaries and negligible for buttons without any cells developed (Sudhakara, 1990). Poor pollination is also one of the major factors responsible for the button shedding in coconut. It has been found to cause lesser rate of setting of buttons into nuts (Karunanithi *et al.*, 2002).

3. Physiological factors

Dropping of buttons or the pistillate flowers before and after fertilization is a common feature in coconuts. However, an abnormal shedding of a large number of buttons might be due to fungal infections or physiological or even environmental factors (Gadd, 1923). It has been also reported that when the growth was arrested due to dry or water logged condition, physiological drought was brought about due to hypodermal thickening up to the root cap reducing the area of absorption of nutrients from the soil (Gadd, 1923). Briton Jones (1940) found that shedding of nuts could be the result of external manifestation of the internal physiological redistribution of substances within the plant. Child (1950) believed that nutfall was a natural phenomenon and shedding was a natural outcome of weakness of the bunch stalk for want of mechanical support in the tissue. Menon and Pandalai (1960) also held the view that shedding of immature nuts occurred when the fruits were almost fully grown but before the kernel or meat had begun to form. Shedding of buttons was also believed to be due to abscission as an outcome of physiological cause happening in the trees (Gadd, 1923; Briton - Jones, 1940 and Child, 1950). Carlos *et al.* (1970) found that the fruit abscissed at the base of the perianth lobe during the early stage of its development and at the base of the ovary during later stages. Two peaks were observed for fruit abscission and growth rate with the latter always preceding the former by 1-2 weeks (Carlos *et al.*, 1970 and Mendoza, 1970). Child (1974) used the term abnormal nutfall to describe a similar phenomenon characterized by a significant fall of nuts by the end of fourth month after the opening of spathe.

4. Plant growth regulators

Coconut trees sprayed with synthetic substances continuously without annual application of manure have shown general depressing effect on production of female flowers in succeeding years due to over-bearing (Anonymous, 1960). Karunanithi *et al.* (2002) reported that plant growth regulators were highly essential for the development of fertilized female flowers into nuts. In some coconut trees, the production of plant growth regulators was below optimal and in such plants, the nutfall was high when compared to other plants.

5. Drought, Water logging and Soil factors

Stockdale (1921) has reported serious nutfall in Sri Lanka when there was excessive rainfall. Gadd (1922) had shown from an account of button shed from January to April that as a result of drought, there was an increase in the number of buttons shed during March and April. Water deficiency affected not only setting of nuts in coconut plantations but also resulted in severe shedding of nuts especially after unusually prolonged period of drought and particularly after the onset of first rains in Sri Lanka. Coconut tree requires about 60 to 80 litres of water per day. Irrigation during summer months was found to be highly essential to reduce the button shedding in coconut (Gadd, 1923). Patel (1938) reported that there was no relationship between shedding of buttons and rainfall or drought. Abeywardena and Mathes (1971) reported that the pollinated flowers, in the early stage of development are highly susceptible to adverse influences like entomological and pathological agents and moisture stress resulting in their shedding as immature nuts. They also found that sudden alternation in soil moisture also leads to heavy button shedding and immature nutfall in coconut. A general increase was however observed in button abscission either when the available soil moisture greatly decreased or excessively increased (Gadaingan, 1971). Anunciado (1974) reported that shedding of button occurred not only when there was deficit in moisture but also during the wettest times of the year. Excessive moisture or water logging condition in the coconut garden was also found to be

associated with nutfall (Ohler, 1984). According to Prasad Rao (1988) if the intensity of rainfall is high, the button shedding is also high, probably due to lack of pollen and pollinating agent during heavy rain as well as due to water logging in coconut gardens leading to physiological drought. Karunanithi *et al.* (2002) observed high percentage of button shedding and immature nutfall when the soil acidity or alkalinity was high. They also found heavy button shedding when there was drought condition or water shortage for a longer period.

6. Nutritional deficiency

A comparative analysis of the problems in various parts of Indo-China (Gadd, 1923) led to the conclusion that the fundamental cause of the button shedding was insufficient nourishment of roots and could be remedied by the application of the nitrogenous manures. But later observations in this aspect in Sri Lanka by Gadd (1923) were found to be contradictory. He found that even plots which were regularly and liberally manured had nut shedding and shedding was comparatively less in plots which rarely received any manurial treatment. Patel (1938) found that shedding of button was more severe in heavy soils than in lighter soils. Field trials conducted at Kasargod and Pilicode(Kerala state) retaining only one bunch and removing rest were conducted with the objective of making available more plant food for the development of all the female flowers in that bunch into nuts. Though the data at Kasargod showed a significant increase in the setting percentage due to the retention of only one bunch, the result did not show significant difference at Pilicode (Anonymous, 1942 a, 1942 b). The fertilizer trial conducted in Sri Lanka and Jamaica revealed that K deficiency could reduce the percentage of flowers reaching maturity (Smith, 1969). He also found high level of N increased the production of female flowers and the percentage of setting was reduced.

7. Infestation by insects

The view that shedding of buttons is due to the attack of pests was first advanced from the British Solomon Islands (Dwyer, 1937). Nair and Abraham (1993) reported cumulative nutfall in coconut due to 24 hours nymphal feeding of coreid bug. Recent outbreak of eriophyid mite (*Aceria guerreonis* Keifer) has caused severe loss to the coconut farmers by means of immature nutfall and poor nut development. This can be considered as the only serious pest directly infesting the nut causing direct loss in yield. The first occurrence of eriophyid mite was reported from Mexico in 1960 (Julia and Marian, 1979). Further, the mite was reported from South America and neighboring few islands by Doreste (1968). The fast spread of the pest was reported between 1977 and 1984 by Mariau (1977), Hall and Espinosa (1981) and Griffith (1984). The pest was reported from Tanzania in 1980 (Seguni, 2000). In Sri Lanka the pest occurrence almost coincided with that of India. This notorious pest on coconut was first reported from Ernakulam district of Kerala state in India (Sathiamma *et al.*, 1998). This was the first report on mite from the Asiatic region. The mite has assumed severe proportion subsequently and known to cause considerable crop loss in Kerala, Tamil Nadu, Karnataka, Pondicherry and parts of Andhra Pradesh, Lakshadweep and Goa (Sathiamma *et al.*, 1998; Vidyasagar, 2000).

Eriophyid mites are microscopic having an elongated worm-like body. The mite takes about 7 to 10 days to complete its life cycle. Under favorable conditions, they multiply and spread rapidly. The dispersal of pest is mainly through the wind. Honey bees and other insects visiting inflorescence of coconut could also act as agents for dispersal of mites. The female mite lays about 200 eggs on an average. Various stages of the mites are seen in the floral bracts and the tender portion of developing nuts covered by the perianth. Colonies of the mite harbour in large numbers in immature nuts of 1 to 5 months growth (Sathiamma *et al.*, 1998).

The mite sucks the sap from meristamatic tissues under the perianth. The infestation by the mite follows immediately after the pollination. Appearance of elongated white streaks below the perianth is the first external manifestation of mite infestation on young buttons. Further these white streaks forms triangular yellow patches. As the nuts grow, warts and longitudinal fissures appear on the nut surface. Severe infestation causes shedding of buttons or malformation of nuts as a result of retarded growth. When the infestation is high in early stages of development, button shedding is also heavy. The sucking of sap from immature nuts results in undersized and malformed nuts with less kernel and thin and hard husk causing heavy loss to coconut cultivators as well as coir industry(Nair *et al.*, 2005).

The population dynamics of

Aceria guerreonis has been studied by various researchers. Griffith (1984) reported that mite attack was more severe during dry climate.

Mariau (1977) observed that drought situation aggravated the mite incidence. In India, the pest activity has been observed throughout the year with a population peak during summer months (Nampoothiri *et al.*, 2002). Studies of Kerala coast revealed that a period of high temperature with intermittent rains causing high humidity favoured higher multiplication and spread of mite (Nair *et al.*, 2003). Ranjith *et al.* (2001) reported that the maximum mite population could be observed on the third and fourth bunches from the first fully opened flower bunch of the palm. Observation on the populations within various age groups of nuts showed that five months old nuts lodged the highest population of mites and in older age group of nuts the population showed declining tendency(Mallik *et al.*, 2003). Mite infestation some times leads to immature nutfall.

8. Fungal infection

The main symptom of this disease is rotting of immature nuts. The infection initiates as a discolored area near the region of attachment of nut to the rachilla and the lesion become water soaked. As the lesion enlarges nuts fall down. Later on, lesions turn brownish in color and the tissue decays very fast especially under humid condition. In the early days, button shedding was thought to be primarily due to the infestation of flowers with different fungi and insect pests (Due point, 1924 & 1931 and Dwyer, 1937). Since the affected part is the fruit, the incidence causes considerable and direct loss in yield

Fruit rot and subsequent nutfall are associated symptoms of several diseases affecting the palm. Johnston (1965) reported that in the incipient stages of bud rot, the falling of immature nuts, staining of the flowers, spikes and the dying and falling over of the undeveloped middle whorl of leaves were common features. Rotting is the conspicuous symptom of fungal infection in immature nuts.

a. *Phytophthora* sp.

Nutfall or 'Mahali' disease has been reported from Sri Lanka by Gadd, (1922) and from northern Kerala in India by Sundararaman and Ramakrishnan (1924). In Kerala the disease occurs only during the south - west monsoon period from June to September. *Phytophthora palmivora* was reported as the causal organism. This disease is characterized by decaying of immature nuts and their fall during rainy season. Water soaked grayish green area develops at the stalk end of the nuts against dark green healthy area around. The lesion development is fast at the stalk end of the nut. The lesions later turn brown and become sunken due to the decay of underlying tissues. The rot extends into the husk and sometimes deep into the endosperm cavity if the shell is not hardened (Menon and Pandalai, 1960; Nambiar, 1994). Petch (1917) and Dwyer (1937) were of the view that 'leaf droop' and 'nutfall' were different manifestations of the *Phytophthora* infection. The infection appeared on very tender tissues in the presence of moisture, under humid condition; the pathogen penetrated the fluid through mesocarp and ramified in that region. Consequently, decay started in the tissues of the host leading to shedding of the nuts (Nambiar, 1994).

The pathogen is active during rainy season and survives in fruit stalk during dry weather, making itself manifest with the onset of favorable condition (Menon and Pandalai, 1960). The disease can be effectively prevented by giving a prophylactic spray with 1 per cent Bordeaux mixture during pre-monsoon period. Sometimes when rainfall is heavy and continuous, a post-monsoon spray will be required. Adoption of phytosanitation measures regular plant protection, cultural practices and fertilizer applications help to prevent the disease incidence (Nambiar, 1994). Bud rot and premature nutfall caused by *Phytophthora* species (mainly *P.palmivora*) are the major disease problem affecting Indonesia and account for extensive losses of both stands and nut production (Bennet *et al.*, 1985). The causal organism of bud rot and premature nutfall of coconut in Cote d' Ivoria has been reported as *Phytophthora katsurae*. *P. katsurae* is also reported to cause fruit rot and heart rot of coconut in Jamaica (Steer and Coates-Beckford, 1990) and Hawaii (Ooka and Uchida, 1984; Uchida *et al.*, 1992).

b. *Lasiodiplodia theobromae* (Pat.) Griffon and Maubl. (*Botryodiplodia theobromae*)

According to Simmonds (1924) shedding of button was associated with the infestation of fungus, *Botryodiplodia* in India (Sundararaman and Ramakrishnan, 1924) and in Philippines (Teodoro, 1925). Fruit rot is observed

frequently in every country where coconut is grown. It has been reported from India (Sundararaman and Ramakrishnan, 1924), Malaysia (Turner, 1963), Colombia (Sanchez Poter, 1966) and Indonesia (Bennet *et al.*, 1986). *Botryodiplodia theobromae* has been reported as a ubiquitous pathogen. Its presence in root of coconut was reported by Menon and Pandalai (1958). Fruit rot caused by this fungus has also been recorded from Brazil, Brunii, Indonesia and Vietnam (Johnston, 1965). Gunasekaran and Srinivasan, (2000) reported the rare occurrence of immature nut fall caused by *Lasiodiplodia theobromae* (*Botryodiplodia theobromae*) in some location in Alappuzha district of Kerala.

Prevalence pattern of immature nutfall and fruitrot in coconut was sparse, less than one percent during 2002 in Kerala. The affected nuts generally presented dry rot symptoms with occasional mummification of infected nuts. The samples collected from disease affected palms yielded *Lasiodiplodia theobromae.* Consistent association of the fungus with fruit was noticed. The Pathogenicity of .*Lasiodiplodia theobromae* has been confirmed by inoculation of immature nuts and reisolation of fungus from inoculated nuts. (Venugopal, 2008). ChandraMohanan and Baby (2004) reported eriophyid mite injury on coconut provides entry points for pathogenic fungi causing rotting and nutfall. Even slight injury due to mite paves way for the pathogen to enter the tissue and cause severe rotting. The rotting starts from the point of mite infestation on the nut surface near the perianth as dark brown to black discoloration. The lesion spreads deep into the internal tissue. When the lesions encircle the perianth or cover 30 percent of the surface area near the perianth region, the nuts get detached from the bunch and shed or remain on the bunch in between other nuts. Mite attack followed by rotting of nuts was noticed in different varieties.

Lakshmanan and Jagadeesan (2004) reported malformation and cracking of nuts in coconut palms due to the interaction of eriophyid mite, *Aceria guerreronis* and *L theobromae* in coconut plantations in Tamil Nadu, India. The fungus produced typical symptoms such as malformation and cracking in the presence of eriophyid mite infestation. The alarming damage in coconut might be due to secondary infection of *L theobromae.* Bernardo *et al.* (2005) reported the incidence of *L. theobromae* causing coconut rot and fall in Roramia, Brazil.

Venugopal and Chandramohanan (2006) reported that the incidence of fruit rot and immature nutfall due to *L.theobromae* was on the increase in southern districts of Kerala state, India, ever since the intensity of eriophyid mite (*A. guerreronis*) infestation increased in this part of the country. Hence, nut samples were collected from 8 southern districts of Kerala state and studies were undertaken to find out the role of fungi in fruit rot of mite infested coconut. Out of 577 samples of coconuts at various stages of development, button to mature nuts, collected from different locations, 445 samples yielded fungi *L. theobromae* Pat., a wound pathogen was found to be the major fungus causing fruit rot and immature nut fall in coconut. The fungus enters the tissue through wounds caused by eriophyid mite in the soft tissue beneath perianth. When nearly mature /mature nuts were infected the infection spread internally into mesocarp without any external lesion or with a minute lesion on the husk surface. Infection in mature nuts continued to spread internally during storage causing rotting of kernel. Fruit rot caused by *L. theobromae* was found throughout the year in Kerala state. *Thielaviopsis paradoxa, Colletotrichum gleosporioides*, and *Fusarium* sp. were also isolated from the lesions on few samples of tender nuts. But, they were reported as only minor pathogens associated with rotting of young nuts Venugopal (2008). Considering the importance of fruit rot caused by *L.theobromae* Venugopal, (2008) has conducted detailed investigation on the diversity of the pathogen, varietal susceptibility, epidemiology and disease management.

d. Other fungi associated with rotting and nutfall

Sulladmath and Shantappa (1979) reported *Botryosphaeria rhodina* (Berk and Curt.) V. Arx as the causal organism of immature nutfall of coconut in Karnataka state. It was observed as a minor problem. Isolations made from shed buttons collected in nets revealed the presence of fungi like *Aspergillus, Penicillium, Phytophthora* sp., *Fusarium* sp.,*Choanephora sp.* and *Pestalotia* sp. (Anonymous,1988 b). Karthikeyan and Bhaskaran (1996) conducted a study at Coconut Research Station, Veppankulam, Tamil Nadu, India to assess the extent of button shedding and premature nutfall due to infection by pathogen. From the shed buttons and

immature nuts of coconuts, three fungi viz., *Aspergillus* sp., *Penicillium* sp., and *C. hawaiiensis* were isolated. *Aspergillus* sp and *Penicillium* sp failed to infect either the shed buttons or immature nuts and buttons in coconut bunches. *Cochlibolus hawaiiensis* Alcorn was recorded for first time in India in coconut (Karthikeyan and Bhaskaran, 1996). *Ganoderma lucidum* (Bhaskaran *et al.*, 1989) and *G. boninense* (Ohler, 1984) infection of coconut palm also cause button shedding.

Based on the research results of several years from different parts of the country the following pests and diseases which need timely management practices can be attributed as the major reason for immature nutfall of coconut 1) *Phytophthora* fruit rot 2) *L.theobromae* infection of nuts of different age groups and 3) Eriophyid mite infestation.

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