INFESTATION PATTERNS OF THE COCONUT MITE (*Eriophyes guerreronis*) AND RESULTING YIELD LOSS IN THE SOUTH WESTERN REGION OF BANGLADESH

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DEDICATED TO

MY BELOVED PARENTS

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ABSTRACT

A study on infestation patterns of the coconut mite on coconuts and resulting yield loss in the south western region of Bangladesh was carried out during the period from April, 2011 to February, 2012. Coconut was collected randomly from Khulna, Satkhira and Bagherhat districts of Bangladesh and graded into five categories. Three fruits were collected from each grade. After this subsequent operation was done in Germplasm Centre and Molicular Horticulture Laboratory of Agrotechnology Discipline, Khulna University, Khulna. The factorial experiment was laid out in Completely Randomized Design with three replications. The experimental treatments consisted of three locations (L_1= Khulna, L_2 = Bagherhat and L_3 = Satkhira); two varieties (V_1= Green and V_2= Brown) and five grades on the basis of mite infestation which are G_0 = nuts with no mite damage, G_1 = nuts with 1-29% surface area damage, G_2 = nuts with 30-59% surface area damage and less than 20% reduction in size, G_3 = nuts with 60-80% surface area damage, 20-30% reduction in size and G_4 = nuts with over 80% surface area damage with 30% reduction and often greatly deformed. The data on fresh weight (g), length (cm), equatorial circumference (cm) of fruit, kernel length (cm), kernel equatorial circumference (cm), kernel weight with water (g), kernel weight without water (g), copra weight (g), dry weight of copra (g), moisture (%) and yield loss have been studied. From the study it was found that most of the cases highest values were recorded from G_0 and the lowest values were recorded from G_4. It was found that the dry weight of copra was significantly varied among the different grades. The highest dry weight (164.33g) was recorded from G_0 and the lowest (386.94g) from G_4. Variety was not significantly varied due to mite infestation. Among the location, the fruits collected from Khulna and Satkhira gave highest values and the lowest value was recorded from the fruits of Bagherhat districts. From the experiment it was found that water loss was observed about 0, 5.5, 34.19, 50 and 62.59% in damage categories G_0, G_1, G_2, G_3 and G_4, respectively. For the copra yield considerable loss was occurred that ware 0, 13.22, 24.90, 38.00 and 52.72% in damage categories G_0, G_1, G_2, G_3 and G_4, respectively. Observed coconut shell losses were 0, 7.28, 15.32, 24.42, and 37.17% corresponding to damage categories G_0, G_1, G_2, G_3 and G_4, respectively. Due to mite infestation about 37.17% coconut shell loss, 62.59% water loss and 52.72% copra yield loss was occurred when nuts with over 80% surface area damaged with 30% reduction of size.

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of the land has great influence on the growth of the palm. The major soil types that support coconut in India are alluvial, red sandy loam, costal sandy and reclaimed soils with a pH ranging from 5.2 to 8.0 (Singh, 1993).

It is a tree that is about 60 to 90 feet high. Stem is thick measuring about 1 to 2 feet. It is light brownish in color. It has a roundish scar marks on the bark and trunk. Leaves are about 8 to 20 feet in length. Leaflets are 2 to 3 feet in length having spear shape. Spadix is distinctly seen. Having female part at the lower end and male at the upper end. Fruit is ovate in shape having a triangular base. It is 10 to 15 inch in length. Its outer skin is very hard and inside its contained fluid. Its flowers in summer and fruits in late summer (Singh, 1993).

The fleshly derived fruits contain fleshy substance, fatty acids, lignin, alkaloids, and certain non organic substances. The mild derived from the fruits contains glucose, sticky substance albumin, tartaric acids, certain minerals and water. Ash of the leaves contains potassium. Oil contains lauric, miristic, palmitic and stireic acids and besides these it contains caprilic acid. Ripe fruit contains about 60 to 71 % of oil. Also contain various compositions from raw coconut such as water 92.32%, total solid matter 7.32%, glucose 5.5%, protein 0.62%, chlorides 0.55% and from ripe coconut such as water 91.28%, glucose 4.82%, sucrose 1.11%, chlorides 0.86%, protein 0.59%. Besides, these contain vitamins A and B (Foale, 2003).

Coconut industry in Bangladesh is mainly confined to traditional activities such as copra making, oil extraction and coir manufacturing and, toddy tapping. Products such as desiccated coconut, coconut based handicrafts; shell powder, shell charcoal and shell based activated carbon are also manufactured in the country on a limited scale. Coconut is a fabulous creation of the world. It has exclusive food value as well as curative properties. All plant parts from root to leaf have numerous usages. It shows decorative properties in the sea beaches increasing its aesthetic value which attracts the visitors as well as tourist from abroad. Its valuable properties have made the fruit as 'white gold' and its greenish view have made a 'green world' (Pearsall, 1999).

much reduced prices and in some cases; labor cost will exceed the income from sales (personal communication with farmers). 'Jelly coconuts' are often marketed locally for the liquid and the tender endosperms in these nuts.

Copra, the dehydrated endosperm of more mature coconuts, is the major coconut export product of most coconut producing countries. Estimated losses in copra yields resulting from coconut mite damage have ranged from 10% in Benin (Mariau and Julia, 1970), 16% in the Ivory Coast (Julia and Mariau, 1979), 20-30% in St. Lucia (Moore *et al.*, 1989), 25% in Grenada (Hall, 1981) and 30- 80% in different areas of Mexico (Hall, 1981; Olvera-Fonseca, 1986). Julia and Mariau (1979) and Moore *et al.* (1989) found copra yield to decline with increasing severity of damage caused by the coconut mite. Mariau and Julia (1970) developed a method to visually estimate the amount of coconut mite damage to nuts. Their visual assessment technique was later modified by Moore *et al.* (1989).

The south-western coastal region of Bangladesh is very much suitable for coconut cultivation. But now the production and quality of coconut decreased due to spot on the fruits of coconut due to mite infestation and dropping of immature fruits. At present the yield of coconut in this region is very low only 40 - 50 per plant per year, which is very low in comparison to India and Sri Lanka (300-400). So, it is very urgent to solve the problem of fruit drop and spot on fruit of coconut due to mite. It will help to assess the extent of damage and loss of yield and quality due to mite infestation in different locations and different varieties of coconut and it will help to increase the quality and production of coconut in this region as well as the country.
Under the above circumstances the present study has been undertaken to fulfill the following objectives.

- To assess the extent of coconut mite damage on coconut plants of different location and varieties in the southwestern region of Bangladesh
- To determine the yield losses of coconut due to mite infestation

CHAPTER II

Literature Review

There is a great paucity of information on the biology and management of the coconut mite, and the information that exists is incomplete (Keifer *et al.*, 1982). The present review was written to organize the available literature on the coconut mite and the coconut industry.

2.1 The coconut tree

Cocos nucifera Beccari or coconut belongs to the palm family, Arecaceae (= Palmaceae) which consists of 200 genera and over 2,000 described species (Child, 1974). According to Woodroof (1970) the term coconut is derived from the Spanish and Portuguese word, "coco", which means "monkey/grotesque face", but the plant is known in many countries by local names. For example, it has been known as "naryal" in India for millennia and as "nut of India" by Cosmos, the Egyptian traveler, in AD 545. The tree itself has been described as, "man's most useful tree", "king of the tropical forest", "tree of life", "tree of heaven" and lazyman's crop, inter alia. (Woodroof, 1970).

Coconut varieties fall under two broad groups, Tall or typica and Dwarf or nana. Tall and Dwarf coconut types may hybridize to produce intermediate forms (Woodroof, 1970; Child, 1974). The Tall variety has greater genetic variability as it is usually cross pollinated. The coconut plant is monoecious, producing both male and female flowers. The male flowers are located distally while the female flowers are found proximally on each inflorescence. The type of pollination is determined by the relative maturation times of the male and female flowers. In the Tall varieties the male flowers open before the female flowers, hindering self pollination while, an overlap of the opening phases of male and female flowers in Dwarf plants allows for self pollination and greater tendency toward homozygosity. Coconuts are also named after areas where they are grown long enough to have developed distinctive characteristics, e.g., Panama Tall, West African Tall and Malayan Dwarf (Woodroof, 1970; Child, 1974). Maypan variety is a hybrid of the Malayan Dwarf and Panama Tall varieties (Anonymous, 1973).

The traditional commercial coconuts were the Tall varieties which were preferred above the Dwarf varieties because of the quality and quantity of copra they produce (Woodroof, 1970). They normally live for over 60 years, are adaptable to a wide range of soil conditions, fairly resistant to diseases and water stress, and start to bear within six to ten years. The Dwarf varieties come into within three to four years, attain full production by the ninth year and have a life span of about 30 to 40 years. While they show greater susceptibility to some diseases, the Dwarf varieties exhibit greater resistance than the Talls to some viral diseases, including lethal yellowing (Woodroof, 1970; Child, 1974).

Each coconut inflorescence emerges from the base of a leaf and is approximately 120° around from the previous one. After fertilization of the female flowers, each inflorescence develops into a cluster of fruits called a bunch. Occasionally the spikelet of an inflorescence is in direct contact with the spikelet remnants of an older bunch (Hall, 1981; Moore and Alexander, 1987).

The native habitat for the coconut palm is unknown because coconut is dispersed by water, although human activity could be credited for much of its dispersal (Child, 1974). Of all the cultivated trees in the world, the coconut palm has the widest geographical range (Ghai and Wadhi, 1983). Ninety percent of the world's coconut acreage lies within 20° N and 20° S of the Equator (Woodroof, 1970; Persley, 1992). The crop is best grown within 600 ft. above sea level, with over 1,250 mm rainfall or a high water table on a rich silty loam. Coconut was introduced into the West Indies at the beginning of the 20th Century (Woodroof, 1970; Child, 1974). The main variety was the Panama Tall found in Guyana, Jamaica, St. Lucia, Venezuela, and Trinidad and Tobago. There was also the dwarf variety, with its Yellow, Red (golden), and Green color morphs (Griffith, 1982a).

2.2 Social and economic importance of coconut

The coconut palm and its fruit are regarded as the most important plant to humans around the world (Child, 1974). Among its most important uses coconut is a food source, provides supplement for body fluids and minerals, and acts as an antihelminthic. The liquid endosperm is also a media for in vitro storage of semen and a growth regulator of plants (Woodroof, 1970). Copra, the dehydrated endosperm of the nut, is next to soybean as a source of oil for food. Coconut oil is also used in cosmetics and pharmaceuticals. The material that remains after the oil is expressed from copra is called oilcake and is used as animal feed (Woodroof, 1970). Coconut shell is used directly as fuel, filler, extender in the synthesis of plastic, to make activated charcoal, household articles, and to produce various distillation products, such as tar, wood spirit and pitch. Coir, a course fiber from the husk of the nut, has various domestic and industrial uses. Coconut root is brewed and used in folk medicine, for example, as a cure for dysentery (Woodroof, 1970).

Coconut accounts for a large part of the national earnings of the Asian and Pacific Coconut Communities (APCC) countries. In 1993 the APCC account for 86% of the world's coconut production. Indonesia, the Philippines, and India accounted for 81% of the coconut produced by the fourteen APCC countries in 1993 and 69% of the World's total. In Jamaica, coconut production has fluctuated over the last 50 years, due to several hurricanes and lethal yellowing disease. Maximum copra production was 19,245 metric tons in 1971 but was reduced to 8,540 in 1974 and to insignificant amounts in the late 1970's. Coconut production in Jamaica began to recover in the 1980's. Today over 90% of the coconut produced goes toward domestic use and copra is of secondary importance.

2.3 Pests of coconut

Besides pathogens, there are several invertebrates (nematodes, arthropods etc.) and vertebrates (rats, birds, etc.) which attack various stages of the plant (Lever, 1969; Krantz *et al.*, 1978; Anonymous, 1983). At least 750 insect pests of coconut have been recorded from around the world. These pests attack the leaves, stems, flowers, nuts and roots of the coconut plant. In the Caribbean over 26 major pests have been recorded. Among them are two species of mites, 15 species of insects and three species of rodents.

2.4 The coconut mite

Of all the coconut pests, the coconut mite is the most important one not only in Bangladesh but also all over the world. The very first record of coconut mite injury was in 1928 in New Guinea (Martyn, 1930). The injury was then believed to be due to a disease caused by a complex of fungi and bacteria (Cardona and Potes, 1971). In the early 1960's the coconut mite was discovered and the family identified (Acari:

Eriophyidae) from samples of coconut in Guerrero, Mexico (Ortega *et al.*, 1965) and Santa Marta, Colombia (Cardona and Potes, 1971) during independent research. In 1965 the coconut mite was described and identified as *Aceria guerreronis* Keifer (Ortega *et al.*, 1965) and in 1971 reclassified by Newkirk and Keifer as *Eriophyes guerreronis* (Keifer) (Olvera-Fonseca, 1986).

The coconut mite first achieved pest status in 1960 in Mexico (Cardona and Potes, 1971) followed by Venezuela (1968), Columbia (1969), Trinidad (1975); Puerto Rico (1977), St. Vincent (1981), Grenada and St. Lucia (1982) and Virgin Islands (1985) (Griffith, 1982b, 1984; Medina-Guad and Abreu, 1986). Damage was also seen in several parts of West Africa including Benin, Cameroon, and Nigeria (Griffith, 1982b, 1984; Medina-Guad and Abreu, 1986). Griffith (1984) attributed this rapid spread of the coconut mite to its ability to take advantage of long distance dispersal by wind currents.

In Jamaica, the coconut mite was first recorded in 1941, in St. Ann parish, but not was recognized as a pest until 1972. The Jamaica coconut industry suggested that an extended period of drought might have led to an outbreak of the mite (Hall, 1981).

Mariau (1969) and Otterbein (1988) noted that climate affects the development of coconut mite populations. Coconut plants nearer the Atlantic Ocean showed less coconut mite damage (Mariau, 1969). In Benin and the Ivory Coast, Julia and Mariau (1979) found levels of attack up to five times higher in the wet seasons than in the dry; the reverse was reported from Guerrero, Mexico (Mariau, 1969). Otterbein (1988) reported that in Costa Rica the greatest nut damage was associated with frequent heavy rainfall and high humidity. Howard *et al.* (1990) found that the coconut mite populations increased immediately after periods of high rainfall in Puerto Rico and Florida but noted that coconut mite population's fluctuations were not associated with dry and wet seasons nor with mean daily temperatures.

2.5 Population dynamics and dispersal of the coconut mite

The coconut mite breeds and feeds under the perianth of coconut fruit and are most active outside the perianth during late nights and early mornings (Hall, 1986; Moore and Alexander, 1987). Colonization of coconuts by coconut mites normally takes place within one to six months after fertilization (Moore *et al.*, 1989). Fertilization takes place within the second month of flowering (Child, 1974). Coconut mite populations peak on 3 to 6 month old nuts, after which, the numbers decline sharply. Thus, nuts over nine months old have relatively low populations (Moore and Alexander, 1987). Mite populations are aggregated (Howard *et al.*, 1990) so that peak densities may exceed 1500 mites/cm^2 (Otterbein, 1988) and may reach about 4600 mites per (Malayan dwarf) nut, about 3 to 4 months old (Howard and Rodriguez, 1991).

Coconut mites leave nuts two to three months before the nuts are fully developed or when damage to the pericarp exceeds 15% of the total surface area because there is no renewal of meristematic tissues (Anonymous, 1985). In addition, damaged nut surfaces tend to secrete resin which traps and kills the mites (Moore and Alexander, 1987). Migration may also be density dependent (Griffith, 1984) and dispersal may be short ranged or long ranged. Short range dispersal is aided by water and insects. Rain may wash off mites on to nearby open flowers (Griffith, 1984; Schliesske, 1988). Coconut flowers are cross-pollinated by insects, particularly Hymenoptera, which also help to disperse coconut mites (Otterbein, 1988). Coconut mites may crawl from infested nuts onto uninfected nuts where these nuts are in contact with each other (Griffith, 1984; Schliesske, 1988). Wind currents are the most important means of long range dispersal. This is particularly so in the dry season when populations are high (Griffith, 1984; Otterbein, 1988; Schliesske, 1988).

2.6 Quantitative assessment of losses caused by the coconut mite

Losses in copra yields ranged from 10% in Benin (Mariau and Julia, 1970), 16% in the Ivory Coast (Julia and Mariau, 1979), 20-30% in St. Lucia (Moore *et al.*, 1989), 25% in Grenada (Hall, 1981) and 30-80% in different areas of Mexico (Hall, 1981; Olvera-Fonseca, 1986). Julia and Mariau (1979) and Moore *et al.* (1989) found copra yield to decline with increasing severity of damage caused by the mite. Damage to the pericarp was categorized through a visual estimation method by Mariau and Julia (1970) and was modified by Moore *et al.* (1989).

2.7 Management of the coconut mite

Chemical control: Generally, chemical controls are either ineffective or impractical and the current emphasis is on biological and cultural control methods. Mariau (1977) carried out the first experiments in the Ivory Coast to test the efficacy of 24 insecticides and acaricides on the coconut mite. The four most effective chemicals were cyhexatin, chinomethionate (morestan), endosulfan and monocrotophos (nuvacron). Successful control was only achieved after up to six applications of these chemicals per year. Similar results were obtained by Mariau and Tchibozo (1973), Hernandez (1978) and Julia and Mariau (1979). However, Otterbein (1988) did not observe any significant control of the mite with these chemicals. Griffith (1984) noted that stem injection of systemic vamidithion was effective against the coconut mite in Brazil and in Trinidad. However, this method of control is traumatic for the coconut trees and impractical for pure stands on large plantations (Julia and Mariau, 1979 and Moore *et al.*, 1989). Moore *et al.* (1989) also argued that these systemic pesticides posed a threat to human health; especially where jelly or water coconuts are heavily consumed.

Environmental control: Petrolatum coatings (Otterbein, 1988) or polybutene stickers, with or without acaricides (Hall, 1986, Moore *et al.*, 1989) did not impede the migration of the coconut mite onto coconuts. Alam (1976) suggested that field sanitation, such as the removal of mite infested nuts and dry leaves, and thinning of nut population in high fruiting trees could reduce coconut mite populations. Proper drainage, weed control, adequate fertilization and replacement or rehabilitation of old plants for controlling the coconut mite have also been advocated (Anonymous, 1985). Moore *et al.* (1991) found increasing levels of potassium and decreasing nitrogen levels to be associated with decreasing mite damage. While some of these cultural practices, including increasing soil water retention, might not directly impact coconut mite populations, they improve the health of the trees and ultimately, their tolerance to damage by the coconut mite. For example, Mariau (1986) found copra loss to decline with irrigation. He suggested that during periods of moisture stress, nut growth is slower and so the meristematic tissue is subjected to extensive damage by the coconut mite. Moore *et al.* (1989) also proposed that greater yields could be achieved through improved agronomic practices, combined with resistant varieties. Sarangamath *et al.* (1976) concluded that copra yields were dependent on various factors, including, variety, age of palm, soil, climate of the area, maturity of the nuts, seasons of harvest and period of storage.

Varietal resistance: Varietal differences in the susceptibility of coconut plants to infestation by the coconut mite have been reported. The shape and color of coconuts are the two main characteristics that determine the susceptibility. Dark green nuts are

CHAPTER III

MATERIALS AND METHODS

The experiment on infestation patterns of the coconut mite on coconuts and resulting yield loss in the south western region of Bangladesh was carried out during the period from April, 2011 to February, 2012. In the study 10 germplasm from each location were taken which were collected randomly from Khulna, Satkhira and Bagherhat Districts of Bangladesh. After collection of coconut others work was done in Germplasm Centre and Horticulture Laboratory of Agrotechnology Discipline, Khulna University, Khulna. In the Laboratory the fruits were studied to determine the different physical characters and yield loss of coconut.

3.1 Experimental Design

The factorial experiment was laid out in Completely Randomized Design with three replications.

3.2 Experimental treatments

The experimental treatments consisted of the factors viz. factor A = three locations such as L_1= Khulna, L_2 = Bagherhat and L_3 = Satkhira; factor B = two varieties such as V_1= Green and V_2= Brown variety and factor C = five grades on the basis of mite infestation which are as follows:

G_0 = nuts with no mite damage

G_1 = nuts with 1-29% surface area damage

G_2 = nuts with 30-59% surface area damage and less than 20% reduction in size

G_3 = nuts with 60-80% surface area damage, 20-30% reduction in size

G_4 = nuts with over 80% surface area damage with 30% reduction and often greatly deformed.

3.3 Experimental Materials

Ninety mature coconuts of five grades were selected as the experimental materials for the investigation. These fruits were collected from Khulna, Satkhira and Bagherhat districts of Bangladesh.

3.4 Collection of coconut

Observations were made on ten randomly selected trees at each location of Satkhira, Bagherhat and Khulna districts. Ten randomly selected coconuts from different varieties were selected based on varieties and grades. Each nut was graded in situ based on the basis of mite infestation. Three nuts of each category and each variety were collected for this investigation.

3.5 Methods of Studying Parameters

By using the following methods physical parameters of the collected coconut fruits germplasm were studied.

3.5.1 Physical Parameter

3.5.1.1 Fresh weight of coconut fruits

The fruit weight was measured by an electric balance. At first, the balance was adjusted to zero mark. The fruits were cleaned and weighted by keeping the fruit on the chamber of the balance. Then the reading was taken in gram (g).

3.5.1.2 Length of coconut fruits

Fresh length of the fruits was estimated by a measuring tape. The values of these parameters were taken in centimeters (cm).

3.5.1.3 Equatorial circumference of coconut fruits

Equatorial circumference of coconut fruits was estimated by a measuring tape. The values of these parameters were taken in centimeters (cm).

3.5.1.4 Kernel length of coconut fruits

After removing husk kernel length of the coconut fruits was estimated by a measuring tape. The values of these parameters were taken in centimeters (cm).

3.5.1.5 Kernel equatorial circumference of coconut fruits

Kernel equatorial circumference of coconut fruits was estimated by a measuring tape after removing husk. The values of these parameters were taken in centimeters (cm).

3.5.1.6 Kernel weight with water

The coconut husk was removed to open the kernel and after removing kernel the weight was measured by an electric balance. At first, the balance was adjusted to zero mark. The kernel were cleaned and weighted by keeping the kernel on the chamber of the balance. Then the reading was taken in gram (g).

3.5.1.7 Kernel weight without water

After removing kernel each nut was broken, the water was released and the nut was reweighed and weight was measured by an electric balance. At first, the balance was adjusted to zero mark. The kernel were cleaned and weighted by keeping the kernel on the chamber of the balance. Then the reading was taken in gram (g).

3.5.1.8 Copra weight

The weight of pulp portion (copra) of fruit was measured by an electric balance. At first, the balance was adjusted to zero mark. After removing the fibers and shell from fruit the remaining pulp portion was estimated by keeping it in the chamber of balance and the reading was taken in gram (g).

3.5.1.9 Dry weight

The dry weight of pulp portion (copra) of fruit was measured by an electric balance. At first, the balance was adjusted to zero mark. After separating the copra, it was weighed and placed in a dryer at 70°C. After 36 hours, when the moisture content was at an average of 6%, the copra weight was taken. And the reading was measured in gram (g).

3.5.1.10 Moisture (%)

The moisture percentage was measured by the following equation-

$$\text{Moisture (\%)} \quad \frac{\text{Fresh weight of copra - Dry weight of copra}}{\text{Fresh weight of copra}} \quad \text{X } 100$$

3.5.2 Yield Loss Assessment

A sample of three coconuts of various locations and varieties were taken from each category for processing. Each coconut was labeled and taken to the laboratory. At first the fresh weight of coconut fruit, fresh length and equatorial circumference of coconut fruit were taken. Then husk was removed to open the kernel. After this the kernel weight with water, kernel length and equatorial circumference of kernel were measured and recorded. Each nut was broken, then the water released and the nut was reweighed. The endosperm was then separated, weighed and placed in a kiln at 70°C. After 36 hours, when the moisture content was at an average of 6%, the copra weight was taken. The effect of mite damage on variety, site and their interactions on copra yield was determined. The yield loss percentage of the economical parts of the coconut fruit was measured by the following equation-

$$\text{Yield loss (\%)} = \frac{\text{Grade 0- Grade X}}{\text{Grade 0}} \times 100$$

Statistical analysis

The recorded data were analyzed statistically with the help of computer package program MSTAT-C and the mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

Results of the experiment on the pattern of coconut mite infestation and resulting yield loss have been presented and discussed in this chapter. The data on fresh weight (g), length (cm), equatorial circumference (cm) fruit, kernel length (cm), kernel equatorial circumference (cm), kernel weight with water (g), kernel weight without water (g), copra weight (g), dry weight of copra (g), moisture (%) and yield loss have been presented in tables and discussed accordingly. Result obtained from the study are presented in tabular form and discussed in this chapter under the following heading and sub headings.

4.1 Fresh weight of coconut fruit (g)

Fresh weight of the coconut fruit was significantly varied among the fruits of different locations due to infestation of coconut mite (Appendix 1). The heaviest coconut fruit was recorded from Khulna (1032.73g) followed by Bagherhat (918.33g) which was statistically similar and the lowest fresh weight of coconut fruit (897.0g) was recorded from the sample of Satkhira (Table 1).

Incase of variety the fresh weight of coconut fruit was not significantly differed (Appendix 1). However, numerically the Brown variety produced the heaver fruit (962.56g) than the variety Green (936.16g) (Table 2).

It was found that the fresh weight of coconut fruit was significantly varied among the different grades (Appendix 1). The heaviest fruit (1198.06g) was recorded from nuts with no mite damage and the lowest fresh weight of coconut (659.17g) was found in nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed (Table 3).

The interaction effect of location and variety was not statistically significant (Appendix 1). However, numerically the brown variety collected from Khulna gave the heaviest fruit (1052.67g) and the lowest fruit weight (885.00g) was recorded from the same variety of Satkhira (Table 4).

The interaction effect of location and different grades was not statistically significant (Appendix 1). However, numerically the interaction of L_1G_0 produced the heaviest fruit (1243.33g) and the lowest fruit weight (568.33g) was recorded from L_3G_4 (Table 5).

It was found from the experiment that the fresh weight of coconut fruit was significantly influenced by the interaction between variety and different grades (Appendix 1). The heaviest fruit weight (1259.44g) was recorded from V_2G_0 and the lowest fruit weight (594.44g) was recorded from V_2G_4 (Table 6).

The interaction effect of location, variety and different grades was not significantly varied due to coconut mite infestation (Appendix 1). However, numerically the interaction $L_1V_2G_0$ produced the heaviest fruit (1363.33g) and the lowest fruit weight (480.00) was recorded from $L_3V_2G_4$ (Table 7).

4.2 The fruit length (cm)

The fruit length of coconut was not significantly varied among the different location (Appendix 1). However, numerically the highest fruit length (21.83cm) was recorded from Bagherhat and the lowest fruit length (21.13cm) was recorded from Khulna (Table 1).

Incase of variety the fruit length of coconut was significantly varied (Appendix 1). The highest fruit length (21.87cm) was recorded from Green variety and the lowest (21.10cm) from the Brown variety (Table 2).

The fruit length of coconut was significantly varied among the different grades (Appendix 1). The longest fruit (24.28cm) was recorded from nuts with no mite damage and the shortest fruit (18.33cm) was recorded from nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed (Table 3).

The interaction effect of variety and location was significantly varied as influenced by coconut mite infestation (Appendix 1). The longest fruit (22.07cm) was found in the Green variety collected from Khulna which was statistically similar to the Green variety collected from Bagherhat (21.53cm), the Brown variety collected from Bagherhat (22.13cm), the Green variety collected from Satkhira (22.00cm) and the Brown variety collected from Satkhira (20.93cm) and the shortest fruit (20.20cm) was observed in Brown variety collected from Khulna (Table 4).

The interaction effect of location and different grades were not significantly influenced by coconut mite infestation (Appendix 1).

Table 1. Effects of coconut mite damage among the three locations viz. Khulna, Bagherhat and Shatkhira

Treatment	Fresh weight of coconut fruit (g)	Length of coconut fruit (cm)	Equatorial circumference of coconut fruit (cm)	Kernel length (cm)	Kernel equatorial circumference (cm)	Kernel weight with water(g)	Kernel weight without water(g)	Copra weight (g)	Dry weight (g)	Moisture (%)
Khulna	1032.73a	21.13	38.17a	12.73	28.53a	650.33a	455.17a	262.45a	126.22	50.85a
Bagherhat	918.33a	21.83	36.83b	12.47	25.50b	510.67b	377.00b	222.27b	118.29	47.24b
Shatkhira	897.00b	21.47	39.23a	13.10	27.40a	606.00ab	447.50a	256.72a	121.45	51.99a
Significance level	0.01	NS	0.05	NS	0.01	0.01	0.01	0.01	NS	0.05
CV%	12.54	6.13	7.94	9.43	8.28	9.61	10.89	11.30	13.92	14.14

The figures having different letter(s) in a column are significantly different at 1% or 5% level and the figures having same letter(s) in a column are not significantly different by DMRT.

NS = Non significant.

Table 2. Effects of coconut mite damage among the two varieties viz. Green Variety and Brown Variety

Treatment	Fresh weight of coconut fruit (g)	Length of coconut fruit (cm)	Equatorial circumference of coconut fruit (cm)	Kernel length (cm)	Kernel equatorial circumference (cm)	Kernel weight with water(g)	Kernel weight without water(g)	Copra weight (g)	Dry weight (g)	Moisture (%)
Green variety	936.16	21.87	39.38	12.59	27.58	587.33	426.56	243.12	120.65	49.36
Brown variety	962.56	21.10	36.78	12.94	26.71	590.67	426.56	251.18	123.32	50.69
Significance level	NS	0.01	0.01	NS	NS	NS	NS	NS	NS	NS
CV%	12.54	6.13	7.94	9.43	8.28	9.61	10.89	11.30	13.92	14.14

The figures having different letter(s) in a column are significantly different at 1% or 5% level and the figures having same letter(s) in a column are not significantly different by DMRT.

NS = Non significant.

Table 3. Effects of coconut mite damage on different grade

Treatment	Fresh weight of coconut fruit (g)	Length of coconut fruit (cm)	Equatorial circumference of coconut fruit (cm)	Kernel length (cm)	Kernel equatorial circumference (cm)	Kernel weight with water(g)	Kernel weight without water(g)	Copra weight (g)	Dry weight (g)	Moisture (%)
G_0	1198.06a	24.28a	43.89a	14.56a	31.44a	764.72a	530.83a	339.59a	164.33a	51.44
G_1	1100.67ab	23.11ab	40.94ab	13.25ab	28.44ab	698.89a	477.22ab	295.58ab	142.60ab	50.87
G_2	942.78ab	21.11bc	38.17ab	12.39ab	26.83abc	575.83b	423.61b	248.85bc	123.41bc	49.87
G_3	846.11bc	20.56bc	36.44bc	12.72ab	25.83bc	518.61b	401.67b	193.31cd	101.88cd	46.87
G_4	659.17c	18.33c	30.94c	10.91b	23.17c	386.94c	299.44c	158.40d	77.69d	51.07
Sig. level	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	NS
CV%	12.54	6.13	7.94	9.43	8.28	9.61	10.89	11.30	13.92	14.14

The figures having different letter(s) in a column are significantly different at 1% or 5% level and the figures having same letter(s) in a column are not significantly different by DMRT.

NS = Non significant.

G_0 = nuts with no mite damage, G_1 = nuts with 1-29% surface area damage, G_2 = nuts with 30-59% surface area damage and less than 20% reduction in size, G_3 = nuts with 60-80% surface area damage, 20-30% reduction in size, G_4 = nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed.

Table 4. Interaction effect between variety and location as influenced by coconut mite infestation

Interaction	Fresh weight of coconut fruit (g)	Length of coconut fruit (cm)	Equatorial circumference of coconut fruit (cm)	Kernel length (cm)	Kernel equatorial circumference (cm)	Kernel weight with water(g)	Kernel weight without water(g)	Copra weight (g)	Dry weight (g)	Moisture (%)
L_1V_1	1012.80	22.07a	41.67a	12.80	29.33a	649.00	463.33	238.09ab	118.83a	48.76
L_1V_2	1052.67	20.20b	34.67b	12.67	27.73ab	651.67	447.00	286.81a	133.60a	52.94
L_2V_1	886.67	21.53a	35.07b	12.23	24.33b	510.33	360.00	234.77ab	127.77a	45.73
L_2V_2	950.00	22.13a	38.60ab	12.70	26.67ab	511.00	394.00	209.78b	108.80b	48.75
L_3V_1	909.00	22.00a	41.40a	12.73	29.07a	602.67	456.33	256.49ab	115.35a	53.58
L_3V_2	885.00	20.93a	37.07ab	12.46	25.73ab	609.33	438.67	256.96ab	127.54a	53.58
Significance level	NS	0.01	0.01	NS	0.01	NS	NS	0.01	0.01	NS
CV%	12.54	6.13	7.94	9.43	8.28	9.61	10.89	11.30	13.92	14.14

The figures having different letter(s) in a column are significantly different at 1% or 5% level and the figures having same letter(s) in a column are not significantly different by DMRT.

NS = Non significant.

L_1= Khulna, L_2 = Bagherhat, L_3 = Satkhira, V_1= Green variety and V_2= Brown variety

Table 5. Interaction effect between location and different grades as influenced by coconut mite infestation

Interaction	Fresh weight of coconut fruit (g)	Length of coconut fruit (cm)	Equatorial circumference of coconut fruit (cm)	Kernel length (cm)	Kernel equatorial circumference (cm)	Kernel weight with water(g)	Kernel weight without water(g)	Copra weight (g)	Dry weight (g)	Moisture (%)
$L_1 G_0$	1243.33	22.83	44.00	14.33ab	33.00	839.17a	560.83	365.01a	169.03	53.67ab
$L_1 G_1$	1209.50	22.67	41.83	13.67abc	31.33	805.83ab	507.50	322.72ab	143.55	55.96a
$L_1 G_2$	1080.83	21.33	37.83	12.50bcd	26.83	622.50cd	428.33	261.61c	124.35	52.32ab
$L_1 G_3$	929.17	20.67	35.00	12.00bcd	26.83	545.00def	437.50	196.10defg	106.03	45.38ab
$L_1 G_4$	700.83	18.17	32.17	11.17cd	24.67	439.17fgh	341.67	166.82fg	88.13	46.89ab
$L_2 G_0$	1136.67	25.17	41.67	13.17bcd	29.67	628.33cd	475.00	314.42b	169.93	46.13ab
$L_2 G_1$	1049.17	23.50	38.33	12.41bcd	27.17	602.50cde	422.50	241.44cd	137.27	42.47b
$L_2 G_2$	890.83	21.00	38.17	11.83bcd	26.50	529.17defg	396.67	225.28cde	120.93	46.32ab
$L_2 G_3$	806.68	20.50	36.00	13.83abc	24.00	470.83efg	353.33	179.96efg	96.84	45.83ab
$L_2 G_4$	708.33	19.00	30.00	11.08cd	20.17	322.50h	237.50	150.26g	66.46	55.46a
$L_3 G_0$	1214.17	24.83	46.00	16.17a	31.67	826.67a	556.67	339.34ab	154.04	54.52a
L_3G_1	1043.33	23.17	42.00	13.67abc	26.83	688.33bc	501.67	322.57ab	146.99	54.18a
L_3G_2	856.68	21.00	38.50	12.83bcd	27.17	575.83cde	445.83	259.67c	124.95	50.97ab
L_3G_3	802.50	20.50	38.33	12.33bcd	26.67	540.00def	414.17	203.93def	102.77	49.42ab
l_3G_4	568.33	17.83	30.67	10.50d	24.66	399.17gh	319.17	158.12fg	78.48	50.86ab
Significance level	NS	NS	NS	0.01	NS	0.01	NS	0.05	NS	0.05
CV%	12.54	6.13	7.94	9.43	8.28	9.61	10.89	11.30	13.92	14.14

The figures having different letter(s) in a column are significantly different at 1% or 5% level and the figures having same letter(s) in a column are not significantly different by DMRT.

NS = Non significant.

L_1= Khulna, L_2 = Bagherhat, L_3 = Satkhira, G_0 = nuts with no mite damage, G_1 = nuts with 1-29% surface area damage, G_2 = nuts with 30-59% surface area damage and less than 20% reduction in size, G_3 = nuts with 60-80% surface area damage, 20-30% reduction in size, G4 = nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed.

Table 6. Interaction effect between variety and different grade as influenced by coconut mite infestation

Interaction	Fresh weight of coconut fruit (g)	Length of coconut fruit (cm)	Equatorial circumference of coconut fruit (cm)	Kernel length (cm)	Kernel equatorial circumference (cm)	Kernel weight with water(g)	Kernel weight without water(g)	Copra weight (g)	Dry weight (g)	Moisture (%)
$V_1 G_0$	1136.67abc	25.11a	44.00	14.33	31.11ab	745.00ab	512.78ab	330.54ab	160.19ab	51.59
$V_1 G_1$	1013.00abcd	22.89abcd	41.78	13.00	27.33abc	648.33bc	447.78abc	268.96bcd	125.95bc	51.74
$V_1 G_2$	921.67bcde	21.11cde	39.11	12.22	27.44abc	580.00cd	420.00dcd	260.95cde	125.43bc	51.41
$V_1 G_3$	885.56cde	20.78de	38.00	12.57	27.22abc	533.33cde	415.56bcd	187.43fg	105.35cd	43.47
$V_1 G_4$	723.89ef	19.44e	34.00	10.83	24.78cd	430.00ef	336.67de	167.70g	86.33cd	48.56
$V_2 G_0$	1259.44a	23.44ab	43.78	14.78	31.78a	784.44a	548.89a	348.63a	168.48a	51.29
$V_2 G_1$	1188.33ab	23.33abc	40.11	13.50	29.56abc	749.44ab	506.67ab	322.19abc	159.25ab	49.99
$V_2 G_2$	963.89bcde	21.11bcde	37.22	12.56	26.22bcd	571.67cd	427.22bcd	236.75def	121.39bc	48.33
$V_2 G_3$	806.67def	20.33e	34.89	12.89	24.44cd	503.89de	387.78cd	199.23efg	98.41cd	50.27
$V_2 G_4$	594.44f	17.22f	27.89	11.00	21.56d	343.89f	262.22e	149.10g	69.05d	53.58
Sig. level	0.01	0.05	NS	NS	0.01	0.01	0.01	0.01	0.01	NS
CV%	12.54	6.13	7.94	9.43	8.28	9.61	10.89	11.30	13.92	14.14

The figures having different letter(s) in a column are significantly different at 1% or 5% level and the figures having same letter(s) in a column are not significantly different by DMRT.

NS = Non significant.

V_1= Green variety and V_2= Brown variety, G_0 = nuts with no mite damage, G_1 = nuts with 1-29% surface area damage, G_2 = nuts with 30-59% surface area damage and less than 20% reduction in size, G_3 = nuts with 60-80% surface area damage, 20-30% reduction in size, G_4 = nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed.

Table 7. Interaction effect among the location, variety and different grade as influenced by coconut mite infestation

Interaction	Fresh weight of coconut fruit (g)	Length of coconut fruit (cm)	Equatorial circumference of coconut fruit (cm)	Kernel length (cm)	Kernel equatorial circumference (cm)	Kernel weight with water(g)	Kernel weight without water(g)	Copra weight (g)	Dry weight (g)	Moisture (%)
$L_1 V_1 G_0$	1123.33	24.00	44.33	14.00	32.33	748.33bcd	518.33bcde	325.15	151.98bcde	53.33
$L_1 V_1 G_1$	1142.33	23.00	44.67	14.00	30.00	768.33bc	450.00defgh	258.37	107.35hijk	58.35
$L_1 V_1 G_2$	1011.67	22.67	41.33	12.67	27.33	658.33cde	450.00defgh	258.43	130.26defghi	49.37
$L_1 V_1 G_3$	955.00	21.33	41.33	12.33	29.67	590.00efgh	498.33bcdef	191.79	112.60ghijk	41.07
$L_1 V_1 G_4$	831.67	19.33	36.67	11.00	27.33	480.00ghi	400.00hij	156.73	91.95jklm	41.66
$L_1 V_2 G_0$	1363.33	21.67	43.67	14.67	33.67	930.00a	603.33a	404.87	186.08a	54.01
$L_1 V_2 G_1$	1276.67	22.33	39.00	13.33	32.67	843.33ab	565.00abc	387.08	179.74ab	53.57
$L_1 V_2 G_2$	1150.00	20.00	34.33	12.33	26.33	586.67efgh	406.67ghij	264.78	118.43fghij	55.28
$L_1 V_2 G_3$	903.33	20.00	28.67	1167	24.00	500.00fghi	376.67hij	200.41	99.46ijkl	49.68
$L_1 V_2 G_4$	570.00	17.00	27.67	11.33	22.00	398.33ijkl	283.33klm	176.91	84.30klmn	52.13
$L_2 V_1 G_0$	1070.00	25.33	38.67	13.33	27.00	636.67def	436.67efghi	333.03	181.53ab	45.50
$L_2 V_1 G_1$	1020.00	22.67	37.00	12.00	25.00	583.33efgh	401.67ghij	239.00	143.88cdefg	38.75
$L_2 V_1 G_2$	850.00	19.67	36.33	11.33	25.00	530.00efghi	380.00hij	241.04	133.85defgh	44.41
$L_2 V_1 G_3$	810.00	20.67	33.33	13.67	23.67	460.00hijk	330.00jkl	185.39	105.69hijkl	42.19
$L_2 V_1 G_4$	683.33	19.33	30.00	10.83	20.33	341.67jkl	251.67lm	174.58	73.88lmn	57.81
$L_2 V_2 G_0$	1203.33	25.00	44.67	13.00	31.67	620.00defg	513.33bcde	295.82	158.34abcde	46.76
$L_2 V_2 G_1$	1078.33	24.33	39.67	12.83	29.33	621.67defg	443.33defghi	243.09	130.66defghi	46.18
$L_2 V_2 G_2$	931.67	22.33	40.00	12.33	28.00	528.33efghi	413.33fghij	209.52	108.00hijk	48.24
$L_4 V_2 G_3$	803.33	20.33	38.67	14.00	24.33	481.67ghi	376.67hij	174.52	87.98jklmn	49.44
$L_2 V_2 G_4$	733.33	18.67	30.00	11.33	20.00	303.33l	223.33m	125.94	59.04n	53.11
$L_3 V_1 G_0$	1216.67	26.00	49.00	15.67	33.33	850.00ab	583.33ab	333.46	147.05cdef	55.94
$L_3 V_1 G_1$	876.67	23.00	43.67	13.00	27.00	593.33efgh	491.67cdefg	308.71	126.63efghi	58.13
$L_3 V_1 G_2$	903.33	21.00	39.67	12.67	30.00	551.67efgh	430.00efghi	283.39	112.17ghijk	60.45
$L_3 V_1 G_3$	891.67	20.33	39.33	11.67	28.33	550.00efgh	418.33fghij	185.10	97.74ijkl	47.15
$L_3 V_1 G_4$	656.67	19.67	35.33	10.67	26.67	468.33hij	358.33ijk	171.79	93.15jklm	46.22
$L_3 V_2 G_0$	1211.67	23.67	43.00	16.67	30.00	803.33ab	530.00abcd	345.21	161.03abcd	53.11
$L_3 V_2 G_1$	1210.00	23.33	41.67	14.33	26.67	783.33bc	511.67bcde	336.41	167.35abc	50.23
$L_3 V_2 G_2$	810.00	21.00	37.33	13.00	24.33	600.00efgh	461.67defgh	235.94	137.74cdefgh	41.48
$L_3 V_2 G_3$	713.33	20.67	37.33	13.00	25.00	530.00efghi	410.00fghij	222.76	107.79hijk	51.69
$L_4 V_2 G_4$	480.00	16.00	26.00	10.33	22.67	330.00kl	280.00klm	144.45	63.81mn	55.49
Sig. level	NS	NS	NS	NS	NS	0.01	0.05	NS	0.05	NS
CV%	12.54	6.13	7.94	9.43	8.28	9.61	10.89	11.30	13.92	14.14

The figures having different letter(s) in a column are significantly different at 1% or 5% level and the figures having same letter(s) in a column are not significantly different by DMRT.

NS = Non significant.

L_1 = Khulna, L_2 = Bagherhat, L_3 = Shatkhira, V_1 = Green variety , V_2 = Brown variety, G_0 = nuts with no mite damage, G_1 = nuts with 1-29% surface area damage, G_2 = nuts with 30-59% surface area damage and less than 20% reduction in size, G_3 = nuts with 60-80% surface area damage, 20-30% reduction in size, G_4 = nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed.

However, numerically the longest length of fruit (25.17cm) was recorded from L_2G_0 and the lowest fruit length (17.83cm) was produced by L_3G_4 (Table 5).

The interaction effect of variety and different grades were significantly influenced by coconut mite infestation (Appendix 1). The highest fruit length (25.11cm) was recorded from V_1G_0 and the lowest fruit length (17.22cm) was recorded from V_2G_4 interaction (Table 6).

The interaction effect of the location, variety and different grades were not significantly influenced by coconut mite infestation (appendix 1). However, numerically the highest fruit length (26.00cm) was recorded from $L_3V_1G_0$ and the lowest fruit length (16.00cm) was recorded from $L_3V_2G_4$ (Table 7).

4.3 Equatorial circumference of coconut fruit (cm)

Equatorial circumference of coconut fruit was significantly varied among the different location at 5% level (Appendix 1). The highest equatorial circumference of coconut fruit was recorded from the fruits of Khulna (38.17cm) followed by Satkhira (39.23cm) which were statistically similar and the lowest equatorial circumference of coconut fruit (36.83cm) was recorded from the sample of Bagherhat (Table 1).

Incase of variety equatorial circumference of coconut fruit was significantly differed (Appendix 1). The highest equatorial circumference of coconut fruit (39.38cm) was recorded from the Green variety and the lowest equatorial circumference of coconut fruit (36.78cm) was recorded from the Brown variety (Table 2).

Equatorial circumference of coconut fruit was significant at 1% level and varied among the different grades (Appendix 1). The highest equatorial circumference (43.89cm) was recorded from nuts with no mite damage followed by nuts with 1-29% surface area damage (40.94cm) and the lowest equatorial circumference (30.9cm) was recorded from nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed (Table 3).

The interaction effect of variety and location was significantly varied as influenced by coconut mite infestation (Appendix 1). Among the interaction the highest equatorial circumference (41.67cm) was recorded from the Green variety collected from Khulna followed by the Green variety collected from Satkhira

(41.40cm) and lowest equatorial circumference (34.67cm) was recorded from the Brown variety collected from Khulna (Table 4).

The interaction effect of location and different grades were not significantly influenced by coconut mite infestation (Appendix 1). However, numerically the highest equatorial circumference (46.00cm) was recorded from L_3G_0 and the lowest equatorial circumference (30.00cm) was recorded from L_2G_4 (Table 5).

The interaction effect of variety and different grades were not significantly influenced by coconut mite infestation (Appendix 1). However, numerically the highest equatorial circumference (44.00cm) was recorded from V_1G_0 and the lowest equatorial circumference (27.89cm) was observed from V_2G_4 (Table 6).

The interaction effect of location, variety and different grades were not significantly influenced by coconut mite infestation (Appendix 1). However, numerically the $L_3V_1G_0$ was produced the highest equatorial circumference (49.00cm) and the lowest equatorial circumference (27.67cm) was produced by $L_1V_2G_4$ (Table 7).

4.4 Kernel length of coconut fruit (cm)

Kernel length of coconut fruit was not significantly varied among the different location (Appendix 1). However, numerically the highest kernel length of coconut fruit (13.00cm) was produced by the fruits of Satkhira and the lowest kernel length of coconut fruit (12.47cm) was recorded from the sample of Bagherhat (Table 1).

Incase of variety kernel length of coconut fruit was not significantly differed (Appendix 1). However, numerically the highest kernel length of coconut fruit (12.94cm) was recorded from the Green variety and the lowest kernel length of coconut fruit (12.59cm) was found from the Brown variety (Table 2).

The kernel length of coconut fruit was significant at 1% level among the different grades (Appendix 1). The highest kernel length (14.56cm) was produced by nuts with no mite damage followed by the nuts with 1-29% surface area damage (13.25cm), nuts with 30-59% surface area damage and less than 20% reduction of size (12.39cm) and the lowest kernel length (10.91cm) was recoded from the sample of the nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed (Table 3).

The interaction effect of variety and location was not significantly varied (Appendix 1). However, numerically the highest kernel length of coconut fruit

(12.80cm) was observed in the Green variety collected from Khulna and the lowest kernel length of coconut fruit (12.23cm) was recorded from the Green variety collected from Bagherhat (Table 4).

The interaction effect of location and different grades were significantly varied by the coconut mite infestation (Appendix 1). The highest kernel length (16.17cm) was recorded from L_3G_0 followed by L_1G_0 (14.33cm) and the lowest kernel length (10.5cm) was recorded from L_3G_4 (Table 5).

The interaction effect of variety and different grades were not significantly varied by the coconut mite infestation (Appendix 1). However, the highest kernel length (14.78cm) was recorded from V_2G_0 followed by V_1G_0 (14.33cm) that are statistically simillar and the lowest kernel length (10.83cm) was recorded from V_1G_4 (Table 6).

The interaction effect of location, variety and different grades were not significantly influenced by coconut mite infestation (Appendix 1). However, numerically the highest kernel length (16.67cm) was recorded from $L_3V_2G_0$ and the lowest kernel length (10.33cm) was produced by $L_3V_2G_4$ (Table 7).

4.5 Kernel equatorial circumference of coconut fruit (cm)

Kernel equatorial circumference of coconut fruit was significantly varied among the different location at 1% level of significance (Appendix 1). The highest kernel equatorial circumference of coconut fruit was recorded from the fruits of Khulna (28.53cm) followed by Satkhira (27.40cm) which were statistically similar and the lowest kernel equatorial circumference of coconut fruit (25.50cm) was observed from the sample of Bagherhat (Table 1).

Incase of variety kernel equatorial circumference of coconut fruit was not significantly varied (Appendix 1). However, numerically the highest kernel equatorial circumference of coconut fruit (27.58cm) was recorded from the Green variety and the lowest (26.71cm) was recorded from the Brown variety (Table 2).

The kernel equatorial circumference of coconut fruit was significant at 1% level and varied among the different grades (Appendix 1). Incase of kernel equatorial circumference of coconut fruit the highest kernel equatorial circumference (31.44cm) was recorded from the sample of nuts with no mite damage followed by nuts with 1-29% surface area damage (28.44cm) and the lowest kernel equatorial circumference (23.17cm) was observed from the sample of nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed (Table 3).

The interaction effect of variety and location was significantly varied at 1% level (Appendix 1). Among the interaction the highest kernel equatorial circumference (29.33cm) was recorded from the Green variety collected from Khulna followed by the Green variety collected from Satkhira (29.07cm) which were statistically similar and the lowest kernel equatorial circumference (24.33cm) was recorded from the Green variety collected from Bagherhat (Table 4).

The interaction effect of location and different grades were not significantly influenced by coconut mite infestation (Appendix 1). However, the highest kernel equatorial circumference (33.00cm) was recorded from L_1G_0 followed L_1G_1 (31.33cm) and L_3G_0 (31.67cm) which were statistically similar and the lowest kernel equatorial circumference (20.17cm) were observed from L_2G_4 (Table 5).

The interaction effect of variety and different grades were significantly varied by the coconut mite infestation (Appendix 1). Among the interaction the highest kernel equatorial circumference (31.78cm) was recorded from V_2G_0 followed by V_1G_0 (31.11cm) and the lowest kernel equatorial circumference (21.56cm) was recorded from V_2G_4 (Table 6).

The interaction effect of location, variety and different grades were not significantly influenced by coconut mite infestation (Appendix 1). However, numerically the highest kernel equatorial circumference (33.67cm) was recorded from $L_1V_2G_0$ and the lowest kernel equatorial circumference (20.00cm) was observed from $L_2V_2G_4$ (Table 7).

4.6 Kernel weight with water (g)

Kernel weight with water was significantly varied among the coconut fruits of different locations due to coconut mite infestation (Appendix 1). The highest kernel weight with water was recorded from the sample of Khulna (650.33g) and the lowest kernel weight with water (510.67g) was produced by the fruits of Bagherhat (Table 1).

Incase of variety the kernel weight with water was not significantly varied (Appendix 1). However, numerically the heaviest kernel with water (590.67g) was produced by the variety Green and the lowest kernel weight with water (587.33g) was recorded from the variety Brown (Table 2).

It was found that the kernel weight with water was significantly varied among the different grades (Appendix 1). The heaviest kernel with water (764.72g) was recorded from nuts with no mite damage followed by nuts with 1-29% surface area damage (698.89g) which were statistically similar and the lowest kernel weight with water (386.94g) was recorded from nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed (Table 3).

The interaction effect of variety and locations were not significantly varied as influenced by coconut mite infestation (Appendix 1). However, the heaviest kernel weight with water (651.67g) was recorded from the Brown variety collected from Khulna and the lowest kernel weight with water (510.33g) was recorded from the Green variety collected from Bagherhat (Table 4).

The interaction effect of location and different grades were significantly varied (Appendix 1). The highest kernel weight with water (839.17g) was recorded from L_1G_0 followed by L_3G_1 (826.67g) which were statistically similar and the lowest kernel weight with water (322.50g) was recorded from L_2G_4 (Table 5).

The interaction effect of variety and different grades were significantly influenced by coconut mite infestation (Appendix 1). The heaviest kernel weight with water (784.44g) was recorded from V_2G_0 followed by V_2G_1 (749.44g) and V_1G_0 (745.00g); and lowest kernel weight with water (343.89g) was observed from V_2G_4 (Table 6).

The interaction effect of location, variety and different grades were significantly influenced by coconut mite infestation (Appendix 1). Among the interaction the heaviest kernel weight with water (930.00g) was recorded from $L_1V_2G_0$ and the lowest kernel weight with water (303.33g) was found in $L_2V_2G_4$ (Table 7).

4.7 Kernel weight without water (g)

Kernel weight without water was significantly varied among the coconut fruits of different locations due to infestation of coconut mite (Appendix 1). The highest kernel weight without water was recorded from the fruits of Khulna (455.17g) followed by Satkhira (447.50g) which were statistically similar and the lowest kernel weight without water (377.00g) was recorded from the sample of Bagherhat (Table 1).

Incase of variety kernel weight without water was not significantly differed due to coconut mite infestation (Appendix 1). However, numerically the Green variety and the Brown variety was produced same kernel weight without water (Table 2).

It was found that the kernel weight without water was significantly varied among the different grades (Appendix 1). The highest kernel weight without water (530.83g) was recorded from nuts with no mite damage followed by the nuts with 1-29% surface area damage (477.22g) and the lowest kernel weight without water (299.44g) was recorded from nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed (Table 3).

The interaction effect of variety and locations were not significantly varied as influenced by coconut mite infestation (Appendix 1). However, the highest kernel weight without water (463.33g) was recorded from the Green variety collected from Khulna and the lowest kernel weight without water (360.00g) was recorded from the Green variety collected from Bagherhat (Table 4).

The interaction effect of location and different grades were not significantly varied (Appendix 1). However, the highest kernel weight without water (560.83g) was recorded from L_1G_0 and the lowest kernel weight with water (322.50g) was recorded from L_2G_4 (Table 5).

The interaction effect of variety and different grades were significantly influenced by coconut mite infestation at 1% level (Appendix 1). The highest kernel weight without water (548.89g) was recorded from V_2G_0 followed by V_1G_0 (512.78g) and V_2G_1 (506.67g); and the lowest kernel weight without water (262.22g) was recorded from V_2G_4 (Table 6).

The interaction effect of location, variety and different grades were significantly influenced by coconut mite infestation (Appendix 1). Among the interaction the heaviest kernel weight without water (603.33g) was produced by $L_1V_2G_0$ and the lowest heaviest kernel weight without water (223.33g) was produced by $L_2V_2G_4$ interaction (Table 7).

4.8 Copra weight (g)

Copra weight was significantly varied among the fruits of different locations due to infestation of coconut mite (Appendix 1). The highest copra weight was recorded from the fruits collected from Khulna (262.45g) followed by Satkhira (256.72g) which were statistically similar and the lowest copra weight (222.27g) was found in the fruits of Bagherhat (Table 1).

Incase of variety copra weight was not significantly differed (Appendix 1). However, numerically the highest copra weight (251.18g) was produced by the Green variety and the lowest copra weight (243.12g) was recorded from the Brown variety (Table 2).

It was found that the copra weight was significantly varied among the different grades (Appendix 1). The highest copra weight (339.59g) was recorded from the nuts with no mite damage followed by nuts with over 1-29% surface area damage (295.58g) and the lowest copra weight (158.40g) was observed from the nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed (Table 3).

The interaction effect of variety and locations were not significantly varied as influenced by coconut mite infestation (Appendix 1). The highest copra weight (286.81g) was recorded from the Brown variety collected from Khulna and lowest copra weight (209.78g) was recorded from the Brown variety collected from Bagherhat (Table 4).

The interaction effect of location and different grades were significantly varied (Appendix 1). The highest copra weight (365.01g) was recorded from L_1G_0 and the lowest copra weight (150.26g) was recorded from L_2G_4 (Table 5).

The interaction effect of variety and different grades were significantly influenced by coconut mite infestation at 1% level (Appendix 1). The highest copra weight (348.63g) was recorded from V_2G_0 followed by V_1G_0 (330.54g) and lowest copra weight (149.10g) was observed from V_2G_4 (Table 6).

The interaction effect of location, variety and different grades were not significantly influenced by coconut mite infestation (Appendix 1). However, numerically the highest copra weight (404.87g) was recorded from $L_1V_2G_0$ and the lowest copra weight (125.94g) was produced by $L_2V_2G_4$ (Table 7).

4.9 Dry weight (g)

Dry weight of copra was not significantly varied among the coconut fruits of different locations due to infestation of coconut mite (Appendix 1). However, numerically the highest dry weight was recorded from the fruits of Khulna (126.22g) and the lowest dry weight (118.29g) was recorded from that of Bagherhat (Table 1).

Incase of variety dry weight of copra was not significantly differed by the experiment (Appendix 1).). However, numerically the highest dry weight (123.32g) was produced by the Green variety and the lowest dry weight (120.65g) was recorded from the Brown variety (Table 2).

It was found that the dry weight of copra was significantly varied among the different grades (Appendix 1). The maximum dry weight (164.33g) was recorded from the nuts with no mite damage followed by the nuts with 1-29% surface area damage(142.60g) and the lowest dry weight (77.69g) was recorded from the nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed (Table 3).

The interaction effect of variety and locations were significantly varied as influenced by coconut mite infestation (Appendix 1). The highest dry weight (133.60g) was recorded from the Brown variety collected from Khulna followed by Green variety collected from Khulna (118.83g), Green variety collected from Bagherhat (127.77g), Green variety collected from Satkhira (115.35g) and Brown variety collected from Satkhira (127.54g) which were statistically similar and the lowest dry weight (108.80g) was recorded from the Brown variety collected from Bagherhat (Table 4).

The interaction effect of location and different grades were not significantly varied (Appendix 1). However, the heaviest dry weight (169.93g) was recorded from L_1G_0 and the lowest dry weight (66.46g) was recorded from L_2G_4 (Table 5).

The interaction effect of variety and different grades were significantly influenced by coconut mite infestation at 1% level (Appendix 1). The highest dry weight (168.48g) was recorded from V_2G_0 followed by V_2G_0 (160.19g) and V_2G_1 (159.25g); and the lowest dry weight (69.05g) was recorded from V_2G_4 (Table 6).

The interaction effect of location, variety and different grades were significantly influenced by coconut mite infestation (Appendix 1). Among the interaction the highest dry weight (186.08g) was produced by $L_1V_2G_0$ and the lowest dry weight (59.04g) was recorded from $L_2V_2G_4$ (Table 7).

4.10 Moisture (%)

Moisture percentage was significantly varied among the coconut fruits of different locations due to infestation of coconut mite (Appendix 1). The highest moisture percentage was recorded from the fruits of Satkhira (51.99%) followed by that of Khulna (50.58%) which were statistically similar and the lowest moisture percentage (47.24%) was observed from the Bagherhat (Table 1).

Incase of variety moisture percentage was not significantly differed (Appendix 1). However, numerically the highest moisture percentage (50.69%) was recorded from the variety Green and the lowest moisture percentage (49.36%) was recorded from the variety Brown (Table 2).

It was found that the moisture percentage was not significantly varied among the different grades (Appendix 1). However, the highest moisture percentage (51.44%) was recorded from the nuts with no mite damage and the lowest moisture percentage (46.87%) was recorded from the nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed (Table 3).

The interaction effect of variety and locations were not significantly varied as influenced by coconut mite infestation (Appendix 1). However, the highest moisture percentage (53.58%) was recorded from the Brown variety collected from Satkhira and lowest moisture percentage (45.73%) was recorded from the Green variety collected from Bagherhat (Table 4).

The interaction effect of location and different grades were significantly varied (Appendix 1). The highest moisture percentage (55.96%) was recorded from L_1G_1 followed by L_2G_4 (55.46%), L_3G_0 (54.52%) L_3G_1 (54.18%) which were statistically similar and the lowest moisture percentage (42.47%) was recorded from L_2G_4 (Table 5).

The interaction effect of variety and different grades were not significantly influenced by coconut mite infestation at 1% level (Appendix 1). However, highest moisture percentage (53.58%) was recorded from V_2G_4 and the lowest moisture percentage (43.47%) was recorded from V_1G_3 (Table 6).

The interaction effect of location, variety and different grades were not significantly influenced by coconut mite infestation (Appendix 1). However, among the interaction the highest moisture percentage (60.45%) was produced by $L_3V_1G_2$ and the lowest moisture percentage (38.75%) was recorded from $L_2V_1G_1$ (Table 7)

4.11 Yield loss of different economical part of coconut due to mite infestation

Due to coconut mite infestation considerable yield loss of economical part occurred and it was increased with the increase of severity of mite infestation. The height coconut shell losses (37.17%) was observed in nuts with over 80% surface area damage with 30% reduction in size and often greatly deformed followed by nuts with 60-80% surface area damage, 20-30% reduction in size (24.42%) and the lowest coconut shell losses (0%) was recorded from nuts with no mite damage followed by nuts with 1-29% surface area damage (7.28%).

The height copra losses (62.59%) was observed in nuts with over 80% surface area damage with 30% reduction in size and often greatly deformed followed by nuts with 60-80% surface area damage, 20-30% reduction in size (50%) and the lowest water losses (0%) was recorded from nuts with no mite damage followed by nuts with 1-29% surface area damage (5.5%).

The height water losses (52.72%) was observed in nuts with over 80% surface area damage with 30% reduction in size and often greatly deformed followed by nuts with 60-80% surface area damage, 20-30% reduction in size (38%) and the lowest copra losses (0%) was recorded from nuts with no mite damage followed by nuts with 1-29% surface area damage (13.22%).

Table 8. Yield loss of different economical part of coconut due to mite infestation

Grade	Coconut shell loss (%)	Loss of water (%)	Loss of copra yield (%)
G_0	0	0	0
G_1	7.28	5.5	13.22
G_2	15.32	34.91	24.90
G_3	24.42	50.00	38.00
G_4	37.17	62.59	52.72

G_0 = nuts with no mite damage, G_1 = nuts with 1-29% surface area damage, G_2 = nuts with 30-59% surface area damage and less than 20% reduction in size, G_3 = nuts with 60-80% surface area damage, 20-30% reduction in size, G_4 = nuts with over 80% surface area damage with 30% reduction and often greatly deformed.

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

A study on infestation patterns of the coconut mite on coconuts and resulting yield loss in the south western region of Bangladesh was carried out during the period from April, 2011 to February, 2012. In the study 10 germplasm from each location were taken. Coconut was collected randomly from Khulna, Satkhira and Bagherhat Districts of Bangladesh and graded into five categories and two varieties. Three fruits were collected from each grade. After this subsequent operation was done in the Germplasm Centre and Molicular Horticulture Laboratory of Agrotechnology Discipline, Khulna University, Khulna.

The factorial experiment was laid out in Completely Randomized Design with three replications. Ninety mature coconuts of five grades were selected as the experimental materials for the investigation. The experimental treatments consisted of three locations (L_1= Khulna, L_2 = Bagherhat and L_3 = Satkhira); two varieties (V_1= Green and V_2= Brown) and five grades on the basis of mite infestation which were G_0 = nuts with no mite damage, G_1 = nuts with 1-29% surface area damage, G_2 = nuts with 30-59% surface area damage and less than 20% reduction in size, G_3 = nuts with 60-80% surface area damage, 20-30% reduction in size and G_4 = nuts with over 80% surface area damage, over 30% reduction and often greatly deformed.

Physical characteristics of coconut fruits were determined under quantitative characters such as fresh weight of coconut fruit (g), fresh fruit length (cm), equatorial circumference of the fruit (cm), kernel length (cm), kernel equatorial circumference (cm), kernel weight with water (g), kernel weight without water (g), copra weight (g), dry weight of copra (g) and moisture (%). Finally yield loss due to mite infestation was determined.

It was revealed from the present study that the fresh weight of the coconut fruit was significantly varied among the fruits of different locations due to infestation of the different location at 1% level of significance. The highest kernel equatorial circumference of coconut fruit was recorded from the fruits of Khulna (28.53cm) followed by that of Satkhira (27.40cm) which were statistically similar and the lowest kernel equatorial circumference (25.50cm) was observed from the sample from Bagherhat.

The interaction effect of variety and different grades were significantly varied by the coconut mite infestation. Among the interaction the highest kernel equatorial circumference (31.78cm) was recorded from V_2G_0 and the lowest kernel equatorial circumference (21.56cm) was observed from V_2G_4.

Kernel weight with water was significantly varied among the coconut fruits of different locations due to coconut mite infestation. The highest kernel weight with water was recorded from the fruits of Khulna (650.33g) and the lowest kernel weight with water (510.67g) was recorded from the fruits of Bagherhat.

It was found that the kernel weight with water was significantly varied among the different grades. The highest kernel weight with water (764.72g) was recorded from nuts with no mite damage followed by the nuts with 1-29% surface area damage (698.89g) which were statistically similar and the lowest kernel weight with water (386.94g) was recorded from nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed.

Kernel weight without water was significantly varied among the coconut fruits of different locations due to infestation of coconut mite. The highest kernel weight without water was recorded from the fruits of Khulna (455.17g) followed by that of Satkhira (447.50g) which were statistically similar and the lowest kernel weight without water (377.00g) was recorded from the fruits of Bagherhat.

It was found that the kernel weight without water was significantly varied among the different grades. The highest kernel weight without water (530.83g) was recorded from nuts with no mite damage and lowest kernel weight without water (299.44g) was recorded from nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed.

The interaction effect of location, variety and different grades were significantly influenced by coconut mite infestation. Among the interaction the highest kernel weight without water (603.33g) was recorded from $L_1V_2G_0$ and the lowest kernel weight without water (223.33g) was observed from $L_2V_2G_4$ interaction.

Copra weight was significantly varied among the fruits of different locations due to infestation of coconut mite. The highest copra weight was recorded from the fruits of Khulna (262.45g) followed by that of Satkhira (256.72g) which were statistically similar and the lowest copra weight (222.27g) was recorded from Bagherhat.

It was found that the copra weight was significantly varied among the different grades. The highest copra weight (339.59g) was recorded from nuts with no mite damage and the lowest copra weight (158.40g) was observed from nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed.

It was found that the dry weight of copra was significantly varied among the different grades. The highest dry weight (164.33g) was recorded from nuts with no mite damage and the lowest dry weight (77.69g) was recorded from nuts with over 80% surface area damage with 30% reduction of size and often greatly deformed.

The interaction effect of variety and locations were significantly varied as influenced by coconut mite infestation. The highest dry weight (133.60g) was recorded from the Brown variety collected from Khulna followed by the Green variety collected from Khulna (118.83g), the Green variety collected from Bagherhat (127.77g), the Green variety collected from Satkhira (115.35g) and the Brown variety collected from Satkhira (127.54g) which were statistically similar and the lowest dry weight (108.80g) was recorded from the Brown variety collected from Bagherhat.

Moisture percentage was significantly varied among the coconut fruits of different locations due to infestation of coconut mite. The highest moisture percentage was recorded from the fruits of Khulna (50.58%) followed by Satkhira (51.99%) which were statistically similar and the lowest moisture percentage (47.24%) was observed from the fruits of Bagherhat.

Due to coconut mite infestation considerable yield loss of economical part occurred and it was increased with the increase of severity of mite infestation. From the experiment it was found that water loss was observed about 0, 5.5, 34.19, 50 and 62.59% in damage categories G_0, G_1, G_2, G_3 and G_4, respectively. For the copra yield considerable loss was occurred that ware 0, 13.22, 24.90, 38.00 and 52.72% in damage categories G_0, G_1, G_2, G_3 and G_4, correspondingly. Observed coconut shell losses were 0, 7.28, 15.32, 24.42, and 37.17% in damage categories G_0, G_1, G_2, G_3 and G_4, respectively.

5.2 Conclusion

From the findings of the present study it might be concluded that Yield was directly influenced by the degree of mite damage. The size of nuts and copra yield decreased with increased coconut mite damage in different location and variety.

From the present study it may be concluded with the following heads

- The coconut mite infestation was lower in Khulna than the Satkhira and Bagherhat.
- Due to mite infestation there was no significant effect on two varieties of coconut such as the Green variety and the Brown variety.
- Due to mite infestation about 37.17% coconut shell loss, 62.59% water loss and 52.72% copra yield loss was occurred when nuts with over 80% surface area damaged with 30% reduction of size.

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