A RESUME OF INVESTIGATIONS ON THE SHEDDING OF BUTTONS IN THE COCONUT *(COCOS NUCIFERA, L)*

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INTRODUCTION

The coconut is a monoecious plant with stamens and pistil distributed in separate flowers on the same tree, the number of these flowers in an inflorescence vary markedly depending upon various factors. In an inflorescence male or staminate flowers exceed the female flowers (popularly known as buttons as they emerge out) and vary from few hundreds to thousands, depending on the length of the flower-bearing region and ramifications. The female, flowers, on the other hand, are relatively fewer than the male ones and vary normally from 6 to 150 depending upon the variety grown and the capacity of individual trees. A large number of these female flowers are shed in the course of development to maturity. The shedding of buttons varied from 55 to 95 per cent—the average on plantation basis being determined to be 75 per cent. Similar figures are recorded by workers in Ceylon (2 and 10). At Kasaragod (23) the shedding of buttons was seen to be comparatively heavier in Dwarf palms than in the Tall ones and some varieties like the Laccadive Green, Andaman, New Guinea, Fiji and F. M. S. Big, showed lesser extent of shedding than other varieties.

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At no other period in the history of cultivation of the coconut has the widespread phenomenon of shedding of buttons in the coconut warranted a more urgent attention from the research workers and the coconut growers than at present. The high prices of the coconut and consequent losses accruing to coconut plantations due to the undue shedding of buttons, has set the coconut growers to think of remedying this defect. Consequently enquiries from coconut growers on suitable methods to check the incidence

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of shedding of buttons have increased greatly.

Although this phenomenon is as ancient as the cultivation of the coconut, very little attention was paid to this till about a decade back. Since then, the research workers have been engaged in investigations on this important phenomenon. They have suggested, as a result of investigations undertaken, several causes for the incidence of fall of buttons, *viz.*, infestation of flowers with fungus and insect pests, nutritional deficiencies in the soil, unfavourable soil and climatic conditions prevailing, failure in the process of fertilization, physiological state of the plant and fundamental disturbances and redistribution of substances within the plant, development of abscission layer, etc. While these attempts have added considerably to the existing knowledge about the phenomenon no one has so far succeeded in finding out a suitable remedy which could be employed in reducing the fall of buttons.

MORPHOLOGY OF THE FLOWER

The coconut palm produces flowering branches (known botanically as spadices) in the axils of leaves. In the initial stages it is completely enclosed in a continuous thick fibrous sheath or spathe which assumes a form of flattened cone. As the spadix grows, it becomes more cylindrical especially in the upper half due to distension caused by the developing flowers of the inflorescence within. This distension causes great pressure on the walls of the spathe with the result that it splits longitudinally down the side which faces outwards and the flowering branch (or the inflorescence) with ramifications and flowers eventually emerges out. The development of the spadix from the time of emergence to the splitting of the spathe takes three to four months and the splitting of the spathe is accomplished in about 24—56 hours.

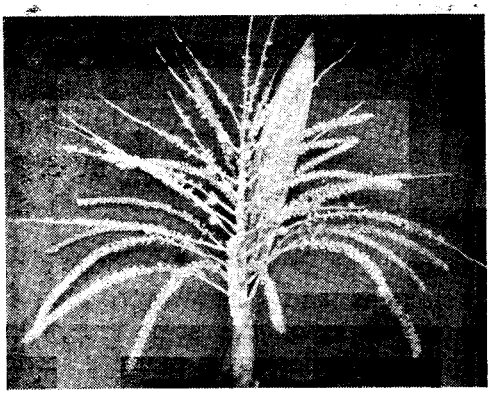

Plate I—A Coconut Inflorescence fully opened

The inflorescence is branched and each branch known as the spikelet, is situated on a fleshy axis or peduncle and has unisexual flowers. Each branch is fringed with numerous male flowers extending from tip downwards and lower down bears one or more female flowers, all the flowers being sessile or subsessile. Each male floret has six perianth leaves arranged in two whorls. Enclosed in this floral envelope, there are six hammer-shaped stamens which yield large quantities of powdery yellow pollen. In the centre of each floret, there is a rudimentary pistil which divides at its apex into three teeth, each bearing a gland secreting nectar. Rarely this rudimentary pistil is absent. The male florets start opening from the tip downwards and liberate the pollen. The opening of male flowers continues for about a month. The female flower is a small spherical body with great resemblance to a small nut. These consist of six floral leaves which are thicker and completely envelop the pistil. When the inflorescence opens the floral leaves of the female flower are tightly folded

over the inner part of the flower and completely hide it. Apart from these, there are two more at the point of attachment of the flowers with the stalk resembling others, but different from them in that they are broader and shorter and termed as the "prophylls" or bracteoles. Usually, there is a male flower on each side of the female resting on the same cushion in which the female is situated. Inside the floral leaves is a small whitish body consisting chiefly of embryonic tissues of the husk with the embryo at the base. After the inflorescence opens out but before fertilization takes place, the mass of tissue continually increases in size and ultimately forces apart floral leaves, disclosing its upper surface which is surmounted by a whitish nipple. When the stigma is ripe, the stigmatic end becomes swollen and the nectar is secreted by the nectaries of the female flower and oozes out through the stigmatic swelling. This nipple is marked by three equidistant grooves which meet at its apex and thus divide the nipple into three triangular sections. When the flower is mature, these three segments separate or open and stand erect, exposing the stigmatic surface for the reception of pollen. Fertilization of the female flower takes place with the help of the pollen, gathered by air or insects and deposited on the stigmatic surface. After fertilization of the stigma, it turns brown and tissues under it collapse forming a small black and more or less circular area containing three shrivelled teeth at the apex of the young fruit. It generally takes four to five weeks from time of opening of the spathe for the stigma to ripen and open. The male flowers drop out completely after the opening and shedding of the pollen. There is also a certain percentage of shedding of the female flowers, which we otherwise term "button shedding".

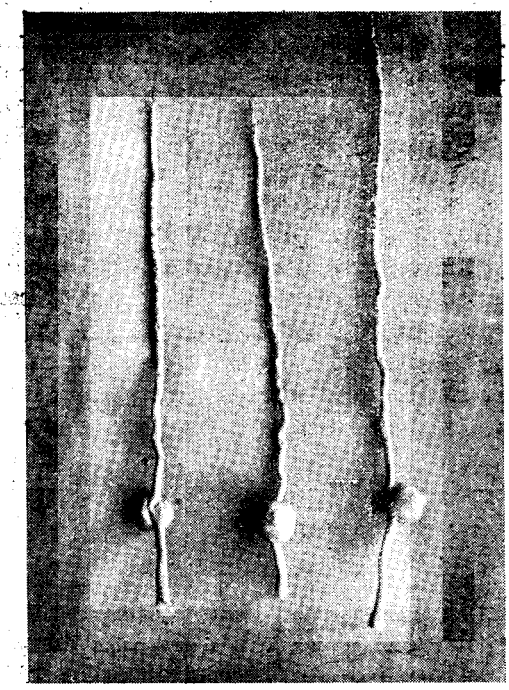

Plate II—Spikelets with female flowers—Receptive Stage

SEQUENCE OF SHEDDING OF BUTTONS

No shedding of buttons is observed till the spathe starts splitting and throws out the flowering branch with its ramifications supporting the buttons. During the period of stigmatic receptivity of the button, the shedding is seen to start. The shedding of buttons is fairly heavy during the first week after receptivity period and it is heaviest during the second, third and fourth week after stigmatic receptivity. Clear indications of reduction in the shedding of buttons is observed during the fifth and sixth week after the receptivity period. The shedding of buttons after six weeks of receptivity is almost negligible. A detailed investigation on shedding (4), showed that the shedding of buttons during the second and third week, after receptivity was significantly higher than in the other

periods of development of the button. The sequence of shedding of buttons was fairly uniform in the numerous spathes selected for study. The shedding of buttons, however, is seen to start earlier and even as early as the period of receptivity in spadices with buttons more than 40 in number.

SHEDDING AS A RESULT OF FUNGUS ATTACK

In the early days of investigation of this phenomenon, the fall of immature buttons was regarded to be primarily due to infestation of the flowers with different ungus and insect pests (8 and 9). Most of the early workers, therefore, concentrated their attention to isolate the fungus, responsible for the shedding. Investigations by workers in Kenya (13) showed that the falling of buttons was due to infestation of flowers with the fungus *Colletotricum*, which caused gumming of tissues at the point of attachment of the button with the inflorescence. In Zanzibar some workers (24 and 25) believed that this was brought about by the gumming disease. In Ceylon (11 and 12), the fall of the buttons, however, was attributed to the infestation of flowers with the fungus *Phytophthora* This view was later supported by research workers in the Philippines (21) and India (20). In Malanesia (18) shedding of buttons was seen associated with the infestation of fungus *Botrydiploidia theobromae.* These findings of the different species of fungi associated with the fall of the buttons suggested that shedding might perhaps be prevented by timely application of fungicidal sprays. Experiments were accordingly conducted in Ceylon (11) to determine the value of spray of Bordeaux mixture as a preventive against shedding of buttons. The results obtained were, however, not encouraging. The failure in preventing the shedding of buttons with spray of fungicides resulted in the belief that this is perhaps brought about by some cause other than infestation of flowers with fungus alone.

SHEDDING RESULTING FROM ATTACK OF INSECT PESTS

Few workers engaged on investigations on this problem believed that the disease was due to the attack of insect pests. This theory was first advanced by workers in the British Solomon Islands (cited in 9). In Taveuni Islands (19) the shedding of buttons was observed to be largely due to the attack of the buttons by a moth (*Acritocera negligence*) a beetle (*Diacalandra taitensis*) and rats. In the recent investigations in British Solomon Islands (14) it has, however, been observed that the premature nut fall was caused by a Coreid bug (*Amblypelta cocophaga*) which was found to be driven out by some species of ants, *viz. Occophylla smargdina subnitida* and *Anoplolepsis longipes.* It was also seen during these investigations that some species of ants (*Pheidole negacephala* and *Dridomyrmex myrmecodiae*) which cannot themselves suppress the bug *Amblypelta,* tend to drive out the beneficial species of ants. It was, therefore, suggested that to reduce shedding of buttons caused due to the bug *Amblypelta,* the trees should be first dusted with an insecticide to kill both the ants and bugs and then followed by introduction of ants *Occophylla.*

SHEDDING CAUSED DUE TO NUTRITIONAL DEFICIENCIES

In recent years, nutritional deficiencies in the soil and the palm have been considered to be other factors responsible for shedding of buttons. In both the temperate and tropical countries the application of nitrogenous manures has

often times been found to increase setting while at other times similar applications resulted in increase in setting and consequently in the yield. Comparative analysis of various plots in Indo-China (cited in 11) where shedding of buttons occurred led to the conclusion that the fundamental cause was the insufficient nourishment of the roots which was remedied by the application of nitrogenous manures. Later observations on this aspect in Ceylon (11) were, however, contradictory as the nut fall was observed even in plots which were regularly and liberally manured and shedding was comparatively less in other plots which rarely received any manurial treatment. Other workers in Ceylon (3) found that fertilizer application which increased the total crop did so by increasing the initial number of female flowers rather than by reducing percentage shed of buttons. In British East Africa (24 and 25) experiments were conducted to ascertain the influence of nitrogen, phosphorus and potash on the shedding of buttons but the results were not known. Workers (7) in Ceylon believed that the fall of buttons was a natural phenomenon since far more female flowers were produced than the palm could bring to maturity. But the fact that the shedding of buttons was equally uniform even in bunches that had very few female flowers and occurred at a definite period in the early development of flowers, however, gave an element of doubt if shedding could really be a natural phenomenon. Some workers (7) believed that the shedding of buttons is an outcome of weakness of the bunch stalks and want of mechanical strength in the tissues.

SHEDDING CAUSED BY UNFAVOURABLE CONDITIONS

Results of investigations on this problem in Kenya (13), British Solomon Islands (cited in 9) and New Guinea (9) showed sufficient evidence to prove that the shedding of buttons is due to unfavourable conditions prevailing. The results obtained showed that shedding of buttons occurred not only when there was deficit of moisture but during wettest times of the year also. In Ceylon (11) it was seen that water deficiency affected not only setting of nuts in coconut plantations but resulted in severe shedding of nuts specially after unusually prolonged period of drought and particularly after the onset of the first rains. Somewhat similar results were obtained in studies undertaken in Kenya (13). Recently, workers in Ceylon (15) therefore, advocated suitable measures to improve water holding capacity of the soil to ward off effects of dry weather. Some of the workers in Ceylon (11) on the other hand found that the shedding of buttons occurred principally during the rains of the North East monsoon which interfered with the absorption of water and aeration of the plant. It was seen that the shedding of buttons was more severe on heavy soils than in others which were lighter. In the Philippines (21) it was observed that the disease occurred only in very wet weather and the malady was far more serious when fungus was also present. It was, therefore, suggested to increase the distance of planting which brought about less wet conditions. Investigations carried out at Kasaragod (4) to find out the effect of prevailing weather conditions on the percentage shedding of buttons showed that although there was some difference in the percentage shedding in the different months, results when reduced to tests of statistical analysis showed that the differences in shedding of buttons in the different months were not found to be significant.

SHEDDING AS A RESULT OF DEFECTIVE POLLINATION

Imperfect or lack of pollination as a *prima facie* cause of shedding of buttons in the coconuts received fair attention at the hands of research workers. Preliminary investigations on this aspect undertaken in Ceylon (17) indicated that it was difficult to determine if the buttons falling away were fertilized or not because by the time they fell the tissues at the base of the nuts and along the Central canal underwent considerable decay. It was, therefore, suggested that an indirect evidence on this point might be obtained by artificially pollinating all the female flowers of an inflorescence and by bagging the inflorescence and preventing pollination in some to determine whether unfertilized nuts fell sooner or later than usual. These trials are in progress at Kasaragod and the results are awaited. In Zanzibar (24 and 25) the fall of buttons was found to be due to abortion of carpels in the female flowers which caused the failure of fertilization. This was also attributed to insufficient nourishment of the pollen grains and the failure of micropylar canal to enlarge, resulting in the failure of the pollen tube to reach the ovule specially due to the lack of moisture in the tissues of the flower.

PHYSIOLOGICAL CONDITIONS FAVOURING SHEDDING OF BUTTONS

In recent years considerable emphasis was laid on physiological condition of plants as an index to ascertaining the function of plants in health and disease. Failure in the past to find a causative organism associated with the disease often gave rise to the belief that the cause of shedding might perhaps be due to physiological or environmental conditions and this view was supported by workers in Ceylon (11) and Trinidad (6). The former explained his view by taking the illustration of the root of the coconut which when arrested in growth due to dry and water logged conditions brought about physiological drought due to formation of hypodermis nearer the root cap or tip reducing the area of absorption of nutrients from the soil. The latter worker showed how the shedding of nuts could be the result of external manifestations and internal physiological redistribution of substances within the plant tissues and, therefore, suggested that the mechanism of growth and development in the coconut which is most delicately balanced and which responded easily to environmental factors required to be investigated thoroughly before any conclusive results were to be obtained.

ABSCISSION, A POSSIBLE CAUSE FOR SHEDDING OF BUTTONS

The phenomenon of fruit fall is of considerable importance in the study of water relationship between the fruit and the plant to which it is attached. In Ceylon (11) it was shown how soil moisture was an important factor in the setting of fruits and showed how conservation of soil moisture could possibly reduce shedding or drop of fruits. As the increase in the shedding of buttons followed a period of drought, it was felt that formation of abscission layer in the tissues at the places where the nuts are attached to the stem, as a result of severe drought, may perhaps cause shedding of buttons. This view was also emphasised by workers in Ceylon (11 and 7) and it was suggested that spraying with hormones might well be tried to check the incidence of the disease. Accordingly, some work in this direction was done at Kayangulam (5) with proprietory hormones, Planofix, Phyomone, Fernoxone and Methoxone. The results obtained from

these trials were not, however, encouraging. Although some of the sprays helped in retention of nuts, they inhibited, however, the development, resulting in formation of barren nuts.

This problem had been under investigation in Ceylon (22) and Madras (1 and 16) for a fairly long time. Consequent on the re-organisation of research work on the coconut under the Indian Central Coconut Committee at Kasaragod, detailed investigations on this vexed problem in its different aspects are under way. The attempts made included not only investigations on the cause responsible for the shed of buttons but also those which would help in evolving a suitable method which will check effectively the shedding of buttons occurring in the plantations. Among the investigations on hand the spraying trials with three different hormones, *viz.*, Planofix, Phyomone and Dichlorophenoxy Acetic acid, in six different concentrations sprayed at varying intervals between successive sprays has showed indications of yielding promising results. Of these hormones tried, the spray of Dichlorophenoxy Acetic acid alone has been found to check efficiently the shedding of buttons. The useful results obtained are being verified from repeated trials to render the results a stamp of accuracy before they are duly publicised.

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