Studies on the occurrence of barren nuts in the coconut (*Cocos nucifera*, L.)

2. Certain aspects of barren nut production with special reference to frequency of incidence and distribution and probable causes of production of different types of barren nuts

By

M. C. NAMBIAR, A. S. PANKAJAKSHAN, T. P. GOPALAKRISHNAN AND K. M. PANDALAI,
Central Coconut Research Station, Kasaragod

Results of preliminary investigations on the importance, morphological features, trends in production, extent of incidence in relation to yield and incidence of different types of barren nuts met with in the coconut plantations were discussed in a previous communication from this Research Station (Gangolly and Nambiar, 1953). Though the phenomenon of barren nut production in coconut has also received some attention in the past (Bartter and Belling, 1907; Furtado, 1924; Ann. Rep. A. R. S., Kasaragod, 1935; Ann. Rep. C.C.R.S., Kasaragod, 1947–'49; John and Menon, 1947; and Menon and Pandalai, 1958) information of the various aspects of barren nut production and possible method of amelioration is indeed very inadequate. Since the endosperm or the kernel is the most important economic product from the palm, any deformity affecting its development will naturally be of great consequence to the cultivators and consumers alike. The present study was, therefore, initiated with a view to collect exhaustive and critical information on the different aspects of barren nut production with special reference to frequency of incidence and distribution and probable causes of production of different types of barren nuts.

MATERIALS AND METHOD

Two thousand fifty-six barren nuts from the bulk harvest of the year 1958 and 265 from 19 predominantly barren nut producing trees of this Research

Station collected during the different months of the year 1961 were classified into the following five types, (Fig. 1):-

(1) Shell cracked at the apex or stigmatic end – A

(2) Shell cracked at the base - B

(3) Barren nuts with liquid endosperm or partial kernel and shell free from cracks – C

(4) Pigmy nut with thick reduced shell and no endosperm – D

(5) Rudimentary type with a cavity in the husk just above the rudimentary shell – E.

The categories 'A','B' and 'C' were further classified according to the presence or absence of endosperm and embryo. All nuts with kernel, irrespective of the quantity present were considered as having 'partial kernel'. Nuts having defective development due to external damages caused mostly by woodpeckers are sometimes misclassified as barren nuts. Such damaged nuts have been excluded from the present study.

The distribution pattern of different types of barren nuts was examined on the basis of actual figures and percentages.

RESULTS

Results of detailed investigation on the frequency distribution and seasonal variation in the production of different types of barren nuts are presented in Tables I and II. Among the five types of barren nuts described above, those having their shell cracked either at the apex (A) or base (B) are more predominane and account for 70 per cent of the total, while types 'C', 'D' and 'E' account for 14, 4 and 12 per cent respectively. From Table II it is further evident that more than 50 per cent of the barren nuts produced during October–February months belong to the type 'B' while 'A' type barren nuts are produced more in numbers during March–July months. But for mild fluctuation, the proportion of type 'C' produced is the same for different months. Comparatively more numbers of type 'D' nuts are produced during September–November months and type 'E' in August. The proportion of rudimentary type of barren nuts is likely to be higher if the unfertilised nuts which develop to a fair size and drop off later on were also to be collected and classified. It is of particular interest that 91 per cent of the barren nuts of the type 'A' is produced during March–July months and 78 per cent of type 'B' during the five months of October-February.

Table III gives a fair indication of the relation between the type of barren nut and the extent of kernel formation in different types. The percentage of

Fig. 1. Five distinct types of barren nuts.

nuts having partial kernel in types 'B' and 'C' are 0.65 and 0.61 respectively, while it is only 0.18 % in type 'A'. 'D' and 'E' types do not generally contain kernel.

Embryo development is very rare in barren nuts. A few instances are, however, noticed in type 'C' and very rarely in type 'D' wherein the development of the embryo and surrounding endosperm at the micropilar end of the nut is quite normal. The frequency of occurrence of different types of barren nuts having embryo is shown in Table IV. In the present investigation 3 out of 657 barren nuts of type 'A' and 28 out of 296 of type 'C' and none of type 'B' had embryo.

The data collected on barren nuts produced in successive bunches of certain high barren nut producing trees are tabulated in Table V. The observations indicate a strong tendency for the regular barren nut producing trees to produce either 'A' or 'B' type only. The season of production of these two types is also distinctly different. Type 'A' barren nuts are produced by one set of trees during April to July months while type 'B' barren nuts are produced by another set of trees during the 4 months of November–February. The other three types are produced at random and very rarely they are found produced by particular trees.

DISCUSSION

Barren nut production in coconuts has been attributed by earlier workers to various causes like defective fertilization (Furtado, 1924), and nutritional deficiency and exhaustion of the palm due to excessive bearing of normal nuts (Gangolly and Nambiar, 1953). It would, however, appear that a satisfactory explanation for the phenomenon of barren nut production can be had only by a correct appreciation of the nature of the different types of barren nuts, since it is quite probable that different and entirely unrelated sets of factors may be responsible for the production of distinct types of barren nuts, as revealed from the facts discussed below.

(1) Barren nuts with cracks in the shell — Types 'A' and 'B'

Among the five types of barren nuts above described, those having their shell cracked at the apex 'A' or base 'B' are more common, accounting for about 70 per cent of the total production of barren nuts. As regards the presence of partial kernel and embryo much variations are observed within and between the two types. While embryo development is totally absent in type 'B', it is rarely found in type 'A'. Thus none of 776 'B' type nuts showed embryo development while three out of 657 'A' type nuts showed the presence of embryo. The development of the kernel on the other hand is relatively more common in both the types, and it is rather frequent in type 'B'; 65 per cent of this type of nuts showing partial kernel formation compared to 18 per cent in type 'A'. The complete absence of kernel in a majority (82 per cent) of 'A' type barren nuts (Table III) may probably be due to cracking of the shell and favourable position of the crack for the consequent draining away of the liquid endosperm, before the kernel formation takes place. In the type 'B' where the cracking of the shell is at the base, the formation of partial kernel, in majority of cases, may be due to the effect of orientation of the nuts on the bunches. Thus, if the barren nut of the type 'A' is so orientated on the bunch that the stigmatic end is towards the top, the liquid endosperm is not completely drained off; more than half the liquid endosperm is likely to be retained at the basal half thereby facilitating the kernel and embryo development at this end. The number of nuts with such orientation is comparatively few. Majority of nuts have their stigmatic end orientated downwards, and this fact probably explains the reason for the significantly higher proportion of nuts having no kernel formation in this type. When the crack in the shell is at the base, the normal position of the nuts on the bunches is more favourable for the partial retention of the liquid endosperm and consequent development of the partial kernel at the stigmatic end. Complete absence of embryo in this type is only to be expected; for, whatever be the position of the nut the crack at the micropilar end does not permit the development of kernel or the embryo.

While the presence or absence of kernel and embryo in the two types of barren nuts can possibly be explained on the basis of the orientation of the nuts and the relative position of the crack on the shell, the factors responsible for the development of the crack itself are not yet known. It has been observed in the present study (Tables I, II and V) that there is a strong tendency for certain trees to produce consistently either 'A' or 'B' type of barren nuts. This may indicate that the production of these types of barren nuts may perhaps be controlled genetically. That this may be so, is also supported by the observation on one of the progenies[3] of tree No. XI/7 belonging to the variety Kappadam which produced the same type of barren nuts as the seed parent. The observation that the type 'A' nuts occur mostly in April–July months and type 'B' in November – February months, however, may indicate the possible influence of seasonal factors also on types of barren nuts produced.

(2) Barren nuts with normal shell 'C' and pigmy nut 'D'

These two types account for about 15-20 per cent of the total production of barren nuts. Type 'C' is characterised by the development of normal shell, presence of either liquid endosperm or partial kernel and may occasionally contain normal embryo. The frequency of this type of barren nuts with embryo is, however, greater than that of nuts with embryo in type 'A'. But the main point of difference between types 'A' and 'C' is the absence of the crack in the shell for the latter. Also in this type, protuberances of integuments are observed in places where there is no kernel formation. The thickening of the integuments is also characteristic of type 'D' which shows neither liquid endosperm nor kernel formation. Unlike the 'A' and 'B' types above described, the

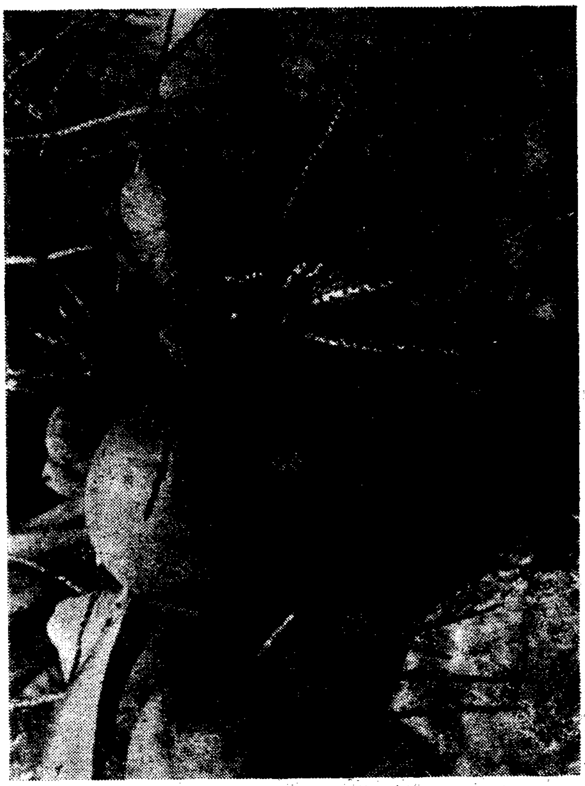

Fig. 2. Rudimentary type of barren nuts (indicated by arrow) in dwarf orange palm. Note the reduced size and linear shape of the barren nuts.

Fig. 3. Rudimentary types of barren nuts produced artificially by prevention of pollination.

Fig. 4. Extraordinarily large number of developing female flowers in one of the progenies of Laccadive small. A few of them (indicated by arrow) are barren nuts of rudimentary type.

production of 'C' and 'D' types is not confined to any particular set of trees but is at random. There is also no pronounced seasonal variation in the frequency of production of these two types. It is, however, likely that some genetical or physiological factors may be responsible for the disturbance in the metabolic processes leading to the normal development of the endosperm in these two types.

In the above four types of barren nuts the development of the mesocarp and endocarp is apparently normal but for the cracking of the endocarp (shell) in type 'A' and 'B' which sets in only at a later stage of shell formation, i. e., by about the sixth month. The presence of kernel in types 'A', 'B' and 'C' and the rare occurrence of embryo in types 'A' and 'C' and liquid endosperm in type 'C' suggest the possibility that there is normal fertilization in these types and that the degeneration of the endosperm is probably a post-fertilization disturbance. The fact that all cases where there is development of endosperm at the micropilar end showed the presence of embryo also, indicate that the inhibition of embryo development is probably due to failure of endosperm development.

(3) *Rudimentary type of barren nuts 'E'*

This type is more frequent in dwarf palms, especially in dwarf orange type (Fig. 2) and also in young palms of the tall variety in the early years of bearing. This type is characterised by the rudimentary solid shell and a cavity in the husk just above the shell. The cavity is first found to develop just above the rudimentary endocarp in the very early stages of nut development. This cavity often extends up to the attachment region and interferes with proper supply of nutrients to the mesocarp. Depending on the extent of damage to the attachment region, these nuts may fall off at different stages of development or stick on to the spike. The development and size of such nuts are, however, very much reduced possibly due to lack of flow of nutrients to the mesocarp. Since fertilization is known to stimulate the growth of maternal tissue the lack of development of endocarp and integuments in this type of barren nuts may possibly be attributed to defective fertilization and consequent degeneration of the ovule. That this may be so has been confirmed by artificial production of this type of barren nuts by prevention of pollination. The inflorescences were emasculated and bagged before the female flowers became receptive, and a few nuts obtained from these bagged inflorescences were all barren with rudimentary shell and cavity in the husk (Fig. 3). Thus direct evidence as to the factors responsible for barrenness is available only in the case of the rudimentary types. It cannot, however, be said that defective pollination alone may be responsible for the production of this type of barren nuts. It has been found in a progeny of *Laccadive small* with extraordinarily large number of female flowers (Fig. 4) especially in the first few inflorescences, that this type of barren nuts occurred very frequently.

It may be that this has been the result of overcrowding of buttons and consequent failure of pollination and / or defective nutrient supply in some of the developing buttons. Again, this type of nuts has been known to result from diseased conditions. Cases of trees producing exclusively this type of nuts as well as those having such nuts in some of the bunches have also been observed. It would thus appear that this type of barren nuts may be the result of (1) failure of pollination, (2) failure of normal fertilization and/or (3) defective megasporogenesis resulting from genetic and environmental factors such as disease conditions.

Almost all the other types of barren nuts described above ('A', 'B', 'C' and 'D') belong to the post-fertilization disturbance group unlike the rudimentary type which is to be regarded as a pre-fertilization disturbance. It is thus possible that in the former types some physiological factors controlled genetically or otherwise may be responsible for the disturbance in the metabolic process resulting in the abnormal developments. These factors operating at different stages of development may give expression to their effect in different ways depending upon the particular metabolic process interfered with.

It is thus clear that a scientific approach to the problem of barren nut production in coconuts with particular emphasis to the different types of barren nuts and the factors responsible for the production of these, alone can be of value in tackling this problem and arriving at possible methods of amelioration.

SUMMARY

Detailed studies on a large number of barren nuts collected from the coconut palms of the Central Coconut Research Station, Kasaragod have made it possible to classify them into five categories, of which those types having their shell cracked either at the apex (A) or base (B) are more predominant and the season of production of these two types are also distinctly different. Type 'A' barren nuts are produced repeatedly by one set of trees during April to July months, while type 'B' barren nuts are repeatedly produced by another set of trees during November to February months. The other three types (C, D and E) are produced at random and very rarely they are found produced by particular trees. Four categories of barren nuts (A, B, C and D) show normal development of all parts of the nut except kernel and embryo while the fifth (E) is a much reduced rudimentary type. In 'A' and 'B' types of barren nuts which are found to occur to a greater extent and which are characterised by the presence of cracks in the shell, kernel and embryo may or may not be present depending upon the orientation of the nuts in the bunch and the relative position of the crack on the shell.

The complete or partial failure of endosperm formation in 'A', 'B', 'C' and 'D' types of barren nuts is, in all probability, the result of post-fertilization

disturbance of the normal metabolic process controlled by either genetical factors or otherwise. The factors operating at different stages of development may give expression to the effect in different ways depending upon the particular metabolic process interfered with. In the case of rudimentary type of barren nuts (E) there is sufficient evidence both direct and indirect to conclude that some pre-fertilization disturbance may be involved such as failure of pollination, failure of normal fertilization and/or defective megasporogenesis resulting from genetical or environmental factors.

ACKNOWLEDGEMENT

The authors are thankful to Sri M. M. Krishna Marar, Agronomist and Dr. C. A. Ninan, Botanist (at present Reader in Botany, University of Kerala), Central Coconut Research Station, Kasaragod for their constructive criticism and valuable suggestions in the preparation of this paper.

REFERENCES

1. Annual Progress Report of the Agricultural Research Station, Kasaragod. 1934-35.
2. Annual Progress Report of the Central Coconut Research Station, Kasaragod, 1947-48.
3. Annual Progress Report of the Central Coconut Research Station, Kasaragod, 1948-49.
4. Barter, A. W. and Belling, J. (1907) Male or seedless coconut. *Agricultural News*, Barbados 6, No. 128, p. 87.
5. Furtado, C. X. (1924) Study of coconut flower and its relation to production. *Gardeners' bull.* Straits Settlements. 3: 261-274.
6. Gangolly, S. R. and Nambiar, M. C. (1953) Studies on the occurrence of barren nuts in coconut. (*Cocos nucifera* L.) 1. Importance, morphological features and frequency in incidence. *Indian Coconut Journal*, Vol. VII, No. 1.
7. John, C. M. and Menon, K. P. V. (1947) Joint report of work done on improvement of coconut in the provinces and states and report of future lines of work. Indian Central Coconut Committee, Ernakulam.
8. Menon, K. P. V. and Pandalai, K. M. (1958) *The Coconut Palm – A Monograph.* Indian Central Coconut Committee, Ernakulam.
9. Patel, J. S. (1938) *The Coconut – Monograph.* Government Press, Madras.

Received in February 1964.

TABLE I

Distribution of barren nuts under different types

1958	TYPES					Total	Woodpecker damaged nuts
	A	B	C	D	E		
January	3	24	17	—	6	50	5
February	21	182	60	1	37	301	96
March	58	20	29	—	19	126	11
April	175	27	32	2	31	267	17
May	181	27	33	4	19	264	39
June	107	23	22	7	23	182	36
July	79	48	25	7	35	194	18
August	19	19	17	6	35	96	17
September	7	8	7	7	4	33	12
October	—	17	12	8	1	38	—
November	7	142	22	29	15	216	28
December	—	239	20	14	17	290	17
	657	776	296	85	242	2056	296

TABLE II

Month-war percentage distribution of barren nuts under different types

1958	TYPES				
	A	B	C	D	E
January	6	48	34	—	12
February	7	61	20	—	12
March	46	16	23	—	15
April	65	10	12	1	12
May	69	10	12	2	7
June	59	13	12	4	12
July	41	25	13	4	18
August	20	20	18	6	36
September	22	24	21	21	12
October	—	45	31	21	3
November	3	66	10	14	7
December	—	82	7	5	6
Overall	14	38	32	4	12

TABLE III

Sub-classification of A, B and C types based on presence or absence of kernel

Types	Number of nuts in which		
	Kernel present	Kernel absent	Total
A	120	537	657
B	505	271	776
C	181	115	296

TABLE IV

Frequency of different types of barren nuts having embryo

Types	Number of nuts in which		Total
	Embryo present	Embryo absent	
A	3	654	657
B	—	776	776
C	28	258	296

TABLE V

Distribution according to type and month of barren nuts produced in certain selected trees during 1961

Sl. No.	Tree No.	January			February			March			April			May			June		
		A	B	Others	A	B	Others	A	B	Others	A	B	Others	A	B	Others	A	B	Others
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	I – 43													16	–	–	4	–	–
2	II – 19													8	–	–	7	–	–
3	II – 79													8	–	–	7	–	–
4	IV – 26													2	–	–	14	–	
5	V – 70																2	–	
6	VI – 67				–	–	1							5	–	–	3	–	
7	VI – 18													3	–	–	8	–	
8	XI – 7										24	–	2	3	–	–	–	–	–
9	27N – 374							–	–	1	6	–	–	4	–	–			
10	RS 40-494										1	–	–	3	–	–	10	–	1
11	VI – 87	–	1	–	–	5	–												
12	27N – 126	–	2	–													–	–	1
13	29N – 14				–	1	–	–	3	–									
14	29S – 591																		
15	VIII – 50	–	1	–				–	1	–									
16	27S – 279	–	2	–													–	–	1
17	39/3b – 226	–	2	–	–	1	–	–	2	–							–	–	1
18	27N – 100	–	1	–	–	1	–												
19	27N – 69	–	1																
	Total	–	10	–	–	8	1	–	6	1	31	–	2	54	–	–	55	–	4

TABLE V (Contd.)

July			August			September			October			November			December			Total		
A	B	Others	A	B	Others	A	B	Others	A	B	Others	A	B	Others	A	B	Others	A	B	Others
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
1	–	–	1	–	–													24	–	–
9	–	–	1	–	–													25	–	–
6	–	–	1	–	–													22	–	–
4	–	–	2	–	–													22	–	–
5	–	–													–	–	3	7	–	3
7	–	–																15	–	1
14	–	–																25	–	–
2	–	–																29	–	2
																		10	–	1
–	–	–	2	–	–													16	–	1
																		–	6	–
															–	2	–	–	4	1
															–	8	–	–	12	–
			–	1	–							–	3	–	–	7	–	–	11	–
			–	2	–													–	4	–
												–	3	–	–	3	–		8	1
															–	3	–		8	1
									–	1	–							–	3	–
									–	–	1	–	1	–				–	2	1
46	–	–	7	3	–				–	1	1	–	7	–	–	23	3	195	58	12