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Growth, Development and Dry Matter Accumulation in the Fruit of *Cocos nucifera* L. var *nana* form *pumila*

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ABSTRACT

The growth and development, from fertilization to maturity, of the fruit of *Cocos nucifera* var. *Nana* form *pumila* and its components, were studied in terms of dry matter accumulation. The development of the fruit showed an approximately sigmoidal pattern with a substantial linear phase during which most of the increase in dry weight occurred. During the linear phase of growth the rate of dry matter accumulation by the whole fruit was about 70.9g/ month. A linear phase was evident in the growth curves of each of the fruit components husk, shell, and endosperm. The growth curves of these components also conformed to a sigmoid pattern.

The husk, shell and endosperm commenced growth in the first, fifth and sixth months respectively. Over the 11 month period of fruit development the three components grew simultaneously only over a three month period from five to eight months after fertilization. The rapid growth phase of the husk, shell and endosperm extended from three to seven months, five to nine months and six to ten months, respectively. During this linear growth phase the average growth rate of the endosperm was 39.9g/ month and the highest rate of growth was 53.1g/ month in the ninth month.

At maturity the total fruit dry weight was 476g with the husk contributing 41.9%, the shell 22.5% and the endosperm 35.6%.

INTRODUCTION

The development of the fruit could be divided into four distinct phases, namely initiation, pre-pollination development, post-pollination development and finally maturation and senescence. In coconut, the inflorescence primordium is first visible in the axil of the fourth leaf, counting from the apex. The first differentiation of the ovary and perianth from the female flower primordium takes place about six to seven months prior to the opening of the spathe (Menon and Pandalai, 1958). This is the stage at which the initiation of the fruit takes place. The period from initiation to fertilization is the pre-pollination phase and the development and increase in size during this period is mainly by cell division.

The growth during the post-pollination phase, that is, from fertilization to maturity is mainly by cell enlargement which is associated with the accumulation of food reserves. The production and accumulation of food reserves depend on (a) the efficiency of the assimilation system, (b) the storage capacity of the fruit and (c) the translocation of assimilates into the developing fruit from the sites of assimilation. As there will be twelve or more bunches of different ages at any particular time (with fruits in various stages of development), competition for assimilates will also influence the amount of food stored in each fruit. Morphological and anatomical changes that take place during the development of the fruit have been discussed by Fandino (1928) and Menon and Pandalai (1958). The physiological factors mentioned above which determine the growth and final size of the fruit may be influenced by environment and genotype.

The fruit of the coconut, which is popularly known as the 'nut', consists of three major components, namely the husk, shell and kernel (endosperm). The kernel is, economically, the most important part of the fruit and therefore the rate of growth of the kernel and the duration of its growth are two important physiological parameters in the development of the fruit. Partitioning of relatively high proporations of dry matter (assimilates) into the husk and shell at the expense of the kernel may also impose a limitation on kernel growth. Very little information is available on the rate of growth and dry matter accumulation of the nut and its components, and on the concurrence of growth phases of the nut components. A period of concurrent growth of the components, if any, is likely to be critical in the development of the fruit as there would be competition between the endosperm, which is most important economically, and the husk and shell. The present study was, therefore, conducted to investigate the development and growth of the nut and its components during the third phase, from fertilization to maturity, in terms of dry weight accumulation.

MATERIALS AND METHODS

The study was carried out on dwarf palms (variety *nana* form *pumila*)at the Isolated Seed Garden at Ambakelle. The date of opening of the inflorescences, in randomly selected palms,were recorded and the developing fruits were sampled at monthly intervals. The age of the nut on the day of the opening of the inflorescence was taken as zero. At each monthly sampling the picked nuts were separated into their components (husk, shell and kernel) and their dry weights obtained by dehydration for at least 72 hours at 90°C Each sample consisted of five nuts and there were three replications. The rainfall received over the period of nut development is presented in Table I.

Table 1. *Rainfall (mm) over the post-pollination phase of fruit development from fertilization to maturity.*

Period	*Rainfall (mm)*	
	Monthly	*Cumulative*
1st month	1.6	1.6
2nd month	2.1	3.7
3rd month	89.7	93.4
4th month	78.3	171.7
5th month	140.6	312.3
6th month	169.3	481.6
7th month	64.6	546.2
8th month	61.3	607.5
9th month	172.6	780.1
10th month	92.5	872.6
11th month	129.9	1002.5
12th month	60.7	1063.2

RESULTS & DISCUSSION

The changes in total fruit dry weight with time are shown in Fig. I. The time course of nut weight increase is approximately sigmoidal with a substantial linear phase during which the greater part of the nut weight is attained. Although the early and late flatter parts of the curve account for much of the time, the increase in dry weight over these two periods is very small. The period of rapid growth was from about four to nine months after fertilization. Thus the development of the nut exhibited three distinct phases: the first phase of slow growth for about four months, the second phase of rapid growth for about five months and the third phase of about two months during which the growth of the nut slows down. These observations are similar to that reported by Nambiar *et-al* (1969). These workers also found that the rate of growth during the second phase was highly correlated with the final volumes and weights of unhusked and husked nuts and copra weight.

The rate of nut growth during the linear phase as calculated by its regression on time was 70.9g month. Dieckert and Dieckert (1973a) reported that half the maximal growth of the nut was reached at about 4.8 months. The final dry weight of the nut recorded in the present study was 476g and half of this maximal growth was attained at about 6.5 months.

The dry weight increase of the nut components, husk, shell and endosperm, during their development is shown in Fig. 2. It is evident that the commencement and termination of the growth of these components took place at different times. However, the growth of all three components overlapped during the three month period from five to eight months after fertilization.

The growth of the husk was very slow upto about three months after fertilization. This was followed by a rapid increase in dry weight for about four months after which the growth slowed down again. The growth of the husk during the rapid stage of development showed an approximately linear response and the equation $y = 42.7x - 109$, was highly significant ($r = 0.985$).

The development of the shell commenced around four months after fertilization and continued up to about nine months. (Fig. 2). There was a rapid dry weight increase of the shell observed between five and nine months. Assuming a linear response for this period, the rate of dry weight change could be expressed by the equation $y = 23.2x - 95.7$, with a correlation coefficient of $r = 0.996$.

The endosperm commenced growing around five months from fertilization and at six months appreciable amounts of semi-solid endosperm had formed. Dieckert and Dieckert (1973a) reported that substantial amounts of endosperm was present between the 6th and 7th months from anthesis. The dry weight increase of the endosperm also followed a sigmoidal pattern with slow growth at the beginning and towards the end of the growth period (Fig. 2). From six to ten months the endosperm dry weight increased rapidly with an average growth rate of 39.9g/ month. The rainfall during this period was 391mm. Accumulation of dry matter in the endosperm ceased after eleven months. With that the increase in dry weight of the whole nut also ceased indicating that no assimilates are transported into the nut after the full development of the endosperm.

Fig. 1. Changes in fruit dry weight with time.

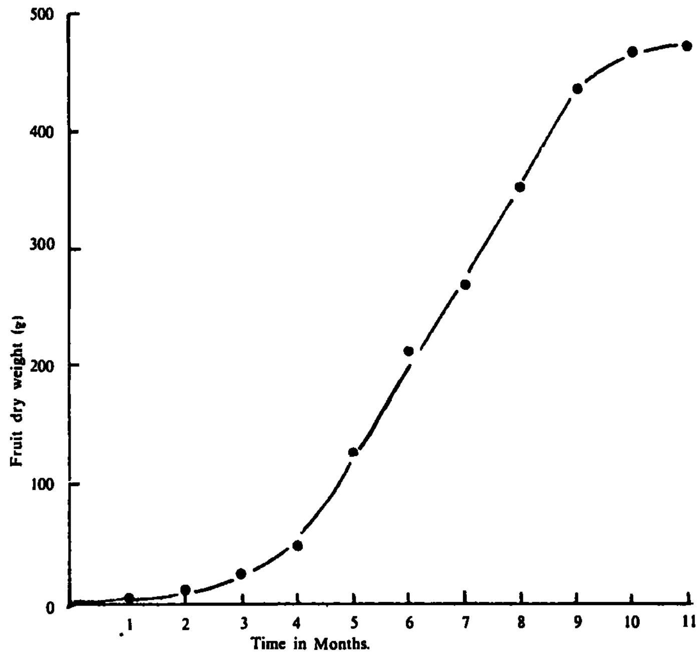
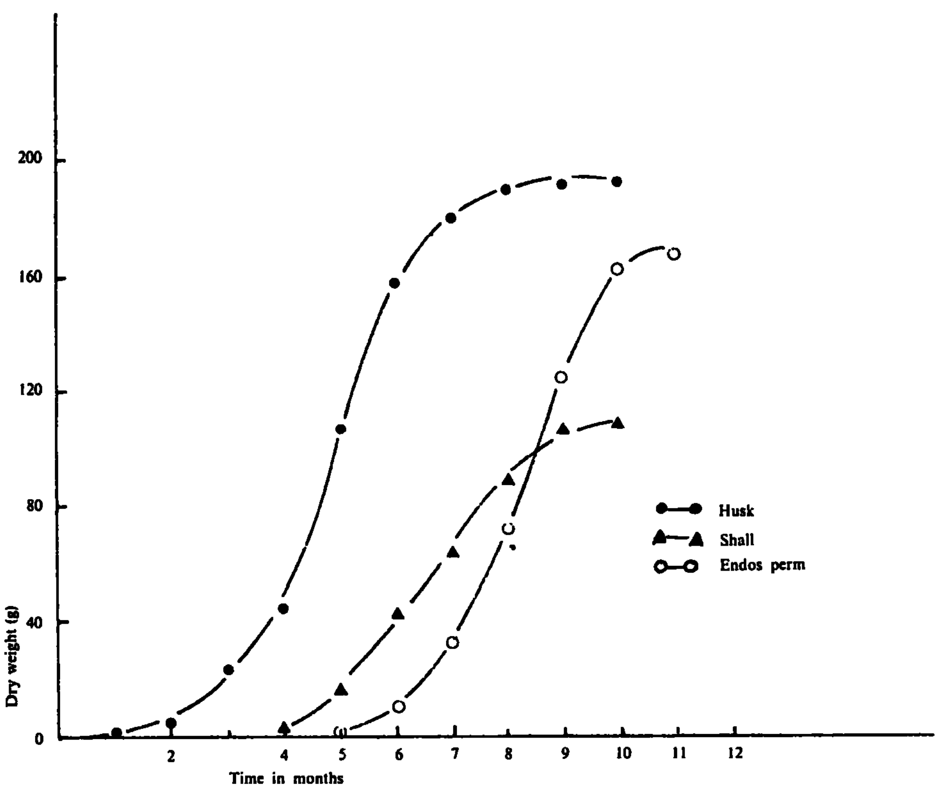


Fig. 2 Dry matter accumulation in the fruit components with time.



At maturity, the fruit weight consisted of 41.9%, 22.5% and 35.6% husk, shell and endosperm, respectively. Reddy *et al.* (1979) studied the proportions of the fruit components in ten varieties of coconut and reported that husk, shell and kernel ranged from 26 to 56%, 12 to 20% and 25 to 41% respectively. These results suggest that there are differences among varieties in the proportions in which assimilates are partitioned into the nut components.

In the present study the average kernel growth rate during the linear phase was 39.9g/ month and the highest growth rate was 53.1g/ month in the ninth month of development. At 172.6mm the rainfall during this month was the highest over the entire period of fruit development. Nathanael (1966) reported a dry weight increase of 66g per nut in the 11th month of development while Mohanadas (1982) observed a dry weight increase of 45g per nut in the eight month of development. These workers have not reported the environmental conditions such as rainfall under which the nuts developed. The differences reported in the highest rate of dry matter accumulation in the kernel may be attributed to either genotypic or environmental factors or both. The effect of environmental factors on nut growth have been reported by Nambiar *et al.* (1969) and Dieckert and Dieckert (1973b). According to the former authors any adverse seasonal factor coinciding with the active period of development, that is the second phase of rapid growth adversely affects the rate of growth and the final size of the nut and copra content. Dieckert and Dieckert (1973b) observed a close correlation between the calendar date on which half the maximal growth is acheived and the average rainfall for the corresponding month. When rainfall was highest during this period maximal seed sizes were attained and conversely. These observations are supported by Davis and Ghosh (1982) who reported that there was an increase in copra weight per nut (endosperm dry weight) in the nuts which received a high rainfall when they were about four to five months old. The large variation observed in the dry weight ratios of nut components within a variety (Reddy *et al.* 1980) may be due to the effects of environmental factors during the period of rapid growth. Further-more, the different proportions of dry matter in the husk, shell and endosperm as noted by Reddy *et al.* (1979) suggest that there may be genotypic differences in partitioning of dry matter into the nut components.

During the first three months of endosperm formation (5 to 8 months) both the husk and shell are growing vigorously and are increasing in weight rapidly. This is no doubt a critical period in the development of the endosperm due to the competition for assimilates by the husk and the shell. It is perhaps significant that the highest growth rate of endosperm was in the ninth month when the husk had ceased growth and shell growth had slowed down considerably.

In the present study only one type of coconut was investigated and only during one season. Studies over several seasons with a number of varieties could provide information about genotypic differences in fruit growth and environmental effects on these physiological processes. Careful evaluation of these processes may assist in the identification of varieties with high yield potential.

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