

A STUDY ON THE PATTERN OF FRUIT DEVELOPMENT IN ROBUSTA COFFEE (*COFFEA CANEPHORA* VAR. *ROBUSTA*)

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ABSTRACT: The present study was carried out in the Regional Coffee Research Station situated in Kerala State of India so as to analyze the pattern of growth and development of fruits in robusta coffee in terms of fruit size, fruit weight and dry matter production in the robusta coffee tract of the country. The study showed that the pattern of fruit growth was similar in different varieties of robusta coffee but it differed from that in arabica coffee. The fruits attained maturity by 300-330 days which consisted of three phases of development with a sigmoidal pattern.

Key words: *Coffea canephora*, robusta coffee, fruit development, fruit length, fruit breadth, fruit volume, fruit dry matter content

INTRODUCTION

Two cultivated species of the genus *Coffea* namely *C. arabica* L. and *C. canephora* Pierre ex Froehner var. *robusta* yield the coffee of commerce. Several improved varieties have been developed by selection and hybridisation in both the species. Robusta is a diploid species ($2n=22$) whereas arabica is tetraploid. *C. arabica* varieties are self fertile whereas *C. canephora* varieties are self sterile. Since beans are the economically important part of the plant, their setting and development have been investigated to a considerable extent. In *C. arabica* the fruits develop and mature in 8-9 months, and in *C. canephora* the fruits develop and mature in 10-11 months. Majority of the studies made on fruit development in coffee are confined to *C. arabica*. Studies on fruit development in robustas are far less. The growth pattern of robusta coffee fruits is less clearly understood [1]. In coffee, the development of fruits is influenced by many factors like genotype and climate [2,3]. Rainfall has got profound influence on initiation of blossom, fruit set and fruit development. Study of the pattern of fruit development helps in understanding the nutritional demand of the trees for growth and optimum yields. Studies have shown that the pattern of development of arabica coffee fruits is double sigmoid [4, 5, 6, 7, 8]. fruit growth is very slow at lower temperatures [9]. Many scientists have reported that the amount of rainfall received during the period of fruit development influences the growth of berries as well as the size of the bean [10, 11, 12]. In coffee pollination takes place within 6 hours after flower opening in bright light and warm windy conditions. The process of fertilisation is completed within 24-48 hours after pollination. The zygote and endosperm nucleus formed as a result of fertilisation undergo a rest period for nearly 60 days in robusta coffee while the integument of the ovule begins to increase in size to perform the nutritive function for zygote. The ovary develops into a globular or oval drupe normally containing two seeds [13]. After fertilisation cell division occurs in the ovaries for the first six to eight weeks but the fruits remain as pinheads, increasing very little in size or weight. However, duration of this pinhead stage varies with climate. In Costa Rica, pinhead stage lasts only for four weeks [4]. Under various conditions this pinhead stage spreads over the first six to ten weeks, when very little growth occurs. This pinhead stage of the berry is suggested to be the dormant period [14] associated with high levels of Abscissic Acid and low levels of Gibberellic Acid [15]. This stage cannot be regarded as dormant, since the berries show high respiration rate [16]. In India, in arabica coffee, up to 42 days after flower opening, berry growth is at minimum [5]. In the case of robusta, this pinhead stage may last for two or three months until there is sufficient moisture in the soil for the pinheads to develop [14].

The second stage of berry growth lasts from 10 to 17 weeks in Kenya [17] and 6 to 15 weeks in India [18]. During this period in arabica coffee fruits increase in size and fresh weight rapidly. This is due to rapid cell expansion and absorption of high water content. The two fruit locules swell to almost full size during this period. The size to which locules swell depends greatly on soil moisture status. Fruits expand during wet weather conditions, become larger with larger locules, which are subsequently filled with larger beans when compared to those that develop during hot and dry weather [19]. In Kenya size of the beans is reported to be determined by the amount of rainfall received during the fruit expansion period [11]. While comparing the development of fruits in *C. arabica* and *C. canephora* at Central Coffee Research Institute, Karnataka, India, it has been pointed out that there is almost linear increase in fruit size up to 90 days in *C. arabica* and up to 150 days in *C. canephora* [6]. Difference in fruit length, breadth and thickness between the species was evident at 60 days of growth. This difference was maintained up to the 120th day, but on the 150th day the differences were much reduced with slightly higher value for length in *C. arabica*. However, the values were higher for breadth and thickness in *C. canephora* at this stage.

In the third stage of fruit development in *C. arabica*, growth of fruits is reported to be slow [1]. During this period, fruits of *C. arabica* attain final size but dry matter was recorded to be lower [7]. In *C. canephora* fruit development differed from *C. arabica* where only two periods of fresh weight increase and a linear increase in dry weight were noticed [18].

Fourth stage of fruit development is approximately 17th to 28th weeks after flowering in arabica. During this period increase in fresh weight is reported to be very less. But, dry matter increases regularly. This is due to increase in dry weight of the bean. Studies have proved that during this period dry matter is deposited mainly in seeds, which reach their final size when the fruit is still green. At this stage, maturity of the beans as well as germination capacity is completed [7, 20]. From the studies conducted in India, it was observed that the second grand period of growth, 26 weeks after blossom represents the final filling of endosperm in arabica. This lasts for a month and it generally coincides with the month of October [18].

In the fifth and last stage of fruit development, changes occur mostly in the pericarp, which increases in size, fresh weight and dry weight. During ripening, pericarp turns to red or yellow, losing chlorophyll and producing ethylene. This period lasts from 30 to 35 weeks after blossom in arabica coffee [19] and 42 to 49 weeks in robusta. The normal duration of flower to mature fruits is about 6 to 8 months in arabica and 9 to 11 months in robusta [21, 22].

However, majority of the works mentioned above have been carried out in arabica coffee. In Kerala state of India, more than 95% of the coffee area is planted to robusta coffee. In view of this, a study on the growth pattern of fruits in terms of fruit size and fruit weight in robusta coffee was carried out at Regional Coffee Research Station, Chundale, Wayanad, Kerala, which is a part of the ecologically unique Western Ghat region of India situated at 13°22' N and 75°28' E at 840m above MSL with an annual rainfall of 2000-3000mm spread over a period of nine months ranging from March to November, average humidity of 88.9%, average minimum and maximum temperature between 17.6°C and 27.3°C. and with soil structure varying from sandy to clayey loams and soil pH ranging from 5.2 to 6.3.

MATERIALS AND METHODS

Fully stabilized accessions/ varieties of robusta coffee selected from the germplasm planted at Regional Coffee Research Station, Chundale, Wayanad, Kerala, India during the year 1980 at a spacing of 10' x 10' with 25 plants per plot were observed for the present study. The statistical design for the study was RBD. The observations were carried out for two years in 2007 and 2008 on six robusta accessions/ varieties (Table 1). Each accession/ variety was considered as a treatment and four replications per treatment were taken. Six plants were observed per plot at random. Natural showers initiated blossom during the month of March each year. Off-season flowers i.e., flowers other than those initiated due to general blossom were debudded from time to time. Initial observation on the ovary was recorded on the day of blossom and further observations were recorded at monthly intervals till the ripening of the berries. Thirty flat fruits were picked at random per each replication and the observations recorded as suggested by Srinivasan (1972) [23]. Pea berries were not included due difficulty in taking measurements. Samples were brought to the laboratory and surface moisture if any was wiped with a clean cloth.

On each sampling day, observations on physical parameters like length, breadth and thickness of fruits were recorded using vernier calipers and the same expressed in millimetres. Volume of the fruits was computed by multiplying length x breadth x thickness x 0.52 as standardised by Reddy (1976) [24]. After recording the fresh weight, fruits were kept in oven at 50°C for 72 hours and the dry weight was recorded. Fresh and dry weights of the fruits are expressed in gram/100 flat fruits. Dry matter production was computed in percent. Mean of two seasons was calculated and data analysed statistically.

Table 1. Details of accessions/ varieties of robusta coffee used for the present study.

S. No.	Accessions/ Varieties	Status
1	BR (Sln. 2R)	Belongs to second series of robusta selections (BR-bold robusta series)- developed by CCRI, India
2	S.274 (Sln. 1R)	Belongs to first series of robusta selections developed by CCRI, India- widely cultivated in Wayanad area, India
3	CxR	Hybrid variety of robusta coffee developed by crossing <i>Coffea congensis</i> (wild coffee species) with <i>Coffea canephora</i> var. robusta
4	S.3399	Elite selection of robusta coffee from Costa Rica
5	S.880	Elite selection of robusta coffee from Uganda
6	S.1932	Elite selection of robusta coffee from Madagascar

RESULTS AND DISCUSSION

Fruit size

The data presented in Table 2 and Fig. 1 revealed the pattern of increase in fruit length of the above varieties of robusta coffee. It was seen that an apparent increase in length of fruits occurs in three distinct phases. This was true in all the six varieties. The first phase of linear growth of fruits was very slow and continued up to 120 days. In the second phase, growth was very rapid and it lasted for 30 days. However, in the third phase, growth rate slowed down considerably and the fruits took about 330 days to attain full length. Growth pattern was the same in all the six varieties studied. During the initial stage and on the 30th day of blossom the difference in length of fruits among the six varieties was not significant. From 60th to 240th day significantly higher fruit length was noticed in CxR. On the 270th day though CxR recorded greater length as compared to other varieties, the difference was not statistically significant. On the 300th and 330th days significantly greater fruit length was noticed in CxR. Thus it is clear that CxR constantly recorded greater fruit length during different developmental stages when compared to the other varieties studied. During the first phase of fruit growth, i.e., from blossom to 120th day, increase in fruit breadth was the minimum and after the 120th day, it was rapid for about 30 days (Table 2 & Fig. 1). During the last phase, i.e., after the rapid growth phase, there was a slow increase in fruit breadth and fruits attained maximum breadth in about 330 days. During the initial stage, the difference in breadth of the fruits was non significant. At 90 days after flowering, CxR had significantly higher fruit breadth. At 120 and 240 days after flowering, it was not statistically significant. S.1932 also recorded higher fruit breadth during the initial and later stages of development (Table 2 & Fig. 2). Fruit thickness also showed the same trend of change as in the case of length and breadth of fruits (Table 2 & Fig. 3). Up to 120 days after flowering the breadth and thickness of fruits was almost same in all the varieties and fruits started exhibiting breadth-thickness differentiation only after the 120th day. From blossom to the 120th day increase in thickness was very slow. After this, there was a rapid increase in thickness for about 30 days and after this rapid phase of increase in thickness, the rate was again slowed down and the fruits attained maximum thickness between the 300th and 330th days. Among the varieties studied, the thickness of fruits was significantly higher in CxR and S.1932 during different stages of growth compared to the others. In the initial month, though the difference was statistically non significant, CxR showed higher fruit thickness. In the period between the 30th day to the 240th day, thickness of the fruit was greater in S.1932. During later stages of development, i.e., from 270th to 330th days, S.1932 showed significantly higher fruit thickness. CxR also recorded significantly higher fruit thickness starting from the 180th day to the 330th day except when observed on the 240th day, where the difference was non significant. It is evident from the observations that fruit thickness was greater in CxR and S.1932 compared to other accessions.

Table 2. Data showing changes in fruit characters in the case of the developing fruits of robusta coffee varieties at 30 days intervals starting from fruit set (mean of two seasons)

1. Fruit length (mm)												
Accessions	Number of days after blossom											
	Initial	30 days	60 days	90 days	120 days	150 days	180 days	210 days	240 days	270 days	300 days	330 days
BR	2.15	2.25	2.88	4.51	5.41	13.05	13.49	13.54	13.71	14.04	14.18	14.20
S.274	2.08	2.29	3.15	4.77	4.78	11.10	13.08	13.14	13.61	13.62	13.72	13.94
C x R	2.43	2.44	3.59	4.71	5.53	12.40	14.51	14.57	15.02	15.27	15.47	15.83
S.3399	2.18	2.20	3.35	4.62	4.83	13.11	13.78	13.91	13.92	13.99	14.25	14.29
S.880	2.10	2.28	3.19	4.87	4.90	13.26	13.41	13.73	13.79	14.51	14.56	14.94
S.1932	2.28	2.61	3.58	4.47	4.77	12.79	13.46	13.60	13.92	13.95	14.07	14.58
CD@5%	NS	NS	0.22	0.22	0.47	0.96	1.02	0.66	0.75	NS	0.70	0.80
2. Fruit breadth (mm)												
Accessions	Number of days after blossom											
	Initial	30 days	60 days	90 days	120 days	150 days	180 days	210 days	240 days	270 days	300 days	330 days
BR	1.20	1.55	1.88	2.95	3.69	10.39	11.28	11.48	11.77	11.83	12.05	12.47
S.274	1.40	1.44	2.01	2.59	3.40	9.84	11.10	11.34	11.50	11.52	12.00	12.15
C x R	1.45	1.58	2.01	2.84	3.83	11.00	11.59	11.84	12.13	12.12	12.85	13.46
S.3399	1.28	1.50	2.07	2.58	3.63	10.85	11.86	11.87	11.88	12.17	12.75	12.78
S.880	1.25	1.71	2.05	2.63	3.60	10.91	11.00	11.31	11.58	11.69	12.21	12.75
S.1932	1.38	1.86	2.17	2.84	3.39	10.79	11.46	11.54	11.70	11.85	12.99	13.10
CD@5%	NS	0.205	0.102	0.175	NS	0.704	0.493	0.488	NS	0.437	0.73	0.834
3. Fruit thickness (mm)												
Accessions	Number of days after blossom											
	Initial	30days	60days	90days	120days	150days	180days	210days	240days	270days	300days	330days
BR	1.20	1.55	1.88	2.95	3.51	9.56	9.79	9.79	10.09	10.10	10.80	10.82
S.274	1.40	1.44	2.01	2.59	3.44	9.07	9.94	9.98	9.98	10.04	10.91	10.96
C x R	1.45	1.58	2.01	2.84	3.07	9.17	10.35	10.42	10.61	10.65	11.85	11.99
S.3399	1.28	1.50	2.07	2.58	3.39	9.49	10.35	10.40	10.41	10.45	10.98	11.03
S.880	1.25	1.71	2.05	2.63	3.60	9.36	9.48	9.74	10.20	10.22	11.74	11.80
S.1932	1.38	1.86	2.17	2.84	3.63	9.89	9.92	9.95	10.45	10.52	11.84	11.93
CD@5%	NS	0.21	0.10	0.18	NS	NS	0.55	0.36	NS	0.37	0.71	0.80
4. Fruit volume (mm ³)												
Accessions	Number of days after blossom											
	Initial	30days	60days	90days	120days	150days	180days	210days	240days	270days	300days	330days
BR	1.61	2.81	5.29	20.41	36.43	674.04	774.65	791.31	846.66	872.32	959.60	1014.49
S.274	2.12	2.47	6.62	16.63	29.07	515.14	750.45	773.29	812.25	819.16	934.03	965.28
C x R	2.66	3.17	7.54	19.75	33.81	650.41	905.10	934.72	1005.49	1024.93	1224.94	1328.46
S.3399	1.71	2.57	7.25	15.99	30.91	701.94	879.59	892.92	895.17	925.18	1037.36	1047.47
S.880	2.26	3.47	6.97	17.52	33.02	704.12	727.16	786.49	846.98	901.44	1085.30	1168.81
S.1932	2.26	4.70	8.77	18.75	30.52	709.73	795.69	812.03	885.00	904.30	1125.27	1184.88
CD@5%	NS	0.93	0.99	2.99	NS	106.32	107.01	78.78	95.86	88.81	120.00	130.48
5. Fresh weight of fruits (g/100 fruits)												
Accessions	Number of days after blossom											
	Initial	30days	60days	90days	120days	150days	180days	210days	240days	270days	300days	330days
BR	0.46	0.53	0.75	2.06	4.88	14.44	89.30	96.50	101.37	109.94	117.20	135.36
S.274	0.49	0.56	0.75	1.98	4.82	14.78	88.02	98.45	102.73	109.20	119.08	135.28
C x R	0.49	0.61	0.84	2.42	5.16	16.27	104.34	105.62	114.79	127.15	138.66	157.11
S.3399	0.50	0.59	0.80	2.20	4.88	15.47	98.19	100.16	100.90	107.31	115.14	139.82
S.880	0.49	0.64	0.79	2.22	4.70	14.80	89.02	97.87	104.49	117.18	125.49	139.00
S.1932	0.47	0.64	0.78	2.32	4.85	5.37	95.56	100.28	103.16	115.26	121.81	144.18
CD @5%	NS	NS	NS	NS	NS	NS	11.92	NS	15.49	15.92	18.817	21.44

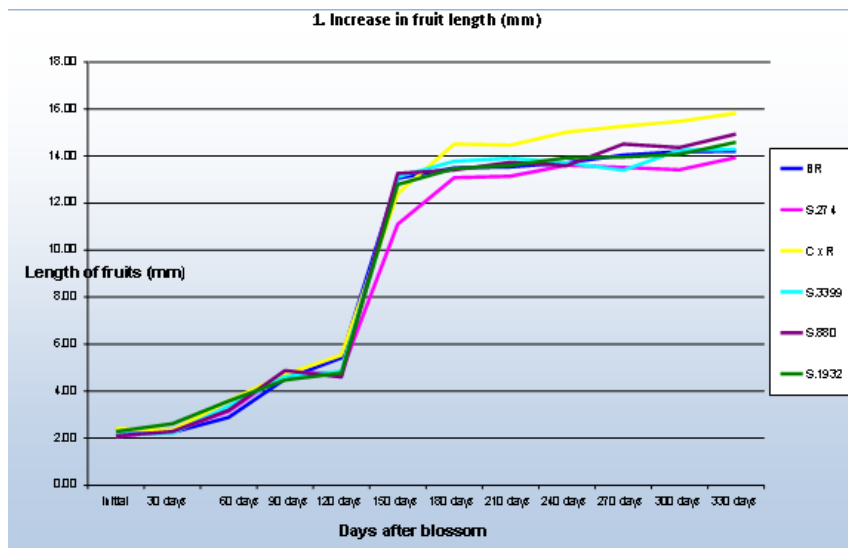
6. Dry weight of fruits(g/100 fruits)												
Accessions	Number of days after blossom											
	Initial	30 days	60 days	90 days	120 days	150 days	180 days	210 days	240 days	270 days	300 days	330 days
BR	0.16	0.17	0.29	0.68	1.06	2.50	14.99	19.66	25.37	33.69	41.15	49.24
S.274	0.17	0.18	0.30	0.63	1.09	2.61	15.49	21.57	26.29	36.67	41.96	49.64
C x R	0.17	0.20	0.34	0.81	1.19	2.97	18.16	23.12	32.29	41.12	51.45	59.69
S.3399	0.17	0.20	0.31	0.73	1.10	2.67	16.42	21.81	26.78	33.92	40.59	52.42
S.880	0.17	0.20	0.32	0.75	1.08	2.66	15.52	19.80	27.11	37.71	44.83	50.88
S.1932	0.16	0.21	0.31	0.79	1.09	2.86	16.49	21.52	26.99	37.20	42.64	53.57
CD@5%	NS	NS	0.02	0.08	NS	NS	1.69	1.91	1.91	4.07	2.89	3.49

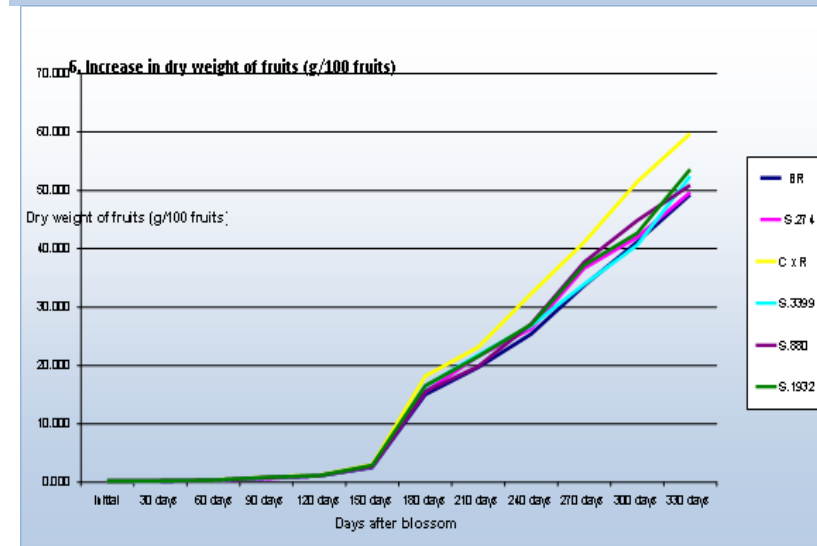
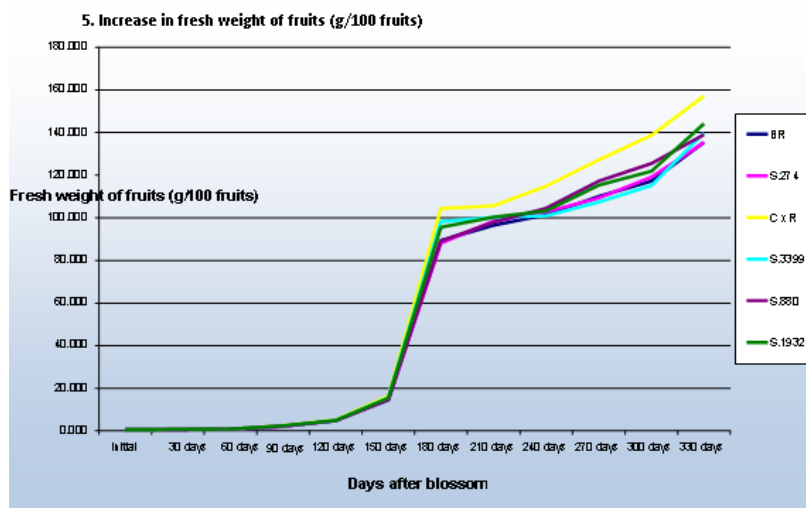
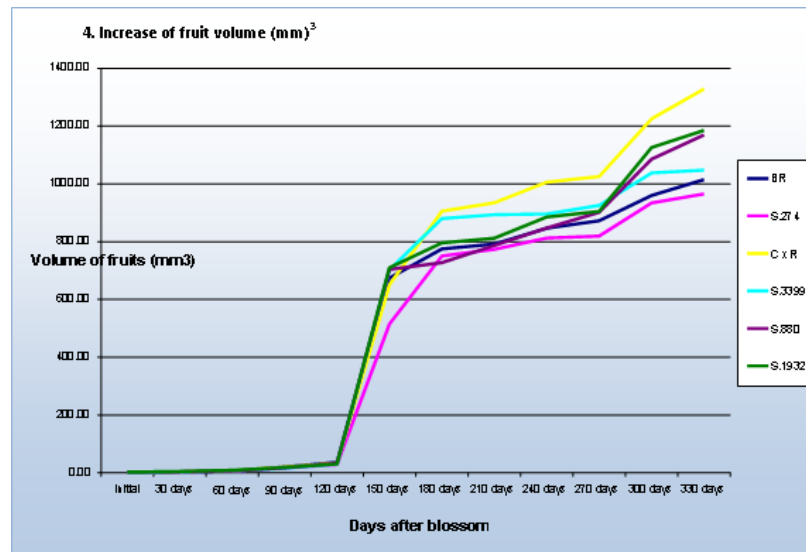
7. Dry matter percentage												
Accessions	Number of days after blossom											
	Initial	30 days	60 days	90 days	120 days	150 days	180 days	210 days	240 days	270 days	300 days	330 days
BR	33.75	36.87	39.00	33.17	21.73	17.26	16.51	20.48	25.03	31.12	35.16	36.40
S.274	33.96	37.31	40.27	31.63	22.53	17.68	16.83	21.18	25.59	31.37	35.25	36.67
C x R	34.87	36.64	40.35	33.61	23.06	18.40	17.67	22.45	28.15	33.83	37.12	38.49
S.3399	34.06	37.70	39.44	32.95	22.41	16.98	17.26	21.45	26.45	31.38	35.45	37.26
S.880	35.55	37.86	41.17	33.09	22.88	17.90	17.03	20.46	25.92	31.51	35.86	36.61
S.1932	33.76	37.31	40.19	33.48	22.54	18.42	17.27	21.46	26.25	32.27	35.05	37.16
CD @5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.36

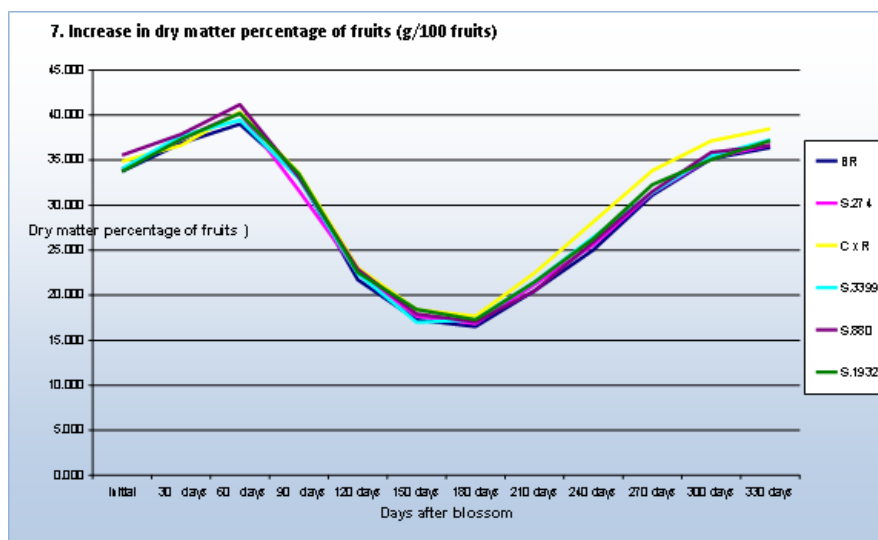
As indicated in the case of length, breadth and thickness of fruits, the increase in volume of fruits also was linear up to 120 days. Thereafter, a rapid increase was noticed for about 30 days and after this, the increase in volume was gradual till maturity of fruits (Table 2 & Fig. 4). Among the six varieties, variation in volume of fruit was not statistically significant during initial stages. Thereafter, CxR recorded significantly higher fruit volume except on 120th day, where it was non significant. In S.1932 and S.880 also, fruit volume was significantly higher on 30th, 60th, 150th, 300th and 330th days after flowering. This indicated that CxR has significantly higher fruit volume compared to other robusta varieties. The data shows that S.1932 and S.880 also have higher fruit volume though not statistically significant in some months.

Dry matter production in fruits during developmental stages

In order to study the growth pattern of berries in different varieties of robusta coffee, fresh weight, dry weight and dry matter production were determined during different periods of growth. For the first 150 days after flowering, the berry growth was minimum and the increase was linear. This was followed by rapid increase in fresh weight of berries up to about 210th day. After this, increase in fresh weight of berries was gradual till maturity (Table 2 & Fig. 5). CxR recorded higher fresh weight of berries throughout berry growth but the difference was not statistically significant till the 150th day after flowering. Thereafter, till maturity, CxR recorded significantly higher fresh weight of berries except when observed on the 210th day. On this day also, CxR recorded higher fresh berry weight as compared to other robusta varieties studied, but it was not statistically significant. Earlier studies also indicated two periods of fresh weight increase of berries in robusta coffee [18]. During the initial stages, increase in dry weight also showed the same trend as fresh weight (Table 2 & Fig. 6). The phase of slow growth continued to about 150 days. After this, fruits started growing rapidly and there was gradual rise in dry weight till maturity. The changes in dry weight of fruits during growth showed a linear pattern of increase during the early stages and gradual increase during later stages. With regard to dry weight, earlier workers also have stated that increase in dry weight is steady and gradual [18]. Berry growth in the case of robusta is slower, hence fruit maturity and ripening generally takes 6-8 weeks more when compared to arabica. Among the varieties, no significant difference on dry weight was noticed during the initial two months. After this, till maturity, CxR showed significantly higher dry weight compared to the others except when observed on the 120th and 150th days where the difference was not statistically significant.







Figs. 1-7. Observations on change in fruit characters at 30 day intervals in robusta coffee

In the case of dry matter percentage of fruits (Table 2 & Fig. 7), during the early days of development it varied from 33.7% to 35.4% in the different robusta varieties studied. A gradual rise in dry matter percent was noticed and it reached the highest (40%) on the 60th day. Thereafter, gradual decline in dry matter percentage was observed and it reached a minimum level of around 17% between the 150th and 180th days. This may be due to increased water content accumulation by robusta cherry after a period of initial growth. Earlier workers have also reported such a condition and they have opined that during the time of rapid growth there was rapid cell expansion, leading to the fruits attaining large water content (80-85%), their locules growing to full size and the endocarp getting lignified. At this stage the maximum volume of the seed is fixed. After the rapid expansion stage, a gradual rise in dry matter production reaching 36% to 37% at fully ripened stage was also noticed by them [10, 25].

Among the six varieties studied presently, the variation in dry matter percentage showed no significant difference except at maturity. At this stage, CxR recorded significantly higher dry matter percentage as against other robusta collections.

It is apparent from the above observations that in robusta coffee, fruits develop in three phases with regard to their size and fresh weight. The increase in size and fresh weight of fruits is minimal up to 120 days after flowering and in the second phase the growth is rapid and lasts for about 30 days. In the third phase increase in fresh weight and size is gradual. Fruits attain maturity and start ripening in 300 to 330 days. Unripe fruits are green. Ripe fruits are red in the robusta selections studied and orange or crimson in colour in CxR. While comparing the development of fruits, earlier workers have stated that there is almost a linear increase in fruit size i.e., in length, breadth and thickness up to 90 days in *C. arabica* and up to 150 days in *C. canephora* [6]. Among the varieties studied, CxR recorded higher fruit volume and fresh weight. Works in India have also shown that the lag period between 90 to 120 days in *C. arabica* and between 150 to 270 days in *C. canephora* is more evident for fruit size than for fruit weight [6]. This also shows that near-maximum fruit size is attained much earlier than fruit weight and further increase in fruit weight is due to changes in internal components, such as endocarp and endosperm development. This information is also supported by embryological studies in coffee [26, 27].

With regard to the dry weight of fruits, the increase was slow up to 180 days and thereafter a steady increase was noticed. But the dry matter percentage depicted a different picture. At the initial stage, the dry matter was 34% and it increased to 40% when observed on the 60th day. Then it got reduced to 16% to 17% between 180th and 210th days and increased up to 36-37% at full maturity. Earlier workers have observed steady and gradual increase in dry weight in robusta coffee giving the appearance of linear growth [18].

Berry growth of robusta coffee differs from that of arabica in having only two periods of fresh weight increase and a single phase of linear increase in dry weight. The pattern of growth as measured by fruit weight during development in robusta coffee observed presently resembles the pattern reported by earlier workers [6, 18]. Based on the studies conducted at Central Coffee Research Institute, India, the timing of fertiliser application in robusta coffee has been standardised [18] in view of evolving package of practices. But, studies conducted by various scientists show that growth of fruits in arabica coffee shows a bisigmoidal curve [4, 28].

CONCLUSION

A study on the growth pattern of fruits in terms of fruit size, fruit weight and dry matter production in robusta coffee was carried out at Regional Coffee Research Station, Chundale, Wayanad, Kerala, India. Fruit growth was studied by measuring changes in fruit weight and size (length, breadth, thickness and volume) during development in five selections and a hybrid of robusta coffee. The pattern of fruit growth was found to be the same in all the varieties and the fruits attained maturity by 300-330 days which consisted of 3 phases. The increase in size and fresh weight of fruits was minimal up to 120 days and it was rapid in the second phase which lasted from 120th day to 150th day after blossom. The increase in the third phase was gradual. Near-maximum fruit size was attained much earlier than fruit weight (150-180 days after flowering) which showed that further increase in fruit weight was mainly due to changes in internal components such as endocarp and endosperm. Among the six varieties studied the hybrid CxR showed significantly greater fruit volume and fruit weight. Berry growth of robusta coffee showed two periods of fresh weight increase and a single phase of linear increase in dry weight whereas in arabica coffee fruit growth has been reported to be bisigmoidal.

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