

Fruit growth in cowphal (*Garcinia cowa*)

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Abstract: Morphological features and growth characteristics of fruits and seeds of Cowphal (*Garcinia cowa* Roxb.) was investigated at Mymensingh (24°26' & 24°54' N and 90°15' & 90°30' E) to assess the harvest maturity of fruits. Flowers were tagged at opening and fruit growth was investigated at 3, 7, 10, 14, 21, 28, 35, 42, 49, 56 and 63 days after flowering (DAF). All the morphological characters of fruits were gradually increased with increasing ages (DAF). The length and diameter became maximum around 63 DAF. Fresh weight of fruit reached maximum between 49 and 63 DAF (c. 37-39 g/fruit). Results concluded that harvest maturity attained around 63 DAF in Cowphal when fruit size was 4-5 cm with fruit weight 37-39 g.

Key words: *Garcinia cowa*, morphology, fruit growth, maturity.

Introduction

'Cowphal' (*Garcinia cowa* Roxb.) is an important fruit trees in the tropics and subtropics, and a member of Guttiferae. Cowphal is most frequently called cowa, kao, kowa, kao-gola etc. (Das and Alam, 2001). Propagation is mainly by seed. *Garcinia* is native to the Malay-Archipelago and the Molucca and Sunda Island. In Bangladesh, it occurs in the forest of Chitagong, Cox's Bazar, Comilla, Chittagong Hill Tracts and Sylhet and is usually grown in clayey moist soil (Das and Alam, 2001). The tree is long with clear bole and cylindrical canopy structure which is suitable for high land agroforestry system. The genera *Garcinia* is widely used as a source of edible fruits, timber, resin, drug and various other natural products. Apart from the aril being consumed as a dessert fruit, the dried fruit rind, which contains tannin and xanthenes and is used as native anti-inflammatory and antidiarrhoeal medicine and for treatment of dysentery (Yapwattanaphun, *et al.* 2002). Young leaves of Cowphal are used as a food additive in many Thai dishes. The yellow juice from the bark of Cowphal yields gamboges soluble in turpentine and forming a yellowish varnish. The fruits of cowphal turn deep green to light green with a patch of yellow/red colour when reaches harvest maturity. Both the fruits droop naturally at maturity causes the physical injury to fruits. Fruit quality and storage duration are greatly influenced by harvesting stage. Harvesting fruits little before ripening stage may be safer but yield may be decreased. Therefore, the fruit should be harvested at proper stage of maturity. Physiological maturity is important to preserve seed and to obtain high percentage of seed germination. There is little information on morphological features (Das and Alam, 2001) and only one report (Roy, 2007) on fruit growth of Cowphal in Bangladesh. But it is necessary to identify the growth stage of maturity or ripening stage of fruits. Therefore, the present study was conducted to investigate fruit growth in terms of increment of length, diameter, weight and absolute growth rate of the species.

Materials and Methods

The investigation was conducted at the Botanical Garden, Bangladesh Agricultural University, Mymensingh (24°26' and 24°54' N and 90°15' & 90°30' E) between April and September, 2007. Data on different morphological characteristics were recorded. Samples from selected plants were collected beginning from the flowering to till maturity. Flowers in the main stem and branches were

tagged using ladder with different coloured plastic sheets at opening of petals *i.e.* at flowering. Flowers were tagged in the female Cowphal plant and ovaries (fruits) were harvested at 3, 7, 10, 14, 21, 28, 35, 42, 49, 56 and 63 days after flowering (DAF). At each DAF 25 fruits were collected and divided into five group representing 5 replications. Freshly harvested fruits were shelled and the seeds were separated out. Length, diameter, fresh and dry weights of pericarp, seed and fruit (pericarp and seed) were recorded at each age. The samples were oven dried at 70-80°C for 72 hours and their corresponding dry weights were recorded. Eleven ages (DAF) of fruits were used as 11 treatments. The completely randomized design (CRD) was followed with five replications. The programme MSTAT (Russel, 1986) was used to analyse the data. Analyses of variances of different parameters were performed by 'F' variance test. The mean of different parameters was compared by least significant difference (Gomez and Gomez, 1984).

Results

Fruit length and diameter: Generally, fruit length followed a sigmoid pattern (Fig. 1A). The fruit length was 0.80 cm at 3 days after flowering (DAF) and became 2.10 cm at 21 DAF and grew rapidly and linearly and reached to a 3.50 cm at 28 DAF followed by a plateau between 56 and 63 DAF (approximately 4.35 cm). Fruit diameter followed a trend also similar to that of fruit length (Fig. 1A).

Fresh and dry weight of pericarp and seed: Changes in fresh and dry weight of pericarp, seed and fruit varied significantly ($P \leq 0.05$) at different days after flowering (DAF) (Fig 1B-D). Pericarp fresh weight showed a double sigmoid curve while seed fresh weight followed a single sigmoid pattern (Fig. 1B, C). Fresh weight of pericarp was 0.16 g at 3 DAF and increased linearly but slowly up to 21 DAF and grew rapidly between 21 and 42 DAF followed by a plateau between 49 and 63 DAF (approximately 32.49 g/fruit) (Fig. 1B). Dry weight of pericarp was very slow up to 21 DAF and became maximum between 49 and 63 DAF (approximately 3.81 g/fruit) (Fig. 1B). It followed a linear pattern of growth. The lowest dry weight of pericarp was observed 0.08 g between 3 and 7 DAF and became 1.42 g at 28 DAF (Fig. 1B). Pericarp dry weight reached maximum (3.81 g/fruit) between 56 and 63 DAF. Visible seed was observed at 14 DAF (Fig. 1C). There was very little seed fresh weight (0.54 g) at 14 DAF and it grew rapidly and linearly up to 49 DAF (5.48 g/seed)

followed by a plateau between 56 and 63 DAF (≈ 6.40 g/seed) (Fig. 1C). Dry weight of seed followed a trend also similar to that of pericarp dry weight (Fig. 1C). Dry weight of seed was very little (0.08 g) at 14 DAF and increased with increasing ages (DAF). It grew slowly up to 28 DAF (0.22g) and reaching maximum at 63 DAF (1.40 g). Total fresh weight of fruit (pericarp plus seed) at different DAF is represented in the Fig. 1D. It showed a double sigmoid pattern with first sigmoid between 3 and 35 DAF, and second one between 35 and 63 DAF. Total

fresh weight of fruit increased slowly between 3 and 21 DAF (around 0.34 g/fruit) followed by a rapid increase up to 49 DAF (37.85 g/fruit) with a plateau between 56 and 63 DAF (Fig. 1D). It followed a linear pattern. Fruit dry weight increased slowly for the first 21 DAF (around 0.24 g/fruit) followed by a rapid but linear increase up to 42 DAF (around 2.28 g/fruit) and thereafter maintained a plateau between 49 and 63 DAF (average of 5.09 g/fruit) (Fig. 1D).

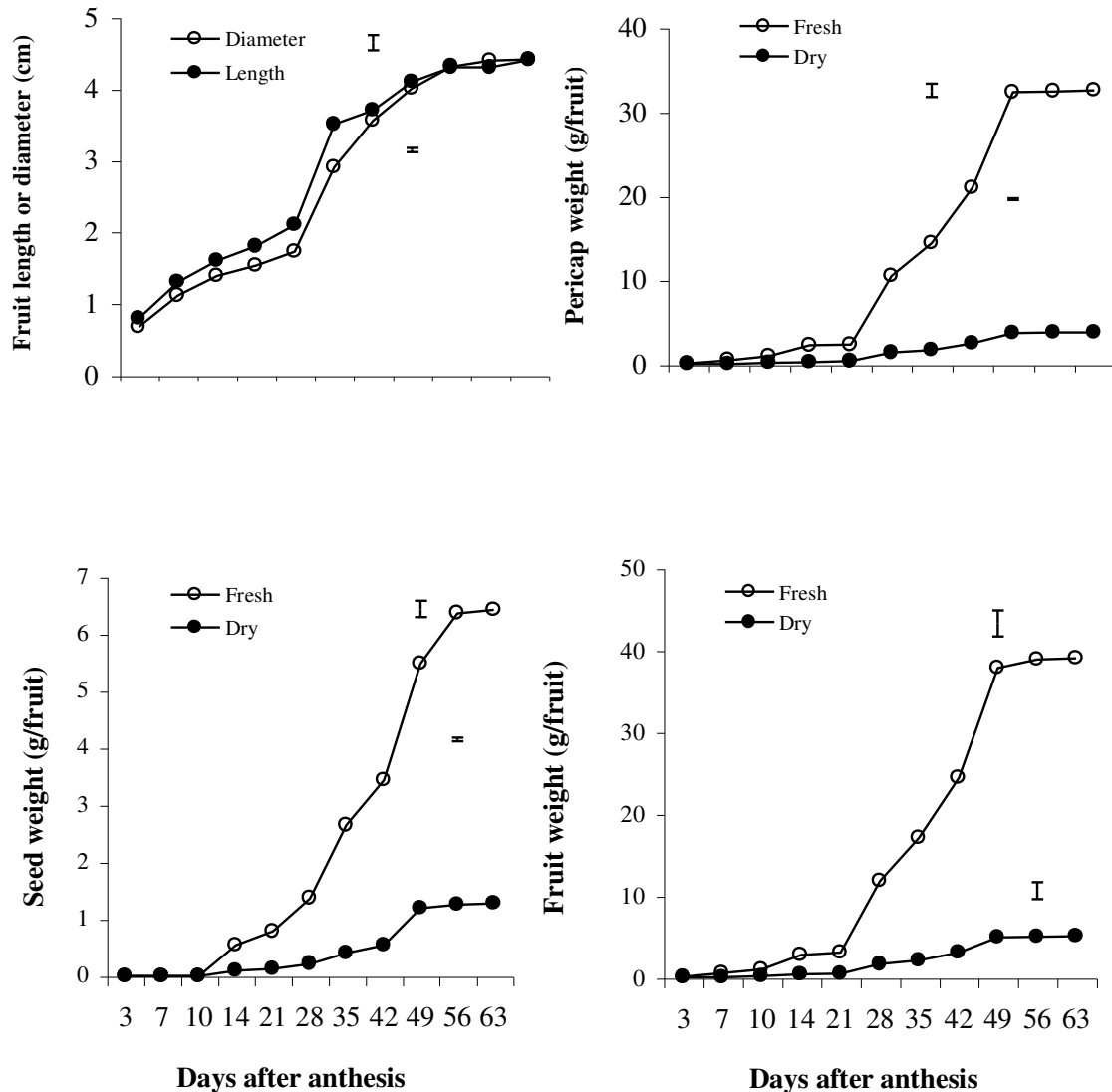


Fig. 1. Changes in fruit length and diameter (A), pericarp fresh and dry weight (B), seed fresh and dry weight (C); and fruit fresh and dry weight (D) at different ages (days after flowering, DAF) in cowphal. Vertical bars are Lsd_{0.05}

Absolute growth rate (AGR): Effect of ages on AGR of pericarp, seed and fruit was significant (Table 1). Generally, AGR of pericarp, seed and fruit increased with increasing ages (DAF) reached maximum between 42 and 49 DAF (0.179, 0.092 and 0.271 gd^{-1} for pericarp, seed and fruit, respectively) followed by a decline. The AGR of pericarp became significantly greater (0.179 gd^{-1}) between

42 and 49 DAF than between 35 and 42 DAF (0.112 gd^{-1}), between 28 and 35 DAF (0.046 gd^{-1}), and between 49 and 56 DAF (0.002 gd^{-1}). AGR of seed was also greater between 42 and 49 (0.092 gd^{-1}) than in the others (average of 0.012 gd^{-1}). AGR of fruit followed more or less similar trend.

Moisture content and pulp to fruit ratio: Moisture content in pericarp increased with increasing ages (DAF) but moisture content in seed showed a reverse trend (Table 2). Moisture content in pericarp was smaller at 3 DAF (62.50%) and became 82.58% between 7 and 21 DAF and reached maximum (88.26%) at around 63 DAF (Table 2). Seed moisture content was greater between 14 and 42 DAF (average of 84.39%) followed by decline to 78.28% at 63 DAF (Table 2). Pulp to fruit ratio was maximum (1.00) between 3 and 10 DAF and then decreased to 0.84 at 56 DAF. The lowest pulp to fruit ratio (0.75) was observed at 63 DAF.

Table 1. Variation in absolute growth rate (AGR) of seed and fruit in Cowphal at different ages (days after flowering, DAF)

| Age (DAF) | AGR (gd ⁻¹) | | |
|---------------------|-------------------------|-------------------|----------|
| | Pericarp | Seed [†] | Fruit |
| 3-7 | 0.010 d | - | 0.010 d |
| 7-10 | 0.027 cd | - | 0.027 d |
| 10-14 | 0.025 cd | 0.025 b | 0.025 d |
| 14-21 | 0.014 cd | 0.004 b | 0.019 d |
| 21-28 | 0.014 cd | 0.002 b | 0.016 b |
| 28-35 | 0.046 c | 0.027 b | 0.073 c |
| 35-42 | 0.112 b | 0.019 b | 0.131 b |
| 42-49 | 0.179 a | 0.092 a | 0.271 a |
| 49-56 | 0.002 d | 0.010 b | 0.012 d |
| 56-63 | 0.004 d | 0.002 b | 0.0007 d |
| Lsd _{0.05} | 0.030 | 0.022 | 0.032 |

In each column, figures bearing uncommon letter(s) are significantly different at P≤0.05 by DMRT. [†]Seeds were visible to naked eyes at 10 DAF; each figure is the mean of 25 (5 fruits × 5 reps) fruits.

Table 2. Moisture content, pulp to fruit ratio at different ages (days after flowering, DAF) in cowphal

| Parameter | Ages (DAF) | | | | | | | | | | | Lsd _{0.05} |
|-----------------------|------------|--------|--------|---------|---------|---------|---------|---------|---------|---------|--------|---------------------|
| | 3 | 7 | 10 | 14 | 21 | 28 | 35 | 42 | 49 | 56 | 63 | |
| Moisture Pericarp (%) | 62.50d | 80.77c | 82.18c | 83.63bc | 83.76bc | 86.76bc | 87.94ab | 87.94ab | 88.32a | 88.31a | 88.26a | 3.790 |
| Seed [†] | - | - | - | 84.47a | 84.30a | 83.94a | 83.33a | 81.48ab | 80.22bc | 80.10bc | 78.28c | 2.824 |
| Pulp: Fruit | 1.00a | 1.00a | 1.00a | 0.88b | 0.86bc | 0.86bc | 0.85bc | 0.84bc | 0.84bc | 0.81bc | 0.75c | 0.099 |

In each row, figures bearing uncommon letter(s) are significantly different at P≤0.05 by DMRT. [†]: Seeds were visible to naked eyes at 14 DAF.

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Discussion
Cowphal (*Garcinia cowa*) are important edible fruit and is grown in different parts of Bangladesh (Das and Alam, 2001). Fruit growth was investigated by measuring length, diameter and weight (fresh and dry) beginning from fruit set (anthesis) to full maturity. Fruit length and diameter became greater (4-5 cm) at 49 days after flowering (DAF) and remained more or less unchanged till 63 DAF indicating maximum fruit size (Fig. 1A). This signifies that when a fruit of Cowphal reaches to approximately 4-5 cm in length or diameter, fruit could be harvested. The present result is similar to the report of Das and Alam (2001) who also observed that mature fruit of Cowphal is 5 cm across in diameter. The edible part of the fleshy fruit is the pericarp. The pericarp fresh weight also reached maximum between 49 and 63 DAF (Fig. 1B) which again suggest the harvesting stage of the fruits. Seed fresh weight became plateau between 56 and 63 DAF but seed dry weight continued to increase slightly at 63 DAF. It appears that seed dry mass is nearer to physiological maturity (PM). Fruit (pericarp + seed) also showed maximum fresh and dry weight between 49 and 63 DAF (37-39 g/fruit) (Fig. 1C) and was supported by Roy (2007). Absolute growth rate of fruit also showed maximum at 49 DAF. Inconsistent pattern in fruit moisture content and pulp to fruit ration indicated that these are not reliable indices of fruit maturity in Cowphal. The elongated oval shape of immature fruit changed to round at harvest maturity. Texture of the fruit remained smooth during the period of growth. Around at 2 months age from flowering, a fruit of Cowphal weigh about 38 g and turn deep green to light green with a patch of yellow/red colour indicating visual index of fruit harvest.

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