Changes in size and weight of calyxes, weight and moisture content of seeds of roselle (*Hibiscus sabdariffa* L.) during development

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Abstract. Plant growth and development is strongly influenced by the environment in which they grow. Therefore the time of harvest of a plant commodity will be different in the tropics and the subtropics. This condition is also the case for the plant which yield calyx. Here we report the development of the calyx to varying stages of maturity in seeds of Roselle (*Hibiscus sabdariffa* L.) during their development. This study allows us to determine the appropriate harvest time. The calyx and seed development were observed at the ages of 17, 21, 25, 29, 33 and 37 days after anthesis was assessed. The results showed that the appropriate harvest time was at the age of 33 days after anthesis where the average weight of calyx and seeds reached 11.9 g and 2.3 g per flower respectively. This present study suggested the physiological mature of seed Roselle was dependent manner from dry weight and moisture content of the seed.

Introduction
Rosal (Hibiscus sabdariffa L.) belongs to the family Malvaceae and is believed to be originated from tropical Africa. It is cultivated in many tropical and subtropical regions of the world for stem fibre, paper pulp or edible calyces, leaves and seeds. Roselle can be found in almost all warm countries such as Saudia Arabia, Sudan, Egypt, India, Thailand, Malaysia and Indonesia [1-3]. The plant takes about 3-4 months to reach the commercial stage of maturity before the flowers are harvested and require 13 hours of sunlight during the first months of growth to prevent premature flowering [4].

An earlier paper reported that Roselle has growing period of 4-6 months from the sowing of the seed to harvesting of the calyx [5]. Harvesting commences once the calyces have reached an optimum size. This point is reached shortly before the seed capsules are ready to open, approximately 15-20 days after blossoming [6]. Determination of optimum time of calyx harvest is an important consideration.
for high calyx yield and quality in Roselle [7]. In Bangladesh, the optimum time for fresh calyx and capsule harvest was around 45 days after anthesis [8].

There are no previous reports regarding optimum time for calyx harvest in Indonesia. Therefore, it is necessary to study this aspect in Indonesia. The present research was aimed to investigate the growth of calyx and seed for assessment of optimum harvesting time for calyxes in Deli Serdang, North Sumatera, Indonesia.

2. Materials and methods
A descriptive, non-factorial experiment was conducted in the Experimental field of the Seed Station, Balai Benih Induk Tanaman Palawija, Tanjung Selamat Village, Deli Serdang Regency, which locates at 2\(^{\circ}\)57'-3\(^{\circ}\)16' latitude and 98\(^{\circ}\)33'-99\(^{\circ}\)27' longitude with elevation 25 m. This study was performed during February to June 2012. Standard agricultural practices (land preparation, weeding and fertilization) were carried out. Seeds of Roselle were sown at a spacing of 1m x 1m. There were 400 plants covering a 20 m\(^2\). The flowers of the plants were tagged since the beginning of anthesis to obtain data at different ages of the calyx, i.e. 17, 21, 25, 29, 33 and 37 days after anthesis.

Ten calyces were harvested at each respective age of maturity and wrapped in polyethene bags to avoid loss of water. Parameters were determined by calculating the average of all samples. Average fresh weight, length and diameter of the calyx, as well as the fresh weight of the capsule that was separated from the calyx were recorded. Following this procedure, the capsules were crushed, and seeds were removed from the capsules to determine the number of seeds, fresh and dry weight of seeds and moisture content of seeds as well.

3. Results and Discussion
Table 1 shows that the calyxes and seeds of the Roselle flower mature coincidently at 33 days. This result therefore lead to harvesting of the calyx and seeds of Roselle can be conducted together. As displayed in Table 1 that the most appropriate harvesting time at the site of the experiment is at 33 days after anthesis.

Table 1. Average fresh weight, length and diameter of calyx, fresh weight of capsule, number, fresh weight, dry weight and moisture content of seeds of Roselle (H. sabdariffa L.) at different stages of seed development

| Days after anthesis | Calyx | Seed |
|---------------------|-------|------|
| Fresh weight (g)    | Length (cm) | Diameter (cm) | Number | Fresh weight (g) | Moisture content (%) |
| 17                  | 10.418 | 4.975 | 3.250 | 4.418 | 22.800 | 2.078 | 0.665 | 67.989 |
| 21                  | 10.805 | 4.910 | 3.270 | 4.615 | 21.600 | 2.125 | 0.825 | 61.174 |
| 25                  | 10.773 | 4.770 | 3.270 | 4.504 | 21.600 | 2.168 | 0.938 | 56.744 |
| 29                  | 11.259 | 4.965 | 3.255 | 4.822 | 19.500 | 2.207 | 1.095 | 50.226 |
| 33                  | 11.896 | 5.120 | 3.260 | 4.682 | 18.900 | 2.295 | 1.190 | 48.148 |
| 37                  | 10.560 | 4.750 | 3.440 | 3.573 | 19.500 | 1.968 | 1.085 | 44.903 |

Throughout development, the calyces increased in either fresh weight, lengths and diameters, with the most rapid growth from 29 days to 33 days after anthesis. Maximum values were obtained at 33 days after anthesis and showed decreases afterwards as depicted in Figure 1. These data indicate that calyx maturity is reached at 33 days after anthesis, which is followed by senescence and drying, explained by the reductions in the data. In relation to this result, to obtain the maximum calyx yield. The present results may be recommended to harvest the roselle at this stage of maturity. Furthermore, it can be observed that the seeds followed a similar development pattern. The highest increase in seed
fresh weight was identical to that for calyx, namely from 29 to 33 days after anthesis, while dry seed weight rather constantly increased up to 33 days after anthesis (Figure 2).

This increase in seed dry weight should be due to the accumulation of food reserves into the seed. This indicates that the seeds have reached their physiological maturity at this stage when dry seed weight stayed at a maximum [9]. Decrease in seed moisture content during development, from 68% at 17 days after anthesis to around 48% at 33 days after anthesis can be explained as the result of an increase in seed reserves during its development, a similar pattern has been reported earlier for kenaf (H. cannabinus L.) seeds [10]. By contrast, the moisture content of oil palm seeds were significantly decreased by lengthy storage of the seeds [11].

![Figure 1. Fresh weight of calyx at various stages of development](image1)

![Figure 2. Fresh and dry weight of seeds at various stages of development](image2)

**Conclusions**

The calyces and seeds of the roselle flower mature coincidently, hence harvesting of the calyx and seeds of Roselle can be conducted together, and that the most appropriate harvesting time at the site of the experiment is at 33 days after anthesis. This present study suggested the physiological mature of seed Roselle was dependent manner from dry weight and moisture content of the seed.

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