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Trend during Growth, Development and Quality Attributes of Ber (*Zizyphus mauritiana* Lamk.) Fruits: A Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

The trends in growth, development and quality attributes of Ber (*Zizyphus mauritiana* Lamk.) included changes observed during growth and development, namely fruiting behavior, physical properties and biochemical components of the ber fruit at different stages of growth and development. Flowering began in mid-September and ended in mid-November with the peak of the flowering period in mid-October. While the fruit setting was between the third week of September to the first week of December, but the peak fruit initiation period was the last week of September to mid-October. During fruit growth, development and yield attribute the percentage of fruit drop and retention also changes. Ber fruits were harvested in five times collections and the peak yield period was the first week of March. In the physical changes, the study revealed that length, width, weight,

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volume, pulp weight, and seed weight increased from fruit set to maturity at all stages of growth and development except for specific weight, which first increased in month of mid-November and then decreased when the fruits continued in the harvest phase. The biochemical changes in fruit in terms of total sugars, ascorbic acid, reducing sugars, non-reducing sugars and total sugars increased steadily from fruit set to maturity, when titratable acidity showed a trend decreasing during fruit growth and development.

Keywords: Development; growth; harvesting; maturity; volume.

1. INTRODUCTION

For a scientific point of view, fruit ripening activity and indices are considered a process in which physical, physiological, and biochemical growth and development deformed to affect appearance, texture, aroma, and flavor [1]. It was explained that Ber (*Zizyphus mauritiana* Lamk.) is an primitive fruit tree from China and India. In fact, it was one of the most important fruits that savant in ancient India during the Vedic ages. In the "Yajurved", written not later than 1000 B.C.little a mentioned about the ber. Ber is native to an area lie down from India through south-west Asia to Malaya. It is tetraploid (2n=48) in nature and also known as Chinese/Chinkee apple, Chinese date, jujube, Indian plum, Indian jujube, Regi pandu and masau, belongs to the family Rhamnaceae and the genus *Zizyphus*. The generic name was derived from Arabic name “Zizouf”. Ber is a tropical fruit tree, evergreen shrub or small tree, spiny character, up to 15 m in height with a trunk 40 cm or more in diameter with a spreading spiny thorns crown, and many drooping branches. The fruit is of different sizes and shapes. It may be oblong or round, oval and ovoid, 1.0-6.25 cm long depending on the variety, the flesh is white and crispy. At the times of ripening, this fruit is a pleasant and little juicy has small skin of the fruit is shiny, smooth, firm but thin. Ber trees grow precisely in subtropical, tropical and also Mediterranean regions of the world. It is successfully cultivated under marginal soils and various types of deserts, like sodium saline soil, ravines, semi-arid, arid areas frost-resistant and thrives well with small care in a wide range of climates and soils. The Ber is widely cultivated for resistance to drought and diverse climate and soil conditions that why it is aliases the "King of Dry Fruits". Ripe ber fruits are rich in nutritional value. The ripe ber fruits have high nutritional values and are commonly scrutinize as a "poor man's fruit". Ber fruit is more nutritive than apple in phosphorus, calcium protein and vitamin 'C' [2] and 100 grams of edible ber fruit contains moisture (85.9%), phosphorus (0.03g), calcium (0.03g), protein (0.8g), fat (0 .1g), carbohydrates (12.88%), iron (0.8 g), carotene (70 IU) and vitamin 'C' (50- 100 mg). The fruit is mostly eaten fresh, but other processed product can be prepared and used, like as dried, pickled, candied and other products such as juice or squash and butter. “A detailed pharmacological examination of *Z. jujube* also states that various Yunani and Ayurvedic medicines containing ber extract used for blood purifiers and also aid indigestion. Decoction and Powder prepared from the roots are effective in ulcers, fever and old wounds. The stem bark is considered to cure diarrhoea. The medicinal values of different parts of the tree and fruits there are many and yet they are not fully utilized” [3]. When candy recipes were evaluated, it was found that using 75% total soluble solids resulted in the highest score. Candy of Umran cultivar of ber prepared according to this recipe was stored for 10 months at room temperature. The ber leaves are used as fodder in dry and arid areas the stem produce good durable quality wood that is used to make various agricultural tools. The wood is also considered a valuable wood and is used in the construction of buildings. Ber wood makes excellent charcoal. Thorny branches are commonly used for agricultural field fences. The tree is a host plant for lac insect (*Laccifer lacca*) breeding. In the states of Bihar and Madhya Pradesh, pond farming is an important practice for ber cultivation. Fruit undergoes various physico-chemical changes during growth, development and yield attributes. Knowledge of these changes helps in plump the superlative for cultural practices such as fertilization, plant growth regulator application, irrigation, fruit thinning and harvesting (Kumar et al., 1992).

Ripening frolic an important role in the quality and shelf life of ber fruit. Reviewing of changes during growth, development and yield attributes are a basic requirement for determining maturity, harvest time and methods.

2. THE CHANGES DURING GROWTH

2.1 Changes in Fruiting Behavior

Flowering: “The flowering and fruiting quality were initiated on the first fourth night of September. The total days was taken for flowering up to fifty six days and the crest period was between seven and thirty five days from the initiation of flowering, which indicated twenty eight days crest for flowering period for ber cv. Narendra Ber Selection-1” (Pandey and Deen 2020). “Total flowering time ranged from sixty eight to ninety four days [4] and fifty seven to seventy five days [5] depending on the cultivar”. “Total flowering time of cultivar Gola was recorded as seventy six days and cultivar Seb seventy two days” [6]. Pareek [7] observed “the shortest flowering time in cultivar Tikadi forty seven days and longest in cultivar Umran seventy one days, a similar result was also observed by [8] in Hissar, in 'Banarsi Karaka' which flowered from September by November, the total number of flowers, (2 percent), appeared in September, (83 percent) three percent in October, and the remaining (15 percent) in November”. Pareek et al. (2007) reported that ber flowering time varied from early June to late November of indifferent varieties in different agro-climatic conditions of India. There was considerable variation in cyme emergence flower (first August- twenty August), bud development seventeen to twenty three days, duration of flowering forty four to seventy days) and duration of peak flowering (twenty three to thirty five days) between different varieties [9].

Fruit set: The term fruit set refers to the initial and noticeable swelling of the ovary that occurs shortly after the petal fall period. The pistils and stamens are the basic flower organs involved in fruit set and fruit formation, although other parts may also enter the fruit structure. Fruit set started from the third week of September and continued till the second fourth night of November, but fruit set peaked during the third week of September to the fourth week of October (Pandey and Deen 2020). A similar result was also found by [8] at Hissar in 'Banarsi Karaka' and reported that flowers appearing in September did not fall at all, those appearing in November showed a set of (2.5 percent) while flowers appearing in October spawn to the extent of (5.5 percent) fruit set.

Fruit Drop: “Immediately after fruit set, there is a very strong drop, which is largely due to insufficient fertilization or degeneration of the ovum. Fruit drop started after fruit set and continued until the harvest peaked during the initial period of fruit growth and development, and the percentage of fruit drop showed a decreasing trend as the fruit progressed to maturity” (Pandey and Deen 2020). “The present findings are also in agreement with the observations recorded by [10] who observed that the peak period of decline in Banarsi Pewandi and Thornless fell during fourteen October to twenty five November and eleven November and nine December while no such crest did not occur in 'Banarsi Karaka' year”. They further found that the highest decline of (94.8 percent) was recorded in Banarsi Pewandi with the highest initial set and the lowest in "Banarsi Karaka" with the lowest initial set. Physical changes of variety Umran and Kathaphal during development were recorded from fifteen November to first fortnight of April with view to study the growth behavior of fruits from fruit set [11]. Fruit size increased rapidly from fruit set to thirty November and relatively slowly from thirty November to thirty December, then increased until twenty March [12].

Fruit Retention: “The Maximum fruit retention (48.06 percent) was recorded in the third week of November (sixty three days after flowering) and minimum (15.25 percent) in the first fourth night of March (168 days after flowering). The initial phase during fruit growth was recorded as higher fruit retention in compression to the later stage” (Pandey and Deen 2020). This finding is in agreement with the observations reported by Sharma et al. [13] evaluated “the cultivars of Banarasi Karaka, Ponda, Ilaichi, Gola and Tikdi. They reported that the peak flowering and fruiting period was September to October for all cultivars. The earliest flowering September eleventh and fruit set initiation September twenty one were observed in Tikdi, which had the shortest flowering forty seven days and fruit set thirty six days duration. The maximum fruit set (28 percent) and fruit retention (20 percent) was observed in Tikdi. The maximum flowering time sixty one days and fruit set fifty days and lowest fruit retention (4 percent) was observed in Illaichi”.

Yield: “The mature fruits were harvest in the second week of February and resemble the first night of the fourth of March. A total of five collections were required for a full harvest, which could be due to flowering and fruit set at different times in the current season by the continuous

growth of the ber plant" (Pandey and Deen 2020). Rahman et al. [14] reported the yield 41.00 kg/plant in cv. ZM-054. The difference in yield compared to the literature is evident as a result of the agro-climatic conditions of the cultivar and the cultural practice.

3. THE CHANGES DURING FRUIT DEVELOPMENT

3.1 Changes in Physical Characters

Fruit length: The fruit length recorded at different stages from planting to harvest showed a pattern of increasing setting to harvest fruit length, but with a rapid increase in length in the early stages of growth. Fruit length increases significantly from the day of fruiting to 168 days of fruiting, which may be due to elongation. These observations show that the length of Banarasi Karaka fruit in all stages of growth and development from seed to maturity increased continuously. Pandey et al. [15] observed that the average fruit length was (2.94 cm) at 70 days and reached a maximum of (4.51 cm) at 168 days after fruiting in Ber Narendra Ber Selection-1. These findings are similar to those reported by Parikh [7], Kumar et al. [16] and Kundi et al. [17]. Faroda [18], Akhundova and Agayev [19], Reddy et al. [20], Ram et al. [21]. The fruit length (4.18 cm) was the highest at 130 days, but it was statistically similar to fruits harvested at 110 and 120 days with length (4.04 cm) and (4.16 cm) respectively. The lowest length of fruits was recorded from the fruits harvested 90 days after fruit set [22].

Fruit breadth: The fruit breadth showed an increasing trend during the studied period. The breadth is increased because cell division, elongation and water accumulation of cell in the fruit. This increase was faster in early growth than in late growth. The breadth of fruit increased continuously in all stages of growth and development, from fruiting to maturity [15], reaching a maximum of (4.66 cm) on 168 days and a minimum of (0.38 cm) at 21 days of flowering. These findings were also confirmed by Dhanumjaya Rao and Subramanyam [23], Brindza et al. [24] and Shukla et al. [25]. The fruits breadth (3.61 cm) was greatest at 130 days, but statistically similar to fruits harvested at 110 and 120 days, with breadth of (3.44 cm) and (3.55 cm) respectively breadth was recorded from harvested fruits 90 days after flowering [22].

Fruit weight: The increase in weight was observed throughout the period of growth and development, but a marginal increase was in the later stage of fruit growth and development. Fruit weight increase indicates metabolite accumulation and cell elongation in the fruit at a rapid rate during the period. A similar trend in ber fruit weight is reported by Bhatia and Gupta (1984) in cvs. Gola, Kaithali and Umran. The minimum fruit weight (75g) at 21 days and a maximum fruit weight of (37.24g) at 168 days after anthesis [15]. Sahu et al. [26] reported that fruit weight was subjected to by genotypes during growth and development stages. Similar result was also observed by Akhundova and Agaev [19], Reddy et al. [20], Ram et al. [21]. Fruit weight was found to be maximum (28.60 g.) after 130 days from fruit set followed by (26.53 g.) at 120 days and (24.33 g.) at 110 days [22].

Fruit volume: The fruit volume increased continuously throughout the growth stage and the increase was rapid in the subsequent stage of fruit growth. The increase in volume indicates the accumulation of metabolites and cell elongation in the fruit at a high rate during the period. Continuous increase in fruit volume was also reported by Raut et al. [27] and Paralkar et al. [28] in Kalipatti fruit. Fruit volume steadily increased from 0.71 cm3 to 37.46 cm^3 at the stage of 21 days to 168 days after fruit set [15]. Fruit volume of different ber genotypes was found to increase with growth progress and development period from 30 days to 150 days [26].

Fruit specific gravity: The specific gravity of ber fruits increased continuously during growth and development. Pandey et al. [15] reported that the maximum fruit specific gravity was 1.51 at day 56, which gradually decreased to 0.97 at 168 day after fruit set. The specific gravity increase due to the accumulation of more metabolites, resulting in a higher mass faster than the increase in volume. A constant change in fruit specific gravity was also recorded by Pandey et al. [29]. The specific gravity obtained at the fruiting stage was 1.06 (g/cm^3), but it continuously decreased after at 105 days after fruiting. The findings are also consistent as reported by Dhanumjaya Rao and Subramanyam [23], Brindza et al. [24], Shukla et al. [25]. Sahu et al. [26] reported changes during growth and development with different genotype of ber fruits in (30 to 180 days) growth and development period.

Pulp weight: The increase in pulp weight corresponded to an increase in fruit weight. The minimum pulp weight (7.54 g) on the 84 days after flowering and maximum pulp weight

(34.17g) on the 168 days after fruit set [15]. This is agreement with the result obtained by Gupta et al. [30] two cultivars of ber viz. Jogia and Kaithli. Sahu et al. [26] reported that maximum (2.69 g) pulp weight was recorded in Gola at 150 days and minimum (1.40 g) Umran at 30 days findings are consistent with Rao and Subramanyam [23].

Seed weight: The seed weight of ber was traceable only from 91 days after deployment and seed weight gradually increased up to 168 days. The maximum seed weight was (3.07 g) on 168 days and the minimum seed weight was found to be (74 g) at 84 days after fruit set in cultivar Narendra Ber Selection-1 [15]. This is agreement with the result obtained by Gupta et al. [30] two cultivars of ber viz. Jogia and Kaithli. Seed weight of ber fruits affected by different genotype during growth and development stages (Sahu et al., 2019), findings are in agreement with Singh and Misra [31].

4. THE CHANGES DURING QUALITY ATTRIBUTE

Total soluble solids: The total soluble solids of ber fruits are increased perpetually with the growing season, which is due to the hydrolysis of polysaccharides to sugar and the synthesis of other water-soluble substances. Fruit TSS content increased by 1.05 °Brix on 21 days of fruit setting to 22.24 °Brix on 168 day after fruit setting (Pandey and Deen 2018). Jawanda and Bal [32] also observed a rapid increase in TSS towards ripening in different ber cultivars. A similar observation was made by Yadav [33] during studies on the growth and development of pevendi ber. Singh and Deen (2021) obseved that total soluble solids increased from 1.04 °Brix to 17.94 °Brix during 186 days of fruit growth and development.

Acidity: The acid content of the ber abate from fruit setting to harvesting, indicating acid accumulation during the initial period at a high rate. The acidity content of ber fruit continuously decreases from (0.41 percent) at 21 days to (0.07 percent) at 168 days (Pandey and Deen 2018). The results are in agreement with those published by Teaotia et al. (1974) in fruits of ber cv. Bansasi Karka. Bal (1981), Bal and Chaunhan [34] also found that ber. The acidity content of Sanaura-2 and Umran decreased slowly during growth and development. Similar observations were reported by Bhatia and Gupta [35] in ber cv. Gola, Kaithali and Umran. Singh and Deen (2021) reported that acidity perpetually declined by (0.39 percent) at 21 days and (0.14 percent at 186 days of growth and development.

Ascorbic acid: "The ascorbic acid is a constantly increasing trend in during mid growth and development. The changes in ascorbic acid are due to the greater synthesis and accumulation of glucose-6-phosphate, which is reserved as a precursor for the synthesis of ascorbic acid in the fruit. The increase in ascorbic acid content ranged from 3.31 mg/100 g to 94 mg/100 g of fruit" (Pandey and Deen 2018). The present finding is in consonance with the earlier report of Bala et al. (1995) who noted increases in ascorbic acid content with advanced maturity of fruit 'Umaran' ber. The changes in the content of ascorbic acid in the fruit pulp were studied in Mehrun-Khedi, Mehrun and M.P.K.V. cultivar during the growth and development of the ber from 20- 120 days after fruit setting. The ascorbic acid content of the ber at different growth and development stage of fruit development indicated an increasing trend up to the maturity stage [36]. Ascorbic acid content increased from (3.29 mg/100 g) to (90.26 mg/100 g) of fruit (Singh and Deen 2021).

Reducing-sugar: "The increase in reducing sugar content of ber fruits is due to the polysaccharides conversion of and non-reducing sugars to reducing-sugars during growth and development. A similar finding has been reported for an increase in reducing-sugars during fruit growth and development" [34,37] (Bal, 1981; Gupta et al., 1983). The reducing sugar content increased from (0.24 percent) at 21 days after fruit setting to (4.81 percent) at 168 days after fruit setting (Pandey and Deen 2018). The reducing-sugar content increased from (0.22 percent) to (4.76) at 21 to 186 days after fruit setting (Singh and Deen 2021).

Non-reducing-sugar: "The content of non-reducing-sugar in the ber increased continuously throughout the growth and development period. The increase in non-reducing-sugar during growth and development due to the hydrolysis of starch to sucrose as the fruit during fruit setting to maturity and ripening. The non-reducing-sugar content was a maximum of (5.78 percent) at 168 days after fruit setting and a minimum of (0.12 percent) at 21 days after fruit setting" (Pandey and Deen 2018). The findings agree with [29]. The total content of sugars in ber fruits increased significantly during growth and development. Non-reducing-sugar was increased from (0.11 percent) to (5.77 percent) at 21 days and 186 days respectively after fruit setting (Singh and Deen 2021).

Total sugar: The increase in total sugar is due to an increase in total soluble solids and a decrease in sugar due to the conversion of polysaccharides to sugars. Gupta et al. (1983) also found that total sugar content continued to increase during fruit development in ber cv. Umran and Gola. The same trend was also observed by Pathare et al. [36] in ber cultivars Mehrun-Khedi, Mehrun and M.P.K.V., during ber fruit growth and maturity from 20 day after fruit setting up to 120 days after fruit setting. Total sugar content has been observed in various ber cultivars during their growth and development ranging from (9.65 to 32.6 percent) in ber (Bartov, 1975). Total sugar content increased from (0.22 to 4.76 percent) from (0.35 to 10.87 percent) at 21 and 186 days respectively after fruit setting (Singh and Deen 2021) [38-43].

5. CONCLUSION

The flowering, fruit setting, fruit drop and fruit retention percentage of ber fruit continuously changed during growth and development. The flowering started from mid of September and completed at second week November and the peak period of fruit setting was first week of October to fourth week of October. A continuous increase in length, breadth, weight, volume of fruit pulp weight, and seed weight was observed from the stage of fruit setting to harvesting. The specific gravity of fruit increased markedly up to third week of November then specific gravity was decreased till harvesting. The yield was obtained by harvesting finished in five picking in February-March. The Total soluble solids, ascorbic acid, reducing sugars non-reducing sugar and total sugar were observed with the growth and development. The gradual decrease in the acidity content of fruit from fruit setting to stage of harvesting. The amount of ascorbic acid increased with the fruit growth and development. The change in ber fruit during growth and development can be concluded reducing sugars ,Non -reducing sugar and total sugars of ber fruit increase during growth and development whereas acidity decrease till harvesting.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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