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Seed development studies on the pattern of changes in seed physical attributes of ber (*Zizyphus mauritiana* Lamk.) cultivars under *Tarai* region

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Abstract
The study on the changes in fruit seed growth and development of eight ber cultivars *viz*., Chhuhara, Chinese, Kalagola, Nazuk, Sanaur-2, Sanaur-4, Umran and ZG-2 was conducted at Horticulture Research Centre, Patharchatta, G. B. Pant University of Agriculture & Technology, Pantnagar, U.S. Nagar, Uttarakhand, India during the season of 2017-18 and 2018-19. The experiment was laid out in two factors Randomized Block Design (RBD) with three replications. Sampling dates and cultivars were considered as the treatments. There were 11 sampling dates commences at 28 days after full bloom (DAFB) to 168 DAFB and observations were taken at biweekly interval. Stone length, diameter, weight and flesh: stone ratio of fruit of different ber cultivars have been found to be increased with advancement of growth and development period. The maximum (2.46 cm) stone length was recorded in Umran and the minimum (1.79 cm) in Chhuhara at 56 DAFB. The maximum (0.80 cm) stone diameter was recorded in ZG-2 and the minimum (0.55 cm) in Nazuk at 56 DAFB. The maximum (1.26 g) stone weight was recorded in Umran and the minimum (0.53 g) in Kalagola and ZG-2 at 56 DAFB. The maximum (4.71) flesh: stone ratio was recorded in ZG-2 and the minimum (1.14) in Chinese at 56 DAFB.

Keywords: Cultivars, Sampling dates, pattern

Introduction
Ber (*Zizyphus mauritiana* Lamk.) or Indian jujube belongs to the genus *Zizyphus* of the family Rhamnaceae which has about 50 genera and more than 600 species (Pareek, 1983) [12]. This fruit is very popular among the people of all social strata for its nourishing value and good taste and lower price. Ber is one of the most nutritious fruits with medicinal value. It is one of the richest source of Vitamin C, next to aonla and guava but better than citrus fruits and apple (Bal and Uppal, 1992) [3]. Ber is also designated as "King of Arid fruits" owing to fact that it can be grown in unproductive, waste, marginal or inferior soil with pH as high as 9.0 in arid and semi-arid regions. Maturity is an integral component of quality, especially in the context of commercial maturity (Will *et al*., 1998) [17]. On the other hand, Index is the sign or indication of the readiness of fruits for harvest according to consumers choice (Bautista, 1990) [4]. The time required for ber fruit to develop from fruit set to maturity is dependent on cultivar and location. Fruits that are allowed to ripen on the tree normally have a shorter shelf life and the best results are obtained if they are picked before the onset of ripening (Al-Niami *et al*., 1989) [2]. Immature fruits do not have satisfactory sweetness and taste. Overmature fruits, on the other hand, lose their attractiveness and crispiness and became slimy in texture within a very short time (Pareek, 2001) [11]. Ripening of fruit may take place either before or after harvest, but it is generally accepted that postharvest ripening of ber only occurs if the fruit is sufficiently mature when picked. Harvesting of fruits at proper stage of maturity is very much important both for maintaining quality and marketing. The studies on changes during growth and development are essential requirement to determine the maturity, harvesting time and method. As the varieties differ in their maturity period it becomes imperative to determine the maturity indices for different cultivars. Maturity indices help in ensuring sensory and nutritional quality. The present investigation was therefore, carried out to know the precise knowledge and understanding of the seasonal changes in physical seed attributes and their

correlation with growth, development and harvest maturity among ber (*Zizyphus mauritiana* Lamk.) cultivars and thereby standardize their optimum harvesting time under *tarai* region of Uttarakhand.

Material and Methods

The present investigation was conducted on existing 40 years old ber orchard at Horticulture Research Centre, Patharchatta, G. B. Pant University of Agriculture & Technology, Pantnagar, U.S. Nagar, Uttarakhand, India during the cropping season of 2017-18 and 2018-19. Eight ber cultivars *viz*., Chhuhara, Chinese, Kalagola, Nazuk, Sanaur-2, Sanaur-4, Umran and ZG-2 were selected for the study. Three trees per cultivar were selected, each of which was considered as a replication. The selected trees were of uniform growth and size, and kept under the uniform cultural practices throughout the experiment during both years. Trees were pruned severely in both years in the 3rd week of May. The experiment was laid out in two factor Randomized Block Design (RBD) with three replications. Fruits were tagged at fruit setting stage and harvested at 28, 42, 56, 70, 84, 98, 112, 126, 140, 154 and 168 days after full bloom (treatments). Sampling dates and cultivars were considered as the treatments. Seed growth characteristics were recorded at 14 days (biweekly) interval beginning from 28 days after full bloom (DAFB) to 168 days after full bloom; thus, there were 11 sampling dates/treatment. Twenty fruits at every sampling date from each tree were plucked randomly from all directions of the tree collected in a polyethylene bags and carried to the postharvest laboratory of the Department of Horticulture and analyzed for studying physical seed parameters on the day of harvesting. Seed length and diameter was measured by digital vernier callipers on each sampling date from randomly selected fruits and the average was expressed in centimeters. Stone weight of twenty fruits per treatment from each replication were weighed on electronic balance and average weight of fruit was obtained and expressed in grams. Flesh: stone ratio was calculated by subtracting average fruit weight with average stone weight and then dividing by average stone weight. The data were analyzed according to the procedure for analysis of two factorial Randomized Block Design (RBD) with three replications as given by (Snedecor and Cochran, 1987) [16]. The overall significance of differences among the treatments was tested, using critical difference (C.D.) at 5% level of significance.

Result and Discussion

Stone length (cm)

The observation on stone length (cm) pattern are presented in Table 1 for the years 2017-18 and 2018-19 revealed that stone length of fruit of different ber cultivars have been found to be increased with advancement of growth and development period. It was evident from the data that no formation of stone took place in the initial two sampling dates i.e. until 42 DAFB in all the cultivars as the seed embryo formation was occurred during the period. Thereafter, a rapid increase in stone length was noticed between 42 DAFB and 56 DAFB in all the cultivars which was followed by very slow and minor increase till 98 DAFB in Nazuk, Sanaur-2 and Umran; 112 DAFB in Chhuhara and Kalagola and 126 DAFB in Sanaur-4. After these slow increases, a sharp drift in stone length was observed 98 DAFB in Nazuk, Sanaur-2 and Umran; 112 DAFB in Chhuhara and Kalagola and 126 DAFB in Sanaur-4 which was followed by a linear increase till the last date of sampling. However, in Chinese and ZG-2 cultivars, linear increase in stone length was observed after 56 DAFB till the last date of sampling. Similar trend was also observed in the fruiting season of 2018-19. Pooled analysis of data also showed similar trend in increase in stone length during both the years of experiment. In 2017-18, the maximum (2.35 cm) stone length was recorded in Umran and the minimum (1.86 cm) in Chinese at 56 DAFB. The maximum (3.00 cm) stone length was recorded in Umran and the minimum (1.97 cm) in Chinese at 154 DAFB. At 168 DAFB, fruiting season was over in some cultivars, Umran recorded the maximum (3.02 cm) stone length followed by Sanaur-2 (2.93 cm) while minimum (1.98 cm) stone length was observed in Chinese. In 2018-19, the maximum (2.56 cm) stone length was recorded in Umran and the minimum (1.70 cm) in Chhuhara at 56 DAFB. The maximum (3.16 cm) stone length was recorded in Umran and the minimum (2.05 cm) in Chhuhara at 154 DAFB. At 168 DAFB Umran recorded the maximum (3.18 cm) stone length followed by Sanaur-2 (2.72 cm) and the minimum (2.07 cm) in Chhuhara. In Pooled data, the maximum (2.46 cm) stone length was recorded in Umran and the minimum (1.79 cm) in Chhuhara at 56 DAFB. The maximum (3.08 cm) stone length was recorded in Umran and the minimum (2.04 cm) in Chinese at 154 DAFB. At 168 DAFB, fruiting season was over in some cultivars except Umran which recorded the maximum (3.10 cm) stone length followed by Sanaur-2 (2.83 cm) and the minimum (2.05 cm) in Chinese. These results are similar to the report of (Gupta *et al*., 1984) [7] who reported that stone size increased with increase in fruit size with the development of fruit. Stone length increased rapidly within 45 days after fruit set followed by slow and minor changes. Rapid increase in stone length during initial stage could be due to fast cell differentiation and cell enlargement initially followed by slow rate (Ram *et al*., 1983) [13]. (Lodh and Pantastico, 1989) [10] reported that the growth began in the form of cell division and enlargement, in which cell division is a major factor in the enlargement and continuing for the fruit on the tree. (Hidayat, 1995) [8] reported that there are two processes that lead to an increase in the size of the fruit i.e. cell division and enlargement, respectively. The cells divided themselves actively and enlargement of meristematic tissue took place.

Stone diameter (cm)

Data with regard to stone diameter (cm) pattern are presented in Table 2 for both the years *viz*., 2017-18 and 2018-19. The data on stone diameter of ber fruits revealed that stone diameter of different ber cultivars have been found to be increased with advancement of growth and development period. It was evident from the data that no formation of stone took place in the initial two sampling dates i.e. until 42 DAFB in all the cultivars. Thereafter, a rapid increase in stone diameter was noticed between 42 DAFB and 56 DAFB in all the cultivars which was followed by very slow and minor increase till 112 DAFB in Kalagola and 126 DAFB in Sanaur-2. A slight drift in stone diameter was observed between 112 DAFB and 126 DAFB in Kalagola, between 126 DAFB and 140 DAFB in Sanaur-2.

Table 1: Stone length pattern of developing fruits of ber cultivars at biweekly interval

Treatments		2017-18								
		Chhuhara (C_1)	Chinese (C_2)	Kalagola (C_3)	Nazuk (C_4)	Sanaur-2 (C_5)	Sanaur-4 (C_6)	Umran (C_7)	ZG-2 (C_8)	Mean
28	D_1	-	-	-	-	-	-	-	-	-
42	D_2	-	-	-	-	-	-	-	-	-
56	D_3	1.89	1.86	2.01	2.32	2.33	2.20	2.35	2.13	2.14
70	D_4	1.93	1.90	2.02	2.39	2.35	2.28	2.82	2.15	2.23
84	D_5	1.94	1.90	2.03	2.40	2.35	2.30	2.82	2.15	2.24
98	D_6	1.95	1.90	2.05	2.41	2.36	2.31	2.84	2.16	2.25
112	D_7	1.99	1.92	2.05	2.52	2.42	2.41	2.97	2.17	2.31
126	D_8	2.11	1.93	2.11	2.57	2.44	2.44	2.98	2.18	2.34
140	D_9	2.12	1.93	2.22	2.57	2.51	2.55	3.00	2.19	2.39
154	D_{10}	2.22	1.97	2.25	2.58	2.92	2.71	3.00	2.21	2.48
168	D_{11}	2.24	1.98	2.27	-	2.93	2.73	3.02	-	2.52
Mean		1.67	1.57	1.73	2.47	2.05	1.99	2.35	2.16	

	C. D.	SE(d)	SE(m)
Time Interval (T)	0.003	0.002	0.001
Cultivar (C)	0.003	0.001	0.001
Interaction (T X C)	0.01	0.005	0.003

2018-19

28	D_1	-	-	-	-	-	-	-	-	-
42	D_2	-	-	-	-	-	-	-	-	-
56	D_3	1.70	2.01	1.89	2.14	2.12	2.05	2.56	2.25	2.09
70	D_4	1.74	2.02	1.90	2.16	2.12	2.11	2.75	2.28	2.14
84	D_5	1.75	2.04	1.92	2.19	2.14	2.13	2.85	2.30	2.17
98	D_6	1.79	2.05	1.93	2.25	2.17	2.21	3.10	2.31	2.23
112	D_7	1.91	2.06	1.98	2.35	2.21	2.25	3.12	2.32	2.27
126	D_8	1.92	2.07	2.08	2.36	2.26	2.31	3.14	2.33	2.31
140	D_9	2.00	2.09	2.11	2.37	2.35	2.45	3.15	2.34	2.36
154	D_{10}	2.05	2.11	2.14	2.38	2.52	2.48	3.16	2.36	2.40
168	D_{11}	2.07	2.13	2.16	-	2.72	2.56	3.18	-	2.47
Mean		1.54	1.69	1.65	2.27	1.87	1.87	2.46	2.31	

	C. D.	SE(d)	SE(m)
Time Interval (T)	0.03	0.015	0.011
Cultivar (C)	0.025	0.013	0.009
Interaction (T X C)	0.084	0.043	0.03

POOLED DATA

28	D_1	-	-	-	-	-	-	-	-	-
42	D_2	-	-	-	-	-	-	-	-	-
56	D_3	1.79	1.94	1.95	2.23	2.22	2.13	2.46	2.19	2.11
70	D_4	1.84	1.96	1.96	2.27	2.23	2.20	2.78	2.21	2.18
84	D_5	1.84	1.97	1.97	2.30	2.25	2.22	2.84	2.23	2.20
98	D_6	1.87	1.97	1.99	2.32	2.26	2.26	2.97	2.23	2.24
112	D_7	1.95	1.99	2.01	2.44	2.31	2.33	3.04	2.24	2.29
126	D_8	2.01	2.00	2.10	2.46	2.35	2.37	3.06	2.25	2.32
140	D_9	2.06	2.01	2.16	2.47	2.43	2.50	3.07	2.27	2.37
154	D_{10}	2.13	2.04	2.20	2.48	2.72	2.59	3.08	2.28	2.44
168	D_{11}	2.15	2.05	2.21	-	2.83	2.64	3.10	-	2.49
Mean		1.61	1.63	1.69	2.37	1.96	1.93	2.40	2.23	

	C. D.	SE(d)	SE(m)
Time Interval (T)	0.015	0.008	0.005
Cultivar (C)	0.013	0.007	0.005
Interaction (T X C)	0.043	0.022	0.015

In Umran, two drift in stone diameter was observed, first between 56 and 70 DAFB and second between 140 and 154 DAFB. However, a linear increase in stone diameter was observed after 56 DAFB in Chhuhara, Nazuk, Sanaur-4 and ZG-2 till the last date of sampling. Similar trend was also observed in the fruiting season of 2018-19. Pooled analysis of data also showed similar trend in increase in stone diameter during both the years of experiment.

In 2017-18, the maximum (0.84 cm) stone diameter was recorded in Chinese and the minimum (0.59 cm) in Nazuk at 56 DAFB. The maximum (1.01 cm) stone diameter was recorded in Umran and Sanaur-2 while the minimum (0.67 cm) in Nazuk at 154 DAFB. At 168 DAFB, when fruiting season was over in some cultivars, Umran and Sanaur-2 recorded the maximum (1.04 cm) stone diameter while it was recorded minimum (0.71 cm) in Chuhhara. In 2018-19, the maximum (0.81 cm) stone diameter was recorded in ZG-2 and the minimum (0.51 cm) in Nazuk at 56 DAFB. The maximum (1.09 cm) stone diameter was recorded in Sanaur-2 while, the minimum (0.62 cm) in Nazuk at 154 DAFB. At 168 DAFB, fruiting season was over in some cultivars except Sanaur-2 which recorded the maximum (1.12 cm) stone diameter followed by Umran (1.10 cm) and the minimum (0.78 cm) in Chhuhara and Sanaur-4. In Pooled data, the maximum (0.80 cm) stone diameter was recorded in ZG-2 and the minimum (0.55 cm) in Nazuk at 56 DAFB. The maximum (1.05 cm) stone diameter was recorded in Sanaur-2 while, the minimum (0.64 cm) in Nazuk at 154 DAFB. At 168 DAFB, fruiting

season was over in some cultivars except Sanaur-2 which recorded the maximum (1.08 cm) stone diameter and the minimum (0.75 cm) in Chhuhara. These findings are similar to the report of (Sahu *et al*., 2019) [14] in ber. These results are similar to the report of (Gupta *et al*., 1984) [7] reported that the stone size increased with increase in fruit size with the development of fruit. Stone diameter increased rapidly within 45 days after fruit set followed by slow and minor changes. Rapid increase in stone breadth during initial stage could be due to fast cell differentiation and cell enlargement initially followed by slow rate (Ram *et al*., 1983) [13]. (Hidayat, 1995) [8] reported that there are two processes that lead to an increase in the size of the fruit i.e. cell division and enlargement, respectively. The cells divided themselves actively and enlargement of meristematic tissue took place.

Table 2: Stone diameter pattern of developing fruits of ber cultivars at biweekly interval

Treatments		2017-18								
		Chhuhara (C_1)	Chinese (C_2)	Kalagola (C_3)	Nazuk (C_4)	Sanaur-2 (C_5)	Sanaur-4 (C_6)	Umran (C_7)	ZG-2 (C_8)	Mean
28	D_1	-	-	-	-	-	-	-	-	-
42	D_2	-	-	-	-	-	-	-	-	-
56	D_3	0.63	0.84	0.67	0.59	0.70	0.80	0.65	0.80	0.71
70	D_4	0.64	0.92	0.67	0.61	0.71	0.81	0.89	0.82	0.76
84	D_5	0.66	0.93	0.68	0.62	0.72	0.81	0.91	0.83	0.77
98	D_6	0.67	0.94	0.68	0.63	0.73	0.81	0.92	0.84	0.78
112	D_7	0.68	0.95	0.71	0.64	0.81	0.82	0.93	0.85	0.80
126	D_8	0.68	0.96	0.84	0.65	0.83	0.82	0.93	0.86	0.82
140	D_9	0.68	0.97	0.84	0.65	1.01	0.82	0.94	0.87	0.85
154	D_{10}	0.69	0.97	0.85	0.67	1.01	0.83	1.01	0.87	0.86
168	D_{11}	0.71	0.99	0.87	-	1.04	0.85	1.04	-	0.91
Mean		0.55	0.77	0.62	0.63	0.69	0.67	0.75	0.84	

	C. D.	SE(d)	SE(m)
Time Interval (T)	0.003	0.001	0.001
Cultivar (C)	0.002	0.001	0.001
Interaction (T X C)	0.008	0.004	0.003

2018-19

28	D_1	-	-	-	-	-	-	-	-	-
42	D_2	-	-	-	-	-	-	-	-	-
56	D_3	0.52	0.65	0.58	0.51	0.62	0.65	0.62	0.81	0.62
70	D_4	0.54	0.69	0.60	0.53	0.65	0.68	0.78	0.84	0.67
84	D_5	0.56	0.75	0.60	0.54	0.68	0.69	0.81	0.85	0.69
98	D_6	0.71	0.81	0.61	0.55	0.81	0.71	0.92	0.88	0.75
112	D_7	0.75	0.85	0.72	0.56	0.87	0.73	0.95	0.90	0.79
126	D_8	0.75	0.86	0.74	0.59	1.02	0.75	0.96	0.91	0.82
140	D_9	0.75	0.87	0.75	0.60	1.04	0.75	1.02	0.92	0.84
154	D_{10}	0.76	0.88	0.76	0.62	1.09	0.76	1.06	0.92	0.86
168	D_{11}	0.78	0.89	0.81	-	1.12	0.78	1.10	-	0.91
Mean		0.56	0.66	0.56	0.56	0.72	0.59	0.75	0.87	

	C. D.	SE(d)	SE(m)
Time Interval (T)	0.009	0.005	0.003
Cultivar (C)	0.008	0.004	0.003
Interaction (T X C)	0.027	0.014	0.01

POOLED DATA

28	D_1	-	-	-	-	-	-	-	-	-
42	D_2	-	-	-	-	-	-	-	-	-
56	D_3	0.57	0.75	0.63	0.55	0.66	0.73	0.63	0.80	0.67
70	D_4	0.59	0.80	0.64	0.57	0.68	0.74	0.84	0.83	0.71
84	D_5	0.61	0.84	0.64	0.58	0.70	0.75	0.86	0.84	0.73
98	D_6	0.69	0.88	0.65	0.59	0.77	0.76	0.92	0.86	0.77
112	D_7	0.71	0.90	0.71	0.60	0.84	0.77	0.94	0.87	0.79
126	D_8	0.72	0.91	0.79	0.62	0.93	0.78	0.94	0.89	0.82
140	D_9	0.72	0.92	0.79	0.62	1.02	0.79	0.98	0.89	0.84
154	D_{10}	0.72	0.93	0.81	0.64	1.05	0.79	1.04	0.89	0.86
168	D_{11}	0.75	0.94	0.84	-	1.08	0.82	1.07	-	0.91
Mean		0.55	0.71	0.59	0.59	0.70	0.63	0.75	0.85	

	C. D.	SE(d)	SE(m)
Time Interval (T)	0.005	0.003	0.002
Cultivar (C)	0.004	0.002	0.002
Interaction (T X C)	0.014	0.007	0.005

Stone weight (g)

Data pertaining to stone weight (g) pattern are presented in Table 3 for the seasons 2017-18 and 2018-19. The data pertaining to the stone weight of ber fruits as influenced by different cultivars during growth and development stages revealed that stone weight has been found to be increased with advancement of growth and development period. It was evident from the data that stone formation did not took place in the initial two sampling dates i.e. until 42 DAFB in all the cultivars as the seed embryo formation was taken place during

the period. Thereafter, a rapid increase in stone weight was noticed between 42 DAFB and 56 DAFB in all the cultivars which was followed by very slow and minor increase till 70 DAFB in Nazuk; 98 DAFB in ZG-2; 112 DAFB in Chhuhara, Kalagola, Sanaur-2 and Umran and 126 DAFB in Sanaur-4. A major drift in stone weight was observed between 112 DAFB and 140 DAFB in Chhuhara, Kalagola, Sanaur-2 and Umran; between 126 DAFB and 140 DAFB in Sanaur-2; between 70 and 84 days in Nazuk and between 98 and 140 DAFB in ZG-2. While in Chinese cultivar, continuous increase in stone weight was observed until 98 DAFB which is followed by a linear increase in fruit weight till the last date of sampling. Similar trend was also observed in the fruiting season of 2018-19. Pooled analysis of data also showed similar trend in increase in stone diameter during both the years of experiment.

In 2017-18, the maximum (1.36 g) stone weight was recorded in Umran and the minimum (0.51 g) in Kalagola at 56 DAFB. The maximum (1.84 g) stone weight was recorded in Umran and the minimum (1.12 g) in Chhuhara at 154 DAFB. At 168 DAFB, Umran recorded the maximum (1.86 g) stone weight followed by Sanaur-2 (1.76 g) and the minimum (1.14 g) in Chhuhara. In 2018-19, initially the maximum (1.15 g) stone weight was recorded in Umran and the minimum (0.54 g) in ZG-2 at 56 DAFB. The maximum (1.85 g) stone weight was recorded in Umran and the minimum (1.18 g) in Chhuhara at 154 DAFB. At 168 DAFB, Umran recorded the maximum (1.86 g) stone weight followed by Sanaur-2 (1.69 g) and the minimum (1.19 g) in Chhuhara. In Pooled data, the maximum (1.26 g) stone weight was recorded in Umran and the minimum (0.53 g) in Kalagola and ZG-2 at 56 DAFB. The maximum (1.85 g) stone weight was recorded in Umran and the minimum (1.15 g) in Chhuhara at 154 DAFB. At 168 DAFB, Umran also recorded the maximum (1.86 g) stone weight followed by Sanaur-2 (1.60 g) and the minimum (1.17 g) in Chhuhara. These results are similar to the report of (Sahu *et al.*, 2019) [14] who reported that weight of stone of fruit of different ber genotype have been found to be increased with advancement of growth and development

Table 3: Stone weight pattern of developing fruits of ber cultivars at biweekly interval

Treatments		2017-18								
		Chhuhara (C_1)	Chinese (C_2)	Kalagola (C_3)	Nazuk (C_4)	Sanaur-2 (C_5)	Sanaur-4 (C_6)	Umran (C_7)	ZG-2 (C_8)	Mean
28	D_1	-	-	-	-	-	-	-	-	-
42	D_2	-	-	-	-	-	-	-	-	-
56	D_3	0.73	1.02	0.51	0.66	1.03	0.79	1.36	0.52	0.83
70	D_4	0.77	1.14	0.55	0.76	1.06	0.82	1.40	0.59	0.89
84	D_5	0.79	1.20	0.58	1.04	1.10	0.86	1.50	0.62	0.96
98	D_6	0.82	1.31	0.62	1.05	1.13	0.91	1.54	0.67	1.01
112	D_7	0.84	1.31	0.71	1.06	1.15	0.94	1.58	0.86	1.06
126	D_8	0.92	1.32	1.19	1.08	1.61	0.97	1.75	1.23	1.23
140	D_9	1.11	1.33	1.21	1.12	1.74	1.53	1.84	1.76	1.46
154	D_{10}	1.12	1.34	1.24	1.14	1.74	1.55	1.84	1.78	1.47
168	D_{11}	1.14	1.35	1.26	-	1.76	1.57	1.86	-	1.49
Mean		0.75	1.03	0.72	0.98	1.12	0.90	1.33	1.00	
			C. D.			SE(d)			SE(m)	
Time Interval (T)			0.016			0.008			0.006	
Cultivar (C)			0.014			0.007			0.005	
Interaction (T X C)			0.046			0.023			0.017	
2018-19										
28	D_1	-	-	-	-	-	-	-	-	-
42	D_2	-	-	-	-	-	-	-	-	-
56	D_3	0.65	1.00	0.55	0.71	0.91	0.70	1.15	0.54	0.78
70	D_4	0.67	1.06	0.58	0.80	0.95	0.78	1.31	0.57	0.84
84	D_5	0.71	1.15	0.61	1.08	0.99	0.79	1.44	0.65	0.93
98	D_6	0.77	1.25	0.64	1.11	1.04	0.93	1.46	0.74	0.99
112	D_7	0.80	1.35	0.75	1.13	1.08	0.99	1.52	0.96	1.07
126	D_8	0.89	1.38	1.20	1.16	1.56	1.04	1.71	1.08	1.25
140	D_9	1.16	1.39	1.24	1.21	1.68	1.62	1.82	1.80	1.49
154	D_{10}	1.18	1.40	1.26	1.21	1.70	1.65	1.85	1.78	1.50
168	D_{11}	1.19	1.41	1.26	-	1.69	1.64	1.86	-	1.50
Mean		0.73	1.04	0.74	1.05	1.06	0.92	1.28	1.01	
			C. D.			SE(d)			SE(m)	
Time Interval (T)			0.017			0.009			0.006	
Cultivar (C)			0.014			0.007			0.005	
Interaction (T X C)			0.048			0.024			0.017	
POOLED DATA										
28	D_1	-	-	-	-	-	-	-	-	-
42	D_2	-	-	-	-	-	-	-	-	-
56	D_3	0.69	1.01	0.53	0.69	0.97	0.74	1.26	0.53	0.80
70	D_4	0.72	1.10	0.57	0.78	1.01	0.80	1.35	0.58	0.86
84	D_5	0.75	1.18	0.59	1.06	1.05	0.83	1.47	0.63	0.95
98	D_6	0.80	1.28	0.63	1.08	1.09	0.92	1.50	0.71	1.00
112	D_7	0.82	1.33	0.73	1.10	1.11	0.96	1.55	0.91	1.07
126	D_8	0.91	1.35	1.19	1.12	1.59	1.01	1.73	1.02	1.24
140	D_9	1.13	1.36	1.22	1.17	1.71	1.58	1.83	1.78	1.47

154	**D_{10}**	1.15	1.37	1.25	1.17	1.72	1.60	1.85	1.78	1.49
168	**D_{11}**	1.17	1.38	1.26	-	1.73	1.60	1.86	-	1.50
Mean		0.74	1.03	0.73	1.02	1.09	0.91	1.31	1.00	

	C. D.	SE(d)	SE(m)
Time Interval (T)	0.012	0.006	0.004
Cultivar (C)	0.01	0.005	0.004
Interaction (T X C)	0.033	0.017	0.012

period. The findings are in line of (Singh and Misra, 2012) [15]. (Gupta *et al*., 1984) [7] reported that the stone weight increased with increase in fruit size with the development of fruit. Stone weight increased rapidly within 45 days after fruit set followed by slow and minor changes. According to (Chitarra and Chitarra, 2005) [6] fruit mass gains due to development and maturation such as the increase in water content, accumulation of sugars and seed maturation.

Flesh: stone ratio

Data with respect to flesh: stone ratio are presented in Table 4 for the seasons 2017-18 and 2018-19. The data regarding flesh: stone ratio of ber fruits revealed that flesh: stone ratio of fruit of different ber cultivars have been found to be increased with advancement of growth and development period. It was evident from the data that a double sigmoid type of pattern was also observed for flesh: stone ratio in ber cultivars. High flesh: stone ratio was observed in the later part of maturity in all cultivars. In Chinese, a gradual increase was observed till 126 DAFB but thereafter a rapid increasing drift was observed between 126 DAFB and 154 DAFB. In Kalagola, flesh: stone ratio was found in lower side initially until 84 DAFB but thereafter a significant increase was noticed until 140 DAFB. Nazuk attained a gradual increase in flesh: stone ratio until 112 DAFB but thereafter it showed a rapid increase until 140 DAFB. In Sanaur-2, flesh: stone ratio was initially low in beginning until 70 DAFB but thereafter two phases of rapid increase was found between 70-98 DAFB and 98-140 DAFB. Sanaur-4 has gradual increase in flesh: stone ratio until 112 DAFB but between 112 and 154 DAFB, a major increase in flesh: stone ratio was noticed. Umran has noticed three phases of increase in flesh: stone ratio i.e. one at 56-98 DAFB, then 98-126 DAFB and the last phase of increase was observed from 126 to 154 DAFB. In ZG-2, flesh: stone ratio was low in the beginning and later part of maturity but it was found higher in middle stage of growth from 70 DAFB to 126 DAFB. In 2017-18, the maximum (4.92) flesh: stone ratio was recorded in ZG-2 and the minimum (1.04) in Chinese at 56 DAFB. The maximum (13.56) flesh: stone ratio was recorded in Sanaur-2 and the minimum (5.96) in ZG-2 at 154 DAFB. At 168 DAFB, fruiting season was over in some cultivars except Sanaur-2 which recorded the maximum (14.96) flesh: stone ratio followed by Umran (14.54) and the minimum (8.69) in Chinese. In 2018-19, the maximum (4.50) flesh: stone ratio was recorded in ZG-2 and the minimum (1.23) flesh: stone ratio in Chinese at 56 DAFB. The maximum (11.63) flesh: stone ratio was recorded in Umran and the minimum (5.46) in ZG-2 at 154 DAFB. At 168 DAFB, fruiting season was over in some cultivars except Sanaur-2 which recorded the maximum (14.98) flesh: stone ratio followed by Umran (13.98) and the minimum (8.35) in Chinese. In Pooled data, the maximum (4.71) flesh: stone ratio was recorded in ZG-2 and the minimum (1.14) in Chinese at 56 DAFB. The maximum (12.76) flesh: stone ratio was recorded in Sanaur-2 and the minimum (5.70) in ZG-2 at 154 DAFB. At 168 DAFB, fruiting season was over in some cultivars except Sanaur-2 which recorded the maximum (14.97) flesh: stone ratio followed by Umran (14.26) and the minimum (8.52) in Chinese. These results are similar to the report of (Islam *et al*., 2015) [9] reported that in BARI KUL-2 cultivar of ber pulp: stone ratio was computed high (17.75) from the fruits harvested 130 days after fruit set while it was recorded minimum (11.21) at 90 days. Moderate pulp: stone ratio was obtained from the fruits harvested at 110 and 120 days after fruit set (15.66 and 16.81, respectively). (Sahu *et al*., 2019) [14] reported that pulp: stone ratio of fruit of different ber genotype have been found to be increased with advancement of growth and development period. The results are in the line of finding by (Akhundova and Agaev, 1989) [1] reported the ratio of pulp to stone in Gola was 0.14 and in Mundia was 0.23. Similar observations were also recorded by (Jan Brindza *et al*., 2011) [5]. (Gupta *et al*., 1984) [7] reported that stone pulp ratio was maximum in immature fruits which decreased with the advancement of maturity. There was a slow and gradual decrease in this ratio upto 75 days of fruit growth followed by a sharp decline. This rapid decrease in stone: pulp ratio can be due to relatively higher increase in pulp as a result of food accumulation.

Table 4: Flesh: stone ratio pattern of developing fruits of ber cultivars at biweekly interval

Treatments		**2017-18**								
		Chhuhara (C_1)	**Chinese (C_2)**	**Kalagola (C_3)**	**Nazuk (C_4)**	**Sanaur-2 (C_5)**	**Sanaur-4 (C_6)**	**Umran (C_7)**	**ZG-2 (C_8)**	**Mean**
28	**D_1**	-	-	-	-	-	-	-	-	-
42	**D_2**	-	-	-	-	-	-	-	-	-
56	**D_3**	1.05	1.04	3.01	2.42	1.23	3.10	1.38	4.92	2.27
70	**D_4**	2.02	1.01	3.24	2.88	2.11	3.00	3.17	6.00	2.93
84	**D_5**	2.65	1.23	3.27	1.93	3.61	3.02	3.45	7.47	3.33
98	**D_6**	2.66	2.00	4.72	2.29	4.35	3.81	3.71	8.37	3.99
112	**D_7**	5.95	2.48	4.83	2.89	5.15	5.54	4.29	9.56	5.09
126	**D_8**	6.12	3.01	5.13	3.86	6.25	7.40	5.96	7.96	6.03
140	**D_9**	6.50	7.07	8.40	8.25	12.42	7.28	9.51	5.85	8.16
154	**D_{10}**	9.13	8.12	10.56	8.11	13.56	10.44	11.87	5.96	9.72
168	**D_{11}**	8.97	8.69	12.69	-	14.96	10.42	14.54	-	11.71
Mean		4.10	3.15	5.08	4.07	5.79	4.91	5.26	7.01	

C. D.	SE(d)	SE(m)

Time Interval (T)				0.177		0.089			0.063	
Cultivar (C)				0.151		0.076			0.054	
Interaction (T X C)				0.499		0.253			0.179	
2018-19										
28	**D_1**	-	-	-	-	-	-	-	-	-
42	**D_2**	-	-	-	-	-	-	-	-	-
56	**D_3**	2.08	1.23	2.82	2.68	1.92	3.13	2.09	4.50	2.56
70	**D_4**	2.46	1.50	2.93	2.44	3.48	3.27	3.50	7.51	3.39
84	**D_5**	2.91	1.80	4.08	1.77	4.15	4.22	4.02	7.10	3.76
98	**D_6**	4.92	2.72	5.22	2.29	5.62	5.45	4.17	8.77	4.90
112	**D_7**	6.79	2.79	7.01	2.41	8.26	5.34	4.63	8.38	5.70
126	**D_8**	7.09	5.70	6.70	5.52	7.98	6.69	6.22	8.39	6.79
140	**D_9**	6.97	7.09	7.28	6.16	9.88	7.31	9.07	5.20	7.37
154	**D_{10}**	8.41	7.58	10.32	6.76	11.96	8.29	11.63	5.46	8.80
168	**D_{11}**	8.46	8.35	11.81	-	14.98	9.33	13.98	-	11.15
Mean		4.55	3.52	5.29	3.75	6.20	4.82	5.39	6.91	

	C. D.	SE(d)	SE(m)
Time Interval (T)	0.144	0.073	0.052
Cultivar (C)	0.123	0.062	0.044
Interaction (T X C)	0.407	0.206	0.146

POOLED DATA										
28	**D_1**	-	-	-	-	-	-	-	-	-
42	**D_2**	-	-	-	-	-	-	-	-	-
56	**D_3**	1.57	1.14	2.92	2.55	1.57	3.12	1.73	4.71	2.41
70	**D_4**	2.24	1.25	3.08	2.66	2.80	3.14	3.33	6.75	3.16
84	**D_5**	2.77	1.51	3.68	1.85	3.88	3.62	3.74	7.28	3.54
98	**D_6**	3.79	2.36	4.97	2.29	4.98	4.63	3.94	8.57	4.44
112	**D_7**	6.37	2.63	5.92	2.65	6.71	5.44	4.46	8.97	5.39
126	**D_8**	6.60	4.35	5.91	4.69	7.12	7.05	6.10	9.44	6.41
140	**D_9**	6.74	7.08	7.84	7.21	11.15	7.29	9.29	5.52	7.77
154	**D_{10}**	8.77	7.86	10.44	7.43	12.76	9.37	11.75	5.70	9.26
168	**D_{11}**	8.72	8.52	12.25	-	14.97	9.88	14.26	-	11.43
Mean		4.32	3.34	5.18	3.91	5.99	4.87	5.33	6.96	

	C. D.	SE(d)	SE(m)
Time Interval (T)	0.116	0.059	0.041
Cultivar (C)	0.099	0.05	0.035
Interaction (T X C)	0.327	0.166	0.117

Conclusion

Stone length fruit of different ber cultivars have been found to be linearly increased with advancement of growth and development period. Rapid increase in stone diameter was noticed between 42 DAFB and 56 DAFB in all the cultivars which was followed by very slow and minor increase till 112 DAFB in Kalagola and 126 DAFB in Sanaur-2. Rapid increase in stone weight was noticed between 42 DAFB and 56 DAFB in all the cultivars followed by very slow and minor increase till 70 DAFB in Nazuk; 98 DAFB in ZG-2; 112 DAFB in Chhuhara, Kalagola, Sanaur-2 and Umran and 126 DAFB in Sanaur-4. Flesh: stone ratio of fruit of different ber cultivars have also been found to be increased with advancement of growth and development period. At 168 DAFB, fruiting season was over in some cultivars except Umran which recorded the maximum (3.10 cm) stone length followed by Sanaur-2 (2.83 cm) and the minimum (2.05 cm) in Chinese. At 168 DAFB, fruiting season was over in some cultivars except Sanaur-2 which recorded the maximum (1.08 cm) stone diameter and the minimum (0.75 cm) in Chhuhara. At 168 DAFB, Umran also recorded the maximum (1.86 g) stone weight followed by Sanaur-2 (1.60 g) and the minimum (1.17 g) in Chhuhara. At 168 DAFB, fruiting season was over in some cultivars except Sanaur-2 which recorded the maximum (14.97) flesh: stone ratio followed by Umran (14.26) and the minimum (8.52) in Chinese.

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