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Changes in sweet cherry buds cvs. Burlat and Regina during different phases of dormancy

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ABSTRACT

Sweet cherry cultivated in temperate climatic conditions, undergoes a period of dormancy to survive the low temperature of winter season and also for successful flowering. This study investigated the variations in bud length, diameter and total sugar of two commercially significant sweet cherry cultivars, Burlat and Regina, throughout three distinct phases of dormancy: paradormancy, endodormancy and ecodormancy. Buds from both cultivars were sampled at 15 days intervals starting during 1st August till 15th of March. Results revealed increase in bud length and diameter during paradormancy period. During endodormancy, both cultivars exhibited minimal changes in bud length and diameter, indicating metabolic dormancy. Subsequent to the release of endodormancy, bud length and diameter showed a gradual increase during ecodormancy, suggesting preparation for growth resumption.Total sugars showed reverse trend i.e., its concentration was recorded highest during endodormancy phase.

Key words: *Bud length, Bud diameter, Total sugar, Burlat, Regina*

Introduction

Sweet cherry (*Prunus avium* L.) is an important stone fruit crop mainly grown in temperate climate regions of the world. It is supposed to be originated from the region between the Black and the Caspian seas. Sweet cherries are produced mainly in Mediterranean countries like Turkey, Italy, Spain and Greece; in Middle Eastern countries such as Iran and Uzbekistan; in United States and in Chile (Fadon *et al*., 2020). In 2022 the world cherry production was recorded as 27 lakh MT on an area of 4.5 lakh ha (FAOSTAT, 2022).Turkey tops as the largest cherry producer in the world with the production of 8.33 lakh MT followed by European Union (8.31 lakh MT) and China (6.8 lakh MT) (STATISTA, 2022). In India cherry is being cultivated over an area of 3557 ha with the production of 10934 MT (FAOSTAT, 2022). The important sweet cherry producing states in India are the northern states of the country, which include Himachal Pradesh, Jammu and Kashmir and Uttarakhand. Moreover, Jammu and Kashmir is the only state that produces 95% of the total cherry production in India.

This nutritive temperate fruit crop which belongs to Rosaceae family is cultivated in temperate cli-

matic conditions, undergoes a period of dormancy to survive the low temperature of winter season (Rothkejal *et al*., 2020). In temperate climate areas deciduous trees enter into a long period of rest during winter months; as the leaves falls in the autumn, until growth resumes in the spring. Dormancy in general in deciduous fruit trees of temperate zone is a phase that allows the fruit trees to survive unfavourable climactic conditions during the winter months and there are three phases of dormancy i.e., paradormancy, endodormancy and ecodormancy (Lang *et al*., 1987). Paradormancy also called as summer dormancy, is the temporary dormancy which proceeds winter or endodormancy in woody plants of temperate region. During this phase, the growth of plant organs, specifically apical dominance, plays a role in regulating the development of buds, rather than relying solely on substances within the buds themselves, as noted by Celine and Deppong (1999). The conclusion of paradormancy coincides with the shedding of leaves. Then in the second phase endodormancy, also known as rest period or true dormancy, buds remain dormant due to growth arresting physiological conditions low temperature and declining photoperiod that regulates the establishment of endodormancy (Cook *et al*., 2017). The release from the state of endodormancy can be triggered by the accumulation of chill units, as described by Alburquerque *et al*. (2008). The third phase of dormancy is ecodormancy also called as quiescent period in which buds remain dormant due to the unfavourable climactic condition (Lang *et al*., 1987). Ecodormancy maintains the biological silence of reproductive organs until the arrival of spring, coinciding with the increase in air temperature and moisture content within the buds, as detailed by Chmielewski and Gotz (2022). Subsequently, after ontogenetic development initiates, the buds begin their blooming phase. During the period of endodormancy, low temperatures triggered different structural and biochemical changes at the cellular level that were related to frost protection (Faust *et al*., 1997) by regulating the osmotic balance. So, the present investigation was carried out in sweet cherry cvs. Burlat and Regina with the objectives to study bud size and carbohydrate changes during different phases of dormancy.

Materials and Method

The present investigation was conducted in theExperimental fields of Division of Fruit Science, SKUAST-Kashmir, Shalimar during the year 2021-22 and 2022-2023. Four-year-old trees of sweet cherry *cvs*. "Burlat" and "Regina" having uniform age, size and vigourgrafted on 'GiSelA 5' rootstocks, planted at distance of 1.5m×3 m was selected for experiment. Theexperiment was laid out in Randomized Block Design with four replication and 16 sampling dates starting fortnightly from 1st August till 15th March. In order to analyse the physical and biochemical characteristics of the cherry buds, flower-bud cluster were taken. The length and diameter of the flower buds were measured from sample taking fortnightly starting from1st August to 15th March to determine the growth and morphological changes in buds. The flower buds' sample were cut longitudinally from centre and length was observed, for diameter width from the centre was observed and measured under a stereo microscope, Olympus SZX7 equipped with Magnus 5.0 MP camera. Measurement was done with the Q-Capture PRO-7 software. Length and diameter of the buds were recorded and expressed in millimetre (mm). Total sugars were determined using the procedure reported by Mandre et al. (2002) and express in mg/g. Statistical analysis was done by R software.

Results

Bud length (mm)

The data pertaining to changes in bud length during dormancy period presented in Table 1, reveals that the bud length at the beginning of bud dormancy (1st August) was recorded, 3.41 ± 0.07, 3.59 ± 0.69 mm for the season 2021/22 and 2022/23 respectively for Burlat and for Regina it was recorded 3.33 ± 0.10,3.49 ± 0.19 mm for the season 2021/22 and 2022/23 respectively. After this period bud length continuously increased throughout dormancy period but the growth slowed down when it reached 15th November (5.21 ± 0.15 and 5.23 ± 0.64 mm for the season 2021/22 and 2022/23 respectively for Burlat cultivar and for Regina it was 4.87 ± 0.17,5.12 ± 0.21 mm for the season 2021/22 and 2022/23 respectively) till 1st February with the value recorded, 5.41 ± 0.62 and 5.43 ± 0.70 mm for the season 2021/22 and 2022/23 respectively for Burlat cultivar and for Regina it was 5.41 ± 0.32,5.35 ± 0.11 mm for the season 2021/22 and 2022/23 respectively. After 1st February it again rose at a rapid rate and the maximum value was recorded during 15th March, 5.92 ± 0.15 and 6.00

± 0.70 mm for the season 2021/22 and 2022/23 respectively for Burlat cultivar and for Regina it was 5.80 ± 0.11,5.88 ± 0.13 mm for the season 2021/22 and 2022/23 respectively.

Bud diameter (mm)

The data presented in Table 1, reveals that the bud diameter at the beginning of bud dormancy (1st August) was recorded, 1.76 ± 0.11, 1.92 ± 0.18 mm for the season 2021/22 and 2022/23 respectively for Burlat and for Regina it was recorded 1.72 ± 0.09,1.84 ± 0.21 mm for the season 2021/22 and 2022/23 respectively. After this period bud diameter continuously increased throughout dormancy period but the growth almost remained constant or slowed down when it reached 1st October till 15th January with the value 2.34 ± 0.03 and 2.42 ± 0.09 mm for the season 2021/22 and 2022/23 respectively for Burlat cultivar and for Regina it was 2.50 ± 0.18,2.46 ± 0.18 mm for the season 2021/22 and 2022/23 respectively. After this the value rose at a rapid rate and reached maximum to 3.13 ± 0.17 and 3.35 ± 0.08 mm for the season 2021/22 and 2022/23 respectively for Burlat cultivar and for Regina it was 3.12 ± 0.37,3.05 ± 0.25 mm for the season 2021/22 and 2022/23 respectively.

Total Sugars (mg/g)

Data presented in Table 2, reveals that the total sugar content during 1st august (beginning of dormancy) was recorded 63.16 ± 1.91, 65.81 ± 1.23 mg/g DW for the season 2021/22 and 2022/23 respectively for Burlat and for Regina it was 65.12 ± 1.12,66.70 ± 1.11 mg/g DW for the season 2021/22 and 2022/23 respectively. After 1st August total sugar content decreased till 15th November and reached minimum value to 45.36 ± 0.97, 47.65 ± 1.84 mg/g DW for the season 2021/22 and 2022/23 respectively for Burlat cultivar and for Regina it was39.98 ± 0.79,43.55 ± 1.32 mg/g DW for the season 2021/22 and 2022/23 respectively. After this period the value get increased till 15th of January for Burlat and 1st February for Regina with the maximum value of 93.37 ± 1.37, 95.62 ± 1.17mg/g DW for the season 2021/22 and 2022/23 respectively for Burlat cultivar and for Regina it is 94.24 ± 1.24, 96.85 ± 1.72mg/g DW for the season 2021/22 and 2022/23 respectively. After that it start decreasing and reached the value of 76.03 ± 1.76,77.65 ± 1.95mg/g DW for the season 2021/22

Table 1. Changes in Bud length (mm) and Bud diameter (mm) in sweet cherry buds cvs. Burlat and Regina throughout different phase of dormancy period

Varieties	Bud Length (mm)				Bud Diameter (mm)			
Sampling Dates	Burlat		Regina		Burlat		Regina	
(DOY: Days of year)	2021-2022	2022-2023	2021-2022	2022-2023	2021-2022	2022-2023	2021-2022	2022-2023
1st August (213)	3.41 ± 0.07	3.59 ± 0.69	3.33 ± 0.10	3.49 ± 0.19	1.76 ± 0.11	1.92 ± 0.18	1.72 ± 0.09	1.84 ± 0.21
15th August (227)	3.67 ± 0.22	3.85 ± 0.65	3.68 ± 0.11	3.83 ± 0.27	1.81 ± 0.16	1.96 ± 0.16	1.90 ± 0.09	1.93 ± 0.26
1st September (244)	4.15 ± 0.07	4.27 ± 0.62	3.92 ± 0.18	4.15 ± 0.29	2.05 ± 0.31	2.16 ± 0.10	2.01 ± 0.14	2.06 ± 0.22
15th September (258)	4.47 ± 0.12	4.50 ± 0.61	4.42 ± 0.43	4.57 ± 0.27	2.10 ± 0.11	2.21 ± 0.13	2.21 ± 0.07	2.17 ± 0.20
1st October (274)	4.53 ± 0.12	4.60 ± 0.61	4.45 ± 0.31	4.70 ± 0.36	2.21 ± 0.15	2.29 ± 0.16	2.25 ± 0.02	2.27 ± 0.13
15th October (288)	5.04 ± 0.06	5.00 ± 0.62	4.75 ± 0.27	4.98 ± 0.34	2.22 ± 0.12	2.29 ± 0.09	2.29 ± 0.06	2.31 ± 0.19
1st November (304)	5.12 ± 0.27	5.10 ± 0.63	4.78 ± 0.41	5.03 ± 0.33	2.25 ± 0.10	2.32 ± 0.06	2.33 ± 0.16	2.35 ± 0.18
15th November (319)	5.21 ± 0.15	5.23 ± 0.64	4.87 ± 0.17	5.12 ± 0.21	2.28 ± 0.12	2.35 ± 0.11	2.40 ± 0.15	2.39 ± 0.21
1stDecember (335)	5.24 ± 0.19	5.27 ± 0.65	5.20 ± 0.12	5.17 ± 0.17	2.29 ± 0.06	2.37 ± 0.11	2.44 ± 0.29	2.41 ± 0.17
15th December (349)	5.28 ± 0.22	5.31 ± 0.66	5.20 ± 0.39	5.21 ± 0.20	2.31 ± 0.06	2.38 ± 0.08	2.46 ± 0.13	2.43 ± 0.24
1st January (1)	5.31 ± 0.25	5.33 ± 0.67	5.28 ± 0.45	5.25 ± 0.20	2.33 ± 0.06	2.40 ± 0.09	2.46 ± 0.14	2.44 ± 0.16
15th January (15)	5.38 ± 0.26	5.36 ± 0.68	5.30 ± 0.16	5.29 ± 0.25	2.34 ± 0.03	2.42 ± 0.09	2.50 ± 0.18	2.46 ± 0.18
1st February (32)	5.41 ± 0.62	5.43 ± 0.70	5.41 ± 0.32	5.35 ± 0.11	2.51 ± 0.13	2.63 ± 0.06	2.58 ± 0.12	2.60 ± 0.20
15th February (46)	5.59 ± 0.19	5.63 ± 0.71	5.51 ± 0.20	5.48 ± 0.16	2.63 ± 0.18	2.70 ± 0.10	2.69 ± 0.08	2.71 ± 0.34
1st March (60)	5.78 ± 0.16	5.86 ± 0.71	5.65 ± 0.07	5.70 ± 0.18	2.78 ± 0.12	2.91 ± 0.13	2.79 ± 0.06	2.86 ± 0.23
15th March (74)	5.92 ± 0.15	6.00 ± 0.70	5.80 ± 0.11	5.88 ± 0.13	3.13 ± 0.17	3.35 ± 0.08	3.12 ± 0.37	3.05 ± 0.25

and 2022/23 respectively (Burlat) and 77.74 ± 1.45, 78.53 ±1.29mg/g DW for the season 2021/22 and 2022/23 respectively for Regina cultivar during 15th of March.

Discussion

Bud size significantly increased during paradormancy which is due to active bud metabolic activity during this period. Subsequently the size of bud remained constant till 1st of February due to the reason that during this period the concentration of abscissic acid content is maximum in buds thus inhibiting cell division by inducing the expression of ICK1, an inhibitor of cyclin-dependant kinases and inhibits expression of CYCD3 and CDKB (De Smet *et al*., 2003), two key cell cycle regulators. Abscissic acid also antagonizes Gibberellic acid (GA), and the accumulation of GA is frequently linked with the processes of plant cell elongation and cell division (Francis and Sorrell, 2001). Persistence of constant value of bud size may also result from environmental cues, particularly short-day lengths and or low temperatures, as suggested by Horvath (2010). Bud size again increased from 1st Feb till 15th March. Bud size increases due to the resumption of active growth processes as environmental conditions become more favourable, especially with the onset of warmer temperatures and increased day lengths, several physiological changes occur like enhance uptake of water and increase accumulation of growth promoting hormones like auxin and gibberelic acid and abscisic acid concentration decreases (Fadon *et al*., 2020). Gibberellic acid (GA), a plant hormone associated with cell elongation and division, accumulates as the buds are released from dormancy (Fadon *et al*., 2020). Specific genetic and molecular pathways are activated during the transition from dormancy to active growth.

The total sugar content in buds of both the varieties was decreased at a very slow rate from 1st August till 15th of November; this slow decreased may be attributed to the weakened activity of amylolytic processes, as noted by Koussa *et al.* (1998) and also due to utilization of sugars in the process of respiration during this period. After 15th November the total sugar increased rapidly and reached maximum during 15th of January i.e., during endodormancy the concentration of total sugars was maximum. This peak is attributed to the mobilization of fructans stored in vacuoles in the form of fructose during cold stress. These fructans are then exported to the intercellular liquid, interfering with the adhesion between the plant surface and extracellular ice. This process serves as a defense mechanism, preventing extracellular ice invasion into cells. The drop in autumn temperatures signals the initiation of starch breakdown, leading to an increase in hexoses. This phenomenon also plays a role in enhancing the cold resistance of flower buds in cherry-growing climates (Blanke *et al*., 2017). Maximum accumulations of sucrose, glucose, and fructose dur-

Table 2. Changes in Total sugar content (mg/g) in sweet cherry buds cvs. Burlat and Regina throughout different phases of dormancy period

Varieties/Sampling Dates (DOY: Days of year)	BURLAT		REGINA	
	2021-2022	2022-2023	2021-2022	2022-2023
1st August (213)	63.16 ± 1.91	65.81 ± 1.23	65.12 ± 1.12	66.70 ± 1.11
15th August (227)	61.72 ± 1.88	64.81 ± 1.21	62.21 ± 1.39	64.79 ± 1.62
1st September (244)	58.51 ± 1.79	61.56 ± 1.73	58.85 ± 1.02	60.43 ± 1.98
15th September (258)	54.41 ± 1.17	57.36 ± 0.93	58.12 ± 1.21	58.70 ± 1.82
1st October (274)	51.24 ± 1.47	54.35 ± 1.62	54.60 ± 1.25	56.17 ± 1.52
15th October (288)	53.06 ± 1.80	53.35 ± 1.94	53.75 ± 1.47	54.32 ± 1.27
1st November (304)	51.37 ± 1.69	52.66 ± 1.02	51.64 ± 1.52	52.21 ± 1.83
15th November (319)	45.36 ± 0.97	47.65 ± 1.84	39.98 ± 0.79	43.55 ± 1.32
1st December (335)	58.77 ± 1.64	62.66 ± 1.86	57.68 ± 1.38	60.25 ± 1.81
15th December (349)	77.41 ± 1.31	80.30 ± 1.20	80.17 ± 0.92	82.74 ± 1.61
1st January (1)	90.23 ± 1.43	93.12 ± 1.87	88.33 ± 1.08	91.90 ±1.53
15th January (15)	93.37 ± 1.37	95.62 ± 1.17	90.29 ± 1.11	93.91 ± 1.69
1st February (32)	92.06 ± 1.38	93.61 ± 1.80	94.24 ± 1.24	96.85 ± 1.72
15th February (46)	88.29 ± 1.20	88.91 ± 1.43	91.42 ± 0.90	93.83 ± 1.78
1st March (60)	82.47 ± 1.26	85.09 ± 1.76	80.02 ± 0.95	83.41 ± 1.00
15th March (74)	76.03 ± 1.76	77.65 ± 1.95	77.74 ± 1.45	78.53 ± 1.29

ing endodormancy are frequently reported and are linked to their cryoprotective properties (guarding buds from winter freezing) and their role in osmotic regulation for bud development (Jouve *et al*., 2007). But after 15th January the concentration again decreases which mark resumption of bud metabolic activity. As spring bring warmer and longer days and the carbohydrate content generally decreases and this supports the remobilization of stored nutrients, providing the plant with the necessary resources for leaf and stem production, independently of external nutrient supply during the active growth period (Chmielewski *et al*., 2017; Jouve *et al*., 2007).

Conclusion

We can conclude that during paradormancy, the growth of cherry buds progressed until the end of leaf fall. Subsequently, throughout the extended period of endodormancy following leaf fall, there was no significant growth or development observed. Nonetheless, an upsurge in bud growth and development occurred with favourable increases in temperature. Specifically, only a consistent rise in air temperature, resulting in increased water content within the buds, facilitated active growth and development.Such insights can aid growers in optimizing management strategies to maximize yield and quality in different cultivars. These findings underscore the importance of considering dormancy dynamicsin sweet cherry cultivation practices.

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