CHARACTERIZATION AND EVALUATION OF DIFFERENT VARIETIES OF SWEET CHERRY (*Prunus avium* L.)

Thesis

by

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CERTIFICATE-I

This is to certify that the thesis titled, **"Characterization and evaluation of different varieties of sweet cherry (*Prunus avium* L.)"** submitted in partial fulfillment of the requirements for the award of the degree of **Master of Science (Horticulture) Fruit Science** in the discipline of **Horticultural Sciences** to Dr Yashwant Singh Parmar University of Horticulture and Forestry, (Nauni) Solan (HP) – 173 230 is a bonafide research work carried out by **Ms Kiranpreet Kaur (H-2020-48-M)** daughter of Mr Jasbir Singh under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been fully acknowledged.

Place: Nauni, Solan (HP)
Dated:

_____
Dr Neena Chauhan
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CERTIFICATE-II

This is to certify that the thesis titled **"Characterization and evaluation of different varieties of sweet cherry (*Prunus avium* L.)"** submitted by **Ms Kiranpreet Kaur (H-2020-48-M)** daughter of Mr Jasbir Singh to Dr Yashwant Singh Parmar University of Horticulture & Forestry, (Nauni) Solan (HP) – 173 230 India in partial fulfilment of the requirements for the degree of **Master of Science (Horticulture) Fruit Science** in the discipline of **Horticultural Sciences** has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External Examiner.

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He who has no faith in himself can never have faith in God.

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ABBREVIATIONS USED

%	:	Per cent
amsl	:	above mean sea level
ANOVA	:	Analysis of variance
CD	:	Critical difference
cm	:	Centimetre
cv(s)	:	Cultivar(s)
CGE	:	Cyanidin glucoside equivalents
DAFB	:	Days after full bloom
DUS	:	Distinctiveness, Uniformity, Stability
et al.	:	Co-workers
E-W	:	East-West
g	:	Gram
ha	:	Hectare
i.e.	:	That is
kg	:	Kilogram
kg/cm^2	:	Kilogram per centimetre square
kg/ha	:	Kilogram per hectare
m	:	Metre
mg	:	Milligram
ml	:	Millilitre
mm	:	Millimetre
MT	:	Metric tonne
N-S	:	North-South
SSC	:	Soluble solid content
TCSA	:	Trunk cross sectional area
^{o}Brix	:	Degree brix
TA	:	Titratable acidity
TSS	:	Total soluble solids
UPOV	:	International Union for Protection of New Plant Varieties
viz.	:	Namely

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Chapter-1

INTRODUCTION

Sweet cherry (*Prunus avium* L.), a deciduous tree originated around the Caspian and Black seas on the borders of Europe and Asia and thrives best in area with a temperate or Mediterranean type climate. It is a fruit that is appreciated worldwide and is economically attractive, producing a high income for producers. Sweet cherries are cultivated commercially in more than forty countries in the world, in temperate Mediterranean and subtropical regions (Webster and Looney, 1996). Trees of cherry generally do not thrive where summers are long and hot or where winter temperatures are high for short periods. Cherries are usually grown in the coldest climates at an altitude of about 1600 to 2700 m above mean sea level requiring 1000 to 1500 hours of chilling period during winters.

Turkey, European units and China are the largest producers of sweet cherry worldwide (Shahbandeh, 2021). Sweet cherry, an important fruit of temperate region, is confined to limited locations of temperate climate of Kashmir, Himachal Pradesh and hills of Uttar Pradesh in India. Jammu and Kashmir is the major producer of cherry in the India with 2748 ha area and 11280 MT production (Anonymous, 2019). In Himachal Pradesh, cherry is grown under 448 ha area having 490 MT productions (Anonymous, 2018). Shimla, Kullu, Mandi, Chamba, and Lahaul & Spiti are the main districts in Himachal Pradesh where cherries are grown extensively and in Shimla alone (Narkanda, Kandyali, Kotgarh-Kumarsen, Rampur, Rohru, and Kotkhai) accounts for 80 per cent of state's total production.

Fruits of sweet cherry are refreshing, diuretic, energetic, anti-infective and have the laxative and detoxifying effect. Besides their recognized good taste and appealing colour, sweet cherries have nutritional and health promoting characteristics due to their richness in organic acids, sugars, vitamins, minerals, volatile compounds and antioxidants compounds as well as fibre content. Sweet cherry commercial quality refers to all aspects related to the external appearance of the product, including fruit weight, colour, firmness, size, shape, sweetness, flavour and aroma with important differences among cultivars (Romano *et al.*, 2006).

Sweet cherries have high nutritional value and non-competence among different temperate fruit crops as per availability in market from mid of May to July month (Zheng *et al.,* 2016). The price of sweet cherries is higher having early ripening time when other fruits

are missing on market. Limited production and more demand for cherry fruits make it high value cash crop. Consumer's demand has also increased for sweet cherry due to its sweet taste, beautiful colour and the high amounts of antioxidants, however, perishability of the fruit is high thus, limiting the shelf life up to 7–10 days (Wani *et al.*, 2014).

There are few dominant cherry cultivars Viz; Stella, Durone Nero –I & II, Van, Sam and Lambert which are grown in different pockets of Himachal Pradesh. The selection and introduction of new sweet cherry cultivars are important to maintaining a competitive fruit industry. New cultivars suitable for constant production, with low vigour of the trees, self-fertility resistance to biotic or abiotic factors and ripening time at the extremities of the cherry's maturation season are prerequisite in changing climatic conditions. Howsoever, standard varieties of sweet cherry with the sudden upsurge of global warming are unable to meet the chilling requirement in temperate areas of Himachal Pradesh, thus, they face the risk of crop failure (Dangi *et al.*, 2021).

The development of new fruit cultivars has generally been based on genetic resources. Main germplasm collection and characterization is performed by describing phenological, pomological and morphological characteristics such as tree vigour and growth habit, fruit quality features, leaf, stone, flower stigma and style, pollen, blooming and harvest time. Data observations and records when compiled helps to better understand the different varieties of a crop. It not only enables us to distinguish a genotype within a species but also the difference between species. With this, we can prepare index of important distinguishable characteristics among them. Qualitative and Quantitative data recorded when analyzed also helps in finding the existence of similar and dissimilar attributes for interpreting genetic variability among different varieties of sweet cherry.

In order to ascertain the suitability of cultivation of cherry varieties and to broaden the genetic base of cherry germplasm, it is proposed to study growth, floral and fruiting behavior and to develop descriptors for proper identification and characterization of sweet cherry varieties. Keeping in view the present study was carried out on sweet cherry varieties available in Gene Bank at the Regional Horticultural Research and Training Station, Mashobra, Shimla (HP) with the following objectives:

a) To study growth, flowering and fruiting behaviour of sweet cherry
b) To evaluate the yield and fruit quality performance of different cherry varieties
c) To develop standard descriptors for sweet cherry varieties

Chapter-2

REVIEW OF LITERATURE

The characterization and evaluation as well as the documentation of plant genetic resources are the key of their utilization. Variability is the process by which differences occur among individuals of the same plant species. Some characteristics especially quantitative one's changes quickly and readily even when environmental conditions change slightly. An attempt has been made in this chapter to review the relevant.

2.1 Vegetative Characters

2.1.1 Tree Characters

Kolev and Dzhuvinov (2005) evaluated nine sweet cherry cultivars on Gisela 5 rootstock namely 'Burlat', 'Nalina', 'Kordia', 'Regina', 'Katalin', 'Hudson', 'Summit', 'Sunburst' and 'Lapins'. Tree growth was recorded for different cherry cultivar and Burlat, Nalina, Katalin, Hudson were found under vigorous growth category, Kordia, Regina and Lapins under moderate growth and Sunburst and Summit under weak growth category.

Schuster (2007) reported columnar tree growth habit in sour cherries, *Prunus cerasus* L., characterized by a natural distinctive upright growth habit, shorter internode length, narrow branches angles and short shoots with fruit set.

Srivastava *et al.* (2014) recorded vegetative and pomological characters to assess genetic variability and diversity in twenty one sweet cherry accessions at Central Institute of Temperate Horticulture, Old Airfield, Rangreth, Srinagar, J&K and found spreading, upright and semi upright type of growth habit, tree height ranged between 1.55 to 2.08 m.

Singh *et al.* (2015) studied variation in tree foliage phenological characters of ten low chill peach under mid hills of Himachal Pradesh. They found that out of ten peach genotypes, five genotype namely Tropic Sweet, Early Grande, Florida Prince, Valle Grande and Florida Grande had spreading type of growth habit, whereas, Saharanpur, Prabhat, Flordaglo and Pratap had erect growth habit and Tropic snow and Tropic Beauty exhibited semi spreading type of growth habit.

Gjamovski *et al.* (2016) evaluated yield and pomological characteristics of nine cherry varieties (Sylvia, Kordia, Sunburst, Van, Summit, Stark Hardy Giant, Regina, Octavia and Slem) and local cherry variety (Dolga Sisela) on Gisela 5 and on the basis of trunk diameter they recorded Kordia as most vigorous variety and Dolga Sisela as the lowest vigorous.

Iurea *et al.* (2017) conducted a trial to evaluate the morphological, pomological and bio-chemical characteristics of cultivar 'Elaiasi' of sweet cherry and took cultivar 'Van' as a control and found medium tree vigour for both of the cultivar.

Five new introduced cultivars of sweet cherry were evaluated by Salehabadi *et al.* (2019) viz. 'Stella', 'Sunburst', 'Summit', 'Subema' and 'Germarsdorfi Coln 3' for different morphological characters. Among different cultivars they observed maximum height in Summit and minimum height in Sunburst cultivar.

Baji *et al.* (2021) evaluated 47 Moroccans sweet cherry genotype for morphological and phenological characteristics. They reported that more than 63 per cent of genotypes had an upright habit and only 17 per cent had dropping growing habit. For vigour, 61 per cent showed intermediate vigour and only 5 per cent genotypes showed weak tree vigour.

Dangi *et al.* (2021) studied genetic variability among twenty sweet cherry varieties and found varied growth habit 'upright' in five varieties and 'semi-upright' to 'spreading' in fifteen varieties.

2.1.2 Foliage Characters

Perez-Sanchez *et al.* (2008) reported the huge variation in foliage characteristics of thirty one sweet cherry cultivars like petiole length (from 2.0 cm to 6.4 cm), leaf blade length (8.9 cm to 15.5 cm), leaf blade width (4.4 cm to 7.6 cm), apical angle (25.8^0 to 59.0^0), basal angle (87.2^0 to 159.1^0) and leaf blade length/width ratio (1.7 to 2.3).

Li *et al.* (2010) studied the shoot growth, flower characters and flower bud differentiation of sweet cherries cv. Hongdeng and Van Vader under different climatic condition of China. They reported that due to earlier phenological development shoots of Hongdeng were longer than Van Vader in subtropical climatic condition of China.

Oraguzie *et al.* (2010) observed leaves of 'Kiona' cultivar as medium to long, elliptical with an acute tip, rounded base, and serrated margins. There were several large reniform gray-purple nectary glands at the base of each leaf.

Olmstead *et al.* (2010) studied variation in leaf petiole from medium to long along with red nectaries which were found one to two in number and oval shaped. They reported large (19 cm) lanceolate shaped leaves, acuminate tip in PC7146-8 (Benton).

Chatzicharissis *et al.* (2013a) characterized and evaluated nine different sweet cherry cultivars under Northern Greece conditions viz., Fraoula Volou, Late Karamela Tripoleos, Napoleon Karamela, Karamela Lilantiou, Kapsiotika, Kifisias Proimotero, Petrokeraso Tragano Achaias, Moshato Tragano Opsimo Evoias and Rainier. They observed variation in leaf blade length (10.6 to 12.6 cm), width (4.7 to 6.0 cm), length/width ratio (1/0.44 to 1/0.54), petiole length (2.7 to 5.2 cm). They also reported number of nectaries to be 1 to mostly 2 per leaf.

Hassan *et al.* (2017) conducted morphological characterization of thirty three apple accessions in Kashmir region. The results showed a significant range in leaf blade length (6.26-12.06 cm), leaf blade width (2.73-7.23 cm) and petiole length (1.53-4.30 cm).

2.2 Floral and Fruiting characters

Lichev *et al.* (2004) evaluated eight sweet cherry varieties viz., Celeste, Vanspur, Lapins, Kordia, Regina, 13-S27-17, Bigarreau Burlat and Van in terms of vigour, productivity and fruit weight. They recorded 'Vanspur' as most precocious variety and Van as most productive. Late blossoming was Regina whereas, largest fruits were recorded in Regina and Celeste.

Sansavini and Lugli (2005) studied and released new cultivars of sweet cherry at University of Bologna viz. 'Sweet Early Panaro I' for large, semi-firm flesh, sweet fruits and low acidity, Grace Star' for precocity, firm, large, fruits and high production.

Kolev and Dzhuvinov (2005) evaluated Nine sweet cherry cultivars on Gisela 5 rootstock namely 'Burlat', 'Nalina', 'Kordia', 'Regina', 'Katalin', 'Hudson', 'Summit', 'Sunburst' and 'Lapins'. Highest yield was recorded in Regina (17.7 kg/tree) followed by Katalin (13.3 kg/tree) and Lapins (11.5 kg/tree). Lowest yield was recorded in Burlat, Nalina,

Hudson, Sunburst. Highest fruit weight was recorded in (14.0 g) and Summit (13.4 g). About mean 10 g Fruit weight recorded in Valina, Katalin, Lapins and Kordia. Less than 10 g was observed in Burlat, Regina and Hudson.

Nine sweet cherry and eight sour cherry varieties were studied by Rodrigues *et al.* (2008). They found that the several quantitative and qualitative evaluations showed a clear difference between sweet and sour cherries with marked variability within the sweet cherry group. They further observed that Burlat and Precoce Bernard have largest open flower diameters and Burlat larand Maringa have the shortest peduncles.

Perez-Sanchez *et al.* (2010) investigated twenty sweet cherry cultivars with twenty six descriptors defined by International Plant Genetic Resources Institute and International Union for the Protection of New Varieties of Plant Cultivars 'Burlat' and '4-70' recorded the highest levels of weight (8.28 g and 8.25 g) and largest fruit was recoded in a local cultivar named 'Carazon'.

Oraguzie *et al.* (2010) studied Kiona cultivar for flower characteristics and recorded flowering 4 to 7 days after Bing cultivar.

Olmstead *et al.* (2011) recorded different flowering characteristics and observed PC7146-8 (Benton) for full bloom 3 to 5 days after late blooming found in Bing. Harvesting date was observed and variation was found 25th June ± 3 for Benton and 27th June ± 1 for Bing. They also found reniform fruit shape with mahogany red coloured skin and red flesh colour with small stone size. Fruit weight recorded as 10.6 g (Benton) and 10.4 g (Bing).

Five Lithuanian sweet cherry cultivars viz. 'Agila', 'Seda', 'Vasare', 'Ventenue' and 'Jurgita' and two Poland cultivars 'Vester & Burlat' were studied by Bieniek *et al.* (2011). They found highest mean fruit weight in 'Jurgita & Agila' and lowest in 'Burlat' cultivar among Poland cultivars.

Radicevic *et al.* (2011) evaluated twenty one different sweet cherry cultivars for morphological and flowering characteristics grown under the agro-environmental conditions of West Serbia and found flowering period ranged between 9 to 13 days.

Chatzicharissis *et al.* (2011) observed Bakirtzeika high quality cultivar that matures one day earlier than Germarsdofer. They further observed that Bakirtzeika had higher productivity and fruit weight than Germarsdofer.

Sirbu *et al.* (2012) recorded the number of days from full bloom to maturity among 9 different cultivars (Cetatuia, Catalina, Bucium, Golia, Maria, Stefan, Tereza, and Boambe de Cotnari) under Iasi, Romania conditions. The earliest cultivars were 'Cetatuia' (56 days) and 'Catalina' (63 days) and the latest was 'Boambe de Cotnari' (76 days).

Chatzicharissis *et al.* (2013a) evaluated the nine different sweet cherry cultivars under Northern Greece conditions viz., Fraoula Volou, Late Karamela Tripoleos, Napoleon Karamela, Karamela Lilantiou, Kapsiotika, Kifisias Proimotero, Petrokeraso Tragano Achaias, Moshato Tragano Opsimo Evoias and Rainier. They reported variation in characters like fruit length (20.3 to 23.5 mm), fruit width (20.0 to 25.0 mm), fruit weight (5.7 to 8.8 g), pedicle length (4.0 to 5.4 cm), stone length (10.0 to 12.4 mm), stone width (7.9 to 9.5 mm), stone weight (0.19 to 0.65 g), and stone/fruit weight ratio (1/8.8 to 1/26.2).

Petruccelli *et al.* (2013) evaluated and characterized thirty-four traditional accessions belonging to sweet cherry in Tuscan (Italy) using a set of forty seven agro-morphological traits established by the UPOV and IBPGR. They found fruit and stone are the most significant variables for discriminating the accessions.

Christopolous (2014) investigated two cherry cultivars 'Adriana' and 'Noire de Meched' for tree yield and found 'Adriana' had (20.1 kg) per tree and 'Noire de Meched' as 17.6 kg/tree in 2009.

Schuster *et al.* (2014) evaluated new cultivars of sweet cherry viz. 'Narana', 'Areko', 'Swing' and 'Habunt' and found 'Areko' had large fruits, 'Narana' was early ripening cultivar and 'Swing' & 'Habunt' as self-compatible varieties.

Srivastava *et al.* (2014) recorded vegetative and pomological characters to assess genetic variability and diversity in twenty one sweet cherry accessions at Central Institute of Temperate Horticulture, Old Airfield, Rangreth, Srinagar, J&K and reported the range of fruit yield from 1.45 kg/tree to 6.6 kg/ tree in their conducted trial.

Milosevic *et al.* (2015) evaluated four sweet cherry cultivars (May Early, Germersdorfer, Sunburst and Celeste) in the Cacak region (Serbia) from 2008 to 2013 for different growth, yield and fruit characteristics They recorded highest yield (6.2 kg/tree) in the cultivar 'May early' while lowest yield (1.02 kg/tree) in cultivar 'Sunburst'. Highest yield efficiency was present in cultivar 'May Early' (0.08 kg/cm^2) and lowest in cultivar 'Sunburst' (0.02 kg/cm^2).

Kazantzis *et al.* (2015) found that TSS was lower in Tsolakeiko than Biggarreau Burlat and Tragana Edessis and fruit maturity was five days later than Bigarreau Burlat.

Gjamovski *et al.* (2016) evaluated sixteen sweet cherry cultivars at Republic of Macedonia viz., Ohridska Ranka, Crvena Krcka, Ohridska Crna, Dolga Siska, Ohridska Zolta Rana, Bela Docna, Dalbazlija, Ohridska Brza, Bela Cresa, Stambolka, Rozeva Cresa, Koleska Rana, Koleska, Bugarka, Ranica and Maticka for determining considerable variation found among characters like fruit weight as (2.3 to 10.7 g), stone weight (0.24 to 0.55 g), stalk length (35.5 to 55.0 mm) and shape of fruit was recorded as reniform, cordate, oblate, circular and elliptic. Also, pistil end of the fruit was found to be flat, pointed and depressed. They reported skin colour as yellow, red and blackish along with flesh colour as cream, yellow and pink.

Bhat *et al.* (2018) determined characteristics related to physical, chemical and yield of sweet cherry (*Prunus avium* L.) cultivars. They recorded highest fruit weight (8.5 g), fruit set (37.10 %) and fruit yield (8.31 kg/tree) in “Sweet Heart”, “Lapins” cultivar was found with highest fruit length (25.69 mm). Highest firmness was recorded in traditional cultivar “Misri” with highest (389 g/mm) and lowest in Makhmali cultivar (271 g/mm) and recorded highest stone ratio in “Stella” cultivar of sweet cherry (19.50) as compared to traditional cultivar Makhmali (12.18). They also recorded the period of full bloom to maturity from 66 to 76 days in sweet cherry with ‘Stella’ earliest to mature (66 days) and ‘Misri’ with latest ripening (80 days) under North Western Himalaya conditions.

Serbezova (2019) analyzed ‘Bigarreau Burlat’, ‘Early Lory’, ‘Kossara’. ‘Bing’, ‘Summit’, ‘Sunburst’, ‘Van’, ‘Kordia’ & ‘Regina’ for fruit size, yield, blooming and ripening period. Largest fruit size recorded in Summit (13 g), Kordia (11 g), Early Lory (9.3 g), Sunburst (9 g), Regina (8.3 g), Kossara (7.8 g) and Burlat (7.4 g). Summit with highest yield 13,600 kg/ha. Bigarreau Burlat, Bing, Van and Kordia were suitable for mechanized harvesting.

Szpadzik *et al.* (2019) studied five cultivars of sweet cherry viz. ‘Techolovan’, ‘Summit’, ‘Sylvia’, ‘Kordia’ and ‘Regina’ and evaluated yield and found highest yield recorded in ‘Sylvia’.

Gannouni and Ammari (2020) characterized introduced varieties viz. Napolen, Van, Morean, Sunburst and stella and a local one Bourargoub. They observed that differentiated

behaviours between cultivars was thrown for bud break, flowering, maturity and leaf fall and the local cultivars Bouargoub recorded the lowest chilling requirement with early flowering and maturity.

Maglakelidze *et al.* (2021) studied phenological and biological features of ten introduced foreign cultivars of apricot in Eastern part of Georgiaon the basis of characteristics and description of floral pattern for five growing seasons, they found cv. Goldrich and Sungiant for mid-season production, cv. Bergeron for high yield and cv. Fardao and Farbly for late season production.

Badzak *et al.* (2021) investigated harvest time of sweet cherry cultivars 'Early Lory, Kordia, Regina' grafted on Gisela 6 Mostar. They found early blossoming period and duration, maturation with 'Early Lory' and late with 'Kordia', whereas, 'Regina' cultivar was recorded with shortest maturation.

2.3 Fruit quality characters

The fruit weight, sugar and organic acid constituents in twelve cultivars and selections of sweet cherries were characterized by Girad and Kopp (1998). They observed that fruit size ranged between 8.8 to 14.5 g and colour of 'Sweet Heart' and 'Lapins' were higher and redder while Salmo was the darkest cherry.

Oukabli and Lighezali (2000) evaluated seventeen sweet cherry varieties in Morocco for time of ripeness, 'fruit size' and yield and observed all traits and found 'Precoce de Bernard' for earliness and 'Rainier' for high yield and fruit quality.

Kalyoncu *et al.* (2009) recorded one earliest (May 19) sweet cherry type grown in Konya region for total soluble solids, color, texture, juice, yield as 18.33 mg/100g, 0.25 kg/cm^2, yield (66.28 %) and fruit mass 2.76 g, color (SP1P50E41).

Perez-Sanchez *et al.* (2010) investigated twenty sweet cherry varieties with twenty six descriptors defined by International Plant Genetic Resources Institute and International Union for the Protection of New Varieties of Plant Cultivars 'Burlat' and '4-70' recorded quite high TSS about 20.28^0 Brix.

Faniadis *et al.* (2010) analysed fruit quality characters of Burlat, Van, Tragana, Mpakirtzeika cultivars of Sweet Cherry. Greater fruit flesh weight (FW) was recorded in

Tragana, Mpakirtzeika' as compared to 'Van' and Burlat and same was recorded as in case of TSS.

Janes *et al.* (2010) evaluated twelve Estonian sweet cherry cultivars for yield, ripening time, fruit weight and biochemical characters (Anu, Arthur, Elle, Eve, Irma, Kaspar, Mupi, Tontu, Elo, Jaago, Taki, Tiki and 2 selections: Polli 2-1 and Polli 4-13 as well as two introduced cultivars Iputj (Russia) and Jurgita (Lithunia) at Polli Horticultural Research Centre. The earliest ripening cultivar recorded in 'Arthur'; largest fruit in Iputj (6.5 g) and Jurgita (6.0 g) and smallest in Elo (3.2 g). Average °Brix found in Tiki (14.6°) to Anu (19.6°). Total sugar content ranged from 7.7 per cent in Jurgita to 11.2 per cent in Arthur. The sugar: acid ratio was high in Iputj, Kasper, Arthur, Anu and Mupi (17.9 to 20.3).

Radicevic *et al.* (2011) recorded the soluble solid contents among six cherry cultivars (Bigarreau Hativ de Burlat, Karina, Kordia, Lapins, Regina and Summit) grafted on Gisela 5 rootstock under West Siberia region and investigated highest total sugar content in Kordia (12.5 %) and lowest in Burlat (10.30 %).

Chatzicharissis *et al.* (2011) studied and compared 'Bakirtzeika' sweet cherry fruit Greek cultivar with 'Germarsdofer' cultivar of sweet cherry and found TSS were comparatively higher in 'Bakirtzeika' from 'Germarsdofer'.

Chatzicharissis *et al.* (2013a) evaluated nine different sweet cherry cultivars viz., Fraoula Volou, Late Karamela Tripoleos, Napoleon Karamela, Karamela Lilantiou, Kapsiotika, Kifisias Proimotero, Petrokeraso Tragano Achaias, Moshato Tragano Opsimo Evoias and Rainier under Northern Greece condition. They recorded TSS from 16.3 °Brix in Napoleon Karamela to 21.1 °Brix in Kapsiotika. They also found Rainier TSS to be 20.6 °Brix while evaluating the cultivar in their trial.

Chatzicharissis *et al.* (2013b) characterized and evaluated two sweet cherry cultivars for different pomological, phenological and biochemical characteristics. They found TSS in Vasiliadi cultivar as 17.3 °Brix and 15.7 °Brix in Ferrovia cultivar

Srivastava *et al.* (2014) recorded fruit yield from 1.45 kg/tree to 6.6 kg/tree and TSS range from 11.3 ^{0} Brix to 17.1 ^{0} Brix in twenty one sweet cherry varieties assessed for genetic variability and genetic diversity at Central Institute of Temperate Horticulture, Old Airfield, Rangreth, Srinagar, J&K.

Calhan *et al.* (2014) reported cultivar ‘Lapins’ was a dark-coloured sweet cherry cultivar that mature by 7 to 15 days later than cultivar ‘Bing’. Cultivar ‘Lapins’ was of commercial interest because of its large size, very firm and resistance to rain cracking. Fruit was mahogany and flesh was red when ripe, its SSC when ripe was similar to cultivar ‘Bing’.

Vavoura *et al.* (2015) characterized four popular sweet cherry cultivars viz Canada Giant, Ferrovia, Lapins and Skeena by physiochemical data analysis and sensory evaluation. They observed that physiochemical parameters viz. titrable acidity, total soluble solids and total phenolic content ranged between 0.21 and 0.28 g malic acid/100g fresh fruit, 13 and 16 ^{0}Brix and 95.14 and 170.35 gallic acid equivalents/100g FW. For cherry firmness order was Canada giant<Ferrovia<Lapins<Skeena and for flower it was Lapins<Canada giant<Skeena≤ Ferrovia.

Gjamovski *et al.* (2016) evaluated yield and pomological characteristics of nine cherry varieties (Sylvia, Kordia, Sunburst, Van, Summit, Stark Hardy Giant, Regina, Octavia and Slem) and local cherry variety (Dolga Sisela) for fruit weight/stone ratio and yield parameters. They recorded highest fruit weight in Dolga Sisela (11.70 g) and Summit (11.43 g) and lowest in Sylvia (7.7 g); fruit weight/stone ratio as 93.58 per cent in ‘Sylvia’ to 47.2 per cent in Summit. Also, ‘highest yield and yield efficiency’ were recorded in Octavia (41.35 kg, 0.46 kg/cm^2) and lowest in Sunburst (13.14 kg, 0.16 kg/cm^2)

Bhat *et al.* (2018) compared traditional and recently introduced cultivars of sweet cherry and found “Stella” cultivar with lowest content of TSS was 17.98 °Brix and Mishri had highest 22.50 °Brix.

Salebadi *et al.* (2019) studied and recorded highest yield in ‘Stella’ and lowest in ‘Sunburst’ among Stella, Suburst, ‘Summit’, ‘Subema’ and ‘Germarsdorfi Coln 3’ at North East of Iran (Shahrood).

Szpadzik *et al.* (2019) studied five cultivars of sweet cherry viz. ‘Techolovan’, ‘Summit’, ‘Sylvia’, ‘Kordia’ and ‘Regina’ and evaluated for soluble solid contents and acidity planted on Gisela 5 rootstock.

Corneanu *et al.* (2020) reported that cultivars Andreias, Bucium, Stefan, Panlica, Golia, Van and Stella had the largest fruit size.

Rodrigues *et al.* (2020) characterized sweet cherry cultivars viz. Durona, Lapins, Summit and Van for biometric, physiochemical and potentio metric profiles. They observed that summit cherry had higher masses and dimensions and lapins had the highest penetration force values and colour values. Van cherries showed the highest total soluble solid content.

Dangi *et al.* (2021) conducted study on twenty different sweet cherry varieties variation for fruit, size, shape, flesh and skin color and found cordate type in ‘Rainier’. Hard fruit firmness was recorded in ‘Lambert’, ‘Rainier’, ‘Red Heart’, ‘Stella’ and ‘Sunburst’.

Chapter-3

MATERIALS AND METHODS

The present investigations entitled “Characterization and evaluation of different varieties of sweet cherry (*Prunus avium* L.)” was carried out in the experimental block of Regional Horticultural Research and Training Station, Mashobra, Shimla. The experimental area is located at an altitude of 2286 meters above mean sea level between 31.1° N Latitude and 77.2° E Longitude. The sweet cherry varieties undertaken for studies were:

CITH-1, CITH-3, CITH-4, CITH-5, CITH-8, CITH-12, CITH-13, CITH-15, CITH-16, Desna, Lambert, Glory, Sweet Heart, Germarsdofer, Merchant, Sunburst, Bigarreau Noir Grossa, Celisor, GuignePourpeaPrecece and Triumph Domini.

Three plants of each of the varieties was studied for recording various observations.

UPOV (2006) test and DUS test guidelines was followed to characterize and evaluate the above listed varieties under study.

3.1 TREE CHARACTERS

3.1.1 Tree habit

It was categorized on the basis of the geometry of the tree crown.

3.1.1.1 Upright

When the height of the tree was distinctly more than its spread and the branches were growing erect (a).

3.1.1.2 Semi-upright

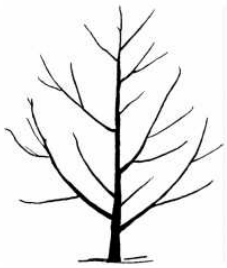
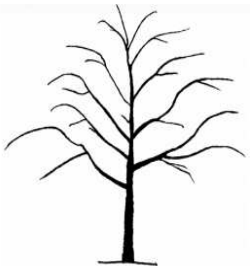
When the height of the tree was slightly more or equal to spread and the branches were less spreading (b).

3.1.1.3 Spreading

When branches were growing outward from the trunk of the tree (c).

3.1.1.4 Drooping

The drooping growth habit was characterized by the pendulous branches hanging downwards (d).

			
(a) Upright	**(b) Semi-upright**	**(c) Spreading**	**(d) Drooping**

3.1.2 Tree height

The height of the tree was measured with the help of calibrated staff from ground level to the tip of tallest branch of the tree and it was expressed in metres (m).

3.1.3 Tree spread

The spread of the tree was measured by a calibrated staff in two directions i.e., North-South (N-S) and East-West (E-W) and the observations were recorded in metres (m).

3.1.4 Trunk diameter

The trunk diameter was measured at the height of 15 cm above from the graft union with the help of measuring tape and was expressed in centimetres (cm).

3.1.5 One year old shoot- thickness mid length

The thickness of mid length of 15 randomly selected one year old shoot on each variety was calculated by measuring the mid of the shoot with vernier calliper and expressed in millimeteres (mm) and further classified on the basis of UPOV guidelines as:

- Thick
- Medium
- Thin

3.1.6 One year old shoot- length of internode

The internodal length of 15 randomly selected one year old shoot on each variety was calculated by dividing the shoot length measured with total number of internodes and expressed in millimetres (mm) and further classified on the basis of DUS test guidelines as:

- Short (< 30 mm)
- Medium (30-40 mm)
- Long (> 40 mm)

	
Short	**Medium**

3.2 FOLIAGE CHARACTERS

Thirty leaves from the middle portion of the current growth were selected during the last week of July for recording observations as suggested by Beyers (1962).

3.2.1 Time of bud burst

The data on bud burst was recorded in each variety. For this, the date on which the first bud had sprouted was taken.

3.2.2 Leaf blade: length(cm)

The length of leaf was measured by a scale from tip of the apex to the base and further classified on the basis of DUS test guidelines as:

- Short (< 15 cm)
- Medium (15-20 cm)
- Long (> 20 cm)

3.2.3 Leaf blade: width(cm)

The width of leaf was measured with a scale at its broadest expands, were further classified on the basis of DUS test guidelines as:

- Narrow (< 5 cm)
- Medium (5-10 cm)
- Broad (> 10 cm)

3.2.4 Leaf blade: length/width ratio

The length/width ratio of the leaves was calculated and further classified on the basis of DUS test guidelines as:

- Small (< 1.5)
- Medium (1.5-3.0)
- Large (> 3.0)

3.2.5 Leaf shape

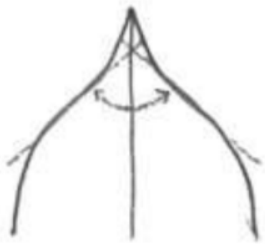
Leaf shape was observed visually following Standard Cyclopedia of Horticulture (Bailey, 1963) and DUS test guidelines, were classified as:

- Obovate
- Lanceolate

	
Obovate	**Lanceolate**

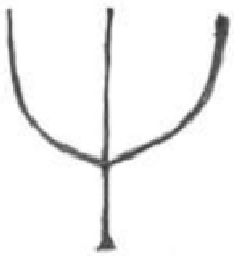
3.2.6 Angle of apex

Angle of leaf apex was observed visually following DUS guidelines and classified as acute and right angled.

	
Acute	**Right angled**

3.2.7 Shape of base

Shape of leaf base was observed visually following DUS guidelines and classified as acute or obtuse.

	
Acute	**Obtuse**

3.2.8 Leaf: length of petiole(cm)

The petiole length was measured with the help of a scale from the juncture of blade to the base of petiole. Average length of petiole of leaves per tree was worked out and further classified on the basis of DUS test guidelines as:

- Short (< 3 cm)
- Medium (3-6 cm)
- Large (> 6 cm)

3.2.9 Leaf area(cm^2)

It was worked out using the digital leaf area meter (LICOR - model 3100 A). Average area of 10 leaves was considered as one replication and 3 such replications were made.

3.2.10 Leaf colour

a) Colour of emerging leaves

b) Colour of mature leaves

Colour charts of the Royal Horticultural Society, London was used to determine the surface colour of the leaves.

3.2.11 Leaf: presence ofnectaries

The nectaries (glands) present at petiole were observed visually and classified as:

- Absent
- Present

3.2.12 Nectaries:colour

The colour of nectaries were observed visually in summer on fully developed leaves from the middle third of a well-developed current season's shoot and further classified on the basis of UPOV test guidelines as:

- Greenish yellow
- Orange yellow
- Light red
- Dark red
- Purple

3.3 FLOWER CHARACTERS

3.3.1 Bearing habit

It was categorized on the basis of the bearing habit of the tree.

3.3.5 Duration of Blooming

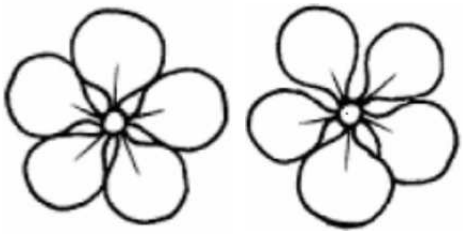
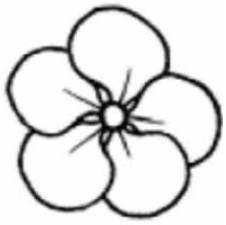
The number of days from the date of opening of first flower to the date of opening of last flower in each variety was determined.

3.3.6 Colour of flowers

The colour of flowers was observed visually.

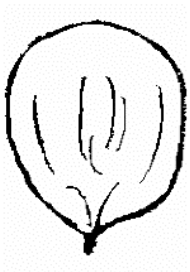
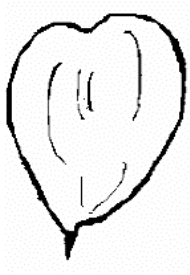
3.3.7 Flower: arrangement of petals

The arrangement of petals was observed visually following UPOV guidelines and marked as free, intermediate or overlapping.

		
Free	**Intermediate**	**Overlapping**

3.3.8 Flower: shape of petals

The shape of petals was observed visually following UPOV guidelines and marked as circular, medium obovate or broad obovate.

		
Circular	**Medium obovate**	**Broad obovate**

3.3.9 Flower: diameter(cm)

The measurements on flower diameter were carried out on completely opened flowers with petals pressed into horizontal position and further classified on the basis of UPOV test guidelines as:

- Small (< 3 cm)
- Medium (3-4 cm)
- Large (> 4 cm)

3.4 FRUIT CHARACTERS

To study fruit characters, 15 representative fruit samples (5 in each replication) were taken at optimum maturity. The average length, breadth and weight were measured. The surface colour of the fruits was observed by comparing it with the colour charts of the Royal Horticultural Society, London.

3.4.1 Fruit weight (g)

The weight of 15 fruits under 3 replicates of each variety was recorded and the average weight per fruit was calculated and further classified on the basis of DUS test guidelines as:

- Small (< 4 g)
- Medium (4-6 g)
- Large (> 6 g)

3.4.2 Fruit size (mm)

The fruit length and fruit width were measured for fruit size with the help of digital Vernier Calipers (Model No. CD-6"CS, Mitutoyo Corp. Japan) and further classified on the basis of DUS test guidelines and fruit size was determined by UPOV guidelines as:

Fruit length (mm)

- Short (< 15 mm)
- Medium (15-20 mm)
- Large (> 20 mm)

Fruit width (mm)

- Narrow (< 15 mm)
- Medium (15-20 mm)
- Broad (> 20 mm)

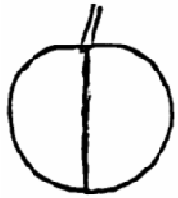
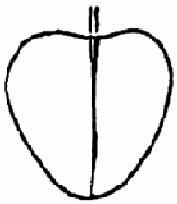
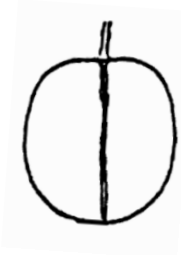
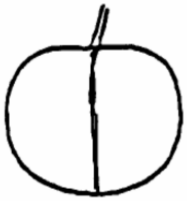
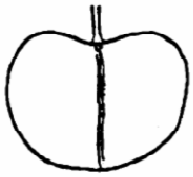
Fruit size (mm)

- Very small
- Small
- Medium

- Large
- Very large

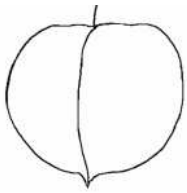
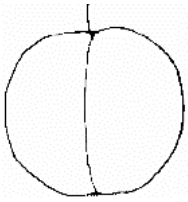
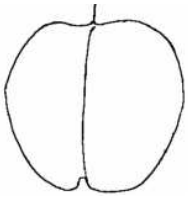
3.4.3 Fruit shape

The shape of fruit was observed visually following UPOV guidelines and classified as round, cordate, elliptic, oblate or reniform.

				
Round	**Cordate**	**Elliptic**	**Oblate**	**Reniform**

3.4.4 Fruit pistil end

Fruit pistil end was determined visually following UPOV guidelines and classified as pointed, flat or depressed.

		
Pointed	**Flat**	**Depressed**

3.4.5 Suture

The presence and absence of suture was visually observed on the fruit.

3.4.6 Fruit skin colour

The surface colour of the fruit was observed visually by comparing it with the colour charts of the Royal Horticultural Society, London and was further categorized on the basis of DUS test guidelines as:

- Yellow with red blush
- Light red
- Red
- Dark red

3.4.7 Fruit flesh colour

The flesh colour of the fruit was observed visually by comparing it with the colour charts of the Royal Horticultural Society, London and was further categorized on the basis of DUS test guidelines as:

- Creamy
- Yellow
- Light red
- Red

3.4.8 Colour of juice

The colour of fruit juice was observed visually by comparing it with the colour charts of the Royal Horticultural Society, London and was further categorized on the basis of UPOV test guidelines as:

- Colourless
- Light yellow
- Pink
- Red
- Purple

3.4.9 Fruit: Length of fruit stalk (mm)

The length of fruit stalk was measured with the digital Vernier Calipers (Model No. CD-6"CS, Mitutoyo Corp. Japan). Average length of fruit stalk of 5 fruits per tree was worked out and further classified on the basis of DUS test guidelines as:

- Short (< 45 mm)
- Medium (45-55 mm)
- Large (> 55 mm)

		
Short	**Medium**	**Large**

3.5 STONE CHARACTERS

For recording observations, stones were washed well so that no pulp remains attached to the stones.

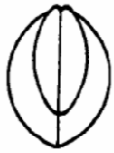
3.5.1 Stone: weight(g)

The weight of 15 stones under 3 replicates of each variety was recorded and the average weight per stone was calculated and further classified on the basis of DUS test guidelines as:

- Small (< 0.3 g)
- Medium (0.3-0.6 g)
- Large (> 0.6 g)

3.5.2 Stone: shape

The shape of stone was determined visually following UPOV guidelines and categorized as slightly elliptic, elliptic or round.

		
Slightly	**Elliptic**	**Round**

3.5.3 Stone: size(mm)

The stone size was recorded by measuring the length and breadth with the help of digital Vernier Calipers (Model No. CD-6"CS, Mitutoyo Corp. Japan).

3.5.4 Pulp/stone ratio

It was worked out by dividing the weight of the fruit pulp by the weight of stone.

3.6 BIOCHEMICAL CHARACTERISTICS OF FRUIT

The following biochemical characteristics of fruit were determined as per the standard procedures given by Ranganna (1986).

3.6.1 Total soluble solids (TSS)

The total soluble solid content of fruits was determined with Erma Hand Refractometer. The prism of the refractometer was washed with distilled water before taking each reading. A drop of fresh juice of fruit was taken on the prism of refractometer and the total soluble solids present in the fruit in ^{o}Brix were reflected on the screen.

3.6.2 Titratable acidity

In each sample, 25 g of fruit pulp was crushed and the volume was made to 250 ml in a volumetric flask by adding distilled water. Out of it, 50 ml extract was taken for the estimation of acidity and the rest was used for determining the total sugars and reducing sugars. 10 ml of this juice extract was titrated against N/10 NaOH solution, using phenolphthalein as an indicator, to a light pink coloured end point. The titratable acidity was calculated in terms of malic acid on the basis of 1 ml of N/10 NaOH = 0.0067 g of anhydrous malic acid. Formula used for calculation of per cent acidity was:

$$\text{Titratable acidity (\%)} = \frac{\text{Titre value} \times \text{Normality of NaOH} \times \text{Volume made} \times \text{Equivalent weight of acid} \times 100}{\text{Weight of sample taken} \times \text{Volume of aliquot taken} \times 1000}$$

3.6.3 Total sugars

Lane and Eynon's volumetric method (A.O.A.C., 1980) was employed for the estimation of sugars. The 200 ml of juice extract remaining after the estimation of acid was used. To this, 10 ml of saturated lead acetate was added. The contents of the flask were shaken and filtered into flask containing 10 ml of potassium oxalate to precipitate the excess of lead. The filtrate was shaken and again filtered after keeping it for few minutes. The 50 ml of the filtrate was taken in 250 ml volumetric flask and to it 5 ml concentrated HCl was added for hydrolysis. It was kept overnight at room temperature. The excess of hydrochloric acid was neutralised with saturated NaOH solution. The total sugars were then estimated by titrating against boiling mixture containing 5 ml each of Fehling A and Fehling B solution, using methylene blue as an indicator. The end point was indicated by the appearance of brick red colour. Total sugars content was expressed as percentage of fresh pulp weight as per the formula:

$$\text{Total sugars (\%)} = \frac{\text{* Factor} \times \text{Dilution}}{\text{Titre value} \times \text{Weight of sample taken} \times \text{Volume of aliquot taken}} \times 100$$

*Factor = 0.05

3.6.4 Reducing sugars

For the estimation of reducing sugars, unhydrolysed but lead free and clarified solution was titrated against boiling solution of 5 ml each of Fehling A and Fehling B using methylene blue as an indicator (A.O.A.C., 1980). Reducing sugars content was expressed as percentage of fresh pulp weight as per the formula given below:

$$\text{Reducing sugars (\%)} = \frac{\text{* Factor} \times \text{Dilution}}{\text{Titre value} \times \text{Weight of sample taken}} \times 100$$

*Factor = 0.05

3.6.5 Non-reducing sugars

The content of non-reducing sugars was calculated by subtracting reducing sugars from total sugars and multiplying the difference by 0.95 which is standard factor. Non-reducing sugars content was also expressed as percentage of fresh pulp weight. The formula used was:

$$\text{Non-reducing sugars (\%)} = (\text{Total sugars} - \text{Reducing sugars}) \times 0.95$$

3.7.6 Sugar/acid ratio

It was worked out by dividing per cent total sugars with per cent titratable acidity.

$$\text{Sugars/acid ratio} = \frac{\text{Total sugars (\%)}}{\text{Titratable acidity (\%)}}$$

3.7 FRUIT YIELD AND MATURITY

3.7.1 Time of harvesting

The date on which fruit was harvested from plants.

3.7.2 Days from full bloom to harvest

Number of days were counted from the date of full bloom to the date of harvest and further characterized as:

- Early (< 55 days)
- Mid (55-60 days)
- Late (> 60 days)

3.8.3 Fruit yield (kg/tree)

Yield was recorded by directly weighing the total number of fruits at the time of harvesting and was expressed as kg per tree.

3.8.4 Yield efficiency

The usual method of obtaining yield efficiency is to calculate kilograms of fruits per square centimeter of cross-sectional area of the trunk. This estimates the efficiency of bearing surface. Yield per hectare (ha) estimates the efficiency of both bearing surface and land surface as given by Westwood (1993):

Yield efficiency (tree unit) = kg yield/cm^2TCSA*

3.9 STATISTICAL ANALYSIS:

The statistical analysis for each character was carried out on mean values. The data were subjected to the analysis of various traits as described by Gomez and Gomez (1984) for Randomized complete Block Design. The following procedures were adopted for estimation of different statistical parameters.

Experimental design: Randomized Complete Block Design (RCBD)

No. of treatments : 20

No. of replications : 3

ANOVA for RCBD shall be as follows:

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F_{cal}
Treatments	(t-1)	S_t	$M_t = S_t/(t-1)$	M_t/M_e
Replications	(r-1)	S_r	$M_r = S_r/(r-1)$	M_r/M_e
Error	(r-1)(t-1)	S_e	$M_e = S_e/(r-1)(t-1)$	
Total	(rt-1)	S_T		

Where,

r = Number of replications

t = Number of treatments

S_r = Sum of squares due to replications

S_t = Sum of squares due to treatments

S_e = Sum of squares due to error

S_T = Total sum of squares

M_r = Mean sum of squares due to replications

M_t = Mean sum of squares due to treatments

M_e = Mean sum of squares due to error

The replication and treatment mean sum of square were tested against error mean squares by 'F' test at (r-1), (r-1) (t-1) and (t-1), (r-1) (t-1) degree of freedom for RCBD at 5per cent level of significance.

The calculated F-values were compared with tabulated F-value. When F-test will be found significant, critical difference was calculated to find out the superiority of one treatment over the others.

The standard error and critical difference shall be calculated as follow:

$CD_{0.05}$ = S.E. (d) x $t_{(0.05)}$ (r-1) (t-1) df

SE (d) ± = $\sqrt{2\ Me/r}$

SE (m) ± = $\sqrt{Me/r}$

Where,

SE (m) ± = Standard error of mean

SE (d) ± = Standard error of difference

$CD_{0.05}$ = Critical difference at 5per cent level of significance

Chapter-4

RESULTS AND DISCUSSION

Morphological observations regarding tree characters, foliage characters, flowers characters and fruit characters were investigated in the present study entitled, **"Characterization and evaluation of different varieties of sweet cherry (*Prunus avium* L.)**". The results obtained for different parameters under study for twenty sweet cherry varieties are presented under different headings.

4.1 TREE CHARACTERS

4.1.1 Tree habit

Present study revealed that out of twenty sweet cherry varieties, fifteen varieties viz; CITH-1, CITH-4, CITH-5, CITH-12, CITH-13, CITH-15, CITH-16, Desna, Glory, Sweet Heart, Germarsdofer, Merchant, Bigarreau Noir Grossa, Celisor, Guigne Pourpea Precece (Table 1) had upright type of growth habit. Whereas, four varieties; CITH-3, CITH-8, Lambert and Triumph Domini had semi upright growth habit and Sunburst was found to have spreading type of growth. (Plate 1)

4.1.2 Tree height(m)

The data presented in Table 1 reveals that tree height differed significantly among different cultivars. The tree height ranged between Glory (2.73 m) to Celisor (5.01 m). The maximum tree height was recorded in Celisor which was statistically at par with CITH-4 (4.90 m), CITH-5 (4.30 m), CITH-16 (4.83 m), Desna (4.28 m), Lambert (4.12 m), Germarsdofer (4.62 m), Merchant (4.79 m), Bigarreau Noir Grossa (4.05 m) and Triumph Domini (4.03 m). The overall mean for the tree height was recorded as 3.93 m.

4.1.3 Tree spread(m)

For this character, mean value was found to be 2.26 m in N-S direction and 2.31 m in E-W direction (Table 1). For E-W direction, maximum tree spread in Germarsdofer was recorded (3.33 m) which was statistically at par with Desna (2.86 m), Lambert (2.96 m) and Celisor (3.00 m), whereas, a minimum was recorded in Glory as (1.13 m). For tree spread in N-S direction, maximum was observed in Celisor (3.16 m) which was found to be statistically at par with Lambert (2.78 m), Desna (2.76 m), Germarsdofer (2.65 m), Bigarreau Noir Grossa

(2.45 m) Triumph Domini (2.60 m), CITH-8 (2.55 m), CITH-15 (2.55 m) and CITH-16 (2.50 m).

4.1.4 Trunk diameter (cm)

Data observed (Table 1) revealed that mean trunk diameter was 27.90 cm for which maximum value was recorded in Desna (36.50 cm) and recorded minimum for Glory (15.36 cm). Varieties viz; CITH-4 (27.83 cm), CITH-8 (29.67 cm), CITH-12 (35.20 cm), CITH-13 (35.36 cm), CITH-16 (27.10 cm), Sweet Heart (29.96 cm), Germarsdofer (30.31 cm), Merchant (29 cm), sunburst (28.73 cm), Bigarreau Noir Grossa (33.06 cm) were found to be statistically at par with Desna. Whereas, CITH-1, CITH-3, Glory and Guigne Pourpea Precece were significantly lower than Desna.

4.1.5 Thickness of mid length (mm)

The thickness of mid length of one year old shoot on each variety was found to be thick, medium and thin. Observations recorded (Table 1) shows CITH-1 (4.89 mm), CITH-3 (4.42 mm), CITH-4 (4.72 mm), CITH-5 (4.10 mm), CITH-13 (4.38 mm), CITH-15 (4.22 mm) and Guigne Pourpea Precece (4.02 mm) as thick, CITH-8 (3.70 mm), CITH-12 (3.35 mm) CITH-16 (3.38 mm) Desna (3.76 mm) Lambert (3.57 mm) Glory (3.01 mm) Sweet Heart (3.53 mm), Merchant (3.37 mm) Sunburst (3.29 mm), Bigarreau Noir Grossa (3.33 mm), Celisor (3.16 mm), Triumph Domini (3.61 mm) as medium and Germarsdofer (2.88 mm) as thin. The mean value for thickness of mid length of one year old shoot was observed (27.90 mm).

4.1.6 Length of internode (mm)

Length of internodes varied significantly among different varieties of sweet cherry. Length of internodes ranged between 14.02 mm to 26.87 mm. Although all the varieties fall under short category (<30 mm) however, maximum length was observed in Lambert (26.87 mm) which was followed by CITH-4 (23.31 mm) and Glory (23.40 mm). The overall mean value for length of internodes was recorded as 20.19 mm (Table 1).

The growth characters of sweet cherry trees were observed as per UPOV (2006) test guidelines and DUS test guidelines and varied considerably amongst tree habit, tree height, tree spread (N-S) (E-W), thickness of mid length of shoot and length of internode into distinct classes. In the present study variation in different tree characters viz; tree habit, tree height,

tree spread, trunk diameter (cm), thickness of mid length shoot (mm) and length of internode (mm) was observed.

Variation in tree habit of sweet cherry varieties were also recorded by Dangi *et al.* (2021) who found 'upright' growth habit in five varieties and 'semi-upright' to 'spreading' in fifteen varieties. However, Baji *et al.* (2021) reported that more than 63 per cent of genotype had an upright habit and only 17 per cent had dropping growing habit and 61 per cent showed intermediate vigour and only 5 per cent genotypes showed weak tree vigour in forty seven Moroccans sweet cherry genotypes. Singh *et al.* (2015) also observed variation in growth habit of peach varieties and recorded that out of ten peach genotypes, five genotype namely Tropic Sweet, Early Grande, Florida Prince, Valle Grande and Florida Grande had spreading type of growth habit, whereas, Saharanpur, Prabhat, Flordaglo and Pratap had erect growth habit and Tropic snow and Tropic Beauty exhibited semi spreading type of growth habit.

As per results, tree height ranged between Glory (2.73 m) to Celisor (5.01 m). The results in present study are in agreement with those of Salehabadi *et al.* (2019) who observed maximum height in Summit and minimum height in Sunburst cultivar of sweet cherry. Lanauskas *et al.* (2012) recorded highest trunk diameter in Gi 497/8 among different clonal rootstocks of sweet cherry. Gjamovski *et al.* (2016) found diameter of the trunk for 'Kordia' variety as most vigorous and 'Dolga Sisela' variety as the lowest.

Thickness of the mid length was recorded and found thickest in CITH-1 (4.89 mm) and thin in Germarsdofer (2.88 mm), which can be related with the study of Cares *et al.*, (2014) in which, he observed variation in internodal length from 1.5 to 2.7 mm.

4.2 Foliage Character

Data recorded for twenty sweet cherry varieties on various foliage characteristics is presented in Table 2 and 3, Plate 2 (a-d).

4.2.1 Leaf length(cm)

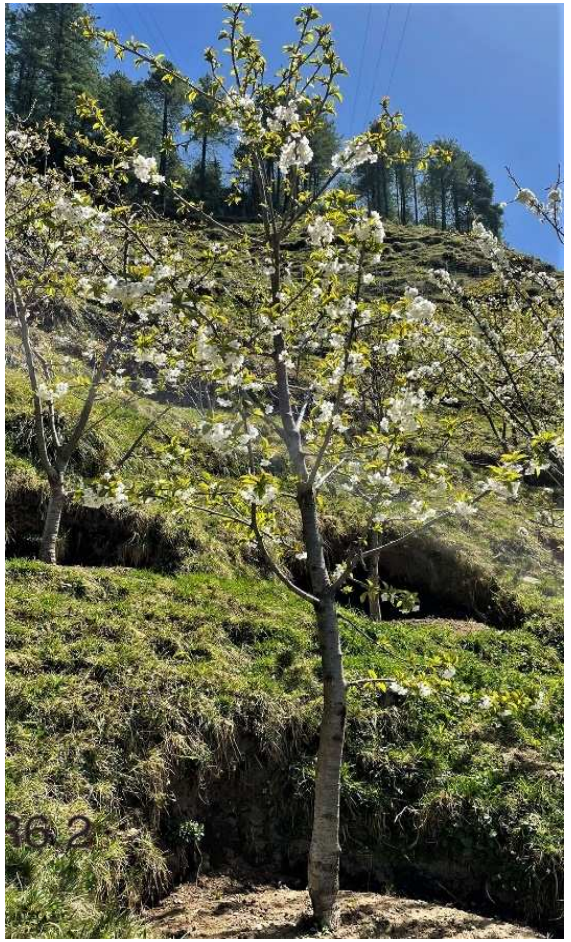
There was significant difference in leaf length of different varieties of sweet cherry. Among sweet cherry variety maximum leaf length was recorded in Celisor (20.30 cm) followed by Lambert (19 cm) and Sweet Heart (15.50 cm) and was not significantly higher than all other varieties. The minimum leaf length was recorded in CITH-3 (12.30 cm). The overall mean value for leaf length was 16.27 cm (Table 2).

Table 1: Tree characters of some sweet cherry varieties

Variety	Tree habit	Tree height (m)	Tree spread (m)		Trunk diameter (cm)	Mid length thickness (mm)	Length of internode (mm)
			(N-S)	(E-W)			
CITH-1	Upright	3.63	2.41	2.13	25.58	4.89	22.58
CITH-3	Semi-Upright	2.81	1.65	1.76	17.10	4.41	21.38
CITH-4	Upright	4.90	2.48	2.16	27.83	4.72	23.31
CITH-5	Upright	4.30	2.05	1.98	20.23	4.10	19.65
CITH-8	Semi-Upright	3.73	2.55	2.55	29.67	3.70	22.93
CITH-12	Upright	3.93	1.39	2.31	35.20	3.35	20.50
CITH-13	Upright	3.85	2.13	2.06	35.36	4.38	20.12
CITH-15	Upright	3.74	2.55	2.55	25.06	4.22	22.85
CITH-16	Upright	4.83	2.38	2.50	27.10	3.38	18.91
Desna	Upright	4.28	2.86	2.76	36.50	3.76	16.95
Lambert	Semi-upright	4.12	2.96	2.78	34.16	3.57	26.87
Glory	Upright	2.73	1.13	1.30	15.36	3.01	23.40
Sweet Heart	Upright	2.96	1.91	2.10	26.96	3.53	18.32
Germarsdofer	Upright	4.62	3.33	2.65	30.71	2.88	16.50
Merchant	Upright	4.79	1.19	2.08	29.00	3.37	20.49
Sunburst	Spreading	3.23	2.09	2.11	28.73	3.49	14.02
Bigarreau Noir Grossa	Upright	4.05	2.31	2.45	33.06	3.33	19.95
Celisor	Upright	5.01	3.00	3.16	29.43	3.16	22.03
GuignePourpeaPrecece	Semi-Upright	3.13	2.58	2.28	20.73	4.02	17.22
Triumph Domini	Semi-Upright	4.03	2.28	2.60	30.26	3.61	15.95
Mean		3.93	2.26	2.31	27.90	3.75	20.19
$CD_{0.05}$		1.04	0.71	0.83	9.64	1.07	6.13

UPRIGHT

SEMI-UPRIGHT



SPREADING

Plate 1 Tree Growth Habit

Table 2: Foliage characters of sweet cherry varieties

Variety	Leaf length (cm)	Status of leaf length(cm)	Leaf width (cm)	Status of leaf width (cm)	Leaf length/width ratio	Status of leaf length/width ratio	Length of petiole (cm)	Status of length of petiole (cm)	Leaf area (cm^2)
CITH-1	14.60	Short	6.60	Medium	2.28	Medium	3.90	Medium	41.05
CITH-3	12.30	Short	6.50	Medium	1.90	Medium	3.13	Medium	53.86
CITH-4	15.10	Medium	6.10	Medium	2.47	Medium	3.27	Medium	47.26
CITH-5	16.10	Medium	6.10	Medium	2.67	Medium	2.83	Medium	46.43
CITH-8	14.60	Short	5.80	Medium	2.53	Medium	4.20	Medium	49.60
CITH-12	16.90	Medium	8.13	Medium	2.08	Medium	3.23	Medium	58.11
CITH-13	18.40	Medium	8.12	Medium	2.26	Medium	3.97	Medium	75.81
CITH-15	16.60	Medium	7.20	Medium	2.31	Medium	3.83	Medium	50.41
CITH-16	14.60	Short	6.40	Medium	2.28	Medium	3.87	Medium	52.02
Desna	18.30	Medium	6.40	Medium	2.89	Medium	4.80	Medium	53.83
Lambert	19.00	Medium	7.70	Medium	2.51	Medium	3.63	Medium	67.66
Glory	14.10	Short	6.50	Medium	2.16	Medium	2.93	Medium	45.97
Sweet Heart	18.50	Medium	7.00	Medium	2.63	Medium	4.13	Medium	64.60
Germarsdofer	15.60	Medium	6.40	Medium	2.44	Medium	3.77	Medium	52.46
Merchant	18.10	Medium	7.30	Medium	2.46	Medium	4.03	Medium	57.53
Sunburst	14.80	Short	6.80	Medium	2.18	Medium	3.57	Medium	56.53
Bigarreau Noir Grossa	16.50	Medium	6.90	Medium	2.39	Medium	3.90	Medium	61.58
Celisor	20.30	Long	8.10	Medium	2.49	Medium	3.73	Medium	83.06
GuignePourpeaPrecece	16.10	Medium	7.20	Medium	2.23	Medium	3.23	Medium	56.62
Triumph Domini	15.10	Medium	6.60	Medium	2.30	Medium	2.67	Short	48.43
Mean	16.27		6.89		2.37		3.63		56.14
$CD_{0.05}$	0.99		0.71		0.31		0.76		3.11

Table 3: Foliage characters of some sweet cherry varieties

Varieties	Time of bud burst	Leaf colour		Leaf shape	Angle of apex	Shape of base	Presence of nectaries	Nectaries colour
		Colour of emerging leaves	Colour of matured leaves					
CITH-1	14th March	Greyed-Orange Group B	Green Group (137-A)	Lanceolate	Acute	Acute	Present	Orange Yellow
CITH-3	15th March	Greyed-Red Group B	Green Group (141-A)	Obovate	Right angled	Acute	Present	Purple
CITH-4	15th March	Greyed-Red Group B	Green Group (141-A)	Lanceolate	Acute	Obtuse	Present	Purple
CITH-5	14th March	Greyed Orange Group B	Green Group (137-A)	Lanceolate	Right angled	Obtuse	Present	Light Red
CITH-8	13th March	Greyed-Red Group B	Green Group (141-A)	Lanceolate	Right angled	Obtuse	Present	Light Red
CITH-12	14th March	Greyed-Red Group A	Green Group (141-A)	Obovate	Right angled	Obtuse	Present	Light Red
CITH-13	14th March	Greyed-Red Group B	Green Group (141-A)	Lanceolate	Right angled	Acute	Present	Greenish Yellow
CITH-15	15th March	Greyed-Orange Group B	Green Group (141-A)	Lanceolate	Acute	Acute	Present	Orange Yellow
CITH-16	16th March	Greyed-Orange Group B	Green Group (141-A)	Lanceolate	Acute	Obtuse	Present	Purple
Desna	10th March	Greyed-Orange Group A	Green Group (141-A)	Lanceolate	Acute	Acute	Present	Light Red
Lambert	18th March	Greyed-Orange Group B	Green Group (141-A)	Lanceolate	Acute	Acute	Present	Orange Yellow
Glory	15th March	Greyed-Orange Group B	Green Group (141-A)	Lanceolate	Acute	Acute	Present	Dark Red
Sweet Heart	13th March	Greyed-Orange Group A	Green Group (141-A)	Obovate	Right angled	Acute	Present	Orange Yellow
Germarsdofer	13th March	Greyed-Orange Group B	Green Group (141-A)	Lanceolate	Acute	Acute	Present	Light Red
Merchant	15th March	Greyed-Orange Group B	Green Group (141-A)	Lanceolate	Right Angled	Obtuse	Present	Dark Red
Sunburst	14th March	Greyed-Orange Group B	Green Group (141-A)	Obovate	Right angled	Acute	Present	Orange Yellow
Bigarreau Noir Grossa	17th March	Greyed-Orange Group A	Green Group (141-A)	Lanceolate	Right Angled	Obtuse	Present	Dark Red
Celisor	14th March	Greyed-Orange Group B	Green Group (141-B)	Lanceolate	Right Angled	Acute	Present	Dark Red
GuignePourpeaPrecece	16th March	Greyed-Orange Group B	Green Group (137-A)	Lanceolate	Right Angled	Obtuse	Present	Light Red
Triumph Domini	13th March	Greyed-Orange Group B	Green Group (141-A)	Obovate	Right Angled	Obtuse	Present	Light Red

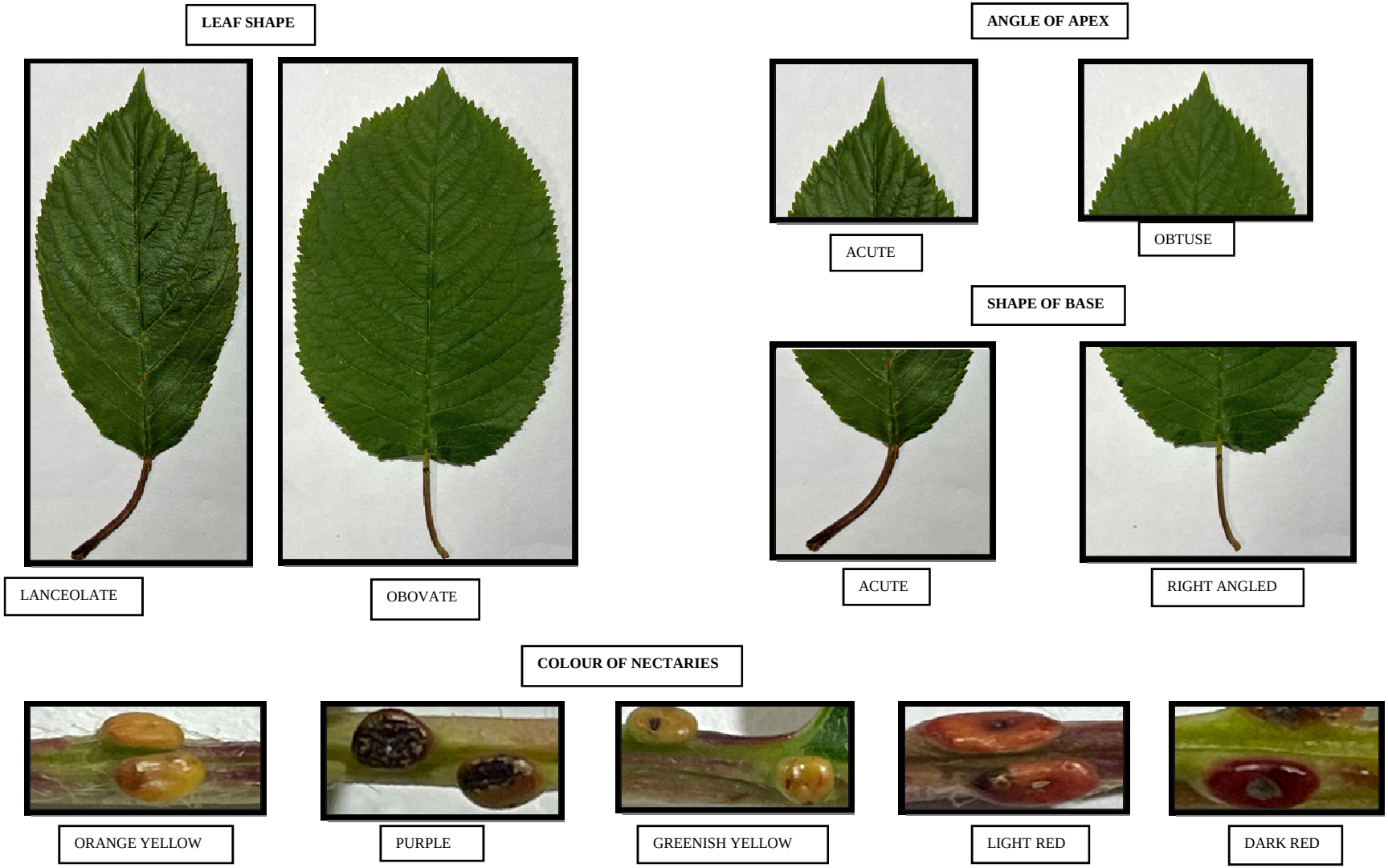


Plate 2 (a-d) Foliage characters of some sweet cherry varieties

4.2.2 Leaf width(cm)

Leaf width also differed significantly among different genotype. Leaf width character was recorded maximum in CITH-12 (8.13 cm) and minimum in CITH-8 (5.80 cm). It was found that CITH-13 (8.12 cm), Celisor (8.10 cm), Lambert (7.70 cm), Merchant (7.30 cm) was statistically at par with CITH-12. The overall mean value for leaf width was 6.89 cm (Table 2).

4.2.3 Leaf length/width ratio

The data on leaf length and width ratio indicate that there was significant difference in various genotypes. The overall mean value for leaf length/width was 2.37 and the highest length/width ratio was found to be 2.89 in Desna and lowest observed in CITH-3 (1.90) Desna was statistically at par with CITH-5 (2.67) and Sweet Heart (2.63) (Table 2).

4.2.4 Length of petiole(cm)

The data (Table 2) indicate that there was significant influence on genotype on petiole length. Petiole length for sweet cherry was recorded and maximum was found in Desna (4.80 cm) which was statistically at par with CITH-8 (4.20 cm), Sweet Heart (4.13 cm) and Merchant (4.03 cm), whereas, minimum was found in Triumph Domini (2.67 cm). The mean for petiole length was 3.63 cm.

4.2.5 Leaf area(cm^2)

Maximum leaf area was recorded in Celisor (83.06 cm^2) followed by CITH-13 (75.81 cm^2), Lambert (67.66 cm^2) and the minimum was recorded in CITH-1 (41.05 cm^2) which was significantly lower than all other sweet cherry varieties. The overall mean for leaf area was recorded as 56.14 cm^2.

4.2.6 Time of bud burst

The growth features of these twenty sweet cherry varieties were recorded and the earliest time of bud burst was identified in Desna on 10^{th} March followed by CITH-8, Germarsdofer, Sweet Heart and Triumph Domini on 13^{th} March, whereas, CITH-1, CITH-5, CITH-12, CITH-13 and Sun Burst on 14^{th} March; CITH-3, CITH-4, CITH-15, Glory and Merchant on 15^{th} March; Guigne Pourpea Prececе and CITH-16 on 16^{th} March; Bigarreau Noir Grossa on 17^{th} March and last was Lambert on 18^{th} March.

4.2.7 Leaf colour

Leaf blade colour in all the varieties in Green Group & Greyed-Orange Group, with slight variation in shade the colour of the emerging leaves Greyed-Orange Group A in Desna, Sweet Heart, Bigarreau Noir Grossa; Greyed-Orange Group B in CITH-5, CITH-15, CITH 16, Lambert, Glory, Germarsdofer, Merchant, Sunburst, Celisor, Guigne Pourpea Prececе and Triumph Domini; Greyed Red Group A in CITH-12; Greyed-Red Group B in CITH-3, CITH-4, CITH-8 and CITH-13. However, colour of matured leaves fell under Green Group. It was 141 A in CITH-3, CITH-4, CITH-8, CITH-12, CITH-13, CITH-15, CITH-16, Desna, Lambert, Glory, Sweet Heart, Germarsdofer, Merchant, Sunburst, Bigarreau Noir Grossa, Triumph Domini; 141 B in Celisor and 137-A in CITH-1, CITH 5, Guigne Pourpea Prececе.

4.2.8 Leaf shape

Healthy and well-developed leaves were observed to record shape so as to classify them as obovate and lanceolate. Leaf shape was observed obovate in CITH-3, CITH-12, Sweet Heart, Sunburst, Triumph Domini whereas, Lanceolate shape in rest of the sweet cherry varieties under study.

4.2.9 Angle of leaf blade apex

On the basis of angle of leaf blade apex, the sweet cherry varieties under study were classified as acute and right angled. The angle of leaf blade apex was acute in CITH-1, CITH-4, CITH-15, CITH-16, Desna, Lambert, Glory, Germarsdofer and right angled in CITH-3, CITH-5, CITH-8, CITH-12, CITH-13, Sweet Heart, Merchant, Sunburst, Bigarreau Noir Grossa, Celisor, Guigne Pourpea Prececе and Triumph Domini.

4.2.10 Shape of base

Shape of leaf blade base was recorded and out of twenty sweet cherry varieties as many as twelve varieties viz., CITH-1, CITH-3, CITH-4, CITH-13, CITH-15, Desna, Lambert, Glory, Sweet Heart, Germarsdofer, Sunburst, Celisor were found to have acute base whereas, eight varieties, viz., CITH-5, CITH-8, CITH-12, CITH-16, Merchant, Bigarreau Noir Grossa, Guigne Pourpea Prececе and Triumph Domini had obtuse base.

4.2.11 Presence of nectaries

Nectaries were found to be present in all the twenty varieties of sweet cherry under study (Table 3).

4.2.12 Nectaries colour

The colour of nectaries varied from Orange yellow in CITH-1, CITH-15, Lambert, Sweet Heart, Sunburst, Purple in CITH-3, CITH-4, CITH-16; Greenish yellow in CITH-13; red colour in Glory, Merchant, Bigarreau Noir Grossa, Celisor, whereas, CITH-5, CITH-8, CITH-12, Desna, Guigne Pourpea Prececе and Triumph Domini had light red colour nectaries.

Variability is the process by which differences occur among individuals of the same plant species. Likewise, variation in leaf characters was also reported by Dangi *et al.* (2021) who found huge variation in time of bud burst, leaf length, leaf width, leaf length/width ratio, leaf area, length of petiole, leaf shape, shape of base, angle of apex, leaf colour and colour of nectaries (Table 2 and 3), moreover, there was no such variation found among presence of nectaries. In the present study, the time of bud burst extended from 10th March in Desna to 18th March in Lambert. Similar variation was observed by Oukabli and Mahhoa (2007) on bud burst ranged from 28th March to 10th April. Variation among different sweet cherry varieties under the leaf blade length, width and length/width ratio was also observed by Perez- Sanchez *et al.* (2008) and they found that leaf blade length varied as 8.9 to 15.5 cm, width as 4.4 to 7.6 cm and length/width ratio as 1.7 to 2.3. Hassan *et al.* (2017) also observed a significant range in leaf blade length (6.26-12.06 cm), leaf blade width (2.73-7.23 cm) and petiole length (1.53-4.30 cm).

The leaf area varied considerably from 83.06 cm^2 (Celisor) to 41.05 cm^2 (CITH-1). These results are in line with those of Dangi *et al.* (2021) who also reported the variation in leaf area within a range of 98.24 cm^2 to 70.79 cm^2. Maximum petiole length was found in Desna (4.80 cm), whereas, minimum in Triumph Domini (2.67 cm) which is in accordance with studies of Chatzicharissis *et al.* (2013a) who also observe variation in length of petiole from 2.7 to 5.2 cm.

As per results, in the present study other foliage characters like shape of leaf which was found as obovate and lanceolate, shape of base as acute and obtuse and angle of apex as acute and right angled can be related to the findings of Ljubojevic *et al.* (2016) where he studied twelve cultivars and selections of sweet and sour cherry for the same. The results obtained in present study are also in line with those of Orgauzie *et al.* (2010) who observed leaves of ‘Kiona’ cultivar as medium to long, elliptical with an acute tip, rounded base, and

serrated margins, and observed several large, reniform, grey-purple nectary at the base of each leaf.

In all the varieties of sweet cherry, the colour of emerging leaves was observed as Greyed-Orange Group with slight variation and matured leaves were observed to have Green Group with slight variation in shade. Nectaries were found present in all the twenty sweet cherry varieties (two in number on each leaf). The results obtained were also in line of those of Olmstead *et al.* (2011) in which they found nectaries, one to two in number and oval shaped. Under the study, colour of the nectaries was observed as greenish yellow, orange yellow, light red, dark red and purple. Similar variation in colour of the nectaries has been reported earlier also by Chatzicharissis *et al.* (2011) Oraguzie *et al.* (2010) and Olmstead *et al.* (2011).

4.3 TIME AND DURATION OF FLOWERING

4.3.1 Bearing habit

Bearing habit was found to be on spurs, one and two year old shoot in all the twenty sweet cherry varieties under study.

4.3.2 Time of opening of first flower

The flower initiation was found to be earliest (13th March) in Desna followed by Sweet Heart and Germarsdofer (15thMarch), CITH-1, CITH-5, CITH-8 (16th March), whereas, Lambert was the last on 21st March (Table 4).

4.3.3 Date of full bloom

The full bloom was earliest (21stMarch) in Desna followed by CITH 13 (23rd March), CITH-4 (24th March), CITH-8 (25th March) and last in Lambert (26th March)

4.3.4 Duration of flowering

The duration was recorded largest (12 days) in CITH-4, CITH-5, CITH-8, CITH-15, Sweet Heart followed by (11 days) in CITH-1, CITH-3, CITH-12, CITH-13, CITH-16, Desna, Glory, Celisor, Guigne Pourpea Prececе; (10 days) in Germarsdofer, Merchant, Bigarreau Noir Grossa and Triumph Domini and shortest (9 days) in Lambert.

4.3.5 Colour of flowers

In the present investigation the flower colour was observed white in all twenty sweet cherry varieties.

4.3.6 Arrangement of petals

The two arrangements of petals viz., intermediate and overlapping was observed as overlapping in CITH-1, CITH-5, CITH-8, CITH-12, CITH-13, CITH-15, CITH-16, Desna, Lambert, Germarsdofer, Merchant, Sunburst, Guigne Pourpea Prececе, Triumph Domini and intermediate in CITH-3, CITH-4, Glory, Sweet Heart, Sunburst, Bigarreau Noir Grossa and Celisor (Plate 3)

4.3.7 Shape of petals

Shape of petals was circular in CITH-8, CITH-15, Desna, Glory, Merchant, Sunburst, Celisor, Guigne Pourpea Prececе; broad obovate in CITH-1, CITH-3, CITH-4, CITH-12, CITH-13, CITH-15, Lambert, Sweet Heart, Germarsdofer, Sunburst, Bigarreau Noir Grossa, Triumph Domini whereas, CITH-5 had medium obovate petal shape (Plate 3)

4.3.8 Flower diameter (cm)

Highest flower diameter (3.61 cm) was recorded in CITH-8 followed by lowest (2.89 cm) in Lambert. The overall mean value was recorded as 3.12 cm. The flower diameter of CITH-8 was statistically at par with CITH-13 (3.57 cm), Merchant (3.47 cm) and Guigne Pourpea Prececе (3.48 cm).

Floral characters also vary considerably among sweet cherry varieties like the foliage characters. In this present study, floral characters such as bearing habit and flower colour did not show any variation. Among other characters, variation was found in time of opening of first flower, full bloom, time of opening of last flower, duration of flowering, arrangement of petals, shape of petals and diameter of flower. The span of three to nine days for earliest and latest flowering was documented by Hodun *et al.* (2002). The onset of flowering of sweet cherry also depends upon the weather condition. However, under identical agro environmental conditions, these results are also in line with Ganji *et al.* (2014) found that flowering period of most of sweet cherry cultivars took 9 and 13 days. Blazkova *et al.* (2010) observed that time of flowering of sweet cherry cultivars varied to some extent during the period of study but Burlat flowered the earliest whereas Kordia flowered the last.

Table 4: Flower characters of some sweet cherry varieties

Variety	Bearing habit	Time of opening of first flower	Date of full bloom	Time of opening of last flower	Duration of flowering (days)	Colour of flowers	Arrangement of petals	Shape of petals	Flower diameter (cm)	Status of flower diameter(cm)
CITH-1	Spurs, one and two year old shoot	16th March	25th March	26th March	11 days	White	Overlapping	Broad Obovate	3.09	Medium
CITH-3	Spurs, one and two year old shoot	18th March	25th March	28th March	11days	White	Intermediate	Broad Obovate	2.95	Small
CITH-4	Spurs, one and two year old shoot	17th March	24th March	28th March	12 days	White	Intermediate	Broad Obovate	3.13	Medium
CITH-5	Spurs, one and two year old shoot	16th March	24th March	26th March	12 days	White	Overlapping	Medium Obovate	3.10	Medium
CITH-8	Spurs, one and two year old shoot	16th March	25thMarch	27thMarch	12 days	White	Overlapping	Circular	3.61	Medium
CITH-12	Spurs, one and two year old shoot	17th March	24th March	27thMarch	11 days	White	Overlapping	Broad Obovate	2.98	Small
CITH-13	Spurs, one and two year old shoot	16th March	23rd March	26th March	11 days	White	Overlapping	Broad Obovate	3.57	Medium
CITH-15	Spurs, one and two year old shoot	17th March	24th March	28thMarch	12days	White	Overlapping	Circular	3.08	Medium
CITH-16	Spurs, one and two year old shoot	18th March	23rd March	28th March	11 days	White	Overlapping	Broad Obovate	3.10	Medium
Desna	Spurs, one and two year old shoot	13th March	21stMarch	23rdMarch	11 days	White	Overlapping	Circular	2.95	Small
Lambert	Spurs, one and two year old shoot	21stMarch	26th March	29thMarch	09days	White	Overlapping	Broad Obovate	2.89	Small
Glory	Spurs, one and two year old shoot	18th March	24th March	28th March	11 Days	White	Intermediate	Circular	3.12	Medium
Sweet Heart	Spurs, one and two year old shoot	15th March	24thMarch	26th March	12 days	White	Intermediate	Broad Obovate	3.30	Medium
Germarsdofer	Spurs, one and two year old shoot	15th March	22ndMarch	24th March	10 days	White	Overlapping	Broad Obovate	3.19	Medium
Merchant	Spurs, one and two year old shoot	17th March	24thMarch	26th March	10 days	White	Overlapping	Circular	3.47	Medium
Sunburst	Spurs, one and two year old shoot	16th March	23rdMarch	27th March	11 days	White	Intermediate	Broad Obovate	3.39	Medium
Bigarreau Noir Grossa	Spurs, one and two year old shoot	19th March	24thMarch	28th March	10days	White	Intermediate	Broad Obovate	3.34	Medium
Celisor	Spurs, one and two year old shoot	16th March	23rdMarch	26th March	11 days	White	Overlapping	Circular	3.15	Medium
GuignePourpeaPrecece	Spurs, one and two year old shoot	18th March	25th March	28th March	11 days	White	Overlapping	Circular	3.48	Medium
Triumph Domini	Spurs, one and two year old shoot	16th March	23rdMarch	25th March	10 days	White	Overlapping	Broad Obovate	3.07	Medium
Mean									3.12	
$CD_{0.05}$									1.89	

Shape Of Petal- Circular
Petal Arrangement- Intermediate

Shape Of Petal- Circular
Petal Arrangement- Overlapping

Shape Of Petal- Broad Obovate
Petal Arrangement- Overlapping

Shape Of Petal- Broad Obovate
Petal Arrangement- Intermediate

Plate 3 Flower characters of some sweet cherry varieties

The colour of the flowers was observed as white and bearing habit was found to be on spurs, one and two year old in all the twenty sweet cherry varieties. Opening of the first flower ranged from 13th March to 21st March and last flower ranged from 23rd March to 29th March, thus, the duration of flowering was recorded shortest in Lambert (9 days) to longest in CITH-4, CITH-5, CITH-8, CITH-15, Sweet Heart (12 days). The results can be related to the studies conducted by Garcia-Montiel *et al.* (2010) where similar results were obtained on duration of flowering. Variation in duration of flowering from 9 to 13 days was also found by Dangi *et al.* (2021) in duration of flowering. Earliest blooming period was observed in Desna (21st March) and late in Lambert (26th March). This result can be related with the type of variation in blooming noticed by Olmstead *et al.* (2011), Chatzicharissis *et al.* (2013b) and Dangi *et al.* (2021). The variation in time of flowering among all the twenty sweet cherry varieties studied may be due to the temperature required as variation in chilling hours on the trial place.

Variation in shape of petal and arrangement of petals was found in this study as overlapping in CITH-1, CITH-5, CITH-8, CITH-12, CITH-13, CITH-15, CITH-16, Desna, Lambert, Germarsdofer, Merchant, Sunburst, Guigne Pourpea Prececе, Triumph Domini and rest were intermediate. Likewise, shape of petals was circular in CITH-8, CITH-15, Desna, Glory, Merchant, Sunburst, Celisor, Guigne Pourpea Prececе; broad obovate in CITH-1, CITH-3, CITH-4, CITH-12, CITH-13, CITH-15, Lambert, Sweet Heart, Germarsdofer, Sunburst, Bigarreau Noir Grossa, Triumph Domini. Whereas, CITH-5 had medium obovate petal shape. Similar results were obtained by Gjamovski *et al.* (2016), who also found petals shape as circular, medium obovate and broad obovate, whereas, arrangement of petals as free, intermediate and overlapping. The diameter of flower also varied from 2.89 cm (Lambert) to 3.61 cm (CITH-8). Similar variation in flower diameter (2.92 to 3.56 cm) has been recently observed by Dangi *et al.* (2021).

4.4 FRUIT CHARACTERS

Recorded data under morpho-physical characteristics of fruits of sweet cherry varieties are presented in Table 5 and 6, Plate 4(a-d).

4.4.1 Fruit weight(g)

According to DUS guidelines, fruit weight was categorized as small, medium and large. Fruit weight was recorded maximum in CITH-4 (10.74 g) which was followed by

Glory (10.04 g) was found to be at statically at par with each other. Whereas, minimum fruit weight was recorded in CITH-15 (1.37 g). Small fruits were found in CITH-15, Lambert, Germarsdofer and Triumph Domini; Medium fruits in CITH-1, CITH-8 and CITH-16; large fruits in CITH-3, CITH-4, CITH-5, CITH-12, CITH-13, Desna, Glory, Sweet Heart, Merchant, Sunburst, Bigarreau Noir Grossa, Celisor and Guigne Pourpea Prececе.

4.4.2 Fruit length(mm)

Highest fruit length was recorded in Glory (24.69 mm) and lowest in CITH-15 (15.04 mm). The overall mean was determined as 22.30 mm. Bigarreau Noir Grossa (25.57 mm), Merchant (24.64 mm), Sunburst (24.49 mm) varieties were found to be at par with Glory.

4.4.3 Fruit width(mm)

Maximum fruit width was recorded in Glory (27 mm), whereas, minimum in CITH-15 (15.04 mm). The overall mean value was determined as 23.67 mm. Glory was statistically at par with Merchant (26.78 mm), CITH-4 (26.65 mm), Celisor (26.36 mm), Sunburst (26.34 mm), CITH-3 (26.14 mm), Desna (26.14 mm), Bigarreau Noir Grossa (26.09 mm), CITH-13 (25.81 mm), Sweet Heart (25.15 mm) and CITH-12 (24.53 mm).

4.4.8 Length of fruit stalk(mm)

Length of fruit stalk was varied from (29.77 mm) to (51.74 mm) and was significantly different in all the sweet cherry varieties. Length of fruit stalk was recorded longest in Triumph Domini (51.74 mm) which was closely followed by CITH-5 (47.93 mm), Glory (46.37 mm) and CITH-8 (42.46 mm) but was significantly higher than all varieties. The shortest length of fruit stalk was observed in CITH-15 (29.77 mm) which was significantly at par with CITH-4 (30.16 mm). The overall mean was determined as 38.31 mm.

4.4.4 Fruit shape

All the twenty sweet cherry varieties were observed so as to classify them according to their fruit shape. CITH-1, CITH-3, CITH-4, CITH-12, Desna, Lambert, Sweet Heart, Merchant, Sunburst, Celisor were found to have reniform type of fruit shape (Table 5), whereas, CITH-13, Glory, Germarsdofer, Guigne Pourpe Prececе and Triumph Domini had cordate type and CITH-5, CITH-8, CITH-15, CITH-16, Sweet Heart, Bigarreau Noir Grossa recorded for oblate type of fruit shape (Plate 4).

4.4.5 Fruit pistil end

Fruit pistil end of sweet cherry was categorised pointed, flat and depressed in the present investigation. Shape of the pistil end varied among sweet cherry variety. It was observed flat at end for CITH-5, CITH-8, CITH-15, CITH-16, Lambert, Glory, Sweet Heart, Germarsdofer, Merchant, Bigarreau Noir Grossa, Guigne Pourpea Prececе, Triumph Domini, whereas, pointed in Desna, Celisor and depressed in CITH-1, CITH-3, CITH-4, CITH-12, CITH-13, Sunburst (Plate 4).

4.4.6 Fruit skin colour

Fruit skin colour under study was in Red Group (46) and Greyed-Purple Group (187), however, slight variation was observed in the shade of the colour. Fruit colour was yellow with red blush (46 A) in CITH-15, Bigarreau Noir Grossa and Guigne Pourpea Prececе varieties and dark red (187 A) in CITH-1, CITH-3, Desna, Glory, Sweet Heart, Germarsdofer, Merchant, Celisor, Triumph Domini and red (187 A) in CITH-4, CITH-15, CITH-8, CITH-16, Lambert and Sunburst (Plate 4).

4.4.7 Fruit flesh colour

Fruit flesh colour in all the twenty sweet cherry varieties was Yellow - Orange Group (20) and Greyed-Purple Group (187), however, slight variation was observed in the shade of the colour fruit flesh colour was dark red (187 A) in CITH-1, CITH-5, CITH-8, CITH-12, CITH-13, CITH-16, Bigarreau Noir Grossa, Guigne Pourpea Prececе; red (187 B) in CITH-3, CITH-4, Sunburst and creamy (20) in CITH 15, Lambert, Desna, Glory, Sweet Heart, Germarsdofer, Merchant, Celisor and Triumph Domini (Plate 4).

4.4.9 Colour of fruit juice

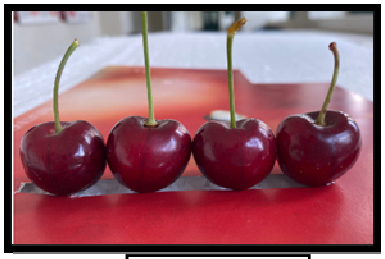
Fruit juice colour was observed and found to be Greyed-Purple Group (187 B) (Purple) in CITH-1, Germarsdofer, Merchant, Celisor and Triumph Domini. Whereas, Greyed-Purple Group 183-B (Red) in CITH-3, CITH-4, Desna, Glory, Sweet Heart, Sunburst and Yellow- Orange Group (20 B) in CITH-5, CITH-8, CITH-12 and (Light Yellow) in CITH-13, CITH-15, CITH-16, Lambert, Bigarreau Noir Grossa, Guigne Pourpea Prececе.

Table 5: Morpho-physical characteristics of some sweet cherry varieties

Variety	Fruit weight (g)	Status of fruit weight (g)	Fruit length (mm)	Status of Fruit Length (mm)	Fruit width (mm)	Status of Fruit Width (mm)	Length of fruit stalk (mm)	Status of Length of fruit stalk (mm)
CITH-1	5.24	Medium	18.94	Medium	21.63	Broad	37.52	Short
CITH-3	8.96	Large	23.39	Large	26.14	Broad	32.76	Short
CITH-4	10.74	Large	23.48	Large	26.65	Broad	30.16	Short
CITH-5	6.33	Large	22.43	Large	22.97	Broad	47.93	Medium
CITH-8	5.96	Medium	21.96	Large	21.97	Broad	42.46	Medium
CITH-12	7.99	Large	22.51	Large	24.53	Broad	36.10	Short
CITH-13	7.79	Large	22.58	Large	25.81	Broad	37.22	Short
CITH-15	1.37	Small	15.56	Medium	15.04	Medium	29.77	Short
CITH-16	5.95	Medium	21.69	Large	21.59	Broad	36.52	Short
Desna	8.18	Large	22.36	Large	26.14	Broad	33.03	Short
Lambert	3.94	Small	17.87	Medium	19.31	Medium	38.90	Short
Glory	10.04	Large	26.49	Large	27.00	Broad	46.37	Medium
Sweet Heart	8.89	Large	22.75	Large	25.15	Broad	38.65	Short
Germarsdofer	2.95	Small	17.71	Medium	17.19	Medium	38.00	Short
Merchant	8.45	Large	24.64	Large	26.78	Broad	36.95	Short
Sunburst	7.93	Large	24.49	Large	26.34	Broad	33.32	Short
Bigarreau Noir Grossa	8.63	Large	25.57	Large	26.09	Broad	38.95	Short
Celisor	7.59	Large	23.21	Large	25.36	Broad	41.69	Short
Guigne Pourpea Precece	7.57	Large	23.57	Large	23.91	Broad	38.20	Short
Triumph Domini	3.45	Small	18.48	Medium	18.74	Medium	51.74	Medium
Mean	6.89		22.304		23.67		38.31	
$CD_{0.05}$	0.39		2.72		3.45		2.01	

SKIN COLOR

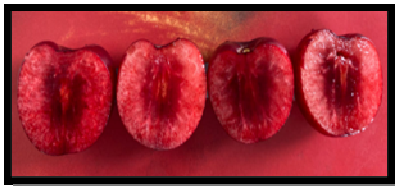
RED



DARK RED

YELLOW WITH RED BLUSH

FLESH COLOR

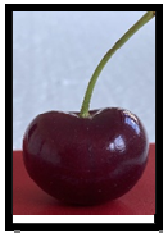


RED

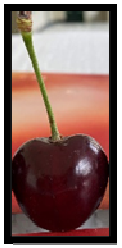
DARK RED

CREAMY

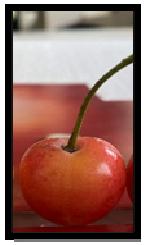
FRUIT SHAPE



RENIFORM

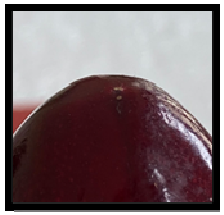


CORDATE



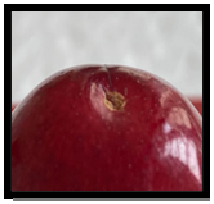
OBLATE

FRUIT PISTIL END



FLAT

POINTED



DEPRESSED

Plate 4 (a-d) Fruit characters of some sweet cherry varieties

Table 6: Morpho-physical characteristics of some sweet cherry varieties

Varieties	Fruit shape	Fruit pistil end	Suture	Fruit skin colour	Fruit flesh colour	Colour of juice
CITH-1	Reniform	Depressed	Absent	Greyed-Purple Group 187-A (Dark red)	Greyed-Purple Group 187-A (Dark red)	Greyed-Purple Group 187-B (Purple)
CITH-3	Reniform	Depressed	Strongly conspicuous	Greyed-Purple Group 187-A (Dark red)	Greyed-Purple Group 185-A (Light red)	Greyed-Purple Group 187-B (Red
CITH-4	Reniform	Depressed	Strongly conspicuous	Greyed-Purple Group 187-A (Red)	Greyed-Purple Group 187-A (Light red)	Greyed-Purple Group 187-B (Red
CITH-5	Oblate	Flat	Very weakly conspicuous	Greyed-Purple Group 187-A (Red)	Yellow -White Group (creamy)	Yellow- Orange Group 20-A (Yellow)
CITH-8	Oblate	Flat	very weakly conspicuous	Greyed-Purple Group 187-A (Red)	Yellow -White Group (creamy)	Yellow- Orange Group 20-A (Yellow)
CITH-12	Reniform	Depressed	Strongly conspicuous	Greyed-Purple Group 187-A (Red)	Yellow -White Group (creamy)	Yellow- Orange Group 20-A (Yellow)
CITH-13	Cordate	Depressed	Weakly conspicuous	Greyed-Purple Group 187-A (Red)	Yellow -White Group(creamy)	Yellow- Orange Group 20-B (Light Yellow)
CITH-15	Oblate	Flat	Conspicuous	Red Group 46-A (Yellow with red blush)	Greyed-Purple Group 187-A (red)	Yellow- Orange Group 20-B (Light Yellow)
CITH-16	Oblate	Flat	very weakly conspicuous	Greyed-Purple Group 187-A (Red)	Yellow -White Group (creamy)	Yellow- Orange Group 20-B (Light Yellow)
Desna	Reniform	Pointed	Strongly conspicuous	Greyed-Purple Group 187-A (Dark red)	Greyed-Purple Group 187-A (red)	Greyed-Purple Group 187-B (Red)
Lambert	Reniform	Flat	weakly conspicuous	Greyed-Purple Group 187-A (Dark red)	Yellow -White Group (creamy)	Yellow- Orange Group 20-B (Light Yellow)
Glory	Cordate	Flat	weakly conspicuous	Greyed-Purple Group 187-A (Dark red)	Greyed-Purple Group 187-A (red)	Greyed-Purple Group 187-B (Red)
Sweet Heart	Oblate	Flat	weakly conspicuous	Greyed-Purple Group 187-A (Dark red)	Greyed-Purple Group 187-A (red)	Greyed-Purple Group 187-B (Red)
Germarsdofer	Cordate	Flat	Absent	Greyed-Purple Group 187-A (Dark red)	Greyed-Purple Group 187-A (Dark red)	Greyed-Purple Group 187-B (Purple)
Merchant	Reniform	Flat	weakly conspicuous	Greyed-Purple Group 187-A (Dark red)	Greyed-Purple Group 187-A (Dark red)	Greyed-Purple Group 187-B (Purple)
Sunburst	Reniform	Depressed	very weakly conspicuous	Greyed-Purple Group 187-A (Red)	Greyed-Purple Group 187-A (red)	Greyed-Purple Group 187-B (Red)
Bigarreau Noir Grossa	Oblate	Flat	very weakly conspicuous	Red Group 46-A (Yellow with red blush)	Yellow -White Group (creamy)	Yellow- Orange Group 20-B (Light Yellow)
Celisor	Reniform	Pointed	very weakly conspicuous	Greyed-Purple Group 187-A (Dark red)	Greyed-Purple Group 187-A (Dark red)	Greyed-Purple Group 187-B (Purple)
GuignePourpeaPrecece	Cordate	Flat	weakly conspicuous	Red Group 46-A (Yellow with red blush)	Yellow -White Group (creamy)	Yellow- Orange Group 20-B (Light Yellow)
Triumph Domini	Cordate	Flat	Absent	Greyed-Purple Group 187-A (Dark red)	Greyed-Purple Group 187-A (Dark red)	Greyed-Purple Group 187-B (Purple)

The data recorded for fruit length under present investigation is in agreement with the study of Dangi *et al.* (2021) who also observed variation in fruit length (23.44 to 16.92 mm) and width (24.48 to 15.97 mm) of sweet cherry varieties. Bhat *et al.* (2018) also reported variation in fruit length and width from 19.50 to 24.80 mm and minimum in 21.10 to 25.69 mm, respectively. Maximum fruit weight was reported in CITH- 4 (10.74 g) and minimum in CITH-15 (1.34 g). Similar results were observed by Dangi *et al.* (2021) as they reported fruit weight ranged from (8.63 g to 3.21 g) and Bhat *et al.,* (2018) reported similar range from (6.0 to 8.15 g). These results are also in line with those of Serbozeva (2019) who also reported variation in cherry fruit size and found largest fruit size in Summit (13 g) and minimum in Burlat (7.4 g).

The stalk length was found maximum in Triumph Domini (51.74 mm) and minimum in CITH-15 (29.74 mm). Similar variation in stalk length was observed ranged from (35.5 to 55.0 mm) by Gjamovski *et al.* (2016). Radunic *et al.* (2014) evaluated nine sweet cherry cultivars for different pomological characteristics. They observed a range of varaiation in fruit weight (4.04 to 6.5 g), Fruit length (17.8 to 22.1 mm) and stalk length (23.6 to 50.3 mm).

In the present study variation in fruit shape (Table 5) viz; reniform, oblate and cordate was recorded for twenty sweet cherry varieties. Similar variation in fruit shapes viz., cordate, reniform, oblate, circular and elliptic in different cherry cultivars was reported by Gjamovski *et al.* (2016) and Dangi *et al.* (2021). Dark skin colour and flesh colour play an important role in the market as they attract the customers. In the present study, variation among all the sweet cherry varieties for fruit skin colour, flesh colour and colour of fruit juice was found with a slight considerable variation. Fruit skin colour was observed as (yellow with red blush, red and dark red), fruit flesh colour (yellow, light red and red), fruit juice colour (creamy, red and purple). Rodrigues *et al.* (2008) observed vermilion or wine red skin colour and cream white flesh colour in saco I and morangao had darker colour both externally and internally. Jahangeer (2015) evaluated 110 diverse genotype of sweet cherry and observed substantial variation in fruit shape. In his study, he found five different shapes and most prominent fruit shape was found reniform and also observed that juice colour extracts from fruits of various genotyoe ranged from colourless to purple colour; out of 110 genotypes only one genotype CHR-SHP-042 was found colourless.

4.5 STONE CHARACTERS

Stone characteristics observed in different sweet cherry varieties is presented in Table 7 and Plate 5.

4.5.1 Stone weight(g)

Maximum stone weight was recorded in Desna (0.53 g) followed by CITH-4 (0.45 g), Celisor (0.43 g), CITH-12 (0.42 g), Sweet Heart and Merchant (0.41 g) but was significantly higher than all varieties. Whereas, minimum stone weight was recorded in Triumph Domini (0.22g) which was significantly at par with Lambert. The overall mean value was determined as 0.34 g (Table 7).

4.5.2 Stone shape

Different stone shape viz., as elliptic, slightly elliptic and round was observed in twenty sweet cherry varieties. Stone shape was slightly elliptic type in CITH-3, CITH-5, CITH-8, CITH-12, CITH-15, CITH-16, Glory, Sweet Heart, Sunburst, Bigarreau Noir Grossa, Celisor, Guigne Pourpea Prececе and Triumph Domini, whereas, round in CITH-1, CITH-4, CITH-13, Desna, Lambert, Germarsdofer and elliptic in Merchant (Plate 5).

4.5.3 Stone size(mm)

Average stone length ranged from 10.11 mm (Triumph Domini) to 12.89 mm (Desna). Maximum length of stone (12.89 mm) was recorded in Desna which was followed by CITH-4 (12.38 mm) and Celisor (12.31 mm) but was significantly higher than all other varieties. Minimum stone length was recorded in Triumph Domini which was closely followed by CITH-1. Maximum stone width was recorded in Desna (12.72 mm), whereas, minimum in Triumph Domini (7.49 mm). The overall mean value was determined as 11.28 mm in stone length and 10.22 mm in stone width.

4.5.4 Pulp/stone ratio

Pulp stone ratio was significantly different in all sweet cherry varieties under studty. Maximum pulp/stone ratio was found in Glory (28.51) followed by CITH-3 (23.88), CITH-4 (22.77), whereas minimum in CITH-15 (3.01). The overall mean value ratio was determined as 17.19.

Table 7: Stone characters of some sweet cherry varieties

Variety	Stone weight (g)	Status of Stone weight (g)	Stone shape	Stone size		Pulp: stone
				Length (mm)	Width (mm)	
CITH-1	0.30	Medium	Round	10.13	8.57	16.33
CITH-3	0.36	Medium	Slightly Elliptic	10.47	8.56	23.88
CITH-4	0.45	Medium	Round	12.38	12.21	22.77
CITH-5	0.38	Medium	Slightly Elliptic	10.50	8.60	15.65
CITH-8	0.40	Medium	Slightly Elliptic	12.20	12.09	13.89
CITH-12	0.42	Medium	Slightly Elliptic	12.28	12.16	18.04
CITH-13	0.39	Medium	Round	11.53	9.89	18.97
CITH-15	0.34	Medium	Slightly Elliptic	11.37	9.60	3.01
CITH-16	0.39	Medium	Slightly Elliptic	10.64	8.91	14.25
Desna	0.53	Medium	Round	12.89	12.72	14.43
Lambert	0.28	Small	Round	10.38	8.36	13.07
Glory	0.34	Medium	Slightly Elliptic	10.39	8.52	28.51
Sweet Heart	0.41	Medium	Slightly Elliptic	12.15	12.09	20.69
Germarsdofer	0.39	Medium	Round	11.54	9.88	6.56
Merchant	0.41	Medium	Elliptic	12.13	12.10	19.61
Sunburst	0.37	Medium	Slightly Elliptic	10.47	12.18	20.43
Bigarreau Noir Grossa	0.39	Medium	Slightly Elliptic	11.46	9.73	21.14
Celisor	0.43	Medium	Slightly Elliptic	12.31	12.19	16.66
GuignePourpeaPrecece	0.34	Medium	Slightly Elliptic	10.38	8.53	21.29
Triumph Domini	0.22	Small	Slightly Elliptic	10.11	7.49	14.70
Mean	0.34			11.28	10.22	17.19
$CD_{0.05}$	0.06			0.25	0.30	2.75

STONE SHAPE

SLIGHTLY ELLIPTIC

ELLIPTIC

ROUND

Plate 5 Stone characters of some sweet cherry varieties

Maximum stone weight was observed in Desna (0.53 g) and minimum in Triumph Domini (0.15 g). These results are in line with those of Dangi *et al.* (2021) and Sirbu *et al.* (2012) who also observed variation in stone weight from 0.15 to 0.49 g and 0.1 to 0.4 g, respectively. Chatzicharissis *et al.* (2013a) who also found similar variation in stone length (10.0 to 12.4 mm) and width (7.9 to 9.5 mm). Variation in pulp stone ratio has been reported recently by Dangi *et al.* (2021) as 22.03 to 11.50 and in the present study, it was observed as 28.51 to 3.01 that can be however related with their study. Among all the twenty sweet cherry varieties under study, the stone shape was observed as round, slightly elliptic and elliptic in shape and similar variation was also reported by Dangi *et al*. (2021) and Matteo *et al.* (2017) in their study.

4.6 BIOCHEMICAL CHARACTERISTICS

Various biochemical characteristics recorded for different sweet cherry varieties are tabulated as under (Table 8) of:

4.6.1 Total soluble solids (°Brix)

According to DUS guidelines, TSS content was categorized as low, medium and high. In the present investigation all the sweet cherry varieties had medium to high TSS content. Highest TSS content (21.04 °Brix) was recorded in CITH-16 followed by CITH- (19.40 °Brix), Desna (19.10 °Brix), CITH-15 (18.86 °Brix), Celisor (18.60 °Brix) and Glory (18.58 °Brix). Whereas, minimum TSS was recorded in Germarsdofer (12.70 °Brix). The overall mean value was found to be 16.65 °Brix.

4.6.2 Titratable acidity (%)

Highest acidity (0.48 %) was in CITH-1 followed by Desna (0.46 %), Germarsdofer (0.46 %) and lowest in varieties CITH-5 and CITH-15 (0.20 %). The overall mean value was found to be 0.36 per cent.

4.6.3 Total sugars (%)

The total sugars content was maximum (12.78 %) in CITH-13 followed by Triumph Domini (12.02 %) and Desna (11.11 %). Minimum total sugars content was recorded in Glory and Sweet Heart (8.46 %). Whereas, overall mean value was determined as 10.28 per cent.

4.6.4 Reducing sugars (%)

Reducing sugars was found maximum in Germarsdofer (6.44 %) and minimum in Lambert (3.70 %). Germarsdofer was found statistically at par with CITH-1 (6.36 %). The overall mean value was determined as 4.94 per cent.

4.6.5 Non-reducing sugars (%)

Maximum content of non-reducing sugars was recorded in CITH-13 (7.16 %) and minimum was recorded in CITH-16 (3.5 %) followed by Lambert (6.55 %), Triumph Domini (6.34 %) and Merchant (6.11 %). The overall mean value was determined as 5.07 per cent.

4.6.6 Sugar/acid ratio

The highest sugar/acid ratio was recorded in CITH-13 (49.76) followed by CITH-8 (49.31), CITH-15 (43.45) and the lowest was recorded in Sunburst (22.41). The overall mean value was determined as 29.73.

In the present study, the TSS content was found ranging between 12.70 °Brix in Germarsdofer and 21.04 °Brix in CITH-16. Janes *et al.* (2010) also recorded variation TSS content in Tiki (14.6 °Brix.) to Anu (19.6 °Brix.). Also, the present study can be related to earlier work done with similar results by Matteo *et al.* (2017), Bhat *et al.* (2018). Dangi *et al.* (2021) also found variation in titrable acidity in their study (0.47 % to 0.24 %).

Highest total sugars content was found in CITH-13 (12.78 %) and lowest in Glory and Sweet Heart (8.46 %). Radicevic *et al.* (2011) also investigated highest total sugar content in Kordia (12.5 %) and lowest in Burlat (10.30 %) among six cherry cultivars grafted on Gisela 5 rootstock. Reducing sugars ranged between (3.70 %) in Lambert and (6.4 %) in Germarsdofer. Similar type of variation in total sugars and reducing sugars (3.57 ± 1.48 to 12.5 ± 0.28 %) was also reported by Usenik *et al.* (2008). In the present study, non-reducing sugars was highest (7.16 %) in CITH-13 and lowest in CITH-16 (3.50 %). The sugar acid ratio varied from CITH-8 (49.31) to Sunburst (22.41). The results obtained by Janes *et al.*, (2010) can be related to the present study as they found high sugar: acid ratio in Iputj, Kasper, Arthur, Anu and Mupi ranged 17.9 to 20.3. The possible reason for variation among all the twenty sweet cherry varieties observed for TSS, acidity and sugars of the fruits in the present study as compared to others can be due to the differences in climatic factors, different maturing period and nutrients available in the soil at the research station at Mashobra.

Table 8: Biochemical characters of some sweet cherry varieties

Variety	TSS (°Brix)	Titratable acidity (%)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Sugar: acid ratio
CITH-1	17.30	0.48	12.43	6.36	5.76	25.47
CITH-3	13.66	0.44	10.20	5.29	4.69	23.3
CITH-4	14.02	0.44	9.794	4.28	5.23	22.43
CITH-5	18.26	0.39	09.35	4.78	4.33	24.09
CITH-8	19.40	0.20	10.11	5.35	4.51	49.31
CITH-12	14.16	0.33	10.30	4.70	5.32	30.84
CITH-13	14.42	0.26	12.78	5.24	7.16	49.76
CITH-15	18.86	0.20	08.93	4.78	3.94	43.45
CITH-16	21.04	0.26	08.81	5.12	3.50	34.32
Desna	19.10	0.46	11.11	5.27	5.54	24.08
Lambert	15.03	0.31	10.60	3.70	6.55	34.50
Glory	18.58	0.36	08.46	4.22	4.02	23.60
Sweet Heart	15.84	0.33	08.46	4.09	4.15	25.35
Germarsdofer	12.70	0.46	11.26	6.44	4.58	24.39
Merchant	16.80	0.44	11.64	5.21	6.11	26.63
Sunburst	17.78	0.44	09.78	4.25	5.25	22.41
Bigarreau Noir Grossa	15.32	0.31	09.72	4.36	5.09	31.46
Celisor	18.60	0.41	10.92	4.99	3.66	26.54
Guigne Pourpea Prececce	17.16	0.33	08.85	5.00	5.63	26.59
Triumph Domini	15.00	0.47	12.02	5.35	6.34	26.08
Mean	16.65	0.36	10.28	4.94	5.07	29.73
$CD_{0.05}$	1.80	0.01	0.86	0.14	0.21	3.35

Table 9: Fruit yield and maturity of some sweet cherry varieties

Varieties	Time of harvesting	Days from full bloom to harvest	Status of days from full bloom to harvest	Fruit yield (kg/tree)	Yield efficiency (kg/ cm^2 of TCSA)
CITH-1	11th May	47 days	Early	3.30	0.01
CITH-3	16th May	50 days	Mid	2.50	0.00
CITH-4	23rd May	60 days	Late	6.00	0.01
CITH-5	23rd May	60 days	Late	2.50	0.01
CITH-8	23rd May	60 days	Late	5.00	0.01
CITH-12	18th May	55 days	Mid	5.00	0.01
CITH-13	16th May	54 days	Mid	3.90	0.01
CITH-15	23rd May	60 days	Late	3.00	0.01
CITH-16	23rd May	61 days	Late	4.50	0.00
Desna	5th May	45 days	Early	6.00	0.01
Lambert	16th May	51 days	Mid	2.50	0.01
Glory	23rd May	60days	Late	2.20	0.01
Sweet Heart	11th May	48 days	Early	6.00	0.01
Germarsdofer	4th May	47 days	Early	7.00	0.00
Merchant	9th May	45 days	Early	2.50	0.01
Sunburst	9th May	47 days	Early	6.50	0.01
Bigarreau Noir Grossa	9th May	45 days	Early	4.50	0.01
Celisor	9th May	47 days	Early	2.50	0.01
GuignePourpeaPrecece	16th May	52 days	Mid	3.00	0.01
Triumph Domini	4th May	43 days	Early	7.00	0.01
Mean				4.08	0.01
$CD_{0.05}$				1.90	N/A

4.7 Fruit Yield and Maturity

4.7.1 Number of days from full bloom to harvest

Number of days from full bloom to harvest ranged from 43 days in Triumph Domini to 61 days in CITH-16 (Table 9).

4.7.2 Time of harvesting

Earliest time of harvesting ranged from 4thMay in Germarsdofer and Triumph Domini to late 23rd May in CITH-4, CITH-5, CITH-8, CITH-15, CITH-16. The dates of maturity in other varieties were (5th May) in Desna, (9th May) in Merchant, Sunburst, Bigarreau Noir Grossa, Celisor, (11th May) in CITH-1 and (12th May) in Lambert, (16th May) in CITH-3, CITH-13, Guigne Pourpea Prececе and (18th May) in CITH-12 (Table 9).

4.7.3 Yield efficiency

No significant variation was observed for yield efficiency among different sweet cherry varieties under study. However, maximum yield efficiency was recorded as 0.01 kg/cm^2 in all the sweet cherry varieties except CITH-3, CITH-16 and Germarsdofer which were found to have negligible yield efficiency. The mean value for yield efficiency was found to be 0.007 kg/cm^2 (Table 8).

4.7.4 Fruit yield

Maximum fruit yield was recorded (7 kg/tree) in Germarsdofer and Triumph Domini and least (2.2 kg/tree) in Glory. Statistically Germarsdofer and Triumph Domini were at par with Sunburst (6.5 kg/tree) and CITH-4, Desna, Sweet Heart (6 kg/tree). The overall mean was recorded as 4.08 kg/tree.

Number of days from full bloom to harvest ranged from 43 days in Triumph Domini to 61 days in CITH-16. Similar variation earlier has also been reported in days from full bloom to harvest by several workers (Sirbu *et al.,* 2012; Bhat *et al.,* 2018 and Dangi *et al*., 2021). Earliest time of harvesting ranged from 4th May in Germarsdofer and Triumph Domini to late 23rd May in CITH-4, CITH-5, CITH-8, CITH-15, CITH-16. Calhan *et al.* (2014) reported cultivar ‘Lapins’ was a dark-coloured sweet cherry cultivar that mature by 7 to 15 days later than cultivar ‘Bing’ and can also be related by the study of Kalyoncu *et al.* (2009). Such variation was also noticed earlier by (Milosevic *et al.*, 2015 and Iurea *et al*. (2017)

Maximum fruit yield was recorded (7 kg/tree) in Germarsdofer and Triumph Domini and least (2.2 kg/tree) in Glory. The present results can be related with Chatzicharissis *et al.* (2013a), they reported fruit yield ranged from 30 to 115 kg/tree; Dangi *et al.* (2021) their study ranged between 51.47 to 80.53 kg/tree and also by Salebadi *et al.* (2019). Maximum yield efficiency was recorded as 0.01 kg/cm^2 in all the sweet cherry varieties except CITH-3, CITH-16 and Germarsdofer which were found to have negligible yield efficiency. The mean value for yield efficiency was found to be 0.007 kg/cm^2. Dangi *et al.* (2021) studied similar variation ranged between 0.13 to 0.22 kg/cm^2. The reason for lower fruit yield and yield efficiency is due to less age of the varieties for bearing at the research station (planted in 2013).

4.2 POMOLOGICAL DESCRIPTION OF THE SWEET CHERRY VARIETIES

Based upon the observations recorded in this research on various characters as per DUS testing and UPOV (2006) guidelines are described below (Plate 6a-e).

CITH-1

Tree Characters

Upright tree habit; medium tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; large trunk diameter; thick mid length; short internodes; yield 3.30 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 14th March; leaf blade length short; width medium; medium length/width ratio; lanceolate leaf shape; acute angled at angle of apex; acute at shape of base; medium petiole length; leaf colour Greyed orange Group B (colour of emerging leaves) and Green Group 137-A (colour of matured leaves); Orange yellow coloured nectarines.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 16thMarch; full bloom on 25th March, opening of last flower on 26th March; duration of flowering for 11 days; white coloured flower; overlapped arrangement of petals; broad obovate shaped petals; medium flower diameter; early in maturity.

Fruit Characters

Fruit weight medium; fruit length medium; broad width; shape reniform; depressed pistil end; suture is absent; Greyed-Purple Group 187-A (Dark Red) fruit skin colour; Greyed-Purple Group 187-A (Red); short fruit stalk length; Greyed-Purple Group 187-B (Purple) colour of fruit juice; suture absent; harvesting on 11th May.

Stone Characters

Stone weight medium; stone shape round.

CITH-3

(Plate 6a)

Tree Characters

Semi-Upright tree habit; small tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; small trunk diameter; thick mid length; short internodes; yield 2.50 kg/tree; yield efficiency 0 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 15th march; leaf blade length short; width medium; medium length/width ratio; obovate leaf shape; right angled at angle of apex; obovate at shape of base; medium petiole length; leaf colour Greyed-Red group B (colour of emerging leaves) and Green Group 141-A (colour of matured leaves); purple coloured nectarines.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 18th March; full bloom on 25th March; opening of last flower on 28th March; duration of flowering for 11 days; white coloured flower; intermediate arrangement of petals; broad obovate shaped petals; small flower diameter; mid in maturity.

Fruit Characters

Fruit weight large; fruit length large; broad width; shape reniform; depressed pistil end; Greyed-Purple Group 187-A (Red) fruit skin colour; Greyed-Purple Group 187-A (Light

Red) fruit flesh colour; short fruit stalk length; Greyed-Purple Group 187-B (Red) colour of fruit juice; strongly conspicuous suture; harvesting on 16th May.

Stone Characters

Stone weight medium; stone shape slightly elliptic.

CITH-4

Tree Characters

Upright tree habit; large tree height; small tree spread in North-South (N-S) direction and in East-West (E-W) direction; large trunk diameter; thick mid length; short internodes; yield 6 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 15th March; leaf blade length medium; width medium; medium length/width ratio; lanceolate leaf shape; acute at angle of apex; obtuse at shape of base; medium petiole length; leaf colourGreyed-Red group B (colour of emerging leaves) and Green Group 141-A (colour of matured leaves); purplecolourednectaries

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 17th march; full bloom on 24th March; opening of last flower on 28th March; duration of flowering for 12 days; white coloured flower; intermediate arrangement of petals; broad obovate shaped petals; medium flower diameter; late in maturity.

Fruit Characters

Fruit weight large; fruit length large; broad width; shape oblate; flat pistil end; Greyed-PurpleGroup 187-A (Red) fruit skin colour; Greyed-PurpleGroup 187-A (Light Red)187-A (Creamy) fruit flesh colour; short fruit stalk length; Greyed-PurpleGroup 187-B (Red) colour of fruit juice; very weakly conspicuous; harvesting on 23rd May.

Stone Characters

Stone weight medium; stone shape round.

CITH-5

Tree Characters

Upright tree habit; large tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; large trunk diameter; thick mid length; short internodes; yield 2.50 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 14th March; leaf blade length medium; width medium; medium length/width ratio; lanceolate leaf shape; right angled at angle of apex; obtuse at shape of base; medium petiole length; leaf colour Greyed-Red group B (colour of emerging leaves) and Green Group 137-A (colour of matured leaves); light red coloured nectaries.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 16th March; full bloom on 24th March; opening of last flower on 26th March; duration of flowering for 12 days; white coloured flower; overlapped arrangement of petals; medium obovate shaped petals; medium obovate flower diameter; late in maturity.

Fruit Characters

Fruit weight large; fruit length large; broad width; shape oblate; flat pistil end; Greyed-Purple Group 187-A (Dark Red) fruit skin colour; Yellow-white Group (Creamy) fruit flesh colour; medium fruit stalk length; Yellow-Orange Group 20-A (Yellow) colour of fruit juice; very weakly conspicuous suture; harvesting on 23rd May.

Stone Characters

Stone weight medium; stone shape slightly elliptic.

CITH-8

Tree Characters

Semi-upright tree habit; medium tree height; small tree spread in North-South (N-S) direction in East-West (E-W) direction; large trunk diameter; medium mid length; short internodes; yield 5 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 13th March; leaf blade length short; width medium; medium length/width ratio; lanceolate leaf shape; right angled at angle of apex; obtuse at shape of base; medium petiole length; leaf colour Greyed-Red group B (colour of emerging leaves) and Green Group 141-A (colour of matured leaves); light red coloured nectaries.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower at 16th March; full bloom on 25th March; opening of last flower on 27th March; duration of flowering for 12 days; white coloured flower; overlapped arrangement of petals; circular shaped petals; medium flower diameter; late in maturity.

Fruit Characters

Fruit weight medium; fruit length large; broad width; shape oblate; flat pistil end; Greyed-Purple Group 187-A (Red) fruit skin colour; Yellow-White Group (Creamy) fruit flesh colour; medium fruit stalk length; Yellow-Orange Group 20-A (Yellow) colour of fruit juice; very weakly conspicuous; harvesting on 23rd May.

Stone Characters

Stone weight medium; stone shape slightly elliptic.

CITH-12

Tree Characters

Upright tree habit; medium tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; large trunk diameter; thick mid length; short internodes; yield 5 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 14th March; leaf blade length medium; width medium; medium length/width ratio; obovate leaf shape; right angled at angle of apex; obtuse at shape of base; medium petiole length; leaf colour Greyed-Red group A (colour of emerging leaves) and Green Group 141-A (colour of matured leaves); light red coloured nectaries.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 17th March; full bloom on 24th March; opening of last flower on 27th March; duration of flowering for 11 days; white coloured flower; overlapped arrangement of petals; broad obovate shaped petals; small flower diameter; mid in maturity.

Fruit Characters

Fruit weight large; fruit length large; width broad; shape reniform; depressed pistil end; Greyed-Purple Group 187-A (Red) fruit skin colour; Yellow-White Group (Creamy) fruit flesh colour; short fruit stalk length; Yellow-Orange Group 20-A (Yellow) colour of fruit juice; strongly conspicuous; harvesting on 18th May.

Stone Characters

Stone weight medium; stone shape slightlyelliptic.

CITH-13

Tree Characters

Upright tree habit; medium tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; largetrunk diameter; thickmid length; short internodes; yield 3.9 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 14th March; leaf blade length medium; width medium; medium length/width ratio; lanceolate leaf shape; right angled at angle of apex; acute at shape of base; medium petiole length; leaf colour Greyed-Red Group B (colour of emerging leaves) and Green Group 141-A (colour of matured leaves); greenish yellow coloured nectaries.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 16th March; full bloom on 23rd March; opening of last flower on 26th March; duration of flowering for 11 days; white coloured flower; overlapped arrangement of petals; broad obovate shaped petals; medium flower diameter; mid in maturity.

Fruit Characters

Fruit weight large; fruit length large; broad width; shape cordate; depressed pistil end; Greyed-Purple Group 187-A (Red) fruit skin colour; Yellow-White Group 21-A (Creamy) fruit flesh colour; short fruit stalk length; Yellow-Orange Group 20-B (Light Yellow) colour of fruit juice; weakly conspicuous; harvesting on 16th May.

Stone Characters

Stone weight medium; stone shape round.

CITH-15

Tree Characters

Uprighttree habit; medium tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; large trunk diameter; thick mid length; short internodes; yield 3 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 15th March; leaf blade length medium; width medium; medium length/width ratio; lanceolate leaf shape; acute at angle of apex; acute at shape of base; medium petiole length; leaf colour Greyed-Orange Group B (colour of emerging leaves) and Green Group 141-A (colour of matured leaves); Orange yellow coloured nectaries.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 17th March; full bloom on 24th March; opening of last flower on 28th March; duration of flowering for 12 days; white coloured flower; overlapped arrangement of petals; circular shaped petals; medium flower diameter; late in maturity.

Fruit Characters

Fruit weight medium; fruit length large; broad width; shape oblate; flat pistil end; Red Group 46-A (Yellow with red blush) fruit skin colour; Greyed- Purple Group 187-A (Red) fruit flesh colour; short fruit stalk length; Yellow-Orange Group 20-B (Light Yellow) colour of fruit juice; conspicuous suture; harvesting on 23rd May.

CITH-3 (Plate 6a)

TREE HABIT

LEAF SHAPE

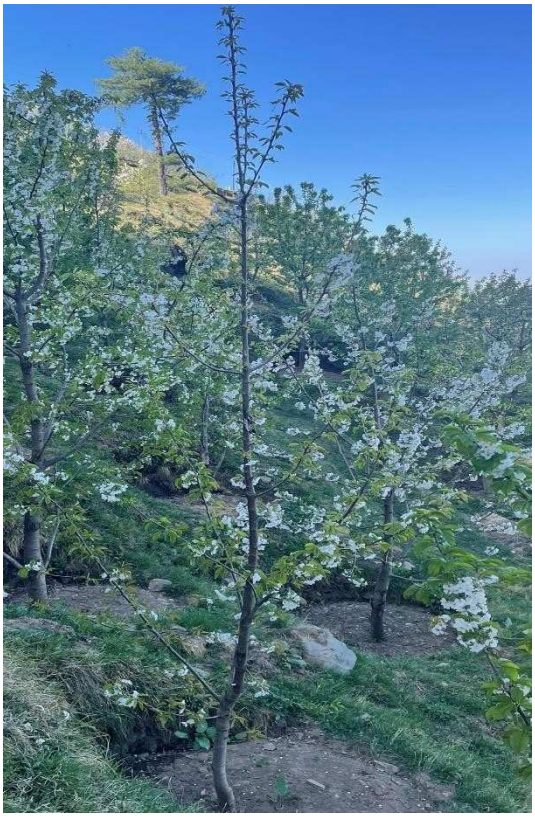
LEAF BASE

LEAF APEX

NECTARIES

FRUIT AND STONE

CITH-16 (Plate 6b)



TREE HABIT

LEAF SHAPE

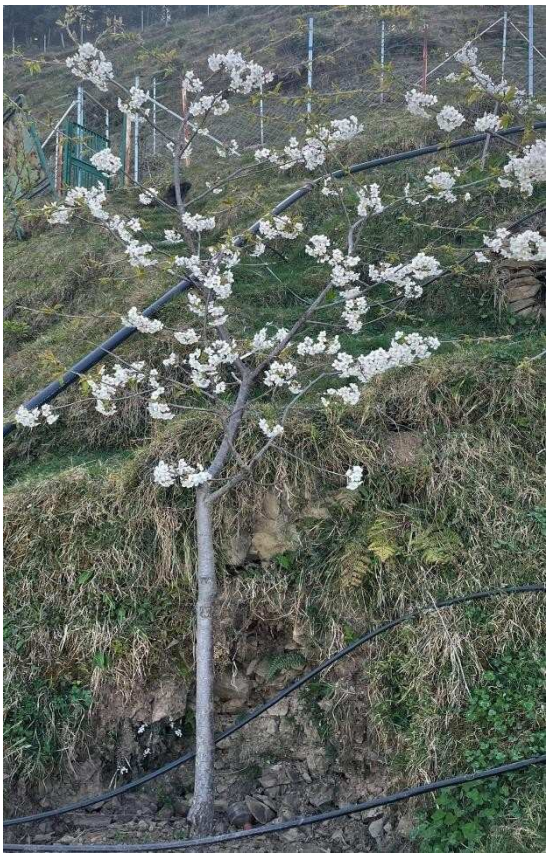
LEAF APEX

LEAF BASE

NECTARIES

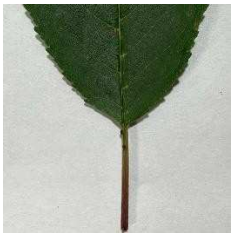
FRUIT AND STONE

GLORY (Plate 6c)

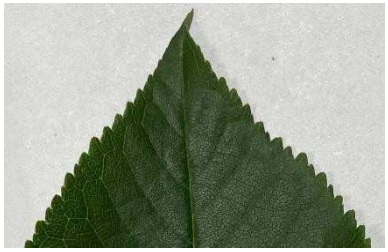


TREE GROWTH

LEAF SHAPE

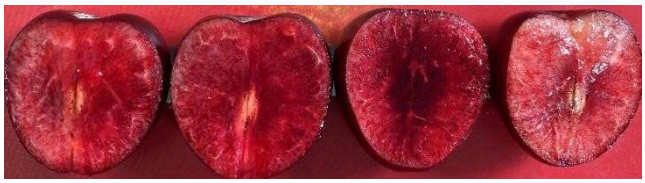


LEAF BASE



LEAF APEX

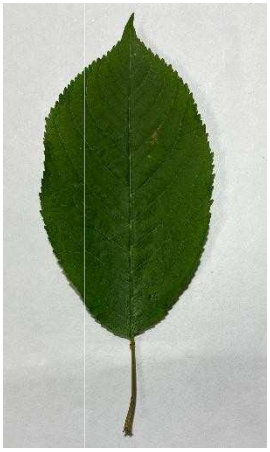
NECTARIES



FRUIT AND STONE

BIGARREAU NOIR GROSSA (Plate 6d)

TREE GROWTH

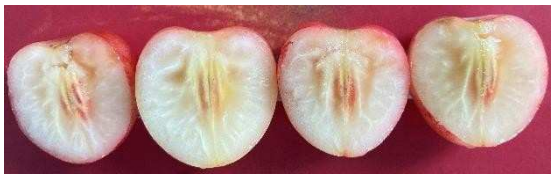


LEAF SHAPE

LEAF APEX

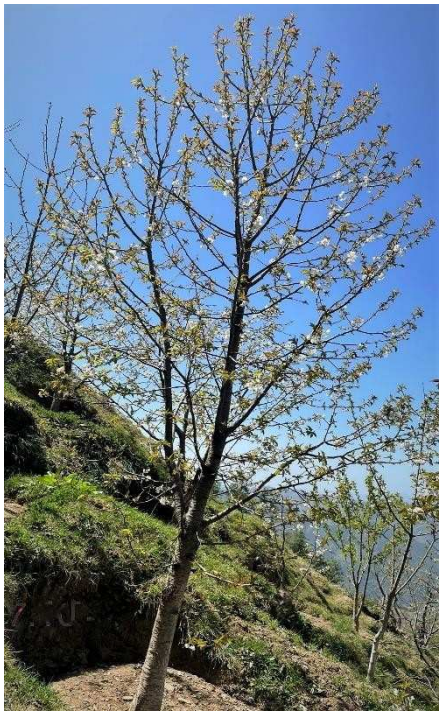
NECTARIES

LEAF BASE

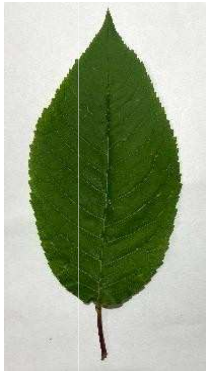


FRUIT AND STONE

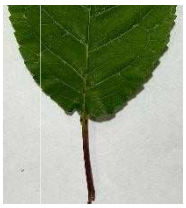
CELISOR (Plate 6e)



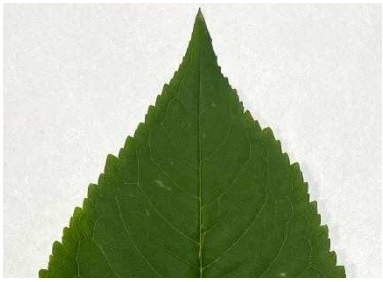
TREE GROWTH



LEAF SHAPE



LEAF BASE



LEAF APEX

NECTARIES

FRUIT AND STONE

Stone Characters

Stone weight medium; stone shape slightly elliptic.

CITH-16

(Plate 6b)

Tree Characters

Uprighttree habit; large tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; medium large trunk diameter; medium mid length; short internodes; 4.50kg/tree yield; yield efficiency 0 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 16th March; leaf blade length short; width medium; medium length/width ratio; lanceolate leaf shape; acute at angle of apex; obtuse at shape of base; medium petiole length; leaf colour Greyed Group B (colour of emerging leaves) and Green Group 141-A (colour of matured leaves); purple coloured nectaries.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 18th March; full bloom on 23rd March; opening of last flower on 28th March; duration of flowering for 11 days; white coloured flower; overlapped arrangement of petals; broad obovate shaped petals; medium flower diameter; late in maturity.

Fruit Characters

Fruit weight large; fruit length large; broad width; shape oblate; flat pistil end; Greyed-Purple Group 187-A (Red) fruit skin colour; Yellow-White Group (Creamy) fruit flesh colour; short fruit stalk length; Yellow-Orange Group 20-B (Light Yellow) colour of fruit juice; very weakly conspicuous suture; harvesting on 23rd May.

Stone Characters

Stone weight medium; stone shape slightly elliptic.

DESNA

(Plate 6c)

Tree Characters

Upright tree habit; large tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; large trunk diameter; medium mid length; short internodes; 6 kg/tree yield; 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 10th March; leaf blade length medium; width medium; medium length/width ratio; lanceolate leaf shape; acute at angle of apex; acute at shape of base; medium petiole length; leaf colour Greyed-Orange Group A (colour of emerging leaves) and Green Group 141-A (colour of matured leaves); light red coloured nectaries.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 13th March; full bloom on 21st March; opening of last flower on23rd March April; duration of flowering for 11 days; white coloured flower; overlapped arrangement of petals; circular shaped petals; small flower diameter; early in maturity.

Fruit Characters

Fruit weight large; fruit length large; width broad; shape reniform; pointed pistil end; Greyed-Purple Group 187-A (Dark Red) fruit skin colour; Greyed-Purple Group 187-A (Red) fruit flesh colour; short fruit stalk length; Greyed-Purple Group 187-B (Red) colour of fruit juice; strongly conspicuous; harvesting on 5th May.

Stone Characters

Stone weight medium; stone round.

LAMBERT

Tree Characters

Semi-upright tree habit; large tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; large trunk diameter; medium mid length; short internodes; yield 6 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 18th March; leaf blade length medium; width medium; medium length/width ratio; lanceolate leaf shape; acute at angle of apex; acute at shape of base; medium petiole length; leaf colour Greyed-Orange Group B (colour of emerging leaves) and Green Group 141-A (colour of matured leaves); orange-yellow coloured nectaries.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 21st March; full bloom on 26th March; opening of last flower on 29th March; duration of flowering for 9 days; white coloured flower; overlapped arrangement of petals; broad obovate shaped petals; small flower diameter; mid in maturity.

Fruit Characters

Fruit weight small; fruit length medium; broad medium; shape reniform; flat pistil end; Greyed-Purple Group 187-A (Dark Red) fruit skin colour; Yellow-White Group (creamy) fruit flesh colour; short fruit stalk length; Yellow-Orange Group (Light Yellow) colour of fruit juice; weakly conspicuous suture; harvesting on 16th May.

Stone Characters

Stone weight small; stone round.

GLORY

(Plate 6c)

Tree Characters

Upright tree habit; small tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; small trunk diameter; medium mid length; short internodes; yield 2.5 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 15th March; leaf blade length short; width medium; medium length/width ratio; lanceolate leaf shape; acute at angle of apex; obtuse at shape of base; medium petiole length; leaf colour Greyed Orange Group B (colour of emerging leaves) and Green Group 141-A (colour of matured leaves); dark red coloured nectaries.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 18th March; full bloom on 24th March; opening of last flower on 28th March; duration of flowering for 11 days; white coloured flower; intermediate arrangement of petals; circular shaped petals; medium flower diameter; late in maturity.

Fruit Characters

Fruit weight large; fruit length large; broad width; shape cordate; flat pistil end; Greyed-Purple Group 187-A (Dark red) fruit skin colour; Greyed-Purple Group 187-A (Red) fruit flesh colour; medium fruit stalk length; Greyed-Purple Group 187-B (Red) colour of fruit juice; weakly conspicuous; harvesting on 23rd May.

Stone Characters

Stone weight medium; stone shape slightly elliptic.

Sweet Heart

Tree Characters

Upright tree habit; small tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; large trunk diameter; medium mid length; short internodes; yield 6 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 13th March; leaf blade length medium; width medium; medium length/width ratio; obovate leaf shape; right angled at angle of apex; acute at shape of base; medium petiole length; leaf colour Greyed-Orange Group A (colour of emerging leaves) and Green Group 141-A (colour of matured leaves); orange yellow coloured nectaries

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 15th March; full bloom on 24th March; opening of last flower on 26th March; duration of flowering for 12 days; white coloured flower; intermediate arrangement of petals; broad obovate shaped petals; medium flower diameter; early in maturity.

Fruit Characters

Fruit weight large; fruit length large; width broad; shape oblate; flat pistil end; Greyed-Purple Group 187-A (Dark Red) fruit skin colour; Greyed-Purple Group 187-A (Red) fruit flesh colour; short fruit stalk length; Greyed-Purple Group 187-B (Red) colour of fruit juice; weakly conspicuous; harvesting on 11th May.

Stone Characters

Stone weight medium; stone shape slightly elliptic.

GERMARSDOFER

Tree Characters

Upright tree habit; large tree height; medium tree spread in North-South (N-S) direction and small tree spread in East-West (E-W) direction; large trunk diameter; thin mid length; short internodes; yield 7 kg/tree; yield efficiency 0 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 13th March; leaf blade length medium; width medium; medium length/width ratio; lanceolate leaf shape; acute at angle of apex; acute at shape of base; medium petiole length; leaf colour Greyed-Orange Group B (colour of emerging leaves) and Green Group 141-A (colour of matured leaves); light red coloured nectaries

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 15th March; full bloom on 22nd March; opening of last flower on 24th March; duration of flowering for 10 days; white coloured flower; overlapped arrangement of petals; broad obovate shaped petals; medium flower diameter; early in maturity.

Fruit Characters

Fruit weight large; fruit length large; broad width; shape oblate; flat pistil end; Greyed-Purple Group 187-A (Dark Red) fruit skin colour; Greyed-Purple Group 187-A (Red) fruit flesh colour; short fruit stalk length; Greyed-Purple Group 187-B (Purple) colour of fruit juice; strong fruit juiciness; harvesting on 4th May.

Stone Characters

Stone weight medium; stone shape round.

MERCHANT

Tree Characters

Upright tree habit; large tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; large trunk diameter; medium mid length; short internodes; 2.5 kg/tree yield; 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 15thMarch; leaf blade length medium; width medium; medium length/width ratio; lanceolate leaf shape; right angled at angle of apex; obtuse at shape of base; medium petiole length; leaf colour Greyed-Orange Group B (colour of emerging leaves) and Green Group 141-B (colour of matured leaves); dark red coloured nectaries.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 17th March; full bloom on 24th March; opening of last flower on 26th March; duration of flowering for 10 days; white coloured flower; overlapped arrangement of petals; circular shaped petals; medium flower diameter; early in maturity.

Fruit Characters

Fruit weight small; fruit length medium; width medium; shape cordate; flat pistil end; Greyed-Purple Group 187-A (Dark Red) fruit skin colour; Greyed-Purple Group 187-A (Dark Red) fruit flesh colour; short fruit stalk length; Greyed-Purple Group 187-B (Purple) colour of fruit juice; absent suture; harvesting on 9th May.

Stone Characters

Stone weight medium; stone shape elliptic.

SUNBURST

Tree Characters

Spreading tree habit; medium tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; small trunk diameter; large mid length; short internodes; yield 6.5 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 15th March; leaf blade length short; width medium; medium length/width ratio; obovate leaf shape; right angled at angle of apex; acute at shape of base; medium petiole length; leaf colour Greyed-Orange Group B (colour of emerging leaves) and Green Group 141-A (colour of matured leaves); orange yellow coloured nectaries.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 16th March; full bloom on 23rd March; opening of last flower on 27th March; duration of flowering for 11 days; white coloured flower; intermediate arrangement of petals; broad obovate shaped petals; medium flower diameter; early in maturity.

Fruit Characters

Fruit weight large; fruit length large; width broad; shape reniform; depressed pistil end; Greyed-Purple Group 187-A (Red) fruit skin colour; Greyed-Purple Group 187-A (Red) fruit flesh colour; short fruit stalk length; Greyed-Purple Group 187-B (Red) colour of fruit juice; very weakly conspicuous suture; harvesting on 9th May.

Stone Characters

Stone weight medium; stone shape slightly elliptic.

BIGARREAU NOIR GROSSA

(Plate 6d)

Tree Characters

Upright tree habit; large tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; large trunk diameter; medium mid length; short internodes; yield 4.5 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 17th March; leaf blade length short; width medium; medium length/width ratio; lanceolate leaf shape; acute at angle of apex; obtuse at shape of base; medium petiole length; leaf colour Yellow-Green Group 153-A (colour of emerging leaves) and Green Group 137-B (colour of matured leaves); dark red coloured nectaries

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 19th March; full bloom on 24th March; opening of last flower on 28thMarch; duration of flowering for 10 days; white coloured flower; intermediate arrangement of petals; broad obovate shaped petals; medium flower diameter; early in maturity.

Fruit Characters

Fruit weight large; fruit length large; broad width; shape oblate; flat pistil end; Red Group 46-A (Yellow with Red Blush) fruit skin colour; Yellow- White Group (creamy) fruit flesh colour; short fruit stalk length; Yellow-Orange Group 20-B (Light Yellow) colour of fruit; very weakly conspicuous suture; harvesting on 9th May.

Stone Characters

Stone weight medium; stone shape slightly elliptic.

CELISOR

(Plate 6e)

Tree Characters

Upright tree habit; large tree height; medium tree spread in North-South (N-S) direction and East-West (E-W) direction; large trunk diameter; medium mid length; short internodes; yield 2.5 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 14thMarch; leaf blade length long; width medium; medium length/width ratio; lanceolate leaf shape; right angled at angle of apex; acute at shape of base; medium petiole length; leaf colour Greyed-Orange Group 152-C (colour of emerging leaves) and Green Group 137-A (colour of matured leaves); dark red coloured nectaries.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 16th March; full bloom on 23rd March; opening of last flower on 26th March; duration of flowering for 11 days; white coloured flower; overlapped arrangement of petals; circular shaped petals; medium flower diameter; early in maturity.

Fruit Characters

Fruit weight large; fruit length large; width broad; shape reniform; pointed pistil end; Greyed-Purple Group 187-A (Dark Red) fruit skin colour; Greyed-Purple Group 187-A (Red) fruit flesh colour; short fruit stalk length; Greyed-Purple Group 187-B (Purple) colour of fruit juice very weakly conspicuous suture; harvesting on 14th May.

Stone Characters

Stone weight medium; stone shapeslightly elliptic.

GUIGNE POURPEA PRECECE

Tree Characters

Semi-Upright tree habit; medium tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; medium trunk diameter; thick mid length; short internodes; yield 3 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 16th March; leaf blade length medium; width medium; medium length/width ratio; lanceolate leaf shape; right angled at angle of apex; obtuse at shape of base; medium petiole length; leaf colour Greyed-Orange Group B (colour of emerging leaves) and Green Group 137-A (colour of matured leaves); light red coloured nectaries.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 18th March; full bloom on 25th March; opening of last flower on 28th March; duration of flowering for 11 days; white coloured flower; overlapped arrangement of petals; circular shaped petals; medium flower diameter; mid in maturity.

Fruit Characters

Fruit weight large; fruit length large; broad width; shape cordate; flat pistil end; Red Group 46-A (Yellow with red blush) fruit skin colour; Yellow-White Group(creamy) fruit flesh colour; short fruit stalk length; Yellow-Orange Group 20-B (Light Yellow) colour of fruit juice; weakly conspicuous suture; harvesting on 16th May.

Stone Characters

Stone weight medium; stone shape slightly elliptic.

TRIUMPH DOMINI

Tree Characters

Semi-Upright tree habit; large tree height; small tree spread in North-South (N-S) direction and East-West (E-W) direction; large trunk diameter; medium mid length; short internodes; yield 7 kg/tree; yield efficiency 0.01 kg/cm^2 of TCSA.

Foliage Characters

Bud burst on 13th March; leaf blade length medium; width medium; medium length/width ratio; obovate leaf shape; right angled at angle of apex; obtuse at shape of base; short petiole length; leaf colour Greyed-Orange Group B (colour of emerging leaves) and Green Group 141-A (colour of matured leaves); light red coloured nectaries.

Floral Characters

Bears on spurs, one and two year old shoot; opening of first flower on 16th March; full bloom on 23rd March; opening of last flower on 25th March; duration of flowering for 10 days; white coloured flower; overlapped arrangement of petals; broad obovate shaped petals; medium flower diameter; early in maturity.

Fruit Characters

Fruit weight small; fruit length medium; width medium; shape cordate, flat pistil end; Greyed-Purple Group 187-A (Dark Red) fruit skin colour; Greyed-Purple Group 187-A (Dark Red) fruit flesh colour; soft fruit firmness; medium fruit stalk length; Greyed-Purple Group 187-B (Purple) colour of fruit juice; suture absent; harvesting on 4th May.

Stone Characters

Stone weight small; stone shape slightly elliptic.

Chapter-5

SUMMARY AND CONCLUSION

The results obtained from the present study entitled, **"Characterization and evaluation of different varieties of sweet cherry (*Prunus avium* L.)**" for twenty different sweet cherry varieties are summarized and concluded as under:

5.1 Maximum tree height was recorded in Celisor (5.01m) and minimum in Glory (2.73 m). Maximum value of tree spread in N-S direction was recorded in Celisor (3.16 m) and minimum value in Glory (1.30 m). Maximum tree spread in E-W direction was recorded in Germarsdofer (3.33 m), whereas; minimum value was only 1.13m in Glory. Maximum trunk diameter was recorded in Desna (36.50 cm) and minimum in Glory (15.36cm). Thickness of mid length of internodes in all the twenty sweet cherry varieties studied ranged between 4.89 mm in CITH-1 and 2.88mm in Germarsdofer. Length of internodes was recorded maximum in Lambert (26.87 mm) and minimum in Sunburst (14.02 mm)

5.2 Earliest time of bud burst was observed on 10th March in Desna and last in Lambert on 18th March. Maximum value of leaf length was recorded (20.30 cm) in Celisor and minimum (12.30 cm) in CITH-3. Leaf width was recorded maximum 8.13 cm in CITH-12 and minimum was recorded (5.80 cm) CITH-8. The value of length/width ratio was found to be highest in Desna (2.89), whereas, lowest value in CITH-13 (1.90). Maximum petiole length was (4.80 cm) in Desna and minimum was (2.67 cm) in Triumph Domini. Leaf area among different sweet cherry varieties varied between 41.05 cm^2 to 83.06 cm^2.

5.3 Among different sweet cherry varieties earliest flower initiation was observed on 13th March in Desna whereas, last was observed on 21st March in Lambert. Earliest full bloom was observed on 21st March in Desna, whereas, last on 26th March in Lambert. In terms of date of opening of first flower 23rd March was observed earliest and last flower was observed to open on 29th March in Lambert. The longest duration was recorded as 12 days in CITH-4, CITH-5, CITH-8, CITH-15 and shortest 9 days in Lambert. The flower diameter was found to be highest in CITH-8 (3.61 cm) and lowest in Lambert (2.89 cm).

5.4 Heaviest fruits were found (10.74 g) in CITH-4 and lightest (1.37 g) were observed in CITH-15. Maximum fruit length and width was recorded in Glory (26.49 mm & 27 mm)) whereas, minimum in CITH-15 (15.56 mm & 15.04 mm). Length of fruit stalk varied from 51.74 mm in Triumph Domini to 29.7 mm in CITH-15.

5.5 Maximum stone weight (0.53 g) was observed in Desna and minimum (0.22 g) in Triumph Domini. Stone length ranged from (10.11 mm) in Triumph Domini to (12.89 mm) in Desna. Maximum width for stone was recorded in Desna (12.72 mm) and minimum in Triumph Domini (7.49 mm). Maximum pulp/stone ratio was found in Glory (28.51) and minimum in CITH-15 (3.01).

5.6 Highest TSS content was found in CITH-16 (21.04°Brix) and lowest in Germarsdofer (12.70°Brix). Highest acidity was recorded in CITH-1 (0.48 %) and lowest in CITH-8 and CITH-15 (0.20 %). Maximum total sugars content was observed in CITH13 (12.78 %) and minimum in Glory and Sweet Heart (8.46 %). Reducing sugars varied from Germarsdofer (6.44 %) to Glory (3.70 %). Maximum content of non-reducing sugars was 7.16 per cent in CITH-13 whereas lowest 3.50 per cent was observed in CITH-16. The highest sugar/acid ratio was recorded in CITH-13 (49.76) and lowest in Sunburst (22.41).

5.7 Maximum fruit yield was found as 7 kg/tree (Germarsdofer) whereas, minimum as 2.2 kg/tree (Lambert). Maximum yield efficiency was (0.013 kg/cm^2) in Sunburst and minimum (0.001 kg/cm^2) in CITH-3. Number of days from full bloom to harvest ranged from 43 days in Triumph Domini to 61 days in CITH-16. Time of harvesting ranged from 4th May in Germarsdofer and Triumph Domini to late 23rd May in CITH-4, CITH-5, CITH-8, CITH-15, and CITH-16.

CONCLUSION:

On the basis of results obtained in the present investigation, it can be concluded that some of the cherry varieties do possess horticulturally desirable characteristics (given below). This information can be used for future research and by breeders for developing new cultivars with optimal characteristics. The descriptive database can afford the opportunity to create an update reference to germplasm and will help in DUS testing of varieties.

Thus, the descriptive database developed will help in DUS testing. Following are some sweet cherry varieties with distinguishing character:

Early maturity	CITH-1, Desna, Sweet Heart, Germarsdofer, Merchant, Sunburst, Bigarreau Noir Grossa, Celisor and Triumph Domini.
Large sized fruits	Glory, Bigarreau Noir Grossa, Merchant, CITH-3, CITH-4, CITH-5, Desna CITH-8, CITH-12, CITH-13, CITH-16, Glory, Sweet Heart and Sunburst.
High TSS	CITH-5, CITH 8, CITH 15, CITH-16, Desna, Glory and Celisior.
Dark red colored	CITH-1, CITH-3, Glory, Sweet Heart, Germarsdofer, Merchant, Celisor and Triumph Domini.
High pulp stone ratio	Glory
High sugar acid ratio	CITH 13, CITH 8 and CITH 15

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APPENDIX-I

ANOVA for tree characters of sweet cherry varieties

Source of variation	df	Tree height (m)			Tree spread in N-S direction (m)			Tree spread in E-W direction (m)			Trunk diameter (cm)			Mid Length Thickness (mm)			Length of internode (mm)		
		SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F
Treatment (T)	2	0.915			0.829			0.068			76.285			1.681			4.71		
Replication (R)	19	28.215	1.485	3.807	9.608	0.506	1.814	15.536	0.818	4.423	2020.21	106.327	3.15	17.857	0.94	2.248	553.158	29.114	2.132
T x R	38	14.823	0.39		10.591	0.279		7.026	0.815		1282.54	33.751		15.884	0.418		518.867	13.654	
Total	59	43.953			21.028			22.63			3379.04			35.442			1076.74		

ANOVA for foliage characters of sweet cherry varieties

Source of variation	df	Leaf length (cm)			Leaf width (cm)			Leaf length/width ratio			Length of petiole (cm)			Leaf area (cm^2)		
		SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F
Treatment (T)	2	23.256			2.061			0.028			0.05			49.822		
Replication (R)	19	223.7	11.774	32.756	27.89	1.468	7.899	2.795	0.147	4.258	15.723	0.828	3.982	609.94	320.892	91.205
T x R	38	13.659	0.359		7.061	0.186		1.313	0.035		7.896	0.208		133.697	3.518	
Total	59	260.615			37.013			4.135			23.67			6280.46		

ANOVA for flower characters of sweet cherry varieties

Source of variation	df	Flower diameter (cm)		
		SS	MS	F
Treatment (T)	2	0.114		
Replication (R)	19	2.597	0.137	16.245
T x R	38	0.32	0.008	
Total	59	3.031		

ANOVA for fruit characteristics of some sweet cherry varieties

Source of variation	df	Fruit weight (g)			Fruit length (mm)			Fruit width (mm)			Length of fruit stalk (mm)		
		SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F
Treatment (T)	2	0.341			143.85			181.438			7.825		
Replication (R)	19	346.265	18.224	326.276	421.829	22.202	8.237	660.247	34.75	8.026	1802.83	94.886	64.442
T x R	38	2.123	0.056		102.422	2.695		164.533	4.33		55.32	1.461	
Total	59	348.728			668.101			1066.22			1866.18		

ANOVA for stone characters of sweet cherry varieties

Source of variation	df	Stone weight (g)			Stone length (mm)			Stone width (mm)			Pulp: stone		
		SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F
Treatment (T)	2	0.102			0.4			0.089			12.513		
Replication (R)	19	0.238	0.013	7.865	47.386	2.494	113.86	178.958	9.419	284.163	186.326	98.066	35.604
T x R	38	0.06	0.002		0.832	0.022		1.26	0.033		104.667	2.754	
Total	59	0.4			48.618			180.306			1980.44		

ANOVA for bio-chemical characters of sweet cherry varieties

Source of variation	df	TSS (°B)			Titratable acidity (%)			Total sugars (%)			Reducing sugars (%)			Non-reducing sugars (%)			Sugar: acid ratio		
		SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F
Treatment (T)	2	1.402			0.087			8.461			0.063			0.101			49.038		
Replication (R)	19	481.205	25.327	53.859	11.118	0.585	13328.64	85.526	4.501	16.788	47.131	2.481	335.252	98.278	5.173	321.502	4144.87	218.151	53.404
T x R	38	17.869	0.47		0.002	0		10.189	0.268		0.281	0.007		0.611	0.016		155.227	4.085	
Total	59	500.476			11.207			104.176			47.475			98.99			4349.13		

ANOVA for fruit yield and maturity characters of sweet cherry varieties

Source of variation	df	Fruit yield (kg/tree)			Fruit Yield Efficiency%		
		SS	MS	F	SS	MS	F
Treatment (T)	2	21.169			0.000		
Replication (R)	19	183.830	9.675	11903.079	0.001	0.000	1.209
T x R	38	0.031	0.001		0.001	0.000	
Total	59	205.030			0.002		

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ABSTRACT

The present investigation entitled **''Characterization and evaluation of different varieties of sweet cherry (*Prunus avium* L.)''** was carried out at Regional Horticulture Research and Training Station, Mashobra, Shimla (HP) during the years 2021 and 2022. The twenty sweet cherry varieties viz., CITH-1, CITH-3, CITH-4, CITH-5, CITH-8, CITH-12, CITH-13, CITH-15, CITH-16, Desna, Lambert, Glory, Sweet Heart, Germarsdofer, Merchant, Sunburst, Bigarreau Noir Grossa, Celisor, Guigne Pourpea Prececе and Triumph Domini were evaluated for the vegetative, floral and fruiting characters. The sweet cherry varieties under study showed variations for different vegetative, floral, and fruiting characters. Among different tree characters, tree habit was observed upright, semi-upright and spreading. Maximum tree height (5.01 m) in Celisor, trunk diameter in Desna (36.50 cm) and length of internodes in Lambert (26.87 mm) was recorded during the study period. The time of bud burst varied from 10th March in Desna and 18th March in Lambert. Longest leaves were found in Celisor (20.3 cm long and 8.1 cm wide). Full bloom varied from 21st March to 26th March. Maximum fruit yield recorded as 7 kg/plant in Germarsdofer and Guigne Pourpea Prececе and minimum as 2.2 kg/ha in Glory. Heaviest fruit was found 10.74 g in CITH-4 and smallest 1.37 g in CITH-15.Maximum pulp/stone ratio recorded in Glory (28.51) while minimum in CITH-15 (3.01). Maximum TSS content was recorded inCITH-16 as 21.04°Brix, whereas, minimum (12.70°Brix) was found in Germarsdofer. Maximum total sugars content was recorded in CITH-13 (12.78 %), whereas, minimum in Glory and Sweet Heart (8.46 %). On the basis of results obtained in the present investigation, it can be concluded that some of the cherry varieties do possess horticulturally desirable characteristics and the information can be used for developing new cultivars with optimal characteristics. The descriptive database can afford the opportunity to create an update reference to germplasm and will help in DUS testing of varieties.

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