STUDIES ON LOW CHILL APPLES (*Malus* × *domestica* Borkh.) IN SUB-MOUNTAIN ZONE OF HIMACHAL PRADESH

Thesis

by

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CERTIFICATE-I

This is to certify that the thesis titled, **"Studies on low chill apples (*Malus* × *domestica* Borkh.) in sub-mountain zone of Himachal Pradesh"** submitted in partial fulfillment of the requirements for the award of the degree of **Doctor of Philosophy Fruit Science** in the discipline of **Horticultural Sciences** to Dr. Yashwant Singh Parmar University of Horticulture & Forestry, (Nauni) Solan (HP) - 173 230 is a bonafide research work carried out by **Mrs. Meena Kumari (H-2015-10-D)** daughter of Shri. Tulsi Ram, 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.

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CERTIFICATE - II

This is to certify that the thesis titled, **"Studies on low chill apples (*Malus* × *domestica* Borkh.) in sub-mountain zone of Himachal Pradesh"** submitted by **Mrs. Meena Kumari (H-2015-10-D)** daughter of Shri Tulsi Ram to the Dr. Yashwant Singh Parmar University of Horticulture and Forestry, (Nauni) Solan (HP) – 173 230 in partial fulfillment of the requirements for the degree of **Doctor of Philosophy 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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ABBREVIATIONS

%	:	Per Cent
°Brix	:	Degree Brix
cm	:	Centimetre
cm^2	:	Centimetre Square
Cvs.	:	Cultivars
et al.	:	Et Alia (co worker)
g	:	Gram
i.e.	:	Id Est (that is)
Kg	:	Kilogram
m	:	Metre
mg	:	Milligram
ml	:	Millilitre
mm	:	Millimetre
N	:	Normality
No	:	Number
TA	:	Titratable acidity
TSS	:	Total Soluble Solids
viz.	:	Videlicet (namely)

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Chapter-1

INTRODUCTION

Apple is one of the world's leading fruit crop widely grown, both in the Northern and Southern hemisphere. China being the largest producer out of 32 major apple producing countries of the world, followed by Turkey, United States, Poland and India. India ranks 5th in world with apple production. Apple belongs to family Rosaceae and originated in Asia Minor. Apple breeders exploited prevailing natural broad phenotypic and genetic diversity and selected superior pomological features in order to meet customer demand for novel and delicious apples. Research on existing apple cultivars indicates a strong consumer preference for exceptional sweetness, crispness, and juiciness (Amyotte *et al.* 2017).

The use of apples and apple juice products is becoming increasingly widespread, and their rich phytochemical profile indicates that they may have a significant impact on the health of the populations that consume them. Exposure to apples and apple products has been associated with beneficial effects on risk, makers and etiology of cancer, cardiovascular illnesses, Alzheimer's disease, and asthma. Additionally, these products may lead to better results in terms of diabetes, weight control, bone health, lung function, gastrointestinal protection, and the cognitive decline of normal aging (Hyson, 2011).

In India, apple is an important temperate fruit crop in India in term of acreage, production, economic value and popular among the society as it is the most important deciduous fruit tree. The major area under commercial apple cultivation falls in north-western hilly states Jammu & Kashmir, Himachal Pradesh and Uttarakhand. Although India ranks 5th in apple production in the world but the productivity is low compared to many advanced countries. Area under apple cultivation in India is 313 000 hectares (ha) with a production of 2 437 000 metric tonnes (MT) (Anonymous, 2022).

Apple has become number one commercial fruit crop in Himachal Pradesh, and is grown over an area of 1,15,680 ha with a production of 6,72,343 MT (Anonymous, 2023). The most widely grown commercial apple cultivars belong to Delicious group, which constitutes 90% of the apple plantations in H.P. (Jindal and Mankotia, 2004). However, under the changing climate scenario, these varieties started declining due to various biotic and abiotic stresses. Many production and protection problems took serious dimension in apple

production leading to low productivity. Under the changing climatic conditions, these varieties did not perform satisfactorily in lower pockets or valley areas of the state especially with respect to colour development. These cultivars are now being replaced in a phased manner with low chill cultivars and high colour strains.

Himachal Pradesh is a hilly state in the North-Western Himalayas with a wide range of agro-climatic conditions and an elevation of 350 to 7000 meters above mean sea level. Apple trees require cool climate for their proper growth and development, they require certain minimum chilling periods for their satisfactory growth and fruiting. Buds of apple trees may not open or blossoming may be uneven if their chilling requirements are not met. This chil1ing process takes place at temperature below 7^0C. Most apple varieties need to experience such temperature for about 1200 hours in order to achieve complete and adequate dormancy. These temperatures are prevalent in the temperate regions but some varieties can manage with as little as 250 hours of chilling, these varieties can be grown successfully in tropical and subtropical zones on high mountains where the altitude provides the necessary cold climate (Kanwar, 1987).

In order to retain the commercial significance of apple fruit in the sub-mountain zone and to achieve good fruit production, it is feasible to use low chill varieties like Anna that are more adaptable. (Nautiyal . 2020).

The advent of low chill genotypes made it possible to grow apples in the warmer climates also. Several tropical countries are now well known to grow apples such as Brazil, Thailand, Indonesia, Guatemala, Chile and many others. As much there is vast scope to augment apple production in India through its cultivation in non conventional areas to meet not only demand of fresh market but also to meet the need of processing units. In Himachal Pradesh too, attempts have been made to grow low chill apples like Anna, HRMN-99, Michal Shlomit etc. in the sub-mountain region below 700 metres above mean sea level. In recent years, considerable apple plantations have come up in districts of Bilaspur, Hamirpur, Kangra and others. Some farmers in warm areas of Bilaspur, Mandi, Kangra, Hamirpur, Solan and Sirmour districts, have started growing traditional varieties of apples but the taste of apples grown here fails to match the quality of those grown in colder areas to warmer and marginal areas. These varieties perform well in warm areas. Farmers from lower areas of Himachal Pradesh for long had been demanding the introduction of low chilling varieties suitable for cultivation in this zone to diversity fruit growing in lower areas. However, the systematic

research to determine the potential of apple cultivation in hot climates representing these districts is lacking. There is also urgent need to develop on the spot database on cultural management practices being followed by the apple growers in lower hills. Low-chilling varieties can expand the scope of apple with around 300 hrs of chilling temperature. To grow apples successfully in areas experiencing mild winters like low Shivalik foothills, these apple varieties have been introduced. It is expected to change the economy of lower areas that were deprived of the apple cultivation so far. In view of the above, it was proposed to undertake field surveys of apple plantations in the lower hills particularly three districts namely Bilaspur, Hamirpur and Kangra to evaluate their performance with the following objective:

Objectives:

i) To evaluate existing apple plantations for growth, yield and fruit quality

ii) To determine status and potential of apple cultivation in the lower hills

Chapter-2

REVIEW OF LITERATURE

Present investigations **"Studies on low chill apples (*Malus* × *domestica* Borkh.) in sub-mountain zone of Himachal Pradesh"** were aimed to study the flowering, pollination, fruit set, yield and fruit quality parameters of low chill apples. Different workers have quoted the importance of various characters. The available literature pertaining to the present studies on various aspects in apple is briefly reviewed under the following heads:

2.1 Flowering, pollination, fruit set and yield

2.2 Fruit quality

2.1 FLOWERING, POLLINATION, FRUIT SET AND YIELD

Rome Beauty and Galia Beauty were described as late flowering cultivars by Fred and Freeman (1942).

Griggs and Iwakiri (1977) assessed various low chill pear cultivars in California and reported that TsuLi required eight days to blossom, Nijisseiki, Chojuro and YaLi took seven days whereas, Shinseiki required at least five days to reach the full bloom stage further study revealed that the physical fruit characters in terms of fruit length ranged from 54 mm to 86 mm, in diameter from 66 mm to 93 mm, and in weight from 146 g to 390 g. Asian pears vary in shape from globular to oblate in Shinseiki, round to oblate in Nijisseiki, oblate to asymmetrical in Chojuro, and turbinate to acute pyriform in YaLi whereas, the skin color was yellow in Shinseiki, yellow green in Kikusui, greenish yellow in Nijisseiki, greenish brown to brown in Chojuro, light greenish yellow in YaLi, and light green to yellow green in TsuLi. Shinseiki harvested first, in July, and Okusankichi harvested last, in October. According to further study they reported that the stalk length was 1.9 cm in Shinseiki and 3.8 cm at its greatest in Okusankichi. The fruit quality was determined to be fair in four kinds, good in two, good to very good in two, fair to good in one, and good to exceptional in four varieties. According to reports, the highest firmness was 10.9 lbs in Chojuru while the least was 6.4 lbs in Kumoi.

Crocker and Sherman (1977) concluded that cross-pollination with Dorsett Golden and FL1W22 resulted in good fruit set for the Anna apple cultivar.

Kahlon and Chhatwal (1978) studied the fruit set in three peach cultivars viz., Floridasun, Peshawari Gola, Sunred. In cross pollination studies, the highest percentage (100%) of fruit set was recorded by using pollen of Floridasun on both the other cultivars and lowest (80%) by Sunred with Peshawari Gola.

The early-maturing apple cultivar 'Vered' (yellow green, red brush, creamy-white flesh) was found to be suitable for cultivation in the foothills due to its low chilling requirement of 250 hours at or below 7°C and yielded a profitable crop in the third year (Dadlani *et al*. 1980).

According to Huang and Powell (1982), cultivars Bevery Hills and Ein Shemer with low chilling requirements were sensitive to heat treatment for two hours at 39°C after cold storage at 4°C. The growth of terminal and lateral bud was promoted whereas in cultivars Marin Onfroy, Delicious, Northern Spy and Cross Bios with high chilling requirements were not stimulated into growth by heat treatment.

Gautam and Chauhan (1986) worked on some low chilling apple cultivars for four years and observed that Tropical Beauty had the highest yield (69.09 kg), whereas, Early Shanburry performed poorly and cropping efficiency was highest in Parlins Beauty and lowest in Early Shanburry. According to further study cultivar Yellow Newton having highest fruit weight (210 g) and fruit size whereas lowest was found in cultivar Early Shanburry (114 g). Among all the low chilling cultivars firmness of fruits was very high, (17.8 to 22.8 lb^2) except Tropical Beauty (15.01 lb^2). In low chilling cultivars Sharp's Early, Gallia Beauty and Parlin's Beauty mostly used for (more than 60 %) of juice processing purpose.

Khajuria *et al*. (1984) examined the performance of low chilling white fleshed peach cultivars in Punjab conditions, and found that the Ranjit Bagh cultivar showed earliest ripening and matured in the second week of May.

Tembwe and Arnold (1985) observed that apple cultivars Anna, Ein Shemer and Dorsett Golden have strong potential for Malawi, both smallholder and commercial production. Cultivar Anna had fifty per cent external red blush with the same shape and superior flavour of cv. Red Delicious having 5 to 7 cm fruit diameter. Aguila (1986) reported seven apple mutants with low chilling requirement with better characters then parents such as

larger fruits, earlier flowering, high percentage of vegetative bud break and high soluble solid content in fruit.

According to Bist and Sharma (1986) the maximum (27.04 %) flower opening recorded in some low chill apple varieties occurred between 12:00 noon and 2:00 pm and further study they revealed that flowering durations varied from ten days in Tamma and Golden Delicious to 17 days in Sharp's Early and Parlin's Beauty.

Subhadrabandhu and Punsri (1987) observed overall growth of forty five varieties for five growing seasons in highland areas of northern Thailand. Low chilling varieties such as Anna, Ein Shemer and Dorsett Golden flowered readily and fruit set was satisfactory. However, fruit set of Anna was much better if cross pollination with Ein Shemer.

Armas Reyes *et al*. (1987) studied the performance of ten-year-old Anna apples on various rootstocks for their adaption to Mexico and found that trees on M26 were smaller than those on M7 and MM111. On every rootstock, yields were modest having equal fruit firmness, although M7 and MM 111 had the biggest fruit sizes. The fruit had a limited shelf life and reaching the climacteric stage after eight days at room temperature after harvest, fruit acidity was high and sugar content was low.

Kumar (1988) observed maximum fruit set in cross pollination whereas, minimum with hand self pollination.

Williams and Menegazzo (1988) studied the low chill apple cultivars such as Anna, Maayan and Dorsett Golden in the highlands of Guatemala USA at lower elevations above 1400 meters and below 2000 meter and observed that these cultivars bloom in January and February and having a harvest in April and May whereas, Anna did not produce well at higher elevations because of the forest. Low chilling cultivars, such as Anna, VC-I, and Dorsett Golden, performed well and were recommended for growing at intermediate altitudes (500 m a.m.s.l) in Venezuela (Monteverde, 1989).

Gautam *et al*. (1990) carried out studies on low chill apple cultivars Anna and Vered (8 year old trees) in 1998-1989 and reveled that these varieties were suitable for Pakhribas Nepal conditions and yielded 0.63 and 1.2 t/ha in the month of late May and June.

Aswapati and Uthaibuthra (1990) at Royal AngKhang Station in Northern Thailand assessed different low chill pears for their fruit characteristics. The firmness of the flesh ranged from 6.4 kg/cm^2 in KoSui to 18.50 kg/cm^2 in RedPear, which was considered to be firmer than Patharnakh (14.29 kg/cm^2). The fruit weight of RedPear was highest i.e. 428.25 g, while KoSui had the lowest weight i.e. 120 g. Most of the cultivars had greenish yellow with yellowish shade flesh colour except RedPear which had yellowish red flesh colour.

Khokhar and Agnihotri (1990) evaluated the performance low chilling peach cultivars in Himachal Pradesh and noted that significantly maximum tree height (500 cm) was found in cv. Early Amber followed by Flordasun (470 cm), while Bonita had the lowest tree height (360 cm) and cultivar Bonita blossomed last (12th March), whereas the cultivars Flordared (23rd February), Shan-i-Punjab (2nd March), and Flordasun (3rd March) were the earliest starting flowering.

Verheij (1990) observed that in the tropical conditions of Netherlands, apple reverts to a shrub when unattained due to the faded feedback control between shoot and root, leading to vigorous new ground shoots. High chilling cultivars have a more pronounced shrub habit and cleistogamy. Low chilling cultivars, better adapted to tropical conditions, grow and fruit more in accordance with high latitude patterns. For example, low chilling apple cultivar Anna does not bear satisfactory fruit in the tropics without cross pollination or parthenocarpic fruits. It branched more freely and maintained the sapstream in the branch.

Elshebini *et al.* (1991) studied the floral biology of three apple cultivars Anna, E-25, Dorsett Golden, the findings revealed that E-25 was earliest and Anna was last to flower among the three cultivars.

Barahona (1992) while studying the 50 apple cultivars grafted mainly on MM.106 in the subtropical zone, reported that low chill apples such as Anna, Dorsett Golden and Slor grew well with lower chilling requirement i.e. 200-500 h.

According to a comparison drawn by Chanana *et al*. (1992) on the flowering studies of low chill peach introductions viz., TA-170, 3-2, 5-12 and Flordasun at PAU study reported that the date recorded on flowering ranged from 21st January to 8th February.

Blasse and Hofmann (1993) classed apple cultivars according to their flowering patterns as early, mid early, or mid late and found that the average flowering time was 11 days, regardless of cultivar.

According to Sharma and Bist (1993), the Winter Banana and Parlins Beauty showed full flowering on March 14th, whereas the Galia Beauty flowered on April 3rd. Further data on weather parameters during their blooming time had a maximum temperature of 21-29 ^{0}C to minimum temperature of 2.5–11.5^{0}C with relative humidity ranged from 21-78 percent and 0-9.30 hours total sunshine each day and 16.20 mm of rainfall in Nauni (Solan) conditions of Himachal Pradesh.

Dashad and Sharma (1993) compared the fruit set under various modes of pollination and reported that mean fruit set of seven cultivars was higher with open pollination (21.41 to 23.24 %) than with caging to exclude insects (0.75-0.82 %). Arafat (1994) obtained 19 to 53 per cent fruit set when apple cultivar Anna was cross pollinated with Bircher, Dorsett Golden and Ein Shemer, whereas open pollination resulted in lower fruit set (5 to 7%) as compared to cross pollination.

Badiyala and Lakhanpal (1994) assessed five low chilling peach cultivars viz. Bonita, Early Amber, Flordared, Flordasun, and Shan-i-Punjab and observed that cv. Flordared had an earlier full bloom on February 8th, while cv. Bonita had the last one on March 12th under Poanta valley conditions of Himachal Pradesh.

Sandhu *et al.* (1994) carried out extensive survey and studied the various fruit characters of pear growing areas of Punjab and adjoining states, they concluded that the fruits of the Red Blush variety were slightly larger (7.9 x 6.1 cm) compared to those of the Punjab Gold (7.8 x 6.0 cm) and the Punjab Nectar (7.7 x 6.0 cm). The highest fruit weight recorded was 139.7 g in Punjab Gold, followed by Red Blush at 134.5 g and Punjab Nectar at 132.0 g. LeConte had the lowest fruit weight, weighing 93.9 g. The highest juice percentage (48.3%) was found in Punjab Nectar, followed by Red Blush (44.2%), Punjab Gold (43.2%), and LeConte (36.3%).

Bepete and Jackson (1995) conducted research at an elevation of 1630 meters in Marondera, Zimbabwe having only 417 hours of annual temperature below or equal to 7.2°C. Low chilling apple cultivars Anna, Maayan, Michal, and Elah on MM I06 rootstock were

found precocious and cropped heavily. They produced an abundance of flowers early in the spring, thus there was obviously no need for use of dormancy breaking sprays. In all five seasons, Anna flowered first with cultivar Maayan whereas, cultivar Elah and Michal flowered later. Accumulated yield over the four cropping seasons was highest in Elah and Maayan (174 kg and 171 kg) and lowest in cultivars Anna and Michal (156 kg and 122 kg).

In the subtropical region of Egypt, two apple cultivars Stark Adina and Orleans with low to medium chilling requirements produced superior quality fruits than the widely grown commercial cultivar Anna (Shaltout, 1995).

Mcartney and Wells (1995) studied the average fruit weight of Asian pears Nijisseiki and Hosui on seedling *P. pyrifolia* rootstock at Lincoln University's Horticultural Research Area in New Zealand during 1989-1990 and reported that the average fruit weight in Nijisseiki was 75 g whereas, in Hosui it was 152 g per fruit.

Fouad *et al.* (1995) studied the floral bud differentiation and activity of Anna apple trees on various rootstocks and revealed that the process of flower bud initiation and differentiation of low chill apple cultivar Anna was split into nine sequential stages from June 13th, 1990, to March 6th, 1991.

Reighard (1995) observed the flowering characteristics of thirteen Asian pear cultivars in South Carolina and revealed that the Chinese cultivars YaLi and ShinLi flowered the earliest (in March), while the Japanese cultivars Twentieth Century and Chojuro flowered ten to twelve days later.

Panhwar (1995) reveled that in the subtropical region of Sindh province, Pakistan receives 3700-4500 heat units and 100-550 chill units and found Anna and Dorsett Golden to be unsatisfactory for cultivation in this region. Every year cultivar Anna blossomed two weeks prior to Dorsett Golden and during the same period of time cultivar Dorsett Golden produced a few fruits, but they were small in terms of quantity and size. Dormex application also did not help these two cultivars in the synchronizing the flowering period.

Sherman and Lyrene (1996) Tropic Sweet originated from off-selection polycross in between N.J. 38 and Anna that is cross fertilized with Anna and Dorsett Golden but are not self-fertile having medium-sized and sweet flavored fruits. Tropic Sweet is recommended in areas where Anna is acclimatized due to its low requirement for winter chilling.

Witte *et al*. 1996 compared the per cent fruit set under three modes of pollination in eight apple cultivars in Belgium. They found that artificial cross pollination always resulted in maximum fruit set followed by open pollination and self pollination.

Kuden and Ozmetli (1997) studied low chill peach cultivars Elegant Lady, Flavocrest, Maycrest, Redcap, Redhaven, Springcrest, Springlady, and Suncrest under subtropical conditions of Turkey and revealed that Elegant Lady earliest to come in flowering February 16th, followed by Flavocrest and Maygrande on February 21st, and the cultivars Springcrest, Redcap, and Redhaven on March 1st.

Chahill *et al.* (1997) evaluated some exotic low chilling peach cultivars under arid-irrigated conditions of Punjab. The study revealed that maximum fruit yield was recorded in cultivar 9-14 (70.70 kg/ha) and minimum in cultivar Sunlight (37.40 kg/ha). The fruit weight and fruit size was excelled by Florda King (91.40 g and 5.60 x 6.10 cm, respectively). Total soluble solids ranged from 9.30 per cent to 11.22 per cent, while, acidity ranged from 0.61 per cent to 0.97 per cent.

Atawia (1997) conducted a trial in Egypt to investigate pollination (control), bagging only, hand self pollination and bagging ,emasculation and bagging , cross pollination using of pollens of apple cultivars Dorsett Golden, Ein Shemer or Red Volos. It was observed that Dorsett Golden proved to be the most effective pollinizer for Anna as it increased fruit set and fruit retention. Moreover, Dorsett Golden pollen improved fruit quality compared with open pollination. Further, cytological studies indicated that Dorsett Golden and Calleryana had more regular chromosome behavior then the other tested pollinizers during meiosis and that their pollen grains were highly viable.

Szabo *et al*. 1997 under Hungary conditions found that cross pollination produced reliable fruit set in the apple cultivars investigated. However, fruit set was poor in Jonagold under high temperature.

Nikolic and Milutinovic (1998) examined the floral characteristics of pear hybrids at Yugoslavia and found that Butirra was the last to flower (8th April) and I/14 showed earliest flowering (5th April) whereas, earliest full bloom was observed in the month of April 8th in V/15 and April 12th in Butirra.

Josan *et al*. (1999) evaluated low chilling peach cultivars Flordasun, Flordared, Pratap, Prabhat, Shan-i-Punjab, and Sharbati under arid-irrigated regions of Punjab and reported that Flordasun, Pratap, and Prabhat had the earliest floral initiation, whereas Shan-i-Punjab was the last to initiate flowering. Among all the examined cultivars, the period of full bloom varied between was 8th to 28th February in 1996 and 10th to 28th February in 1997.

Abdel *et al.* (1999) conducted experiment at El Kanater Research Station in Egypt, the flowering period of Dorsett Golden apple was 35-38 days, which coincided with the flowering period of Anna (28-32 days). Flowering period in Ein Shemer was comparably shorter (14-21 days). This period did not completely coincide with the flowering period of Anna. According to further study, the type of parent pollen affected the fruit form of three different apple cultivars. When Anna was crossed with Dorsett Golden, the resulting fruits were flat and round but, when Ein Shemer was employed as the pollinator, the fruits were round and elongated. The best fruit colour was achieved through open pollination when Anna pollinated by Dorsett Golden or Ein Shemer, reddish colourations were noticed on the fruit surface further, study also indicated that more viable seeds per fruit were related to an improvement in fruit quality.

Mamouni (1999) carried out an experiment to find the best pollinator for Anna and the results showed that Dorsett Golden produced 43 % of the fruit set and cultivars Ein Shemer had more than 20 % of the fruit set compatibility.

Sumrah *et al*. (2000) evaluated the performance of low chilling apple cultivars viz.Anna, Tropical Beauty and Ein Shemer at Horticulture Research Station, Soan Valley Pakistan during 1995-1997 and revealed that cultivar Anna was recommended for early maturity (2nd week of July) having significantly larger fruits (7.67cm length, 7.1cm diameter and 138.67g weight) with good colour as compared to other cultivars while Tropical Beauty matured in late August having smallest size of fruits (5.19 cm length, 4.53cm diameter 127.67gm). The difference in TSS (°B) was non-significant among all the cultivars.

Agamy *et al*. (2001) revealed that low chill apple cultivars Anna and Dorsett Golden (seven year old) required more heat units to reach full bloom to fruit set.

According to Tosun *et al*. (2001), the fowering time of 14 peach cultivars, including Glohaven, June Gold, Redhaven, and Dixired, varied from March 16th to 26th.

Jana and Sharma (2002) studied pollination in different apple cultivars under temperate climate of Himachal Pradesh and observed that in self-pollinated cultivars maximum fruit set was found in Red Baron (5.76%) and minimum in EC 161286 (2.09%). Whereas cross-pollinated cultivars fruit set was highest in Red Baron crossed with EC 16128 (76.17%) and lowest in EC 161287 crossed with EC 161286 (9.9%). Red Baron resulted in the highest fruit set percentage (55.75%), followed by EC 161287 (47.10%).

Said (2002) revealed that 30-50 ppm Sitofix applied at the full bloom stage was most effective in improving the fruit yield and quality of apple cv. Anna.

Kaul (2002) observed the growth pattern of peach cultivars viz. Pratap, Flordasun and Shan-i-Punjab in Sri Ganganagar, Rajasthan. They recorded a considerable variation in stone weight ranged from 1.08 g in Shan-i-Punjab to 1.89 g in Pratap.

Neelam and Ishtiaq (2002) evaluated fifteen peach cultivars in Pakistan and observed maximum fruit length (5.59 cm) in cultivar Loring and maximum fruit diameter (5.51 cm), fruit weight (83.31 g), stone weight (8.70 g) and pulp to stone ratio (0.27) in cultivar Earli Grande.

Rouse and Sherman (2002) evaluated peach cultivars in South Florida, U.S.A. They observed that cultivars Flordastar and Flordaprince were first to mature (mid April) and were most suitable for commercial production in South Florida, U.S.A.

Singh (2002) studied the semi-soft pear's fruiting behavior at Punjab Agricultural University New Orchard in Ludhiana from 1998 to 2001.The range of the pedicel's length variation was 3.35 cm to 4.32 cm. Strain XI had maximum fruit length (7.63 cm) and Strain XII had the minimum (5.62 cm). On the other hand, Strain XV had the maximum fruit width (6.50 cm) and Strain VII had the smallest (5.89 cm) in terms of fruit width. Fruit weight ranged from 125.5 g to 170.1 g, according to their findings. 4.46 kg/cm^2 to 5.42 kg/cm^2 was the range of firmness. Juice percentages were recorded for each strain, with Strain I having the highest proportion (58.07%) and Strain XV the lowest percentage (54.28%).

Kanwar *et al*. (2002) found that Flordaprince bloomed first, with a mean full bloom date of February 10th followed by Flordaglo and Tropical Beauty with mean full bloom dates of February 12th.

Powell (2002) evaluated certain Asian pear types at Alabama A&M University and reported that fruit sizes ranged from small (20th century) to medium (Kosui, YaLi), medium-large (Shinseiki, Doitsu), and large (Shinko, Chojuro). Eight varieties had smooth skin, whereas six had russeted skin. Kosui had brown skin, Housi had green skin, and Shinseiki had greenish yellow skin. Ichiban Nashi was very early to harvest and Korean Giant was the last, while other types were mid-maturing type.

Hernandez (2002) studied the suitability of apple cultivars Anna, Maayan, and Elba as pollinators for Agua Nueva II grafted onto MM106. The results showed that Maayan flowering period overlapped the most with Agua Nueva II, while the fruit set percentages of Anna, Elba, and Maayan were 18.7, 12.9, and 13.4%, respectively.

Jaeger *et al*. (2003) studied six genotypes of *Pyrus* spp. in New Zealand and evaluated by using a multidisciplinary approach. Firmness was recorded maximum (5.4 KgF) in Packham's Triumph followed by Buerre Bosc (4.6 KgF), Pear A (3.5 KgF), Pear B (2.6 KgF) and minimum (0.6 KgF) in Doyene du Comice and fruit weight ranged from 146.5 g (Buerre Bosc) to 252.7 g (Pear B).

According to Bist *et al*. (2003), in the early bearing group, Gola had significantly higher leaf length (14.15 cm), leaf breadth (7.07 cm), and leaf area (14.59 cm^2) than Patharnakh and in the late bearing group, Tumariya had higher leaf breadth and China had the highest leaf length and leaf area.

Dubey (2003) reported 76.30 per cent, 75.13 per cent and 72.19 per cent fruit set in TA-170, Flordasun and Sharbati peach cultivars, respectively in a study conducted in Arunachal Pradesh.

Mohamed (2003) investigated the chilling requirements and effective temperatures for breaking the endodormancy of apple cv. Anna and observed that when chilling period increased from 200 to 600 h, the flower bud break percentage progressively increased.

During 1997-1998, in Southern China the leaf area, morphological makeup, and stomatal density of Asian pear cultivars Huanghua and Jingshiu- II were studied by Xie and Luo (2003) and found that the range of leaf area as varying from 10.75 cm^2 to 35.74 cm^2

Arzani (2004) assessed the fruiting characteristics of a few Asian pear cultivars grafted onto European pear seedling rootstocks in 2002 and reported that the cultivars KS'7, KS'10, and KS'11 mature early (in July), KS'6, KS'13, and KS'14 mid-maturing (in August), and KS'12 (October) and KS'8 (November) late maturing. Different cultivars vary in fruit weight from 145 g to 769 g and pedicel length from 2 cm to 4 cm. Maximum fruit firmness (3.8 kg/cm^2) was recorded in KS13, whereas minimum fruit firmness (1.5 kg/cm^2) was observed in the local cultivar.

Sharma *at al*. (2004) conducted an experiment at Nauni, Solan, Himachal Pradesh, India during 1999-2001 on twelve low chilling 15 years old apple cultivars raised on seedling. The finding reaveled that cultivars Tropical Beauty was found best genotype for the growth characters like plant height (6.60 m), spread (5.67m), and trunk girth (64.50 cm), tree volume (111.20 m^3), leaf area (60.67 cm^2) and fruit set per unit shoot length (15.25 %) in further study they observed that earliest flowering was recorded in Anna and highest yield was recorded in Tropical Beauty (15.82 Kg/plant). Cultivar Parlin Beauty was recorded as promising next to Tropical beauty from many desirable traits whereas high number of flowers per unit shoots length and longest duration of flowering found in cultivar Chahla.

Turyomurugyendro *et al*. 2004 studied fruiting for apple cultivars Anna and Dorsett Golden after two year with 5 kg/tree yield and no significant yield difference was observed at different altitude in Kabale, Uganda climatic conditions.

Pitera and Odziemkowski (2004) studied three Japanese cultivars of Asian pears in terms of growth, yield, and fruit quality at the experimental orchard of Warsaw Agricultural University in Poland during 1999-2003 and reported that the pears Shinseiki, Chojuro, Hosui, and Conference flower from 25th April to 4th May. Study also revealed that Hosui and Conference were more vigorous than Chojuro and Shinseiki. The trunk cross sectional areas of Hosui and Conference were almost 30% larger than those of Chojuro and Shinseiki.

Shyamali (2006) observed that low chill pear Patharnakh produced the highest yield (140.58 kg/tree) and Punjab Gold produced the lowest yield (68.49 kg/tree) of various pear cultivars.

Carter (2007) studied that low chill apple varieties Anna, Dorsett Golden and Ein Shemer performed well in the sub-tropical areas which receive less than 300 hr or no winter

chill. Some other varieties like Pettingill, Yellow Bellflower and Winter Banana adapted well under warm winter climates.

Patel *et al*. 2007 conducted studies in Meghalaya on the physico-chemical traits of local cultivar Meghalaya Local and low chilling peach cultivars TA-170, Flordasun, Shan-i-Punjab, he reported that TA-170 had the highest recorded fruit weight (61.96 g), fruit diameter (4.80 cm), and fruit length (4.83 cm) and pulp to stone ratio (13.83).

Reighard *et al*. (2008) found considerable differences in cumulative yield efficiency (kg/cm^2) amongst Asian pear cultivars in South Carolina and found that Atago had a yield efficiency (4.16) that was more than twice that of Hosui (1.87) while Shinko (3.48) was also yield efficient

Boonprakob (2008) evaluated Thai Tiger^{TM} series of low chilling peaches viz. TXW-1113-1, TXW-1C4, TXW-1490 and TXW-1491-1 in subtropical highland and regions of Thailand. The time of full bloom was recorded from 27thJanuary (TXW-1C4) to 5th February in (TXW-1490 and TXW-1491).

In various sand pear genotypes, Ahmed (2008) studied the time and duration of flowering and found that the highest flowering duration in BG25 (Farashishi) was 22 days, while the minimum flowering duration in RT8 (Btung) and BG23 (Kashmiri nakh) was 12 days.

Dhillon and Shyamali (2008) examined the growth stages of some Asian soft pear types at Department of Horticulture at Punjab Agricultural University in Ludhiana and reported that fruit sizes increased from 1.84 cm x 1.72 cm to 4.12 cm x 4.50 cm in Shinseiki 1.86 cm x 1.82 cm to 4.49 cm x 4.49 cm in Nijisseiki, 1.84 cm x 1.76 cm to 4.94 cm x 5.35 cm in Hosui and 1.65 cm x 1.67 cm to 4.74 cm x 5.21 cm in Kosui from 25 to 122 DAFB. At the time of maturity, all cultivars showed a consistent decline in the number of lenticels/cm^2. While Shinseiki and Nijisseiki reached a comparable level of 122 DAFB, Hosui and Kosui did not exhibit any discernible decline in the number of lenticels beyond 114 DAFB.

Josan *et al*. (2009) evaluated the performance of different low chilling peach cultivars under North Indian conditions and found that Shan-i-Punjab had a maximum fruit weight of 75.50 g, which was higher than the other cultivars under study.

Singh *et al*. (2009) investigated the suitability of low chilling peach cultivars Earlygrande, Flordaprince, Shan-i-Punjab, Flordasun, Prabhat, and Sharbati, for flowering behavior in an irrigated dry ecosystem at Abohar, Punjab and observed that floral duration ranged from 33 to 46 days, with flower initiation started early in Flordasun (23th January) and last in Earligrande (11th February). Furteher study also reaveled that Early Grande produced the heaviest fruits (85.5 g), followed by Prabhat (75.5 g) and Shan-i-Punjab (72.5 g). The largest and smallest fruit sizes (length and breadth) were measured in Prabhat (5.50 × 5.32 cm^2), Shan-i-Punjab (5.68 × 5.10 cm^2), and Florda Sun (4.62 × 4.4 cm^2).

Raina (2009) investigated morphological features to analyze the genetic diversity in pear germplasm and found that Strains I, II, and V and Strain VI had the earliest flowering dates, from February 15th to February 20th. However, strains III and IV showed a delayed start to flowering on February 16th to February 22thunder the climatic conditions of Ludhiana, Punjab.

Low chill pears were evaluated by Kumar *et al*. (2010) for vegetative, reproductive, and fruit quality traits in the Tarai region of Uttarakhand and also studied the flowering durations ranging from 5th February to 21st March and three to five days were observed as the full bloom period for early maturing genotypes from 3th March to the 15th March further, study revealed significant difference in the trunk girth between Patharnakh and Pant Pear-1, Mehal, Kieffer, and LeConte. The maximum trunk girth (56.9 cm) was recorded in Patharnakh, and the minimum (19.3 cm) in Pant Pear-6. Additionally, pear trees (Kieffer) and Mehal) showed drooping type growth habit and the majority of trees (Patharnakh, Smith, Sand Pear, LeConte and Thumb Pear) had an upright growth pattern. According to further study Pant Pear-6 had the highest fruit weight (115.8 g), followed by Pant Pear-3 (113.3 g), and Mehal had the lowest (34.2 g). Fruit width and length ranged from 4.7 cm (Pant Pear-10) to 7.0 cm (Patharnakh) and 4.3 cm (Mehal) to 8.7 cm (China), respectively. Round (Pant Pear-2, Pant Pear) to globose (Pant Pear-7) to pyriform (Pant Pear-1, Pant Pear-3) to pyriform with narrow neck (LeConte) were the fruit shapes that were observed. Pant Pear-3, Pant Pear-6, Tumaria, China, and LeConte had the highest levels of juice, while Pant Pear-13 had the lowest, whereas, highest fruit production (26.5 q/ha) was found in Pant Pear-3, while the lowest (10.2 q/ha) was found in cultivar Mehal. Significant difference was also observed in fruit yield of cultivars Pant Pear-3, Pant Pear-6, Pant Pear-10, and sand pear when compared to Patharnakh.

Hauagge (2010) released a low chill apple cultivar IPR Julieta performed well in sub-tropical climatic conditions having chilling requirement of 100-500 CU, resistant to necrotic leaf blotch disease, commercial fruit quality, highly productive and a suitable pollinizer for Eva.

Meena *et al.* (2011) observed variability in floral characters in peach cultivars under Rajsthan conditions. The cultivar Pratap (7th February) was found to be earliest to flower while Shan-i-Punjab was found to be late in flowering (15th February).

While evaluating the low chill cultivars under mid hill conditions of Himachal Pradesh, Sharma (2011) observed that Pink Lady was earliest among all the cultivars the flower viz. date of bud bust with minimum 12 days duration of flowering and fruit set charecterstics as compared to other cultivars.

Yepthomi (2011) studied the time and duration of flowering in low-chill peach cultivars viz., Tropic Sweet, Saharanpur Prabhat, Earli Grande, Flordaprince, Tropic Snow, Flordaglo, Valle Grande, Tropic Beauty, Pratap and Flordagrande. The flowering period started from 17th of January and extended till 26th February. The longest duration (39 days) of flowering was recorded in cv. Pratap and shortest (28 days) in cv. Tropic Sweet.

According to Kang *et al*. (2011), the shape of leaves varies from elliptical (SuperGold, Chuwhangbae) to narrow elliptical (Manpungbae), with a dentate margin and an acute apex. At the Pear Research Station of the National Institute of Horticultural and Herbal Science in Korea leaf bases of various Asian pear cultivars were observed to range from sharp to spherical.

According to Bhat (2012) fruit weight varied from minimum 7.27g in Kainth to maximum 162.63 g in Patharnakh. He also observed that pear genotypes under investigation had significantly different pedicel lengths and diameters and recorded maximum pedicel length (5.53cm) in YaLi while the minimum (2.32 cm) in Patharnakh whereas, maximum pedicel diameter (1.02 cm) in Patharnakh and the minimum (0.13 cm) in Shaira.

Singh and Bhatia (2012) performed an experiment at Horticulture Research Station Seobag, Kullu and found that apple required average 330 GDD with 4^0C as base temperature from bud bust to petal fall stage.

Yadav *et al*. (2012) found that the Asian pear cultivar Shinsui yielded medium to large fruits, higher juice content with grit cells, dull white flesh color and maturity period was observed to be late in Shinsui (1st September to 15th September).

Tamura (2012) noted differences in fruit weight and firmness in Nijisseiki pears grafted on several rootstocks during 1995 and 1996 under Japanese conditions and reported the range of firmness was 5.02 lbs to 6.10 lbs and 4.97 lbs to 5.10 lbs and fruit weight ranged between 250 g and 317 g. during the year 1995 and 1996, respectively.

Lopes *et al*. 2013 evaluated Princesa apples under semi arid conditions in northeastern Brazil and indicated that phonological cycle was completed in 123 days. According to the present work, cultivar Princesa has potential for apple production under semiarid climate conditions.

Dhillon and Gill (2013) investigated the impact of climate on the hard pear flowering behavior in the Punjab district of Amritsar during the year 2009-2010. The time of initiation of flowering was between 27th February and 2nd March and ended between 21st March to 23rd March while duration of flowering varied from 9 to 20 days.

In Egypt, Sherif *et al.* (2014) investigated the flowering habits of LeConte pear trees and a selected pearclone. The flowering period started from 27th February in selected clone whereas in LeConte, flowering started on 7th March.

Fetena *et al*. 2014 found great potential for apple production in highland climates of Ethiopia. Despite this fact, farm yields are frequently in range 4.2 to 8.3 t/ ha in comparison to 40-60 t/ ha achievable is good growth conditions. Therefore, applied research on agronomic packages for improving productivity, identification of best varieties and sharing information on interventions in production of apple was recommended.

Verma *et al*. (2014) studied 23 genotypes of Kashmiri Nakh and reported significant variations in fruit yield ranging from 190 to 1614 kg/tree, TB-3 (1614 kg/tree) was the genotype with the highest productivity followed by TB-1 (1600 kg/tree) and TB-2 (800 kg/tree), The genotype CHB-1 had a low yield (190 kg/tree)

Miranda *et al*. (2015) resulted that cultivar Princesa compared to Eva showed better fruit production performance under Brazilian semi-arid conditions. Furthermore, nitrogen

doses fertilized through irrigation water have no effect on fruit production of Eva and Princesa apple cultivar.

Castro *et al*. (2016) studied the reproductive behavior in low chill apple cultivars Caricia, Eva and Princesa under warmer zones of Argentina and reported that flowering period ranged between August to October with wide variation and fruit set by cross pollination was high. These cultivars showed partial to self incompatibility.

Melke *et al*. 2016 evaluated three low chill apples (Anna, Dorsett Golden and Princesa) in Central highlands of Ethiopia at Debrebirhan on average lower crop load effects on increased fruit set and quality and early thining increases the overall quality of fruits including fruit size, weigh

Jan (2016) examined the foliage characteristics of several genotypes of sand pear and reported that the base of the leaf was obtuse in 24 selections and right angled in 6 selections. In every genotype under investigation, the leaf apex had an acute shape and the margins ranged from bluntly to strongly serrated.

Ikinci and Bolat (2016) while studying the phenological and pomological charecterstics of six apple cultivars grafted on M9 and MM106 observed that in Anna on M9 full bloom occurred on March 25th and April 7th in cultivar Williams Pride on MM106 and harvesting duration varied from July 10th (Vista Bella/M9) and August 12th (Mondial Gala/MM106). Anna/M9 occupied first position with respect of cumulative yield (167.34 kg/tree) and the yield of fruits per cm^2 of trunk cross-sectional area (3.08 kg/cm^2) in the first nine cropping years.

Walsh *et al*. (2016) recorded the yield and yield efficiency of different Asian pear varieties for sustainable crop production at two sites in Maryland and reported that in Kosui and Shinko yield was observed as varying from 4.2 kg/tree to 23.2 kg/tree whereas, Atago (0.92), Olympic (0.53), Hosui (0.45), and Shinko (1.05) had the highest yield efficiency (kg/cm) and Isiiwase (0.13) had the lowest yield efficiency.

Saito (2016) reported that the fruit weight ranged from 700 g in Niitaka to 500 g in Akizuki, 450 g in Hosui, 400 g in Shinko, and 350 g in Kosui. Fruit shapes varied, with oblate in Nansui, fusiform in Shinko, spherical in Hosui, and orbicular in Niitaka and Kosui

further study also reported that Kosui was an early maturing type, Hosui as mid maturing and Niitaka as late maturing type cultivar of pear.

Pramanick *et al*. (2017) evaluated various apple cultivars and found that Red Delicious had 8.10 days the shortest time from bud burst to first blossom followed by Parlin's Beauty 9.60 days, while Schlomit and Maayan cultivars took 14.20 and 13.20 days, respectively. Tamma and Tropical Beauty completed flowering 7.00 and 7.50 days, respectively, while cultivars Chahla (11.50) and Schlomit (11.00) recorded maximum number of days from the first flower opening to full bloom. The fruit production per plant varied greatly with cultivar Tamma producing the highest yield of 15.80 kg/plant, followed by Early McIntosh and cultivar Red June recorded lower yields of 18.50 kg/tree. On the other hand, cultivar Tropical Beauty had the highest yield of 35.90 kg/plant, while Michael had on par (28.60 kg/plant).

Curi *et al*. (2017) studied the performance of different peach cultivars in tropical climates and revealed that cultivars Bonao and Diamante recorded maximum diameter (7.43 mm) and fruit length (88.93 mm) of fruits, respectively.

Kumar (2017) classified pear cultivars according to their physical characteristics in a study at Punjab Agricultural University, Ludhiana. The range of fruit firmness was 3.41–10.86 kg/cm. The fruit weight of Punjab Beauty was recorded to be highest (166.04 g) followed by Keiffer (147.57 g) and Housi (77.77 g). Fruit diameter and length varied from 51.53 mm (Kosui) to 68.76 mm (Orient) and 46.46 mm (Kosui) to 74.27 mm (Tisuli), respectively. The fruit was oblong to pyriform in Punjab Gold, round in Hosui, turbinate to roundish in Punjab Soft, and round in Punjab Nakh.

Abbas *et al*. (2018) evaluated nine different pear varieties in the Soon Valley region of Pakistan and recorded the fruit yield of each variety. The Barttlet pear had the highest fruit yield (98.80 kg), followed by the Concord (80.20 kg), Pear White (75.20 kg), and LeConte (50.20 kg) pear.

Kaiser and Ernest (2018) studied the low chill pear performance under Kentucy climate conditions and reported that an increase in the production of 50 Asian pear cultivars with 200 to 250 fruits per tree on 7-year-old trees and 500 to 700 fruits per tree on over 10-year-old trees.

Sosna (2018) studied the yield and growth intensity of various Asian pear tree cultivars at the Fruit Experimental Station in Samotwor during the year 2008- 2015, he further reported that yield and yield efficiency varied from 64.6 kg/tree Nijisseiki to 127.6 kg/tree Chojuro and from 1.05 $kgcm^2$ Conference to 3.21 $kgcm^2$ Chojuro, respectively.

Anwar *et al*. (2020) studied the pollination performance in low chill apple cultivars Ein Shemer, E25 and Dorsett Golden under the Egyptian climatic conditions and reported that cultivar Dorsett Golden as the best pollinizer for Anna.

2.2 FRUIT QUALITY

Thirty-two apple cultivars were evaluated by Miller and Baker (1983) at Gainsville and Monticello, Florida (USA) receiving 350-550 chilling hours and found that out of thirty two apple cultivars Anna, Dorsett Golden, Michal, Elah, Maayan, and Schlomit were adapted and had satisfactory fruit quality.

Gautam and Chauhan (1986) found that Tropical Beauty had the lowest titratable acidity (0.32%), whereas Early Shanburry had the highest acidity (1.06%) whereas, highest reducing sugar (7.79%) was found in Galia Beauty and the lowest (6.5%) in Tropical beauty. Similarly, Parlins Beauty and Sharp Early having highest total sugars than Early Shanburry.

Khokhar and Agnihotri (1990) studied five cultivars of low chilling peaches and found that the total sugars content varied from 6.22% in Bonita to 8.2% in Early Amber.

Gautam *et al*. (1990) conducted trails on apples in 1988-1989 and reported that low chill apple cultivar Anna fruits having 6.37% and Vered fruits having 7.07% total soluble solids (TSS).

Badiyala and Lakhanpal (1994) studied fruit quality parameter under Himachal Pradesh conditions and reported that the highest total sugar content (8.50%) was found in cultivar Shan-i-Punjab while the lowest total sugars content (7.10%) was found in Bonita.

Eight Asian pear cultivars were evaluated by Rajapakse and Newall (1995) on the basis of morphological and physiological changes in the southeast United States during maturity and ripening period and noticed that the typical TSS content in ripe fruit varied between 10% and 13%, with Shinko having the lowest and Shinsui having the highest TSS content respectivaly.

According to Singh *et al*. (1997) in low chill peach cultivars Shan-i-Punjab had the highest reducing sugars content (4.40%), while Rochan had the lowest (2.43%). Sharbati had the highest total sugars content (9.44%), while Sunred had the lowest (6.14%).

The quality of Buerre Bosc and Doyenne du Comice pears in Havelock North, New Zealand, was investigated by Elgar *et al*. in 1997. They found that for both cultivars, titratable acidity gradually decreased after ripening, from 0.18 percent to 0.10 percent in Buerre Bosc and 0.17 percent to 0.11 percent in Doyenne du Cornice. However, the concentrations of soluble solids for Buerre Bosc and Doyenne du Comice rose from 10.2% to 11.4 % and 10.5% to 11.7%, respectively.

Kher and Dorjay (2001) evaluated physico-chemical characteristics of some low chilling peach cultivars and reported that cultivar Shan-i-Punjab had the highest TSS (12.1%) and acidity (0.68%) as compared to cultivar Flordasun whereas, TSS:Acid ratio was determined to be lowest in Flordasun (17.14) and highest (19.18) in Flordared. TSS content was reported to vary from 10.5% in cultivar Flordared to 12.1% in Shan-i-Punjab.

Ravi and Tshering (2001) evaluate low chilling peach cultivars with regard to physico-chemical characteristics and noted that total sugars ranged from 7.64 percent in Flordared to 8.35 percent in Shan-i-Punjab; reducing sugars were noted to be 4.12, 4.23, and 3.66% in Flordasun, Shan-i-Punjab, and Flordared, respectively, and non-reducing sugars as 3.93, 4.12, and 3.98 percent in Flordasun, Shan-i-Punjab, and Flordared, respectively under Jammu conditions

Hernandez *et al*. (2002) studied the suitability of apple cultivars Anna, Maayan, and Elba as pollinators for Agua Nueva-II grafted onto MM106. The results showed that Maayan flowering period overlapped the most with Agua Nueva-II, while the fruit set percentages of Anna, Elba, and Maayan were 18.7, 12.9, and 13.4%, respectively.

Wen and Sherman (2002) reported that in peaches, total soluble solids and acidity ranged from 8.20 to 14.90 ºB and 0.13 to 1.40 per cent respectively and the largest fruit with highest fruit weight (124±5g) was obtained in Flordaking.

Sandhu *et al.* (2002) studied the various quality parameters of Asian pear cultivars under Punjab conditions and concluded that the maximum fruit firmness 10.74 lb/inch2 and TSS 12.16% was found in cultivar Shinseiki 10.74 lb/inch2 and TSS (12.16%) whereas Kosui

had the minimum fruit firmness of 7.19 lb/inch2. YaLi having the lowest TSS 10.08% and maximum acid content (0.71%) and minimum in Hosuim (0.21%) among the Asian pears.

Jaeger *et al.* (2003) examined the physico-chemical properties of fruit samples from six distinct pear genotypes, they discovered that the TSS was lowest (10.1°B) in Pear A and highest (13.1°B) in Doyene du Comice, followed by 12.8°B in Packhams Triumph, 12.0°B in Pear B, 10.5°B in Nashi, and 12.0°B in Pear B.

Sharma *et al*. (2004) evaluated fifteen years old 12 low chilling apple cultivars raised on seedling rootstock at Nauni, Solan (HP) during 1991-2001. Tropical Beauty considered the best genotype for the characters like non reducing sugars (1.92%) and total sugars (8.48%) and Parlin's Beauty was the best genotype for the characters like reducing sugars and recorded as a promising next to Tropical Beauty for many desirable traits.At fruit maturity, Dhillon *et al*. (2007) recorded 15.16% TSS evaluated in Punjab Gold and (15.01%) in Punjab Beauty.

Singh (2008) evaluated a few low chill Asian pear varieties in the Punjab climatic conditions. During the fruit's development, the total sugars content increased in Punjab Nectar (2.36% to 11.49%), Punjab Beauty (4.37% to 12.36%), Punjab Soft (2.82% to 11.83%), and Pathanakh (1.64% to 13.96%).

Iglesias (2008) studied the early maturing pear cultivars in Spain varied in their acid level and TSS content. They observed that Precoce di Fiorano had the highest TSS content (15.5°B), while Etrusca recorded the lowest (10.8°B), while acidity ranged from 1.5 g/l to 5.4 g/l.

Khoshghalb *et al.* (2008) conducted research at the Department of Horticultural Science, Tarbiat Modares University (TMU), Tehran, Iran, on the fruit quality characteristics of a few Asian pear fruits in connection to harvest time, ripening, and storage conditions. They found that acidity ranged from 0.16 mg/100 g to 0.43 mg/100 g and TSS varied from 4.9°B to 19.3°B.

Arzani *et al.* (2008) analyzed the physico-chemical properties of one European and two Asian pear varieties in Iran and reported that TSS, acidity, and sugar:acid ratio were found to differ between 13.1°B and 14.1°B, 0.22 % and 0.31 %, and 42.25 and 56.40, respectively.

According to Josan *et al*. (2009) the performance of a few low chilling peach cultivars, Earligrande had the lowest TSS (8.70%) and Prabhat the highest (9.93%). While the least TSS (10.7 ^{o}B) was recorded in cultivar Prabhat. Singh *et al*. (2009) reported the highest TSS content (13.1 ^{o}B) in Flordaprince, followed by Earligrande and Sharbati (11.7 ^{o}B). Maximum acidity was observed in Flordaprince (0.94 %) followed by Earligrande (0.80 %) and minimum in Prabhat (0.31 %).

Sharma (2010) evaluated the nutritional and value-added product potential of sand pear at CSK Himachal Pradesh Krishi Vishvidhyalaya, Palampur, in the Department of Food Science and Nutrition during 2008 - 2010 and found that Total sugars, reducing sugars, and non-reducing sugars were found to be 7.40%, 6.13%, and 1.27%, respectively.

Kumar *et al*. (2010) studied various low chill pears in Uttarakhand and found that total sugars varied from 6.1% in cultivar Mehal to 9.1% in cultivar LeConte. While other germplasm was found to differ greatly from Patharnakh and no significant differences were found between Pant Pear-6, Pant Pear-7, China, and Sand Pear.

Hauagge (2010) released a low chill apple cultivar IPR Julieta that performed well in sub-tropical climatic conditions having chilling requirement of 100-500 CU, resistant to necrotic leaf blotch disease, commercial fruit quality, highly productive and a suitable pollinizer for Eva.

Nine Asian pear cultivars (Atago, Hosui, Isiiwase, Kosui, Olympic, Shinko, Shinsui, YaLi, and Yoinashi) were evaluated for fruit quality criteria by Jurick *et al*. (2015) at the Wye Research and Education Center in Queenstown, Maryland, USA. TSS and acidity varied from 10.9°B to 15.9°B in Atago, and from 0.10% to 0.19% for Kosui and Hosui, respectively

Kumar (2017) studied biochemical characteristics of different pear cultivars at Punjab Agricultural University, Ludhiana and reported that total soluble solids content of varieties ranged from 9.70% (Punjab soft) to 14% (Punjab Beauty), acidity was found to be highest(0.28%) in Orient and lowest (0.15%) in Shinseiki. However, Shinseiki had the highest TSS/acid ratio (89.53) and the lowest (41.07) in "Orient.

Fruit traits are the ultimate deciding factors that determine variation and its adoption by orchardist. Pramanick *et al*. (2017) reported that mean fruit weight ranged from 65.70 g in Red June to 130.40 g in Tropical Beauty. Cultivar Red June although registered lower values

of other fruit traits but had maximum value of TSS content (12.40 ºB) and minimum content was observed in Schlomit (9.30 ºB). They further reported that titratable acidity ranged from 0.22 per cent in Anna to 0.78 per cent in Tamma and total sugars varied from 4.70 to 8.20 per cent and maximum value being obtained for Tropical Beauty followed by Parlin's Beauty (6.55%), while, Anna had minimum (4.70%) total sugars content.

Abbas *et al.* (2018) investigated several pear cultivars Pakistan Soon Valley region under various climatic conditions. The highest titratable acidity (0.44%) was found in Kashmiri Nakh, followed by Kasmiri Nashpati (0.41%) and LeConte (0.29%). The range of the total soluble solids content was 6.60% to 15.80%. The Pear Selection-1 had the highest TSS content (15.80%), followed by Pear White and Bagugosha (15%), while the Kashmiri Nakh had the lowest (6.60%).

In their evaluation of the fruit quality parameters of wild pear fruit at Solan, Dhiman *et al*. (2018) found that the average value of TSS was 12.56°B and the average value of titratable acidity was 1.23%.

Verma and Kushwaha (2018) conducted research in Pantnagar, Uttarakhand to determine the impact of maturation on the physico-chemical characteristics of Gola pear fruit and reported that at mature stages of pear TSS content of 12.33°B and acidity as 0.47% whereas, during the ripening stages TSS content was measured as 14.0°B and acidity was measured as 0.34%. They also reported that the sugar/acid ratio changed from 34.61 to 42.53 throughout the mature to ripe stage.

Necas *et al.* (2020) assessed the pomological and phenological parameters of several Asian pear varieties under middle European conditions. They observed that TSS varied from 11.08 percent in JuLi to 11.62 percent in Kieffer and 15.57 percent in Chojuro and titratable acidity varied among different cultivars, from 0.12% to 0.39%.

Chapter-3

MATERIALS AND METHODS

The present investigations entitled **"Studies on low chill apples (*Malus* × *domestica* Borkh.) in sub-mountain zone of Himachal Pradesh"** were carried out during the years 2017-2018. The details of experimental sites, materials used and methodologies adopted to execute the studies have been described under following heads:

3.1 STUDY AREA

The study was conducted in Bilaspur, Hamirpur and Kangra districts of Himachal Pradesh to study the low chill apple cultivars. The region earmarked for the studies falls under the Humid Sub-Tropical Zone, which stretched from a latitude between 31°35 to 32°59' North and a longitude between 76°44' to 77° 45' East with an elevation ranging from 290 m to 6401 m above mean sea level. The exact place and geographical location of selected low chill apple cultivars are detailed in Appendix I. Morpho-physical and biochemical studies were performed in the laboratories of Department of Fruit Science, College of Horticulture, Dr YS Parmar University of Horticulture & Forestry Nauni, Solan (H.P), India.

3.2 EXPERIMENTAL DETAILS

The studies were carried out on three low chill apple cultivars namely Anna, HRMN-99 and Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh. Plant age of the cultivars was from 6-7 years and each cultivar was selected on the basis of uniform vigour and was maintained under uniform cultural practices during the entire course of investigation. All the three cultivars were planted on seedling rootstock and the orchard was maintained in irrigated condition. A preliminary extensive survey was conducted in each of the three district's selected orchards and interactions was held with farmers to collect feedback information based on a questionnaire, as given below:

SURVEY INQUIRY FORM (QUESTIONNAIRE)

Altitude ----------

Latitude ----------

Longitude ----------

Place/Location ----------

Name of the Farmer/Owner ----------

Cultivar name ----------

No. of plants/cultivar wise ----------

Table 3.1 Locations and low chill apple cultivars selected in Kangra, Hamirpur and Bilaspur Districts of Himachal Pradesh

Code	Detail of Code	Code	Detail of Code	Code	Detail of Code
AK1	A-Anna K-Kangra 1-Dasola	HK1	H-HRMN-99 K-Kangra 1-Dasola	DK1	D-Dorsett Golden K-Kangra 1-Dasola
AK2	A-Anna K-Kangra 2-Dargella	HK2	H-HRMN-99 K-Kangra 2-Dargella	DK2	D-Dorsett Golden K-Kangra 2-Dargella
AK3	A-Anna K-Kangra 3-Manala	HK3	H-HRMN-99 K-Kangra 3-Manala	DK3	D-Dorsett Golden K-Kangra 3-Manala
AK4	A-Anna K-Kangra 4-Naganpatt	HK4	H-HRMN-99 K-Kangra 4-Naganpatt	DK4	D-Dorsett Golden K-Kangra 3-Naganpatt
AK5	A-Anna K-Kangra 5-Bandi	HK5	H-HRMN-99 K-Kangra 5-Bandi	DK5	D-Dorsett Golden K-Kangra 4-Bandi
AK6	A-Anna K-Kangra 6-Dhanotu	HK6	H-HRMN-99 K-Kangra 6-Dhanotu	DK6	D-Dorsett Golden K-Kangra 5-Dhanotu
AK7	A-Anna K-Kangra 7-Razol	HK7	H-HRMN-99 K-Kangra 7-Razol	DK7	D-Dorsett Golden K-Kangra 6-Razol
AK8	A-Anna K-Kangra 8-Bhariyada	HK8	H-HRMN-99 K-Kangra 8-Bhariyada	DK8	D-Dorsett Golden K-Kangra 7-Bhariyada
AK9	A-Anna K-Kangra 9-Gummer	HK9	H-HRMN-99 K-Kangra 9-Gummer	DK9	D-Dorsett Golden K-Kangra 8-Gummer
AK10	A-Anna K-Kangra 10-Shehorpain	HK10	H-HRMN-99 K-Kangra 10-Shehorpain	DK10	D-Dorsett Golden K-Kangra 9-Shehorpain
AH1	A-Anna H-Hamirpur 1-Kuleda	HH1	H-HRMN-99 H-Hamirpur 1-Kuleda	DH1	D-Dorsett Golden H-Hamirpur 1-Kuleda
AH2	A-Anna H-Hamirpur 2-Chakmoh	HH2	H-HRMN-99 H-Hamirpur 2-Chakmoh	DH2	D-Dorsett Golden K-Hamirpur 2-Chakmoh
AH3	A-Anna H-Hamirpur 3-Badgram	HH3	H-HRMN-99 H-Hamirpur 3-Badgram	DH3	D-Dorsett Golden K-Hamirpur 3-Badgram

AH4	A-Anna H-Hamirpur 4-Bhutlar	HH4	H-HRMN-99 H-Hamirpur 4-Bhutlar	DH4	D-Dorsett Golden K-Hamirpur 4-Bhutlar
AH5	A-Anna H-Hamirpur 5-Garli	HH5	H-HRMN-99 H-Hamirpur 5-Garli	DH5	D-Dorsett Golden K-Hamirpur 5-Garli
AH6	A-Anna H-Hamirpur 6-Lafran	HH6	H-HRMN-99 H-Hamirpur 6-Lafran	DH6	D-Dorsett Golden K-Hamirpur 6-Lafran
AH7	A-Anna H-Hamirpur 7-Jeoli Devi	HH7	H-HRMN-99 H-Hamirpur 7-Jeoli Devi	DH7	D-Dorsett Golden K-Hamirpur 7-Jeoli Devi
AH8	A-Anna H-Hamirpur 8-Bani	HH8	H-HRMN-99 H-Hamirpur 8-Bani	DH8	D-Dorsett Golden K-Hamirpur 8-Bani
AH9	A-Anna H-Hamirpur 9-Kaswar	HH9	H-HRMN-99 H-Hamirpur 9-Kaswar	DH9	D-Dorsett Golden K-Hamirpur 9-Kaswar
AH10	A-Anna H-Hamirpur 10-Maharal	HH10	H-HRMN-99 H-Hamirpur 10-Maharal	DH10	D-Dorsett Golden K-Hamirpur 10-Maharal
AB1	A-Anna B-Bilaspur 1-Paniala	HB1	H-HRMN-99 B-Bilaspur 1-Paniala	DB1	D-Dorsett Golden K-Bilaspur 1-Paniala
AB2	A-Anna B-Bilaspur 2-Kuthera	HB2	H-HRMN-99 B-Bilaspur 2-Kuthera	DB2	D-Dorsett Golden K-Bilaspur 2-Kuthera
AB3	A-Anna B-Bilaspur 3-Amarpur	HB3	H-HRMN-99 B-Bilaspur 3-Amarpur	DB3	D-Dorsett Golden K-Bilaspur 3-Amarpur
AB4	A-Anna B-Bilaspur 4-Pantera	HB4	H-HRMN-99 B-Bilaspur 4-Pantera	DB4	D-Dorsett Golden K-Bilaspur 4-Pantera
AB5	A-Anna B-Bilaspur 5-Dumehar	HB5	H-HRMN-99 B-Bilaspur 5-Dumehar	DB5	D-Dorsett Golden K-Bilaspur 5-Dumehar
AB6	A-Anna B-Bilaspur 6-Lingri	HB6	H-HRMN-99 B-Bilaspur 6-Lingri	DB6	D-Dorsett Golden K-Bilaspur 6-Lingri
AB7	A-Anna B-Bilaspur 7-Dangar	HB7	H-HRMN-99 B-Bilaspur 7-Dangar	DB7	D-Dorsett Golden K-Bilaspur 7-Dangar
AB8	A-Anna B-Bilaspur 8-Nalti	HB8	H-HRMN-99 B-Bilaspur 8-Nalti	DB8	D-Dorsett Golden K-Bilaspur 8-Nalti
AB9	A-Anna B-Bilaspur 9-Kothipur	HB9	H-HRMN-99 B-Bilaspur 9-Kothipur	DB9	D-Dorsett Golden K-Bilaspur 9-Kothipur
AB10	A-Anna B-Bilaspur 10-Jhandutta	HB10	H-HRMN-99 B-Bilaspur 10-Jhandutta	DB10	D-Dorsett Golden K-Bilaspur 10-Jhandutta

3.3 OBSERVATIONS RECORDED

The experiment was laid out in a Randomized Block Design with three replications. All the marked trees were subjected to evaluation studies. Variations recorded for different character as per standard apple descriptors (IBPGR, 1982) and DUS test guidelines (UPOV, 2005) which are as follows:

3.3.1 GROWTH CHARACTERS

The growth parameters were recorded after the plants entered into dormancy and prior to pruning. The observations recorded were as follow:

3.3.1.1 Tree height (m)

The height of the tree was measured in meter (m) with the help of a graduated flag staff from the soil surface to the top of tree and was expressed in meters.

3.3.1.2 Tree spread (m)

The spread of the tree was recorded in meter (m) with the help of a graduated staff across the tree in North-South and East-West directions and average of both the measurements was worked out as mean value.

3.3.1.3 Tree volume (m^3)

Total above ground volume of each tree was calculated from height and spread measurements as per method suggested by Westwood (1993) as given below:

1. For a tree that was taller than its width
   Volume = $4/3\ \pi\ ab^2$
2. For a tree that was wider than its height
   Volume = $4/3\ \pi\ a^2b$

Where, $\pi = 3.14$

a = the length of major axis (height)

b = ½ the length of minor axis (spread)

3.3.1.4 Trunk girth (cm)

The trunk girth was measured with the help of measuring tape from the trees of each replication at a height of 15 cm above the graft union.

3.3.1.5 Annual shoots growth (cm)

Three shoots from the current season's growth were randomly selected from each replication around the periphery of the tree and the length was measured at the end of growing season. The mean value was worked out and expressed in centimeters.

3.3.1.6 Yield per tree (kg) and Productivity (t/ha)

The crop loads from each tree was recorded and mean value was expressed as the yield per tree and productivity of each cultivar was calculated by multiplying the yield per tree with the tree density per hectare.

3.3.2 PHENOLOGICAL CHARACTERS

3.3.2.1 Time of leaf bud burst (initiation)

The time of initiation of leaf bud burst was determined by the unfolding of leaf primodia from the shoot axis in at least 3-4 buds.

3.3.2.2 Time of floral bud burst

Floral bud burst time was measured from the opening of the flower bud to the calyx cracking stage.

3.3.2.3 Time of full bloom

The full bloom time in each cultivar was noted when more than 75 per cent of the flowers have opened and was recorded as date of peak flowering (full bloom).

3.3.2.4 Duration of flowering

The days from the date of first flower opening to the date of petal fall was taken as duration of flowering.

3.3.3 FOLIAGE CHARACTERS

3.3.3.1 Leaf area (cm^2)

Fully expanded leaves were collected from all over the periphery of mother tree, Leaf area was directly measured with the help of leaf area meter LI-COR 3100. The values so obtained were divided by the number of leaves in order to calculate the average leaf area and it was expressed as square centimeters (cm^2).

3.3.3.2 Leaf apex shape

Leaf apex shape was classified as per standard descriptors based on physical observation.

3.3.3.3 Leaf base shape

Leaf base shape was classified according to standard descriptors based on physical observation

3.4.4 FRUIT SET STUDIES

3.4.4.1 Selfing by bagging

For selfing, about 100 flower buds were selected and open flowers, if any, were removed. The selected flower buds were bagged in muslin cloth bags on all sides of the tree. The data on fruit set were recorded three weeks after bagging.

Fruit set per 100 flowers was calculated in all the cultivars as given below

$$\text{Fruit set (\%)} = \frac{\text{Number of fruit set}}{\text{Number of flowers}} \times 100$$

3.4.4.2 Open pollination

In order to study the fruit set under natural conditions, about 100 flower buds were marked on all sides of the trees for each cultivar and data were recorded three weeks after full bloom.

Fruit set per 100 flowers was calculated in all the cultivars as given below

$$\text{Fruit set (\%)} = \frac{\text{Number of fruit set}}{\text{Number of flower}} \times 100$$

3.4.5 MORPHO-PHYSICAL FRUIT CHARACTERS

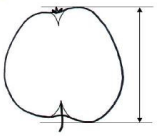
Fruits from the selected cultivars examined for various morpho-physical characteristics as given below:-

3.4.5.1 Fruit weight (g)

Fruits were weighed using an electronic balance and was expressed as average weight in grams (g) calculated.

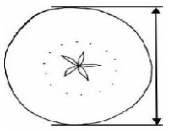
3.4.5.2 Fruit length (cm)

Fruit length was measured from fruit base to distal end (lobes) as illustrated below with the help of a digital Vernier calliper. The average length was calculated and expressed in centimeters (cm).



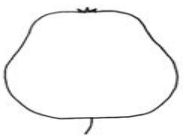
3.4.5.3 Fruit breadth (cm)

With the help of digital Vernier calliper, fruit breadth was measured as illustrated below.The average breadth was calculated and expressed in centimeters (cm).

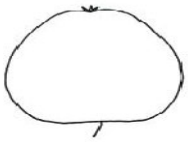


3.4.5.4 Fruit shape

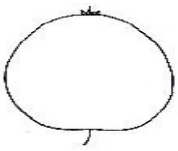
Fruit shape was visually assessed and characterized as per standard descriptors as illustrated below



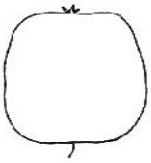
1. Cylindrical waisted



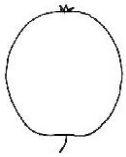
2. Conic



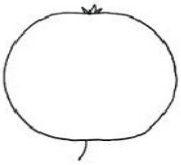
3. Ovoid



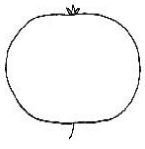
4. Cylindrical



5. Ellipsoid



6. Globose



7. Obloid

3.4.5.5 Surface of fruit

Physical inspection of the fruit was performed to categorize exterior surface as

1. Smooth
2. Rough

3.4.5.6 Fruit apex

Fruit apex was observed externally to describe as per the standard descriptors given below

1. Smooth
2. Wrinkled
3. Grooved
4. Other

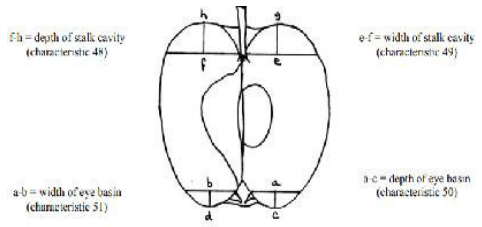
3.4.5.7 Fruit base

Base of the fruits was visually observed and categories as:

1. Narrow
2. Intermediate
3. Broad

3.4.5.8 Fruit base cavity depth

Depth of fruit base cavities was measured with the help of digital Vernier callipers at fruit base. The average depth was worked out and expressed in centimeters (cm).



3.4.5.9 Fruit ground colour

Skin ground colour of fruit was assigned as per colour chart of Royal Horticultural Society.

3.4.5.10 Fruit over colour

Fruit skin over colour was assigned as per colour chart of Royal Horticultural Society.

3.4.5.11 Fruit skin lenticels

The abundance of lenticels on fruits was estimated visually to classify as under :

1. Few
2. Medium
3. Many

3.4.5.12 Flesh colour

Fresh fruits cut into halves were observed visually for flesh colour and was categorized as

1. White
2. Cream
3. Yellowish
4. Greenish
5. Pinkish
6. Reddish

3.4.5.13 Fruit firmness

Flesh firmness of fruit was measured after removing the skin (0.8 cm) by using Effigy Penetrometer (Model FT 327) with plunger of 11 mm diameter and was expressed as kg/cm2.

3.4.5.14 Harvest time

The time of picking of fruits by the farmers / growers was taken as harvest time.

3.4.5.15 Eating quality (dessert)

Eating quality of fruits based on combined assessment of flavour, acidity, sweetness, aroma was judged by five penalists at optimum eating time and categorisation was made as under

1. Extremely poor
2. Very poor
3. Poor
4. Poor to intermediate
5. Intermediate
6. Intermediate to good
7. Good
8. Very good
9. Extremely good

3.4.5.16 Number of seed/fruit

Seeds removed from fruit core were counted leaving out the chaffy and shrivelled seeds.

3.4.5.17 Shelf life (days)

The period of time starting from harvesting and extending up to the start of rotting of fruits was considered as shelf life and was expressed as number of days.

3.4.6 ORGANOLEPTIC ANALYSIS

Sensory analysis

Following the 'Hedonic Rating Test', fruit samples were evaluated for sensory qualities such as pulp texture, pulp taste, and juiciness. On a ten point scale, each character was assigned a distinct score. Panellists rated the samples as per Ranganna (2009) hedonic scale in the format given below:

Sample No	Pulp Texture (10)	Pulp Taste (10)	Pulp Juiciness (10)

<<

3.4.7 BIOCHEMICAL ANALYSIS

Biochemical analysis of harvested fruits was undertaken using standard methods:

3.4.7.1 Total soluble solids (TSS)

The TSS content in fruits was determined by using "Erma – Hand Refractometer" (0 to 32˚ B) which was calibrated with distilled water before use. A few drops of fruit juice was placed on the prism and reading was recorded (A.O.A.C, 1980) which was expressed as °Brix.

3.4.7.2 Titratable acidity

The titratable acidity was determined by standard method (Ranganna, 1995). Twenty five gram of fruit pulp was thoroughly homogenized with distilled water in an electric blender and the final volume was made up to 250 ml in a volumetric flask. 50 ml extract was taken to estimate titratable acidity and the remaining 200 ml was kept aside to be used for the estimation of total and reducing sugars. 50 ml of the extract was filtered through Whatman No. 1 filter paper. 10 ml of this discolored juice was titrated against N/10 NaOH solution,

using phenolphthalein as an indicator till pink colour appeared as end point. The total titratable acidity was calculated in terms of malic acid and expressed in percentage.

$$\text{Titratable acidity (\%)} = \frac{\text{Titre value x Normality of Alkali x Volume made up x Equivalent weight of acid x 100}}{\text{Volume of sample taken for estimation x Volume of aliquot taken x 1000}}$$

3.4.7.3 Total sugars

The sugar content of the fruit was determined by volumetric method based on the principle that fruit sucrose content is quantitatively hydrolyzed to glucose and fructose in the presence of hydrochloric acid as described by Ranganna (1995). To the remaining 200 ml extract left from titratable acidity estimation in a 250 ml volumetric flask, 5 ml of 45 percent standard lead acetate was added. After 5-10 minutes, 5 ml of 22 percent potassium oxalate was added to precipitate the excess of lead acetate and the volume was made to 250 ml followed by the filtration of the solution. Subsequently, 50 ml of the filtrate was taken and hydrolyzed by adding 5 ml of concentrated HCl. The solution was kept overnight for hydrolysis at room temperature. Next day the excess of HCl was neutralized with saturated NaOH solution and the final volume was made up to 250 ml with distilled water. The total sugars were then calculated by titrating boiling mixture of 5 ml each of Fehling A and Fehling B against hydrolyzed solution with the help of methylene blue as indicator. The end point was indicated by the appearance of brick red colour. The total sugar was expressed as percentage of fresh weight of fruit pulp.

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

*Factor = 0.05

3.4.7.4 Reducing sugars

The remaining unhydrolyzed, deleaded and clarified solution obtained from the total sugar estimation, was titrated against a boiling solution of 5 ml each of Fehling A and Fehling B using methylene blue as an indicator (Ranganna, 1995). Reducing sugars content was expressed as percentage of fresh pulp weight.

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

*Factor = 0.05

3.4.7.5 Non-reducing sugars

The amount of non-reducing sugars was calculated by subtracting the reducing sugars from total sugars and multiplying the difference by a standard factor i.e. 0.95. The results were expressed as per cent sugars.

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

3.4.8 STATISTICAL ANALYSIS

The statistical analysis was carried out for each observed character under study using MS-Excel. The mean values of data were subjected to analysis of variance as described by Gomez and Gomez (1984) for Randomized Block Design. The level of significance was tested for different variables at 5 per cent level of significance. For estimation of different statistical parameters, following procedure and formulae were adopted:

3.4.1 Analysis of variance

Sources of variation	Degree of freedom	Sum of square	Mean sum of square	Fcal
Replication	r-1	Sr	$\frac{\text{Sr}}{(\text{r}-1)} = \text{Mr}$	$\frac{\text{Mt}}{\text{Me}}$
Treatment	t-1	St	$\frac{\text{St}}{(\text{t}-1)} = \text{Mt}$	$\frac{\text{Mr}}{\text{Me}}$
Error	(r-1)(t-1)	Se	$\frac{\text{Se}}{(\text{r}-1)(\text{t}-1)} = \text{Me}$	
Total	(rt-1)	ST		

Where,

r = Number of replications

t = Number of treatments

Sr = Sum of square due to replications

St = Sum of square due to treatments

Se = Sum of square due to error

S_T = Total sum of squares

Mr = Mean sum of square due to replications

Mt = Mean sum of square due to treatments

Me = Mean sum of square due to error

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

The standard error and critical differences was calculated as follows:

SE (m) ± = $\sqrt{\frac{Me}{r}}$

SE (d) ± = $\sqrt{\frac{2Me}{r}}$

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

SE (m) ± = Standard error of mean

SE (d) ± = Standard error of differences

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

Chapter-4

RESULTS AND DISCUSSION

The present investigations entitled **"Studies on low chill apples (*Malus* × *domestica* Borkh.) in sub-mountain zone of Himachal Pradesh"** were carried out in the Kangra Hamirpur and Bilaspur Districts of Himachal Pradesh, during the years 2017 and 2018. The data recorded on different parameters were analysed statistically and the results obtained on different aspects have been presented under the following headings.

4.1 GROWTH AND CROPPING CHARACTERISTICS IN ANNA

4.1.1 Tree height

The data on plant height obtained during both the years along with pooled mean in respect of low chill apple cultivar Anna has been presented in Table 1.

During 2017, plant height varied from 2.49 m to 3.10 m. The maximum plant height was attained by AK1 (3.10 m) which was found to be statistically at par with AK5 (3.04 m), AH9 (3.00 m), AK8 (2.96 m) and AK6 (2.95 m) and AH10 (2.93 m). The minimum tree height was recorded in the AB4 (2.49 m) which was statistically at par with AB9, AH8 (2.58 m), AB1 (2.59 m), AB3 (2.60 m), AH2 (2.62 m), AB7 (2.63 m) and AH1 (2.65 m).

Similar trends were observed during 2018 where in the maximum plant height (3.55 m) was recorded in AK1 while the minimum (2.88 m) was observed in AH8 which was also found to be statistically at par with AB1(2.89 m), AB9 (2.90 m), AB3 (2.93 m), AB4, AB7 (2.94 m), AH1 (2.96 m), AB2 (2.97 m) and AH2 (2.98 m).

The pooled mean plant height ranged from 2.71 m to 3.32 m. A similar trend was observed where the maximum plant height was recorded in AK1 (3.32 m) and the minimum plant height (2.71 m) was observed in AB4 which was also found to be statistically at par with AH8 (2.73 m), AB1 and AB9 (2.74 m).

4.1.2 Tree girth

Data pertaining to tree girth was also recorded during both the years and pooled data was also calculated (Table 1). The analysis of variance revealed significant differences for tree girth characteristics and the results thus obtained are described as follows:-

The data relating to tree girth recorded during 2017 indicated that the mean values varied from 13.15 cm to 19.89 cm. The maximum tree girth (19.89 cm) was recorded in AK2 which was statistically at par with AK9 (19.25 cm), AK5 (19.23 cm), AH7 (18.94 cm) and AH2 (18.72 cm). The minimum tree girth (13.15 cm) was recorded in AB8 which was statistically at par with AH6 (13.68 cm), AB1 (13.86 cm), AB4 (14.22 cm), and AB10 (14.37 cm).

Table 1. Tree height and tree girth of low chill apple cultivar Anna in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Tree height (m)			Tree girth (cm)		
	2017	2018	Pooled	2017	2018	Pooled
AK1	3.10	3.55	3.32	15.20	16.48	15.84
AK2	2.74	3.06	2.90	19.89	22.87	21.38
AK3	2.89	3.26	3.07	17.59	19.84	18.71
AK4	2.80	3.10	2.95	16.15	17.47	16.81
AK5	3.04	3.35	3.19	19.23	20.65	19.94
AK6	2.95	3.30	3.12	15.64	18.62	17.13
AK7	2.83	3.23	3.03	17.65	21.38	19.52
AK8	2.96	3.31	3.14	17.70	20.33	19.01
AK9	2.68	3.09	2.89	19.25	21.45	20.35
AK10	2.77	3.17	2.97	17.45	18.60	18.03
AH1	2.65	2.96	2.81	14.53	15.19	14.86
AH2	2.62	2.98	2.80	18.72	20.35	19.53
AH3	2.79	3.14	2.97	16.20	18.42	17.31
AH4	2.68	2.99	2.83	15.13	17.63	16.38
AH5	2.76	3.06	2.91	17.06	19.54	18.30
AH6	2.67	3.32	3.00	13.68	23.76	18.72
AH7	2.74	3.07	2.90	18.94	19.40	19.17
AH8	2.58	2.88	2.73	17.58	18.39	17.99
AH9	3.00	3.33	3.18	15.23	16.28	15.75
AH10	2.93	3.27	3.10	17.46	19.37	18.41
AB1	2.59	2.89	2.74	13.86	17.20	15.53
AB2	2.68	2.97	2.83	15.30	23.01	19.15
AB3	2.60	2.93	2.77	16.74	21.45	19.09
AB4	2.49	2.94	2.71	14.22	19.23	16.72
AB5	2.84	3.16	3.00	14.98	16.43	15.71
AB6	2.72	3.01	2.87	15.42	20.81	18.12
AB7	2.63	2.94	2.79	16.03	23.72	19.88
AB8	2.80	3.18	2.99	13.15	22.74	17.94
AB9	2.58	2.90	2.74	15.87	22.80	19.34
AB10	2.69	2.99	2.84	14.37	19.92	17.15
$CD_{0.05}$	0.17	0.10	0.04	1.22	2.10	0.31

During 2018, the tree girth varied from 15.19 cm to 23.76 cm. The maximum tree girth (23.76 cm) was recorded in AH6 which was statistically at par with AB7 (23.72 cm), AB2 (23.01 cm), AB8 (22.74 cm), AB9 (22.80 cm) and AK2 (22.87 cm). The minimum tree girth (15.19 cm) was recorded in AH1 which was statistically at par with AH9 (16.28 cm), AB5 (16.43 cm), AK1 (16.48 cm) and AB1 (17.20 cm). However, the differences between the values were minimal.

A perusal of pooled data revealed that significantly maximum tree girth (21.38 cm) was recorded in AK2 and minimum tree girth (14.86 cm) in AH1. A perusal of pooled data revealed that significantly maximum tree girth (21.38 cm) was recorded in AK2 and minimum tree girth (14.86 cm) in AH1. Sharma *et al.* (2004) and Kumar *et al.* (2017) while working on low altitude conditions of different agroclimatic conditions were of the opinion that variation in trunk girth was influenced by cultivar plantation site, climate change and genetic makeup of the cultivar.

4.1.3 Tree spread

It is evident from the data presented in Table 2 that the mean tree spread values during 2017 varied from 1.10 m to 1.41 m. The maximum tree spread (1.41 m) was recorded in AK2 which was statistically at par with AK10 (1.39 m), AH6 (1.37 m), AK1 (1.37 m) and AK7 (1.36 m). The minimum tree spread (1.10 m) was observed in AB9 which was statistically at par with AB7 (1.13 m). Similar trend was observed during 2018 where in the maximum tree spread (1.54 m) was recorded in AK2 which was statistically at par with AK9 (1.53 m), AK1 (1.52 m), AK10 (1.51 m), AK6, AK7 (1.50 m), AK3, AH7 (1.43m) and the minimum tree spread (1.22 m) in AB1 which was statistically at par with AB9 (1.24 m) and AB7 (1.25 m)

On examining the pooled data maximum tree spread (1.48 m) was recorded in AK2 which was statistically at par with AK9 (1.47 m) whereas the minimum tree spread (1.17 m) was recorded in AB9 and AB1.

4.1.4 Tree volume

Data pertaining to tree volume have been also recorded for the years 2017 and 2018 and mean value was also calculated. The analysis of variance revealed significant differences for tree volume characteristics.

Table 2. Tree spread and tree volume of low chill apple cultivar Anna in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Tree spread (m)			Tree volume (m^3)		
	2017	2018	Pooled	2017	2018	Pooled
AK1	1.37	1.52	1.45	1.41	1.79	1.60
AK2	1.41	1.54	1.48	1.28	1.57	1.43
AK3	1.35	1.48	1.42	1.30	1.60	1.45
AK4	1.28	1.42	1.35	1.19	1.46	1.33
AK5	1.23	1.36	1.30	1.24	1.51	1.38
AK6	1.32	1.45	1.39	1.29	1.59	1.44
AK7	1.36	1.50	1.43	1.28	1.61	1.45
AK8	1.25	1.40	1.33	1.03	1.37	1.20
AK9	1.40	1.53	1.47	1.25	1.57	1.41
AK10	1.39	1.51	1.45	1.28	1.59	1.44
AH1	1.20	1.32	1.26	1.06	1.30	1.18
AH2	1.27	1.40	1.34	1.11	1.39	1.25
AH3	1.33	1.43	1.38	1.23	1.49	1.36
AH4	1.31	1.46	1.39	1.17	1.45	1.31
AH5	1.26	1.37	1.32	1.15	1.39	1.27
AH6	1.37	1.50	1.44	1.37	1.66	1.51
AH7	1.34	1.48	1.41	1.22	1.51	1.37
AH8	1.29	1.41	1.35	1.11	1.35	1.23
AH9	1.21	1.34	1.28	1.22	1.48	1.35
AH10	1.28	1.38	1.33	1.25	1.50	1.37
AB1	1.11	1.22	1.17	0.96	1.17	1.06
AB2	1.17	1.31	1.24	1.04	1.29	1.17
AB3	1.28	1.42	1.35	1.11	1.38	1.25
AB4	1.22	1.34	1.28	1.20	1.47	1.34
AB5	1.30	1.44	1.37	1.23	1.51	1.37
AB6	1.26	1.39	1.33	1.14	1.39	1.27
AB7	1.13	1.25	1.19	0.99	1.22	1.11
AB8	1.18	1.29	1.24	1.10	1.36	1.23
AB9	1.10	1.24	1.17	0.94	1.20	1.07
AB10	1.25	1.37	1.31	1.12	1.36	1.24
$CD_{0.05}$	0.05	0.06	0.01	0.05	0.07	0.01

The data relating to tree volume recorded during 2017 indicated that the maximum tree volume (1.41 m3) was recorded in AK1 which was statistically at par with AH6 (1.37 m^3) and the minimum was observed in AB9 (0.94 m^3) which was found to be statistically at par with AB1 (0.96 m^3) and AB7 (0.99 m^3).

Similar trend was observed during 2018 as well as in the pooled mean i.e. maximum tree volume of 1.79 m^3 and 1.60 m^3 and minimum tree volume of 1.17 m^3 and 1.06 m^3 were recorded in AK1 and AB1, respectively whereas during 2018, the minimum tree volume was found to be statistically at par with AB9 (1.20 m^3) and AB7 (1.22 m^3) and in the pooled mean the minimum tree volume was found to be statistically at par only with AB9 (1.07 m^3)

4.1.5 Annual shoot extension growth

Annual shoot extension growth was studied during 2017 (Table 3) the mean values were observed to vary from 30.13 cm to 41.72 cm. The maximum annual shoot extension growth (41.72 cm) was recorded in AK9 which was found to be statistically at par with AK3 (41.35 cm), AH8 (40.67 cm), AK6 (40.08 cm), AH4 (39.92 cm) and AK4 (39.15 cm) and the minimum annual shoot extension growth (30.13 cm) was recorded in AB4 which was statistically at par with AB7 (30.52 cm), AB2 (32.61cm) and AH10 (32.90 cm).

The annual shoot extension growth values varied from 33.62 cm to 46.35 cm during 2018. The maximum annual shoot extension growth (46.35 cm) was recorded in AK9 which was statistically at par with AK3 (45.44 cm), AH8 (44.29 m), AH2 (44.90 cm), AK4 (43.99 cm), AK6 (43.26 cm), AH4 (43.23 cm) and AK10 (42.89 cm) and the minimum annual shoot extension growth (33.62 cm) was recorded in AB7 which was statistically at par with AH10 (35.59 cm), AB2 (36.12 cm), AH6 (36.15 cm), AB4 (36.19 cm), AH1 (36.82 cm), AH3 (37.11 cm) and AK8 (37.13 cm).

Similarly, the pooled data of annual shoot extension growth also recorded the highest value (44.04 cm) in AK9 and lowest (32.07 cm) was observed in AB7.

The present studies on tree growth characters *viz.* tree girth, tree height, tree spread, tree volume and annual shoot growth in different low chill apple cultivars revealed significant differences. The marked differences in the tree vigour were due to the varietal characteristics and can be attributed to the genetic makeup of the scion cultivar (Sullivan, 1960).

4.1.6 Tree yield

Data pertaining to tree yield have been also recorded for the years 2017, 2018 and pooled mean value was also calculated (Table 3).

A perusal of data presented in Table 3 revealed that the tree yield in Anna during 2017 varied from 6.09 kg to 8.29 kg/plant. The maximum tree yield (8.29 kg) was recorded in AK5 which was statistically at par with AK10 (8.17 kg) and AK2 (8.12kg). The minimum tree yield (6.09 kg) was recorded in AB3 and it was found to be statistically at par with AB1 (6.16 kg), AB2 (6.24 kg), AH3 (6.27 kg) and AB6 (6.36 kg).

During 2018, the tree yield varied from 7.04 kg to 10.51 kg/plant (Table 3). The maximum tree yield (10.51 kg) was recorded in AK1 which was statistically at par with

AK10 (10.25 kg) and AK6 (10.22 kg). Whereas, the minimum tree yield (7.04 kg) was recorded in AB1 which was found to be statistically at par with AB4 (7.26 kg) and AH7 (7.35kg).

When the pooled mean of the tree yield was studied, it was observed that the maximum tree yield (9.21 kg) was recorded in AK10 and minimum (6.60 kg) in AB1.

Table 3. Annual extension shoot growth, yield and productivity of low chill apple cultivar Anna in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Annual shoot extension growth (cm)			Tree yield (kg/plant)			Productivity (t/ha)		
	2018	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
AK1	36.62	40.24	38.43	7.25	10.51	8.88	3.01	4.37	3.69
AK2	33.28	38.69	35.98	8.12	9.25	8.69	3.37	3.84	3.60
AK3	41.35	45.44	43.40	7.45	7.59	7.52	3.09	3.15	3.12
AK4	39.15	43.99	41.57	7.33	7.83	7.58	3.04	3.26	3.15
AK5	35.10	39.15	37.12	8.29	8.57	8.43	3.44	3.56	3.50
AK6	40.08	43.26	41.67	7.94	10.22	9.08	3.30	4.25	3.77
AK7	37.39	41.84	39.61	7.35	9.24	8.30	3.05	3.84	3.44
AK8	33.86	37.13	35.49	7.52	8.82	8.17	3.12	3.66	3.39
AK9	41.72	46.35	44.04	7.58	9.08	8.33	3.15	3.77	3.46
AK10	38.65	42.89	40.77	8.17	10.25	9.21	3.39	4.26	3.82
AH1	35.72	36.82	36.27	7.52	9.56	8.54	3.12	3.97	3.54
AH2	38.73	44.90	41.82	6.71	7.83	7.27	2.79	3.25	3.02
AH3	34.69	37.11	35.90	6.27	8.08	7.18	2.60	3.36	2.98
AH4	39.92	43.23	41.58	7.03	9.44	8.24	2.92	3.92	3.42
AH5	35.97	38.19	37.08	6.65	9.32	7.99	2.76	3.87	3.31
AH6	33.95	36.15	35.05	7.36	8.59	7.98	3.06	3.57	3.31
AH7	36.55	40.90	38.73	6.51	7.35	6.93	2.70	3.05	2.87
AH8	40.67	44.92	42.80	7.23	7.55	7.39	3.01	3.14	3.07
AH9	34.54	38.02	36.28	6.74	9.45	8.10	2.80	3.93	3.36
AH10	32.90	35.59	34.25	7.13	8.27	7.70	2.97	3.44	3.20
AB1	37.23	41.20	39.22	6.16	7.04	6.60	2.57	2.93	2.75
AB2	32.61	36.12	34.37	6.24	8.58	7.41	2.59	3.56	3.07
AB3	35.59	40.29	37.94	6.09	7.85	6.97	2.94	3.26	3.10
AB4	30.13	36.19	33.16	6.45	7.26	6.86	2.68	3.02	2.85
AB5	36.25	41.13	38.69	7.05	8.84	7.95	2.93	3.67	3.30
AB6	33.62	37.70	35.66	6.36	7.93	7.15	2.64	3.29	2.96
AB7	30.52	33.62	32.07	7.45	8.08	7.77	3.09	3.36	3.22
AB8	34.68	37.56	36.12	6.78	8.56	7.67	2.82	3.56	3.19
AB9	37.49	40.45	38.97	7.25	8.65	7.95	3.02	3.59	3.30
AB10	35.70	38.30	37.00	6.92	8.42	7.67	2.87	3.50	3.18
$CD_{0.05}$	2.87	3.76	0.60	0.33	0.42	0.07	0.13	0.17	0.03

The present results are in line with the findings of Sharma *et al.* (2018) who reported lower values of yield in the range of 3.60-9.68 kg/plant under mid hill conditions of Himachal Pradesh. Contrary to this, Pramanick *et al.* (2018) and Kumar *et al.* (2006) recorded higher yields under conditions of Himachal Pradesh and Uttaranchal. Many workers (Wazbinska *et al.* 2003, Oguz *et al.* 2011, Milatovic and Durovic 2012, Dadashpour *et al.* 2012, Miller *et al.* 2015, Fioravanco *et al.* 2017 and Ghazaeian *et al*. 2018) have reported that different apple cultivars varied in yield potential under different agro climatic conditions.

4.1.7 Productivity

The data relating to productivity (Table 3) recorded during 2017 indicated the variations from 2.57 to 3.44 t/ha. The maximum productivity (3.44 t /ha) was recorded in AK5 which was statistically at par with AK10 (3.39 t /ha) and AK2 (3.37 t /ha). The minimum productivity (2.57 t/ha) was in AB1 which were statistically at par with AB2 (2.59 t/ha), AH3 (2.60 t/ha), AB6 (2.64 t/ha), AB4 (2.68 t/ha) and AH7 (2.70 t/ha).

During the following years maximum productivity (4.37t /ha) was recorded in AK1 which was however statistically at par with AK10 (4.26 t /ha) and AK6 (4.25 t /ha). The minimum productivity (2.93 t/ha) was recorded in AB1 which was statistically at par with AB4 (3.02 t/ha) and AH7 (3.05 t/ha).

The pooled data on productivity showed that significantly the highest value (3.83t/ha) in AK10 and lowest (2.75 t/ha) in AB1.

4.2 GROWTH AND CROPPING CHARACTERISTICS IN HRMN-99

4.2.1 Tree height

The data on plant height obtained during 2017, 2018 and pooled mean of the tree height of low chill apple cultivar HRMN-99 have been presented in Table 4.

During 2017 the plant height was found to be varying from 2.13 m to 2.77 m. The maximum plant height was attained by HK7 (2.77 m), which was found to be statistically at par with HK5 (2.73 m), HK2 (2.68 m), HK8 (2.64 m) and HH6 (2.60 m). The minimum tree height was recorded in HB2 (2.13 m) which was statistically at par with HB9 (2.15 m), HB1 (2.16m), HB4 (2.19 m), HB7 (2.22 m), HB3 (2.25 m), HB5 (2.27 m), and HB6 (2.30 m).

During 2018, maximum plant height (3.08 m) was recorded in HK5 which was found to be statistically at par with HK7 (3.06 m), HK8 (2.95 m). The minimum tree height was recorded in the HB1 (2.46 m) which was statistically at par with HB4 (2.47 m), HB2 (2.50 m), HB-7 (2.51 m), HB9 (2.53 m), HB5 (2.57 m) and HB6 (2.59 m)

The pooled data on plant height ranged from 2.31 m to 2.91 m. The maximum plant height was recorded in the HK7 (2.91 m) which was at par with HK5 (2.90 m) and the minimum plant height (2.31 m) was observed in HB1 which was found to be at par with HB2 (2.32 m), HB4 (2.33 m) and HB9 (2.34 m).

Table 4. Tree height and tree girth of low chill apple cultivar HRMN-99 in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Tree height (m)			Tree girth (cm)		
	2017	2018	Pooled	2017	2018	Pooled
HK1	2.35	2.65	2.50	17.77	19.28	18.52
HK2	2.68	2.93	2.80	21.01	24.98	22.99
HK3	2.59	2.87	2.73	20.65	22.25	21.45
HK4	2.47	2.84	2.66	16.25	20.32	18.29
HK5	2.73	3.08	2.90	19.77	22.42	21.10
HK6	2.57	2.89	2.73	19.28	20.98	20.13
HK7	2.77	3.06	2.91	20.38	23.71	22.04
HK8	2.64	2.95	2.80	19.89	21.60	20.75
HK9	2.53	2.83	2.68	21.52	23.31	22.41
HK10	2.41	2.73	2.57	21.02	21.45	21.24
HH1	2.43	2.72	2.58	17.23	19.20	18.22
HH2	2.31	2.64	2.48	21.84	22.34	22.09
HH3	2.55	2.86	2.71	18.35	20.45	19.40
HH4	2.38	2.66	2.52	20.52	21.54	21.03
HH5	2.58	2.89	2.73	19.81	21.56	20.69
HH6	2.60	2.91	2.76	21.72	23.81	22.77
HH7	2.34	2.74	2.54	17.41	18.72	18.06
HH8	2.49	2.81	2.65	18.47	19.64	19.05
HH9	2.36	2.63	2.50	21.74	22.86	22.30
HH10	2.51	2.80	2.66	17.30	18.90	18.10
HB1	2.16	2.46	2.31	15.21	16.19	15.70
HB2	2.13	2.50	2.32	17.93	18.32	18.13
HB3	2.25	2.65	2.45	19.33	21.84	20.59
HB4	2.19	2.47	2.33	16.19	18.32	17.26
HB5	2.27	2.57	2.42	18.53	20.88	19.70
HB6	2.30	2.59	2.44	19.16	22.32	20.74
HB7	2.22	2.51	2.37	16.85	17.23	17.04
HB8	2.37	2.70	2.54	15.20	16.05	15.62
HB9	2.15	2.53	2.34	18.44	19.47	18.96
HB10	2.39	2.74	2.56	16.96	17.87	17.42
$CD_{0.05}$	0.17	0.13	0.05	2.05	1.78	0.35

4.2.2 Tree girth

The data relating to tree girth (Table 4) recorded during 2017 was assessed and it was observed that mean values varied from 15.20 cm to 21.84 cm. The maximum tree girth (21.84 cm) was recorded in HH2 which was statistically at par with HH9 (21.74 cm), HH6 (21.72 cm), HK9 (21.52 cm), HK-10 (21.02 cm), HK2 (21.01cm), HK3 (20.65 cm), HH4 (20.52 cm), HK7 (20.38 cm) HK8 (19.89 cm) and HH5 (19.81 cm). The minimum tree girth (15.20 cm) was recorded in HB8 which was statistically at par with HB1 (15.21 cm), HB4 (16.19 cm), HK4 (16.25 cm), HB7 (16.85), HB10 (16.96 cm) and HH1 (17.23cm)

During the following year, when the data on tree girth was examined, it was found to vary from the 16.05 cm to 24.98 cm. The maximum tree girth (24.98 cm) was recorded in HK2 which was statistically at par with HH6 (23.81 cm), HK7 (23.71 cm) and HK9 (23.31 cm) while the minimum tree girth (16.05 cm) was recorded in HB8 which was statistically at par with HB1 (16.19 cm) and HB7 (17.23 cm).

A perusal of data concerning to pooled mean of the tree girth revealed that the maximum tree girth was recorded in HK2 (22.99 cm) and it was statistically at par with HH6 (22.77 cm) while the minimum tree girth (15.62 cm) was recorded in HB8 which is statistically at par with HB1 (15.70 cm).

4.2.3 Tree spread

The data pertaining to tree spread recorded during 2017 have been presented in the Table 5. It is evident from the data that the mean tree spread values varied from 1.01 m to 1.31 m. The maximum tree spread (1.31 m) was recorded in HK1 which was statistically at par with HK6 (1.30 m), HK4 (1.29 m), HK9 (1.28 m), HK8 (1.27 m) and HK-10 (1.26 m). On the other hand, the minimum tree spread HB8 (1.01 m) which was at par with HB9 (1.03 m) and HB1 (1.05 m)

Similar trend was observed during 2018 where in the markedly maximum tree spread (1.43 m) was recorded in HK6 through it was statistically at par with HK1 (1.42 m), HK9 (1.41 m), HK4 (1.39m), HK8 and HH9 (1.38 m), HK2 (1.37 m). The minimum tree spread (1.12 m) was observed in HB8 which was at par with HB9 (1.14 m) and HB1 (1.16 m).

The data with concerning to pooled mean of the tree spread revealed a largest value in HK6 and HK1 (1.37 m) whereas the lowest (1.07 m) tree spread was recorded in HB8.

4.2.4 Tree volume

A perusal of data presented in table 5 revealed that during 2017 indicated that the maximum tree volume (1.12 m^3) was recorded in HK5 which was statistically at par with (1.11 m^3) HK2, HK6, HK7, HK8 and HK9 (1.08 m^3) while the minimum was observed in HB9 (0.74 m^3) through it was at statistically at par with (0.75 m^3) HB1.

Through data recorded indicated a maximum tree volume (1.38 $m^{3)}$ in HK5 which was statistically at par with HK6 (1.37 m^3), HK7 (1.36 m^3), HK8 (1.35 m^3) and HK9, HK2 (1.33 m^3) and a minimum (0.95 m^3) in HB1 which was however found to be statistically at par with HB9 (0.96 m^3) and HB8 (1.01 m^3).

Table 5. Tree spread and tree volume of low chill apple cultivar HRMN-99 in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Tree spread (m)			Tree volume (m^3)		
	2017	2018	Pooled	2017	2018	Pooled
HK1	1.31	1.42	1.37	1.02	1.25	1.14
HK2	1.25	1.37	1.31	1.11	1.33	1.22
HK3	1.20	1.31	1.26	1.03	1.25	1.14
HK4	1.29	1.39	1.34	1.06	1.31	1.19
HK5	1.23	1.35	1.29	1.12	1.38	1.25
HK6	1.30	1.43	1.37	1.11	1.37	1.24
HK7	1.21	1.34	1.28	1.11	1.36	1.24
HK8	1.27	1.38	1.33	1.11	1.35	1.23
HK9	1.28	1.41	1.35	1.08	1.33	1.20
HK10	1.26	1.36	1.31	1.01	1.23	1.12
HH1	1.12	1.23	1.18	0.90	1.11	1.01
HH2	1.15	1.26	1.21	0.88	1.21	1.05
HH3	1.19	1.32	1.26	1.00	1.26	1.13
HH4	1.24	1.34	1.29	0.98	1.19	1.08
HH5	1.10	1.21	1.16	0.94	1.16	1.05
HH6	1.22	1.33	1.28	1.05	1.29	1.17
HH7	1.18	1.29	1.24	0.92	1.18	1.05
HH8	1.21	1.31	1.26	1.00	1.22	1.11
HH9	1.25	1.37	1.31	0.98	1.20	1.09
HH10	1.17	1.28	1.22	0.98	1.19	1.08
HB1	1.05	1.16	1.11	0.75	0.95	0.85
HB2	1.18	1.30	1.24	0.84	1.08	0.96
HB3	1.21	1.33	1.27	0.91	1.17	1.04
HB4	1.22	1.32	1.27	0.89	1.08	0.99
HB5	1.14	1.25	1.20	0.86	1.07	0.96
HB6	1.07	1.19	1.13	0.82	1.02	0.92
HB7	1.17	1.28	1.23	0.86	1.07	0.97
HB8	1.01	1.12	1.07	0.80	1.01	0.90
HB9	1.03	1.14	1.09	0.74	0.96	0.85
HB10	1.16	1.27	1.22	0.92	1.16	1.04
$CD_{0.05}$	0.05	0.06	0.01	0.05	0.06	0.01

Pooled mean indicated that the maximum tree volume (1.25 m^3) was recorded in HK5 which was statistically at par with HK7, HK6 (1.24 m^3) and minimum (0.85 m^3) in HB9, HB1.

4.2.5 Annual shoot extension growth

Data pertaining to annual shoot extension growth recorded during 2017 and 2018 as well as pooled mean values have been presented in Table 6. The analysis of variance revealed significant differences in the annual shoot extension growth characteristics among different genotype in different locations. The results thus obtained are described as follows

The data relating to annual shoot extension growth recorded during 2017 indicated that the mean values varied from 34.47 cm to 38.05 cm. The maximum annual shoot extension growth (38.05 cm) was recorded in HK8 which was statistically at par with HK7 (37.83 cm), HH6 (36.65 cm), HK9 (36.33 cm), HK1 (36.23 cm), HH1 (35.70 cm), HK4 (35.42 cm) and HK5 (35.38 cm). The minimum annual shoot extension growth (24.47cm) was recorded in HB1 which was statistically at par with HB2 (25.21 cm), HB6 (26.53 cm) HB3 (26.56 cm) and HB8 (27.18 cm).

On examining the data relating to annual shoot extension growth recorded during 2018, it was observed that the mean values varied from 27.91 cm to 42.92 cm. The maximum annual shoot extension growth (42.92 cm) was recorded in HK8 which was statistically at par with HK1 (41.05cm), HK9 (40.44 cm), HK7 (40.21 cm), HK4 (39.41 cm), HK6 (39.23 cm), HK2 (38.99 cm) and HH1 (38.82 cm). The minimum annual shoot extension growth (27.91 cm) was recorded in HB1 which was statistically at par with HB6 (29.62 cm), HB2 (29.77 cm), HB8 (30.07 cm), HB3 (30.90 cm) and HB10 (31.05cm)

The data related to pooled mean exhibited the maximum annual shoot extension growth in HK8 (40.49 cm) and minimum in HB1 (26.19 cm).

4.2.6 Tree yield

Data pertaining to tree yield recorded during 2017 and 2018 along with the pooled data is given in Table 6.

The data relating to tree yield recorded during 2017 indicated that the values varied from 5.28 kg to 7.08 kg/plant. The maximum tree yield (7.08 kg) was recorded in HK3 which was statistically at par with HK6 (7.05 kg) while the minimum (5.28 kg) tree yield was found

in HB4. However, during 2018, the tree yield which varied from 6.01 kg to 9.02 kg was found to be maximum (9.02 kg) in HK10 and the minimum tree yield was recorded in HB8 (6.01 kg). A similar trend was observed in the pooled data whereas the maximum tree yield was observed in HK6 (7.80 kg) which was at par with HK-10 (7.79 kg) and minimum was recorded in HB8 (5.94 kg).

Table 6. Annual extension shoot growth, yield and productivity of low chill apple cultivar HRMN-99 in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Annual Shoot extension growth (cm)			Tree yield (kg/plant)			Productivity (t/ha)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
HK1	36.23	41.05	38.64	6.54	8.04	7.29	2.72	3.34	3.03
HK2	34.68	38.99	36.84	6.73	8.36	7.54	2.79	3.47	3.13
HK3	31.81	34.29	33.05	7.08	8.19	7.63	2.94	3.40	3.17
HK4	35.42	39.41	37.42	6.62	8.17	7.39	2.75	3.39	3.07
HK5	35.38	38.81	37.09	6.72	8.25	7.48	2.79	3.43	3.11
HK6	34.75	39.23	36.99	7.05	8.52	7.80	2.93	3.54	3.23
HK7	37.83	40.21	39.02	6.82	8.11	7.46	2.83	3.37	3.10
HK8	38.05	42.92	40.49	6.59	8.47	7.53	2.74	3.52	3.13
HK9	36.33	40.44	38.38	6.94	8.55	7.74	2.88	3.56	3.22
HK10	33.73	36.82	35.28	6.57	9.02	7.79	2.73	3.75	3.24
HH1	35.70	38.82	37.26	6.02	8.58	7.30	2.50	3.56	3.03
HH2	30.15	34.09	32.12	6.23	7.06	6.64	2.59	2.93	2.76
HH3	29.23	32.99	31.11	6.57	8.47	7.50	2.73	3.52	3.12
HH4	32.53	36.62	34.58	6.32	8.53	7.42	2.62	3.54	3.08
HH5	31.84	34.10	32.97	6.05	7.45	6.75	2.51	3.09	2.80
HH6	36.65	37.96	37.30	6.14	7.02	6.58	2.55	2.91	2.73
HH7	33.11	36.92	35.02	6.25	8.49	7.37	2.60	3.53	3.06
HH8	34.38	37.28	35.83	6.52	7.03	6.77	2.71	2.92	2.81
HH9	33.03	35.94	34.49	6.43	8.54	7.48	2.67	3.55	3.11
HH10	31.22	36.51	33.86	6.12	7.03	6.57	2.54	2.92	2.73
HB1	24.47	27.91	26.19	5.49	8.09	6.79	2.28	3.36	2.82
HB2	25.21	29.77	27.49	5.57	6.52	6.04	2.31	2.71	2.51
HB3	26.56	30.90	28.73	6.12	7.07	6.59	2.54	2.94	2.74
HB4	28.37	32.15	30.26	5.28	7.56	6.42	2.19	3.14	2.66
HB5	31.70	35.12	33.41	5.42	8.03	6.72	2.25	3.34	2.79
HB6	26.53	29.62	28.07	5.94	7.83	6.88	2.47	3.26	2.86
HB7	29.60	33.34	31.47	5.49	7.25	6.37	2.28	3.01	2.64
HB8	27.18	30.07	28.63	5.87	6.01	5.94	2.44	2.50	2.47
HB9	30.10	33.61	31.86	5.55	8.29	6.92	2.30	3.45	2.87
HB10	28.05	31.05	29.55	6.03	7.48	6.75	2.50	3.11	2.80
$CD_{0.05}$	2.81	4.10	0.63	0.05	0.35	0.05	0.11	0.15	0.02

4.2.7 Productivity

The data relating on productivity presented in Table 6 revealed that the values varied from 2.19 to 2.94 t/ha. The maximum productivity (2.94 t /ha) was recorded in the HK3 which was statistically at par with HK6 (2.93 t /ha), HK9 (2.88 t /ha), HK7 (2.83 t /ha). The minimum productivity of 2.19 t/ha was recorded in HB4 which were statistically at par with HB5 (2.25 t/ha), HB1, HB7 (2.28 t/ha) and HB9 (2.30 t/ha).

During 2018 the maximum productivity (3.75 t /ha) was recorded in HK-10 and minimum productivity in HB8 (2.50 t/ha) while the pooled data indicated the highest value (3.24t/ha) in HK6, HK10 which was at par with HK9 (3.22 t /ha) whereas the lowest value was found in HB8 (2.47 t/ha)**.**

Similar studies were carried out by Gautam and Chauhan (1986) on some low chilling apple cultivars for four years and they observed that Tropical Beauty had the highest yield (69.09 kg) whereas, Early Shanburry performed poorly while cropping efficiency was highest in Parlins Beauty and lowest in Early Shanburry.

4.3 GROWTH AND CROPPING CHARACTERISTICS IN DORSETT GOLDEN

4.3.1 Tree height

The data of low chill apple cultivar Dorsett Golden obtained during 2017 and 2018 along with the pooled data have been presented in Table 7.

The plant height values varied from 1.68 to 2.16 m during 2017 and the maximum plant height was attained by DK9 (2.16 m), which was found to be statistically at par with DK5 (2.15 m), DK1, DK7 (2.13 m), DH1, DK10 (2.12 m), DH4 (2.11 m), DK2 and DH7 (2.10 m). The minimum tree height was recorded in the DB6 (1.68 m).

During 2018 that markedly maximum plant height (2.42 m) was recorded in DK1 which was found to be statistically at par with DK9 (2.37 m), DK7 (2.35 m), DK10 (2.34 m) and DH7 (2.33 m). The minimum tree height 1.97 m was recorded in the DB1 which was found to be statistically at par with DB6 (2.01 m), DH5 (2.03 m) and DB7 (2.04 m)

On examining the pooled data of plant height it was found that the maximum plant height was recorded (2.28 m) in DK1 which was statistically at par with DK9 (2.26 m) and minimum (1.85 m) was recorded in DB6.

4.3.2 Tree girth

Data pertaining to tree girth have been also recorded for the years 2017 and 2018 and its pooled data given in Table 7.

The data relating to tree girth recorded during 2017 indicated that the mean values varied from 8.29 cm to 14.65 cm. The maximum tree girth (14.65 cm) was recorded in DB5 which was statistically at par with DB10 (13.97 cm) and DB4 (13.80 cm). The minimum tree girth (8.29 cm) was recorded in DH5 which was statistically at par with DH1 (8.64 cm), DH3 (8.71 cm), DH8 (8.93 cm), DH10 (8.97 cm), DK1 (9.07cm), DH7 (9.48 cm), DH4, (9.64cm) and DK9 (9.73 cm).

Table 7. Tree height and tree girth of low chill apple cultivar Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Tree height (m)			Tree girth (cm)		
	2017	2018	Pooled	2017	2018	Pooled
DK1	2.13	2.42	2.28	9.07	15.06	12.07
DK2	2.10	2.27	2.18	10.84	12.04	11.44
DK3	2.07	2.26	2.16	10.05	16.83	13.44
DK4	1.99	2.14	2.07	11.66	15.25	13.45
DK5	2.15	2.31	2.23	11.27	16.92	14.09
DK6	2.06	2.22	2.14	11.35	13.32	12.33
DK7	2.13	2.35	2.24	12.33	14.29	13.31
DK8	1.96	2.24	2.10	11.16	17.64	14.40
DK9	2.16	2.37	2.26	9.73	13.14	11.43
DK10	2.12	2.34	2.23	10.94	15.25	13.10
DH1	2.12	2.27	2.19	8.64	13.18	10.91
DH2	1.95	2.12	2.03	10.36	14.23	12.30
DH3	2.09	2.28	2.19	8.71	15.38	12.04
DH4	2.11	2.31	2.21	9.64	12.81	11.22
DH5	1.88	2.03	1.95	8.29	13.98	11.14
DH6	1.93	2.10	2.01	10.86	15.78	13.32
DH7	2.10	2.33	2.21	9.48	12.85	11.16
DH8	1.94	2.16	2.05	8.93	16.39	12.66
DH9	1.90	2.13	2.02	10.56	14.54	12.55
DH10	2.07	2.25	2.16	8.97	13.58	11.28
DB1	1.82	1.97	1.90	11.13	13.07	12.10
DB2	1.97	2.16	2.06	11.83	13.69	12.76
DB3	1.88	2.08	1.98	12.71	15.21	13.96
DB4	2.06	2.24	2.15	13.80	13.89	13.85
DB5	2.01	2.26	2.13	14.65	15.01	14.83
DB6	1.68	2.01	1.85	11.77	14.12	12.95
DB7	1.84	2.04	1.94	12.83	15.67	14.25
DB8	2.00	2.20	2.10	12.53	15.19	13.86
DB9	1.92	2.11	2.02	11.39	15.44	13.41
DB10	1.90	2.1	2.00	13.97	14.63	14.30
$CD_{0.05}$	0.06	0.10	0.03	1.45	NS	0.28

The data with respect to pooled mean of the tree girth recorded the maximum value (14.83 cm) in DB5 and minimum (10.91 cm) in DH1 found to be statistically at par with DH5 (11.14 cm) and DH7 (11.16 cm).

4.3.3 Tree spread

It is evident from the data presented in Table 8 that the mean tree spread values during 2017 varied from 0.85 m to 1.92 m. The highest tree spread (1.92 m) was recorded in DK7 and the lowest tree spread (0.85 m) was observed in DH7 which it was however found to be statistically at par with DK3, DH6 (0.87 m), DK8 (0.88 m), DK5, DB1 (0.89 m) and DB6 (0.90 m).

During 2018 the markedly maximum tree spread (2.02 m) was recorded in DK7. The minimum tree spread (0.96 m) was observed in DB3, DK10 which was at par with DH7 (0.97 m), DB1, DH6 (0.99 m), DK3 (1.00 m) and DB6, DK8 (1.01m).

As far as pooled data is concerned, the maximum tree spread of 1.97 m was recorded in DK7 whereas the minimum tree spread (0.91 m) was recorded in DH7 and DB3.

4.3.4 Tree volume

Data pertaining to tree volume have been also recorded for the years 2017 and 2018 and pooled mean value was also calculated. The analysis of variance revealed significant differences for tree volume characteristics.

A perusal of the data relating to tree volume presented in Table 8 revealed that that the maximum tree volume (1.36 m^3) was recorded in DK7 and minimum (0.50 m^3) was observed in DB6 which was at par with (0.53 m^3) DB3.

During 2018 the data indicated that the maximum tree volume was recorded in DK7 (1.58 m^3) which was statistically different from all other trees grown in different locations. The minimum tree volume of (0.65 m^3) was found in DB1 which was statistically at par with DB3 (0.66 m^3) and DB6 (0.68 m^3) and DH5,DH6 (0.69 m^3).

Table 8. Tree spread and tree volume of low chill apple cultivar Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Tree spread (m)			Tree volume (m^3)		
	2017	2018	Pooled	2017	2018	Pooled
DK1	1.12	1.24	1.18	0.81	1.00	0.90
DK2	0.99	1.10	1.04	0.69	0.83	0.76
DK3	0.87	1.00	0.94	0.60	0.75	0.68
DK4	1.13	1.25	1.19	0.75	0.89	0.82
DK5	0.89	1.01	0.95	0.64	0.78	0.71
DK6	1.08	1.19	1.14	0.72	0.88	0.80
DK7	1.92	2.02	1.97	1.36	1.58	1.47
DK8	0.88	1.01	0.95	0.57	0.75	0.66
DK9	1.09	1.20	1.15	0.78	0.95	0.86
DK10	1.86	0.96	1.41	1.31	0.75	1.03
DH1	0.97	1.08	1.03	0.68	0.82	0.75
DH2	1.07	1.17	1.12	0.69	0.82	0.76
DH3	1.10	1.22	1.16	0.76	0.92	0.84
DH4	1.09	1.19	1.14	0.76	0.91	0.84
DH5	0.92	1.02	0.97	0.57	0.69	0.63
DH6	0.87	0.99	0.93	0.56	0.69	0.62
DH7	0.85	0.97	0.91	0.59	0.75	0.67
DH8	1.02	1.12	1.07	0.66	0.80	0.73
DH9	0.99	1.10	1.05	0.63	0.78	0.70
DH10	0.94	1.05	1.00	0.65	0.79	0.72
DB1	0.89	0.99	0.94	0.54	0.65	0.59
DB2	0.97	1.19	1.08	0.64	0.85	0.75
DB3	0.85	0.96	0.91	0.53	0.66	0.60
DB4	0.99	1.11	1.05	0.68	0.83	0.75
DB5	1.00	1.10	1.05	0.70	0.83	0.76
DB6	0.90	1.01	0.96	0.50	0.68	0.59
DB7	1.05	1.16	1.11	0.64	0.79	0.71
DB8	0.94	1.04	0.99	0.63	0.76	0.69
DB9	1.00	1.12	1.06	0.64	0.79	0.71
DB10	1.01	1.14	1.08	0.64	0.80	0.72
$CD_{0.05}$	0.05	0.05	0.01	0.03	0.04	0.01

Pooled mean indicated that the maximum tree volume (1.47 m^3) was recorded in DK7 and minimum was observed in DB1, DB6 (0.59 m^3) and which was statistically at par with DB3 (0.60 m^3).

4.3.5 Annual shoot extension growth

Data pertaining to annual shoot extension growth recorded during 2017 and 2018 and pooled data are presented in Table 9. The analysis of variance revealed significant differences in the annual shoot extension growth characteristics. The results thus obtained are described as below

The data given in Table 9 relating to annual shoot extension growth recorded during 2017 indicated that the mean values varied from 23.50 cm to 38.21 cm. The maximum annual shoot extension growth (38.21 cm) was recorded in DK4 which was statistically at par with DK10 (38.10 cm), DK8 (37.71 cm), DH9 (35.62 cm), DK7 (36.54 cm), DK9 (35.32 cm) and DK2 (35.19 cm). The minimum annual shoot extension growth (23.50 cm) was in DB3 which was statistically at par with DB7 (24.28 cm), DB1 (25.45 cm), DB10 (25.38 cm) and DB8 (26.11 cm).

The data relating to annual shoot extension growth recorded during 2018 indicated that the mean values varied from 26.40 cm to 41.11 cm. The maximum annual shoot extension growth of 41.11 cm was observed in DK4 which was statistically at par with DK10 (40.70 cm), DK8 (40.20 cm), DK7 (39.11 cm), DH9 (38.92 cm) and DK9 (38.82 cm). The minimum annual shoot extension growth of 26.40 cm was recorded in DB3 which was statistically at par with DB10 (27.81 cm), DB7 (27.94 cm) and DB1 (28.62 cm).

The data concerning to the highest pooled annual shoot extension growth of 39.66 cm was recorded in DK4 which was found to be statistically at par DK10 (39.40 cm) and lowest (24.95 cm) was recorded in DB3.

4.4.6 Tree yield

Data pertaining to tree yield recorded during both the years and the pooled data that was calculated is presented in Table 9.

During 2017, the data relating to tree yield was found to vary from 5.17 kg to 7.45 kg/plant. The maximum tree yield (7.45 kg) was recorded in DH1 which was statistically at par with DH2 (7.39 kg), DH3 (7.32kg), DH10 (7.25kg) and DH7 (7.21 kg). The minimum tree yield (5.17 kg) was found in DB1 which was found to be statistically at par with DB4 (5.27kg), DB3 (5.33kg), DB10 (5.35 kg) and DB6 (5.39 kg)

During 2018 the tree yield varied from 6.17 kg to 8.59 kg. The maximum tree yield (8.59 kg) was recorded in DK7 which was statistically at par with DK3 (8.57 kg) and DK2 (8.39 kg). The minimum tree yield (6.17 kg) was recorded in DB7 which was statistically at par with DB6 (6.24 kg), DB4 (6.38 kg) and DB3 (6.41 kg).

The data concerning to pooled mean similar trend of the maximum tree yield was observed in DK2 (7.70 kg) which was at par with DH3 (7.69 kg) and DK7 (7.67 kg) and minimum (5.82 kg) was recorded in DB6 which was at par with DB4 (5.83 kg) and DB7 ,DB3 (5.87 kg).

Table 9. Annual extension shoot growth, yield and productivity of low chill apple cultivar Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Annual Shoot extension growth (cm)			Tree yield (kg/plant)			Productivity (t/hac)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
DK1	30.12	32.71	31.42	6.19	8.09	7.14	2.57	3.37	2.97
DK2	35.19	37.66	36.42	7.00	8.39	7.70	2.91	3.49	3.20
DK3	30.33	33.18	31.76	6.53	8.57	7.55	2.71	3.57	3.14
DK4	38.21	41.11	39.66	6.18	8.03	7.11	2.57	3.34	2.96
DK5	30.19	34.00	32.10	6.83	8.28	7.56	2.84	3.44	3.14
DK6	33.67	37.06	35.37	7.02	8.23	7.63	2.92	3.42	3.17
DK7	36.54	39.11	37.82	6.75	8.59	7.67	2.8	3.57	3.19
DK8	37.71	40.20	38.95	6.2	8.13	7.17	2.57	3.38	2.98
DK9	35.32	38.82	37.07	6.49	8.25	7.37	2.69	3.43	3.07
DK10	38.10	40.70	39.40	6.95	8.19	7.57	2.89	3.41	3.15
DH1	28.53	31.70	30.12	7.45	7.51	7.48	3.09	3.12	3.11
DH2	33.15	36.85	35.00	7.39	7.68	7.54	3.07	3.19	3.14
DH3	30.99	32.04	31.52	7.32	8.05	7.69	3.06	3.35	3.20
DH4	34.15	37.19	35.67	7.16	7.49	7.33	2.97	3.12	3.05
DH5	30.75	33.27	32.01	6.85	7.53	7.19	2.84	3.13	2.99
DH6	33.67	36.32	35.00	6.72	7.27	7.00	3.09	3.02	2.91
DH7	29.72	33.75	31.74	7.21	7.88	7.55	2.99	3.28	3.14
DH8	33.82	35.80	34.81	6.28	7.69	6.99	2.61	3.20	2.91
DH9	35.62	38.92	37.27	6.36	7.92	7.14	2.65	3.29	2.97
DH10	28.26	30.13	29.20	7.25	7.36	7.31	3.02	3.06	3.04
DB1	25.45	28.62	27.03	5.17	7.43	6.30	2.15	3.09	2.62
DB2	30.55	32.15	31.35	6.42	6.58	6.50	2.67	2.74	2.70
DB3	23.50	26.40	24.95	5.33	6.41	5.87	2.21	2.67	2.44
DB4	32.05	34.91	33.48	5.27	6.38	5.83	2.19	2.65	2.43
DB5	26.83	30.12	28.48	5.58	7.26	6.42	2.32	3.02	2.67
DB6	31.40	33.43	32.42	5.39	6.24	5.82	2.24	2.60	2.42
DB7	24.28	27.94	26.11	5.56	6.17	5.87	2.31	2.57	2.44
DB8	26.11	29.80	27.96	5.49	6.59	6.04	2.28	2.74	2.51
DB9	28.77	31.78	30.27	5.46	6.83	6.15	2.27	2.84	2.56
DB10	25.38	27.81	26.60	5.35	7.22	6.29	2.23	3.00	2.62
$CD_{0.05}$	3.11	2.89	0.54	0.26	0.30	0.05	0.10	0.13	0.02

4.5.6 Productivity

The data relating to productivity (Table 9) when examined was found to vary from 2.15 to 3.09 t/ha during 2017. The maximum productivity (3.09 t /ha) was recorded in DH1 which was statistically at par with DH2 (3.07 t /ha), DH3 (3.06 t /ha), DH10 (3.02t /ha) and DH7 (2.99 t /ha). The minimum productivity (2.15 t/ha) was recorded in DB1 which was statistically at par with DB4 (2.19 t/ha), DB3 (2.21 t/ha), and DB10 (2.23 t/ha), DB6 (2.24 t/ha).

During 2018, the maximum productivity (3.57 t /ha) was recorded in DK3, DK7 which was statistically at par with DK5 (3.44 t/ha), DK2 (3.49 t/ha) and minimum (2.57 t/ha) was found in DB7 which was statistically at par with DK6 (2.60 t/ha), DB4 (2.65 t/ha) and DB3 (2.67 t/ha) similar to the observations made in 2017, the pooled productivity was also observed to be highest (3.20 t/ha) in DK2, DH4 which was statistically at par with DK7 (3.19 t/ha), however the lowest (2.42 t/ha) productivity was recorded in DB6 which was statistically at par with DB4 (2.43 t/ha), DB3, DB7 (2.44 t/ha). These findings are in congruence with that of Gautum and Chauhan (1986) who investigated the varietal variations during the year 1980-1983 with respect to growth, yield and quality characters of some low chilling apple cultivars and found that Tropical Beauty had maximum trunk girth (32.60 cm), and average cumulative yield (69.09 kg per plant) whereas Tamma, Sharp's Early and Early Shanburry were poor in yield performance thereby signifying a variable growth and cropping trend among different low chilling cultivars.

4.4 LEAF CHARECTERSTICS

4.4.1 Leaf area

It is evident from the data given in Table 10 that the maximum leaf area (47.78 cm^2) in Anna during 2017 was recorded in AK8 which was statistically at par with AH5 (46. 33 cm^2), AB7 (46.14 cm^2), AH2 (45.83 cm^2), AK4 (45.66 cm^2), AB1(45.18 cm^2), AB8 (44.71 cm^2), AK10 (44.54 cm^2), AB4 (44.45 cm^2) and AH9 (44.41 cm^2) whereas the minimum leaf area was found in AB3 (36.11 cm^2) which was observed statistically at par with AB6 (37.54 cm^2), AK2 (38.27 cm^2), AK7 (38.80 cm^2), AB10 (39.41 cm^2), AH1(39.43 cm^2), AK5 (39.63 cm^2), AK9 (39.65 cm^2), AH8 (39.65 cm^2) and AB5 (39.77 cm^2).

During 2018 maximum leaf area (49.77 cm^2) was recorded in AK8 which was statistically at par with AB7 (49.22 cm^2), AH5 (48.92 cm^2), AK4 (48.89 cm^2), AH2 (47.39 cm^2), AB1 (47.15 cm^2) and AK10 (46.81 cm^2). Whereas, minimum leaf area was found in AB3 (38.76 cm^2) which was statistically at par with AB6 (39.40 cm^2), AH8 (40.20 cm^2), AH1 (40.42 cm^2), AK5 (40.73 cm^2), AK2 (40.75 cm^2), AB5 (41.39 cm^2), AB10 (41.59 cm^2) and AK7 (41.69 cm^2).

When the data was pooled, leaf area was found to be highest in AK8 (48.78 cm) which was statistically at par with AB7 (47.68 cm^2) and AH5 (47.62 cm^2) and the lowest leaf area was found in AB3 (37.44 cm^2) which was found at par with AB6 (38.47 cm^2).

4.4.2 Leaf area

The data relating to leaf area recorded in low chill apple cultivar HRMN-99 during 2017 (Table 10) indicated that the maximum leaf area (50.85 cm^2) was recorded in HK7 which was statistically at par with HK2 (50.23 cm^2), HK8 (49.54 cm^2), HK3 (49.44 cm^2), HK6 (48.62 cm^2), HK10 (47.72 cm^2) and HH1(47.53 cm^2). Minimum leaf area was found in HH3 (38.41 cm^2) which was observed to be statistically at par with HB5 (38.80 cm^2), HH7 (38.82 cm^2), HK9 (39.70 cm^2), HB10 (39.74 cm^2), HB1 (39.87 cm^2), HB9 (40.21 cm^2), HH4 (40.29 cm^2), HB3 (40.63 cm^2) and HH9 (41.34 cm^2).

During 2018 the maximum leaf area (52.49 cm^2) was recorded in HK7 which was statistically at par with HK2 (52.30 cm^2), HK6 (51.30 cm^2), HK8 (50.92 cm^2), HK10 (50.43 cm^2), HK3 (50.39 cm^2) and HH1 (49.25 cm^2) and minimum leaf area was found in HH3 (40.22 cm^2) which was statistically at par with HB5 (40.43 cm^2), HB3 (41.61 cm^2), HB1 (41.84 cm^2), HH7 (41.93 cm^2), HB10 (42.19 cm^2), HH9 (42.35 cm^2) and HH4 (42.51 cm^2).

In case of pooled data HK7 recorded the maximum (51.67 cm^2) leaf area which was statistically at par with HK2 (51.27 cm^2) and HK8 (50.23 cm^2) and the minimum leaf area (39.32 cm^2) was recorded in HH3 which was found at par with HB5 (39.61 cm^2) and HH7 (40.37 cm^2).

4.4.3 Leaf area

The data relating to leaf area recorded in low chill apple cultivar Dorsett Golden (Table 10) during 2017 indicated that the maximum leaf area (52.28 cm^2) was recorded in DK2 which was statistically at par with DH8 (50.75 cm^2), DK10 (50.54 cm^2), DB8 (49.83 cm^2), DH7 (48.45 cm^2) DK6 (48.45 cm^2) and DB6 (48.39 cm^2). Minimum leaf area was found in DH9 (40.35 cm^2) which was observed statistically at par with DH2 (40.71 cm^2), DB9 (41.06 cm^2), DB1 (41.34 cm^2), DH6 (42.62 cm^2), DB5 (42.84 cm^2), DH3 (42.92 cm^2), DB7 (43.18 cm^2), DH1 (43.19 cm^2), DK7 (43.21 cm^2) DB3 (43.33 cm^2) and DH1, DH5 (44.15 cm^2).

During 2018, the maximum leaf area (53.75 cm^2) was recorded in DK10 which was statistically at par with DK2 (53.51 cm^2), DB6 (51.52 cm^2), DK6 (51.51 cm^2), DK3 (51.30 cm^2), DH8 (51.24 cm^2) and DB8 (50.41 cm^2) whereas minimum leaf area was found in DH9

(41.31 cm^2) which was statistically at par with DB1 (43.39 cm^2), DH2 (43.45 cm^2), DH6 (43.53 cm^2), DH1 (44.29 cm^2) and DB9 (44.69 cm^2).

Similar to the observations in the first year, the highest leaf area in pooled data was recorded in DK2 (52.89 cm^2) which was statistically at par with DK10 (52.15 cm^2) and the lowest leaf area (40.83 cm^2) was recorded in DH9 which was found at par with DH2 (42.08 cm^2) and DB1 (42.37 cm^2).

Table 10. Leaf area of low chill apple cultivars Anna, HRMN-99 and Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Anna Leaf area (cm^2)			Tree code	HRMN Leaf area (cm^2)			Tree code	Dorsett Golden Leaf area (cm^2)		
	2017	2018	Pooled		2017	2018	Pooled		2017	2018	Pooled
AK1	40.56	42.51	41.54	HK1	45.65	48.72	47.19	DK1	44.15	46.12	45.14
AK2	38.27	40.75	39.51	HK2	50.23	52.30	51.27	DK2	52.28	53.51	52.89
AK3	43.74	44.91	44.33	HK3	49.44	50.39	49.91	DK3	49.32	51.30	50.31
AK4	45.66	48.89	47.28	HK4	46.32	47.48	46.90	DK4	46.19	48.45	47.32
AK5	39.62	40.73	40.18	HK5	44.19	46.27	45.23	DK5	45.25	47.32	46.28
AK6	41.71	43.58	42.64	HK6	48.62	51.30	49.96	DK6	48.45	51.51	49.98
AK7	38.80	41.69	40.25	HK7	50.85	52.49	51.67	DK7	43.21	45.12	44.16
AK8	47.78	49.77	48.78	HK8	49.54	50.92	50.23	DK8	47.39	48.34	47.86
AK9	39.65	40.75	40.20	HK9	39.70	42.39	41.05	DK9	46.51	47.44	46.97
AK10	44.54	46.81	45.67	HK10	47.72	50.43	49.08	DK10	50.54	53.75	52.15
AH1	39.43	40.42	39.93	HH1	47.53	49.25	48.39	DH1	43.19	44.29	43.74
AH2	45.82	47.39	46.61	HH2	43.34	45.44	44.39	DH2	40.71	43.45	42.08
AH3	40.39	42.53	41.46	HH3	38.41	40.22	39.32	DH3	42.92	45.70	44.31
AH4	42.28	44.46	43.37	HH4	40.29	42.51	41.40	DH4	47.25	49.14	48.20
AH5	46.32	48.92	47.62	HH5	46.71	47.13	46.92	DH5	44.15	46.89	45.52
AH6	43.32	45.87	44.60	HH6	44.32	46.84	45.58	DH6	42.62	43.53	43.08
AH7	41.70	42.84	42.27	HH7	38.82	41.93	40.37	DH7	48.45	49.49	48.97
AH8	39.65	40.20	39.93	HH8	46.17	47.25	46.71	DH8	50.75	51.24	51.00
AH9	44.41	45.27	44.84	HH9	41.34	42.35	41.85	DH9	40.35	41.31	40.83
AH10	40.79	43.89	42.35	HH10	44.88	45.29	45.09	DH10	47.46	48.54	48.00
AB1	45.18	47.15	46.17	HB1	39.87	41.84	40.86	DB1	41.34	43.39	42.37
AB2	40.39	42.42	41.41	HB2	46.90	48.59	47.75	DB2	46.50	46.24	46.37
AB3	36.11	38.76	37.44	HB3	40.63	41.61	41.12	DB3	43.33	45.15	44.24
AB4	44.45	45.51	44.98	HB4	45.22	47.32	46.27	DB4	47.92	48.29	48.11
AB5	39.77	41.39	40.58	HB5	38.80	40.43	39.61	DB5	42.84	45.85	44.34
AB6	37.53	39.40	38.47	HB6	42.82	43.96	43.39	DB6	48.39	51.52	49.96
AB7	46.13	49.22	47.68	HB7	43.17	45.72	44.44	DB7	43.18	45.65	44.41
AB8	44.71	45.34	45.03	HB8	45.77	46.82	46.29	DB8	49.83	50.41	50.12
AB9	40.21	42.29	41.25	HB9	40.21	43.77	41.99	DB9	41.06	44.69	42.88
AB10	39.41	41.59	40.50	HB10	39.74	42.19	40.97	DB10	45.14	46.55	45.84
$CD_{0.05}$	4.02	3.29	1.39		4.05	3.38	1.48		3.99	3.58	1.82

4.4.4 Leaf apex and leaf base shape

Based on the standard apple descriptors (IBPGR, 1982) and DUS test guidelines (UPOV, 2005) the leaf apex and base shape of all the investigated cultivars of Anna, HRMN-99 and Dorsett Golden (Table 11) were observed to be acuminate in leaf apex shape and acute in leaf base shape. Variation in leaf characteristics among the different cultivars of pears was also reported by Kang *et al*. (2011), who observed that the shape of leaves varied from elliptical (SuperGold, Chuwhangbae) to narrow elliptical (Manpungbae), with a dentate margin and an acute apex while the leaf bases of various Asian pear cultivars were observed to range from sharp to spherical.

Table 11. Leaf shape of low chill apple cultivars Anna, HRMN-99 and Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Anna		Tree code	HRMN		Tree code	Dorsett Golden	
	Leaf Apex shape	Leaf base shape		Leaf Apex shape	Leaf base shape		Leaf Apex shape	Leaf base shape
AK1	Acuminate	Acute	HK1	Acuminate	Acute	DK1	Acuminate	Acute
AK2	Acuminate	Acute	HK2	Acuminate	Acute	DK2	Acuminate	Acute
AK3	Acuminate	Acute	HK3	Acuminate	Acute	DK3	Acuminate	Acute
AK4	Acuminate	Acute	HK4	Acuminate	Acute	DK4	Acuminate	Acute
AK5	Acuminate	Acute	HK5	Acuminate	Acute	DK5	Acuminate	Acute
AK6	Acuminate	Acute	HK6	Acuminate	Acute	DK6	Acuminate	Acute
AK7	Acuminate	Acute	HK7	Acuminate	Acute	DK7	Acuminate	Acute
AK8	Acuminate	Acute	HK8	Acuminate	Acute	DK8	Acuminate	Acute
AK9	Acuminate	Acute	HK9	Acuminate	Acute	DK9	Acuminate	Acute
AK10	Acuminate	Acute	HK10	Acuminate	Acute	DK10	Acuminate	Acute
AH1	Acuminate	Acute	HH1	Acuminate	Acute	DH1	Acuminate	Acute
AH2	Acuminate	Acute	HH2	Acuminate	Acute	DH2	Acuminate	Acute
AH3	Acuminate	Acute	HH3	Acuminate	Acute	DH3	Acuminate	Acute
AH4	Acuminate	Acute	HH4	Acuminate	Acute	DH4	Acuminate	Acute
AH5	Acuminate	Acute	HH5	Acuminate	Acute	DH5	Acuminate	Acute
AH6	Acuminate	Acute	HH6	Acuminate	Acute	DH6	Acuminate	Acute
AH7	Acuminate	Acute	HH7	Acuminate	Acute	DH7	Acuminate	Acute
AH8	Acuminate	Acute	HH8	Acuminate	Acute	DH8	Acuminate	Acute
AH9	Acuminate	Acute	HH9	Acuminate	Acute	DH9	Acuminate	Acute
AH10	Acuminate	Acute	HH10	Acuminate	Acute	DH10	Acuminate	Acute
AB1	Acuminate	Acute	HB1	Acuminate	Acute	DB1	Acuminate	Acute
AB2	Acuminate	Acute	HB2	Acuminate	Acute	DB2	Acuminate	Acute
AB3	Acuminate	Acute	HB3	Acuminate	Acute	DB3	Acuminate	Acute
AB4	Acuminate	Acute	HB4	Acuminate	Acute	DB4	Acuminate	Acute
AB5	Acuminate	Acute	HB5	Acuminate	Acute	DB5	Acuminate	Acute
AB6	Acuminate	Acute	HB6	Acuminate	Acute	DB6	Acuminate	Acute
AB7	Acuminate	Acute	HB7	Acuminate	Acute	DB7	Acuminate	Acute
AB8	Acuminate	Acute	HB8	Acuminate	Acute	DB8	Acuminate	Acute
AB9	Acuminate	Acute	HB9	Acuminate	Acute	DB9	Acuminate	Acute
AB10	Acuminate	Acute	HB10	Acuminate	Acute	DB10	Acuminate	Acute

4.5 FLOWERING CHARACTERISTICS IN ANNA

The analysis of variance tested for flowering characteristics revealed significant differences among low chill apple cultivars i.e. Anna, HRMN-99 and Dorsett Golden. The data relating to flowering characters viz, date of leaf bud burst, date of anthesis, full bloom, duration of flowering and date of harvest recorded during both the years is presented in Table 10 and the results so obtained are described as follows:

4.5.1 Date of leaf bud burst

The leaf bud burst initiation in 2017 was earliest in AH1 which was on 1st February followed by AH2, AH4 and AH8 on 2nd February. The last bud burst was recorded in AK5 which was on 7th February. During next season the leaf bud burst initiation was earliest in AH1, AH2 and AH4 which was on 5th February followed by AH8, AH3 and AB7 on 6th February whereas, AK7 and AK9 were the last to initiate leaf bud burst which were on 7th February and 9th February, respectively.

4.5.2 Date of anthesis

During 2017 the flower initiation was earliest (7th February) in AH4 followed by AB7 and AH1 on 8th February. The last to initiate flowering was noticed in AK9 which was on 15th February. During the next season the initiation of flowering was earliest in AH2 (11th February) followed by AH1, AH3, AH4 and AB7 on 12th February. AK7 and AK10 were the last to initiate flowering (18th February).

4.5.3 Time of full bloom

The time of full bloom was recorded when more than 75 per cent flowers had opened. The earliest full bloom in 2017 was observed in AH4 (12th February) followed by AH1 and AH8 on 13th February, respectively whereas**,** latest full bloom was observed in AK10 which was on 21st February. During 2018, the earliest full bloom in AH2 which was on 17th February followed by AH3, BL7 and AH4 on 18th February and last to attain full bloom was observed in AK7 and AK9 which was on 25th February.

4.5.4 Duration of flowering

The duration of flowering period during 2017, extended from 10 days to 14 days in AK3. In 2018 flowering duration extended from 12 days to 14 days.

The results of present study on flowering parameters are in accordance with the findings of Farooqui *et al*. (1986), Kumar and Verma (2001), Sharma (2002), Sharma *et al*. (2004), Singh *et al*. (2005) and Singh (2013) who reported variation in the time and duration of flowering while evaluating different apple cultivars under different growing conditions. They advocated that the differences in time and duration of flowering may be attributed to genetic make-up of cultivars and the prevailing climatic conditions in a particular site.

4.5.6 Date of harvest

The harvesting period during 2017 ranged from 12th -19th June while during 2018 it ranged from 14th -21st June.

Table 12. Flowering characters of low chill apple cultivar Anna in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Date of leaf bud burst		Date of anthesis		Date of full bloom		Duration of flowering		Date of harvest	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
AK1	05/02/2017	08/02/2018	10/02/2017	16/02/2018	15/02/2017	22/02/2018	11	12	18/06/2017	20/06/2018
AK2	04/02/2017	07/02/2018	10/02/2017	13/02/2018	16/02/2017	19/02/2018	12	13	16/06/2017	18/06/2018
AK3	06/02/2017	10/02/2018	12/02/2017	16/02/2018	19/02/2017	22/02/2018	14	13	17/06/2017	19/06/2018
AK4	04/02/2017	07/02/2018	11/02/2017	15/02/2018	17/02/2017	21/02/2018	12	12	16/06/2017	17/06/2018
AK5	07/02/2017	10/02/2018	13/02/2017	16/02/2018	18/02/2017	24/02/2018	11	14	18/06/2017	20/06/2018
AK6	05/02/2017	09/02/2018	11/02/2017	17/02/2018	18/02/2017	23/02/2018	12	12	19/06/2017	21/06/2018
AK7	07/02/2017	11/02/02018	14/02/2017	18/02/2018	19/02/2017	25/02/2018	12	13	17/06/2017	19/06/2018
AK8	05/02/2017	08/02/2018	10/02/2017	15/02/2018	16/02/2017	22/02/2018	12	14	18/06/2017	21/06/2018
AK9	08/02/2017	11/02/2018	15/02/2017	17/02/2018	20/02/2017	25/02/2018	12	14	19/06/2017	20/06/2018
AK10	07/02/2017	10/02/2018	14/02/2017	18/02/2018	21/02/2017	24/02/2018	12	12	20/06/2017	21/06/2018
AH1	01/02/2017	05/02/2018	08/02/2017	12/02/2018	13/02/2017	19/02/2018	11	14	12/06/2017	14/06/2018
AH2	02/02/2017	05/02/2018	09/02/2017	11/02/2018	15/02/2017	17/02/2018	11	12	14/06/2017	16/06/2018
AH3	03/02/2017	06/02/2018	09/02/2017	12/02/2018	14/02/2017	18/02/2018	10	12	12/06/2017	14/06/2018
AH4	02/02/2017	05/02/2018	07/02/2017	12/02/2018	12/02/2017	18/02/2018	10	12	13/06/2017	15/06/2018
AH5	05/02/2017	09/02/2018	10/02/2017	15/02/2018	17/02/2017	21/02/2018	13	13	12/06/2017	15/06/2018
AH6	03/02/2017	07/02/2018	09/02/2017	14/02/2018	14/02/2017	20/02/2018	10	13	15/06/2017	17/06/2018
AH7	04/02/2017	08/02/2018	10/02/2017	14/02/2018	16/02/2017	21/02/2018	12	14	13/06/2017	15/06/2018
AH8	02/02/2017	06/02/2018	08/02/2017	12/02/2018	13/02/2017	19/02/2018	11	14	14/06/2017	16/06/2018
AH9	06/02/2017	09/02/2018	12/02/2017	16/02/2018	18/02/2017	23/02/2018	13	13	15/06/2017	17/06/2018
AH10	04/02/2017	07/02/2018	09/02/2017	13/02/2018	14/02/2017	20/02/2018	11	14	14/06/2017	16/06/2018
AB1	03/02/2017	06/02/2018	09/02/2017	13/02/2018	15/02/2017	20/02/2018	11	13	18/06/2017	20/06/2018
AB2	04/02/2017	07/02/2018	10/02/2017	15/02/2018	16/02/2017	22/02/2018	11	14	21/06/2017	22/06/2018
AB3	05/02/2017	08/02/2018	11/02/2017	14/02/2018	18/02/2017	20/02/2018	13	13	20/06/2017	23/06/2018
AB4	04/02/2017	07/02/2018	10/02/2017	13/02/2018	17/02/2017	19/02/2018	12	12	19/06/2017	20/06/2018
AB5	06/02/2017	09/02/2018	12/02/2017	16/02/2018	18/02/2017	23/02/2018	11	14	20/06/2017	22/06/2018
AB6	05/02/2017	08/02/2018	11/02/2017	14/02/2018	19/02/2017	20/02/2018	13	12	19/06/2017	21/06/2018
AB7	03/02/2017	06/02/2018	08/02/2017	12/02/2018	15/02/2017	18/02/2018	13	13	20/06/2017	24/06/2018
AB8	06/02/2017	10/02/2018	13/02/2017	17/02/2018	18/02/2017	24/02/2018	11	13	19/06/2017	23/06/2018
AB9	06/02/2017	09/02/2018	12/02/2017	15/02/2018	18/02/2017	22/02/2018	13	13	18/06/2017	21/06/2018
AB10	05/02/2017	08/02/2018	11/02/2017	14/02/2018	17/02/2017	20/02/2018	12	13	20/06/2017	24/06/2018

4.6 FLOWERING CHARACTERISTICS IN HRMN-99

4.6.1 Date of leaf bud burst

The leaf bud burst initiation in 2017 was earliest in HH9 and HH5 on 1st February followed by HH6 and HH3 on 2nd February. The latest to bud burst was observed in HB3, HB7 and HB10 on 7th February. In the next season the leaf bud burst initiation was earliest in HH5, HH9 on 3rd February followed by HH6 on 4th February. HB3 and HB7 were the last to initiate leaf bud burst which was on 10th February.

4.6.2 Date of anthesis

The flower initiation in 2017 was earliest in HM5 and HH9 on 6th February followed by HH3 on 7th February. The last to initiate flowering was noticed in HB7 which was on 15th February. In the next season during 2018 the initiation of flowering was earliest in HH5, HH9 on 9th February followed by HH6 on 10th February. HB7 was last to initiate flowering which was on 17th February.

4.6.3 Time of full bloom

The time of full bloom was recorded when more than 75 per cent flowers had opened. Full bloom in 2017 was earliest in HH9 (11th February) followed by HH5 (12th February) whereas**,** latest full bloom was observed in HB7 on 21st February. During, 2018 earliest full bloom was recorded in HH5 and HH9 on (15th February) followed by HH6, HK7 and HM3 on 18th February and latest full bloom was observed in HB7 on 24th February.

4.6.4 Duration of flowering

The duration of flowering period during 2017, extended from 11 to 14 days and during 2018 duration of flowering period extended from 11 days to 16 days.

Similarly Singh *et al.* (2002) from his study in Kullu Valley indicated that flowering duration ranged from 10 to 15 days with high synchronization of full bloom period among the cultivars. Which is in line with the present work where the period varied from 11-14 days. Similar synchronization has also been reported by Hernandez *et al.* (2002). Various studies have shown cultivars of same or different make up are known to show variation for the studied parameter which most likely are due to genetic makeup of the cultivar(s), prevailing climatic conditions of the orchard location, may have directly or indirectly influenced the duration of flowering.

4.6.5 Date of Harvest

The date of harvesting ranged from 10th to 22nd June in 2017 and from 12th to 24th June in 2018.

Table 13. Flowering characters of low chill apple cultivar HRMN-99 in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Date of leaf bud burst		Date of anthesis		Date of full bloom		Duration of flowering		Date of harvest	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
HK1	05/02/2017	08/02/2018	10/02/2017	15/02/2018	15/02/2017	22/02/2018	12	14	16/06/2017	18//06/2018
HK2	04/02/2017	06/02/2018	09/02/2017	14/02/2018	14/02/2017	21/02/2018	12	15	18/06/2017	21/06/2018
HK3	06/02/2017	09/02/2018	12/02/2017	15/02/2018	17/02/2017	23/02/2018	11	15	15/06/2017	17/06/2018
HK4	05/02/2017	08/02/2018	11/02/2017	14/02/2018	16/02/2017	22/02/2018	13	14	19/06/2017	20/06/2018
HK5	04/02/2017	07/02/2018	10/02/2017	13/02/2018	17/02/2017	19/02/2018	14	13	18/06/2017	21/06/2018
HK6	05/02/2017	08/02/2018	11/02/2017	15/02/2018	17/02/2017	21/02/2018	14	13	18/06/2017	22/06/2018
HK7	03/02/2017	06/02/2018	09/02/2017	12/02/2018	16/02/2017	18/02/2018	14	14	16/06/2017	18/06/2018
HK8	04/02/2017	07/02/2018	11/02/2017	15/02/2018	18/02/2017	20/02/2018	14	12	19/06/2017	21/06/2018
HK9	03/02/2017	05/02/0217	10/02/2017	11/02/2018	15/02/2017	17/02/2018	12	12	17/06/2017	20/06/2018
HK10	05/02/2017	08/02/2018	11/02/2017	14/02/2018	17/02/2017	21/02/2018	12	15	15/06/2017	18/06/2018
HH1	04/02/2017	07/02/2018	09/02/2017	13/02/2018	15/02/2017	20/02/2018	13	14	11/06/2017	14/06/2018
HH2	03/02/2017	06/02/2018	08/02/2017	12/02/2018	13/02/2017	19/02/2018	11	13	10/06/2017	13/06/2018
HH3	02/02/2017	05/02/2018	07/02/2017	11/02/2018	15/02/2017	18/02/2018	14	15	12/06/2017	14/06/2018
HH4	03/02/2017	05/02/2018	09/02/2017	12/02/2018	14/02/2017	20/02/2018	11	16	13/06/2017	16/06/2018
HH5	01/02/2017	03/02/2018	06/02/2017	09/02/2018	12/02/2017	15/02/2018	12	13	10/06/2017	13/06/2018
HH6	02/02/2017	04/02/2018	08/02/2017	10/02/2018	15/02/2017	18/02/2018	14	15	11/06/2017	14/06/2018
HH7	04/02/2017	06/02/2018	09/02/2017	12/02/2018	14/02/2017	19/02/2018	12	15	13/06/2017	15/06/2018
HH8	03/02/2017	06/02/2018	09/02/2017	13/02/2018	15/02/2017	20/02/2018	12	13	14/06/2017	16/06/2018
HH9	01/02/2017	03/02/2018	06/02/2017	09/02/2018	11/02/2017	15/02/2018	11	13	12/06/2017	15/06/2018
HH10	05/02/2017	07/02/2018	11/02/2017	14/02/2018	16/02/2017	20/02/2018	12	14	10/06/2017	12/06/2018
HB1	06/02/2017	09/02/2018	12/02/2017	16/02/2018	18/02/2017	22/02/2018	13	14	18/06/2017	21/06/2018
HB2	05/02/2017	08/02/2018	10/02/2017	14/02/2018	16/02/2017	20/02/2018	12	13	20/06/2017	22/06/2018
HB3	07/02/2017	10/02/2018	14/02/2017	16/02/2018	20/02/2017	23/02/2018	14	15	22/06/2017	24/06/2018
HB4	05/02/2017	07/02/2018	12/02/2017	13/02/2018	18/02/2017	20/02/2018	13	15	20/06/2017	23/06/2018
HB5	06/02/2017	09/02/2018	13/02/2017	15/02/2018	19/02/2017	22/02/2018	14	14	21/06/2017	24/06/2018
HB6	06/02/2017	08/02/2018	12/02/2017	16/02/2018	17/02/2017	23/02/2018	11	14	19/06/2017	21/06/2018
HB7	07/02/2017	10/02/2018	15/02/2017	17/02/2018	21/02/2017	24/02/2018	13	13	22/06/2017	25/06/2018
HB8	05/02/2017	07/02/2018	11/02/2017	13/02/2018	16/02/2017	19/02/2018	12	13	23/06/2017	25/06/2018
HB9	05/02/2017	09/02/2018	13/02/2017	15/02/2018	19/02/2017	20/02/2018	12	11	21/06/2017	24/06/2018
HB10	07/02/2017	08/02/2018	14/02/2017	14/02/2018	20/02/2017	21/02/2018	14	14	22/06/2017	26/06/2018

4.7 FLOWERING CHARACTERISTICS IN DORSETT GOLDEN

4.7.1 Date of leaf bud burst

The leaf bud burst initiation (Table14) was earliest in DH2 on 3rd February followed by DH4, DH8 on 4th February and DK9 was the last to initiate leaf bud burst on 10th

February. Similarly the leaf bud burst initiation in 2018 was also found to be earliest in DH2 on 6th February followed by DH3, DH4 and DH8 on 7th February. The latest to bud burst was recorded in DK9 on 14th February.

4.7.2 Date of anthesis

The flower initiation in 2017 was earliest in DH2 which was observed to be on 9th February followed by DH1, DH4, DH6 and DB1 on 11th February. The last to initiate flowering was noticed in DK9 and DK10 which was on 17th February. In the next season during 2018 the initiation of flowering was earliest in DH2 on 12th February followed by DH1, DH8 on 13thFebruary, where as DK9 was the last to initiate flowering which was on 21st February.

4.7.3 Time of full bloom

The time of full bloom was recorded when more than 75 per cent flowers had opened. Full bloom in 2017 was observed to be earliest in DH2 i.e. on 16th February followed by DH6 on 17th February whereas, late full bloom was observed in DK3 on 24th February. During, 2018 full bloom was recorded to be earliest in DH2 on 18th February followed by DH8 on 11th February and the latest full bloom was observed in DK9 which was on 28th February.

4.7.4 Duration of flowering

The duration of flowering period during 2017, extended from 12 days to 16 days. During 2018 duration of flowering period extended from 10 days to 16 days. Variation in flowering behavior of different low chilling apple cultivars was also studied by other workers. Bist and Sharma (1986) studied flowering behaviour of ten low-chilling apple cultivars and found that flowering durations varied from 10 days in Tamma and Golden Delicious to 17 days in Sharp's Early and Parlin's Beauty. Elshebini *et al.* (1991) who studied the floral biology of three apple cultivars Anna, E-25, Dorsett Golden, reported that E-25 was earliest and Anna was last to flower among the three cultivars under investigation.

4.7.5 Date of Harvest

The date of harvest extended from 26th June to 15th July in 2017 and from 28th June to 17th July in 2018.

Table 14. Flowering characters of low chill apple cultivar Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Date of leaf bud burst		Date of anthesis		Date of full bloom		Duration of flowering		Date of harvest	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
DK1	07/02/2017	10/02/2018	14/02/2017	17/02/2018	21/02/2017	24/02/2018	13	14	02/07/2017	04/07/2018
DK2	06/02/2017	09/02/2018	13/02/2017	15/02/2018	19/02/2017	21/02/2018	12	14	04/07/2017	06/07/2018
DK3	08/02/2017	10/02/2018	16/02/2017	16/02/2018	24/02/2017	23/02/2018	14	14	03/07/2017	04/07/2018
DK4	06/02/2017	09/02/2018	12/02/2017	16/02/2018	20/02/2017	22/02/2018	15	13	02/07/2017	05/07/2018
DK5	09/02/2017	12/02/2018	16/02/2017	19/02/2018	22/02/2017	26/02/2018	12	12	05/07/2017	07/07/2018
DK6	07/02/2017	10/02/2018	15/02/2017	17/02/2018	23/02/2017	24/02/2018	15	14	03/07/2017	05/07/2018
DK7	09/02/2017	13/02/2018	16/02/2017	20/02/2018	22/02/2017	27/02/2018	13	10	02/07/2017	04/07/2018
DK8	07/02/2017	11/02/2018	14/02/2017	17/02/2018	21/02/2017	23/02/2018	15	13	07/07/2017	09/07/2018
DK9	10/02/2017	14/02/2018	17/02/2017	21/02/2018	23/02/2017	28/02/2018	13	10	06/07/2017	08/07/2018
DK10	09/02/2017	12/02/2018	17/02/2017	18/02/2018	25/02/2017	25/02/2018	14	11	09/07/2017	10/07/2018
DH1	04/02/2017	07/02/2018	11/02/2017	13/02/2018	19/02/2017	21/02/2018	15	16	29/06/2017	30/06/2018
DH2	03/02/2017	06/02/2018	09/02/2017	12/02/2018	16/02/2017	18/02/2018	14	13	30/06/2017	01/07/2018
DH3	05/02/2017	07/02/2018	12/02/2017	14/02/2018	18/02/2017	21/02/2018	14	14	28/06/2017	29/06/2018
DH4	04/02/2017	07/02/2018	11/02/2017	15/02/2018	18/02/2017	22/02/2018	16	13	26/06/2017	30/06/2018
DH5	07/02/2017	10/02/2018	15/02/2017	16/02/2018	21/02/2017	23/02/2018	13	14	27/06/2017	28/06/2018
DH6	05/02/2017	09/02/2018	11/02/2017	15/02/2018	17/02/2017	21/02/2018	12	13	29/06/2017	31/06/2018
DH7	06/02/2017	10/02/2018	13/02/2017	16/02/2018	20/02/2017	23/02/2018	13	15	31/06/2017	02/07/2018
DH8	04/02/2017	07/02/2018	12/02/2017	13/02/2018	19/02/2017	19/02/2018	14	13	29/06/2017	30/06/2018
DH9	08/02/2017	11/02/2018	14/02/2017	17/02/2018	22/02/2017	24/02/2018	14	14	28/06/2017	31/06/2018
DH10	06/02/2017	09/02/2018	13/02/2017	16/02/2018	20/02/2017	23/02/2018	14	13	26/06/2017	28/06/2018
DB1	05/02/2017	08/02/2018	11/02/2017	15/02/2018	18/02/2017	21/02/2018	13	12	08/07/2017	10/07/2018
DB2	07/02/2018	10/02/2018	14/02/2017	16/02/2018	22/02/2017	23/02/2018	15	14	10/07/2017	13/07/2018
DB3	08/02/2017	12/02/2018	16/02/2017	19/02/2018	23/02/2017	27/02/2018	14	12	09/07/2017	12/07/2018
DB4	06/02/2017	09/02/2018	14/02/2017	16/02/2018	20/02/2017	22/02/2018	13	12	08/07/2017	10/07/2018
DB5	08/02/2017	11/02/2018	14/02/2017	17/02/2018	21/02/2017	24/02/2018	14	14	10/07/2017	13/07/2018
DB6	07/02/2017	10/02/2018	13/02/2017	16/02/2018	20/02/2017	23/02/2018	13	13	12/07/2017	14/07/2018
DB7	06/02/2017	08/02/2018	13/02/2017	14/02/2018	19/02/2017	21/02/2018	13	14	15/07/2017	17/07/2018
DB8	09/02/2017	11/02/2018	15/02/2017	18/02/2018	22/02/2017	25/02/2018	14	14	13/07/2017	15/07/2018
DB9	08/02/2017	10/02/2018	16/02/2017	17/02/2018	22/02/2017	23/02/2018	12	12	12/07/2017	14/07/2018
DB10	08/02/2017	11/02/2018	15/02/2017	17/02/2018	23/02/2017	24/02/2018	15	14	14/07/2017	16/07/2018

4.8 FRUIT SET STUDIES

The data on fruit set of different low chill apple cultivars viz. Anna, HRMN-99 and Dorsett Golden recorded during 2017 and 2018 as well as pooled data is given in Table 15.

4.8.1 Selfing by bagging

The perusal of data presented in Table 15 revealed that the fruit set (selfing) in Anna during 2017 varied from 11.72 to 24.14 per cent. Maximum fruit set was recorded in AK10 (24.14 %) which was found to be statistically at par with AK8 (23.62 %), AK4 (23.15 %), AK2 (22.70 %) and AK6 (22.42 %) and the minimum fruit set was found in AB3 (11.72 %)

which was observed to be statistically at pat with AB10 (11.88 %), AH1 (12.22 %), AB6 (12.38 %), AH6 (13.82 %) and AB4 (13.84 %).

Similarly, during 2018 similarly the fruit set was found to be maximum in AK10 (29.40 %) which was found to be statistically at par with AK8 (28.37 %), AK6 (28.28 %), AK2 (27.74 %), AK4 (27.68 %), AK3 (26.52%), AH2 (26.46%) and AK9 (26.19%) and the minimum fruit set was found in AB10 (16.69%) which was found to be statistically at par with AB3 (17.25 %), AB6 (17.31 %), AH1 (17.71%), AH6 (18.41%) AH8 (18.48%) AH3 (19.16 %), AB8 (19.37%) and AB4 (19.41%)

When the pooled mean of the fruit set was studied it was observed that the maximum (26.77 %) fruit set was recorded in AK10 and minimum (14.29 %) in AB10 which was found to be statistically at par with AB3 (14.49 %) and in AB6 (14.84 %).

4.8.2 Selfing by bagging

It is evident from the data presented in Table 15 revealed that the fruit set (selfing) in HRMN-99 during 2017 varied from 9.59 to 21.72 per cent. Maximum fruit set was recorded in HK3 (21.72 %) which was found to be statistically at par with HK-10 (21.26 %), HK7 (21.18 %), HK2 (20.29%) and HK5 (20.19%) and the minimum fruit set (9.59 %) was found in HB6 which was statistically at par with HB3 (10.27%) and HB4 (11.48 %).

During 2018, the fruit set was found to be maximum in HB7 (32.52 %) which was found to be statistically at par with HB4 (32.09 %), HB2 (31.69 %), HB6 (31.62 %), HB10 (31.07 %), HB1 (29.31%), HB5 (28.81%), HB9 (28.76%), HB3 (28.36 %) and the minimum fruit set was found in HH1 (16.32%) which was found to be statistically at par with HH5 (17.23 %), HH9 (17.68 %), HH2 (18.52%), HH6 (19.68%) and in HH8 (19.92%)

When the pooled mean of the fruit set was studied it was observed that the highest (24.34%) fruit set was recorded in HK7 which was found to be statistically at par with HK3 (24.20%) however, lowest was recorded in HH1 (14.06%).

4.8.3 Selfing by bagging

A perusal of data presented in Table 15 revealed that the fruit set (selfing) in Dorsett Golden during 2017 varied from 11.38 to 24.56 %. Maximum fruit set was recorded in DK8 (24.56 %) which was found to be statistically at par with DK4 (24.53 %), DK2 (23.70 %) and

DK10 (23.44%) and the minimum fruit set was found in DB1 (11.38 %) which was statistically at par with DB5 (12.12 %).

Table 15. Fruit set studies (selfing) of low chill apple cultivars Anna, HRMN-99 and Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Anna Selfing (%)			Tree code	HRMN-99 Selfing (%)			Tree code	Dorsett Golden Selfing (%)		
	2017	2018	Pooled		2017	2018	Pooled		2017	2018	Pooled
AK1	19.84	25.13	22.48	HK1	18.65	24.78	21.71	DK1	20.92	26.23	23.57
AK2	22.70	27.74	25.22	HK2	20.29	25.55	22.92	DK2	23.70	28.15	25.92
AK3	21.19	26.52	23.85	HK3	21.72	26.69	24.20	DK3	19.61	23.24	21.43
AK4	23.15	27.68	25.42	HK4	18.17	25.10	21.64	DK4	24.53	29.34	26.94
AK5	20.12	24.59	22.35	HK5	20.19	24.68	22.44	DK5	22.49	25.52	24.01
AK6	22.42	28.28	25.35	HK6	19.06	23.01	21.04	DK6	19.15	24.93	22.04
AK7	19.71	24.56	22.13	HK7	21.18	27.50	24.34	DK7	21.06	26.51	23.78
AK8	23.62	28.37	26.00	HK8	18.35	21.33	19.84	DK8	24.56	28.98	26.77
AK9	21.46	26.19	23.82	HK9	19.53	22.83	21.18	DK9	22.09	26.43	24.26
AK10	24.14	29.40	26.77	HK10	21.26	25.11	23.18	DK10	23.44	29.61	26.52
AH1	12.22	17.71	14.97	HH1	11.80	16.32	14.06	DH1	14.12	19.20	16.66
AH2	20.49	26.46	23.47	HH2	13.75	18.52	16.14	DH2	17.52	22.38	19.95
AH3	15.26	19.16	17.21	HH3	18.32	22.24	20.28	DH3	13.63	18.59	16.11
AH4	18.49	21.31	19.90	HH4	15.62	21.16	18.39	DH4	19.44	24.46	21.95
AH5	16.25	22.34	19.29	HH5	12.89	17.23	15.06	DH5	16.67	21.05	18.86
AH6	13.82	18.41	16.12	HH6	14.72	19.68	17.20	DH6	13.49	17.58	15.54
AH7	17.26	21.53	19.40	HH7	16.96	22.10	19.53	DH7	15.24	21.66	18.45
AH8	14.61	18.48	16.54	HH8	15.20	19.92	17.56	DH8	20.86	24.28	22.57
AH9	19.28	24.33	21.80	HH9	13.49	17.68	15.58	DH9	14.56	19.62	17.09
AH10	18.42	22.75	20.59	HH10	16.52	20.95	18.73	DH10	16.34	22.10	19.22
AB1	17.91	23.63	20.77	HB1	12.45	29.31	20.88	DB1	11.38	15.18	13.28
AB2	15.66	21.70	18.68	HB2	14.26	31.69	22.97	DB2	13.11	20.68	16.90
AB3	11.72	17.25	14.49	HB3	10.27	28.36	19.32	DB3	15.42	19.53	17.47
AB4	13.84	19.41	16.63	HB4	11.48	32.09	21.79	DB4	17.31	21.25	19.28
AB5	18.47	22.38	20.42	HB5	13.21	28.81	21.01	DB5	12.12	17.16	14.64
AB6	12.38	17.31	14.84	HB6	9.59	31.62	20.61	DB6	16.09	20.02	18.05
AB7	16.06	21.65	18.86	HB7	12.71	32.52	22.61	DB7	14.22	18.12	16.17
AB8	14.21	19.37	16.79	HB8	14.47	25.88	20.18	DB8	13.80	17.47	15.63
AB9	17.75	22.48	20.12	HB9	11.85	28.76	20.31	DB9	16.01	19.66	17.84
AB10	11.88	16.69	14.29	HB10	13.29	31.07	22.18	DB10	12.57	18.73	15.65
$CD_{0.05}$	2.27	3.90	0.58		1.90	3.95	0.56		1.65	3.37	0.48

Similarly during 2018, the fruit set was found to be maximum in DK10 (29.61%) which was found to be statistically at par with DK4 (29.34 %), DK8 (28.98 %), DK2 (28.15 %), DK7 (26.51 %) and DK9 (26.43%) and the minimum fruit set was found in DB1 (15.18%) which was found to be statistically at par with DB5 (17.16 %), DB8 (17.47 %), DH6 (17.58%) and DB7 (18.12%).

However, when the pooled mean of the fruit set was studied, it was observed that the maximum (26.94 %) fruit set was recorded in DK4 through it was found to be statistically at par with DK8 (26.77%) and DK10 (26.52%) while, minimum was recorded in DB1 (13.28%).

4.9 FRUIT SET STUDIES IN OPEN POLLINATION

The fruit set of different low chill apple cultivars viz. Anna, HRMN-99 and Dorsett Golden were recorded under open pollination during 2017 and 2018 along with the pooled data have been presented in Table 16.

4.9.1 Open pollination

It is obvious from the data presented in Table 16 that the fruit set (open pollination) in Anna during 2017 varied from 33.10 to 43.13%. Maximum fruit set was recorded in AK7 (43.13%) which was found to be statistically at par with AK5 (42.97 %), AK9 (42.59 %), AH3 (42.48%), AH8 (42.18%), AK4 (41.38%) and AH6 (41.13%) and the minimum fruit set was recorded in AB2 (33.10 %) which was observed to be statistically at par with AB9 (33.29%) and AB1 (34.32 %).

An almost similar trend was observed in 2018, when the maximum fruit set was recorded in AK7 (47.89 %) which was found statistically at par with AB3 (47.23%), AH4 (46.99 %), AK9 (46.29 %), AH8 (46.10 %), AK5 (45.88 %), AH3 (45.62%), AK10 (45.50%), AK3 (45.23%), AB7, AH6 (45.19%), AK2 (44.95%), AK4 (44.67%), AH10 (44.10%), AB4 (43.88%), AK6 (43.76%), and AK1 (43.64%). The minimum fruit set was found in AB2 (36.36%) which was found to be statistically at par with AB1 (37.20 %), AB9 (37.87 %), AH2 (39.17%), AH5 (39.18 %), AH7 (39.61%) and AB5 (39.64%).

Similar in case of pooled mean, of the fruit set was observed to be highest (45.51%) fruit in AK7 and lowest in (34.73%) in AB2.

4.9.2 Open pollination

A perusal of data presented in Table 16 revealed that the fruit set (open pollination) in HRMN-99 during 2017 varied from 29.19 to 39.46 %. Maximum fruit set was recorded in HK7 (39.46 %) which was statistically at par with HK3 (39.23 %), and HK5 (38.23%) and the minimum fruit set was found in HB9 (29.19 %) which was statistically at par with HB5 (29.40 %), HB1 (30.10%), HB8 (30.48%) and HB4 (31.07 %).

Similarly during 2018, the fruit set was found to be maximum in HK7 (46.69 %) which was found statistically at par with HK9 (43.96 %), HK3 (43.30 %) and HK4 (42.61%) whereas, the minimum fruit set was found in HB9 (33.21%) which was found to be statistically at par with HB4 (34.64 %), HB2 (34.90 %), HB8 (34.94%), HB7 (35.12%), HH7 (35.28%), HB5 (35.91%), HB3 (36.23%), HB1, HB6 (36.24%), HH4 (36.57%), HH1 (36.87%), HB10 (37.10%), HH9 (37.54%) and in HH6 (37.87%)

A similar trend was observed when the pooled mean of the fruit set was studied wherein the maximum (43.07%) fruit set was recorded in HK7 and the minimum was recorded in HB9 (31.20%).

4.9.3 Open pollination

A perusal of data presented in Table 16 revealed that the fruit set (open pollination) in Dorsett Golden during 2017 varied from 41.87 to 52.22 %. Maximum fruit set was recorded in DK2 (55.22 %) which was found to be statistically at par with DK7 (52.18 %), DK5 (51.75 %) and DH2 (50.84%), DH5 (50.51%), DK3 (50.34%) and DK10 (50.29%) and the minimum fruit set was found in DB3 (41.87 %), which was statistically at par with DB6 (41.88 %), DB5 (42.08%), DB1 (42.12%), DB9 (42.39%), DB4 (43.13%), DB10 (43.21%) and DB7 (43.98 %).

A similar trend was observed in 2018, where in the fruit set was found to be maximum in DK2 (56.50%) which was found statistically at par with DK5 (55.95 %), DK7 (55.51 %), DK3 (54.67 %), DK6 (54.50 %), DH2 (54.37%), DH5 (53.96%), DK10 (53.72%), DH8 (53.64%), DK1 (53.43%), DH10 (53.06%), DH4 (52.72%), DK8 (52.67%) and DH7 (52.35%) and the minimum fruit set was found in DB5 (45.54%) which was found to be statistically at par with DB9 (45.59 %), DB3 (45.61 %), DB6 (46.41 %), DB4 (46.56%),

DB10 (46.73%), DB2 (47.52%), DB7 (47.78%), DH1 (48.42%), DB1 (48.62%), DB8 (48.81%) and DH9 (49.47%).

When the pooled mean of the fruit set was studied it was observed that the maximum (54.36 %) fruit set was recorded in DK2 which was found to be statistically at par with DK5 (53.85%) and DK7 (53.84%) however, minimum was recorded in DB3 (43.74%) which was found to be statistically at par with DB5 (43.81%), DB9 (43.99%) and DB6 (44.15%).

Table 16. Fruit set studies (open pollination) of low chill apple cultivars Anna, HRMN-99 and Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Anna Open pollination (%)			Tree code	HRMN-99 Open pollination (%)			Tree code	Dorsett Golden Open pollination (%)		
	2017	2018	Pooled		2017	2018	Pooled		2017	2018	Pooled
AK1	37.23	43.64	40.44	HK1	35.62	38.24	36.93	DK1	47.41	53.43	50.42
AK2	40.53	44.95	42.74	HK2	37.51	40.22	38.86	DK2	52.22	56.50	54.36
AK3	39.27	45.23	42.25	HK3	39.23	43.30	41.27	DK3	50.34	54.67	52.50
AK4	41.38	44.67	43.03	HK4	36.14	42.61	39.37	DK4	48.80	51.48	50.14
AK5	42.97	45.88	44.42	HK5	38.23	41.79	40.01	DK5	51.75	55.95	53.85
AK6	38.32	43.76	41.04	HK6	35.56	38.45	37.00	DK6	49.38	54.50	51.94
AK7	43.13	47.89	45.51	HK7	39.46	46.69	43.07	DK7	52.18	55.51	53.84
AK8	39.92	42.34	41.13	HK8	36.71	40.78	38.74	DK8	48.33	52.67	50.50
AK9	42.59	46.29	44.44	HK9	37.32	43.96	40.64	DK9	47.48	51.70	49.59
AK10	40.95	45.50	43.23	HK10	35.24	40.75	37.99	DK10	50.29	53.72	52.01
AH1	39.03	43.06	41.05	HH1	31.90	36.87	34.38	DH1	45.28	48.42	46.85
AH2	35.72	39.17	37.45	HH2	34.22	38.93	36.58	DH2	50.84	54.37	52.60
AH3	42.48	45.62	44.05	HH3	35.10	41.11	38.11	DH3	46.20	51.55	48.87
AH4	40.92	46.99	43.95	HH4	32.91	36.57	34.74	DH4	48.75	52.72	50.74
AH5	36.28	39.18	37.73	HH5	35.11	39.13	37.12	DH5	50.51	53.96	52.23
AH6	41.13	45.19	43.16	HH6	33.20	37.87	35.54	DH6	47.29	50.67	48.98
AH7	37.24	39.61	38.43	HH7	31.66	35.28	33.47	DH7	49.42	52.35	50.89
AH8	42.18	46.10	44.14	HH8	34.74	40.15	37.44	DH8	46.36	53.64	50.00
AH9	38.14	42.96	40.55	HH9	32.52	37.54	35.03	DH9	45.71	49.47	47.59
AH10	40.25	44.10	42.18	HH10	35.12	38.06	36.59	DH10	49.16	53.06	51.11
AB1	34.32	37.20	35.76	HB1	30.10	36.24	33.17	DB1	42.12	48.62	45.37
AB2	33.10	36.36	34.73	HB2	29.34	34.90	32.12	DB2	44.99	47.52	46.26
AB3	40.35	47.23	43.79	HB3	32.41	36.23	34.32	DB3	41.87	45.61	43.74
AB4	38.53	43.88	41.21	HB4	31.07	34.64	32.86	DB4	43.13	46.56	44.85
AB5	35.92	39.64	37.78	HB5	29.40	35.91	32.66	DB5	42.08	45.54	43.81
AB6	37.89	40.99	39.44	HB6	31.21	36.24	33.73	DB6	41.88	46.41	44.15
AB7	39.03	45.19	42.11	HB7	32.01	35.12	33.57	DB7	43.98	47.78	45.88
AB8	36.20	41.49	38.85	HB8	30.48	34.94	32.71	DB8	44.74	48.81	46.78
AB9	33.29	37.87	35.58	HB9	29.19	33.21	31.20	DB9	42.39	45.59	43.99
AB10	38.50	42.10	40.30	HB10	31.91	37.10	34.51	DB10	43.21	46.73	44.97
$CD_{0.05}$	2.15	4.32	0.62		1.88	4.81	0.66		2.59	4.54	0.67

Similar results were reported by Castro *et al.* (2017) in low chill apple cultivars which registered a significantly greater fruit set in cross and open pollination. Anwar *et al.* (2020) reported that low chill apple cultivar Dorsett Golden is effective in improving the fruit set of Anna in terms of open pollination. The observed variation in fruit set was entirely based on the genetic makeup of the cultivars i.e. self compatible or self-incompatible, pollen fertility and prevailing climatic condition, which either enhanced fruit set (moderate temperate and relative humidity) or decreased fruit set (very hot and humid conditions, lack of vector visits etc.).

4.10 FRUIT PHYSICAL PARAMETERS IN ANNA

4.10.1 Fruit Length

The data pertaining to fruit length (Table 17) revealed that fruit length of Anna under study ranged between 58.28 to 69.55 mm. The significantly largest fruit length (69.55 mm) in AK6 which was found at par with AK8 (68.74mm), AK2 (68.21mm), AK5 (67.52 mm), AH3 (67.22 mm), AH10 (66.74 mm), AH1 (66.61), AK9 (66.56 mm), AH6 (66.24 mm) and AK10 (66.16 mm). The smallest fruit length was found in AB4 (58.28mm) which was statistically at par AB2 (59.25 mm), AB5 (59.74 mm), AB10 (60.21 mm), AB6 (60.59 mm), AB7 (60.85mm), AK7 (61.21 mm), AH7 (61.24 mm) and AB9 (61.33 mm) during 2017.

During 2018, the significantly largest fruit length (70.94 mm) was recorded in AK8 which was found at par AH3 (69.67mm), AK2 (69.38 mm), AK4 (69.32 mm), AH10 (69.29 mm), AK5 (69.28 mm), AH9 (69.21 mm), AH1 (69.18 mm), AK9 (68.82 mm), AK6 (68.78 mm), AB1 (68.50 mm), AB8 (68.37 mm) and AH6 (68.18 mm). The minimum fruit length was found in AB5 (61.39 mm) which was found statistically at par AB2 (63.05 mm), AB7 (63.31 mm), AH7 (63.43 mm), AB4 (63.52 mm) and AB9 (64.40 mm),

Similar trend was observed in the data concerning to pooled mean of the fruit length recorded significantly maximum fruit length (69.84 mm) in AK8. The minimum fruit length (60.57 mm) was recorded in AB5 which was found statistically to be at par AB4 (60.90 mm) and AB2 (61.15 mm).

4.10.2 Fruit Width

During 2017, the data pertaining to fruit width (Table 17) revealed fruit width of cultivar Anna under study ranged between 54.24 to 63.48 mm. The significantly largest fruit

width (63.48 mm) was recorded in AH1 which was found statistically to be at par AK6 (63.38 mm), AK8 (62.69 mm) and AK5 (61.81 mm). The smallest fruit width was found in AB4 (54.24 mm) which was at par AB2 (54.64 mm), AH8 (55.14 mm), AH4 (55.20 mm), AB3 (55.23 mm), AB7 (55.38 mm), AB10 (55.60 mm), AK7 (56.46 mm), AB9 (56.65 mm), AH7 (56.93 mm) and AB1 (57.05 mm).

During 2018, the significantly maximum fruit width (66.57 mm) was recorded in AK2 which was found statistically at par with AH1 (65.82 mm), AK4 (65.24 mm), AH3 (64.57 mm), AH9 (64.36 mm), AH10 (63.89 mm) and AK3 (63.53 mm). The minimum fruit width was found in AB7 (55.12 mm) which was statistically at par with AB10 (56.03 mm), AB5 (56.10 mm), AB2 (57.13 mm) and AB4 (57.29 mm)

The data concerning to pooled mean of the fruit width significantly recorded maximum (64.65 mm) in AH1 and the minimum (55.25 mm) was in AB7, which was found to be at par with AB4 (55.77mm). According to Sharma (2011) and Verma *et al.* (2014) apple cultivars evaluated under low hill conditions of Himachal Pradesh, indicated variation in fruit breadth ranged from (41.58 to 73.28 mm and 65.29 to 69.45) and findings are near to that recorded in present study. The observation on this parameter is also very close to the findings of Sumrah *et al.* (2000), Sharma *et al.* (2004), Kumar *et al.* (2006), Singh *et al.* (2005), Dadashpour *et al.* (2012), Ikinci and Bolat (2017) and Pramanick *et al.* (2018) who recorded trait variation in the range of 48-76.9 mm whereas Sharma and Chauhan (2008) recorded higher fruit breadth values (75 mm-85 mm).

4.10.3 Fruit Weight

The average fruit weight of cultivar Anna under investigation ranged from 100.02 to 135.40 g per fruit (Table 18). The highest fruit weight (135.40 g) was recorded in a significant way in AK6 which was statistically at par with AK8 (134.59 g), AK2 (132.54 g) and AK5 130.37g. The lowest fruit weight (100.02 g) was recorded in AB5 which was found statistically at par with AB4 (104.76 g).

The significantly highest fruit weight (145.63 g was recorded in AK8 which was found at par with AK5 (144.32 g), AK6 (143.45 g), AH10 (142.02g), AK2 (141.28 g) and AH1 (140.93 g) whereas the lowest fruit weight was found in AB5 (109.47 g)

Similar trend was recorded in the data concerning pooled mean of the fruit weight which was highest (140.11 g) in AK8 found at par with AK6 (139.43 g) and the minimum fruit weight in AB5 (104.75g).

Table 17. Fruit length, width and weight of low chill apple cultivar Anna in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Fruit length (mm)			Fruit width (mm)			Fruit weight (g)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
AK1	65.44	65.58	65.51	58.35	61.48	59.92	120.81	127.01	123.91
AK2	68.21	69.38	68.80	59.04	66.57	62.81	132.54	141.28	136.91
AK3	65.63	67.24	66.44	59.45	63.53	61.49	125.79	136.23	131.01
AK4	65.29	69.32	67.31	60.53	65.24	62.89	126.82	138.64	132.73
AK5	67.52	69.28	68.40	61.81	61.56	61.69	130.37	144.32	137.35
AK6	69.55	68.78	69.17	63.38	61.89	62.64	135.40	143.45	139.43
AK7	61.21	67.35	64.28	56.46	60.19	58.33	122.12	129.71	125.92
AK8	68.74	70.94	69.84	62.69	62.91	62.80	134.59	145.63	140.11
AK9	66.56	68.82	67.69	57.65	62.98	60.32	123.15	137.77	130.46
AK10	66.16	67.24	66.70	59.17	61.19	60.18	127.61	133.66	130.64
AH1	66.61	69.18	67.90	63.48	65.82	64.65	128.36	140.93	134.65
AH2	63.38	67.12	65.25	58.45	59.21	58.83	118.24	129.34	123.79
AH3	67.22	69.67	68.45	60.11	64.57	62.34	126.78	137.21	132.00
AH4	63.48	67.45	65.47	55.20	60.24	57.72	120.47	129.86	125.17
AH5	62.61	67.02	64.82	58.73	60.52	59.63	124.16	132.79	128.48
AH6	66.24	68.18	67.21	57.83	63.32	60.58	127.39	128.03	127.71
AH7	61.24	63.43	62.34	56.93	60.45	58.69	121.53	129.66	125.60
AH8	62.81	66.71	64.76	55.14	62.15	58.65	119.41	135.38	127.40
AH9	65.32	69.21	67.27	58.21	64.36	61.29	123.27	138.54	130.91
AH10	66.74	69.29	68.02	59.68	63.89	61.79	128.75	142.02	135.39
AB1	63.67	68.50	66.09	57.05	59.41	58.23	120.25	132.67	126.46
AB2	59.25	63.05	61.15	54.64	57.13	55.89	106.42	117.66	112.04
AB3	62.70	67.12	64.91	55.23	62.20	58.72	119.16	129.34	124.25
AB4	58.28	63.52	60.90	54.24	57.29	55.77	104.76	116.91	110.84
AB5	59.74	61.39	60.57	60.06	56.10	58.08	100.02	109.47	104.75
AB6	60.59	65.30	62.95	57.89	61.24	59.57	114.21	126.51	120.36
AB7	60.85	63.31	62.08	55.38	55.12	55.25	109.39	120.17	114.78
AB8	65.11	68.37	66.74	57.14	59.98	58.56	116.32	127.27	121.80
AB9	61.33	64.40	62.87	56.65	58.33	57.49	110.10	122.6	116.35
AB10	60.21	66.15	63.18	55.60	56.03	55.82	112.49	123.09	117.79
$CD_{0.05}$	3.39	3.04	0.58	2.89	3.09	0.54	5.74	5.70	1.03

4.10.4 Fruit base cavity depth

The data relating to fruit base cavity depth recorded during 2017 indicated that average fruit base cavity depth ranged from 1.20 cm to 1.84 cm (Table 18). The maximum fruit base cavity depth (1.84 cm) was recorded in AH10 which was statistically at par with AH9 (1.79 cm) and AH6 (1.78 cm) and the minimum (1.20 cm) was recorded in AK1 which was statistically at par with AB2 (1.25 cm).

Kangra

Hamirpur

Bilaspur

Plate 1. Fruiting in low chill apple cultivar Anna

The significantly highest fruit base cavity depth ranged from 1.29 to 2.00 cm (Table 18). The highest fruit base cavity depth (2.00 cm) was recorded in AH5, AB1 which was statistically at par with AH6 (1.99 cm), AH9, AB9 (1.98 cm) and AK9 (1.94 cm) and the lowest fruit base cavity depth AH1 (1.29 cm) was recorded in during 2018.

Table 18. Fruit base cavity depth, fruit firmness and average seed number of low chill apple cultivar Anna in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Fruit base cavity depth (cm)			Fruit firmness (kg/cm^2)			Average Seed number
	2017	2018	Pooled	2017	2018	Pooled	
AK1	1.20	1.30	1.25	7.49	7.38	7.44	5.50
AK2	1.34	1.54	1.44	7.33	7.52	7.43	7.00
AK3	1.39	1.62	1.51	6.98	7.58	7.28	4.50
AK4	1.50	1.74	1.62	7.12	7.40	7.26	6.00
AK5	1.69	1.59	1.64	7.38	7.61	7.50	6.00
AK6	1.70	1.49	1.60	7.23	7.48	7.35	5.00
AK7	1.35	1.64	1.50	6.99	7.53	7.26	5.50
AK8	1.55	1.71	1.63	7.32	7.47	7.40	6.50
AK9	1.65	1.94	1.80	7.10	7.59	7.34	5.50
AK10	1.72	1.72	1.72	7.29	7.43	7.36	4.00
AH1	1.49	1.29	1.39	6.50	6.91	6.71	5.50
AH2	1.65	1.51	1.58	7.15	7.30	7.23	4.50
AH3	1.51	1.59	1.55	7.20	7.08	7.14	4.50
AH4	1.32	1.64	1.48	6.53	7.35	6.94	4.50
AH5	1.56	2.00	1.78	6.69	7.81	7.25	6.00
AH6	1.78	1.99	1.89	7.21	7.20	7.21	4.50
AH7	1.59	1.93	1.76	7.05	6.83	6.94	4.50
AH8	1.72	1.92	1.82	6.75	7.18	6.97	6.00
AH9	1.79	1.98	1.89	6.89	7.44	7.17	6.00
AH10	1.84	1.89	1.87	6.57	6.85	6.71	6.00
AB1	1.30	2.00	1.65	5.29	5.97	5.63	5.50
AB2	1.25	1.61	1.43	5.53	5.35	5.44	5.50
AB3	1.40	1.59	1.50	6.78	6.87	6.83	5.50
AB4	1.53	1.50	1.52	7.02	5.72	6.37	4.50
AB5	1.44	1.62	1.53	6.90	6.83	6.87	5.00
AB6	1.35	1.70	1.53	7.00	5.62	6.31	5.00
AB7	1.75	1.68	1.72	5.81	6.80	6.31	6.00
AB8	1.49	1.92	1.71	6.65	5.93	6.29	4.50
AB9	1.34	1.98	1.66	5.97	5.55	5.76	6.50
AB10	1.38	1.83	1.61	7.09	7.10	7.10	5.50
$CD_{0.05}$	0.07	0.06	0.01	NS	0.24	NS	NS

The data concerned with to pooled mean of the fruit base cavity depth on close examination revealed that AH6, AH9 recorded the maximum (1.89) and AK1 recorded the minimum (1.25) fruit base cavity depth.

4.10.5 Fruit firmness

The data relating to fruit firmness recorded during 2018 indicated that the fruit firmness values varied from 5.35 to 7.81 kg/cm^2. The significantly highest firmness was observed in AH5 (7.81 kg/cm^2) which was statistically at par with AK5 (7.61 kg/cm^2), AK9 (7.59 kg/cm^2) and AK3 (7.58 kg/cm^2) and the minimum fruit firmness was recorded in AB2 (5.35 kg/cm^2) which was at par with AB9 (5.55 kg/cm^2)

4.11 FRUIT PHYSICAL PARAMETERS IN HRMN-99

4.11.1 Fruit Length

The analysis of variance revealed a significant difference among low chill apple cultivar HRMN-99 for physical parameters of fruits. The data related to physical characteristics of fruits are given in Table19 which are explained as follows:

The data pertaining to fruit length (Table 19) revealed that fruit length in HRMN-99 during 2017 ranged between 58.16 to 68.64 mm. The significantly maximum fruit length (68.64 mm) was recorded in HK4 which was found to be at par with HH6 (66.86 mm), HK1 (66.75 mm) and HK8 (65.56 mm). The minimum fruit length was found in HK3 (58.16 mm) which was found to be at par with HB7 (58.25 mm), HK5 (59.40 mm), HB1 (59.43 mm), HH1 (59.84 mm), HB3 (60.18mm), HB2 (60.44 mm), HB6 (60.56 mm) HB4 (60.88 mm) and HB9 (61.17 mm).

During 2018, the highest fruit length (69.89 mm) in HK10 which was found to be at par with HH2 (69.34 mm), HK4 (68.92 mm), HK1 (68.42 mm), HH9 (68.20 mm), HH6 (67.53 mm) and HB4 (67.51 mm). The minimum fruit length was found to be (54.45 mm) HK9.

The data concerning pooled mean of the fruit length recorded a significantly maximum fruit length (68.78 mm) in HK4, while the minimum fruit length (58.95 mm) was recorded in HK9**.**

4.11.2 Fruit Width

During 2017, the data pertaining to fruit width (Table 19) revealed variation in fruit width in cultivar HRMN-99 under study which ranged between 51.19 to 62.96 mm. The significantly largest fruit width (62.96 mm) was recorded in HH6 which was found at par

with HH2 (61.46 mm), HK10 (61.40 mm), HK8 (61.38 mm), HB8 (61.32 mm) and HK4 (60.42 mm). The smallest fruit width was found in HB7 (51.19 mm) which was found to be at par with HB3(52.08 mm), HK3 (52.46 mm), HB1 (53.12 mm), HK5 (53.20 mm), HB2 (53.82 mm).

During 2018, the largest fruit width (64.57 mm) was recorded in HK5 which was found to be at par with HK1 (63.77 mm), HK8 (63.26 mm), HK4 (62.85 mm), HK6 (62.58 mm), HK7 (62.41 mm), HH4 (62.25 mm), HK2 (61.96 mm) and HH2 (61.65 mm). The smallest fruit width was found to be at par with HH3 (53.11 mm) which was found to be at par HB10 (54.20 mm).

When pooled mean of the fruit width was examined the largest fruit width was recorded in HH6 (62.66 mm) which was at par with HK8 (62.32 mm) and the smallest (53.81 mm) was recorded in HH3 which was found at par with HB10 (54.33 mm).

The variation in size of the fruits has been reported by several workers (Rathore, 1986, Kumar and Verma, 2001, Sumrah *et al*. 2000, Sharma and Chauhan, 2008). They reported that variation in size is a varietal character and is also influenced by climatic conditions and management practices.

4.11.3 Fruit weight

In 2017 the average fruit weight under investigation ranged from 95.37 to 128.23 g per fruit (Table 19). The highest fruit weight (128.23 g) was recorded in HK4 which was statistically at par with HK8 (127.75 g), HK10 (126.15 g) and HH2 (125.73 g), HK1 (125.54 g) and HH4 (124.39 g). The lowest fruit weight (95.37 g) was recorded in HB3 which was found statistically at par with HB5 (97.41g) HB1 (98.42 g) and HB6 (100.29 g).

In 2018, the significantly highest fruit weight (139.37 g) was recorded in HK4 which was found to be at par with HK10 (138.93 g), HK5 (137.21 g), HK8 (136.59 g), and HH2 (134.48 g). The lowest fruit weight was found in HB3 (107.56 g) which was found to be statistically at par with HB1 (110.34 g)

Similar trend was recorded in the data concerning pooled mean of the fruit weight wherein the highest (133.80 g) fruit weight was recorded in HK4 and the lowest fruit weight (101.47g) was recorded in HB3.

Table 19. Fruit length, width and weight of low chill apple cultivar HRMN-99 in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Fruit length (mm)			Fruit width (mm)			Fruit weight (g)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
HK1	66.75	68.42	67.59	59.30	63.77	61.54	125.54	134.03	129.79
HK2	62.87	66.32	64.60	59.51	61.96	60.74	110.56	122.48	116.52
HK3	58.16	65.40	61.78	52.46	60.17	56.32	115.30	121.67	118.49
HK4	68.64	68.92	68.78	60.42	62.85	61.64	128.23	139.37	133.80
HK5	59.40	66.48	62.94	53.20	64.57	58.89	117.60	137.21	127.41
HK6	63.60	67.02	65.31	57.92	62.58	60.25	123.58	130.42	127.00
HK7	63.59	66.53	65.06	59.05	62.41	60.73	112.66	123.61	118.14
HK8	65.56	67.15	66.36	61.38	63.26	62.32	127.75	136.59	132.17
HK9	63.45	54.45	58.95	58.13	59.08	58.61	114.12	123.33	118.73
HK10	65.38	69.89	67.64	61.4	59.97	60.69	126.15	138.93	132.54
HH1	59.84	62.40	61.12	55.38	56.21	55.80	107.2	115.19	111.20
HH2	64.19	69.34	66.77	61.46	61.65	61.56	125.73	134.48	130.11
HH3	62.03	59.30	60.67	54.50	53.11	53.81	109.15	116.50	112.83
HH4	64.11	66.89	65.50	59.92	62.25	61.09	124.39	131.39	127.89
HH5	64.73	63.98	64.36	58.83	60.52	59.68	105.21	117.06	111.14
HH6	66.86	67.53	67.20	62.96	62.36	62.66	121.43	131.68	126.56
HH7	61.64	63.11	62.38	55.34	59.24	57.29	119.29	126.54	122.92
HH8	64.29	60.03	62.16	57.66	57.22	57.44	106.45	117.67	112.06
HH9	65.08	68.20	66.64	58.42	59.47	58.95	122.84	132.75	127.80
HH10	64.27	67.25	65.76	57.11	59.36	58.24	120.06	128.53	124.30
HB1	59.43	61.66	60.55	53.12	56.15	54.64	98.42	110.34	104.38
HB2	60.44	64.42	62.43	53.82	57.29	55.56	105.63	117.38	111.51
HB3	60.18	65.27	62.73	52.08	57.18	54.63	95.37	107.56	101.47
HB4	60.88	67.51	64.20	55.40	58.22	56.81	118.63	127.39	123.01
HB5	62.76	65.91	64.34	55.18	58.83	57.01	97.41	115.93	106.67
HB6	60.56	64.51	62.54	59.89	60.29	60.09	100.29	112.52	106.41
HB7	58.25	65.86	62.06	51.19	61.42	56.31	112.55	120.10	116.33
HB8	64.09	66.23	65.16	61.32	59.67	60.50	116.30	125.33	120.82
HB9	61.17	61.39	61.28	55.29	57.62	56.46	103.23	112.65	107.94
HB10	61.40	60.43	60.92	54.45	54.20	54.33	110.37	119.75	115.06
$CD_{0.05}$	3.22	2.42	0.51	2.89	2.92	0.52	4.56	4.92	0.86

4.11.4 Fruit base cavity depth

In the year 2017, the data relating to fruit base cavity depth indicated that the average depth ranged from 1.18 cm to 1.75 cm (Table 20). The maximum fruit base cavity depth (1.75 cm) was recorded in HK5 which was statistically at par with HH6 (1.73 cm) HK4 (1.71

Kangra

Hamirpur

Bilaspur

Plate 2 Fruiting in low chill apple cultivar HRMN-99

cm), HK10 (1.70 cm) and HK9 (1.69 cm). The minimum HK1 (1.18 cm) was recorded in which was statistically at par with HH7 (1.20 cm), HK7 (1.21 cm), HB3 (1.22 cm), HH3 (1.23 cm) and HK1, HH5 (1.25 cm).

Table 20. Fruit base cavity depth, fruit firmness and average seed number of low chill apple cultivar HRMN-99 in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Fruit base cavity depth (cm)			Fruit firmness (kg/cm^2)			Average seed Number
	2017	2018	Pooled	2017	2018	Pooled	
HK1	1.18	1.31	1.25	5.84	6.10	5.97	5.50
HK2	1.25	1.39	1.32	6.30	6.35	6.33	5.50
HK3	1.62	1.42	1.52	5.98	6.19	6.09	5.50
HK4	1.71	1.50	1.61	6.21	6.33	6.27	4.50
HK5	1.75	1.30	1.53	6.38	6.21	6.29	6.00
HK6	1.32	1.43	1.38	6.48	6.49	6.49	5.00
HK7	1.21	1.35	1.28	5.93	6.55	6.24	6.00
HK8	1.30	1.41	1.35	6.37	6.17	6.27	6.50
HK9	1.69	1.48	1.59	5.85	6.30	6.08	5.50
HK10	1.70	1.53	1.61	6.32	6.47	6.40	6.00
HH1	1.30	1.90	1.60	5.79	5.69	5.74	7.00
HH2	1.39	1.85	1.62	6.25	5.42	5.84	6.00
HH3	1.23	1.35	1.29	6.14	6.23	6.19	5.50
HH4	1.64	1.81	1.73	6.09	5.46	5.78	5.50
HH5	1.25	1.79	1.52	5.95	5.39	5.67	5.50
HH6	1.73	1.70	1.72	5.72	5.55	5.64	6.00
HH7	1.20	1.33	1.27	6.21	6.21	6.21	7.00
HH8	1.28	1.80	1.54	6.16	5.37	5.77	5.50
HH9	1.32	1.42	1.37	5.99	6.23	6.11	5.50
HH10	1.53	1.53	1.53	5.83	6.32	6.08	7.00
HB1	1.53	1.60	1.57	6.05	5.57	5.81	5.50
HB2	1.64	1.53	1.59	5.51	5.39	5.45	6.00
HB3	1.22	1.30	1.26	5.18	6.00	5.59	6.00
HB4	1.33	1.38	1.36	5.95	5.78	5.87	6.00
HB5	1.29	1.44	1.37	6.03	6.01	6.02	5.50
HB6	1.44	1.48	1.46	5.84	5.63	5.74	6.50
HB7	1.59	1.32	1.46	5.59	5.83	5.71	6.50
HB8	1.63	1.30	1.47	6.09	5.96	6.03	6.50
HB9	1.70	1.59	1.65	5.74	6.03	5.88	6.00
HB10	1.37	1.64	1.51	5.68	5.60	5.64	6.00
$CD_{0.05}$	0.07	0.06	0.01	NS	NS	NS	NS

In the year 2018 the maximum fruit base cavity depth was ranged from 1.30 cm to 1.90 cm (Table 20). The maximum fruit base cavity depth (1.90 cm) was recorded in HH1 which was statistically at par with HH2 (1.85 cm) and the minimum fruit base cavity depth

(1.30 cm) was recorded in HB3 which was statistically at par with HK1 (1.31 cm), HB7 (1.32 cm), HH7 (1.33 cm) and HH3, HK7 (1.35 cm).

The data concerning pooled mean of the fruit base cavity depth when examined revealed that the maximum value was observed in HH4 (1.73 cm) which was statistically at par with HH6 (1.72 cm) and the minimum in HK1 (1.25 cm) which was statistically at par with HB3 (1.26 cm).

4.12 FRUIT PHYSICAL PARAMETER IN DORSETT GOLDEN

4.12.1 Fruit Length

It is evident from Table 21 that the fruit length of cultivar in Dorsett Golden during 2017 ranged between 50.31 to 59.28 mm. The significantly maximum fruit length (59.28 mm) was recorded in DK8 which was found at par DB10 (59.22 mm), DH10 (58.45 mm), DH2 (58.31 mm), DB5 (58.15 mm), DB8 (57.85 mm), DK4 (57.32 mm), DH8 (57.11mm) DK9 (56.81 mm) and DK2 (56.62 mm). The minimum fruit length was found in DK3 (50.31 mm) which was at par with DH4 (50.62 mm), DK5, DH1 (51.33 mm), DH7 (52.17 mm) and DB1 (53.28 mm).

During 2018, the significantly maximum fruit length (60.81 mm) was recorded in DH3 which was found to be at par with DK4 (60.63 mm), DB2 (60.13 mm), DH6 (59.56 mm) and DK9 (58.97 mm). The minimum fruit length was found in DK7 (48.39 mm) which was at par with DK3 (50.26 mm), DB5 (50.31 mm), DB3 (50.32 mm) and DB7 (50.38 mm).

The data concerning pooled mean of the fruit length was significantly maximum in DK4 (58.98 mm), DH3 (58.49 mm), DK8 (58.35 mm) and minimum in DK3 (50.29 mm) which was at par with DK5 (51.03 mm).

4.12.2 Fruit width

The data pertaining to fruit width (Table 21) revealed a variation in fruit width of Dorsett Golden under study which ranged between 55.34 to 68.05 mm. The significantly highest fruit width (68.05 mm) was recorded in DB8 which was found to be at par with DB10 (65.05 mm). The minimum fruit width was in DK5 (55.34 mm) which was found to be at par DB7 (56.26 mm). DH1 (56.35 mm), DK3 (56.97 mm), DB1 (57.42 mm) and DH4 (57.51 mm).

Kangra

Hamirpur

Bilaspur

Plate 3. Fruiting in low chill apple cultivar Dorsett Golden

Table 21. Fruit length, fruit width and fruit weight of low chill apple cultivar Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Fruit length (mm)			Fruit width (mm)			Fruit weight(g)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
DK1	54.81	52.43	53.62	59.35	59.32	59.34	88.21	99.50	93.85
DK2	56.62	55.83	56.23	60.13	63.09	61.61	112.26	120.97	116.61
DK3	50.31	50.26	50.29	56.97	57.19	57.08	90.97	97.13	94.05
DK4	57.32	60.63	58.98	60.59	64.43	62.51	114.64	123.33	118.98
DK5	51.33	50.72	51.03	55.34	58.81	57.08	93.12	99.17	96.14
DK6	55.24	56.22	55.73	62.03	60.08	61.06	101.4	111.12	106.26
DK7	55.21	48.39	51.80	59.06	58.71	58.89	89.36	96.49	92.92
DK8	59.28	57.42	58.35	63.33	61.38	62.36	108.05	118.35	113.20
DK9	56.81	58.97	57.89	60.12	64.97	62.55	110.95	119.33	115.14
DK10	54.52	56.52	55.52	59.36	60.36	59.86	102.29	111.19	106.74
DH1	51.33	54.39	52.86	56.35	59.62	57.99	95.20	101.24	98.22
DH2	58.31	57.52	57.92	65.01	62.54	63.78	109.81	116.45	113.13
DH3	56.17	60.81	58.49	61.62	68.49	65.06	102.10	109.55	105.82
DH4	50.62	52.73	51.68	57.51	61.74	59.63	97.72	88.70	93.21
DH5	56.13	52.09	54.11	63.22	60.17	61.70	100.53	108.13	104.33
DH6	53.47	59.56	56.52	61.91	65.57	63.74	96.27	107.17	101.72
DH7	52.17	56.70	54.44	59.57	62.63	61.10	107.29	112.31	109.8
DH8	57.11	57.62	57.37	62.02	61.58	61.80	105.80	117.54	111.67
DH9	55.29	56.09	55.69	60.09	65.98	63.04	110.74	122.34	116.54
DH10	58.45	55.08	56.77	62.65	59.08	60.87	104.67	116.39	110.53
DB1	53.28	56.43	54.86	57.42	51.70	54.56	86.69	97.29	91.99
DB2	54.45	60.13	57.29	59.12	64.57	61.85	103.16	112.35	107.75
DB3	53.35	50.32	51.84	61.33	56.12	58.73	89.42	96.97	93.19
DB4	54.91	53.52	54.22	60.43	58.62	59.53	107.28	118.15	112.71
DB5	58.15	50.31	54.23	62.85	60.62	61.74	94.32	86.36	90.34
DB6	55.17	57.18	56.18	60.42	65.24	62.83	108.52	120.76	114.64
DB7	53.39	50.38	51.89	56.26	55.22	55.74	84.19	94.49	89.34
DB8	57.85	57.35	57.60	68.05	60.18	64.12	102.31	114.43	108.37
DB9	54.35	50.49	52.42	59.52	56.73	58.13	85.48	93.54	89.51
DB10	59.22	52.35	55.79	65.05	60.24	62.65	106.55	100.6	103.57
$CD_{0.05}$	3.02	2.00	1.01	3.01	2.76	1.26	4.72	4.20	0.81

On the contrary during 2018, the significantly maximum fruit width (68.49 mm) was recorded in DH3 which was found to be at par with DH9 (65.98 mm) and the minimum fruit width was found to be in DB1 (51.70 mm).

The data concerning pooled mean of the fruit width was significantly highest (65.06 mm) in DH3 was found to be at par with DB8 (64.12 mm) and the minimum (54.56 mm) was recorded in DB1 which was found to be at par with DB7 (55.74 mm).

4.12.3 Fruit weight

During 2017 the average fruit weight for the cultivar Dorsett Golden under investigation ranged from 84.19 to 114.64 g per fruit (Table 21). The maximum fruit weight (114.64 g) was recorded in a significant way in DK4 which was found to be statistically at par with DK2 (112.26 g), DK9 (110.95 g) and DH9 (110.74 g). The smallest fruit weight (84.19 g) was recorded in DB7 which was found to be statistically at par with DB9 (85.48 g), DB1 (86.69 g) and DK1 (88.21g).

In 2018, the significantly maximum fruit weight (123.33 g) was recorded in DK4 which was found to be at par with DH9 (122.34 g), DK2 (120.97 g), DB6 (120.76 g) and DK9 (119.33 g) and the minimum fruit weight was found in DB5 (86.36 g)) which was at par with DH4 (88.70 g).

Similar trend was recorded in the pooled data of fruit weight wherein the maximum (118.98 g) fruit weight was recorded in DK4 and the minimum fruit weight (89.34 g) was recorded in DB7 which was found to be at par with DB9 (89.51 g).

4.12.4 Fruit base cavity depth

The data relating to fruit base cavity depth recorded during 2017 indicated that values ranged from 0.79 cm to 0.91 cm (Table 22). The maximum fruit base cavity depth (0.91 cm) was recorded in DK1, DB8 and in DH6 which was statistically at par with DK4, DH1, DB7 (0.90 cm), DH7, DB6, DB10 (0.89 cm) and DK3, DB3, DH5 (0.88 cm). The minimum (0.79 cm) fruit base cavity depth was recorded in DH10 which was statistically similar with DK2, DK10 (0.80 cm), DK5, DB4, DH4 (0.81 cm) and DK8 (0.82 cm).

In the following year, fruit base cavity depth ranged from 0.80 to 1.01 cm (Table 22), the highest (1.01 cm) of which was recorded in DB5 and it was statistically at par with DK4, DH3 (1.00 cm) and DK5 (0.99 cm) and the lowest fruit base cavity depth (0.80 cm) was recorded in DK1, DH7, DB4 which was recorded at par with DK10, DB10 (0.82 cm), DB2 (0.83 cm) and DH6, DH10 (0.84 cm).

The highest (0.95 cm) pooled mean of the fruit base cavity depth was recorded in DK4 which was found to be statistically at par with DH3 (0.94 cm) and the lowest (0.81 cm) was recorded in DK10 and DB4 which was statistically at par with (0.82 cm) DH10.

4.12.5 Fruit firmness

It is clear from the data presented in Table 22 that fruit firmness recorded during 2017 indicated variations from 6.21 kg/cm^2 to 7.95 kg/cm^2. The significantly maximum firmness (7.95 kg/cm^2) was found in DK6 which was statistically found to be at par with DH9 (7.87 kg/cm^2), DK5 (7.84 kg/cm^2), DK2 (7.78 kg/cm^2), DK4 (7.72 kg/cm^2) DH5 (7.69 kg/cm^2), DH3 (7.67 kg/cm^2), DB5 (7.62 kg/cm^2) and DB10 (7.63 kg/cm^2) and the minimum fruit firmness (6.21 kg/cm^2) was recorded in DB1 which was observed to be at par with DB4 (6.25kg/cm^2), DB9 (6.29 kg/cm^2), DB6 (6.39 kg/cm^2), DB2 (6.44 kg/cm^2) DH2 (6.50 kg/cm^2) and DH4 (6.53kg/cm^2).

The data relating to fruit firmness recorded during 2018 indicated that the values varied from 6.00 kg/cm^2 to 7.86 kg/cm^2. The maximum firmness (7.86 kg/cm^2) was found in DK1 which is statistically at par with DK8 (7.65 kg/cm^2) and the minimum fruit firmness (6.00 kg/cm^2) was recorded in DH2 which was found to be at par with DK7 (6.20 kg/cm^2) and DK3 (6.22 kg/cm^2).

The data concerning to pooled mean of the firmness was found to be maximum (7.78 kg/cm^2) in DK6 and the minimum fruit firmness (6.49 kg/cm^2) was recorded in DK7 which was found to be at par with DH2 (6.50 kg/cm^2). Armas Reyes *et al*. (1987) studied the performance of ten-year-old Anna apples on various rootstocks for their adaption to Mexico and found yields were modest having equal fruit firmness, although M7 and MM 111 had the biggest fruit sizes. Monteverde, (1989) reported that low chilling cultivars, such as Anna, HRMN-99, and Dorsett Golden, performed well and were recommended for growing at intermediate altitudes (500 m a.m.s.l) in Venezuela. On the contrary, Panhwar (1995) reported that Anna and Dorsett Golden were unsatisfactory for cultivation in the subtropical region of Sindh province, Pakistan. Every year cultivar Anna blossomed two weeks prior to Dorsett Golden and during the same period of time cultivar Dorsett Golden produced a few fruits, but they were small in terms of quantity and size and even Dormex application also did not help these two cultivars in synchronizing the flowering period.

Table 22. Fruit base cavity depth, fruit firmness and average seed number of low chill apple cultivar Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	Fruit base cavity depth (cm)			Fruit firmness (kg/cm$^{2)}$)			Average seed number
	2017	2018	Pooled	2017	2018	Pooled	
DK1	0.91	0.80	0.86	6.81	7.86	7.34	6.50
DK2	0.80	0.92	0.86	7.78	7.38	7.58	7.50
DK3	0.88	0.95	0.91	6.94	6.22	6.58	7.00
DK4	0.90	1.00	0.95	7.72	6.83	7.28	6.00
DK5	0.81	0.99	0.90	7.84	7.57	7.71	5.50
DK6	0.84	0.93	0.89	7.95	7.60	7.78	6.50
DK7	0.86	0.90	0.88	6.77	6.20	6.49	7.00
DK8	0.82	0.94	0.88	7.59	7.65	7.62	7.00
DK9	0.83	0.93	0.88	6.81	6.51	6.66	6.00
DK10	0.80	0.82	0.81	7.52	7.25	7.39	7.50
DH1	0.90	0.87	0.88	6.50	7.09	6.80	7.50
DH2	0.85	0.89	0.87	7.00	6.00	6.50	6.00
DH3	0.87	1.00	0.94	7.67	7.18	7.43	7.00
DH4	0.81	0.94	0.87	6.53	6.73	6.63	7.50
DH5	0.88	0.90	0.89	7.69	7.20	7.45	7.50
DH6	0.91	0.84	0.88	6.88	7.57	7.23	6.00
DH7	0.89	0.80	0.85	6.94	6.32	6.63	5.00
DH8	0.84	0.90	0.87	7.19	6.94	7.07	6.00
DH9	0.83	0.93	0.88	7.87	7.38	7.63	6.50
DH10	0.79	0.84	0.82	6.73	6.86	6.80	7.50
DB1	0.84	0.95	0.90	6.21	7.01	6.61	7.00
DB2	0.87	0.83	0.85	6.44	6.73	6.59	5.00
DB3	0.88	0.89	0.89	7.53	6.45	6.99	6.50
DB4	0.81	0.80	0.81	6.25	6.84	6.55	7.00
DB5	0.83	1.01	0.92	7.62	6.52	7.07	6.50
DB6	0.89	0.93	0.91	6.39	6.72	6.56	7.50
DB7	0.90	0.94	0.92	7.08	6.66	6.87	7.50
DB8	0.91	0.85	0.88	7.50	6.48	6.99	6.00
DB9	0.85	0.89	0.87	6.29	7.09	6.69	6.50
DB10	0.89	0.82	0.86	7.63	6.77	7.20	6.00
$CD_{0.05}$	0.03	0.04	0.01	0.34	0.25	0.05	NS

4.13 ORGANOLEPTIC ANALYSIS

Sensory evaluation of fruit samples with respect to all the three low chill apple cultivars namely Anna, HRMN-99 and Dorsett Golden was conducted for various characters

such as, pulp texture, pulp taste and juiciness acceptance. Marks ranging from of 1 to 10 was allotted depicted the range from very poor to excellent so as to find out the most acceptable low chill apple cultivar from consumer's point of view. The results presented in Table 23 revealed that the pulp texture with respect to cultivar Anna ranged from 5 to 8 while that in HRMN-99 ranged from 5 to 7 and in Dorsett Golden from 5 to 8. When the result on pulp taste (Table 23) was examined it was observed that the taste ranged from 5 to 8 in case of Anna, 5 to 7 in HRMN-99 and 5 to 8 in Dorsett Golden. Similarly when the results on juiciness was studied, it was found that the juiciness ranged from 5 to 7 in Anna and HRMN-99 while it ranged from 5 to 8 in Dorsett Golden.

Table 23. Sensory evaluation of low chill apple cultivar Anna, HRMN-99 and Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree Code	Anna			Tree Code	HRMN99			Tree Code	Dorsett Golden		
	Pulp texture	Pulp taste	Juiciness		Pulp texture	Pulp taste	Juiciness		Pulp texture	Pulp taste	Juiciness
AK1	7	8	6	HK1	5	6	7	DK1	8	8	7
AK2	6	7	5	HK2	6	5	6	DK2	7	7	6
AK3	7	8	6	HK3	5	5	5	DK3	6	8	7
AK4	8	6	7	HK4	5	6	7	DK4	7	7	8
AK5	6	7	5	HK5	6	7	6	DK5	8	6	7
AK6	7	7	6	HK6	5	5	5	DK6	8	7	6
AK7	6	8	7	HK7	6	6	6	DK7	7	6	7
AK8	8	6	7	HK8	5	7	6	DK8	6	7	8
AK9	7	7	6	HK9	6	5	7	DK9	8	8	6
AK10	6	8	7	HK10	6	6	5	DK10	7	7	8
AH1	6	5	5	HH1	5	6	7	DH1	6	5	7
AH2	7	7	6	HH2	5	5	6	DH2	6	7	6
AH3	6	7	5	HH3	5	6	7	DH3	7	5	5
AH4	5	6	6	HH4	6	5	6	DH4	7	6	7
AH5	7	7	5	HH5	5	5	6	DH5	5	6	7
AH6	6	6	6	HH6	6	7	7	DH6	6	7	6
AH7	6	7	5	HH7	5	6	6	DH7	7	6	5
AH8	6	7	6	HH8	6	5	5	DH8	6	7	7
AH9	7	7	7	HH9	6	7	5	DH9	7	8	6
AH10	6	6	5	HH10	7	5	6	DH10	6	5	5
AB1	5	6	6	HB1	5	5	6	DB1	8	6	6
AB2	6	7	5	HB2	6	6	5	DB2	6	7	5
AB3	6	5	6	HB3	5	5	6	DB3	7	5	6
AB4	5	5	5	HB4	6	5	7	DB4	7	6	5
AB5	5	7	6	HB5	5	6	6	DB5	6	6	6
AB6	7	6	7	HB6	7	6	7	DB6	5	6	5
AB7	6	6	6	HB7	6	7	5	DB7	8	7	5
AB8	5	6	5	HB8	5	5	6	DB8	7	8	6
AB9	6	6	5	HB9	6	5	6	DB9	5	7	5
AB10	6	7	6	HB10	7	6	5	DB10	6	8	6

4.14 FRUIT BIOCHEMICAL CHARACTERISTICS IN ANNA

4.14.1 Total soluble solids

Data pertaining to total soluble solids (TSS °Brix) have been recorded for the years 2017 and 2018 along with pooled data are presented in Table 24. The analysis of variance revealed a significant difference for total soluble solids characteristics. The results thus obtained are described as follows:

The data relating to total soluble solids recorded during 2017 indicated that the mean total soluble solids values varied from 9.23 °Brix to 10.50 °Brix. The highest TSS (10.50 °Brix) was recorded in AK3 which was closely followed by AK4 (10.43° Brix), AK10 (10.38 °Brix), AK1 (10.35 °Brix), AH6 (10.28 °Brix), AH9 (10.26 °Brix), AH7 (10.21 °Brix) and AK2 (10.20 °Brix). The lowest TSS (9.23 °Brix) was observed in AB3 which was at par with AB1 (9.26 °Brix), AB5 (9.40 °Brix), AB10 (9.43 °Brix), AH8 (9.49 °Brix), AB8 (9.53°Brix) and AH1 (9.56 °Brix).

The data relating to total soluble solids recorded during 2018 indicated that the mean TSS values varied from 9.80 °Brix to 10.96 °Brix. The maximum TSS (10.96 °Brix) was recorded in AK9 closely followed by AK1 (10.95°Brix), AH9 (10.92 °Brix), AK2 (10.91 °Brix), AB3 (10.90 °Brix)AB3 (10.90 °Brix), AK4 (10.89 °Brix), AH5, AB 5 (10.88°Brix), AK7 (10.85 °Brix), AH1 (10.79°Brix), AH3 (10.78 °Brix), AK6 (10.78°Brix) and AB10 (10.78°Brix). The minimum TSS was recorded in AB1 (9.80 °Brix) closely followed by AH2 (9.81°Brix), AK3 (9.82 °Brix), AK5, AH4 (9.83 °Brix), AK8, AH10 (9.84 °Brix), AH6 (9.94 °Brix), AB2, AB6 (9.95 °Brix), AH8 (9.96 °Brix) and AB4, AB9 (9.97 °Brix).

The presented pooled data on to total soluble solids indicated that the values ranged from 9.53 °Brix to 10.66 °Brix. The maximum TSS (10.66 °Brix) in pooled mean was observed in AK4 which was found statistically at par with AK1 (10.65 °Brix), AH9 (10.59 °Brix) and AK5, AK2 (10.55°Brix) whereas, minimum TSS (9.53°Brix) was observed in AB1.

4.12.2 Titratable acidity

The data pertaining to fruit titrable acidity (TA) content is presented in Table 24. It is evident from the data that titrable acidity during 2017 ranged from 0.30 to 0.48% .The highest TA (0.48 %) was recorded in AK2 and AH7 closely followed by AB4 (0.47%) and AB7 ,

AH3 (0.46%). The lowest TA (0.30 %) was observed in AH5 which was found at par with AH2 (0.32 %).

On the contrary during 2017 the maximum TA (0.45 %) was recorded in AB3 closely followed by AH6, AB6, AB8 (0.43%). The lowest TA (0.30 %) was observed in AH10 as was the case in 2017, though it was found to be at par with AK1 (0.31%) and AB2, AH1, AH7 (0.32%).

The presented data concerning pooled mean titrable acidity indicated that the values ranged from 0.32 to 0.45%. The maximum TA (0.45 %) was observed in AK2 which was statistically at par with AH3, AB7 (0.44 %). Whereas, minimum TA (0.32 %) was observed in AH5 which was found to be statistically at par with AK4 (0.33%)

4.12.3 Total Sugars

The data pertaining to total sugars content is presented in Table 24. It is evident from the data that total sugars in 2017 ranged from 7.99 to 9.19%. The maximum total sugars (9.19 %) was recorded in AK4 which was found to be at par AK10 (9.14 %), AK3, (9.13 %) AK1 (9.04%) AH9 (8.97 %), AH5 (8.98 %), AH6 (8.89 %), AH2 (8.88 %) and AH7 (8.83 %). The minimum total sugars (7.99 %) was in AB3 which was at par with AB1 (8.06 %), AB5 (8.11 %), AB10 (8.19 %), AH8 (8.22 %), AH1, AB8 (8.30 %), AK5 (8.31%) and AH10 (8.34 %).

During 2018, the maximum total sugars (9.66 %) was recorded in AH5 closely followed by AK1 (9.65%), AK2 (9.53%), AB10 (9.51%), AH3 (9.49 %), AK10 (9.45 %) and AH1 (9.37 %). The minimum total sugars (8.05 %) was observed for AK3 which was found at par with AH8, AH10 (8.14%), AB6 (8.22%), AB2 (8.23%), AB1 (8.26%), AH6 (8.31%) and AK8 (8.34 %).

The presented pooled data concerning to total sugars indicated that the values ranged from 8.16 to 9.35 %. The maximum total sugars (9.35 %) was observed in AK1which was found to be statistically at par with AH5 (9.32%), AK10 (9.30%) and AK4 (9.28%). Whereas, the minimum total sugars observed in AB1 (8.16 %) which was statistically at par with AH8 (8.18 %).

4.12.4 Reducing Sugars

A perusal of data presented in Table 24 revealed that the reducing sugars during 2017 ranged from 4.08 to 5.25%. The highest reducing sugars (5.25 %) was recorded in AK4

which was observed at par with AK10 (5.23 %), AK8 (5.20 %), AK3, AK9 (5.14 %) and AK1 (5.11 %) The lowest reducing sugar (4.08 %) was observed in AB3 which was found to be at par with AH8 (4.27 %).

During 2018 the highest reducing sugars (5.81 %) was recorded in AH5 closely followed by AK1 (5.73 %), AB10 (5.70%), AH3 (5.67 %) and AK2 (5.62 %). The lowest reducing sugars (4.13 %) were observed in AB6 which was found at par with AK3 (4.26).

Table 24. Biochemical analysis of apple cultivar Anna in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	TSS (° B)			Titrable Acidity (%)			Total Sugars (%)			Reducing Sugars (%)			Non Reducing Sugar (%)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
AK1	10.35	10.95	10.65	0.43	0.31	0.37	9.04	9.65	9.35	5.11	5.73	5.42	3.73	3.72	3.73
AK2	10.20	10.91	10.55	0.48	0.41	0.45	8.80	9.53	9.17	4.70	5.62	5.16	3.89	3.71	3.80
AK3	10.50	9.82	10.16	0.42	0.37	0.40	9.13	8.05	8.59	5.14	4.26	4.70	3.79	3.60	3.70
AK4	10.43	10.89	10.66	0.33	0.33	0.33	9.19	9.36	9.28	5.25	5.52	5.39	3.74	3.64	3.69
AK5	9.62	9.83	9.73	0.42	0.38	0.40	8.31	8.41	8.36	4.40	4.76	4.58	3.71	3.46	3.59
AK6	9.75	10.78	10.27	0.33	0.36	0.35	8.56	9.32	8.94	4.64	5.45	5.05	3.72	3.67	3.69
AK7	9.80	10.85	10.33	0.43	0.35	0.39	8.46	9.2	8.83	4.48	5.21	4.85	3.78	3.79	3.79
AK8	9.93	9.84	9.89	0.36	0.40	0.38	8.62	8.34	8.48	5.20	4.65	4.93	3.24	3.50	3.37
AK9	9.85	10.96	10.41	0.34	0.42	0.38	8.63	9.24	8.94	5.14	5.52	5.33	3.31	3.53	3.42
AK10	10.38	10.72	10.55	0.39	0.38	0.39	9.14	9.45	9.30	5.23	5.6	5.42	3.71	3.65	3.68
AH1	9.56	10.79	10.18	0.41	0.32	0.37	8.30	9.37	8.84	4.35	5.38	4.87	3.75	3.79	3.77
AH2	10.12	9.81	9.97	0.32	0.35	0.34	8.88	8.36	8.62	4.90	4.47	4.69	3.78	3.69	3.74
AH3	9.88	10.78	10.33	0.46	0.42	0.44	8.55	9.49	9.02	4.54	5.67	5.11	3.80	3.62	3.71
AH4	10.00	9.83	9.92	0.34	0.37	0.36	8.70	8.26	8.48	4.58	4.96	4.77	3.91	3.13	3.52
AH5	10.14	10.88	10.51	0.30	0.33	0.32	8.98	9.66	9.32	4.88	5.81	5.35	3.89	3.65	3.77
AH6	10.28	9.94	10.11	0.42	0.43	0.42	8.89	8.31	8.60	4.97	5.06	5.02	3.72	3.08	3.40
AH7	10.21	10.45	10.33	0.48	0.32	0.40	8.83	9.15	8.99	4.98	5.21	5.10	3.65	3.74	3.69
AH8	9.49	9.96	9.73	0.41	0.42	0.42	8.22	8.14	8.18	4.27	4.85	4.56	3.75	3.12	3.44
AH9	10.26	10.92	10.59	0.35	0.40	0.38	8.97	9.12	9.05	5.00	5.25	5.13	3.77	3.67	3.72
AH10	9.76	9.84	9.80	0.43	0.30	0.36	8.34	8.14	8.24	4.33	4.95	4.64	3.80	3.03	3.42
AB1	9.26	9.80	9.53	0.38	0.34	0.36	8.06	8.26	8.16	4.59	4.56	4.58	3.29	3.51	3.40
AB2	9.79	9.95	9.87	0.37	0.32	0.35	8.55	8.23	8.39	4.68	4.44	4.56	3.67	3.60	3.64
AB3	9.23	10.90	10.07	0.39	0.45	0.42	7.99	9.15	8.57	4.08	5.13	4.61	3.71	3.81	3.76
AB4	10.08	9.97	10.03	0.47	0.35	0.41	8.76	8.42	8.59	4.51	4.66	4.59	4.03	3.57	3.80
AB5	9.40	10.88	10.14	0.40	0.39	0.40	8.11	9.29	8.70	4.35	5.6	4.98	3.57	3.50	3.54
AB6	10.10	9.95	10.03	0.38	0.43	0.40	8.78	8.22	8.50	4.87	4.13	4.50	3.71	3.88	3.80
AB7	9.89	10.65	10.27	0.46	0.42	0.44	8.44	9.03	8.74	4.92	5.28	5.10	3.34	3.56	3.45
AB8	9.53	10.72	10.13	0.35	0.43	0.39	8.30	8.89	8.60	4.37	5.22	4.80	3.73	3.48	3.61
AB9	10.12	9.97	10.05	0.39	0.35	0.37	8.81	8.42	8.62	5.00	4.66	4.83	3.61	3.57	3.59
AB10	9.43	10.78	10.11	0.38	0.38	0.38	8.19	9.51	8.85	4.45	5.70	5.08	3.55	3.61	3.58
$CD_{0.05}$	0.35	0.19	0.11	0.02	0.02	0.01	0.36	0.29	0.07	0.22	0.20	0.04	0.17	0.16	0.03

The data concerning reducing sugars in Table 24 indicated that pooled mean values ranged from 4.50 to 5.42 %. The maximum reducing sugars (5.42 %) was observed in AK1, AK10 which was found to be statistically at par with AK4 (5.39 %). Whereas, minimum reducing sugars (4.50 %) was observed in AB6.

4.12.5 Non-Reducing Sugars

It is evident from Table 24 that non-reducing sugars during 2017 ranged from 3.24 to 4.03%. The highest non-reducing sugars (4.03 %) was recorded in AB4 which was observed statistically at par with AH4 (3.91%) and AK2, AH5 (3.89 %). The lowest non-reducing sugars (3.24 %) was observed in AK8 which was at par with AB1 (3.29 %), AK9 (3.31 %) and AB7 (3.34 %).

The data pertaining to non-reducing sugar content presented in Table 24 revealed that the maximum non-reducing sugars (3.88 %) during 2018 was recorded in AB6 which was observed statistically at par with AB3 (3.81 %), AH1, AK7 (3.79%), AH7 (3.74%) and AK1 (3.72 %). The lowest non-reducing sugars (3.03 %) was observed in AH10 which was statistically at par with AH6 (3.08 %), AH8 (3.12 %) and AH4 (3.13 %).

The pooled data on non-reducing sugars indicated that the pooled mean values ranged from 3.37 to 3.80 %. The maximum non-reducing sugars (3.80 %) was observed in AK2, AB6, AB4 which was statistically at par with AK7 (3.79 %), AH1 and AH5 (3.77 %). Whereas, minimum non-reducing sugars (3.37 %) was observed in AK8 which was statistically at par with AH6 and AB1 (3.40 %).

4.15 FRUIT BIOCHEMICAL CHARACTERISTICS IN HRMN-99

4.15.1 Total soluble solids

Data pertaining to total soluble solids recorded in low chill apple cultivar viz. HRMN-99 for the years 2017 and 2018 as well as pooled data are presented Table 25. The analysis of variance revealed significant differences for total soluble solids characteristics. The results thus obtained are described as follows:

The data relating to total soluble solids recorded during 2017 indicated that the values varied from 10.24° Brix to 11.99 °Brix. The maximum TSS (11.99 °Brix) was recorded in HK10 and HH10 closely followed by HH9, HK9 (11.92 °Brix) and HK1, HH1 (11.63 °Brix). The minimum TSS (10.24 °Brix) was observed in HB10 which was at par with HK4, HH4

(10.35 °Brix), HB6 (10.48 °Brix), HB9 (10.57 °Brix), HB4 (10.59 °Brix), HB3 (10.62°Brix) and HK2, HH2 (10.68 °Brix).

The data relating to total soluble solids recorded during 2018 indicated that the mean TSS values varied from 10.61 °Brix to 11.85 °Brix. The maximum TSS (11.85 °Brix) was recorded in HK10 which was found to be closely at par with HK1(11.84 °Brix), HK5, HK9, HH4 (11.82 °Brix), HH6 (11.81°Brix) , HB5 (11.79 °Brix) and HB3 (11.70 °Brix) while the minimum TSS was recorded in (10.61 °Brix) HB10 closely followed by HB1(10.62 °Brix), HH3 (10.64 °Brix), HB8 (10.65 °Brix), HH9 (10.67 °Brix), HB4 (10.69 °Brix), HB7 (11.73 °Brix), HH7 (10.75 °Brix), HB9 (10.78 °Brix), HK4 (10.79 °Brix), HB2 (10.81 °Brix), HK3 (10.83 °Brix), HK6 (10.85 °Brix), HK7 (10.92 °Brix), HK2 (10.96 °Brix), HH5 (10.97 °Brix) HB6 (10.99 °Brix) and HH8, HK8 (11.00 °Brix).

The presented data concerning total soluble solids indicated that pooled mean values ranged from 10.42 °Brix to 11.92 °Brix. The maximum TSS (11.92 °Brix) pooled mean was observed in HK10 which was found to be closely at par with HK9 (11.87 °Brix)whereas, minimum TSS (10.42 °Brix) was observed in HB10.

4.15.2 Titratable acidity

A perusal of data presented in Table 25 revealed that the data pertaining to fruit titratable acidity (TA) content ranged from 0.19 to 0.35 %. The maximum TA (0.35 %) was found in HB2 which is closely followed by HB1 (0.34 %) and HB10 (0.33%). The minimum TA (0.19 %) was observed in HB5 which was found at par with HB6 (0.20 %) and HB3 (0.22 %).

The maximum TA (0.31 %) in 2018 recorded in HK1, HH4 which was statistically at par with HK6, HH1, HB2, HK8 (0.30 %), HH10, HH6, HB1, HB3, HK5, HH9, HB7 and HB4 (0.29 %). The minimum TA (0.20 %) was observed in HH5 which was at par with HK7, HK4 (0.21 %), HK2 (0.22 %) and HH8 (0.23 %).

The presented data concerning titrable acidity also revealed that that pooled mean values ranged from 0.23 to 0.32%. The maximum TA (0.32 %) was observed in HH4, HB2 (0.32 %), and HB1 which was found at par with HK6 (0.30 %) whereas, minimum TA (0.23 %) was observed in HB5, HB6 and which was at par with HK10, HH5 (0.24 %).

4.15.3 Total Sugars

The data pertaining to total sugars content is presented in Table 25. It is clear from the data that total sugars in 2017, ranged from 8.99 to 10.76%. The maximum total sugars (10.76 %) was recorded in HK10, HH10 which was recorded at par with (10.71%) HK9, HH9 and in HK1 as well as HH1 (10.43 %) the minimum total sugars (8.99 %) was observed in HB10 which was found at par with HH4, HK4 (9.13 %), HB6 (9.34 %), HB4 (9.35 %), HB9 (9.38 %) and HB2 (9.44 %).

The maximum total sugars (10.71 %) during 2018 was found in HK9 which was followed by HK1 (10.64 %), HK5 (10.55%), HB3, HB5 (10.42 %) and HK10 (10.41 %). The minimum total sugars (9.06 %) was observed in HB10 which was at par with HH3 (9.08 %), HH9 (9.19%), HB8 (9.20%), HB7 (9.24%), HK3 (9.26%), HK4 (9.38) and HK7 (9.41%).

The presented data concerning total sugars indicated that pooled mean values ranged from 9.03 to 10.71 %. The maximum total sugars (10.71 %) was observed in HK9 whereas, minimum (9.03 %) was observed in HB10.

4.15.4 Reducing Sugars

A critical examination of the data presented in Table 25 showed that the reducing sugars in 2017 ranged from 5.01 to 6.97%. The maximum reducing sugars (6.97 %) was recorded in HK10, HH10 which was observed at par with HK9, HH9 (6.90 %) and HK1, HH1 (6.84 %). The minimum reducing sugars (5.01 %) were observed in HB10 which was at par with HK4, HH4 (5.18 %).

During 2018, the maximum reducing sugars (7.12 %) was recorded in HK1, HK9 which was at par with HH4 (7.00 %) and the minimum reducing sugars (5.51 %) was observed in HK3 which was at par with HK7 (5.62%), HB10 (5.67%), HB9 (5.68 %), HK4 (5.70%), HH3 (5.74%) and HB8 (5.78%).

The presented pooled data indicated that pooled mean the values ranged from 5.34 to 7.01 %. The maximum reducing sugars (7.01 %) were observed for in HK9 which was statistically at par with HK1 (6.98 %). Whereas, minimum reducing sugars (5.34 %) was observed in HB10.

4.15.5 Non-Reducing Sugars

The data pertaining to non-reducing sugars content is presented in Table 25 It is evident from the data that non-reducing sugars during 2017 ranged from 3.35 to 4.01%. The

maximum non-reducing sugars (4.01 %) was recorded in HB9 which was statistically at par with HB8 (3.97 %). The minimum non-reducing sugars (3.35 %) was observed in HK6 and HH6 which was found at par with HK1, HH1 (3.41 %) as well as in HK7, HH7 (3.48 %).

Table 25. Biochemical analysis of apple cultivar HRMN-99 in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	TSS (° B)			Titrable Acidity (%)			Total Sugars (%)			Reducing Sugars (%)			Non Reducing Sugar (%)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
HK1	11.63	11.84	11.73	0.23	0.31	0.27	10.43	10.64	10.53	6.84	7.12	6.98	3.41	3.34	3.38
HK2	10.68	10.96	10.82	0.30	0.22	0.26	9.45	9.44	9.45	5.43	6.12	5.78	3.81	3.15	3.48
HK3	11.01	10.83	10.92	0.31	0.27	0.29	9.83	9.26	9.55	5.94	5.51	5.73	3.69	3.56	3.63
HK4	10.35	10.79	10.57	0.32	0.21	0.26	9.13	9.38	9.26	5.18	5.7	5.44	3.75	3.49	3.62
HK5	11.51	11.82	11.66	0.29	0.28	0.28	10.27	10.55	10.41	6.28	7.06	6.67	3.79	3.31	3.55
HK6	11.28	10.85	11.06	0.30	0.30	0.30	10.07	9.57	9.82	6.54	6.05	6.30	3.35	3.34	3.35
HK7	11.24	10.92	11.08	0.28	0.21	0.25	10.10	9.41	9.76	6.43	5.62	6.03	3.48	3.60	3.54
HK8	11.26	11.00	11.13	0.26	0.30	0.28	10.15	9.81	9.98	6.46	6.19	6.33	3.50	3.43	3.47
HK9	11.92	11.82	11.87	0.25	0.26	0.26	10.71	10.71	10.71	6.9	7.12	7.01	3.61	3.41	3.51
HK10	11.99	11.85	11.92	0.24	0.24	0.24	10.76	10.41	10.59	6.97	6.41	6.69	3.60	3.80	3.70
HH1	11.63	10.89	11.26	0.23	0.30	0.27	10.43	9.64	10.03	6.84	6.15	6.50	3.41	3.31	3.36
HH2	10.68	11.11	10.89	0.30	0.24	0.27	9.45	9.57	9.51	5.43	6.31	5.87	3.81	3.09	3.45
HH3	11.01	10.64	10.82	0.31	0.26	0.28	9.83	9.08	9.46	5.94	5.74	5.84	3.69	3.17	3.43
HH4	10.35	11.82	11.08	0.32	0.31	0.32	9.13	10.21	9.67	5.18	7.00	6.09	3.75	3.04	3.40
HH5	11.51	10.97	11.24	0.29	0.20	0.24	10.27	9.57	9.92	6.28	5.98	6.13	3.79	3.41	3.60
HH6	11.28	11.81	11.54	0.30	0.29	0.29	10.07	10.22	10.15	6.54	6.8	6.67	3.35	3.24	3.30
HH7	11.24	10.75	10.99	0.28	0.25	0.27	10.10	9.51	9.81	6.43	6.03	6.23	3.48	3.30	3.39
HH8	11.26	11.00	11.13	0.26	0.23	0.25	10.15	9.57	9.86	6.46	6.05	6.26	3.50	3.34	3.42
HH9	11.92	10.67	11.29	0.25	0.28	0.27	10.71	9.19	9.95	6.90	5.68	6.29	3.61	3.33	3.47
HH10	11.99	11.36	11.67	0.24	0.29	0.27	10.76	9.97	10.37	6.97	6.31	6.64	3.6	3.47	3.54
HB1	10.96	10.62	10.79	0.34	0.29	0.32	9.64	9.44	9.54	5.86	5.63	5.75	3.59	3.61	3.60
HB2	10.75	10.81	10.78	0.35	0.30	0.32	9.44	9.69	9.57	5.62	6.57	6.10	3.62	2.96	3.29
HB3	10.62	11.7	11.16	0.22	0.29	0.25	9.55	10.42	9.99	5.78	6.3	6.04	3.58	3.91	3.75
HB4	10.59	10.69	10.64	0.26	0.28	0.27	9.35	9.53	9.44	5.67	6.42	6.05	3.49	2.95	3.22
HB5	10.98	11.79	11.38	0.19	0.27	0.23	9.94	10.42	10.18	5.96	6.41	6.19	3.78	3.80	3.79
HB6	10.48	10.99	10.73	0.20	0.26	0.23	9.34	9.77	9.56	5.61	6.77	6.19	3.54	2.85	3.20
HB7	11.02	10.73	10.87	0.26	0.28	0.27	9.87	9.24	9.56	6.13	5.90	6.02	3.55	3.17	3.36
HB8	10.69	10.65	10.67	0.27	0.25	0.26	9.54	9.20	9.37	5.57	5.78	5.68	3.97	3.24	3.61
HB9	10.57	10.78	10.67	0.29	0.24	0.27	9.38	9.60	9.49	5.37	6.58	5.98	4.01	2.86	3.44
HB10	10.24	10.61	10.42	0.33	0.25	0.29	8.99	9.06	9.03	5.01	5.67	5.34	3.78	3.22	3.50
$CD_{0.05}$	0.44	0.47	0.07	0.02	0.03	0.01	0.45	0.35	0.07	0.24	0.28	0.05	0.13	0.14	0.02

In 2018, the maximum non-reducing sugars (3.91 %) was recorded in HB3 which was observed statistically at par with HK10 and HB5 (3.80 %). The lowest non-reducing sugars (2.85 %) was in HB6 which was found at par with HB9 (2.89 %), HB4 (2.95 %) and HB2 (2.96 %).

As far as pooled data is concerned non-reducing sugars indicated that values ranged from 3.22 to 3.79 %. The maximum non-reducing sugars (3.79 %) was observed in HB5 whereas, minimum non-reducing sugars was recorded in HB4 (3.22 %).

4.16 FRUIT BIOCHEMICAL CHARACTERISTICS IN DORSETT GOLDEN

4.16.1 Total soluble solids

Data pertaining to total soluble solids have been recorded in low chill apple cultivar Dorsett Golden for the years 2017 and 2018 as well as pooled data also calculated (Table 26). The analysis of variance revealed significant differences for total soluble solids characteristics .The results thus obtained are described as follows:

The data relating to total soluble solids recorded during 2017 indicated that the mean total soluble solids values varied from 10.12° Brix to 11.99 °Brix. The maximum TSS (11.99 °Brix) was recorded in DK1, closely followed by DK5 (11.97 °Brix), DK9 (11.91 °Brix), DK4, DH10 (11.89 °Brix), DK2 (11.86 °Brix), DK3 (11.74 °Brix), DH8 (11.63 °Brix) DH6 (11.59 °Brix) and DK6 (11.56 °Brix). The minimum TSS (10.12 °Brix) was observed in DB3, which was at par with DB1 (10.15 °Brix), DH2 (10.32 °Brix), DB8 (10.36 °Brix), DB10 (10.40 °Brix), DH7 (10.43 °Brix) DH5 (10.50 °Brix) and DH9 (10.52 °Brix).

The data relating to total soluble solids recorded during 2018 indicated that the mean TSS values varied from 10.59 °Brix to 11.99 °Brix. The maximum TSS (11.99 °Brix) was recorded in DK5 closely followed by DK1 (11.98° Brix), DK7 (11.95° Brix), DK2 (11.82 °Brix), DK9 (11.81 °Brix), DH9 (11.79 °Brix), DB7 (11.76 °Brix), DH3 (11.74 °Brix), DH4 (11.71 °Brix), DB4 (11.67 °Brix) and DH7 (11.59 °Brix). The minimum TSS (10.59 °Brix) was observed in DK10 which was found at par with DB6 (10.60 °Brix), DH6 (10.62 °Brix), DB9 (10.63 °Brix), DK4 (10.66 °Brix), DB2 (10.69 °Brix), DB10, DK6, DH8 (10.71°Brix) and DH1 (10.92 °Brix).

The presented data concerning to total soluble solids indicated that pooled mean values ranged from 10.56 °Brix to 11.99 °Brix. The maximum TSS (11.99 °Brix) was observed in DK1 which was statistically at par with DK5 (11.98 °Brix), whereas, minimum

TSS (10.56) was observed in DB10 which was found statistically at par with DB1 (10.58 °Brix).

4.16.2 Titratable acidity

It is evident from the data presented in table 26 that titratable acidity (TA) ranged from 0.44 to 0.55 per cent in 2017. The maximum TA (0.55 %) was recorded in DK10 closely followed by DK8, DB2 (0.54 %) and DK2, DK3 (0.53%). The lowest TA (0.44 %) was observed in DH9 which was found at par with DK6, DH1 (0.45 %) and DH7, DB7 (0.46%).

The maximum TA (0.51 %) was recorded in DH6 which was statistically at par with DH5 (0.50%), DK4, DH1 (0.49%) and DK7, DH3, DH9, DB8, DB3 (0.48%). The minimum TA (0.40 %) was observed in DK3 which was found at par with DK2, DH10, DB6, DK10 (0.41%), DB2, DK5, DK9, DH4 (0.42%) and DK1, DH6 (0.43%) during 2018.

The pooled mean values ranged from 0.43 to 0.50%, where in the maximum TA (0.50 %) was observed for the DK4, DK7, DK8 and DB3 which was statistically at par with DH2, DH3, DH5, DB1, DB8 (0.49 %), whereas, minimum TA (0.43 %) was found in DB6 (0.43%)

4.16.3 Total Sugars

It is evident from the data given in Table 26 that total sugars ranged from 8.64 to 10.62% in 2017. The maximum total sugars (10.62 %) was recorded in DK5 which was observed at par with DK1 (10.38%), DH10 (10.37 %), DK9 (10.32%) and DK4 (10.29%). The minimum sugars (8.64 %) was observed in DB1, DB3 which was found at par with DB8 (8.66 %), DH8 (8.93 %) during 2017.

The maximum total sugars (10.72 %) was recorded in DK5 closely followed by DK7 (10.56 %), DK9 (10.50%), DK1 (10.45 %), DH3 (10.36%). The minimum total sugars (8.97 %) was observed in DB9, DB2 which was found at par with DH1 (9.03 %), DK3 (9.16%), DB6 (9.21%), DH6 (9.23%), DK4 (9.25%), DK6 (9.31%), DK10 (9.32%), DB1 (9.34%), and DH8 (9.36 %) during 2018.

The presented data concerning to pooled values of total sugars indicated that ranged from 9.20 to 10.67 %. The maximum total sugars (10.67 %) was observed in DK5 whereas,

minimum total sugars (9.20 %) was observed in DB3 which was observed at par with DB10 (9.26 %).

4.16.4 Reducing Sugars

The data pertaining to reducing sugars content is presented in Table 26. It is evident from the data that reducing sugars in 2017 ranged from 4.86 to 6.68%. The highest reducing sugars (6.68 %) was recorded in DK5 which was observed at par with DK6 (6.54 %), DK4 (6.46 %) and DH1 (6.45 %). The lowest reducing sugar (4.86 %) was in DB3 which was at par with DB3 (4.74 %).

Similarly during 2018 the maximum reducing sugars (7.27 %) was recorded for in DK1. The minimum reducing sugars (5.05 %) were observed for DH6 which was found at par with DK10 (5.13 %), DB2 (5.15 %), DB9 (5.17 %), DK6, DB1 (5.19%) and DK3 (5.21 %).

The presented data concerning to reducing sugars indicated that pooled mean values ranged from 5.10 to 6.75 %. The maximum reducing sugars (6.75 %) was observed in DK1 which was found statistically at par with DK5 (6.71 %). Whereas, minimum reducing sugars (5.10 %) was observed in DB1.

4.16.5 Non-Reducing Sugars

The data pertaining to non -reducing sugars content is presented in Table 26. It is evident from the data that non-reducing sugars during 2017 ranged from 3.24 to 3.94 %. The maximum non-reducing sugars (3.94 %) was in DK1 which was observed statistically at par with DK7 (3.92 %), DH10 (3.91 %), DH9 (3.90 %), DH5 (3.89 %), DK9 (3.88 %), DH7, DK8 (3.80 %). The lowest non-reducing sugars (3.24 %) was observed in DH1 which was observed statistically at par with DH2 (3.30 %).

The data pertaining to non-reducing sugars content is presented in Table 26. The maximum non-reducing sugars (3.98 %) was recorded in DK10 which was observed statistically at par with DH6 (3.97 %), DK8 (3.95%), DB1 (3.94%), DK6, DH5 (3.91 %), DH7 (3.90 %) and DH8 (3.89%). The minimum non-reducing sugars (3.02 %) was observed for the genotype DK1 which was found at par with DH9 (3.15 %) during 2018.

The presented data concerning to non-reducing sugars indicated that pooled mean values ranged from 3.38 to 3.94 %. The maximum non-reducing sugars (3.94 %) was in DK10 was found to be statistically at par with DK7 (3.91%), whereas, minimum non-reducing sugars (3.38 %) was observed in DH1 and DH2.

Table 26. Biochemical analysis of apple cultivar Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree code	TSS (° B)			Titrable Acidity (%)			Total Sugars (%)			Reducing Sugars (%)			Non Reducing Sugar (%)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
DK1	11.99	11.98	11.99	0.51	0.43	0.47	10.38	10.45	10.42	6.23	7.27	6.75	3.94	3.02	3.48
DK2	11.86	11.82	11.84	0.53	0.41	0.47	10.13	10.11	10.12	6.12	6.48	6.30	3.80	3.44	3.62
DK3	11.74	11.42	11.58	0.53	0.40	0.47	10.01	9.16	9.59	6.16	5.21	5.69	3.65	3.75	3.70
DK4	11.89	10.66	11.28	0.51	0.49	0.50	10.29	9.25	9.77	6.46	5.40	5.93	3.62	3.65	3.64
DK5	11.97	11.99	11.98	0.49	0.42	0.46	10.62	10.72	10.67	6.68	6.73	6.71	3.75	3.79	3.77
DK6	11.56	10.71	11.14	0.45	0.45	0.45	10.22	9.31	9.77	6.54	5.19	5.87	3.49	3.91	3.70
DK7	11.49	11.95	11.72	0.52	0.48	0.50	9.99	10.56	10.28	5.86	6.45	6.16	3.92	3.90	3.91
DK8	11.53	11.46	11.50	0.54	0.46	0.50	10.06	10.06	10.06	6.05	5.90	5.98	3.80	3.95	3.88
DK9	11.91	11.81	11.86	0.49	0.42	0.46	10.32	10.50	10.41	6.23	6.47	6.35	3.88	3.82	3.85
DK10	11.20	10.59	10.90	0.55	0.41	0.48	9.55	9.32	9.44	5.44	5.13	5.29	3.90	3.98	3.94
DH1	11.21	10.92	11.07	0.45	0.49	0.47	9.87	9.03	9.45	6.45	5.33	5.89	3.24	3.51	3.38
DH2	10.32	11.49	10.91	0.47	0.51	0.49	8.93	9.88	9.41	5.45	6.24	5.85	3.30	3.45	3.38
DH3	11.52	11.74	11.63	0.50	0.48	0.49	10.11	10.36	10.24	6.32	6.75	6.54	3.60	3.42	3.51
DH4	11.30	11.71	11.51	0.52	0.42	0.47	9.92	9.99	9.96	6.07	6.27	6.17	3.65	3.53	3.59
DH5	10.50	11.48	10.99	0.47	0.50	0.49	9.18	10.00	9.59	5.08	5.88	5.48	3.89	3.91	3.90
DH6	11.59	10.62	11.11	0.51	0.43	0.47	10.19	9.23	9.71	6.20	5.05	5.63	3.79	3.97	3.88
DH7	10.43	11.59	11.01	0.46	0.47	0.46	9.10	10.14	9.62	5.10	6.14	5.62	3.80	3.8	3.80
DH8	11.63	10.71	11.17	0.48	0.45	0.47	10.24	9.36	9.80	6.32	5.26	5.79	3.72	3.89	3.81
DH9	10.52	11.79	11.16	0.44	0.48	0.46	9.19	10.21	9.70	5.89	6.89	6.39	3.90	3.15	3.53
DH10	11.89	11.50	11.70	0.51	0.41	0.46	10.37	9.88	10.13	6.25	6.43	6.34	3.91	3.27	3.59
DB1	10.15	11.00	10.58	0.51	0.46	0.49	8.64	9.34	8.99	5.00	5.19	5.10	3.45	3.94	3.70
DB2	11.39	10.69	11.04	0.54	0.42	0.48	9.75	8.97	9.36	6.06	5.15	5.61	3.50	3.62	3.56
DB3	10.12	11.21	10.67	0.52	0.48	0.50	8.64	9.76	9.20	4.86	6.04	5.45	3.59	3.53	3.56
DB4	11.24	11.67	11.46	0.48	0.44	0.46	9.89	10.27	10.08	6.00	6.49	6.25	3.69	3.59	3.64
DB5	11.28	11.47	11.38	0.47	0.45	0.46	9.96	9.92	9.94	5.79	6.22	6.01	3.96	3.51	3.74
DB6	11.19	10.6	10.90	0.45	0.41	0.43	9.84	9.21	9.53	5.86	5.57	5.72	3.78	3.45	3.62
DB7	11.00	11.76	11.38	0.46	0.47	0.47	9.57	10.09	9.83	5.61	6.48	6.05	3.76	3.42	3.59
DB8	10.36	11.49	10.93	0.50	0.48	0.49	8.66	10.02	9.34	4.74	6.12	5.43	3.72	3.50	3.61
DB9	11.42	10.63	11.03	0.49	0.47	0.48	10.05	8.97	9.51	6.41	5.17	5.79	3.45	3.61	3.53
DB10	10.4	10.71	10.56	0.47	0.45	0.46	9.08	9.43	9.26	5.30	5.49	5.40	3.51	3.74	3.63
$CD_{0.05}$	0.45	0.42	0.08	0.02	0.03	0.01	0.33	0.42	0.08	0.25	0.25	0.05	0.16	0.17	0.03

Lot of work has been done on the physico-chemical characteristics of different apple varieties throughout the world. These parameters may vary from place to place depending on climatic factors and management practices. In the foregoing discussion on physico-chemical characteristics (TSS, acidity, total sugars, reducing sugars, non-reducing sugars, phenols etc.)

of different cultivars, the results are within the limited range but shows slight variation compared with the findings of other workers.

4.17 NON METRIC CHARACTERSTICS IN ANNA

Under the present investigation non-metric characters have been recorded as per the apple descriptor and as per UPOV guidelines. On examining the data presented in Table 27 all the fruit samples of cultivar Anna had cylindrical fruit shape, smooth surface, intermediate fruit base, smooth fruit apex, few fruit skin lenticels, white flesh color and good eating quality and The observations recorded on the development of ground color belonged to Yellow green group 150 C and over colour belonged to Greyed red group 180 C. Average shelf life (days) was recorded to ranged from 6 to 8 days. Under present investigation have been recorded as per the apple descriptor developed by Watkins and Smith (1982), who indicated varied fruit shape types of large number of apple cultivars.

4.18 NON METRIC CHARACTERISTICS IN HRMN-99

Under present investigation non-metric characters have been recorded as per the apple descriptor and as per UPOV guidelines. All the fruits samples (HK1 to HB10) of HRMN-99 had cylindrical fruit shape, smooth surface of fruit, intermediate fruit base, smooth fruit apex, few fruit skin lenticels, white flesh color and good eating quality. The observations recorded on the development of ground color belonged to Yellow green group150 C and over colour belonged to Greyed red group180 B. Average shelf life (days) was recorded to vary from 6 to 7 days (Table 28).

4.19 NON METRIC CHARACTERISTICS IN DORSETT GOLDEN

Under present investigation non-metric characters have been recorded as per the apple descriptor and as per UPOV guidelines (Table 29). All the fruits samples of Dorsett Golden (DK1 to DB10) had conic fruit shape, smooth surface of fruit, intermediate fruit base, smooth fruit apex, few fruit skin lenticels, white flesh color and good eating quality. The observations recorded on the development of ground color belonged to Yellow green group150 C and over colour belonged to Yellow group 7C. Average shelf life (days) in Dorsett Golden recoded was recorded to range from 7 to 9 days.

Table 27. Physical characters of apple cultivar Anna in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree Code	Fruit shape	Surface of fruit	Fruit base	Fruit apex	Fruit skin lenticels	Surface colour		Flesh color	Eating quality	Average shelf life (at ambient temperature)
						Ground colour	Over colour			
AK1	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7 days
AK2	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	8 days
AK3	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AK4	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AK5	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	8days
AK6	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	8 days
AK7	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AK8	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	8days
AK9	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AK10	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AH1	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	6days
AH2	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7 days
AH3	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AH4	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	6days
AH5	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	6days
AH6	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AH7	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	6days
AH8	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	6days
AH9	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AH10	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AB1	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AB2	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AB3	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AB4	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AB5	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AB6	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AB7	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AB8	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AB9	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days
AB10	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180C	Cream White	Good	7days

Table 28. Physical characters of apple cultivar HRMN-99 in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree Code	Fruit shape	Surface of fruit	Fruit base	Fruit apex	Fruit skin lenticels	Surface colour		Flesh color	Eating quality	Average Shelf life (at ambient temperature)
						Ground colour	Over colour			
HK1	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HK2	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	7 days
HK3	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HK4	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	7 days
HK5	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	7 days
HK6	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	7 days
HK7	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HK8	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	7 days
HK9	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	7 days
HK10	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	7 days
HH1	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HH2	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HH3	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HH4	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HH5	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HH6	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HH7	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HH8	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HH9	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HH10	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HB1	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	7days
HB2	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HB3	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HB4	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	7days
HB5	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HB6	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days
HB7	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	7days
HB8	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6days
HB9	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	7days
HB10	Cylindrical	Smooth	Intermediate	Smooth	Few	Yellow green group150 C	Greyed red group 180B	White	Intermediate	6 days

Table 29. Physical characters of apple cultivar Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh

Tree Code	Fruit shape	Surface of fruit	Fruit base	Fruit apex	Fruit skin lenticels	Surface colour		Flesh color	Eating quality	Average Shelf life (at ambient temperature)
						Ground colour	Over colour			
DK1	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8 days
DK2	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	9 days
DK3	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8days
DK4	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8days
DK5	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8days
DK6	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8days
DK7	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	9 days
DK8	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8 days
DK9	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	9 days
DK10	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	9 days
DH1	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	7 days
DH2	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8 days
DH3	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	7 days
DH4	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	7 days
DH5	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	7days
DH6	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	7 days
DH7	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8 days
DH8	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8 days
DH9	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	7days
DH10	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	7 days
DB1	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8 days
DB2	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	9 days
DB3	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	9 days
DB4	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8 days
DB5	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8 days
DB6	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8 days
DB7	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8 days
DB8	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	9 days
DB9	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8 days
DB10	Conic	Smooth	Intermediate	Smooth	few	Yellow green group150 B	Yellow group 7C	White	Good	8 days

Chapter-5

SUMMARY AND CONCLUSION

The present investigations entitled **"Studies on low chill apples (*Malus* × *domestica* Borkh.) in sub-mountain zone of Himachal Pradesh"** were carried out on three low chill apple cultivars namely Anna, HRMN-99 and Dorsett Golden in Kangra, Hamirpur and Bilaspur districts of Himachal Pradesh.

- Tree height ranged from 2.71 (AB4) to 3.32 m (AK1) in Anna, 2.31 (HB1) to 2.91 m (HK7) in HRMN-99 and 1.85 (DB6) to 2.28 m (DK1) in cultivar Dorsett Golden. Tree girth ranged from 14.86 (AH1) to 21.38 cm (AK2) in Anna, 15.62 (HB8) to 22.99 cm (HK2) in HRMN-99 and 10.91 (DH1) to 14.83 cm (DB5) in Dorsett Golden. Tree Spread ranged from 1.17 (AB1), (AB9) to 1.48m (AK2) in Anna, 1.07 (HB8) to 1.37m (HK1) and (HK6) in HRMN-99 and 0.91 (DB3), (DH7) to 1.97 m (DK7) in Dorsett Golden. Tree volume ranged from 1.06 (AB1) to 1.60 m^3 (AK1) in Anna, 0.85 m^3 (HB9), (HB1) to 1.25 m^3 (HK5) in HRMN-99 and 0.59 m^3 (DB1), (DB6) to 1.47m^3 (DK7) in Dorsett Golden. Annual extension shoot growth ranged from 32.07 (AB7) to 44.04 cm (AK9) in Anna, 26.19 (HB1) to 40.49 cm (HK8) in HRMN-99 and 24.95 (DB3) to 39.66 cm (DK4) in Dorsett Golden. Fruit yield per tree ranged from 6.60 (AB1) to 9.21 kg/tree (AK10) in Anna, 5.94 (HB8) to 7.80 kg/tree (HK6) in HRMN-99 and 5.82 (DB6) to 7.70 kg/tree (DK2) in Dorsett Golden whereas productivity ranged from 2.75 (AB1) to 3.82t /ha (AK10) in Anna, 2.47 (HB8) to 3.24t /ha (HK10) in HRMN-99 and 2.39 (DB8) to 3.33 t/ha (DH1).
- Leaf area ranged from 37.44 (AB3) to 48.78 cm^2 (AK8) in Anna, 39.32 (HH3) to 51.67 cm^2 (HK7) in HRMN-99 and 40.83 (DH9) to 52.09 cm^2 (DK2) in Dorsett Golden.
- Date of earliest leaf bud burst was recorded on 01/02/16 (AH1) in Anna, on 01/02/2016 (HH9) in HRMN-99, on 03/02/2016 in (DH2) Dorsett Golden. Date of anthesis was recorded on 07/02/2016 (AH4) in Anna. 06/02/2016 (HH9) in HRMN-99 and on 09/02/2016 (DH2) in Dorsett Golden. Time of full bloom was found earliest on (AH4) 12/02/16 in Anna, 11/02/2016 (HH9) in HRMN-99 and 16/02/2016 (DH3) in Dorsett Golden. Duration of flowering extended from 10 to 14 days in Anna, 11 to 14 days in HRMN-99 and 12-16 days in Dorsett Golden. Date of harvest

ranged from 12th to 19th June, 2016 in Anna, 10th June to 22nd June, 2016 in HRMN-99 and 26th June to 15th July, 2016 in Dorsett Golden.

- Date of earliest leaf bud burst was recorded on 05/02/17 (AH1), (AH2), (AH4) in Anna, on 03/02/2017 (HH5), (HH9) in HRMN-99, on 06/02/2017 in (DH2) Dorsett Golden. Date of anthesis was recorded on 11/02/2017 (AH2) in Anna. 09/02/2017 (HH5), (HH9) in HRMN-99 and on 12/02/2017 (DH2) in Dorsett Golden. Time of full bloom was found earliest on (AH2) 17/02/17 in Anna, 15/02/2017 (HH5), (HH9) in HRMN-99 and 18/02/2017 (DH2) in Dorsett Golden. Duration of flowering extended from 12 to 14 days in Anna, 11 to 16 days in HRMN-99 and 10-16 in Dorsett Golden. Date of harvest ranged from 14th to 21st June, 2017 in Anna, 12th June to 25th June, 2017 in HRMN-99 and 28th June to 17th July, 2017 in Dorsett Golden.
- Fruit set ranged from 14.29 (AB10) to 26.77 % (AK10) in Anna, 14.06 (HH1) to 24.34 % (HK7) in HRMN-99, 13.28 (DB1) to 26.94 % (DK4) in Dorsett Golden under selfing by bagging whereas 34.73 (AB2) to 45.51 % (AK7) in Anna, 31.20 (HB9) to 43.07 % (HK7) in HRMN-99 and 43.74 (DB3) to 54.36 % (DK2) in Dorsett Golden under open pollination studies.
- Fruit length ranged from 60.57 mm (AB5) to 69.84 mm (AK8) in Anna, 58.95 (HK9) to 68.78 mm (HK4) in HRMN-99 and 50.29 (DK3) to 58.98 (DK4) in Dorsett Golden. Fruit width ranged from 55.25 mm (AB7) to 64.65 mm (AH1) in Anna, 53.81 (HH3) to 62.66 mm (HH6) in HRMN-99 and 54.56 (DB1) to 65.06 (DH3) in Dorsett Golden. Fruit weight ranged from 104.75 (AB5) to 140.11 g (AK8) in Anna, 101.47 (HB3) to 133.80g (HK4) in HRMN-99 and 89.34 (DB7) to 118.98g (DK4) in Dorsett Golden. Fruit base cavity depth ranged from 1.25 (AK1) to 1.89 kg/cm^2 (AH6) in Anna, 1.25(HK1) to 1.73 kg/cm^2 (HH4) in HRMN-99 and 0.81 (DK10), (DB4) to 0.95 kg/cm^2 (DK4) in Dorsett Golden.
- Total soluble solids was ranged from 9.53 (AB1) to 10.66 °B (AK4) in Anna, 10.42 (HB10) to 11.9 °B (HK10) in HRMN-99 and 10.56 (DB10) to 11.99 °B (DK1) in Dorsett Golden. Titrable acidity ranged from 0.32(AH5) to 0.45 % (AK2) in Anna , 0.23 (HB6), (HB5) to 0.32 % (HB2), (HB1) and (HH4) in HRMN-99 and 0.43 (DB6) to 0.50 % (DK4), (DB3), (DB 8) and (DK7) in Dorsett Goden. Total sugars ranged from 8.16 (AB1) to 9.35 % (AK1) in Anna, 9.03 (HB10) to 10.71 % (HK9) in HRMN-99 and 9.20 (DB3) to 10.67 (DK5) in Dorsett Golden. Reducing sugars ranged from 4.50 (AB6) to 5.42 % (AK1) and (AK10) in Anna, 5.34 (HB10) to 7.01

% (HK9) in HRMN-99 and 5.10 (DB1) to 6.75 % (DK1) in Dorsett Golden. Non-reducing sugars ranged from 3.37 (AK8) to 3.80 % (AK2), (AB4) and (AB6) in Anna, 3.22 (HB4) to 3.79 % (HB5) in HRMN-99 and 3.38 (DH1), (DH2) to 3.94 % (DK10) in Dorsett Golden.

- All the fruit samples of cultivar Anna had cylindrical fruit shape, smooth surface, intermediate fruit base, smooth fruit apex, few fruit skin lenticels, white flesh color and good eating quality. Fruit surface colour was observed to be Yellow Green Group 150 C (ground colour) and Greyed Red Group 180 C (over colour). Cultivar HRMN-99 had cylindrical fruit shape, smooth surface, intermediate fruit base smooth fruit apex, few fruit skin lenticels with white flesh color and good eating quality. Fruit surface colour was observed to be fall in the Yellow Green Group 150 C (ground colour) and Greyed Red Group 180 B (over colour) whereas in cultivar Dorsett Golden all the fruit samples had conic fruit shape, smooth surface, intermediate fruit base, smooth fruit apex, few fruit skin lenticels , white flesh colour and good eating quality. Fruit surface colour was observed to be in the Yellow Green Group 150 B (ground colour) and Greyed Red Group 7C (over colour).

CONCLUSION

On the basis of the results obtained from the of present findings, it is concluded that among the low chill apple cultivars namely, Anna, HRMN-99 and Dorsett Golden, Anna was found promising for lower hills of Himachal Pradesh as it gave higher yield of better quality fruits as compared to HRMN-99 and Dorsett Golden cultivars. However, Dorsett Golden a pollinizer performed well in terms of yield and fruit quality, and it also improved the yield of Anna cultivar. The cultivation of these cultivars will defiantly boost the apple orcharding for the upliftment of the farming community of lower foothills as the fruits of these cultivars fetches better price in the market due to its early harvesting. However, there is a need to educate farmers in all the aspects of training, pruning and orchard management practices for remunerative returns and longer life span of plantations.

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APPENDIX-I

Survey inquiry form (Questionnaire)

Sr. No	Location	Name of Farmers	Latitude	Longitude	Altitude	Cultivar Name	No of Plants /Cultivar wise
1	Dasola	Karam Chand	32.2142°N	76.2276°E	830	Anna HRMN-99, Dorsett Golden	200- Anna-90 HRMN-99 : 60 Dorsett Golden-50
2	Dargella	Puran Chand	32.2137°N	76.2286°E	816	Anna HRMN-99, Dorsett Golden	150- Anna-60 HRMN-99 : 60 Dorsett Golden-30
3	Manala	Saligram	32.2134°N	76.2263°E	822	Anna HRMN-99, Dorsett Golden	180- Anna-50 HRMN- 99:100 Dorsett Golden-50
4	Naganpatt	Satyajeet	32.1841°N	76.2747°E	723	Anna HRMN-99, Dorsett Golden	140- Anna-40 HRMN-99:40 Dorsett Golden-60
5	Bandi	Manohar Lal	32.1849°N	76.2768°E	676	Anna HRMN-99, Dorsett Golden	200- Anna-70 HRMN-99:70 Dorsett Golden-60
6	Dhanotu	Harvansh	32.1900°N	76.3620°E	741	Anna HRMN-99, Dorsett Golden	300- Anna-120 HRMN-99:100 Dorsett Golden-80
7	Razol	Maya Devi	32.1648°N	76.2597°E	680	Anna HRMN-99, Dorsett Golden	350- Anna-100 HRMN-99:150 Dorsett Golden-100
8	Bhariyada	Hans Raj	31.9607°N	75.9185°E	585	Anna HRMN-99, Dorsett Golden	170- Anna-50 HRMN-99:70 Dorsett Golden-50
9	Gummer	Gurdev Singh	31.7085°N	76.5706°E	569	Anna HRMN-99, Dorsett Golden	210- Anna-90 HRMN-99:60 Dorsett Golden-30
10	Shehorpain	Rakesh Pal	31.8752°N	76.3202°E	558	Anna HRMN-99, Dorsett Golden	250- Anna-100 HRMN-99:100 Dorsett Golden-50
11	Kuleda	Tulsi Ram	32.5717°N	76.5273°E	938	Anna HRMN-99, Dorsett Golden	300- Anna-100 HRMN-99:100 Dorsett Golden-100
12	Chakmoh	Pritam Chand	31.5075°N	76.4607°E	754	Anna HRMN-99, Dorsett Golden	280- Anna-100 HRMN-99:100 Dorsett Golden-80

13	Badgram	Karan Chandel	31.4042°N	76.6476°E	635	Anna HRMN-99, Dorsett Golden	350- Anna-100 HRMN-99:150 Dorsett Golden-100
14	Bhutlar	Mahinder Singh	31.4970°N	76.4695°E	375	Anna HRMN-99, Dorsett Golden	90- Anna-30 HRMN-99:30 Dorsett Golden-30
15	Garli	Jyoti Sharma	31.8090°N	76.2378°E	512	Anna HRMN-99, Dorsett Golden	200- Anna-80 HRMN-99:80 Dorsett Golden-40
16	Lafran	Kuldeep Chand	32.1228°N	76.0656°E	389	Anna HRMN-99, Dorsett Golden	250- Anna-80 HRMN-99:100 Dorsett Golden-70
17	Jeoli Devi	Kulveer	32.1856°N	76.1256°E	375	Anna HRMN-99, Dorsett Golden	100- Anna-40 HRMN-99:30 Dorsett Golden-30
18	Bani	Suresh Baniyal	31.5446°N	76.4809°E	875	Anna HRMN-99, Dorsett Golden	70- Anna-25 HRMN-99:25 Dorsett Golden-20
19	Kaswar	Roshan Lal	31.6729°N	76.4915°E	754	Anna HRMN-99, Dorsett Golden	230- Anna-100 HRMN-99:70 Dorsett Golden-50
20	Maharal	Preetam Singh	31.4806°N	76.5907°E	755	Anna HRMN-99, Dorsett Golden	290- Anna-100 HRMN-99:100 Dorsett Golden-90
21	Paniala	Harman Sharma	31.7125°N	76.4766°E	705	Anna HRMN-99, Dorsett Golden	100- Anna-30 HRMN-99:50 Dorsett Golden-20
22	Kuthera	Joginder	31.5114°N	76.7295°E	375	Anna HRMN-99, Dorsett Golden	120- Anna-40 HRMN-99:50 Dorsett Golden-30
23	Amarpur	Kamal	31.4024°N	76.7134°E	395	Anna HRMN-99, Dorsett Golden	250- Anna-100 HRMN-99:100 Dorsett Golden-50
24	Pantera	KaramDutt Sharma	31.4419°N	76.7120°E	372	Anna HRMN-99, Dorsett Golden	150- Anna-70 HRMN-99:50 Dorsett Golden-30
25	Dumehar	Manoj Kumar	31.5740°N	76.6486°E	378	Anna HRMN-99, Dorsett Golden	250- Anna-80 HRMN-99:100 Dorsett Golden-70
26	Lingri	Rajesh Kumar	31.3419 °N	76.6885°E	648	Anna HRMN-99, Dorsett Golden	165- Anna-65 HRMN-99:60

							Dorsett Golden-40
27	Dangar	Daulat Ram	31.5193°N	76.6319°E	662	Anna HRMN-99, Dorsett Golden	140- Anna-50 HRMN-99:50 Dorsett Golden-40
28	Nalti	Ajay Rattan	31.5432°N	76.7062°E	485	Anna HRMN-99, Dorsett Golden	90- Anna-30 HRMN-99:30 Dorsett Golden-30
29	Kothipur	Krishan Lal	31.2908°N	76.7440°E	420	Anna HRMN-99, Dorsett Golden	150- Anna-70 HRMN-99:50 Dorsett Golden-30
30	Jhandutta	Jeet Ram Katwal	31.3711°N	76.6427°E	375	Anna HRMN-99, Dorsett Golden	110- Anna-30 HRMN-99:50 Dorsett Golden-30

APPENDIX-II

1. ANOVA for tree height of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.069	0.034	0.948	0.00000
TREATMENTS	28	1.993	0.071	1.932	
ERROR	56	2.062	0.036		
TOTAL	86	4.125			

2. ANOVA for tree height of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.007	0.003	0.456	0.00000
TREATMENTS	30	3.012	0.100	12.582	
ERROR	60	0.478	0.007		
TOTAL	92	3.498			

3. ANOVA for tree height of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.077	0.019	0.850	0.00000
TREATMENTS	28	77.513	2.768	3.694	0.00000
YEAR	1	13.071	13.071	576.082	
TREAT*YEAR	28	20.981	0.749	33.0247	
POOLED ERROR	112	2.541	0.022		
TOTAL	173	40.841			

4. ANOVA for tree girth of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.885	0.442	0.792	0.00000
TREATMENTS	29	286.143	9.867	17.653	
ERROR	58	32.418	0.558		
TOTAL	89	319.447			

5. ANOVA for tree girth of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	7.559	3.779	2.363	0.00000
TREATMENTS	30	1295.383	43.179	27.005	
ERROR	60	95.934	1.598		
TOTAL	92	1398.877			

6. ANOVA for tree girth of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	8.445	2.111	1.908	0.00000
TREATMENTS	29	141.147	4.867	0.481	0.00000
YEAR	1	562.692	562.692	508.538	
TREAT*YEAR	29	293.340	10.115	9.141	
POOLED ERROR	116	128.352	1.106		
TOTAL	179	1133.978			

7. ANOVA for tree spread of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	0.519	0.00000
TREATMENTS	29	0.614	0.021	20.559	
ERROR	58	0.059	0.001		
TOTAL	89	0.675			

8. ANOVA for tree spread of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	0.176	0.00000
TREATMENTS	29	0.673	0.023	17.471	
ERROR	58	0.077	0.001		
TOTAL	89	0.750			

9. ANOVA for tree spread of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.001	0.001	0.326	0.00000
TREATMENTS	29	1.279	0.044	37.404	0.00000
YEAR	1	0.739	0.739	626.987	
TREAT*YEAR	29	0.008	0.001	0.237	
POOLED ERROR	116	0.136	0.001		
TOTAL	179	2.165			

10. ANOVA for tree volume of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.685	0.097	0.00000
TREATMENTS	29	1.184	0.040	41.246	
ERROR	58	0.057	0.001		
TOTAL	89	1.241			

11. ANOVA for tree volume of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	0.445	0.00000
TREATMENTS	29	1.753	0.060	37.151	
ERROR	58	0.094	0.001		
TOTAL	89	1.849			

12. ANOVA for tree volume of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.002	0.001	0.314	0.00000
TREATMENTS	29	2.884	0.099	75.987	0.00000
YEAR	1	3.455	3.455	2639.57	
TREAT*YEAR	29	0.053	0.001	1.413	
POOLED ERROR	116	0.151	0.001		
TOTAL	179	6.546			

13. ANOVA for annual shoot extension growth of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	3.566	1.783	0.579	0.00000
TREATMENTS	29	778.220	26.835	8.718	
ERROR	58	178.515	3.077		
TOTAL	89	960.302			

14. ANOVA for annual shoot extension growth of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	4.983	2.491	0.469	0.00000
TREATMENTS	29	976.726	33.680	6.349	
ERROR	58	307.650	5.304		
TOTAL	89	1289.36			

15. ANOVA for annual shoot extension growth of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	8.550	2.137	0.510	0.00000
TREATMENTS	29	1697.215	58.524	13.964	0.00000
YEAR	1	635.253	635.253	151.572	
TREAT*YEAR	29	57.732	1.990	0.475	
POOLED ERROR	116	486.165	4.191		
TOTAL	179	2884.916			

16. ANOVA for tree yield of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.212	0.106	2.662	0.00000
TREATMENTS	29	31.972	1.102	27.602	
ERROR	58	2.316	0.0399		
TOTAL	89	34.501			

17. ANOVA for tree yield of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.0145	0.007	0.110	0.00000
TREATMENTS	29	71.492	2.465	37.421	
ERROR	58	3.820	0.0658		
TOTAL	89	75.327			

18. ANOVA for tree yield of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.227	0.056	1.073	0.00000
TREATMENTS	29	77.213	2.662	2.941	0.00000
YEAR	1	101.745	101.745	1922.988	
TREAT*YEAR	29	26.251	0.905	17.108	
POOLED ERROR	116	6.137	0.052		
TOTAL	179	211.575			

19. ANOVA for productivity of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.002	0.001	0.194	0.00000
TREATMENTS	29	4.936	0.170	25.351	
ERROR	58	0.389	0.006		
TOTAL	89	5.328			

20. ANOVA for productivity of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.007	0.003	0.384	0.00000
TREATMENTS	29	12.335	0.425	41.709	
ERROR	58	0.591	0.010		
TOTAL	89	12.934			

21. ANOVA for productivity of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.010	0.002	0.308	0.00000
TREATMENTS	29	12.617	0.435	2.711	0.00000
YEAR	1	16.854	16.854	1993.247	
TREAT*YEAR	29	4.653	0.160	18.975	
POOLED ERROR	116	0.980	0.008		
TOTAL	179	35.116			

22. ANOVA for tree height of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.012	0.006	0.057	0.00000
TREATMENTS	29	2.676	0.092	0.849	
ERROR	58	6.298	0.108		
TOTAL	89	8.986			

23. ANOVA for tree height of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.003	0.001	0.282	0.00000
TREATMENTS	29	2.502	0.086	13.906	
ERROR	58	0.359	0.006		
TOTAL	89	2.865			

24. ANOVA for tree height of HRMN-99 (Pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.015	0.003	0.069	0.00000
TREATMENTS	29	5.116	0.176	3.073	0.00000
YEAR	1	4.530	4.530	78.932	
TREAT*YEAR	29	0.062	0.002	0.037	
POOLED ERROR	116	6.657	0.057		
TOTAL	179	16.382			

25. ANOVA for tree girth of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	2.684	1.342106	0.8565	0.00000
TREATMENTS	29	334.553	11.536	7.362	
ERROR	58	90.884	1.566		
TOTAL	89	428.121			

26. ANOVA for tree girth of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	1.522	0.761	0.645	0.00000
TREATMENTS	29	452.069	15.588	13.212	
ERROR	58	68.428	1.179		
TOTAL	89	522.02			

27. ANOVA for tree girth of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	4.206	1.051	0.765	0.00000
TREATMENTS	29	744.314	25.666	18.688	0.00000
YEAR	1	135.688	135.688	98.798	
TREAT*YEAR	29	42.308	1.458	1.062	
POOLED ERROR	116	159.312	1.373		
TOTAL	179	1085.83			

28. ANOVA for tree spread of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	0.223	0.00000
TREATMENTS	29	0.543	0.018	18.496	
ERROR	58	0.058	0.001		
TOTAL	89	0.603			

29. ANOVA for tree spread of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.002	0.001	1.104	0.00000
TREATMENTS	29	0.565	0.019	15.613	
ERROR	58	0.072	0.001		
TOTAL	89	0.640			

30. ANOVA for tree spread of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.003	0.001	0.709	0.00000
TREATMENTS	29	1.105	0.038	33.697	0.00000
YEAR	1	0.576	0.576	509.854	
TREAT*YEAR	29	0.003	0.001	0.112	
POOLED ERROR	116	0.131	0.001		
TOTAL	179	1.820			

31. ANOVA for tree volume of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.002	0.001	0.132	0.00000
TREATMENTS	29	1.0851	0.037	46.993	
ERROR	58	0.046	0.007		
TOTAL	89	1.131			

32. ANOVA for tree volume of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.006	0.008	0.681	0.00000
TREATMENTS	29	1.323	0.045	38.057	
ERROR	58	0.069	0.001		
TOTAL	89	1.395			

33. ANOVA for tree volume of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.001	0.001	0.462	0.00000
TREATMENTS	29	2.375	0.081	82.078	0.00000
YEAR	1	2.421	2.421	2426.372	
TREAT*YEAR	29	0.033	0.001	1.166	
POOLED ERROR	116	0.115	0.001		
TOTAL	179	4.948			

34. ANOVA for annual shoot extension growth of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.708	0.354	0.120	0.00000
TREATMENTS	29	1281.495	44.189	14.974	
ERROR	58	171.159	2.951		
TOTAL	89	1453.363			

35. ANOVA for annual shoot extension growth of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	5.095	2.547	0.422	0.00000
TREATMENTS	29	2910.916	100.376	16.633	
ERROR	58	350.007	6.034		
TOTAL	89	3266.021			

36. ANOVA for annual shoot extension growth of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	5.804	1.451	0.323	0.00000
TREATMENTS	29	3595.485	123.982	6.023	0.00000
YEAR	1	788.524	788.524	175.507	
TREAT*YEAR	29	596.926	20.5836	4.581	
POOLED ERROR	116	521.166	4.492		
TOTAL	179	5507.907			

37. ANOVA for tree yield of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.004	0.002	0.090	0.00000
TREATMENTS	29	22.176	0.764	33.056	
ERROR	58	1.341	0.023		
TOTAL	89	23.522			

38. ANOVA for tree yield of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.101	0.050	1.113	0.00000
TREATMENTS	29	45.409	1.565	34.422	
ERROR	58	2.638	0.045		
TOTAL	89	48.148			

39. ANOVA for tree yield of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.105	0.026	0.768	0.00000
TREATMENTS	29	48.231	1.663	2.492	0.00000
YEAR	1	119.756	119.756	3490.292	
TREAT*YEAR	29	19.354	0.667	19.450	
POOLED ERROR	116	3.980	0.034		
TOTAL	179	191.427			

40. ANOVA for productivity of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.017	0.008	1.839	0.00000
TREATMENTS	29	3.846	0.132	28.503	
ERROR	58	0.269	0.004		
TOTAL	89	4.133			

41. ANOVA for productivity of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.007	0.003	0.436	0.00000
TREATMENTS	29	7.86	0.271	31.007	
ERROR	58	0.507	0.008		
TOTAL	89	8.376			

42. ANOVA for productivity of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.024	0.006	0.924	0.00000
TREATMENTS	29	8.343	0.287	2.479	0.00000
YEAR	1	20.767	20.767	3100.294	
TREAT*YEAR	29	3.365	0.116	17.322	
POOLED ERROR	116	0.777	0.006		
TOTAL	179	33.277			

43. ANOVA for tree height of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.005	0.002	0.025	0.00000
TREATMENTS	29	2.688	0.092	0.859	
ERROR	58	6.258	0.107		
TOTAL	89	8.952			

44. ANOVA for tree height of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.003	0.001	0.282	0.00000
TREATMENTS	29	2.502	0.086	13.906	
ERROR	58	0.359	0.006		
TOTAL	89	2.865			

45. ANOVA for tree height of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.008	0.002	0.039	0.00000
TREATMENTS	29	5.122	0.176	3.095	0.00000
YEAR	1	4.423	4.423	77.522	
TREAT*YEAR	29	0.068	0.002	0.041	
POOLED ERROR	116	6.618	0.057		
TOTAL	179	16.241			

46. ANOVA for tree girth of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.806	0.403	0.510	0.00000
TREATMENTS	29	352.438	12.153	15.383	
ERROR	58	45.819	0.789		
TOTAL	89	399.064			

47. ANOVA for tree girth of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.780	0.390	0.367	0.00000
TREATMENTS	29	204.839	7.063	6.658	
ERROR	58	61.526	1.060		
TOTAL	89	267.145			

48. ANOVA for tree girth of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	1.586	0.396	0.428	0.00000
TREATMENTS	29	226.993	7.827	0.687	0.00000
YEAR	1	434.890	434.890	469.951	
TREAT*YEAR	29	330.284	11.389	12.307	
POOLED ERROR	116	107.345	0.925		
TOTAL	179	1101.1			

49. ANOVA for tree spread of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.004	0.002	2.661	0.00000
TREATMENTS	29	5.248	0.180	216.279	
ERROR	58	0.048	0.001		
TOTAL	89	5.301			

50. ANOVA for tree spread of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	0.941	0.00000
TREATMENTS	29	3.174	0.109	116.187	
ERROR	58	0.054	0.001		
TOTAL	89	3.230			

51. ANOVA for tree spread of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.001	0.001	1.750	0.00000
TREATMENTS	29	6.905	0.238	4.551	
YEAR	1	0.303	0.303	341.108	0.00000
TREAT*YEAR	29	1.517	0.052	58.824	
POOLED ERROR	116	0.103	0.001		
TOTAL	179	8.835			

52. ANOVA for tree volume of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	0.549	0.00000
TREATMENTS	29	3.121	0.107	268.761	
ERROR	58	0.023	0.001		
TOTAL	89	3.145			

53. ANOVA for tree volume of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	1.235	0.00000
TREATMENTS	29	2.371	0.081	133.489	
ERROR	58	0.035	0.001		
TOTAL	89	2.408			

54. ANOVA for tree volume of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.001	0.001	0.964	0.00000
TREATMENTS	29	4.724	0.162	6.147	0.00000
YEAR	1	0.736	0.736	1454.466	
TREAT*YEAR	29	0.768	0.026	52.321	
POOLED ERROR	116	0.058	0.001		
TOTAL	179	6.290			

55. ANOVA for annual shoot extension growth of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	8.598	4.299	1.190	0.00000
TREATMENTS	29	1496.348	51.598	14.292	
ERROR	58	209.385	3.610		
TOTAL	89	1714.332			

56. ANOVA for annual shoot extension growth of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	31.986	15.993	5.108	0.00000
TREATMENTS	29	1463.092	50.451	16.115	
ERROR	58	181.572	3.130		
TOTAL	89	1676.65			

57. ANOVA for annual shoot extension growth of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	40.585	10.146	3.010	0.00000
TREATMENTS	29	2938.797	101.337	30.067	0.00000
YEAR	1	362.248	362.248	107.481	
TREAT*YEAR	29	20.642	0.711	0.211	
POOLED ERROR	116	390.957	3.370		
TOTAL	179	3753.23			

58. ANOVA for tree yield of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.137	0.068	2.619	0.00000
TREATMENTS	29	47.523	1.638	62.473	
ERROR	58	1.521	0.026		
TOTAL	89	49.182			

59. ANOVA for tree yield of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.174	0.087	2.572	0.00000
TREATMENTS	29	45.325	1.562	46.023	
ERROR	58	1.969	0.033		
TOTAL	89	47.469			

60. ANOVA for tree yield of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.312	0.078	2.593	0.00000
TREATMENTS	29	75.141	2.591	4.243	0.00000
YEAR	1	61.565	61.565	2045.675	
TREAT*YEAR	29	17.706	0.610	20.288	
POOLED ERROR	116	3.491	0.030		
TOTAL	179	158.217			

61. ANOVA for productivity of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.0189	0.009	2.330	0.00000
TREATMENTS	29	8.728	0.301	74.089	
ERROR	58	0.235	0.004		
TOTAL	89	8.983			

62. ANOVA for productivity of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.003	0.001	0.303	0.00000
TREATMENTS	29	7.828	0.269	44.223	
ERROR	58	0.354	0.005		
TOTAL	89	8.185			

63. ANOVA for productivity of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.022	0.005	1.113	0.00000
TREATMENTS	29	10.459	0.360	1.715	0.00000
YEAR	1	16.799	16.799	3304.918	
TREAT*YEAR	29	6.097	0.210	41.364	
POOLED ERROR	116	0.589	0.005		
TOTAL	179	33.968			

64. ANOVA for leaf area of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	7.247	3.623	0.599	0.00000
TREATMENTS	29	791.070	27.278	4.516	
ERROR	58	350.302	6.039		
TOTAL	89	1148.62			

65. ANOVA for leaf area of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	2.690	1.345	0.332	0.00000
TREATMENTS	29	853.101	29.417	7.272	
ERROR	58	234.619	4.045		
TOTAL	89	1090.411			

66. ANOVA for leaf area of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	9.937	2.484	0.492	0.00000
TREATMENTS	29	1619.501	55.844	11.075	0.00000
YEAR	1	161.496	161.496	32.027	
TREAT*YEAR	29	24.670	0.850	0.168	
POOLED ERROR	116	584.921	5.042		
TOTAL	179	2400.527			

67. ANOVA for leaf area of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	12.344	6.172	1.006	0.00000
TREATMENTS	29	1241.928	42.825	6.980	
ERROR	58	355.839	6.135		
TOTAL	89	1610.112			

68. ANOVA for leaf area of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	1.862	0.931	0.218	0.00000
TREATMENTS	29	1158.565	39.950	9.357	
ERROR	58	247.633	4.269		
TOTAL	89	1408.06			

69. ANOVA for leaf area of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	14.206	3.551	0.682	0.00000
TREATMENTS	29	2372.308	81.803	15.724	0.00000
YEAR	1	156.468	156.468	30.076	
TREAT*YEAR	29	28.185	0.971	0.186	
POOLED ERROR	116	603.472	5.202		
TOTAL	179	3174.641			

70. ANOVA for leaf area of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	11.841	5.920	0.995	0.00000
TREATMENTS	29	926.443	31.946	5.371	
ERROR	58	344.945	5.947		
TOTAL	89	1283.231			

71. ANOVA for leaf area of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	3.989	1.994	0.415	0.00000
TREATMENTS	29	855.887	29.513	6.152	
ERROR	58	278.245	4.797		
TOTAL	89	1138.122			

72. ANOVA for leaf area of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	15.831	3.957	0.736	0.00000
TREATMENTS	29	1739.856	59.995	11.167	0.00000
YEAR	1	143.116	143.116	26.639	
TREAT*YEAR	29	42.475	1.464	0.272	
POOLED ERROR	116	623.190	5.372		
TOTAL	179	2564.469			

73. ANOVA for fruit set under selfing of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	16.732	8.366	4.348	0.00000
TREATMENTS	29	1202.157	41.453	21.547	
ERROR	58	111.583	1.923		
TOTAL	89	1330.473			

74. ANOVA for fruit set under selfing of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	38.046	19.023	3.338	0.00000
TREATMENTS	29	1235.004	42.586	7.474	
ERROR	58	330.460	5.697		
TOTAL	89	1603.511			

75. ANOVA for fruit set under selfing of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	54.779	13.694	3.593	0.00000
TREATMENTS	29	2412.84	83.201	21.833	0.00000
YEAR	1	1102.55	1102.55	289.328	
TREAT*YEAR	29	24.319	0.838	0.220	
POOLED ERROR	116	442.043	3.810		
TOTAL	179	4036.533			

76. ANOVA for fruit set under selfing of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.051	0.025	0.018	0.00000
TREATMENTS	29	1088.345	37.529	27.638	
ERROR	58	78.756	1.357		
TOTAL	89	1167.152			

77. ANOVA for fruit set under selfing of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	15.675	7.837	1.339	0.00000
TREATMENTS	29	1961.812	67.648	11.563	
ERROR	58	339.311	5.850		
TOTAL	89	2316.8			

78. ANOVA for fruit set under selfing of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	15.726	3.931	1.090	0.00000
TREATMENTS	29	1238.66	42.712	0.683	0.00000
YEAR	1	3678.954	3678.954	1020.789	
TREAT*YEAR	29	1811.497	62.465	17.332	
POOLED ERROR	116	418.067	3.604		
TOTAL	179	7162.905			

79. ANOVA for fruit set under selfing of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.612	0.306	0.298	0.00000
TREATMENTS	29	1400.293	48.285	47.157	
ERROR	58	59.387	1.023		
TOTAL	89	1460.293			

80. ANOVA for fruit set under selfing of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	41.273	20.636	4.860	0.00000
TREATMENTS	29	1403.446	48.394	11.397	
ERROR	58	246.282	4.246		
TOTAL	89	1691.002			

81. ANOVA for fruit set under selfing of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	41.886	10.471	3.973	0.00000
TREATMENTS	29	2757.656	95.091	36.086	0.00000
YEAR	1	1011.244	1011.244	383.761	
TREAT*YEAR	29	46.082	1.589	0.603	
POOLED ERROR	116	305.670	2.635		
TOTAL	179	4162.539			

82. ANOVA for fruit set under open pollination of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.917	0.458	0.265	0.00000
TREATMENTS	29	677.561	23.364	13.524	
ERROR	58	100.196	1.727		
TOTAL	89	778.675			

83. ANOVA for fruit set under open pollination of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	9.605	4.802	0.686	0.00000
TREATMENTS	29	860.390	29.668	4.237	
ERROR	58	406.053	7.001		
TOTAL	89	1276.049			

84. ANOVA for fruit set under open pollination of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	10.522	2.630	0.602	0.00000
TREATMENTS	29	1470.733	50.714	11.620	0.00000
YEAR	1	810.242	810.242	185.655	
TREAT*YEAR	29	67.219	2.317	0.531	
POOLED ERROR	116	506.25	4.364		
TOTAL	179	2864.968			

85. ANOVA for fruit set under open pollination of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	2.982	1.491	1.132	0.00000
TREATMENTS	29	764.999	26.379	20.034	
ERROR	58	76.368	1.316		
TOTAL	89	844.350			

86. ANOVA for fruit set under open pollination of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	6.125	3.062	0.353	0.00000
TREATMENTS	29	879.260	30.319	3.503	
ERROR	58	501.864	8.652		
TOTAL	89	1387.25			

87. ANOVA for fruit set under open pollination of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	9.108	2.277	0.456	0.00000
TREATMENTS	29	1573.635	54.263	10.885	0.00000
YEAR	1	954.948	954.948	191.573	
TREAT*YEAR	29	70.625	2.435	0.488	
POOLED ERROR	116	578.232	4.984		
TOTAL	179	3186.55			

88. ANOVA for fruit set under open pollination of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	4.656	2.328	0.923	0.00000
TREATMENTS	29	976.167	33.660	13.352	
ERROR	58	146.211	2.520		
TOTAL	89	1127.036			

89. ANOVA for fruit set under open pollination of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	38.745	19.372	2.505	0.00000
TREATMENTS	29	1029.782	35.509	4.592	
ERROR	58	448.503	7.732		
TOTAL	89	1517.031			

90. ANOVA for fruit set under open pollination of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	43.402	10.850	2.116	0.00000
TREATMENTS	29	1955.127	67.418	13.150	0.00000
YEAR	1	737.221	737.221	143.796	
TREAT*YEAR	29	50.822	1.752	0.341	
POOLED ERROR	116	594.715	5.126		
TOTAL	179	3381.288			

91. ANOVA for fruit length of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	4.371	2.185	0.509	0.00000
TREATMENTS	29	813.777	28.061	6.539	
ERROR	58	248.895	4.291		
TOTAL	89	1067.044			

92. ANOVA for fruit length of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	7.089	3.544	1.026	0.00000
TREATMENTS	29	492.271	16.974	4.914	
ERROR	58	200.329	3.453		
TOTAL	89	699.690			

93. ANOVA for fruit length of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	11.461	2.865	0.739	0.00000
TREATMENTS	29	1190.071	41.036	10.596	0.00000
YEAR	1	410.508	410.508	106.002	
TREAT*YEAR	29	115.978	3.999	1.032	
POOLED ERROR	116	449.224	3.872		
TOTAL	179	2177.243			

94. ANOVA for fruit width of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	4.522	2.261	0.723	0.00000
TREATMENTS	29	559.442	19.291	6.175	
ERROR	58	181.181	3.123		
TOTAL	89	745.146			

95. ANOVA for fruit width of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	2.325	1.162	0.325	0.00000
TREATMENTS	29	765.179	26.385	7.384	
ERROR	58	207.250	3.573		
TOTAL	89	974.755			

96. ANOVA for fruit width of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	6.848	1.712	0.511	0.00000
TREATMENTS	29	1022.982	35.275	3.391	0.00000
YEAR	1	393.650	393.650	117.558	
TREAT*YEAR	29	301.639	10.401	3.106	
POOLED ERROR	116	388.432	3.348		
TOTAL	179	2113.552			

97. ANOVA for fruit weight of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	29.774	14.887	1.205	0.00000
TREATMENTS	29	6744.482	232.568	18.831	
ERROR	58	716.281	12.349		
TOTAL	89	7490.539			

98. ANOVA for fruit weight of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	8.419	4.209	0.346	0.00000
TREATMENTS	29	6843.395	235.979	19.399	
ERROR	58	705.513	12.164		
TOTAL	89	7557.328			

99. ANOVA for fruit weight of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	38.194	9.548	0.779	0.00000
TREATMENTS	29	13175.44	454.325	37.067	0.00000
YEAR	1	5007.769	5007.769	408.569	
TREAT*YEAR	29	412.435	14.221	1.160	
POOLED ERROR	116	1421.794	12.256		
TOTAL	179	20055.63			

100. ANOVA for fruit base cavity depth of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	5.4	0.028	0.00000
TREATMENTS	29	2.773	0.095	50.556	
ERROR	58	0.109	0.001		
TOTAL	89	2.883			

101. ANOVA for fruit base cavity depth of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	0.115	0.00000
TREATMENTS	29	3.644	0.125	81.601	
ERROR	58	0.089	0.001		
TOTAL	89	3.734			

102. ANOVA for fruit base cavity depth of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.001	0.001	0.067	0.00000
TREATMENTS	29	4.219	0.145	1.918	0.00000
YEAR	1	1.733	1.733	1010.375	
TREAT*YEAR	29	2.198	0.075	44.190	
POOLED ERROR	116	0.199	0.001		
TOTAL	179	8.351			

103. ANOVA for fruit firmness of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.405	0.202	0.485	0.00000
TREATMENTS	29	25.659	0.884	2.119	
ERROR	58	24.215	0.417		
TOTAL	89	50.279			

104. ANOVA for fruit firmness of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.107	0.053	2.496	0.00000
TREATMENTS	29	43.080	1.485	68.949	
ERROR	58	1.249	0.021		
TOTAL	89	44.438			

105. ANOVA for fruit firmness of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.513	0.128	0.584	0.00000
TREATMENTS	29	54.939	1.894	3.980	0.00000
YEAR	1	0.746	0.746	3.401	
TREAT*YEAR	29	13.800	0.475	2.167	
POOLED ERROR	116	25.464	0.219		
TOTAL	179	95.464			

106. ANOVA for fruit seeds of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.043	0.021	1.048	0.00000
TREATMENTS	29	93.6	3.227	154.063	
ERROR	58	1.215	0.020		
TOTAL	89	94.859			

107. ANOVA for fruit seeds of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.012	0.006	0.331	0.00000
TREATMENTS	29	86	2.965	160.861	
ERROR	58	1.069	0.018		
TOTAL	89	87.081			

108. ANOVA for fruit seeds of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.056	0.014	0.712	0.00000
TREATMENTS	29	98.8	3.406	1.222	0.00000
YEAR	1	0.2	0.2	10.151	
TREAT*YEAR	29	80.8	2.786	141.486	
POOLED ERROR	116	2.284	0.019		
TOTAL	179	182.140			

109. ANOVA for fruit length of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	3.708	1.854	0.476	0.00000
TREATMENTS	29	607.122	20.935	5.380	
ERROR	58	225.693	3.891		
TOTAL	89	836.524			

110. ANOVA for fruit length of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	6.481	3.240	1.481	0.00000
TREATMENTS	29	1035.25	35.698	16.321	
ERROR	58	126.858	2.187		
TOTAL	89	1168.59			

111. ANOVA for fruit length of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	10.190	2.547	0.838258	0.00000
TREATMENTS	29	1110.836	38.304	2.089	0.00000
YEAR	1	232.562	232.562	76.519	
TREAT*YEAR	29	531.535	18.328	6.030	
POOLED ERROR	116	352.551	3.039		
TOTAL	179	2237.676			

112. ANOVA for fruit width of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	11.867	5.933	1.902	0.00000
TREATMENTS	29	926.392	31.944	10.242	
ERROR	58	180.897	3.118		
TOTAL	89	1119.157			

113. ANOVA for fruit width of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.173	0.086	0.027	0.00000
TREATMENTS	29	689.904	23.789	7.440	
ERROR	58	185.454	3.197		
TOTAL	89	875.531			

114. ANOVA for fruit width of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	12.040	3.010	0.953	0.00000
TREATMENTS	29	1199.381	41.357	2.8767	0.00000
YEAR	1	294.835	294.835	93.355	
TREAT*YEAR	29	416.915	14.376	4.552	
POOLED ERROR	116	366.351	3.158		
TOTAL	179	2289.524			

115. ANOVA for fruit weight of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.866	0.433	0.055	0.00000
TREATMENTS	29	8163.133	281.487	36.104	
ERROR	58	452.198	7.7965		
TOTAL	89	8616.198			

116. ANOVA for fruit weight of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	85.734	42.867	4.733	0.00000
TREATMENTS	29	7086.178	244.351	26.981	
ERROR	58	525.263	9.056		
TOTAL	89	7697.175			

117. ANOVA for fruit weight of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	86.601	21.650	2.569	0.00000
TREATMENTS	29	14849.43	512.049	37.135	0.00000
YEAR	1	4710.71	4710.71	559.042	
TREAT*YEAR	29	399.876	13.788	1.636	
POOLED ERROR	116	977.460	8.426		
TOTAL	179	21024.08			

118. ANOVA for fruit base cavity depth of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	0.397	0.00000
TREATMENTS	29	3.347	0.115	61.711	
ERROR	58	0.108	0.001		
TOTAL	89	3.457			

119. ANOVA for fruit base cavity depth of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	0.563	0.00000
TREATMENTS	29	2.852	0.098	62.807	
ERROR	58	0.090	0.001		
TOTAL	89	2.945			

120. ANOVA for fruit base cavity depth of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.003	0.001	0.473	0.00000
TREATMENTS	29	3.425	0.118	1.233	0.00000
YEAR	1	0.168	0.168	98.060	
TREAT*YEAR	29	2.775	0.095	55.696	
POOLED ERROR	116	0.199	0.001		
TOTAL	179	6.571			

121. ANOVA for fruit firmness of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.245	0.122	0.897	0.00000
TREATMENTS	29	7.188	0.247	1.812	
ERROR	58	7.931	0.136		
TOTAL	89	15.365			

122. ANOVA for fruit firmness of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.038	0.019	0.785	0.00000
TREATMENTS	29	12.120	0.417	17.232	
ERROR	58	1.406	0.024		
TOTAL	89	13.564			

123. ANOVA for fruit firmness of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.283	0.070	0.881	0.00000
TREATMENTS	29	12.831	0.442	1.980	0.00000
YEAR	1	0.019	0.019	0.237	
TREAT*YEAR	29	6.477	0.223	2.774	
POOLED ERROR	116	9.338	0.080		
TOTAL	179	28.949			

124. ANOVA for fruit seeds of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.022	0.011	0.506	0.00000
TREATMENTS	29	80.1	2.762	125.576	
ERROR	58	1.275	0.021		
TOTAL	89	81.398			

125. ANOVA for fruit seeds of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.018	0.0093	0.307	0.00000
TREATMENTS	29	56.1	1.934	63.660	
ERROR	58	1.762	0.030		
TOTAL	89	57.881			

126. ANOVA for fruit seeds of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.041	0.010	0.391	0.00000
TREATMENTS	29	58.2	2.006	0.746	0.00000
YEAR	1	0	0	0	
TREAT*YEAR	29	78	2.689	102.692	
POOLED ERROR	116	3.038	0.026		
TOTAL	179	139.279			

127. ANOVA for fruit length of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	3.958	1.979	0.578	0.00000
TREATMENTS	29	547.965	18.895	5.519	
ERROR	58	198.546	3.423		
TOTAL	89	750.470			

128. ANOVA for fruit length of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	7.123	3.561	2.370	0.00000
TREATMENTS	29	1104.235	38.077	25.341	
ERROR	58	87.148	1.502		
TOTAL	89	1198.507			

129. ANOVA for fruit length of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	11.081	2.778	1.124	0.00000
TREATMENTS	29	1069.734	36.887	1.836	0.00000
YEAR	1	1.909	1.909	0.775	
TREAT*YEAR	29	582.467	20.085	8.155	
POOLED ERROR	116	285.695	2.462		
TOTAL	179	1950.888			

130. ANOVA for fruit width of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	8.704	4.352	1.279	0.00000
TREATMENTS	29	701.08	24.175	7.106	
ERROR	58	197.294	3.401		
TOTAL	89	907.0788			

131. ANOVA for fruit width of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	10.154	5.076	1.774	0.00000
TREATMENTS	29	1120.613	38.641	13.502	
ERROR	58	165.981	2.861		
TOTAL	89	1296.749			

132. ANOVA for fruit width of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	18.858	4.714	1.505	0.00000
TREATMENTS	29	1158.525	39.949	1.746	0.00000
YEAR	1	3.444	3.444	1.099	
TREAT*YEAR	29	663.168	22.867	7.302	
POOLED ERROR	116	363.276	3.131		
TOTAL	179	2207.272			

133. ANOVA for fruit weight of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	31.395	15.697	1.884	0.00000
TREATMENTS	29	6803.177	234.593	28.156	
ERROR	58	483.234	8.331		
TOTAL	89	7317.806			

134. ANOVA for fruit weight of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	19.770	9.885	1.497	0.00000
TREATMENTS	29	10237.31	353.010	53.470	
ERROR	58	382.917	6.602		
TOTAL	89	10639.99			

135. ANOVA for fruit weight of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	51.165	12.791	1.713	0.00000
TREATMENTS	29	15723.04	542.173	11.934	0.00000
YEAR	1	2465.088	2465.088	330.138	
TREAT*YEAR	29	1317.444	45.429	6.084	
POOLED ERROR	116	866.151	7.466		
TOTAL	179	20422.89			

136. ANOVA for fruit base cavity depth of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	1.819	0.00000
TREATMENTS	29	0.124	0.004	10.507	
ERROR	58	0.023	0.001		
TOTAL	89	0.149			

137. ANOVA for fruit base cavity depth of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	1.521	0.00000
TREATMENTS	29	0.336	0.011	19.790	
ERROR	58	0.034	0.001		
TOTAL	89	0.372			

138. ANOVA for fruit base cavity depth of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.003	0.001	1.644	0.00000
TREATMENTS	29	0.195	0.006	0.737	0.00000
YEAR	1	0.085	0.085	172.503	
TREAT*YEAR	29	0.265	0.009	18.393	
POOLED ERROR	116	0.057	0.001		
TOTAL	179	0.608			

139. ANOVA for fruit firmness of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.047	0.023	0.565	0.00000
TREATMENTS	29	27.023	0.931	22.026	
ERROR	58	2.453	0.042		
TOTAL	89	29.525			

140. ANOVA for fruit firmness of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.133	0.066	2.719	0.00000
TREATMENTS	29	19.938	0.687	27.936	
ERROR	58	1.427	0.024		
TOTAL	89	21.499			

141. ANOVA for fruit firmness of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.181	0.045	1.358	0.00000
TREATMENTS	29	30.105	1.038	1.785	0.00000
YEAR	1	1.836	1.836	54.880	
TREAT*YEAR	29	16.856	0.581	17.373	
POOLED ERROR	116	3.881	0.033		
TOTAL	179	52.861			

142. ANOVA for fruit seeds of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.070	0.035	1.199	0.00000
TREATMENTS	29	93.6	3.227	110.547	
ERROR	58	1.693	0.029		
TOTAL	89	95.363			

143. ANOVA for fruit seeds of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.147	0.073	2.453	0.00000
TREATMENTS	29	86.9	2.996	99.801	
ERROR	58	1.741	0.030		
TOTAL	89	88.788			

144. ANOVA for fruit seeds of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.217	0.054	1.834	0.00000
TREATMENTS	29	98.05	3.381	1.189	0.00000
YEAR	1	0.05	0.05	1.688	
TREAT*YEAR	29	82.45	2.843	96.015	
POOLED ERROR	116	3.434	0.029		
TOTAL	179	184.202			

ANOVA for fruit TSS of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.558	0.279	0.956	0.00000
TREATMENTS	29	10.989	0.378	1.296	
ERROR	58	16.950	0.292		
TOTAL	89	28.499			

145. ANOVA for fruit TSS of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.015	0.007	0.108	0.00000
TREATMENTS	29	19.959	0.688	9.526	
ERROR	58	4.190	0.072		
TOTAL	89	24.165			

146. ANOVA for fruit TSS of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.574	0.143	0.788	0.00000
TREATMENTS	29	15.011	0.517	0.941	0.00000
YEAR	1	11.222	11.222	61.576	
TREAT*YEAR	29	15.937	0.549	3.015	
POOLED ERROR	116	21.140	0.182		
TOTAL	179	63.886			

147. ANOVA for fruit titratable acidity of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	0.952	0.00000
TREATMENTS	29	0.208	0.007	38.463	
ERROR	58	0.010	0.001		
TOTAL	89	0.219			

148. ANOVA for fruit titratable acidity of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	0.897	0.00000
TREATMENTS	29	0.157	0.005	26.713	
ERROR	58	0.011	0.001		
TOTAL	89	0.170			

149. ANOVA for fruit titratable acidity of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.001	0.001	0.924	0.00000
TREATMENTS	29	0.188	0.006	1.065	0.00000
YEAR	1	0.017	0.017	91.508	
TREAT*YEAR	29	0.177	0.006	31.309	
POOLED ERROR	116	0.022	0.001		
TOTAL	179	0.407			

150. ANOVA for fruit total sugars of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.125	0.062	1.262	0.00000
TREATMENTS	29	10.063	0.347	6.983	
ERROR	58	2.882	0.049		
TOTAL	89	13.070			

151. ANOVA for fruit total sugars of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.016	0.008	0.132	0.00000
TREATMENTS	29	26.831	0.925	15.176	
ERROR	58	3.535	0.060		
TOTAL	89	30.383			

152. ANOVA for fruit total sugars of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.141	0.035	0.639	0.00000
TREATMENTS	29	19.945	0.687	1.176	0.00000
YEAR	1	2.767	2.767	50.028	
TREAT*YEAR	29	16.948	0.584	10.563	
POOLED ERROR	116	6.417	0.055		
TOTAL	179	46.221			

153. ANOVA for fruit reducing sugars of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	0.020	0.00000
TREATMENTS	29	9.585	0.330	18.156	
ERROR	58	1.055	0.018		
TOTAL	89	10.642			

154. ANOVA for fruit reducing sugars of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.030	0.015	1.007	0.00000
TREATMENTS	29	19.749	0.681	45.065	
ERROR	58	0.876	0.015		
TOTAL	89	20.656			

155. ANOVA for fruit reducing sugars of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.031	0.007	0.467	0.00000
TREATMENTS	29	14.562	0.502	0.985	0.00000
YEAR	1	6.498	6.498	390.066	
TREAT*YEAR	29	14.772	0.509	30.579	
POOLED ERROR	116	1.932	0.016		
TOTAL	179	37.797			

156. ANOVA for fruit non- reducing sugars of Anna (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.015	0.007	0.729	0.00000
TREATMENTS	29	2.966	0.102	9.440	
ERROR	58	0.628	0.010		
TOTAL	89	3.610			

157. ANOVA for fruit non- reducing sugars of Anna (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.006	0.003	0.293	0.00000
TREATMENTS	29	4.020	0.138	13.102	
ERROR	58	0.613	0.010		
TOTAL	89	4.640			

158. ANOVA for fruit non- reducing sugars of Anna (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.022	0.005	0.514	0.00000
TREATMENTS	29	3.477	0.119	0.990	0.00000
YEAR	1	0.712	0.712	66.499	
TREAT*YEAR	29	3.510	0.121	11.303	
POOLED ERROR	116	1.242	0.010		
TOTAL	179	8.963			

159. ANOVA for fruit TSS of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.060	0.030	0.413	0.00000
TREATMENTS	29	23.094	0.796	10.935	
ERROR	58	4.223	0.072		
TOTAL	89	27.379			

160. ANOVA for fruit TSS of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.486	0.243	2.890	0.00000
TREATMENTS	29	18.399	0.634	7.540	
ERROR	58	4.880	0.084		
TOTAL	89	23.766			

161. ANOVA for fruit TSS of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.546	0.136	1.741	0.00000
TREATMENTS	29	27.737	0.956	2.016	0.00000
YEAR	1	0.009	0.009	0.117	
TREAT*YEAR	29	13.757	0.474	6.044	
POOLED ERROR	116	9.104	0.0784		
TOTAL	179	51.154			

162. ANOVA for fruit titratable acidity of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	5.67	2.84	0.001	0.00000
TREATMENTS	29	0.142	0.004	28.517	
ERROR	58	0.009	0.001		
TOTAL	89	0.152			

163. ANOVA for fruit titratable acidity of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.003	0.001	0.773	0.00000
TREATMENTS	29	0.086	0.002	11.957	
ERROR	58	0.014	0.001		
TOTAL	89	0.101			

164. ANOVA for fruit titratable acidity of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.001	9.66	0.458	0.00000
TREATMENTS	29	0.100	0.003	0.781	0.00000
YEAR	1	0.004	0.004	23.356	
TREAT*YEAR	29	0.128	0.004	21.007	
POOLED ERROR	116	0.024	0.002		
TOTAL	179	0.258			

165. ANOVA for fruit total sugars of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.167	0.083	1.098	0.00000
TREATMENTS	29	23.221	0.800	10.506	
ERROR	58	4.420	0.076		
TOTAL	89	27.809			

166. ANOVA for fruit total sugars of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.107	0.053	1.201	0.00000
TREATMENTS	29	20.777	0.716	16.030	
ERROR	58	2.592	0.044		
TOTAL	89	23.477			

167. ANOVA for fruit total sugar of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.274	0.068	1.136	0.00000
TREATMENTS	29	30.35946	1.046	2.225	0.00000
YEAR	1	1.134	1.134	18.764	
TREAT*YEAR	29	13.639	0.470	7.780	
POOLED ERROR	116	7.012	0.060		
TOTAL	179	52.420			

168. ANOVA for fruit reducing sugar of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.074	0.037	1.684	0.00000
TREATMENTS	29	30.869	1.064	48.406	
ERROR	58	1.275	0.021		
TOTAL	89	32.219			

169. ANOVA for fruit reducing sugar of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.069	0.034	1.189	0.00000
TREATMENTS	29	20.176	0.695	23.709	
ERROR	58	1.702	0.029		
TOTAL	89	21.948			

170. ANOVA for fruit reducing sugar of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.143	0.035	1.401	0.00000
TREATMENTS	29	29.098	1.003	1.325	0.00000
YEAR	1	0.994	0.994	38.743	
TREAT*YEAR	29	21.947	0.756	29.481	
POOLED ERROR	116	2.977	0.025		
TOTAL	179	55.162			

171. ANOVA for fruit non-reducing sugar of HRMN-99 (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.027	0.013	1.920	0.00000
TREATMENTS	29	2.490	0.085	12.112	
ERROR	58	0.411	0.007		
TOTAL	89	2.929			

172. ANOVA for fruit non-reducing sugar of HRMN-99 (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.002	0.001	0.148	0.00000
TREATMENTS	29	6.111	0.210	29.832	
ERROR	58	0.409	0.007		
TOTAL	89	6.523			

173. ANOVA for fruit non-reducing sugar of HRMN-99 (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.029	0.007	1.0362	0.00000
TREATMENTS	29	3.686	0.127	0.749	0.00000
YEAR	1	4.219	4.2197	596.202	
TREAT*YEAR	29	4.916	0.169	23.952	
POOLED ERROR	116	0.821	0.007		
TOTAL	179	13.672			

174. ANOVA for fruit TSS of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.314	0.157	2.086	0.00000
TREATMENTS	29	30.682	1.058	14.028	
ERROR	58	4.374	0.075		
TOTAL	89	35.371			

175. ANOVA for fruit TSS of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.190	0.0954	1.468	0.00000
TREATMENTS	29	21.337	0.735	11.322	
ERROR	58	3.768	0.064		
TOTAL	89	25.296			

176. ANOVA for fruit TSS of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.505	0.126	1.800	0.00000
TREATMENTS	29	28.333	0.977	1.196	0.00000
YEAR	1	0.330	0.330	4.704	
TREAT*YEAR	29	23.685	0.816	11.634	
POOLED ERROR	116	8.143	0.070		
TOTAL	179	60.998			

177. ANOVA for fruit titratable acidity of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	2.029	0.00000
TREATMENTS	29	0.081	0.002	13.244	
ERROR	58	0.012	0.001		
TOTAL	89	0.094			

178. ANOVA for fruit titratable acidity of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.001	0.001	0.689	0.00000
TREATMENTS	29	0.085	0.002	10.636	0.00000
ERROR	58	0.016	0.001		
TOTAL	89	0.101			

179. ANOVA for fruit titratable acidity of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.001	0.001	1.271	0.00000
TREATMENTS	29	0.050	0.001	0.441	0.00000
YEAR	1	0.079	0.079	326.754	
TREAT*YEAR	29	0.115	0.003	16.330	
POOLED ERROR	116	0.028	0.001		
TOTAL	179	0.275			

180. ANOVA for fruit total sugars of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.035	0.017	0.439	0.00000
TREATMENTS	29	28.232	0.973	24.083	
ERROR	58	2.344	0.040		
TOTAL	89	30.612			

181. ANOVA for fruit total sugars of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.026	0.013	0.203	0.00000
TREATMENTS	29	23.747	0.818	12.571	
ERROR	58	3.777	0.065		
TOTAL	89	27.551			

182. ANOVA for fruit total sugars of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.061	0.015	0.293	0.00000
TREATMENTS	29	28.367	0.978	1.201	0.00000
YEAR	1	0.028	0.028	0.537	
TREAT*YEAR	29	23.613	0.814	15.427	
POOLED ERROR	116	6.122	0.052		
TOTAL	179	58.193			

183. ANOVA for fruit reducing sugars of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.077	0.038	1.696	0.00000
TREATMENTS	29	24.888	0.858	37.358	
ERROR	58	1.332	0.022		
TOTAL	89	26.298			

184. ANOVA for fruit reducing sugars of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.039	0.019	0.828	0.00000
TREATMENTS	29	35.312	1.217	50.856	
ERROR	58	1.388	0.023		
TOTAL	89	36.740			

185. ANOVA for fruit reducing sugars of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.117	0.029	1.253	0.00000
TREATMENTS	29	30.537	1.053	1.029	0.00000
YEAR	1	0.172	0.172	7.374	
TREAT*YEAR	29	29.663	1.022	43.604	
POOLED ERROR	116	2.721	0.023		
TOTAL	179	63.212			

186. ANOVA for fruit non-reducing sugars of Dorsett Golden (2016)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.004	0.002	0.237	0.00000
TREATMENTS	29	3.202	0.110	10.848	
ERROR	58	0.590	0.010		
TOTAL	89	3.797			

187. ANOVA for fruit non-reducing sugars of Dorsett Golden (2017)

SOURCE	DF	SS	MS	F	Significance
REPLICATIONS	2	0.007	0.003	0.366	0.00000
TREATMENTS	29	5.519	0.190	18.200	
ERROR	58	0.606	0.010		
TOTAL	89	6.1339			

188. ANOVA for fruit non-reducing sugars of Dorsett Golden (pooled)

SOURCE	DF	SS	MS	F	Significance
REP/YEAR	4	0.012	0.003	0.303	0.00000
TREATMENTS	29	4.116	0.141	0.893	0.00000
YEAR	1	0.187	0.187	18.167	
TREAT*YEAR	29	4.606	0.158	15.393	
POOLED ERROR	116	1.1969	0.010		
TOTAL	179	10.119			

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Abstract

The present investigations entitled **"Studies on low chill apples (*Malus* × *domestica* Borkh.) in sub-mountain zone of Himachal Pradesh"** were carried out during 2017-2018 at Kangra, Hamirpur and Bilaspur Districts of Himachal Pradesh. Apple cultivation in the warmer area of HP is slowly gaining popularity and this has an encouraging potential for the diversification of fruit cultivation in the lower areas. Keeping this in view an attempt has been made with the objectives to evaluate the existing low chilling apple plantations grown on seedling rootstock and to determine the status and potential of their cultivation in the lower hills of Himachal Pradesh. Based on the evaluation study cultivar Anna has been observed to be perform better in terms of tree height (3.32 m) AK, tree girth (21.38 cm) in AK2, tree volume (1.60m^3) in AK1, yield (9.21kg/plant) in AK10, productivity (3.82t/ha) in AK10, whereas in terms of fruit length (69.80 mm), fruit weight (140.11 g) in AK8, fruit base cavity depth (1.89kg/cm^3) in AH6 the best fruit shape and surface colour. Dorestt Golden had highest fruit setting in terms of selfing (26.94%) and in open pollination (54.36%), similarly, Dorsett Golden fruit also had maximum width (68.49 mm) in DH3, highest TSS (11.99°B) in DK1, titrable acidity (0.50%) in DK4 and non-reducing sugar (3.94 %) in DK10. However, Dorsett Golden a pollinizer also improved the yield of Anna cultivar. The cultivation of these cultivars will defiantly boost the apple orcharding for the upliftment of the farming community of lower foothills as the fruits of these cultivars fetches better price in the market due to its early harvesting. However, there is a need to educate farmers in all the aspects of training, pruning and orchard management practices for remunerative returns and longer life span of plantations.

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