Performance of strawberry cultivars in low polytunnels and open field in Shivalik foothills of Himachal Pradesh

TANUJ BHARDWAJ* and VISHAL S RANA

Department of Fruit Science, College of Horticulture
Dr YS Parmar University of Horticulture and Forestry
Nauni, Solan 173230 Himachal Pradesh, India
*Email for correspondence: tanujbhardwaj05@gmail.com

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ABSTRACT

This study investigates the performance of diverse strawberry cultivars under both open field and low polytunnel conditions in the Shivalik foothills of Himachal Pradesh over two growing seasons (2022-2023 and 2023-2024). Research was conducted at the experimental farm of the Regional Horticultural Research and Training Station, Dhaulakuan, Sirmaur, Himachal Pradesh. Vegetative, floral and fruit characteristics were meticulously evaluated using standard descriptors and established methodologies, with data analysis performed using RBD (factorial) design and SPSS software. Significant variations in vegetative traits were observed among cultivars; for instance, leaf number per plant ranged from approximately 23 in Sweet Charlie to over 42 in Shimla Delicious and Jutogh Special, with cultivar genetic makeup being the primary influencing factor. Regarding floral characteristics, days to flower after planting were notably reduced under polytunnels (an average of 113.14 days) compared to open field (117.25 days) and flowering duration was also extended in polytunnels (87.05 days vs 83.56 days in open field). The earliest first flower opening was consistently observed around January 21 in cultivars like Chandler, regardless of growing conditions in both the years. For fruit characteristics, substantial differences were recorded across cultivars; fruit length, for example, ranged from approximately 26 cm in Shimla Delicious to over 69 cm in Sweet Sensation. Maximum fruit length (up to 71.18 cm) and breadth (up to 51.34 mm) was recorded for Sweet Sensation under polytunnel conditions, although direct growing condition effects on these dimensions were not always significant. Fruit firmness was also categorized with Chandler being rated very firm while Jutogh Special, Selva and Shimla Delicious were very soft. This research provides quantitative insights into cultivar suitability and highlights the benefits of polytunnel cultivation for enhancing strawberry productivity and specific fruit qualities in the region.

Keywords: Strawberry cultivation; polytunnel; open field; cultivar performance; fruit characteristics; vegetative characteristics; floral characteristics; Himachal Pradesh

INTRODUCTION

Strawberry (*Fragaria* × *ananassa* Duch), a fascinating and popular fruit from the Rosaceae family, is thought to have originated from a cross between two wild species, *Fragaria virginiana* and *F chiloensis*. This herbaceous perennial is successfully cultivated across diverse climates, including tropical and temperate regions. Its widespread cultivation is attributed to its significant genetic diversity, high heterozygosity and remarkable adaptability to various environments. Strawberry plants are characterized by basal leaves and fibrous roots growing from a central crown. Their distinctive leaves are complex, featuring three saw-toothed and hairy leaflets. Flowers, typically white but occasionally red, are borne in small clusters on slender stalks emerging from leaf axils. Vegetative propagation occurs as the plant matures, with woody root systems and 'mother' crowns sending out runners that root upon contact with the soil. Botanically, the strawberry fruit is considered an 'accessory fruit' rather than a true berry. Currently, strawberries are grown in a wide array of environments, from high-altitude tropical regions and sub-tropical plains to desert-like areas. Given their shallow root systems, dry periods can severely impact both crop survival and yield. In

India, large-scale strawberry production has recently been boosted by the establishment of numerous agro-based companies. This versatile crop is also easily grown in home gardens, including pots and rooftops. Globally, strawberries are a significant food source and are highly sought after by the food processing industry for products like toffee, ice cream, candy and jams. Several promising high-yielding cultivars, such as Selva, Addie, Sweet Charlie, Camarosa and Winter Dawn, have been successfully introduced to India from North America and Europe.

When ripe and fresh, the strawberry fruit is a rich source of vitamins and minerals. Its high levels of vitamin C, folate and phenolic compounds establish it as a valuable source of bioactive compounds (Proteggente et al 2002). This fruit is also packed with phytochemicals and antioxidants, which may contribute to blood sugar regulation and heart health. From an economic and commercial perspective, strawberries are highly significant due to their widespread consumption, both fresh and processed into products like jams, juices and jellies. Nutritionally, genetically, and agronomically, this fruit crop is considered among the most studied berries.

Growing strawberries under covered structures, such as polytunnels, can notably reduce winter injury and plant mortality, while significantly boosting productivity. This is particularly beneficial in ecological environments like the lower Shivalik hills, where winter temperatures fluctuate with warmer days and colder nights. The use of low clear plastic tunnels over strawberry beds is known to promote early cropping, prevent bed erosion and increase overall yields.

Albregts and Chandler (1993) reported on this potential across various agro-climatic conditions. Furthermore, mulching is considered an essential component of the strawberry production system. Across the nation, strawberries are cultivated using diverse synthetic and organic mulches, with choices influenced by local climate and material availability.

MATERIAL and METHODS

The present investigations were carried out at the experimental farm of Regional Horticultural Research and Training Station, Dr YS Parmar University of Horticulture and Forestry, Dhaulakuan, Sirmaur, Himachal Pradesh, during the years 2022-2023 and 2023-2024. The research trial was laid out using RBD (factorial) design and SPSS software was used to analyze the data.

Vegetative characteristics: The growth habit, plant spread, foliage density etc were recorded as per standard strawberry descriptors using DUS test guidelines.

The plant vigour, categorized into strong, medium and weak, was observed visually. Average of five plants was considered as one replication and three such replications were visualized. Data on number of leaves were recorded from fifteen plants from each replication at the end of harvest and the average value was expressed as leaf number per plant. The shape of base of terminal leaflet was examined visually to check the variation in different cultivars and categorized as acute, obtuse and rounded.

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

Floral characteristics: Days to flower after planting is the period between the dates of planting to the date of first flower opening in each cultivar and was recorded for calculating the days taken to flowering as per the procedure presented by Kindmox et al (1996). The date on which the first flower in a cultivar opened was recorded and indicated as the date of opening of first flower. The date of opening of first flower in each cultivar was recorded to estimate the duration of flowering period.

Fruit characteristics: The length of fifteen fruits per cultivar was measured with vernier calliper from calyx plug to the pointed end or apex of the fruit. The diameter of fifteen fruits per cultivar was measured from the shoulders of the berries with the help of vernier calliper. The colour of fruit was recorded with the help of colour chart of the Royal Horticultural Society, London. The firmness of ten randomly selected berries was measured with the help of a penetrometer (Push-Pull Dynamometer, model: DT101, Kg, 1 × 10 gr/Lb 2 × 0.02 Lb), with the plunger of diameter 0.0380 inches/ 0.96 mm and the average was expressed in kg per cm^2. The fruit firmness was categorized as: 0-0.25 kg per cm^2: very soft, 0.25-0.5 kg per cm^2: soft, 0.5-0.75 kg per cm^2: medium, 0.75-1 kg per cm^2: firm and 1-1.25 Kkg per cm^2: very firm.

RESULTS and DISCUSSION

The scope of improvement of any crop depends upon the magnitude of genetic variability present in the available germplasm. Greater the variability in the available germplasm, better would be the chances of selecting superior genotypes (Simmonds 1962).

Vegetative characteristics

Growth habit, foliage density and plant vigour: Table 1 depicts that six cultivars namely Addie, Doughlas, Fern, Shimla Delicious, Sweet Ann and Sweet Charlie exhibited spreading; five cultivars viz Chandler, Elyana, Florida Beauty, Jutogh Special and Selva exhibited semi-upright and four cultivars namely Camarosa, Etna, Sweet Sensation and Winter Dawn exhibited upright growth habit. The differences in the growth habits of different cultivars may be attributed to genetic makeup of the cultivars. The cultivars Camarosa, Elyana, Sweet Ann and Sweet Sensation registered strong; Addie, Chandler, Douglas, Etna, Fern, Florida Beauty, Selva, Shimla Delicious and Winter Dawn registered medium and Jutogh Special and Sweet Charlie registered weak vigour. Camarosa, Elyana, Jutogh Special, Shimla Delicious, Sweet Ann and Sweet Sensation recorded dense; Addie, Douglas, Florida Beauty, Selva and Winter Dawn recorded medium and Chandler, Etna, Fern and Sweet Charlie exhibited sparse foliage density. The changes in physiology of strawberry cultivars to express growth characteristics have been interpreted due to genetic diversity and variation in environmental responses among cultivars (Larson 1994).

Number of leaves: Performance of different strawberry cultivars for number of leaves per plant are presented in Table 2. Maximum number of leaves was recorded in Shimla Delicious (42.97) and Jutogh Special (42.95), which were statistically at par as against minimum in Chandler (20.97). There was no effect of growing conditions on number of leaves. In the interaction cultivar × growing condition, Shimla Delicious (44.80) in open field and Jutogh Special (43.95) in polytunnel recorded maximum number of leaves, which were at par and minimum was recorded in Chandler (20.00), Fern (21.00) and Sweet Charlie (21.50) in polytunnel, the three being at par and Chandler in open field (21.95).

The variation in number of leaves could be affected by differences in favourable temperature, light and photoperiods of the Shivalik foothills of Himachal Pradesh. However, Shimla Delicious possibly responded better with respect to soil nutritional status, available metabolites and their allocation to the above ground plant parts as compared to other cultivars (Smeets 1955, Rao and Lal 2010). It was also observed that this cultivar responded better in terms of vegetative characteristics. This variation has been explained by Neetu and Sharma (2018) who observed maximum number of leaves in the cultivar Nabila.

Shape of base terminal and leaf colour: Data given in Table 3 show that the shape of base of terminal

Table 1. Growth habit, plant vigour and foliage density of strawberry cultivars

Cultivar	Growth habit	Plant vigour	Foliage density
Addie	Spreading	Medium	Medium
Camarosa	Upright	Strong	Dense
Chandler	Semi- upright	Medium	Sparse
Doughlas	Spreading	Medium	Medium
Elyana	Semi- upright	Strong	Dense
Etna	Upright	Medium	Sparse
Fern	Spreading	Medium	Sparse
Florida Beauty	Semi- upright	Medium	Medium
Jutogh Special	Semi- upright	Weak	Dense
Selva	Semi- upright	Medium	Medium
Shimla Delicious	Spreading	Medium	Dense
Sweet Ann	Spreading	Strong	Dense
Sweet Charlie	Spreading	Weak	Sparse
Sweet Sensation	Upright	Strong	Dense
Winter Dawn	Upright	Medium	Medium

Table 2. Effect of growing conditions on the leaf number of strawberry cultivars

Cultivar	Number of leaves/plant		
	Open field	Polytunnel	Mean
Addie	26.30	25.80	26.05
Camarosa	36.30	40.15	38.22
Chandler	21.95	20.00	20.97
Doughlas	23.15	23.65	23.40
Elyana	29.10	33.30	31.20
Etna	31.30	36.15	33.72
Fern	24.45	21.00	22.72
Florida Beauty	32.30	35.60	33.95
Jutogh Special	41.95	43.95	42.95
Selva	34.45	34.30	34.37
Shimla Delicious	44.80	41.15	42.97
Sweet Ann	26.45	23.45	24.95
Sweet Charlie	24.80	21.50	23.15
Sweet Sensation	24.80	25.45	25.12
Winter Dawn	36.00	34.10	35.05
Mean	30.54	30.65	

$CD_{0.05}$

Cultivar	0.54
Growing condition	NS
Cultivar × Growing condition	2.12

Table 3. Shape of base terminal and leaf colour of strawberry cultivars

Cultivar	Shape	Leaf Colour
Addie	Acute	Yellow-green group 147 A
Camarosa	Acute	Yellow-green group 137 A
Chandler	Rounded	Yellow-green group 147 A
Doughlas	Acute	Yellow-green group 147 A
Elyana	Obtuse	Yellow-green group 147 A
Etna	Acute	Yellow-green group 147 A
Fern	Obtuse	Green group 139 A
Florida Beauty	Acute	Yellow-green group 146 A
Jutogh Special	Obtuse	Green group 137 A
Selva	Obtuse	Green group 137 A
Shimla Delicious	Rounded	Green group 137 A
Sweet Ann	Obtuse	Yellow-green group 146 A
Sweet Charlie	Rounded	Yellow-green group 147 A
Sweet Sensation	Obtuse	Yellow-green group 147 A
Winter Dawn	Rounded	Yellow-green group 147 A

leaflet was acute, obtuse and rounded. Obtuse leaflet base was recorded in Elyana, Fern, Jutogh Special, Selva, Sweet Ann and Sweet Sensation; acute in Addie, Camarosa, Doughlas, Etna and Florida Beauty and rounded in Chandler, Shimla Delicious, Sweet Charlie and Winter Dawn. The variation in shape of the base of terminal leaflet of cultivars may be due to their inherent characteristics and prevailing environmental conditions.

Leaf colour was recorded as Yellow-Green Group 147 A in eight cultivars namely Addie, Chandler,

Douglas, Elyana, Etna, Sweet Charlie, Sweet Sensation and Winter Dawn; Yellow-Green Group 146 A in Florida Beauty and Sweet Ann; Yellow-Green Group 137 A in Camarosa; Green Group 137 A in Jutogh Special, Selva and Shimla Delicious and Green Group 139 A in Fern. The variation in leaf colour of different cultivars may be attributed to their genetic makeup coupled with environmental conditions. It was observed that cultivars like Shimla Delicious, Selva and Jutogh Special which are cultivated in colder areas exhibited similar leaf colour.

Floral characteristics

Number of days to flower after planting: A perusal of data presented in Table 4 indicate that among cultivars, minimum number of days to flower after planting was taken by Winter Dawn (96.58) and maximum by Selva (129.23) and Shimla Delicious (128.43), the latter two being at par. Lower number of days to flower after planting was taken in polytunnel (113.14) as compared to 117.25 in open field. In case of interaction, Winter Dawn (94.15) and Florida Beauty (96.60) took minimum number of days in polytunnel, and were at par. However, Selva (130.00) and Shimla Delicious (129.50) in open field and Selva (128.45) in polytunnel took maximum number of days to flower, which were at par.

The number of days to flower after planting among strawberry cultivars is mainly influenced by the genetic factors, as each cultivar has its own inherent growth cycle and response to environment. Some are early flowering, while others are late. Environmental conditions such as temperature, light duration (photoperiod) and soil fertility play vital role in flowering process of strawberry. Additionally, plant vigour, transplanting shock and overall health can also affect plant transition from vegetative growth to reproductive stage. Hormonal balance and stress conditions can delay flowering as reported by several researchers like Gupta and Tripathi (2012), Das et al (2015) and Ahmad et al (2018) who reported that flowering in strawberry cultivars depends on day length and temperature.

Table 4. Effect of growing conditions on the days to flower after planting and duration of flowering of strawberry cultivars

Cultivar	Days to flower after planting			Flowering duration (days)		
	Open field	Polytunnel	Mean	Open field	Polytunnel	Mean
Addie	121.65	117.80	119.73	43.15	50.65	46.90
Camarosa	106.80	103.65	105.23	77.50	75.50	76.50
Chandler	106.95	100.45	103.70	59.00	65.00	62.00
Doughlas	127.15	126.80	126.98	99.65	108.00	103.83
Elyana	113.50	109.15	111.33	66.00	68.15	67.08
Etna	122.80	120.65	121.73	56.15	53.15	54.65
Fern	125.35	123.80	124.58	129.00	134.00	131.50
Florida Beauty	105.50	96.60	101.05	73.15	73.95	73.55
Jutogh Special	126.15	123.85	125.00	108.00	119.35	113.68
Selva	130.00	128.45	129.23	138.45	141.15	139.80
Shimla Delicious	129.50	127.35	128.43	128.60	129.35	128.98
Sweet Ann	116.80	107.17	111.99	52.80	52.20	52.50
Sweet Charlie	119.20	115.00	117.10	81.65	85.50	83.58
Sweet Sensation	108.50	102.30	105.40	42.15	45.45	43.80
Winter Dawn	99.00	94.15	96.58	73.65	82.30	77.98
Mean	117.25	113.14		83.56	87.05	

$CD_{0.05}$

	Days to flower after planting	Flowering duration
Cultivar	0.94	0.92
Growing condition	2.58	2.54
Cultivar × Growing condition	2.58	3.59

Duration of flowering: The data on duration of flowering in different cultivars as influenced by growing conditions are presented in Table 4. Flowering duration was maximum in Selva (139.80 days) and minimum in Sweet Sensation (43.80 days). It was more in polytunnel (87.05 days) and lower in open field (83.56 days). In the interaction effect, maximum duration was observed in Selva in polytunnel (141.15 days) and open field (138.45 days), the two treatments being at par and minimum in Sweet Sensation (42.15 days) and Addie (43.15 days) in open field and Sweet Sensation (45.45 days) in polytunnel, which were at par.

The length of time strawberries flower, can vary among different cultivars and this is typically due to a mix of genetic and environmental factors. From a genetic standpoint, some cultivars are simply bred to have a longer flowering period, which gives a more extended harvest season. Others are designed for a shorter, more concentrated bloom, leading to a more synchronized fruit production. Environmental conditions also play a big role. Factors like light, temperature and nutrient availability can all influence how long a strawberry plant flowers (Sharma et al 2002). Ideal growing conditions will support a longer flowering period, while stresses from things like excessive heat or drought can shorten it. Ultimately, the duration of flowering in strawberries is a result of the intricate interaction between a cultivar's genetic potential and the conditions it's grown in (Joolka and Badiyala 1983).

Opening of first flower: The data concerning the opening of the first flower during 2022 and 2023 are presented in Fig 1. In 2022, under open field conditions, the opening of the first flower was observed between January 21 and February 5. Among the cultivars, Selva and Sweet Ann both exhibited the earliest opening of the first flower on January 21. The latest opening, on February 5, was noted in Shimla Delicious. Under polytunnel, the opening of the first flower occurred from January 21 to February 9. Chandler recorded the earliest opening (January 21), while the latest (February 9) was observed in Shimla Delicious. In 2023, under open field conditions, the opening of the first flower was recorded between January 21 and February 10. Chandler was the earliest to flower (January 21) and Shimla Delicious was the last to show the opening of its first flower (February 10).

Under polytunnel conditions, the opening of the first flower ranged from January 24 to February 13. Chandler was observed to flower earliest (January 24), and Shimla Delicious recorded the latest opening (February 13). Variations in these characteristics may be attributed to the amount of heat received during the growth period (Joolka and Badiyala 1983) and the prevailing climatic conditions, particularly day length during growth (Kindmox et al 1996).

Fruit characteristics

Fruit length: Analyzing the data in Table 5, it was observed that Sweet Sensation produced the longest fruits overall, measuring 69.77 cm. In contrast, Fern (25.01 cm) and Douglas (25.47 cm) had the shortest fruits, with their lengths being statistically similar. Interestingly, the different growing conditions (polytunnel versus open field) didn't show a significant impact on fruit length. When looking at the interaction between cultivar and growing conditions, Sweet Sensation grown in a polytunnel yielded the longest fruits at 71.18 cm at par with Sweet Ann in a polytunnel (68.81 cm) and Sweet Sensation in the open field (68.36 cm). The shortest fruits were observed in Shimla Delicious grown in the open field (24.03 cm), Douglas in polytunnel (24.30 cm), Fern in the open field (24.33 cm), Fern in a polytunnel (25.70 cm) and Jutogh Special (26.36 cm) and Douglas (26.64 cm) in the open field, all of which were statistically similar in length. The increased fruit length may be due to environmental factors such as increased day length and sun light which might have enhanced the cell expansion and development of the fruit (Janick and Eggert 1968, Moore et al 1970). Significant variation among different strawberry cultivars may be due to the difference in genotypic effect as observed by Dhaliwal and Singh (1983).

Fruit breadth: A perusal of data presented in Table 5 indicate that maximum (49.94 mm) fruit breadth was recorded in Sweet Sensation followed by Elyana (47.23 mm) and Camarosa (47.04 mm) and minimum (19.82 mm) in Jutogh Special. There was no affect of growing conditions on fruit breadth. Under interaction effect, Sweet Sensation in polytunnel (51.34 mm) and open field (48.53 mm) and Camarosa in polytunnel (48.32 mm) showed maximum fruit breadth and Jutogh Special in open field (19.09 mm) and polytunnel (20.56 mm), Addie (21.15 mm) and Doughlas (22.26) in open field, the minimum and were at par.

Agro-climatic conditions in the experimental area might have directly influenced the fruit

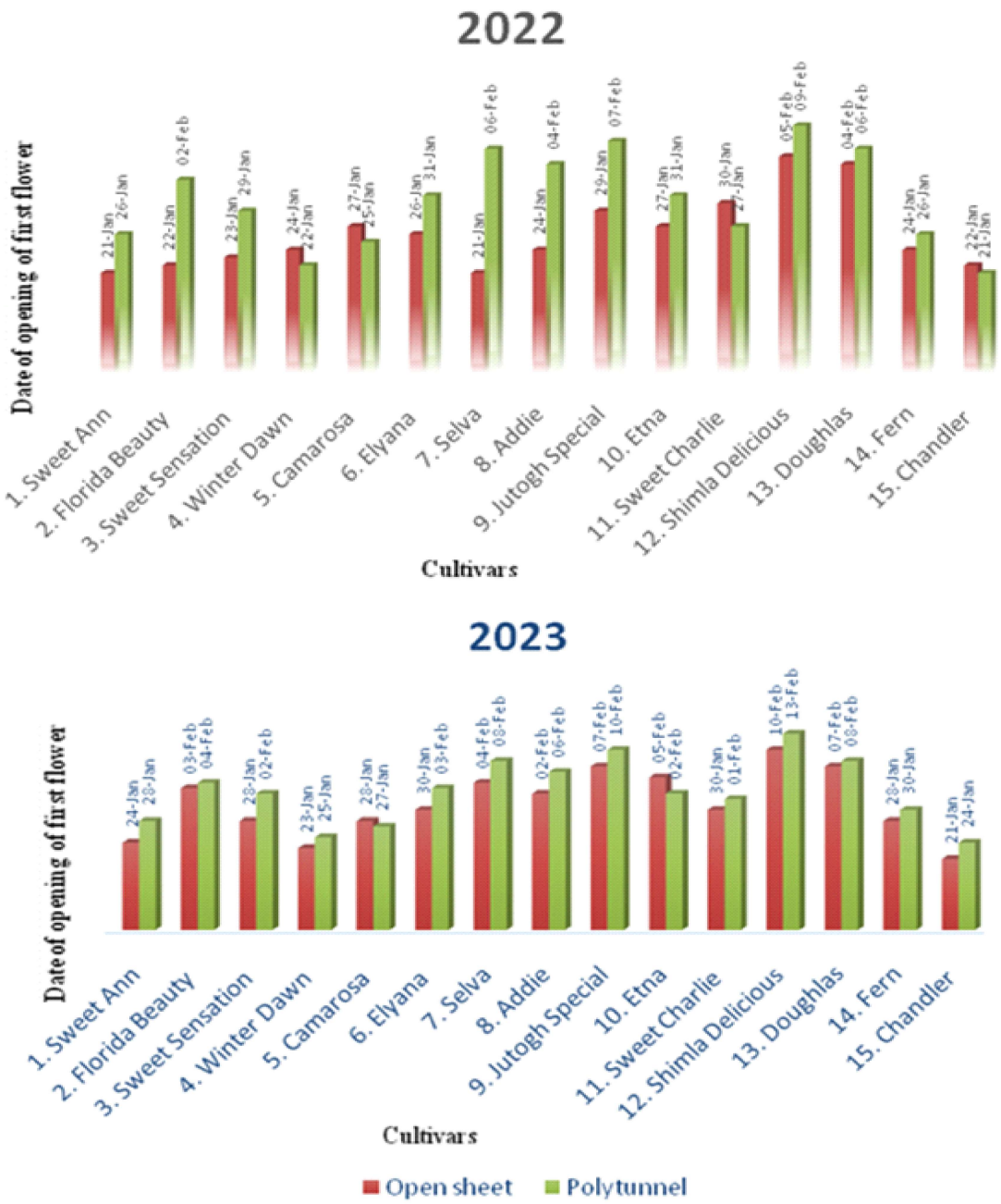

Fig 1. Effect of growing conditions on opening of first flower in strawberry cultivars

development and size of the different cultivars. Variation of fruit diameter has been reported by Flanagan et al (2020) in costal Virginia. They reported that with the increase in day length and sunlight exposure, fruit breadth increased. With the initiation of the secondary fruit and exposure to high temperature during second half of April to May, there was decrease in fruit size.

Fruit firmness: The strawberry cultivars were categorized as very soft, soft, medium, firm and very firm for fruit firmness (Table 6). Very soft firmness was recorded in Jutogh Special, Selva and Shimla Delicious; soft in Addie, Douglas, Florida Beauty and Winter Dawn; medium in Elyana, Etna, Fern, Sweet Ann and Sweet Charlie; firm in Camarosa and Sweet Sensation and very firm in Chandler.

The variation in fruit firmness of different strawberry cultivars may be a genetic factor and differences may also be attributed to the prevailing growing conditions, especially high temperature (Polat

Table 5. Effect of growing conditions on the fruit length and breadth of strawberry cultivars

Cultivar	Fruit length (mm)			Fruit breadth (mm)		
	Open field	Polytunnel	Mean	Open field	Polytunnel	Mean
Addie	36.07	39.32	37.69	21.15	23.23	22.19
Camarosa	48.27	50.57	49.42	45.76	48.32	47.04
Chandler	44.73	41.39	43.06	34.19	36.56	35.38
Doughlas	26.64	24.30	25.47	22.26	23.93	23.09
Elyana	46.41	47.46	46.93	46.71	47.75	47.23
Etna	30.38	32.03	31.21	24.10	25.91	25.01
Fern	24.33	25.70	25.01	23.91	25.97	24.94
Florida Beauty	50.99	52.77	51.88	36.63	39.62	38.12
Jutogh Special	26.36	31.04	28.70	19.09	20.56	19.82
Selva	33.50	35.67	34.58	24.92	26.40	25.66
Shimla Delicious	24.03	28.75	26.39	26.44	28.07	27.25
Sweet Ann	64.99	68.81	66.90	44.31	47.67	45.99
Sweet Charlie	39.96	39.81	39.88	32.21	32.80	32.50
Sweet Sensation	68.36	71.18	69.77	48.53	51.34	49.94
Winter Dawn	56.81	58.89	57.85	41.95	44.64	43.30
Mean	41.45	43.17		32.80	34.84	

$CD_{0.05}$

Cultivar	1.19	0.85
Growing condition	NS	NS
Cultivar × Growing condition	4.62	3.30

Table 6. Fruit firmness of strawberry cultivars

Fruit Firmness	Cultivar
Very Soft	Jutogh Special, Selva, Shimla Delicious
Soft	Addie, Doughlas, Florida Beauty, Winter Dawn
Medium	Elyana, Etna, Sweet Ann, Sweet Charlie, Fern
Firm	Camarosa, Sweet Sensation
Very Firm	Chandler

et al 2017). The firmness of fruits is related to fruit quality at harvest and subsequent quality during storage (Pradas et al 2015).

CONCLUSION

These investigations into strawberry cultivation in the Shivalik foothills of Himachal Pradesh provided valuable insights into the performance of various cultivars under both open field and polytunnel conditions. It was observed that the choice of cultivar significantly influenced vegetative characteristics like growth habit, plant vigour, foliage density and leaf number, with Shimla Delicious and Jutogh Special generally exhibiting robust vegetative growth. Polytunnel cultivation generally promoted earlier and longer flowering periods compared to open field. Specifically, Winter Dawn showed the quickest transition to flowering, while Selva exhibited the longest flowering duration. Significant differences in fruit length and breadth were recorded among cultivars. Sweet Sensation consistently produced the longest and broadest fruits, especially under polytunnel conditions. While growing conditions did not universally affect fruit length and breadth, specific interactions between cultivars and their environment were noted, indicating that factors like light exposure and day length contributed to fruit development. Fruit firmness, a crucial quality attribute, also varied considerably among cultivars, ranging from very soft to very firm.

Overall, the study underscores the importance of selecting appropriate cultivars tailored to specific growing conditions in the Shivalik foothills. The use of polytunnels was shown to positively influence several key performance indicators, including earlier flowering and potentially larger fruit size, contributing to enhanced productivity in this region. This research provides foundational data for optimizing strawberry cultivation practices and cultivar selection for improved yield and quality in similar agro-climatic zones.

REFERENCES

Ahmad M, Banday FA, Bhat MY, Sharma MK, Dar MA, Khalil A and Nazir N 2018. Performance of exotic strawberry varieties under temperate conditions of northwestern Himalayas. Indian Journal of Horticulture **75(4):** 698-702.

Albregts EE and Chandler CK 1993. Effect of polyethylene mulch colour on the fruiting response of strawberry. Proceedings of the Soil and Crop Science Society of Florida **52:** 40-43.

Das AK, Singh KP, Prasad B and Kumar R 2015. Evaluation of cultivars of strawberry, a temperate fruit for its adaptability as well as productivity in sub-tropical agro-climatic condition of Supaul district in Bihar. Asian Journal of Horticulture **10(2):** 278-281.

Dhaliwal GS and Singh K 1983. Evaluation of strawberry cultivars under Ludhiana conditions. Haryana Journal of Horticultural Sciences **12:** 36-40.

Flanagan RD, Samtani JB, Manchester MA, Romelczyk S, Johnson CS, Lawrence W and Pattison J 2020. On-farm evaluation of strawberry cultivars in coastal Virginia. HortTechnology **30(6):** 789-796.

Gupta AK and Tripathi VK 2012. Efficacy of *Azotobacter* and vermicompost alone and in combination on vegetative growth, flowering and yield of strawberry (*Fragaria* × *ananassa* Duch) cv Chandler. Progressive Horticulture **44(2):** 256-261.

Janick J and Eggert DA 1968. Factors affecting fruit size in the strawberry. Proceedings of the American Society of Horticultural Sciences **93:** 311-316.

Joolka NK and Badiyala SD 1983. Studies on the comparative performance of strawberry cultivars. Haryana Journal of Horticultural Sciences **12(3-4):** 173-177.

Kindmox U, Anderson H and Petersen O 1996. Yield and quality attributes of strawberry cultivar grown in Denmark. Fruit Variety Journal **3:** 160-167.

Larson KD 1994. Strawberry. In: Handbook of environmental physiology of fruit crops. Vol 1. Temperate crops (B Schaffer and PC Anderson, Eds), CRC Press, Boca Raton, Florida, pp 271-297.

Moore JN, Brown GR and Brown ED 1970. Comparison of factors influencing fruit size in large-fruited and small-fruited clones of strawberry. Journal of the American Society of Horticultural Science **95:** 827-831.

Neetu and Sharma SP 2018. Evaluation of strawberry cultivars for growth and yield characteristics in plain region of Chhattisgarh, India. International Journal of Current Microbiology and Applied Sciences **7(2):** 2835-2840.

Polat M, Kankaya A and Askin M 2017. Determination of some chemical properties of Sweet Ann and Kabarla strawberry cultivars in highland climate. Scientific Papers, Series B: Horticulture **61:** 51-53.

Pradas I, Medina JJ, Ortiz V and Moreno-Rojas JM 2015. Fuentepina and Amiga, two new strawberry cultivars: evaluation of genotype, ripening and seasonal effects on quality characteristics and health-promoting compounds. Journal of Berry Research **5(3):** 157-171.

Proteggente AR, Pannala AS, Paganga G, van Buren L, Wagner E, Wiseman S, van de Put F, Dacombe C and Rice-Evans CA 2002. The antioxidant activity of regularly consumed fruit and vegetables reflects their phenolic and vitamin C composition. Free Radical Research **36:** 217-233.

Rao VK and Lal B 2010. Evaluation of promising strawberry genotypes under Garhwal Himalayan conditions. Indian Journal of Horticulture **67(4):** 470-474.

Sharma RM, Khajuria AK and Kher R 2002. Evaluation of some strawberry (*Fragaria* × *ananassa* Duch) cultivars in Jammu plains. Indian Journal of Plant Genetic Resources **15(1):** 64-66.

Simmonds NW 1962. Variability in crop plants, its use and conservation. Botanical Review **37(3):** 422-465.

Smeets L 1955. Runner formation in strawberry plants in autumn and winter. Euphytica **4(3):** 240-244.