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## A review on characterisation and evaluation of strawberry germplasm for growth, yield, and quality traits under controlled environmental and open field conditions

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### Abstract

The Strawberry has wide diversity and it performs variously in different agro climatic conditions. Hence, evaluation and characterisation of different cultivars needs to be done. What is the effect on growth, yield and fruit quality if it is cultivated in different areas under polytunnels and open environment. Many Researchers have done a great work in evaluating the cultivars that are more suitable to their region which gives the best yield, best fruit quality and best plant growth. This review contains the work of the scientists who have cultivated different strawberry cultivars in different climatic regions under different environmental conditions and found the best results.

**Keywords:** Growth, strawberry, yield, germplasm, quality, flowering, polytunnel

### Introduction

Strawberry (*Fragaria x ananassa* Duch.) belongs to Rosaceae family having octaploid chromosome number 56 ( $2n=8x$ ). It is a cross of two American species *F. chiloensis* and *F. virginiana*. Strawberry is a fruit of temperate climate but its cultivation can be done successfully in subtropical climate also. The cultivated strawberry (*Fragaria x ananassa* Duch.) originated in France in 17th century. It is now grown in all over India. Its progenies are native to the new world. Strawberry is grown widely throughout the Europe, Canada, South America and many other countries. The major producing countries are USA, Spain, Japan, Mexico, Italy, Russia, and Turkey. In India, mainly cultivated in Maharashtra, Himachal Pradesh, J&K and Uttarakhand.

Genotypic diversity and easy environmental adaptations make strawberry most widely distributed fruit crops in the world. Strawberry is a rich source of vitamins and minerals likely vitamin C and has 60 mg ascorbic acid per 100 g of pulp.

The Strawberry is an aggregate fruit. The seeds of strawberry are known as achenes. The number of tiny specks are present on its surface known as achenes. Thalamus is the edible portion of fruit (95% part of fruit is edible). Strawberry is perennial, and has stoloniferous herbs which spread by stolons and runners. Strawberry fruit has 3 leaflets which arise from the crown of the plant. These are blunt, thick. The flowers are white in colour arranged in small clusters. Fruit is small in size and colour is from light to deep red. Flesh of fruit is soft with pleasant aroma. Hermaphrodite as well as unisexual plants are produced in strawberry.

Strawberry covers 9.2 lakh hectare area (73 countries) in the world and annual production of strawberry is estimated to be 45.9 lakh. Total area under strawberry cultivation in India is 1 lakh hectare. There annual production is nearly about 5000 million tonnes (NHB 2017). India is exporting strawberry fruit to different countries like Austria, Bangladesh, Germany, Jordan.

The various cultivars of strawberry perform differently under different agro climatic conditions because of its wide diversity. Therefore, its cultivars are characterised and evaluated on various Quantitative and Qualitative parameters. Various Research Projects are conducted at different agro climatic zones to evaluate the varietal variation in strawberry for morphological, yield and quality traits, genetic variability, genetic advance, genetic divergence in straw, determine the heritability and correlation for various traits of strawberry and to identify suitable Germplasm for natural environment and controlled environmental conditions.

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### Biochemical parameters

Bhojaraj Belakud, Vijay Bahadur and VM Prasad (2015) [1] conducted a research on 15 strawberry cultivars. Using RBD, they concluded that Chandler variety showed higher yield of bigger sized fruits. Maximum juice content (89.98%) was found in Belruby and maximum acidity (0.19%) was found in Phenomenal and Selva cultivars. Sweet Charlie found to be having very less acidity (0.09%). Maximum Ascorbic acid (50.00%) was present in Phenomenal. Highest pH of juice (5.92) was seen in Sweet Charlie.

SP Sharma and Gowardhan Verma (2020) [8] evaluated that Nabila variety of Strawberry produce higher yield in Chhattisgarh plains followed by Camerosa and Kanla. Maximum TSS, Total sugars and Reducing sugars were found in Nabila. Highest Ascorbic acid and acidity were found to be present in Camerosa.

T. Vandendriessche *et al.* (2011) [3] experimented on 9 strawberry cultivars for flavour evaluation. They used 1 penten-3-ol as marker for unripe strawberries and methyl butanoate and methyl hexanoate for ripe strawberries. They observed that ripe strawberries had high sugar content and were less acidic and less firm.

In Himachal Pradesh, an experiment was conducted to evaluate yield and quality traits by Girish Sharma and MS Thakur (2008) [4]. They found that Chandler variety showed maximum fruit length, breadth and weight and maximum yield (1.18 g/plot) also. Catskill contained highest acidity and highest sugar/acidity ratio was seen in Selva. However, Chandler and Selva performed best.

J. Diamanti *et al.* (2012) [5] did screening analysis on strawberry for nutritional parameters. They observed genetic variability of bioactive compounds in old genotypes and found that old strawberry genotypes are rich source of nutritional traits.

Katrina Kelly *et al.* (2016) [6] compared the physicochemical characteristics and Post-harvest performance of the new sensation "Florida127" of strawberry with other commercial standard strawberry cultivars. They concluded that the new variety Florida 127 has high sugar content and has longer shelf life.

Sonia Kumari *et al.* (2020) [7] grew 15 strawberry cultivars in Himachal Pradesh mid hills to check the Quality and Yield characters of these varieties. They found that 'Sweet Charlie' was early to flower and had maximum total sugars (8.02%) and 'Chandler' showed longer duration of flowering. 'Selva' showed highest TSS while 'Etna' showed highest titrable acidity (0.94%).

Neetu *et al.* (2019) worked on 6 varieties of strawberry namely, Nabila, Rania, Kamila, Camerosa, Flavia, Flaminia to check the varietal screening of these under open field conditions. They observed that Nabila produced highest yield and then Camerosa and Kamila. Highest TSS and Total sugars was observed in Nabila, Rania and Flavia and Camerosa followed by Flavia showed maximum ascorbic acid and acidity.

### Growth and Development

Ankita Sahu and JS Chandel (2014) conducted research on 13 Strawberry Genotypes under mid hills of North Western Himalayas. They concluded that Chandler produce highest yield. Maximum TSS was found in Sweet Charlie and Maximum anthocyanin content in Sequoia. Maximum plant height and leaf area was found in Camerosa and Festival cultivars.

Experiment on 3 Cultivars was conducted in Bangladesh by, MK Ahsan, H. Mehraj, M. Hussain, MM Rahman and AFM

Jamal Uddin (2014) [10]. They concluded that Festival cultivar produced highest yield, tallest plants, and maximum fruit weight. The minimum yield was produced by Rabi-03.

Ratan Kumar, Sailabala Dei, HP Sharma, RK Sohane (2018) [11] conducted experiment on 4 strawberry cultivars in Rohtas district of Bihar. The cultivars cultivated were Festival, Sweet Charlie, Kamila and Local Sweety. They concluded that Festival produced maximum yield, maximum fruit weight and maximum plant height. They found that higher yield, best quality and optimal plant growth can be obtained in suitable microclimate. Rajbir Singh *et al.* (2008) conducted an experiment to observe the effect of vermicompost on growth and yield of strawberry cv. Chandler. They applied 4 different concentrations of vermicompost (2.5, 5.0, 7.5, and 10.0 t ha<sup>-1</sup>) on the plants. They observed increase in plant spread, leaf area. There were no physiological disorders and diseases seen in plants. They concluded that 7.5 t ha<sup>-1</sup> showed best results.

Kang *et al.* (2020) [13] found in an experiment conducted by them, strawberry grown by cutting propagation is better than pinning propagation method. It gives better results, better growth and yield. They also concluded that hydroponics gives better yield of strawberry as compared to soil cultivation. E.G. Adlercreutz *et al.* (2020) [14] conducted an experiment in the Atlantic coast production area of Buenos Aires, Argentina to evaluate the biennial production of strawberry and what effect is seen on the growth parameters. They observed that two-year-old plants showed better growth patterns and better yield as compared to one-year old plant. Crown and leaf area of two-year-old plants was 2 times and 3 times higher, respectively. Claudineia *et al.* (2013) conducted research on the genetic diversity of strawberry hybrids supported ISSR markers and determined the genetic variability in 84 strawberry hybrids produced from crosses like 'Camino Real' x 'Sweet Charlie', 'Dover' x 'Oso Grande' etc. Md. Shamiul Haque *et al.* (2015) [16] worked on 18 tissue culture variants of strawberry and found out significant variation among them. They evaluated that crown spread, petiole length, pollen sterility had positive effect on the yield obtained per plant.

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### Effect of Growth Regulators

Study on the impact of plant growth regulators on the growth, yield and quality attributes of strawberry variant sweet Charlie by Rakesh Kumar, S Saravanan, Parshant Bakshi, JN Srivastava (2011) [17]. Foliar application of Gibberellic acid (25, 50 and 75 ppm), triacontanol (1.25, 2.5 and 5 ppm) and cycocel (300, 600 and 900 ppm) on strawberry cv. Sweet Charlie. They concluded that 75 ppm gibberellic acid spray showed better vegetative growth and 900 ppm cycocel spray found to be best for obtaining best fruit quality. Kruger *et al.* (2012) [18] did an experiment to note the effect on growth, yield, quality and length of strawberry when cultivated at 5 different locations in Europe. On north (Stjordal, Norway, 63°03'N) and south (Ancona, Italy, 43°03'N). They evaluated that the acidity, soluble solids and dry matter was highest on northern sites as compared to southern site.

Galleta (1984) [19] conducted an experiment on 10 strawberry varieties and 15 selections. They evaluated Allstar, Earliglow and Raritan with yields 28000, 25000 and 31900 lb/acre respectively. Sandeep Singh *et al.* (2020) conducted a research on strawberry cv. Chandler to see the effect of Pusa Hydrogel and Plant growth regulators on its Growth, Flowering and Fruiting. They used Pusa hydrogel (25g and 50g), Cycocel (500 ppm and 1000 ppm) and Triacontanol (100 ppm and 150 ppm) application on strawberry cv. Chandler. As a result, they found that Treatment (Triacontanol (150 ppm) + Cycocel

(500 ppm) + Pusa hydrogel (50g) induced better flowering and fruiting and Treatment (Triacantanol (150 ppm) + Pusa hydrogel (50 g) gave maximum growth.

### Controlled Environmental conditions Yield

Krzysztof Klamkowski and Waldemar Treder (2008) <sup>[21]</sup>, cultivated 3 cultivars namely, Elsanta, Elkat, Salut under greenhouse environment to check the effect of drought stress on growth, yield, morphological and physiological parameters. The results were that the drought stress had a very much effect on leaf area; it came out to be very less. Elsanta produced the highest yield and best drought tolerating cultivar. An experiment on strawberry cultivars cultivated on high salt concentration soils by C. Kaya, H. Kirmak, D. Higgs, K. Saltali (2002) <sup>[22]</sup>. They found that salinity decreases yield and growth of plants but this problem can be overcome by adding Ca to the highly saline soil. Maheshgowda *et al.* (2015-2016) researched on 7 cultivars of strawberry under naturally ventilated polyhouse conditions. They concluded that out of the 8 cultivars Sabrina gave highest yield and maximum growth. High tunnel conditions produce highest yield and precocious plants was revealed by Sorkel Kadir *et al.* (2006) <sup>[24]</sup>. He grew Sweet Charlie and Chandler. Chandler came out to be best under high tunnels conditions. NC Sharma, SD Sharma, RS Spehia (2013) <sup>[25]</sup> conducted research to see the effect to yellow and red coloured plastic mulches on growth, yield and quality of strawberry cultivars. They evaluated that red coloured plastic mulches are best for increasing yield, growth and fruit quality if grown under polyhouse conditions. Identification and characterization of different phenolic compounds in strawberry done by Kjersti Aaby *et al.* (2007) <sup>[26]</sup>. They used High performance liquid chromatography detectors like diode array, mass spectrometer in positive and negative mode and coulometric array. They detected 40 Phenolic compounds in strawberry cultivars. A Kumar, I Ahad (2012) <sup>[27]</sup> conducted research to evaluate the yield, growth and biological parameters under protected cultivation in Kashmir valley. They evaluated that Chandler, Tioga and Catskill are best grown under these conditions. Alexandra Wagstaffe (2006) <sup>[28]</sup> conducted an experiment on strawberry 'Everest' to check the effect of thermo dormancy at temperature 260 for 5, 10, 20, and 30 days in July. They concluded that high temperature did not reduce the flower initiation was highest during the high temp. Conditions as compared to low temperature. Luigi Morra *et al.* (2016) <sup>[29]</sup> conducted an experiment to check the mulching effect of Mater- Bi biodegradable film and LDPE on yield and quality of strawberry cultivars (Savrina and Fortuna). They observed that Savrina gave highest yield on LDPE while Fortuna on Mater- Bi film. There were no modifications in physicochemical parameters. Sahana BJ evaluated the effect of organic manures on growth and yield of strawberry cultivated under naturally ventilated polyhouse. They used Vermicompost + Jeevamruth @ 500ml per pot + Beejamruth seedling treatment. They applied it on strawberry cultivars and observed that 'Winter Dawn' showed maximum yield. Nithin KM experimented to note the effect of chitosan on growth and yield of strawberry cultivars cultivated under naturally ventilated polyhouse. They evaluated that chitosan application @ 3g per litre at 45, 90 and 135 days after planting gave better vegetative growth and maximum yield. Pari Zahedipour-Sheshglani *et al.* (2020) <sup>[32]</sup> studied the effect of 24-epibrassinolide on yield of strawberry cultivars. They found that EBL foliar spray induced early ripening. It had no effect on increasing the yield and quality of strawberry

cultivars. Poonam Bhagat and Hement Panigrahi (2019) studied the effect of Bio-fertilizers on the growth, yield and Quality of strawberry cv. Nabila under net tunnel conditions. Treatment of RDF + Azospirillum (@ 7kg/ha) + Phosphate Solubilizing Bacteria (@ 6kg/ha) + VAM (@ 10 kg/ha), gave maximum fruits 41.80% more as compared to control and had considerable influence on fruit length, diameter, weight, volume and specific gravity.

Parween Muhammad Kareem Rozbiany *et al.* (2020) studied the effect of photoperiod on growth and yield of two strawberry cultivars (Festival and Albion). They evaluated that 12 h photoperiod showed maximum flowering and fruiting induction as compared to 10 h photoperiod. They observed that 'Albion' strawberry successfully induced in 12 h photoperiod than 'Festival'. A short-day treatment of 12 h photoperiod is recommended for both the varieties. Maria *et al.* (2018) conducted an experiment to analyse the yield and quality performance of Italia and American strawberry genotypes in Brazil. They used Randomized Block Design with 11 treatments within which Italian cultivars (CREA-FRF CE51, CREA-FRF PIR 29, CREA-FRF PA3, CREA-FRF CE56, CREA-FRF Jonica and CREA-FRF Pircinque) and American cultivars (Albion, Camerosa, San Andreas, Camino Real and Aromas) with 4 replications per treatment, 8 plants per plot, gave total 32plants/ cultivar. Highest phyllochron found in Albion and lowest in CREA-FRF. Highest yield observed in Camino Real, CREA-FRF Pircinque and better soluble solids found in Italian cultivars. Italian cultivars gave better yield in comparison with American cultivars.

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