

REVIEW ARTICLE

Strawberry: New hope of doubling farmers' income

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ABSTRACT

The strawberry's nutritional and potential health benefits make it a highly regarded fruit, and its production has increased rapidly in recent years. However, due to its seasonality, high perishability, and strict quality standards, it can result in significant surpluses that negatively influence the social and economic situations in the places where it is produced. In India, strawberry performs equally well in the temperate climate, sub-tropical in plains and, or tropical at a higher elevation. The main reason strawberry production is still in its infancy in India, despite its attractive fruits and pleasant flavor, is that it is a perishable crop. Several commercial organizations have recently established several pilot projects for large-scale strawberry cultivation. Farmers in the subtropics who live near a big cities, like, New Delhi, Lucknow, etc., have profitably cultivated strawberries during the winter months by using plant material propagated by runners in the hill states of India. Strawberry growers in the hills, thus, have two sources of earning potential from strawberry cultivation. A comparison of cultivars and economics of strawberry cultivation is presented.

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INTRODUCTION

Strawberry (*Fragaria ananassa*, Rosaceae), is an important cash crop cultivated worldwide, including India. Strawberry species belong to the family Rosaceae. Strawberry is a berry-like fruit that can be widely grown in the tropical and subtropical regions of the world. Strawberry fruits may provide several sensory and health benefits to consumers, such as micronutrients, high fiber and Vitamin-C content. Compared to other fruit crops, it offers the quickest returns and the highest returns per unit area on the initial capital investment. Strawberries are expensive and frequently used in fresh and prepared dishes, such as fruit juices, jellies, jams, ice cream, pies, syrups, chocolate, and many beverages

prepared through strawberry fruits. There is a great demand for fresh strawberries on the global market. Strawberry occupies the most important place in the world among fruits like grapes. Customers favor it, and when no other fruit is available in the spring season, strawberry fruit is available for consumption. Because of this, until other fruits reach the market, the fruits get buyers at higher prices. Nowadays, strawberries are cultivated in regions that range from subtropical plains in the tropics to high altitudes and even temperate areas such as the deserts of Israel. Being a crop with shallow roots, plant death and crop damage are possible during the dry season. Cultivation of strawberry crops has earlier received much impetus in India, with

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significant corporations establishing several agro-based facilities principally dedicated to producing strawberry fruits on a huge scale. As annual herbs, this fruit crop can be easily grown in home gardens, balcony gardens, pots, etc. Strawberry is now grown in various agro-climatic conditions in India. (such as states of Chattisgarh, Jammu and Kashmir, Jharkhand, Leh, Lucknow, Meghalaya, and Rajasthan).

Medicinal property of strawberry fruit

The nutrients in 100 grams of raw strawberries are Water 91%; Calories 32; Carbohydrates 7.7 gm; Sugar 4.9 gm; Fiber 2 gm; Protein 0.7 gm and Fat 0.3 gm. The heart shape of strawberry fruit is very beneficial for human health. The strawberry fruits have a significant amount of micronutrients, such as minerals, folate, ascorbic acid and phenolic substances; most are natural antioxidants and give the maximum nutritional quality of strawberries. These substances are vital for good health, but strawberry phenolics stand out for their powerful antioxidant and anti-inflammatory effects. They also have direct and indirect antimicrobial, anti-allergy, and anti-hypertensive properties, as well as the ability to inhibit some physiological enzyme and receptor activities. These effective small packages shield the heart, boost HDL cholesterol, reduce blood pressure, and prevent asthma, cancer and heart disease because this fruit is a rich source of ellagic acid. Strawberry fruit is packed with vitamins and fibers. Strawberries are sodium, and fat, cholesterol-free, low-calorie fruit. They are a good provider of manganese and potassium and are among the top 20 fruits in terms of antioxidant power. Eight strawberries, or one serving, are equivalent to more vitamin C than an orange.

Description of plant botany

The strawberry plant has a short, thickened stem referred to as a "crown" and a growing point at the top and roots at the bottom. "Fleshy buds" in the crown in the early spring sprout new leaves and flower clusters. It is preferred from a cultural perspective, 1-2 "side stems" known as branch crowns that emerge in the late fall. Each branching crown creates its own "flower cluster," or inflorescence, which increases the production of the primary crown. Main crowns and branch crowns

are structurally similar, terminal growing point of each crown develops an inflorescence. Average daily temperatures in November cause sluggish branch crown creation and flower development when temperatures rise more than 50 °F, primarily in October. To encourage continued reproductive growth in the Camarosa cultivar, row coverings may be a viable alternative in November. 3-5 branch crowns are formed – a Camarosa variety plant when the fruiting starts in January to February.

Area and production

In India, the strawberry crop is cultivated in the hilly region. Its main cultivation center is the Dehradun and Nainital district of Uttarakhand, Mahabaleshwar in Maharashtra, Kashmir Valley, and the Kalimpong district of West Bengal. Nowadays, the crop can be easily cultivated with higher production in the plains of Maharashtra (Nashik Pune and Sangli). In India, Maharashtra is the top producing state both in area and production followed by Haryana, Punjab, U.P., J&K, U.K. and lower hills of H.P. with a total area of 0.21 thousand ha and production of 1.61 thousand Metric Tons. The crop is also grown throughout Europe, Canada, and South America.

Varieties/Cultivars

Several large-fruited and high-yielding varieties such as Addie, Belrubi, Chandler, Confitura Dana, Douglas, Etna, Gorella, Pajaro, Sweet Charlie, Selva, and have been introduced into India from North America and Europe. Some of the variety is day-neutral, like Brighton, Etna, Fern Majestic, Phenomenal, and Selva, and may be adapted under Indian climatic conditions. Farmers in the vicinity of Delhi and the states of Punjab, Haryana, Karnataka, Maharashtra, and Uttar Pradesh, tropical and sub-tropical areas, have profitably cultivated the strawberry fruit crop during the cold season and obtained the planting materials (runner) above the hilly region of Uttarakhand and Himachal Pradesh. In Indian climatic conditions, some strawberry cultivars like Belrubi, Chandler, Fern, Pajaro, Selva, Tioga, Torrey, are also easily grown. Other varieties like Bangalore, Blakemore, Dilpasand, Florida 90, Local Jeolikot, Katrain, Premier, Red cost, Sweet, Pusa Early Dwarf & are also cultivated in Indian climatic conditions.

Table1: Popular cultivars of strawberry worldwide

S. No.	Cultivars	The geographic area for cultivation	Details of cultivars	Origin
1.	Albion	California, USA, Mexico	These varieties are day-neutral and rich in sugar content and flavor. A cross of 'Diamante' and 'Cal 94.16-1' developed at the University of California and released in the year of 2006, 'Albion' produces, conical, long fruit with a firm texture.	University of California-Davis
2.	Camarosa	California, China, Spain	An early mid-season June-bearing variety, 'Camarosa' does well in warmer climate. University of California and released in 1992	University of California-Davis
3.	Chandler	California, China, Spain	A mid-season June-bearing variety, this variety are large, firm, flavorful fruits with that classic conical in shape and best grow in full sunlight conditions, Bred at the University of California and released in 1983.	University of California-Davis
4.	All Star	California	This variety was developed by the USDA and plant breeders at the University of Maryland, the cross of 'US 4419' and 'MDVS 3184' first released in 1981.	California
5.	El Dorado	California	The variety is similar to the varieties like 'Camarosa' and 'Ventana.' medium-sized hollow center of the fruit	California
6.	Jubilee	California	Driscoll's Jubilee is said to be the best tasting strawberry variety in England. Good eating quality.	California
7.	Florida Festival	SE USA, Mexico, Spain, Turkey	This variety is superior in disease resistance and excellent pollination under cool, humid conditions that results in a high percentage of marketable fruit.	SE USA, Mexico, Spain, Turkey
8.	Sweet Charlie	SE USA, Turkey	This variety can easily grow under subtropical conditions. This cultivar is known for its high yields and is rich in sweetness and flavor.	SE USA, Turkey
9.	Hood	NW USA	Hood strawberries have evolved as the gold standard in sweet, juicy flavor. These medium-sized berries are known for their high sugar content and deep red color.	NW USA
10.	Maehyang	South Korea	This variety is trendy in Hong Kong and Singapore, where it is considered a premium strawberry variety.	South Korea
11.	Osmanlı	Turkey	Osmanlı', is conventional, light pink, tiny, soft and primarily used in jam-making.	Turkey
12.	Elsanta	Europe	This is a vigorous plant with deep green foliage; large flowers; and big, shiny, mouthwatering berries that ripen mid-summer.	Europe

Improved agro-technologies

Temperate climates are optimal for strawberry growth. It is a short-day plant; for bloom initiation, it needs exposure to roughly ten days with fewer than 8 hours of sunshine. The plants do not develop and are dormant throughout the winter. The plant's dormancy is broken during this time by exposure to low temperatures. Plants continue growth and start to bloom in the spring season when the days get longer, and the temperature rises. The kinds cultivated in milder subtropical climates don't require chilling and keep growing even in the winter. The best soil for growing strawberries is a deep, well-draining sandy loam rich in humus (more than 2% organic matter). The development of the disease is aided by heavy clay soils that are typically poorly drained and obstruct properly scheduled field operations. After 4 to 5 ploughings with a proper gap between each, the field is

ploughed to a fine tilth. It is necessary to plank for correct leveling. Then, furrows are opened at the suggested intervals. When preparing the land, well-decomposed or rotten Farm Yard Manure (25 t/ha) is fully included. Runners that form after the blooming season are used for propagation. The plants may be permitted to produce as many runners as they want, but no fruits. All the plants with robust root systems should be used to establish a new plantation. 10 to 17 runners are typically produced through a single strawberry plant.

Planting techniques

Three key planting methods include 1) Matted row system, which is the ideal system for cultivars that give fruit in June. This technique allows all runners to develop and daughter plants to freely root into a matted row no wider than two feet. In rows 90 cm to 120 cm (3 feet to 4 feet), the strawberry

plants should be spaced 45 cm to 75 cm (18 inches to 30 inches) apart. 2) Spaced-row system: With this method, the number of daughter plants that can develop from a mother plant is constrained. In rows of 1 meter to 2 meters (3 feet to 7 feet) apart, the mother plants are placed 46 cm to 76 cm (18 to 30 inches) apart. No closer than 4 inches separate the daughter plants so they can root. From the mother plants, all additional runners are removed or clipped. The benefits of this technique include higher yields, larger berries, and fewer infections, even though it requires more maintenance. With all runners cut off to urge the plant to concentrate on fruit production, the hill or plasticulture system exploits the crowns to generate fruit. In most places, it is used to develop day-neutral kinds, but in climates where the plants can withstand both winter and summer conditions, it is also used to grow short-day varieties. In raised beds with plastic coverings, plants are transplanted. The plastic accelerates production, heats the soil, and kills weeds. The creation of raised beds also enhances soil drainage. When strawberry plants are planted in a hill system, which provides large yields but only survives for a few years, they are cultivated more densely. For hill production, the standard planting density is 50,000 plants per ha for single rows and 75,000 plants per ha for double or triple row plantings. The more abundant kinds are separated farther.

When they are in the vegetative stage, strawberries are highly vulnerable to frost (as compared to their hibernation during cold winters). Such frosts are possible in the springtime. Therefore, it is advised to mulch strawberries harvested from

fields when they fall between mid-November and mid-December. After a few days of -6°C temperatures, mulch the ground with straw (20°F). To obscure them from view, enough straw should be scattered over the plants. After a week of settling, cover the rows with more straw, spreading it out in a layer up to 7–10 cm (3–4 inches) deep. Mulch should be left around the plants to prevent the fruit from contacting the soil and preserve soil moisture. Mulching also aids in weed and grass control, protects against extremely cold temperatures, and aids in keeping berries clean during harvest. During winters, mulching is used to prevent root damage brought on by rapid freezing and thawing of the soil and the subsequent heaving of the plants out of the ground. Mulching can be done with a variety of materials. The most popular mulch is straw. Around 9 tonnes of wheat straw per ha would make up a typical layer of straw mulch for winter protection. Over the plants, the mulch layer should be between 15 and 20 cm (6 and 8 inches) deep.

Crop management

At the time of first harvesting, strawberries should be fertilized after renovation in July for the following season. To ensure that the fertilizer reaches the root zone, water it in. This treatment is applied to keep the plants healthy and to encourage new growth, which leads to the emergence of more fruit buds. Avoid over-fertilizing because this promotes excessive vegetative growth, lowers yields, increases losses from foliar diseases and frost, and results in winter damage. On the other hand, they are sensitive to the situation known as



Figure 1: Paddy straw mulching in the strawberry field (left) and packed fruits ready for market sale

water logging, which deprives the roots of oxygen and creates the ideal environment for microbial and fungal illnesses that are transmitted through the soil. The maximum yields of huge berries can be obtained with continuous good water status. A minimum of 25 mm (1 inch) of water should be given to strawberries each week. While the fruit develops during the early bloom period until the conclusion of harvest, up to 50 mm (2 inches) of water should be applied every week. During the dry months of August and September, watering should continue. This later water helps the strawberry plants experience less stress, promoting fruit bud development the following year.

Harvesting time and method

After initial blooming, berries typically ripen in 28 to 30 days (or as little as 20 days under ideal circumstances). 11 to 12 days may pass between the first bloom and the complete bloom. Over the first 4 to 6 days after harvest, there is a noticeable increase in the quantity of ripe fruit. Under typical temperatures, berries are harvested for six to seven pickings every other day. When the plants are damp, avoid harvesting fruit. As quickly as possible, refrigerate the gathered berries and keep them out of the sun. Pick the berries once they have reached their full colour, size, and flavour potential. After being picked, berries do not get better in quality. When picking by hand, it is wise to hire enough pickers to finish at midday, when it is coolest, and pickers are most productive. To prevent spoiling, harvested berries should be delivered and sold within 24 hours of harvest. Six pickers can gather an acre's worth of berries or around 10,000 pounds throughout the season. Throughout the season, the typical picker can produce 10 quarts (12-15 pounds) each hour. The standard picker may gather up to 175 pints in a 10-hour day under ideal circumstances.

Runners for future planning

As a plant grows, strawberries create runners that spread out and new plant roots that result in the growth of other plants. The distance between the first runners is roughly 15 cm (6 inches). Per plant, only a few runners should be allowed before additional runners are removed to encourage crown growth. Each row should not be wider than 60 cm (24 inches) to ensure convenient planting access. Outside, 60-cm-wide runner plants should be pinned back into the row to take root or removed if they

get too crowded (less than 15 cm between plants). Before they take root, the runners can be placed into the proper row width and secured with tiny stones, soil mounds, or traditional hairpins. The crowns begin to grow a few leaves and blossom buds soon after planting. The entire flowering season should be used to pinch off all blooms. The following year's yields will be higher due to the increased runner growth and plant vigor filling the bed. Early in the summer, runner plants start to poke their heads through the crowns. The rows should be completed with these.

Cost of cultivation

Since strawberries are low-growing, they may fit 50,000 – 60,000 plants per hectare when planted at a closer spacing of 60x30cm. Consequently, 125–175 quintals of the crop are produced per acre. A farmer can make between 15 and 20 lacs by selling the strawberry at the local minimum price of Rs. 100 kg (Table 2). Because strawberry plants are more expensive and their production requires a lot of resources and attention, a hectare of the crop costs between \$8 and \$9 million to cultivate. Within just six months, a farmer can earn a net profit of Rs. 7-8 lacs per acre.

Table 2: Approximate cost of cultivation and net profit

Strawberry yield	: The yield of 125-175 quintal per hectare is under ideal conditions.
Market price ₹ @	: 100 rupee/kg, but the rate depends upon location.
Gross returns	: 15-20 lacs
Cost of cultivation	: 8-9 lacs per hectare
Net return (per ha)	: 7-8 lacs per hectare

Challenges and opportunities for strawberry growers

The issues that the farming community is having regarding agricultural businesses have become of the utmost importance since it acts as an essential source for policymakers in formulating policies for the welfare of the farming community. The growers must adhere to several rules and regulations regarding various cultivation areas and the environment. Worker protection standards (WPS), labor pay, housing, water management, fumigant management, and food safety are among the laws and regulations that producers must

follow. Many of these regulations safeguard the environment, consumers, and labor. However, following these regulations has increased the operational load on growers and made company operations more difficult. In terms of marketing issues with their produce, strawberry growers had to deal with a lack of scientific storage facilities, non-availability of an agricultural processing unit, lack of a minimum support price, low payment by wholesalers and retailers, a decrease in local market demand, high packaging material costs, a lack of transportation infrastructure in some locations, a lack of accurate market information, and improper grower training. Growers in the hills can make money in addition to selling strawberry fruits by making planting materials for plains in the winter. Today, strawberries are grown throughout India in various agro-climatic areas, including the states of Meghalaya, Jharkhand, Leh, Jammu and Kashmir, Uttar Pradesh (Lucknow, Barabanki, Jhansi), Chattisgarh, Mahabaleshwar-Panchgani in Maharashtra, and Rajasthan.

CONCLUSION

Strawberry fruits are rich in several nutrients, especially phenolics with red colour due to anthocyanins that hold promise for producing quality red wine with medicinal properties. Strawberry is a high economic price crop that is more sensitive to the rainy season, as the open field condition has seen almost 100% mortality during the rainy season. Considering the broad applications of strawberries in various fruit industries, the demand for strawberry raw materials is growing daily in the international and national markets. It is necessary to cultivate strawberries on a large scale in the northern Avadh region (humid subtropical climate) of India to meet the demand sustainably. Therefore, the biggest problem before the researchers is to develop environment-friendly, cheap, sustainable, disease-free varieties, fruity quality and economic agro-technology for strawberries. Overall, if we can establish inexpensive agro-technology for strawberry cultivation, growing this crop will benefit the farmers in the coming days.

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