

PROTECTED CULTIVATION OF FRUIT CROPS: OPPORTUNITIES AND CHALLENGES

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Abstract– Protected fruit culture has grown rapidly and widely, and it has now established itself as an important branch of fruit cultivation. It allows for some regulation of wind velocity, humidity, temperature, atmospheric composition, mineral elements, and light intensity and it has greatly contributed to a better knowledge of growth factor requirements and inputs for increasing crop output. Here is a summary of a quick introduction, methods of fruit crop cultivation under protected cultivation, growing of various fruit crops for protected cultivation, their results and other information.

INTRODUCTION

Protected cultivation is a crop-growing method in which the plant's microclimate is easily adjusted to meet the plant's needs for optimal growth and development. In India, over 30,000 acres of land is under protected agriculture, with states like Maharashtra and Karnataka leading the way. Progressive farmers are now cultivating high-value crops and flowers under commercially protected conditions. (Maitra *et al.*, 2020). Intensified agriculture's energy inputs have climbed by 137 per cent in the last 40 years, while land utilisation has increased by less than 10%. (Pellegrini and Fernandez, 2018). Fruits and vegetables are packed with nutrients. They are high in vitamins, minerals, fibre, antioxidants, and other micronutrients, making them good food sources for fighting malnutrition. Indirectly, horticultural crops can help to combat poverty, malnutrition, and environmental degradation. Through direct sales and added value, their market value contributes to generation of income, easing rural poverty and offering greater possibilities to purchase nutritious food (Singh *et al.*, 2019). Various forms of protected farming practices suitable for a certain type of agroclimatic zone have arisen as agriculture has progressed. Protected agriculture is a specific type of farming. Protected farming is used to grow crops by modifying the natural environment of the crop in order to extend the harvest season (Aman *et al.*, 2018).

Greenhouse technology has traditionally been used for protected farming. Commercial greenhouse production is carried out in 115 nations across the world as per FAO. The world's total greenhouse agricultural production area is estimated to be 623302 hectares. (Khan *et al.*, 2018). The greenhouse has a steep roof, a broad span, and greater internal room, making it more suited to growing fruit trees in the off-season. The greenhouse is resistant to natural calamities such as high winds and snow pressure, as well as having a long lifespan.

As a result, developing a new eco-friendly fruit tree growth technology has become a prominent topic in the recent study. (Chen and Boddu, 2022). Food security has become a more pressing concern for all countries throughout the world, especially as the global population continues to rise and arable land shrinks as a result of urbanisation. (Sagheer *et al.*, 2020)

Why protected cultivation?

According to the United Nations, the current global population is 7.7 billion people, with estimates of 8.6 billion in 2030 and 9.8 billion in 2050. To feed the world's population by 2050, 42 percent more agriculture and 120 percent more water will be required. When we factor in other issues like water constraints and labour shortages, we can see how tough traditional outdoor agriculture is. Protected agriculture in greenhouses is one of the best solutions for increasing food and agricultural

production (Sagheer *et al.*, 2020). To compensate for the concomitant growth in population for food species, food production will have to be doubled. The concern with this is seen in the yield of existing agricultural and fresh water harvesting structures: even with our resources, 1.0 billion people suffer from malnutrition today, and 1.2 billion live in water-scarce areas (Khan *et al.*, 2018)

The greenhouse's environmental factors, such as temperature, humidity, light, and CO₂ concentration, can be artificially adjusted. Flowering is accelerated, fruit ripening is accelerated, yields are increased, berry quality is improved, the harvest season is extended, and berry losses due to rain and frost are reduced in greenhouses. Greenhouse cultivation may provide producers with more economic benefits, therefore it is widely used in northeast China and is fast expanding internationally (Wang *et al.*, 2021). The issues of sustainable food production faced by both irregular climatic conditions and rising population pressure on agricultural land have their remedies in protected agriculture, with 140.8 Mha of net cultivated area on the decline (Lenka, 2020)

Main fruit crops grown under protected cultivation

With 6.5 million hectares of land under fruit crops, India is the world's second-largest fruit-growing country after China. More area is expected to be dedicated to protected agriculture in the near future. Strawberry is maybe the only fruit crop grown commercially and profitably in India under protected cultivation. Raspberry, papaya, loquat, grapes, banana, apple, plum, peach, strawberry, mango, and other fruit crops with high production potential under protected cultivation include raspberry, papaya, loquat, grapes, banana, apple, plum, peach, strawberry, mango, and others. For example, growing bananas under a shielded structure offers its own set of benefits, such as wind protection, lower water requirements, and protection against sigatoka disease, all of which add up to a higher yield. Through the application of shade net techniques, the geographical disadvantage can be mitigated. Strawberry growing, for example, is most common in India's hilly regions. It can, however, be grown in any state through protected cultivation (Lenka, 2020). To evaluate the development characteristics of mature strawberry plants during cultivation under three distinct wavelengths of LED light (blue, red, and blue plus red), and to measure fruit quality When the impacts

of different LED lights were investigated, it was discovered that when ambient light was supplemented with either blue LED light or a combination of blue and red LED light, the PG produced significantly more fruits (Choi *et al.*, 2015). Protected agriculture is rapidly evolving and becoming increasingly beneficial for growers. It is advantageous for generating high-quality export products. Strawberry, grape, and nectarine are the three principal crops, with strawberry accounting for the majority of production. The protected cultivation production system allows for the development of organic fruit, the reduction of insect pest incidence, the avoidance of fruit cracking, and the hardening of tissue culture, as well as cut, budded, layered, and grafted plants (Aman *et al.*, 2018)

The peach in the greenhouse grew well, and the fruit colouring stage and ripening stage were roughly the same or earlier than those in the "two coverings and three films" greenhouse construction. (Chen and Boddu, 2022). Because of its modest height, herbaceous character, and growing habit, as well as its popularity as a greenhouse crop, pineapple is perhaps the most suitable tropical fruit crop for greenhouse culture (Sauco, 2002). The following are the key advantages of growing apricots and peaches in greenhouses: (1) early maturity; (2) high fruit quality, storage life, and market closeness; and (3) good plant health, appropriate for organic farming (Martinez-Gomez *et al.*, 2021).

To trigger bud break and bloom, highbush blueberries require a significant amount of cold exposure. Due to insufficient chilling requirements in the greenhouse, bud breaking and flowering are typically delayed and uneven, resulting in decreased blueberry yields or even no harvest. Dormancy breaking agents like HC have been shown in numerous studies to be able to replace some of the freezing need, accelerate and synchronise bud breaking and flowering, and hasten fruit maturity (Wang *et al.*, 2021). ACC promoted papaya plant growth, blooming, fruit development, and, as a result, yields, resulting in more and heavier fruits at a lesser cost. Finally, in the current economic environment, active temperature and humidity control inside the greenhouse may be a more viable method in subtropical locations where open-air cultivation is not possible (Salinas *et al.*, 2021)

In the autumn-winter period in Poland, strawberry and wild strawberry cultivars were

cultivated in the same controlled greenhouse conditions on coconut mats in gutters, irradiated with sodium lamps. Strawberry is not as well suited to gutter horticulture as wild strawberry. In terms of leaf biometric measures, gas-exchange parameters, and some biochemical features, San Andreas' (strawberry) and 'Regina' (wild strawberry) responded more favourably to the provided greenhouse conditions (Lema-Ruminska *et al.*, 2021).

Different ways of protected cultivation:

Hydroponics- In 1936, Dr. W.F. Gericke coined the term "hydroponics" to describe the growing of edible and ornamental plants in a solution of water and dissolved nutrients. It literally translates to "working water," with "hydro" denoting "water" and "ponos" denoting "labour." For example, Babylon's hanging gardens, the Aztecs' floating gardens in Mexico, and the Chinese's floating gardens. Gericke built the first commercial hydroponic unit in the United States in 1930. Crops grown in towers could reduce the demand for additional land. Protected cultivation can result in higher yields and more effective use of inputs (water, fertiliser, and herbicides). The efficient use of natural light is a major benefit of hydroponic greenhouse agriculture. Fruit development is aided by the presence of light. Light falls on both the upper and lower parts of the plant in a hydroponic greenhouse. Both top and lower fruit develop at the very same time due to the equal dispersion of light. Plants in a hydroponic greenhouse system are never stressed since water and nutrients are constantly available to them (Khan *et al.*, 2018).

In hydroponic cultivation, new organic substrates have been introduced to replace peat, which is a non-renewable resource, and to reduce the use of rockwool and perlite, which are difficult to recycle (Gajc-Wolska *et al.*, 2014)

Aeroponics - Aeroponics is a type of hydroponic plant cultivation that involves suspending plant roots in a closed chamber and misting them with a complete nutritional solution (Murali Mugundhan *et al.*, 2011) or in other words Aeroponics is a method of growing plants in a confined or semi-closed environment by spraying a nutrient-rich fluid into the plant's roots (Agina Effat *et al.*, 2018). Aeroponics eliminates the need for a solid or aggregate growing media, allowing for easy root access. Temperature, nutrition content, pH, humidity, misting duration and frequency, and oxygen availability are all controlled by the misting

and chamber system. 1) Root material free of dirt, soil-borne organisms, or adulteration from alien plant species pollutants; 2) Potential for better root productivity and phytochemical consistency because of uniform nutrition and water availability, as well as decreased disease risk. The production and consistency of phytochemical constituents are both excellent in the study. (Murali Mugundhan *et al.*, 2011).

Aquaponics - The combined culture of fish and plants in recirculating systems is known as aquaponics. Plants grown hydroponically get nutrients that are expelled directly by the fish or created by the microbial decomposition of organic wastes. The majority of the nutrients required for plant growth are found in fish feed. Fish waste metabolites are eliminated through nitrification and direct uptake by the plants when the aquaculture effluent runs through the hydroponic component of the recirculation system, thereby cleaning the water, which is then returned to the fish-rearing component for reuse (Agina Effat *et al.*, 2018).

4) Geoponics - When a plant is moved from the ground, it dies. You must undertake geoponics plant research at the location where the plant grows. Plants produced in geoponics may be susceptible to a variety of illnesses, pesticides, weeds, and other issues brought on by the presence of soil. Water is always used in excess of what is required for irrigation. Fertilizing plants is always a chore, and it must be done manually the majority of the time. Because there are so many variables to consider in geoponics, such as whether the soil already contains enough nutrients to grow the plants or whether it needs to be enhanced with the proper mix of minerals, the plant's nutrition cannot be guaranteed. The Yield and Unstable are affected by the environment (Murali Mugundhan *et al.*, 2011)

Constraints in fruit production under protected cultivation

Fruit crop production is hampered by a lack of sunlight, temperature changes, a lack of or excess of moisture, weed development, wind velocity, and atmospheric carbon dioxide. All of these constraints are tied to climate variables, either directly or indirectly, and protected cultivation has helped to reduce them (Aman *et al.*, 2018). Although greenhouses are meant to protect crops from a variety of hazards, most viruses and pests are impossible to avoid. Spores and aerosols containing bacteria are driven into doorways and ventilators by

Various Fruit Crops Grown Under Protected Cultivation and their Results :

S. No	Fruit Name	Factors to be noted	Conclusion	References
1	Strawberry	to evaluate the development characteristics of mature strawberry plants during cultivation under three distinct wavelengths of LED light (blue, red, and blue plus red), and to measure fruit quality	When ambient light was supplied with either blue LED light or a combination of blue and red LED light, the PG produced more fruits.	(Choi <i>et al.</i> , 2015)
2	Strawberry, grape, nectarine	for producing quality production for export.	Reduce the frequency of insect pests, avoid fruit cracking, and avoid frost injury, as well as hardening of tissue culture, cut, budded, layered, and grafted plants.	(Aman <i>et al.</i> , 2018)
3	Peach	Growing of peach in greenhouse	The fruit colouring stage and ripening stage of the peach in the greenhouse were substantially the same or sooner than those in the greenhouse structure of "two coverings and three films."	(Chen and Boddu, 2022)
4	Pineapple	Growing of pineapple under protected cultivation	Due to its modest height, herbaceous nature, and growing habit, as well as its popularity as a greenhouse crop, it is arguably the best suited to greenhouse production.	(Sauco 2002)
5	Apricot	Apricot cultivation under Green house.	Precocity, great fruit quality, storage life, market proximity, and good plant health make this a strong choice for organic farming.	(Martinez-Gomez <i>et al.</i> , 2021)
6	Peach	Peach cultivation under Green house.	This is a strong choice for organic farming because of its precocity, great fruit quality, storage life, market proximity, and good plant health.	(Martinez-Gomez <i>et al.</i> , 2021)
7	Highbush Blueberries	Highbush blueberries cultivation under Green house	Delayed and uneven bud breaking and blooming are common in greenhouses due to insufficient cooling requirements, leading in decreased blueberry yields or no harvest at all.	(Wang <i>et al.</i> , 2021)
8	Papaya	Papaya protected cultivation under ACC (Active Climate Control)	ACC promoted papaya plant growth, blooming, fruit development, and, as a result, yields, resulting in more and heavier fruits at a lesser cost.	(Salinas <i>et al.</i> , 2021)
9	Strawberry and Wild Strawberry	Strawberry cultivation under Greenhouse.	Strawberry is not as well suited to gutter horticulture as wild strawberry. In terms of leaf biometric metrics and	(Lema-Ruminska <i>et al.</i> , 2021)

Various Fruit Crops Grown Under Protected Cultivation and their Results :

S. No	Fruit Name	Factors to be noted	Conclusion	References
			gas-exchange parameters, San Andreas' (strawberry) and 'Regina' (wild strawberry) responded more favourably to the given greenhouse conditions.	

the wind. Windblown dust transports soilborne germs to footwear and machinery. Insects that enter the greenhouse can transmit viruses and carry bacteria and fungi, while irrigation water can include aquatic fungi. Pathogens and pests are tough to remove once inside a greenhouse (Singh *et al.*, 2019).

Commercial vegetable cultivation has become a costly enterprise due to rising input costs. One major factor is the shrinking availability of arable land as a result of increased urbanisation. Furthermore, accelerated poverty and unemployment are prevalent in all emerging-market cities, which can be avoided by using soilless agriculture to cultivate fresh vegetables in the surrounding suburbs. Soilless farming is the practise of producing a variety of crops without the use of soil as a rooting medium (Sallam *et al.*, 2021). Artificial heating or cooling during the winter or summer is required to maintain an optimal microclimate inside a protected structure, which raises the cost of production.

The cultivation of crops in greenhouses is a type of intensive agriculture. Because it needs more effort and materials than open-field systems Because greenhouse production costs are significantly greater than those in the field, greenhouse crop production procedures must be more efficient than those utilised in traditional field systems (Rodriguez *et al.*, 2007). The following are the primary limiting factors for fruit tree production in greenhouse conditions to consider: (1) light scarcity at higher altitudes; (2) absence of cold for bud breaking, flowering, and fruit development; (3) potentially extreme temperatures in warm regions, which reduce the photosynthesis rate; and (4) a reduction in fruit quality, colouring, and aroma compounds in some warm conditions with light day/night temperature variations (Martinez-Gomez *et al.*, 2021). Furthermore, high indoor temperatures can make working conditions harmful for workers during both the growth and harvesting phases of the crop (Castronuovo *et al.*, 2017).

CONCLUSION

Protected agriculture is rapidly evolving and becoming more beneficial for producers every day. It is advantageous for generating high-quality products for export. Strawberry, grape, and nectarine are now the 3 main crops, with strawberry accounting for the majority of them. Protected cultivation production technique allows for the development of organic fruit, the reduction of insect pest incidence, the avoidance of fruit cracking, and the hardening of tissue culture, as well as cut, budded, layered, and grafted plants. Due to a lack of native types suitable for growing beneath protected structures, specific varieties must be bred. Each crop's production technology under protected conditions should be standardised. There is a need for more research into protected culture in other fruit crops. As a result, the quality criteria of the crop cultivated in protected cultivation are generally superior to those grown in the field. To improve the quality of fruit crops, there is also a need to focus on improving the structures, growing practises, and physiological research of the plants.

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