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Exploring the Potential and Challenges of Dragon Fruit Cultivation in Punjab: A Systematic Review

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Dragon fruit (*Hylocereus spp.*) cultivation has gained significant attention globally due to its nutritional value, unique appearance and potential economic benefits. The necessity of climate change adaptation highlights the need for dragon fruit production in Punjab. Growing robust and drought-tolerant crops like dragon fruit is essential as traditional crops grow more susceptible to unpredictable weather patterns and temperature extremes. Additionally, growing dragon fruit can help diversify farming methods, lessen dependency on crops that require a lot of water, and increase farmers' ability to withstand the hazards brought on by climate change. Punjab may take advantage of a profitable market opportunity and lessen the negative effects of climate change on agriculture by embracing dragon fruit production. The purpose of the study is to determine whether Punjab's agroclimatic conditions are suitable for growing dragon fruit and to pinpoint the obstacles preventing its widespread use.

Another possible avenue for Punjab's agricultural diversification is the production of dragon fruit. The viability and difficulties of establishing dragon fruit agriculture in the area are examined in this systematic review. This study evaluates the elements that affect dragon fruit farming, including climatic appropriateness, soil needs, agricultural methods, economic viability, and regulatory frameworks, by conducting a thorough review of the literature. Issues including illness prevention, pest control, and market accessibility are also examined. The results demonstrate the potential advantages of growing dragon fruit in Punjab while also emphasizing the need for specialized approaches to address current issues.

Keywords: Dragon fruit, Punjab, Potential, Feasibility, Challenges, Cultivation, Agriculture.

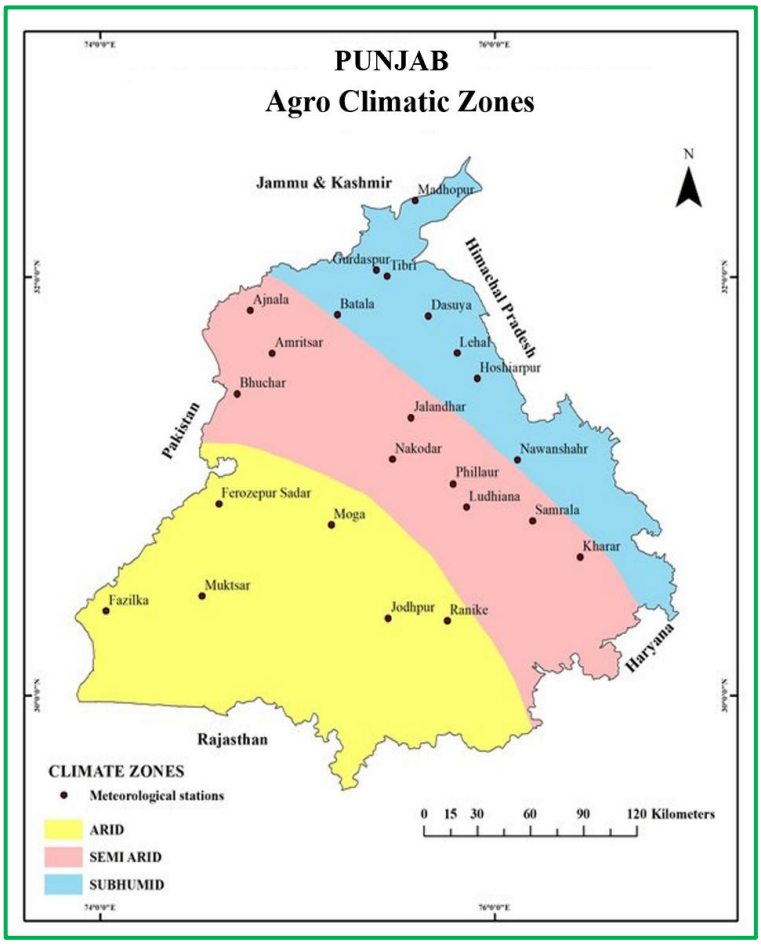
Introduction

The tropical fruit known as dragon fruit, or pitaya or pitahaya, is a member of the Cactaceae family's Hylocereus genus. It is referred to as dragon fruit due to its look, which includes its leather-like skin and pronounced scaly spikes on the fruit's surface (Lehmann, 2019). Pitahaya is another name for it, and it may be connected to the names of tall cactus species that bear fruit. Central and Northern South America are home to Pitayaroja, whereas Mexico is the origin of Pitaya (Morton, 1987). Dragon fruit is native to Central and South America, but because of its high market demand, nutritional content, and aesthetic appeal, its cultivation has spread around the world. It is commonly used as juice and in restaurant fruit salads. Because dragon fruit has a high vitamin C content, regular consumption helps fight against cough and asthma as well as speed up the healing of cuts and wounds (Luders and Mahon, 2006).

In recent years, there has been growing interest in cultivating dragon fruit in regions with diverse climatic conditions, including semi-arid and subtropical regions. Evidence from several nations as well as current studies released by a few commercial organizations indicate that the production of dragon fruit has expanded dramatically over the last ten years (Chen

and Paull, 2018; Mordorintelligence, 2020). With all of these facts, this fruit is becoming popular all over the world and also becoming more and more well-liked among Indian farmers, business owners, and customers in both rural and urban locations. It was introduced to India in the late 1990s, and output is now slowly increasing. Farmers in the Indian states of Karnataka, Kerala, Tamil Nadu, Maharashtra, Gujarat, Orissa, West Bengal, Andhra Pradesh, and the Andaman and Nicobar Islands have already begun cultivating this fruit (Kumar et al., 2022). Some Indian farmers have proposed adopting dragon fruit farming technology for commercial production in the last three to five years (Pathak et al., 2020). Punjab is one of the states that are working in this area to grow dragon fruit locally in order to increase the revenue of its farmers. The northern Indian state of Punjab is well known for its agricultural output, which is mostly concentrated on the production of wheat, rice, and cotton. Crop variety, however, is crucial for both farmers' revenue generation and sustainable agriculture.

The production of dragon fruit offers Punjab's agricultural landscape a chance for diversification, with possible financial gains and environmental sustainability. Two dragon fruit types, Red Dragon 1 and White Dragon 1, have been recommended for commercial production by the Punjab Agricultural University (PAU) after five years of testing. Goyal (2023) claims that this program gives farmers the opportunity to boost crop diversity and boost yields while addressing issues like unclean soil and depleting water sources. In addition to the aforementioned, Punjab Agricultural University (PAU) launched a NABARD-sponsored project to promote dragon fruit cultivation in Faridkot with the aim of enhancing rural development and giving farmers more power. The initiative offers financial support, technical training, and other tools to help farmers develop profitable businesses, along with the introduction of two new dragon fruit types (Krishi Jagran, 2023). PAU also organizing training programmes and workshops agricultural scientists so that they can aware farmers about dragon fruit cultivation. Therefore, it is essential to explore the potential and opportunities of dragon fruit cultivation in Punjab, so that farmers could take advantage of this opportunity and diversity their crops to enhance their income in a sustainable way.



Study Area: Map: 01

(Source: Panjab Agricultural University, Ludhiana)

Research Objectives

- To assess the suitability and potential of Punjab's agro-climatic conditions for Dragon Fruit Cultivation.
- To identify the barriers hindering the adoption of Dragon Fruit Cultivation in Punjab.

Research Methodology

This study uses a systematic methodology to examine the potential and challenges of dragon fruit production in Punjab. A comprehensive literature review that summarizes study findings from several scholarly journals, government publications, and private studies forms its basis. Sources that provide insight into the history of dragon fruit cultivation in India and across the world include case studies, agricultural reports, and peer-reviewed articles. The data collecting phase only uses secondary data from credible sources, like as research institutions, foreign publications, and reports from organizations like Punjab Agricultural University (PAU) and NABARD. These contain thorough information on agroclimatic compatibility, soil requirements, and the feasibility of commercially farming dragon fruit. Using a theme analysis, the findings are categorized into several significant areas, including market barriers, controlling pests and diseases, soil requirements, climatic suitability, and economic viability. This makes it easier to identify possible challenges as well as opportunities specific to dragon fruit cultivation in Punjab. Comparative analysis is used to evaluate the agroclimatic conditions of Punjab with data from southern Indian states, Thailand, and Vietnam. This comparison assesses how well dragon fruit cultivation adapts to the semi-arid, subtropical environment of Punjab. Finally, the study uses these findings to assess the viability of dragon fruit cultivation in Punjab and provides recommendations for overcoming challenges. To ensure the successful implementation of dragon fruit farming in the region, it is imperative to improve market accessibility, provide technical help, and increase farmer awareness.

Results and Discussion

From the extensive literature review it has been found that

The comprehensive analysis emphasizes that due to its extensive health and medical advantages, dragon fruit, pitaya, or strawberry pear (Hylocereus spp. and Selenicereus spp.) is becoming a super crop, even on marginal soil. Basically, it is a climbing cactus vine that is native to Central and South America, tolerant to abiotic conditions, and resistant to illnesses and pests. Numerous benefits come with it, such as low water and nutrient requirements, comparatively little resources needed for orchard establishment and upkeep, the ability to produce fruit multiple times a year, the potential to maintain a high yield for up to 20 years, a high benefit-to-cost ratio, and high levels of nutraceuticals and functional properties (rich in antioxidants and fiber, for example). All of these characteristics entice producers all over the world to start and build dragon fruit farms, offer chances for international export, and promote the production of high-quality food to satisfy consumer demand.

Due to its xerophyte characteristics, this crassulacean acid metabolism (CAM) plant may flourish in a variety of agroclimatic, including those with high temperatures and limited water supplies. With 500–1500 mm of rainfall, dragon fruit may be grown economically up to 1700 m in height. Since its roots are shallow (less than 40 cm), it may be grown in a variety of soil types as long as there isn't too much moisture present. Dragon fruit survives with minimal water. When grown outdoors, they require 600mm to 1300mm of rain per year (24 to 510 inches) (Sharma, 2016). The dragon fruit plant enjoys a dry tropical climate with temperatures averaging 20-29 °C, although it can withstand short periods of 38-40 °C and 0 °C (Sharma et al., 2016). However, the best growing conditions for commercial dragon fruit orchards are slightly acidic (pH 5.5–6.0) loamy soil that is rich in organic matter and has an ambient temperature between 20 and 30°C. Thus, during the past 20 years, tropical Asian nations have seen a surge in the popularity of dragon fruit, leading to its commercial production worldwide (Sanoamuang, 2019). Although it can tolerate temperatures as low as 0°C for brief periods of time and as high as 38°C, the dragon fruit plant prefers a dry tropical climate with an average temperature of 20–29°C (Karunakaran, et.al., 2014). Temperatures over 40°C will harm the plants and result in stem yellowing. Areas with high rainfall are unsuitable for crops since it might result in fruit and blossom drop (Karunakaran and Arivalagan, 2019).

Therefore, there is a lot of potential for growing dragon fruit in Punjab because of its adaptation to semi-arid and subtropical temperatures. Because dragon fruit (Hylocereus spp.) grows well in comparable agro-climatic circumstances, it is a viable option for places like Punjab that are experiencing rising water shortages and climatic unpredictability, according to research from Thailand and Vietnam (Merten, 2003). Successful plantings in the southern regions of India have shown that the climate of Punjab, which is defined by hot summers and moderate winters, is suitable for the cultivation of dragon fruit (Singh et al., 2020). The agroclimatic conditions, which include sufficient sunlight and moderate temperature variations, are ideal for the cultivation of dragon fruit. Punjab has a climate that is conducive to dragon fruit growing, with moderate annual rainfall of between 500 and 1,200 mm helping to fulfil the crop's water needs. The temperature in the area, which varies from 20 to 35 degrees Celsius, is ideal for dragon fruit because the plant likes warm to hot weather. Furthermore, Punjab's soil, which is primarily sandy loam, has good drainage qualities that help to avoid waterlogging, which is essential for encouraging strong root development. Punjab is a potential location for the growth of dragon fruit growing because of these stable circumstances. The harsher winters in Punjab, however, might provide difficulties; in order to guarantee the best output, regulated conditions or protected structures are needed. Studies carried out in Southeast Asia have confirmed the economic sustainability of dragon fruit production, with farmers reporting larger profit margins than for traditional crops like wheat and rice. Similar results are expected in Punjab, where an annual revenue of ₹5–6 lakhs per acre is predicted (Kumar et al., 2019).

Since PAU (Panjab Agricultural University, Ludhiana) has officially recommended two varieties of Red Dragon 1 and White Dragon 1, more farmers will presumably adopt dragon fruit farming as a crop that fetches good prices in the open market. A few farmers have been practicing dragon fruit farming in the state for a few years, and they are making money from it (Dr. Harminder Singh, principal fruit scientist, PAU, Ludhiana, 2023). For example; Raman Salaria, a former engineer from Punjab who is now a farmer, grows dragon fruit on his farm in Pathankot and uses organic agricultural practices to generate Rs. 5 lakhs in revenue annually per acre. His investment in dragon fruit cultivation and his gradual transition from chemical to organic farming have shown to be both economically and environmentally sound (Pratap, 2023). As a result, dragon fruit is a lucrative alternative to agricultural diversification, supporting Punjab's goal of avoiding water-intensive crops. Another positive development is the economic feasibility of dragon fruit cultivation. Dragon fruit is a lucrative diversification option since it has higher demand and better profit margins than traditional crops. According to the research, Punjabi farmers stand to benefit from the higher yields per hectare, especially when contrasted with crops like rice and wheat that need more water. This would help with water conservation measures.

Challenges

Despite its potential, dragon fruit cultivation in Punjab faces several challenges**:**

- Limited Awareness: Many farmers lack knowledge about dragon fruit cultivation practices, including planting techniques, pest and disease management and post-harvest handling. Notwithstanding these benefits, a number of obstacles prevent dragon fruit from being widely used in Punjab. Farmers' lack of knowledge and technical expertise is one of the main problems. According to research done in Taiwan, non-traditional producing locations frequently lack the specialized expertise needed for dragon fruit development, such as trellising systems, pruning techniques, and pest management (Lakshmeshwara et al., 2024). Because Punjabi farmers are used to growing traditional crops, in-depth training programs are required to close this knowledge gap.
- High Initial Investment: Establishing a dragon fruit orchard requires significant initial investment in land preparation, planting material, irrigation infrastructure and support structures. Dragon fruit plantations demand a large initial investment, which presents another significant barrier. According to research from Brazil, infrastructure, planting supplies, and irrigation systems must be purchased in full before starting a dragon fruit

farm (Parada et al., 2021). The requirement to shield plants from the harsher winter weather in Punjab may necessitate the construction of greenhouse-like buildings, which would increase this expense.

- Pest and Disease Management: Dragon fruit is susceptible to pests such as fruit flies and diseases like anthracnose, requiring effective pest management strategies. Another big obstacle is managing pests and diseases. Dragon fruit is prone to illnesses like anthracnose and pests like fruit flies, which have been documented in a number of places, including Mexico and Vietnam. The bacterial and fungal infections that cause brown spots, anthracnose, and stem rots are significant illnesses that impact the dragon fruit production. The crop is more vulnerable to these diseases during periods of heavy rainfall, overwatering, or soggy conditions. The Andaman Islands in India have also been the source of reports of anthracnose from other nations (Balendres et al., 2019). It is necessary to create efficient pest control plans specifically tailored for Punjab, such as the usage of integrated pest management (IPM) methods and organic insecticides.
- Market Access: While there is growing demand for dragon fruit, establishing market linkages and ensuring fair prices for farmers remains a challenge. Two other obstacles are infrastructure and market access. Global demand for dragon fruit is rising, but connecting Punjabi growers to markets is still a problem. Due to the perishable nature of dragon fruit and insufficient cold storage facilities, studies conducted in Malaysia reveal that small-scale farmers frequently fail to obtain regular market access (Wakchaure et al., 2015). Similar problems are expected in Punjab, where there is a lack of sophisticated cold chain infrastructure.

Conclusion and Recommendations

Dragon fruit cultivation holds promise as a profitable crop option for Punjab farmers, given its suitability to the region's agro-climatic conditions and market demand. Addressing challenges related to awareness, investment, technical know-how and market access is essential for promoting its adoption and ensuring sustainable growth of the dragon fruit industry in Punjab. Strategic interventions, including awareness programs, financial incentives, research support, and policy reforms, are needed to harness the full potential of dragon fruit cultivation in Punjab, contributing to agricultural diversification, income generation and rural development. However, the following recommendations are necessary to take advantage of this opportunity:

- Awareness and Training Programs: Conduct workshops, training sessions and field demonstrations to educate farmers about dragon fruit cultivation practices and benefits.
- Subsidies and Financial Incentives: Provide subsidies or financial assistance to farmers for establishing dragon fruit orchards, purchasing planting material, and installing irrigation systems.
- Research and Extension Services: Invest in research and extension services to develop region-specific best practices for dragon fruit cultivation and provide ongoing technical support to farmers.
- Market Linkages: Facilitate market linkages through farmer-producer organizations, cooperatives, and agro-industrial partnerships to ensure fair prices and market access for dragon fruit growers.
- Policy Support: Formulate policies supportive of dragon fruit cultivation, including land lease arrangements, credit facilities, and insurance coverage for farmers.

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