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Dragon Fruit Farming in Nepal: A Comprehensive Review

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Abstract Dragon fruit is a promising horticultural crop due to its resilience to pests, diseases, and abiotic stresses, as well as its nature to thrive on marginal lands. Dragon fruit can be grown in a in a wide range of soils, from sandy loam to clay loam, particularly in the Terai and lower hills of Nepal. A temperature of about 25 °C is suitable for its growth, and about 7-10 hours of sunlight are required for active growth and development. Dragon fruit is propagated by using cuttings and seeds, but seed is less favorable. Red pitaya, American beauty, Costarican sunset and white pitaya are widely popular varieties of dragon fruit in Nepal. The fruits are produced between June and September and harvested three or four times per month. Lack of market, high production costs, and lack of proper knowledge were the major problems in dragon fruit farming. This review points out the cultivation practices and challenges of dragon fruit in the country, aiming to help future research.
Keywords Dragon fruit; *Hylocereus* spp.; Cultivation; Challenges; Nepal

Introduction

Due to its medicinal and health benefits, dragon fruit, pitaya or strawberry pear (*Hylocereus* spp. and *Selenicereus* spp.), or kamalam, is becoming a super crop everywhere, even in marginal lands. It is essentially a climbing cactus vine native to Central and South America that is resilient to pests and diseases as well as abiotic stresses. It belongs to the Cactaceae family. It is popular for its unique aesthetic appeal, displaying a spectrum of vibrant colors in both its flesh and skin, ranging from red and pink to white and pink, red-purple, or yellow and white (Luu et al., 2021). This tropical and subtropical fruit is especially suitable for the Terai region and can even be successfully cultivated in the lower hills, thriving at altitudes up to 800 meters above sea level (Dhakal et al., 2021).

It has many benefits, such as low water and nutrient requirements, relatively low resource requirements for setting up the orchard and maintaining it, the ability to sustain a high yield for up to 20 years, a high benefit to cost ratio, and a high level of nutraceuticals and functional properties (e.g. rich in antioxidants and fibres). Because of its antioxidant properties, dragon fruit is often referred to as a "super-fruit" by many people. Dragon fruit, rich in fiber, water-soluble compounds, vitamin C, and antioxidants, offers a range of health benefits, including weight management and improved digestion. It also aids in reducing LDL cholesterol levels and boosting immune function (Hossain et al., 2021). All of these characteristics are enticing growers worldwide to start and grow their dragon fruit farming operations.

Dragon fruit was brought for first time in Nepal by veterinary doctor Jagannath Rai from USA through his friend in 2057 BS. After that this fruit has been distributed in 42 districts of Nepal, but farmers from Kavre, Sunsari, Bhairahawa, Dang, Lamjung, Pokhara, Kapilvastu has started commercial cultivation. Now a days it is extending in various parts of Nepal. Dragon fruit has potential for agro-tourism in Nepal. The purpose of this review is to provide a concise overview of its cultivation practices and challenges in the country, aiming to help future research.

1 Environment

1.1 Soil

Optimum soil environment is basic requirement for achieving higher yields. Dragon fruit can be grown wide range of soil from sandy loam to clay loam. However, well drained sandy soil with good organic matter is best for its cultivation. It can be grown in considerable degree of soil acidity and alkalinity but optimum pH is about 5-7. It cannot be cultivated in waterlogged condition.

1.2 Temperature

Dragon fruit is a semi-epiphytic plant that prefers a dry tropical or subtropical climate. Temperature about 25 °C suitable for its growth and when fruits are growing on the plant, its needs a temperature of 30 °C-35 °C but plant can also tolerate maximum temperature of 40 °C and minimum of 7 °C.

1.3 Moisture

For obtaining better yield 1,145-2,540 mm/year of rainfall is required. If the area is under irrigation, the about 1 inch of water is required weekly to the plants such that plants does not get completely dry.

1.4 Light

Light is important factor influencing growth, flowering and stem development. Dragon fruit belongs to photophilic plant species. About 7-10 hours of bright sunlight is highly useful for active growth and ripening. Compact lamps are also used for warming the dragon fruit trees.

2 Propagation and Planting Method

The most common propagation method in dragon fruit cultivation is by using cuttings, although it can also be propagated by seeds. However, using seeds is less favorable as it takes longer and does not retain the mother plant's characteristics, making it unsuitable for commercial cultivation.

For planting in the field, cuttings of about 20-30 cm in length should be used and treated with a 0.5% solution of Agallol or Aretan. The recommended pit size for planting is 60 cm × 60 cm × 60 cm, with a spacing of 2 meters between plants. This spacing allows for a plant density of 1,700 plants per acre of land.

3 Pitaya Varieties

Dragon fruit, also known as pitaya, is cultivated in various varieties, including Red pitaya, Pitaya Roja, Pitaya Amarilla, Yellow pitahaya, Alice, American beauty, Bloody mary, Cosmic Charlie, Costarican sunset, Dark star, David bowie, Delight, each with unique characteristics in terms of appearance, taste, and cultivation requirements. In Nepal, several varieties have gained popularity among farmers due to their adaptability to the local climate and soil conditions. The primary varieties of dragon fruit grown in Nepal include Red pitaya, American beauty, Costarican sunset, and White pitaya (Rijal, 2019).

3.1 Red Pitaya

Red pitaya is characterized by its vibrant red skin and red flesh. This variety is favored for its rich, sweet flavor and high nutritional content, including antioxidants, vitamins, and minerals (Huang et al., 2021). It is commonly cultivated in regions with a warm climate and well-drained soil. Red pitaya is known for its relatively high yield and robust growth, making it a popular choice among Nepali farmers.

3.2 American beauty

The American beauty variety is notable for its large, attractive fruit with red skin and purple-red flesh (Goenaga et al., 2020). It is highly valued for its sweet, mildly tangy flavor and high antioxidant content. This variety is also known for its disease resistance and adaptability to different growing conditions, making it suitable for diverse agricultural regions in Nepal.

3.3 Costarican sunset

Costarican Sunset is a variety that features bright red skin with vibrant red flesh. It is appreciated for its juicy texture and balanced sweetness. This variety has a strong growth habit and can produce abundant yields under optimal conditions. Costarican Sunset is particularly popular in Nepal due to its high market demand and appealing appearance.

3.4 White pitaya

White pitaya is distinguished by its white flesh and red or yellow skin. It has a mildly sweet flavor with a hint of tartness, making it a refreshing choice for consumers. This variety is well-suited to the Nepali climate and is relatively easy to cultivate. White pitaya is also known for its long shelf life and versatility in culinary uses.

The cultivation of these varieties in Nepal has been driven by the increasing demand for exotic fruits and the suitability of the country's climate for dragon fruit farming. Farmers are continually experimenting with different varieties to improve yield, taste, and marketability. The choice of variety depends on several factors, including local climate conditions, soil type, and market preferences.

4 Training and Pruning

The dragon fruit vine requires support from concrete, wooden poles, or wall columns because it is an epiphytic climbing cactus. Aerial roots must be linked to the column by an immature stem in order for them to develop and grow. Only a few primary stems are permitted to grow, while lateral shoots are prohibited.

Concrete or hard wood posts are advised since the chosen column must have long durability and strength to sustain the weight of a vine canopy greater than 100 kg. Typically, a 2 m tall cement pole or post is used for this, and it must be buried 30 to 40 cm beneath the surface of the earth. For drooping the stems downward side, the concrete circular or rectangular frame or trye is fixed on the top of pole. or steel wires.

5 Manures and Fertilizer

In dragon fruit cultivation, it's crucial to fertilize plants twice: once in early spring and again after the plants finish flowering. The general recommended dose for fertilization is 70:90:40 NPK (Nitrogen, Phosphorus, and Potassium) per year per plant. Nitrogen is a vital nutrient that promotes vigorous vegetative growth, improving leaf and stem development. It is particularly important during the early growth stages of dragon fruit plants (Hariyanto et al., 2023). Excessive nitrogen, however, can lead to excessive vegetative growth at the expense of fruit production, so careful management is necessary. Phosphorus is crucial for root development and enhances the plant’s ability to absorb water and nutrients. It also plays a key role in flower and fruit formation, thus directly affecting the yield (Hariyanto et al., 2023). Phosphorus should be applied at moderate levels to avoid deficiency symptoms such as stunted growth and poor flowering. Potassium contributes to the overall health of the plant by regulating physiological functions such as water uptake, enzyme activation, and protein synthesis. It is particularly important for improving fruit size, quality, and shelf life. A balanced supply of potassium ensures that the dragon fruit has good texture and taste.

In addition to chemical fertilizers, the application of organic manures like compost is highly beneficial for dragon fruit plants. Compost should be applied at a rate of 10-15 kg per plant. Organic manure improves soil structure, increases microbial activity, and enhances the soil’s water-holding capacity. It also provides a slow-release source of nutrients, promoting sustainable plant growth.

6 Water Management

The shallow root system of dragon fruit is primarily distributed between 15 to 30 cm of soil. Therefore, irrigation must be ensured to provide sufficient water during dry seasons. Scientific irrigation methods significantly impact the growth and yield of dragon fruit, with drip irrigation being considered one of the most effective methods.

6.1 Irrigation methods

Drip irrigation not only enhances water use efficiency but also reduces soil erosion and water evaporation. Research has shown that drip irrigation can significantly improve the growth condition and fruit yield of dragon fruit (Muslim et al., 2019). During summer or dry days, applying 2-4 liters of water per plant twice weekly is adequate.

6.2 Irrigation frequency and water volume

Stable water supply is essential for the growth of dragon fruit, especially during its flowering and fruiting periods. It is generally recommended to maintain a twice-weekly irrigation frequency during dry seasons, with 2-4 liters of water per application to ensure normal growth and development of the plants. However, specific irrigation frequency and water volume should be adjusted according to local climate conditions, soil type, and the growth stage of the dragon fruit.

6.3 Water quality management

The quality of water used for irrigation is also crucial for the growth of dragon fruit. Dragon fruit is sensitive to salinity; therefore, low-salinity water sources should be used for irrigation. Additionally, the pH of the irrigation water should be maintained between 6.0 and 7.5 to ensure optimal nutrient absorption and plant health.

6.4 Rainy season and drainage management

During the rainy season, excessive rainfall may lead to waterlogging in the soil, affecting the respiration and health of the root system of dragon fruit. Therefore, a good drainage system is essential to avoid waterlogging and root rot diseases. Drainage ditches can be set up in the planting area to ensure excess rainwater is drained promptly.

6.5 Dry season and water resource storage

In the dry season, the storage and management of water resources are particularly important. Reservoirs, water tanks, or rainwater harvesting systems can be used to store water for future use. Moreover, a reasonable irrigation schedule and water resource management strategy can effectively address the challenges of the dry season, ensuring stable and sustainable development of dragon fruit cultivation.

By implementing scientific water management measures, dragon fruit cultivation can maintain good growth conditions under various climate conditions, improve yield and fruit quality, and maximize economic benefits.

7 Weed Management

In the cultivation of dragon fruit, weed management is a crucial aspect. Weeds not only compete with dragon fruit for nutrients, water, and light but can also host pests and diseases, negatively impacting the growth of dragon fruit. Therefore, regular weeding is a necessary measure.

7.1 Manual and mechanical weeding

Manual weeding is a traditional and effective method, especially suitable for small-scale farming or areas with dense weed growth. By manually pulling out weeds, the roots can be completely removed, reducing the chances of regrowth. Manual weeding is typically conducted during the early planting stages and throughout the growth period, requiring frequent inspections and timely intervention.

For large-scale cultivation, mechanical weeding is a highly efficient option. Using weeding machines can significantly reduce labor intensity and time costs, improving weeding efficiency. Mechanical weeding is suitable for handling weeds between rows, but care must be taken to avoid damaging the dragon fruit plants.

7.2 Chemical weeding

The use of chemical herbicides can effectively control weed growth, but it is crucial to carefully select the appropriate type and dosage of herbicide to avoid adverse effects on dragon fruit and the environment. When

using chemical herbicides, it is important to follow pesticide use regulations and opt for environmentally friendly products whenever possible.

7.3 Biological weeding

Biological weeding is an environmentally friendly method of weed management, involving the introduction of natural weed predators or the use of biological agents to control weed growth (Ani et al., 2018). For example, certain insects, bacteria, or fungi can be used to inhibit weed reproduction and spread. This method not only reduces the use of chemicals but also helps maintain ecological balance.

7.4 Mulching

Mulching materials (such as black plastic film, straw, or weed mats) have multiple functions in dragon fruit cultivation. They can effectively prevent weed growth, retain moisture, regulate temperature, and improve soil structure. Mulching materials should be laid around the plants and regularly checked for effectiveness, with replacements made as necessary.

Weed management in dragon fruit cultivation should combine manual, mechanical, chemical, and biological methods, selecting the most suitable strategy based on specific conditions. Proper weed management can not only enhance the yield and quality of dragon fruit but also promote sustainable agricultural development.

8 Plant Protection Measures

8.1 Diseases

Anthracnose: Anthracnose can be controlled by pre-harvest spraying with Mancozeb (2 g/lit), Carbendazim (1 g/lit), Thiophanate methyl (1 g/lit), or Chlorothalonil (2 g/lit), three times at a 15 d interval.

Brown Spot: Cleanup in the field (collection and disposal of fallen diseased fruits, leaves and vines). vines can be pruned to have less density, which will make the crop less humid. copper-based fungicides sprayed on time.

8.2 Pest

Aphids: Prune to avoid a dense canopy, avoid intercropping with different hosts, and improve natural enemies by incorporating agroforestry and flower strips as natural habitats around the field. Spray Lambda, Cyhalothrin, Cypermethrin, Amidacloprid, Acetamipride, etc. at a rate of 1 m/ L of water.

Mealybugs: Spray profenophos 50 EC @ 2 mL, acephate 75 SP @ 1 g/L, quinalphos 25 EC @ 2 mL, chlorpyriphos 25 EC @ 2 mL, or thiodicarb 75 WP @ 2 g/L.

9 Flowering and Fruiting

The off-white dragon fruit flower blooms at night. Pollinators are drawn to them by their scent. Early in the morning is the best time to pollinate the dragon fruit with honey bees (*Apis cerema*), little honey bees (*Apis florae*), and rock bees (*Apis dorsata*).

Around semi-arid regions, dragon fruit flowering begins in June. Under standard cultivation procedures, there were five harvests total, but with good management techniques, two more flushes were collected each year. Large numbers of blossoms will be visible on every plant when the first flowering begins after a protracted dry period. A maximum of 80 blooms should be kept on each pole at a time after blossom thinning. Pay close attention as well.

10 Harvesting and Yields

After 12 to 15 months from the date of planting, the plant begins to produce. The fruits are produced by the plants between June and September, and they may be harvested three or four times per month.

The fruit weight varied from 300 to 800 grams, and the three-year-old planting produced an average yield of 30 to 35 kilograms from a single post. The annual yield of dragon fruit is typically 8-10 tonnes/ha.

11 Post-Harvest Management

Post-harvest management is a critical aspect of dragon fruit farming, ensuring that the fruit remains fresh and retains its quality from the time of harvest until it reaches the consumer. Proper handling and storage can significantly extend the shelf life of dragon fruits, minimizing losses and maximizing profitability for farmers.

Dragon fruits should be harvested when they reach full maturity, which is indicated by a change in skin color to red or yellow, depending on the variety. Harvesting is typically done manually using clean, sharp tools to avoid damaging the fruit. It is crucial to handle the fruits gently to prevent bruising and mechanical injury, which can lead to post-harvest decay.

After harvesting, dragon fruits are sorted and graded based on size, color, and external appearance. Fruits are categorized into different grades, with premium grades fetching higher market prices. This step is essential to meet market standards and consumer preferences.

Dragon fruits are cleaned to remove dirt, debris, and pesticide residues. This can be done using clean water or a mild detergent solution, followed by rinsing with clean water. Proper cleaning helps in reducing microbial load and enhances the appearance of the fruit.

Pre-cooling is an essential step to rapidly remove field heat from the harvested fruits. It helps in slowing down the metabolic processes, thereby extending the shelf life of the fruit. Forced-air cooling or hydro-cooling methods are commonly used for pre-cooling dragon fruits.

Packaging plays a vital role in protecting dragon fruits during transportation and storage. Fruits are typically packed in corrugated cardboard boxes with appropriate cushioning materials to prevent damage. Each box should be labeled with relevant information such as grade, weight, and handling instructions.

Proper storage conditions are crucial for maintaining the quality of dragon fruits. The ideal storage temperature for dragon fruits is between 6 °C-10 °C with a relative humidity of 85%-90%. Under these conditions, dragon fruits can be kept fresh for up to four weeks. Storage at lower temperatures can lead to chilling injury, while higher temperatures can accelerate ripening and spoilage.

By implementing these post-harvest management practices, farmers can significantly improve the shelf life and marketability of dragon fruits, ensuring that consumers receive high-quality, fresh fruits.

12 Challenges for Cultivation

The risky character of the new commodities market hampered the crop's adoption process since there would be uncertainty in obtaining the correct price for the produce. The high expense of cultivation was discovered to be the second most critical barrier impeding adoption. Therefore, for better results, the government must offer subsidies, training, and related various extension works through NARC, INGOs, and NGOs.

13 Conclusion

In conclusion, dragon fruit farming in Nepal is one of the best prospects for agricultural diversification and overall economic growth. This review describes the prospects of dragon fruits cultivation in Nepal and discusses its high tolerance to unfavorable factors and low demands on resources. There is no doubt that there are constraints of uncertainty in the market and high production cost but with these come the opportunities of enhancing the living standards of small farmers and food security. By combining all synthetic and analytical efforts, there is a big potential for the development of dragon fruit farming as a high-value agricultural enterprise in Nepal through support from government authorities.

Authors' contributions

AC, KPU: Conceptualized the review, led the literature search, revisions, and writing the manuscript. SA, KT: Assisted with the literature search, managed references, and writing the manuscript. All authors read and approved the final manuscript.

Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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