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Importance and advanced production practices for high value dragon fruit (*Hylocereus* spp.) crop: A review

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Abstract

Dragon fruit (*Hylocereus* spp.) crop is an important tropical plant belongs to family cactaceae, it is rich in essential nutrients viz. vitamins, minerals, carbohydrates, dietary fibres and antioxidants compounds. This fruit is popular due to its rich nutritional characteristics. Dragon fruit or pitaya is an unbelievable fruit that provides strong nutraceutical benefits due to its prebiotic function and multiple pharmaceutical and medicinal properties such as anti-oxidant, anti-cancerous, anti-diabetic, anti-microbial and hepato protective characteristics. The fruit also has capacity of wound healing, anti-anemic, anti-viral, anti-inflammatory and microvascular protective properties. These pharmaceutical and medicinal properties are due to different phyto-constituents such as polyphenols, pigments, flavonoids, fatty acids, terpenoids, steroids, vitamins, sugars, minerals and dietary fibres which are found in the fruits' peel, seeds and flesh. It boosts up immunity system of our body. This review describes adoptability, cultivation practices, nutritional values and importance of Dragon fruit. Dragon fruit crop has characteristics of good adaptability due to its cactus nature and grown well in medium heavy soils. Dragon plants are commercially propagated by stem cuttings. Flowering buds are emerged out in plants after 15-18 months of planting and it come in full blooming stage after 28-30 days of the bud emergence. The productivity and quality of Dragon fruit vary depending on the species, cultural practices of cultivation, place and harvesting time. It is a short duration, fast growing, high return perennial crop suited for income generation to small and marginal farmers. Investigation on different techniques of package of practices and importance of this fruit may reveal the scope of the crop for farmers and end user to extend cultivation area and demand of the fruit.

Keywords: Cultivation techniques, fruit, nutritional value, pitaya

1. Introduction

Dragon fruit (*Hylocereus* spp.) also known as pitaya. It is a fast growing perennial vine cactus belongs to Cactaceae family originated from Mexico and South America. The fruit crops has covered area of tropical and sub-tropical America, Asia, Australia and the Middle East from its Centre of origin. Its cultivation practices well established in Australia, Cambodia, China, Israel, Japan, Nicaragua, Peru, Philippines, Spain, Sri Lanka, Taiwan, Thailand, South-Western USA and Vietnam (Mizrahi and Nerd, 1999; Nobel and Dla Barrera, 2002) ^[13, 16]. Dragon fruit crop has been popularized also in South East Asia (Patwary *et al.*, 2013) ^[5]. Cultivation practices of Dragon fruit is increasing in last few years owing to its medicinal and economic importance and finally its usefulness as raw materials to provide chemical compounds with rich antioxidant capability (Parmar *et al.*, 2019) ^[17]. It has become increasingly popular due to its unique shape and taste along with its health benefit and medicinal value. Gujarat, Karnataka and Maharashtra are the major producing state of India sharing about 70% of total dragon fruits production. Dragon plant showed attractive characteristics due to its exotic appearance (Liaotrakoon, 2013) ^[8]. Dragon fruit's plant is a fast-growing perennial vine generally propagated commercially through vegetative means by stem cutting. Due to its nutritional values, fruit crop is considered as an important economic fruit species in the world (Rifat *et al.*, 2019) ^[19]. The species, cultivar, season, place, climate, cultivation practices, water availability, transport, handling and storage facility may affect the chemical compounds of Dragon fruit (Franke *et al.*, 2004; Wall, 2006) ^[29, 27]. Dragon crop has great potential for adaption as a new crop for growers due to its less water requirement and good survival to the high temperatures (Trivellini *et al.*, 2020) ^[25]. Dragon fruit is a highly nutritious fruit known for its pleasant taste, crisp texture, and richness in sugars and

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Antioxidants (Rao and Sasanka, 2015) ^[21]. It contains water-soluble fiber, along with significant amounts of vitamin C and antioxidants such as betalains, hydroxycinnamates, and flavonoids, which provide multiple health benefits (Moshfeghi *et al.*, 2013) ^[14]. These include aiding in weight management, improving digestion, lowering LDL cholesterol levels, and boosting the immune system. Hydroxycinnamates are particularly noted for their cancer-preventing properties, while flavonoids contribute to brain and cardiovascular health by reducing the risk of heart disease. Additionally, dragon fruit has antimicrobial properties, helping to protect the body from bacteria and fungi (Verma *et al.*, 2017) ^[26]. Its popularity in Asia can be attributed to its nutritional benefits, attractive appearance, and vibrant color (Harivaindaran *et al.*, 2008; Hoa *et al.*, 2006) ^[6, 7]. Dragon fruit is consumed both fresh and in processed forms such as juices, jams, and syrups. However, despite the fact that dragon fruit peels, which make up about 22% of the fruit, are rich in polyphenols. A potent source of antioxidants, they are often discarded rather than being fully utilized. In recent years, dragon fruit cultivation has been expanding in various parts of India, owing to its adaptability to different climates and environmental conditions. Despite this, there is still limited research and information available on optimal cultivation practices and production aspects (Karunakaran and Arivalagan, 2019) ^[9]. As a commercially promising plant, dragon fruit offers substantial health benefits, a longer shelf life, and the ability to thrive in water-scarce regions. However, it has yet to gain widespread attention from Indian farmers. This review focuses on compiling current knowledge regarding cultivation techniques, nutritional values, and the overall significance of dragon fruit based on recent studies.

2. Nutritional value of Dragon fruit

Nutrient	Amount (Per 100 g)
Water	87.0 g
Protein	1.1 g
Fat	0.4 g
Carbohydrates	11.0 g
Fibre	3.0 g
Vit. B1	0.04 mg
Vit. B2	0.05 mg
Vit. C	20.5 mg
Ca	8.5 mg
Fe	1.9 mg
P	22.5 mg

Source: FAO, 2002 and <https://www.heelwithfood.org>

3. Dragon fruit plantbotanical characters

The Dragon fruit plant (*Hylocereus spp.*) is a fast-growing, evergreen, perennial vine belonging to the family Cactaceae, characterized by its leafless, thin, vine-like branches, it can climb to heights of up to 10 meters. The plant's stems are typically triangular, with three sides, though sometimes they may have four or five sides. These stems are green, fleshy, jointed, and highly branched, with each segment having three wavy ribs and corneous edges. Some varieties are spineless, while others feature 1-3 small spines along the green stems (Patel and Ishnava, 2019) ^[18]. The plant's aerial roots, which grow from the underside of the stems, help absorb water and anchor the plant to vertical surfaces.

Dragon fruit flowers are usually large, white, nocturnal, and fragrant. Measuring 25-30 cm in length and 15-17 cm in width, they are hermaphroditic, meaning they contain both male and female reproductive organs (Merten, 2003) ^[12]. The fruit is an

oblong to ovoid fleshy berry, typically 6-12 cm in length and 4-9 cm in diameter, with a red outer skin adorned with large bracteoles. The pulp inside is white, embedded with numerous small black seeds. On average, the fruit weighs between 350 and 400 grams, though it can reach up to 900 grams.

There are three primary types of dragon fruit: red skin with white pulp (*Hylocereus undatus*), red skin with red pulp (*Hylocereus monacanthus*, formerly called as *H. polyrhizus*), and yellow skin with white pulp (*Hylocereus megalanthus*, previously known as *Selenicereus megalanthus*) (Patwary *et al.*, 2013) ^[5]. The red-fleshed varieties are especially noted for being rich in antioxidants. Dragon fruit is an epiphytic or xerophytic plant, requiring structural support to grow vertically. While numerous species of *Hylocereus* exist, most are cultivated for ornamental purposes due to their striking flowers, with only five species being significant fruit producers. This perennial plant has a long commercial lifespan, lasting up to 20 years, and begins fruit production as early as the second year after planting

4. Production practices

Plants grown from seeds do not produce true-to-type offspring, leading to considerable variability among plants. As a result, seeds are generally not used for the commercial propagation of dragon fruit (Tripathi *et al.*, 2014) ^[24]. Instead, dragon fruit is commercially propagated through vegetative means, primarily using stem cuttings. For optimal results, a mature cutting of 15-30 cm from the entire or a portion of the stem should be used. To minimize the risk of diseases, particularly rots, the cuttings should be treated with fungicides and cured in a cool, dry location for 5-7 days before planting. Rooted cuttings are typically ready for transplantation into the main field after 30-40 days of growth in a nursery. For proper air circulation and disease prevention, planting spacing of 3.0-4.0 m x 3.0 m is recommended. In low-fertility dryland areas, a denser plant population with spacing of 3.0 m x 2.5 m is advised to offset any reduction in yield per unit area.

Although dragon fruit is a type of cactus, it does not tolerate extreme temperatures or excessive light exposure. The plant thrives in warm climates, making it well-suited for semi-arid regions (Feng-ru and Chung-Ruey, 1997) ^[4]. Ideal growth temperatures range between 18 °C and 25 °C, with adequate relative humidity. Environmental factors such as photoperiod, temperature, rainfall, light intensity, and humidity levels influence the flowering and fruit-setting processes in dragon fruit (Mallik *et al.*, 2018) ^[11].

Dragon fruit can be successfully cultivated in a wide variety of soils, though loamy soils rich in organic matter and with a slightly acidic pH (5.5-6.5) are ideal. The best results are seen in areas with average rainfall ranging from 500 to 1500 mm.

4.1 Training and pruning

Dragon fruit is a climbing cactus with epiphytic growth habits, meaning that it requires support structures like concrete, wooden posts, or wall columns to climb. Immature stems should be tied to these supports to help the aerial roots develop and attach to the column. Lateral shoots are limited, allowing only 2-3 main stems to grow. The support column must be durable and strong enough to bear the weight of the vine canopy, which can exceed 100 kg. Therefore, concrete or hardwood posts are ideal. Typically, cement poles or posts about 2 meters in height are used, with the base buried 30-40 cm into the ground for stability. A circular or rectangular concrete frame or tire is often fixed at the top of the post to encourage the vines to droop downward. It is important not to use steel wires or iron frames, as these can

damage the vines. Support posts should be installed before planting to ensure they are secure for the vines to climb. Usually, three to four plants are planted around each post. Planting is typically done during the rainy season, with ridges about 50 cm high created to help support the plants. Four cuttings are planted per post. As the vines grow rapidly, there is an increased risk of them lodging or falling to the ground. To prevent this, vines must be tied securely, and lateral branches regularly pruned. Structural pruning is necessary to manage the vine's growth. Only the outer leading vine is allowed to grow until it reaches the top of the trellis, after which free branching is permitted. The number of branches should be reduced to 30-50 by trimming unwanted branches, a process known as production training. After harvesting, approximately 50 main branches should be retained, with one or two secondary branches allowed to grow on each main branch. Any tertiary or quaternary branches should be pruned, and the cut ends treated with fungicide to prevent disease.

4.2 Nutrient management

Dragon fruit requires a balanced and careful application of manure and fertilizers to achieve higher yields. During the early stages of growth, higher levels of nitrogen are necessary for robust vegetative development, while in later stages, increased amounts of phosphorus and potassium are crucial. Calcium and other micronutrients also play an essential role in enhancing crop growth. Organic matter is vital for dragon fruit development, and each plant should receive 10 to 15 kg of organic compost or farmyard manure (FYM). In cases where soil fertility is poor, it's recommended to apply 10-15 kg FYM along with 100 g of single super phosphate (SSP) per plant at the time of planting.

Chemical fertilizers should be applied about 2 to 3 months after planting, once the plant begins to show growth. The type and quantity of chemical fertilizers depend on soil quality. In light soils with poor fertility, during the first two years, 500 g of urea, 500 g of phosphorus (P), and 300 g of potassium (K) should be applied per pole annually, divided into four doses at three-month intervals. As the plant matures and requires more nutrients, from the third year onward, each pole (Supporting four plants) should receive 800 g of nitrogen (N), 900 g of phosphorus, and 550 g of potassium annually. This should be distributed in three applications: one just after harvest, one during flower setting, and one after fruit setting. Nutrients should be applied both at the base of the plant and through fertigation using a drip system installed at the top of the pole to feed aerial roots (Nangare *et al.*, 2020) ^[15]. For an established crop, a recommended fertilizer regimen includes applying 40 kg of FYM, 50 g of urea, 100 g of triple super phosphate (TSP), 100 g of muriate of potash (MoP), 100 g of gypsum, and 10 g of borax per pit to increase fruit production (Rahim *et al.*, 2009) ^[28]. The recommended dose during the first year is 50: 50: 100 g of urea, single super phosphate, and muriate of potash per pillar, along with 10-12 kg of organic manure per plant, with the dose increasing by 2 kg per year. Fertilizers should be applied in 2-3 splits, with the first application in February-March before flowering, and the second in November-December after harvest to ensure better fruit quality (Kumar *et al.*, 2022) ^[10].

The root system of the dragon fruit plant is shallow, allowing it to efficiently absorb even small amounts of nutrients. Combining mineral and organic fertilizers is especially beneficial for the plant. An experiment conducted at BCKV, Kolkata, India, revealed that the best results in terms of yield and quality were obtained with a fertilizer dose of 450 kg

nitrogen, 350 kg phosphorus (P_2O_5), and 300 kg potassium (K_2O) per hectare. These nutrients were supplied in four split doses per pillar, each supporting four plants, with 10%, 10%, and 30% applied before flowering, 20%, 40%, and 25% during fruit setting, 30%, 20%, and 30% at harvest, and 40%, 30%, and 15% two months after harvest (Anon, 2017) ^[1].

4.3 Water management

Dragon fruit requires minimal water during its most critical period of water availability, which occurs from March to June. Flowering in this crop begins in June and can continue until October. Irrigation is necessary only during extended dry spells. However, the crop is intentionally subjected to water stress during the pre-bloom period (April-May) to encourage the production of more flowers. A drip irrigation system is often used to maintain optimal soil moisture during the fruit development stage. During the first and second years, the irrigation requirement is typically around 1000-1500 liters per pole per year. In India, the flowering and fruiting of dragon fruit coincide with the rainy season, so it is important to prevent waterlogging and excess moisture caused by rainfall to avoid damage to the crop.

4.4 Flowering and fruiting

Dragon fruit flowers bloom at night and are off-white in color. Their pleasant fragrance attracts pollinators. Effective pollinators for dragon fruit include the honey bee (*Apis cerana*), little honey bee (*Apis florea*), and rock bee (*Apis dorsata*), which are active in pollination during the early morning hours (Pushpakumara *et al.*, 2005) ^[20]. Flowering typically occurs from May to August, and the fruits are ready for harvest 30-40 days after they set. In semi-arid regions, flowering usually begins in June. To ensure optimal fruit production, thinning of flowers is necessary, limiting the number of flowers to a maximum of 80 per pole at any given time. Additionally, care must be taken to remove any fruits that are growing too closely together on the same branch. Dragon fruit exhibits indeterminate growth, meaning that flowering and fruiting can occur simultaneously. As the fruits begin to change color from green to red, they should be covered with cotton bags to protect them from bird damage and pests. There is significant variation in the size and shape of the fruits between different varieties, and currently, there is limited knowledge regarding the specific varietal and production characteristics of dragon fruit (Karunakaran and Arivalagan, 2019) ^[9].

4.5 Pest and Disease Management

Dragon fruit is relatively resistant to many pests and diseases, though it is affected by a few notable ones. Common pests include mealy bugs, aphids, and termites, which are sap-sucking insects that feed on the plant's sweet sap. Aphids, in particular, attract ants, which then feed on the plant as well. Other pests like mites and thrips, while not fatal to the plant, can negatively affect its overall health. Additionally, fruit flies have been observed damaging dragon fruit, and the use of pheromone traps in orchards is recommended for controlling fruit flies.

While dragon fruit is generally tolerant to most pests and diseases, some diseases do pose a threat. These include anthracnose, brown spots, and stem rots caused by both fungal and bacterial pathogens. Anthracnose, caused by *Colletotrichum siamense*, has been reported in India, particularly in the Andaman Islands (Abirami *et al.*, 2019) ^[2]. Stem rot, caused by *Xanthomonas* species, is another concern, especially in areas with heavy rainfall. Proper drainage, wider plant spacing, and

ensuring good air circulation and sunlight can help mitigate the risk of these diseases.

Sunburn is another issue commonly noticed in dragon fruit plantations, particularly when temperatures exceed 38 °C. If too much water is applied to the plant, root rot can occur. In regions like Vietnam, fruit flies are a major pest affecting fruit quality. Aphids can infest flowers or fruits, and young plants may be susceptible to slugs and snails under damp conditions. Other diseases such as stem rot caused by *Xanthomonas campestris* and brown spots on fruits caused by *Dothiorella* have been reported in some areas. Viruses, such as Cactus Virus X (CVX), can also affect dragon fruit, leading to stunted, malformed, and mottled growth.

4.6 Harvesting

The dragon fruit plant begins to yield fruit approximately 12-15 months after planting. The optimal maturity of the fruit is indicated by a change in the epicarp colour from green to red, with the best harvesting time identified as seven days after this colour transition. Typically, fruiting occurs between June and September, with dragon fruit maturing 30-35 days after flowering.

4.7 Yield

The weight of dragon fruit typically ranges from 300 to 800 grams, with an average yield of about 30 to 35 kg per post from plants that are three years old.

5. Conclusion

Dragon fruit is a fast-return perennial crop that offers high yields, providing a consistent income for growers. Despite the high initial establishment costs associated with cement poles and trellises, it is increasingly popular among farmers due to its significant financial returns (Thokchom *et al.*, 2019) ^[23]. When cultivated in water-scarce regions, dragon fruit can be a valuable asset for smallholders and entrepreneurial farmers. Once established, the plants can produce for approximately 15-20 years. They begin generating income about 1.5 years after planting, primarily through the sale of pruned plant parts for propagation, and from the second year onward, through the sale of the fruits.

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