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Dragon an exotic super fruit: A review

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Abstract

Dragon, a recently introduced super fruit in Indian markets, is getting fabulous popularity among farmers due to its nutraceutical value, attractive colour and delicious pulp with edible black seed embedded in its pulp, excellent export potential and highly remunerative. It starts producing fruits 14-16 months after planting of stem cuttings and keeps producing fruits up to 20 years with long fruiting period usually from May to December in several flushes. The fruits are available in two colours, *i.e.*, Red-skinned and (ii) Yellow-skinned. It is also preferred to grow in kitchen gardens because of its gorgeous nocturnal white flowers. Under Indian conditions, two species, *i.e.*, (i) *Hylocereus costaricensis*, which is red-fleshed pitaya and (ii) *Hylocereus undatus*, which is a white-fleshed pitaya is particular in West Bengal. This review includes research findings on cultivation practices of dragon fruit under Indian conditions so that the farmers and consumers may be familiar with dragon fruit.

Keywords: dragon fruit, ecology, harvesting, nutraceutical value, nutrient requirement, reproductive biology

Introduction

Dragon fruit is the species of cactus, which is originally grown in southern Mexico and South and Central America (Britton and Rose, 1963; Morton, 1987; Mizrahi *et al.*, 1997) [6, 25, 24]. In early 19th century, the French brought it to Southeast Asia. It is recently introduced in India and considered a promising and highly remunerative fruit crop. Its fruits are very attractive with mouth melting pulp and black edible seed embedded in pulp, which is very high in nutritive value. Now a day, it is the centre of attraction for the growers of India. It is a long day plant with beautiful night blooming flowers named as *Queen of the Night*, meaning *Noble Woman*. Dragon fruit is also known by other names also, *i.e.*, strawberry pear, *Pithaya*, night blooming cereus, belle of the night, Cinderella plant and Jesus in the cradle. The name *Pitaya* has been given to dragon fruit because of the bracts or scales on its skin, hence known as *the scaly fruit*. It has ornamental value because of its large gorgeous creamy white flowers of 22-25 cm diameter, which bloom at night. It is considered as a fruit of 21st century (Gunaseena and Pushpakumara, 2006; Gunaseena *et al.*, 2006). There are three types of dragon fruit, *i.e.*, (i) *Hylocereus undatus*— white flesh with pink skin, *i.e.*, (ii) *Hylocereus polyrhizus*— red flesh with pink skin, *i.e.*, (iii) *Hylocereus costaricensis* – with violet red flesh and pink skin and *Hylocereus (Selenicereus) megalanthus* – white flesh with yellow skin.

The biggest advantage of this crop is that once planted, it will grow for about 20 years, and 1 hectare could accommodate about 800 dragon fruit plant. It is mainly grown commercially in Israel, Vietnam, Taiwan, Nicaragua, Australia and the United states (Merten, 2003) [22]. It starts fruit bearing in the second year after planting and optimum production within five years. This article mainly concentrates on how to cultivate dragon fruit based on the literature and research work done on the genus *Hylocereus* and species *costaricensis*. *Hylocereus* comprises 16 species, which are endemic to Latin America and they are not very popular among the growers and researchers. Very few research works have been done on this fruit crop in India. Specific topics associated with the difficulties met by countries that have introduced the new species. Therefore, the research thrust must be given in the following areas; floral biology and ecophysiology. This article mainly focus on literature available on *Hylocereus*, grouping the references which covers importance, botany, vegetative and reproductive biology, cultivation, manuring, pollination, harvesting, pest & disease. So that everyone become familiar with dragon fruit.

Nutritional security and importance of dragon fruit

Proximate nutraceutical values in g or mg per 100 g edible portion of white-flesh dragon fruit are as follows: moisture (85.3%), protein (1.1), fat (0.57), crude fiber (1.34), energy (Kcal)

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(67.7), ash (0.56), carbohydrates (11.2), glucose (5.7), fructose (3.2), sucrose (not detected), sorbitol (0.33); vitamin C (3.0), vitamin A (0.01), niacin (2.8), Ca (10.2), Fe (3.37), Mg (38.9), P (27.75), K (272.0), Na (8.9) and Zn (0.35) and for red-flesh fruit, moisture (82.5-83.0), protein (0.159-0.229), fat (0.21-0.61), crude fiber (0.7-0.9) and ascorbic acid (8-9) (Jaafar *et al.*, 2009). Dragon fruit, young stems of *Hylocereus undatus* are edible as well as fresh flower buds that are eaten as vegetables, while dried ones are used for homemade medicine. In Taiwan, dry flowers are consumed as vegetables besides this it is also taken in the form of juice, jam, or preserves according to the taste needed, besides used as fresh table fruit. According to Luders and Mc Mahon, G., (2006) [18] it is widely used as juice and in fruit salads at restaurants. Regular consumption of Dragon fruit helps in fighting against cough and asthma; also it helps for healing wounds and cuts quickly due to it contains high amount of vitamin C. However, the high level of vitamin C found in Dragon fruit plays an important role to enhance immune system and also to stimulate the activity of other antioxidant in the body. In addition to being used as a food coloring agents, consumption of Dragon fruit mostly as fresh fruit as relieving thirst due to it contains high water level compared with other nutrient levels. Health benefits of Dragon fruit are also rich in flavonoids that act against cardio related problems, also dragon fruit aids to treat bleeding problems of vaginal discharge. Dragon fruits are rich in fibers; however, it aids in digestion of food. Dragon fruit is also packed with B vitamin group (B₁, B₂ and B₃) which possess an important role in health benefit. Vitamin B₁ helps in increasing energy production and in carbohydrate metabolism, Vitamin B₂ in Dragon Fruit acts as a multivitamin; however, it aids to improve and recover the loss of appetite. And Vitamin B₃ present in dragon fruit plays an important role in lowering bad cholesterol levels; it provides smooth and moisturizes skin appearance. As well as it improves eye sight and prevent hypertension. Dragon fruit is also helpful in reducing blood

sugar levels in people suffering from type 2 diabetes. Studies suggest that dragon fruit helps in controlling the blood sugar level for diabetes patients. It contains high level of phosphorus and calcium. It helps to reinforce bones and play an important role in tissue formation and forms healthy teeth.

Botanical classification

Dragon fruit belongs to the botanical family Cactaceae and genus *Hylocereus*. This genus is mainly characterized by climbing vine cactus with aerial roots that bear a glabrous attractive berry with large scales reported by Fournet, (2002) [13]. *Hylocereus* spp. are diploid ($2n = 22$) (De Dios, 2004; Lichtenzveig, *et al.*, 2000) [10, 16]. In Latin America, family Cactaceae (Caryophyllales) comprises between 120 and 200 genera consisting of having 1500 and 2000 species are grown (Spichiger *et al.*, (2000) [31]. Cactaceae are mainly appreciated for their ornamental qualities, but they also include nearly 250 cultivated species of fruit-bearing and industrial crops (Fouqué, 1969) [12]. However, few species are of economic value. The genus *Opuntia* Mill. is probably the most widely cultivated for its fruits (cactus pear, prickly pear, Barbary fig or tuna).

At present world market contributes four types of dragon fruit (i) red skin, white flesh (*Hylocereus undatus*), mainly from Vietnam and Thailand (ii) red skin, red flesh (*Hylocereus polyrhizus*) come mainly from Israel and Malaysia (iii) red skin, purple flesh (*Hylocereus costaricensis*) from Guatemala, Nicaragua, Ecuador, and Israel and (iv) yellow skin, white flesh (*Hylocereus (Selenicereus) megalanthus*) from Colombia and Ecuador (Fig. 1). The red-skin with white flesh, red-skin with red flesh, and red-skin with purple flesh and yellow-skin with white flesh accounts approximately 94, 4.0, 1.5 and 0.5% shares in world market. Guesstimates can put on current world dragon fruit production to be more than 2.1 million tonnes over an area of 1.12 lakh ha (2017-18). Vietnam, China, Indonesia, Thailand, Taiwan, Malaysia, Philippines, Comodia, India and USA are the leading producers.



Fig 1: Four different types of dragon fruit in world market

Origin, distribution and ecology of Dragon fruit

Most *Hylocereus* species originate principally is originated in Mexico and Central and South America (Mizrahi *et al.*, 1997; Daubresse Balayer, 1999) [25, 8]. Today *Hylocereus* sp. are distributed over the world (in tropical and subtropical regions) but *H. undatus* is the most cosmopolitan species in India

followed by *H. costaricensis*. Because of the hardy nature of this fruit crop it can survive adverse climatic conditions of arid and semi-arid region of India. *Hylocereus* species are semi-epiphytes and consequently normally prefer to grow in the half-shade (conditions provided in nature by trees), however, *H. undatus*, *H. costaricensis* and *H. purpusii*, are

some species can be grown in full sun. However, very hot sun and insufficient water may lead to burning of the stems and flower bud drop. In the Neveg Desert in Israel, the most favorable conditions for growth and fruit production were found to be 30% shade for *H. polyrhizus* (Raveh *et al.*, 1998)^[29]. In the French West Indies (Guadeloupe and Saint-Martin), cultivation of *H. trigonus* is only possible with about 50% shade. Excess water systematically results in the abscission of flowers and young fruits (Barbeau, G. 1990 and Le Bellec, 2004)^[4, 15]. *Hylocereus* species can adapt to different types of well-drained soil (Daubresse Balayer, 1999; Barbeau, 1990 and Bárcenas, 1994)^[8, 4, 5]. In Vietnam, *H. undatus* has undergone extensive development with nearly 2000 ha under cultivation (Daubresse Balayer, 1999)^[8].

Vegetative and reproductive biology of red and white Pitaya

The flowers of these two species appear from the uplifting of areoles; they are large (more or less 30 cm) (Anon, 2017)^[1], in the shape of a funnel and nocturnal. The ovary is located at the base of a long tube carrying the foliaceous scales to the exterior is 3 cm in length (Anon, 2017)^[1]. There are numerous stamens on a slender anther stalk. The unusually large, tubular style is 20 cm in length and 0.5 cm in diameter (Anon, 2017)^[1], the stigmas have 21 slender lobes, creamy green in colour (Daubresse Balayer, 1999; Luders, 1999; Anon, 2017)^[8, 19, 1]. Floral growth does not depend on water availability, but on day length; in Vietnam, floral induction is often triggered using artificial light to increase day length but, water unavailability after bud break will cause death of bud and flower drop (Anon, 2017)^[1]. The floral buds can remain in the latent stage for many weeks (Daubresse Balayer, 1999)^[8] and the beginning of flowering generally occurs after the rainy season (Barbeau, 1990 and Anon, 2017)^[4, 1]. In the southern hemisphere, *H. undatus* and *H. costaricensis* flower from November to April and, in the northern hemisphere, from May to October (Barbeau, 1990 and N'Guyen, 1996)^[4, 16]. Under west Bengal condition flowering begins from May and extended up to 1st week of December after 14 months of planting of the cutting with seven major flowering cycles (Anon, 2017)^[1]. Flowering period is between 3 to 4 weeks flushes (Barbeau, 1990; Le Bellec, 2004)^[4, 14] which makes it possible to see floral buds, flowers, young fruits and mature fruits on the same plant at the same time. The periods between the appearance of floral buds (lifting of the areole) and flowering (stage 1), and between flower anthesis and fruit harvest (stage 2) are very short: around 15 to 20 days for the first stage and 30 days for the second stage. Dehiscence takes place a few hours before the complete opening of the flower. Pollen is abundant, heavy and not powdery and yellow in colour. Flowers opening time is mainly at between 20:00-20:30 pm the stigma dominates the stamens (the position of the stigma at this stage encourages allogamy). Flowers bloom only for a day and then close (whether fertilized or not) in the morning of the day after anthesis. The following day, petals become soft and then slowly dry. The lower part of a non-fertilized flower becomes yellowish and the whole flower falls off 4 to 6 days later, while the lower part of a fertilized flower remains greenish and increases enormously in volume, indicating that the fruit has set (Anon, 2017)^[1].

Cultivation techniques of Dragon fruit

Cultivation of dragon fruit already started in different part of west Bengal with many success stories of farmer from

different regions. However, it was first successfully grown in Gujarat state. Many nursery men started propagation for raising planting material of dragon fruit.

Propagation and planting density

H. undatus and *H. costaricensis* can be multiplied naturally and very easily by cutting off the stem as soon as it touches the ground (Fouque, 1969)^[12]. It takes 14 months to come to bearing under west Bengal condition; however duration may vary in different locality for different climatic conditions. Seeds can also be used as propagation material but it will take 3 years to come to bearing. The hardiness of the crop enables it to survive under field condition. Provided cuttings are at least (50 to 70) cm in length (N'Guyen, 1996)^[16] and are regularly watered in order to ensure satisfactory rooting. If all these conditions are provided around 90% of the cuttings, ensure rooting (Le Bellec, 2003)^[14]. The distance between plants depends on the type of support used. With a vertical support a 2–3 m distance between planting lines is required which could accommodate 2000 and 3750 cuttings/ ha, at the rate of three cuttings per support is planted (N'Guyen, 1996 and Barbeau, 1990)^[16, 4]. With horizontal or inclined supports the density can be much higher since the cuttings are planted every 50–75 cm around the production table (6500 cuttings ha⁻¹) or along the inclined support (6500 cuttings–1) (Le Bellec, 2003)^[14]. Planting at a distance of 2.5 m each to row and between the plants with 4 cutting/ support can accommodate 6400 plants / ha and also gives good yields and quality of fruits (Anon, 2017)^[1]. The height of these different types of support should be between (1.40 and 1.60) m for vertical supports and between (1 and 1.20) m for horizontal and inclined supports to facilitate management of the crop.

Scenario of Dragon fruit cultivation in India

Dragon fruit is a semi epiphytic vine plant which can climb naturally to any natural or artificial support they meet (trees, wood or cement posts, stone walls, etc.) due to presence of aerial roots. Many different types of support are used, but mainly vertical supports made of wood or cement and iron posts are mainly used (N'Guyen, 1996 and Barbeau, 1990)^[16, 4]. Plant growth is rapid and continuous, though possibly with a vegetative rest period when the climatic conditions are unfavorable (drought and very low temperatures). Growing them flat on the ground is not recommended, firstly because it makes cultivation more difficult (pollination, harvest, etc.), secondly because contact with the ground causes damage to the vines (Le Bellec, 2003)^[14]. Pitahaya are thus best grown on living or dead supports (De Dios, *et al.*, 2000 and Barbeau, 1990)^[9, 4]. Plant growth is rapid and continuous, though possibly with a vegetative rest period when the climatic conditions are unfavorable (drought and very low temperatures). When vertical and horizontal supports are used, pruning is important and the stems should be selected in such a way as to force the plant to climb over the entire support. All lateral growth and parts of the plant facing the ground should be removed, while the main stems and branch stems are kept, except those that touch the ground. Major pruning is carried out the first year after planting. Whatever the support used, the stem must be attached to it with a clip. The aim of maintenance pruning is to limit bunch growth and this should be carried out as early as the second year after planting. In practice, the extent of pruning depends on the type of support and its strength. For example, a 3-year-old plant weighs around 70 kg (Le Bellec, 2003)^[14]. Even if

this weight is not in itself a problem for the different types of support, bunches may not be able to withstand high speed winds. Pruning consists of removing all the damaged stems from the plant in addition to those that are entangled with one another. The post-harvest pruning encourages the growth of new young shoots that will bear flowers the following year.

National Status

Dragon fruit production in India

In India, dragon fruit was introduced during the late 1990 (Arivalgan *et al.*, 2019) [2]. Thereafter, area under its cultivation was gradually increased from 4 to 400 ha in different states during 2005–2017 (Table 1). Initially cultivation of dragon fruit was started by the farmers from Karnataka, Maharashtra, Gujarat, Kerala, Tamil Nadu, Orissa, West Bengal, Andhra Pradesh, Telangana and Andaman & Nicobar Islands. Nowadays, its cultivation has extended to Rajasthan, Punjab, Haryana, Madhya Pradesh, Uttar Pradesh and North Eastern States. According to recent estimates, India's dragon fruit production increased drastically to more than 12,000 MT over an area of 3,000–4,000 ha in 2020. These estimates are based on the first-hand information collected by the ICAR–NIASM from progressive growers, entrepreneurs, consultants and officials of state agricultural departments across the country.

Table 1: Year wise estimated area (ha) under dragon fruit cultivation in India

Years	Area (ha) under cultivation
1990	Introduced in India (0.5)
2005	4.0
2010	12.0
2012	15.0
2014	35.0
2017	400.0
2020	3,085.0

Source: Digital and printed information available in public domain. #data collected by ICAR– NIASM

The sudden rise in production and cultivated area are mainly because of states like Karnataka, Maharashtra, Gujarat, Telegana, Andhra Pradesh and West Bengal, which have taken initiatives to promote commercial production after 2018 onwards. Out of total 3,085 ha, more than 80% area (2,468 ha) is under new cultivation with less than 18 months old plantation. Further, average productivity of these areas is ranging from 1.5 to 3.1 MT/ha. While remaining 20% cultivation area (617 ha) is already well established and attained its full maturity level with average productivity of 8–13.5 MT/ha. Indian farmers, who follows good cultivation practices under drip irrigation, can get up to 4.5 tonnes of fruit per ha in the first year after planting, up to 7.5–10 tonnes/ha in the second years and 16–24 tonnes/ha on third year onwards.

Water and nutrient management

Necessity of regional specific optimization of irrigation practices/ fertigation schedules depending upon soil and climatic conditions. About 2–4 litres of water weekly twice per plant is sufficient during the summer/dry days. However, water requirement may increase or decrease depending upon soil, climate and plant health. Development of standard irrigation methods seems to be prerequisite for improving fruit yield, quality and water productivity of degraded and rainfed areas. Installation of drip system could be main

practice in orchards of dryland areas. Thus, possibility of finalizing the location of drip lines on surface, middle and top of the poles need to be explored since plant has also a kind of entangled stem roots sometimes floating in air. Most of the times, roots of dragon fruit spread over top of the soil surface and it might dry up easily resulting in adverse effect on the fruit growth and production. In these situations, sprinkling with water pump mounted behind the mini-tractor could be immediate solution to overcome the problem. In low land water logged areas, planting beds need to be raised as furrow and ditch system. The aim of furrow is to increase the soil layer for root systems above to protect the plants from water logging. Further, to avoid problems of floodwater occurred during rainy season, there is need of constructing soil barrier around orchard (Saradhulhat *et al.*, 2018).

Pollination

The lack of genetic diversity and/or the absence of pollinating agents in certain production areas mean that manual cross-pollination is needed to ensure fruit set and development (Weiss, *et al.*, 1994; Le Bellec, 2004; Castillo *et al.*, 2003) [15, 7]. Manual pollination is simple and this operation is facilitated by the floral characteristics of *Hylocereus*, as the different floral parts are huge. Finally, manual pollination may be carried out from before anthesis of the flower (from 4:30 P.M.) until 11:00 A.M. the next day. These manual pollinations are worth undertaking and the fruits obtained are of excellent quality (Le Bellec, 2004) [15]. A butterfly belonging to the *Sphingidae* family, of the genus *Maduca* (Daubresse Balayer, 1999) [8] and early morning by bees (Anon, 2017) [1]. Pollination is accomplished by opening the flower by pinching the bulging part. This reveals the stigmata, which are then covered with pollen with a brush. Alternatively, the anthers can be directly deposited (with minimal pressure) on the stigmata with the fingers. The pollen can be removed from a flower of a different clone (or from another species) and stored in a box until needed. The pollen removed from two flowers will be enough for around 100 pollinations with a brush. It can be stored for from (3 to 9) months at –18 °C to –196 °C without risk. Fruits obtained after pollination using pollen stored at 4 °C for (3 to 9) months are very small (Metz, *et al.*, 2000) [23]. However, the quality of the fruits resulting from free pollination is generally lower than that of those obtained by manual cross-pollination (Le Bellec, 2004) [15].

Harvesting

The fruit skin colors very late in the maturation stage, changing from green to red or rosy-pink (25 or 27) days (depending on the species) after anthesis (Nerd, *et al.*, 1999) [27]. It will take 30 days for harvest to *H. costaricensis* (Anon, 2017) [1]. Four or five days later, the fruits reach their maximal colouration and leads to splitting and cause economical loss (Anon, 2017) [1]. The first harvest begins from the 14th months (*H. costaricensis*) after the cuttings were planted under west Bengal condition; the time period between flowering and harvest is short and varies only slightly, from (27 to 33) days depending on the ecology (Barbeau, 1990 and Le Bellec, 2004) [4, 15]. The yield depends on planting density and is around (10 to 30) t/ha (Barbeau, 1990; Le Bellec, 2003 and Anon, 2017) [4, 14, 1]. The absence of a peduncle makes picking difficult. The present harvesting technique of simply move the fruit in clock wise direction and twisting the fruit cause less or no injury to the fruits (Anon, 2017) [1]. The fruits are not very

fragile, but to ensure a good quality product certain precautions should be taken; for example, careful handling during processing and storage, especially for *H. costaricensis* whose foliated scales is brittle.

Insect, disease, predators and disorders in dragon fruit

Dragon fruit is comparatively free of pests, diseases and disorders. However, there should not be any complacency in measures for protection of dragon fruit orchards. Prevalence of insects and pests like ants, nematodes, scale insects, mealy bugs are common in dragon fruit in India and can be easily controlled by application of insecticides. Reports similar to those documented by researchers (Athipunyakom *et al.*, 2015; Lin *et al.*, 2016; Masyahit *et al.*, 2009) [3, 17, 21] in other countries, are appearing in Indian context (Arivalagan *et al.*, 2019) [2] with respect to occurrence of some fungal and bacterial pathogens origin diseases such as anthracnose, brown spots, stem rots and stem canker severely affect yields and quality of dragon fruits. Excess light makes the plant vulnerable to diseases like bacterial rot. Further, sun burn and calcium (Ca) deficiency aggravates the diseases. Hence, timely detection and necessary precautions are needed at farmers' end to protect the dragon fruit crop.

Few pests have been recorded on *Hylocereus*. Ants belonging to the genera *Atta* (Barbeau, 1990) [4] and *Solenopsis* (N'Guyen, 1996; Le Bellec, 2004) [16, 15] are very notorious pest and can cause major damage to the plants as well as to the flowers and fruits. *Cotinus mutabilis* perforates the stem and *Leptoglossus zonatus* sucks the sap, leaving stains and some deformation (Barbeau, 1990) [4]. Different species of aphids and scales have also been observed on fruits and flowers. Rats and birds can cause serious damage, mainly to flowers (Le Bellec, 2003) [14] and fruits (N'Guyen, 1996) [16] as well as ripe fruits. In fact, bees can be extremely efficient and, after only a few hours of activity, they will have harvested all the pollen. The pollen must thus be collected before the bees arrive and manual pollination carried out the next morning as soon as the bees have left the plantation. Different fungal (*Gloeosporium agaves*, *Macssonina agaves*, *Dothiorella* sp. and *Botryosphaeria dothidea*), viral (Cactus virus X), and bacterial (*Xanthomonas* sp. and *Erwinia* sp.) diseases are also reported in the literature and can have major consequences (N'Guyen, 1996; Barbeau, 1990) [16, 4].

Conclusion

From the above article it is concluded that commercially, dragon fruit appear to have numerous selling points; they are attractive in shape and colour, and very good nutraceutical property which attract growers from all over the India. The red flesh species *i.e.* *Hylocereus costaricensis* are additionally rich in betalains, meeting the increasing trade interest for antioxidant products and natural food colorant. Fruits are easy to keep fresh under room condition. Numerous processed products can also be made from the pulp of the fruit. The crop is hardy and can survive diverse in climatic condition for flowering and fruiting and in soil condition with good drainage. In general, they produce fruits quickly and few diseases and pests are encountered now. This fruit crop needs research in different aspects.

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