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Dragon fruit: An exotic super future fruit of India

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Abstract

Dragon fruit a recently introduced super fruit in Indian market. It is getting tremendous popularity among growers because of its attractive fruit colour and mouthwatering pulp with edible black seed imbedded inside the pulp, nutraceutical value, excellent export potential and highly remunerative in nature as produces yield from 14- 16 months after planting of stem cutting and yield up to 20 years with long crop cycle from May – December in different flushes in each and every year. It is also a part of urban horticulture because of its beautiful nocturnal showy white flowers which can be used in moon garden. *Hylocereus costaricensis*, red fleshed pitaya and *H. undatus*, a white fleshed pitaya is two major species growing under Indian condition especially in West Bengal. This review deals with the knowledge regarding cultivation of dragon fruit based on literature and some of research findings in Indian condition so all become familiar with dragon fruit.

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

1. Introduction

Dragon fruit a recently introduced super fruit in India, is considered to be a promising, remunerative fruit crop. Fruit has very attractive colour and mellow mouth melting pulp with black colour edible seed embeded in the pulp along with tremendous nutritive property which attract the growers from different part of India to cultivate this fruit crop which is originated in Mexico and Central and South America (Britton and Rose, 1963; Morton, 1987 and Mizrahi *et al.*, 1997) [6, 20, 19]. It is a long day plant with beautiful night blooming flower that is nicknamed as “Noble Woman” or “Queen of the Night”. The fruit is also known as Strawberry Pear, Dragon fruit, Pithaya, Night blooming Cereus, Belle of the night, Conderella plant and Jesus in the Cradle. Fruit is named as pitaya because of the bracts or scales on the fruit skin and hence the name of pitaya meaning “the scaly fruit”. It has ornamental value due to the beauty of their large flowers (25 cm) that bloom at night; they are creamy white in color. It is considered as a fruit crop for future (Gunaseena and pushpakumara, 2006 and Gunaseena *et al.*, 2006) [23]. The fruit comes in three types, all with leathery, slightly leafy skin: *Hylocereus undatus*— white flesh with pink skin, *Hylocereus polyrhizus*— red flesh with pink skin, *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 being grown commercially in Israel, Vietnam, Taiwan, Nicaragua, Australia and the United states (Merten, 2003) [17]. It produces fruit in the second year after planting and attain in full production within five years. This article concentrates mainly on how to cultivate dragon fruit based on the literature available and research work done in Bidhan Chandra Krishi Viswavidyalaya with the genus *Hylocereus* and species *costaricensis*. *Hylocereus* comprises 16 species, which are endemic to Latin America and they are not very well known among the growers and researchers and have only recently been the subject of studies. 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. So, the research thrust must be given in the following areas; floral biology and ecophysiology. The aims of this article were to draw up a list of literature currently 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.

2. 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) (67.7), ash (0.56), carbohydrates (11.2), glucose (5.7), fructose (3.2), sucrose (not detected),

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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) [12].

Regarding different uses of Dragon fruit, young stems of *H. 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) [16] 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 colouring 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 is 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 the glucose found in 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.

3. 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) [11]. *Hylocereus* spp. are diploid ($2n = 22$) (De Dios, 2004 and Lichtenzveig, *et al.* 2000) [9, 15]. The dicotyledonous family Cactaceae (Caryophyllales) comprises between 120 and 200 genera consisting of between 1500 and 2000 species found especially in the semi-desert, hot tropical regions of Latin America reported by Spichiger *et al.*, (2000) [26]. Cactaceae are mainly appreciated for their ornamental qualities, but they also include nearly 250 cultivated species of fruit-bearing and industrial crops (Fouqué, 1969) [1]. 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) and *Dactylopius coccus* O. Costa, the host of the cochineal insect from which red dye is extracted (Mizrahi *et al.*, 1997) [19]. The cochineal insect is also raised on *Nopalea cochenillifera* (L.) Salm-Dyck (Spichiger, *et al.* 2000) [26]. We focused more particularly on the *Hylocereus* species. There are many contradictions concerning the

botanical classification of *Hylocereus* (Mizrahi *et al.*, 1997 and Daubresse Balayer, 1999) [19, 8] that are probably explained by the similar morphological characteristics and / or environmental conditions. The Britton and Rose classification (Britton and Rose., 1963) [6] was followed commonly but also the results of recent genetic analyses (Tel-Zur *et al.*, 2004) [27] took into consideration.

The five-species determined by Britton and Rose classification Britton and Rose (1963) [6] can be more precisely described:

1. *H. purpusii* (Weing.) Britton and Rose - has very large (25 cm) flowers with margins; outer perianth segments are more or less reddish; middle perianth segments golden and inner perianth segments white. It presents scarlet, oblong fruit covered with large scales (length: 10–15 cm; weight: 150– 400 g); red flesh with many small black seeds; pleasant flesh texture, but not very pronounced.
2. *H. polyrhizus* (Web.) Britton and Rose - has very long (25–30 cm) flowers with margins; outer reddish perianth segments, especially at the tips; and rather short and yellowish stigma lobes. Its scarlet fruit (length: 10– 12 cm; weight: 130–350 g) is oblong and covered with scales that vary in size; it has a red flesh with many small black seeds, pleasant flesh texture and good taste.
3. *H. costaricensis* (Web.) Britton and Rose – Represented by vigorous vines, perhaps the stoutest of this genus. Stems are waxy white and flowers are nearly the same as *H. polyrhizus*; its scarlet fruit (diameter: 10–15 cm; weight: 250–600 g) is ovoid and covered with scales that vary in size; it has a red purple flesh with many small black seeds, pleasant flesh texture and good taste.
4. *H. undatus* (Haw.) Britton and Rose - has long and green stems, more or less horny in the age margins. Flowers are very long (up to 29 cm), outer perianth segments are green (or yellow-green) and inner perianth segments pure white. Its rosy-red fruit (length: 15–22 cm; weight: 300– 800 g) is oblong and covered with large and long scales, red and green at the tips; it has a white flesh with many small black seeds, pleasant flesh texture and a good taste.
5. *H. trigonus* (Haw.) Saff - represented by slender, green with margins, not horny stems. The areoles are located on the top of the rib's undulation. Spines, at first greenish, soon turn dark brown. Its red fruit (diameter: 7–9 cm; weight: 120–250 g) is ovoid or oblong, becoming nearly smooth; the white flesh has many small black seeds and pleasant flesh texture, but not a very pronounced flavour.

3.1 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 and Daubresse Balayer, 1999) [19, 8]. Today *Hylocereus* sp. are distributed all 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)

[24]. 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, 14]. *Hylocereus* species can adapt to different types of well-drained soil (Daubresse Balayer, 1999; Barbeau, 1990 and Bárcenas, 1994) [4, 8], 5. In Vietnam, *H. undatus* has undergone extensive development with nearly 2000 ha under cultivation (Daubresse Balayer, 1999) [8].

3.2 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) [3], 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) [3]. 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) [3]; the stigmas have 21 slender lobes, creamy green in colour (Daubresse Balayer, 1999; Luders, 1999 and Anon, 2017) [8, 3]. 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 however water unavailability after bud break will cause death of bud and flower drop (Anon, 2017) [3]. 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, 3]. 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) [21, 4]. 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) [3]. The number of flowering episodes or flushes depends on the species: seven to eight for *H. costaricensis* (Anon, 2017) [3] and five to six for *H. undatus*. There is a period of 3 to 4 weeks between flowering flushes (Barbeau, 1990 and 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 open at between 20:00 and 20:30; 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) [3].

4. 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.

4.1 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 (Fouqué, 1969) [1]. 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) [21] 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) [13]. 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) [21, 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) [13]. 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) [3]. 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.

4.2 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.) (Rondón, 1998), 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 (N'Guyen, 1996 and Barbeau, 1990) [21, 4] and on horizontal and inclined supports. 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) [13]. Pitahaya are thus best grown on living or dead supports (De Dios, *et.al.*, 2000 and Barbeau, 1990) [10, 4]. Plant growth is rapid and continuous, though possibly with a vegetative rest period when the climatic conditions are unfavourable (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) [13]. Even if this weight is not in itself a problem for the different types of support, bunches may not be able to withstand violent 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.

4.3 Mineral nutrition and irrigation requirement

For better yield performance of the crop proper nutrient requirement is needed. The pitahaya's root system is superficial and can rapidly assimilate even the smallest quantity of nutrients. Mineral and organic nutrition is particularly advantageous and, when they are combined, their experiment conducted in Bidhan Chandra Krishi Viswavidyalaya for different combination of N, P, K fertilizer doses revealed the dose of N₄₅₀ P_{2O₅}₃₅₀ K_{2O}₃₀₀ perform best result for yield and quality. The nutrients were supplied as per treatment schedule in four split doses to each pillar having four plants @ 10, 10 and 30% of total, before flowering, 20, 40 and 25% at fruit set, 30, 20 and 30% at harvest and finally 40, 30 and 15 % of total N P_{2O₅} K_{2O} after two months of harvest (Anon, 2017) [3].

Even if pitahaya can survive with very low rainfall, many months of drought, when good quality fruits are required, a regular water supply is needed. Regular irrigation is important, because it enables the plant to build sufficient reserves not only to flower at the most favourable time but also to ensure the development of the fruits. Local micro-irrigation is recommended. In addition to the efficiency of the water supplied by this system, micro-irrigation avoids uneven and excess watering that can result in the flowers and the young fruits falling off (Barbeau, 1990) [4].

4.4 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 and Castillo *et al.*, 2003) [28, 14, 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) [14]. A butterfly belonging to the *Sphingidae* family, of the genus *Maduca* (Daubresse Balayer, 1999) [8] and early morning by bees (Anon, 2017) [3]. 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). 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) [14].

4.5 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) [22]. It will take 30 days for harvest to *H. costaricensis* (Anon, 2017) [3]. Four or five days later, the fruits reach their

maximal colouration and leads to splitting and cause economical loss (Anon, 2017) [3]. 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, 14]. The yield depends on planting density and is around (10 to 30) t/ha (Barbeau, 1990 [4]; Le Bellec, 2003 [13] and Anon, 2017) [3]. 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) [3]. 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.

5. Pests and diseases

Few pests have been recorded on *Hylocereus*. Ants belonging to the genera *Atta* (Barbeau, 1990) [4] and *Solenopsis* (N'Guyen, 1996 and Le Bellec, 2004) [21, 14] 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) [13] and fruits (N'Guyen, 1996) [21] 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 and Barbeau, 1990) [21, 4].

6. 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 H. costaricensis* are additionally rich in betalains, meeting the increasing trade interest for antioxidant products and natural food colourant. Fruits are easy to keep fresh under room condition. Several processed products can also be made from the pulp of the fruit. The crop is hardy and can survive in any type of climatic condition favourable for flowering and fruiting and soil condition provided with good drainage. In general, they produce fruits quickly and few diseases and pests are encountered at the present time. This fruit crop needs research in different aspects.

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