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## Dragon ERA: Knocking door in India

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**Abstract**

Pitaya, strawberry pear or dragon fruit (*Hylocereus undatus*) is the 'Wonderous Fruit' of the 21<sup>st</sup> century is set to ring in a revolution in the Indian Horticulture scenario. It is originally a cactus vine of the genus *Hylocereus*, tolerant to the arid environment and resistant to pests, diseases. The neglected mine areas where other commercial crops are not suitable to cultivate, it has the potential to survive in a dry area and adaptive to various marginal soil conditions. Now, it is knocking door in various agro-climatic zones of India. The most of the successful tidings are coming from Gujarat where it is cultivated as a monocrop. Dragon fruit is suitable for growing in regions that have spells of dry weather with supplementary irrigation. The farmers in these areas will benefit immensely if the species is improved and cultural practices studied for its incorporation into the existing farming systems.

**Keywords:** *Hylocereus*, biology, nutritive property, agronomic practices

**Introduction**

Dragon fruit belongs to the genus *Hylocereus*, also known as Strawberry Pear, Dragon Fruit, Pitaya, Night Blooming Cereus, Belle of the Night, Conderella Plant and Jesus in the Cradle, is trending among farmers in tropical and subtropical areas as a future fruit crop (Gunasena and Pushpakumara, 2006) [10]. It is a long day plant, having ornamental value due to the beauty of their large night blooming flowers. That's why, it is also popular with the nicknames "Noble Woman" and "Queen of the Night" (Luders *et al.*, 2006) [16]. Dragon fruit is native to Central America and being cultivated in at least 22 countries in the tropics including Australia, Cambodia, China, Malaysia, Thailand, and Srilanka and also in Bangladesh (Mizrahi and Nerd, 1999; Nerd *et al.*, 2002; Nobel and Barerra, 2002) [19, 18, 22]. It is being grown commercially in Israel, Vietnam, Taiwan, Nicaragua, Australia and the United states (Merten, 2003) [17].

Earlier this fruit was unknown and has come to represent a growing niche in the exotic fruit market but due to its tremendous nutritive property, attractive colour and mellow mouth melting pulp with black colour edible seed, it is knocking door in various agro-climatic zones of India *viz.*, Karnataka, Maharashtra, West Bengal and Andhra Pradesh. It is encroaching areas of South Gujarat like Surat, Tapi and Bharuch districts. Many farmers in Narmada district too are likely to go in for dragon fruit cultivation. It can be good cash crop for farmers. Not much disease affects this plant and ordinary problems like root rot, sunburn, bird attacks *etc* can be taken care of easily. Now, it is gaining the much more appreciation as of its low requirement of water and tillage practices. Except for the high initial establishment cost due to the use of trellises, the other agronomic practices are easy and less expensive, hence the low maintenance cost. The biggest advantage of this crop is that once planted, it will grow for about 20 years and one hectare could accommodate 1000 to 2000 dragon fruit plants. It bears fruit in the second year after planting and attains full production within five years.

The next decade is a decade of agri-business, as food shortages are being observed due to neglectance of the agricultural production. Efforts of farmers underline the enthusiasm and entrepreneurial spirit, which when pursued cautiously, can make the occupation fulfilling and rewarding. Thus, the numerous selling points of dragon fruit allow its different possible uses to be envisaged as fresh, fruit or processed.

**Nutritional composition and importance of dragon fruit**

The texture of dragon fruit can be compared with kiwifruit due to the presence of black, crunchy seeds. The raw flesh is mildly sweet and low in calories. Seeds are eaten together with the flesh, have a nutty taste and are rich in lipids (Ariffin *et al.*, 2009) [2]. According to Taiwan

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Food Industry Development and Research Authorities (2005)<sup>[25]</sup>, the fruit is rich in nutritive value (Table 1). Among the pitaya species, *Hylocereus polyrhizus* (red flesh) fruits are edible and a rich source of nutrients and minerals such as vitamin B1, vitamin B2, vitamin B3, vitamin C, protein, fat, carbohydrate, crude fibre, flavonoid, thiamin, niacin, pyridoxine, cobalamin, glucose, phenolic, betacyanins, polyphenol, carotene, phosphorus, iron and phytoalbumin. The dragon fruit helps in the digestive process, prevent colon cancer, diabetes, neutralize toxic substances like heavy metal, reduce cholesterol levels, high blood pressure and can help against asthma and cough. It is also rich in potassium, sodium and calcium which are good as health perspective. According to Kanjana *et al.* (2006)<sup>[11]</sup>, presence of pectin in dragon fruit marks its importance for jam, jelly as it helps in jellification in proper concentration of pH and sugar.

**Table 1:** Chemical composition of dragon fruit

Ingredient	Amount
Moisture (%)	82.5-83.0
Protein (%)	0.16-0.23
Fat (%)	0.21-0.61
Fibre (%)	0.7-0.9
Calcium (mg/100 g)	6.3-8.8
Phosphorus (mg/100 g)	30.2-36.1
Iron (mg/100 g)	0.50-0.61
Vitamin-C (mg/100 g)	8-9
Pectin (%)	0.20-1.04

### Origin and distribution of *hylocereus*

Dragon fruit (*Hylocereus* spp.) is a plant genus that was originating from Latin America (Bauer, 2003)<sup>[4]</sup>. The spread of the dragon fruit in Asia was believed to occur in the 19th century. In early 2000, it began to be known and cultivated in Indonesia, especially in Pasuruan region. Today, they are distributed all over the world (in tropical and subtropical regions), but *Hylocereus undatus* is the most cosmopolitan species. In their original region, the fruits of *Hylocereus* spp. are the main traditional fruit and the most widely consumed local fruit. Initially, this plant was introduced as an ornamental plant because of its unique flower. However, after being known the complex nutritional contents, dragon fruit is cultivated for the purpose of consumption (Kristanto, 2003)<sup>[12]</sup>. There are several species of dragon fruit that was cultivated in Indonesia, they are white dragon fruit (*Hylocereus undatus*); pink dragon fruit (*Hylocereus* spp.); red dragon fruit (*Hylocereus polyrhizus*); purplish-red dragon fruit (*Hylocereus costaricensis*); and yellow dragon fruit (*Hylocereus megalanthus*) (Andoko and Nurrasyid, 2012)<sup>[1]</sup>. Generally, the differences of dragon fruit can be easily known by some distinguishing morphological characters such as fruit size, fruit colour and number of spines at the areola that was formed on branch/stem segments (Tran and Yen, 2014)<sup>[26]</sup>. Now, it is being introduced to various agro-climatic zones of India *viz.*, Karnataka, Maharashtra, West Bengal and Andhra Pradesh. It is encroaching areas of South Gujarat like Surat, Tapi and Bharuch districts. Many farmers in Narmada district too are likely to go in for dragon fruit cultivation. It can be good cash crop for farmers. Its cultivation can pick up in South Gujarat and the region can aspire to be a major producer of the fruit.

### Botanical description

Dragon fruit is a perennial, epiphytic tropical climbing cactus with aerial roots that bear a glabrous berry with large scales

belongs to the Genus *Hylocereus*, family Cactaceae from the subfamily Cactoidea of the tribe Cactea (Cheah *et al.*, 2016; Tripathi *et al.*, 2014; Gunasen *et al.*, 2006). *Hylocereus* spp. are diploid ( $2n = 22$ ). 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. Cactaceae are mainly appreciated for their ornamental qualities, but they also include nearly 250 cultivated species of fruit-bearing and industrial crops. 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. In Latin America, many different cultivated species and fruits are referred to as pitahaya, a generic and vernacular name that renders their botanical classification difficult. However, all pitahaya are grouped into four main genera: *Stenocereus* Britton & Rose, *Cereus* Mill., *Selenicereus* (A. Berger) Riccob and *Hylocereus* Britton & Rose. We focused more particularly on the *Hylocereus* species. There are many contradictions concerning the botanical classification of *Hylocereus* that are probably explained by the similar morphological characteristics and / or environmental conditions. Thus, there are 16 species of *Hylocereus*, whose ornamental value is due to the beauty of their large flowers (15–25 cm) that bloom at night; they are creamy white in color, except *H. stenopterus* and *H. extensus* whose petals are red and rose pink. Even if all these species can potentially produce fruits, only a certain number are cultivated for this purpose and our study was limited to those.

The five species determined by Britton and Rose (1963) classification can be more precisely described: –

- *H. purpusii* (Weing.) Britton & 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. *H. purpusii* is closely related to *H. ocamponis* (S.D.) Britton & Rose, the two being distinguished only by the acicular and slender spines of *H. ocamponis*.
- *H. polyrhizus* (Web.) Britton & 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. *H. venezuelensis* Britton & Rose is closely related to *H. polyrhizus*, the only difference being whole (*H. polyrhizus*) or bifid stigma lobes (*H. venezuelensis*).
- *H. costaricensis* (Web.) Britton & Rose presents vigorous vines, perhaps the stoutest of this genus. Stems are waxywhite 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 redpurple flesh with many small black seeds, pleasant flesh texture and good taste. A few varieties are known in Costa Rica: 'Lisa', 'Cebra' and 'Rosa'.
- *H. undatus* (Haw.) Britton & 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.

- *H. trigonus* (Haw.) Saff. presents 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.

### Planting

The planting of seedlings or cuttings in a well-prepared hole is the commonest method for establishing a dragon fruit plantation. The hole should be about 30 cm deep and 20 cm wide. The soil should be loosened on the sides of the hole-walls as they help in development of root systems. These pits are filled by top soil, farmyard manure or compost with 100 g of single super phosphate. Plant the cured cuttings directly into the soil at a depth of at least 1.5-2 inches. Provide a stake as support for the new plants like wooden or concrete posts, a wall or a fence. The supporting post is planted at the centre of the planting hole, well in advance by embedding it on concrete to make it firm to enable the vine to climb. Dragon fruit plants are placed near the post. The planting distance depends on the size, slope of field and type of trellis used. Generally, in single post system planting is done at 3x3 m distance. Optimum planting distance provides adequate air circulation and reduces chance of occurrence of diseases. The number of plants for each post may vary from 1-4 plants. Generally, planting should be done in rainy season i.e. June-July for better establishment. If irrigation is available, planting may be done in other season also. The best time of planting is late afternoon or early evening.

### Training

The Dragon fruit plants are fast growing vines and produce dense branches in initial stage. The main stem has to be trained properly so it can use the support structure. Tie the stem to the support structure. The lateral buds and branches should prune to grow towards stand. Once vines reach up to the top of the stand, the branches are allowed to grow. The removal of tip of stem induces lateral branching. The well grown vine may produce 30 to 50 branches in a year and may be more than 100 branches in 4 years. These branches should be trimmed for better aeration, easy cultural operation and prevention of diseases and pests.

### Pruning and trimming

Once the plants attain the enough size, they should be pruned by removal of dried branch, diseases branches and any stem that touches the soil. This helps in maintaining growth and vigour of plants. There should be 50 main branches with 1 or 2 single branches after harvesting. Pruning may induce flowering and stem branching. Pruning is also done after harvesting and can be done 1-3 times per year.

### Pollination and self-incompatibility

The lack of genetic diversity and the absence of pollinating agents in certain production areas indicated that manual cross pollination is needed to ensure fruit set and development (Weiss *et al.*, 1994; Le Bellec, 2004; Castillo *et al.*, 2003) [28, 6, 18]. 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 before anthesis (4:30 P.M.) of the flower 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]. 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 on the stigma with the fingers. The pollen can be removed from a flower of 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 3 to 9 months at -18 °C to -196 °C. The quality of the fruits resulting from open pollination is generally lower than that of manual cross-pollination (Le Bellec, 2004) [14]. The natural or open pollination is generally carried out by butterflies and bees (Daubresse Balayer, 1999) [9].

One of the obstacles in increasing production of dragon fruit is the plant ability to set fruit. Natural fruit setting rate of dragon fruit is very low due to the nature of the self-incompatibility. Self-incompatibility causes failed in pollination and fertilization of the flower. The stigma of flower is extrude to outside, while the anther position intrude and lower than the stigma. Therefore, efficient pollination could be achieved by cross pollination of compatible clones (Lichtenzweig *et al.*, 2000; Nerd and Mizrahi, 1997; Weiss *et al.*, 1994) [15, 18, 19]. Hence, to avoid low fruit set, mixed plantings with several genotypes is recommended.

### Floral induction for off-season flowering

Dragon fruit naturally flowers only between March and October in the Northern tropical region due to long day period. Extension of production over off-season fruiting associated with larger and sweeter fruits that could be sold in the markets during the off-seasons and fetch premium price. Saradhulhat *et al.* (2009) [24] investigated that supplemented fluorescent light could induce flowering during short day season. The plants in natural conditions (control) did not flower during the experiment, whereas all supplemented light treatments exhibited induced flower buds within 43-48 days. The duration from the bud emergence to fruit harvest was about 112 days in all light treatments. The night-break treatment yielded 67 % fruit set, maximum fruit number and fruit weight.

### Manures and fertilizers

Judicious application of manures and fertilizers is needed for better yield performance. The pitahaya's root system is superficial and can rapidly assimilate even the smallest quantity of nutrients. Mineral and organic nutrition is advantageous and when they are combined, their effect is even more beneficial. Dragon fruit can be grown organically without applying inorganic fertilizers or pesticides hence it has market potential as a healthy organic fruit. Organic manures such as cattle or poultry manure or well decomposed compost can be used. The current trend in many countries is to use organic manures without any chemical fertilizers due to the high international demand for organically produced fruits, particularly demanded by the European markets.

### Irrigation

Dragon fruit, being a member of the family Cactaceae and rooted from tropical rainforests requires plenty of water for the growth. But, it can also survive with low rainfall, many months of drought, but irrigation is important, as 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. The crop should be subjected to a dry period in the pre-bloom period to produce more flowers. Adequate soil moisture is required in the top 15-30 cm of the soil particularly during the dry spells for flower and fruit development. If the rainfall is well distributed irrigation may not be required. The rainfall requirement is 1145-2540 mm per year. Excessive irrigation is not desirable as it may promote bacterial and fungal diseases. Thus, 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) [3]. Micro-irrigation systems will be very useful to control soil moisture. Mulching is necessary to reduce moisture loss and maintain moisture status in the soil.

### Harvesting and yield

The maturity index for the dragon fruit harvesting is changing of fruit colour from green to red or rosy-pink i.e. 25-27 days after anthesis (Nerd *et al.*, 1999) [18]. Four or five days later, the fruits reach their maximal colouration and leads to splitting and cause economical loss (Perween, 2017) [23]. As dragon fruit is a non-climacteric fruit (Nerd *et al.*, 1999) [18], fruits have to be picked at maximum sugar levels and acidity. At peak ripeness, the fruits become pink-red, although the scales remain green. Peak ripening reaches at 40-50 days after flowering. If fruits are left longer up to 50 days, the fruit becomes sweeter and heavier (Chang and Yen, 1997) [7]. Since over ripe fruits have less shelf life and a tendency to split. Thus, it is important to harvest fruit at the correct time. The fruits have to be harvested selectively as they ripen at different times. Most often harvesting is done twice a week. The harvesting is done carefully using pruning knives without damaging the fruits. 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 (Perween, 2017) [23]. After harvesting, the fruits should be kept in a cool shady place before storage.

The fruit weight ranges from 300 to 800 g and each plant produces 40 to 100 fruits per year. One plant normally yields 15 to 25 kg of fruits (Tripathi *et al.*, 2014) [27]. The proper management of the vines and fruit thinning improves the size of the fruit and yield. The flowers and fruits can be thinned to improve the fruit size and quality, which is important from market perspective.

### Pests and diseases

Dragon fruit is comparatively free of pests and diseases. The common pests reported are ants and bees. Ants (N'Guyen, 1996; Le Bellec, 2004) [14] are very notorious pest and can cause major damage to the plants as well as to the flowers and fruits. Bees can be extremely efficient in harvesting of all the pollen in very few hours of activity. Thus, pollen must be collected before the bees arrive and manual pollination carried out the next morning as soon as the bees have left the plantation. Other than the above, scale insects, mealy bugs, beetles, slugs, snails, borers, caterpillars, termites, nematodes, fruit flies, bats, rats and birds can also be seen rarely. These pests should be monitored regularly and controlled when observed. 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 (N'Guyen, 1996 and Barbeau, 1990). Few diseases *viz.*, soft watery stem rot caused by *Xanthomonas compestris* due to over-watering, brown spots caused by *Dothiorella* and anthracnose have been reported.

### Conclusion and future impact

There is considerable potential for the expansion of dragon fruit cultivation in most of the countries. Initially, due to insufficient knowledge about this new crop, we have not identified the environmental areas favourable for growing, the potential markets and the production technologies. But with the passing time, we are much able not even to grow them but can use this crop as an asset for the establishment of large scale plantations for small stakeholders. In addition, it is a good candidate for the development of sustainable agroforestry systems which would avoid risks and therefore increase farmer's income particularly in the dry and arid zone areas. Therefore, the government and policy makers should be encouraged to promote dragon fruit production in the dry, arid and semi-arid areas to take advantage of its economic and nutritional benefits.

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