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Dragon fruit cultivation:

A potential crop for north eastern hill region

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In India, dragon fruit has been named as Kamalam and though there are many varieties, the commonly cultivated dragon fruit species are, Hylocereus polyrhizu *(Red skin and red flesh),* Hylocereus costaricensis *(red skin and purple flesh), and* Hylocereus undatus *(red skin white flesh) and* Hylocereus megalanthus *(yellow skin white flesh). Red fleshed varieties are mostly preferred in India namely, Moroccan Red, Jumbo Red and Vietnam Red, etc. Rooted stem cuttings (15–25 cm) collected from the mother plants are used as planting material. Planting spacing is 2m × 2m or 3m × 3m (plant to plant and row to row). Concrete poles or even angle iron poles fitted with a tyre on the top are used for supporting the growing plants. Bearing plants are fertilized @11 Kg FYM + 12 Kg vermicompost and 143 g urea + 138 g MOP + 52 g SSP per plant at three months interval for maintaining the tree growth and fruiting. Hand pollination at 7.30–8.30 pm in the night is critical for better fruit set as the flowers arepin type heterostyly in nature. Yield varies from 25–35 kg/pole and around 62.0–85 t/ha.*

Keywords: *Hylocereus polyrhizu*, Jumbo red, Moroccan red, Vietnam red

IN India, dragon fruit has been named as Kamalam by the Chief Minister of Gujarat, Shri Vijay Rupani in 2021 resembling the fruit colour and shape as lotus. Scientific name of Kamalam fruit is *Hylocereus* spp. and family Cactaceae. It is also called as pitaya fruit, pitahaya fruit, strawberry pear, etc. in different countries. Centre of origin of this fruit is southern Mexico as well as in central and south American parts. However, southeast Asian countries became the leading producer of this fruit over the years. This fruit was first introduced by the European Missionaries during 19th century in this part of the world. At present countries namely, Vietnam, China, Mexico, Colombia, Nicaragua, Ecuador, Thailand, Malaysia, Indonesia, Australia and United States are the major dragon fruit producing countries. In India, this fruit was introduced in late 90s and presently Gujarat, Karnataka and Maharashtra are leading producer in the country. However, almost all the Indian states have introduced this fruit and initiated its cultivation including sub-tropical zone of Himachal Pradesh and Jammu and Kashmir, even in Rajasthan. Among the north eastern Indian states, commercial cultivation has been started in Tripura, Mizoram and Nagaland. This fruit may be considered as super fruit because of its richness in minerals, vitamins and antioxidants content. On the basis of 100g fresh fruit weight, it contains 80–85% water, 4.5–7.5 g total sugars, 4–10 mg vitamin C, 0.2–0.3 mg acidity in the form of lactic acid, 14–18^{0}B TSS, 2.5–3.0% dietary fiber, 10–13 g carbohydrate, 1.0–1.2 g protein, 270–400 mg potassium, 27.0–39.0 mg magnesium, 0.7–1.0 mg iron and 18 mg calcium and 19.0–36.0 mg phosphorus, 59 IU of vitamin A, 0.1 mg riboflavin, 150 µg vitamin E, 0.04 mg Vitamin B1 (Thiamine), 0.16 mg Vitamin B3 (Niacin). Pink flesh fruits have higher phenolics and flavonoids content (40–60 mg GAE and 20–40 mg CE, respectively), whereas, white fleshed fruits contains 15–20 mg GAE and 10–20mg CE, respectively. It provides 60–66 kcal calories of energy. This fruit is an immune booster, digestion helper and minimizes risk of diabetes, heart ailment, and cancer. The plant may be described as fast-growing cactus type climber having flashy and succulent green branches which are actually stems with wavy ribbed margins and small spines along the edges

of the stem. There is a suppressed bud at each point of the spines spaced (areola) from which flower bud arises. This plant is grouped under perennial semi epiphytic or xerophytic.

Three major countries namely Vietnam, China and Indonesia contribute more than 90% of dragon fruit production of the world. Vietnam produced 1.4 million tonnes of dragon fruit over an area of 55,000 ha with productivity of 22–35 t/ha. Around 80% dragon fruit produced in Vietnam is exported to China. Area in India is around 14.51 thousand ha under Kamalam with production of around 53.72 thousand MT. Considering the vast potential of this fruit, it has been planned to expand area under dragon fruit to 50,000 ha from present area. This fruit has a very high domestic as well as inter-nation market demand. China, Europe and America are the major importing markets for the dragon fruits produced in Asia. India has also started to export it to mainly Qatar, Maldives and Saudi Arabia. Vietnam, China and Ecuador are leading exporter of dragon fruit.

Climate

Suitable under tropical and sub-tropical, high humid to dry areas. Optimum temperature range is 6–20^{0}C in winter and 25–40^{0}C in summer. Rainfall in the range of 500 mm (Baramati, Maharashtra)–2500 mm (Tripura). It cannot be cultivated in low land with waterlogged conditions. Dragon fruit plants are very much delicate and sensitive to sub-zero and freezing temperature causes freezing injury and has been reported to be not suitable for temperate zone. Whereas, very high temperature above 400^{0}C for longer period or cloudy sky with high humidity and continuously heavy rain is also detrimental for plant growth and flowering and fruit growth.

Soil

All types of soils, but loose, well fertile, rich in organic matter, sandy to loam soil is good. The ideal soil pH ranges 5.0 –7.0. Water stagnation around the collar region will cause rooting of the fleshy stem exposing the mid rib vein.

Planting materials

Production of quality planting material is very much important for dragon fruit to avoid spread of diseases like anthracnose and bacterial spot, and insects like mealy bug and aphids. Due care should be taken in selecting the nurseries for supply of the plants as there is huge demand for the plants in different states. Mother plants should be maintained properly under better fertilization and insect-disease management protocol. Stems of 20–30 cm from one year old growth are collected and planted in poly bags containing rooting medium of soil:sand:FYM/vermicompost (3:1:1) or soilless medium such as cocopeat. Rooting media is treated with fungicides such as carbendazim + mancozeband/or *Trichoderma* formulations to avoid soil borne diseases. Cuttings may be collected from June to October and nursery is raised in poly house or net house

Propagation of dragon fruit by stem cuttings

protecting from direct rain and sun radiation. Plants are ready for planting in the field after 5–8 months. Plants may be sold @₹ 50–60/plant and apart from earning form the fruits, any nurseryman or gardener can earn huge money by selling quality planting materials only considering the high demand. Planting time is July to August. Grafting on seedlings has been found to be successful, but growth of the grafted plants just after grafting was not satisfactory, in comparison to rooted cutting. Rooted plants may be wrapped in moss grass or newspapers properly in bundles to prevent desiccation and packed in corrugated fiber boxes (CFB) for long distance transportation.

Varieties

Species specific varieties: Varieties are designated on the basis of skin and flesh colour and these traits of the fruits are species specific. Different species are, *Hylocereus polyrhizus*, Skin and flesh of this species is red; *Hylocereus costaricensis*, Fruit skin is red and flesh is attractive purple; *Hylocereus undatus*, Fruit skin is red while flesh is white; and *Hylocereus megalanthus*, is yellow skinned fruit with white flesh. Fruits with red skin and red or purple flesh are mostly liked by the consumer. However, fruit with red skin and white flesh are also in high demand in China.

On the basis of skin and flesh colour:

- **Red varieties:** This group has pink skin with dark red flesh. Varieties that fall under this type are Costa rican sunset, Bloody mary, Red jaina, Zamorano, Alice red, Moroccan red, Jumbo red, Vietnam red and Natural mystic.
- **Pink varieties:** Have pink-red flesh with red skin. Varieties like Delight, Dark star, Purple haze, Makisupa, Cosmic charlie, Townsend and American beauty come in this type.
- **White varieties:** Fruits are pink skinned and white fleshed. Varieties are David bowie, LA woman, Delight, Alice and Neitzel.

Dragon Fruit Plantation under Mulching and drip irrigation system

- **Yellow varieties:** Yellow skinned fruits with white flesh. Varieties are *Pitaya megalanthus* and Israeli yellow, Colombia yellow and Golden dragon.

Planting system

Spacing: Spacing for dragon fruit in the main field depends on the planting system. Spacing may be 2 m × 2 m or 3 m × 3 m for square planting system. In another improvised wire trellis system, plant to plant spacing may be 1–1.5 m and row to row of 1.5–2 m.

Support poles and planting: Dargon fruit plant is climbing in nature and cannot stand on its own. Therefore, there is requirement of strong support system. Traditionally, poles are made of concerts with 3 numbers of 8–10 mm rods at the center. Specification of poles is, 6–7.0 feet height and 4–6 inches diameter. Base of the pole inserted 1 ft. into the soil and fixed by pouring concrete cement mix. A bike tyre is placed on the top of the pole supported with prefixed 2–3 ft. long iron rods. Cost per pole may be around ₹500–600. Generally, four plants are planted per pole from four directions at a distance of 30 cm from the base of the pole. However, two plants may be planted considering the ease of canopy management. Angle iron poles may also be used and T-bar made of angle iron rods are fixed at 1–1.5 m spacing and 2–3 galvanized wires are placed on the top of the T bar along the row. Single plants are trained on these T bars and growing branches hangs on both the sides.

Fertilizer management

Integrated nutrient management (INM) is very much important considering the nature of plant growth and 4–5 flushed of flowering from May to September. Tap root is absent and adventitious and shallow roots requires better nutrient supply around the top soil. Dragon fruit plants are heavy feeder and fertilizer along with organic manure should be applied in split doses at various growth stages. Organic management with sufficient quality of FYM, vermicompost, biofertilizers, rock phosphates, bone meals and oil cakes has also been adopted by many farmers in India. However, a standardized INM schedule comprises bioagents such as VAM formulation (50g/plant) and *Azotobactor formulation* @50 g/plant, which is applied at the time of planting in the pit along with FYM and vermicompost.

Table 1. Schedule of fertilizer application in dragon fruit

Growth stage of plants for fertilizer application	Fertilizer dose/plant	
	Urea + SSP + MOP (g/plant)	Vermicom post + FYM (Kg/ plant)
One month after planting	13+12.5+5	1+1
Six month after planting (g/ plant)	26+25+10	2 +3
12 month after planting	40+38+15	3+4
15 month after planting	52+50+20	4+5
18 month after planting (Before flowering)	65+63+24	5+6
21 after planting (Fruit Development)	78+75+27	6+7
24 month after planting	92.0+88+32	7+8
27 months after planting	105+100+37	8+9
30 month after planting	117+113+42	9+10
33 months after planting	130+125+47	10+11
36 month after planting	143+138+52	11+12
After 36 months i.e. in the 3rd year of planting, all the plants attain full bearing potential and starts bearing. Considering the synchronization of vegetative and reproductive growth, manures and fertilisers are applied in several split doses at specified growth stages as mentioned below: This schedule is followed in the successive years.		
1st split dose: In last week of May (Just after the first flush of fruiting)	143+138+52	12 kg + 12 kg
2nd split dose: In last week of July (Just after the end of 2nd fruiting cycle)	143+138+52	12 kg + 12 kg
3rd split dose: In last week of September (Just after the 3rd flush of the fruiting)	143+138+52	12 kg + 12 kg
4th spilt dose: In the month of November (to encourage the vegetative growth and healthy fruiting bud initiation)	143+138+52	12 kg + 12 kg
5th split dose: In the month of February for better flowering of 1st flush of fruiting in the second year	143+138+52	12 kg + 12 kg

Intercropping

It is always advisable to utilize the interspaces by growing short duration low height annual crops in the initial year before the start of fruiting stage. Suitable crops are French bean, green peas, spinach, leafy coriander, onion and marigold in winter season; and cowpeas, amaranthus and any other location specific crops fulfilling the intercropping criteria.

Irrigation management

Soil water conservation by mulching is very useful for better plant growth and fruit quality. Resource conservation technology is beneficial by adopting mulching and micro irrigation. Mulching with organic materials such as paddy straw or biomass which will improve the soil fertility after decomposition. Black polyethylene (30–40 micron) or weed mat mulching along

the row with provision of ease of fertilizer application at the basin is generally good for conserving soil moisture, soil temperature and enhance microbial activities. Drip irrigation with four drippers at each four plants with discharge rate of 6–8 L/h is good. Crassulacean acid metabolism (CAM) mode of photosynthesis restricts water loss via transpiration during the heat of the day. However, irrigation during dry spell @1.5–2.0 L water/day through drip system is essential for better plant growth and fruit production or at the interval of 15–20 days depending upon the mulching type and season.

Foliar application

N: P:K (19:19:19) @2 g/L water in first week of January and August.Three sprays of micronutrient especially Zn (0.1%) and boron (0.5%) at each three fruiting developing stages (i.e. in June, July and August). Commercial growth promoters and organic formulations can be also applied as per the prescribed recommendations.

Pollination

Pollination management is very much essential for this fruit as flower opens at 7–9 pm in the night i.e. dragon fruit flowering is nocturnal. Moreover, flowers are hermaphrodite but heterostyly (distyle) in nature with androecium part (filaments along with anthers i.e. male parts) remains at the base of the flower and gynoecium part (style) over grows and come out of the flower. As a result, pollens of the same flower do not reach the stigma surface. Only bats are reported to act as pollinator in the night. Therefore, to ensure better pollination, hand pollination is done for higher fruit set. Pollens may be collected separately and are placed on the stigma surface by fine brash. In the next day pollinated flowers remain closed and gradually fruit set occurs and fruit development starts. Appropriate time for pollinations 7–9 pm in the night.

Fruit bearing

Fruiting takes place in 3–4 flushes from June to October. Fruit shape is oblong to oval, unripe fruits are deep green which turns into reddish pink in case of red skinned varieties. Fruits mature in 35–40 days after flowering and right harvest stage of fruit is when fruit skin including bracts turned full red. Fruit attains around 300–400 g weight on an average and TSS approx. 13–14^{0}B. Being non-climacteric in nature, fruits will not ripe significantly after being harvested. Shelf life varies from 7–20 days (approx.).

Harvesting

Fruits mature in 1–1½ months after fruit set. Fruits are harvested when skin starts to turn green to red/rosy pink. Yield varies from 25–35 kg/pole and around 62.0–85 t/ha. Market price of fresh fruit: ₹ 200–300/kg.

Table 2. Cost of cultivation on hectare basis with pole spacing of 2 m x 2 m

Head	Numbers or Unit	Rate (₹/ Unit)	Amount (₹)
Field preparation and pit digging	1 ha	50000	50000.00
Concrete pole	2500	500	1250000.00
Plants	10000 @4 plants/pole	50	500000.00
Tyre	2500	100	250000.00
Fertilizer and manures, irrigation, mulching, etc./year	10000 plants	30	300000.00
Cultural operations weeding, intercropping, foliar sprays, etc./year	10000 plants	20	200000.00
Total			2550000.00

Diseases and insect-pests

Initially dragon fruit plants were thought to be free from major diseases and insects. But recently, incidence of few diseases have been reported which are threatening the plantations in north eastern India. Anthracnose (*Colletotrichum spp.*) is one of the major diseases which infect the stem as well as fruits. Incidence may vary from 10–60% in the plantations resulting into drying of plants. Stem canker caused by *Neoscytalidium dimidiatum* has been reported in India. Preventive measures are important to protect the plants from such diseases by avoiding heavy stem cutting. Spray of appropriate fungicides should be done. Cactus virus X (CVX) have also been reported on dragon fruit plants with symptoms of numerous small, dull yellowish spots on the stem, drying of stem tissues, stunted, malformed and mottled growth of fruits. Whenever stems are pruned, secateurs should be well sterilized with spirit or alcohol. Cut end should be treated with Copper based fungicide paste. Diseases like stem rot (*Xanthomonas campestris*) and brown spots on fruits (*Dothiorella spp.*) also occur in dragon fruit plants. Bacterial spots may also be noticed in some plants. The insects namely mealy bugs, aphids, mites, fruit fly and termite have been found damaging the plants and fruit.

SUMMARY

Dragon fruit has been found an economical, high value fruit crops for the north eastern India. The farmers can get a higher yield and income by the adoption of the good agricultural practices.

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