MORPHOLOGY AND PHYSIOLOGY OF PITAYA AND IT FUTURE PROSPECTS IN INDONESIA

MORFOLOGI DAN FISIOLOGI BUAH NAGA DAN PROSPEK MASA DEPANNYA DI INDONESIA

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ABSTRACT

Pitaya or known as dragon fruit (*Hylocereus* spp.) is a fleshy fruit of climbing cacti, originated from America tropics. In Indonesia, this fruit is relatively new but has already got a good place and good price in the markets. The three most common pitaya species available in Indonesia are red skin with white flesh (*Hylocereus undatus* Haw. Britton&Rose), red skin with red flesh (*Hylocereus* sp.) and red skin with strong red flesh (*Hylocereus polyrhizus* Webb. Britton&Rose). Other two species available in small quantity are red skin with red-purple flesh (*Hylocereus costaricencis* Web. Britton&Rose) and yellow pitaya (*Selenicereus megalanthus* A. Berger Riccob). On the island of Lombok, pitaya plantations were first established in 2006 and the first production was in 2008. Cultural practices are very basic and some areas, such as stand (support systems), pruning, and fertilizer, pest, as well as disease managements need some improvements. Physiology, flowering behaviour, pollination, and fruit growth and development of pitaya are discussed in this paper.

Key words: pitaya, cultural practice, flowering, pollination, metaxenia, fruiting season

ABSTRAK

Pitaya atau banyak dikenal dengan nama buah naga (Hylocereus spp.) *adalah buah berdaging segar dari kaktus merambat yang berasal dari benua Amerika tropik. Di Indonesia, buah ini relatif baru dan sudah mendapatkan tempat dan harga yang baik di pasaran. Tiga spesies buah naga yang umum terdapat di Indonesia adalah buah naga merah dengan daging buah putih* (Hylocereus undatus Haw. Britton&Rose), *buah naga kulit merah dengan daging buah merah* (Hylocereus sp.) *dan kulit merah dengan daging buah sangat merah* (Hylocereus polyhirzus Web. Britton&Rose). *Dua spesies lainnya yang dijumpai dalam jumlah yang relatif sedikit adalah buah naga kulit merah dengan daging buah merah keunguan* (Hylocereus costaricencis Web. Britton&Rose) *dan buah naga kuning* (Selenicerius megalanthus A. Berger Riccob). *Di pulau Lombok, kebun-kebun buah naga pertama kali dijumpai sekitar tahun 2006 dan produksi pertama pada tahun 2008. Teknik budidaya yang diterapkan sangat sederhana sehingga dalam beberapa hal, seperti tiang penyangga, pemangkasan, pemupukan serta pengelolaan hama dan penyakit perlu dilakukan perbaikan. Fisiologi, perilaku pembungaan, penyerbukan, pertumbuhan dan perkembangan buah tanaman buah naga dibahas dalam tulisan ini.*

Kata-kata kunci: buah naga, teknik budidaya, pembungaan, penyerbukan, metaxenia, musim berbuah

INTRODUCTION

Indonesia is one of the tropical fruits exporting countries in Asia. The main fruits exported are: mangosteen, orange, pineaple, banana and mango with total value of US $234,867,444 in 2008, along with other fruits (Deptan, 2009). Other fruits produced in Indonesia in large quantities are guava, rock melon, avocado, durian, water melon, pawpaw, rambutan, snake fruit and jackfuit. The main export destination countries are China, Hongkong, Taiwan, Uni Emirates Arabs, Japan and USA. Recently, Indonesian government tries to open fruit market to Australia, especially for mangosteen, but most of the fruit exporters prefer to market their fruit to China because of it larger market. In terms of import, Indonesia just spends around 0,6% of its export values for some sub-tropical and tropical fruits, such as pears, kiwi fruits, apple and dragon fruit.

Recent data show that Indonesia imports around 200 – 400 ton per year of dragon fruit from Thailand and Vietnam (Anon, 2008). Dragon fruit, also known as prickly pear or strawberry pear or

pitahaya or pitaya, is a tropical fruit originated from the tropics of America. In scientific litertures, dragon fruit is broadly known as pitaya and this name will be used for the rest of the paper to refer to dragon fruit.

In 2001, in Asia - Pasific regions, pitaya can be found only in Israel, Vietnam, Thailand, Malaysia and Australia (Anon, 2006). At present time, pitaya can be found in almost all of Asian tropical countries and some reports also show that pitaya is grown in Taiwan (± 23° N altitude) and Ishigaki island, Japan (24°N altitude) (Liou *et al*., 2001; Nomura *et al*., 2005). Vietnam and Thailand are the main pitaya exporters to Asian countries and Israel suplies European Union countries. Pitaya fruit first entered Indonesian markets in 2003 along with some stem cuttings. Since that time, pitaya has got a good place in Indonesian markets, especially among the Chinese ethnic, because this fruit is always available during Chinese new year celebration. During this celebration, pitaya has a special place in the hearts of Chinese ethnic in Indonesia because they believe that pitaya brings good luck for them. Even though the price of pitaya is relatively high for most Indonesian people, range from IDR 20.000 to IDR 40.000, depending on pitaya types and markets, demand on this fruit is high. This is shown by the large quantity of import as reported earlier.

Because of its good market, pitaya plantations grow very fast in Indonesia. Most big plantations are in the island of Java and smaller ones in other islands. In the island of Lombok, pitaya plantations are found in dryland areas of North Lombok, Central Lombok and East Lombok (Jaya, 2009). Early plantation in Java was started in 2003 and since 2005 has expanded to more places in Central and East Java. In the island of Lombok, pitaya plantation was started in 2006 and the first fruit production was in 2008. Pitaya production in Lombok has not met consumer demand and most of the fruits available in Lombok markets come from Java. Therefore, growing pitaya in Lombok island or in Indonesia in general, where conditions for pitaya growth are favorable, is promising.

PITAYA MORPHOLOGY, ECOLOGY AND PHYSIOLOGY

There are many species of pitaya (Figure 1) but those mostly available in Indonesian markets are: red pitaya with white flesh (*Hylocereus undatus* Hawth. Britton&Rose), red pitaya with red flesh (*Hylocereus* sp.) and red pitaya with strong red flesh (*Hylocereus polyrhizus* Webb. Britton&Rose). In addition to those three species, there are also species that have red skin with red-purple flesh (*Hylocereus costaricensis* Webb. Britton&Rose), and yellow skin with white flesh (*Selenicereus megalanthus* A. Berger Riccob). The last two species are available in small quantity and therefore are very expensive. Fruit weight of all red pitayas, except *H. polyrhizus*, can reach 500 g or more (Le Bellec *et al*., 2006) while fruit weight of yellow pitaya is less than 250 g (Mizrahi *et al*., 2004). Maximum fruit weight of *H. polyrhizus* is 350 g (Le Bellec *et al*., 2006).

Figure 1. Clock wise, *Hylocereus undatus*, *Hylocereus* sp., *Hylocereus costaricensis* and *Hylocereus polyrhizus* (Photos: various sources)

Figure 2. Yellow pitaya (*Selenicerus megalanhus*) fruit with spines still intact (Picture: Mizrahi *et al*., 2002)

H. undatus's fruit is oblong, covered with large and long scales, red and green at the tips and has many soft edible black seeds. Fruit length is 15 – 22 cm, diameter is 8 – 11 cm and fuit weight is 300 – 800 g (Le Bellec *et al*., 2006; Jaya, 2009). Fruit morphology of *Hylocereus* sp. (red pitaya with red flesh) is the same as that of in *H. undatus* fruit, except the fruit shape is rather ovoid and the diameter of the fruit is somewhat larger in *Hylocereus* sp. Fruit size of *H. polyrhizus* is the smallest among these red pitayas with maximum fruit weight around 350 g. The fruit of *H. costaricensis* is 10 – 15 cm in diameter with 250 – 600 g in weight. The shape is ovoid and covered with scales are that vary in size. The flesh texture is pleasant and has many edible black seeds (Le Bellec *et al*., 2006). *S. megalanthus* fruit's is oblong and covered with tubercles and spines (Figure 2), the flesh has edible seeds, which are larger in size compared to those of other species (Weiss *et al*., 1994; Mizrahi *et al*., 2004).

Pitaya belongs to Cactaceae family, a climbing cacti with aerial roots, fleshy with 3-winged heavy, marginally wavy, much-branched, segmented stem (Hart, 2005). As other cactus family, pitaya can be reproduced vegetatively and it grows well at high temperatures of up to 38^{o} – 40^{o}C, but fails to set flower at those temperature ranges (Nerd *et al*., 2002; Le Bellec *et al*., 2006). Generative reproduction is possible by using seeds but germination will not occur in the dark (Simão *et al*., 2007). This plant grows well in areas with rainfall ranges of 340 – 3500 mm per year at altitude of up to 2750 m above sea level (Le Bellec *et al*., 2006).

Figure 3. Clock wise, flower morphology of *H. undatus*, *H. polyrhizus*, *H. costaricensis* and *S. megalanthus* (Pictures: various souces)

Pitaya flower (Figure 3) is large with approximately 27,5 cm in length, depending on species, and open at night time or known as nocturnal flower (Zee *et al*., 2004). In *H. undatus*, the outer perianth is green or yellowish green while the inner perianth colour is clean white with flower length of around 29 cm. Flower of *H. polyrhizus* is slightly longer than that of *H. undatus* with reddish perianth colour (Hart, 2005; Le Bellec *et al*., 2006). *S. megalanthus*'s flower is considered as very long, 32 – 38 cm, with funnel shape and white colour (Wikipedia, 2009). *H. costacicencis*'s flower is very similar to *H. undatus* flower, except the outer perianth colour is more yellowish and has strong perfume.

Pitaya has CAM (crassulacean acid metabolism) photosynthetic pathway, and hence, is very efficient in using water (Mizrahi and Nerd, 1999; Mizrahi *et al*., 2007). With these physiological characteristics, this plant is mostly grown in marginal lands in the tropics. Stomata are located deep in the stems (that act as leaves) and in some species, such as *H. polyrhizus*, the stem has waxy cover to prevent direct exposure of the stomata to the sunlight. Unlike *H. polyrhizus*, *H. undatus*'s stomata do not have waxy cover, and therefore this species is the most sensitive to high radiation (Mizrahi and Nerd, 1999). When photon irradiance exceeds 2000 µmol m^{-2} s^{-1}, plant is usually stunted and its colour is yellowish. Shading (30 – 60%) was reported to improve plant growth in the high radiation conditions (Raveh *et al*., 1998; Mizrahi and Nerd, 1999).

MARKET DEMAND, FLOWERING HABITS, AND PEST AND DISEASE PROBLEMS

Demand on pitaya fruit in Indonesia is all year round but the highest demand is usually during the Chinese New Year celebration (January or February). During this new year celebration, the demand can jump up to 25% compared to other times of the year. To meet this demand, pitaya fruits are imported mainly from Thailand and Vietnam (Anon, 2008).

In Indonesian market, pitaya is usually available in large quantities during the period of November to April. This period is considered as pitaya fruit season in Indonesia. Why only during this period? Most of pitaya plantations that already produce fruits are located in the island of Java (Anon, 2007; Anon, 2008), latitude 7º – 9ºS, which means that during this period the plants receive somewhat longer radiation than in the other months. Even though there is no scientific paper reporting photo sensitivity of this plant, Luders and McMahon (2006) stated that pitaya is a long day plant. This can be true since in some countries in northern hemisphere, such as Costa Rica, Israel and Japan, this plant produces fruit during summer and autumn seasons only (Weiss *et al*., 1994; Nomura *et al*., 2005; Esquivel *et al*., 2007). In New South Wales, Australia, (29ºS latitude) flowering season of pitaya is on February to April (Hart, 2005). However, the main constrain of flowering in those countries mentioned earlier is probably not the sunlight but rather the temperature. Considering the slight difference in photoperiod in Indonesia, this plant may be able to flower all year around as long as the other growing conditions, such as water, nutrient and temperature are optimum.

Flowers of pitaya flush (anthesis together) in waves. In the northern part of Lombok island, Indonesia (8ºS latitude), *H. undatus* flower flushes in 11 waves (Jaya, 2009), while in Israel (31ºN latitude), eight (8) waves of flushes were reported (Mizrahi and Nerd, 1999). The time span between flushes reported by Jaya (2009) is two weeks. This flowering characteristic has made it difficult for the grower to supply continous fruits to a special niche market. In some species of pitaya, such as *H. polyrhizus* and *S. megalanthus*, efficient pollination can be achieved by cross pollination with the most compatible pollen group. This cross pollination affect fruit characteristics and fruit development and this phenomenon is known as metaxenia (Mizrahi *et al*., 2004).

Since the time of fruit development is affected by the source of pollen, then it is suggested to grow more clones in the plantation areas. By having more clones, more pollen sources with varying characteristics are available and these can affect fruit development period, either longer or shorter. With this exhibition of metaxenia in pitaya, fruit supply to markets can be made continous during the fruiting period by cross pollination with specific clones (Mizrahi *et al*., 2004). Another consideration in pollination is the availability of pollinator. In its country of origin, pollination is done by local little bats (Mizrahi and Nerd, 1999) that is not available in Indonesia. What animal or insects help the pollination and whether some pitaya species are self pollinated or cross pollinated, requires further study.

Figure 4. Pest and diseases problems in *H. undatus* plantation in northern part of Lombok island. Clock wise: beetle (*Protaetia impavida*), bacterial stem rot, early sign of anthracnose and dry tips

Apart from flowering and fruiting complexities, pitaya also has pest and disease problems (Figure 4). The main pest problem reported by Jaya (2009) in pitaya grown on the island of Lombok during the dry season is beetle (*Protaetia impavida*). Other pest noted around the plantation and the plants is ant, but this pest does not cause as great harm as what the beetle does. During the rainy season, diseases are main concern. Recent study showed that stem rots caused by *Fusarium*, *Phytium*, *Acremonium* and *Pytophthora* are very common (Isnaini *et al*., 2009). It is also reported eslewhere that anthracnose and virus are also started to become problems in pitaya (Liou *et al*., 2001; Palmateer *et al*., 2007).

Cultural practice for growing pitaya needs to be developed since this fruit crop is relatively new for some fruit growers in Indonesia. Research on management practices, such as fertilizer types and application, support systems and prunning time are urgently needed. Plants grown in single pose support system was reported to yield 30% more than that in other suppost systems, such as "T" or "V" types (Yusoff *et al*., 2008). Pitaya grown on the island of Lombok mainly uses a very simple support system, that use living trees as the main support and some bamboo sticks as additional supports (Figure 5). This kind of support system is not last long and requires replacement in approximately every three years. Replacing the degraded bamboo sticks is not an easy job to do and the risk of breaking pitaya's stem during the replacement process is high. In modern growing system, large capital is needed as an overhead cost to built single post support system that made of concrete and iron sticks. In the long run, this single post support system will be more feasible to operate compare to that of the simple support system and less risk of loosing the plant.

FUTURE PROSPECTS OF PITAYA IN INDONESIA

The great market demand, especially in big cities such as Jakarta and Surabaya (Anon, 2007), has made pitaya has a great future in Indonesia. The long day requirement to flower is also an important consideration in expanding pitaya plantation. Islands in the southern part of equator, such as Java and Lombok that lay at around 7^{o}S of latitude, have a long day period from October to March. During this period pitaya was reported to flower and to fruit in those two islands (Anon, 2007; Jaya, 2009). This also means that islands or countries in the nothern part of the equator have a short day period during those months that prevent them from producing pitaya. High demands in the northern hemisphere, especially during the Chinese New Year that usually falls between January and February, is becoming important export markets for Indonesia.

Figure 5. Support system used in pitaya plantation in the nothern part of Lombok island, mainly made from live plant sticks (broken arrow) and bamboo sticks (straight arrow)

Low cost of plant maintenance and easiness to grow have made pitaya gains popularity very fast in Indonesia. The growing area of pitaya is expanding rapidly, from Pasuruan to Jepara and to Banjarnegara on the island of Java, in the last couple of years (Anon, 2007). On the other side, some findings stated that pitaya is rich in antioxidant in the form of betacyanins (Stintzing *et al*., 2002; Wu *et al*., 2006), that can improve human health, have also helped this fruit to gain popularity. Because of its popularity, pitaya has a great future in Indonesian markets.

CONCLUSIONS

Pitaya is a new fruit in Indonesian markets and has great potential in the future because of its great market demand, both in Indonesia and overseas. Indonesia can play important role in pitaya market in the future since the areas in this country meet ecological requirements of pitaya to grow and to fruit. The challenge for the future is how to make this fruit available all year round by producing off-season fruits and to adjust fruit development time to make a continous supply. Culture management should be improved to increase yield and to prevent the spread of pest and diseases, which are currently not a big threat to the grower in Indonesia.

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