

CURRENT STATUS OF DRAGON FRUIT AND ITS PROSPECTS IN THE PHILIPPINES

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ABSTRACT

Dubbed as “dragon pearl fruit”, “green dragon”, “dragon crystal”, and “strawberry pear”; the dragon fruit (Genus: Hylocereus) is native to Mexico and Northern South America. In the Philippines, it was introduced in the 16th century most probably through trading and exchange of goods by the Spaniards and the Filipinos. They are now found on six continents in Southeast Asian countries such as Malaysia, Vietnam, Taiwan, Thailand, Philippines and the Southeast Coast of China. Fruit growers in Asian countries may be ahead when it comes to cultivating dragon fruit but farmers in the Philippines are catching up in terms of technology and market development. The commercial production of dragon fruit started in the Ilocos region with a one hectare farm that blossomed into a multimillion-peso enterprise where its productivity was enhanced through the S and T intervention of DOST-PCAARRD Science and Technology Based- Farm (STBF), a technology transfer modality. The current area of production in the region is 200 hectares. The bright potential of dragon fruit spread so fast and there is already a total of 450 hectares planted to dragon fruit in the country. With the developed packaged of technology, the increased productivity is realized during the regular and off season with a technology of using artificial light. But despite of this, there are still concerns on diseases, postharvest losses during transport and limited supply of fresh fruits during off season. It is now a lucrative industry with only few key players are engaged to produce good quality fruits due to high investment cost on a per hectare basis compared to locally grown fruits. Because of its production and economic importance, this fruit is categorized under a high value crop and showed competitive advantage for the local fruit industry. Therefore, the focus of this paper is to develop a technology chain and identify critical factors that can be translated into an Industry Strategic Plan (ISP) for Dragon Fruit in the Philippines for the next five years to reduce the production cost, induce resistance to diseases, and produce quality fruits to command better price in the export market.

Keywords: dragon fruit, Science and Technology Based-Farm (STBF), technology chain

INTRODUCTION

Dragon fruit production has become a lucrative industry in the Philippines. What used to be a backyard ornamental plant has been propagated, cultivated, and fruits reaped making what now “the Philippines dragon fruit industry” worth millions of pesos. Dragon fruit (*Hylocereus* spp.) is a member of the cactus family (Cactaceae) and is known to be a native of Mexico and Northern South America. The Spaniards introduced dragon fruit to the Philippines in the 16th century (Nobel 2002) most probably through trading and exchange of goods. The fruit crop is now extensively planted on a commercial scale in many tropical regions, particularly in Vietnam and other South-East Asian countries Malaysia, Taiwan, Thailand including the Philippines. It is also commercially cultivated and widely distributed in some parts of the United States of America (USA), Australia, and Israel (CABI 2018). Other common names of dragon fruit include pitaya, pitahaya, dragon pearl fruit, green dragon, dragon crystal, and strawberry pearl. In the Philippines, it is locally known as *saniata* which means light and wealth. The three species commonly cultivated are *Hylocereus undatus* (red skin and white flesh) and *Hylocereus costaricensis* (red skin and red pulp), and *Hylocereus megalanthus* (yellow skin and white pulp (ERDB 2013).

Tracing back, the origin of first dragon fruit planting materials in the country were Taiwan and Vietnam. It was in 1992 when a white-fleshed variety was introduced to the Philippines by a Chinese businessman, Mr. Alex Litton who brought planting materials from Taiwan. He started the production in his six hectare farm in Cavite Province. Soon after, planting materials were dispersed to other farms in Cavite which increased the area

planted to dragon fruit. One of the recipients was Mr. Edilberto R. Silan who has ventured into intercropping with dragon fruit as the major crop. Currently, Mr. Silan has a total of twelve (12) hectares plantation in Cavite (Personal Communication, April 10, 2018). He shared his knowledge to other farmers with a total of 30 hectares dragon fruit farm.

Mrs. Edita A. Dacuycuy started backyard production in Burgos, Ilocos Norte in 2005. The backyard then turned into the first dragon fruit plantation in the Ilocos Region and named as Rare Eagles Forest Marine and Agricultural Development (REFMAD) Farms. At present, Mrs. Dacuycuy has a total of 20 hectares dragon fruit plantation in the Region planted with three self-pollinating commercial varieties (Personal Communication, March 26, 2018). Farm productivity was further enhanced when her farm was turned into a Science and Technology Based-Farm (STBF) through DOST-PCAARRD assistance. Mrs. Dacuycuy and Mr. Silan are also recognized as *Magsasaka Siyentista* (Farmer Scientist) by the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development of the Department of Science and Technology (DOST-PCAARRD).

The fruit has become popular because of its health benefits. Numerous reports show that dragon fruit is rich in proline, potassium, magnesium, calcium, sodium, and also contains iron, zinc, and copper (Khalili 2006; Le Bellec *et al.* 2006). Red dragon fruit is also high in antioxidant activity compared to other fruits and vegetables (Mahattanatawee *et al.* 2006). These results suggest that the fruit has potential in preventing risk of acquiring non-communicable diseases such as cardiovascular diseases, hypertension, diabetes mellitus, and anemia. With its health benefits and good taste, dragon fruit became a food trend to the health conscious group. As higher demand dictates higher price, dragon fruit is sold at around 3-4 USD/kg (PhP 150-200) in local markets. This enticed some growers to shift to dragon fruit production from mango such as in Guimaras, Cebu, and General Santos City (Adriano 2015), and coffee and pineapple in Cavite.

This paper aims to develop a technology chain and identify critical factors in production that can be translated into an Industry Strategic Plan (ISP) for dragon fruit in the Philippines for the next five years. The plan will target to reduce production cost, induce resistance to diseases, and produce quality fruits. This will command better price in the export market and result in increased income and improved livelihood of dragon fruit growers in the Philippines.

CURRENT STATUS OF DRAGON FRUIT INDUSTRY IN THE PHILIPPINES

Situationer

Area planted to dragon fruit in the Philippines has been increasing in the last six years. From 182 hectares (ha) in 2012, the country's total area planted to dragon fruit in 2017 is 450 ha (PSA 2018). The same trend can be observed with annual production wherein it increased from 256 to 1,463 metric tons (MT) (Table 1). Yield per hectare shows a positive trend as well from 1.41 to 3.25 MT (Fig. 1). In selected plantations, 4-6 MT/ha can be produced from newly-established plantations while as high as 10-15 mt/ha/year is possible for established plants considering the 6-12 harvesting cycles per year. This can be attributed to the initiatives of the government in partnership with private farm owners and growers' associations to increase productivity in farms since dragon fruit is recognized as a high value crop. Shown in Table 2 are the top five producing regions in the Philippines in 2017 which are mainly in Luzon (Ilocos, Cagayan Valley, CALABARZON, and Central Luzon Regions) while Central Visayas ranked fifth. The annual production volume in these regions ranges from 106-507 MT. Ilocos Norte province has the largest area planted to dragon fruit in the country. In 2012, the area and number of dragon fruit growers in the said province were 51.21 ha and 289, respectively (Table 3) (DOST-PCAARRD 2012).

Area and production values in the Philippines are however smaller compared with its neighboring countries. Vietnam, the leading exporter of dragon fruit in the world, has almost 40,000 ha area devoted to dragon fruit with a volume of production reaching about 1 million metric tons (mt) (Australian Department of Agriculture and Water Resources 2017) valued at US\$ 895.70 million (VNA 2016). Further, commercial farms in Vietnam yield an average of 22-35 MT/ha/year (Nguyen *et al.* 2015). Malaysia has 1,641 ha in 2013 and production of 11,000 MT (Kek Hoe 2017). Dragon fruit is also an introduced crop in Indonesia and large scale production was started in the year 2000. Total area planted in two of the major dragon fruit production areas in Indonesia (Banyuwangi, East Java and East Kalimantan) is already at least 4,300 ha. Recently, 117,700 mt was harvested from 2,300 ha in Banyuwangi (Riska 2016; The Jakarta Post 2018).

Table 1. Area planted and production of dragon fruit in the Philippines (2012-2017).

Parameter	Year					
	2012	2013	2014	2015	2016	2017
Area (ha)	181.90	223.53	295.40	329.34	407.55	449.50
Production (mt)	256.45	411.48	671.79	863.46	1,237.77	1,462.51
Source: PSA, 2018						

Table 2. Top five dragon fruit producing regions in the Philippines (2017).

Rank	Region	Production (mt)
1	Ilocos Region	507.06
2	Cagayan Valley Region	364.80
3	CALABARZON	205.46
4	Central Luzon	199.62
5	Central Visayas	105.70
Source: PSA, 2018		

Table 3. Area and number of dragon fruit growers in the province of Ilocos Norte (2012).

Municipalities	Area (ha)	Grower/s
<i>District I</i>		
Adams	0.04	1
Bacarra	2.39	9
Bangui	0.01	1
Burgos	20.29	12
Laoag City	5.69	38
Pagudpud	1.30	4
Pasuquin	1.64	15
Piddig	0.04	1
Sarrat	2.70	5
Vintar	0.60	6
<i>District II</i>		
Badoc	0.30	7
Banna	0.12	4
Batac City	3.11	52
Currimaos	1.66	31
Dingras	0.52	10
Marcos	0.21	4
Nueva Era	0.03	1
Paoay	3.00	18
Pinili	1.31	10
San Nicolas	6.21	56
Solsona	0.04	4
Total	51.21	289
Source: DOST-PCAARRD, 2012		

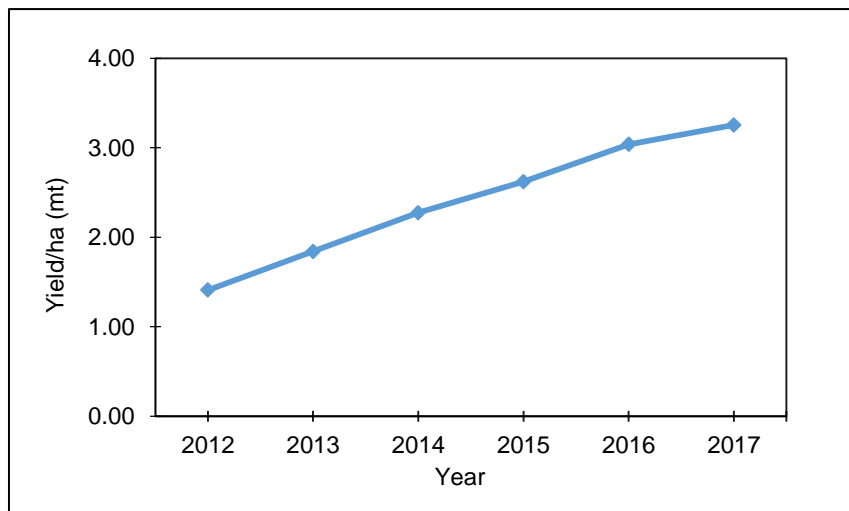


Fig. 1. Yield in metric tons (mt) per hectare of dragon fruit in the Philippines from 2012-2017 (PSA 2018).

Industry problems

The booming industry of dragon fruit in the Philippines is hampered by problems on pest and diseases, inferior variety, postharvest losses during transport, and seasonality of dragon fruit which results in limited supply of fresh fruits during off season. Pascua (2015) also cited that high cost of production due to intensive cultivation by applying inorganic fertilizers; high cost of initial investment and problems on credit; unavailability of postharvest facilities and technologies had affected the shelf life and continuous supply of fruits. Further, development of Quality Assurance Protocol (QAP) and Good Agricultural Practices (GAP) are yet to be developed and adopted to have globally competitive products. To address these problems, science and technology (S&T) gaps have to be identified to be able to come up with S&T interventions as solutions to the abovementioned problems.

Key players of the industry

DOST-PCAARRD crafts industry strategic S&T plans (ISP) for priority crops/commodities in the country. This plan is then translated into a Research and Development (R&D) program to fill the gaps with S&T interventions. While ISP has been crafted for major fruit crops banana, mango, pineapple, and minor fruits citrus, durian, papaya, and pummelo, there is no ISP for dragon fruit yet. However, DOST-PCAARRD recognizes dragon fruit as a regional priority commodity, particularly the Ilocos Region as the major producer of the crop. Hence, DOST-PCAARRD is among the key players in the industry.

Under the Department of Agriculture's (DA) Philippine Rural Development Project (PRDP), dragon fruit is also a priority commodity in the Ilocos Region. PRDP is designed to establish the government platform for a modern, climate-smart and market-oriented agri-fishery sector. The project partners with Local Government Units (LGU) and the private sector in providing key infrastructure, facilities, technology, and information that will raise incomes, productivity, and competitiveness in the countryside. Its major components are infrastructure development, enterprise development, local planning, and project support (DA 2018).

In the Ilocos Region, key players include the Mariano Marcos State University (MMSU), Ilocos Agriculture and Resources Research and Development Consortium (ILARRDEC), Ilocos Provincial Agriculture Office, Department of Agriculture-Regional Field Office-1 (DA-RFO 1), Department of Education (DepEd), Department of Trade and Industry (DTI), DA-Philippine Rice Research Institute (PhilRice), DA-Cotton Development Administration (CODA), and Kailokoan Guaneco Cooperative (KASACOO). The strong support extended to dragon fruit growers by the local government units (LGUs) in the said region is also notable.

Dragon fruit technology chain

The technology chain or value chain of dragon fruit covers areas in production, postharvest and processing, and trade and marketing (Fig. 2). Areas in production are varietal improvement and selection, production of planting materials, cultural management, and pest management while postharvest and processing includes harvesting, postharvest handling, processing and value adding. Trade and marketing is another crucial component of the chain. As earlier mentioned, problems, gaps, and constraints are identified in these areas and resolved through S&T interventions. More importantly, transfer of developed and matured technologies to end users in the dragon fruit industry should also be facilitated. Technology transfer strategies or modalities of DOST-PCAARRD are deployment, extension, and commercialization. Information dissemination, advocacy and promotion of such are also conducted.

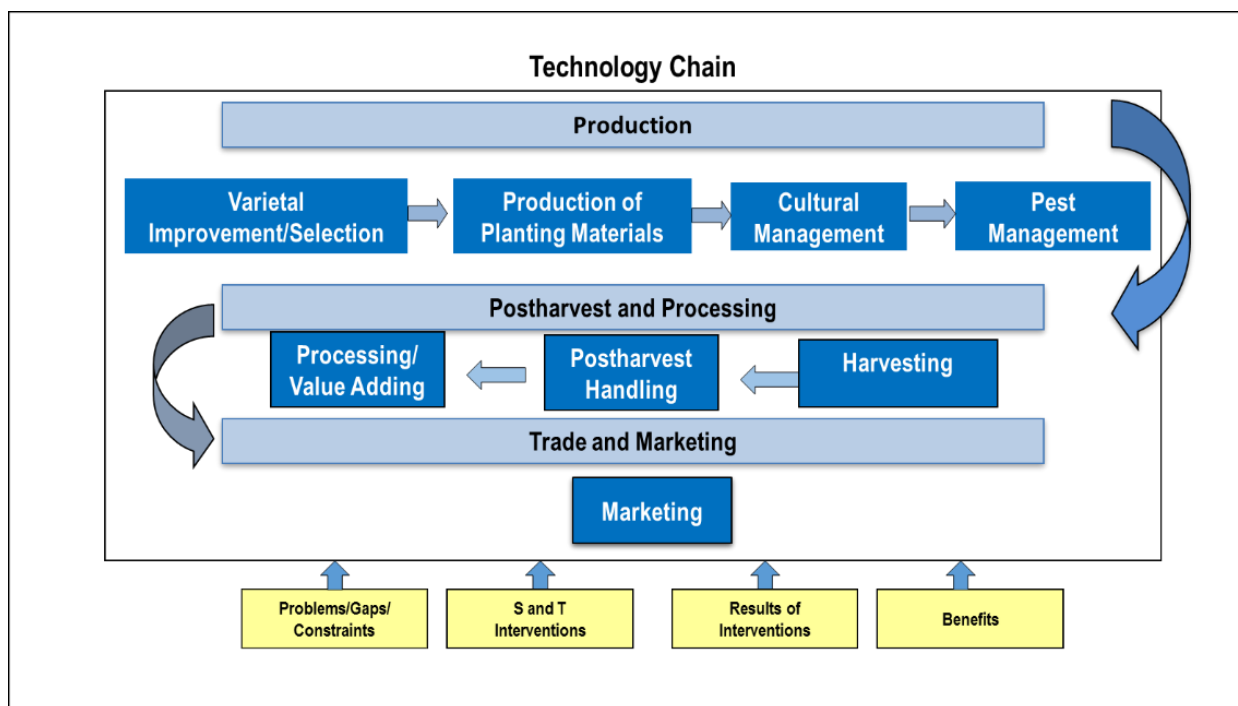


Fig. 2. Identified areas in the technology chain of dragon fruit in the Philippines.

Production

Varietal improvement

There were already completed initiatives in some of these areas. In varietal improvement and selection, six dragon fruit varieties have been developed in the Ilocos Region. These are Saniata 1 (Imee), Saniata 2 (Imelda), Saniata 3 (Miriam), Saniata 4 (Edit), Saniata 5 (Mimi), and Saniata 6 (Elena) (Table 4) (Pascua *et al.* no date). Cuttings are the common planting material and DA has established the prescribed selling price for dragon fruit at 0.60 US\$/cutting (PhP 30) (DA 2012).

Table 4. Dragon fruit varieties developed in the Philippines.							
Variety Name	Fruiting Season	Fruit Weight (g)	Peel Color	Flesh Color	Edible Portion (%)	TSS (% Brix)	Texture
Saniata 1 (Imee)	April-November	337	light red	brick red	75	13.6	grainy
Saniata 2 (Imelda)	April-December	401	light red	light red	75	13.3	grainy
Saniata 3 (Miriam)	May-November	466	hot pink	white	81	11.2	grainy
Saniata 4 (Edit)	April-December	374	Canada red	brick red	73	12.4	grainy
Saniata 5 (Mimi)	May-November	245	sunset glow	crimson	69	13.5	grainy
Saniata 6 (Elena)	April-November	75	yellow	white	41	(no data)	smooth
Source: Pascua <i>et al.</i> (no date)							

Since the varieties currently being used are introduced to the country in 1992 without proper characterization and identification, so it is imperative that a varietal improvement program be included in the future plan. There is a need to develop diversity in species to search for varieties or cultivars with inherit resistance to diseases, increased yield, improved fruit quality and prolonged shelf life.

Cultural management

Climatic and soil conditions in many parts of the country suits dragon fruit requirements. Inorganic and organic production systems are practiced in the Philippines. The crop is a long day plant and production season is from April to November. Kakawate (*Gliricidia sepium*) (40 x 50 x 200 cm) or cement posts (15 x 15 x 200 cm) are usually used as support posts with old motorcycle tire as crown support.

Fertilizer recommendation at different stages of the crop is also available, a result of research trials conducted by ILARRDEC (Table 5). Organic fertilizers are applied liberally at the base of the posts while inorganic fertilizers such as complete (14-14-14), urea, and muriate of potash are dibbled 5-8 cm away from the base of the plant to avoid direct contact with the plants. Application of foliar fertilizer is also done late in the afternoon every two weeks or depending on the recommendation of the manufacturer.

Plant Age/Month	Approximate fertilizer requirement/post			
	Organic (no. of shovel)	14-14-14 (g)	Urea (g)	Muriate of Potash (g)
<i>Planting to one year</i>				
At planting	1	81	54	18
3 months	0	81	54	18
6 months	1	81	54	18
9 months	1	81	54	18
<i>One year and succeeding years</i>				
November	2	324	0	0
January	0	324	0	0
April	2	324	0	126
June/July	0	324	0	144
Source: Pascua and Gabriel (no date)				

Newly established plants are irrigated twice a week thereafter and after applying fertilizers except during rainy days. Other cultural management practices employed are the following: tying, training and topping of shoots; pruning of stems to obtain an open, manageable, and productive umbrella canopy; weeding; and pest and disease management.

Intercropping is practiced in many farms. For instance, intercropping combinations in the farm of Mr. Silan are the following: dragon fruit-corn; coconut-tomato-dragon fruit; coconut-dragon fruit; dragon fruit-tomato; dragon fruit-papaya. Other components of his integrated farm are native pig production and vermiculture (Personal Communication, March 5, 2014).

As a long day plant, dragon fruit is seasonal and fruits are available from April to November. Off-season production of the fruits (October-March) is made possible by manipulating the environment through artificial lighting using 6-watt Light Emitting Diode (LED) bulbs or 26-watt compact fluorescent lamps (CFL). Breaking the dark period using artificial lighting from 10:00 in the evening until 2:00 the following morning can induce the plant to flower during short day-months of October-March. The bulbs are suspended at the center of the four posts of dragon cactus five feet above the ground (Pascua and Gabriel, no date). This study was led by Mr. Leonardo T. Pascua of ILARRDEC and the technology has been tested in the farm of Mrs. Dacuycuy in Ilocos Norte. At present, Mrs. Dacuycuy follows the 2 x 2 m distance of planting for the installation of extended daylight for off-season fruit production to use electricity efficiently while maximizing the lighted parts of the plants (Personal Communication, March 26, 2018).

Though package of technology on nutrient management is available in some parts of the country, the cost of investment is very high. This resulted in high production cost per hectare. An alternative approach is to utilize the available technological interventions such as use of bio-fertilizers such as Mykovam, Bio-N, vermicompost which may reduce production cost. A study on the best combination of inorganic and organic must be established both for intercropping and monoculture production systems.

Pest management

Common pests of dragon fruit in the Philippines affecting almost all plant parts are ants, scale insects, mealy bugs, borers, and fruitfly causing damage to the shoots and fruits and rotting. Flower beetles (family Cetoniinae) is another important pest damaging the reproductive parts of the flowers hindering fruit development while other species feed on the fruits. Recommended control measures against ants and scale insects are spraying of soap solution or Chlorpyrifos-based insecticide on the affected plant parts (Pascua and Gabriel, no date; Tacio 2013). Pheromone traps such as methyl eugenol and fruit bagging using plastic bags, newspapers, and *katsa* (flour cloth) are also proven effective against fruitfly.

On diseases, Mr. Silan reported that soft rot and anthracnose are the two major problems that contribute to low yields of dragon fruit (Personal Communication, April 10, 2018). His principle of good health soil condition can reduce infection like using vermicomposting and organic fertilizers in combination with appropriate inorganic compounds. Mohd (2015) reported that serious diseases affecting dragon fruit are anthracnose caused by *Colletotrichum gleosporioides*, stem necrosis (*Culvularia lunata*), stem canker (*Neoscytalidium dimidiatum*), and stem rot (*Fusarium proliferatum*). In the Philippines, copper-based fungicides applied at appropriate dosage and at the right time are recommended for a wide range of dragon fruit diseases (Tacio 2013).

Therefore, the current pest management on dragon fruit is fragmented or it is independently applied in managing specific pests or diseases. The available technologies must be validated and develop an integrated pest management approach with inclusion of using environmentally-sound approaches to keep balance of species diversity in the ecosystem.

Postharvest and processing

Harvesting, postharvest handling, processing and value adding are under this area. Fruits are harvested at 28-35 days after flowering when full red color and swelling of the navel is observed. Fruits are ripe when the color changes from green to red, pink, or yellow. Several researches on extending the shelf life of dragon fruit has been conducted by the Postharvest Horticulture Training and Research Center (PHTRC) of the College of Agriculture and Food Science (CAFS) of the University of the Philippines Los Baños (UPLB). The specific areas include appropriate packaging and coating, delaying bract senescence, and chilling injury alleviation (Rodeo *et al.* 2018). PHTRC has conducted studies on the use of Modified Atmosphere Packaging (MAP) in prolonging the shelf life of fruits including dragon fruit. Another study conducted at PHTRC by Castro (2017) showed that temperature conditioning for three (3) days at 10°C resulted in four (4) weeks storage life and six (6) days shelf life of the fruit. Further, visual quality of the fruit was maintained, and rate of bract or scale yellowing, weight loss and shriveling were reduced. Red and white-fleshed dragon fruit were also found to be suitable for fresh cut processing with the application of 5 ppm 1-methylcyclopropene or 1-MCP (inhibitor of ethylene action) (Tadeo 2016). 1-MCP increased antioxidant activity, delayed flesh translucency, and decreased titratable acidity (TA) of fresh-cut dragon fruit.

The Philippines Bureau of Agriculture and Fisheries Product Standards (BAFS) under the Department of Agriculture has also developed the Philippine National Standard for Fresh Fruit – Dragon Fruit – Classification and Grading (PNS/BAFPS 115:2013). Recent technology developments in the industry are presented in the PNS. The PNS also intends to harmonize with ASEAN standards and Codex requirements in heavy metals, pesticide residues and hygiene (BAFS 2013).

Food and non-food products derived from dragon fruit such as ice cream, jam, jelly, puree, wine, vinegar, tea, cookies, pastries, and soap bars have found a stable market (Adriano 2013) in the country. Recipes such as macaroni, siomai, lumpiang shanghai, cupcake, and empanadita were also developed by the Mariano Marcos State University (MMSU) and the Cavite State University (CvSU).

Technology transfer

DOST-PCAARRD transfers developed and matured technologies through deployment, extension, and commercialization. Other technology transfer related activities are information dissemination, advocacy and promotion of such. Deployment and extension are considered when effective technology utilization and adoption are influenced by non-market considerations while commercialization is pursuant to the Philippine Technology Transfer Act of 2009 (Republic Act 10055). Extension and deployment-cum extension are the most common pathways for most technologies generated through DOST-PCAARRD funding (Catibog 2017).

As an example, DOST-PCAARRD and ILARRDEC partnered and established a Science and Technology-Based Farm (STBF) on the production of organic dragon fruit in Ilocos Norte to transfer to appropriate beneficiaries the technology generated from R&D activities on dragon fruit. The abovementioned S&T Interventions in improving productivity and income derived from dragon fruit were showcased in the farm of Farmer Scientist Edita Dacuycuy in Burgos, Ilocos Norte. The project established a chemical-free production technology for dragon fruit; developed strategies to prolong fruit shelf life; and promoted the S&T interventions to farmer-adopters in the community. The first dragon fruit festival was also held in Ilocos Norte in 2011 through the project. The festival was spearheaded by DOST-PCAARRD through its Farms and Industry Encounters through the Science and Technology Agenda or FIESTA (meaning “feast”) in partnership with the industry key players in the said province. FIESTA showcases gains from S&T is the Council’s technology commercialization strategy so regional S&T based products reach their target markets nationwide (DOST-PCAARRD 2012).

Trade and marketing

Commercial growers are usually the traders of their produce. Cost of production per hectare with 1,600 posts (2.5 x 2.5 m spacing) is estimated at 12,633 US\$ (PhP 631,650) on the first year while succeeding years require around 3,000 US\$/year (PhP 150,000). Dragon fruit commands a premium price in the local markets where fruits are sold at 3-4 US\$/kg (PhP 150-200/kg). The 4-6 MT/ha yield can give a return of 12,000-18,000 US\$ (P600,000-P900,000) (at 3 US\$/kg) while greater profit is expected in the following years when plants are already established.

The Philippines has also entered the export market when more than 600 kg fruits from REF MAD Farms in Ilocos Norte was shipped to British Columbia, Canada for the first time in August 2016 through fruit and vegetable importer Pahoa Produce Ltd. (PNA 2016). Dragon fruit was sold at US\$17.76 /kg in Canada on that year. Exporters should be accredited by the Bureau of Plant Industry (BPI) pursuant to the BPI Memorandum Order No. 40 Series of 2012. The Memorandum presents the guidelines for the accreditation of exporters, traders, growers and packing facilities for export of fruits and vegetables (BPI 2012).

No importation of fresh dragon fruit has been recorded according to the Bureau of Plant Industry-National Plant Quarantine Services Division (BPI-NPQSD). Only planting materials from Taiwan have entered the country. However, in case exportation to the Philippines will interest neighboring countries especially with the implementation of free trade agreements (FTA), the DA Department Circular No. 04 or the *Guidelines on the Importation of Plants, Planting Materials and Plant Products for Commercial Purposes* has to be followed (DA 2016). The directive presents a rationalized and enhanced requirements and procedures in the importation of plants, planting materials and plant products (including fresh fruits) for commercial purposes. Further, if dragon fruit importation will be pursued, Pest Risk Analysis (PRA) on the commodity needs to be conducted.

Importing and exporting should also abide the plant quarantine policies in the Philippines. These include Presidential Decree (PD) 1433 or the Plant Quarantine Decree of 1978. PD 1433 or known as *Promulgating the Plant Quarantine Law of 1978, thereby revising and consolidating existing plant quarantine laws to further improve and strengthen the plant quarantine service of the Bureau of Plant Industry (BPI)* (Official Gazette 2018). The decree was issued to address economic losses due to injury on agricultural crops brought about by plant pests which have become increasingly significant; prevent introduction, incursion, establishment and subsequent spread of plant pests by regulating the international and domestic movements of plants and plant products; and strengthen plant quarantine as preventive measure and actual front-line defense against the introduction or incursion into the country of plant pests which are destructive to agricultural crops.

PROSPECTS

While S&T interventions in many areas of the technology chain have been undertaken which delivered technologies that improved productivity and income, optimization of these technologies is essential. There are also remaining gaps in the chain that need to be addressed through continuous R&D activities. Varietal improvement is a never-ending process considering the changing weather patterns and emergence of new pest and diseases. New improved varieties are needed. Smart water management, optimization of the integrated nutrient management and off-season production technologies, and comprehensive pest and disease management protocols have to be generated as well.

Prolonging the shelf life of dragon fruit is critical especially if export market is targeted. Thus, continuous R&D on postharvest management should be done. Related to this is the R&D on postharvest mechanization for quality standards. Enhancement of the current PNS for fresh dragon fruit and development of the PNS on GAP for dragon fruit production would be very helpful for the growers to be able to produce high quality and safe to consume fruits for the domestic and global market.

In trading and marketing, China has expressed in 2012 its interest in exporting dragon fruit products from the Philippines (Dizon 2013). FTAs with countries in Asia and the Pacific should be looked into by local dragon fruit growers to be able tap the export market according to the Philippine Bureau on Export Trade Promotion. However, analysis by Mr. Leonardo Pascua, project leader of the dragon fruit research and development extension of MMSU suggests that the dragon fruit area in the country should be expanded and reach at least 1,000 ha for the Philippines to be able to supply the global market (Adriano 2013).

CONCLUSION

Dragon fruit production in the Philippines is a growing industry. It is considered as a high value fruit crop and recognized as a regional priority commodity in the Ilocos Region. Area, annual production, and yield per hectare has been increasing in the last six years due to government efforts in partnership with private farm owners, growers' associations, research institutions, and other key players in the industry. Values are however smaller compared with the country's neighboring countries Vietnam, Malaysia, and Indonesia. But farmers in the Philippines are catching up in terms of technology and market development. Problems however hamper the development of the dragon fruit industry in the country. DOST-PCAARRD developed a technology chain covering the areas in production, postharvest and processing, trade and marketing, and technology transfer to address the industry problems by filling-in the gaps with S&T interventions. This can be translated into an Industry Strategic Plan (ISP) for dragon fruit. There are also prospects in R&D, trade and marketing, and relevant policies that can improve the industry in the coming years for it to be able to supply local demand and compete in the global market.

REFERENCES

- Adriano, L. 2013. Dragon fruit takes over Ilocos Norte. INQUIRER.net. July 11, 2013. (<http://newsinfo.inquirer.net/443189/dragon-fruit-takes-over-ilocos-norte#ixzz58k17auMJ>; Accessed 31 March 2018).
- Adriano, L. 2015. Dragon fruit growing business gains ground. INQUIRER.net. October 14, 2015. (<http://business.inquirer.net/200760/dragon-fruit-growing-business-gains-ground>; Accessed 31 March 2018).
- Australian Department of Agriculture and Water Resources. 2017. Final report for the review of biosecurity import requirements for fresh dragon fruit from Vietnam. January 2017. Department of Agriculture and Water Resources, Canberra, Australia. (<http://www.agriculture.gov.au/biosecurity/risk-analysis/plant/dragon-fruit-from-vietnam/final-report>; Accessed 31 March 2018).
- BAFS (Bureau of Agriculture and Fisheries Standards). 2013. Philippine National Standard for Fresh Fruit – Dragon Fruit (Pitahayas) Grading and Classification. PNS/BAFPS 115:2013. ICS 67.080.10.
- BPI (Bureau of Plant Industry). 2012. Memorandum Order No. 40 Series of 2012, Subject: Guidelines for the accreditation of exporters, traders, growers and packing facilities for export of fruits and vegetables. Bureau of Plant Industry, Manila, Philippines. (<http://spsissuances.da.gov.ph/attachments/article/272/BPI%20Memorandum%20Order%20No.%2040%20S2012.pdf>; Accessed 10 April 2018).
- CABI (Center for Agriculture and Biosciences International). 2018. Datasheet: *Hylocereus undatus* (dragon fruit). Center for Agriculture and Biosciences International. (<https://www.cabi.org/isc/datasheet/27317>; Accessed 1 April 2018).
- Castro, A.C. 2017. Physicochemical and physiological responses of red-fleshed dragon fruit [*Hylocereus polyrhizus* (Weber) Britton and Rose] to low temperature conditioning and chitosan coating. MS Thesis. University of the Philippines Los Baños, College, Laguna, Philippines. Available at the UPLB Library.
- Catibog, N.A. 2017. Redefining technology transfer in the agri-aqua sector. DOST-PCAARRD Quick Information Dispatch, 3 April 2017. (<http://www.pcaarrd.dost.gov.ph/home/portal/index.php/quick-information-dispatch/2897-redefining-technology-transfer-in-the-philippine-agri-aqua-sector>; Accessed 6 April 2018).
- DA (Department of Agriculture). 2012. Administrative Order No. 22 Series of 2012, Subject: Prescribing the selling prices of vegetable seeds and plant materials. Department of Agriculture, Quezon City, Philippines.
- DA (Department of Agriculture). 2018. No. of Commodities Covered by the VCAs as of March 16, 2018. Department of Agriculture-Philippine Rural Development Project. (<http://www.sp-v3.daprdp.net/Vca/region>; Accessed 16 March 2018).
- DA (Department of Agriculture). 2016. DA Department Circular No. 04. Series of 2016, Subject: Guidelines on the importation of plants, planting materials and plant products for commercial purposes. Department of Agriculture, Quezon City, Philippines. (http://bpi.da.gov.ph/bpi/images/PDF_file/DA%20DEPT%20CIRCULAR%2004.pdf; Accessed 10 April 2018).
- Dizon, D. 2013. Asian dragons. ABS-CBNnews.com. September 30, 2013. (<http://news.abs->

- cbn.com/business/09/30/13/asian-dragons; Accessed 6 April 2018).
- DOST-PCAARRD. 2012. Facts on Dragon Fruit. PCAARRD Fiesta: Dragon Fruit Festival. Dragon Fruit Issue, March 2012. Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development-Department of Science and Technology (DOST-PCAARRD), Los Baños, Laguna, Philippines. 27 pp.
- ERDB (Ecosystems Research and Development Bureau). 2013. Dragon Fruit and Palawan Cherry. Vol. 25 Nos. 1, January – April 2013. Research Information Series on Ecosystems. ERDB, College 4031, Laguna. 17 pp.
- Khalili, R.M.A., *et al.* 2006. Proximate composition and selected mineral determination in organically grown red pitaya (*Hylocereus* sp.). *J. Trop. Agric. and Fd. Sc.* 34(2) (2006): 269–27.
- Kek Hoe, T. 2017. Planting density of red pitaya (*Hylocereus polyrhizus*) to achieve optimum yield under Malaysia weather. *International Journal of Agriculture Innovations and Research*, Vol. 6, Issue 2, ISSN (Online) 2319-1473: 354-358.
- Le Bellec, F. and F. Vaillant. 2006. Pitahaya (*Hylocereus* spp.): A new fruit crop, a market with a future. *Fruits*, Vol. 61 (4): 237-250.
- Mahattanatawee, K. *et al.* 2006. Total antioxidant activity and fiber content of select Florida-grown tropical fruits. *J. Agric. Food Chem.* 2006, 54, 7355-7363.
- Mohd, M.H. 2015. An overview of fungal diseases of pitaya in Malaysia. Paper presented during the Workshop on Improving Pitaya Production and Marketing, Kaohsiung, Taiwan.
- Nguyen, V.H., J. Campbell, H.H. Nguyen, and M.C. Nguyen. 2015. Development and implementation of GAP on pitaya in Vietnam: status and challenges. In: Jiang, Y.L., P.C. Liu, and P.H. Huang (Eds.). *Improving pitaya production and marketing*. Food and Fertilizer Technology Center, Taipei, Taiwan. pp. 155-164.
- Nobel, P.S. 2002. *Cacti: Biology and Uses*. University of California Press, Berkeley and Los Angeles, California, USA. 280 pp.
- Official Gazette. 2018. Presidential Decree No. 1433, s. 1978. Malacañang Records Office, Republic of the Philippines. (<http://www.officialgazette.gov.ph/1978/06/10/presidential-decree-no-1433-s-1978/>; Accessed 10 April 2018).
- Pascua, L.T., M.E. Pascua and M.L.S. Gabriel. 2015. Dragon Fruit Production and Marketing in the Philippines: Its Status, Constraints and Prospects. In Jiang, Y.L., P.C. Liu, and P.H. Huang (eds.). *Improving pitaya production and marketing*. Food and Fertilizer Technology Center, Taipei, Taiwan. pp. 47-63.
- Pascua, L.T. and M.L.S. Gabriel. No date. How to grow dragon cactus (Brochure). Ilocos Agriculture Aquatic Resources and Development Consortium (ILAAARDEC) and Mariano Marcos State University (MMSU), Batac City, Ilocos Norte, Philippines.
- Pascua, L.T., M.L.S. Gabriel and B.U. Bilgera. No date. Dragon cactus varieties (Brochure). Ilocos Agriculture Aquatic Resources and Development Consortium (ILAAARDEC) and Mariano Marcos State University (MMSU), Batac City, Ilocos Norte, Philippines.
- PNA (Philippine News Agency). 2016. Ilocos dragon fruit penetrates Canadian market. August 29, 2016. (<http://2016.mb.com.ph/2016/08/29/ilocos-dragon-fruit-penetrates-canadian-market/>; Accessed 31 March 2018).
- PSA (Philippine Statistics Authority). 2018. Dragon Fruit Area Planted in the Philippines per Region and Province: 2012-2017. Crops Statistics Division, Philippine Statistics Authority, Quezon City, Philippines.
- PSA (Philippine Statistics Authority). 2018. Dragon Fruit Volume of Production in the Philippines per Region and Province: 2012-2017. Crops Statistics Division, Philippine Statistics Authority, Quezon City, Philippines.
- Riska, J.D. Emilda and R.P. Yanda. 2016. Research on management of the dragon fruit diseases in Indonesia. Paper presented during the Regional workshop on the control of dragon fruit diseases, Mekong Institute, Khon Kaen, Thailand, 4-8 September 2016.
- Rodeo, A.D., A.C. Castro and E.B. Esguerra. 2018. Postharvest handling of dragon fruit or pitaya (*Hylocereus* spp.) in the Philippines. Unpublished.
- Tacio, H.D. 2013. Growing Dragon Fruit. *Marid Agribusiness Digest*. December 2013: 27-30.
- Tadeo, P.R.M. 2016. Physico-chemical, physiological, and microbiological responses of fresh-cut red and white species of dragon fruit (*Hylocereus* spp.) to 1-methylcyclopropene (1-MCP) treatment. MS Thesis. University of the Philippines Los Baños, College, Laguna, Philippines. Available at the UPLB Library.
- The Jakarta Post. 2018. Banyuwangi dragon fruit a tasty treat for tourists. The Jakarta Post. January 3, 2018. (<http://www.thejakartapost.com/travel/2018/01/02/banyuwangi-dragon-fruit-a-tasty-treat-for-tourists.html>; Accessed 6 April 2018).
- VNA. 2016. Vietnamese dragon fruit exported to 40 markets. (<https://en.vietnamplus.vn/vietnamese-dragon-fruit-exported-to-40-markets/114008.vnp>; Accessed 1 April 2018).

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