Developing production guidelines for growing high-value specialty melons for domestic and export markets

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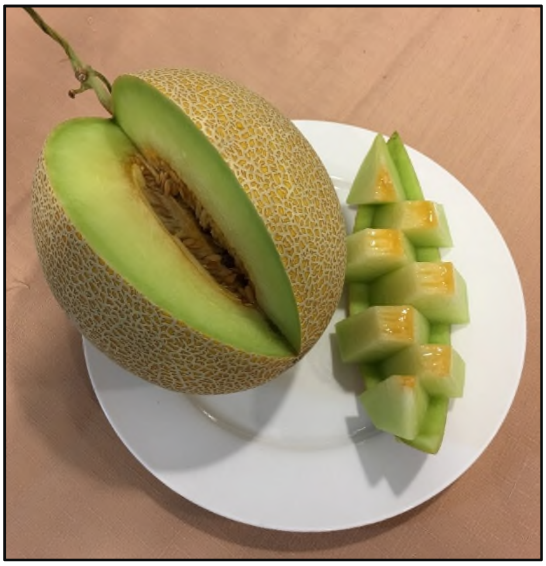
Summary

Queensland production of melons (*Cucumis melo* L.), typically rockmelon and honeydew fruits, is seasonal and practiced entirely outdoors. The horticulture industry has limited knowledge about using protected cropping as a technology to mitigate the effects of climate variability in melon crops. Some new specialty melon types now available in Australia require favourable environmental conditions and specific growing practices in order to obtain fruits with good visual and eating quality. Adoption of protected cropping could be a forthcoming technology to add diversity in fruit appearance, flavour and aroma, and guarantee consistent high quality of melons in domestic markets and potential export markets in Asia and NZ. This Agri-Science Queensland Innovation Opportunity project supported primary crop evaluations that contributed to critical information for the development of guidelines to produce specialty melons with protective cropping systems in the tropics. Three melon crops grown between September 2017 and June 2018 tested 21 cultivars of fruit types new to Australia. The management of crops followed specific agronomic practices for soilless production and plant canopy management. Crop performance and visual and eating quality were assessed and a range of desired attributes were identified for rind colour and net patterns, flesh colour, texture and shelf life. There were examples of cultivars with remarkable sweet flesh (total soluble solids up to 16 °Bx) in large fruits. A group of promising cultivars had total marketable yields that ranged from 5.5 to10 kg/m^2 with fruit weights that ranged from 0.9 to 2.0 kg/fruit, and where total soluble solids ranged from 12 to 16 °Bx. The outcome of this work prompted a small group of industry stakeholders to consider the development of a melon export program. A subsequent granted project under the Growing Queensland's Food Exports pilot program aims to initially send high quality fruit samples to Asian markets. The Department of Agriculture and Fisheries is providing support with research and development on melon agronomy practices.



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Background

Melon (*Cucumis melo* L.) fruits of type rockmelon (Reticulatus Group) and honeydew (Indorus Group) are the two most commonly grown and consumed in Australia. In 2016, melons were grown in approximately 2,500 ha under field production systems that typically include practices such as plug transplants, drip irrigation and fertigation, and polyethylene film mulch. Approximately a 33 to 40% of the area with melon crops is annually grown in the state of Queensland, where production in 2016 reached 22,300 tons and had an approximate gross value of 30 $m. Approximately 33% of this melon production was exported and had a value of 12.4 $m (Hort Innovation Australia, 2016). Common marketable yields are 27.5 t/ha (1,800 30-litre-trays) for rockmelons and 30.5 t/ha (2,000 30-litre-trays) for honeydews (DAFF, 2014), which on a per plant yield basis correspond to 2.1 and 2.3 kg/plant, respectively.

The Bowen-Burdekin region in the Dry Tropics produces about 40% of the melons in Queensland, with harvests that target demand in the southern metropolitan areas of Australia during winter. Melon crops are established after the rainy season in mid to late February. Thereafter, sequential plantings continue until early September. Early crops may be harvested in May and late crops in December. Climate variability can lead to changes in terms of plant stand establishment, marketable yields and production periods. Excessive rain, especially near harvest time, can result in serious fruit breakdown and poor quality fruit with low sugar content (DAFF, 2014). In the field, yield reductions can occur as a result of soil borne diseases (e.g. *Fusarium* spp.) and foliar diseases (e.g. *Podosphaera xanthii* and *Pseudoperonospora cubensis*), which annually affect crops to different degree, depending, among other factors, on favourable climatic conditions for disease infection and spread.

Lack of uniformity in fruit maturity at harvesting, is another problem that can lead to variability in the melon quality offered to the consumer. Fruits that set on flowers at different times and node positions along the vine lead to variability in ripeness among fruits at harvest time. This can have an impact on consumption as surveys have identified that increase in consumption is hampered by relative low satisfaction in consumers purchasing melons. Some of the reasons expressed by consumers are poor or inconsistent eating quality (e.g. in regards to sweetness and aroma) and poor external or internal quality (e.g. blemishes on the rind or on the fruit surface, which were associated to internal rots) as well as the uncertainty of eating quality when prediction is based on fruit visual appearance.

In addition to rockmelons and honeydews, there is a large range of melon fruit types broadly classified as “specialty melons” in the Australian domestic market. Some of these melon types are widely grown overseas but can require specific growing conditions and postharvest handling in order to achieve acceptable yields with consistent high fruit quality. As a response to the market demanding greater diversity of the melon commodity, a few melon growers in Queensland have started to grow some fruit types that are new in the domestic market. As an example, it is now possible to find in supermarkets “piel de sapo” (the Spanish name which translates to “toad skin”) and small canary types (both Inodorus Group), melons that are common in Mediterranean countries. Other fruit types are uncommon, and examples are Galia (Reticulatus Group), Charentais (Reticulatus Group), Hami (Inodorus Group) and a range of Asian types (developed from cross breeding genetic materials of Reticulatus and Inodorus groups). Some Galia type melons have been evaluated in field crops in North Queensland but yield and quality were inconsistent because of variable environmental conditions (e.g. rainfalls), foliar diseases, and decay of fruits in contact with soil, and cultivars tested had a short shelf life.

Growers may aim to target niche markets by supplying ripened specialty melons at specific times of the year. There are also opportunities to supply specific melon fruit types to overseas markets in Asia and New Zealand. It will be critical that growers in the tropics consider new production systems that ensure consistent supply of high quality fruit, have a low risk for crop failure, and are economically viable. Simple greenhouse structures and polyethylene tunnels are components in protected cropping systems widely used overseas for growing specialty melons but these structures are rarely used in Queensland or even in Australia. Growers testing and adopting protected cropping in the tropics need guidelines for production of melons. A gap analysis for adopting the use of protected cropping systems in the Australian tropics (VG16024) was completed by DAF in 2018 (Hort Innovation Australia, 2018). The report details benefits and challenges of protected cropping as well as technology options that could assist targeting market opportunities in the melon supply chains by a segment of the industry.

Project Objectives

The objective of this project was to gain information on the potential yields, fruit visual quality (e.g. fruit shape and size, rind texture and flesh colours) and eating quality (e.g. aroma, sweetness, flesh firmness and juiciness), as well as problems that may arise from growing specialty melons under low-cost protective cropping structures in North Queensland. The collected information on agronomic practices and further evaluations and visual materials will be used by the DAF project team to compile guidelines for producing high quality melons. The guidelines will assist growers that would like to target potential niche domestic and export markets.

In the DAF's Impact Map link, this project relates to *Adapting protected cropping systems; Transform tropical horticulture production to increase industry productivity through reducing climate & biological risks, resulting in improved quality and extended seasonality for the consumer*. The activities were co-funded by project HORT2014-080 (Integrating protected cropping systems into high value vegetable value chains in the Pacific and Australia).

Methodology

Melon crops were grown in a protective structure in a commercial farm near Ayr, Queensland. The high passively ventilated greenhouse (30-m wide x 70-m long) had a saw-tooth roof design. The roof cover was a semi-transparent, woven polyethylene film. Side walls were ventilated and covered with insect exclusion screens. In a soilless media production system, two plants were planted per container (11-L polyethylene pots filled with either pine bark or coconut coir). The containers were aligned as single rows and were connected to a pipe along the ground level which collected the drained irrigation solution. The separation between plant rows was 1.6 m and the in-row container distance was 0.40 m. The plant population density was 3.2 plants/m^2. Three melon crops were started 7 September 2017 (direct seeding in containers) and in 8 March and 4 April 2018 (both initiated by transplanting seedlings) (Table 1). A range of melon fruit types and cultivars were tested (Table 2).

The melon plants were pruned to form a main stem which was supported vertically on a trellis that had polyethylene twines hanging from overhead steel cables extended along the plant rows. The method of pruning kept two to three lateral shoots after the 7th leaf node. These lateral shoots were then cut off after their second leaf node, once the growing fruits set at the first leaf node (counting from the main stem) reached approximately 3 cm in diameter. In these trials, because bees could not be used inside the commercial greenhouse, pollination was done manually during the mornings. For the purpose of collecting information on fruit development, flowers were labelled with the pollination date. After setting 2 to 3 fruits on nodes 7 to 9, only 1 or two fruits were left per plant (the misshapen fruits were removed). The remaining lateral shoots were removed and once the main stem reached the overhead wire (height of 1.8 m) the main growing stem was terminated.

Table 1 – Melon crops grown in a greenhouse in north Queensland.

Crops evaluated	Crop 1	Crop 2	Crop 3
Cultivars tested (Plants per cultivar)	7 (15)	1 (90)	13 (16)
Sowing date	7/09/2017	23/02/2018	16/03/2018
Transplanting date in greenhouse	(direct seeding)	8/03/2018	4/04/2018
Hand pollination	7/09/2017	27/03 to 1/04/2018	22/04 to 30/04/2018
Harvesting date	20/11/2017	21/05/2018	19/06 to 22/06/2018
Days from sowing to transplant	--	13	19
Days from transplant to pollination	34 (from sowing)	19	18-26
Days from pollination to harvest	40-47	55	53-58
Total days Sowing-to-Harvest	**74-81**	**87**	**95-98**
Total days Transplant-to-Harvest	**--**	**74**	**76-79**

Table 2 – Various specialty melon types evaluated in a greenhouse in north Queensland.

Cultivar name	Fruit type	*Cucumis melo* Group	Rind texture & colour of net and background	Flesh colour
1	Hami	Inodorus	Smooth skin; light yellow	White
2, 3, 6, 7	Asian	Reticulatus x Inodorus	Light grey net over light or dark green	Green
8, 9, 11	Cantaloupe	Reticulatus	Light grey net over light or dark green	Orange
14	Galia	Reticulatus	Light brown net over gold	Green
12	Cantaloupe	Reticulatus	Light brown net over gold	Orange
10, 13, 15	Charentais x Cantaloupe	Cantaloupensis x Reticulatus	Light grey net over light green or yellow; dark green sutures	Orange
16	Canary	Inodorus	Smooth skin; yellow	White

Plants were fertigated daily with a complete nutrient solution. Nitrogen concentration level started at 100 mg/L at transplanting and was gradually increased up to 160 mg/L after three weeks after transplanting (WAT). Potassium concentration level started at 177 mg/L at transplanting and was increased to 250 mg/L after four WAT. All other nutrients were kept at the same concentration level during the cropping season. The target nutrient concentration levels were: (in mg/L) P:50; Ca:140; Mg:47; Fe:2.8; S:65; Zn:0.3; B:0.7; Cu:0.2; Mo:0.1, and Mn: 0.9. During most of the crop cycle the irrigation solution was kept within ranges of 6.2 to 6.5 for pH and 2.1 to 2.5 dS/m for electrical conductivity (EC). Fertigation events were scheduled on a time basis, with an average of one irrigation event every hour, between 6 am and 6 pm. The volume of irrigation per plant per day increased from 0.5 L to 2 L during the cropping season. Targeted irrigation drainage from the containers was 5 to 20%. The irrigation volume was reduced by half during the last two and a half weeks before the fruits were harvested. The growing practices were modifications from previous research work conducted by DAF in north Queensland and research at the University of Florida (Cantliffe et al., 2004; Hochmuth and Cantliffe, 1990; Mitchell et al., 2007; Jovicich and Wiggenhauser, 2015a, 2015b). An integrated pest management program was implemented and included the use of active ingredient spinosad to reduce populations of western flower thrips (*Frankliniella occidentalis*) and preventive releases of biological control agents. The parasitic wasp *Aphidious colemani* was released to suppress melon aphid (*Aphis gossypii*) populations, and the predatory mite *Neoseiulus californicus* was released to supress two spotted red mite (*Tetranichus urticae*) populations. The screened greenhouse structure prevented the entrance of larger insects. Most melon cultivars had genetic resistance to the foliar disease powdery mildew (*Podosphaera xanthii*); however, a solution with potassium bicarbonate was sprayed as a preventative protectant fungicide. Downy mildew (*Pseudoperonospora cubensis*) and anthracnose (*Colletotrichum orbiculare*) were not present on crops because leaves did not get wet from rainfall events.

Each cultivar was harvested when fruits reached maturity for consumption. Fruits were counted, weighed and assessed for quality defects that would make them unmarketable. The soluble sugar content (indexed as total soluble solids of fruit juice, TSS and reported as °Bx) was measured using a hand-held digital refractometer, with measurements started a few days before and after fruit harvest. Fruits were stored in a refrigerated room (6 to 8 °C and relative humidity in the range of 80 to 85%) for three days until they were assessed for quality. In the third crop, some fruits were assessed for visual and eating quality after 15 and 30 days from harvest. Selected information is presented in this report, mostly using one Galia-type cultivar as an example of potential yield and quality outcomes.

Results and discussion

Table 3 is presented as an example of fruit yield outcomes for a Galia-type cultivar transplanted in March 2018. Image 1 has the three sizes of fruits harvested in this cultivar. The total marketable yields averaged 1.67 fruits per plant at harvesting time. Larger fruits (>1.9 kg/fruit) were sweeter (i.e. had higher °Bx levels) and grew in plants that held a single fruit. Along the 1.8 m stems, plants had a total number of nodes in the range of 20 to 23. Fruits were allowed to set on the lateral shoots developing on nodes number 7 up to 9 along the main stem. In subsequent trials, production will be evaluated when one or two fruits set at higher level nodes. The extension of the vegetative period should allow plants develop thicker stems and larger root systems, which will possibly lead to greater yields of larger fruit. The targeted fruit size will also depend on market demand and it is a trait that can be manipulated with agronomic practices.

Restricting the number of fruits to a uniform number of fruits per plant throughout the same crop, and ensuring fruits are located on nearby lateral shoots along the stem, would lead to a cohort of fruit that share a similar age (±1 to 3 days difference between pollination dates). This would make changes of fertigation practices (e.g. reduction in N concentration levels; increase of EC, and gradual decrease of irrigation volume before harvest) easier to manage and it should reduce variability in fruit size and fruit quality. Overall, the crop management practices that were applied with the Galia-type cultivar led to a relatively uniform and synchronised production with low variability in parameters that describe fruit eating and visual qualities at the time of a single harvest. Total soluble solids reached up to 16 °Bx and in general were greater than 12 °Bx.

Visuals were taken throughout the cropping period recording management practices and inputs required. Image 2 presents a summarised sequence of photos for key crop activities in the Galia-type cultivar. These included transplanting seedlings, trellising and pruning plants, pollination (bees would be used in commercial crops), and fruit development stages until harvest in May 2018.

The cultivars 1 to 13 planted in April 2018 were from a range of fruit types (Table 2 and Image 3). Means for marketable fruit yield, total soluble solids and relative fruit weight (overall fruit weight was in the range 0.9 to 1.9 kg/fruit) are presented in Figure 1. Performance of cultivars was varied. Considering all cultivars, marketable fruit yields in weight and fruit number ranged from 2.6 to 9.9 kg/m^2 (Figure 1) and from 1.6 to 6.2 fruit/m^2, respectively. Total yields (marketable and non-marketable fruit combined) in weight and fruit number ranged from 6.5 to 11.3 kg/m^2, and from 4.8 to 7.2 fruit/m^2. Among cultivars, values for total soluble solids in fruit juice were in the range of 9.6 to 14.5 °Bx when averaging measurements taken two and six days after harvest and with fruits stored at temperatures between 6 and 8 °C. Nine of the 13 cultivars had Brix levels that were higher than 12.

Among the 13 cultivars there were three that were more sensitive to powdery mildew disease (mainly cultivars 1, 3, and 12) (Figure 1). Some cultivars (i.e. cultivars 6 and 7) had a few plants that presented symptoms of a basal stem rot. It was also evident that some cultivars required less irrigation as fruit cracking was the main fruit disorder that increased the number of non-marketable fruits (i.e. cultivars 3, 4 and 5). These cultivars may still produce good quality fruits but they would require a different fertigation management than the one practiced for all cultivars. Pests were not a production constrain as they were managed well with the biological control program.

Signs on fruits that indicated fruit harvest readiness was quite variable among fruit types. For example, in some cultivars fruit developed a slit that extended around the peduncle's abscission zone while others had no slit and they would not detach from the vine when reaching maturity (a good feature in vertically trellised crops). Some cultivars which had fruits that would not detach from the peduncle developed radial cracks at the base of the peduncle, a sign that served as an indicator to harvest. The senescence of leaves next to the fruit were also signs noted as indicators of harvesting time.

From these evaluations, group of promising cultivars had total marketable yields that ranged from 5.5 to 10 kg/m^2 with fruit weights that ranged from 0.9 to 2 kg/fruit, and where total soluble solids ranged from 12 to 16 °Bx.

With the assessments on crop performance and visual and eating quality a range of desired attributes were identified for rind colour and net patterns, flesh colour, and texture (Image 3 and 4). Information gathered from the crops grown in this project allowed to increase knowledge on management practices that can be used to substantially increase fruit quality. The information is assisting in the development of a small production manual that aims to outline guidelines for growing melons using protected cropping in the tropics.

Table 3 – Fruit yield of Galia-type melons in a single harvest of a crop grown from 2 February to 21 May 2018 in north Queensland.

	Fruit size	Fruit weight[1]			Fruit number		TSS[2]
Fruit categories	Length x Diameter (cm)	(kg/ fruit)	(kg/ plant)	(kg/ m^2)	(No./ plant)	(No./ m^2)	(°Bx)
Small (0.7-1.3 kg)	14 x 13	1.09	0.66	2.05	0.60	1.88	11-13
Medium (1.31-1.9 kg)	16 x 14	1.53	1.04	4.37	0.91	2.85	12-13.5
Large[3] (1.91-2.5 kg)	18 x 15	2.19	0.34	1.06	0.16	0.49	14-16.5
All sizes		--	2.04	7.48	1.67	5.22	--

[1] Plant density 3.1 plants/m^2.
[2] Total Soluble Solids.
[3] Large fruits developed when there was a single fruit per plant.

Image 1 – Small, medium and large size fruits of a Galia-type fruit grown in a greenhouse in north Queensland in 2018.

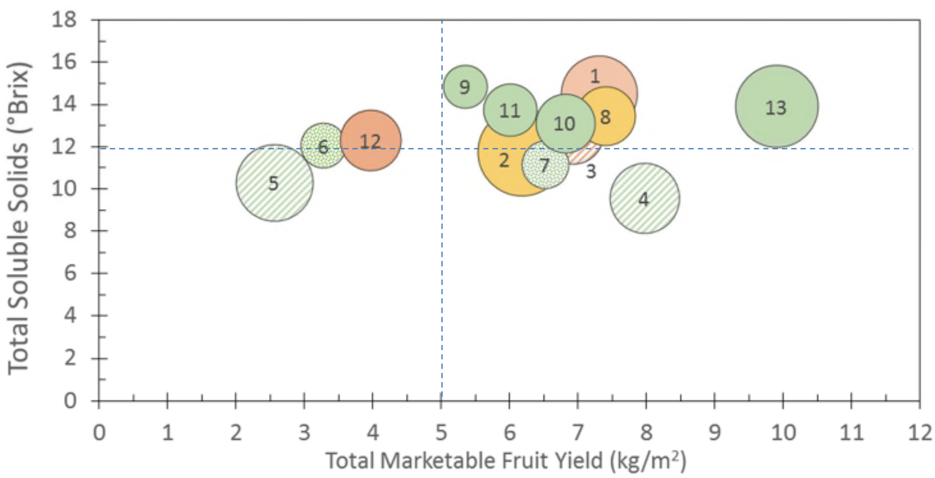

Figure 1 – Means for marketable fruit yield, total soluble solids and fruit weight (circle diameter is relative to fruit weight in the range 0.9 to 1.9 kg/fruit) in thirteen specialty melon cultivars (1 to 13) grown in a greenhouse in north Queensland in 2018. Green, orange and red colours in circles correspond to 'none', 'slight' and 'high' powdery mildew incidence on leaves, respectively. Diagonal pattern in circle indicates that fruit cracking was the main fruit disorder in non-marketable fruits (not shown). Dot pattern indicates that plants were affected by stem rot. Fruits of these cultivars appear in Image 3.

Image 2 – Example of greenhouse cropping practices used to grow high quality specialty melons in north Queensland.

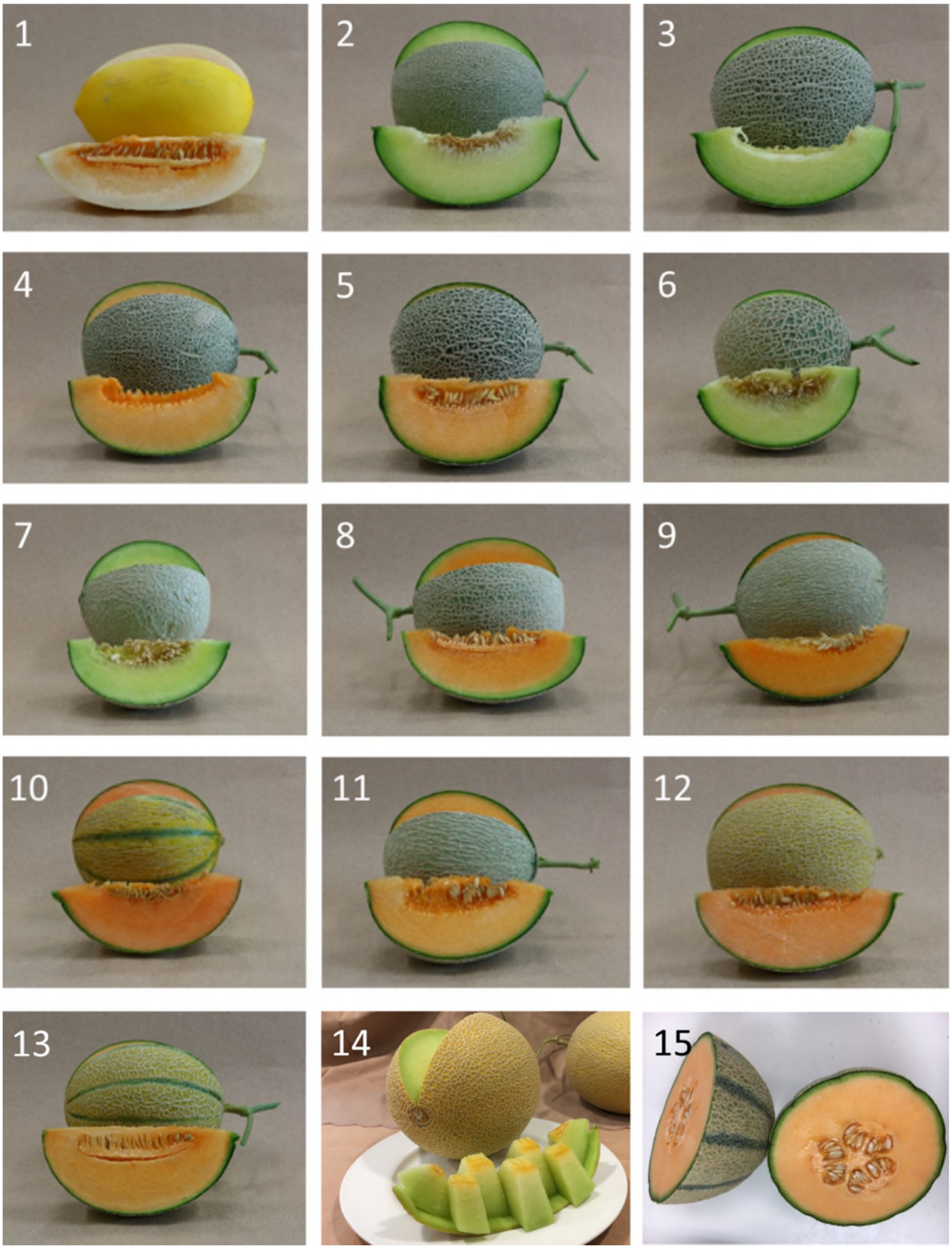

Image 3 – A range of specialty melon fruit types and cultivars evaluated in a greenhouse in north Queensland in 2018.

Image 4 – Fruits of four of the specialty melon types evaluated in a greenhouse in north Queensland in 2018.

Conclusions/Significance/Recommendations

This project collected information (not all presented here) that significantly increased knowledge about production methods for growing melons with protected cropping systems in Queensland. The information was critical to support the development of production guidelines.

With protective cropping, a melon crop would occupy an area under the structure during 3 to 3.5 months of the year; therefore 3 to 4 crops could be grown per year. For maximum economic returns, the high quality fruits would have to target niche markets and attract prices much higher field-grown melon fruits. Marketing programs will have to differentiate greenhouse-grown melon fruits from field-grown fruits. Limited quality observations were taken to evaluate quality during shelf life and additional postharvest studies should be conducted using the most promising cultivars, and also with fruits produced at different times during the year. When aiming for high sugar content, the number of fruits per plant (from one to two) and the fruit position in the plant will be determined through the practices of pruning and pollination (commercially carried out with bees). Grown inside greenhouses or poly-tunnels, specialty melons should probably lead to overall returns that at least match those for current Lebanese or continental cucumber crops.

Melon fruit samples from trial plots were sent to markets in Brisbane and Townsville and received feedback on eating and/or visual qualities for some cultivars. Positive feedback and constructive criticism on quality was received from: visitors from Japan; Brisbane Market Buyers; Queensland Trade and Investment Commissioners for Japan and Singapore; local Thai and Japanese restaurants; and a Growers Burdekin Produce contest. Melon agronomy for protected cropping systems was discussed with Japanese researchers visiting the melon trial in North Queensland in mid-June (Visitors travelled under the Memorandum of Cooperation Qld DAF and Japanese Ministry of Agriculture, Forestry and Fisheries). In March, during project activities in Fiji under HORT 2014-080, Elio was able to visit a large Korean farm where agronomy practices of greenhouse-grown melons were discussed.

Key Messages

The Department of Agriculture and Fisheries has pioneered trials on protected cropping systems in the Queensland tropics (Hort Innovation Australia, 2018). Innovative growing practices have been tested in commercial farms and have produced marketable yields of melons 2.5 times greater than the average yield of field-grown crops and with increased and more consistent quality. Melon fruit types evaluated in these trials are novel in the Australian market and had excellent eating and visual quality. Some of these fruit could be used in export programs if quality is maintained after air and sea freight (post-harvest evaluations are still required). Queensland Trade and Investment Commissioners for Japan and Singapore, have commented that some of the tested fruits match desired melon quality characteristics by consumers in these countries.

Where to next

Crop plots grown by DAF during this work and small R&D activities on melons carried out previously by the team provided the background knowledge to develop a project proposal with a commercial business, growers, and the Port of Townsville under the Growing Queensland's Food Export Capability program. Funding for this project was granted in May 2018. DAF will be providing technical expertise for growing fruit samples for overseas markets. The project "*A collaborative value chain evaluation to demonstrate the feasibility of exporting high quality melons from North Queensland*" has as the overall objective to develop a proof of concept for commercial horticultural export from north Queensland through the demonstration of production and supply of melons with improved eating quality by strengthening value chain relationships between overseas buyers and Queensland producers, export businesses, transport companies, and research organisations. Through market development, specific crop production systems, and improved transport logistics, an interdisciplinary team of value chain players will collaborate with regional growers and industry stakeholders to demonstrate that export of high quality melons can be a business opportunity to increase economic returns in North Queensland.

The outcomes in this project justify examination of new genetic materials, economic feasibility studies, and adaptive research on fertigation and canopy management to refine crop growing recommendations for specific fruit types and cultivars. Future evaluations should also examine protected cropping of melons grown in soil (a trial was conducted in early 2017) and under high poly-tunnels as this could be a low-cost production system for field growers that decide to test protected cropping for the first time.

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Budget Summary

The budget covered operating costs for crop and office inputs, travelling to the site in the Burdekin, a trip to Brisbane to show produce samples and discuss subsequent project, components to modify a fertigation system, tools and measurement equipment required for work on greenhouse-grown melons.

Table 4 – Budget

Expenses	**Actual ($)**
Office, Print, Books, & Computer consumables	1,250
Vehicle use (Fleet & External for Townsville-Burdekin & Brisbane-Gatton)	4,370
Travel Airfares, Accommodation & Meals (Townsville-Brisbane)	919
Portable equipment (e.g. refractometer, irrigation controller, temp. & humidity sensors, pruning tools)	1,850
Agriculture chemicals and other crop consumable inputs (e.g. fertiliser, biological control agents, pot media, etc.)	1,271
Cold room use	340
Total	10,000