Technology adoption among melon agropreneurs in Sabah and Sarawak: An analysis using Fuzzy Logic
(Tahap penggunaan teknologi dalam kalangan usahawan tani melon di Sabah dan Sarawak: Analisis menggunakan logik kabur)

Rasmuna Mazwan Muhammad*, Nik Rozana Nik Mohd Masdek*, Siti Zahrah Ponari*
Jilum Anak Makup** and Rozhan Abu Dardak***

Abstract
Melon was recognised as one of the most competitive fruits in the local
and international markets, and thus, has been emphasised to be cultivated
commercially. However, the production of this commodity seems to fluctuate
and drop lately. There are many factors that contribute to these issues. This study
aims to identify the application of technology by melon agropreneurs in Sabah
and Sarawak. This study focuses on three types of melons namely watermelon,
honeydew and rockmelon. The farmers are categorised as conventional and
fertigation cultivation practices. This study used the method of Fuzzy Logic
Model (FLM) in determining the level of technology adopted by the agriculture
industry as it is the most widely used method by previous researchers. The FLM
analysis showed that the technology adoption by all fertigation agropreneurs is
at the low level. Meanwhile, for the conventional agropreneurs, only 3% of them
reached a moderate level of technology adoption, while the rest 97% were at
the low level. The results showed that the technology achievement index among
fertigation agropreneurs was low at 0.293 with the technology gap (0.057).
The technology achievement index for conventional agropreneurs is also low
at 0.290 with the technology gap (0.104). It can be concluded that the practice
of technology adoption among melon agropreneurs in Sabah and Sarawak was
almost similar despite a small gap for both types of cultivation. This finding
proved that there was no significant difference in terms of the technology
adoption between the highest score and lowest score of technology practitioners
in Sabah and Sarawak for both cultivation systems. This study provides guidance
to technology generators to produce the most needed technology such as cost-
effective technology that improve fruit quality. In addition, technology transfer to
Sabah and Sarawak melon agropreneurs should be enhanced in order to increase
the technology in melon cultivation practices.

*Economic and Social Science Research Centre, MARDI Headquarters, Persiaran MARDI-UPM,
43400 Serdang, Selangor
** MARDI Sarawak, Lot 411, Blok 14, Jalan Sultan Tengah, Petrajaya, 93055 Kuching
***Strategic Planning and Innovation Management, MARDI Headquarters, Persiaran MARDI-UPM,
43400 Serdang, Selangor
E-mail: rasmuna@mardi.gov.my

Introduction

Melon is one of the important fruits in Malaysia. In general, more than 6,000 hectares of land were cultivated with melons in 2015. They are cultivated in almost all regions which contributed to the economic development of farmers. Sabah and Sarawak are two main states having the largest area of melon cultivation in Malaysia. However, production of melons in Sabah and Sarawak experienced a fluctuation trend from 2011 to 2016. The highest production was recorded in 2012 with a total yield of 12,149.40 metric tonnes, with a value of RM18.47 million. However, the value decreased substantially to RM3.9 million in 2015. The production of melon in Sabah slightly increased to 3,624.70 metric tonnes with the value of RM4.6 million in 2016. In Sarawak, the highest production was recorded in 2011 about 16 144.40 metric tonnes and is worth around RM24.05 million. However, there was a slight decrease in production around 9,661.8 metric tonnes in 2014. Subsequently, the total production declined to 8,765.10 metric tonnes in 2016, reaching a value of RM11,131,700 (DOA 2016). It could be seen that the cultivated area of melons is parallel to the decreasing of melon production. Despite market issues, pest and diseases such as cut-worm and diamondback moth also contribute to the decline of melon production in Sabah (*Figure 1* and *2*).

In order to remain competitive in the global market, melon agropreneurs need to be equipped with new knowledge, as well as technology related to melon cultivation. Melon agropreneurs should always be proactive in finding new ways or technology to increase their production and be ahead in the industry. The benchmarking technology provides a method of comparing the performance of Malaysia's current practices, with the best practices and technology application by others. However, information on the level of technology practices among melon producers in Malaysia is still lacking. Thus, this study aims to identify the technology practices in Malaysia, specifically to measure the level of technology adoption among melon agropreneurs in Sabah and Sarawak. A comparative analysis was carried out between the standard farm practices by melon agropreneurs and the best practices recommended by MARDI to identify the gaps.
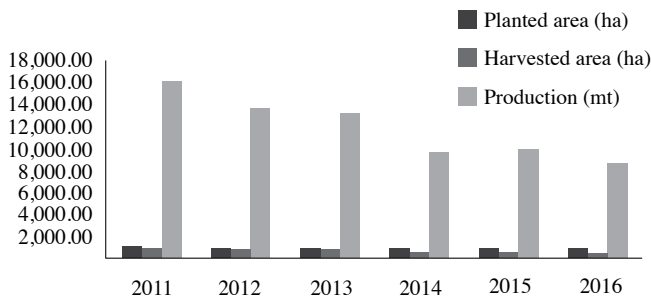
Technology in melon cultivation

Technology is a very important element in farming activities. According to Rasmuna et al. (2015), income and total production have a significant association with the technology index. This means that the higher the level of technology adoption, the higher the income and total production. The increase in production is associated with technology injection (Agrofood Statistics 2014). For example, the injection of technology obviously contributes to this increase. Among notable technology involved is the fertigation system using automatic dripper and enhanced fertiliser.

Malaysian Agricultural Research and Development Institute (MARDI) is a leading agency on technology development as well as transferring the technology since it was established nearly 50 years ago. MARDI has developed many technologies along the value chain of fruit production including for melons. MARDI developed the *Superhort* melon variety which is considered among the best as compared to existing hybrids in terms of its sweetness, shape, yield, maturity and disease resistance (Rasmuna and Nik Rozana 2016). The technology is transferred to farmers through technical training, seminars and publications. For example, MARDI has published a manual of rockmelon cultivation by using a more systematic, and coordinated approach which can be adopted by agropreneurs. The book has been widely used as a reference in most of the agencies under the Ministry of Agriculture and Agro-based Industry (MOA) as well as by agropreneurs. Other related technologies on melons are related
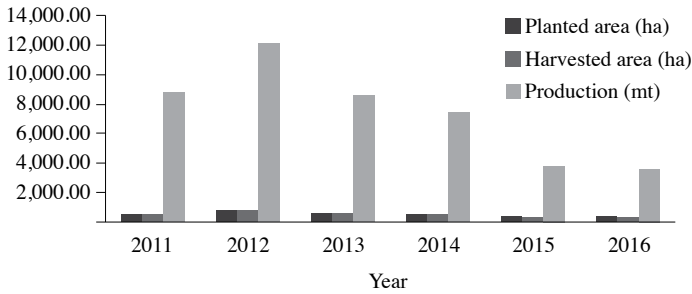
Source: DOA (2016)

Figure 1. Cultivated area, harvested area and production in Sabah (2011 – 2016)

Source: DOA (2016)

Figure 2. Cultivated area, harvested area and production in Sarawak (2011 – 2016)

to fertiliser formulation, planting system and processing melons for its juice.

Basically, there are six technologies developed for melon cultivation in Malaysia. There are water management, cultivation, fertilisation, agronomic practices, pest and disease management and postharvest handling technologies. Among the notable technology used by agropreneurs is the fertigation system using automatic dripper and enhanced fertiliser.

In general, melon agropreneurs in Malaysia practices two cultivation system which are fertigation (open system, closed system, semi-closed system) and conventional. Fertigation system is a crop management practice that allows a timely supply of water through drip irrigation coupled with an accurate rate of fertiliser application, thereby simultaneously improving crop nutrient uptake. Under the fertigation system, agropreneurs can apply

fertiliser more accurately and uniform without wastage. In addition, this system enables the agropreneurs to use less labour and minimises the use of water per unit area. This system is mainly used by rockmelon agropreneurs.

This system also produces higher productivity in a small area. On the contrary, conventional system is a traditional approach whereby the melons are cultivated on the ground. The conventional system is still considered the best method for cultivating watermelons and honeydews, which requires a wider area so as to ease the plant to get nutrients. Majority of the watermelon agropreneurs use organic fertiliser mixed with potassium to increase fruit sweetness (brix).

Methodology
The study was carried out in Sabah and Sarawak involving 51 melon agropreneurs.

21

The selection of respondents was done using purposive sampling. Structured questionnaires were used to collect the farmers' background as well as adoption of technology. Interviews were also carried out and guided by trained enumerators. The first part of the questionnaire solicited demographic information, such as age, gender and farm location. The second part included items pertaining to the usage of technology. Interviews were also conducted to gauge information regarding the process involved during harvesting, cultivation, post-harvest handling and other processes related to the technology. Information about management practices, cultivation process as well as planting procedures were obtained from various sources, such as the DOA as well as detail information regarding the publication from China, Taiwan and the USA. Other relevant secondary data were obtained from journal articles, patents, books and government reports. The data were analysed using descriptive statistics and Fuzzy Logic Model (FLM). FLM was chosen to identify the level of technology adoption and benchmark the technology status of melon production.

Fuzzy Logic Model (FLM)

Fuzzy Logic Model (FLM) is commonly used by researchers to benchmark the performance of farms or industry. It is a tool to identify a standard of performance. Despite of technology adoption index, FLM can also identify the technology that should be emphasised and strengthened. The FLM used in this study is based on the concepts of fuzzy set theory used in past research by Zadeh (1965), Ronan and Clearly (2000) and Kale and Karaman (2011). FLM analysis was conducted for both fertigation system and conventional system. Among the important criteria involved in FLM are the input of the selected technology, parameter and output. The

benchmarking indices were categorised into three performance levels, which are best, moderate and low, in which the score indicates the best: ≥ 0.6, moderate: $0.36 < x < 0.6$, and the low: ≤ 0.36, as defined by Zadeh (1965). *Table 1* shows the scale indicators of technology level applied in this study.

The Fuzzy Logic Model was applied to benchmark the technology status in melon production using six parameters, namely:

i. Water management technology
ii. Cultivation technology
iii. Fertilisation technology
iv. Agronomic practices technology
v. Pest and disease management technology
vi. Postharvest handling technology

Findings and discussion
Cultivation of melon

The study revealed that melon cultivations in Sabah and Sarawak are dominated by male agropreneurs (89.4%). The age of the agropreneurs is in the range between 41 – 50 years. Around 78% of melon agropreneurs in Sabah and Sarawak are still using the conventional system and about 22% of the them are using the fertigation system. Most of the agropreneurs used hybrid seed which is imported from Taiwan. The conventional agropreneurs who produces watermelon and honeydew used *New Dragon*, *Black Beauty* and *Jade Dew* varieties. While the fertigation agropreneurs used *Glamour* varieties. These varieties have good characteristics such as short in maturity, produce higher yield and quality fruit. The agropreneurs select the varieties based on the demand at local market.

Table 1. Technological level scale indicator

Best: ≥ 0.6
Moderate: $0.36 < x < 0.6$
Least: $x \leq 0.36$
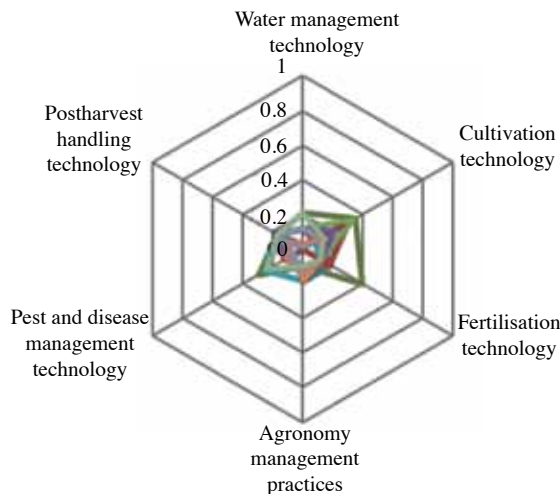
Technology adoption by fertigation agropreneurs

All fertigation agropreneurs surveyed in Sabah and Sarawak cultivates rockmelon. Six technology benchmarking indicators were identified for evaluating the technology adoption by fertigation agropreneurs. The benchmark parameter showed that technology usage among melon agropreneurs were at the low scale, as shown in spider chart in *Figure 3*. The figure shows that only the cultivation technology is relatively score high, while other technology indicators (water management technology, fertilisation technology, technology of agronomic practices, pest and disease management technology and postharvest handling technology) were considered at low scale.

This finding indicates that the fertigation agropreneurs did not follow the good agricultural practices which were recommended by MARDI through the manual. Fertigation is a comprehensive cultivation system that requires the agropreneurs to follow the process completely. The failure to follow the system will lead to low productivity and low quality of fruits.

Figure 4 shows the level of technology adoption practices among rockmelon agropreneurs in Sabah and Sarawak. The FLM analysis showed that all of the rockmelon agropreneurs adopted technology with score less than 0.35. This indicates that the level of technology adoption for rockmelon cultivation is still very low. The study also revealed that only a few of melon agropreneurs were practicing the fertigation system due to the difficulty in obtaining inputs for fertigation cultivation method which causes farmers to be more interested in maintaining the conventional way of producing melons (Rasmuna et al. 2016).

Technology adoption by conventional agropreneurs

All conventional agropreneurs surveyed in Sabah and Sarawak cultivates water melon and honeydew. This section discusses the level of technology utilisation by conventional agropreneurs. In general, the conventional agropreneurs also do not follow the manual of watermelon cultivation recommended by MARDI or DOA. Many of them still practiced the traditional cultivation system such as using rain-fall water, traditional agronomic practices and

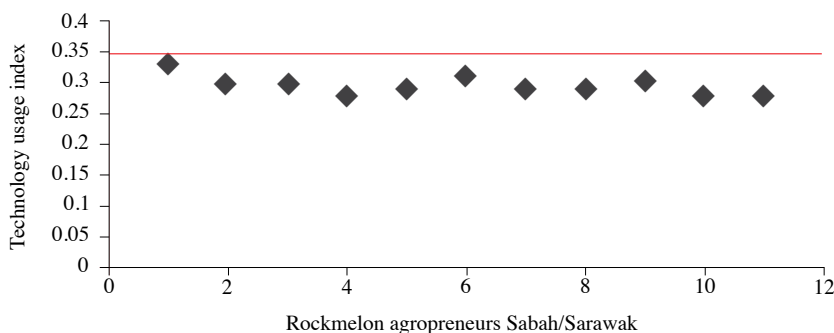*Figure 3. Rockmelon fertigation system Spider Web Fuzzy Index by parameters*

Figure 4. Benchmarking index of rockmelon agropreneurs: Fertigation system

managing their farm traditionally. This study revealed that the technology mostly adopted by the conventional agropreneurs is the water management technology. Using the Fuzzy Logic parameters, the water management technology achieved the moderate level while the remaining technology were at least level (*Figure 5*). This study also revealed that out of 35 respondents, only one agropreneur score 0.363 or moderate level of technology adoption (*Figure 6*).

Technology gap among melon agropreneurs in Sabah and Sarawak
Comparison between the technology gaps is shown in *Figure 7*. Technology gap refers to the difference between the minimum and maximum technology index value. The results showed that the index of Fuzzy Logic among agropreneurs that practicing the fertigation system was 0.293, while for the conventional system was 0.290. Although there was a small gap for both types of cultivation system, it can be concluded that the practice of technology adoption among Sabah and Sarawak melon agropreneurs appears to be similar. This proves that there is no significant difference in technology practices between the highest score melon agropreneur with the lowest score agropreneur in Sabah and Sarawak for each cultivation system. According to the findings, overall technology adoption among melon agropreneurs in Sabah and Sarawak were at low level.

Pearson Correlation Coefficient Analysis
Pearson Correlation Coefficient Analysis was conducted to measure the relationship between fuzzy index technology and socioeconomic element (*Table 2*). There was a medium and positive correlation between technology index and production (0.364) and education (0.382). The more skillful and knowledgeable agropreneurs are about technology, the higher its production. In other words, for agropreneurs who are willing to adopt the technology, their production will be higher. This result confirms the finding by Rasmuna (2015), whereby technology adoption will lead to higher production.

Conclusion
Technology adoption by melon agropreneurs in Sabah and Sarawak is still very low. The entrepreneurs prefer to use conventional cultivation system and traditional practices. As a result, the productivity of the farm is unsustainable and tends to fluctuate in nature. The government needs to address this issue by formulating specific strategies and programmes that could encourage the entrepreneurs to use modern technologies.

Penetration of innovation to the farmers via technology transfer is an important factor in determining the effectiveness of modern technology in melon cultivation, especially in Sabah and Sarawak. Initiatives by the entrepreneur himself to derive the technology may extend their knowledge on the requirement of the technology.
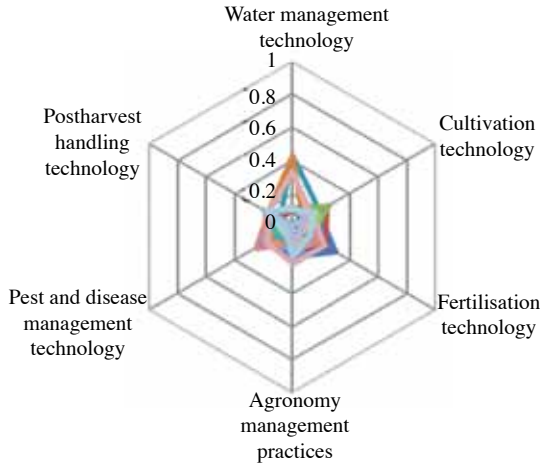
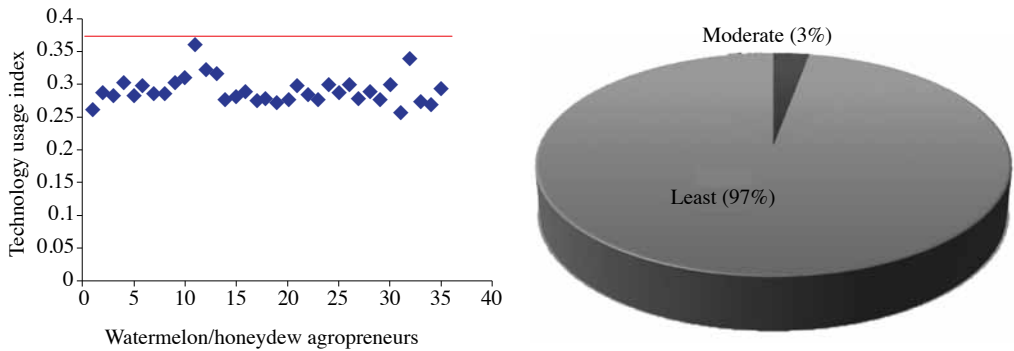*Figure 5. Watermelon and honeydew conventional system Spider Web Fuzzy Index*

*Figure 6. Benchmarking index of watermelon and honeydew agropreneurs:
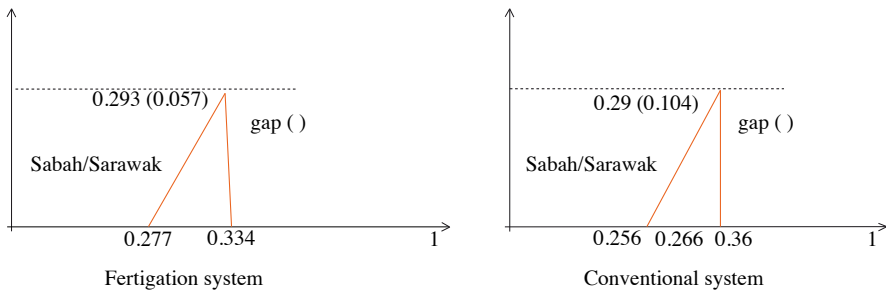Conventional system*

*Figure 7. The technology gap between the fertigation system and the conventional system practiced
between melon agropreneurs in Sabah and Sarawak*

Table 2. Pearson Correlation Coefficient Analysis for socioeconomy element

		AGE	EDU	EXP.	PRODUCTION	HSH	INCOME
Fuzzy Index	Pearson Correlation	.033	.382**	−.026	.364**	−.052	−.046
	Sig. (2-tailed)	.766	.000	.821	.008	.654	.696
	N	84	84	76	52	76	76

**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

Furthermore, it takes courage to face the risks in leveraging the operations by investing or making loans to acquire technology in their farming practices.

The implementation of programmes or courses related to technology transfer may be useful in ensuring a more effective technology adoption among melon agropreneurs in Sabah and Sarawak, which will contribute towards maximising the use of existing and future technology. Thus, the recommended system and initiatives are needed to improve industry practices for melon cultivation in Malaysia.

Acknowledgement

References

Anon. (2014). *Agrofood Statistics*. Ministry of Agriculture and Agro-Based Industry Malaysia

Kale, S. and Karaman, E.A. (2011). *A fuzzy logic model for benchmarking the knowledge management performance of construction firms*. Canadian, pp. 464 – 475

National Agro-food Policy 2011-2020. Retrieved on 5 Mar. 2016 from http://www.moa.gov.my/web/guest/dasar-n

Nik Rozana, N.M.M., Suntharalingam, C. and Othman, M.F. (2017). Competitiveness of Malaysia's fruits in the global market: Revealed comparative advantage analysis. *Malaysian Journal of Mathematical Sciences* 11: 143 – 157

Rasmuna Mazwan, M., Mohd Syauqi, N., Mohd Zaffrie, M.A. and Siti Zahrah, P. (2015). *Kajian Menanda Aras Teknologi Pengeluaran Tembikai*. Laporan Projek Sosioekonomi, Pusat Penyelidikan Ekonomi dan Sains Sosial, MARDI: Serdang

Rasmuna Mazwan, M., Hairazi, R., Mohd Zaffrie, M.A., Syahrin, S., Nor Amna A'liah, M.N., Nik Rozana, N.M., Siti Zahrah, P., Nor Hayati, S. dan Jilum, M. (2016). *Kajian Penilaian Tahap Penggunaan Teknologi Moden Di Sepanjang Rantaian Nilai Aktiviti Pengeluaran Tembikai Di Malaysia*. Laporan Kajian Sosioekonomi. Pusat Penyelidikan Ekonomi dan Sains Sosial, MARDI: Serdang

Rasmuna Mazwan, M. and Nik Rozana, N.M.M. (2016). *Overview of Melon Industry in Malaysia*. FFTC Agricultural Policy Platform. Retrieved on 9 Sept. 2016 from http://ap.fftc.agnet.org/ap_db.php?id=677

Ronan, G. and Clearly, G. (2000). Best practices benchmarking in Australian agriculture: issues and challenges. Paper presented at 44th annual conference. 23 – 25 Jan, 2000

Schultz., Theodore W. Transforming Traditional Agriculture. *Yale University Press*, 1964.

Zadeh, L. (1965). Fuzzy sets. *Information and Control* 8(3): 338 – 353

Rasmuna Mazwan Muhammad, Nik Rozana Nik Mohd Masdek,
Siti Zahrah Ponari, Jilum Anak Makup and Rozhan Abu Dardak

Abstrak

Melon merupakan antara buah-buahan utama yang telah diberi penekanan untuk ditanam secara komersial. Kajian ini bertujuan untuk menanda aras dan mengenal pasti tahap amalan penggunaan teknologi dalam kalangan usahawan melon secara sistem fertigasi (tembikai wangi) dan sistem konvensional (tembikai dan tembikai susu) di Sabah dan Sarawak. Kajian ini memberi tumpuan kepada tiga jenis tembikai iaitu tembikai, tembikai susu (sistem konvensional) dan tembikai wangi (sistem fertigasi). Kaedah Model Logik Kabur (*Fuzzy Logic Model*) dalam menentukan tahap penggunaan teknologi dalam industri pertanian adalah salah satu pendekatan yang paling banyak digunakan. Analisis FLM menunjukkan bahawa keseluruhan usahawan tani fertigasi berada pada tahap paling rendah. Sementara itu, untuk usahawan tani konvensional di Sabah dan Sarawak, hanya 3% daripadanya mencapai tahap penggunaan teknologi yang sederhana dan 97% berada di tahap paling rendah (kurang memuaskan). Hasil kajian menunjukkan bahawa pencapaian indeks teknologi dalam kalangan usahawan tani sistem fertigasi adalah pada tahap yang rendah iaitu 0.293 dengan jurang teknologi (0.057). Pencapaian indeks bagi usahawan tani sistem konvensional juga adalah pada tahap rendah iaitu 0.290 dengan jurang teknologi (0.104). Ini menunjukkan bahawa amalan penggunaan teknologi dalam kalangan usahawan melon di Sabah dan Sarawak hampir sama walaupun terdapat jurang yang kecil bagi kedua-dua jenis penanaman tersebut. Ini juga membuktikan bahawa tidak terdapat perbezaan yang ketara dari segi penggunaan teknologi di antara pengamal teknologi yang mendapat skor tertinggi dengan skor terendah di Sabah dan Sarawak untuk kedua-dua sistem penanaman. Kajian ini turut memberi panduan kepada penjana teknologi untuk menghasilkan teknologi terkini seperti teknologi meningkatkan kualiti buah yang kos efektif. Di samping itu, pemindahan teknologi kepada usahawan tani melon di Sabah dan Sarawak perlu dipergiatkan agar tahap amalan penggunaan teknologi usahawan turut meningkat.