Studies on Durian Production in Malaysia using Agricultural Statistics and Farmer Survey

農業統計データと農家調査からみた
マレーシアのドリアン生産量に関する研究

Department of Tourism Science,
Graduate School of Urban Environmental Sciences,
Tokyo Metropolitan University

20854502
Aoi Eguchi

Supervisor
Professor Dr. Shinya Numata

Abstract

Agricultural statistics are widely recognised as important information for studies such as spatio-temporal trend analysis of yields, production forecasting and yield gap analysis. The reliability of agricultural statistics therefore influences the conclusions of those studies and the policy decisions on which they are based. On the other hand, in many developing countries, the quality and quantity of agricultural statistics are degraded by the lack of technical capacity, funds and personnel in the units responsible for collecting, compiling, analysing and disseminating them, mainly due to low priority.

Among agricultural crops, fruit trees are prone to imbalance in supply and demand because they are perennial crops that take many years to bear fruit, weather conditions prior to the year in which fruit is grown have a cumulative effect on fruit growth and yield, and fruit cannot be stored for long periods. Furthermore, fruit trees are in high demand among tourists and are an important source of income for the region, so there is a need to monitor and control production. However, there is very limited research on the reliability of agricultural statistical data, which is the base of information on production for fruit trees.

Durian (*Durio zibethinus*), the subject of this study, is a tropical fruit tree native to Southeast Asia, belonging to the mallow family Durioceae. Durian is mainly cultivated in Thailand, Malaysia and Indonesia, especially in Malaysia, where it has a high economic value and a stable supply is required. On the other hand, it has been shown that there is spatio-temporal variability in durian production, so while information on productivity is important, knowledge of the range of variability in durian production and how it varies by region is very limited.

Durian production in Malaysia is published in the Department of Agriculture Malaysia's fruit tree statistics. However, the meaning of the

terms used in the fruit tree statistics is not clear due to many unclear definitions and collection methods. In addition, the distribution channels of fruit trees in Malaysia are complex, and it is not clear what distribution channels the agricultural statistics data cover in collecting data. Therefore, when discussing the characteristics of durian production, it is necessary to take into account not only the statistical data but also the actual status of durian production, but reports on the current status of durian production are limited.

Therefore, the objectives of this study are 1) to identify the spatio-temporal characteristics of durian production in Malaysia from the statistical data, 2) to identify the current status of durian production from the farmer survey, and 3) to identify the spatio-temporal characteristics and constraints of durian production in agricultural statistics based on the current status of production from the farmer survey.

The results from the farmer survey revealed that about half of the small-scale farmers sold their harvested fruits directly and that about three-quarters of the farmers did not record their production. It is impossible to determine the amount of production sold directly if no records are kept, and if such production is not included in the statistical data, then the statistical data on durian production may be an underestimate.

In addition, while the statistical data did not show much variation in durian production, more than 90% of the farmers surveyed felt that there was variation in production. Considering that the total number of varieties identified for cultivation in the farmer survey was 75, that more than 70% of the farmers said that the variation depended on the variety, and that the variation in production per unit area per province was greater than the variation for the country as a whole, it is likely that the statistical data offset the magnitude and timing of the variation depending on the

variety and the province in which it is located. It is likely that this is offset by the variety. As a result, the range of variation in the statistical data may have been smaller than the variation perceived by the farmers in the survey on a single farm per variety.

In the statistical data, the fact that seasonality was not taken into account and that the data were not classified according to variety made it difficult to understand the characteristics of durian production and to scientifically verify the amount of durian produced. The durian is harvested either once or twice a year, depending on the area, but the current statistical data are yearly. As a result, it is not possible to distinguish between the two harvesting seasons, and farmer surveys have revealed that the minor harvesting season spans from December to January. Therefore, the annual data do not correspond to the harvest season and are not considered appropriate for discussing annual variation.

In this study, the spatio-temporal characteristics and constraints of durian production in agricultural statistics were identified for durian in Malaysia, based on the current status of production through farmer surveys. The results suggest that the percentage of farmers who sell their durian directly is higher than in previous studies, and that the durian production in the statistical data may underestimate the actual production. In addition, the statistical data were not classified by species and did not take into account seasonality, which made it difficult to discuss production fluctuations.It is therefore necessary to develop a basis for future surveys to estimate the volume of direct sales and to collect more accurate statistical data by month and by main variety.

要旨

　農業統計は、収穫量の時空間的な傾向分析、生産予測、収量ギャップ分析等の研究のための重要な情報として広く認識されている。したがって、農業統計の信頼性はそれらの研究の結論、およびそれらの研究をベースとした政策決定に影響を及ぼす。一方で多くの開発途上国では、優先順位の低さなどから、農業統計の収集、編集、分析、普及を担当するユニットの技術力と資金、人員が不足していることにより、農業統計の質と量は低下している。

　農作物の中でも果樹は、永年性作物であり結果するまでに長い年月を要すること、果実が生育する年以前の気象条件等が果実生育や収量に累積的に影響することや、果実が長期保存できないことから需給バランスが崩れやすい。さらに、果樹は観光客の間で需要が高く、地域にとって重要な収入源となることから、生産量の把握、管理が必要とされている。しかし、果樹を対象にした農業統計データの信頼性に関する研究は非常に限られている。

　本研究の対象であるドリアン（*Durio zibethinus*）は、アオイ科 Durio 属に分類される、東南アジア原産の熱帯果樹である。ドリアンは主に、タイ・マレーシア・インドネシアで栽培されており、特にマレーシアにおいては経済的な価値が高く、安定的な供給が求められている。一方で、ドリアン生産量には時空間的な変動があることが明らかになっており、そのため生産性に関する情報は重要であるが、ドリアン生産量の変動の幅や、地域による変動の差についての知見は非常に限られている。

　マレーシアのドリアン生産量はマレーシア農業庁の果樹統計データで公開されている。しかし、果樹統計での用語の定義や収集方法に不明点が多いことから、その意味するところが明らかでない。また、マレーシアの果樹の流通経路は複雑であり、農業統計データがどのような流通経路を対象にデータを収集しているかは不明である。そのため、ドリアン生産量の特徴について議論する際には、統計データだけではなく実際のドリアン生産の現状も踏まえる必要があると考えられるが、ドリアン生産の現状についての報告は限られている。

　そこで本研究の目的は、1) 統計データからみたマレーシアのドリアン生

産量の時空間的な特徴を明らかにすること、2) 農家調査からドリアン生産の現状を明らかにすること、3) 農家調査による生産の現状を踏まえ、農業統計のドリアン生産量の時空間的な特徴と制約を明らかにすることである。

　その結果、農家調査より、本研究の回答者である小規模農家の約半数が収穫した果実を直接販売していたこと、そして農家の約 4 分の 3 は生産量の記録をしていないことが明らかになった。直接販売される生産量について、記録がない場合はその量を把握することは不可能であり、もしこのような生産量が統計データに含まれていない場合、統計データのドリアン生産量は過小評価されている可能性がある。

　また、統計データではドリアン生産量にそれほど大きな変動は見られなかった一方で、農家調査では 90%以上が生産量に変動を感じていた。今回の農家調査で栽培が確認された品種の総数が 75 種と多く、7 割以上の農家が変動は品種により異なると回答したこと、州ごとの単位面積当たり生産量変動が国全体の変動より大きかったことを考慮すると、統計データでは品種により、位置する州により異なる変動の大きさや時期が相殺されていると考えられる。その結果、アンケート調査で対象とした農家が一つの農園で品種ごとに感じる変動よりも、統計データの変動の幅が小さかった可能性がある。

　また、統計データについて、季節性が考慮されていないこと、品種による分類がされていないことは、ドリアン生産の特徴の把握、ドリアン生産量に関する科学的な検証を難しくしていた。ドリアンの収穫期は地域により年に 1 回もしくは 2 回あるが、現在の統計データは年ごとである。そのため、2 回ある収穫期の分別ができないほか、農家調査の結果、マイナーな収穫時期が 12 月から 1 月にまたがっていることが明らかになった。そのため、年データは収穫期と対応しておらず、年変動を議論するデータとしては適切ではないと考えられる。

　本研究では、マレーシアのドリアンについて、農家調査による生産の現状を踏まえ、農業統計のドリアン生産量の時空間的な特徴と制約を明らかにした。その結果、直接販売をする農家の割合が先行研究より多く、統計データのドリアン生産量は実際の生産量を過小評価している可能性が示唆された。

また、統計データは品種による分類がされておらず、季節性が考慮されていないことから、生産量変動の議論を難しくしていた。したがって、今後、直接販売の量を推定するための調査や、月ごと、主な品種ごと等のより精度の高い統計データを収集するための基盤づくりが必要である。

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1. Introduction

Agricultural statistics are widely recognised as important information for studies such as spatio-temporal trend analysis of yields (Ahmad et al. 2020), production forecasting (Jayne and Rashid 2010) and yield gap analysis(Tittonell and Giller 2013). Therefore, the reliability of agricultural statistics influences the conclusions of those studies(Hauser and van Asten 2008) and the policy decisions based on those studies (Sumberg 2012). On the other hand, in many developing countries, the quality and quantity of agricultural statistics are declining due to a lack of technical capacity, funds and personnel in the units responsible for collecting, compiling, analysing and disseminating them, mainly because of low priorities, and the importance of improving their reliability has been recognised(World Bank, FAO and United Nations Statistical Commission 2011).

Among agricultural crops, fruit trees are perennial crops and take many years to bear fruit (Mizutani et al. 2002; Shimura et al. 2000). In addition, fruit trees are prone to supply and demand imbalances because weather conditions prior to the year of fruit growth cumulatively affect fruit growth and yield, and fruit cannot be stored for long periods (Ministry of the Environment 2018). Furthermore, fruit trees are in high demand among tourists and are an important source of income for the region (Torres 2002), so there is a need to monitor and control production. However, studies on the reliability of agricultural statistical data for fruit trees are very limited.

The subject of this study, the durian (*Durio zibethinus*), known as the king of fruits, is a tropical fruit tree native to Southeast Asia, belonging to the mallow family Durioceae (Lim 1990). Durian is mainly cultivated in Thailand, Malaysia and Indonesia, especially in Malaysia where it has a high economic value (DOA 2021). This is because durian is

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the most abundant fruit tree in Malaysia in terms of both yield and value, and the market is expected to expand due to increasing export demand, especially from China (FFTC-AP 2018). Therefore, while a stable supply is required, it is clear that there is spatio-temporal variation in durian production (Ahmad et al. 2020). Although information on production is important to ensure a stable supply, our knowledge of the range of variation in durian production and how it varies across regions is very limited.

Durian production is published in the Department of Agriculture (DOA) fruit tree statistics and is the basis of the only previous study on durian production by Ahmad et al. (2020). However, the meaning of the terms in the fruit tree statistics is not clear due to many unclear definitions and collection methods. In addition, the traditional and customary distribution channels for fruit in Malaysia are dominated by wholesalers and other intermediaries in a multi-layered manner (Man, Nawi, and Ismail 2009). As a result, there are many and complex distribution channels, and it is unclear what distribution channels the agricultural statistics data cover in collecting data. Furthermore, it is possible that the production of durian in Malaysia from direct sales, which are not marketed and not reflected in agricultural statistics, is too large to be ignored. In fact, most of the durian peels used in the environmental and chemical engineering studies were collected from stalls where direct sales are likely to account for the majority, rather than supermarkets, etc.(Thines, Abdullah, and Mubarak 2017; Pang et al. 2019; Sebayang et al. 2017; Wai, AlKarkhi, and Easa 2010) . Therefore, when discussing the characteristics of durian production, it is necessary to take into account not only the statistical data but also the actual status of durian production, but there are limited reports on the current status of durian production.

Therefore, the objectives of this study are 1) to identify the spatio-

temporal characteristics of durian production in Malaysia from statistical data, 2) to identify the current status of durian production from farmer surveys, and 3) to identify the spatio-temporal characteristics and constraints of durian production in agricultural statistics based on the current status of production from farmer surveys (Fig. 1).
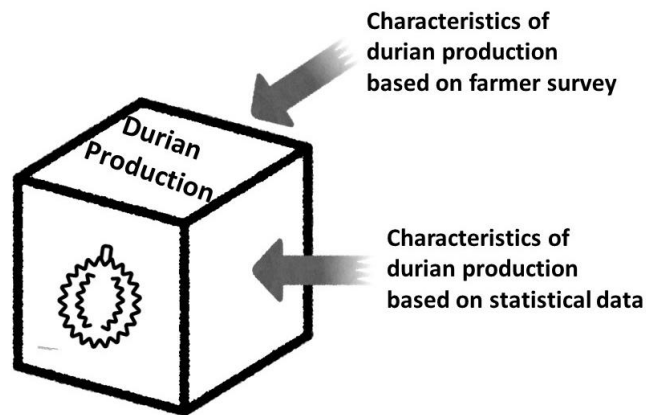
Fig. 1 Research Framework

2. Literature review

2-1. Characteristics of fruit trees

Fruit trees are trees that produce edible fruits and seeds. According to Mizutani et al. (2002) and Shimura et al. (2000), there are three main characteristics of fruit trees. The first is that they are perennial crops, meaning that they require many years to bear fruit. As a result, they are less adaptable to climate than annual crops and are therefore more vulnerable to climate change (Ministry of the Environment 2018). Secondly, they are nutritional breeders. In the case of many fruit trees, propagation is by grafting. This is because when seeds of a certain variety of fruit tree are sown, it is usually not possible to obtain an individual with the same characteristics as that of the variety, due to various mutations. Thirdly, weather conditions prior to the year in which the fruit is to be grown have a cumulative effect on fruit growth and yield. If the previous year's crop is too large or harvested too late, it will not be able to store sufficient nutrients and fruit growth and quality will be greatly affected.

2-2. Fruit statistics in Malaysia

Statistical data on fruit crops (STATISTIC TAMANAN BUAH-BUAHAN, Fruit Crops Statistic) are published annually by DOA of the Ministry of Agriculture and Food Industries Malaysia (Fig. 2).

Fig. 2 Cover of Fruit Crops Statistic 2020 (DOA 2021)

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The fruit crops statistics cover 21 varieties of major fruits (Star Fruit, Papaya, Cempedak, Sapodilla, Dokong, Duku, Durian, Guava, Langsat, Pomelo, Sweet Orange, Mango, Mangosteen, Dragon Fruit, Pineapple, Jack Fruit, Banana, Pulasan, Rambutan, Salak and Watermelon). For each of these fruits, the annual planted area, harvested area, production and value of production at national, provincial and group level are summarized (e.g. Table 1).

Table 1 Planted area, Harvested area, Production, Value of production of Mangosteen in Johor, 2020 (DOA 2021)

DAERAH District	MANGGIS Mangosteen			
	Keluasan Hectareage (Ha)	Luas Berhasil Harvested Area (Ha)	Pengeluaran Production (Mt)	Nilai Pengeluaran Value Of Production (RM'000)
Batu Pahat	3.3	1.5	10.7	30.0
Johor Bahru	2.5	0.6	16.5	46.2
Kluang	31.7	11.3	154.1	431.5
Kota Tinggi	54.0	34.8	164.7	461.0
Kulai	6.4	3.2	36.8	103.1
Mersing	1.6	1.6	6.9	19.3
Muar	237.5	136.7	1,270.9	3,558.7
Pontian	14.0	12.0	203.5	569.8
Segamat	287.9	164.2	1,485.4	4,159.1
Tangkak	108.3	84.5	1,639.8	4,591.5
JUMLAH	**747.2**	**450.4**	**4,989.3**	**13,970.1**

The method of data collection is described in the Fruit crops statistic as follows.

"EXPLANATORY NOTES
1. Introduction
   This statistics for year 2020 are the report on 21 varieties of major fruit crops and 43 varieties of others fruit crops.

2. Source of Information and Data Collection
   Data for all types of fruits are compiled annually from

AgrIs Geo Portal collected monthly by Agriculture Assistants (AA's). For Sabah, Sarawak and W.P. Labuan, data supplied from each state Department of Agriculture. Data submitted by the states then verified again together before published.

3. Concept and Scope of Crop Hectarage

3.1 The hectarage of each crop is based on the Crop Hectarage Equivalent (CHE). The CHE for a permanent crop is obtained by dividing the total trees planted on a particular lot by the recommended planting density per ha of that particular crop.

3.2 Crop Hectarage covers all agricultural areas in Malaysia including small holder sectors (individual or group), estates, agricultural land development schemes and others.

4. Estimate of Yield Production

The method of estimating the yield for production obtained from crop production survey (CPS) through sampling done by Agriculture Assistants. Besides, the production also obtained using estimation based on potential yield or farm record.

5. Value of Production (RM)

Production value is based on average ex-farm prices at the national level obtained from " Buku Warta Barangan 2020" issued by FAMA. This is going well with the draft plan for "Jihad Orang Tengah" implemented by the Ministry of Agriculture and Food Industries. "

(DOA 2021)

Agris Geo portal is a website used for information gathering and interaction for officers (Hassan et al. 2010). Therefore, it is assumed that the agricultural assistants upload the yield related data collected monthly to the Agris Geo portal.

The DOA used sampling as a method of collecting fruit tree production estimates, and production values were calculated on the basis of production volumes. It also used estimates calculated from Crop Hectarage Equivalent (CHE) as the method of collecting cropped area (DOA 2017). CHE is the area required per fruit tree calculated from the estimated planting distance multiplied by the actual number of fruit trees planted. The recommended planting distance used to calculate the CHE is 10m x 10m for durian (Table 2). However, the details of how the harvested area was calculated, the survey targets and the sampling method are not known.

Table 2 Number of Trees per Acres and Hectare by recommended planting distance (DOA 2017)

Fruits	Planting System	Planting Distance (m)	Number of Trees Per Acre	Number of Trees Per Hectare
Durian	Squares	10 × 10	40	100
	Rectangle	8 × 18	28	69
	Rectangle	9 × 16	28	69

2-3. Fruit distribution channels in Malaysia

The fruit supply chain in Malaysia is characterized by the multi-layered dominance of traditional wholesalers and other intermediaries, and traditional and customary ways in terms of organization, structure and distribution (Man, Nawi, and Ismail 2009). Even after the rise of hypermarkets, the large suburban supermarkets that developed mainly

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in Europe, this trend has not changed, as purchases in traditional shops still account for about 30% of sales.

Market research by (Man, Nawi, and Ismail 2009) through face-to-face interviews with selected market participants, including retailers (hypermarkets, supermarkets, wet markets, and retail outlets), wholesalers, transporters, processors, packers, assemblers, and growers, revealed that The local supply chain of fruit in Malaysia has been partially revealed (Fig. 3).
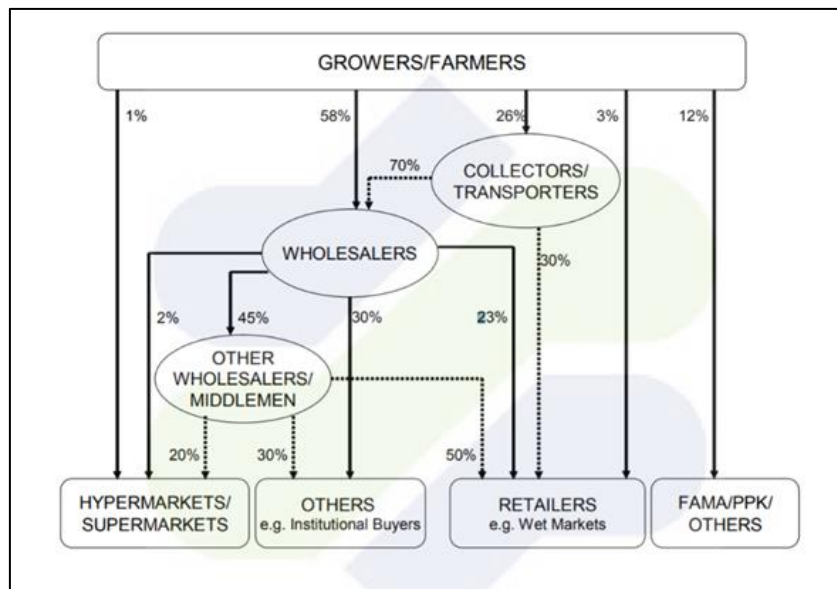
Fig. 3 Fresh Fruit Supply Chain (Man, Nawi, and Ismail 2009)

In the first phase, most fruit farmers (58%) sold their fruits to wholesalers. A further 26% sold to collectors/transporters, 12% to the Federal Agricultural Marketing Authority (FAMA)/Pertubuhan Peladang Kawasan (PPK)/others, 3% to retailers and 1% to hypermarkets. Fruit farmers who sold fruit to wholesalers were more than twice as likely as those who sold fruit to collectors and transporters. From collectors, 70% went to wholesalers and the

remaining 30% to retailers. From wholesalers, 45% went to other wholesalers, 30% to institutional investors and 23% to retailers. The remaining 2% went to hypermarkets. At the wholesaler level, 50% went to retailers, 20% to hypermarkets and the remaining 30% to institutional investors. However, only 3.5% of farmers sold to night markets or retail outlets.

3. Methods

3-1. What is durian?

Durian (*Durio zibethinus*), known as the king of fruits because of its unique aroma and taste, is an evergreen tree belonging to the Family Malvaceae, genus Durio (Lim 1990). Durian is currently cultivated in Thailand, Malaysia, Vietnam, Indonesia, the Philippines and northern Australia(Wannarat and Tantrakoonsab 2018). In Malaysia, the main durian growing areas are Johor, Negeri Sembilan, Pahang, Kelantan and Perak (FAMA 2011)(Fig. 4).
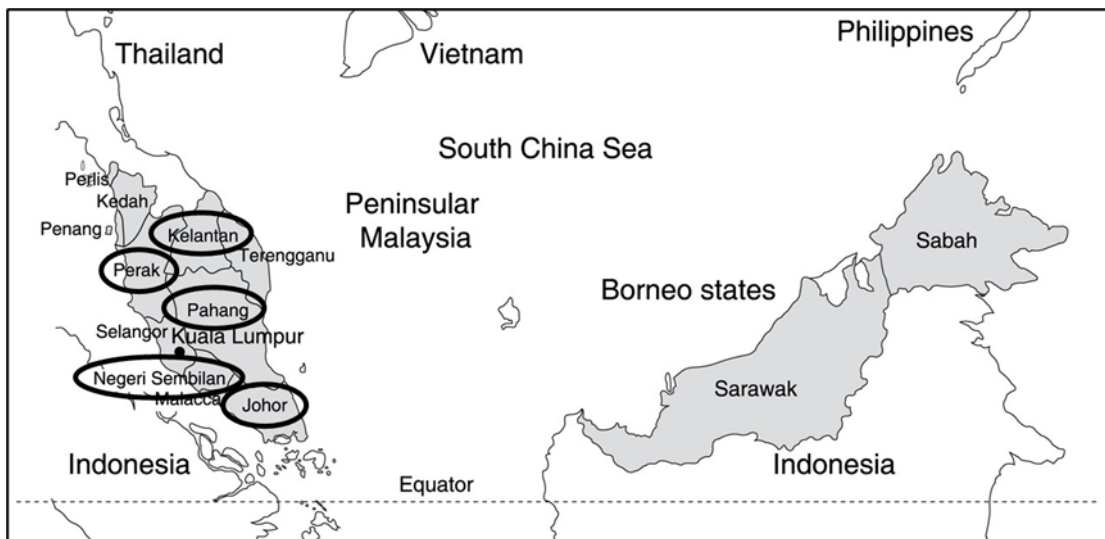

Fig. 4 The main durian growing areas in Malaysia and surrounding countries (Mohd-Zaki et al. 2014)

The durian fruit is egg-shaped, 15-30 cm long, 12.5-15 cm wide and weighs up to 8 kg (DOAPhilippine 2016)(Fig. 5a, b).
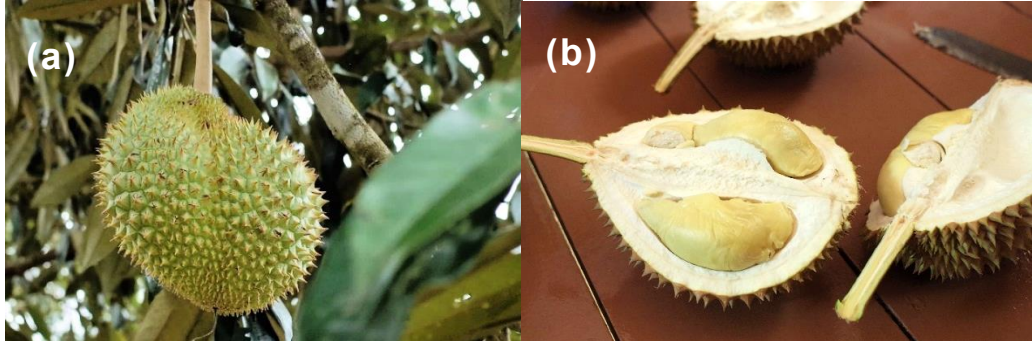
Fig. 5 (a) Durian (photographed by the author on 8 July 2019 in Endau Rompin National Park), (b) Edible part of durian (ibid.)

The flowering and fruiting periods of durian are seasonal and correlate with rainfall patterns that are closely related to monsoon activity (Fig. 6). Dryness and low temperature are required for flowering and fruiting of durian, and flowering is known to begin after the dry season in both the east and west coasts of Peninsular Malaysia (Othman, Suranant, and Others 1995; Salakpetch 2005; Zainab, Zainal Abidin, and Norzila 2002; Ong and Lee 21-28 August 1981).

The rainfall pattern in Peninsular Malaysia can be divided into two zones, monomodeal and bimodal seasonal distributions (Fig. 7). The West coast (west and south) has two monthly rainfall minimums, December-February and June-August, with flowering beginning in February and July and harvesting beginning in May and October respectively. The west coast (north-west and north-east), there is only one minimum, December-February, with flowering starting in February and harvest in June (T. K. Lim and Luders 1997; Hoe and Palaniappan 2008)(Fig. 8).

Fig. 6 Monsoon in Peninsular Malaysia

Fig. 7 Geographical patterns of monthly lowest temperature recorded (lines) and monthly rainfall (bars) at 16 meteorological stations on the Malay Peninsula(Numata et al. 2003).

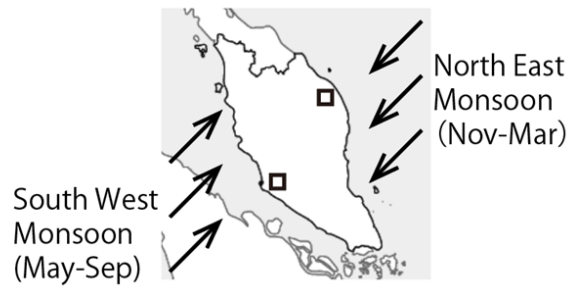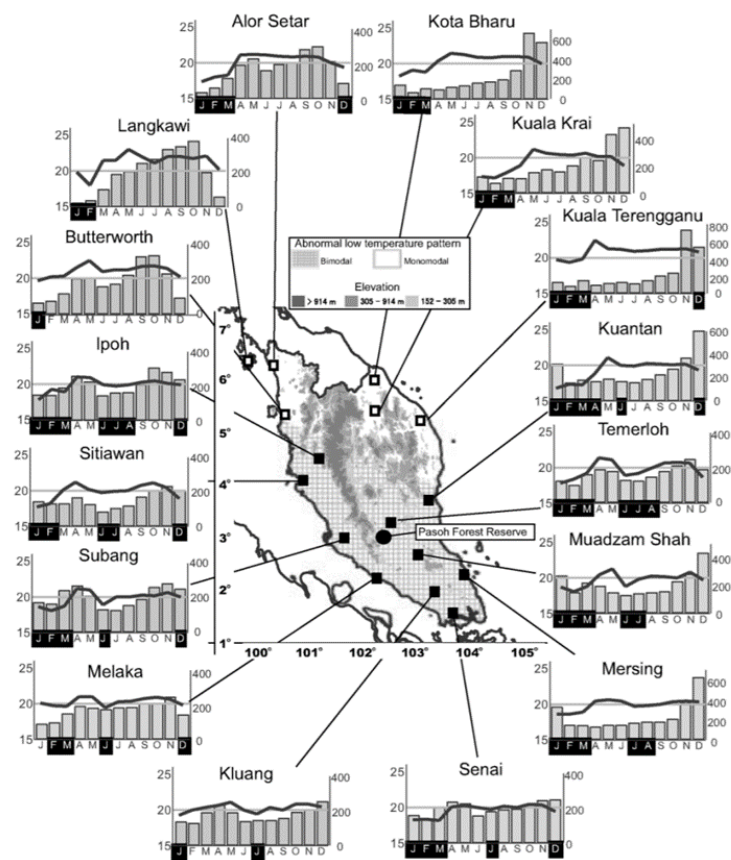|	J	F	M	A	M	J	J	A	S	O	N	D
West coast	Dry season		Flowering✳→		Fruiting◎→	Dry season			Flowering✳→		Fruiting◎→	
East coast	Dry season	Flowering✳→		Fruiting◎→								
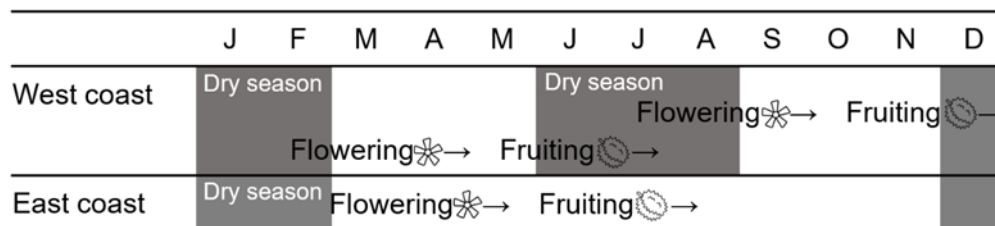
Fig. 8 Rainfall patterns of Peninsular Malaysia and Durian flowering and fruiting season (T. K. Lim and Luders 1997)

Durian varieties vary in size, shape, seed coat color, pulp color, smell, texture and color (Watanabe 2016). The registration of durian varieties was initiated by the DOA in 1934 and there are currently 139 varieties registered in the National Crop List. Of these, D24, D101 (Red Fresh) and D197 (Musang King) are recommended for commercial cultivation (FAMA 2011). These varieties are in high demand in the market due to their good taste and relatively uniform quality. In addition to the registered varieties, other Kampung Durian (Local Durian) are also grown and marketed. Kampung Durian is a general term for durians grown from seeds rather than through nutritional reproduction such as grafting(Watanabe 2016).

Durian is one of the fruits that is expected to contribute to Malaysia's economy as its market expands with increasing export demand. The durian is one of the nine premium fruits selected under Malaysia's National Agri-Food Policy (2011-2020) and is recognized as an economically important fruit tree alongside coconut and pineapple (FFTC Agricultural Policy Platform (FFTC-AP) 2018). In addition, the Malaysian durian, especially the Musang King (D197) variety, is gaining popularity in China as a symbol of gourmet food and wealth (SANKEI DIGITAL INC 2018). According to the DOA,

durian shipments to China in the first half of 2018 more than doubled from the same period in 2017. Furthermore, the ban on the export of whole durian was lifted in August 2018, which is expected to increase shipments (the Sun 2019). On the other hand, the establishment of many durian plantations to meet the growing export demand has resulted in problems such as conflicts with indigenous people and destruction of wildlife habitats (Kamal and Lim 2019; the Sun 2019).

3-2. Durian production based on statistical data

Data on the area planted, harvested, production and production value of durian in Malaysia were collected. Data collection was done by using (A) Fruit Crops Statistic (B) Drian's New Source of Wealth (C) Agrofood Statistics (Table 3).

Table 3 Data source

A	Fruit Crop Statistic (2012, 2015-2018, 2020) (PERANGKAAN TANAMAN BUAH-BUAHAN)
B	Durian's New Source of Wealth (SUMBER KEKAYAAN BAHARU DURIAN)
C	Agrofood Statistics (2014, 2019) (PERANGKAAN AGROMAKANAN)

Table 4 Data availability (County level)

Year	Planted Area	Harvested Area	Production	Value of Production
2000	B	×	B	×
2001	B	×	B	×
2002	B	×	B	×
2003	B	×	B	×
2004	B	×	B	×
2005	B	×	B	×
2006	B	×	B	×
2007	B	×	B	×
2008	B	×	B	×
2009	B, C (2014)	C (2014)	B, C (2014)	C (2014)
2010	B, C (2014)	C (2014)	B, C (2014)	C (2014)
2011	B, C (2014)	C (2014)	B, C (2014)	C (2014)
2012	B, C (2014)	C (2014)	B, C (2014)	C (2014)
2013	B, C (2014)	C (2014)	B, C (2014)	C (2014)
2014	B, C (2019)	B, C (2019)	B, C (2019)	B, C (2019)
2015	B, C (2019)	C (2019)	B, C (2019)	C (2019)
2016	A (2020), B, C (2019)	C (2019)	A (2020), B, C (2019)	C (2019)
2017	A (2020), C (2019)	C (2019)	A (2020), C (2019)	C (2019)
2018	A (2020), C (2019)	C (2019)	A (2020), C (2019)	C (2019)
2019	A (2020), C (2019)	C (2019)	A (2020), C (2019)	C (2019)
2020	A (2020)	A (2020)	A (2020)	A (2020)

Table 5 Data availability (States level)

Year	Planted Area	Harvested Area	Production	Value of Production
2000	×	×	×	×
2001	×	×	×	×
2002	×	×	×	×
2003	×	×	×	×
2004	×	×	×	×
2005	×	×	×	×
2006	×	×	×	×
2007	×	×	×	×
2008	A (2012)	×	A (2012)	×
2009	A (2012)	×	A (2012)	×
2010	A (2012)	×	A (2012)	×
2011	A (2012, 2015)	×	A (2012, 2015)	×
2012	A (2012, 2015)	A (2012)	A (2012, 2015)	A (2012)
2013	A (2015)	×	A (2015)	×
2014	A (2015)	×	A (2015)	×
2015	A (2015)	A (2015)	A (2015)	A (2015)
2016	A (2020)	A (2016)	A (2020)	A (2016)
2017	A (2020)	A (2017)	A (2020)	A (2017)
2018	A (2020)	A (2018)	A (2020)	A (2018)
2019	A (2020)	×	A (2020)	×
2020	A (2020)	A (2020)	A (2020)	A (2020)

In order to identify the temporal characteristics of durian production in Malaysia, the area planted, harvested, production and production value of durian at the national level were graphically summarized and the Coefficient of Variation (CV) was calculated. The Coefficient of Variation is the standard deviation divided by the mean and is used to assess the relative variability of the data.

In order to identify the regional characteristics, the production, harvested area and yield per unit area at the state level in 2020 were mapped. The mean and standard deviation of yield per unit area (Mt/Ha) were also calculated in order to clarify the differences in production variability between regions.

3-3. Farmer survey on durian production

An online questionnaire using Google forms was carried out among durian farmers in Malaysia from 14 to 30 April 2021. A total of 159 responses were collected by posting the questionnaire on Facebook groups (KELAB DURIAN MALAYSIA, PERSATUAN PENANAM DURIAN MALAYSIA). The questionnaire asked for information about the farm (state, area, year of open, number of cultivars, name of cultivar, shipping method) and about production (harvest time, pollination method, whether production records exist). The questionnaire was written in both Malay and English.

4. Results

4-1. Durian production based on statistical data

The planted area of durian in Malaysia (CV=0.22) showed a decreasing trend from 2000 (122760Ha) to 2020 (76895Ha) (Fig. 8). The harvested area (CV=0.11) did not show any particular trend of change around 50000Ha, but was relatively low only in 2017 (Fig. 9).
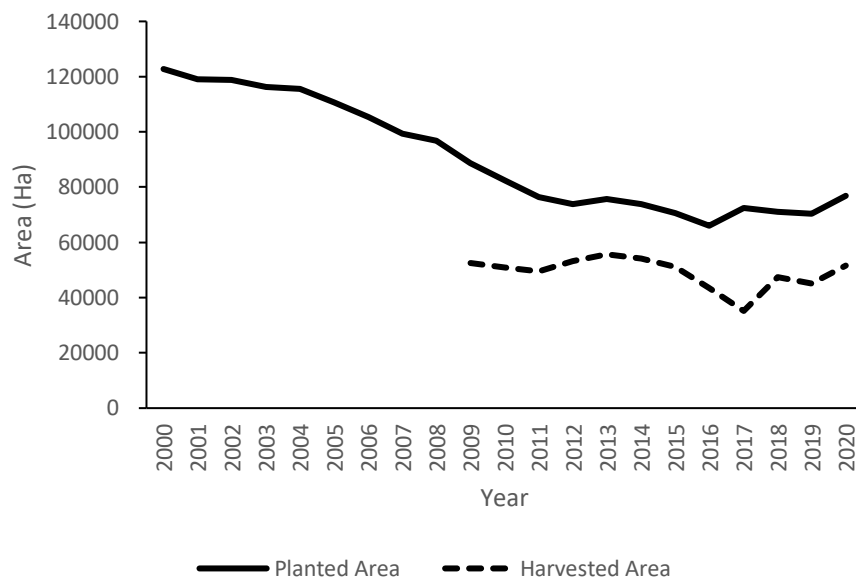

Fig. 9 Planted area (2000-2020) and harvested area (2009-2020) of durian in Malaysia

The production (CV = 0.16) showed variations (Fig. 10). There was an almost double difference between the highest production in 2004 (399661Mt) and the lowest in 2017 (210874Mt). The decrease in production in 2017 was also seen in the harvested area.
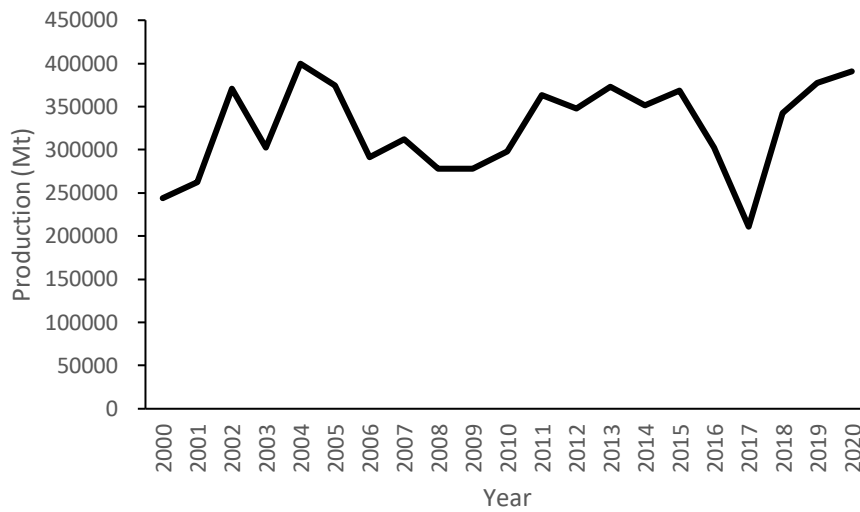
Fig. 10 Production of durian in Malaysia (2000-2020)

The value of production (CV = 0.67) showed a significant increase after 2017, almost quadrupling in the 10 years since 2009 (Fig. 11). Despite a significant decrease in production in 2017, the value of production increased compared to 2016.
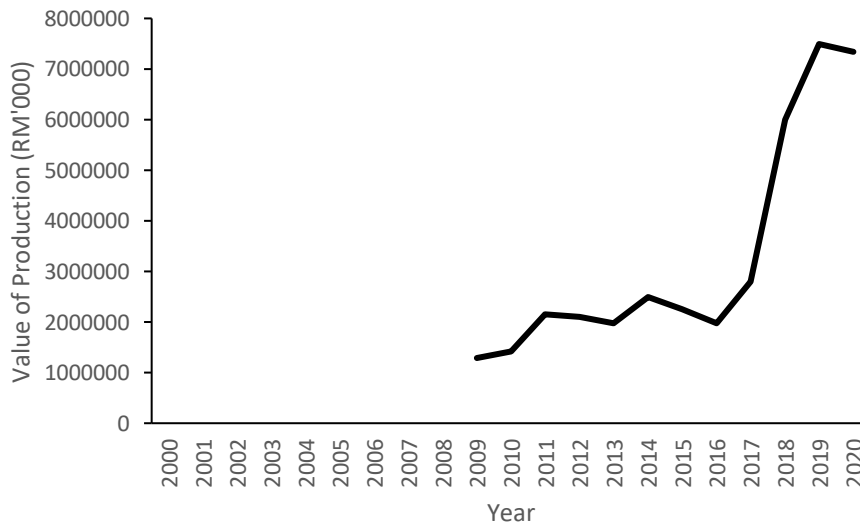
Fig. 11 Production value of durian in Malaysia (2009-2020)

Yield per unit area has fluctuated, but has shown an overall increasing trend, increasing about 2.5 times in the 20 years between 2000 and 2020 (Fig. 12).

Fig. 12 Yield per unit area of durian in Malaysia (2009-2020)

Both production, harvested area and yield were higher in the southern and central parts of Peninsular Malaysia (Johor and Pahang), with the total production of Johor and Pahang accounting for about 50% of the total durian production in 2020 (Fig. 13). These two states also tended to have higher yields per unit area than the other states.

(a) Production (Mt)

	0 – 20000
	20000 – 40000
	40000 – 60000
	60000 – 80000
	80000 – 100000
	100000 – 117365

(b) Harvested Area (Ha)

	200 – 2000
	2000 – 4000
	4000 – 6000
	6000 – 8000
	8000 – 10000
	10000 – 12000
	12000 – 13819

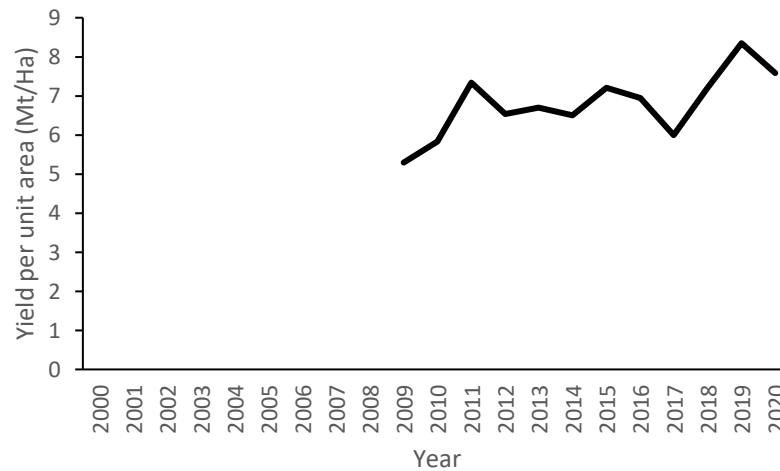(c) Yield per unit area (Mt/Ha)

	4.12 – 5
	5 – 6
	6 – 7
	7 – 8
	8 – 9
	9 – 9.18
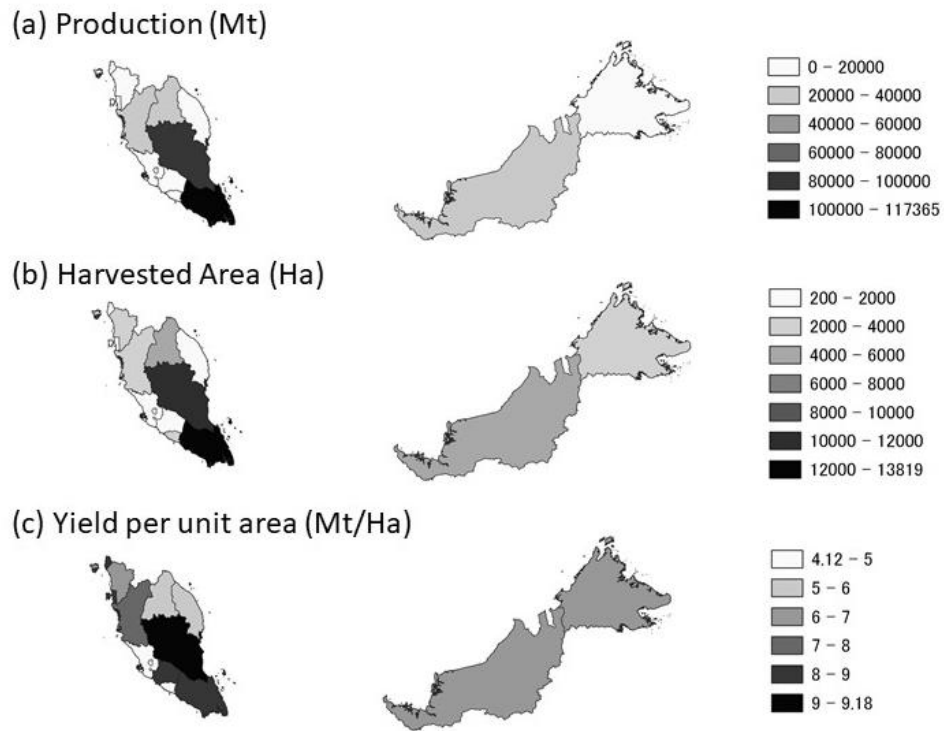
Fig. 13 Regional characteristics of (a) production, (b) harvested area and (c) yield per unit area of durian in Malaysia (2020)

In terms of yield per unit area per state, the highest was in Malacca, followed by Negril Sembilan and Perak, all three of which are located on the west coast of Peninsular Malaysia (Fig. 14). Malacca was also the state with the highest variability. The standard deviation of the average yield per unit area for Malaysia as a whole was smaller than that of the remaining 12 states, excluding Sarawak.
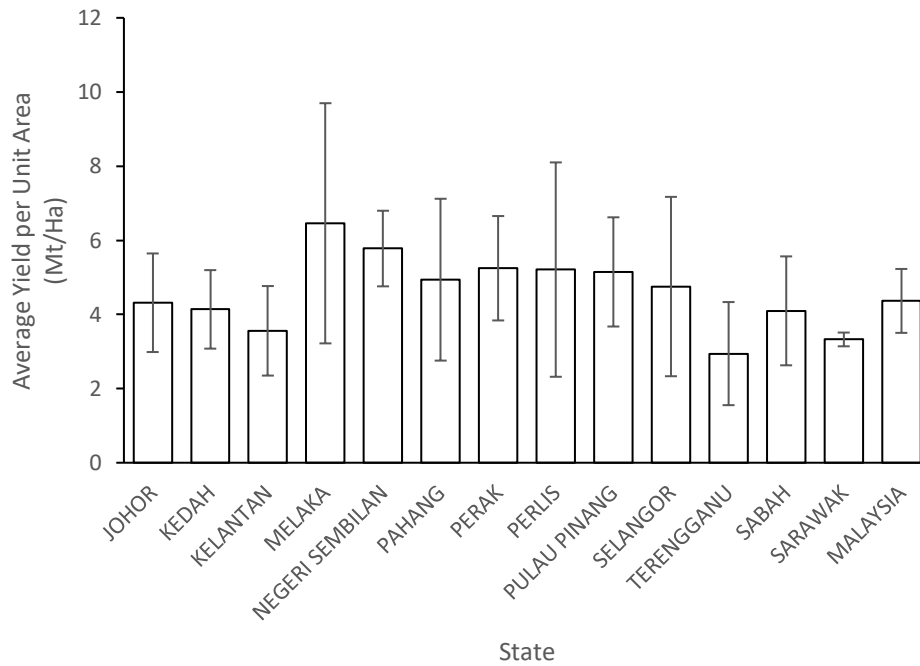
Fig. 14 Average yield per unit area per province (2008-2020) and standard deviation

4-2. Farmer survey on durian production

A total of 159 durian farmers responded to the questionnaire survey. The province where the farms are located was the most common with 25 (15.4%) from Perak, followed by Kedah and Kelantan with 23 (14.2%) each (Fig. 15).

Fig. 15 State in which the farm is located (n=159)

The mean and median size of the farms (n=157) was 4.8 acres ($\fallingdotseq$ 2.0 Ha) and 3.0 acres ($\fallingdotseq$ 1.2 Ha) respectively. The year of opening of the farm was 2010-2021 for most of the respondents 51 (32.7%), followed by 1981-1990 for 25 (16.0%) (Fig. 16).
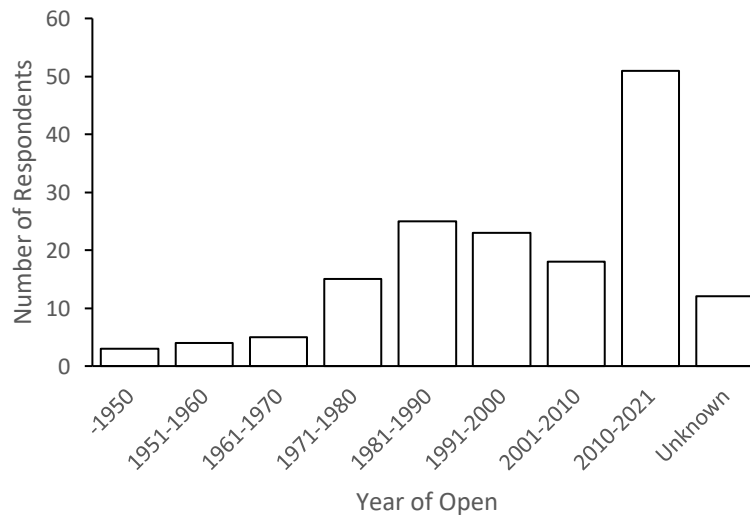
Fig. 16 Year of opening of the farm (n=156)

The mean and median number of varieties grown on the farms (n=144) was 8.1 and 5 respectively; the total number of varieties named by the 149 respondents was 75, of which the top 13 varieties accou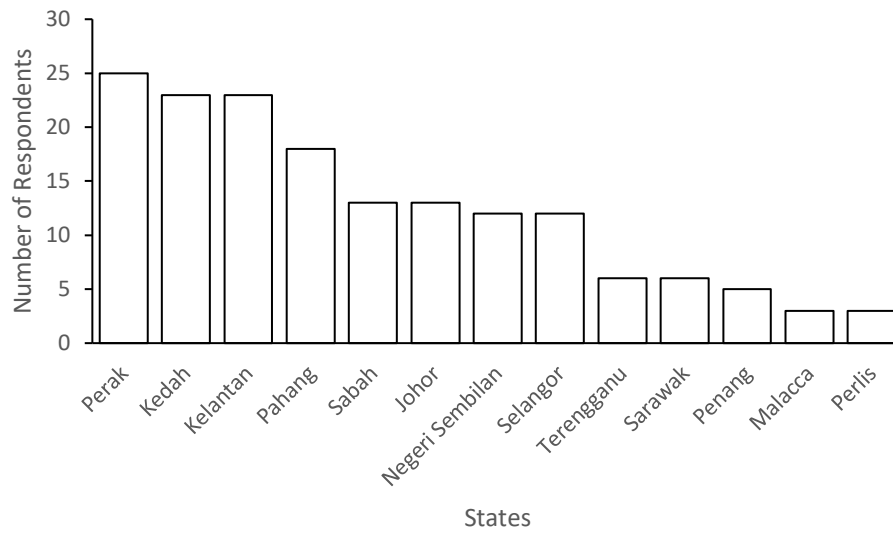nted for about 80% of the responses (Fig. 17). More than half of the respondents grew Musang King (97 respondents, 65%) or Duri Hitam (75 respondents, 50.3%). Durian Kampung, which is not a cultivar but has different characteristics in different regions, was also reported to be grown by 84 (56.4%) of the respondents.
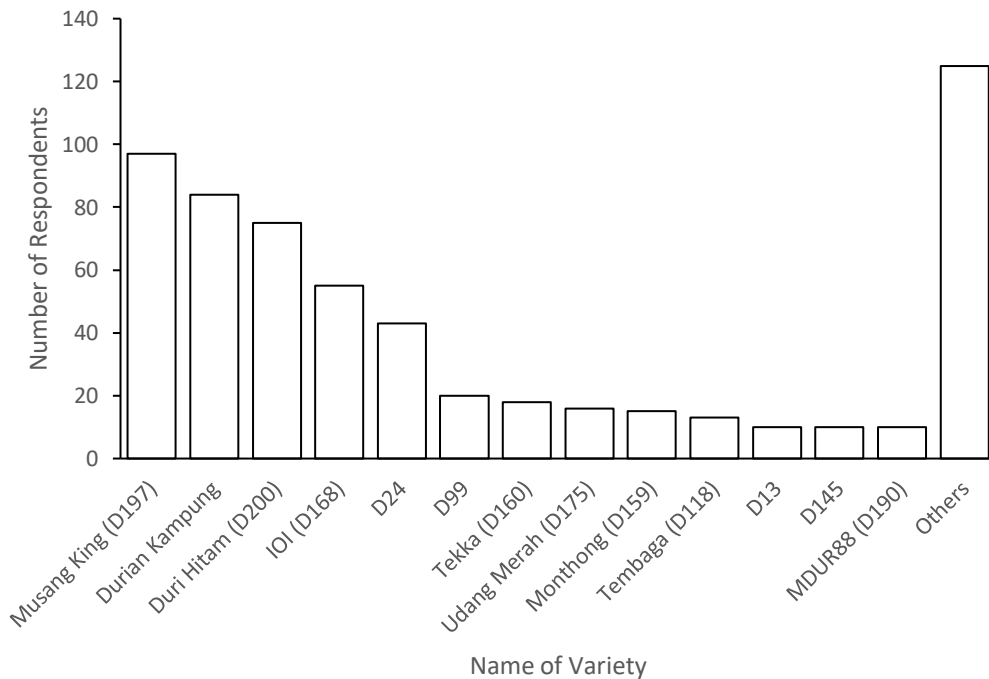
Fig. 17 Varieties cultivated (n=149)

In terms of distribution channels, 48 (49.0%) of the respondents sold their property themselves and 46 (47.0%) sold to an intermediary (Fig. 18). Home consumption and gifting accounted for less than 5% of the respondents, 4 (4.1%) and 3 (3.1%) respectively.
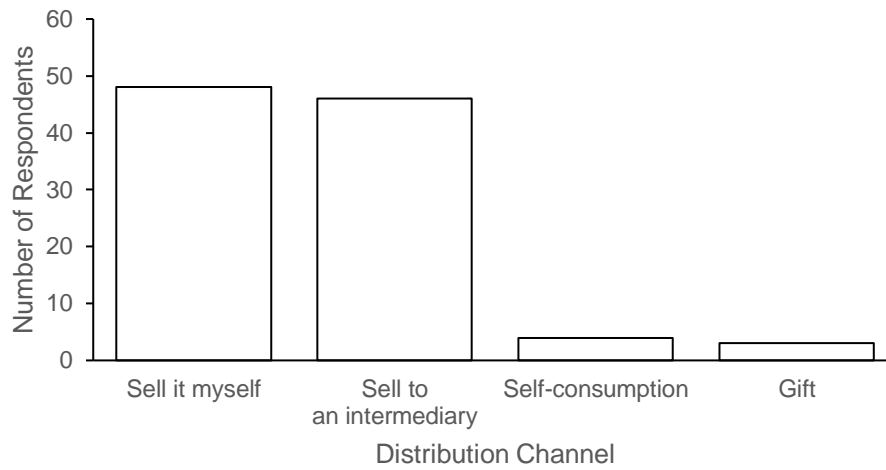
Fig. 18 Distribution channels (n=98)

The most common harvesting months were June (65 respondents, 43.3%), July (71 respondents, 47.3%) and August (36 respondents, 24.0%) (Fig. 19). Other small harvest seasons were in December (15 respondents, 10.0%) and January (8 respondents, 5.3%).
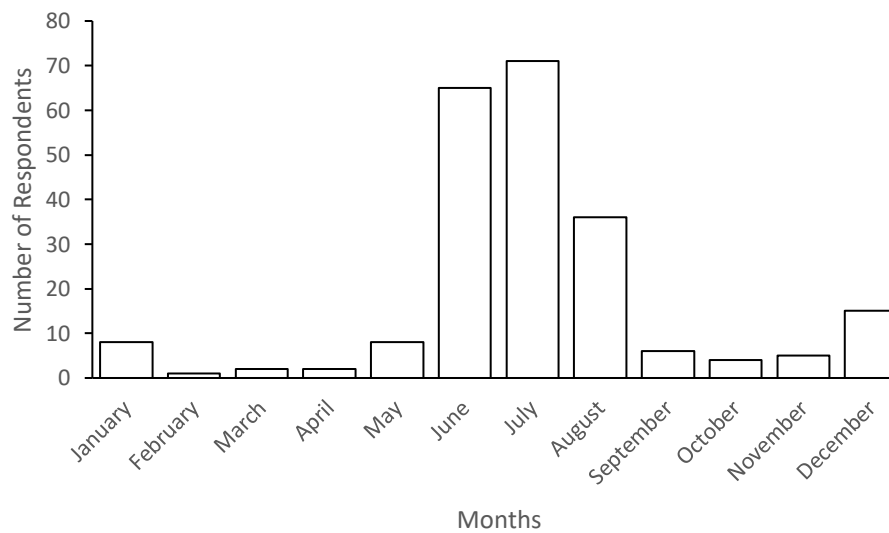
Fig. 19 Harvesting season (n=150)

Durian is self-incompatible (Othman, Suranant, and Others 1995). Most of the pollinators were pollinated naturally by 141 (94.0%) and 5 (3.3%) by artificial pollination.

Thirty-six respondents (23.5%) recorded their harvest and 117 respondents (76.5%) did not record their harvest (Fig. 20).
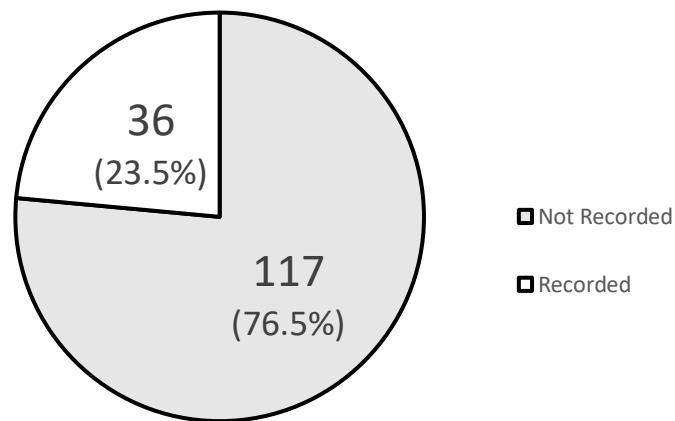
Fig. 20 Production records available (n=153)

A total of 139 respondents (91.4%) felt that the yield fluctuated, while 13 (8.6%) said they did not (Fig. 21).
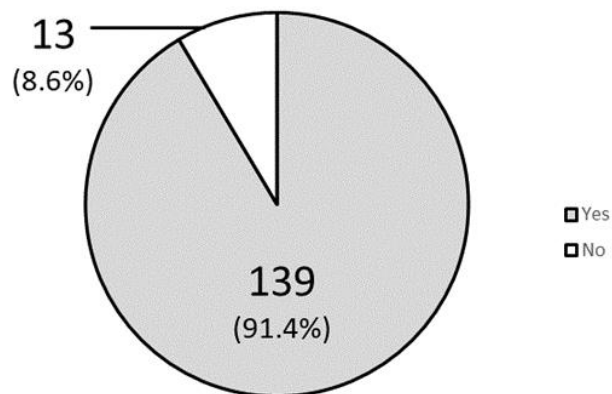
Fig. 21 Production volume fluctuations (n=152)

Of the 139 respondents who perceived yield variability, 102 (73.4%) indicated that there was a difference in yield variability between varieties, 31 (22.3%) indicated no difference and 6 (4.3%) were not sure (Fig. 22).
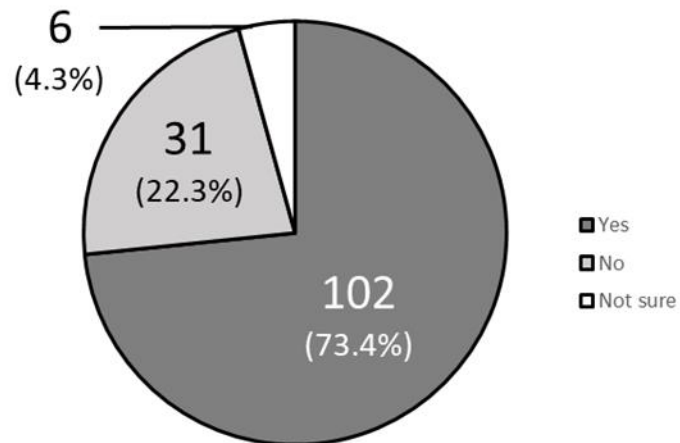
Fig. 22 Differences in the fluctuations in production between varieties (n=139)

5. Discussion

5-1. Characteristics of durian production based on statistical data

Statistical data showed that durian production in Malaysia varied by a factor of up to two (Fig. 10). The yield per unit area also showed a fluctuating upward trend (Fig. 12), but the standard deviation for the country as a whole was smaller than the standard deviation for the states (Fig. 14). It is possible that different climatic conditions in the different provinces resulted in different years of good and bad harvests, which offset each other in the national figures, resulting in a smaller range of variation.

In addition, despite the absence of a significant trend in production, the value of production has almost quadrupled over the past decade (Fig. 11), as demand for Malaysian durian (especially the premium variety Musang King) increased in China between 2017 and 2018, and international demand has led to higher domestic market prices. prices are believed to have increased. Indeed, according to the DOA, the value of durian shipments from Malaysia to China in the first eight months of 2018 was more than double that of the same period in 2017.

The states of Malacca, Negri Sembilan and Perak, which had particularly high yields per unit area, are located on the west coast of Peninsular Malaysia (Fig. 13). Since the statistical data used in this study is the total production of one year and the total production of two harvesting seasons in the west coast of Peninsular Malaysia, the yield per unit area was higher than the other states. The flowering and fruiting periods of durian are seasonal and correlate with rainfall patterns that are closely related to monsoon activity (Lim and Luders 1997, Figures 6, 7 and 8). Dryness and low temperatures are required for flowering and fruiting of durian, and flowering is known to begin after the dry season in both the east and west coasts of Peninsular

Malaysia (Ong and Lee 21-28 August 1981; Othman, Suranant, and Others 1995; Zainab, Zainal Abidin, and Norzila 2002; Salakpetch 2005, Fig. 18). Therefore, in eastern Peninsular Malaysia, durian is harvested once a year, whereas on the west coast, there are two harvest seasons per year, but it is likely that the different harvest seasons are combined in the annual statistical data.

The reasons for the decline in the area planted between 2000 and 2010 (Fig. 9) are not clear and need to be investigated in more detail, including changes in social institutions and collection methods.

5-2. Characteristics of durian production based on farmer survey

The farmer survey revealed that the percentage of farmers who sell their harvested fruits directly is higher than the percentage found in previous studies. The proportion of farmers who sell directly to consumers has been estimated to be one-third(Fatimah 1999) or 3% (Man, Nawi, and Ismail 2009), but in this study it was about half (49%) (Fig. 18). This may be due to the fact that the development of the internet in the last two decades has lowered the barriers to durian cultivation and sales. Therefore, the percentage of direct sales, which may not be reflected in the statistical data, may be on the way to increase and it will be more important to understand these production volumes in the future.

In addition, 75 varieties were named by 149 farmers in this study. This was 54% of the 139 varieties registered in the National Crop List of DOA Malaysia; three varieties were recommended for cultivation by FAMA (D24, D101 and Musang King), 13 varieties were considered popular among growers by DOA (D24, D99 (Kop Kecil), D123 (Chanee), D145 (Beserah), D158 (Kan Yau), D159 (Mon thong), D168 (Hajjah Hasmah), D169 (Tok Litok), D175 (Udang Merah),

D188(MDUR78), D190(MDUR88), D197(Raja kunyit)), but it is clear that more varieties are being grown.

The farms that opened in recent years (2010-2021) tended to introduce not only well-known varieties but also other varieties. Of the 51 recently opened farms, 47 (92.1%) grew Musang King and 41 (80.4%) grew D200 (Black Thorn). On the other hand, a total of 46 varieties were grown on 51 farms, indicating that varieties other than the famous ones are still very popular. On the other hand, durian kampong, which was grown by more than half (84 respondents, 56.4%) of the total respondents, is no longer chosen by 34% of the recently opened farms.

The average size of durian plantations among the respondents in this study was 4.8 acres, with 90% of the respondents having small plantations smaller than 10 acres. Since 94% of the farmers used natural pollination, it is possible that many of the respondents in this study are small-scale farmers who are engaged in coarse farming. In addition, since the questionnaire was posted on Facebook and the responses were collected in this study, the respondents may be biased towards younger age groups who have easy access to social networking sites.

5-3. Characteristics of durian production based on statistical data and farmer survey

It was found that about half of the small-scale farmers who responded to this study sold their harvested fruit directly and that about three quarters of the farmers did not record their production (Figures 18, 20). It is impossible to determine the amount of production sold directly if no records are kept, and if such production is not included in the statistical data, then the statistical data on durian production

may be an underestimate.

In addition, the statistical data did not show much variation in durian production (Figure 10), while more than 90% of the farmers surveyed felt that there was variation in production (Figure 21). Considering that the total number of cultivated varieties is 75, that more than 70% of the farmers said that the variability depends on the variety (Fig. 22), and that the variability of production per unit area per province was greater than the variability of the country as a whole, it is likely that the variability in the statistical data offsets the magnitude and timing of the variability depending on the province in which it is located. This could be considered. This suggests that the range of variability in the statistical data may have been smaller than the variability perceived by the farmers surveyed in the questionnaire on a single farm per variety.

Furthermore, the questionnaire revealed that the number of cultivars grown was much higher than that recommended by the government (DOA, FAMA). Since different varieties are expected to produce different weights of a single fruit, the change in the proportion of constituent varieties due to the migration of popular varieties may have affected the production weight.

Regarding the statistical data, the fact that seasonality was not taken into account and that the data was not classified according to variety made it difficult to understand the characteristics of durian production and to scientifically verify durian production. The durian is harvested either once or twice a year, depending on the region, but the current statistical data are yearly. As a result, it is not possible to distinguish between the two harvest seasons, and the questionnaire survey revealed that the minor harvest season spans from December to January (Figure 19). Therefore, the annual data do not correspond to

the harvest season and are not considered appropriate for discussing annual variation.

In the future, it will be necessary to lay the groundwork for collecting more accurate statistical data (by month and by main variety). In addition, it would be possible to estimate the volume of off-market distribution, which was not known in this study, by conducting interviews with farmers and stalls.

6. Conclusion

This study clarified the spatio-temporal characteristics and constraints of durian production in agricultural statistics, based on the current production status of durian, a tropical fruit tree native to Southeast Asia, especially in Malaysia, where its economic value is high and stable production is required, through a farmer survey. The results show that the proportion of farmers who sell durian directly is higher than in previous studies. In the absence of records on the amount of production sold directly, it is impossible to ascertain its volume. Therefore, if such production volumes are not included in the statistical data, the durian production volumes in the statistical data may be underestimated. While more than 90% of the farmers reported that their production varied, the variation in production from the statistical data was relatively small. The fact that the questionnaire revealed that the variability varied by variety, and the agricultural statistics data revealed that the magnitude of the variability varied according to the province in which the farmer was located, suggests that the annual statistical data for the country as a whole may have offset these variations, resulting in a smaller range of variability. In addition, the fact that seasonality was not taken into account in the statistical data and that the data were not classified according to variety made it difficult to understand the characteristics of durian production and to scientifically verify the quantities of durian produced. Therefore, in the future, it is necessary to carry out surveys to estimate the amount of off-market distribution and to lay the foundations for the collection of more accurate (monthly and variety-wise) statistical data.

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Appendix

Questionnaire used in the farmer survey on durian production

Soal selidik mengenai pengeluaran durian

Helo, Nama saya Eguchi Aoi dan saya merupakan pelajar tahun kedua kursus Sarjana di Jabatan Sains Pelancongan di Universiti Metropolitan Tokyo.
Saya sedang membuat kajian saya yang bertajuk "Meramalkan penuaian durian menggunakan data cuaca".
Penyelidikan saya masih di peringkat awal dan sekarang saya sedang mencari maklumat tentang penghasilan durian.
Dalam penyelidikan saya, saya ingin mendapatkan maklum balas daripada petani durian mengenai rekod dan turun naik pengeluaran durian, berdasarkan pengalaman dan persepsi anda di ladang.
Kami sangat berterima kasih jika anda dapat membantu kami dengan menjawab soal selidik kami.

\<English\>
Hello, My name is Eguchi Aoi and I am a second year student of the Master's course in the Tourism Science Department at Tokyo Metropolitan University.
I am doing my master's research on the theme of "Predicting durian harvest using weather data".
My research is still in its early stages and I am currently investigating the production of durian.
In my research, I would like to get feedback from durian farmers about the production records and fluctuations, based on your experiences and perceptions in the field.
We would be grateful if you could help us by answering our questionnaire.

1. Mengenai ladang (1.About your farm)

1-1 Di manakah ladang anda? (negeri) (Where is your farm?)

- ☐ Johor
- ☐ Kedah
- ☐ Kelantan
- ☐ Melaka
- ☐ Negeri Sembilan
- ☐ Pahang
- ☐ Pulau Pinang
- ☐ Perak
- ☐ Perlis
- ☐ Selangor
- ☐ Terengganu
- ☐ Sabah
- ☐ Sarawak
- ☐ その他: _____

1-2 Berapakah ukuran ladang anda? (m2) (What is the size of your farm?)

回答を入力

1-3 Bilakah ladang anda ditubuhkan? (When was your farm established?)

- [ ] -1950
- [ ] 1951-1960
- [ ] 1961-1970
- [ ] 1971-1980
- [ ] 1981-1990
- [ ] 1991-2000
- [ ] 2001-2010
- [ ] 2010-2017
- [ ] 2017-2021
- [ ] Tidak diketahui

1-4 Berapa banyak jenis durian yang anda tanam?(How many types of durian do you grow?)

回答を入力

1-4-2 Bolehkah anda memberitahu saya nama jenis durian anda jika boleh?(Could you tell me the name of the variety if possible?)

回答を入力

1-5 Bilakah musim menuai durian di ladang anda?(When is the durian harvesting season ?)

- [ ] January
- [ ] February
- [ ] March
- [ ] April
- [ ] May
- [ ] June
- [ ] July
- [ ] August
- [ ] September
- [ ] October
- [ ] November
- [ ] December
- [ ] その他: _____

1-5-1 Sekiranya masa penuaian berbeza-beza bergantung pada jenisnya, sila beritahu saya maklumatnya. (If the harvest seasaon varies depending on the variety, please tell me the details)

回答を入力

1-6 Apa jenis kaedah pendebungaan yang anda gunakan? (What kind of pollination method do you use?)

○ Pendebungaan semula jadi

○ Pendebungaan buatan

○ その他: _____

2. Mengenai rekod pengeluaran (About record of production)

2-1 Adakah anda menyimpan rekod pengeluaran durian anda? (Do you keep a record of your durian production?)

☐ Yes

☐ (No

Sekiranya anda menjawab Ya, sila jawab juga soalan-soalan berikut. Sekiranya Tidak, sila terus jawab ke Soalan 3. (If you answered Yes, please also answer the following questions. If No, please skip to Question 3.)

2-2 Adakah rekod pengeluaran durian disimpan setiap hari atau bulanan atau tahunan? (Are the records kept daily or monthly or yearly?)

☐ Hari (Daily)

☐ Bulanan (Monthly)

☐ Tahunan (Yearly)

☐ その他:

2-3 Adakah rekod pengeluaran durian dibahagikan mengikut jenis? (Are the records broken down by variety?)

☐ Yes

☐ No

2-4 Bilakah rekod pengeluaran durian paling lama yang pernah disimpan? (When are the oldest records kept?)

回答を入力

3 Mengenai Turun naik pengeluaran (About fluctuations in production)

3-1 Adakah anda merasakan terdapat turun naik dalam pengeluaran durian? (Do you feel that there are fluctuations in durian production?)

- [ ] Yes
- [ ] No
- [ ] その他: _____

3-2 Adakah anda merasakan turun naik dalam pengeluaran durian dari jenis ke jenis? (Do you feel that fluctuations in durian production vary from variety to variety?)

- ○ Yes
- ○ No
- ○ その他: _____

3-3 Apa yang anda anggap sebagai penyebab turun naik? (What do you consider to be the triggers of fluctuations?)

回答を入力

4. Mengenai Saluran pengedaran (About Distribution channels)

4-1Bagaimana dan Di mana anda menghantar produk anda? (How and Where do you ship your products?)

回答を入力

4-2 Sekiranya terdapat lebih daripada satu destinasi, berapakah bahagian masing-masing ke setiap destinasi? (If there is more than one destination, what is the proportion of each?)

回答を入力

Terima kasih kerana meluangkan masa untuk menjawab. Pada akhir bulan April, kami merancang untuk melakukan tinjauan wawancara yang lebih terperinci (panggilan video, dll.) dengan petani durian. (Kira-kira 30 minit) Kami sangat menghargai jika anda dapat bekerjasama dengan tinjauan ini.
Thank you for taking the time to answer. At the end of April, we plan to conduct a more detailed interview survey (video call, etc.) with durian farmers. (About 30 minutes)We would appreciate it if you could cooperate with the survey.

Sekiranya anda ingin bekerjasama dengan penyelidikan terperinci, sila masukkan nombor telefon atau alamat e-mel anda. (If you would like to cooperate with the detailed investigation, please enter your telephone number or email address.)

回答を入力