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Moringa oleifera Distribution in Java and Lesser Sunda Islands Attributed with Annual Rainfall

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Abstract

Moringa (*Moringa oleifera* Lam.) is a cultivated plant that reported have many benefits. Indonesian people have utilized moringa as a vegetable widely but it is never used as functional food. The distribution data of moringa in Indonesia is needed to develop moringa as an additional nutrient for functional food. The aim of the research was to draw up the distribution map of moringa in Java and Lesser Sunda Islands (LSI). In addition, this distribution map was also attributed with average annual rainfall to know the preference of moringa to life depend on the rainfall. This research has been conducted with four approaches: collecting specimens, direct observation of living plant, direct observation of specimen herbarium and literature study. All data were analyzed and arranged into the distribution maps of moringa in Java and the LSI attributed with annual rainfall. The result showed that moringa in entire Java mostly distributed in the area of Jakarta, West Java, Central Java, Yogyakarta, the north part of East Java, Madura and Kangean. While, moringa in LSI distributed in the southern part of Bali, Lombok, Sumbawa, Kupang, Flores, Sumba and Alor. The average annual rainfall of 1500-2000 mm is the most ideal condition for moringa plants to grow well. This map and information can be utilized by the stakeholders to determine the most appropriate place for moringa cultivation and their development as as a functional food.

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INTRODUCTION

Moringa (*Moringa oleifera* Lam.) is a cultivated plant belong to the Moringaceae. Moringa is also known as drumstick tree, horseradish tree, and ben oil tree (USDA, 2018). Moringa is a fast-growing tree with many branches. It can be shrubs or cork tree up to 10 m tall and 30 cm in diameter. Moringa has the tuberous with pungent bark root, compound leaves, inflorescence creamy flower with fragrant and the fruit is green at young and becoming brown when mature and the seeds are sub-globose shape with three thin wings. Moringa reportedly originated from northwestern India (Sastrapradja *et al.*, 1977) and Pakistan (Polprasid, 1994; Backer & Brink, 1963) or Himalaya (Heyne, 1987; Steenis, 2005) then introduced to Southeast Asia (including Indonesia) and spreading in the tropical areas (Polprasid, 1994).

Moringa is reported to have many benefits, some of them are to be used as medicines (Wiguna, 2018), anti-oxidants (Badriyah *et al.*, 2017), anti-bacterial (Suriaman & Khasanah, 2017; Wadji *et al.*, 2017), anti-fungi (Kurniawan, 2015), bio-pesticides (Suwahyono, 2008), bio-stimulant (Culver *et al.*, 2012; Abdalla, 2013), improving quality of water (Susanto *et al.*, 2007; Suwahyono, 2008; Yuliastri, 2010) and waste water treatment (Januardi *et al.*, 2014). Moringa also has been used as animal feed (Sjofjan, 2008; Suwahyono, 2008), improved nutrition of food (Zakaria *et al.*, 2016), organic fertilizer, pulp materials, oil (Suwahyono, 2008), raw materials of soap (Argohartono & Wiguna, 2018) and as vegetables (Suwahyono, 2008). In Southeast Asia, moringa is mainly used as a vegetable. Some parts of moringa that can be used as a vegetable are flowers, leaves and young fruits.

Indonesian people have utilized moringa as a vegetable widely. Moringa can be one of the national foods because it is considered as a local plant in Indonesia. It is important to develop moringa as an additional nutrient for functional food. Distribution data of moringa in Indonesia is needed for realizing this goal. This basic data can be utilized by the stakeholders to determine an area for developing of the moringa as a functional food. To build a valid data distribution of moringa in Indonesia, we can use herbarium specimen data supported by some references. Moreover, it can also be done through the exploration activities to get additional data about the herbarium specimens or only direct observation without collecting any specimens.

The observation of specimen in Herbarium Bogoriense (BO), study of literature, direct observation and exploration of moringa have been conducted by the Research Center for Biology, Indonesian Institute of Sciences (LIPI) recently. From those data, a map of the distribution of moringa in Indonesia had been prepared. Unfortunately, only very limited data of moringa distribution were available. So, it was only a small part of the area of Indonesia began to be mapped. That situation made it only possible to make a map for areas of Java and Lesser Sunda Islands (LSI). LSI is a group of islands of Indonesia and Timor-Leste, comprises many islands with Bali, Lombok, Sumbawa, Sumba, Flores, and Timor as the main islands. Most of them are part of Indonesia, administered as the provinces of Bali, West Nusa Tenggara, and East Nusa Tenggara. It is only the eastern half of Timor Island that is not part of Indonesia but stands as another country, Timor-Leste.

Through this mapping, it is expected to initiate the mapping of moringa in other regions throughout Indonesia. On the other hand, we put this map overlapping with an average annual rainfall in Java dan LSI to analyze the tendency of moringa to life based on the annual rainfall.

METHODS

The research was conducted with four approaches. The first approach was direct exploration by modifying the exploration method by Rugayah *et al.* (2004), exploring the research location and only collecting the moringa specimens. Exploration was conducted in May 2018 in the LSI, especially in West, East, North and Central Lombok and in July 2018 in Sumba, especially in Southwest, West, Central and East Sumba.

The specimens of moringa were labelled and stored in newspaper folds then moistened with 70% alcohol. Those specimens then were shipped to the Herbarium Bogoriense (BO) for further processing. Supporting data recorded were plant height, flower colour, location, collection date, collection number, collector, and so on.

The second approach was direct exploration without collecting the specimens. The third approach was observation of moringa specimens in BO. The data of the location of each specimen observed was recorded and summarized in an observation table. The fourth approach was based on literature study of moringa. All of the literature that reporting moringa in Java and the LSI were summarized. Finally, all data from those four approaches were analyzed and arranged into the distribution maps of moringa in Java and the

LSI. After that, overlapping map between moringa distribution and annual rainfall map based on Sulistya *et al.* (2011) was created.

RESULTS AND DISCUSSION

There were four specimens of moringa (Figure 1) that collected recently from Lombok Island and five specimens from Sumba Island. Those specimens were stored in BO. In total, as many as 36 moringa specimen collections of BO from Java and LSI were observed. While, there were 18 literatures of moringa distribution in Java and LSI were studied. In addition, 25 data were obtained from direct observation of moringa in Java and LSI. In total, as many as 79 data were obtained (Table 1) to build the map of moringa distribution in Java and LSI (Figure 2-7). The map of average annual rainfall created referred to the map of average annual rainfall by Sulistya *et al.* (2011). This distribution map of moringa is attributed to average annual rainfall in Java dan LSI to analyze the tendency of moringa to life based on annual rainfall.

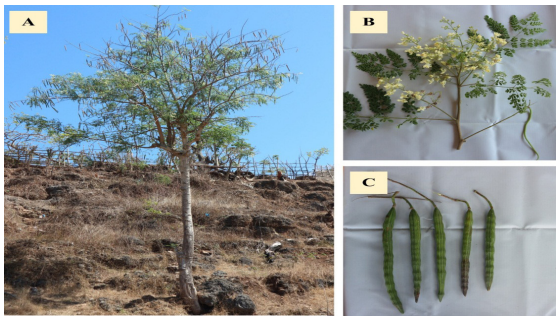

Figure 1. *Moringa oleifera*, A. habit, B. leaves with inflorescence flowers, C. fruits (Photos: Ridwan)

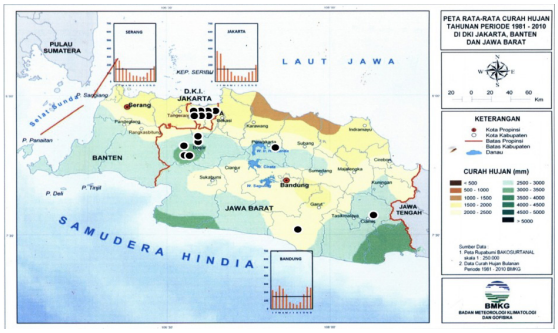

Figure 2. The distribution of *Moringa oleifera* (black dots) in Jakarta, West Java and Banten attributed to the average annual rainfall map (average annual rainfall map by Sulistya *et al.*, 2011)

According to Figure 2, the distribution of moringa in the western part of Java is concentrated in the Jakarta and Bogor (West Java). This map arranged from the data of BO specimens collected in colonial period. So, it is not surprising if the distribution of moringa focused in Jakarta and Bogor, the place where the researchers performed their plant taxonomy study at the first time since they came to Indonesia in colonial era (Rifai, 2007). There were about 46% of moringa grew in the area with an average annual rainfall of 1500-2000 mm and the other 54% grew at an average annual rainfall of 2,000-3,500 mm. Although Mitariastini (2016) stated that moringa usually grows in annual rainfall of 250-1500 mm, this does not rule out the possibility that moringa can grow in the higher annual rainfall.

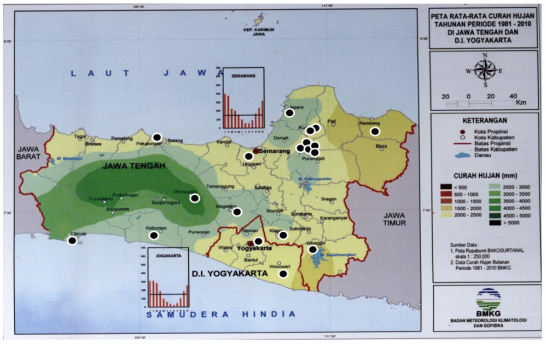

Figure 3. The distribution of *Moringa oleifera* (black dots) in Central Java and Yogyakarta attributed to the average annual rainfall map (average annual rainfall map by Sulistya *et al.*, 2011)

The distribution of moringa in the center area of Java island is presented on Figure 3. Moringa found in almost all area of Central Java and Yogyakarta. As many as 63% of moringa grew in the area with an average annual rainfall of 2000-2500 mm. Only about 11% of moringa grew in the area with an average annual rainfall of 1500-2000 mm and the other 26% in the area with an average annual rainfall of 2500-4000 mm. This condition proves that moringa can grow well in the area with an average rainfall of more than 1500 mm as mentioned by Mitariastini (2016). Most of the moringa in the center area of Java was found along the road in the urban area and also near of the rice fields. Mukhlison (2013) stated that moringa is suitable for the urban area because this plant can grow without any particular maintenance.

Table 1. Distribution of moringa in Java and Lesser Sunda Islands based on exploration data, direct observation, observation of herbarium specimens and related literature

No.	Location	Collector & No./Reference/Source
Jakarta, West Java and Banten		
1	Batavia, Eiland Noordwachter (now Jakarta)	Slooten & Backer 35052 (BO)
2	Batavia, Eiland Edam (now Jakarta)	Backer 30983 (BO)
3	Batavia, Eiland Edam (now Jakarta)	Boschma 145 (BO)
4	Batavia, Eiland Noundwachter (now Jakarta)	Boschma 24 (BO)
5	Batavia, Tandjong Priok (now Tanjung Priuk, Jakarta)	Backer s.n. (BO)
6	Batavia, Weltweureden, G. Sahari Sentiong (now Jakarta)	Backer s.n. (BO)
7	Weltereds Goenoeng Sahari, Sentiong (now Jakarta)	Harreveld 1564 (BO)
8	Batavia, Leuwiliang (w.n. Buitenzorg) (now West Java)	Bakhuizen v/d Brink 5915 (BO)
9	West Java, Cikarawang, Dramaga	Desiwati (2013)
10	West Java, Purwakarta	Yuliastri (2010)
11	West Java, Cibinong	Riastiwi (direct observation)
12	West Java, Ciamis	Rahayu (direct observation)
13	West Java, South Garut	Ridwan (direct observation)
14	Java (allegedly Bogor)	Backer 7703 (BO)
15	Java (allegedly Bogor)	Koorders 5138 (BO)
Central Java and Yogyakarta		
1	Central Java, Rembang, Doekoeh Bringin roet G. Tandan	Thorenaar 191 (BO)
2	Central Java, Semarang, Kedoengdjati (now Kedungjati)	Koorders 24518 (BO)
3	Central Java, Semarang, Kedoengdjati (now Kedungjati)	Koorders 24930 (BO)
4	Central Java, Semarang, Kedoengdjati (now Kedungjati)	Koorders 5181 (BO)
5	Central Java, Semarang, Kedoengdjati (now Kedungjati)	Koorders 5184 (BO)
6	Central Java, Semarang, Kedoengdjati (now Kedungjati)	Koorders 5182 (BO)
7	Central Java, Semarang, Koedoes (now Kudus)	Leg. Ign. 3128 (BO)
8	Central Java, Semarang, Koedoes (now Kudus)	Leg. Ign. 1138 (BO)
9	Central Java, Jepara	Badriyah *et al*. (2017)
10	Central Java, Wonosobo	Wadji *et al*. (2017)
11	Central Java, Magelang	Nugrahaeni (direct observation)
12	Central Java, Klaten	Prawesti (direct observation)
13	Central Java, Wonogiri	Prawesti (direct observation)
14	Central Java, Nusa Kambangan	Rahayu (direct observation)
15	Central Java, Semarang	Nugrahaeni (direct observation)
16	Central Java, Pekalongan	Nugrahaeni (direct observation)
17	Central Java, Bagelen, Keboemen (now Kebumen)	Brinkman 360 (BO)
18	Yogyakarta, Gunung Kidul	Sulistyawati *et al*. (2017)
19	Yogyakarta	Nugrahaeni (direct observation)
East Java, Madura and Vicinity		
1	Kangean Islands, Ardjasa	Backer 27162 (BO)
2	Kangean Islands, Ardjasa	Dommers 184 (BO)
3	East Java, Soerabaya (now Surabaya)	Boschma s.n. (BO)
4	East Java, Soemenep (now Sumenep)	Boer 12 (BO)
5	East Java, Sumenep	Fawaid *et al*. (2016)
6	East Java, Madura	Bahriyah *et al*. (2015)
7	East Java, Madura	Hastuti *et al*. (2015)

No.	Location	Collector & No./Reference/Source
8	East Java, Madura	Backer & Brink (1963)
9	East Java, Madura	Sastrapradja *et al.* (1977)
10	East Java, Pasuruan	Anwar *et al.* (2014)
11	East Java, Bojonegoro	Sjofjan (2008)
12	East Java, Sidoarjo	Nugrahaeni (direct observation)
13	East Java, Lamongan	Nugrahaeni (direct observation)
Lesser Sunda Islands		
Bali		
1	Bali	Girmansyah *et al.* (2013)
2	Badung, Abiansemal	Damayanto (direct observation)
3	Badung, Canggu	Ridwan (direct observation)
4	Badung, Petang	Damayanto (direct observation)
5	Badung, Sibang Gede	Damayanto (direct observation)
6	Buleleng, Singaraja	Meigaria *et al.* (2016)
7	Gianyar, Blahbatuh	Damayanto (direct observation)
8	Gianyar, Saba	Damayanto (direct observation)
9	Gianyar, Singapadu	Damayanto (direct observation)
10	Gianyar, Tampak Siring	Damayanto (direct observation)
11	Gianyar, Payangan	Damayanto (direct observation)
12	Tabanan, Petiga	Adiputra (2009)
13	Jembrana, Negara	Damayanto (direct observation)
14	Karan gasem, Taman Ujung	Damayanto (direct observation)
West Nusa Tenggara		
1	Central Lombok, Mandalika	Ridwan, Aryani & Tri 1 (BO)
2	West Lombok, Sengigi	Ridwan, Aryani & Tri 3 (BO)
3	West Lombok, 'Sungigi' (now Sengigi)	Tobe & Utami 1021 (BO)
4	North Lombok, Khayangan	Ridwan, Aryani & Tri 4 (BO)
5	North Lombok	Rianto (2017)
6	East Lombok, Labuhan Aji	Ridwan, Aryani & Tri 2 (BO)
7	Mataram	Ridwan (direct observation)
8	Sumbawa, Bima	Suriaman & Khasanah (2017)
East Nusa Tenggara		
1	East Nusa Tenggara	Dewanti *et al.* (2016)
2	Timor, Alor Islands, Atimelang	Bois 56 (BO)
3	Arich, Ind, Timor, Koepang (now Kupang)	Teysmann 211669 (BO)
4	Flores, Moemere	Horst 77 (BO)
5	East Sumba, Waingapu	Ridwan (direct observation)
6	East Sumba, Waingapu,, Kamameru	Ridwan, Leksonowati & Handayani 02 (BO)
7	East Sumba, Pandawai, Kadungbul	Ridwan, Leksonowati & Handayani 05 (BO)
8	Central Sumba, Katikutanan, Kabelawuntu	Ridwan, Leksonowati & Handayani 06 (BO)
9	West Sumba, Waikabubak, Buuweri	Ridwan, Leksonowati & Handayani 08 (BO)
10	Southwest Sumba, Tambolaka, Weerenna	Ridwan, Leksonowati & Handayani 13 (BO)

Figure 4. The distribution of *Moringa oleifera* (black dots) in East Java, Madura and vicinity attributed to the average annual rainfall maps (average annual rainfall map by Sulistya *et al.*, 2011)

The distribution of moringa in the eastern area of Java island can be seen on Figure 4. Moringa found only in several areas, particularly in the northern part of East Java, Madura Island and also Kangean Island. This map arranged mostly based on the reference data supported by little information from herbarium data. In the eastern part of Java, about 69% of moringa grew in the area with an average annual rainfall of 1500-2000 mm. Only about 31% of moringa grew in the area with an average annual rainfall of 1000-1500 mm. Similar to those mentioned earlier, it proves that moringa can grow well in the area with average rainfall of more than 1500 mm.

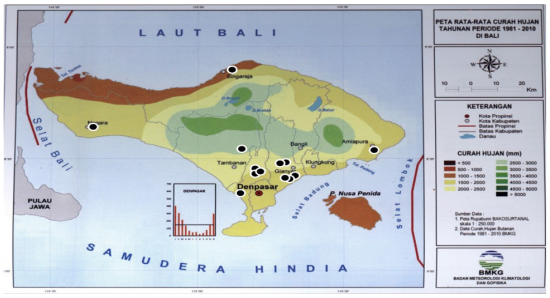

Figure 5. The distribution of *Moringa oleifera* (black dots) in Bali attributed to an average annual rainfall map (average annual rainfall map by Sulistya *et al.*, 2011)

Based on the Figure 5, moringa distribution was concentrated in the southern part of Bali as the center of observation. The data of this area was built based on direct observation from the author (Damayanto). According to the Figure 5, as many as 62% of moringa found in the area with an average annual rainfall of 1500-2000 mm. Only about 8% of moringa grew in the area with an average annual rainfall of 1000-1500 mm. As many as 31% of moringa found in the area with an average annual rainfall of 2000-3000 mm. This condition also proves that moringa can grow well in the area with an average rainfall of more than 1500 mm.

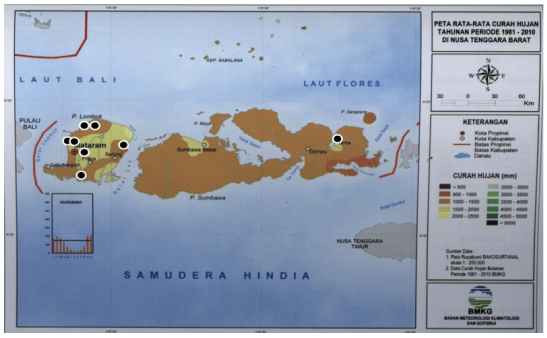

Figure 6. The distribution of *Moringa oleifera* (black dots) in West Nusa Tenggara is attributed to average annual rainfall map (average annual rainfall map from Sulistya *et al.*, 2011)

According to the Figure 6, the distribution of moringa in West Nusa Tenggara was concentrated in Lombok Island as a result of the exploration activity in Lombok recently. In West Nusa Tenggara, 75% of moringa found in the area with an average annual rainfall of 1000-1500 mm. Only about 25% of moringa grew in the area with an average annual rainfall of 1500-2000 mm. It seems that moringa in West Nusa Tenggara usually grows in annual rainfall of up to 1500 mm as well as the data mentioned by Mitariastini (2016).

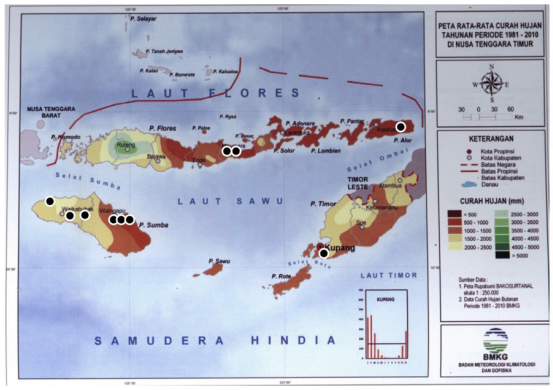

Figure 7. The distribution of *Moringa oleifera* (black dots) in West Nusa Tenggara attributed to average annual rainfall map (average annual rainfall map by Sulistya *et al.*, 2011)

Based on the Figure 7, moringa in East Nusa Tenggara found scattered in Kupang, Flores, Sumba and Alor Island. There was only little data available to build this map. Therefore, it is needed more study of moringa in East Nusa Tenggara to establish a comprehensive map. In East Nusa Tenggara, 50% of moringa found in the area with an average annual rainfall of 500-

1000 mm. Only 10% of moringa grew in the area with average annual rainfall of 1000-1500 mm and only 40% in 1500-2000 mm. Based on Mitariastini (2016), moringa usually grows in annual rainfall of 250-1500 mm. This conditions also occur in East Nusa Tenggara.

All distribution maps of moringa (figure 2-7) was processed into a diagram as seen in Figure 8. Based on Figure 8, it can be inferred that 44% of moringa found in areas with an average annual rainfall of 1500-2000 mm, followed by 20% in an average annual rainfall of 2000-2500 mm. As many as 8% were found in lowest average annual rainfall (500-1000 mm) and only 5% of moringa found in the highest average annual rainfall (3000-3500 mm).

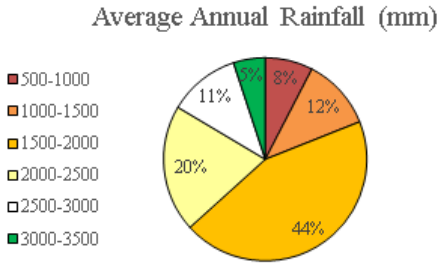

Figure 8. Trend of average annual rainfall of *Moringa oleifera* in Java and LSI

Based on the Figure 8, indicate that an average annual rainfall of 1500-2000 mm is the most ideal for moringa plants to grow. Murdjoko *et al.* (2016) mentioned that an area with high humidity, rainfall, and sunlight intensity makes many plants to get their optimum growth. However, Mitariastini (2016) stated that moringa usually grows in annual rainfall of 250-1500 mm with the temperature 20-35°C. On another hand, Polprasid (1994) stated that moringa is a tropical plant, both under wet and any seasonal conditions. Although moringa can withstand drought and high rainfall intensity, if the ground is waterlogged, then the roots have a tendency to rot (Prisdiminggo *et al.*, 2011; Mitariastini, 2016). Furthermore, moringa can grow in various soils but thrives best in fertile, well-drained sandy loams (Polprasid, 1994), clay or sandy clay with pH of 5-9 (Mitariastini, 2016). In this research, some moringa in Sumba grew in pH 6-7. Moringa grew well at lower elevation but can be found in up to 1300 m altitude (Polprasid, 1994). In Java, moringa found in up to 300 m altitude or might grow in a higher place (Heyne, 1987). According to Mitariastini (2016), the ideal altitude for moringa planting is less than 600 m.

Actually, this study provided the basic data of distribution of moringa in Java and LSI, as well as, an information of an ideal condition of rainfall for moringa to grow. This data may use by stakeholder or researcher in determining policies or further studies that related to functional food development of moringa.

CONCLUSION

Moringa plants in entire Java are mostly distributed in the area of Jakarta, West Java, Central Java, Yogyakarta, the northern part of East Java, Madura Island, and Kangean Islands. While, in LSI they are distributed in the southern part of Bali, Lombok Island, Sumbawa, Kupang, Flores, Sumba and Alor Island. The average annual rainfall of 1500-2000 mm is the ideal condition for moringa to grow well.

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