Selected nutmeg parent trees from nutmeg population in Bogor: Their fruit yield, essential oil content, and morphological characteristics

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Abstract. Indonesia has been a long-time well known as high quality of nutmeg. Nutmeg is native to Indonesia, with an origin in the Maluku islands. Then, spread out and scattered into other parts of Indonesia. Bogor is one of the nutmeg production centers in West Java with a wide range of products. However, there have been no scientific studies that provide a complete picture of the genetic identity of Bogor Nutmeg. The research aimed to identify the main morphological character and fruit quality components for selecting candidates of selected parent trees of the Bogor population nutmeg, to be promoted as a new superior variety. Mass positive selection was used to identify established parent trees by observing the main morphological characters, production, and quality. Results confirmed that the selected parent tree of Bogor nutmeg had fulfilled the technical requirement as the candidate of new superior varieties for fruit yield (> 5000 grains/tree/year), essential oil content (> 20%), and myristicin (> 10%), which were varied according to the age of the fruit. The nutmeg population in Bogor is characterized by the size and shape of round or oval fruit, the size, and shape of lanceolate or oblong leaves.

1. Introduction

Nutmeg is native to Indonesia with a center of origin and genetic diversity in the Moluccas islands, such as in Banda Island, Siau, North Moluccas, and Papua [1,2]. Some reports suggest that the species is found mainly scattered in Indonesia and Papua New Guinea [3]. At these habitats, the growth of nutmeg plants showed variation in morphological characters as well as production. It’s due to most of the nutmeg tree was propagated using generative seeds. Nutmeg is a dioecious-cross-pollinated tree, so then the seeds derived from generative propagation will form new variants.

Among the plantation-tree, nutmeg is the second largest foreign exchange earner after pepper, with export value reaching USD 109.217 million, or equivalent to IDR 1.62 trillion/year. Of the total area of nutmeg plantation, 196,686 ha, five areas as the largest are North Moluccas (49,224 ha), Moluccas (32,728 ha), Aceh (23,993 ha), North Sulawesi (22,274 ha), and West Java (7,514 ha) [4]. Bogor Regency (1,670 ha) and Sukabumi (1,475 ha) has long been known as nutmeg development centers in West Java with a wide range of products. Farmers in both regions each claim as the center of processed and traded nutmeg and raw materials-derived. Nutmeg developed well in Bogor and Sukabumi. However, its genetic identity is unknown because no varieties of nutmeg were released from the two
regions. Based on the results on inventory data from the centers of development of nutmeg in Bogor Regency, there are indications that Banda is the origin of Bogor nutmeg, which is now widespread, carried by the Vereenigde Oostindische Compagnie (VOC) from the Moluccas Islands. Nevertheless, no scientific studies provide a complete picture of the genetic identity of Bogor Nutmeg and nutmeg grown in central origin (Moluccas Islands) and its relationship.

Bogor nutmeg, which the people have cultivated, is spread across several districts in the Bogor Regency scope. Even the seeds from several locations in Bogor Regency have spread to various regions in Indonesia. The nutmeg production center in Bogor includes six villages, namely (1) Sadeng in Leuwisadeng district, (2) Cipayung Girang in Mega Mendung district, (3) Tugu Jaya in Cigombong district, (4) Taman Sari district, (5) Tajur Halang in Cijeruk district, and (6) Caringin in Caringin district. Two locations out of six can be traced clearly for their origin, namely Sadeng in Leuwisadeng district and Taman Sari. Nutmeg cultivation in Taman Sari district was located in two different blocks, separated from the distance, so that it divided into two other locations, namely Taman Sari and Curug Nangka.

Observation to identify Bogor nutmeg character is worth performing. Identification can be done by selecting the seeds-source population at the centers of production and distribution and then setting the high-yielding blocks (from now on referred to as BPT, Blok Penghasil Tinggi). Further, select for the parent trees (from now on referred to as PIT, Pohon Induk Terpilih), followed by identifying morphological characters, production, and quality components, to be compared with the standard nutmeg variety from the center of its origin (Maluku Islands). All trees appointed as parent trees (PIT) and high yielding block (BPT) must have morphological, productivity, and quality characteristics to Decree of the Minister of Agriculture No. 320/Kpts/KB.020/10/2015 on Guidelines for Production, Certification, Distribution, and Control on Nutmeg seeds (Myristica fragrans Houtt.) [5].

To maintain the existence of good seeds products of nutmeg, mace, essential oils, and other derivative products, nutmeg farmers, through relevant agencies in the area, began to intensify cultivation and rejuvenation and expand the planting area. Based on the regulations on plant cultivation, seeds used for cultivation should be derived from varieties that have been released by the Ministry of the Agriculture Republic of Indonesia (Permentan No.50/Permentan/KB.020/9/2015)[6], concerning guidelines for Production, Certification, Distribution, and Control of Seed). The plant breeding process to develop new varieties for tree crops with desirable characteristics requires considerable off time. The Ministry of Agriculture had released five select types of nutmeg by selecting parent trees from a local population that already exists. Therefore, to support the expansion of the cultivation area to improve the quality of processed product’s nutmeg in its development center, an approach that can be taken is to select the superior parent trees from the existing population (BPT and PIT). The study aimed to observe the selected parent tree (PIT) of Bogor nutmeg to determine the new high-yielding and high-quality nutmeg variety.

2. Methods

2.1. Selection of high-yielding block parent trees of nutmeg

Determination of high-yielding block refers to the morphology, production, and quality of nutmeg’s existing population at each location (from desk study) and then selected by the Mass Positive Selection method (selecting the best). Block was selected based on the uniformity of crop performance (morphology and growth), a cultivated plant of the uniform age range, and the same variety. The selection provisions of the high-yielding blocks (BPT) and selected parent trees (PIT) refer to the Decree of the Minister of Agriculture No. 320/Kpts/KB.020/10/2015 on Guidelines for Production, Certification, Distribution, and Control on Nutmeg seeds [5]. From selected BPT, then the parent trees selection was performed refers to selecting individuals by observing morphological characters, production, and quality. The selected parent trees (PIT) required uniform morphology, high fruit production, and quality according to ISO/Trade standard, with strong and good habitus, pest and diseases free, located near each other (within the same population), an original or varieties are not hybrids one.
The selected tree that qualified as parent trees (PIT) from each location are Sadeng, Leuwisadeng district (20 PIT), Taman Sari district (4 PIT), and Curug Nangka district (2 PIT). High-yielding block (BPT) and parent tree (PIT) selection were performed based on criteria as follows:

a) High-yielding block selection
   - The location is easy to reach by transportation
   - Climate is following the requirements
   - The minimum land area is about 0.5 ha, with an approximate population of 50 trees.
   - The appearance of plant morphology (canopies, leaves, fruits, seeds) is relatively uniform
   - The origin of plants is known clearly.
   - Crop conditions do not show symptoms of pest and disease attacks
   - Fruit production of at least 3,000 grains per tree per year and relatively stable.

b) Parents tree selection
   - The high-yield nutmeg trees (5,000 pieces of tree per year) within the high-yielding blocks were selected based on farmers’ information and direct observation in the field.
   - The parent trees were selected of about 10% from existing trees in high-yielding blocks with the best character, especially the highest production and relatively stable.

2.2. Determination of fruit yield from nutmeg parent trees
The main component of nutmeg’s economic sense is a fruit, including mace and kernel. Fruit production is the total number of fruits harvested in one year per parent tree. Observation of fruit production was carried out for two years. Fruit production is the main component that determines the quality of nutmeg variety, besides the bioactive compound. Therefore, the identification of Bogor nutmeg’s population was made based on the quality of fruit, including the kernel and mace, carried out in the laboratory-based on ISO predetermined. The samples used were the fruits harvested at around 4-6 months (young fruit) and an old one-harvested at about 9-10 months old fruit.

2.3. Analysis of essential oils of nutmeg fruits
According to Indonesia Nasional Standard, the essential oils of the kernel, flesh, and mace of nutmeg fruits were obtained using distillation method as cajuput essential oils distillation (SNI No. 3954-2014) [7]. Meanwhile, the main compound of essential-oils of selected parts of nutmeg fruit was analyzed by GC-MS (Agilent Technologies 7890 Gas Chromatograph with AutoSampler and 5975 Mass Selective Detector and Chemstation Data System), according to the laboratory standard method of Health District-Laboratory of DKI Jakarta Province (Lab-Dopping). The GC-MS was carried out under the following conditions: electron impact initiation model, electron energy 70 eV, with the helium carrier gas, HP Ultra 2 column, capillary column size 30m (length) × 0.20mm ID × 0.11 µm film thickness, the initial column temperature 80ºC was then increased at a rate of 3ºC min-1 to reaches 150ºC and is held for 1 minute, then the temperature is raised again at a rate of 20ºC minute-1 until it reaches 280ºC and is fit for 26 minutes, injection port temperature is 250ºC, ion source temperature is 230ºC, separator temperature is 280ºC, quadrupole temperature is 140ºC, constant flow column mode, column flow 1.2 ml.minutes-1, injection volume 5 µl, and separation ratio 8: 1. GC-MS is connected to a monitor and printer that presents chromatograms and a table of the pure compound-types order with their respective retention times and each compound-percentage concentration. The analysis was only done once without replication.

2.4. Morphological characterization of nutmeg parent trees
Morphological characters were measured according to modify Tropical Fruits Descriptors [8,9], based on direct observation methods to the tree-habitus, leaf, fruit, and seeds of each individual. The sample used for cluster analysis was selected from 24 parent trees (PIT) that had complete characteristic data and represented the population. According to those criteria, there are 14 parent trees (PIT) selected. Clustering was used to measure the genetic relationship between trees using the Euclidean-based clustering method.
3. Results and Discussion

3.1. High-yielding block and selected parent tree

Based on observations in several centers of cultivation of nutmeg in Bogor Regency, three locations of high-yielding blocks have been chosen to be observed as prospective seeds source of superior varieties of Bogor nutmeg. Nutmeg in Bogor Regency was planted at 25 districts amongst 40, with a total area of 1,670 ha [4,5]. Characteristics of location for selected high-yielding block were as in table 1.

Table 1. Main characteristics of the location for high-yielding block of nutmeg in Bogor Regency

| Characteristic                  | Leuwisadeng (H. Satri) | Tamansari (Euis) | Curug Nangka (M. Hatta) |
|--------------------------------|------------------------|------------------|-------------------------|
| Altitude (m dpl)               | 470                    | 576              | 556                     |
| Seeds source                   | Tamansari Bogor        | Tamansari Bogor  | Tamansari Bogor         |
| Planting year                  | 1969 (2 trees)         |                  |                         |
|                                | 1979 (500 trees)       |                  |                         |
| Age of plantation              | Parents tree: 36–46 years | Parents tree: 20-70 years | >40 years |
|                                | Offspring: 8-15 years  | Offspring: 8 years | Offspring: 8 years      |
| Average fruit production (grains/year) | >3000                  | >3000            | >3000                   |
| Land area                      | 3 ha                   | 1 ha             | 1 ha                    |

The interviews with farmers in three of the mentioned locations show that the nutmeg seeds in the three sites are from the same spot, e.g., Village Sukamantri of Districts Tamansari, Bogor Regency. Nutmeg in the area of Tamansari was brought from Banda island in the Dutch colonial era of the 1900s. The offspring of Banda nutmeg is so far spread throughout the District of Bogor and surrounding areas. These inventory results followed de Guzman et al. [10], which mentioned that the Banda Nutmeg population originated in the Southern Moluccas, especially Ambon and Banda, known as *Myristica fragrans*. This species then spread out to the Northern Sulawesi, Java Island, Papua, Southern Asia, and Grenada.

Table 2. Annual fruit production per year of nutmeg at three high-yielding blocks of Bogor Regency in the first and second year of observation

| Location               | Age of tree (year) | Area (ha) | No. of tree | No. selected parent tree | Means no. of fruit yield (grains/tree/year) |
|------------------------|--------------------|-----------|-------------|--------------------------|---------------------------------------------|
| *First Year*           |                    |           |             |                          |                                             |
| Block I (Curug Nangka) | 40                 | 1         | 120         | 2                        | 5025 ± 388                                  |
| Block II (Tamansari)   | 20-70              | 1         | 100         | 4                        | 5075 ± 176                                  |
| Block III (Leuwisadeng)| 36-46              | 2         | 300         | 20                       | 6726 ± 1050                                 |
| Means                  |                    |           |             |                          | 5608 ± 888                                  |
| *Second Year*          |                    |           |             |                          |                                             |
| Block I (Curug Nangka) | 40                 | 1         | 120         | 2                        | 6400 ± 424                                  |
| Block II (Tamansari)   | 20-70              | 1         | 100         | 4                        | 6600 ± 548                                  |
| Block III (Leuwisadeng)| 36-46              | 2         | 300         | 20                       | 6906 ± 1213                                 |
| Block I (Curug Nangka) | 40                 | 1         | 120         | 2                        | 6400 ± 424                                  |
| Means                  |                    |           |             |                          | 6820 ± 1090                                 |

Based on preliminary inventory results, nutmegs’ production from productive crops over 20 years-old trees within the three selected Bogor district locations, averaging more than 3,000 fruits per tree. Therefore, these three locations can be chosen as high-yielding nutmeg blocks. Then the parent tree
(PIT) was selected from each block following the Decree of the Minister of Agriculture No.320/Kpts/KB.020/10/2015 [5]. Fruit production from selected PIT is shown in table 2.

Observations on fruit production obtained from 2 harvests year (2015 and 2016) show the highest number of fruits in Block III (Leuwisadeng). At that location, nutmeg populations were present in the same bed with relatively dense plant spacing (5-7m). At the I and II high-yielding block, nutmeg plantations were present in one village within adjacent locations. The observations show that although the spacing is relatively dense, the nutmeg population in Leuwisadeng can produce optimum fruits. Such conditions may be caused by differences in rainfall in all three locations. Leuwisadeng is located in an area with rain precipitation, and the number of rainy days is relatively lower than those of others. However, based on the Decree of the Minister of Agriculture No. 320/Kpts/KB.020/10/2015 [5], those three high-yielding blocks are potential sources of superior seeds of nutmeg. Moreover, based on individual observation on each selected parent tree, the highest number of annual fruits per tree was found at Leuwisadeng (Block III) with 9,736 fruits/tree/year, e.g., PIT No. 13 and 8,530 fruits/tree/year, e.g., PIT No. 72 (data are not shown). In cashew, the same perennial tree-crops producing fruit, the agro-climatic stress index and amount of rainfall, and the number of rainy days were the main factors determining cashew trees’ production [11].

| Table 3. The means of essential oils content and quality of flesh, kernel, and mace of nutmeg from the high yielding blocks /selected trees in Bogor Regency, in the second year of observation |
|---------------------------------------------------------------|
| **Parameter** | **Location** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Essential oils contents (%)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Flesh | 1.00 | 1.48 | 1.50 | - |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Kernel | 6.67 | 7.50 | 9.50 | 1.85 (Tobelo 1) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Mace | 28.47 | 10.57 | 32.11 | 20 (Banda) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Myristicin (%)** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Flesh | 31.21 | 38.25 | 24.15 | - |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Kernel | 8.75 | 16.38 | 18.05 | 3.78 (Tobelo 1) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Mace | 23.88 | 17.6 | 18.94 | 13.70 (Banda) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Data was taken from the second harvest of each location

*According to descriptors for the released varieties of Indonesian nutmeg

Besides fruit production, nutmeg superiority is also determined by quality, especially the content and quality of essential oils and myristicin. Essential oils and myristicin usually obtain from the flesh, kernel, and mace, but both the kernel and mace quality are the best. The results of quality analysis of flesh, kernel, and mace are shown in table 3. The laboratory analysis results (table 4) show that the Bogor nutmeg has the advantage of essential oil content in the mace and kernel compared with the improved varieties that have been released. Bogor nutmeg is often harvested at a young age (4-6 months) so that its essential oil content is high. The flesh was also contained essential oils at only a small amount.

Since Bogor nutmeg harvested varies according to age, the essential oils and their bioactive compound can differ. The results of essential oils analysis from a different age of kernel and mace are given in table 4. Morphologically, the kernel age is differentiated by its color, namely the light kernel with light brown grain color, the medium kernel with dark brown grain color, and the old kernel with black grain color. Meanwhile, the mace is divided into two colors: the young light mace with pink /not full red color, and the old mace with full red color.

Bogor nutmeg essential oil meets ESA standards (>6.5%). Its fruit and kernel, which were harvested earlier, at about 3-7 months old, had the highest average of essential oil content (13.83 ± 1.61%) and mace from medium-aged fruit (14.08 ± 1.93%). Both were found higher than that of old harvested kernel and mace. According to a previous study, the essential oil analysis of nutmeg kernel using GC-MS
revealed that its main components were α-pinene, limonene, terpineol, safrole, and myristicin [12]. The analysis of Bogor nutmeg by using GC-MS showed that the chemical components in the essential oils of kernel and mace were α-pinene, sabinene, myrcene, limonene, γ-terpineol, terpeneol, safrole, methyl eugenol, and myristicin and myristic acid (table 5). Myristicin, safrole, and elemicin are hallucinogens [13]. High myristicin and safrole provide a strong aroma. Bogor Nutmeg essential oil has a specific characteristic, e.g., a strong aroma derived from high myristicin content. The essential oils content of Bogor nutmeg, especially from the medium-aged mace, has the highest myristicin levels (34.37%), followed by old mace (32.69%). Safrole and iso-safrole are usually used as food flavorings. The maximum limit for safrole as a flavoring is 15 mg/kg in foods containing a kernel or mace of nutmeg, while for spiced meat products is 10 mg/kg [14]. So far, the safrole content in Bogor nutmeg essential oils has remained to save to be consumed.

Table 4. The essential oil content and main chemical components of the kernel and mace of the parent tree of Bogor nutmeg at a different age

| Bioactive compound (%) | Young Kernel | Medium Kernel | Mature Kernel | Young Mace | Medium Mace | Mature Mace |
|------------------------|--------------|---------------|---------------|------------|-------------|-------------|
| Essential oils         | 13.83 ± 1.61 | 7.58 ± 1.18   | 4.72 ± 0.14   | 14.08 ± 1.93 | 11.15 ± 1.03 |
| Myristicin             | 17.53 ± 7.49 | 21.82 ± 0.17  | 10.93 ± 4.84  | 34.37 ± 7.23 | 32.69 ± 9.07 |
| ALPHA - PINENE (-)     | 6.63 ± 9.38  | 12.13 ± 0.69  | 2.92 ± 4.13   | 4.83 ± 2.62  | 5.11 ± 1.29  |
| Beta – Pinene          | 2.83 ± 4.01  | 4.125 ± 0.87  | 0             | 3.84 ± 2.72  | 6.11 ± 2.33  |
| Sabinene               | 30.41 ± 0.72 | 25.84 ± 0.03  | 33.07 ± 4.13  | 10.84 ± 2.57 | 14.49 ± 1.12 |
| Beta-myrcene           | 2.48 ± 0.33  | 2.245 ± 0.08  | 2.78 ± 0.33   | 0.78 ± 0.37  | 1.4 ± 0.11   |
| ALPHA-TERPINENE        | 2.75 ± 0.48  | 2.49 ± 0.37   | 2.23 ± 0.01   | 2.06 ± 0.78  | 1.86 ± 0.36  |
| Sabinene               | 2.23 ± 0.29  | 0.49 ± 0.69   | 1.83 ± 0.94   | 0           | 0.85 ± 1.20  |
| Gamma-Terpinen         | 4.14 ± 0.69  | 3.84 ± 0.54   | 3.29 ± 0.19   | 3.40 ± 1.14  | 3.24 ± 0.30  |
| o-Cymene               | 0            | 0.17 ± 0.29   | 0.47 ± 0.67   | 1.52 ± 0.36  | 0.50 ± 0.71  |
| 4-terpineol            | 5.84 ± 3.68  | 7.40 ± 0.16   | 28.55 ± 34.52 | 17.73 ± 0.23 | 14.83 ± 4.10 |
| ALPHA-TERPINOL         | 0.28 ± 0.40  | 0.34 ± 0.30   | 0             | 0.62 ± 0.88  | 1.47 ± 0.40  |
| Safrole                | 2.59 ± 0.15  | 3.47 ± 0.82   | 2.96 ± 1.44   | 6.77 ± 0.57  | 6.31 ± 0.39  |
| Eugenol                | 0            | 0.17 ± 0.29   | 0             | 1.01 ± 0.99  | 1.63 ± 0.17  |
| Beta-Pellandrene       | 0            | 2.05 ± 0.01   | 0             | 1.35 ± 0.29  | 0           |
| D-Limonene             | 0.93 ± 1.32  | 3.02 ± 0.06   | 2.81 ± 1.54   | 0           | 0           |
| trans-Isoueugenol      | 0.44 ± 0.76  | 0.33 ± 0.46   | 0             | 0           | 0           |
| IR-Alpha-Pine          | 3.86 ± 6.68  | 0             | 11.91 ± 4.44  | 0           | 0           |
| Elimycin               | 0            | 0.29 ± 0.46   | 7.5 ± 9.48    | 0.83 ± 1.45  | 0.63 ± 0.90  |
| 3-Carene               | 2.41 ± 3.41  | 1.23 ± 2.13   | 0             | 0           | 0           |
| methyl eugenol         | 0            | 0             | 0.58 ± 0.82   | 0           | 0           |

Note: Data was taken from second-year harvest and average from 3 location; 0 = not detected.

3.2. Morphological characteristics
The use of cluster analysis is intended to classify observational data into several classes/clusters with grouping criteria based on the incapacity size. Characteristics of observation in a cluster have a low degree of insignificance, while among clusters have a high degree of incompetence [15]. Inconsistencies between objects can be measured using distance sizes such as Euclidean distance (root feature). The closer or smaller the euclidean distance between the genotypes signifies, the more similar the genotype.

The cluster analysis of 14 genotypes of nutmeg plants from three high-yielding blocks in Bogor Regency (Tamansari, Curug Nangka, and Leuwisadeng) used 23 characters (plant height, north-south canopy width, east-west canopy width, stem circumference, branch angle, length branch, number of loci, number of locus per branch, number of stages, length of fruit stalk, fruit diameter, fruit length, fruit
weight, fruit thickness, kernel length, kernel weight, mace weight, leaf length, leaf width, leaves, and thick leaves).

In the 8.02 Euclidean value of absorption, all tested genotypes can be grouped into two clusters. The-I group consists of 12 genotypes, including TMS01, TMS02, CN02, SAD02, CN03, SAD01, SAD13, SAD54, SAD73, TMS03, TMS04, and SAD72. Cluster II consists of two genotypes, including CN01 and SAD11. In the first (I) group, SAD13 with SAD54 has the smallest Euclidean distance of 3.70, which means the two genotypes have the closest relationship. The second (II) group only consists of 2 genotypes with a 7.00 Euclidean distance. Overall, the euclidean value amongst those tested genotypes remained smalls. It was suggested that the nutmeg population has a closer similarity in morphological characters (figure 1).

Figure 1. Cluster analyses amongst 14 individuals of nutmeg plants from three high-yielding blocks in Bogor Regency (Tamansari, Curug Nangka, and Leuwisadeng) using 23 morphological characters. TMS = selected parent trees of Tamansari; CN = selected parent trees of Curug Nangka; SAD = selected parents tree of Leuwisadeng.

Morphological characters such as the leaf, branches, tree canopy, and other performance amongst the population of observed high-yielding block of Bogor nutmeg remains the same, as shown in cluster analyses (figure 1), which indicated with the small euclidean values for all parameters observed. The essential characteristic differing between varieties of nutmeg is fruit characters. The shape of nutmeg-fruit in three high-yielding blocks is almost the same, round or rounded slightly oval at the fruit base, with low variation, almost non-variant, like nutmeg-native region, Banda Island, in the Moluccas (figure 2). Based on the fruit’s observation, it can be concluded that Bogor nutmeg at the three high-yielding
blocks has similarities in fruit shape with the originated location of Banda nutmeg in Banda island. These suggest that variation within the population of offspring Banda Nutmeg scattered in the Bogor area remained low, as its originated varieties at its nature places, in Banda Island.

More specific studies, such as DNA markers, merely needed to be challenged to differentiate the nutmeg population. An application of the DNA barcoding method with matK gene as markers revealed that Sangihe nutmeg has 100% identity with *Myristica fatua*, *M. maingayi*, and *M. globose* [16]. According to de Guzman & Siemonsma [10], the Banda Nutmeg population originated in the Southern Moluccas, especially Ambon and Banda, known as *M. fragrans*. This species then spread out to the Northern Sulawesi (including Sangihe), Java Island, Papua, Southern Asia, and Grenada. Therefore, matK gene cannot be used to differentiate species in *Myristica*.

4. Conclusions
The selected parent tree of Bogor nutmeg has fulfilled the technical requirement as the candidate of new superior varieties for fruit yield of more than 5000 grains/tree/year and essential oils >20%. Leuwisadeng (Block III) shows the highest fruit yield (9,736 fruits/tree/year (PIT No. 13) and 8,530 fruits/tree/year (PIT No. 72)). The essential oil contents and composition were varied according to their age and part of fruit harvested. The highest essential oil content was 32.11% of mace from Leuwisadeng and myristicin of 38.25% of Curug Nangka’s flesh. The nutmeg population in Bogor is characterized by the size and shape of rounded or rounded-oval fruit, the size and shape of lanceolate or oblong leaves. These morphological characteristics have similarities with the main character of fruit and nutmeg found in the area of origin, Banda Island.

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