

Effect of natural male and female (sex ratio) on nutmeg (*Myristica fragrans*) production on Maluku

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Abstract. The composition of males and females is very influential on the productivity of nutmeg plants. This research aimed to get the composition of male, female, and shade types related to the productivity of the nutmeg plant in the center of nutmeg in Maluku. Nested Design Three-Factor. Production centers are divided: Large Island, Medium Island and Small Island, determined as Factor A. Data on the number of trees Ratio male: female as factor B (B1 = ratio <1:10); (B2 = ratio 1:10 - 1:15); and (B3 = ratio > 1:20). Minimum of five female nutmeg samples for observation of production in a layered (Proportional Stratified Random Sample) harvest season in a year as a replication, namely Harvest I; Harvest II; and Harvest III. The results showed that the natural sex ratio of nutmeg was 1:10 in Small Island, Medium Island, and Big Island. The average productivity of nutmeg was 1,494, 1,465, and 1,296 fruit/tree/year, respectively. The farming system in Small Island was a monoculture of 100% shade plants, while in Medium and Big Island, the farming system was 33% - 50% shade plants and 50% - 67% other perennial crops.

1 Introduction

Ambon and Banda Islands are the main nutmeg producers in Maluku Province. Most of the nutmeg in these two places are smallholder plantations, with the largest volume of production found on Banda Island. Nutmeg is a tropical plant native to Indonesia originating from the Maluku archipelago, particularly Banda Island which produces essential oil and is one of the important export commodities [1]. This plant is one of the specific commodities in the Maluku region besides cloves, which are it is hoped that it can contribute to the economy for the region, more specifically for the farming community in order to increase their income and welfare. Nutmeg (*Myristica fragrans* Houtt) is an important plantation crop that has economic value and is multipurpose compared to other spices and produces two products of high economic value, namely the nutmeg and mace covering the seeds. Both products produce essential oils, spices, and medicinal ingredients [2].

The areas for developing nutmeg in Maluku include Central Maluku, East Seram, West Seram, Buru, South Buru, Southeast Maluku and Ambon. The area of the nutmeg plant in

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Maluku province reaches 31,675 ha with production reaching 5,774 tons [3] or about 11 percent of Indonesia's total nutmeg production. Maluku nutmeg production in 2018 was 5,774 tons below North Maluku 8,325 tons and Aceh 6,273 tons [4]. Potential areas for the development of nutmeg are Maluku, North Maluku, Papua, North Sulawesi, Nangroe Aceh Darusalam, West Sumatra and West Java [5].

Nutmeg plants consist of female, male, monoecious, trimonoecius plants and identified hermaphrodite flowers [6]. The prediction of seeds produced is based on the morphology of seed and root branching with the ratio of the prediction ratio of seed sex, rooting and branching of seedlings, namely 3: 1, 9: 6: 1 and 9: 3: 3: 1, with the female sex type being more dominant than other types of sex [6]. The results of crosses between plant types (intraspecific) and between the unique traits of each parent will increase genetic diversity [7].

Improving the quality and quantity of seeds and mace is the main target in the cultivation of nutmeg [8]. The development of nutmeg plants using seeds is constrained by the problem of the composition of male and female nutmeg plants where the seeds produced from the seeds will segregate into male and female plants with almost equal proportions. Thus, almost half of the population of planting material is male and cannot produce fruit. Generally, the number of productive trees (female) only reaches 45% of the existing plant population and the rest is male nutmeg [9]. The development of nutmeg with clonal / vegetative seeds (grafting, leaf cuttings and tissue culture) has several advantages including the plant population that can be adjusted ideally with the ratio of male to female being 1:10 or 1:20, the juvenile period is shorter, plant production and productivity can be increasing the extent of unity and the quality of results is more guaranteed [10].

In Maluku, almost all of the nutmeg plants owned by the community and by plantation companies, the plant material comes from generative seeds (seeds) so that the composition of teak and female (sex ratio) of nutmeg plants remains a problem. To overcome the problem of the composition of teak and female nutmeg plants, one of them is by providing vegetative plant material (seeds) or clonal seeds through vegetative propagation, namely grafting, and leaf cuttings. With this system, the composition of male and female nutmeg plants from the plant population can be ideally adjusted with the male to female ratio (sex ratio) is 1: 10 or 1: 20 [10]. The composition of male and female natural nutmeg plants in a plant population in a nutmeg production center varies according to region and has not been well recorded.

To determine the composition of teak and female nutmeg plants in production centers, it is necessary to study the effect of natural nutmeg teak and female composition (sex ratio) on the yield of nutmeg plants. Thus, this study aims; (1) looking at the effect of natural male and female composition (sex ratio) on nutmeg yields at nutmeg production centers in Maluku, and (2) obtaining information on male and female composition data (sex ratio) of natural nutmeg which are capable of producing.

2 Methodology

This research was conducted at the nutmeg production center in Maluku. The research was carried out from January - December 2017 at nutmeg production centers in Maluku using a survey method with a PRA (Participatory Rural Appraisal) approach. The study used a Two-Factor Nested Design. The production center is determined as Factor A (island size) consisting of three levels, namely A1 = large island (Seram Island), A2 = medium (Ambon Island), and A3 = small island (Gorom Island). The male: female ratio as Factor B consists of three levels nested in factor A, namely B1 = ratio < 1:10; B2 = ratio 1:10 - 1:15; and B3 = ratio > 1:20. From the centers of nutmeg production on the big, medium and small islands, three sub-districts were selected and for each sub-district, three villages with the widest and uniform distribution of nutmeg were selected in layers (Propositional Stratified Random Sample). Each village was classified into the largest area of nutmeg plantations (> 5 ha),

medium (2-5 ha), and the least (< 2 ha). The number of male and female trees in each plot was recorded and five female trees were selected as sample plants for observation of production at each harvest in a year (one year, three harvests). The expanse of nutmeg plantations (three kinds) and harvest time (three times) were determined as replicates (nine times). The selection of sample plants (female trees) was carried out randomly (Promotional Random Sample).

Data analysis used statistical methods, consisting of analysis of variance / ANOVA (F-test) to determine the effect of treatment and t-test (DMRT) to see the effect between the treatments tested.

3 Results and discussion

3.1 General condition of research location

The location of the assessment is on three island sizes, namely; Big Island (Seram Island), Medium Island (Ambon Island) and Small Island (Gorom Island). The determination of large, medium and small islands is based on the distribution of nutmeg plants and the closest and easily accessible accessibility. In 2014 the expansion of nutmeg increased due to an expansion program of around 1500 hectares in five districts, particularly in Maluku Province, namely East Seram (200 ha), Central Maluku (400 ha), South Buru (200 ha), West Maluku (175 ha), South Maluku (175 ha), West Seram (250 ha), and Ambon (100 ha) [11].

3.1.1 Seram island

Seram Island with an area of 18,654.80 km², 340 km long and 60 km wide, is the largest island in an archipelago in Maluku Province which is located north of Ambon Island, Maluku Province, namely at the ordinate point 3°19'42"LS and 129°15'58"BT [12]. The highest point of the island of Seram is Mount Binaiya with a height of 3,019 m above sea level (asl). On Seram Island, there are three regencies, namely Central Maluku district with the capital city of Masohi and two districts resulting from the division, namely East Seram Regency with the capital city of Bula and West Seram Regency with the capital city of Piru. location of the nutmeg plant in Central Maluku District, Seram Island is located in 10 sub-districts (Tabel 1). The research location is in Central Maluku district according to its close accessibility and easy reach.

Tabel 1. The distribution of pala plantation in ten subdistricts of Central Maluku District, Seram Island

No	District	Land area (ha)	Percentage (%)
1.	Tehoru	530	18
2.	Masohi City	4	0,13
3.	Telutih	876	29
4.	Amahai	415	13,87
5.	Elpaputih	380	13
6.	Teo Nila Serua	198	7
7.	North Seram	272	9
8.	North West Seram	195	6
9.	North Seram Kobi	73	2
10.	North Seram Seti	63	2
Total		30006	100

Notes: Percentage on table is percent of the total area of nutmeg in the district of Central Maluku

Tehoru sub-district is a sub-district that has the widest area and Teluti Baru village was chosen as the location for the Natural Male and Female Composition Study (Sex Ratio) because of its close accessibility and easy reach. The type of nutmeg found in Teluti Baru village, Tehoru sub-district is the Banda nutmeg type.

3.1.2 Ambon island

The Ambon Island, which is located between a cluster of a thousand islands, was once the center of VOC activities when it came to looking for spices in Maluku. Ambon Island is very famous for its natural beauty both on land and sea, which is located between the ordinate points which are 3°38'32"LS dan 128°8'13"BT with land area of 803.90 km². Location of nutmeg plants in Ambon Island is administratively included in Central Maluku district (Tabel 2) [13].

Table 2. The distribution of pala plantation in Central Maluku District

No	District	Land area (ha)	Percentage (%)
1.	Salahutu	343	13
2.	Leihitu	1.403	54
3.	Leihitu Barat	846	33
	Total	2.592	100

One of the research locations on Ambon Island is Hattu Village, West Leihitu District. The type of nutmeg found in Hatu village, Leihitu Barat sub-district is the Banda nutmeg.

3.1.3 Gorom island

Gorom Island is one of the 45 islands in Eastern Seram, and is located at 4°0'24,000" LS dan 131°24'46,000" BT with an area of 91.30 km² and a total population of 131,707 people [14]. Gorom Island consists of two sub-districts, namely Gorom Island sub-district and East Gorom sub-district. North side: Seram Sea; South side: Wakate District; East side: East Gorom District West side: Panjang Island District. The capital of Gorom Island sub-district is Kataloka State which oversees 24 (twenty-four) Administrative Countries / Countries. The 24 (twenty-four) Administrative Countries / Countries are located in rural areas. With details of 5 (five) Countries and 19 (nineteen) Administrative Countries. Administrative Affairs (Village). Types / accessions of Nutmeg found on Gorom Island (Eastern Seram) are: Andan Nutmeg (Banda nutmeg), Onin Nutmeg (Papua Nutmeg) and Liat Nutmeg (Nutmeg Pornakan). Considering that Gorom Island only has two sub-districts and its accessibility is the closest and easiest to reach, it is recommended that the study location be located in the Gorom Island sub-district, namely Day Village.

3.2 Effect of male and female nutmeg ratios on production

Based on gender, nutmeg plants (family Myristicaceae) can be divided into two groups, namely dioecious and monoecious. Types of *Myristica fragrans* according to [15] tend to be dioecious, namely male and female flowers are on different trees [15] also stated that trees those with male flowers can be divided into two, namely unisexual males (male trees that do not bear fruit) and bisexual males (males with little fruit). The pollination process of dioecious plants almost always occurs using pollen from other trees (outcrossing obligate). Nutmeg is a dioecious plant, so it is known that there is male, female and hermaphrodite plants. Fruit is only produced by female and hermaphrodite plants, whereas male plants only produce flowers necessary for pollination. The composition between male and female (sex

ratio) is generally one male plant for 10-30 female plants. In general, of the 100 seeds planted, only 55% of the seeds are grown, while the rest are male (40%) and have one home (5%) [16]. However, according to [17] the ideal composition is one male plant for eight females. Furthermore, it is said that based on field observations, the closer the distance between female plants to male plants, generally the more fruit. Thus, in addition to the composition (sex ratio), the correct position between female and male plants in the field also needs to be considered so that female plants can produce optimally. [18] states that nutmeg pollination will be successful if there are 10% of the most popular scattered trees in the population, while according to MOA 50/2015 the ratio of male to female trees in the garden area is at least 1:20. This comparison is difficult to obtain because based on the results of chromosome analysis on germinated nutmeg seeds, the ratio of male: female (androecious: gynoecious) trees is 1: 1 [15] Furthermore [19] reported that nutmeg trees in four areas in Fakfak had a higher number of female trees than the number of male trees.

Information about the natural male and female composition (sex ratio) in the field has not been widely reported. Based on the results of the statistical analysis of the nested design where the ratio of male: female nutmeg nested at the location / island is presented in Table 3. Table 3 shows that there is an interaction effect between the ratio of male and female nutmeg and location / island on nutmeg production of nutmeg per tree per year. The highest production of nutmeg per tree per year (1,494 fruit/tree/year) was achieved at the male: female ratio (<1:10) nested on the small islands (Gorom) and was not significantly different from the medium islands (Ambon), while on the large islands (Spooky) is different. Furthermore, Table 3 shows that the male: female ratio (<1:10) both on small islands and on medium and large islands is significantly different to the production of nutmeg compared to the male: female nutmeg ratio (1:10 - 1:20) and > 1: 20. Thus the ratio of male and female nutmeg naturally is <1:10 [10], explaining that the composition of male and female nutmeg plants from the plant population can be ideally adjusted with the male to female ratio (sex ratio) is 1: 10.

Table 3. The effect of interaction male: females nutmeg on location / island on average nutmeg production per tree per year

Location / Island	Male and Female Ratio			Average
	< 1:10	1:10 – 1:20	> 1:20	
Seram Island / Large Island	^A 1296 b	^{AB} 1239 b	^B 1161 b	1232
Ambon Island / moderate island	^A 1465 a	^B 1288 b	^B 1209 a	1321
Gorom island / small island	^A 1494 a	^B 1331 a	^C 1225 a	1350
Average	1418	1286	1199	1301

Note: - Inline average numbers preceded by the same letter are not significantly different between sex ratios at a 95% accuracy level DMRT test
 - The average number of a row followed by the same letter is not significantly different between locations/islands at an accuracy level of 95% for the DMRT test

Nutmeg plants have male and female flowers on different trees, making it difficult to determine the number of male and female trees expected to be planted in the garden. This sex ratio problem needs a solution. The ratio of male height will reduce productivity per unit area of land [20]. Furthermore, according to [21] there is a difference in the ratio of male and female to nutmeg grown in KP Cicurug. This fact requires the need for further research so as not to decrease or reduce production. [22] found that there were differences in myristicin content in male and female leaves. In male nutmeg leaves, myristicin content was 70.54% and female leaves were 14.57%. The difference in levels is very important to be studied

further to detect male plants early. If this is proven, then it can be given to differentiate between males and females while the young plants will become new knowledge in farming, so that there is no need to wait for the plants to mature to determine the types of males and females.

According to [23] distribution of sex ratio of nutmeg plants Female: Male in the village Nuruwe got 505:15, Kamal village 466:195 and Lohiatala village 358: 182 plants. This is influenced by the genetic nature of the plant itself starting from that plant grow until it goes through a developmental process [24] as well as the habits of farmers in the village of Kamal mostly replace the male nutmeg plant which is old which is inherited from parents/ancestors. Amount female nutmeg population of 1329 plants is higher compared to male nutmeg which only 528 plants. The success of nutmeg production is strongly supported by the technique of determining male and female nutmeg during the nursery [25].

Small Islands (Gorom) provide significantly higher nutmeg production (1,350 fruits / tree / year) compared to Medium Islands (Ambon) and Large Islands (Seram) (Table 3). This is because nutmeg farming on small islands is monoculture, while on Medium and Large Islands it is polyculture where in addition to nutmeg there are also other perennial crops such as horticultural fruit and plantation crops.

Furthermore, Table 4 shows that the harvest I average was significantly higher (2,258 fruits / tree / year) compared to harvest II (1,100 fruits/ tree⁻¹ year⁻¹) and harvest III (513 fruits tree⁻¹ year⁻¹). However, if viewed from the location /Island, it can be seen that Small Island (Gorom) has a higher average yield (1355 fruits tree⁻¹ year⁻¹) and is significantly different from Large Island. (1232 fruits plant⁻¹ year⁻¹). The age of the plants on the islands where the research is located is over 15 years old and the types are on Gorom Island, there are Andan nutmeg (Banda nutmeg), Onin nutmeg (Papua nutmeg) and Liat nutmeg (pornakan nutmeg), on Ambon Island, local Tuni nutmeg (Banda nutmeg type) and on Seram Island the banda nutmeg type.

Table 4. Effect is the location / island on nutmeg production

Location/Island	Repeat			Average
	Harvest I	Harvest II	Harvest III	
Seram Island / Large Island	2207	1021	468	1232 b
Ambon Island / moderate island	2255	1133	559	1316 a
Gorom island / small island	2313	1146	607	1355 a
Average	2258 A	1100 B	513 C	1301

Note: The average preceded by the same letter in the row and followed by the same letter in the same column is not significantly different at the 95% accuracy level of the DMRT test

3.3 Nutmeg farming system

Nutmeg is a shade crop. Nutmeg plants in Small Islands (Gorom) have 100% shade plants, while Large Islands (Seram) only 33% shade plants and 67% horticultural crops and / or plantation crops and medium islands (Ambon) 50% shade plants and 50% planting of fruit and / or plantation crops (Table 5).

Table 5. Percentage of Nutmeg Shade Types at Various Locations / Islands in Maluku

Shade Type	Location / Island			Average
	Seram Island	Ambon Island	Gorom island	
Shade	33	50	100	61
Horticulture / plantation	67	50	0	39
Amount	100	100	100	100



Fig. 1. Nutmeg overlay < 2 ha (left), 2-5 ha (middle), > 5 ha (right) in the village

Walnuts are the main type of shade for nutmeg both on Small Islands / Gorom (rank 1), Medium Islands / Ambon (rank 2) and on Large Islands / Seram (rank 3), as presented in Table 6. Furthermore, Table 6 shows that the Small Islands (Gorom) there are no other perennial crops (fruit horticulture and plantations) in the nutmeg area. Thus, it can be said that the cultivation of nutmeg on Small Islands is cultivated in monoculture, while on Large Islands (Seram) and Medium Islands (Ambon) it is cultivated in a polyculture manner because there are approximately 8 types of horticultural fruit and plantation crops (Table 6). Large Island (Seram), cocoa and cloves are intercropping plants with nutmeg, while Medium Islands (Ambon), cloves and langsats are intercropping with nutmeg plants.

Maluku farmers generally cultivate their nutmeg in a mixed cropping system or hamlet system by combining agriculture and forest or forestry trees in the same space and time. Mixed crops that farmers cultivate are annual crops such as durian, langsats, walnuts and others. Apart from growing nutmeg, farmers also cultivate other types of plantation crops such as cloves (*Syzygium aromaticum L.*), coconut (*Cocos nucifera*), and cocoa (*Theobroma cacao L.*). Other types of plantation crops are cultivated by farmers in the nutmeg planting area to fulfill their family's daily needs.

Table 6. Types of shade plants and other annual crops (Fruit Horticulture and Plantation) found on Large, Medium and Small Islands

Location/Island	Plant Type	Total		Rank
		Type	Amount	
Seram/Big Island	Shade	Walnuts	49	1
		Lingua	4	2
		Wild/Gondal	3	3
		Ketapang	2	4
	Horticulture/Plantation	Durian	62	3
		Coconut	45	4
		Langsat	26	5
		Mangosteen	22	7
		Sago	24	6
		Rambutan	4	8
Ambon/Medium Island	Shade	Clove	106	2
		Cocoa	300	1
		Sugar Palm	20	1
		Papaya	5	3
		Pule	4	4
		Gomu	5	5
		Salawaku	2	7
		Gondal	3	6
	Horticulture/Plantation	Walnuts	16	2
		Gayang	1	8
Durian		27	3	
Mangosteen		6	4	
Langsat		150	2	
Guava		6	4	
Gorom/Small Island	Shade	Mango	6	4
		Clove	246	1
		Coconut	3	5
		Papaya	1	6
		Walnuts	192	1
Horticulture/Plantation	Banyan/Beringin	50	3	
	Pule	67	2	
Gorom/Small Island	Shade	Gondal	13	4
		Gomu	6	5
		-	-	-
		-	-	-

4 Conclusion

The composition of male and female nutmeg plants naturally significantly affected the yield of nutmeg tree⁻¹ year⁻¹. The composition of male and female (1:10) plants of nutmeg both on Small Island (Gorom), Medium Island (Ambon) and Large Island (Seram), gave the highest average nutmeg yield nutmeg tree⁻¹ year⁻¹ consecutively 1,494 fruits, 1,465 pieces; and 1,296 fruits nutmeg tree⁻¹ year⁻¹. The first harvest (April-May) of nutmeg in three locations/Islands (Seram, Ambon, and Gorom) gave the highest yield of nutmeg (2,258 pieces nutmeg tree⁻¹ year⁻¹) compared to the second harvest from August to September (1,100 pieces) nutmeg tree⁻¹ year⁻¹) and harvest III November-December (513 fruits nutmeg tree⁻¹ year⁻¹). The nutmeg cropping pattern system on Small Islands (P. Gorom) is a monoculture where 100% of the trees are covered, while on Medium Islands (P. Ambon) and large Islands (P. Seram) the farming system is polyculture where there are 33% - 50 % shade plants and 50% - 67% there are other perennial crops (fruit horticulture and plantation crops).

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