INFESTATION OF THE PAPAYA MEALYBUG IN HOME YARD PLANTS IN BANDAR LAMPUNG, INDONESIA[1]

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Abstract

Survey of the papaya mealybug infestation that has been done in more than 100 home yards in Bandar Lampung City and vicinity during the period of October – November 2009 informed that the papaya plants in 8 out of 13 subdistricts in the city were in general severely infested by the papaya mealybug. However, the infestation was less severe in areas farther away north or west from the city. No northward infestation was found in Wates Village and Bandar Jaya Village (Central Lampung District) nor was it westward in Gadingrejo Subdistrict and Pringsewu Subdistrict (Pringsewu District). The population build-up, invasion, and geographical spread of the mealybug were thought to be associated with the symbiotic activity of either one or more of the six ant genera. This study also recorded that 31 plant genera (other than *Carica*) of 20 families were found infested by the mealybug, including 5 plant genera that have been previously reported (*Hibiscus*, *Citrus*, *Capsicum*, *Persea*, and *Mangifera*). It is clearly shown from this study that such important food crop genera as *Zea* (corn), *Glycine* (soybean), and *Manihot* (cassava) were also found severely and massively infested by the papaya mealybug.

Introduction

The papaya mealybug (*Paracoccus marginatus* Williams & Granara de Willink, Hemiptera: Pseudococcidae) is the major insect pest of papaya worlwide and is of tropical origin (Walker *et al.*, 2003). They are considered to be native of Mexico or Central America. Specimens of these insects were first collected in 1955 and described in 1992 from Belize, Costa Rica, and Mexico (Williams & Granara de Willink, 1992). During 1994 the papaya mealybug has infested 14 Carribean countries and four years later was found in Florida, USA. The insects were then also found in Texas and California. In 2001 the mealybug was found in Chicago, Illinois. Later, the mealybug was recorded in the Pacific islands including Hawaii, i.e. in the central island of Maui in 2004, up north in the island of Oahu in 2005 and down south in the big island of Hawaii in 2006 (Heu *et al.*, 2007).

The papaya mealybug continued invading. In 2008, a senior colleague in Bogor, West Java, informed that papaya plants in the area have been massively and severely attacked by the mealybug. Owing to rapid distribution of these insects on the one hand and intense public transportations of agricultural products between Java and Sumatra through Lampung on the other hand, it has been

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warned off that the invasion of this pest might have reached Lampung Province. However, the actual infestation in Lampung has not been found until only recently (2009), mostly in home yards in the area of Bandar Lampung and vicinity.

The papaya mealybug is polyphagous with papaya plants as their main host. Friamsa *et al.* (2009) have studied the mealybug life cycle in papaya plant in Bogor. The female life history starts from eggs, passes through three-instar nymphs, and ends with adults while that of male includes eggs, three-instar nymphs, pupae, and adults. Females are wingless while males, which are rarely encountered, are winged. Early instar nymphs of the melaybug are sometimes called 'crawlers' because they are actively moving while adult females are practically sessile (Kalshoven, 1981). Beside attacking papaya plants, the papaya mealybug has been known to attack more than 20 other plant genera, including *Hibiscus*, *Citrus*, *Gossypium*, *Mangifera*, *Solanum*, *Capsicum*, *Ipomoea*, and *Persea* (Walker *et al.*, 2007; Friamsa *et al.*, 2009). Thus, fruit, vegetable, and ornamental crops are potentially threatened by these pestiferous insects.

What is the status of the papaya mealybug infestation in Lampung Province, especially that in the Capital City of Bandar Lampung and vicinity? What plants other than papaya are attacked by the papaya mealybug? The objectives of this study were 1) to document the spread of papaya mealybug infestation in Bandar Lampung City and vicinity and 2) to inventory plants other than papaya that are also attacked by the papaya mealybug.

Materials and Methods

Inventory of the papaya mealybug infestation was done by surveying home yards in Bandar Lampung City and vicinity during the period of October – November 2009. The home yard samples were selected based on two main considerations, i.e. 1) the presence of papaya plant(s) therein and 2) the accessibility of the yards for observation (located along the streets and welcomed reception from the home owners). Nine out of 13 subdistricts of Bandar Lampung City were observed (Table 1). In addition, 9 adjacent subdistricts were also observed (Table 2). Within those subdistricts, a total of 133 home yard samples were selected from 45 villages (Table 1, Tabel 2). The papaya plants in each home yard sample were observed in a rapid manner and tallied for the mealybug infestation, i.e. whether they were severely infested (severe), less severely infested (light), or not infested (free) by the mealybug (Table 3). The magnitute of the infestation was expressed in number of papaya plants per home yard sample. The mealybug infestations were then averaged by subdistricts (within Bandar Lampung City) and by villages (outside the city). The mealybug infestation was plotted by subdistricts or villages and analysed descriptively.

Occasionally, ants were found tending the mealybug in the papaya plants. In that case these ants were collected manually and secured in glass vials containing alcohol solution (70%) for preservation and later identification. Ant identification at generic level was done under a dissecting microscope using Bolton (1994) and Hashimoto (2003) as references. The resulting genus names were then re-checked and compared with color photographs of Sumatra Ants (Alpert & Susilo, 2005) and a reference collection of South East Asian ants (gift from Prof. S. Yamane, Kagoshima University, Japan).

All other plants in each home yard sample located within a radius of ca. 5 m from the papaya plant were identified, tallied, and observed for the mealybug infestation. The first step was to identify their local or Indonesian names. Then the

local (Indonesian) names were re-checked for their generic names and grouped into their family and orders using van Steenis (2006) and related references (including USDA). The identified plants were then tabulated in two separate lists, i.e. those found infested and those found un-infested by the mealybug.

Table 1. Number of home yards in Bandar Lampung City selected as samples, grouped by villages and subdistricts

No.	Subdistricts	Villages	Number of samples (home yards)
1.	Kedaton	Kota Sepang	2
		Labuhan ratu	1
		Kampung baru	6
		Penengahan	4
2.	Kemiling	Beringin Raya	3
		Pinang Jaya	1
		Sumberejo	2
3.	Panjang	Way Gubak	2
4	Rajabasa	Rajabasa	2
		Rajabasa Jaya	2
		Gedong Meneng	31
5.	Sukabumi	Sukabumi	2
6.	Sukarame	Harapan Jaya	6
7.	Tanjung Senang	Labuhandalam	4
		Way Kandis	3
8.	Tj. Karang Barat	Gunung Terang	3
		Langkapura	2
9.	Tj. Karang Timur	Campang Raya	6
	Total	18	82

Results and Discussion

Observation shows that the papaya mealybug indeed infested the papaya plants across the subdistricts within Bandar Lampung City with various severity (Figure 1). Severe infestations were apparent in almost all observed subdistricts except Sukabumi. In the subdistricts Kedaton, Kemiling, Rajabasa, and Tanjung Senang, on average 3 to 7 papaya plants were grown per home yard and practically all were found severely infested by the mealybug. In constrast, papaya plants in Sukabumi Subdistrict were not infested or infested only lightly. Severe as well as light mealybug infestations, however, were apparent in the rest of the subdistricts (Panjang, Sukarame, Tj. Karang Barat, Tj. Karang Timur).

Table 2. Number of home yards adjacent to Bandar Lampung City selected as samples, grouped by villages and subdistricts

No.	Subdistricts*	Villages	Number of samples (home yards)
1.	Jati Agung	Fajar baru	1
		Jati Mulyo	1
2.	Natar	Hajimena	7
		Pemanggilan	2
		Bumisari	1
		Candimas	2
		Branti	3
		Banjarnegeri	2
3.	Tegineneng	Tegineneng	2
		Bumiagung	1
		Kotaagung	1
4.	Bumiratu Nuban	Wates	2
5.	Gunungsugih	Gunungsugih	3
6.	Bandar Jaya	Bandar Jaya	4
7.	Gedongtataan	Kurungan Nyawa	1
		Negeri Sakti	2
		Bernung	2
		Tamansari	1
		Wiyono	2
		Bagelen	2
		Kutoarjo	1
8.	Gadingrejo	Gadingrejo	2
		Tulungagung	1
		Wonokrio	1
		Tambahrejo	1
		Wates	2
9.	Pringsewu	Sidoarjo	1
	Total	27	51

*) 1 & 2 = subdistricts of South Lampung Distric; 3 & 7 = subdistricts of Pesawaran District; 4, 5, & 6 = subdistricts of Central Lampung District; 8 & 9 = subdistricts of Pringsewu District; subdistricts 1 – 6 and 7 – 9 are north (north east) and west direction of Bandar Lampung City), respectively. Note that there are two different villages with the same name Wates, the first one is located north in Bumiratu Nuban Subdistrict while the other is located west in Gadingrejo Subdistrict.

Table 3. Criteria used for rapid assessment of the papaya mealybug infestation in Bandar Lampung City and vicinity

Infestation	Criteria
Severe	Plant dead, totally or severely defoliated, only youngest leaves left and curled, fruit or leaf fall, dead, or heavily colonized by the mealybug
Light	No defoliation but the mealybug present on fruits or leaves
Free	No mealybugs nor damage on fruits or leaves

Villages in Figure 2 are located north or north east of Bandar Lampung City. As can be seen in general, papaya plants that were severely attacked by the mealybug (solid-black rectangles) tended to be found closer to the city (left portion of the horizontal axis, i.e. villages Fajar Baru, Jatimulyo, Hajimena, Pemanggilan, Bumisari). The farther north the villages are from the city the less mealybug infestation is apparent in the villages. Papaya plants unattacked or only lightly attacked by the mealybug (solid-grey and blank rectangles) tended to be found in villages farther north from the city, starting from Branti (26 km north) then Banjarnegeri (28 km), Tegineneng (30 km) and Bumiagung (32 km), noting a couple break points of severe attacks in villages Kotaagung (33 km north) and Wates (38 km north). It is very clear, however, that papaya plants in the farthest north villages (Gunungsugih, 45 km; Bandar Jaya, 50 km) were practically free from the mealybug attack.

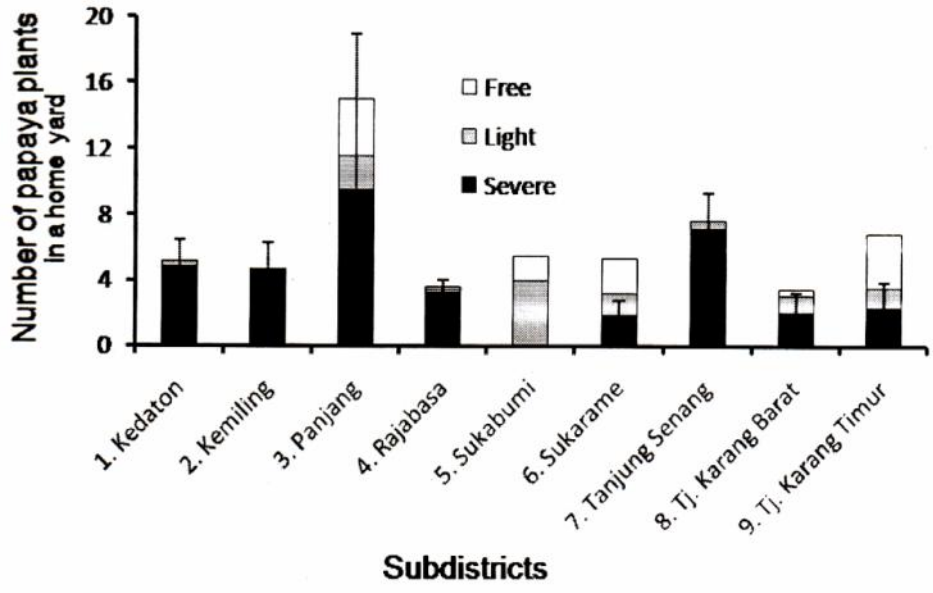

Figure 1. Infestation of the papaya mealybug in home yards across subdistricts of Bandar Lampung City (bars = standard errors of severe infestations)

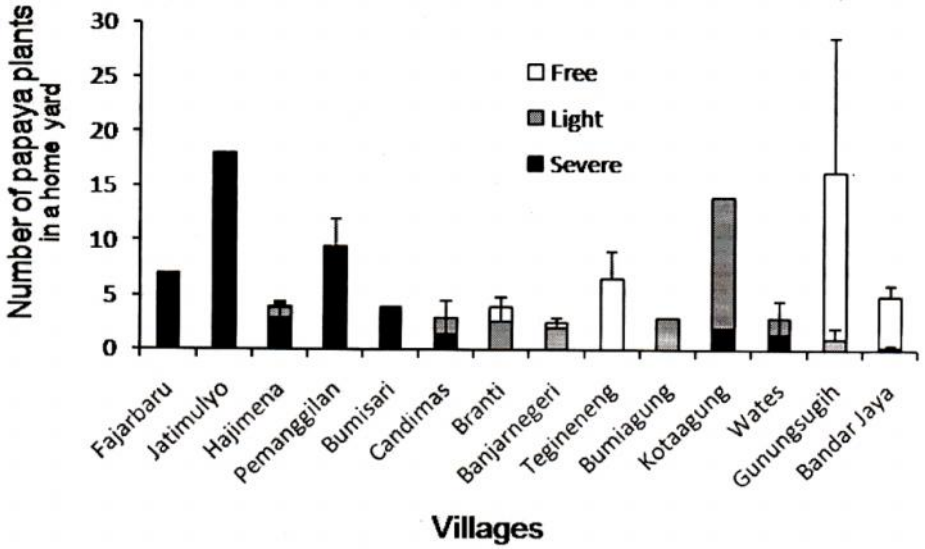

Figure 2. Infestation of the papaya mealybug in home yards in a range of villages located north to north east of Bandar Lampung City (data were averaged by villages with bars indicated their standard errors; single datum was presented as it was without bar)

Similar decreasing trend of the mealybug infestation was also apparent in villages that are located farther west of Bandar Lampung City (Figure 3). Severe infestations were found in villages located west of but close to the city (Kurungan Nyawa, 1 km; Negeri Sakti, 5 km; Bernung, 8 km) and infestations appear to decline farther westward. The infestation practically ended in Gadingrejo (25 km) and continued to be absent in the further west villages (Tulungagung, 28 km; Wonokrio, 29 km; Tambahrejo, 30 km; Wates, 32 km; Sidoarjo, 34 km).

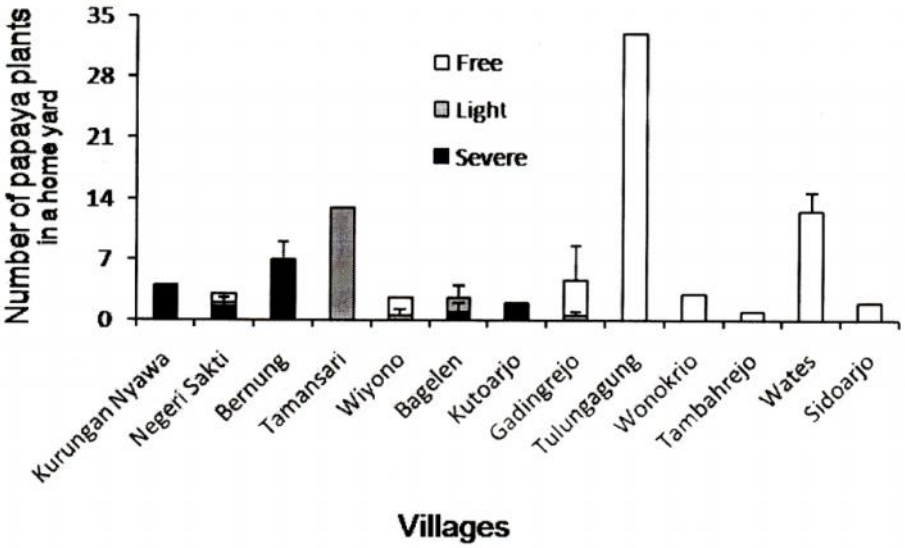

Figure 3. Infestation of the papaya mealybug in home yards in a range of villages located west of Bandar Lampung City (data were averaged by villages with bars indicated their standard errors; single datum was presented as it was without bar)

Two pieces of information could be drawn from the spread of papaya mealybug infestation data as shown above. First, the infestation varied but mostly severe within Bandar Lampung City. Second, the infestation became less severe as the location of the papaya plants got farther away north or west from the city. Did those indicate whether Bandar Lampung City be the next source of papaya mealybug infestations for other areas in the province, after itself just rapidly and severely invaded by the mealybugs from Java island ?

The phenomenon of rapid invasion and spread of the papaya mealybugs within an area and from an area to other area leads to a question as what factors may have contributed to it. In terms of movement, mealybugs are practically sessile as have been mentioned previously, except their winged males and neonates ('crawlers') (Kalshoven, 1981; Walker *et al.*, 2003). As are local pseudococcids, the males, if any (Kalshoven, 1981), are weak fliers so that it would be less probable that they be associated with the massive invasions and spread. Or, if males were numerous and strong, it would still be less probable that they would fly towards a new host plant except when females have been already there. Males are known to be attracted to females that exert sex pheromones (Walker *et al.*, 2003). The question now becomes: What are the major factors that may have contributed to the establishment of females in new host plants in the first place ?

We argue that some kinds of mutualistic symbiosis between the mealybug and ants be an important factor that might promote population establishment, rapid invasion and spread of the mealybug in new areas. Some cases of other mealybug-ant symbiotic relationships have been recorded in some agroecosystems in Lampung, including those in *Theobroma* (Margareta, 2006; Lestari, 2009), in *Mangifera* (Nasution, 2006), and in *Citrus* (Rohamah, 2006). In those systems, some kinds of ants gain honeydew that has been secreted by the mealybug and, in return, the mealybug is protected by the ants against its natural enemies or herbivorous competitors. No less important, the ants help the mealybug disperse and introduce crawlers (nymphs) to new host plants. The newly-introduced mealybug nymphs then develop and establish new colonies in the host plants. In this study six ant genera were found to associate with the papaya mealybug (Table 4). Ants protect the papaya mealybug from their competitors (other plantlice) and/or natural enemies including predators and parasitoids as indicated in Walker *et al.* (2003). Various kinds of lady beetles, lacewings, hover flies, and parasitoids could have been present locally (Kalshoven, 1981) but they might not be effective to regulate the mealybug population after perhaps being chased away by the ants. Eggs of lacewings (characteristically with long stalks) were often found sticking out along the margins of severely infested papaya leaves but their larvae (which should have been more conspicuous than the eggs) were never encountered in the observation. Thus, the population build-up of the papaya mealybug be expected because local natural enemies were ineffective against it and this ineffectivity could intuitively be attributable to the role of local ants as the mealybug's strong mutual symbionts. This prediction certainly needs and can be tested through further investigation. Recently, a similar plantlouse-ant symbiotic case has been studied in yard-long been agroecosystems where ants contributed to the endurance of a plantlouse population (in this case *Aphis* sp.) against insecticide as the artificial stressor (Susilo *et al.*, 2009).

Table 4. Ants that were found tending the papaya mealybug in the field

No.	Genus	Subfamily
1.	*Dolichoderus*	Dolichoderinae
2.	*Anoplolepis*	Formicinae
3.	*Polyrhachis*	Formicinae
4.	*Oecophylla*	Formicinae
5.	*Monomorium*	Myrmicinae
6.	*Tetramorium*	Myrmicinae

What were other kinds of plants that were potentially being used by the papaya mealybug as its alternative host plants? Table 5 shows 31 plant genera (other than *Carica*) of 20 families that were found infested while Table 6 of those found uninfested by the papaya mealybug (55 genera of 34 families). Clearly, this study confirmed at least five plant genera as the mealybug's host plants, i.e. *Hibiscus*, *Citrus*, *Capsicum*, *Persea*, and *Mangifera* (Table 5). Meanwhile, two genera previously reported as the mealybug host (*Gossypium* and *Ipomoea*) were found uninfested in this study. It is warned, however, that such important food crops as *Zea* (corn), *Glycine* (soybean), and *Manihot* (cassava) were also found severely and massively infested by the mealybug.

If both lists are compared we will find three groups of plant families in relation with the mealybug infestation. Some families share infested as well as uninfested members. The second group consits genera that were found exclusively infested, and third group consits others that were found exclusively uninfested. The first group includes Apocynaceae (templetree family), Araceae (arum family), Euphorbiaceae (spurge family), Fabaceae (legume family), Poaceae (grass family), Rubiaceae, Rutaceae (rue family), and Solanaceae (tomato family). The second group (exclusively infested) includes Acanthaceae (acanthus family), Cactaceae (cactus family), Anacardiaceae (sumac family), Annonaceae (custard-apple family), Lauraceae (avocado family), Malvaceae (cotton family), Moraceae (jackfruit family), Myrtaceae (rose-apple fruit family), Sapotaceae (sapodilla family), Sterculiaceae (cacao family), and Theaceae (tea family). The third group is the rest of families in Table 6, i.e. Agavaceae, Amaranthaceae, Araliaceae, Arecaceae, Bromeliaceae, Cannaceae, Capparaceae, Casuarinaceae, Combretaceae, Convolvulaceae, Cucurbitaceae, Gnetaceae, Liliaceae, Magnoliaceae, Meliaceae, Nyctaginaceae, Oleaceae, Oxalidaceae, Pandanaceae, Passifloraceae, Pinacaeae, Piperaceae, Rosaceae, sapindaceae, Verbenaceae, and Zingiberaceae.

Table 5. List of plants other than papaya that were found infested by the papaya mealybug

No.	Indonesian Names	Number		Genus	Family	Order
		Total	Infested			
1.	Talas	41	5	*Colocasia*	Araceae	Arales
2.	Aglonema	10	10	*Aglaonema*	Araceae	Arales
3.	Philodendron	7	7	*Philodendron*	Araceae	Arales
4.	Kaktus	1	1	*Opuntia*	Cactaceae	Caryophyllales
5.	Jagung	516	224	*Zea*	Poaceae	Cyperales
6.	Sawo	1	1	*Manilkara*	Sapotaceae	Ebenales
7.	Singkong	785	219	*Manihot*	Euphorbiaceae	Euphorbiales
8.	Puring	5	5	*Codiaeum*	Euphorbiaceae	Euphorbiales
9.	Jarak	22	1	*Jatropha*	Euphorbiaceae	Euphorbiales
10.	Singkong Karet	83	2	*Manihot*	Euphorbiaceae	Euphorbiales
11.	Katuk	8	1	*Sauropus*	Euphorbiaceae	Euphorbiales
12.	Petai Cina	46	2	*Leucaena*	Fabaceae	Fabales
13.	Kedelai	1,146	1,022	*Glycine*	Fabaceae	Fabales
14.	Dadap	2	1	*Erythrina*	Fabaceae	Fabales
15.	Kamboja Jepang	17	16	*Adenium*	Apocynaceae	Gentianales
16.	Alpukat	4	1	*Persea*	Lauraceae	Laurales
17.	Kenanga	1	1	*Cananga*	Annonaceae	Magnoliales
18.	Srikaya	10	1	*Annona*	Annonaceae	Magnoliales
19.	Kembang Sepatu	36	27	*Hibiscus*	Malvaceae	Malvales
20.	Kakao	8	3	*Theobroma*	Sterculiaceae	Malvales
21.	Jambu biji	6	4	*Psidium*	Myrtaceae	Myrtales
22.	Jambu air	6	2	*Eugenia*	Myrtaceae	Myrtales
23.	Asoka	4	1	*Ixora*	Rubiaceae	Rubiales
24.	Nusa Indah	1	1	*Mussaenda*	Rubiaceae	Rubiales
25.	Mangga	168	1	*Mangifera*	Anacardiaceae	Sapindales
26.	Cusenta	1	1	*Clausena*	Rutaceae	Sapindales
27.	Asystasia	6	5	*Asystasia*	Acanthaceae	Scrophulariales
28.	Cabai	9	1	*Capsicum*	Solanaceae	Solanales
29.	Teh-tehan	2	1	*Camellia*	Theaceae	Theales
30.	Nangka	10	2	*Artocarpus*	Moraceae	Urticales
31.	Pisang	387	8	*Musa*	Musaceae	Zingiberales

*)the observed number of papaya plants were 1140 (total) and 885 (infested)

Table 5. List of plants other than papaya that were found un-infested by the papaya mealybug

No.	Indonesian Names	Number	Genus	Family	Order
1.	Akasia	1	*Acacia*	Fabaceae	Fabales
2.	Mangkokan	3	*Nothopanax*	Araliaceae	Apiales
3.	Iles-iles	2	*Amorphophalus*	Aracae	Arales
4.	Aren	8	*Arenga*	Arecacae	Arecales
5.	Kelapa	9	*Cocos*	Arecacae	Arecales
6.	Salak	4	*Salacca*	Arecacae	Arecales
7.	Nanas	24	*Ananas*	Bromeliaceae	Bromeliales
8.	Mamang	1	*Cleome*	Capparaceae	Capparales
9.	Bayam	1	*Amaranthus*	Amaranthaceae	Caryophyllales
10.	Bogenvil	12	*Bougainvillea*	Nyctaginaceae	Caryophyllales
11	Pukul Empat	10	*Mirabilis*	Nyctaginaceae	Caryophyllales
12.	Cemara	3	*Casuarina*	Casuarinaceae	Casuarinales
13.	Alang-alang	3	*Imperata*	Poaceae	Cyperales
14.	Bambu hias	1	*Bambusa*	Poaceae	Cyperales
15.	Sereh	9	*Cymbopogon*	Poaceae	Cyperales
16.	Eforbia	32	*Euphorbia*	Euphorbiaceae	Euphorbiales
17.	Pohon Asem	1	*Tamarindus*	Fabaceae	Fabales
18.	Petai	1	*Parkia*	Fabaceae	Fabales
19.	Jengkol	7	*Archidendron*	Fabaceae	Fabales
20.	Kacang tanah	35	*Arachis*	Fabaceae	Fabales
21.	Orok-orok	2	*Crotalaria*	Fabaceae	Fabales
22.	Sonokeling	27	*Dalbergia*	Fabaceae	Fabales
23.	Kamboja	7	*Plumeria*	Apocynaceae	Gentianales
24.	BungaTerompet	1	*Mandevilla*	Apocynaceae	Gentianales
25.	Belimbing Wuluh	5	*Averrhoa*	Oxalidaceae	Geraniales
26.	Melinjo	5	*Gnetum*	Gnetaceae	Gnetales
27.	Jati Putih	1	*Gmelina*	Verbenaceae	Lamiales
28.	Jarong	43	*Stachytarpheta*	Verbenaceae	Lamiales
29.	Jati	32	*Tectona*	Verbenaceae	Lamiales
30.	Tembelekan	8	*Lantana*	Verbenaceae	Lamiales
31.	Lidah Mertua	13	*Sansevieria*	Agavaceae	Liliales
32.	Daun Suji	1	*Pleomele*	Liliaceae	Liliales
33.	Cempaka	1	*Talauma*	Magnoliaceae	Magnoliales
34.	Kantil	4	*Michelia*	Magnoliaceae	Magnoliales
35.	Ketapang	4	*Terminalia*	Combretaceae	Myrtales

Table 5 (Continued)

No.	Indonesian Names	Number	Genus	Family	Order
36.	Pandan	1	*Pandanus*	Pandanaceae	Pandanales
37.	Pinus	2	*Pinus*	Pinaceae	Pinales
38.	Sirih Hutan	7	*Piper*	Piperaceae	Piperales
39.	Mawar	1	*Rosa*	Rosaceae	Rosales
40.	Mengkudu	2	*Morinda*	Rubiaceae	Rubiales
41.	Kopi	1	*Coffea*	Rubiaceae	Rubiales
42.	Mahoni	3	*Swietenia*	Meliaceae	Sapindales
43.	Mindi	27	*Melia*	Melieceae	Sapindales
44.	Maja	3	*Aegle*	Rutaceae	Sapindales
45.	Rambutan	2	*Nephelium*	Sapindaceae	Sapindales
46.	Kelengkeng	1	*Euphoria*	Sapindaceae	Sapindales
47.	Melati	2	*Jasminum*	Oleaceae	Scrophulariales
48.	Bunga Wungu	6	*Pharbitis*	Convolvulaceae	Solanales
49.	Leunca	3	*Solanum*	Solanaceae	Solanales
50.	Sedap Malam	36	*Cestrum*	Solanaceae	Solanales
51.	Ubi Jalar	1	*Ipomoea*	Solanaceae	Solanales
52.	Labu Kuning	1	*Cucurbita*	Cucurbitaceae	Violales
53.	Markisa	1	*Passiflora*	Passifloraceae	Violales
54.	Ganyong	3	*Canna*	Cannaceae	Zingiberales
55.	Laos	26	*Alpinia*	Zingeberaceae	Zingiberales

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