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Diversity of bananas (*Musa* spp.) in Madura Island, East Java: exploration and inventory

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Key words: Banana, Diversity, Madura island, *Musa* spp., Purwodadi Botanic Garden.

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Abstract

Banana exploration study has been conducted in Madura Island covering areas of Bangkalan, Sampang, Pamekasan and Sumenep Districts. This paper presents the results of survey, inventory and diversity of bananas in Madura Island including its habitat aspects, agronomic practices and diseases problems. Results showed that banana plants are widely distributed in Madura Island, it grows wild in coastal line, road sides and river banks, or cultivated mostly by small scale farmers in backyards, drylands, intercropped with annual and/or perennial crops. It's mostly cultivated subsistently with less consideration to cultivation practices for home consumption or for local markets. Major diseases such as bunchy top and wilts have largely spread to the areas, with highest occurrences and intensities in Bangkalan and Pamekasan Districts. Spreads of leaf late blight disease were found sporadically in all areas; with Pamekasan District has the lowest disease intensity. About 37 recognizable banana cultivars with local Madurese names were known with any possible synonymies within the cultivars. It comprises of 15 dessert bananas, 17 cooking bananas and 5 dual purposess bananas. From this exploration, about 21 living banana specimens consist of 83 suckers were collected from the sites to be ex-situ conserved in Purwodadi Botanic Garden, Pasuruan.

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Introduction

South East Asia is considered as the origin and diversity center of bananas (*Musa* spp.). It possess great wealth of bananas both wild species and cultivated varieties (cultivars) (Simmonds, 1959; Espino et. al., 1992; Nasution, 1991). It is believed that edible bananas originated from intra- and inter-specific hybridizations between wild subspecies of *Musa acuminata* (A genome donor) and *Musa balbisiana* (B genome donor). They have been selected and domesticated for a long time ago by farmers from the progeny of either one or two those wild parent species. As a result, the various types can be classified on the basis of their genome composition, as AA, AB (diploids), AAA, AAB, ABB, BBB (triploids), and AAAA, AABB, ABBB (tetraploids) (Simmonds, 1959; De Langhe *et. al.*, 2010).

Diversity in the genus *Musa* is important as the basic element that sustains production of bananas. Breeders use diversity to produce improved varieties, allowing the crop to be grown in a wide range of environments, tolerant to both biotic and abiotic stresses and to meet the varied needs of the millions of people who depend on it for food and income. Hence, *Musa* diversity is should be conserved (both *in-situ* and *ex-situ*), characterized and evaluated to support the banana breeding (INIBAP, 2002). Approximately there are 60 banana national collection in the world, functioning to varying levels of activity in terms of developing their collections and distributing accessions (INIBAP, 2006).

Banana exploration and collecting mission has been conducted in April 2014 in Madura Island. Madura is an island off the north-eastern coast of Java, separated from Java by the narrow Strait of Madura. Madura Island is included in the administrative region of East Java, covering a total area of approximately 5.168 km². It divided into four districs *e.g.* Bangkalan, Sampang, Pamekasan and Sumenep (position from west to east) (Rochana, 2012). Geologically the island of Madura is included as Great Sunda Islands (Sundaland), a continuation of the northern part of the island of Java, the continuation of the limestone mountains located in the north and the south valley of Solo (Van Bemellen, 1949).

Banana is a pioneer plant. They can grow in various environmental conditions including in harsh environment like Madura Island. Ecologically, Madura Island has dry ecotype in a tropical weather, limy land, low rainfall, and low soil productivity in consequence as continuation of the Solo limestone mountains (Rochana, 2012). It is presumed that bananas in Madura Island are rather tolerant to drought stress from high salinity and dry climate. Banana plants are fruiting all year round so that playing crucial role as alternative food source in dry season to support food security in Madura.

This study aims to survey, inventorize and identify morphologically subjected to the diversity of bananas in Madura Island including its habitat aspects, agronomic practices and pests and diseases problems. So far there is no database inventory of banana diversity from Madura Island. Such basic researches are needed to provide scientific information that can be the basis for further development of the bananas in Indonesia especially for drought tolerant banana improvement. Living banana plant specimens were collected from the sites to be *ex-situ* conserved in Purwodadi Botanic Garden, Pasuruan. The important role of an *ex-situ* conservation of *Musa* germplasm are providing long-term and sustainable conservation of *Musa* genetic resources, maintaining a source of genetic diversity and related informaton in the public domain, contributing to understanding *Musa* diversity through characterization, evaluation and documentation, providing a service for the safe movement of germplasm and related information and developing also transfering ex-situ conservation technologies (INIBAP, 2002).

Material and methods

Exploration method

Banana exploration study was conducted in 21 – 26 April 2014 covering some random sampling areas in

four districts *e.g*. Bangkalan, Sampang, Pamekasan and Sumenep (Fig. 2). The study was using exploratory research through direct survey and observation methods along the roads passed accross Madura Island. Targeted locations informations were gathered via open-ended interview to local peoples and banana traders in the local fruit markets which consider as the center of banana-producing areas. Living specimens in form of suckers (minimum three suckers per accession) were collected to be *ex-situ* conserved in Purwodadi Botanic Garden, prioritized to wild species and unique local cultivars.

Identification of bananas

The diversity of bananas found along the exploration sites were noted, inventarized, characterized and documented. The local name of bananas in Madurese language, meaning in Indonesian language and its cultivar synonimies also utilization were derived by open-ended interview to local farmers. Banana genomic group identification on the field conducted using taxonomic score card by Simmonds & Shepherd (1955). Fifteen diagnostic characters used to differentiate *Musa acuminata* from *Musa balbisiana* cultivars and their hybrids *e.g*. pseudostem colour, petiolar canal, peduncle, pedicels, ovules, bract shoulder, bract curling, bract shape, bract apex, bract colour, bract colour fading, bract scar, free tepal of male flower, male flower colour and stigma colour.

Habitat study

Site informations were recorded including its latitude-longitude (mapping using Google Earth 2003), habitat type, altititude, actual soil pH, temperature and air humidity. In addition, composite soil sample per district were taken to be analyzed its soil profiles in Laboratory of Soil, Faculty of Agriculture, Brawijaya University. Clustering analysis Bray-Curtis index using PAleontological STatistics (PAST) software version 1.94b were perform subjected to soil profile results to analyzed its soil similarity pattern.

Agronomic practices and diseases study

Direct open-ended interviews to local farmers were carried out to obtain agronomic practices and other supporting information related to banana cultivation. The occurrences and intensity of diseases were recorded using scoring criteria according to types and severity of diseases morphological symptoms modified method of Brooks (1999) by Hapsari & Masrum (2012); the scores were ranging from 0 (healthy) to 3 (severe) (Table 1).

Table 1. Scoring criteria based on morphological types and severity of diseases symptoms.

Score	Severity type	Morphological symptoms
0	Healthy looking plants	No visual symptoms of diseases (0%)
1	Slight diseases infected	Visual symptoms of diseases 1 – 25 %
2	Moderate diseases infected	Visual symptoms of diseases 26 – 50 %
3	Severe diseases infected	Visual symptoms of diseases ≥ 51%

Result and discussion

Diversity of bananas in Madura Island

About 37 recognizable cultivar names of bananas were known in Madura Island with local names and any possible synonymies within the cultivars (Table 2, Fig. 2). The selection of banana varieties grown by farmers depend on the preferences of consumers and also consider on the compliance to agroclimatic conditions in a region (Simmonds, 1959). Madura Island is occupied by ethnic Madurese which has their own local language called Madurese language (Bahasa Madura), so that banana cultivars name mostly in Madurese. Madurese language is member of the Malayo-Sumbawan branch family of Austronesian languages, which is also spoken in part of eastern Java and on many of the 66 outlying islands. Madurese has more linguistic similarities to the Malay-Sumatran group than to Javanese or Sundanese (Ebrey *et. al.*, 1993; Tyron, 1995).

Table 2. Banana cultivars recognised and cultivated by farmers in Madura Island.

No.	Local name (Madurese)	Meaning (English)	Cultivar synonim	Consumption type
1.	Belindang	N/K	N/A	Cooking
2.	Besusu	N/K	Susu	Dessert
3.	Bigi	Seeded	Klutuk, Biji, Batu	Cooking
4.	Biru	Green	Ambon, Ijo	Dessert
5.	Cabol	Dwarf	Cebol	Dessert
6.	Cantil	N/K	N/A	Dessert
7.	Ci Uci	N/K	N/A	Dual purposes*
8.	Ejar	N/K	Agung	Cooking
9.	Elang	Eagle, hawk	Agung	Cooking
10.	Embug	N/K	Embuk, Raja Molo	Dual Purposes*
11.	Gading	Ivory	Berlin Kuning	Dessert
12.	Jabol	N/K	N/A	Dessert
13.	Kidang	Deer	Musang, Moseng	Cooking
14.	Klotok	N/K	Klutuk, Biji	Cooking
15.	Kripik	Chips	N/A	Cooking
16.	Kusta putih	White Kusta?	Kepok Putih	Cooking
17.	Loncah	N/K	Agung	Cooking
18.	Lumut	Green like mosses	N/A	Cooking
19.	Madu	Honey	N/A	Dual purposes*
20.	Mas	Gold	Emas	Dessert
21.	Merlin	N/K	Berlin	Dessert
22.	Monol	N/K	Susu	Dessert
23.	Nangkak	N/K	Nangka	Cooking
24.	Ongkap	N/K	N/A	Dual purposes*
25.	Osok	N/K	N/A	Cooking
26.	Pakak Madu	Astringent honey	Rojo	Dual purposes*
27.	Pakak Merah	Red astringent	N/A	Dessert
28.	Pakak Santen	Astringent-coconut milk	N/A	Cooking
29.	Pakak Semarang	Astringent – from Semarang?	Susu	Dessert
30.	Pinurun	N/K	Ambon	Dessert
31.	Polutan	N/K	Ambon	Dessert
32.	Rosok	N/K	N/A	Cooking
33.	Salindang	Shawl	Selendang	Dessert
34.	Sanda agung	Big Sanda?	N/A	Dessert
35.	Soboh Biru	Green Saba	Sobo Ijo	Cooking
36.	Soboh Putih	White Saba	Sobo Awu	Cooking
37.	Sobu Ambung	Grey Saba	Saba	Cooking

Note : N/K = not known; N/A = not avalable; *) Dual purposes = can be consumed as both dessert and cooking banana

Banana cultivars were named in local languange mostly based on its specific morphological characteristic, sensory perception and also its utilization. For example Biru cultivar was named due to its fruit color is “biru” (green). Pakak Santen cultivar was named due to its tasted pakak (astringent) and the pulp color is like “santen” (white as coconut milk). Kripik cultivar was named due to its utilization into “kripik” (chips) (Table 2). The presence of numerous cultivar names and synonyms in different languages and dialects of the region is become common problem confronting banana taxonomists and horticulturists in Southeast Asia (Valmayor *et al*, 2000). In addition to morphological characterization, molecular studies are necessary to conduct to determine the possibility of name similarities and variations between and within cultivars (INIBAP, 2006).

Banana fruit can be eaten raw as dessert banana or cooked as cooking banana, or for dual purposess. The ripe flesh of dessert bananas contains of carbohydrates in form of sugars while in cooking bananas is remain in starch so that it must be cooked

to become palatable (Simmonds 1959; Burkill, 1987). About 15 cultivars cultivated by farmers in Madura Island are dessert bananas, 17 cultivars are cooking bananas and 5 cultivars are dual purposess bananas (Table 2).

Commercialization led to the disappearing of various local, native and unpopular banana varieties then replaced by common commercial varieties. Those issues into considerations that makes the *ex-situ* conservation efforts for local Indonesian banana germplasm is become very important (Hapsari, 2011). From this exploration collecting mission in Madura Island obtained about 21 living banana cultivars consist of 83 suckers to be *ex-situ* conserved in Purwodadi Botanic Garden (Table 3, Fig. 1, Fig. 2).

Table 3. Banana accessions collected from Madura Island to be ex-situ conserved in Purwodadi Botanic Garden.

No.	Cultivar local name	Collector code	Botanical name and genomic group	Locality
1	Madu	AM1	*Musa x paradisiaca* (AAB)	Larangan Berma, Batu Putih, Sumenep
2	Kusta Putih	AM2	*Musa x paradisiaca* (ABB)	Larangan Berma, Batu Putih, Sumenep
3	Belindang	AM3	*Musa x paradisiaca* (AAB)	Tengidan, Batu Putih, Sumenep
4	Lumut	AM4	*Musa acuminata* cv (AAA)	Tengidan, Batu Putih, Sumenep
5	Sobu Ambung	AM5	*Musa x paradisiaca* (ABB)	Banjar Barat, Gapura, Sumenep
6	Jabol	AM6	*Musa acuminata* cv (AAA)	Daramista, Lenteng, Sumenep
7	Pakak Santen	AM7	*Musa x paradisiaca* (AAB)	Pamaroh, Kadur, Pamekasan
8	Embuk	AM8	*Musa acuminata* cv (AAA)	Bicorong, Pakong, Pamekasan
9	Selendang	AM9	*Musa acuminata* cv (AAA)	Tampojung Gua, Waru, Pamekasan
10	Nangkah	AM10	*Musa x paradisiaca* (AAB)	Tangsir Laok, Waru, Pamekasan
11	Osok	AM11	*Musa x paradisiaca* (AAB)	Lesong Laok, Batu Marmar, Pamekasan
12	Elang	AM12	*Musa x paradisiaca* (AAB)	Bulangan Barat, Pegantenan, Pamekasan
13	Sabeh Biru	AM13	*Musa x paradisiaca* (ABB)	Camplong, Camplong, Sampang
14	Pakak Merah	AM14	*Musa x paradisiaca* (AAB)	Sogiyan Tarkalah, Omben, Sampang
15	Ongkap	AM15	*Musa x paradisiaca* (AAB)	Blu'uran, Karang Penang, Sampang
16	Moseng	AM16	*Musa acuminata* cv (AAA)	Bunten Barat, Ketapang, Sampang
17	Rosok	AM17	*Musa x paradisiaca* (AAB)	Lajing, Arosbaya, Bangkalan
18	Ci Uci	AM18	*Musa acuminata* cv (AAA)	Lajing, Arosbaya, Bangkalan
19	Masang	AM19	*Musa x paradisiaca* (AAB)	Bayeman, Tragah, Bangkalan
20	Gading	AM20	*Musa acuminata* cv (AA)	Tumbin, Tragah, Bangkalan
21	Mas	AM21	*Musa acuminata* cv (AA)	Paterongan, Galis, Bangkalan

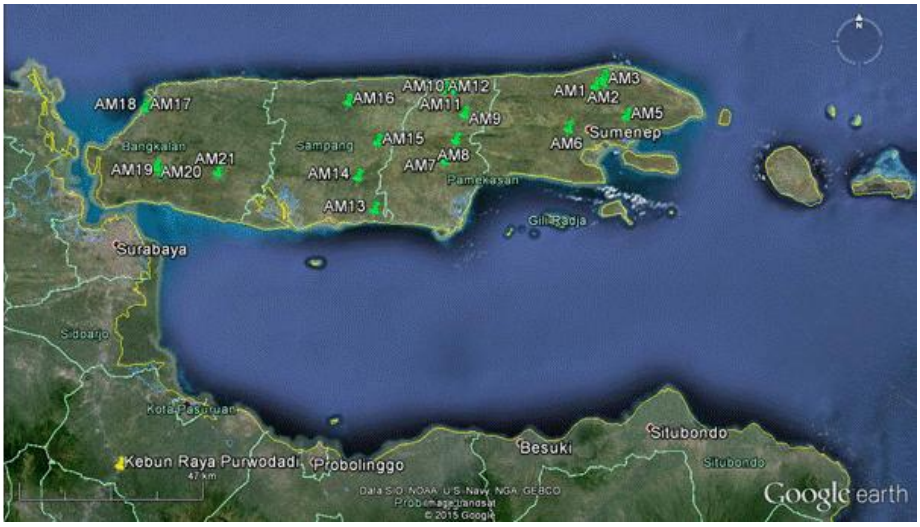

Fig. 1. Map of banana exploration and location where accessions collected from Madura Island (Google Earth 2003). Note: AM1-21=collector code of banana accession, see Table 2.

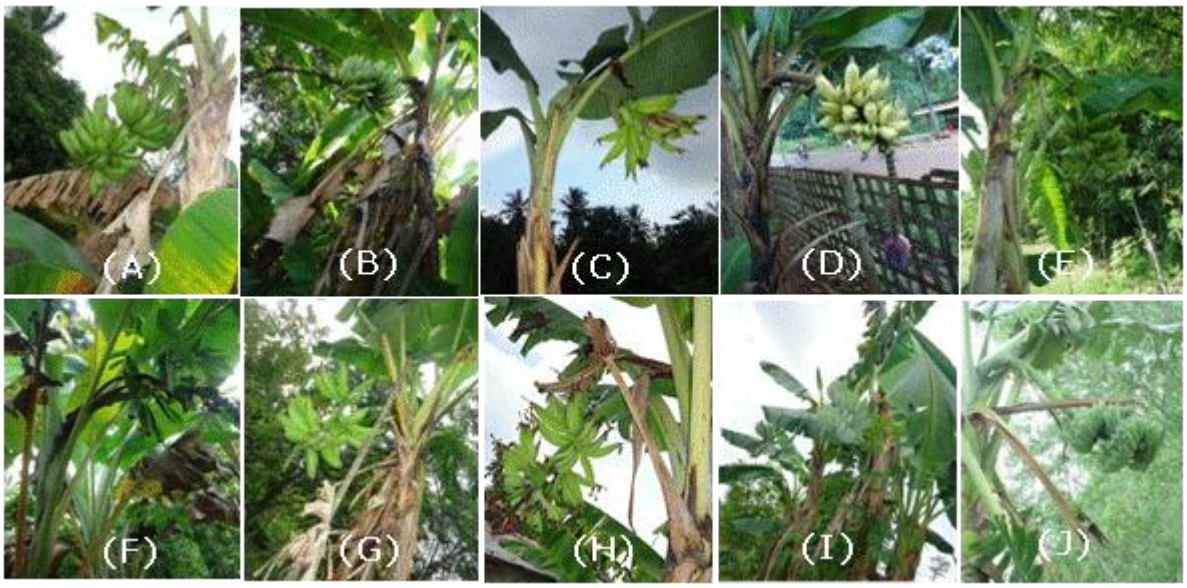

Fig. 2. Banana cultivars cultivated by farmers in Madura Island: (A) Belindang, (B) Ci Uci, (C) Elang, (D) Gading, (E) Kusta Putih, (F) Masang, (G) Osok, (H) Nangkah, (I) Sobu Ambung and (J) Ongkap.

Identification using morphological characters showed that it comprises of 2 *Musa acuminta* cultivars diploid (AA), 6 *Musa acuminata* cultivars triploid (AAA), 9 *Musa x pradisiaca* (AAB) and 4 *Musa x paradisiaca* (ABB). Molecular studies are needed to validate its genomic composition over the morphological identification, analyze its genetic variability and relationship within and among cultivars also its ancestral parents. Molecular studies offer objective and reliable results without interference from any environment factors. Molecular methods deoxyribonucleic acid/DNA based can be used to determine bananas genome composition *e.g.* flow cytometry (Doležel *et. al.*, 1994), Random Amplified Polymorphism DNA/RAPD (Sukartini, 2008), Amplified Fragment Length Polymorphism/AFLP (Wong *et. al.*, 2001), Polymerase Chain Reaction-Restriction Fragment Lenth Polymorphism/PCR-RFLP (Nwakanma *et. al.*, 2003), Simple Sequence Repeats/SSR or microsatelite (de Jesus *et. al.*, 2013). Conservation and breeding programs of bananas required a series of research activities include inventory, characterization and thorough evaluation of germplasm also in depth studies to diversity, relationship and evolution at both species and sub species of the genus *Musa*. In addition to morphological and agronomic characters determination in today's era of biotechnology, research at the molecular level is also performed (Megia, 2005).

Some unique and attractive banana cultivars found cultivated in Madura Island in which showing morphological variation to the common cultivar found in Java *viz.* cultivar Ci Uci (Fig. 2-B), Elang (Fig. 2-C), Gading (Fig. 2-D), Masang (Fig. 2-F) and Nangkah (Fig. 2-H). Gading cultivar has fruit shape resembles common Berlin cultivar but it has ivory-yellow peel color even still unripe. Masang cultivar has slender pseudostem with small and few fruits 2 to 3 fingers per hand and tasted sweet. Nangkah cultivar has yellowish pseudostem but red in midrib while common Nangkah cultivar is all in green. Elang cultivar looks like Agung cultivar from Lumajang with 2-3 long fingers per hand and few hands per bunch. Ci uci cultivar looks like common Raja cultivar but it has horizontal bunch.

Distribution and habitat of bananas in Madura Island

Banana plants are widely distributed in Madura Island (Fig. 1), at altitudes ranged from 19 m to 276 m above sea level, relative air humidity ranged 68% to

85% and air temperature 29,9 °C to 33,9 °C. It grows wild in coastal line, road sides and river banks, or cultivated mostly by small scale farmers in homegarden or backyards, drylands, intercropped with annual and/or perennial crops. The optimum conditions of banana plants grown on flat land at altitudes below 500 m above sea level with soil acidity pH 4.5-7.5. Daily temperatures range from 25°C-27°C with high rainfall intensity 2000-3000 mm/year (Cahyono, 1996; Suhardiman, 1997). But it still can be found at altitude up to 2000 m above sea level (Nasution & Yamada, 2001).

Soil analysis results showed that soil in Madura Island has neutral pH (6,9 – 7,2) but low Carbon/Nitrogen ratio (7-8) means that nitrogen level is lack available for plants. Soil texture in Pamekasan is silty clay while the others are clay. According LRC standard (1983), soil mineral profiles in Madura island has high level in Phosphorus except in Pamekasan, moderate in Kalium and Natrium. Cation Exchange Capacity is high in Bangkalan whereas the others are low. Clustering analysis showed that soil profiles in Sampang and Sumenep is 99% similar whereas soil profiles in Bangkalan is quite similar to Pamekasan with 82% similarity (Fig. 3). As pioneer plant, bananas may adapt to wide range of environmental conditions so that bananas can be found evenly in Madura Island even the soil profiles and air temperature are not optimum for banana production.

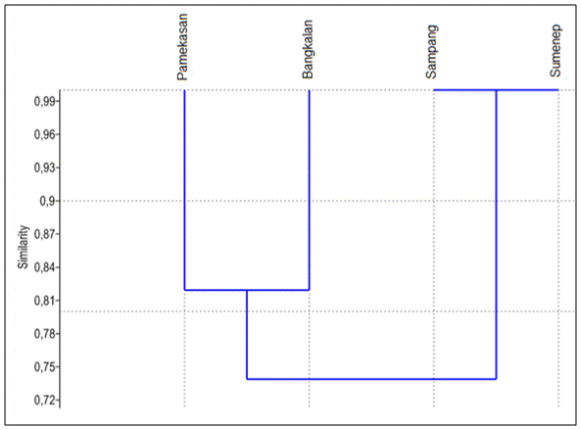

Fig. 3. Clustering analysis results of soil profiles in Madura Island.

Agronomic practices and occurrence of banana diseases

Banana plants are largely cultivated in Madura subsistently with less considerations to cultivation practices. Simple cultivation practices conducted by farmers.*e.g*. using manure fertilizer, weeding, make drainage in rainy season and simple eradication to pests and diseases. The yields are for both for self/home-consumption or locally traded in local markets. In addition, other plant parts from the roots up to the leaves are widely used by people for various purposes *e.g*. for wrapping material, dyeing agent, ropes, medicinal purposes, *etc*.

Scoring to the occurrences of major diseases showed that two major banana diseases *e.g*. bunchy top disease and wilts disease (fungal and bacterial) are already distributed and widespread in Madura Island. Highest occurrences and intensities of bunchy top were found in Tragah sub-district of Bangkalan. Wilts disease were found in all sub districts with high intensity in Pamekasan districts (Fig. 4). Both major diseases devastated banana plants in the region and causing abandonment of banana plantation.

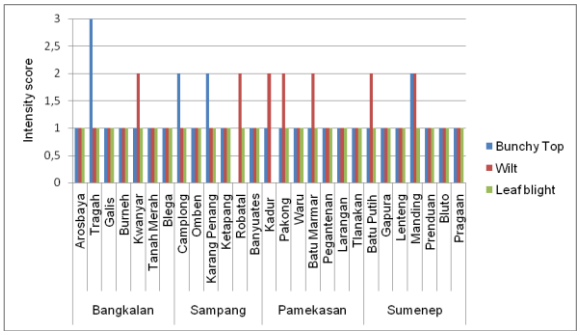

Fig. 4. Occurrence and intensity of banana diseases in Madura Island.

Banana *Musa acuminata* cultivars including AA and AAA group genomes tend to be susceptible to bunchy top disease but tolerant to wilts disease meanwhile banana cultivars with one or two B genomes tend to be more tolerant to bunchy top disease but susceptible to wilt disease (Hapsari & Masrum, 2012). Farmers learned to planting cultivars which rather tolerant to its specific diseases problems in each area.

Spreads of minor disease *i.e* .leaf late blight were found sporadically in all areas of Madura with Pamekasan District has the lowest occurrence (Fig. 4), leaf late blight diseases causing minor loss to banana yields. Farmers in Madura Island controlling the diseases by simple eradicating the infected plants and then burn it.

Conclusion

Banana plants were widely grown and cultivated in Madura Island though it has harsh and hot environment. It was cultivated subsistently with less consideration to cultivation practices. Banana bunchy top, wilts and leaf late blight diseases were already spreads in the island. From this exploration collecting mission in Madura Island obtained about 21 living banana cultivars in local Madurese name consist of 83 suckers to be ex-situ conserved in Purwodadi Botanic Garden. Identification using morphological characters showed that it comprises of 2 *Musa acuminta* cultivars diploid (AA), 6 *Musa acuminata* cultivars triploid (AAA), 9 *Musa x pradisiaca* (AAB) and 4 *Musa x paradisiaca* (ABB). Banana cultivars in Madura Island showing morpological variation to the common cultivars found in Java.

Recommendation(s)

Molecular study is needed subjected to bananas from Madura Island to validate its genome composition also analyse its genetic variability and relationship within and among cultivars also their ancestral parents.

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