PRELIMINARY SCREENING RESISTANCE OF *MUSA* GERMPLASMS FOR BANANA BUNCHY TOP DISEASE IN PURWODADI BOTANIC GARDEN, PASURUAN, EAST JAVA

Skrining Resistensi Pendahuluan Pada Plasma Nutfah Pisang Untuk Penyakit Kerdil Pisang Di Kebun Raya Purwodadi, Pasuruan, Jawa Timur

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Abstrak

Penyakit kerdil pisang (Banana Bunchy Top Disease) merupakan salah satu penyakit serius yang disebabkan oleh virus, yang mengancam pertanaman pisang di seluruh dunia baik lokal maupun regional. Beberapa kultivar pisang diketahui lebih tahan terhadap infeksi virus, tapi belum ada kultivar yang dianggap tahan terhadap penyakit kerdil. Keterjadian penyakit kerdil berikut tipe dan gejala serangan diamati pada populasi koleksi pisang tanpa adanya inokulasi buatan. Hasil pengamatan pada tahun 2007 menunjukkan bahwa 12,14% dari total aksesi menunjukkan positif terinfeksi penyakit kerdil. Keterjadian penyakit kerdil meningkat pesat sebanyak dua kali lipat per tahun, 28,57% pada Oktober 2010 dan 54,29% pada Oktober 2011. Penyebaran dan perkembangan penyaki kerdil ini optimum pada kondisi yang lembab dengan intensitas curah hujan dan suhu lingkungan yang tinggi, tanah yang subur dan intensitas cahaya yang rendah atau ternaungi. Pada monitoring terakhir bulan Februari 2012, tanaman pisang yang terinfeksi meningkat hingga 62,14 % yang terdiri dari 64 aksesi positif terinfeksi dan 39 aksesi tanpa gejala. Tiga puluh sembilan aksesi tanpa gejala tersebut diindikasikan sebagai kultivar pisang yang toleran terhadap penyakit kerdil antara lain Pisang kepok (BBB), Pisang sobo (BBB), Pisang Bandung (ABB), Pisang Nangka (AAB), Pisang Candi (AAB) dan Pisang Raja Marto (AAB). Hasil studi awal ini sesuai dengan beberapa studi sebelumnya yang menunjukkan bahwa genotipe dengan satu atau dua genom B cenderung lebih toleran terhadap penyakit kerdil. Namun beberapa kultivar yang diketahui cenderung toleran penyakit kerdil diindikasikan rentan terhadap penyakit layu

darah. Beberapa kultivar juga menunjukkan gejala komplikasi penyakit kerdil dan layu darah.

Kata kunci: Kebun Raya Purwodadi, *Musa*, penyakit kerdil, penyaringan, pisang

Abstract

Banana Bunchy Top Disease (BBTD) caused by Banana Bunchy Top Virus (BBTV) is one of the most serious banana diseases, constraint and devastate to the local and regional banana production. Some of banana cultivars were more readily infected by the virus, but considering no cultivars is resistant. The incidences of BBTD and the type and severity symptoms in natural conditions without any artificial inoculation were recorded. The observations results on 2009 showed that 12,14% of the total accessions indicated positively infected BBTD. The BBTD incidences were increased rapidly about twofolds per year, 28,57% in October 2011 and 54,29% in October 2011. The spread and development of BBTD is optimum at humid, high rainfall intensity and temperatures, high soil fertility and also low light intensity or shaded. The latest monitoring on February 2012 (62,14%) comprises of 64 accessions were positively infected and 39 accessions were symptomless. Those symptomless accessions were initially indicated as tolerant banana cultivars to BBTD e.g. Pisang Kepok (BBB), Pisang Sobo (BBB), Pisang Bandung (ABB), Pisang Nangka (AAB), Pisang Candi (AAB) and Pisang Raja Marto (AAB). These preliminary results are in agreement with several previous studies indicated that genotypes with one or two B genomes tend to be more tolerant to BBTD. However several cultivars which known tend to BBTD tolerant are indicated susceptible to Blood Disease. Some cultivars also showing complication symptoms both BBTD and Blood Disease.

Keywords: banana, bunchy top disease, *Musa*, Purwodadi Botanic Garden, screening

INTRODUCTION

Bananas (*Musa* spp.) are tropical agricultural commodities with a great socio-economic importance especially among the rural community. Bananas are cultivated in over 100 countries in the tropical and subtropical regions of the world where they constitute a major staple food crop for millions of people, as well as providing a valued source of income through local and international trade. They are the developing world's fourth most important global food crop after rice, wheat and maize in terms of gross value of production (Frison & Sharrock, 1998). In many developing countries, the bulk of banana production (almost 85 percent) is self-consumed or locally traded, thereby playing a crucial role in food security

FAO, 2003). The role of bananas is becoming more important because of its nutritional value and the diversity of uses of the fruit through processing are now well recognized (Setyobudi, 1998). In Indonesia, the total national growing areas of bananas reached 101.276 hectares with a total production of 5.755.073 tonnes in 2010. They are mostly growing in backyards and very little as an estate crop (Setyobudi, 1998; Ministry of Agriculture RI, 2012).

Banana Bunchy Top Disease (BBTD) caused by Banana Bunchy Top Virus (BBTV) is one of the most serious banana diseases, constraint and devastate to the local and regional banana production. Once established, it is extremely difficult to eradicate or manage. The disease was first recorded as causing serious damage in Fiji Islands in early 1889 (Jackson and Wright, 2005), American Samoa in 1967 and Hawaii in 1989 (Ferreira *et al.*, 1997) and has been subsequently been identified in the Pacific region, Asia and Africa (Thomas *et al.*, 1994). First discovered in Indonesia in 1978 in Cimahi and Padalarang, Bandung regency (Semangun, 2007), and then widespread all over Indonesia.

BBTD is transmitted locally in a persistent, circulative manner by the banana aphid (*Pentalonia nigronervosa* Coq.*).* Distribution over long distances occurs by the movement of infected vegetative planting material such as suckers, corms, and tissue-cultured plantlets. BBTD is not soil-borne and is unlikely to be spread on cutting tools (Thomas *et al*, 1994). The initial symptoms of BBTD consist of dark green streaks in the veins of lower portions of the leaf midrib and the leaf stem. As the disease progresses, infected leaves become progressively stunted and malformed and have a more upright bearing than usual, they appear to be 'bunched' at the top of the plant. BBTD cannot be cured since there is no effective formula to kill the virus. BBTD can be effectively controlled by the eradication of diseased plants, killing the aphids and the use of virus-free planting material obtained through meristem culture (Ferreira *et al.*, 1997; Constantinides & McHugh, 2003; INIBAP, 2001).

Some banana varieties are more readily infected with the virus, but no variety of bananas is considered resistant (Ferreira *et al.*, 1997). This study was conducted to investigate the resistance level of some Indonesian banana cultivars collection of Purwodadi Botanic Garden to BBTD.

MATERIAL AND METHODS

The study was conducted at *Musa* germplasm collections of Purwodadi Botanic Garden – Indonesian Institute of Sciences. It is located in a low land-dry area of Pasuruan District about 65 km south of Surabaya, East Java. Plots of *Musa* germplasm collections located in Region II, Area VI, Vak XXIV A, B, D and E at an altitude of 300 m above sea level, with the averaged rainfall about 2366 mm per year.

BBTD incidences were observed through field inventory, direct inspection and monitoring to *Musa* accessions subjected to BBTD symptoms in natural conditions without any artificial inoculation (Table 1). First observations were conducted in 2009. Details BBTD evaluation were conducted in October 2010, then monitoring after one year (October 2011) and the last re-evaluation in February 2012. In the meantime, the incidences of Banana Blood

Diseases to *Musa* accessions also observed roughly in 2011 and 2012 as supporting data to BBTD incidences according to EPPO quarantine pest (2012) in order to investigate its correlations.

Further development of BBTD on *Musa* germplasm collection plots were investigated through field observations to the occurences of aphids vector on banana plants (Semangun, 2007) and environmental conditions monitoring (2009 to February 2012). Identification of aphid vectors on banana plants were carried out based on its simple morphological characters and through references. Environmental conditions including weeds and shade trees identification and inventory were carried out. Soil samples were analyzed at Soil Science Department Laboratory of Brawijaya University-Malang, East Java.

Field climatic conditions including temperature, rainfall intensity, amount of rainy days and relative humidity were recorded daily at Purwodadi Botanic Garden Climatic Station.

The incidences of BBTD were assessed by the below formulae:

$$\mathbf{I = n/N \times 100\ \%}$$

Where; I = Incidences of BBTD (%), n = number of *Musa* accession infected by BBTD, N = total number of *Musa* accession observed.

The type and severity symptoms were recorded visually based on the scoring table (Table 1), modified method of Brooks (1999).

Table 1. Scoring criteria based on morphology types and severity BBTD symptoms

Score	Types and severity BBTD symptoms
0	- Healthy looking plants, no visual symptoms of BBTD
1	- Slight BBTD infected: slight marginal chlorosis and leaf narrowing. - 1 to 2 infected plants per cluster
2	- Moderate BBTD infected: moderate marginal chlorosis, leaf narrowing, twisting, distorting and stunting. - 3 to 4 infected plants per cluster
3	- Severe BBTD infected: severe marginal chlorosis, leaf narrowing, twisting, distorting, stunting and necrosis. - All or more than 4 infected plants per cluster

RESULTS AND DISCUSSIONS

BBTD is caused by a virus from the Babuvirus, Nanoviridae (Jacqueline *et al.*, 2007; obtained from infected plants, plant tissue in the propagation, through tissue culture, and through the movement of farm equipment (Thomas *et al*, 1994; Ferreira *et al*, 1997).

Aphid vector *P. nigronervosa* Coq. is a small insect with a body length 1.2-1.5 mm the wing

span of approximately 5 mm with reddish brown or green to dark brown color and shiny body. Immature aphids are lighter colored and the wings have a distinctive black edge (Jacqueline *et al.*, 2007; Semangun, 2007). Nymphs are globular, pale greenish to greenish yellow to brown or black in color (Figure 1). During observation, the aphids were found in banana plants, there were seasonal changes in population development with greatest abundace in rainy or wet season. Colonies of aphids were seen under concealed conditions, hidden in the whorl of banana plants, mostly colonized inside leaf sheaths, leaves lower surface and at the base of the petiole base (Figure 1). Since aphids produce sweet exudates, so that along with the aphids also occurs ants which also might take parts in spreading the aphid colonies along the way between banana plants (Chancellor and Arano, 1997) .

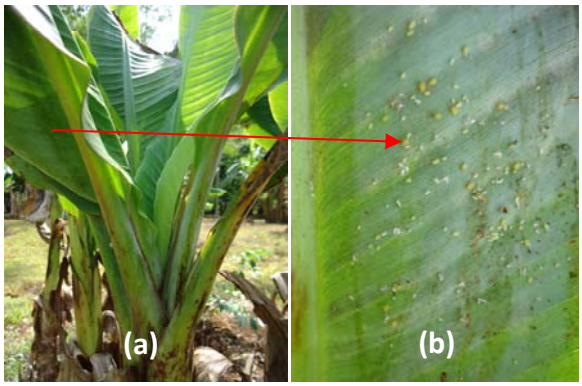

Figure 1. Colonies of aphids nymphs at petioles base (a) and leaf lower surface (b) of banana plants.

The aphids become infective in the transmission of BBTD acquire the virus after at least 4 to 18 hours of feeding on an infected plant. Local transmission occurs when the aphid, feeds on an infected banana plant and takes in virus particles together with the plant sap. If the infected aphid feeds on a healthy banana plant, the virus is passed on to that plant and it will become infected and eventually develop symptoms. Aphids can be carried long distances can be carried about by people on banana suckers or leaves (Jackson and Wright, 1995). The aphid can retain the virus through its adult life, for a period of 15 to 20 days. During this time, the aphid can transmit the virus to a healthy banana plant by feeding on it in 15 minutes to two hours. Disease symptoms usually appear in 25 days to 85 days later. Symptom development was affected by plant age and plant height. Incubation period for each cultivar varied so that the emergence of symptoms in each cultivar will vary as well (Su *et al.*, 1992; Thomas *et al.*, 1994; Ferreira *et al.*, 1997; Hooks *et al.*, 2008).

BBTD Incidences in Musa germplasm collections - Purwodadi Botanic Garden

Musa germplasm collections – Purwodadi Botanic Garden located at the same plot areas over a period of more than 20 years. Interference of both biotic and abiotic factors in such a long period of time, has led to the pests

and diseases outbreak to the accessions (Hapsari, 2011), including the BBTD outbreak. Field inspection and observation on 2009 showed that 12,14% of the accessions indicated positively infected BBTD. Further details observation in October 2010 showed that the BBTD incidences were increased to 28,57% and continue to increased 54,29% in October 2012 and 62,14% in February 2012 (Figure 2).

The development of BBTD in *Musa* germplasm collections - Purwodadi Botanic Garden

The BBTD incidences in *Musa* germplasm collections - Purwodadi Botanic Garden were increased rapidly about twice a year (Figure 2). The spread and the development of BBTD is optimum at humid, high rainfall intensity and high temperatures, high soil fertility and also low light intensity or shaded (Semangun, 2007). The climatic conditions the environmental conditions observed in *Musa* germplasm plots – Purwodadi Botanic Garden were optimum for the spread and development of the virus. The average climatic conditions between 2009-2012 were warm, humid and high intensity of rainfall (Table 2). Sue *et al* (1992) noted that the aphid vector did not transmit the virus if donor plant was grown at 16°C for one month while the transmission rate was 55% at 20°C and increased 100% at 30°C, and tends to be highest at temperatures 25°C (Jacqueline *et al*, 2007).

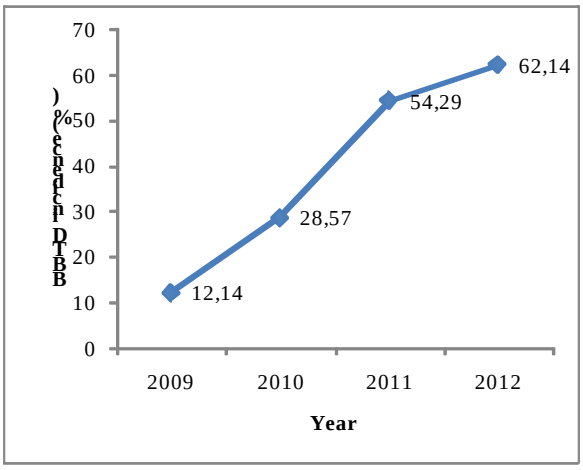

Figure 2. BBTD incidence in *Musa* germplasm collections - Purwodadi Botanic Garden (2009-2012).

Table 2. The average climatic parameters per month recorded at Purwodadi Botanic Garden (2009-2012)

Parameter	Year			
	2009	2010	2011	Feb-2012
Average temperature per month (oC)	26,58	26,27	26,21	26,53
Average rainfall intensity per month (mm)	146,92	9,48	8,46	16,97
Average amount of rainy days per month (rainy day)	18,00	20,08	15,08	24,00
Average relative humidity per month (%)	76,52	80,66	78,48	78,19

Results on soil samples analyses from *Musa* germplasm plots showed that it had vertisol soil type, silty clay textures, good soil fertility with averaged pH 6,4; C/N ratio 7,0; Cation Exchange Capacity 38,75me/100g; Base saturation 38,3 % and Moisture content at field capacity 52,47%.

In some areas of the plots also shaded by some medium to big trees *e.g. Sterculia foetida, Polyalthia longifolia, Swietenia mahagoni,Citrus histric, Pterocarpus indicus, Albizzia procea, Lannea coromandelica, Leucaena leucocephala, etc.* Weeds observed on field *e.g. Paspalum conjugatum, Eleusine indica, Tridax procumbens, Elephantopus scaber, Centella asiatica, Mimosa pudica, Ageratum conyzoides, Emilia sonchifolia, Cyperus* sp., *Oxalis* sp., *Colocasia* sp., *Mikania* sp., *etc.* These weeds also might take roles in the virus spreading. Aphids also live on some weeds, other related plants; other alternate hosts outside Musaceae family such as *Caladium bicolor*, *Canna* sp., *Colocasia esculenta*, *Costus* sp., *Heliconia* sp, that can act as reservoir to BBTV and can serve as foci of infection on the spread of BBTD (Dela Cueva *et al*, 2009).

BBTD resistance levels on *Musa* germplasm collections - Purwodadi Botanic Garden

The last BBTD monitoring in February 2012 indicated that about 39 accessions showed asymptomatic or healthy looking, 27 accessions showed mild symptoms, 11 accessions showed moderate symptoms and 26 accessions showed severe symptoms (Table 3, Figure 3). When a plant becomes infected, the first and second leaf produced after infection may also have a yellowish margin (slight symptoms). The third leaf to emerge after infection is reduced in size, more yellowish and has wavy leaf edges that curve upward and then the leaves become twisting, distorting and stunting (moderate symptoms). Plants in an advanced stage of infection are stunted and the throat of the plant is choked with a "rosette" of short, narrow, erect leaves, giving the typical "bunchy top" appearance (severe symptoms) (Jackson and Wright, 2005).

A range of symptoms can occur in BBTD-affected plants according to the time and the growth stage of the plant when infection occured. Early infected banana plants usually causes a severe conditions and will not bear fruits. If the mature plants were infected by BBTV, the new leaves difficulty to grow, smaller than normal, wavy and have chlorotic leaf margins, it may bear fruits, but the banana hands and fingers are likely to be distorted and twisted. On very late infected banana plants may bear normal fruits but in poor performance and has no economic value (Simmonds, 1959; Thomas et al, 1994; Ferreira *et al.*, 1997; Ji Su *et al.*, 2000; Widyastuti & Hidayat, 2005; Jackson and Wright, 2005).

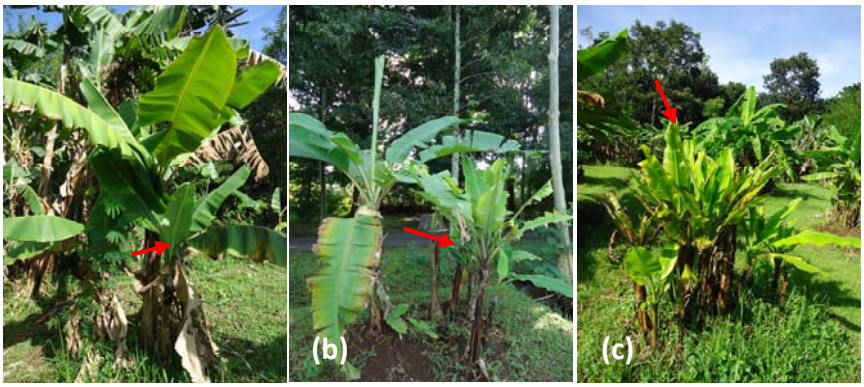

Figure 3. *Musa* collections positive infected by BBTD: a. Pisang Williams (AAA) scored 1, Pisang Nona (AAA) scored 2, Pisang Emas (AA) scored 3.

Table 3. BBTD scoring results in *Musa* germplasm plots at Purwodadi Botanic Garden (2010-2012)

Score	Number of accessions observed		
	2010	**2011**	**2012**
0	80 (71, 43%)	48 (45, 71%)	39 (37, 86%)
1	18 (16, 07%)	27 (25, 71%)	27 (26, 21%)
2	3 (2, 68%)	8 (7, 62%)	11 (10, 68%)
3	11 (9, 82%)	22 (20, 95%)	26 (25, 24%)
Total accessions	**112**	**105**	**103**

These preliminary screening results indicated that 39 cultivars had a tendency to be more tolerant to BBTD (Table 4). The wild *Musa* species were known resistant to BBTD, i.e. Pisang Cici Hutan (*M. acuminata* Colla var. *rutilifes*) and Unti Darek (*M. acuminata* Colla var. *tomentosa*), Klutuk and Klutuk Wulung (*M. balbisisana* Colla). Based on its genomic grouping, the results showed the trend that banana cultivars from the genome group AAB, ABB and BBB tend to more tolerant to BBTD than cultivars of AA and AAA genomic group (Table 4 and Table 5). As shown at Table 5, mostly AA and AAA cultivars and moderare AAB were positively infected by BBTD.

Table 4. Thirty nine Selected banana cultivars with no visual symptoms of BBTD in February 2012

No.	Vernacular name	Accession Number	Origin	Genome Group	Type
1	Cici Hutan (*M. acuminata var. rutilifes*)	P19810983	Tuban – E. Java	AA	Wild, seedy
2	Cici Hutan (*M. acuminata var. rutilifes*)	N/A	Lesser Sunda Islands	AA	Wild, seedy
3	Unti Darek (*M. acuminata var. tomentosa*)	N/A	North Sulawesi	AA	Wild, seedy
4	Mas Mirah	P19921160	Lesser Sunda Islands	AA	Dessert
5	Pothoroko	P197706158	Banyuwangi – E. Java	AAA	Dessert
6	Raja Kenongo	P19810568	Pasuruan – E. Java	AAA	Dessert
7	Candi	P19800417	Pasuruan – E. Java	AAB	Cooking
8	Raja Marto	N/A	C. Java	AAB	Dessert
9	Raja Warangan	P19940550	Yogyakarta	AAB	Dual purpose
10	Nangka	P19810567	Pasuruan – E. Java	AAB	Cooking
11	Lempeneng	P1975064	Kebumen – C. Java	AAB	Dessert
12	Raja Lingi	P19760188	Yogyakarta	AAB	Dessert
13	Jambe	P19770482	Tulungagung – E. Java	AAB	Dessert
14	Ronggolawe	P198203185	Ngawi – E. Java	AAB	Dual purpose
15	Dokare	P1977121	Pasuruan – E Java	AAB	Dual purpose
16	Sri	P19720219	Pasuruan – E. Java	ABB	Dual purpose
17	Brentel Warangan	P19940551	Yogyakarta	ABB	Dessert
18	Kates	P1972051	Pasuruan – E. Java	ABB	Dessert
19	Bandung	N/A	C. Java	ABB	Dessert
20	Raja Wesi	P198203186	Ngawi – E. Java	ABB	Dual purpose
21	Usuk	N/A	E. Java	ABB	Cooking
22	Rayab	P1972044	Pasuruan – E. Java	ABB	Dessert
23	Lempeleng	P19940543	Yogyakarta	ABB	Dual purpose
24	Susu Gabug	P19820670	P. Bawean – E. Java	ABB	Dual purpose
25	Kripik	P1974104	Probolinggo – E. Java	ABB	Cooking
26	Kepok Bung	P197707143	Magetan – E. Java	BBB/ABB	Cooking
27	Ebung	P19760731	Ponorogo – E. Java	BBB/ABB	Cooking
28	Bung	P198203190	Ngawi – E. Java	BBB/ABB	Cooking
29	Sobo Londo	P19720215	Pasuruan – E. Java	BBB/ABB	Cooking
30	Sobo Awu	P19720224	Pasuruan – E. Java	BBB/ABB	Cooking
31	Tlekung	N/A	Malang – E. Java	BBB/ABB	Cooking

No.	Vernacular name	Accession Number	Origin	Genome Group	Type
32	Klutuk Wulung	P197707103	Kebumen – C. Java	BB	Wild, seedy
33	Klutuk	P1980041	Pasuruan – E. Java	BB	Wild, seedy
34	Klutuk Sukun	P1974108	Yogyakarta	BB	Cooking
35	Musa sp.	P199907263	Solok – W. Sumatera	N/A	Wild, seedy
36	Baflo	P19961213	Buru Islands - Maluku	N/A	Dual purpose
37	Raja Dengkul	P19940534	Yogyakarta	N/A	Dessert
38	Raja Prentel	P1972027	Pasuruan – E. Java	N/A	Dessert
39	Umbuk	P1972076	Purworejo – C. Java	N/A	Dessert

Notes:
- References for the genomic group informations: Simmonds (1959), Jumari and Pudjoarinto (2000), Valmayor *et al* (2000) and Hapsari (2012).
- N/A : information is not available

Table 5. Banana cultivars positively infected by BBTD in February 2012

Scoring Level	Cultivars
1	Rejang (AA), High Gate (AAA), Williams (AAA), Songgroito (AAA), Kayu (AAA), Kisto (AAA), Pulut (AAB), Raja Lumut, Seribu (AAB), Triolin (AAB), Raja Nangka (AAB), Slendang*, Cici tak berbiji*, Gembrot*, Raja Ketan*, Gember*, Raja Buntet*, Sabrang*.
2	Kreas (AAA), Kongkong (AAA), Santen (AAA), Nona (AAA), Billa (AAA), Palembang (AAA), Rayap (AA), Pulut (AAB), Tanduk Hijau (AAB), Raja Gintung*
3	Emas (AA), Berlin (AA), Trimulin (AA), Jaran (AA), Gold Finger (AA), Blitung (AAA), Salah Roso Dengkel (AAA), Morosebo (AAA), Byok (AAA), Ambon Hong (AAA), Susu (AAA), Ijo (AAA), Raja Pendek (AAA), Raja Talun (AAB), Sepet (AAB), Bali (AAB), Raja Molo (AAB), Wilus Kecil*, Bawean*, Raja Prentel*, Umbuk*, Samarinda *, Kulit Tipis*.

Notes:
- References for the genomic group informations: Simmonds (1959), Jumari and Pudjoarinto (2000), Valmayor *et al* (2000) and Hapsari (2012).
- * = Genomic group information is not available

These preliminary results are in agreement with the previous study by Niyongere to banana cultivars from Burundi (2011) which indicated that genotypes with one or two B genomes tend to be more tolerant to BBTD. Also in agreement with Constantinides & McHugh (2003) indicate that cooking type bananas (Apple like) tend to be more tolerant to BBTD than dessert bananas (Cavendish). *Musa* of AA, AAA and AAB groups are mostly known as dessert bananas, due its sugary and sweet with slightly acidic predominant taste. But fruit of *Musa* ABB and BBB group requires some cooking to become palatable, those are why they are called cooking bananas. Some of *Musa* AAB group are consume both as dual purpose, both as dessert and cooking banana (Espino *et al,* 1992).

The results of several previous screening study for BBTD resistance on banana cultivars were varies and showing inconsistent results. Semangun (2007) noted that there is not much difference in the resistance to BBTD among the cultivars. Pisang Ambon Putih, Ambon Lumut, Ambon Jepang, Raja Sere, Moli, Kepok, Mas and Tanduk are known to be susceptible to BBTD, but Cook (1975) in Semangun (2007) reported that Pisang Ambon (Gross Michel) are more resistant than other cultivars. Sulyo *et al.,* (1992) in Semangun (2007), reported that Pisang Klutuk, Kapas and Seribu as resistant cultivar to BBTD.

However, Soguilon *et al.,* (1995) noted that cultivars possessing the 'B' or *Musa balbisiana* genome are susceptible to Banana Blood Disease. Several cultivars which known tend to BBTD tolerant are indicated susceptible to Banana Blood Disease and also some cultivars showing complication symptoms both BBTD and Blood Disease (Table 6). Bacterial Wilt disease caused by a Gram negative bacterium *Ralstonia solanacearum* (Smith) Yabuuchi *et al.* (EPPO quarantine pest, 2012) also become major disease causing serious damage and losses in banana plantation. Symptoms are vary according to the growth stage and the infection route. Fully expanded leaves of plants of all ages show a conspicuous transient yellowing, followed by loss of turgor, desiccation and necrosis then followed by death of the whole plant. The disease has recently caused the virtual abandonment of plantations due to sudden death of cultivated banana plants (Edden-Green, 1994; Satoko *et al*, 2004).

Table 6. Banana cultivars indicated BBTD and Blood Disease in Purwodadi Botanic Garden

Infection Status		Cultivars
BBTD	**Blood Disease**	
–	+	Sri, Susu Gabug, Pothoroko, Kepok Bung, Tlekung, Baflo, Ebung, Usuk, Unti darek, rayab, Sobo Londo, Candi, Brentel Warangan, Lempeleng, Raja Dengkul, Raja Prentel, Nangka, Dokare, Bandung, Jambe, Klutuk Sukun, Raja Kenongo, Kripik, Sobo Awu, Raja Wesi
+	+	Blitung, Salah Roso Dengkel, Kayu, Kisto, Pulut, Raja Lumut, Kreas, Seribu, Byok, Kongkong, Santen, Raja Talun, Raja Ketan, Raja Siem, Ambon Hong, Gember, Billa, Trimulin, Raja Buntet, Raja Warangan, Tanduk Hijau, Bawean, Palembang, Kepok Ungu, Raja Bandung, Kepok Putih, Rayap, Sabrang, Triolin, Raja Pulut, Raja Gintung, Songgroito, Umbuk, Ijo, Raja Pendek, Susu, Gajih Putih, Raja Molo, Kayu

BBTD can persist naturally in banana plants causing no apparent symptoms of the disease or the plants remain healthy-looking and asymptomatic, mostly in in micro-culture propagation. Asymptomatic plants can be act and serve as reservoir, become a source of inoculums on the spread of BBTD (Drew *et al.*, 1989). Furthermore, it has been experimentally proven that there are alternate hosts of BBTV outside *Musaceae* family (Dela Cueva *et al.*, 2009). The presence of BBTV in plants can be early detected through serological test uses techniques such as Enzyme-Linked Immunosorbent Assay (ELISA). Basic method is

the binding of virus by antibody-labeled protein then measured at a specific optical density (A 405 nm). It also can be detected using a PCR assay (Hooks *et al.*, 2008), Capture Immuno Polymerase Chain Reaction (ICPPCR) with the 100% same result (Megia and Anceau, 1997). Further diagnostic tests through ELISA or ICPCR to the 39 symptomless accessions need to conduct to confirm the extent of latent infections and may results some resistant banana cultivars to BBTD or to serve as virus reservoir.

CONCLUSION

BBTD is caused by a virus which is persistently transmitted from plant to plant by aphid vector *Pentalonia nigronervosa* Coq. and from place to place by people transporting planting materials obtained from infected plants and through the movement of farm equipments. The spread and the development of BBTD is optimum at humid, high rainfall intensity, high temperatures, high soil fertility and also low light intensity or shaded. The preliminary screening results indicate that 39 cultivars have a tendency to be more tolerant. The wild *Musa* species are known to be resistant to BBTD. The genotypic trend showed that cultivars of AAB, ABB and BBB genome groups tend to be more tolerant to BBTD than cultivars of AA and AAA in which *Musa* genotypes with one or two B genomes tend to be more tolerant to BBTD. However several cultivars which known tend to BBTD tolerant are indicated susceptible to Blood Disease and also some cultivars showing complication symptoms both BBTD and Blood Disease. Further diagnostic test of the 39 symptomless accessions need to be conducted to confirm the extent of latent infections. The results may show some resistant banana cultivars to BBTD or serve as virus reservoir.

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