GENETIC VARIATION OF WILD *Musa acuminata* COLLA FROM INDONESIA BASED ON RAPD AND ISSR MARKERS

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GENETIC VARIATION OF WILD *Musa acuminata* COLLA FROM INDONESIA BASED ON RAPD AND ISSR MARKERS

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Running title: Genetic of wild *Musa acuminata* Colla from Indonesia

ABSTRACT

Musa acuminata Colla is one of the progenitors of cultivated bananas today, and Indonesia is the center of origin and diversity of *M. acuminata.* Genetic variation of wild *M. acuminata* from Indonesia has not been studied extensively. This study was conducted to assess genetic variation of wild *M. acuminata* from Indonesia based on 10 RAPD (Random Amplified Polymorphic DNA) and 10 ISSR (Inter Simple Sequence Repeats) markers. The genetic properties of 17 populations of wild *M. acuminata* were analyzed by Popgene 1.32 based on Nei's unbiased measures of genetic identity and genetic distance. A total of 443 DNA bands were produced, 425 (95.94%) of which were polymorphic. Cluster analysis of combined data of RAPD and ISSR produced a dendrogram which separated the population of *M. acuminata* (A genome) from *M. balbisiana* (B genome), but not from *M. schizocarpa* (S genome). Genetic distance (Nei, 1978) of the 17 populations of wild *M. acuminata* ranged from 0.3676 to 0.1634. The highest genetic distance was observed between *M. acuminata* var *rutilifes* (from East Java) and *M. acuminata* var *sumatrana* (from West Sumatra). The percentages of polymorphic loci among the 17 populations of *M. acuminata* ranged from 9.93% to 39.73%. Nei's (1973) gene diversity (h) ranged from 0.041 to 0.1418. *M. acuminata* var *malaccensis* population was the most diverse population among the 17 *M. acuminata* populations studied. The high level of genetic diversity of the wild *M. acuminata* from Indonesia emphasizes the need for conservation and preservation of the natural population and its use in banana breeding program.

Keywords: Indonesia, genetic variation, ISSR, RAPD, wild *Musa acuminata*

INTRODUCTION

Bananas (*Musa* spp., family *Musaceae,* order Zingiberales) are important crops in Indonesia and the world. They are essential components of the diet and important sources of income for about 400 million people in over 120 countries in the tropical and sub-tropical zones (Jones, 2000). The *Musa* genus*,* together with other genera (*Ensete* and *Musella*), is an herbaceous monocot plant. There are two sections within the genus, *Callimusa* and *Musa*. Section *Callimusa* is a combination of three former sections i.e. *Australimusa* (x=10), *Ingentimusa* (x=7) and *Callimusa* (x=10), while section *Musa* is formerly *Eumusa* (x=11) and *Rhodochlamys* (x=11) (Häkkinen, 2013). Genus *Musa* carries A genome (*M. acuminata* Colla), B genome (*M. balbisiana* Colla), S genome (*M. schizocarpa* Simmonds), and T genome (*M. textilis* Née). There is no observed natural hybridization between B, T, or S genome, but *M. acuminata* hybridizes with *M. balbisiana, M.*

schizocarpa and *M. textilis.* Although there are few cultivated bananas with S and T genomes, only two species are regarded as the ancestors of cultivated bananas, i.e. *M. acuminata* and *M. balbisisana* (Simmond and Shepherd, 1955). The fruits of these plants contain many seeds with a small amount of edible pulp. The wild-seeded bananas in the genus *Musa* represent some of the best sources of genetic diversity that can be used in the breeding of new edible bananas (Häkkinen and Wallace, 2011).

Musa acuminata is a complex species that is divided into at least 7 sub-species with different geographic distributions (Simmonds and Shepherd, 1955; Perrier et al., 2011). The 7 sub-species are: *M. acuminata* subsp. *acuminata, M. acuminata* subsp. *errans (*Blanco) RV Valmayor, *M. acuminata* subsp. *halabanensis* (Meijer) M Hotta, *M. acuminata* subsp. *malaccensis* (Ridl.) NW Simmonds, *M. acuminata* subsp. *microcarpa* (Becc.) NW Simmonds*, M. acuminata* subsp. *siamea* NW Simmonds, and *M. acuminata* subsp. *truncata* (Ridl.). Nasution (1991) described 15 varieties of *M. acuminata* from Indonesia based on their morphology, and three of them (*M. acuminata* var. *alasensis, M. acuminata* var *nakaii* and *M. acuminata* var. *rutilifes)* are classified as rare plants of Indonesia (Mogea et al. 2001). Wild *M. acuminata* serves an important role in banana breeding, specifically in providing genetic resources for disease resistance (Javed et al., 2004; Uma et al., 2006; Sutanto et al., 2014; Fraser-Smith et al., 2016).

Assessment of genetic variation is a representative tool for the management of genetic resources and plant breeding program. Although genetic diversity of wild *M. acuminata* has been studied extensively (Wong et al., 2001; Wong et al., 2002, Bartos et al., 2005; Raboin et al., 2005; Li et al., 2010; Liu et al., 2010; Christelová et al., 2011; Perrier et al., 2011; D'Hont et al., 2012; Mukunthakumar et al., 2013; Čížková et al., 2015; Martanti et al., 2015; Sardos et al., 2016), only a small amount of the material used for these studies originated from Indonesia. Herein, we study and analyze the genetic variation of wild bananas within *Musa acuminata* species from Indonesia using Random Amplified Polymorphic DNA (RAPD) and Inter Simple Sequence Repeats (ISSR) markers.

RAPD has been used as a cost-effective method for analyzing genetic variation (Williams et al., 1990; Welsh and McClelland, 1990). Although it has been reported for limited reproducible results for DNA amplification, RAPD has been used for analyzing banana genetic diversity (Kaemmer et al., 1992; Howell et al., 1994; Bhat and Jarret, 1995; Uma et al., 2006; Jain et al., 2007; Poerba and Ahmad, 2010*a*, 2010*b*, 2012; Poerba and Ahmad, 2013; Faure et al., 1993; Pillay et al., 2000, 2006; Lamare and Rao, 2015). Likewise, Inter Simple Sequence Repeats (ISSR) is a cost-effective method for studying genetic variation, with no need of previous genome sequence, fast, and a dominant marker (Zietkiewicz et al., 1994). The use of dominant marker for assessing the genetic variation within individual genotype and population is promising because many polymorphic loci could be generated with ease at a short time without previous genome sequence information (Nybom and Bartish, 2000; Nybom, 2004). Polymorphisms within individual genotype are mainly caused by different sequences in one or two primer binding sites and could indicate the presence or absence of the amplified products (Sperisen and Bucher, 1998).

MATERIALS AND METHODS

Materials and Methods

A total of 209 samples (from 19 populations) of wild bananas, *M. acuminata* (A genome), *M. balbisiana* (B genome) and *M. schizocarpa* NW Simmonds (S genome) collected from different locations in Indonesia were used in this study (Table 1). Descriptions of all accessions were based on morphology as described by Nasution (1991) and IPGRI-INIBAB/CIRAD (1996).

Total DNA was extracted from young leaves by Cetyltrimetylammonium bromide (CTAB) method (Syamkumar et al. 2003) with modification, i.e., using 4% CTAB and an addition of 0.1 g Polyvinylpirrolidone (PVP) for each reaction. The analyses were conducted with RAPD method (Williams et al. 1990). Ten selected RAPD primers (OPA-02, OPA-07, OPA-13, OPA-18, OPB-07, OPB-18, OPN-06, OPN-12, OPN-14, OPU-06 (Operon Technology Ltd) and ten selected ISSR primers (University of British Columbia, Canada), i.e. UBC-811, UBC-814, UBC-815, UBC-822, UBC-823, UBC-826, UBC-834, UBC-835, UBC-843 and UBC-844, were used in this study.

PCR reactions for RAPD analyses were conducted at a total volume of 15 µl, containing 0.2 nM dNTPs; 1X reaction buffer; 2 mM MgCl2; 25 ng DNA sample; 1 pmole single primer; and 1unit Taq DNA polymerase (Promega Go Taq Flexy DNA Polymerase) using Thermocycler (Takara) for 45 cycles. The first heating was at a temperature of 94°C for 2 minutes, then followed by 45 cycles which consisted of 1 minute of denaturation at 94°C, 1 minute of annealing at 36°C, and 2 minutes of extension at 72°C. After the 45 cycles ended, 5 minutes of DNA extension at 72°C and cooling at 25°C followed. PCR reactions for ISSR analyses were conducted as follows: 5 minutes of denaturation at 94°C, followed by 30 cycles of 1 minute of denaturation at 94°C, 45 seconds of annealing at 50°C, and 2 minutes of DNA extensions at 72°C. After the 30 cycles were finished, the reaction was terminated by 5 minutes of extension at 72°C.

Visualization of RAPD and ISSR Bands

Electrophoresis was carried out on 2.0% agarose gel using ATTO mini gel apparatus and run at 100 volt for 50 minutes. RAPD and ISSR bands were stained using 1X Gel RedTM staining solution (Biotium) for 30 minutes. The bands were then observed under UV light and photographed using a gel documentation system (ATTO).

Data Analysis

Only clear and visible RAPD and ISSR bands were selected and scored for the presence (1) and absence (0) of a band. Band's size was calculated based on 100 bp plus (Fermentas) DNA marker. Genetic distance was analyzed by Popgene 1.32 (Yeh et al., 1997) based on Nei's unbiased measures of genetic identity and genetic distance (Nei, 1978). Cluster analysis was performed with unweighted pair group method with arithmetic averages (UPGMA) based on Nei's (1972) genetic distance using Popgene 1.32 (Yeh et al., 1997). The dendrograms produced were viewed with Treeview (Page 1998).

RESULTS AND DISCUSSION

RAPD and ISSR bands

A total of 443 RAPD and ISSR bands with sizes ranging from 100-2600 bp were produced, and 425 bands (95.95%) were polymorphic. The highest number of bands (27 bands) was produced by OPN-12, while the least number of bands (15 bands) was made by UBC-843. Primers of OPU-06, UBC-826, UBC-835, UBC-843, and UBC-844 generated 100% polymorphic bands. Each primer produced 22.15 bands, with an average of 21.15 polymorphic bands (Table 2). Primer OPN-14 produced the lowest number of polymorphic bands (90.91%). The results suggested that each wild banana genotype observed had DNA variations.

In this study, more polymorphism bands were produced than those of Mukunthakumar et al. (2013), which produced 87.5% RAPD polymorphism bands - Das et al. (2018) which produced 53.83% ISSR polymorphism bands and Lamere & Rao (2015) which produced 85.09% and 90.06% for RAPD and ISSR polymorphic bands respectively. RAPD is easy, fast and affordable and widely used for banana diversity studies (Kaemmer et al., 1992; Howell et al., 1994; Bhat and Jarret, 1995; Uma et al., 2006; Jain et al., 2007; Poerba and Ahmad, 2010*a;* Poerba et al., 2010), 2012; Poerba and Ahmad, 2013; Faure et al., 1993; Pillay et al., 2000, 2006; Lamare and Rao, 2015), meanwhile ISSR provide higher reproducibility (Bornet and Branchard, 2012).

The polymorphism level of arbitrary markers, RAPD and ISSR, is according to primer sequences and either the position or number of annealing region in the template sequences (William et al., 1990). Therefore, studies with different genetic property and marker will results in diversity of polymorphic content. The combined markers of RAPD and ISSR and the more genotypes used in this study were probably the most influenced factors that contributed to the high polymorphism. This result showed that the 20 primers were effective in bringing out differences among the wild *Musa* genotypes.

Table 2. Number of amplified DNA bands using 20 primers of RAPD and ISSR of wild *Musa acuminata* from Indonesia

No	Primer code	Nucleotide sequence (5' - 3')	∑DNA bands	∑Polymorphic bands	(%)	Size (bp)
1	OPA-02	TGCCGAGCTG	26	25	96.15	100-1500
2	OPA-07	GAAACGGGTG	22	21	95.45	200-2500
3	OPA-13	CAGCACCCAC	22	21	95.45	250-2200
4	OPA-18	AGGTGACCGT	23	22	95.65	250-1600
5	OPB-07	GGTGACGCAG	21	20	95.24	300-1600
6	OPB-18	CCACAGCAGT	25	23	92	250-2200
7	OPN-06	GAGACGCACA	24	23	95.83	200-2400
8	OPN-12	CACAGACACC	27	26	96.3	200-2600
9	OPN-14	TCGTGCGGGT	22	20	90.91	300-3000
10	OPU-06	ACCTTTGCGG	23	23	100	150-2200
11	UBC-811	GAG AGA GAG AGA GAG AC	22	21	95.45	300-2200
12	UBC-814	CTC TCT CTC TCT CTC TA	23	22	95.65	350-2000
13	UBC-815	CTC TCT CTC TCT CTC TG	22	21	95.45	250-2200
14	UBC-822	TCT CTC TCT CTC TCT CA	22	20	90.91	250-2000
15	UBC-823	TCT CTC TCT CTC TCT CC	18	17	94.44	300-2000
16	UBC-826	ACA CAC ACA CAC ACA CC	22	22	100	300-2200
17	UBC-834	AGA GAG AGA GAG AGA GYT	23	22	95.65	200-1800
18	UBC-835	AGA GAG AGA GAG AGA GYC	22	22	100	250-2000
19	UBC-843	CTC TCT CTC TCT CTC TRA	15	15	100	250-2200
20	UBC-844	CTC TCT CTC TCT CTC TRC	19	19	100	250-2200
		Total	443	425		

Population genetic diversity of *M. acuminata*

Nei's genetic distances (1973) of the 17 populations of *M. acuminata* ranged from 0.3676 to 0.1634, with 20.42% genetic diversity. The lowest genetic distance was observed between *M. acuminata* subsp. *banksii* (from Papua) and *M. acuminata* var *acuminata* (from Papua), *M. acuminata* var. *flava* (from Kalimantan) and *M. acuminata* var. *microcarpa* (from Kalimantan), while the highest genetic distance observed between *M. acuminata* var *rutilifes* (from East Java) and *M.acuminata* var *sumatrana* (from West Sumatra) (Table 3). *Musa acuminata* ssp. *banksii* and *M. acuminata* var. *acuminata* originated in Papua, geographically isolated from the other subspecies or varieties, and *M. acuminata* subsp. *banksii* is a preferential autogamous (Carreel et al., 2002). Likewise *M. acuminata* var. *flava* and *M. acuminata* var. *microcarpa* originated in Kalimantan, isolated from other subspecies or varieties, they constitute the same species according to De Langhe et al. (2009). The lower genetic distance of populations in the same geographic region is might be because isolation drives the evolution for a particular trait with similar genetic properties, in contrast distinct environment or geographical condition will lead in to other adaptation pattern and genetic properties.

Table 3. Nei’s (1973) genetic identity and genetic distance of 19 populations of *Musa* spp.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	****	0.7744	0.7766	0.6773	0.7369	0.7204	0.7032	0.7509	0.6841	0.7262	0.7616	0.7478	0.7028	0.6738	0.6731	0.7014	0.7127	0.6876	0.6611
2	0.2557	****	**0.8366**	0.6818	0.7502	0.6872	0.7109	0.7575	0.6933	0.7411	0.7286	0,7650	0.7019	0.7011	0.6906	0.7649	0.7367	0.6982	0.6684
3	0.2528	**0.1784**	****	0.6587	0.7516	0.7002	0.6765	0.7626	0.6773	0.7037	0.7447	0.7199	0.7127	0.6581	0.6546	0.7482	0.7536	0.6682	0.6481
4	0.3897	0.3831	0.4175	****	0.7094	0.6533	0.6863	0.7035	0.7054	0.6921	0.7198	0.6819	0.7126	0.6571	0.6802	0.6582	0.6836	0.7102	0.6502
5	0.3053	0.2874	0.2856	0.3434	****	0.7564	0.7587	0.7493	0.7272	0.7718	0.7823	0.7257	7.7381	0.7533	0.6966	0.7196	0,8080	0,7230	0.6854
6	0,3280	0.3571	0.3564	0.4258	0.2792	****	0.7059	0.7011	0.6794	0,6870	0.7577	0.6777	0.6793	0.6658	0.6731	0,6840	0.7097	0.6821	0.6423
7	0.3521	0.3413	0.3909	0.3765	0.2762	0.3483	****	0.6955	0.7042	0.7257	0.7662	0.7024	0.7397	0.7062	0.6745	0,6620	0.7648	0.7087	0.6607
8	0.2864	0.2778	0,2710	0.3517	0.2887	0.3552	0.3631	****	0.7056	0.7169	0.7758	**0.8306**	0.7016	0.7311	0,7110	0.7451	0.7348	0.7362	0.6828
9	0.3797	0.3663	0.3896	0,3490	0.3186	0.3865	0.3507	0.3487	****	0.7296	0.7823	0.6827	0.6658	0.6794	0.6589	0.6986	0.7253	0.6947	0.6527
10	0,3200	0.2997	0.3514	0,3680	0,2590	0.3755	0.3206	0.3328	0.3153	****	0.7458	0.6971	0.6972	0.6606	0.6994	0.6725	0.7376	0.7146	0.6427
11	0.2724	0.3166	0.2948	0.3288	0.2456	0.2775	0.2664	0.2538	0.2455	0.2933	****	0.7496	0.7327	0.7126	0.7268	0.7454	0.7672	0.7702	0.7024
12	0.2906	0.2679	0.3287	0.3829	0.3206	0.3891	0.3533	**0.1857**	0.3817	0.3609	0.2883	****	0.6969	0.7261	0,7020	0.7425	0.7355	0.7066	0.6804
13	0.3527	0,3540	0.3387	0.3388	0.3036	0.3868	0.3015	0.3543	0.4068	0.3607	0,3110	0.3611	****	0.6954	0.6729	0.6815	0.7442	0.7048	0,6490
14	0.3948	0.3551	0.4184	0,4200	0.2833	0.4067	0.3478	0.3132	0.3866	0.4146	0.3388	0,3200	0.3633	****	**0.6313**	0.6869	0.7279	0.6663	0.6657
15	0.3958	0.3702	0.4237	0.3854	0.3616	0.3958	0.3938	0.3411	0.4172	0.3575	0.3191	0.3538	0.3962	**0.4599**	****	0.6735	0,6700	0.6885	0.6651
16	0.3547	0,2680	0.2901	0.4183	0.3291	0.3798	0.4125	0.2943	0.3587	0.3967	0.2939	0.2977	0.3834	0.3755	0.3952	****	0.7266	0,6820	0,6240
17	0.3387	0.3055	0.2829	0.3804	0.2132	0.3429	0.2681	0.3081	0.3211	0.3044	0.2651	0.3071	0.2955	0.3176	0.4005	0.3194	****	0,7140	0.6668
18	0.3746	0.3593	0.4031	0.3422	0.3244	0.3826	0.3443	0.3062	0.3642	0,3360	0.2611	0.3473	0.3499	0,4060	0.3733	0.3827	0.3368	****	0.6917
19	0.4139	0.4028	0.4337	0.4304	0.3778	0.4427	0.4144	0.3815	0.4267	0,4420	0.3533	0,3850	0.4324	0,4070	0.4078	0.4716	0.4052	0.3686	****

Notes:

Nei's genetic identity (above diagonal) and genetic distance (below diagonal).

1 = *Musa acuminata* Colla subsp. *banksii* (F. Muell.) NW Simmonds (Sulawesi Utara); 2 = *Musa acuminata* Colla subsp. *banksii* (F. Muell.) NW Simmonds (Papua); 3 = *M. acuminata* Colla var. *acuminata*, 4 = *M. acuminata* Colla var. *alasensis* Nasution, 5= *M. acuminata* Colla var. *bantamensis* Nasution, 6 = *M. acuminata* Colla var. *breviformis* Nasution, 7 = *M. acuminata* Colla var. *cerifera* (Backer) Nasution, 8 = *M. acuminata* Colla var. *flava* (Ridl.) Nasution, 9 = *M. acuminata* Colla var. *halabanensis* (Meijer) Nasution, 10 = *M. acuminata* Colla var. *longipetiolata* Nasution, 11 = *M. acuminata* Colla var. *malaccensis* (Ridl.) Nasution, 12 = *M. acuminata* Colla var. *microcarpa* (Becc.) Nasution, 13 = *M. acuminata* Colla var. *nakaii* Nasution, 14 = *M. acuminata* Colla var. *rutilifes* Nasution, 15 = *M. acuminata* Colla var. *sumatrana* (Becc.) Nasution, 16 = *M. acuminata* Colla var. *tomentosa* (K.Sch.) Nasution 17 = *M. acuminata* Colla var. *zebrina* (v. Houtte) Nasution, 18 = *M.schizocarpa* NW Simmonds, dan 19 = *M. balbisiana* Colla.

Genetic properties of 17 populations of *M. acuminata* varied. The percentages of polymorphic loci for the 17 populations of *M. acuminata* ranged from 9.93% to 39.73%. It means that genetic variation within each population of *M. acuminata* varies from the lowest 9.93% (within *M. acuminata* var. *acuminata*) to the highest 39.73% (within *M. acuminata* var. *malaccensis).* Nei’s (1973) gene diversity (h) ranged from 0.041 to 0.1418. *Musa acuminata* var *malaccensis* had the highest percentages of polymorphic loci and Nei’s (1973) gene diversity among the 17 population of wild *M. acuminata*; while *M. acuminata* var. *acuminata* had the lowest (Table 4). *M. balbisiana* had the lowest polymorphic loci among 19 populations. The fact that *M. balbisiana* was not originated from Indonesia, and it was introduced and naturalized (De Langhe, 2009), could be the possible explanation why its genetic variation in Indonesia was the lowest. All the 209 samples had na, ne, Nei’s gene diversity, and Shannon Information Index values of 1.9594, 1.5277, 0.3126, and 0.4727, respectively (Table 4).

Table 4. Genetic properties of 19 populations of *Musa* spp. from Indonesia

No	Population	Sample size	na	ne	h	I	Number of polymorphic loci	(%)
1	*M. acuminata* subsp. *banksii* (Sulawesi)	6	1.2099	1.1557	0.0855	0.1239	93	20.99%
2	*M. acuminata* subsp. *banksii* (Papua)	21	1.2777	1.0511	0.0387	0.0714	123	27.77%
3	*M. acuminata* var. *acuminata* (Papua)	10	1.0993	1.0725	0.041	0.0596	44	9.93%
4	*M. acuminata* var. *alasensis*	10	1.1174	1.0749	0.043	0.0637	52	11.74%
5	*M. acuminata* var. *bantamensis*	8	1.2054	1.1463	0.082	0.1196	91	20.54%
6	*M. acuminata* var. *breviformis*	7	1.14	1.1127	0.0603	0.0863	62	14.00%
7	*M. acuminata* var. *cerifera*	6	1.1693	1.1147	0.0645	0.0948	75	16.93%
8	*M. acuminata* var. *flava*	13	1.2754	1.1773	0.1024	0.1516	122	27.54%
9	*M. acuminata* var. *halabanensis*	10	1.1332	1.084	0.0484	0.0719	59	13.32%
10	*M. acuminata* var. *longipetiolata*	14	1.1558	1.1061	0.0608	0.0894	69	15.58%
11	*M. acuminata* var. *malaccensis*	19	1.3973	1.2458	0.1418	0.2106	176	39.73%
12	*M. acuminata* var. *microcarpa*	9	1.1287	1.0884	0.0502	0.0736	57	12.87%
13	*M. acuminata* var. *nakaii*	7	1.1986	1.1476	0.0816	0.1183	88	19.86%
14	*M. acuminata* var. *rutilifes*	10	1.1174	1.0984	0.0533	0.0758	52	11.74%
15	*M. acuminata* var. *sumatrana*	14	1.1219	1.0813	0.0471	0.0693	54	12.19%
16	*M. acuminata* var. *tomentosa*	11	1.1309	1.0725	0.0432	0.0657	58	13.09%
17	*M. acuminata* var. *zebrina*	11	1.2483	1.1139	0.0719	0.1129	110	24.83%
18	*M. schizocarpa*	11	1.1174	1.05	0.0321	0.051	52	11.74%
19	*M. balbisiana*	12	1.0767	1.0436	0.0257	0.0389	34	7.67%
		209	1.9594	1.5277	0.3126	0.4727	425	95.94%

Notes:

* na = Observed number of alleles

* ne = Effective number of alleles [Kimura & Crow (1964)]

* h = Nei's (1973) gene diversity

* I = Shannon's Information index [Lewontin (1972)]

Population diversity indexes such as allele frequencies (na and ne), Nei’s gene diversity (h), and Shannon’s information index (I) define the genome composition of a population. In this study, observed number of alleles (na) and effective number of allele (ne) from combined RAPD and ISSR data were lower than those of other research (Lamare and Rao, 2015; Mukunthakumar et al., 2013). Combination of a marker and genotypes will produce observed and diversity of alleles in a certain level, this is make a sense that our result are different to the previous studies.This could be due to different markers and genotypes used. Lamare and Rao (2015) used more markers (58) on 25 different genotypes. In this study, na and ne values ranged from 1.0767 to 1.3973 and from 1.0436 to 1.072, respectively. Nei’s (1973) gene diversity within population ranged from 0.057 to 0.1418. Total Nei’s (1973) gene diversity was 0.3126. *Musa acuminata* var *malaccensis* had the highest percentage of polymorphic loci and Nei’s (1973) gene diversity among the 17 populations of wild

M. acuminata, with the values of na, ne, h, I and percentage of polymorphism of 1.3973, 1.2458, 0.1418, 0.2106, and 39.73%, respectively. *M. acuminata* var. *acuminata* had the lowest percentage of polymorphic loci and Nei's (1973) gene diversity, with the values of na, ne, h, I, and percentage of polymorphism of 1.0993, 1.0725, 0.0596, and 9.95%, respectively.

Cluster Analysis

Cluster analysis of combined data of RAPD and ISSR produced a dendrogram which separated the population of *M. acuminata* (1-17) from *M.balbisiana* (19), but not from *M schizocarpa* (18) (Figure 1). This result is interesting because *M. acuminata* (carrying A genome) and *M. schizocarpa* (carrying S genome) were in the same cluster. However, this finding may need further study, specifically to identify the marker specified for each genome with more stringent markers such as AFLP (Wong et al., 2001; Opara et al., 2010), SSR (Christelova et at., 2017) or specific locus markers (Volkaert, 2011) to resolve the clustering between *M. acuminata* and *M. schizocarpa*.

Cluster 1 consisted of 6 populations, namely: 1 *M. acuminata* subsp *banksii* (North Sulawesi), 2 (*M. acuminata* subsp *banksii* (Papua), 3 *M. acuminata* var *acuminata* (Papua), 8 *M. acuminata* var *flava* (Central Kalimantan), 12 *M. acuminata* var *microcrapa* (Central Kalimantan) and 16 *M. acuminata* var *tomentosa* (North Sulawesi). Cluster 2 consisted of 6 populations of 5 *M. acuminata* var *bantamensis*, 17 *M. acuminata* var *zebrina*, 11 *M. acuminata* var *malaccensis*, 7 *M. acuminata* var *cerifera*, 10 *M. acuminata* var *longipetiolata*, and *M. acuminata* var *nakaii*. The rest 6 populations (14 *M. acuminata* var *rutilifes*, 18 *M. schizocarpa*, 6 *M. acuminata* var *breviformis*, 9 *M. acuminata* var *halabanensis*, 15 *M. acuminata* var *sumatrana*, 4 *M. acuminata* var *alasensis*) were separated within cluster of *M. acuminata–M schizocarpa* (Figure 1). The results were different from those of Nasution's study (1991) using morphological characters. Based on morphological characters, *M. acuminata* was divided into two groups. Group 1 were varieties of *alasensis, halabanensis, acuminata, tomentosa, flava and sumatrana.* The other group were varieties of *nakaii, zebrina, cerifera, longipetiolata, bantamensis, rutilifes, breviformis, malaccensis and microcarpa.* Some of the varieties such as *flava,* and *microcarpa* which was in different morphological group were in the same cluster (1). Likewise, varieties of *halabanensis,* and *rutilifes* which was in different morphological group were in the same cluster (3).

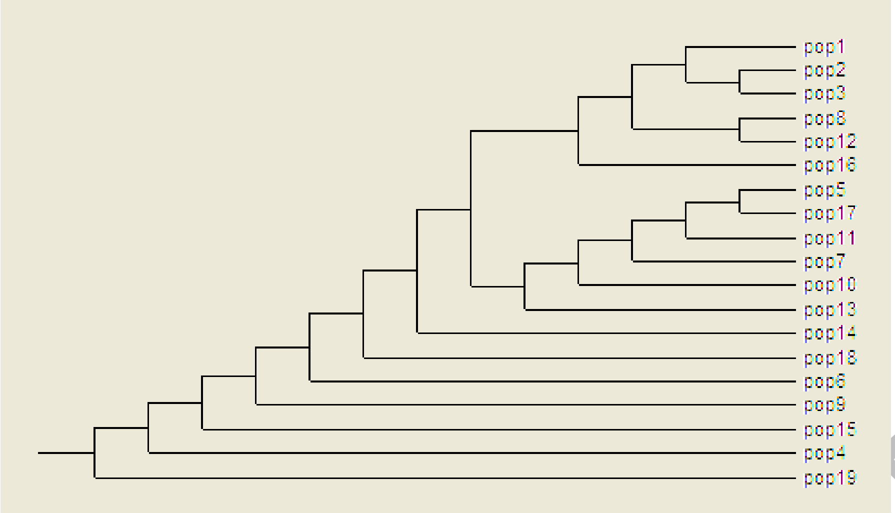

Figure 1. Dendrogram of 19 populations of *Musa* spp. from Indonesia based on Nei's genetic distance

Notes: 1 = *Musa acuminata* Colla subsp. *banksii* (F. Muell.) NW Simmonds (Sulawesi Utara); 2 = *Musa acuminata* Colla subsp. *banksii* (F. Muell.) NW Simmonds (Papua); 3 = *M. acuminata* Colla var. *acuminata*, 4 = *M. acuminata* Colla var. *alasensis* Nasution, 5 = *M. acuminata* Colla var. *bantamensis* Nasution, 6 = *M. acuminata* Colla var. *breviformis* Nasution, 7 = *M. acuminata* Colla var. *cerifera* (Backer) Nasution, 8 = *M. acuminata* Colla var. *flava* (Ridl.) Nasution, 9 = *M. acuminata* Colla var. *halabanensis* (Meijer) Nasution, 10 = *M. acuminata* Colla var. *longipetiolata* Nasution, 11 = *M. acuminata* Colla var. *malaccensis* (Ridl.) Nasution, 12 = *M. acuminata* Colla var. *microcarpa* (Becc.) Nasution, 13 = *M. acuminata* Colla var. *nakaii* Nasution, 14 = *M. acuminata* Colla var. *rutilifes* Nasution, 15 = *M. acuminata* Colla var. *sumatrana* (Becc.) Nasution, 16 = *M. acuminata* Colla var. *tomentosa* (K.Sch.) Nasution 17 = *M. acuminata* Colla var. *zebrina* (v. Houtte) Nasution, 18 = *M. schizocarpa* NW Simmonds, and 19 = *M. balbisiana* Colla.

The different properties of genetic variation of wild *M. acuminata* from Indonesia confirm that genetically the wild *M. acuminata* is diverse. The wild *M. acuminata* collection in this study is high valuable material that need further population genetic diversity as as well as trait variation studies, subsequently combined with cultivated banana study to contribute in banana breeding program. Utilization of more advance molecular marker is essential for the future studies, for example,athe need for conservation and preservation of the wild *M. acuminata*. Further studies of population genetic as well as genetic diversity of wild *M. acuminata* using more advanced molecular techniques would be needed for better understanding of genetics for use in conservation and banana breeding programs. The variability of *M. acuminata* is important and far above the number of *M. acuminata* reported in neighbouring countries (Pollefeys et al., 2004). The infra-specific variation of *Musa acuminata* is far more complex than is understood from its subspecies classification, and can provide more promising parent forms/cultivars for breeding than have been exploited until now (MusaNet, 2016). Utilization of more advance molecular marker is essential for the future studies, for example, multi locus markers can correlate alleles between domesticated banana from the wild relatives (Volkaert, 2011) or SNPs which can provide a high resolution of durum wheat genetic diversity (Ren et al., 2013). This study is a corner stone for better understanding of Indonesian banana genetics which useful for banana breeding and conservation programs.

CONCLUSIONS

Twenty RAPD and ISSR markers used in this study could generate a high percentage of polymorphic bands (95.95%). A total of 17 populations of wild *M. acuminata* from Indonesia have different genetic properties with genetic distances (Nei 1973) ranging from 0.3676 to 0.1634, with 20.42% genetic diversity. The highest genetic distance was observed between *M. acuminata* var *rutilifes* (from East Java) and *M. acuminata* var *sumatrana* (from West Sumatra). *Musa acuminata* var *malaccensis* had the highest percentage of polymorphic loci and Nei's (1973) gene diversity among the 17 populations of wild *M. acuminata*, while *M. acuminata* var. *acuminata* had the lowest.

Cluster analysis of combined data of RAPD and ISSR produced a dendrogram which separated the population of *M. acuminata* (A genome) from *M. balbisiana* (B genome), but not from *M. schizocarpa* (S genome). The different properties of genetic variation of wild *M. acuminata* from Indonesia confirm that genetically the wild *M. acuminata* is diverse. The wild *M. acuminata* collection in this study is high valuable material that need further population genetic, genetic diversity as well as trait variation studies, subsequently combined with cultivated banana study to contribute in banana breeding program.

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Table 1. List of samples used in the study

No	Coll. number	Scientific name	Local name	Origin
1	PAN01	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Yaki, Pisang Wolai	Sulawesi Utara
2	PAN08	*Musa acuminata* Colla subsp. *banksii* (F.Muell.) Simmonds	Pisang Yaki, Pisang Wolai	Sulawesi Utara
3	PAN09	*Musa acuminata* Colla subsp. *banksii* (F.Muell.) Simmonds	Pisang Yaki, Pisang Wolai	Sulawesi Utara
4	A12X	*Musa acuminata* Colla subsp. *banksii* (F.Muell.) Simmonds	Pisang Yaki, Pisang Wolai	Sulawesi Utara
5	A42X	*Musa acuminata* Colla subsp. *banksii* (F.Muell.) Simmonds	Pisang Yaki, Pisang Wolai	Sulawesi Utara
6	A62X	*Musa acuminata* Colla subsp. *banksii* (F.Muell.) Simmonds	Pisang Yaki, Pisang Wolai	Sulawesi Utara
7	PA 01	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
8	PA 02	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
9	PA 03	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
10	PA 04	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
11	PA 07	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
12	PA 08	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
13	PA 09	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
14	PA 10	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
15	PA 11	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
16	PA 13	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
17	PA 14	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
18	PA 15	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
19	PA 16	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
20	PA 17	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
21	PA 18	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
22	PA 19	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
23	PA 21	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
24	PA 23	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
25	PA 24	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
26	PA 25	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
27	PA 26	*Musa acuminata* Colla subsp. banksii (F.Muell.) Simmonds	Pisang Hutan	Timika, Papua
28	PA61	*Musa acuminata* Colla var. acuminata	Pisang Hutan	Sentani, Papua
29	PA79a	*Musa acuminata* Colla var. acuminata	Pisang Hutan	Manokwari, Papua Barat
30	PA79b	*Musa acuminata* Colla var. acuminata	Pisang Hutan	Manokwari, Papua Barat
31	PA84	*Musa acuminata* Colla var. acuminata	Pisang Hutan	Manokwari, Papua Barat
32	PA85	*Musa acuminata* Colla var. acuminata	Pisang Hutan	Manokwari, Papua Barat
33	PA86	*Musa acuminata* Colla var. acuminata	Pisang Hutan	Manokwari, Papua Barat
34	PA89	*Musa acuminata* Colla var. acuminata	Pisang Hutan	Manokwari, Papua Barat
35	PA90	*Musa acuminata* Colla var. acuminata	Pisang Hutan	Manokwari, Papua Barat
36	PA91	*Musa acuminata* Colla var. acuminata	Pisang Hutan	Manokwari, Papua Barat
37	PA96	*Musa acuminata* Colla var. acuminata	Pisang Hutan	Manokwari, Papua Barat
38	PN 07	*Musa acuminata* Colla var. *alasensis* Nasution	Pisang Runcim	Aceh Tenggara
39	PN 11	*Musa acuminata* Colla var. *alasensis* Nasution	Pisang Keken	Aceh Tenggara
40	PN 18	*Musa acuminata* Colla var. *alasensis* Nasution	Pisang Keken	Aceh Tenggara
41	PN 20	*Musa acuminata* Colla var. *alasensis* Nasution	Pisang Keken	Aceh Tenggara
42	PN 22	*Musa acuminata* Colla var. *alasensis* Nasution	Pisang Keken	Aceh Tenggara
43	PN 23	*Musa acuminata* Colla var. *alasensis* Nasution	Pisang Keken	Aceh Tenggara
44	PN 24	*Musa acuminata* Colla var. *alasensis* Nasution	Pisang Keken	Aceh Tenggara
45	PN 25	*Musa acuminata* Colla var. *alasensis* Nasution	Galuh Rincim	Aceh Tenggara
46	PN 27	*Musa acuminata* Colla var. *alasensis* Nasution	Galuh Rincim	Aceh Tenggara
47	PN 28	*Musa acuminata* Colla var. *alasensis* Nasution	Galuh Rincim	Aceh Tenggara
48	II 23B#3	*Musa acuminata* Colla var. *bantamensis* Nasution	Cau Kole	Jawa Barat
49	II23B#4	*Musa acuminata* Colla var. *bantamensis* Nasution	Cau Kole	Jawa Barat
50	II 23B#5	*Musa acuminata* Colla var. *bantamensis* Nasution	Cau Kole	Jawa Barat
51	APH 192	*Musa acuminata* Colla var. *bantamensis* Nasution	Cau Kole	Jawa Barat
52	APH 193	*Musa acuminata* Colla var. *bantamensis* Nasution	Cau Kole	Jawa Barat
53	APH 194	*Musa acuminata* Colla var. *bantamensis* Nasution	Cau Kole	Jawa Barat
54	APH 195	*Musa acuminata* Colla var. *bantamensis* Nasution	Cau Kole	Jawa Barat
55	APH 196	*Musa acuminata* Colla var. *bantamensis* Nasution	Cau Kole	Jawa Barat
56	IV2B#1	*Musa acuminata* Colla var. *breviformis* Nasution	Cau Kole	Jawa Barat
57	IV2B#2	*Musa acuminata* Colla var. *breviformis* Nasution	Cau Kole	Jawa Barat
58	IV2B#3	*Musa acuminata* Colla var. *breviformis* Nasution	Cau Kole	Jawa Barat
59	IV2B#4	*Musa acuminata* Colla var. *breviformis* Nasution	Cau Kole	Jawa Barat
60	IV2B#5	*Musa acuminata* Colla var. *breviformis* Nasution	Cau Kole	Jawa Barat
61	PHD25	*Musa acuminata* Colla var. *breviformis* Nasution	Cau Kole	Jawa Barat
62	PHD26	*Musa acuminata* Colla var. *breviformis* Nasution	Cau Kole	Jawa Barat
63	PSNA02	*Musa acuminata* Colla var. *cerifera* Nasution	Cau Kole	Jawa Barat
64	PSNA03	*Musa acuminata* Colla var. *cerifera* Nasution	Cau Kole	Jawa Barat
65	PSNA04	*Musa acuminata* Colla var. *cerifera* Nasution	Cau Kole	Jawa Barat
66	PSNA05	*Musa acuminata* Colla var. *cerifera* Nasution	Cau Kole	Jawa Barat
67	PSNA07	*Musa acuminata* Colla var. *cerifera* Nasution	Cau Kole	Jawa Barat
68	PSNA09	*Musa acuminata* Colla var. *cerifera* Nasution	Cau Kole	Jawa Barat
69	PNK18b	*Musa acuminata* Colla var. *flava* (Ridl.) Nasution	Pisang Hutan/Pisang Monyet	Kalimantan Tengah
70	PNK18c	*Musa acuminata* Colla var. *flava* (Ridl.) Nasution	Pisang Hutan/Pisang Monyet	Kalimantan Tengah
71	PNK19b	*Musa acuminata* Colla var. *flava* (Ridl.) Nasution	Pisang Hutan/Pisang Monyet	Kalimantan Tengah
72	PNK26	*Musa acuminata* Colla var. *flava* (Ridl.) Nasution	Pisang Hutan/Pisang Monyet	Kalimantan Tengah
73	PNk27b	*Musa acuminata* Colla var. *flava* (Ridl.) Nasution	Pisang Hutan/Pisang Monyet	Kalimantan Tengah
74	PNK28a	*Musa acuminata* Colla var. *flava* (Ridl.) Nasution	Pisang Hutan/Pisang Monyet	Kalimantan Tengah

75	PNK42a	*Musa acuminata* Colla var. *flava* (Ridl.) Nasution	Pisang Hutan/Pisang Monyet	Kalimantan Tengah
76	PNK43a	*Musa acuminata* Colla var. *flava* (Ridl.) Nasution	Pisang Hutan/Pisang Monyet	Kalimantan Tengah
77	PNK43b	*Musa acuminata* Colla var. *flava* (Ridl.) Nasution	Pisang Hutan/Pisang Monyet	Kalimantan Tengah
78	PNK46	*Musa acuminata* Colla var. *flava* (Ridl.) Nasution	Pisang Hutan/Pisang Monyet	Kalimantan Tengah
79	PNK48	*Musa acuminata* Colla var. *flava* (Ridl.) Nasution	Pisang Hutan/Pisang Monyet	Kalimantan Tengah
80	PNK51	*Musa acuminata* Colla var. *flava* (Ridl.) Nasution	Pisang Hutan/Pisang Monyet	Kalimantan Tengah
81	PNK84a	*Musa acuminata* Colla var. *flava* (Ridl.) Nasution	Pisang Hutan/Pisang Monyet	Kalimantan Tengah
82	PS 104	*Musa acuminata* Colla var. *halabanensis* (Meijer) Nasution	Pisang Hutan	Sumatera Selatan
83	PS 105	*Musa acuminata* Colla var. *halabanensis* (Meijer) Nasution	Pisang Hutan	Sumatera Selatan
84	PS 107	*Musa acuminata* Colla var. *halabanensis* (Meijer) Nasution	Pisang Hutan	Sumatera Selatan
85	PS 108	*Musa acuminata* Colla var. *halabanensis* (Meijer) Nasution	Pisang Hutan	Sumatera Selatan
86	PS 109	*Musa acuminata* Colla var. *halabanensis* (Meijer) Nasution	Pisang Hutan	Sumatera Selatan
87	PS 121	*Musa acuminata* Colla var. *halabanensis* (Meijer) Nasution	Pisang Hutan	Sumatera Selatan
88	PS 122	*Musa acuminata* Colla var. *halabanensis* (Meijer) Nasution	Pisang Hutan	Sumatera Selatan
89	PS 125	*Musa acuminata* Colla var. *halabanensis* (Meijer) Nasution	Pisang Hutan	Sumatera Selatan
90	PS 129	*Musa acuminata* Colla var. *halabanensis* (Meijer) Nasution	Pisang Hutan	Sumatera Selatan
91	PS 130	*Musa acuminata* Colla var. *halabanensis* (Meijer) Nasution	Pisang Hutan	Sumatera Selatan
92	PS02	*Musa acuminata* Colla var. *longipetiolata* Nasution	Pisang Tengkayak	Sumatera Selatan
93	PS04	*Musa acuminata* Colla var. *longipetiolata* Nasution	Pisang Tengkayak	Sumatera Selatan
94	PS06	*Musa acuminata* Colla var. *longipetiolata* Nasution	Pisang Tengkayak	Sumatera Selatan
95	PS07	*Musa acuminata* Colla var. *longipetiolata* Nasution	Pisang Tengkayak	Sumatera Selatan
96	PS08	*Musa acuminata* Colla var. *longipetiolata* Nasution	Pisang Tengkayak	Sumatera Selatan
97	PS10	*Musa acuminata* Colla var. *longipetiolata* Nasution	Pisang Tengkayak	Sumatera Selatan
98	PS11	*Musa acuminata* Colla var. *longipetiolata* Nasution	Pisang Tengkayak	Sumatera Selatan
99	PS12	*Musa acuminata* Colla var. *longipetiolata* Nasution	Pisang Tengkayak	Sumatera Selatan
100	PS21	*Musa acuminata* Colla var. *longipetiolata* Nasution	Pisang Tengkayak	Sumatera Selatan
101	PS25	*Musa acuminata* Colla var. *longipetiolata* Nasution	Pisang Tengkayak	Sumatera Selatan
102	PS26	*Musa acuminata* Colla var. *longipetiolata* Nasution	Pisang Tengkayak	Sumatera Selatan
103	PS27	*Musa acuminata* Colla var. *longipetiolata* Nasution	Pisang Tengkayak	Sumatera Selatan
104	PS28	*Musa acuminata* Colla var. *longipetiolata* Nasution	Pisang Tengkayak	Sumatera Selatan
105	PS29	*Musa acuminata* Colla var. *longipetiolata* Nasution	Pisang Tengkayak	Sumatera Selatan
106	APH 40	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
107	APH 41	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
108	APH 42	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
109	APH 43	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
110	APH 258	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
111	APH 259	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
112	APH 260	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
113	APH 266	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
114	APH 301	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
115	APH 302	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
116	APH 303	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
117	PHD-124	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
118	II 17B #1	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
119	II 17B #2	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
120	II 17B #4	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
121	II 17B #5	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
122	APH 416	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
123	APH 419	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
124	APH 420	*Musa acuminata* Colla var. *malaccensis* (Ridl.) Nasution	Cau Kole	Jawa Barat
125	PNK07	*Musa acuminata* Colla var. *microcarpa* (Becc.) Nasution	Pisang Saluku	Kalimantan Tengah
126	PNK08a	*Musa acuminata* Colla var. *microcarpa* (Becc.) Nasution	Pisang Saluku	Kalimantan Tengah
127	PNK08b	*Musa acuminata* Colla var. *microcarpa* (Becc.) Nasution	Pisang Saluku	Kalimantan Tengah
128	PNK13a	*Musa acuminata* Colla var. *microcarpa* (Becc.) Nasution	Pisang Saluku	Kalimantan Tengah
129	PNK13b	*Musa acuminata* Colla var. *microcarpa* (Becc.) Nasution	Pisang Saluku	Kalimantan Tengah
130	PNK32a	*Musa acuminata* Colla var. *microcarpa* (Becc.) Nasution	Pisang Saluku	Kalimantan Tengah
131	PNK32b	*Musa acuminata* Colla var. *microcarpa* (Becc.) Nasution	Pisang Saluku	Kalimantan Tengah
132	PNK14a	*Musa acuminata* Colla var. *microcarpa* (Becc.) Nasution	Pisang Saluku	Kalimantan Tengah
133	PNK14b	*Musa acuminata* Colla var. *microcarpa* (Becc.) Nasution	Pisang Saluku	Kalimantan Tengah
134	APH235	*Musa acuminata* Colla var. *nakaii* Nasution	Cau Kole Beureum	Jawa Barat
135	APH236	*Musa acuminata* Colla var. *nakaii* Nasution	Cau Kole Beureum	Jawa Barat
136	APH314	*Musa acuminata* Colla var. *nakaii* Nasution	Cau Kole Beureum	Jawa Barat
137	PSNAH1a	*Musa acuminata* Colla var. *nakaii* Nasution	Cau Kole Beureum	Jawa Barat
138	PSNAH 06	*Musa acuminata* Colla var. *nakaii* Nasution	Cau Kole Beureum	Jawa Barat
139	PSNAH 14	*Musa acuminata* Colla var. *nakaii* Nasution	Cau Kole Beureum	Jawa Barat
140	PSNAH 15	*Musa acuminata* Colla var. *nakaii* Nasution	Cau Kole Beureum	Jawa Barat
141	PAA32	*Musa acuminata* Colla var. *sumatrana* (Becc.) Nasution	Pisang Karuak	Sumatera Barat
142	PAA48	*Musa acuminata* Colla var. *sumatrana* (Becc.) Nasution	Pisang Karuak	Sumatera Barat
143	PAA49	*Musa acuminata* Colla var. *sumatrana* (Becc.) Nasution	Pisang Karuak	Sumatera Barat
144	PAA50	*Musa acuminata* Colla var. *sumatrana* (Becc.) Nasution	Pisang Karuak	Sumatera Barat
145	PAA69	*Musa acuminata* Colla var. *sumatrana* (Becc.) Nasution	Pisang Karuak	Sumatera Barat
146	PAA70	*Musa acuminata* Colla var. *sumatrana* (Becc.) Nasution	Pisang Karuak	Sumatera Barat
147	PAA94	*Musa acuminata* Colla var. *sumatrana* (Becc.) Nasution	Pisang Palapah	Sumatera Barat
148	PAA95	*Musa acuminata* Colla var. *sumatrana* (Becc.) Nasution	Pisang Palapah	Sumatera Barat
149	PAA96	*Musa acuminata* Colla var. *sumatrana* (Becc.) Nasution	Pisang Palapah	Sumatera Barat

150	PAA107	*Musa acuminata* Colla var. *sumatrana* (Becc.) Nasution	Pisang Palapah	Sumatera Barat
151	PAA108	*Musa acuminata* Colla var. *sumatrana* (Becc.) Nasution	Pisang Palapah	Sumatera Barat
152	PAA110	*Musa acuminata* Colla var. *sumatrana* (Becc.) Nasution	Pisang Palapah	Sumatera Barat
153	PAA190	*Musa acuminata* Colla var. *sumatrana* (Becc.) Nasution	Pisang Palapah	Sumatera Barat
154	PAA200	*Musa acuminata* Colla var. *sumatrana* (Becc.) Nasution	Pisang Palapah	Sumatera Barat
155	PH 04	*Musa acuminata* Colla var. *rutilifes* Nasution	Pisang Cici	Jawa Timur
156	PH 05	*Musa acuminata* Colla var. *rutilifes* Nasution	Pisang Cici	Jawa Timur
157	PH 06	*Musa acuminata* Colla var. *rutilifes* Nasution	Pisang Cici	Jawa Timur
158	PH 07	*Musa acuminata* Colla var. *rutilifes* Nasution	Pisang Cici	Jawa Timur
159	PH 08	*Musa acuminata* Colla var. *rutilifes* Nasution	Pisang Cici	Jawa Timur
160	PH 09	*Musa acuminata* Colla var. *rutilifes* Nasution	Pisang Cici	Jawa Timur
161	PH 12	*Musa acuminata* Colla var. *rutilifes* Nasution	Pisang Cici	Jawa Timur
162	PH 15	*Musa acuminata* Colla var. *rutilifes* Nasution	Pisang Cici	Jawa Timur
163	PH 16	*Musa acuminata* Colla var. *rutilifes* Nasution	Pisang Cici	Jawa Timur
164	PH 19	*Musa acuminata* Colla var. *rutilifes* Nasution	Pisang Cici	Jawa Timur
165	PAR 72	*Musa acuminata* Colla var. *tomentosa* (K.Sch.) Nasution	Unti Darek	Sulawesi Selatan
166	PAR 73	*Musa acuminata* Colla var. *tomentosa* (K.Sch.) Nasution	Unti Darek	Sulawesi Selatan
167	PAR 74	*Musa acuminata* Colla var. *tomentosa* (K.Sch.) Nasution	Unti Darek	Sulawesi Selatan
168	PAR 76	*Musa acuminata* Colla var. *tomentosa* (K.Sch.) Nasution	Unti Darek	Sulawesi Selatan
169	PAR 78	*Musa acuminata* Colla var. *tomentosa* (K.Sch.) Nasution	Unti Darek	Sulawesi Selatan
170	PAR 93	*Musa acuminata* Colla var. *tomentosa* (K.Sch.) Nasution	Unti Darek	Sulawesi Selatan
171	PAR 94	*Musa acuminata* Colla var. *tomentosa* (K.Sch.) Nasution	Unti Darek	Sulawesi Selatan
172	PAR 100	*Musa acuminata* Colla var. *tomentosa* (K.Sch.) Nasution	Unti Darek	Sulawesi Selatan
173	PAR 101	*Musa acuminata* Colla var. *tomentosa* (K.Sch.) Nasution	Unti Darek	Sulawesi Selatan
174	PAR 103	*Musa acuminata* Colla var. *tomentosa* (K.Sch.) Nasution	Unti Darek	Sulawesi Selatan
175	PAR 106	*Musa acuminata* Colla var. *tomentosa* (K.Sch.) Nasution	Unti Darek	Sulawesi Selatan
176	III 21A#1	*Musa acuminata* Colla var. *zebrina* (v. Houtte) Nasution	Cau Kole Beureum	Jawa Barat
177	III 21A#3	*Musa acuminata* Colla var. *zebrina* (v. Houtte) Nasution	Cau Kole Beureum	Jawa Barat
178	III 21A#4	*Musa acuminata* Colla var. *zebrina* (v. Houtte) Nasution	Cau Kole Beureum	Jawa Barat
179	III 21A#5	*Musa acuminata* Colla var. *zebrina* (v. Houtte) Nasution	Cau Kole Beureum	Jawa Barat
180	III20G#1	*Musa acuminata* Colla var. *zebrina* (v. Houtte) Nasution	Cau Kole Beureum	Jawa Barat
181	III20G#2	*Musa acuminata* Colla var. *zebrina* (v. Houtte) Nasution	Cau Kole Beureum	Jawa Barat
182	III20G#3	*Musa acuminata* Colla var. *zebrina* (v. Houtte) Nasution	Cau Kole Beureum	Jawa Barat
183	III20G#5	*Musa acuminata* Colla var. *zebrina* (v. Houtte) Nasution	Cau Kole Beureum	Jawa Barat
184	II23A#3	*Musa acuminata* Colla var. *zebrina* (v. Houtte) Nasution	Cau Kole Beureum	Jawa Barat
185	II23B#1	*Musa acuminata* Colla var. *zebrina* (v. Houtte) Nasution	Cau Kole Beureum	Jawa Barat
186	II23B#2	*Musa acuminata* Colla var. *zebrina* (v. Houtte) Nasution	Cau Kole Beureum	Jawa Barat
187	PA 64	*Musa schizocarpa* NW Simmonds	Pisang Hutan	Papua
188	PA 66	*Musa schizocarpa* NW Simmonds	Pisang Hutan	Papua
189	PA 67	*Musa schizocarpa* NW Simmonds	Pisang Hutan	Papua
190	PA 68	*Musa schizocarpa* NW Simmonds	Pisang Hutan	Papua
191	PA 69	*Musa schizocarpa* NW Simmonds	Pisang Hutan	Papua
192	PA 76	*Musa schizocarpa* NW Simmonds	Pisang Hutan	Papua
193	PA 87	*Musa schizocarpa* NW Simmonds	Pisang Hutan	Papua
194	PA 92	*Musa schizocarpa* NW Simmonds	Pisang Hutan	Papua
195	PA 93	*Musa schizocarpa* NW Simmonds	Pisang Hutan	Papua
196	PA 95	*Musa schizocarpa* NW Simmonds	Pisang Hutan	Papua
197	PA 103	*Musa schizocarpa* NW Simmonds	Pisang Hutan	Papua
198	II20C#1	*Musa balbisiana* Colla	Pisang Klutuk	Jawa Barat
199	II20C#2	*Musa balbisiana* Colla	Pisang Klutuk	Jawa Barat
200	PHD22	*Musa balbisiana* Colla	Pisang Klutuk	Jawa Barat
201	PHD97	*Musa balbisiana* Colla	Pisang Klutuk	Jawa Barat
202	PHD101	*Musa balbisiana* Colla	Pisang Klutuk	Jawa Barat
203	PHD106	*Musa balbisiana* Colla	Pisang Klutuk	Jawa Barat
204	P001	*Musa balbisiana* Colla	Pisang Klutuk	Bali
205	PAR62	*Musa balbisiana* Colla	Pisang Klutuk	Sulawesi Selatan
206	PAR63	*Musa balbisiana* Colla	Pisang Klutuk	Sulawesi Selatan
207	II18C#1	*Musa balbisiana* Colla	Pisang Klutuk Sukun	Yogyakarta
208	II18C#3	*Musa balbisiana* Colla	Pisang Klutuk Sukun	Yogyakarta
209	I3C#1	*Musa balbisiana* Colla	Pisang Klutuk Wulung	Yogyakarta