Current Huanglongbing status and management in Indonesia

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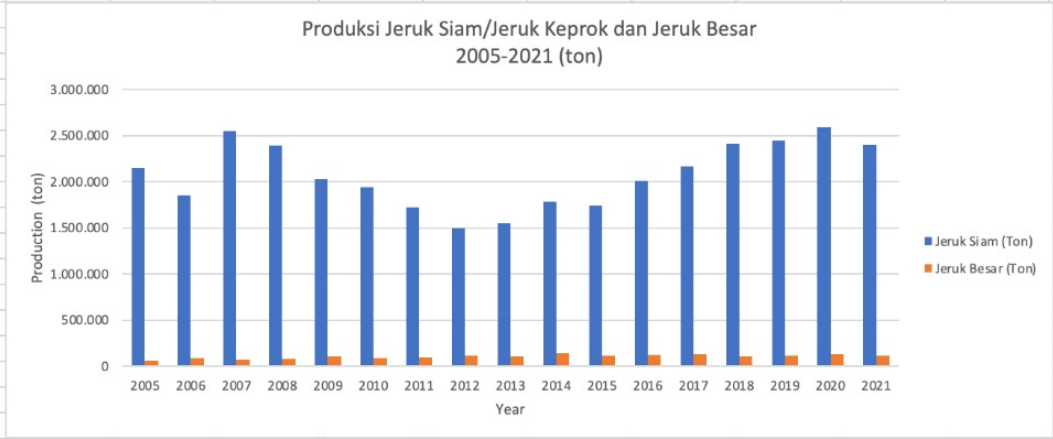
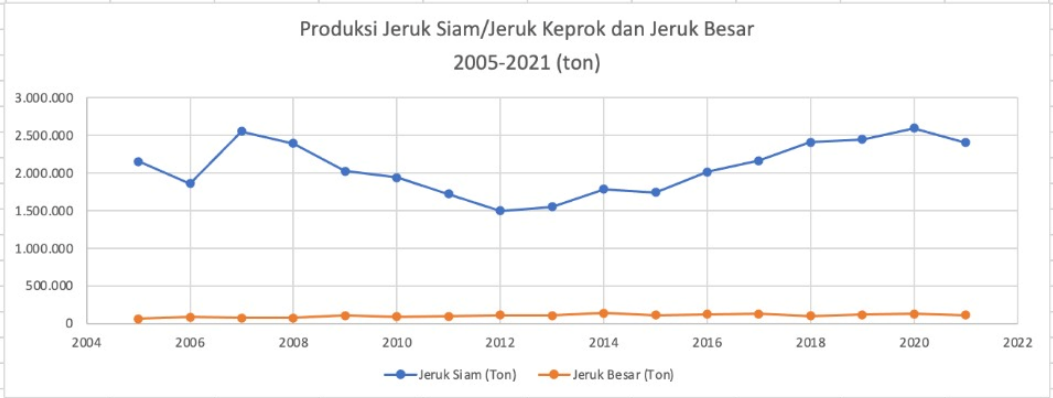
Citrus Production in Indonesia 2005 - 2021

No	Tahun	Jeruk Siam (Ton)	Jeruk Besar (Ton)
1	2005	2.150.219	63.800
2	2006	1.857.453	85.691
3	2007	2.551.635	74.249
4	2008	2.391.011	76.621
5	2009	2.025.840	105.928
6	2010	1.937.773	91.131
7	2011	1.721.880	97.069
8	2012	1.498.396	113.388
9	2013	1.548.401	106.344
10	2014	1.785.264	141.296
11	2015	1.744.393	111.753
12	2016	2.014.214	124.260
13	2017	2.165.189	130.130
14	2018	2.408.043	102.399
15	2019	2.444.518	118.972
16	2020	2.593.384	129.568
17	2021	2.401.064	112.797





The trend of citrus production in Indonesia is match with the trend of HLB development that the disease declines the production severely in 5 – 7 years

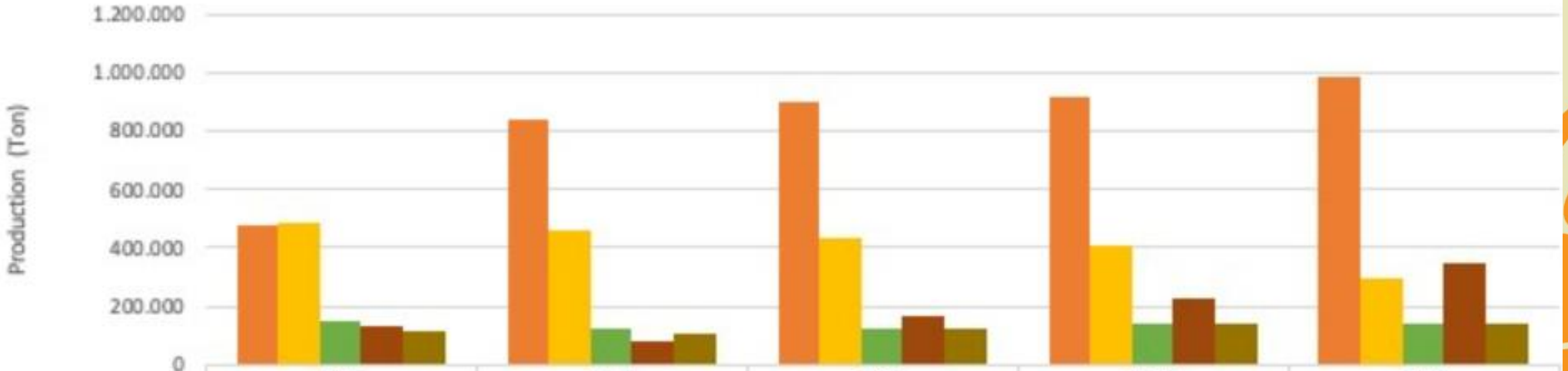
Citrus Productivity in Indonesia

1985 – 2009 : increasing from **8 to 20 ton**/h

2020 : Citrus orchards at 57.000 ha with 2,5 million ton production = **43.8 ton** /h

Now days : Farmers said 100 kg/tree/year means **60 ton**/ha at normal density planting system of 600 trees/ha

Top 5 Provinces of Citrus Production Centre at ≥ 100.000 ton per year from 2015 – 2019



	2015	2016	2017	2018	2019
East Java	480.935	837.369	898.279	918.679	985.455
North Sumatera	483.006	459.149	435.454	409.683	296.934
West Kalimantan	147.371	124.202	126.502	142.917	139.312
Bali	129.136	83.739	168.383	224.671	348.756
South Kalimantan	112.301	108.211	123.874	144.763	141.232

The highest production is in East Java where there was located the Indonesian Citrus and Subtropical Fruit Research Institute or now BRIN with great contribution on the management of National Citrus Production

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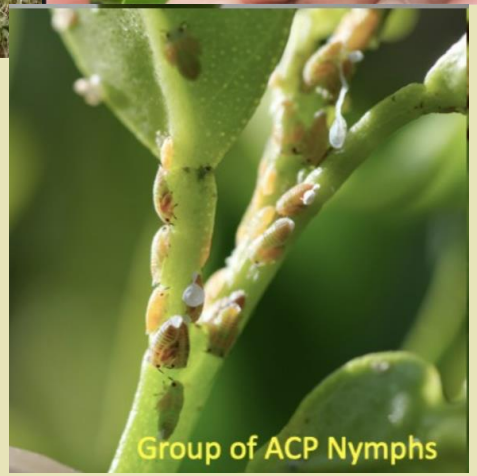
Favorable citrus varieties commonly cultivated in Indonesia

HLB in Indonesia

- In the citrus production centers there are small holder farms with less than 1 h land
- The small holder farmers distributed scattered in the area, using planting material that may not healthy but some with HLB infection
- Management of plant diseases and pests depend on the individual capital
- Due to the competition with HLB development mostly farmers cultivated early harvest cultivar: Siem mandarin/tangerine that can be produce fruit on the second year after planting of grafted seedlings
- Siem mandarin is HLB susceptible that may completely destroyed in about 7 years, however that period may have been profitable



Typical symptom and PCR confirmation of HLB infection is quite common found in many citrus orchards in Indonesia

HLB incidence/severity in Indonesia

- Nurhadi 2015 reported that

- 1940 : very severe
- 1990 : 62,34% citrus dead in Tulungagung East Java
- 1988-1996 : 60% citrus dead in Bali
- 2008 : 31% citrus in West Kalimantan declined
- 2020 in South Sulawesi HLB incidence : 17 – 35% with the severity 54% - 83% (Prida 2021)

The latest Survey of HLB in Indonesia in 2023 –ACIAR HORT 2019/164 (Dr. Achmad Himawan et al.)

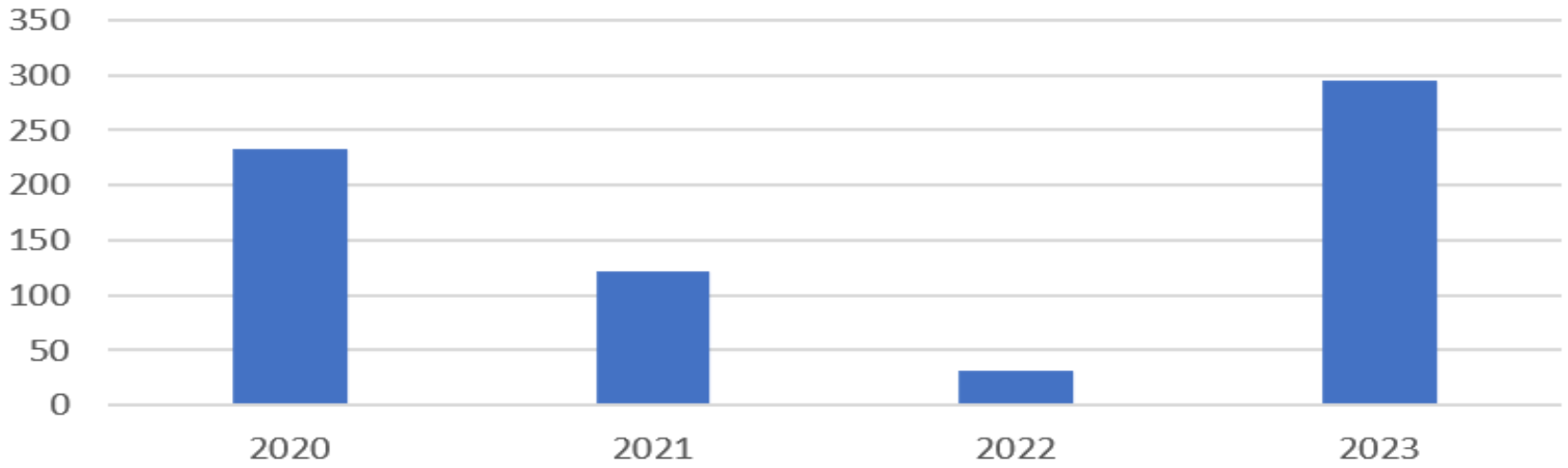
Location	Number of leaf samples	Number of leaf samples for PCR check	number of HLB positive sample	HLB positive samples (%)	ACP Status
Malang	5	5	2	**40**	No ACP
Jember	3	3	0	0	No ACP
Banyuwangi	5	5	1	**20**	Clas negative
Bengkulu	70	8 (composite)	0	0	**Clas negative**
West Kalimantan	96	96	22	**22,9**	**Clas positive**
Indramayu	26	10 (composite)	1	10	No ACP
Cianjur	38	8 (composite)	5	**62,5**	On process
Bali	36	36	0	0	No ACP

Directorate of Horticultural Crop Protection 2024

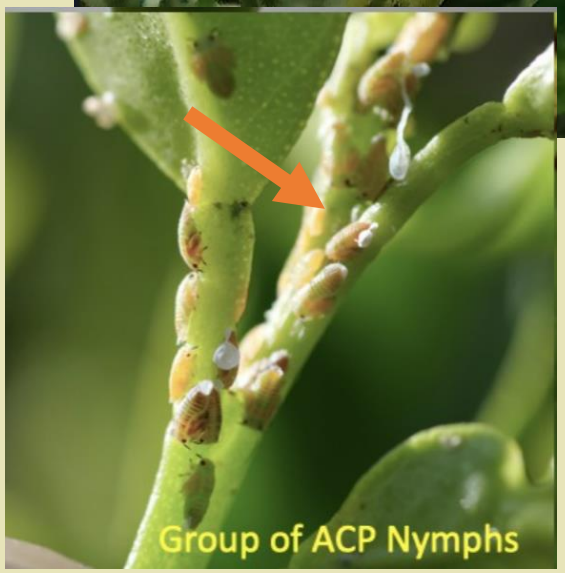
KAB/KOTA, PROVINSI	Sum of TOTAL LTS (Ha)
Bali	**5,00**
Kabupaten Buleleng	5,00
Bengkulu	**15,50**
Kabupaten Rejang Lebong	15,50
Jawa Timur	**217,60**
Kabupaten Malang	183,00
Kabupaten Jember	25,00
Kota Batu	6,00
Kabupaten Jombang	3,00
Kabupaten Tulungagung	0,60
Kalimantan Barat	**47,99**
Kabupaten Sambas	38,54
Kabupaten Mempawah	9,45
Kalimantan Selatan	**5,01**
Kabupaten Banjar	5,00
Kabupaten Tanah Laut	0,01
Lampung	**2,08**
Kabupaten Lampung Selatan	2,08
Sulawesi Tenggara	**1,50**
Kabupaten Konawe Selatan	1,50
Kabupaten Buton Selatan	0,00
Sumatera Selatan	**0,01**
Kabupaten Ogan Ilir	0,01
TOTAL LTS CVPD	294,69

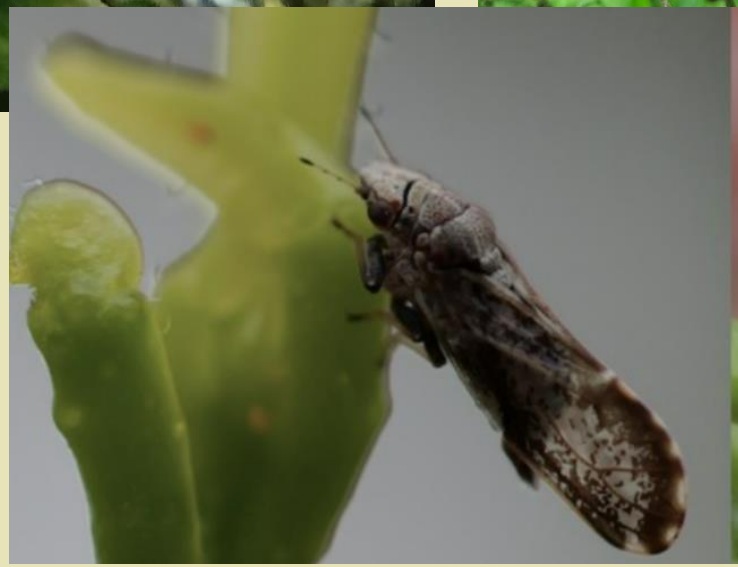
The Additional of HLB Infection in 2023

The Additional HLB Infection in Indonesia

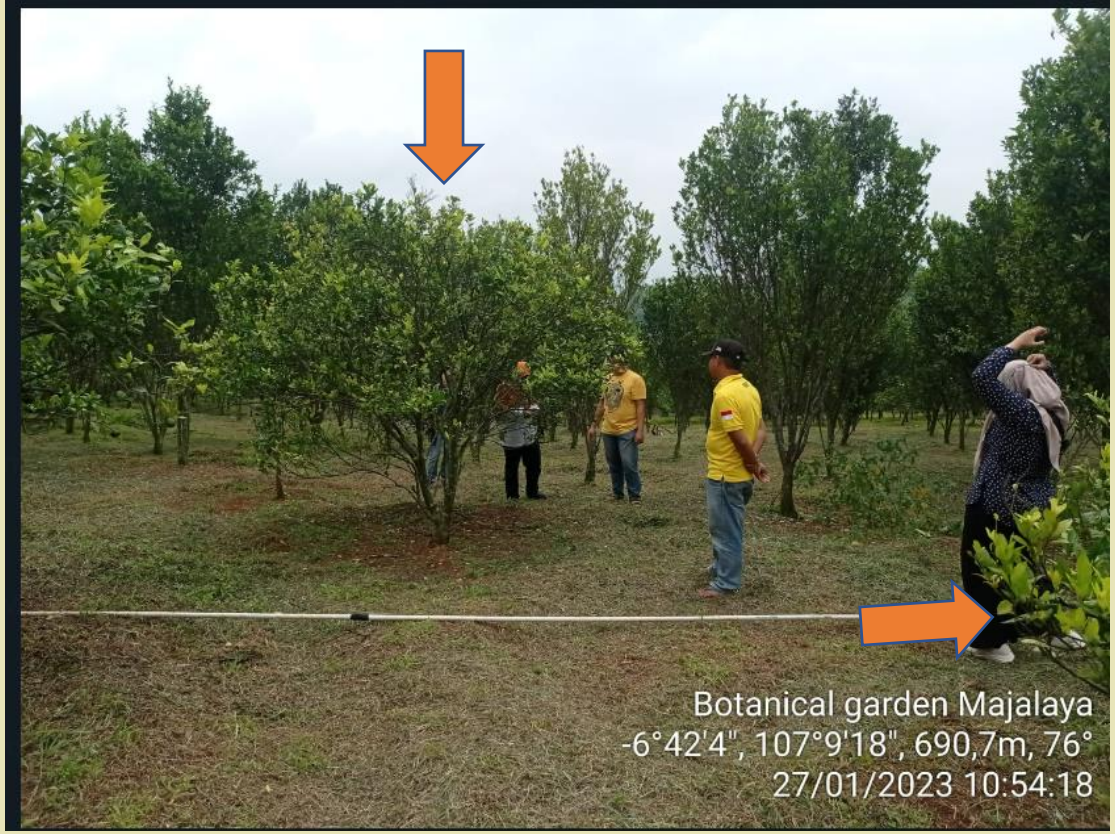


Tahun	LTS HLB/CVPD (Ha)
2020	233,47
2021	121,94
2022	31,82
2023	294,69





The infected trees and the psyllid vectors are found in the field, however; now days the psyllid population in citrus orchards is quite low due to intensive application of insecticides



HLB infected seedlings was planted among healthy seedlings, behave as the source of HLB inoculum with the availability of the psyllid vector causing the failure of production

Muraya paniculata fences

HLB symptom

The alternative host of the HLB psyllid vector and the pathogen is frequently found as ornamental plant or fences

Result

Table 1. List of *Murraya* spp. samples used for phylogenetic analysis and detection of CLas by PCR and qPCR

Code Sample	Source	Finding ACP	HLB detection*												Name based on result phylogenetic tree
			April 6th, 2022			May 20th, 2022			Dec 16th, 2022			June 1st, 2023			
			Las606/ LSS	Las931/ LSS (Ct)	SerraMetF /MetR (Ct)	Las606/ LSS	Las931/ LSS (Ct)	SerraMetF /MetR (Ct)	Las606/ LSS	Las931/ LSS (Ct)	SerraMetF /MetR (Ct)	Las606/ LSS	Las931/ LSS (Ct)	SerraMetF /MetR (Ct)	
25-P1 (p)	Purworejo								+	23,39	26,56	+	22,16	25,41	*M. paniculata*
25-P2 p	Purworejo								+	22,41	26,83	+	23,09	28,4	*M. paniculata*
12-FKG p	UGM	Y	+	22,32	25,51	+	22,73	26,33	+	21,53	25,64	+	22,31	25,67	*M. paniculata*
UGM1 p	UGM	Y	+	22,44	26,05	+	23,09	27,78	+	21,17	25,42	+	23,13	27,21	*M. paniculata*
13-UGM3 s	UGM	Y							+	28,89	33,28	+	24,07	30,84	*M. sumatrana*
18-UGM18 s	UGM	Y							-	33,91	36,26	-			*M. sumatrana*
27-TP s	UGM	Y							+	22,73	26,36	+	23,21	26,51	*M. sumatrana*
11-FPN s	UGM	Y	+	24,21	28,75	+	25,56	28,15	+	23,06	26,1	-	29,79	34,79	*M. sumatrana*
32-342BGR	BBG								-	35,71	38,63				*M. lucida*
33-349BGR	BBG								-	33,51	36,2				*M. sumatrana*
35-A345BGR	BBG								-	36,89	38,55				*M. sumatrana*
29-232BGR	BBG								-	32,21	35,26				*M. paniculata*
28-350BGR	BBG								-	34,14	38,09				*M. omphalocarpa*
BRB1	Borobudur	Y				+	21.73	25.54	+	22.56	26.82				*M. paniculata*
BRB2	Borobudur	Y				+	22.23	26.13	+	22.17	26.62				*M. paniculata*
BRB3	Borobudur	Y				+	24.75	30.29	+	23.72	29.92				*M. sumatrana*
Citrus reticulata cv. Siem	Purworejo		+	19,84	23,21	+	20	24,31	+	19,33	23,52	+	19,42	24,2	
Healthy M. sumatrana				0	0		0	0		0	0		0	0	
Healthy M. paniculata				0	0		0	0		0	0		0	0	
Rhizobium sp.				0	0		0	0		0	0		0	0	
Serratia sp.					0			0			0			0	

HLB in Muraya

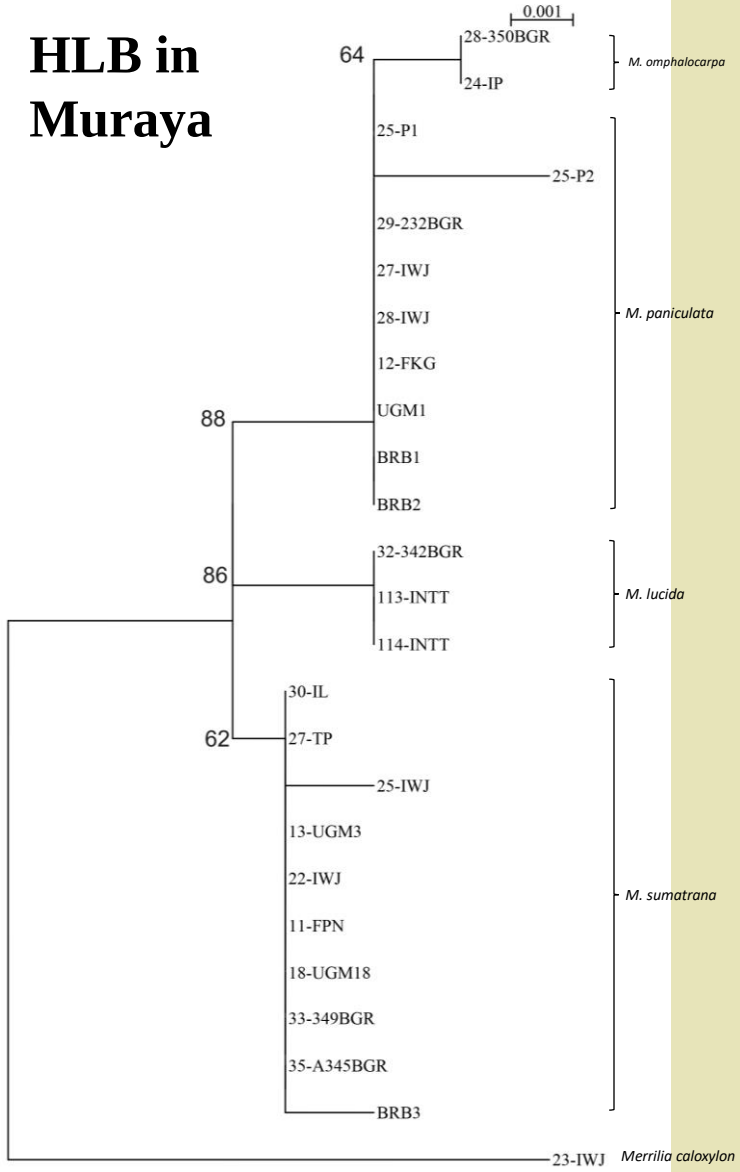


Fig 1. 50% majority-rule bootstrap consensus tree of the matK-5'trnK region of accessions of *Murraya* spp. derived from maximum parsimony analysis. *Merrilia caloxylon* was used as the outgroup. Bootstrap values are provided as percentages from 1000 replications.

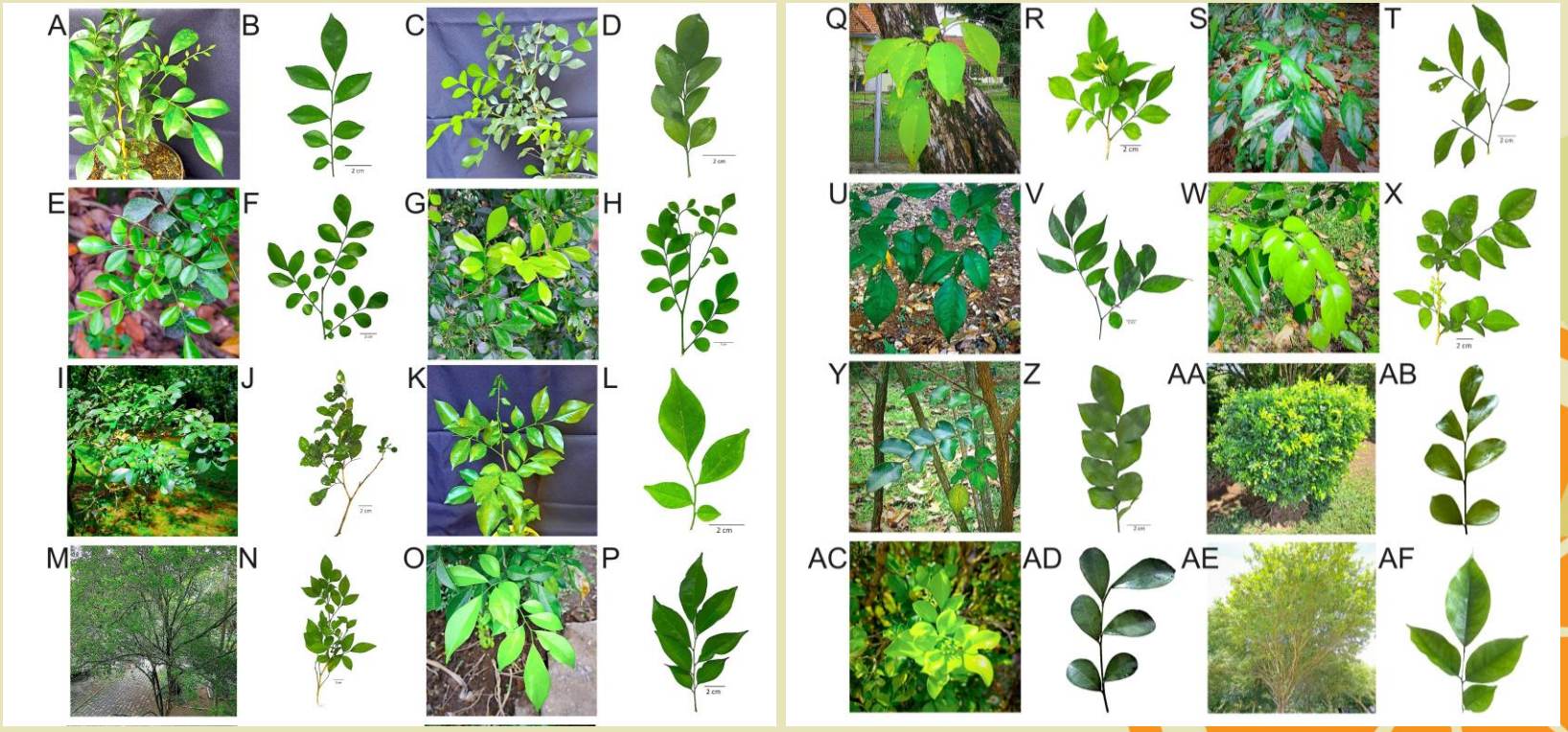


Fig 1. General performance of Murraya leaves. **A-B**: 25-P1; **C-D**: 25-P2; **E-F**:12-FKG; **G-H**: UGM1; **I-J**: 29-232BGR; **K-L**: 11-FPN; **M-N**: 27-TP; **O-P**: 13-UGM3; **Q-R**: 18-UGM18; **S-T**: 33-349BGR; **U-V**: 35-A345BGR; **W-X**: 28-350BGR; **Y-Z**: 32-342BGR; **AA-AB**: BRB1; **AC-AD**: BRB2; **AE-AF**: BRB3

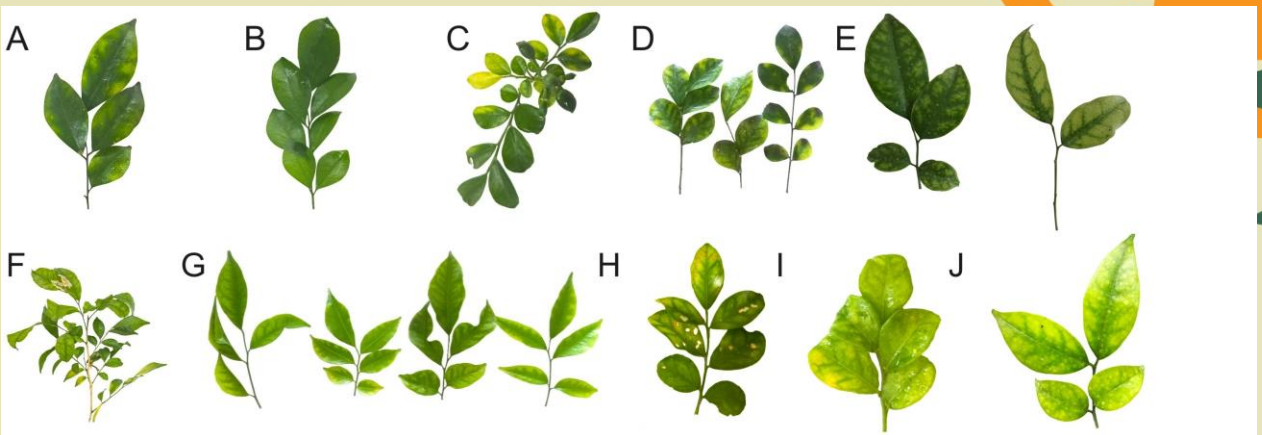


Fig 3. Yellowing blotching on Murraya spp. A: 25-P125-P1; B: 25-P2; C: 12-FKG; D: UGM1; E: 13-UGM3; F: 27-TP; G: 11-FPN; H: BRB1; I: BRB2: J: BRB3

Secure vs open area citrus nurseries and ““disease free certified” citrus seedlings

Scions and rootstock seedlings may kept in insect proof screen houses, however the grafted seedlings are acclimated in open land that not enough distance from HLB endemic orchards

HLB Management Practices in Indonesia

- Infected tree/orchard eradication : partially eradication is common with bad neighbors neglecting their orchards
- Few areas with totally eradication in good coordination of farmer groups
- Replanting with “certified or disease free” seedlings
- Intensive application of pesticides
- Insect trapping with insecticides
- Biological control maybe applied using natural enemies or PGPR
- IPM for disease management and growth/fruit production improvement

Pesticide Applications

Insecticides on Trapping Devices

Insecticide Spraying

Highly fruit production trees

Replanting with certified disease free seedlings

Good growth of replanting trees

Success Story

- Total eradication in the production center area followed by plant rotation for years with no Citrus
- Replanting using healthy certified seedlings
- Regular Pesticide Applications (at least 6 x/year)
- Regular monitoring on the HLB symptom appearance and early infected tree eradication
- Best health management through balance and regular applications of fertilizers, irrigation, pruning, additional rootstock planting, etc.
- Maintaining natural enemies
- Suitable commodities for interplanting citrus – cash crops

Irrigation/drainage canals in the orchard

Natural Enemy of Ent Colonies

Positive Activities Practices for managing plant health

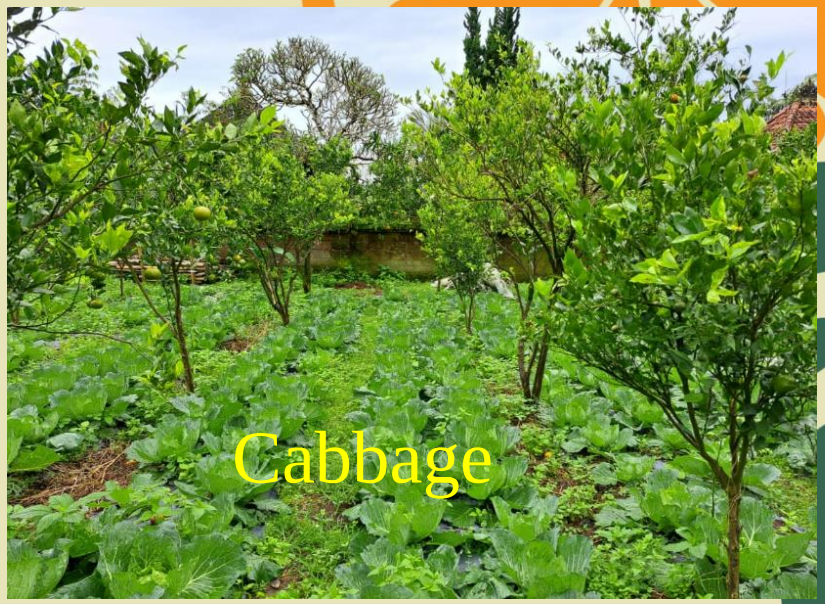
Additional Root Stock Planting

Successful citrus (Siam tangerine) production in Jember East Java, Indramayu West Java (Siam tangerine), Bengkulu (RGL mandarin)

Inter Cropping System of Citrus with Cash Crops

- Encouraging citrus farmers to increase additional income from the cash crops followed by improving citrus health management
- Encouraging citrus farmers to do horticultural business practices
- Ecological friendly activities for suppressing pests and diseases

Citrus – Cash Crop Intercropping



Intercropping of Citrus Mandarin and Ginger

The cash crop may contribute on suppressing the introduction of ACP into the orchards

In Bali

In East Java

Profitable cash crops that may produce VOC for ACP repellent

Horticultural Villages, a Government national program

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Economic Horticultural Area Corporation area

- **Gov subsidition**

✓ Planting Materials
✓ Fertilizers
✓ OPT Management
- Sustainable cultivation
✓ Post Harvest processing facilitation,
- Post harvest processing
✓ Registration of the Hort Village and product certification
✓ Capital loan, machinery, institution, and marketing support

ONE VILLAGE ONE VARIETY

5 HA

10 HA

- The availability of fresh and proceeded products
- Export product improvement
- Agrotouris Hortikultural crop development

Improvement of farmer lifehood

Abuscular Mycorhizal Fungi (AMF) Application

- AMF treatment was effective in increasing the growth of citrus plants from all rootstocks and rootstock/scion combination, and effectively reduced disease incidence and severity up to 11 months after AMF inoculation.
- *C. jambhiri* rootstock and *C. jambhiri/C. reticulata* gave the best responds to AMF treatment.

Rootstock resistance categories

Rootstock	Disease severity range (%)	Resistance categories
F. japonica cv. "Salam"	63.00-64.78	Susceptible
C. limonia	54.88-58.51	Susceptible
C. reshni	53.19-59.00	Susceptible
C. jambhiri	30.39	Moderately Susceptible

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Rootstock/scion resistance categories

Num	Grafting combination	Disease severity (%)	Resistance category
1	*F. japonica cv. "Salam/C.nobilis*	66.79	Susceptible
2	*C.reshni/ C reticulate*	46.68	Moderately susceptible
3	*C.limonia/C.nobilis*	43.74	Moderately susceptible
4	*C.reshni/C. nobilis*	43.41	Moderately susceptible
5	*F. japonica cv. "Salam"/C.reticulata*	42.02	Moderately susceptible
6	*C.limonia/C.reticulata*	38.44	Moderately susceptible
7	*C.jambhiri//C.nobilis*	33.25	Moderately susceptible
8	*C.jambhiri/C.reticulata*	33.15	Moderately susceptible

Journal of
Plant Protection Research

Original article

The feeding behavior of Diaphorina citri monitored using an electrical penetration graph (DC-EPG) on citrus plants treated with Bacillus cereus and Bacillus velezensis

Highlights

- Candidatus Liberibacter asiaticus, a phloem-limited bacteria, was transmitted by the Asian citrus psyllid Diaphorina citri
- The effect of Bacillus on citrus plant growth and the feeding behavior of Diaphorina citri was evaluated
- The application of Bacillus cereus and Bacillus velezensis enhanced plant resistance to stylet penetration of Diaphorina citri on the citrus phloem tissues

Keywords

Bacillus cereus, citrus, Bacillus velezensis, Diaphorina citri, electrical penetration graph

Abstract

Diaphorina citri, an important pest and insect vector that can transmit the pathogenic bacteria Candidatus Liberibacter asiaticus, causing Huanglongbing disease, is one of the challenges in citrus agriculture. Integrated pest management by utilizing microorganisms is a wise and efficient alternative without damaging the environment. Utilization of Plant Growth Promoting Rhizobacteria (PGPR), such as Bacillus cereus and Bacillus velezensis, is a potential strategy for the biological control of plant diseases or insect vectors. By inducing systemic resistance in plants, PGPR can enhance plant defense against diseases and insect pests while activating molecular and physiological changes in plants. This research aimed to determine the effect of B. cereus and B. velezensis on the plant growth and feeding behavior of D. citri. The height and volume of the plant canopy were observed periodically for six months, while the feeding behavior of D. citri was monitored using the Electrical Penetration Graph (DC-EPG). The results showed increased height and volume of the citrus plant canopy treated with B. cereus, indicating that B. cereus could act as a PGPR. The application of B. cereus and B. velezensis to citrus seedlings affected the feeding behavior of D. citri. D citri showed difficulty in penetrating the phloem tissue of citrus plants.

Manuscript under review at Journal of Plant Protection Research

PGPR Application for ACP suppression

Future Outlooks

- Plant Resistance Mechanisms
  - Physic
  - Sec Metabolite
  - Genetic
  - Etc

Thank you for attention and appreciation for ACIAR HORT 2019/164 and Horticulture Innovation Australia for research funding and ACC24 attending

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