Trailblazers in Science
Lecture Series by the National Scientists
October 17, 2017, Naval, Biliran

Soil properties as predictor for *suppressive* or *conducive* soils to PANAMA DISEASE

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BY LUISA CHESHIRE

Tuesday 12th January 2016, 23:54 Hong Kong

Philippines hit by Panama disease

Panama disease and El Niño are wiping out banana plantations in the Philippines

The Philippines' billion-dollar banana industry is losing plantations to disease and extreme weather, according to trade figures.

The Pilipino Banana Growers and Exporters Association (PBGEA) reported a loss of over 2,000ha in Mindanao during 2015, which represents 5.1 per cent of total banana acreage in the key growing region.

PBGEA executive director Stephen Antig told the SunStar newspaper that banana growers have suffered losses from Panama disease, as well as from the devastating effects of the El Niño weather pattern.

Mindanao's banana acreage fell from 44,479.65ha in 2014 to 42,316.41ha in 2015 as a result, he said. Production volumes also dropped between January and September 2015 to 85,324,491 boxes, compared with 90,147,480 boxes for the prior year period.

Stock Update As of	2GO		ABA	
10/13/2017 03:20 PM	35,400	-1.98%	120,000	-1.43%
	19.80		0.345	

Deadly disease puts Philippines banana industry under threat

By Eva Visperas (The Philippine Star) | Updated March 20, 2016 - 12:00am

DAVAO CITY, Philippines – A total of 15,500 hectares of banana plantations have been affected by the deadly Fusarium wilt disease in Southern Mindanao, posing a serious threat to food security and economic welfare.

This fungus, recognized as among the most destructive diseases of the banana worldwide, causes wilting and mass plant die-offs.

Virgilio Gutierrez, focal person of the Department of Agriculture Davao Region, said there are at least 700 farmers who have been affected by the Fusarium wilt disease.

Davao del Norte was the most affected province followed by Compostela Valley, Davao City, Davao del Sur

Disease could wipe out cavendish bananas–PBGEA

By **Mary Grace Padin** - May 3, 2016

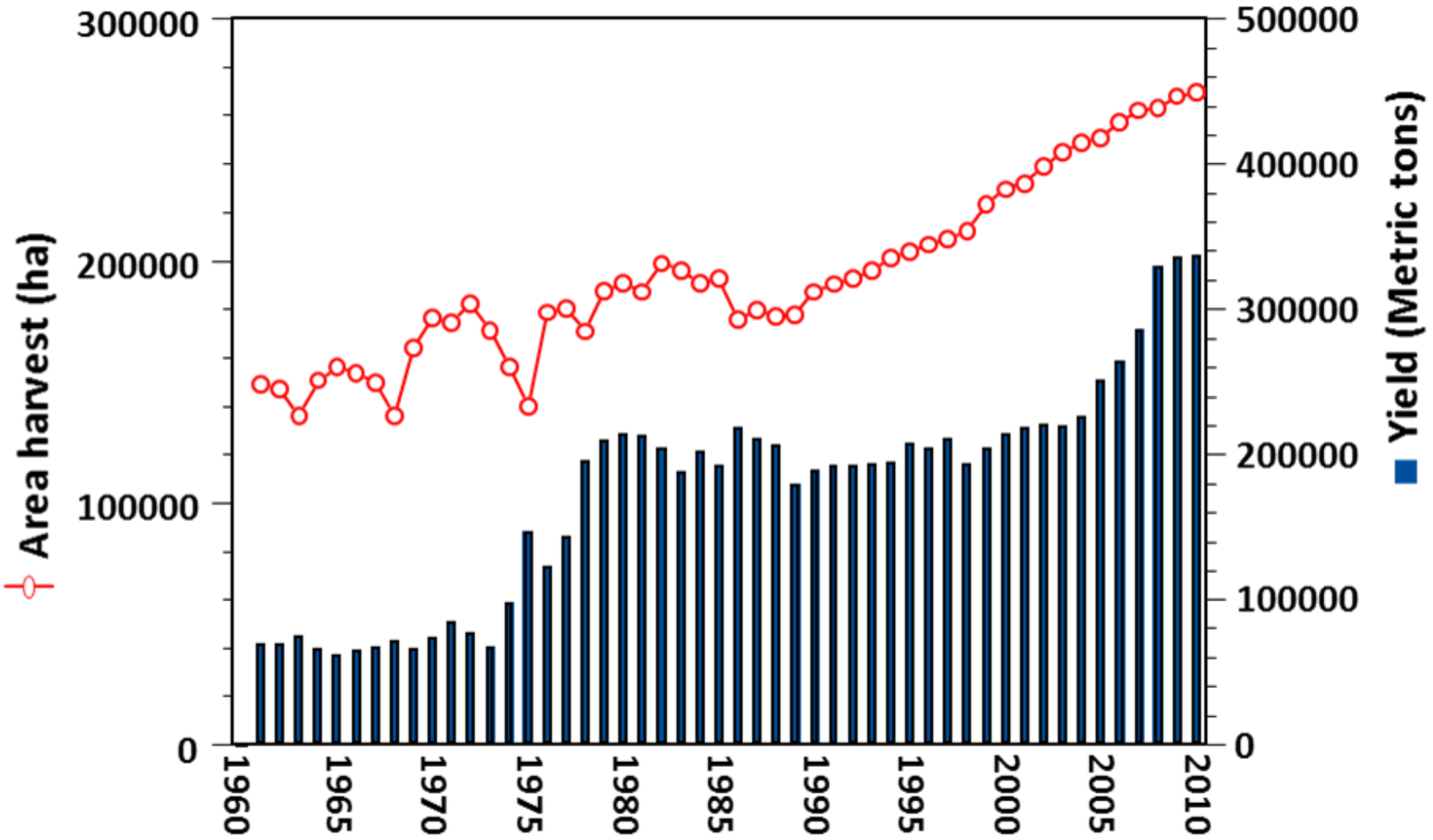
The infestation of Panama disease or fusarium wilt in banana plantations, if not immediately controlled, could wipe out local cavendish bananas, banana growers and exporters said on Tuesday.

Pilipino Banana Growers and Exporters Association (PBGEA) Executive Director Stephen Antig said the disease keeps growers and exporters on their toes.

"The industry is definitely worried that the cavendish variety might become obsolete," Antig told the BusinessMirror in an interview.

Citing data from the Department of Agriculture (DA), Antig said about 15,500 hectares of banana plantations, mostly in Region 11, have already been affected by the disease.

Area harvested & yield of banana in the Philippines



FAO Stat 2016

Cavendish variety

Bananagedon (Panama disease)

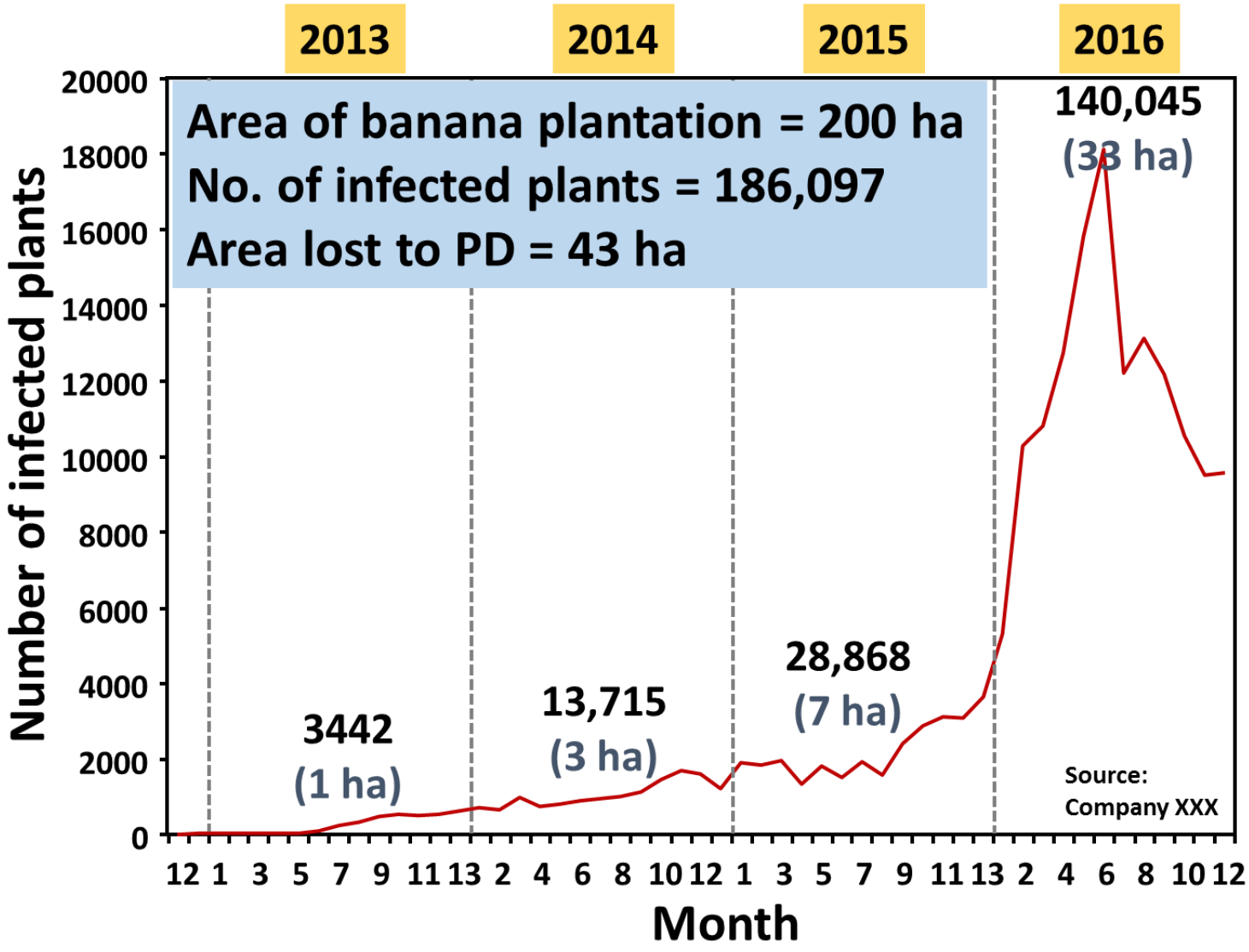
Thousands of hectares of plantations have been wiped out in China, Indonesia, Malaysia and in the Philippines.

Bananagedon (Panama disease)

- soil-borne fungus (***Fusarium oxysporum f.sp. cubense***)
- Fungal spores can survive in soils for several decades [1], thus, susceptible banana varieties of the disease cannot be planted successfully for up to 30 years [2].

[1] Ploetz & Correll, 1988; [2] Stover, 1993

Panama Disease (PD) infestation



Dr. Alfredo Locerona Farm - Kapalong

e 0.6 to 0.8 BSR 75% small hands

After IBG application 1.8 BSR 95% big hands

GOOD NEWS

IBG can finally contain diseases after years of research.
Treatment by IBG technicians recommended

Banana Disease Control

•Panama•Moko•Bunchy Top, etc.

Upon opening of container in China,
No SGRT with IBG bananas in
cold room storage, IBG bananas
can be kept fresh for 60 days.

到中国开柜以后
IBG香蕉没有青软
冷藏保存60天依然新鲜。

Rice

- 6-10 tons per harvest recovery rate 75-78%
- No tungro disease • No fungicide needed

Research gaps…

- **No known method** is available to control and/or eradicate PD.
- PD spread is high (conducive) in other soils, while others are not (suppressive).
- Soil condition is important in the course of its infection.
- Knowledge of soil characteristics is fundamental to ***planning suitable management strategies for the control of PD.***

Working hypotheses (WH)…

WH 1. Suppressive and conducive soils to PD have different soil physical and chemical properties

WH2. High OM and total N in soils is conducive to PD infestation

Study sites

0 0.25 0.5 1
Kilometers

San Jose

0 0.25 0.5 1
Kilometers

N

0 0.15 0.3 0.6
Kilometers

Maribulan

0 0.15 0.3 0.6
Kilometers

References: Satellite Images of San Jose and Maribulan taken from Google Earth, Mindanao map taken from NAMRIA, coordinates taken with GPS

Legend

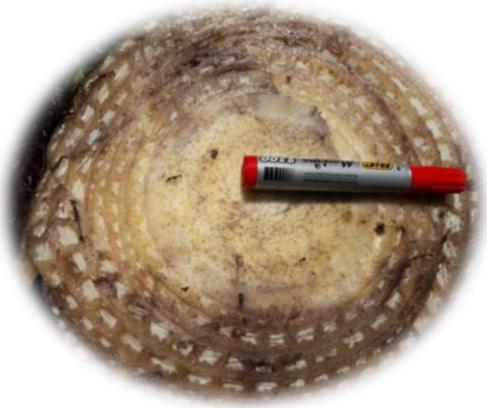
FOC Positive Sampling Site

FOC Negative Sampling Site

Site 1 (Maribulan, Alabel General Santos)

(-) Suppressive

(+) Conducive



Site 2 (San Jose, Alabel General Santos)

(-) Suppressive

(+) Conducive

WH 1

Suppressive & conducive soils to PD have different physical properties

Sample	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Soil texture class*
Maribulan, General Santos					
Supressive (*n=5*)	0-10	44 (5)	28 (3)	28 (4)	Clay loam
Conducive (*n=5*)	0-10	48 (3)	26 (1)	26 (3)	Sandy clay loam
Supressive (*n=5*)	10-30	41 (5)	28 (2)	31 (3)	Clay loam
Conducive (*n=5*)	10-30	44 (4)	26 (2)	30 (3)	Clay loam
Supressive (*n=5*)	30-50	39 (3)^{b}	27 (1)^{a}	34 (2)	Clay loam
Conducive (*n=5*)	30-50	44 (4)^{a}	23 (2)^{b}	33 (2)	Clay loam
San Jose, General Santos					
Suppressive (*n=9*)	0-10	65 (6)^{b}	22 (8)	12 (7)	Sandy loam
Conducive (*n=9*)	0-10	70 (3)^{a}	19 (4)	11 (3)	Sandy loam
Suppressive (*n=9*)	10-30	64 (5)^{b}	22 (7)^{a}	13 (6)	Sandy loam
Conducive (*n=9*)	10-30	73 (4)^{a}	16 (3)^{b}	11 (3)	Sandy loam
Suppressive (*n=9*)	30-50	63 (9)^{b}	24 (9)^{a}	13 (4)	Sandy loam
Conducive (*n=9*)	30-50	72 (4)^{a}	15 (3)^{b}	13 (2)	Sandy loam

Different letter superscripts on same properties and depth indicate significant differences at $p<0.05$

Values in parentheses are standard deviations

*USDA classification

WH 1

Suppressive & conducive soils to PD have different chemical properties

Sample	Depth (cm)	pH (water)	OM (%)	Avail P (mg/kg)	Exchangeable bases (cmol/kg) Ca	Mg	Na	K	CECpH 7 (cmol/kg)
Maribulan, General Santos									
Supressive (*n=5*)	0-10	6.4 (0.2)	**1.2 (0.3)^{b}**	**11.4 (7.5)^{b}**	**26.1 (5.2)^{a}**	**7.4 (0.4)^{a}**	**1.0 (0.1)^{a}**	**3.7 (1.6)^{b}**	18.1 (1.2)
Conducive (*n=5*)	0-10	6.2 (0.2)	**1.8 (0.4)^{a}**	**40.2 (14.3)^{a}**	**18.9 (1.3)^{b}**	**5.8 (1.0)^{b}**	**0.6 (0.2)^{b}**	**9.6 (2.7)^{a}**	18.1 (0.9)
Supressive (*n=5*)	10-30	**6.5 (0.3)^{a}**	1.1 (0.3)	**12.6 (11.9)^{b}**	**24.4 (2.4)^{a}**	**7.4 (0.4)^{a}**	1.7 (1.7)	**2.6 (0.8)^{b}**	17.2 (1.1)
Conducive (*n=5*)	10-30	**6.0 (0.3)^{b}**	1.4 (0.2)	**31.0 (4.4)^{a}**	**18.9 (1.3)^{b}**	**6.7 (0.3)^{b}**	0.6 (0.1)	**4.8 (0.9)^{a}**	16.5 (1.2)
Supressive (*n=5*)	30-50	6.3 (0.3)	1.0 (0.1)	13.6 (6.1)	**23.7 (2.2)^{a}**	7.3 (0.6)	0.9 (0.1)	2.0 (0.4)	17.2 (1.3)
Conducive (*n=5*)	30-50	6.1 (0.1)	1.2 (0.3)	26.0 (6.1)	**19.9 (2.0)^{b}**	7.3 (0.4)	1.3 (1.1)	2.6 (0.5)	17.8 (1.7)
San Jose, General Santos									
Suppressive (*n=9*)	0-10	6.7 (0.5)	**1.3 (0.5)^{b}**	7.1 (3.8)	5.4 (2.2)	1.1 (0.6)	0.6 (0.2)	0.7 (0.7)	4.7 (1.5)
Conducive (*n=9*)	0-10	6.3 (0.5)	**2.4 (0.8)^{a}**	10.7 (7.4)	7.3 (2.4)	2.8 (2.5)	0.4 (0.2)	0.9 (0.5)	3.5 (1.2)
Suppressive (*n=9*)	10-30	6.2 (0.7)	**1.2 (0.3)^{b}**	4.7 (1.2)	4.7 (1.7)	1.3 (0.6)	**0.8 (0.3)^{a}**	0.4 (0.3)	**5.1 (1.2)^{a}**
Conducive (*n=9*)	10-30	6.1 (0.5)	**1.7 (0.5)^{a}**	6.1 (2.7)	5.4 (1.2)	1.5 (0.4)	**0.5 (0.2)^{b}**	0.7 (0.4)	**2.9 (1.5)^{b}**
Suppressive (*n=9*)	30-50	6.2 (0.6)	**1.0 (0.4)^{b}**	3.8 (1.6)	4.5 (2.2)	1.3 (0.4)	0.9 (0.5)	0.3 (0.1)	**4.4 (0.7)^{a}**
Conducive (*n=9*)	30-50	6.0 (0.4)	**1.4 (0.3)^{a}**	3.7 (1.2)	4.6 (0.8)	1.4 (0.4)	0.9 (1.2)	0.5 (0.3)	**2.9 (1.2)^{b}**

Different letter superscripts on same properties and depth indicate significant differences at $p < 0.05$

Values in parentheses are standard deviations

WH 1

General trends

Sample	Depth (cm)	pH (water)	OM (%)	Avail P (mg/kg)	Exchangeable bases (cmol/kg) Ca	Mg	Na	K	CECpH 7 (cmol/kg)
Maribulan, General Santos									
Supressive (*n=5*)	0-10	6.4 (0.2)	**1.2 (0.3)^{b}**	**11.4 (7.5)^{b}**	**26.1 (5.2)^{a}**	**7.4 (0.4)^{a}**	**1.0 (0.1)^{a}**	**3.7 (1.6)^{b}**	18.1 (1.2)
Conducive (*n=5*)	0-10	6.2 (0.2)	**1.8 (0.4)^{a}**	**40.2 (14.3)^{a}**	**18.9 (1.3)^{b}**	**5.8 (1.0)^{b}**	**0.6 (0.2)^{b}**	**9.6 (2.7)^{a}**	18.1 (0.9)
Supres									(1.1)
Condu									(1.2)
Supres									(1.3)
Condu									(1.7)
Suppre									(1.5)
Condu									(1.2)
Suppressive (*n=9*)	10-30	6.2 (0.7)	**1.2 (0.3)^{b}**	4.7 (1.2)	4.7 (1.7)	1.3 (0.6)	**0.8 (0.3)^{a}**	0.4 (0.3)	**5.1 (1.2)^{a}**
Conducive (*n=9*)	10-30	6.1 (0.5)	**1.7 (0.5)^{a}**	6.1 (2.7)	5.4 (1.2)	1.5 (0.4)	**0.5 (0.2)^{b}**	0.7 (0.4)	**2.9 (1.5)^{b}**
Suppressive (*n=9*)	30-50	6.2 (0.6)	**1.0 (0.4)^{b}**	3.8 (1.6)	4.5 (2.2)	1.3 (0.4)	0.9 (0.5)	0.3 (0.1)	**4.4 (0.7)^{a}**
Conducive (*n=9*)	30-50	6.0 (0.4)	**1.4 (0.3)^{a}**	3.7 (1.2)	4.6 (0.8)	1.4 (0.4)	0.9 (1.2)	0.5 (0.3)	**2.9 (1.2)^{b}**

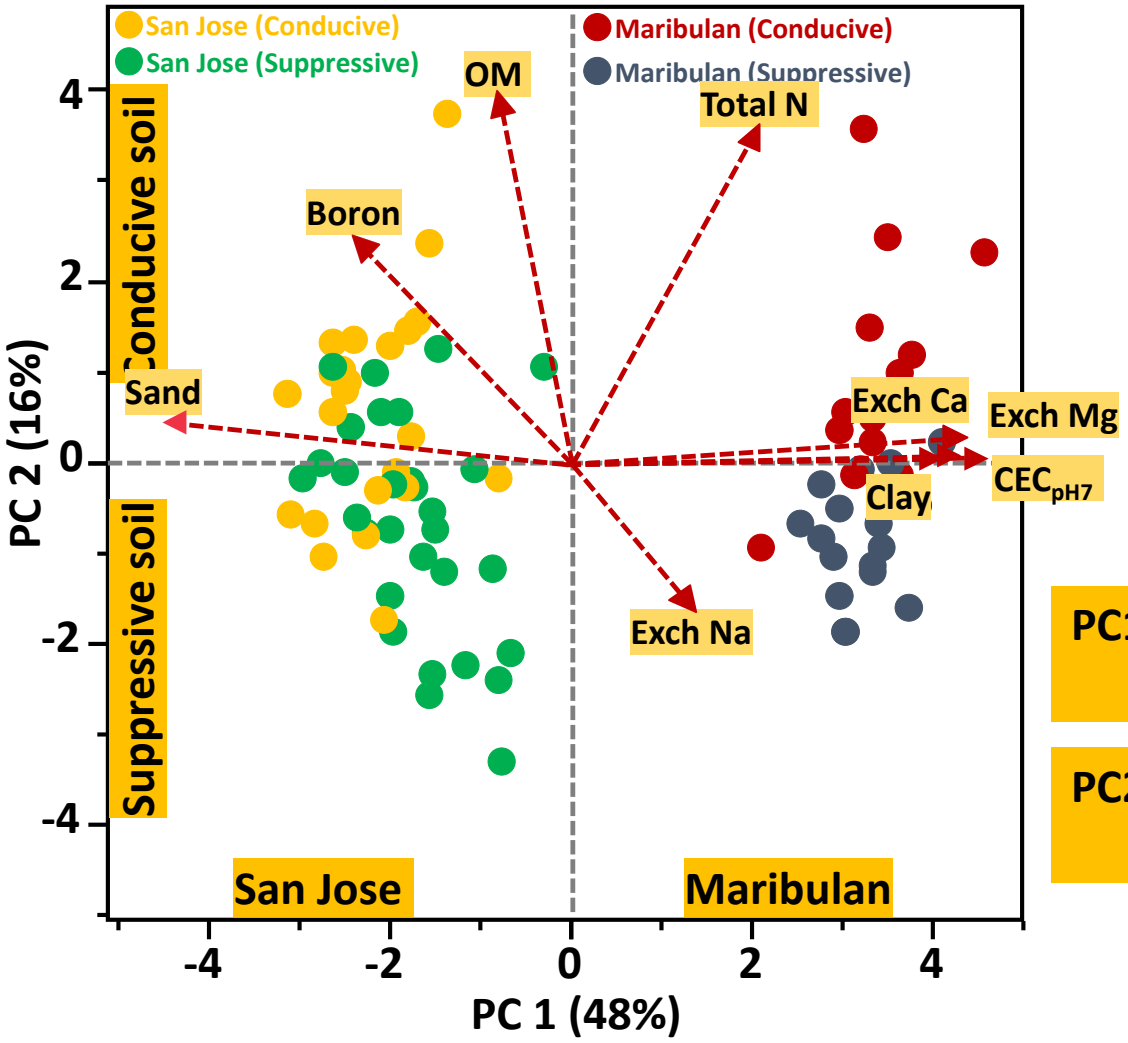
Different letter superscripts on same properties and depth indicate significant differences at $p < 0.05$

Values in parentheses are standard deviations

Samples	pH	OM	Total N	Avail P	K	Na
Conducive	↓	↑	↑	↑	↑	↓
Suppressive	↑	↓	↓	↓	↓	↑

WH 2

Principal components (PC) extracted from the principal component analysis (PCA) of all selected properties



Eigenvectors

	Prin1	Prin2
pH	0.01587	0.00352
Avail P	0.27506	0.26682
Ca	0.37450	0.00347
Mg	0.36730	-0.02045
Na	0.10911	-0.26063
K	0.29062	0.23035
CEC	0.39301	-0.02395
OM %	-0.05292	0.59718
sand	-0.37520	0.10710
silt	0.23611	-0.14898
clay	0.35789	-0.04777
Total N (%)	0.18534	0.52806
B (ppm)	-0.19063	0.36795

PC1: (+): CEC, Exch Ca, Exch Mg, clay
(-): Sand

PC2: (+): OM, Total N, Boron
(-): Exch Na

Conclusion……..

Working hypothesis	Yes/No	Remarks
WH 1: Suppressive & conducive soils have different soil physical & chemical properties	Yes	Suppressive soils: **Exch Na** Conducive soils: **OM, Total N, Boron**
WH2: High OM and total N in soil is conducive to PD infestation	Yes	Important soil properties: **OM, Total N, Boron**

Soil properties can be used as proxies in predicting suppressive and conducive soils to PD.

Future directions…

1. **Microbial communities** between rhizosphere and non-rhizosphere soils and between suppressive and conducive soils.
   - soil metagenomics studies

2. **Role of sodium** in the suppression of PD and its impact to soil fertility
   - field and laboratory experiments (need collaborator from Mindanao)

May contribute to the understanding of PD and its control