Physicochemical and Microbiological Properties of Amazonian Soils under Intensive Crop System

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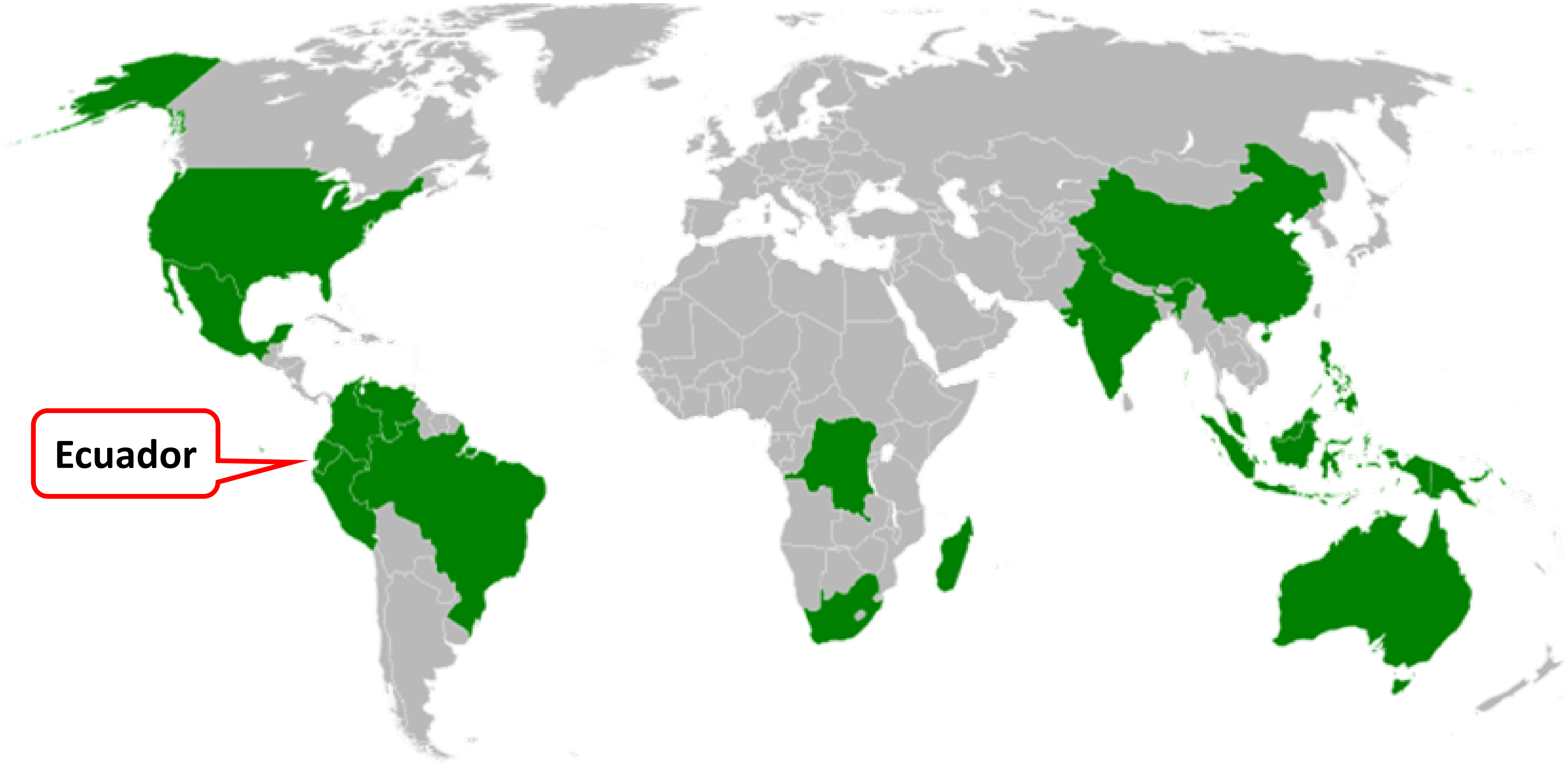
Diversification: key for sustainability

Industrialized agriculture:
- Specialization of the monoculture of more economically productive species.
- Supported by the use of agrochemicals, mechanization and genetically modified crops.

Lead to:
- Lost of farmers autonomy.
- Environmental problems have been generated in the agroecosystem, which finally have an impact on global productivity.

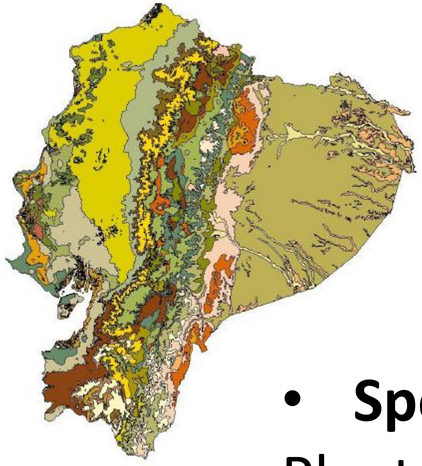
Biodiversity is the base for sustainable development
***Convention on Biological Diversity* (2020)**

Diversification: key for sustainability



United Nations Environment Program's World Conservation Monitoring Center (2019)

Megadiversity of Ecuador



- **<u>Biodiversity</u>**
  There are 46 different ecosystems

- **Species**:

Plants: 25 000
Reptiles: 483
Amphibians: 629
Mammals: 440
Birds: 1 690
Microorganisms
Ecosystem services

Importance of pitahaya as a diversifier crop

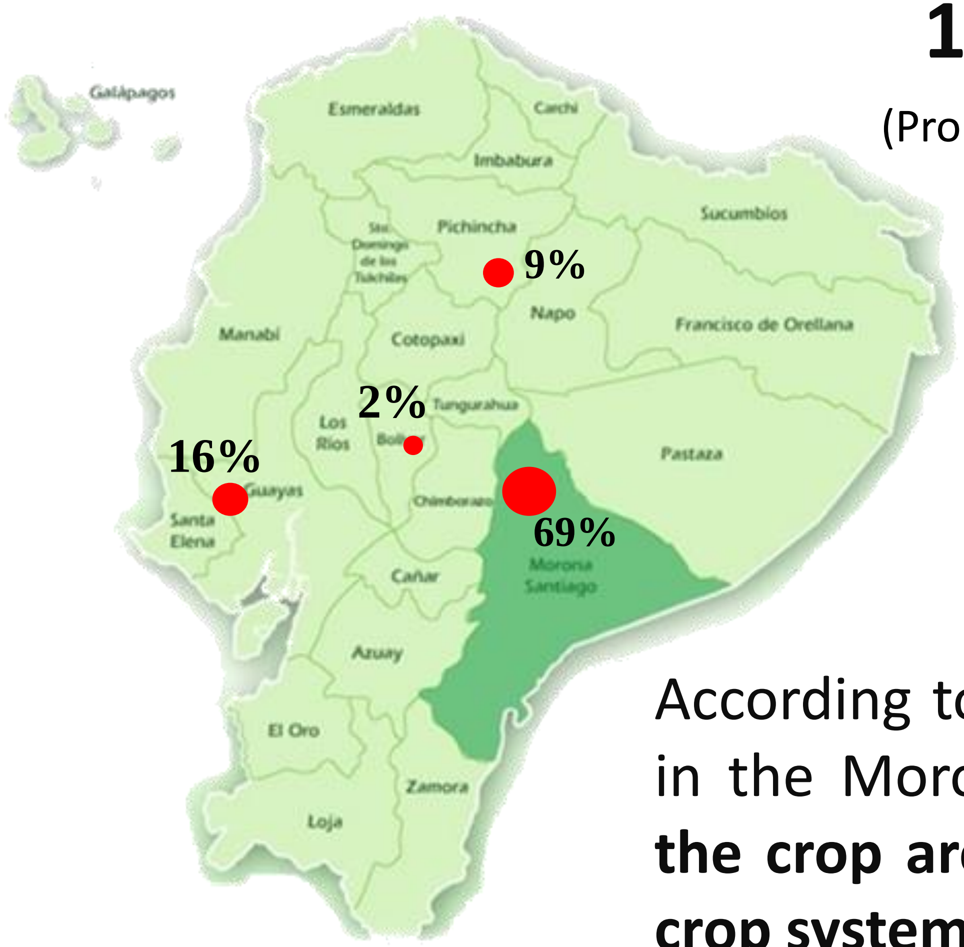
The Ecuadorian Amazon represents **43%** of the national territory

It has **605 052 ha (11.8%)** of its surface for agricultural use

Importance of pitahaya as a diversifier crop

- **Adaptation to Amazonian climates:**
  Poor soils with very low pH.
- **High yields per area:**
  From 10-15 $t\ ha^{-1}$.
- **Medicinal and nutritional properties:**
  Antioxidants, laxatives, stimulates the immune system, prevents degenerative diseases, proteins, vitamins (C), and minerals.
- **High economic returns:**
  $ 40-45 million USD per year.
- **Easy markets:**
  Stable commercialization to more than 4 continents.

Importance of pitahaya as a diversifier crop

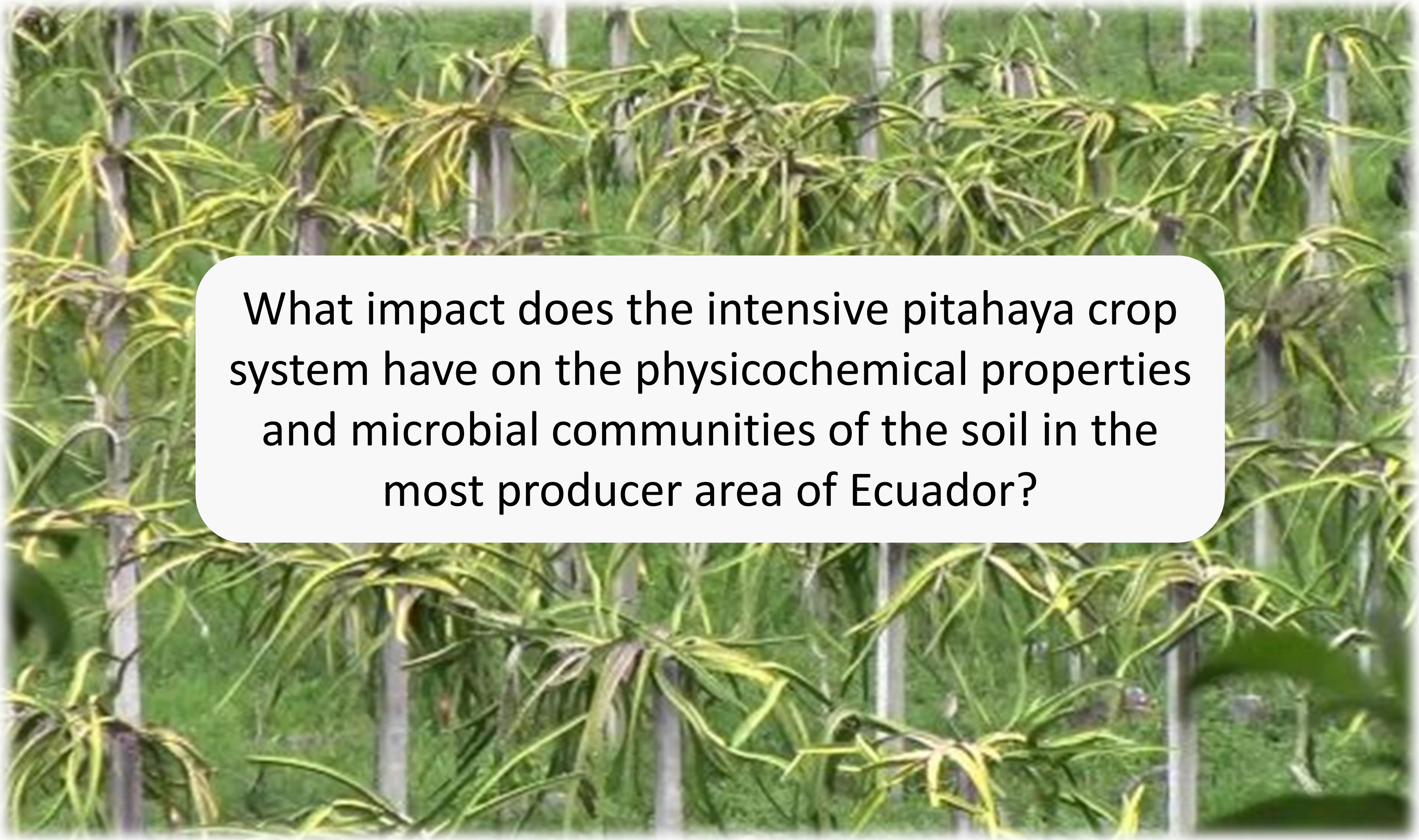


1 737 ha

(ProEcuador, 2018)

According to the 1st census of pitahaya (MAG, 2019), in the Morona Santiago province about **2 000 ha of the crop are planted, most of them under intensive crop system.**

Importance of pitahaya as a diversifier crop



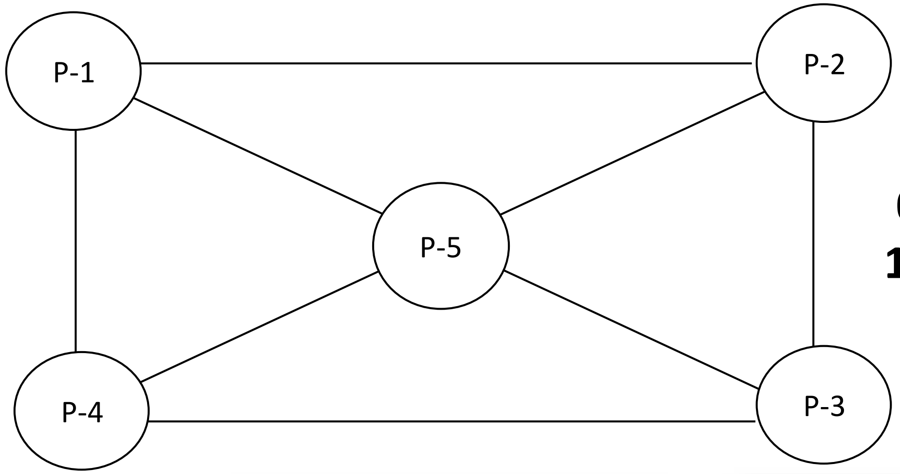
What impact does the intensive pitahaya crop system have on the physicochemical properties and microbial communities of the soil in the most producer area of Ecuador?

Objectives

To determine the effect of pitahaya (*Hylocereus triangularis*) intensive crop system on physicochemical properties and microbiological parameters of Amazonian soils.

Experimental área: soil sampling

5 composite samples in 3,5 ha for each crop



Depths
0 - 10 cm
10 - 30 cm

Pitahaya

Tea

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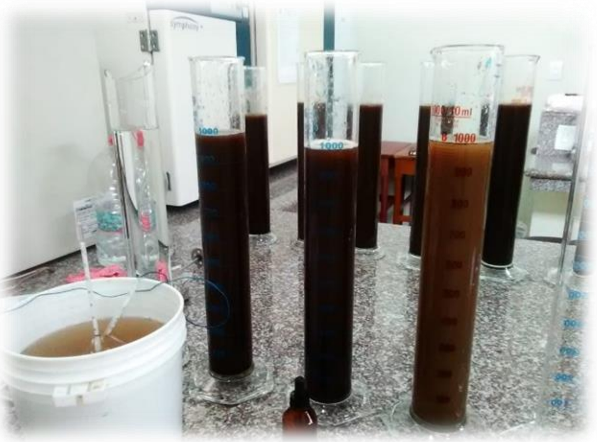
Soil samples analyses

Physical properties



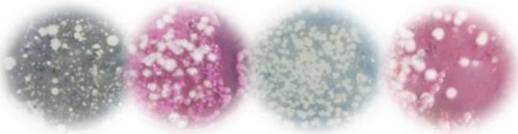
- **Texture:** hydrometer method of BOUYOUCUS, (Burt, 2004).
- **Apparent density:** metal cylinder method (Kiessling, 2012).
- **Saturated hydraulic conductivity:** variable load method (Gabriels, Lobo y Pulido; 2013).
- **Distribution of pore sizes:** tension table method (Bravo *et al.*, 2017).

Chemical properties

- **Soil organic matter (OM):** calcination, (Schulte y Hopkins, 1996).
- **Soil pH:** Potentiometer method (López y Zamora, 2016).
- **Exchangeable aluminum and acidity:** titration method with NaOH (Kenyi y Rodríguez, 2017).
- **% total nitrogen (TN):** Kjeldahl method, (CHEMILAB, 2015).
- **Exchangeable bases (Ca, Mg, K y P):** Olsen modificado, (Bravo, 2015).

Microbiological indicators

- **Quantification of bacterial and fungal communities:** Colony Forming Units (CFU), quantitative dilutions and plating in Petri dishes (Chandrapati y Williams, 2014).
- **Microbial growth kinetics:** 24h, 48h, 72h, 7 days.
- **Microbial diversity:** Simpson index (D_{Si})
  Shannon index ($H´$)



Effect on soil texture

Table 1. Soil texture under crop systems (pitahaya and tea).

Crop system	Sand (%)	Silt (%)	Clay (%)	Textural class
		Depth 0-10 cm		
Pitahaya	49,4±6.57	28.0±1.58	16,6±2.76	Sandy loam
Tea	58±1.37	30,8±0.86	11,2±1.15	Sandy loam
		Depth 10-30 cm		
Pitahaya	57,6±8.45	29,6±1.93	6,8±0.96	Sandy loam
Tea	62,2±4.58	25,2±2.61	12,6±2.50	Sandy loam

No significant differences (p <0.05) for the variables evaluated were shown.

Soil samples analyses

Table 2. Physical soil properties under crop systems (pitahaya and tea).

Sistema de cultivos	Ad ($mg*m^{-3}$)	K_{sat} ($cm*h^{-1}$)	Tp (%)	Ap (%)	Rp (%)
	Depth 0 - 10 cm				
Pitahaya	0,41±0.06	25.86±21.87	91,05±21.76	24,21±8.59	87,04±13.20
Tea	0,32±0.007	15,61±6.05	86,14±2.25	17,10±3.21	69,04±3.41
	Depth 10 - 30 cm				
Pitahaya	0,38±0.01	0,36±0.15	87,32±0.89	8,51±0.27	78,81±0.83
Tea	0,33±0.02	0,10±0.01	89,72±1.54	7,84±0.38	81,88±1.22

No significant differences ($p < 0.05$) for the variables evaluated were shown.

Ad: apparent density, K_{sat}: saturated hydraulic conductivity, Tp: total porosity, Ap: aeration porosity, Rp: retention porosity.

Soil samples analyses

Table 3. Chemical soil properties under crop systems (pitahaya and tea).

Properties	Crop systems: Pitahaya (Depth 0-10 cm)	Crop systems: Tea (Depth 0-10 cm)	
pH	5,06±0.13	4,90±0.09	low
Al+H	1,14±0.24	1,5±0.23	high
Al^{+}	0,42±0.07	0,54±0.10	low
% TN	**0,55b±0.02**	**0,71a±0.02**	medium
P	6,14±1.76	8,10a±1.25	low
K^{+1}	0,19±0.21	0,16±0.03	low
Ca^{+2}	1,47±0.81	0,54±0.04	low
Mg^{+2}	0,37±0.07	0,29±0.02	low
% OM	**27,06b±1.42**	**33,3a±1.73**	high

Properties	Crop systems: Pitahaya (Depth 10-30 cm)	Crop systems: Tea (Depth 10-30 cm)	
pH	5,16±0.08	4,93±0.08	low
Al+H	0,68±0.15	0,84±0.06	high
Al^{+}	0,32±0.07	0,38±0.04	low
% TN	**0,79a±0.07**	**0,50b±0.21**	medium
P	3,54±1.60	2,42b±0.37	low
K^{+1}	0,19±0.04	0,09±0.01	low
Ca^{+2}	0,81±0.23	0,34±0.03	low
Mg^{+2}	0,19±0.006	0,18±0.008	low
% OM	8,95±1.43	9,81±0.63	high

Al+H: exchangeable acidity (meq 100g of soil^{-1}); Al+: exchangeable aluminum (meq 100g of soil^{-1}); % TN: percentage of total nitrogen; P: phosphorus (mg * kg^{-1}); K + 1: potassium (meq 100g of soil^{-1}); Ca^{+2}: calcium (meq 100g of soil^{-1}); Mg^{+2}: magnesium (meq 100g of soil^{-1}); % OM: percentage of organic matter. The values for the rows are the result of five replications for each treatment ± the standard error of the mean. Unequal letters in the rows differ $p < 0.05$ by Tukey HSD.

Soil samples analyses

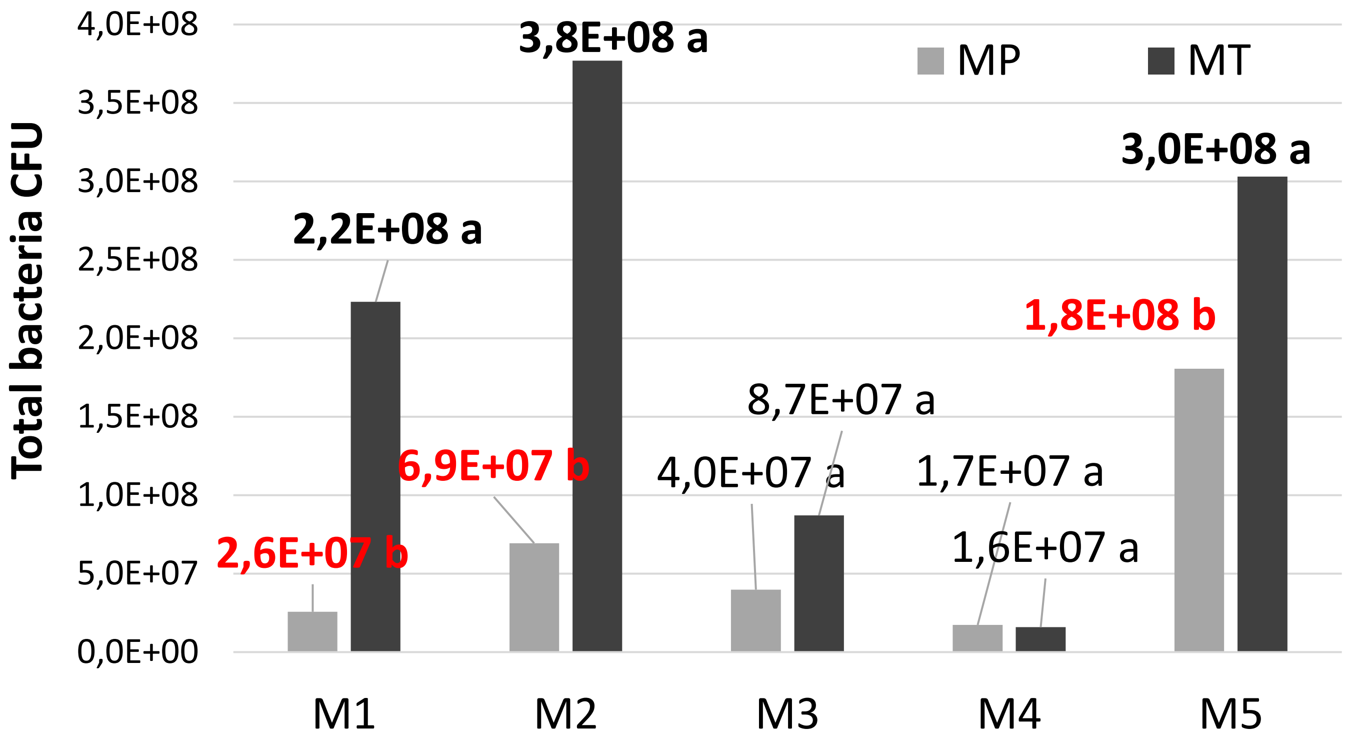
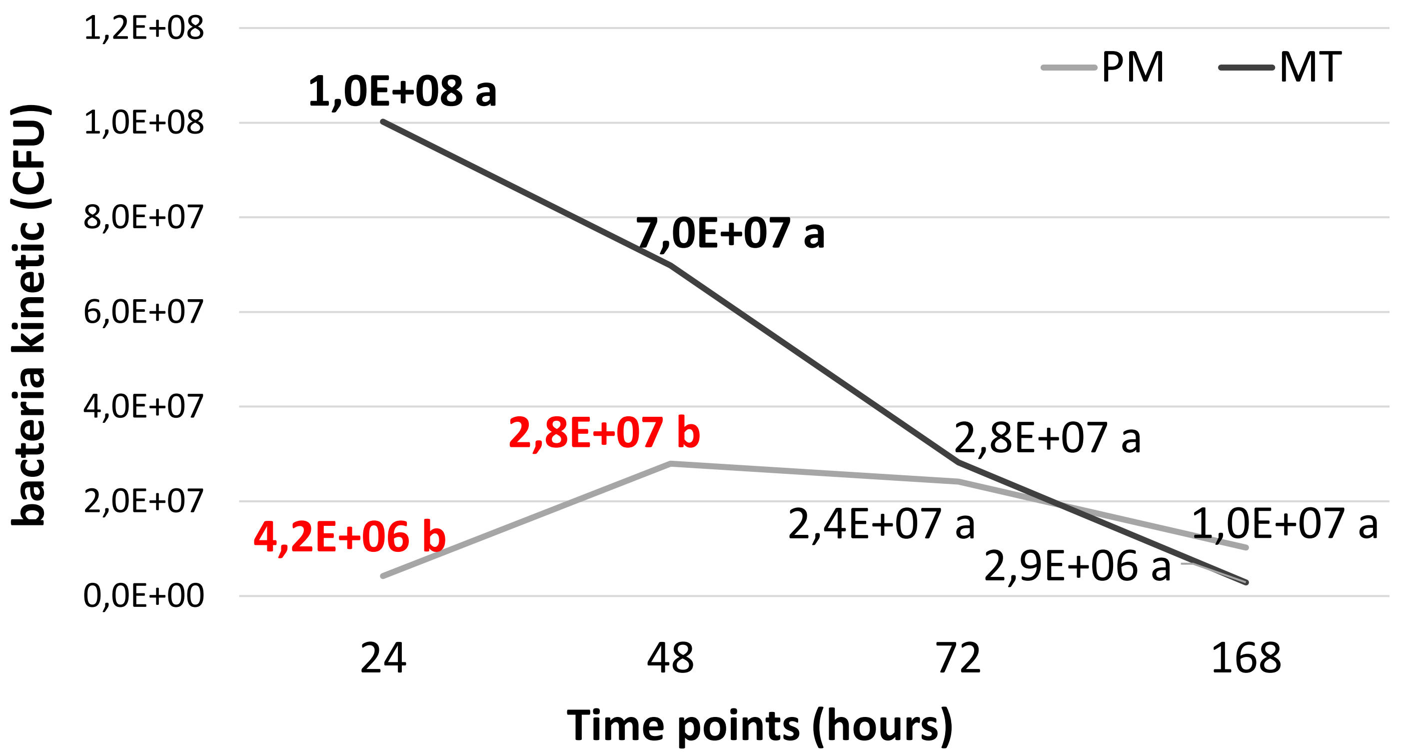


Figure 1. Bacteria Colonies Forming Units (CFU) under **pitahaya (MP)** and **tea (MT)** crop systems. Unequal letters over columns differ p<0.05 by Dunnett C.

Soil samples analyses



Faster growth of bacteria in tea culture compared to pitahaya.

It shows the bacteria adaptation to the ecosystem without agrochemicals application.

Figure 2. Bacteria kinetic (CFU) under **pitahaya (PM)** and **tea (MT)** crop systems at 24 h, 48h, 72 h and 7 days after plating. Unequal letters over columns differ p<0.05 by Dunnett C.

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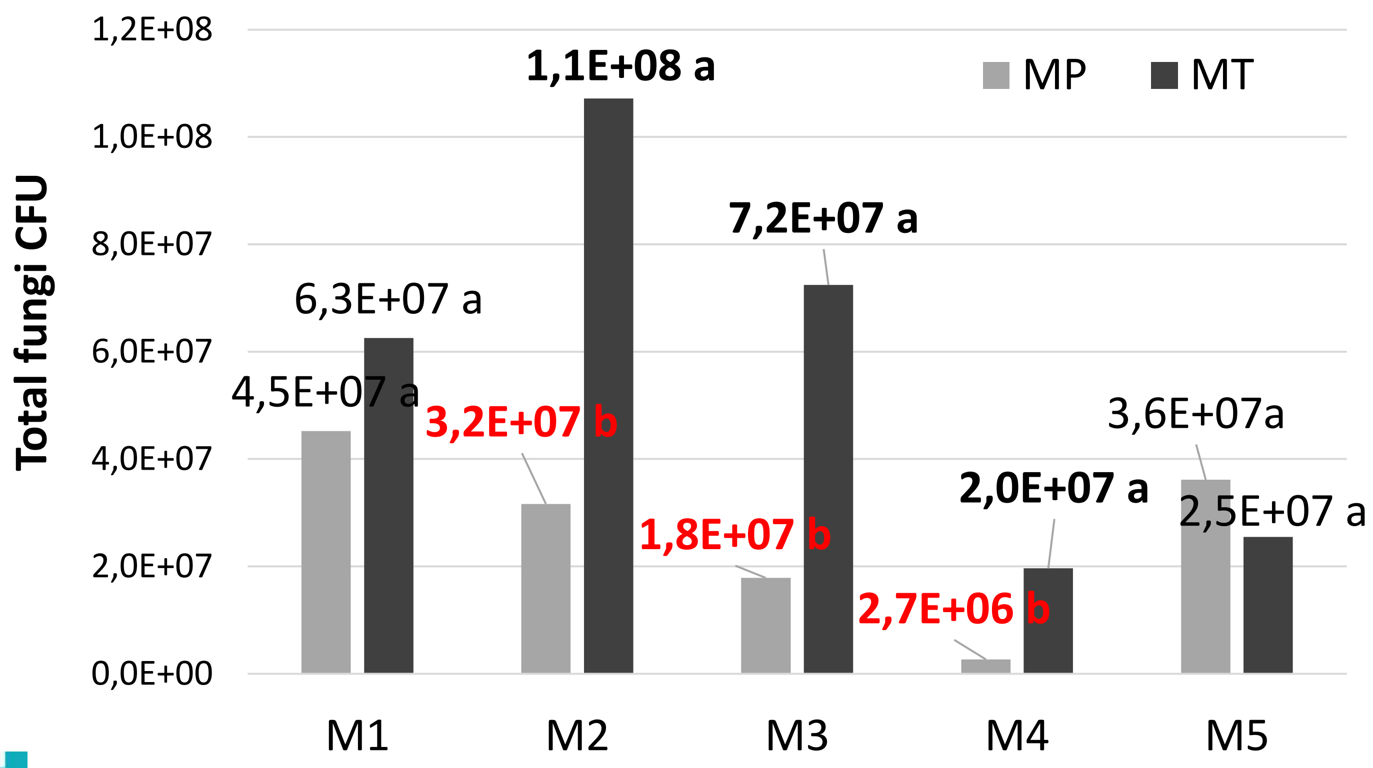


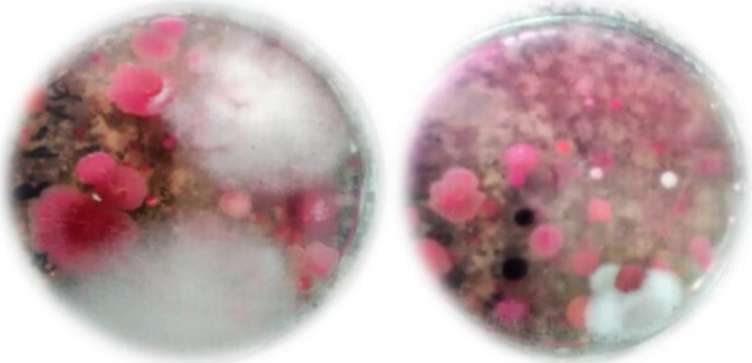
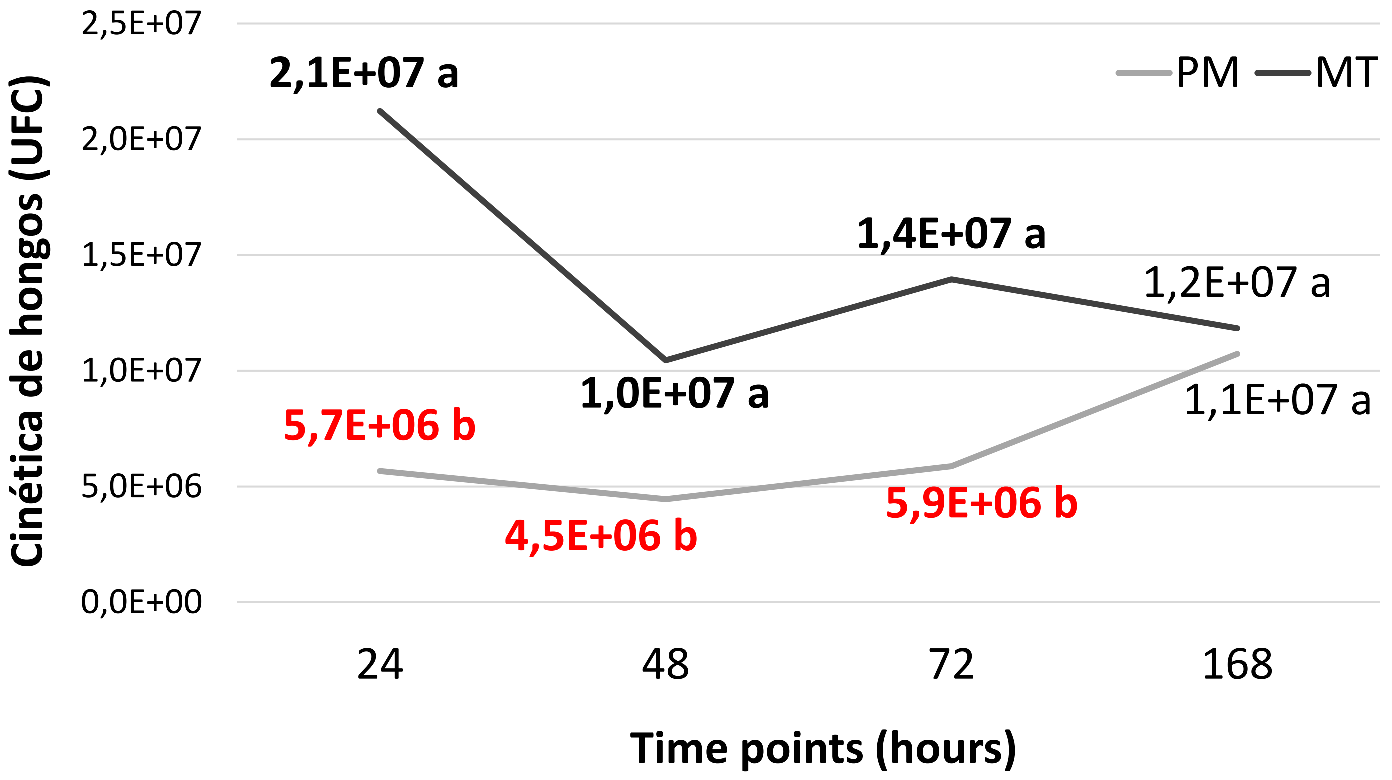


Figure 3. Fungal Colonies Forming Units (CFU) under **pitahaya (MP)** and **tea (MT)** crop systems. Unequal letters over columns differ p<0.05 by Dunnett C.

Soil samples analyses

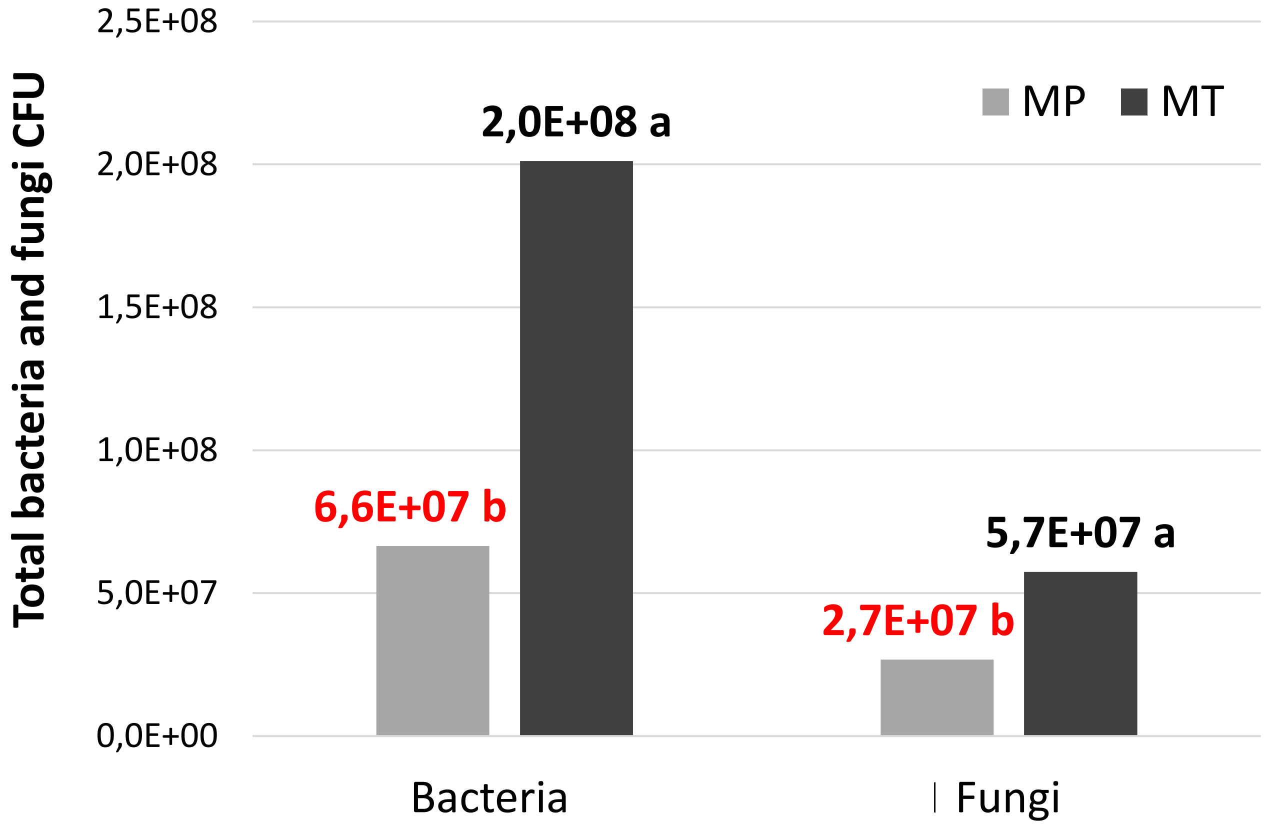


Faster growth of bacteria in tea culture compared to pitahaya.

It shows the bacteria adaptation to the ecosystem without agrochemicals application.

Figure 4. Fungal kinetic (CFU) under **pitahaya (PM)** and **tea (MT)** crop systems at 24 h, 48h, 72 h and 7 days after plating. Unequal letters over columns differ $p<0.05$ by Dunnett C.

Soil samples analyses



Significant reduction of CFU in pitahaya

Bacteria: 67%

Fungi: 52%

Figure 5. Comparison of **total CFU of bacteria and fungi** in soils with **pitahaya (MP) and tea (MT)** crop systems. Unequal letters over columns differ $p<0.05$ by Dunnett C

Soil samples analyses

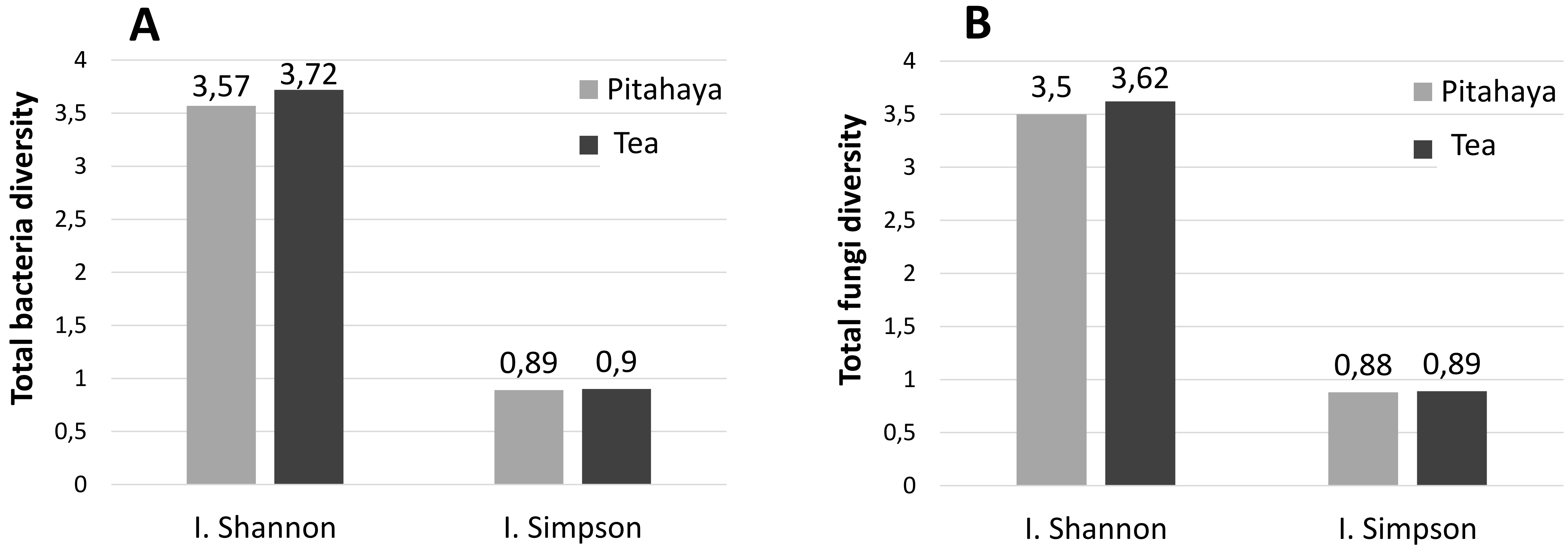


Figure 6. Comparison of diversity indices for bacteria (A) and fungi (B) in soils with pitahaya and tea crop systems. Shannon index (H´), Simpson index (Dsi).

Conclusions

- The intensive pitahaya crop system does not have a negative effect on the texture and physical properties of the soils. However, it reduces the % TN and% OM.

- Bacterial and fungal communities have low adaptability to pitahaya soils, demonstrated in growth kinetics at 24 and 48 h.

- The intensive pitahaya crop system reduces bacterial communities by 67% and fungal communities by 52%. Ecosystem services are compromised.

- The intensive pitahaya crop system does not significantly influence the diversity of communities of fungi and bacteria in the soil.

Perspectives

- Carry out studies in other production areas of pitahaya under Amazonian conditions and with organic crops to validate these results.
- Perform molecular analysis of the prominent isolates obtained for the determination of potential biofertilizers, biocontrollers or bioremediators.
- Make the producers aware of the negative effect of the intensive pitahaya crop system on soil microorganisms, the % TN and % OM.

Aknowledgment

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