Can improved soil health lead to improved production? A diagnostic baseline for smallholder organic export banana

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Can soil health data orient grower continual improvement strategies?

Export banana production offers a weekly income to small growers. Once plantations are established, production costs are relatively modest, but growers face challenges in meeting both household needs and banana production expenses like fertilizers. Technicians from marketing organizations advice and monitor growers on certification standards and harvest logistics, but not productivity or economic returns. Improvement of ecological processes like nutrient cycling, water storage and natural pest control linked to soil health were shown to increase crop productivity in Fontagro-financed small-plot research from 2014-2017 in the 3 main banana exporting countries. In a new project to reach 2400 growers, national teams in Dominican Republic, Peru and Ecuador are working with producer associations to integrate soil health promotion strategies into grower cropping routines. Continuous improvement and benchmarking are data-based approaches in which growers assess current practices, implement new practices and monitor changes for new improvement opportunities.

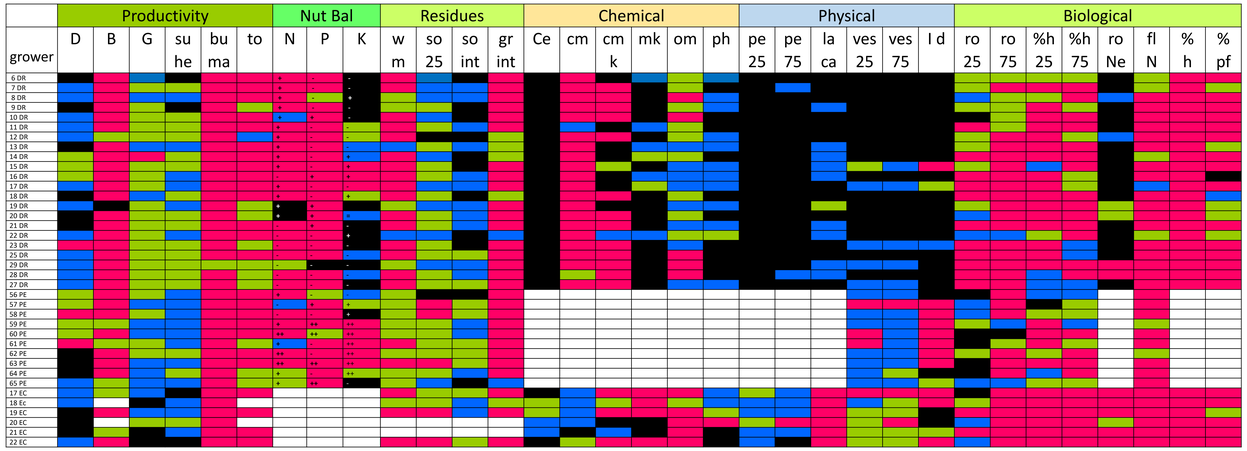
What soil health indicators / what range of values (DR) are proposed?

Category	Indicators	Very much	Much	Improvement possible	Optimum
Production Factors	Mat density/ha	<1800, >2800	1800-2000; 2600-2800	2000-2200; 2400-2600	2200-2400
	Bunch weight (kg)	<21	21-23	23-25	>25
	Stem girth (cm)	<50	50-60	60-70	>70
	Sucker height (m)	<0.5	0.5-1.0	1.0-1.5	>1.5
	Bunches.mat/year	<1.1	1.1-1.3	1.3-1.5	>1.5
	Production (ton/ha/year)	<50	50-60	60-70	>70
Nutrient balance	Nitrogen balance	Deficit or excess >75%	Deficit or excess 50-75%	Deficit or excess 25-50%	Deficit or excess <25%
	Phorphorus balance				
	Potassium balance				
Residues & cover crops	Whorl mgt 75 cm	<0.5	0.5-1.5	1.5-2.5	2.5-3
	Soil cover 25 cm	<0.5	0.5-1.5	1.5-2.5	2.5-3
	Soil cover interrow	<0.5	0.5-1.5	1.5-2.5	2.5-3
	Green cover interrow	<0.5	0.5-1.5	1.5-2.5	2.5-3
Chemical Factors	E.C.	<0.1; >1.4	0.1-0.2; 1.2-1.4	0.2-0.3; 1.0-1.2	0.3-1.0
	Ca/Mg	<1.0; >9	1.5.-2.0; 7.5-9	2.0-3.0; 6-7.5	3.-6.
	Ca+Mg/K	<4; >55	4.0-7.0; 48-55	7.0-10.0; 40-47	10.0 – 40
	Mg/K	<1; >15	1-2.5; 13.5-15	2.5-4.0; 12-13.5	4.0-12
	% OM	<2.0	2-2.5	2.5-3.5	>3.5
	pH	<5. ;>8.5	5.-5.7; 8-8.5	5.7-6.5; 7.5-8	6.5-7.5
Physical factors	Penetrometer – 25 cm	>400	300-400	200-300	<200
	Penetrometer – 75 cm	>400	300-400	200-300	<200
	Labile carbon (mg/kg)	<250	250-500	500-750	>750
	VESS 25	>3	2.25-3.0	1.5-2.25	<1.5
	VESS 75	>3	2.25-3.0	1.5-2.25	<1.5
	Internal drainage	>1.5	1-1.5	1	1
Biological Factors	Total roots 25 cm (gm)	<20	20-30	30-40	>50
	Total roots 75 cm (gm)	<15	15-25	25-35	>35
	% healthy roots 25 cm	<70	70-80	80-90	>90
	% healthy roots 75 cm	<70	70-80	80-90	>90
	Root nematodes	>7000	5000-7000	3000-5000	<3000
	Total FL nematodes	<200	200-350	350-500	>500
	% free living herbívores	>40%	30-40	20-30	<20%
	% FL fungivore.predators	<5%	5-10	10-15	>15%

Study approach: 50 growers and project teams in each country collect data to assess current soil health. Each grower maps indicator values to determine potential areas for improved practices. Groups of growers and field technicians discuss feasibility of practices, steps in testing and a monitoring schedule. Each zone/country established different ranges for the 33 variables in 6 dimensions of soil health to rate the potential for improvement. while most variables had common ranges.

What opportunities to improve soil health in smallholder organic banana?

Soil health scoring by category and indicator for a subset of growers from each country are shown below with color scoring based on the color codes in the individual grower format shown to the left. The format below is proposed to stimulate not only analysis for continual improvement by individual growers, but also benchmarking by association and for the sector to orient technical advice. The indicators can be viewed individually by column, in blocks of columns by category, by countries across the matrix and by line for individual growers. Monitoring of indicators of practices changeable on short term will provide a dynamic view of banana soil health.



Does soil health offer opportunities for continual improvement of banana productivity?

Our 33 indicators can be used to assess opportunities in five ecological processes making up soil health. Certain indicators address only one process, while others address multiple functions as shown below. As a block soil physical properties appear to be optimum for good root development. However, root volume and health provide contradictory evidence. Other specific indicators are optimum – electrical conductivity and certain cation ratios, although the high calcium in dry zone soils affect ratios. Bunch sizes and bunch interval are low generating low yields. Nutrient balance – over and under application – is common and internal nutrient recycling is underexploited. **Possible practices: Low cost** – residue placement, legume covers, adjust nutrient balance. **Higher cost** – irrigation and drainage, increased nutrients, hedgerows for diversified mulch.

Process / function	Production/ vigor			Nutrient supply			Internal nutrient cycling			Medium – abundant root volume, water capture / storage, oxygen			Natural pest control		
Indicators	Bunch weight stem girth, bunch interval, tons/ha, mat density			N, P, K budgets, pH, cation ratios			Residue distribution, OM, labile carbon, N fixation, residue diversity			Compaction, internal drainage, total root biomass / % necrotic, soil surface structure, OM, EC			Root nematodes, FLN, functional groups FLN, % necrotic roots		
Opportunities	DR	PE	EC	DR	PE	EC	DR	PE	EC	DR	PE	EC	DR	PE	EC

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