Sustainable Cocoa Production

The Role of Soil Health

SUMMARY

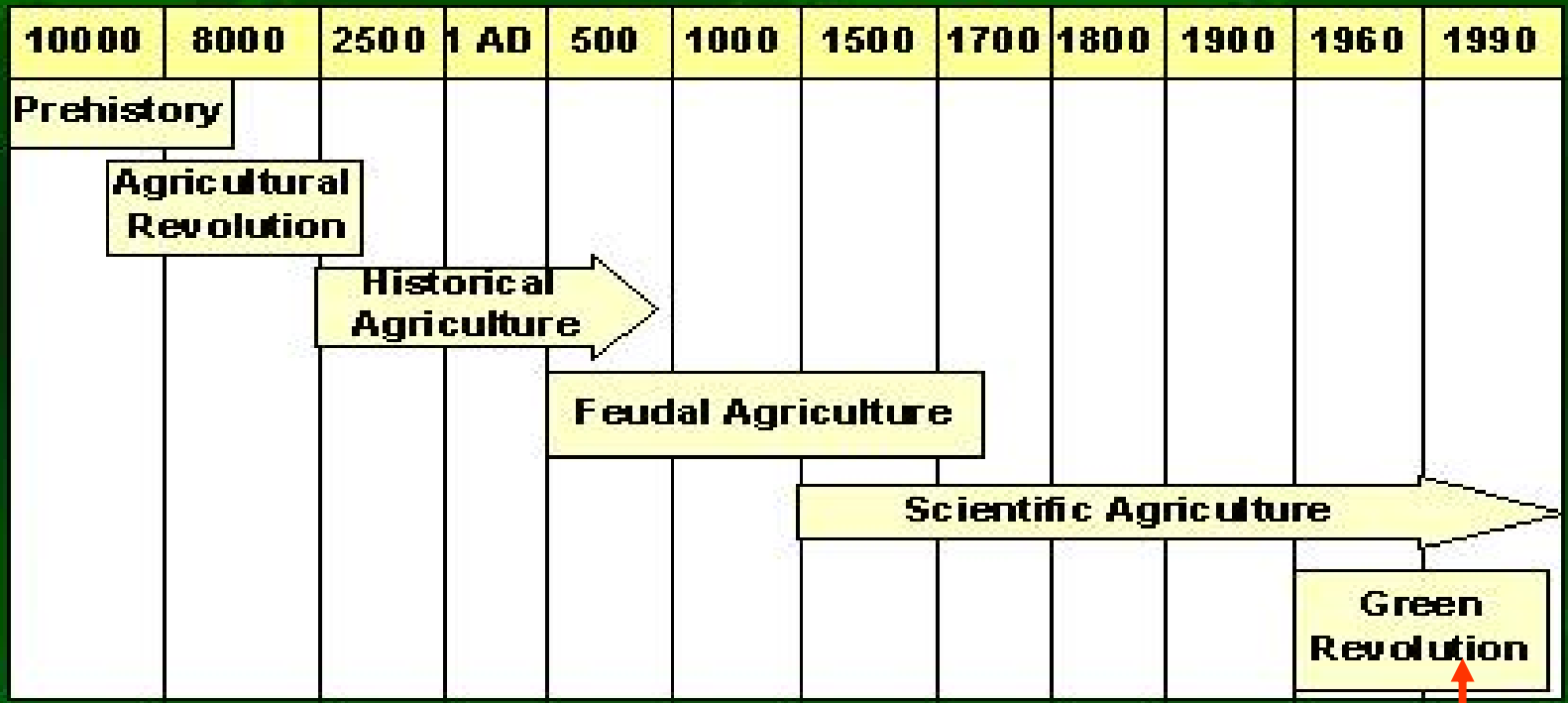
- What do we mean by sustainable cocoa?
- Agricultural trends
- Soil health overview- a humanised view
- Three examples of soil health in action
- How to manage nutrients for cocoa production, based on healthy soils approach

Components of sustainable cocoa production

- Social benefits are evident
- Economic benefits accrue to the farmer
- Farmers are active participants in the value chain
- The market(s) remains viable
- The agro ecology of cocoa production is enhanced, or at least, not degraded

Adapted from ???

Evolution of Agriculture



1970's onwards: The rise of sustainable agriculture or the *The New Green Revolution*

So, what was the Green Revolution?

- a transformation of agriculture production and systems in developing nations, from the 1940's onwards that featured:
  - New crop varieties
  - Widespread irrigation usage
  - Intensive usage of mineral fertilisers
  - Intensive usage of agri-chemicals
  - Scaling up of mechanised agriculture

Some major impacts of the Green Revolution

- Tremendous increase in food production, that kept pace with rising populations- now at peak
- Economic- increased production costs, reliance on high yields, risk exposure
- Social- bigger farms and farmers benefited, smallholders dependent on credit
- Ecological- huge increase in water use, pesticide contamination, food safety issues, land clearing and degradation, biodiversity loss

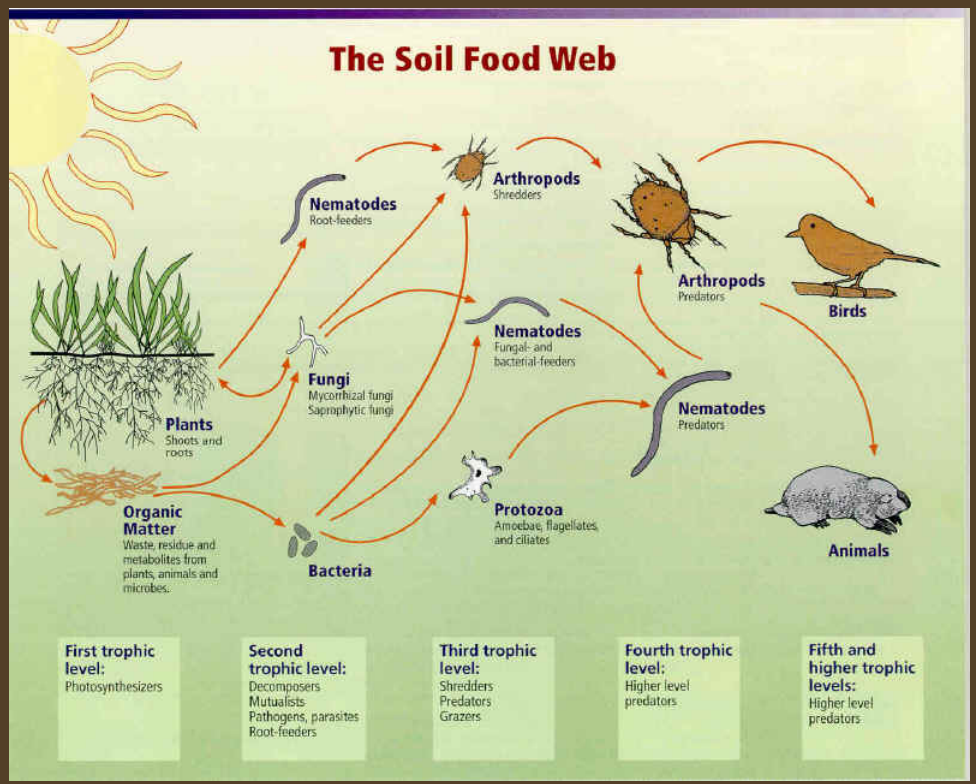
From Green1 to Green 2: The Sustainable Agriculture Movement

- Organic Farming
- Permaculture and Bio Dynamics
- Holistic Farming
- Conservation Agriculture
- Sustainable Agricultural Systems
- Agricultural Biodiversity
- Low External Input Agriculture LEIA
- Others……

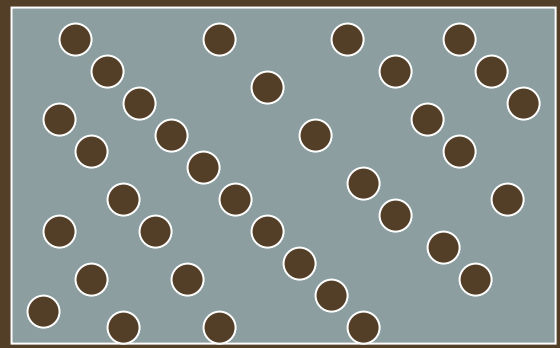
Soil management is the common link

Views on soils

1: living and breathing, dynamic



2 : static, dead- an inert medium or sponge, capable of holding water and nutrients (hydroponics model)



FAO statement:

The quality and health of soil *determine agriculture sustainability, environmental quality and, as a consequence of both - plant, animal and human health* (Haberem, FAO, 1992)

What is a healthy soil for cocoa production? (humanised)

- It has a great sense of humus: lots of organic matter
- Has a good body: well drained and aerated, good structure and aggregate stability, moderate soil resistance
- Good for upset stomachs: pH 6.5 to 7.5
- It moves and breathes: lots of crawlies and smallies
- Loves a drink: water is readily available to plants and soil flora and fauna
- Is well dressed: good ground cover (>75%), protected from sun and wind
- It knows its roots: large numbers of healthy and active roots able to uptake nutrients easily
- Smells great! Rich and earthy
- Looks great! Dark coloured.
- **A SOIL IN BALANCE: between the living (biological) and the dead (chemical/physical) - inputs can disturb this balance**

What’s going on down there in the roots???

From


DEAD OR
ALIVE????
Tan Hung- Fs/ Fa


DEAD OR
ALIVE???
BP18- Doan Ket
Fu -- Fk soil

It’s a busy place…

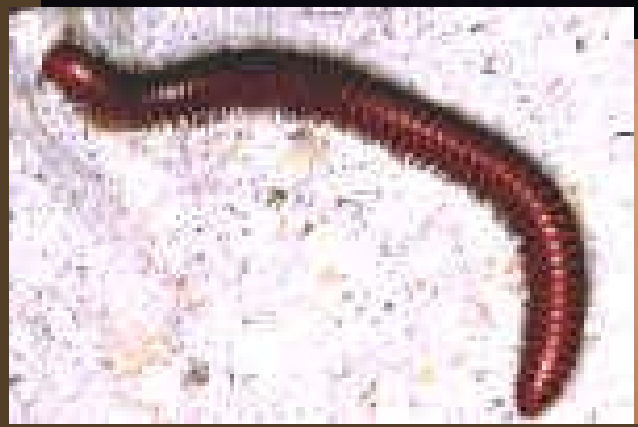
What goes on inside soils.

- Soil engineering services- housing, water, gas, energy, road construction for soil dwellers
- Soil sanitary services
- Soil waste conversion and food production
- Soil bio-security services
- Soil homeland security services
- Soil rehabilitation and restoration services

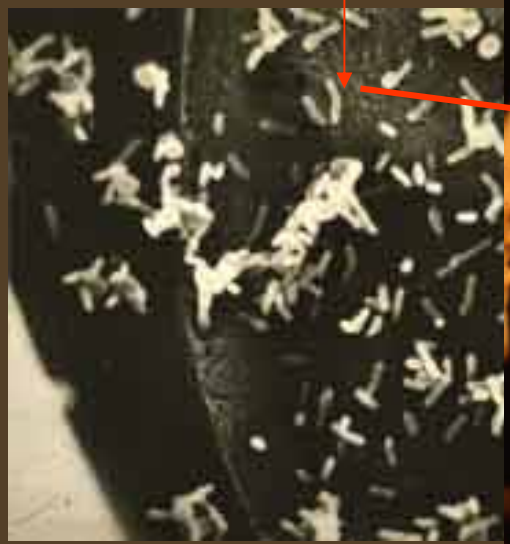
Earthworms and other soil animals: conversion of organic matter into soil nutrients and develop good soil structure

= ***Soil engineers***

photos USDA,CSIRO, UWA

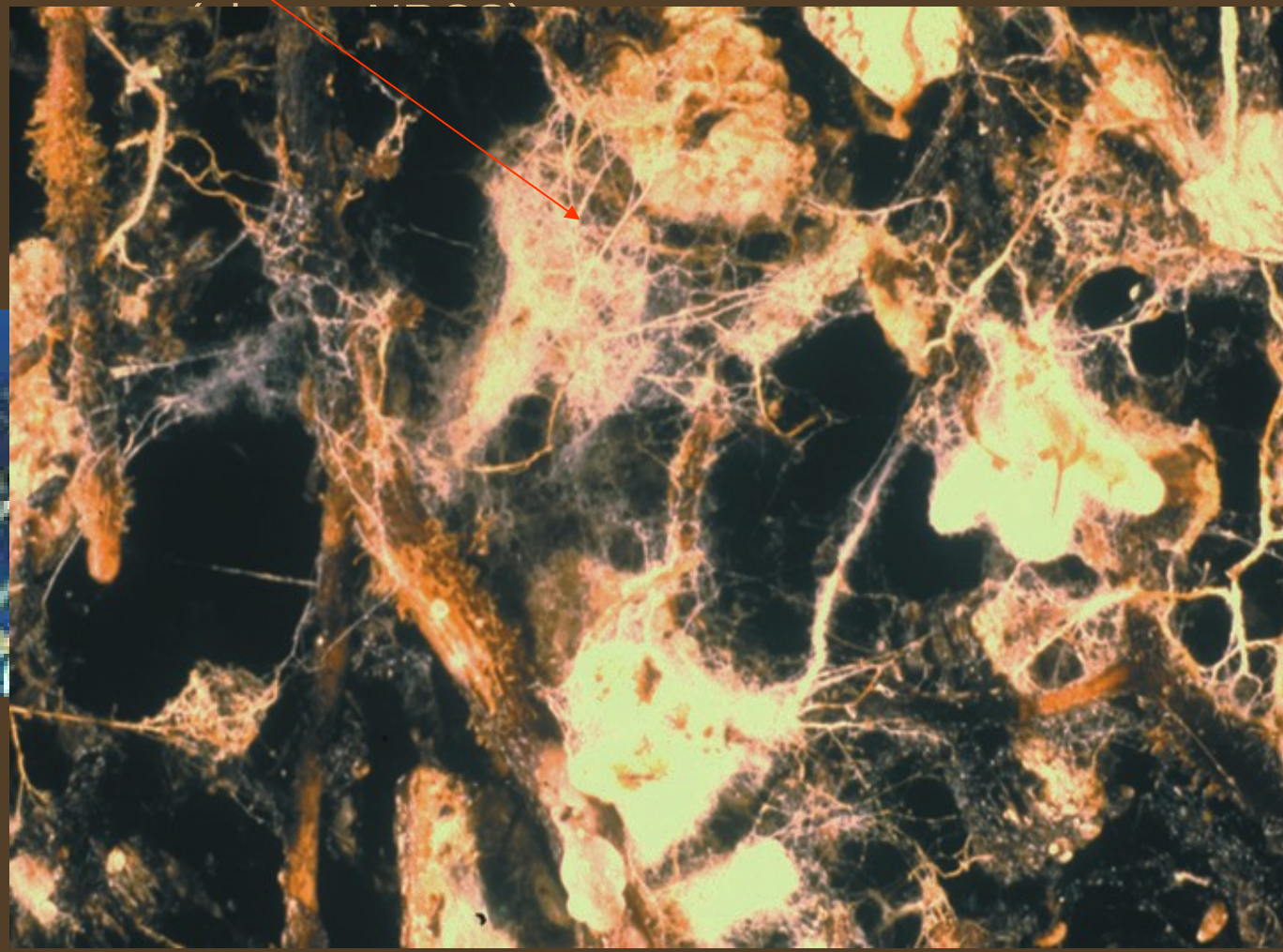


Energy converters Six genera of the *Rhizobiaceae* bacterial family =Nitrogen production in the soil up to several hundred Kg/ha

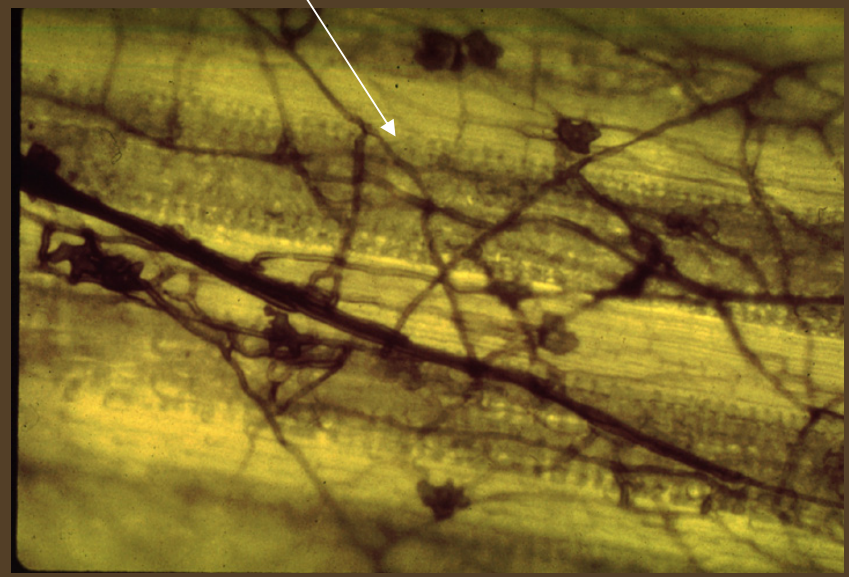


Photos NRCS

FOOD production **Arbuscular mycorrhizae** (many crop species) and **ectomycorrhizae** (only woody species; mostly trees)= enhanced nutrient uptake by roots



WASTE converters Fungi as digesters of wood and leaves and as bio-control agents for control of both plant fungal diseases and insect pests



USDA

Bio security. Entomopathogenic nematodes to control a wide range of insect pests and some fungal pathogens, and pathogenic nematodes

Photos NRCS

MONITORS: The universal symbol of healthy ecosystems

Others services…

- **Protozoa:** eat bacteria and food for nematodes
- **PGPB's** plant growth promoting bacterias (soil antibiotics and detoxifiers)
- **Suppressive soils.** Soils that show greater relative resistance to disease expression in plants- soils slightly alkaline or neutral pH

Case studies of the benefits of healthy soils

CASE 1: Restoring soil fertility and increased tea yields with **earthworms** and organic fertilisers

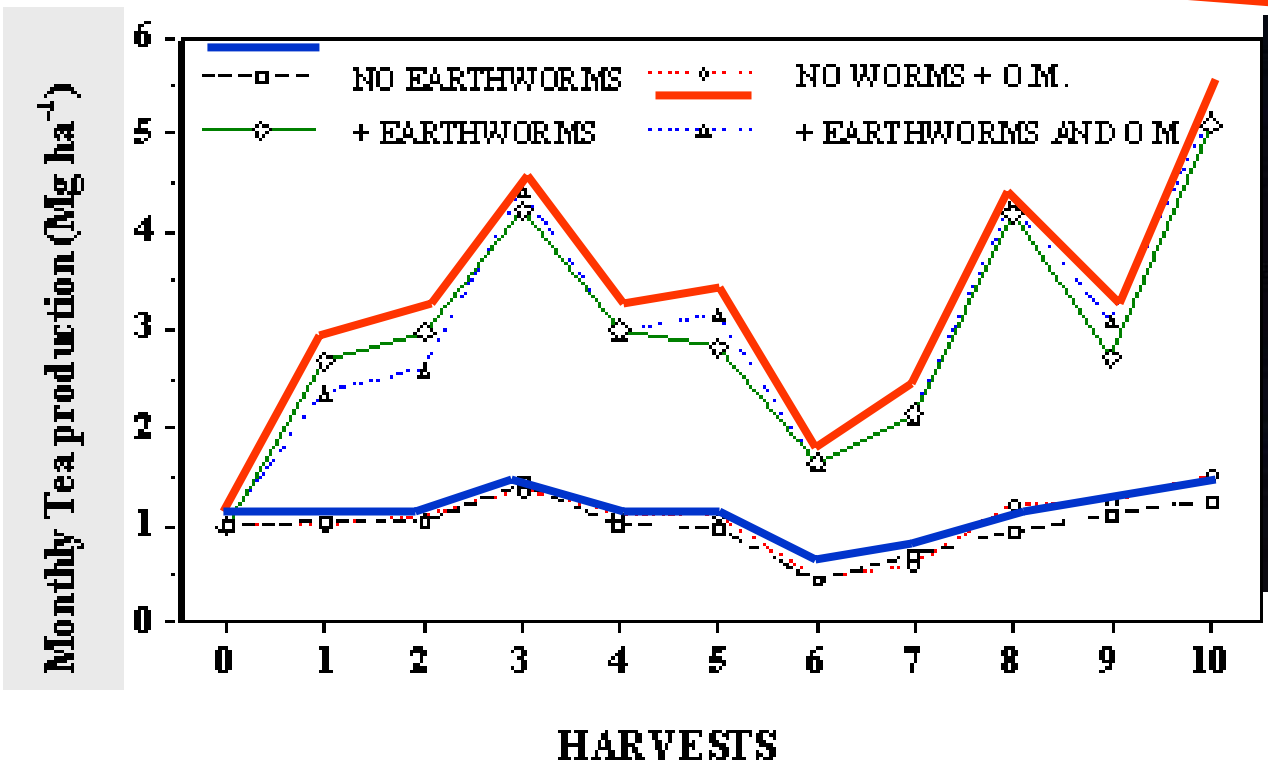


Figure 1. Effect of organic matter and earthworm application alone and together on monthly green tea leaf production in Tamil Nadu, India (data from Giri, 1995 and Senapati, unpublished).

Tea is a high value plantation crop in India with an old history (many estates are >100 years old). In recent years, green tea production has stabilized, despite increasing application of external inputs such as fertilizers and pesticides. The long-term exploitation of soil under the tea gardens has led to important changes in various soil physical, chemical and biological conditions, decreasing organic matter content, cation exchange, water-holding capacity, soil biota (reduced up to 70%) and pH, simultaneously increasing concentrations of toxic aluminum.

CASE 2: Managing termites and organic resources to improve soil productivity in degraded soils

The judicious application of surface organic matter to feed termites promotes their capacity to regenerate crusted soils.

Table 1. Effect of termite addition to two different mulch types on cowpea yields and soil physical and chemical properties in a degraded Sahelian soil (Burkina Faso) (from Mando, 1997).

Treatments	Yield (T ha^{-1})	Mineral N (mg kg^{-1})	K (mg kg^{-1})	Total P (mg kg^{-1})	K_{sat}* (10^{-5} ms^{-1})
Cowdung +termites	**1.02**	**21**	**87.5**	**130.5**	**1.2**
Straw + termites	0.6	10.0	26.0	106.5	1.7
Cowdung only	0.01	10.5	50.4	140.2	0.9
Straw only	**0.1**	**10.1**	**29.6**	**75.7**	**0.5**

K_{sat} = Saturated hydraulic conductivity

CASE 3: The use of organic amendments to reduce nematode infections in common bean

Amendment	Nematode index	Bean shoot weight g/plant
Marigold leaves	3.5	5.6
Neem leaves	3.5	7.4
Chicken Manure	2.1	11.1
Cow Manure	4.6	5.4
Carbofuran	6.8	3.0
Control	6.5	2.2

Bean yields reduced from 1500 to 750 kg/ha with nematode infections

The need for healthy soils

- Healthy soils means healthy crops and healthy people
- Healthy soils are not a luxury item: they are indispensable for the future of agriculture
- To avoid reliance on intensive, costly, unsustainable high inputs farming systems
- For a healthy environment- water, gas and nutrient cycles take place in the soil

Assessing soil health…the simple way

Soil health card

Spade and trowel

pH kit

Wire probe

Quadrant 1m

Plastic jar and water

Soil health card

Result….. TEST	POOR	FAIR	GOOD	SCORES FOR 3 TESTS			
Use the sequence of tests as follows:	1…….2……3	4……..5……6	7…….8……..9	Group A	Group B	Group c	Averages
GROUND COVER	Less than 50% coverage	50-75% coverage	More > 75% coverage				
SOIL HARDNESS	Wire probe does not penetrate	Wire probes goes in less than 20 cm with difficultly	Wire probe goes in easily to 20 cm or more				
ROOT DEVELOPMENT	Nil or very few fine roots seen	Some roots mainly near the surface	Many fine roots throughout the soil				
DIVERSITY SOIL ORGANISMS	Less than 2 types soil animals seen	Two to five types soil animals seen	More than five types soil animals seen				
SOIL pH Top soil Bottom soil	pH is 5.5 or less	pH 5.5 - 6	pH 6-7.5				
SOIL TEXTURE top soil bottom soil	Sand…….clayey sand	Heavy clay….light clay	Clay loam….. loam				
SOIL STRUCTURE top soil bottom soil	Hard pressure does not smash or is Massive- few crumbs	Hard to firm pressure- Brittle- smashes into many small pieces	Firm to soft pressure - mainly breaks into crumbs,				
SOIL STABILITY top soil bottom soil	Soil pieces fell apart in less than 1 minute	Pieces intact after 1 minute	Intact after swirling also				
EARTHWORMS POPULATION	Less than 3 worms counted	4-6 worms counted	More than 6 worms counted				
SOIL COLOUR	Lower fertility: tan, light yellow, orange, light grey	Medium fertility: light brown, reddish,	Higher fertility: black, dark brown dark grey				

Do it regularly and compare results

How to make soils healthy for cocoa production

Rational usage of pesticides, fungicides, mineral fertilisers

Use Rock Phosphate and other rocks to provide P, minerals and TE's

Managing soil pH- not acid or alkaline

Managing soil structure, soil water, soil air- little cultivation, and water to plant and atmospheric demands. Keep it moist, not saturated

Use cover crops ie Nitrogen fixing legumes- also to control weeds

Adding soil organic matter- manures, farm wastes, preferably composted ie cocoa pod husk (CPB/ PPR/nutrients)

Protecting soil surface by use of mulches

- temperature regulation
- surface layer properties- no crusts or water repellant soils
- safe environment for soil organisms
- conservation of water in the soil
- reducing erosion and rain impact

- **Monitor soil health and fertility and plant nutrition.- complex or simple systems, just start ie soil health card.**

Nutrient application for healthy soils

Based upon:

- Cocoa plant nutrient demand at different growth stages
- Different ages of cocoa plants
- Existing soil health and status

Identify correct dose to apply- what the plant needs, the soil and the crops needs

Table 9: Combined whole tree nutrient requirement for growing the trees and producing pods at different ages, in **g/tree/ year**. (From tables, A, B)

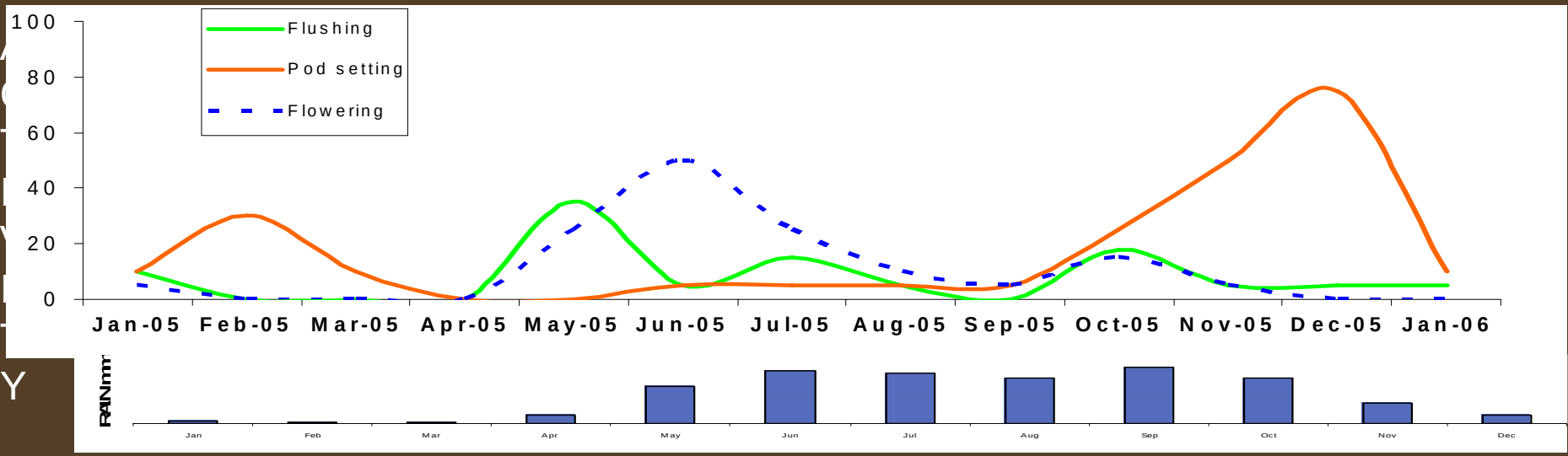
Tree age	**Nitrogen g/ tree/ year**	**Phosphorus g/ tree/year**	**Potassium g/ tree/ year**	**Calcium g/tree/year**	**Magnesium g/tree/year**
6 -12months	**20**	**20**	**10**	5	2
1- 2 years	155	16	165	126	53
2-3 years	160	12	170	30	30
3- 4 years	170	18	200	40	30
4-5 years	115	30	260	180	60
5 -6 years	115	25	200	70	25
Total over 5 years	**740**	**102**	**1000**	**450**	**200**

Step 2: select type of nutrients – go organic

Produce	Amount applied g/tree	Wet or dry product	(N) g	(P_2O_5) g	(K_2O) g	(CaO) g	(MgO) g	TE g	Organic matter
Urea	100g	Dry	46	-	-	-	-	-	-
pig manure (*)	1 kg	Dry	6.5	2	6	2	1	Yes	250
Cattle manure (*)	1 kg	Dry	4,5	2	5	4	1	Yes	200
Goat manure (*)	1 kg	Dry	8.3	2	7	3	2	Yes	310
pod husk	1 kg	Wet	12	2	45	4	2	Yes	Yes
Crop residues-CROTALARI	1 kg	Wet	5	1	5	5	1	Yes	Yes

Step 3: Select right times to apply

PHENOLOGY BASED APPROACH TO INPUTS TIMING



MACRO FERTILISER INPUTS	pH test: lime or dolomite				Nito 40% Photpho 50 %		Photpho 50 % Kali 40%		Kali 60%		
MICRO NUTRIENT INPUTS					Zinc, Boron, Iron, Mn, Mo application						
PRUNING AND SHAPING		CHUPONS and sanitation		MAIN PRUNING- sanitation, internal structure and height control			CHUPONS and sanitation		CHUPONS and sanitation		
DISEASE MANAGEMENT TASKS					Trunk injection phosphonate		VSD pruning	Blackpod harvest,	Blackpod harvest,	Blackpod harvest,	Trunk injection phosphon
PEST MANAGEMENT TASKS	Termite scouting and treatment		Termite scouting and treatment		Helopeltis and mirids control		Helopeltis and mirids control		Helopeltis and mirids control		
MULCHING, WEEDING AND GROUND COVER TASKS	Add more mulch		Add more mulch		Weed control	Reduce mulch in Mekong farms	Weed control	Add more mulch (except Mekong)	Weed control		Weed con
WATERING											
POD storage and HARVESTING											

STEP 4: Calendar based on plant needs

Table 2. Nutrient application baseline guide for cocoa at different ages

Plant age	**(N) g/plant**	**(P_2O_5) g/plant**	**(K_2O) g/plant**	**(CaO) g/plant**	**(MgO) g/plant**
4-6 months	**10**	**10**	**5**	250 g per plant of agricultural lime inside hole **and 100 g rockphosphate, outside hole**	
9 months	**10**	**10**	**5**		
12 months	**40**	**5**	**40**	60 g/plant limestone or dolomite	
15 months	**40**	**5**	**40**	**30**	**12**
18 months	**40**	**5**	**40**	**30**	**12**
Tree flowering and cropping starts					
25-36 months	**160**	**15**	**170**	**30**	**30**
Flushing (May)	40% N	40% P_2O_5	-		
Flowering (June-July)	20%N-	30% P_2O_5-	20% K_2O		
Pod setting (Aug-Sep)	20%N-	10% P_2O_5	40% K_2O		
Pod filling (Nov/Dec)	20% N	20% P_2O_5	40% K_2O-		

For more information…

SUCCESS Alliance Viet Nam
Training manual- Soil Health and Cocoa Production