2nd International Workshop on Alternative Potash

Regional agrominerals as support to Evergreen Revolution

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AdvancedPotashTechnologies

MIT

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CPRM
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UK | Malaysia | Singapore

UNIVERSIDADE FEDERAL DO PARÁ

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Plan Presentation

- **Historical overview**

Agricultural revolutions

Selection and breeding

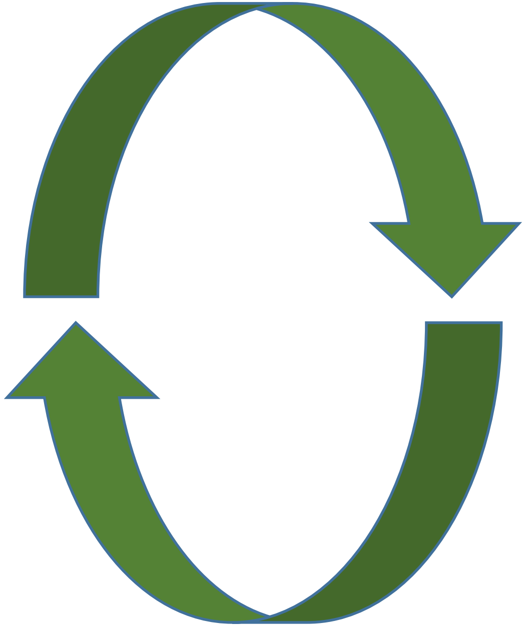
Ecological intensification

- **North-South Dualities**

Dependence on natural resources

Chemical inputs

Technological exhaustion



- **Evergreen Revolution**

Regional resources

Agroecosystem evolution

Long term sustainability

- **Biological functioning**

Agroecosystems

Microbiomes

Biological inputs

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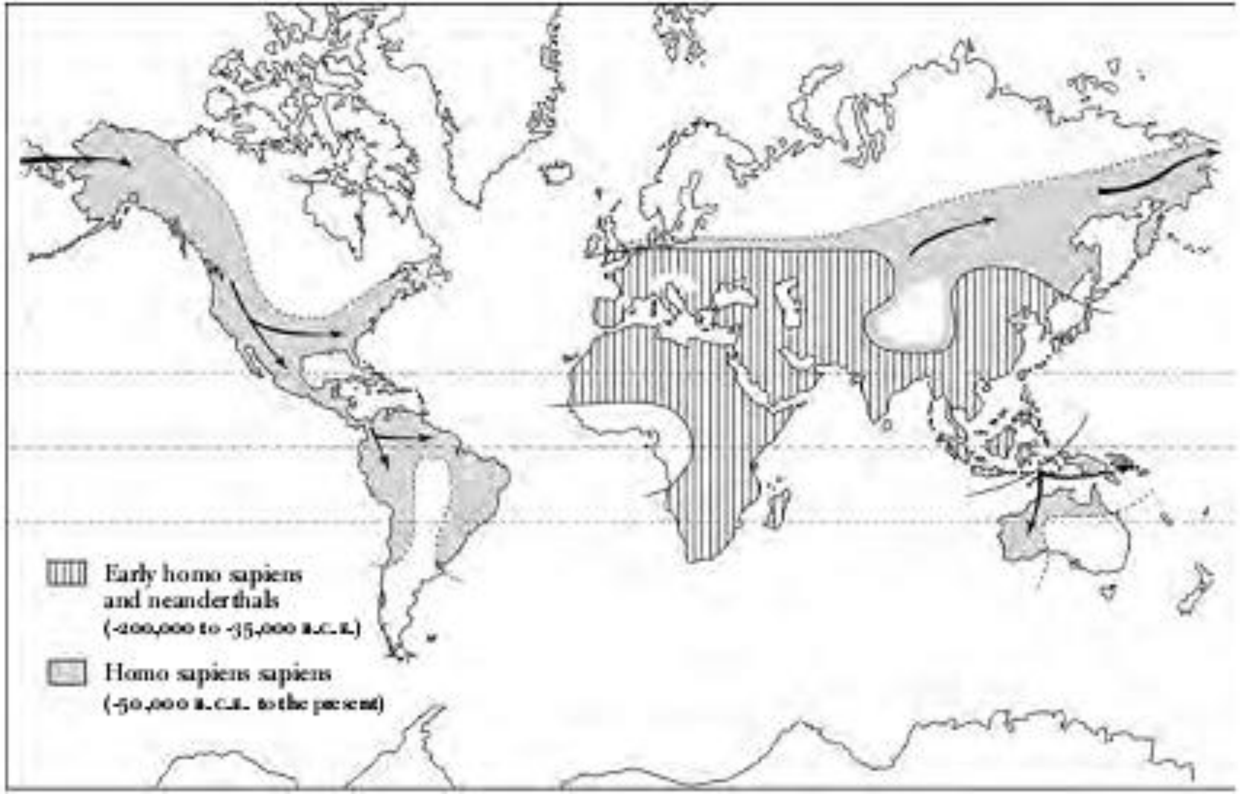
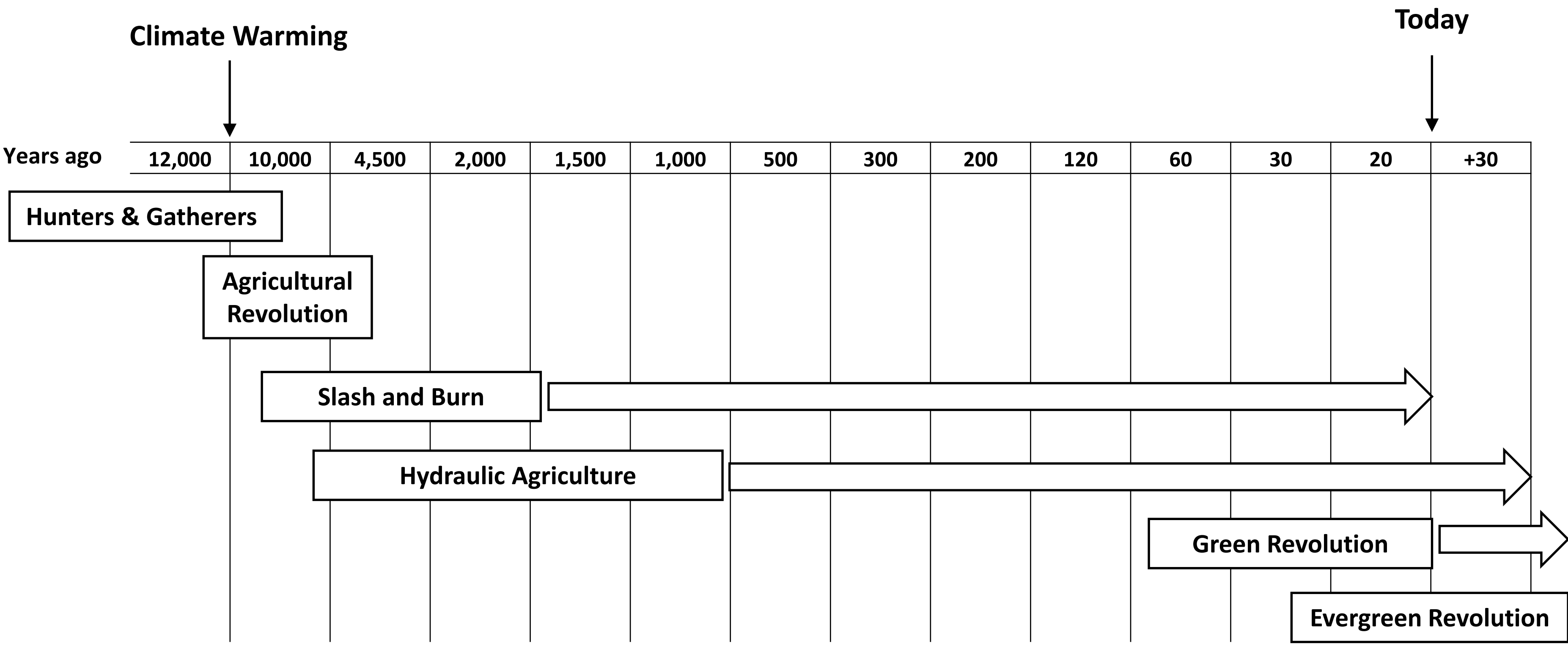
Historical overview - After climate warming

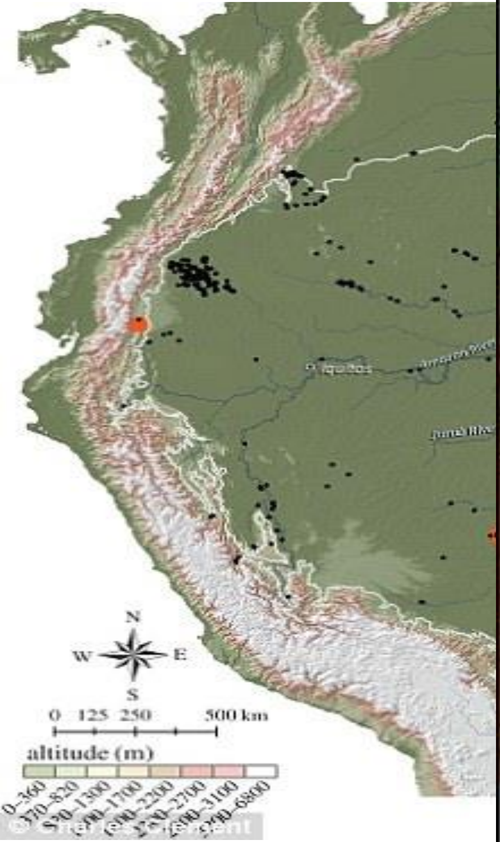


Mazoyer e Roudart (2006) A History of World Agriculture

Historical overview - Timeline of Agriculture



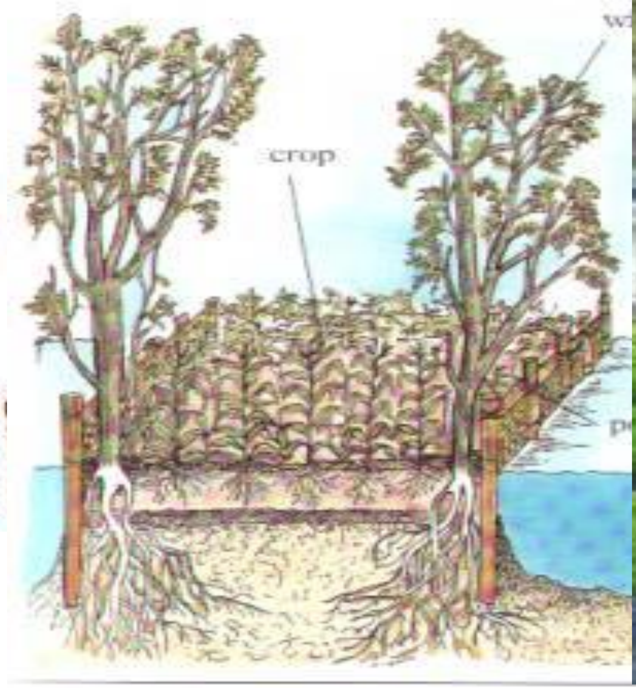
Historical overview - Amazonian Dark Earth



Amazonian dark earth - *terra preta*

Left a nutrient-poor *oxisol*; right an oxisol transformed into fertile *terra preta* - photo courtesy of Bruno Glaser

Historical overview – Chinampas in Mesoamerica



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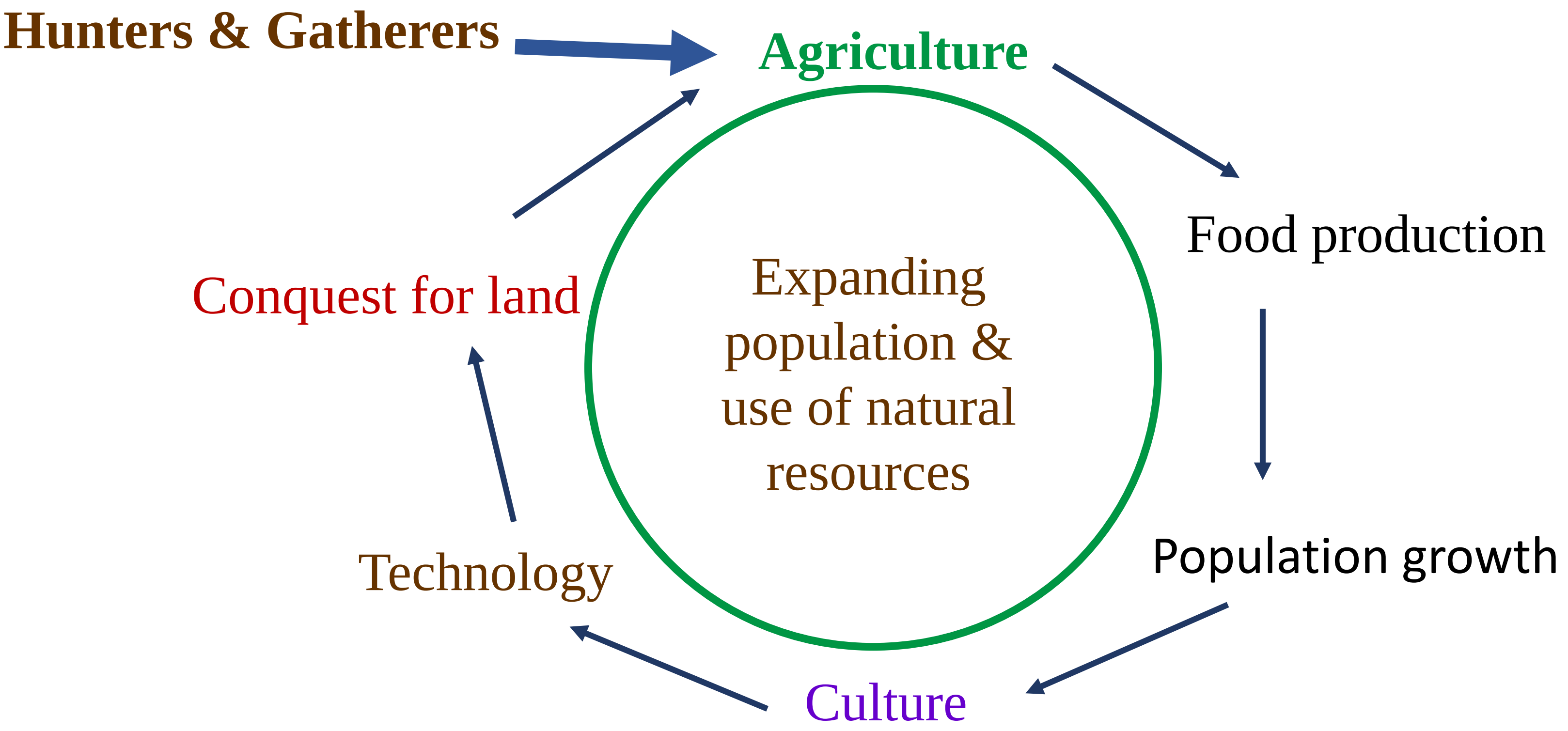
Historical overview - Agriculture and human development



Adapted from Diamond (1997) Guns, Germs, and Steel: the Fates of Human Societies

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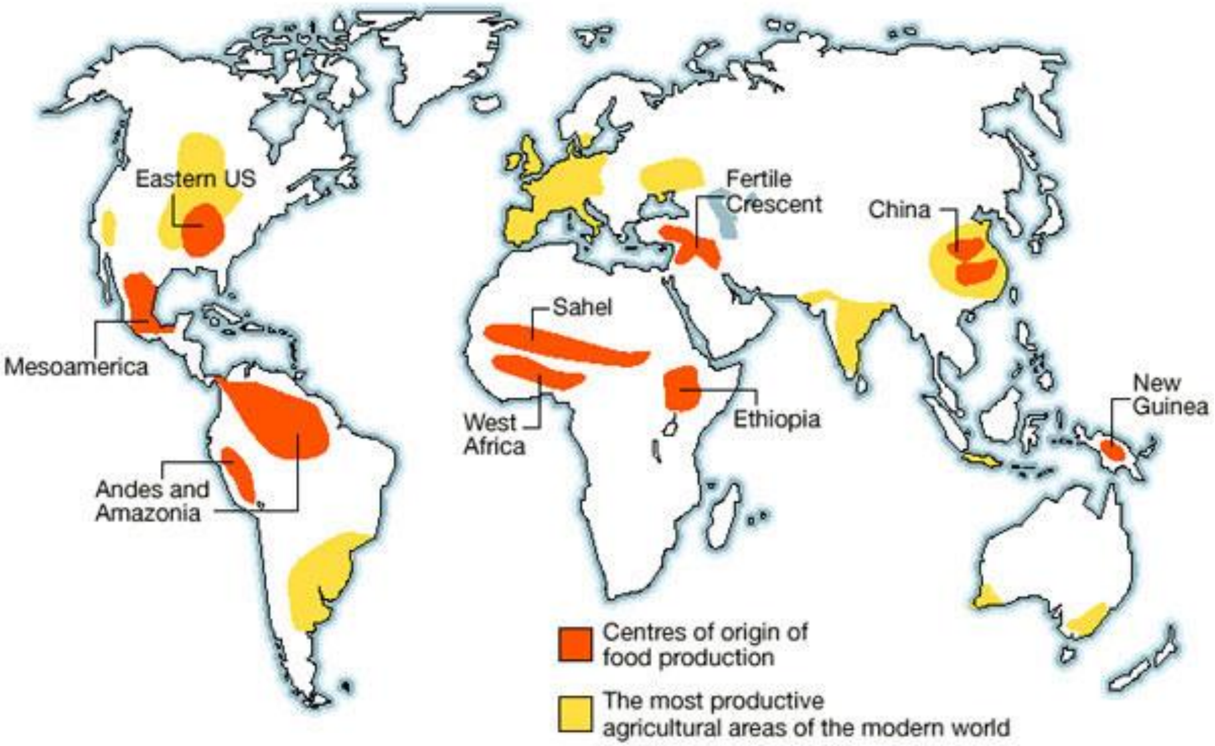
Historical overview - Centers of origin of crops



http://www.nature.com/nature/journal/v418/n6898/images/nature01019-f2.2.jpg

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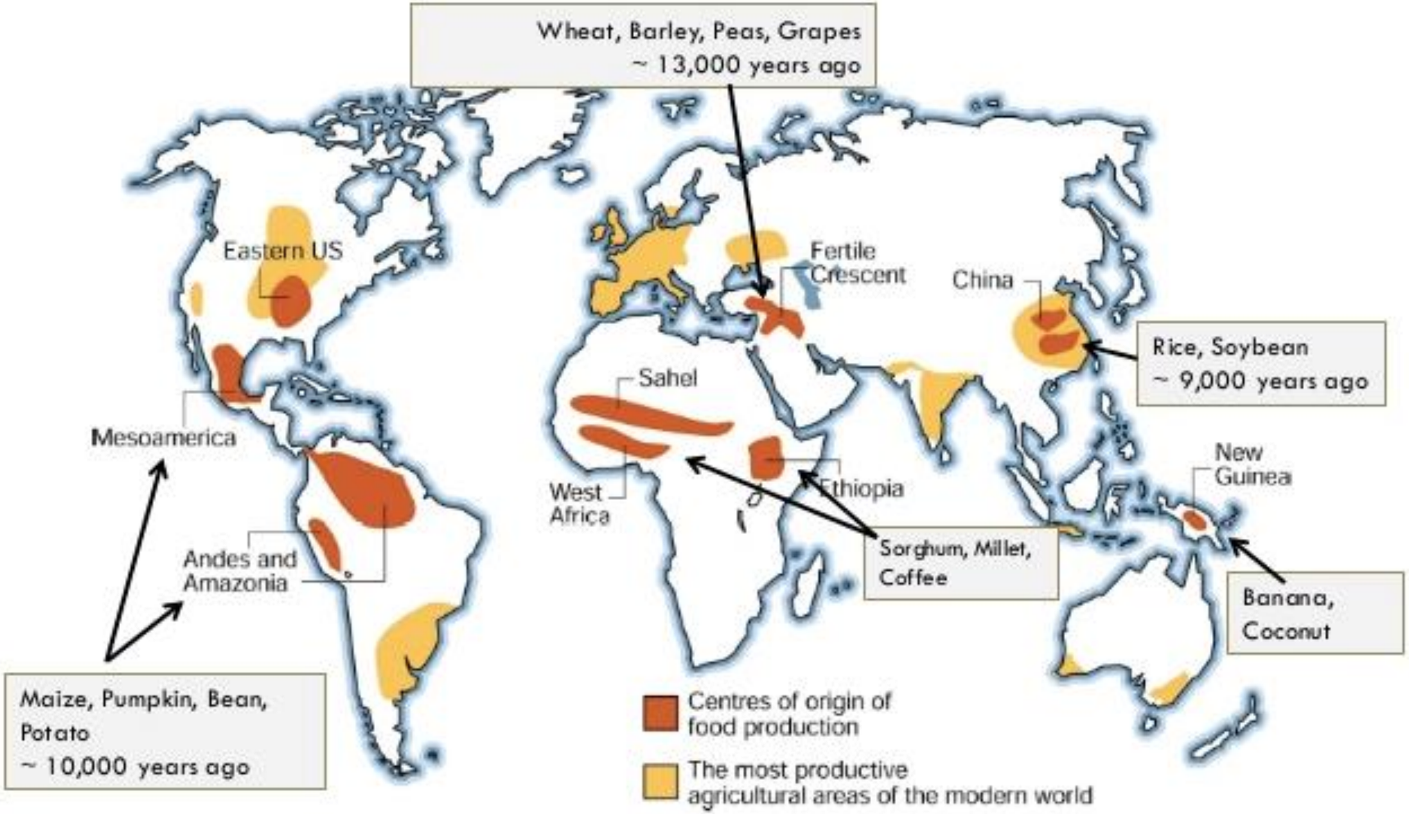
Historical overview - Centers of origin of crops



Gruissen (2013) A coalition of plant and crop societies across the Globe

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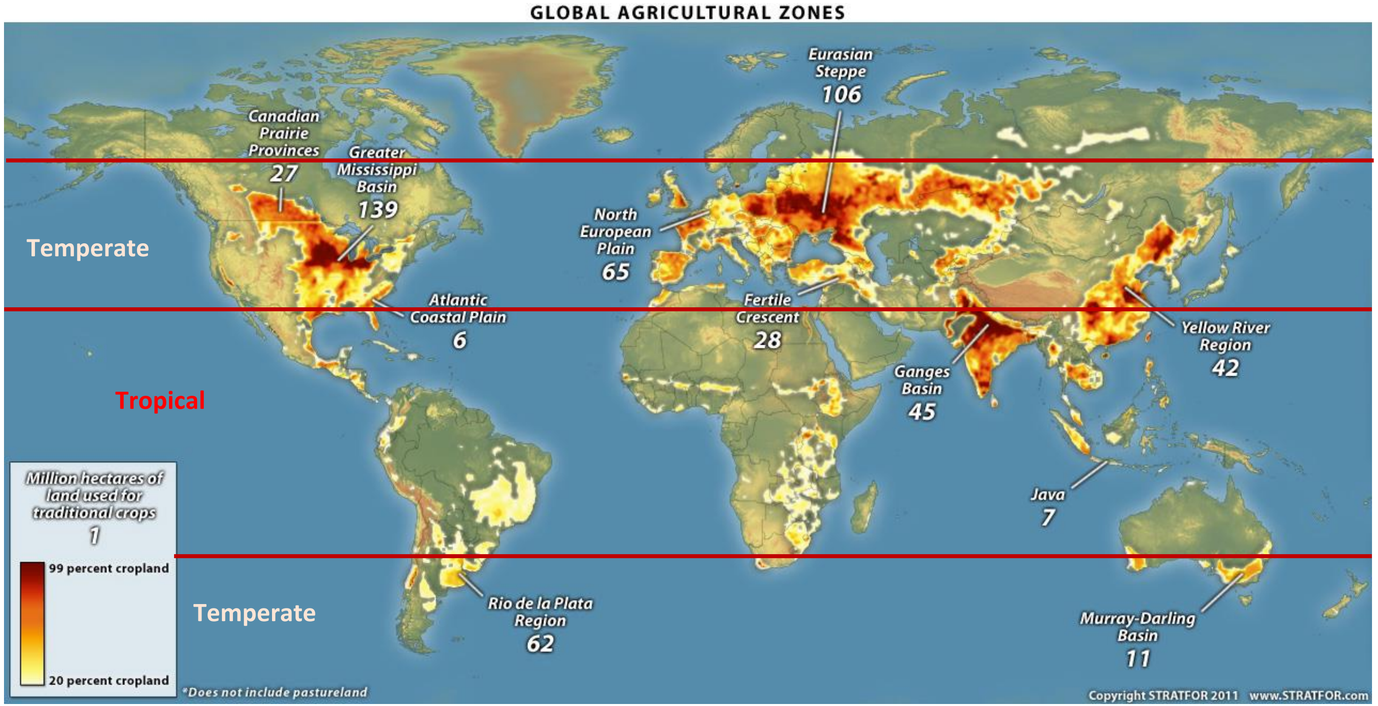
North-South Dualities - Land use intensity



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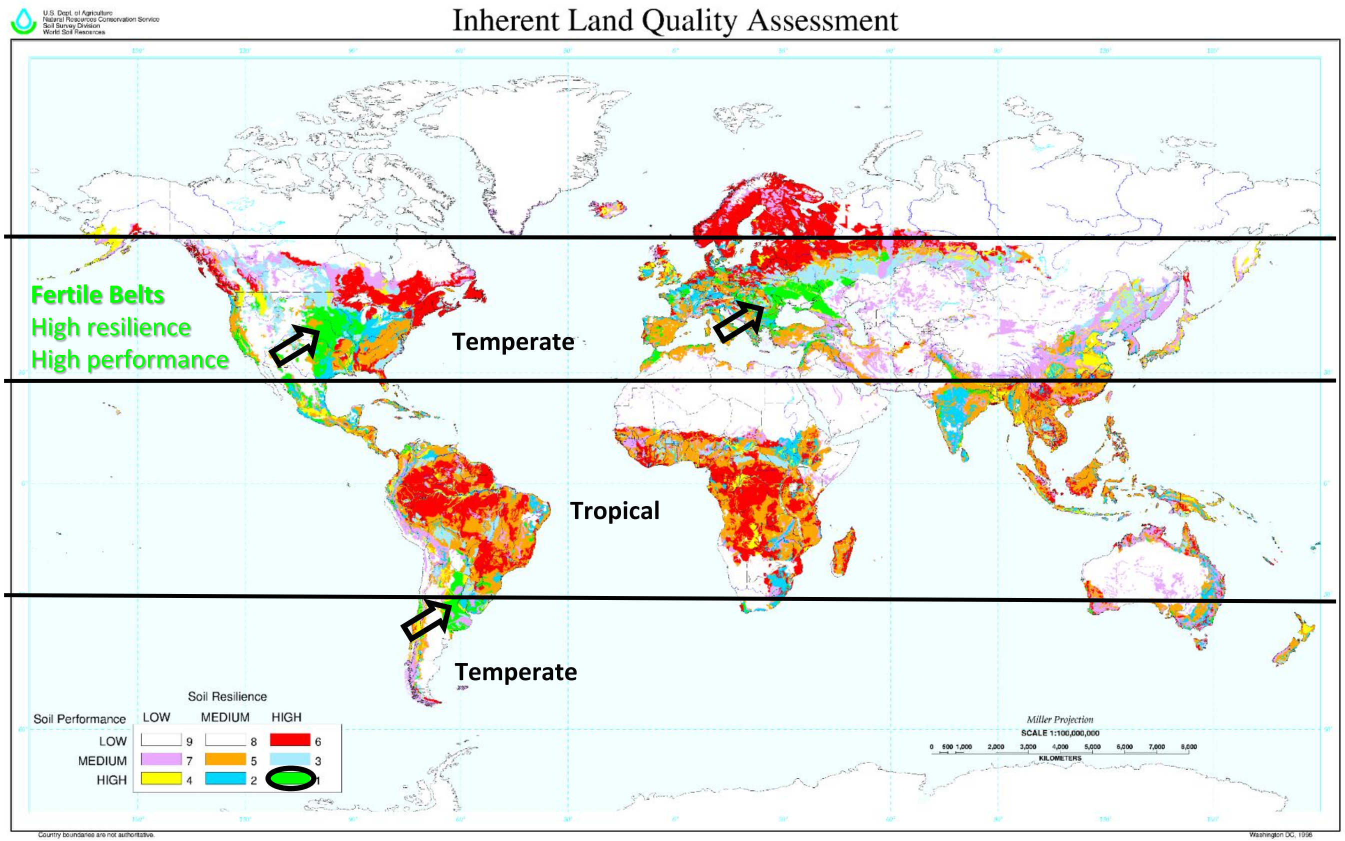
North-South Dualities - Soil Quality



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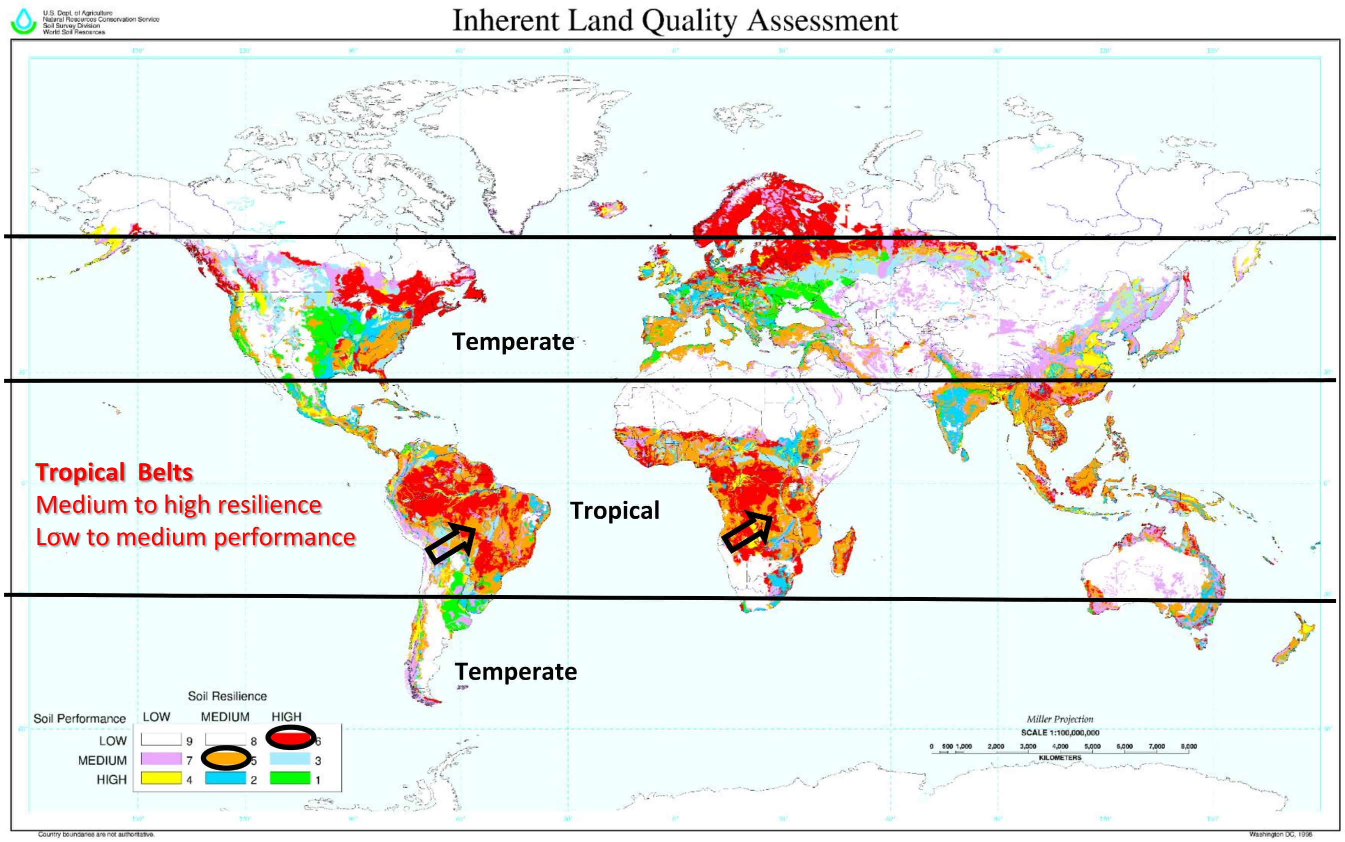
North-South Dualities - Soil Quality



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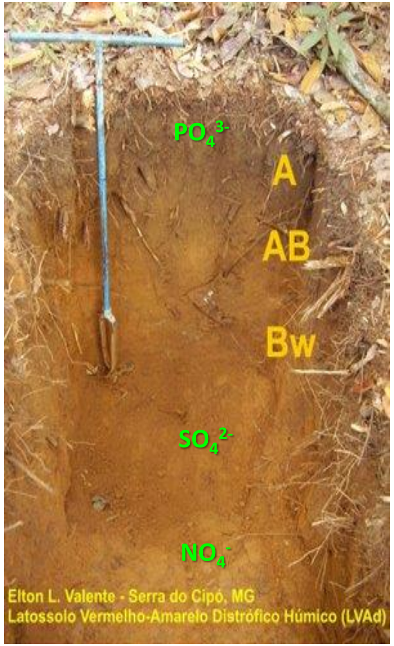
North-South Dualities - Agricultural soils

Temperate

Anions: SiO_4^{-4}, PO_4^{3-}, SO_4^{2-}, NO_4^{-}

Tropical



Cations: Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}

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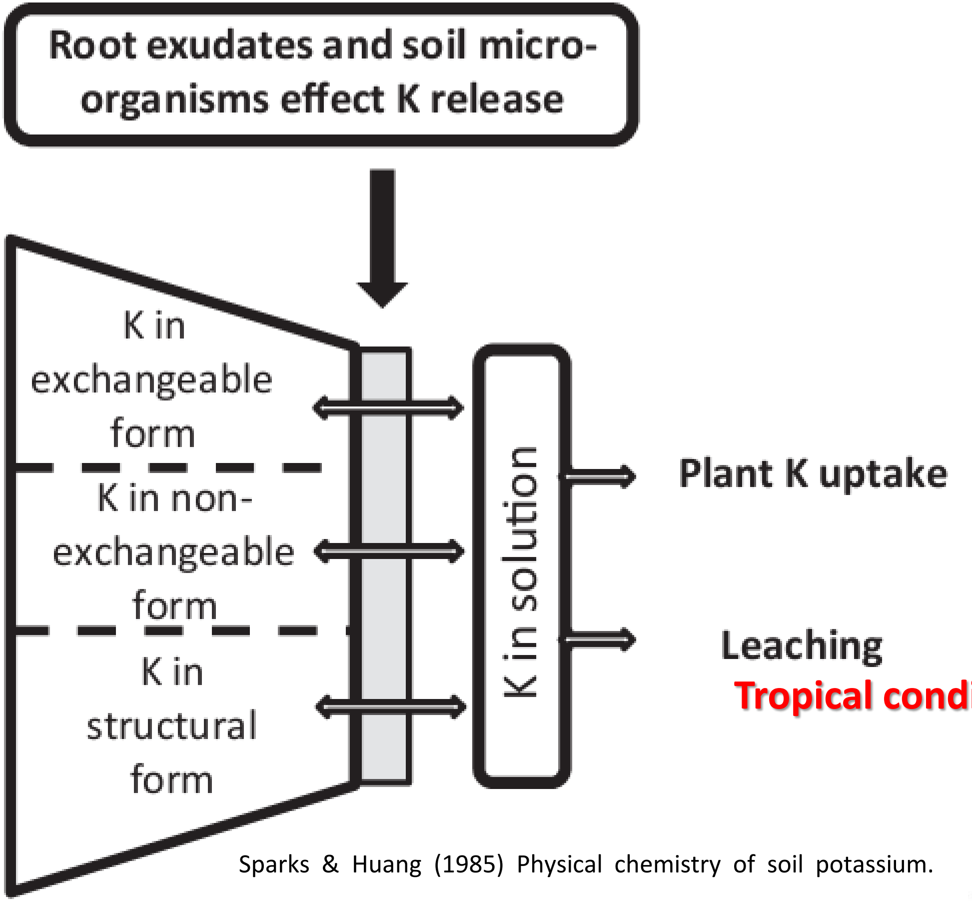
North-South Dualities - Agricultural soils

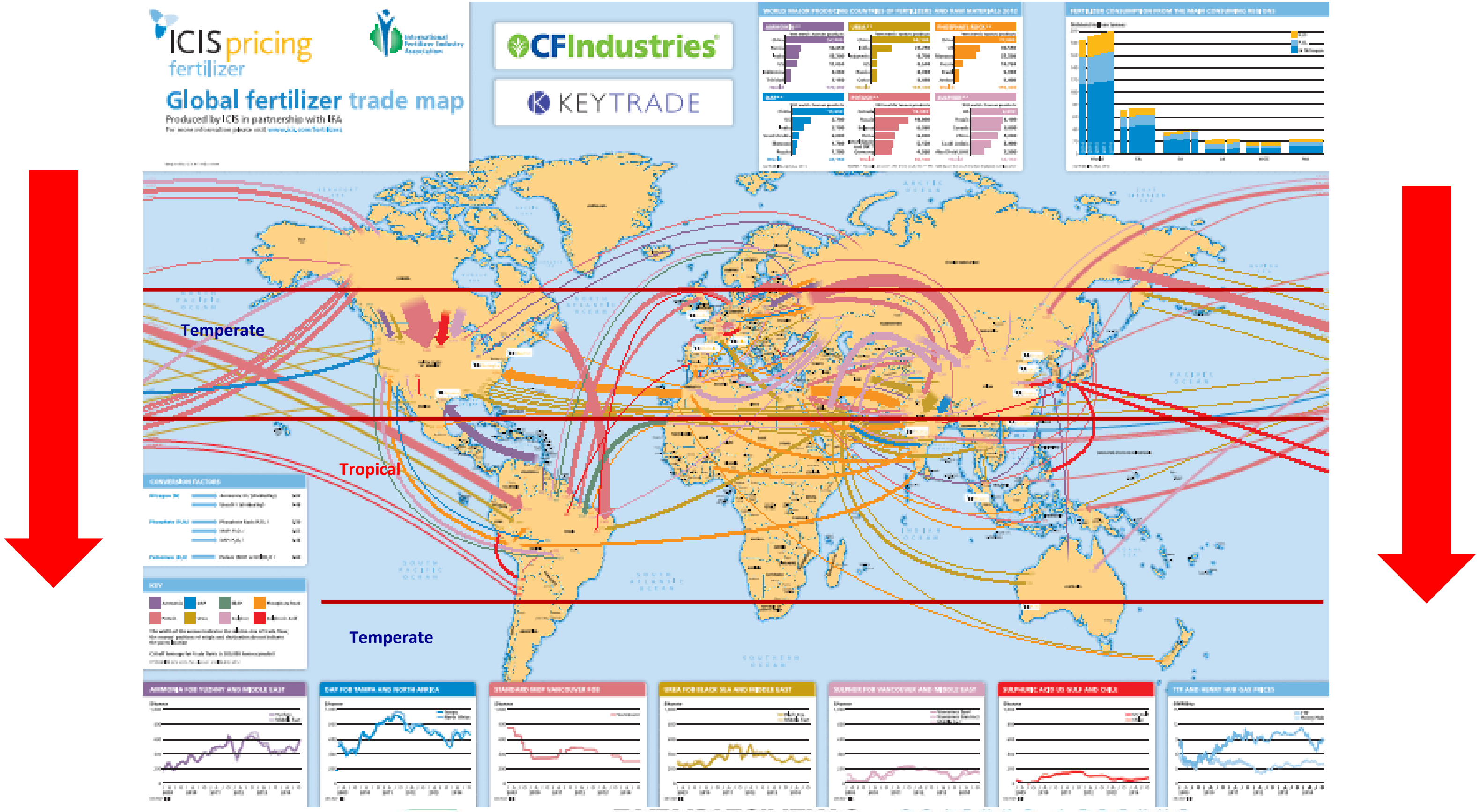
Temperate conditions



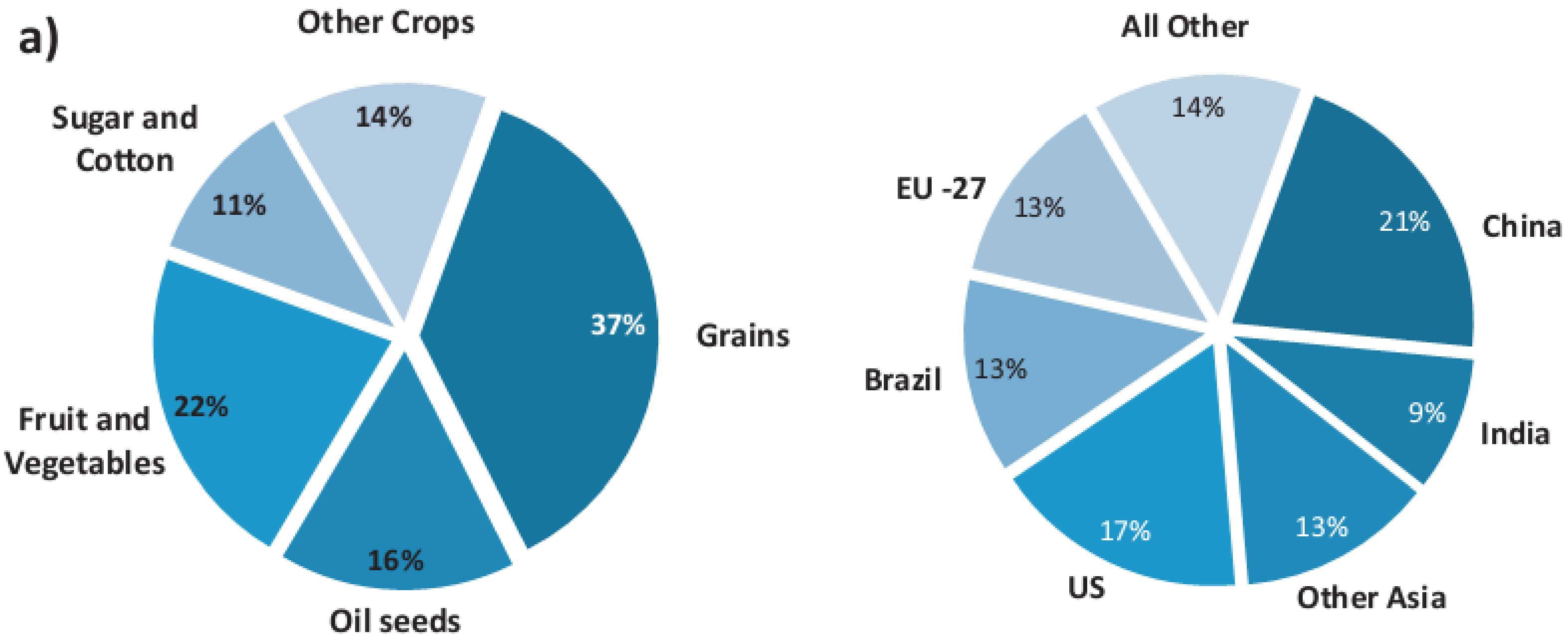
Tropical conditions

Sparks & Huang (1985) Physical chemistry of soil potassium.

North-South Dualities - Fertilizer commodities



North-South Dualities - Potash consumptions



Zorb et al (2014) Potassium in agriculture

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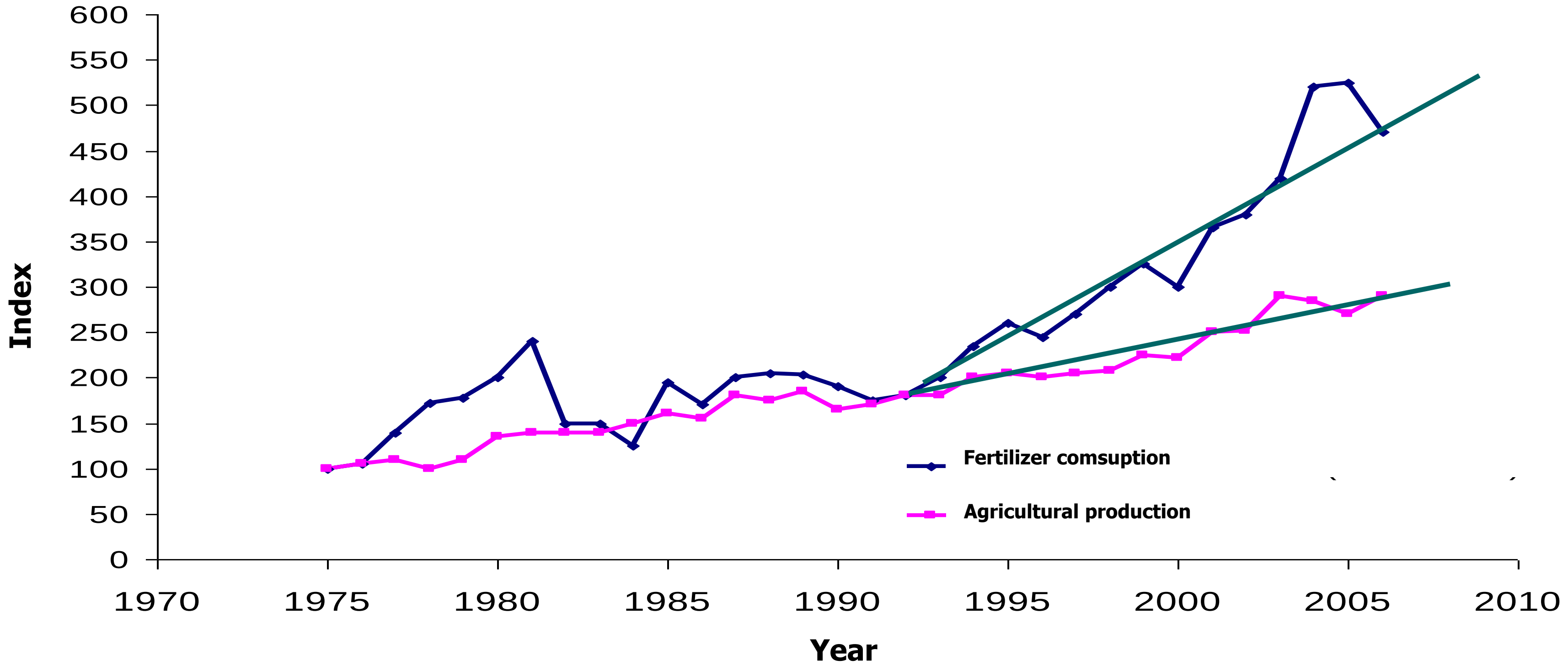
Technological Exhaustion - Nutrient efficiency



Sources: Anda; IBGE e Lopes, A. S., 2007 (compiled by Polidoro, 2012)

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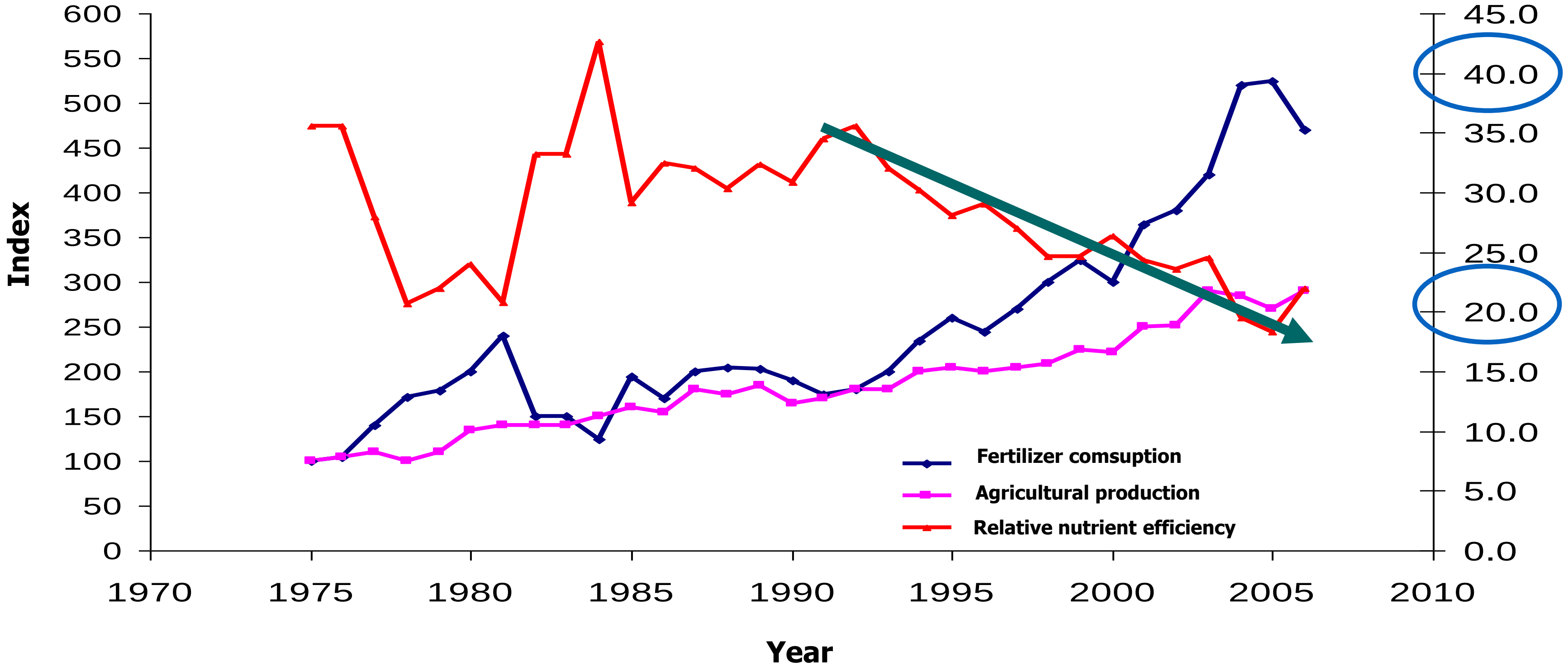
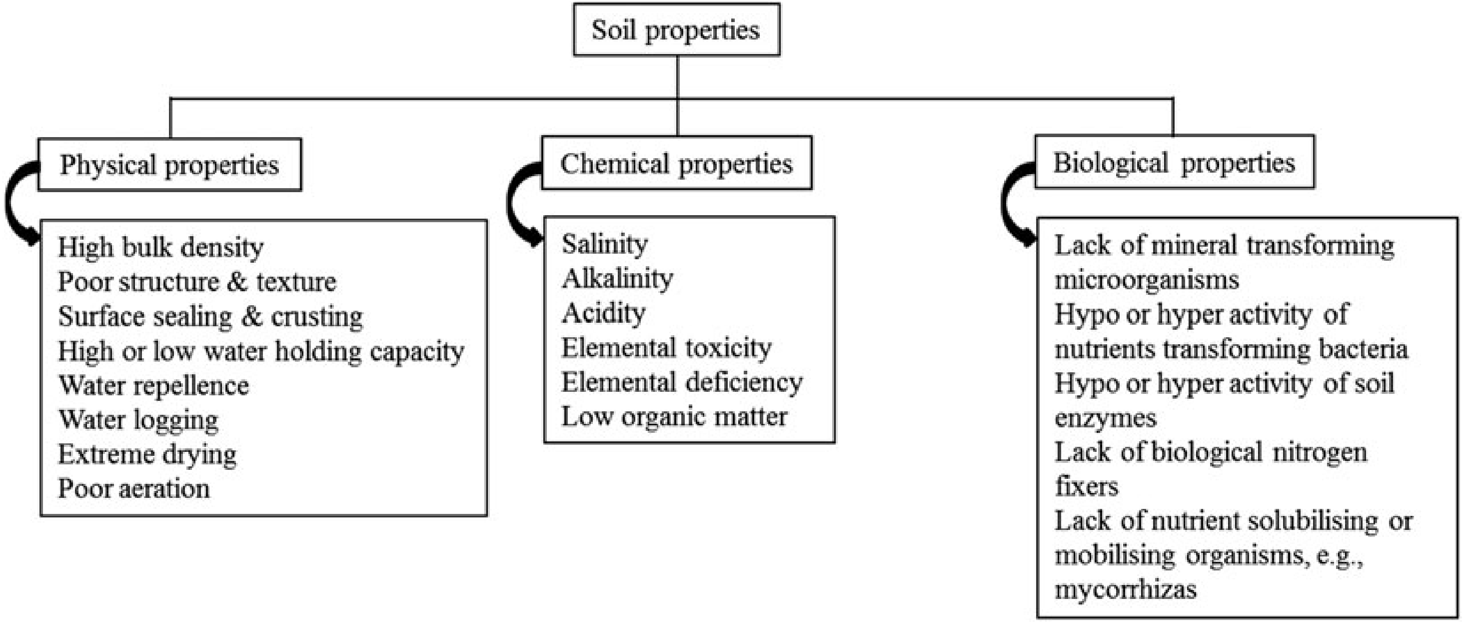
Technological Exhaustion - Nutrient efficiency



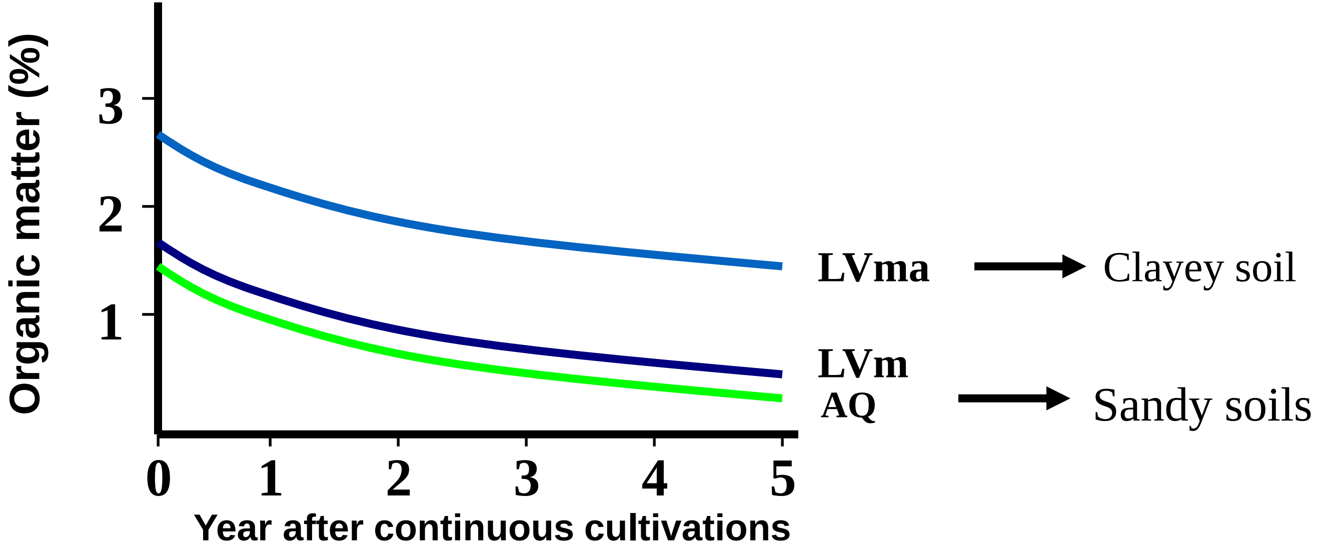
Sources: Anda; IBGE e Lopes, A. S., 2007 (compiled by Polidoro, 2012)

Technological Exhaustion - Nutrient efficiency



Sarkar & Naidu (2015) Nutrient and Water Use Efficiency in Soil: The Influence of Geological Mineral Amendments .
A. Rakshit et al. (eds.), Nutrient Use Efficiency: from Basics to Advances

Technological Exhaustion – Loss of organic matter



OM reduction
AQ - 80%
LVm - 76%
LVma - 41%

Source: Silva et al. (1994)

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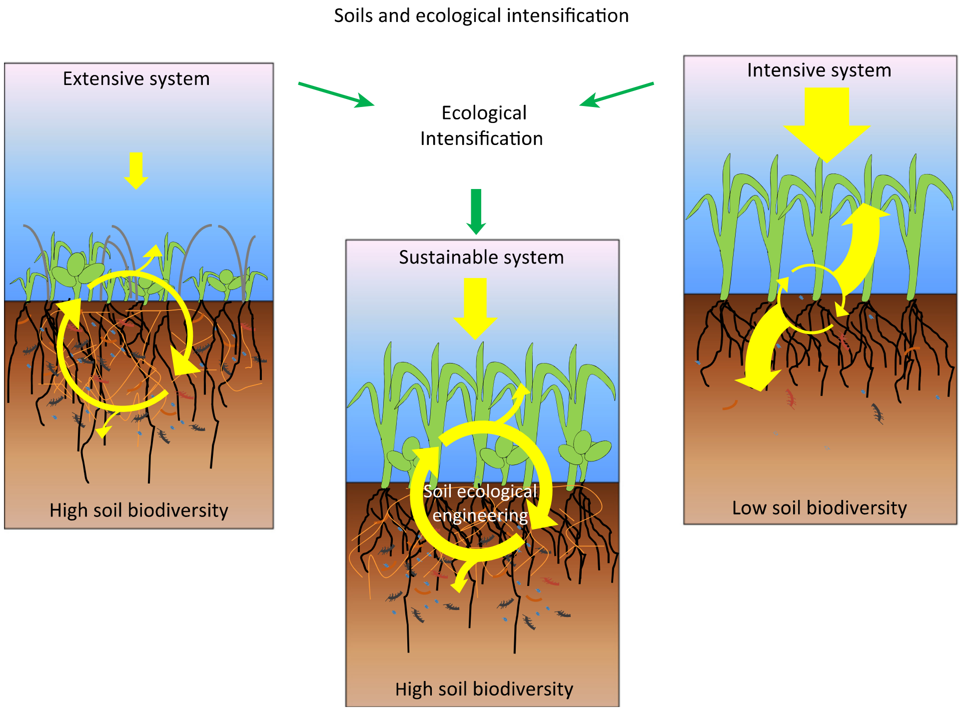
Technological Exhaustion - Nutrient efficiency



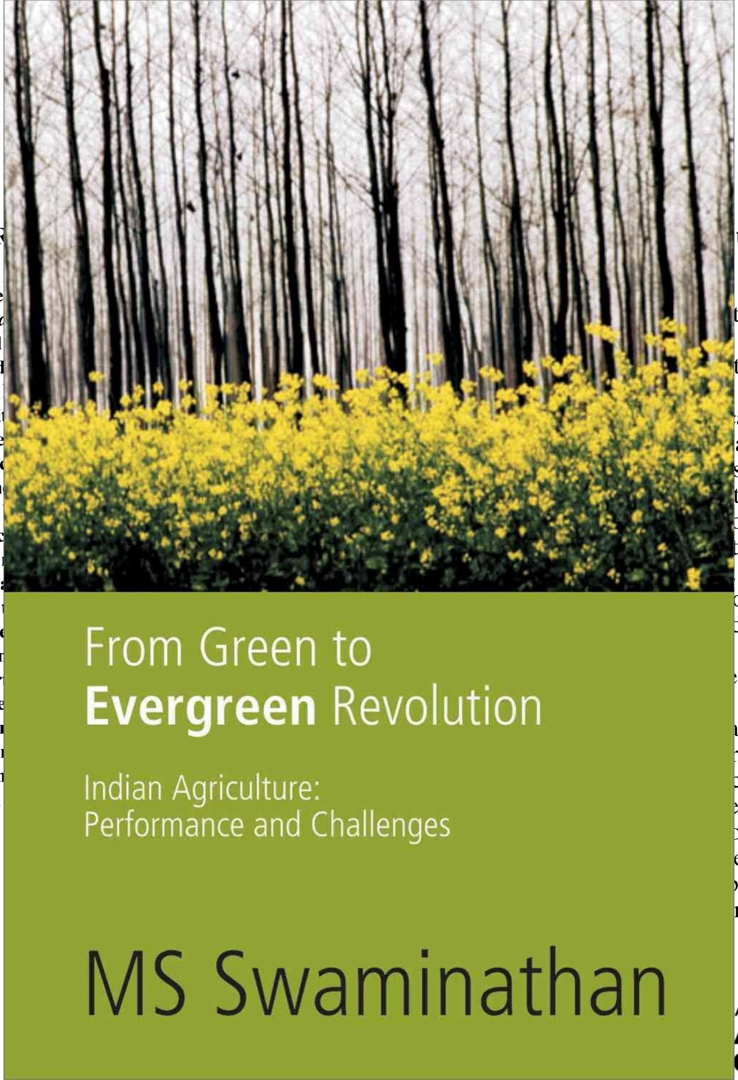
Bender et al (2016) An Underground Revolution: Biodiversity and Soil Ecological Engineering for Agricultural Sustainability.

New paradigma

ABSTR

The Green Revolution was the
chitecture and physiological prope
(*Triticum aestivum* L.), rice (*Oryza*
sorghum (*Sorghum bicolor* L.), and
stature contributed to providing ad
high productivity, without inducing
vest index. Similarly, photoinsensit
cultivar to seasons with appropriate
Revolution led to increased produc
and, thereby, conserved arable lan
technology, however, was criticized
and social scientists for its deficienc
cause market-purchased inputs are
rich farmers are able to take adv
Environmentalists emphasized that
pesticides, as well as the monoculture
serious environmental problems, in
tance and the degradation of soil fer
often women were excluded from te
ing to their marginalization. The G
many developing countries, includin
balance between population growth
uted to an alignment of population
produce the needed food and other

THE CHALLENGE NOW is to



to shape our ag-

coined by Dr.
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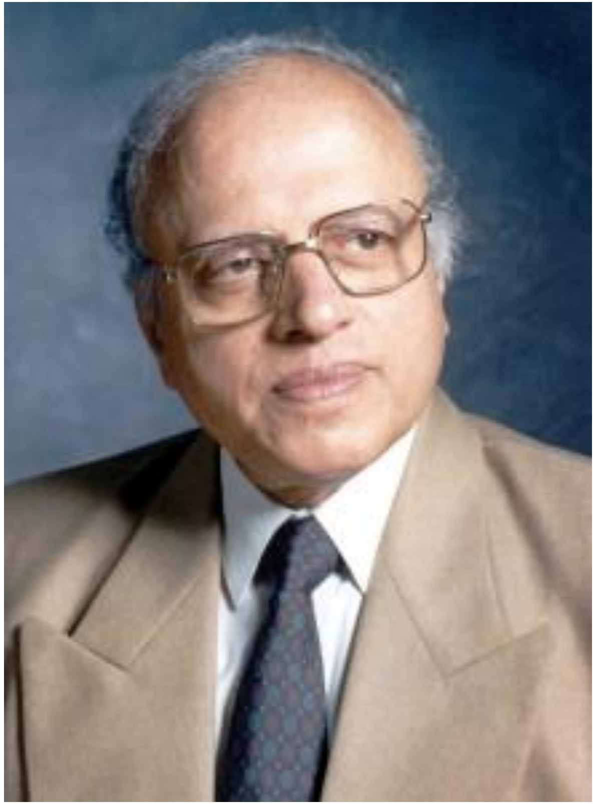

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Technological Exhaustion – Proposed solutions

16th World Fertilizer Congress of CIEC, Rio de Janeiro (2014)

- ✓ 1. Nanotechnology to produce controlled or slow-release fertilizers
- ✓ 2. Clay minerals to control nutrient release
- ✓ 3. Organomineral fertilizers from NPK sources and agro-industrial waste

- ✓ 4. Biostimulants, biofertilizers, and biochar from humic acids and organic compounds generated in the farm or formed by organic waste from human processes
- ✓ 5. Use of *in natura* regional rocks (stonemeal)
- ✓ 6. New materials based on silicate rock transforming by hydrothermal processes (hydropotash)

Types of agrominerals

Anion		Rock type*	Main Cations	Crust cover (% area)[10]	Water solubility
Carbonate	CO_3^{2-}	Limestone (sedimentary)[1] Carbonatite (igneous)[2] Marble (metamorphic)[3]	Ca^{2+}, Mg^{2+}	10.0	Low
Sulphate	SO_4^{2-}	Evaporitic deposits (sedimentary)[4]	Ca^{2+}, **K^{+}**	0,0	Very high
Chloride	Cl^{-1}	Evaporitic deposits (sedimentary)	**K^{+}**	0,0	Very high
Phosphate	PO_4^{3-}	Phosphorite (sedimentary)[5] Phoscorite (igneous)[6]	Ca^{2+}	0,0	Low
Silicate	SiO_4^{4-}	Sedimentary[7] Igneous[8] Metamorphic[9]	Ca^{2+}, Mg^{2+}, **K^{+}**	90.0	Very low

*Research examples: [1]Sousa et al. (1989); [2]Andrade et al. (2002); [3]Raymundo et al. (2013); [4]Freire et al. (2014); [5]Chaves et al. (2013); [6]Resende et al. (2006); [7]Lopes (1971); [8]Mancuso et al. (2014); [9]Duarte et al. (2012).
[10]Scoffin (1987).

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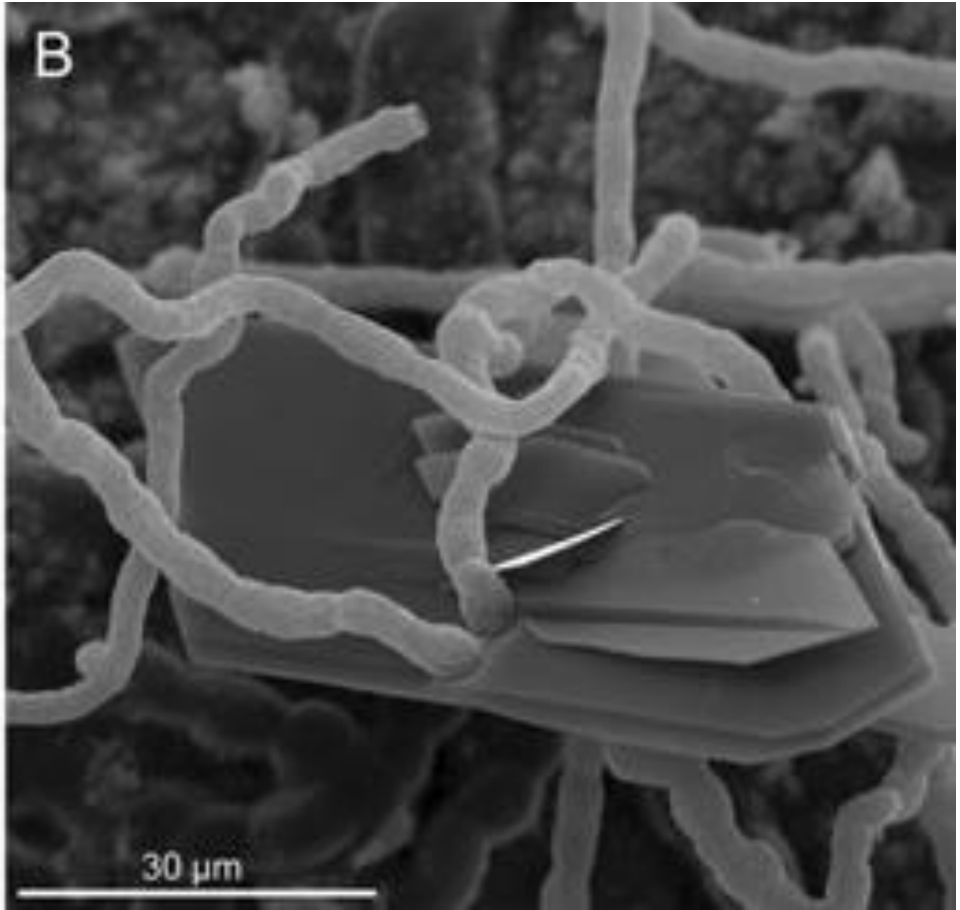
Bioweathering

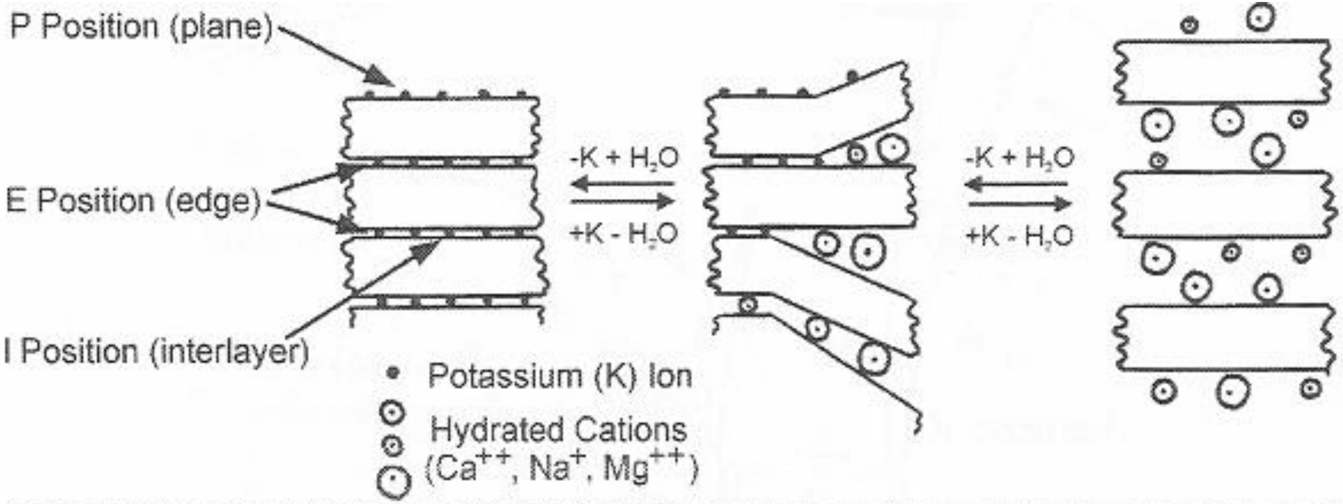
Bioweathering

Bonneville et al (2011) Tree-mycorrhiza Symbiosis accelerate mineral weathering. *Geoch. Cosmoch. Acta, 75:6988-7005*



Bioweathering

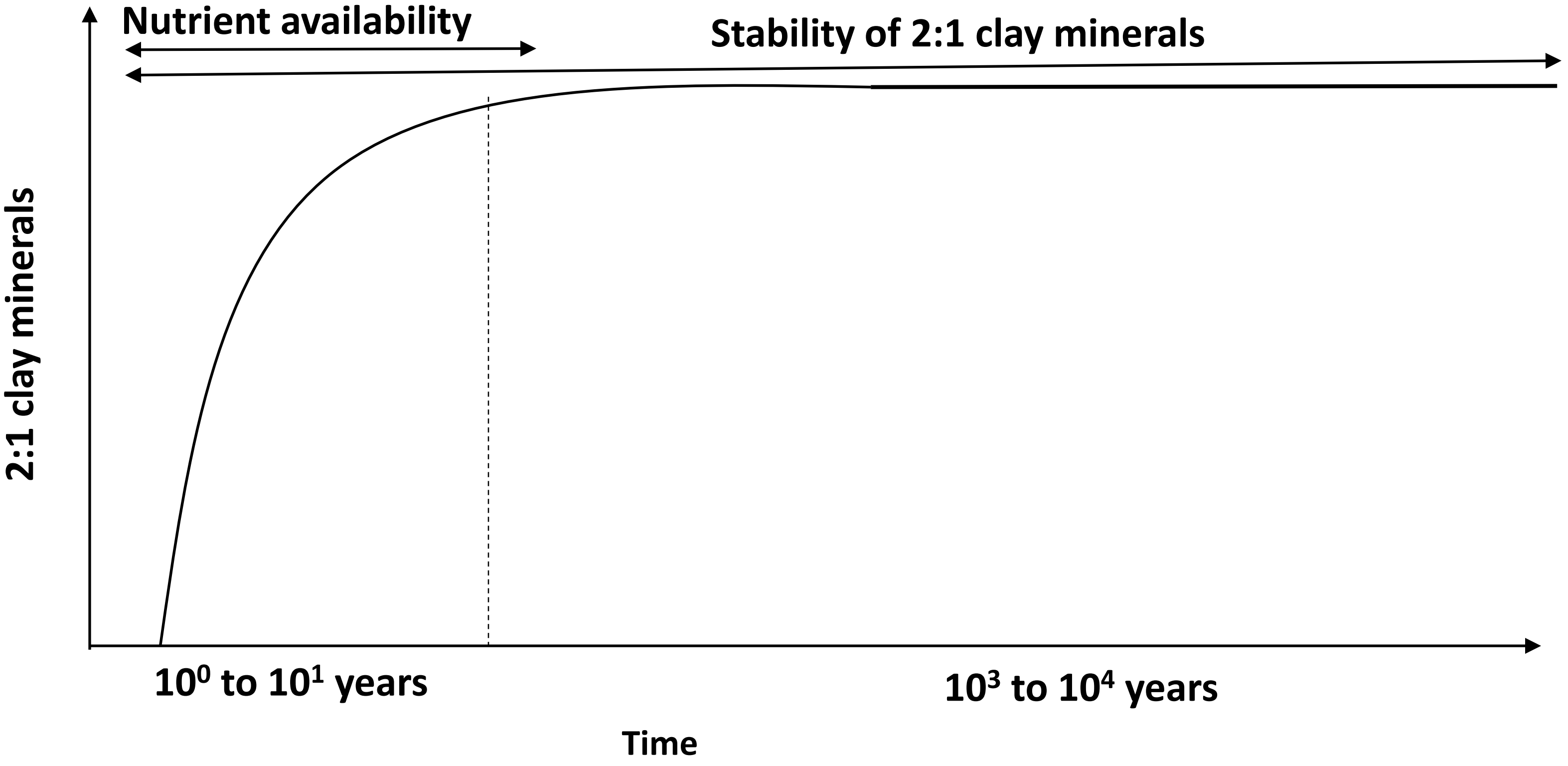
Biotite ⟹ Vermiculite + K +Si +Mg +Fe



K Content (%)	10	4-6	<1
CEC	0	30-50	150

Van Straaten (2007)

Bioweathering



Rhizosphere development

Source: Embrapa Cerrados 2017

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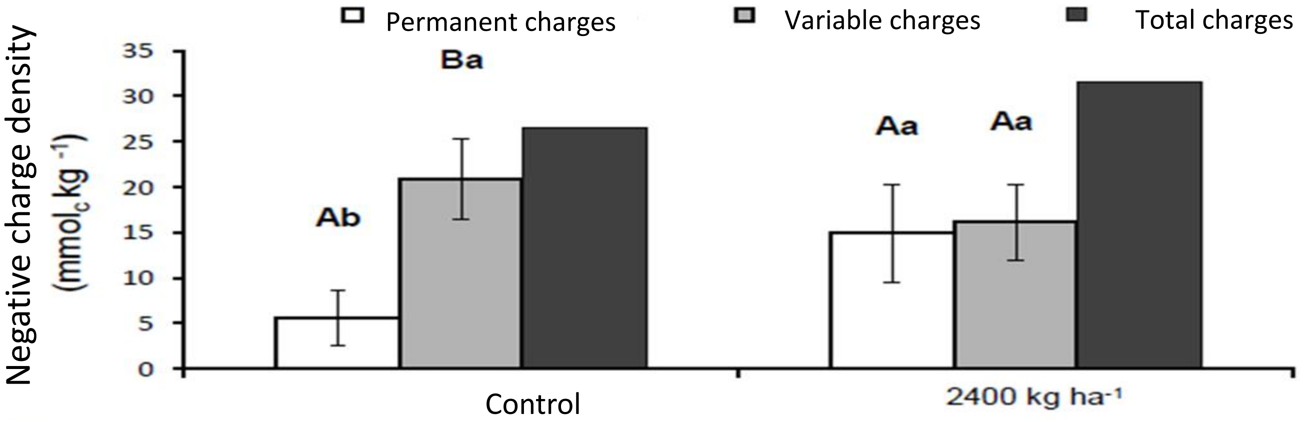
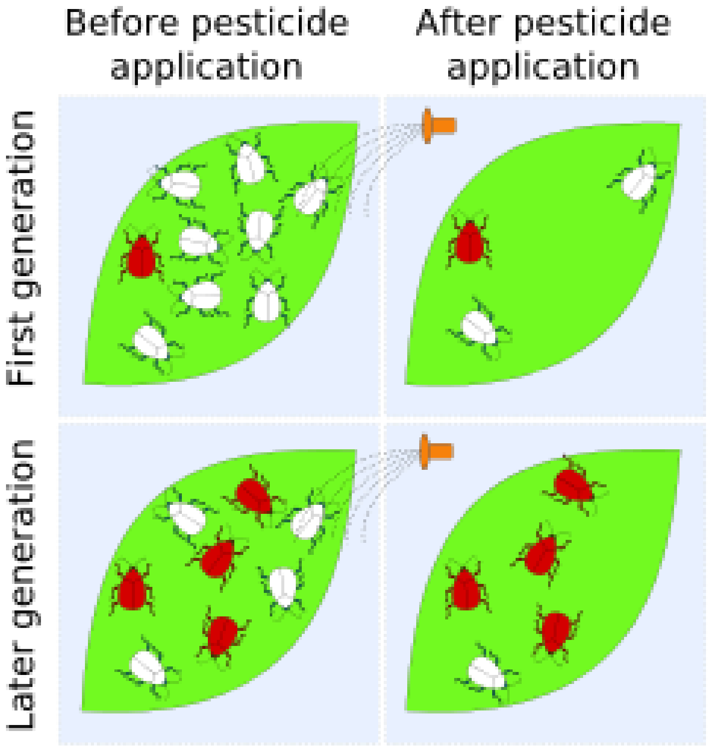
Surface charge formation



SANTOS, L.F; RODRIGUES, L.M.; MACHADO, L.L.; MOL, A.R.; SODRÉ, F.F.; BUSATO, J.G. CUNHA, J.C.; RUIZ, H.A.; FREIRE, M.B.G.; ALVAREZ, V.H.; FERNANDEZ, R.B. (2015) Cargas elétricas e liberação de nutrientes num Latossolo sob adição de sienito finamente moído. XXXV CBCS, Natal-RN, Resumos. Disponível: http://www.cbcs2015.com.br/anais/index.php#menuanais

Technological Exhaustion - Pest and disease control



https://commons.wikimedia.org/wiki/File%3APest_resistance_labelled_light.svg

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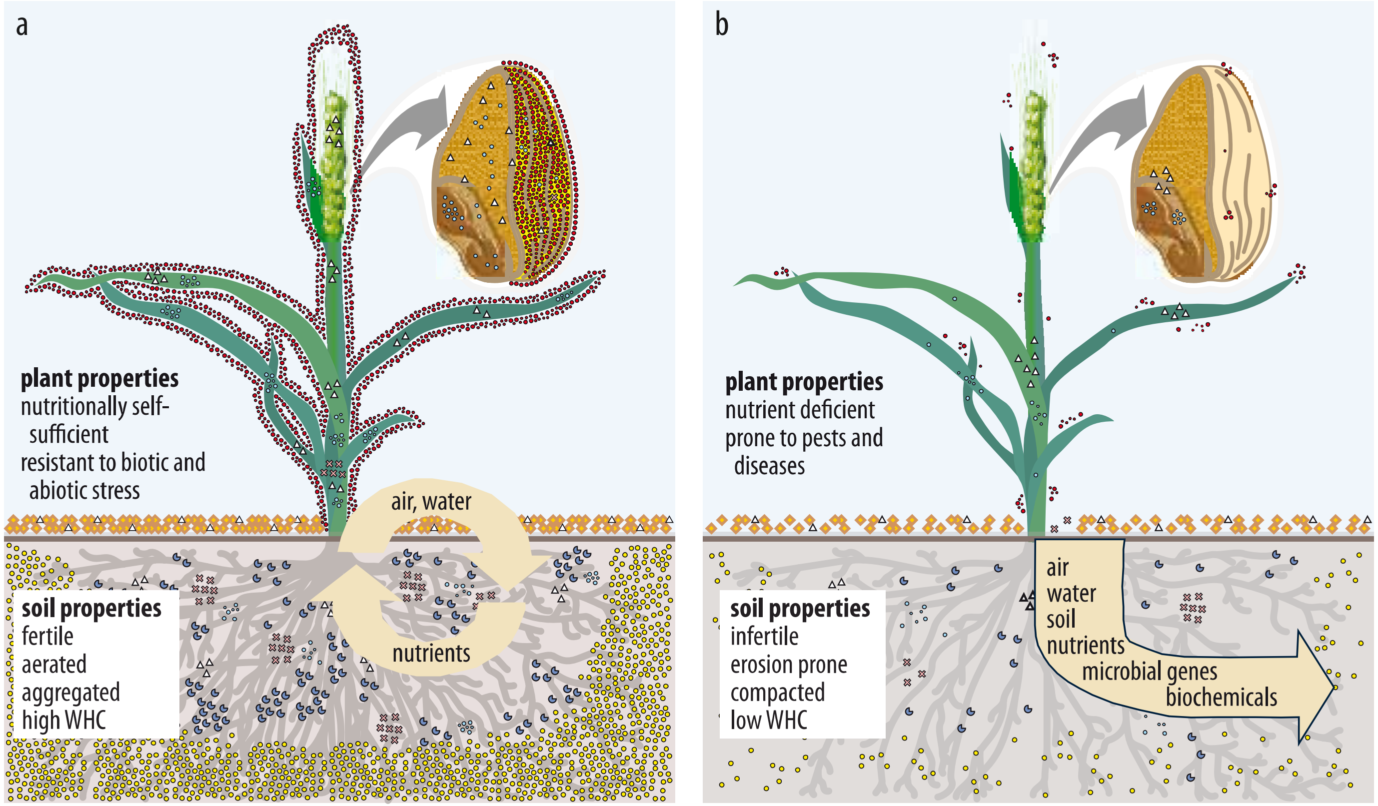
Solution:
Biological control

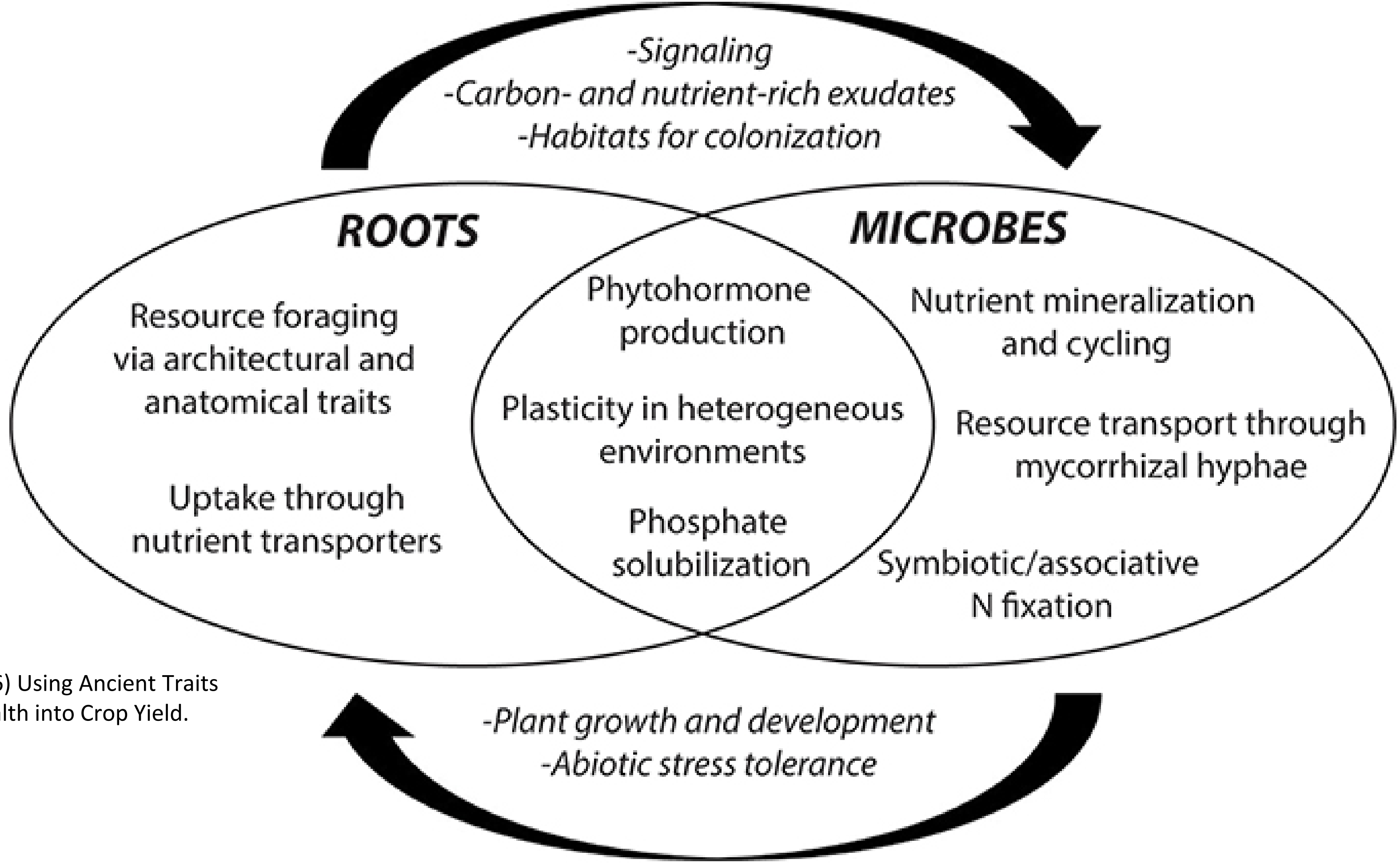
Solution: Biological equilibrium



Lucero, M. E.; Debolt, Seth; Unc, A.; Ruiz-Font, A.; Reyes, L. V.; McCulley, Rebecca L.; Alderman, S. C.; Dinkins, R. D.; Barrow, J. R.; and Samac, D. A., "Using Microbial Community Interactions within Plant Microbiomes to Advance an Evergreen Agricultural Revolution" (2014). Plant and Soil Sciences Faculty Publications. Paper 41.

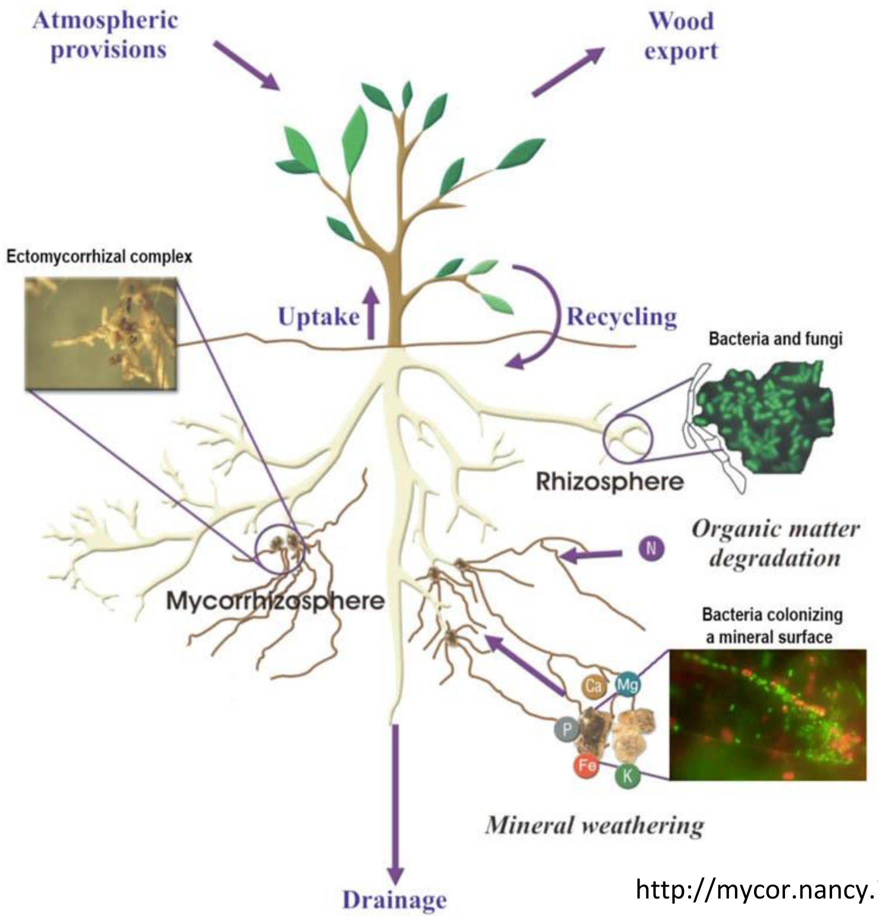
http://uknowledge.uky.edu/pss_facpub/41

Solution - Biological equilibrium



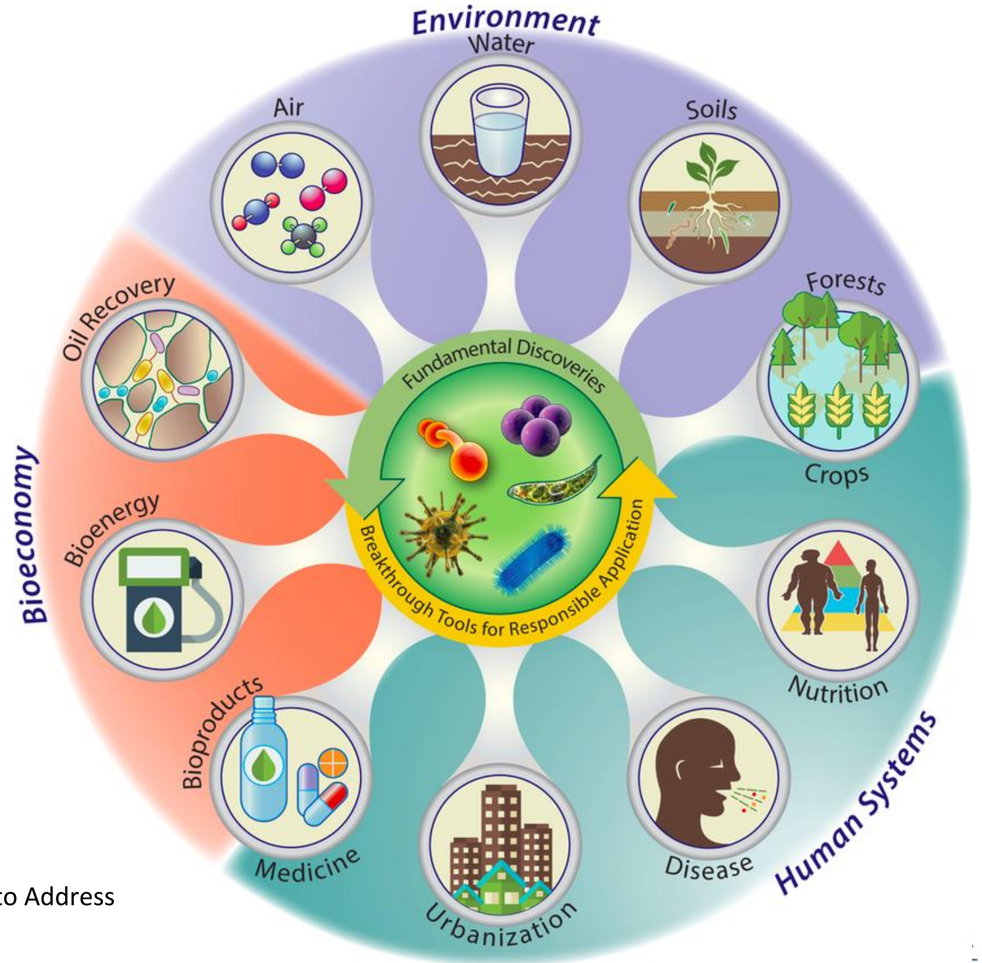
Schmidt et al (2016) Using Ancient Traits to Convert Soil Health into Crop Yield.

Solution: Biological equilibrium



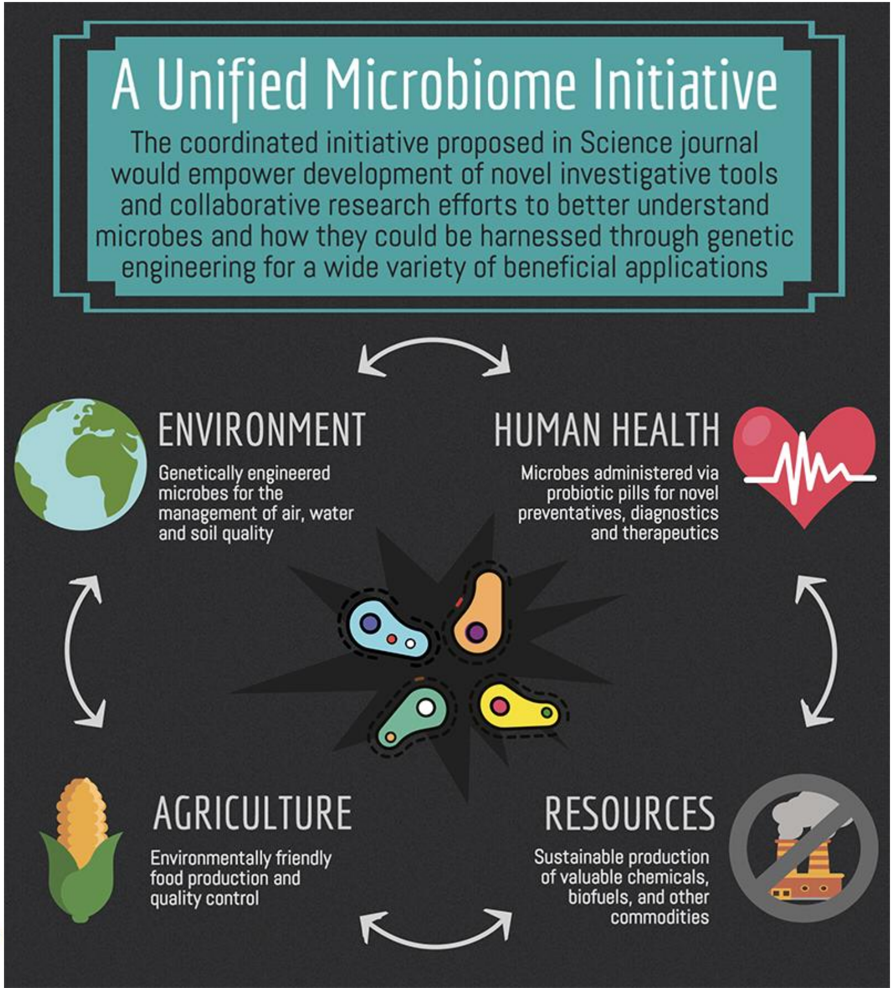
http://mycor.nancy.inra.fr/IAM/?page_id=727

Solution: Biological equilibrium



Blaser et al (2016) Toward a Predictive Understanding of Earth's Microbiomes to Address 21st Century Challenges

Solution: Biological equilibrium



http://news.harvard.edu/gazette/story/2015/10/microbiomes-could-hold-keys-to-improving-life/

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New Paradigma: Evergreen Revolution

- ✓ 1. Biostimulants, biofertilizers, and biochar from humic acids and organic compounds generated in the farm or formed by organic waste from human processes
- ✓ 2. Use of *in natura* regional rocks (stonemeal)
- ✓ 3. Silicate rock processing by hydrothermal processes (hydropotash)
- ✓ 4. Management of soil and plant microbiomes

New Paradigma: Evergreen Revolution

Ecosystem Function	Soil Biological Management Strategy	
	Enhancing Overall Soil Biodiversity	Targeted Soil Ecological Engineering
Pest control	+	+
Plant nutrient uptake		+
Reduction of nutrient losses		+
Soil formation	+	
Carbon sequestration	+	+

Bender et al (2016) An Underground Revolution: Biodiversity and Soil Ecological Engineering for Agricultural Sustainability.

MINISTÉRIO DA AGRICULTURA, PECUÁRIA E ABASTECIMENTO

Evergreen Revolution

Use of local and regional resources

Mineral Base - new agrominerals as controlled release sources, permanent CTC generation and increased nutrient use efficiency

Management - increase in biological activity (production system and biological inputs)

Thanks!