CIRAD

AGRO-ECOLOGY

Direct seeding on vegetal cover

UR1: Cropping system with direct seeding and cover crops

Pictures and illustrations by: O. Husson, L. Séguy, A. Chabanne, F. Tivet and N. Chorrier

Conventional agriculture

Soil structure (rooting, water) is managed through mechanical ploughing

Nutrition is made by (heavy) mineral fertilisation

Weed competition is reduced by ploughing and (heavy) use of chemicals

Conventional systems
Short term answers

Partial control of weeds
(Need to regularly change herbicides)

Improvement of soil structure
Mineral fertilisers intimately mixed with ploughed horizons

Redistribution of bases and P

Conventional systems
Limitations

Ploughing

Shallow improvement of soil structure

Creation of a plough-layer

Shallow rooting
Weak root exploration for water and nutrients

Conventional systems
Limitations

Ploughing

Temporary improvement
of soil structure

Creation of a crust

Increased run-off
Reduced infiltration

Conventional systems Limitations

Ploughing

Bare soil

No hydric or thermic regulation

Conventional systems Limitations

Ploughing

Lixiviation-leaching
Loss of nutrients
(no recycling as shallow rooting)
Pollution

Limitations of conventional systems

Destruction of fauna and flora

Ploughing

Herbicides and pesticides (as plants are weak)

Mineral fertilisers (Nitrogen sulphate, etc.)

Decreasing soil porosity: habitat for microbs, O_2, water, etc

Conventional systems Limitations

Ploughing

Sensitivity to erosion

Loss of soil and nutrients
Pollution

Severe erosion marks in soya bean field. Brazil

Lavaka **Madagascar**

Run-off **Brazil**

Destruction of irrigation network and paddy fields.
Central Highlands. Madagascar.

Wind erosion

South Goïas
Brazil

Vietnam

For subsistence, the forest remains the only available area...

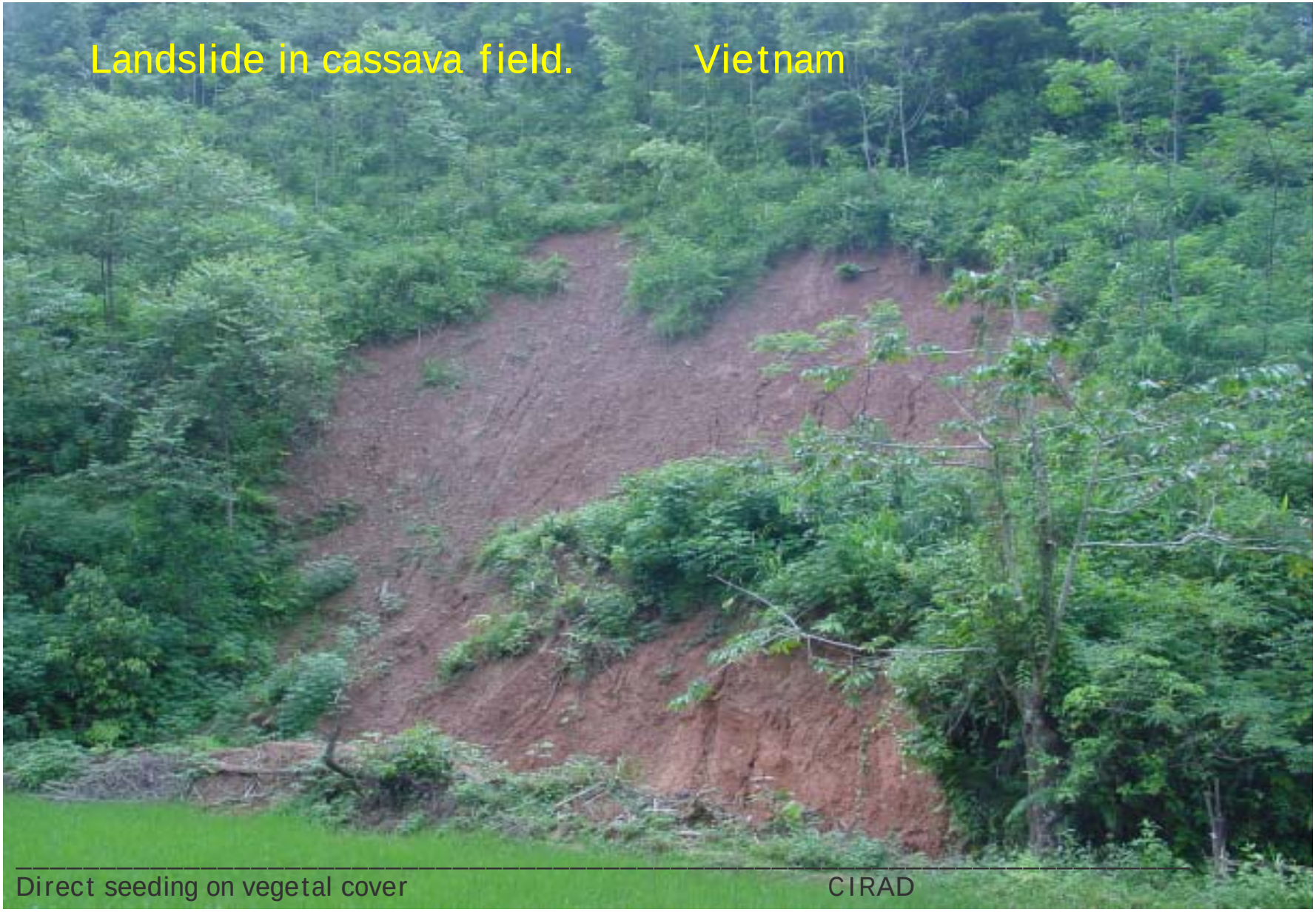
Slash-and-burn systems

Limitations of slash-and-burn systems

Improvement during the fallow period, but very fast decrease during cultivation due to:

Burning: loss of organic matter, volatilisation of nutrients, destruction of fauna and flora

Erosion


Landslide in cassava field. Vietnam


Fairy chemneys. Vietnam.

Environmental costs

Forest destruction: Forest area: Dropped from 56 to 10 % of total area in Vietnam since 1960.
Soil erosion: tremendous.
Floods: reduction of buffer capacity

Pollution (ground water by fertilisers and chemicals)

Social and economic costs

Health and even life
Destruction of infrastructure: paddy fields, irrigation systems, roads, dams, etc.
Loss of agricultural land
---> migration to urban areas
Equipment, fuel
Time

Fertilisers (300kg K /ha/year near Paris when 3t/ha available in first 1m of soil), pesticides

Natural resources assets depletion

Rural economy based on this capital

Collapsing of rural economy

What future in these conditions?

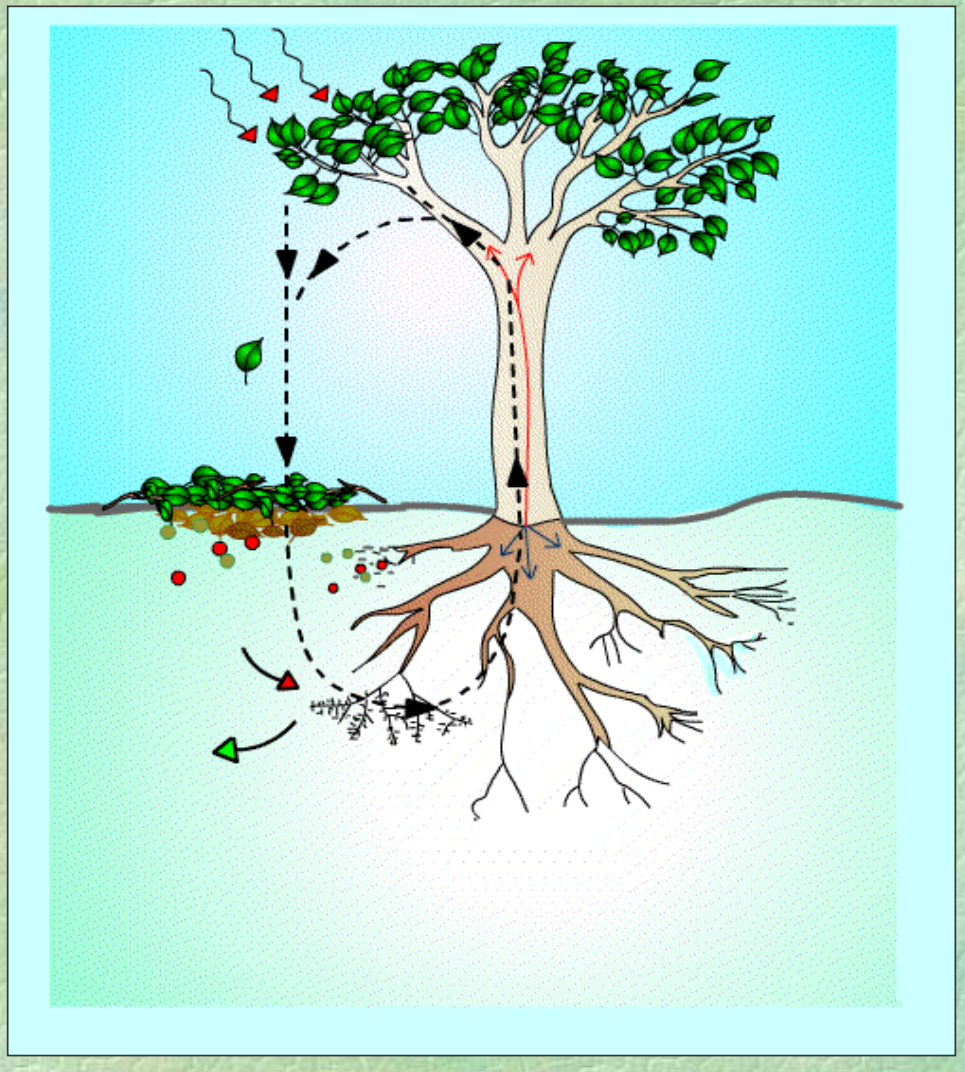
Agro-ecological techniques

Principles

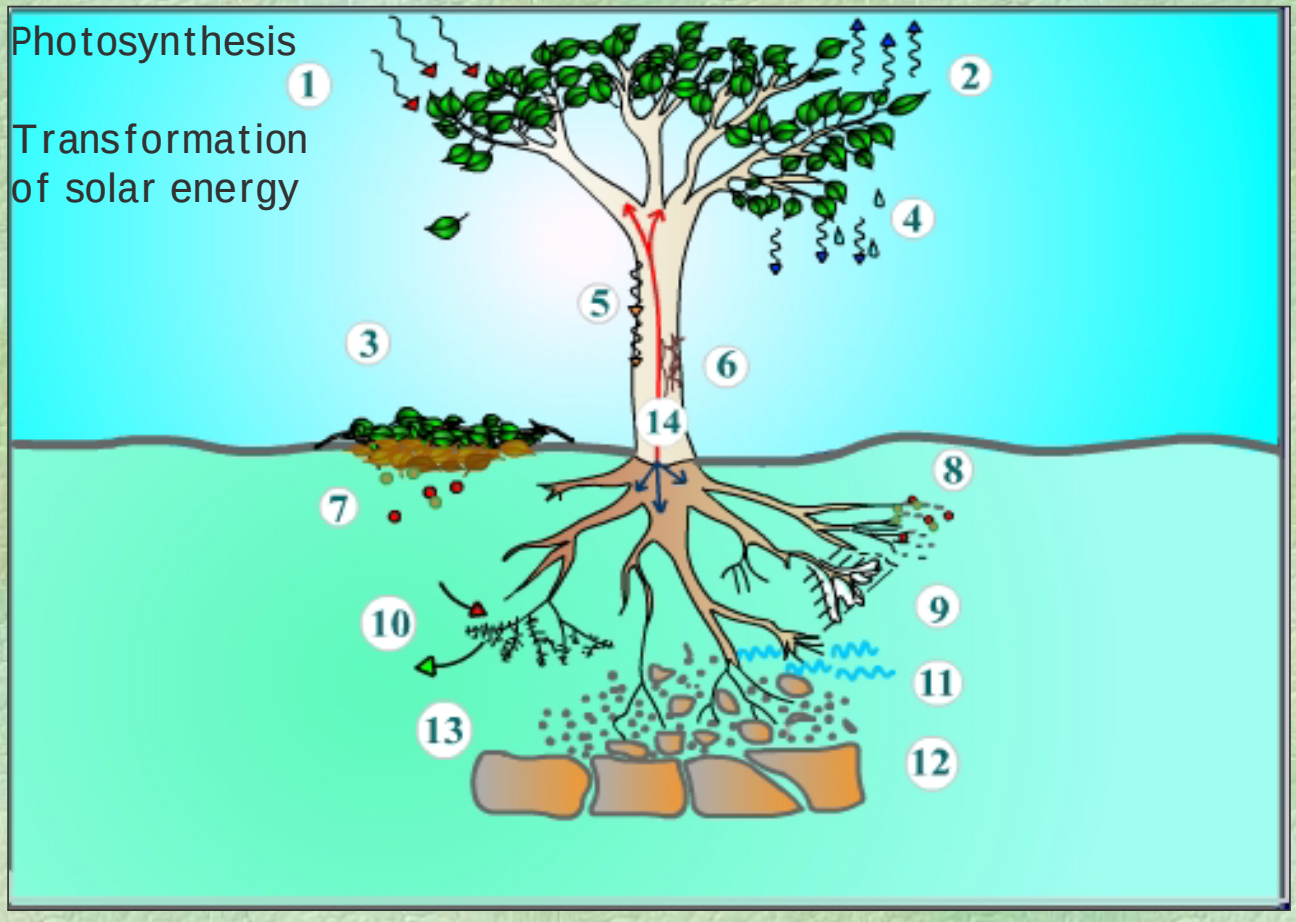
Copy a forest ecosystem

Speed up processes

Maintain main functions



The functions of plants in relation to soil genesis



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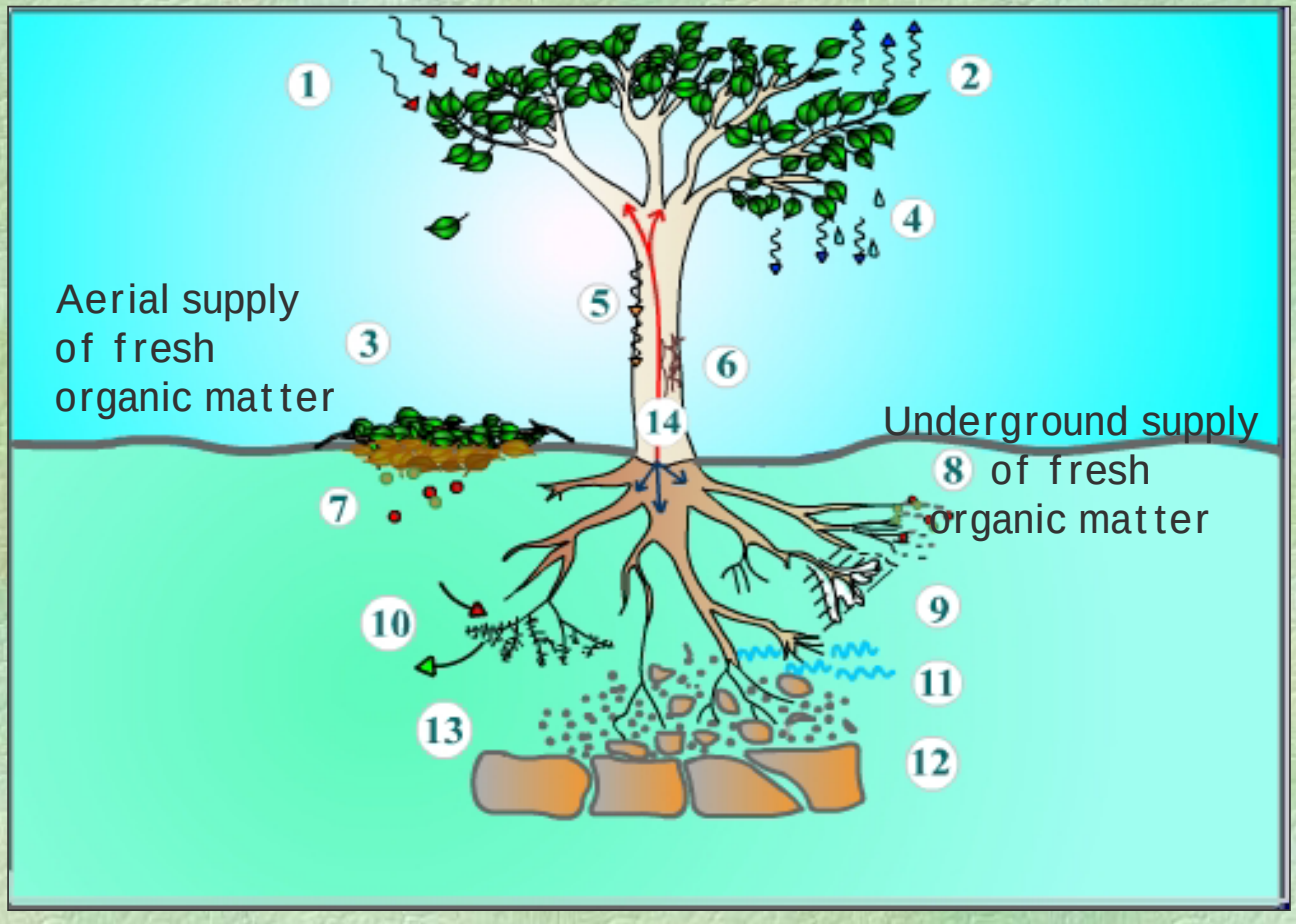

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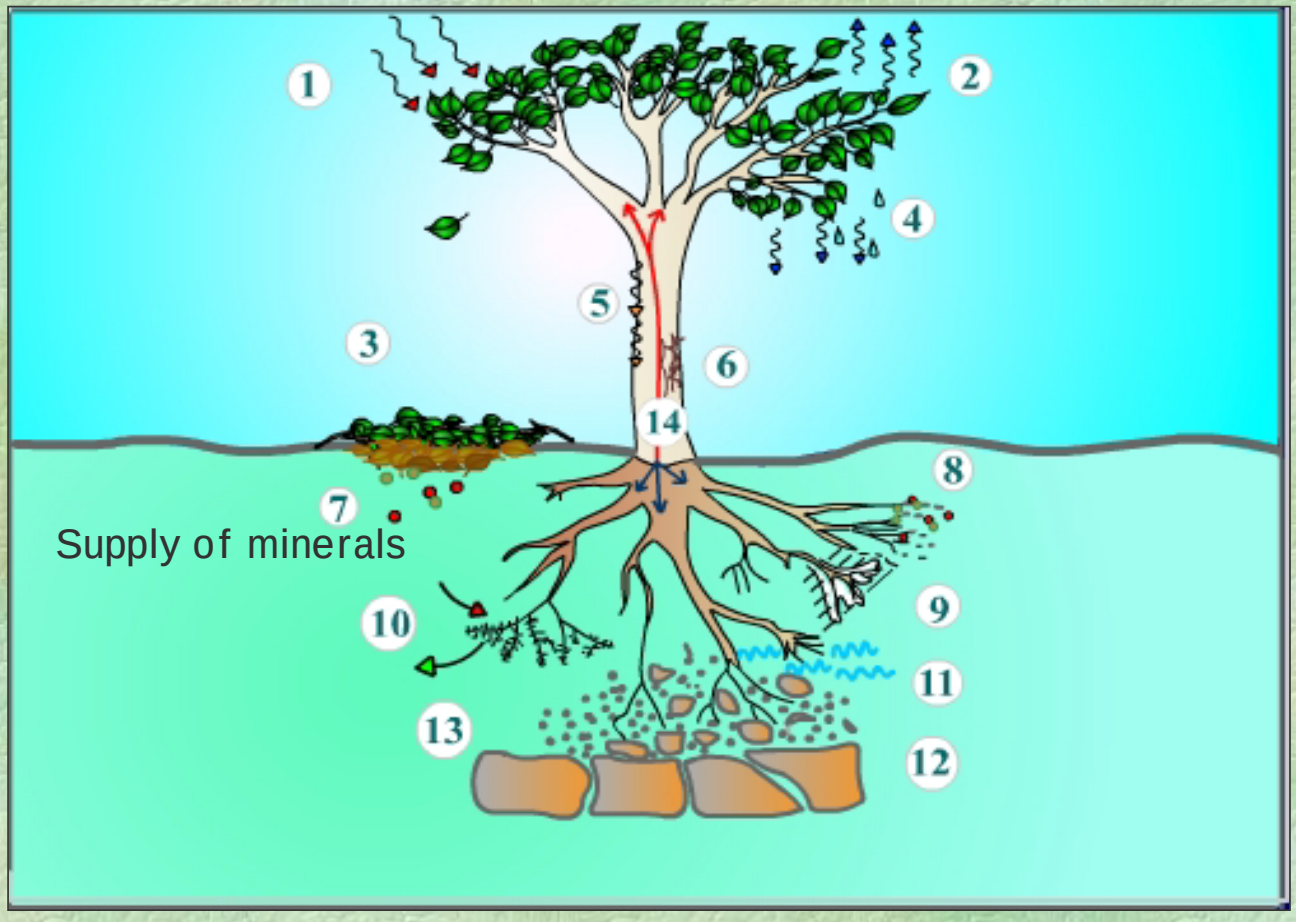

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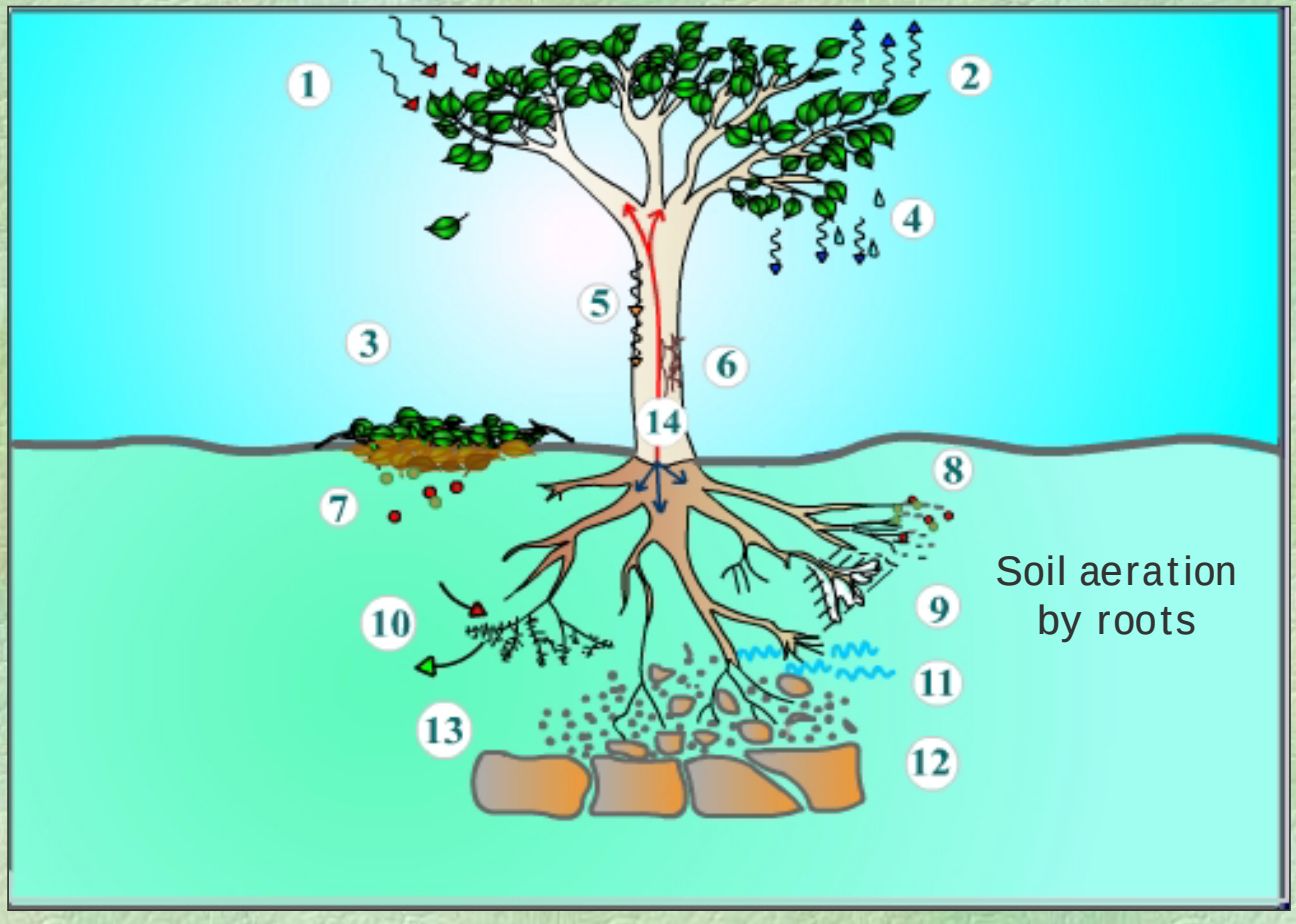

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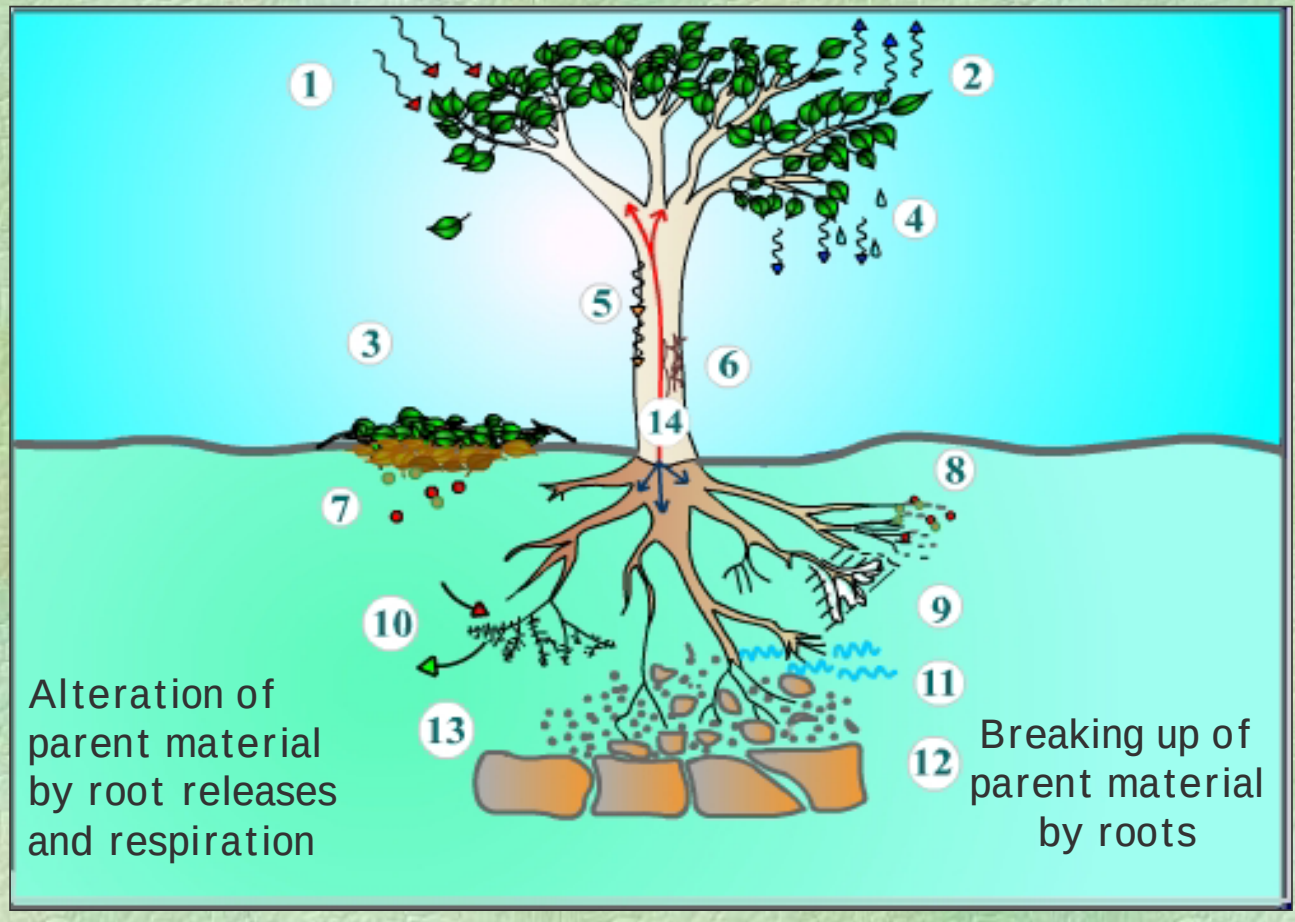

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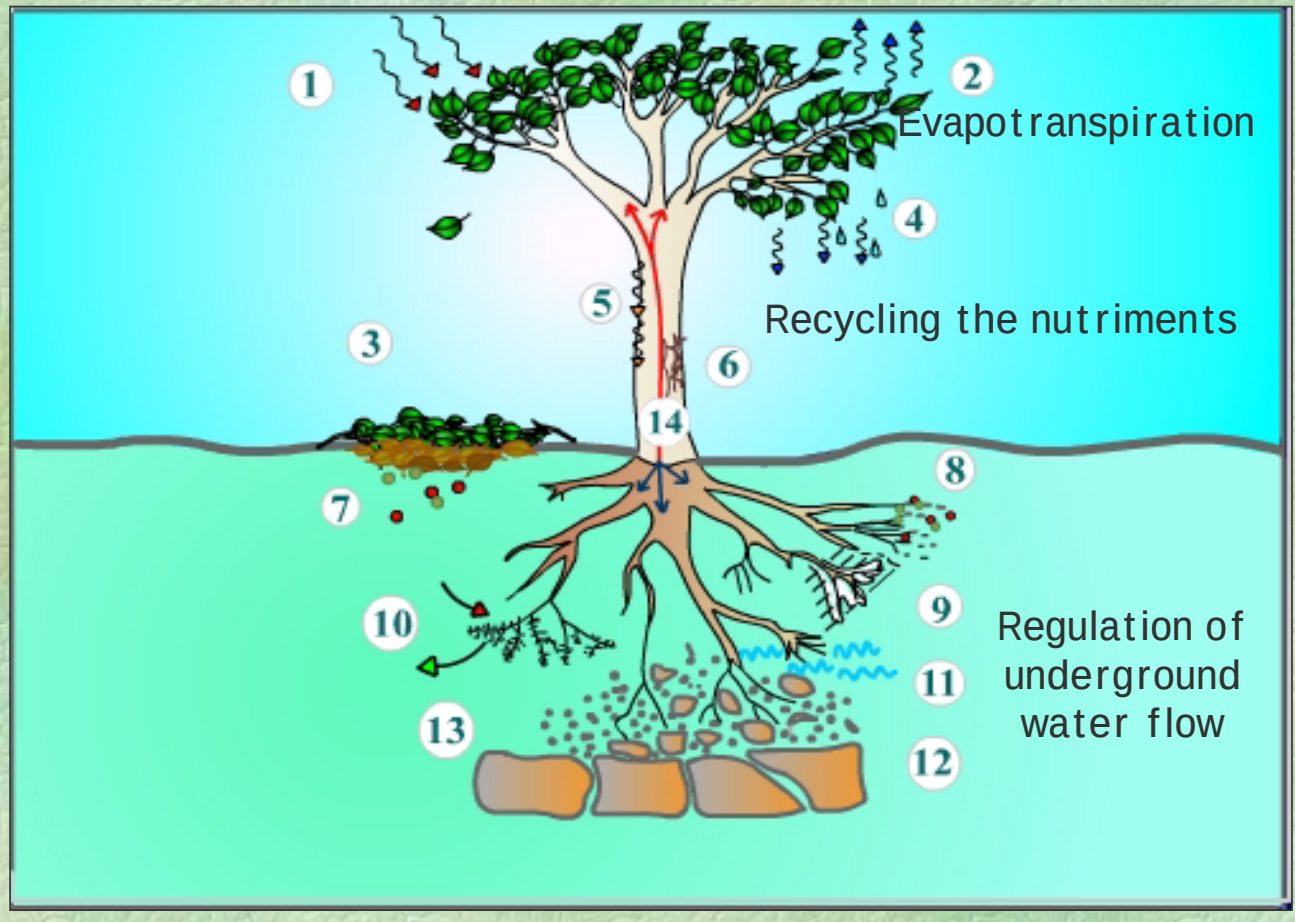
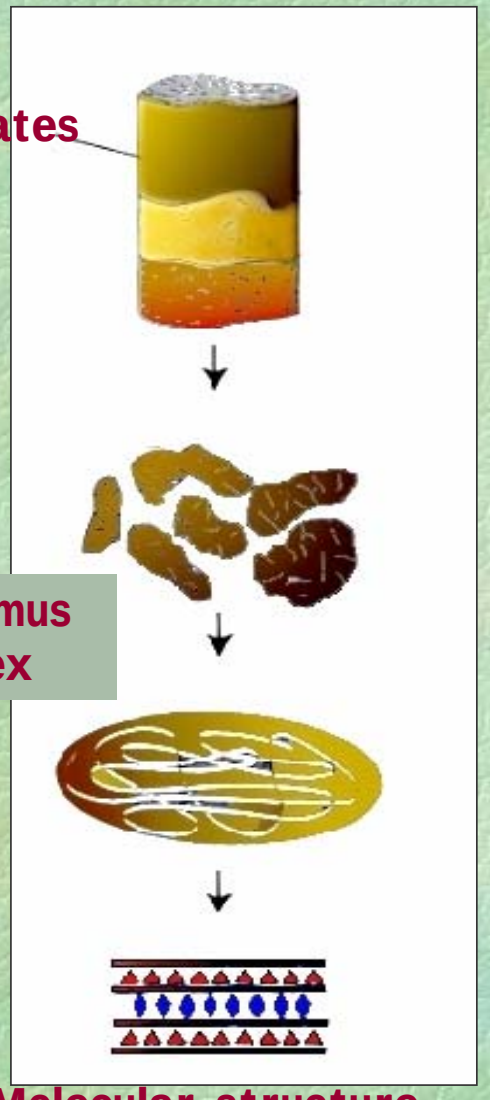


As forests, plants are capable of producing a litter

Organic matter accumulates in surface

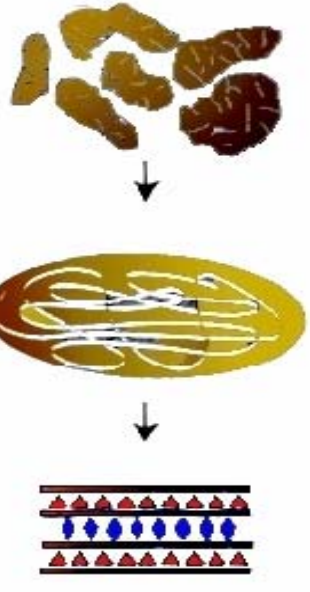
Soil is improved

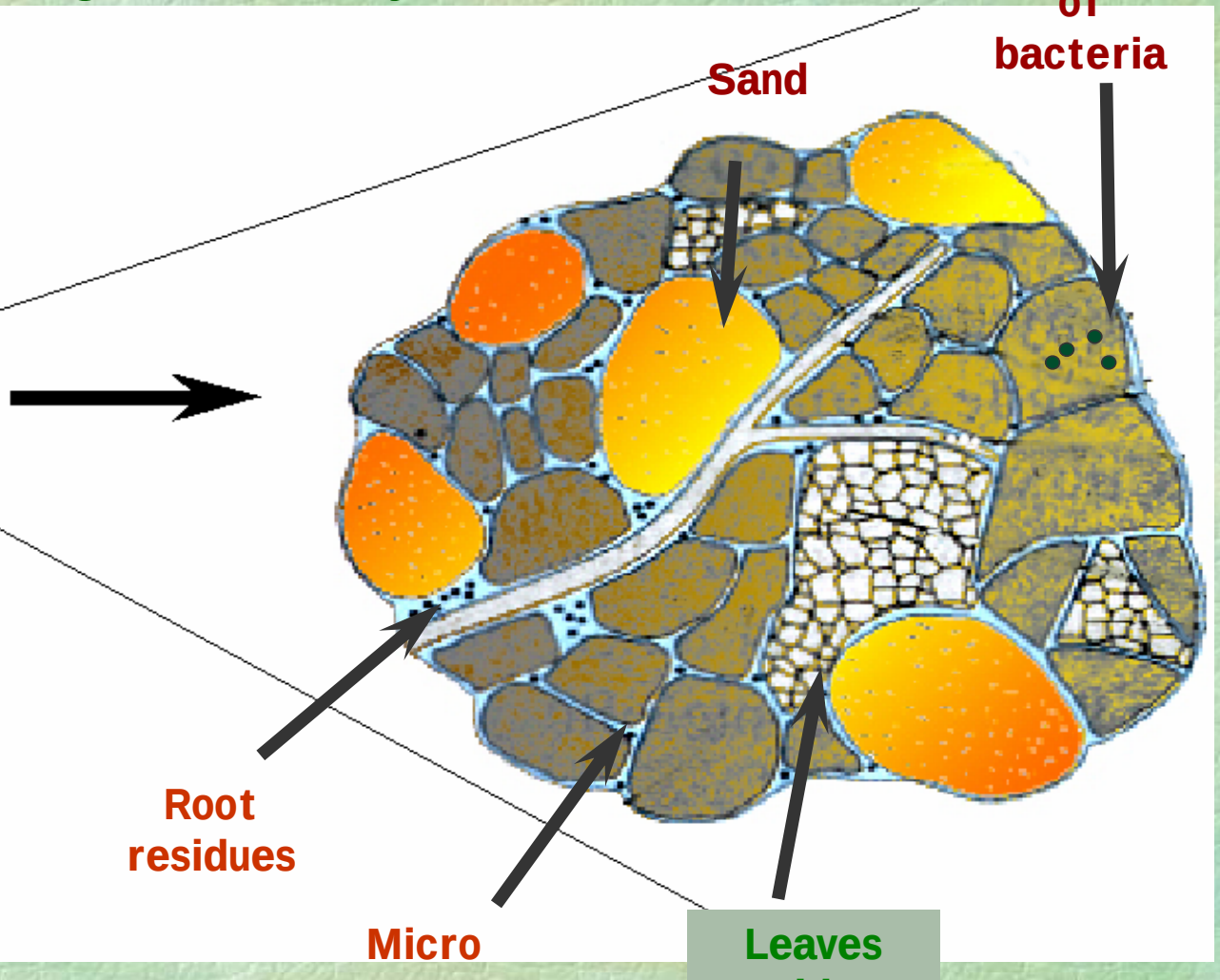
Clay - humus complex

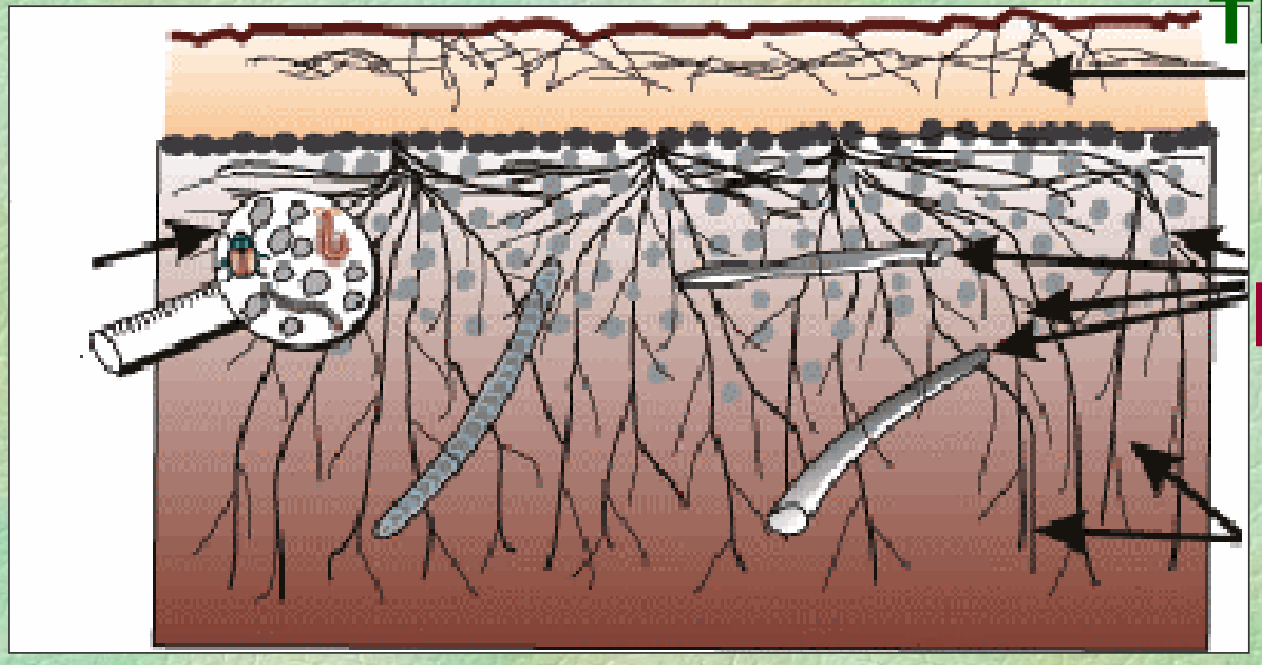


The biologic factory is on

Agrégates





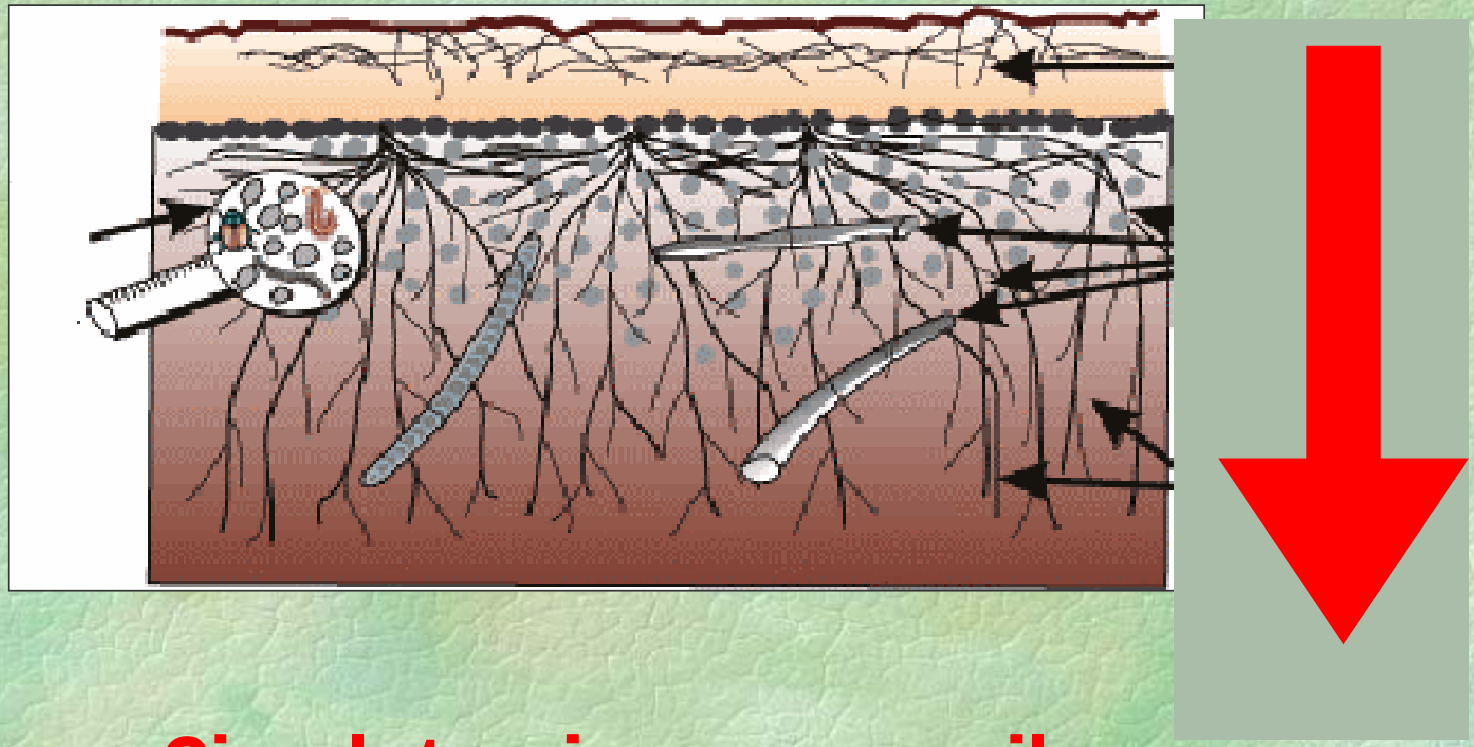


Thick mulch

Biological activity

Soil is a biological bioreactor

Water infiltrates…



…Circulates in porous soils


Biological activity is restored...

Soil fauna is back

Brachiaria humidicola **roots, forage plant**
Vietnam


Brachiaria brizantha strong roots


A natural forest ecosystem
is sustainable as soil
is continuously created
and permanently protected.
Direct seeding on vegetal cover
CIRAD
©Nicolas Chorier / Cirad

How can we reproduce such systems? How can we maintain and speed up these fundamental functions?

Principles

Always keep the soil covered with a dead or living mulch

Principles

Always keep the soil covered with a dead or living mulch

Replace mechanical ploughing by biological improvement of soil structure

Advantages

Permanent soil cover

Reduction of evaporation

Advantages

Permanent soil cover

Buffering temperature

Fresh organic matter
Humidity

Development of biological activity

Advantages

Soil structure

Improved by roots


Brachiaria ruziziensis


Brachiaria brizantha

Advantages

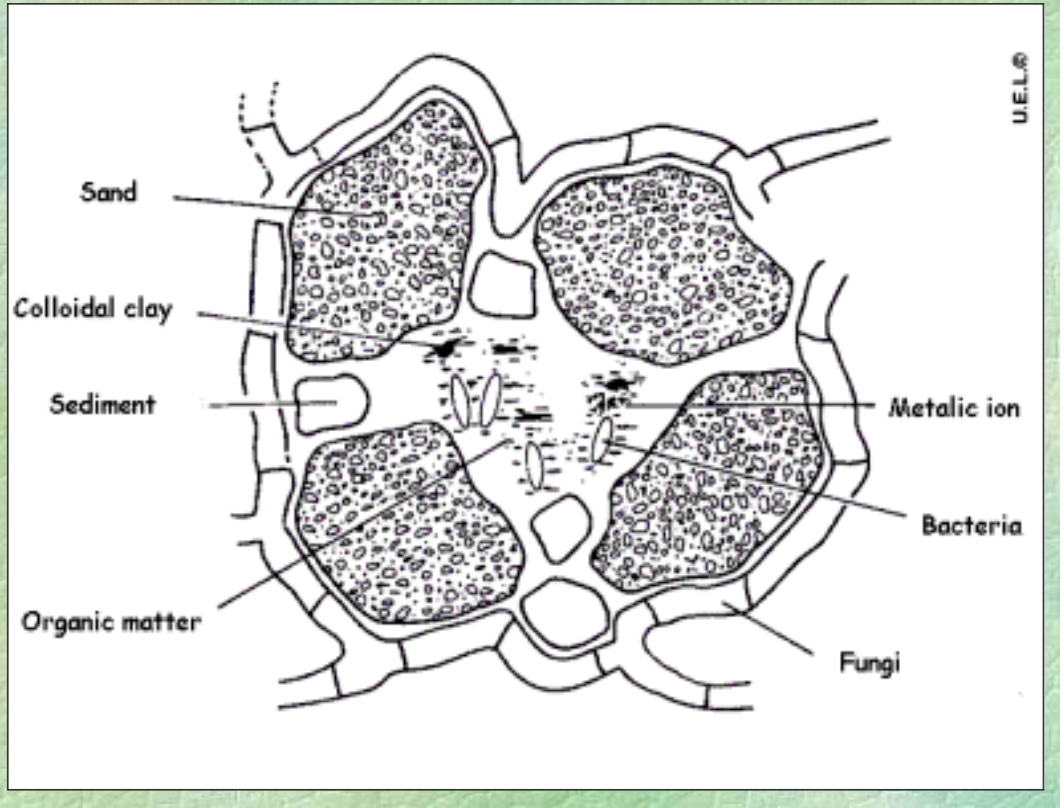
Soil structure

Improved by macrofauna

Advantages

Soil structure

Improved and stabilised by organic matter and microflora (fungi, polysaccharides)



Advantages

Soil structure and biological activity:
A virtuous cycle:

Biological activity is favoured by good soil structure.

Biological activity helps development of good soil structure

Advantages

Permanent soil cover

Protection against impact of drops with high kinetic energy

Advantages

Permanent soil cover

Erosion controlled

Structure preventing compaction

Advantages

Permanent soil cover

Weeds Control

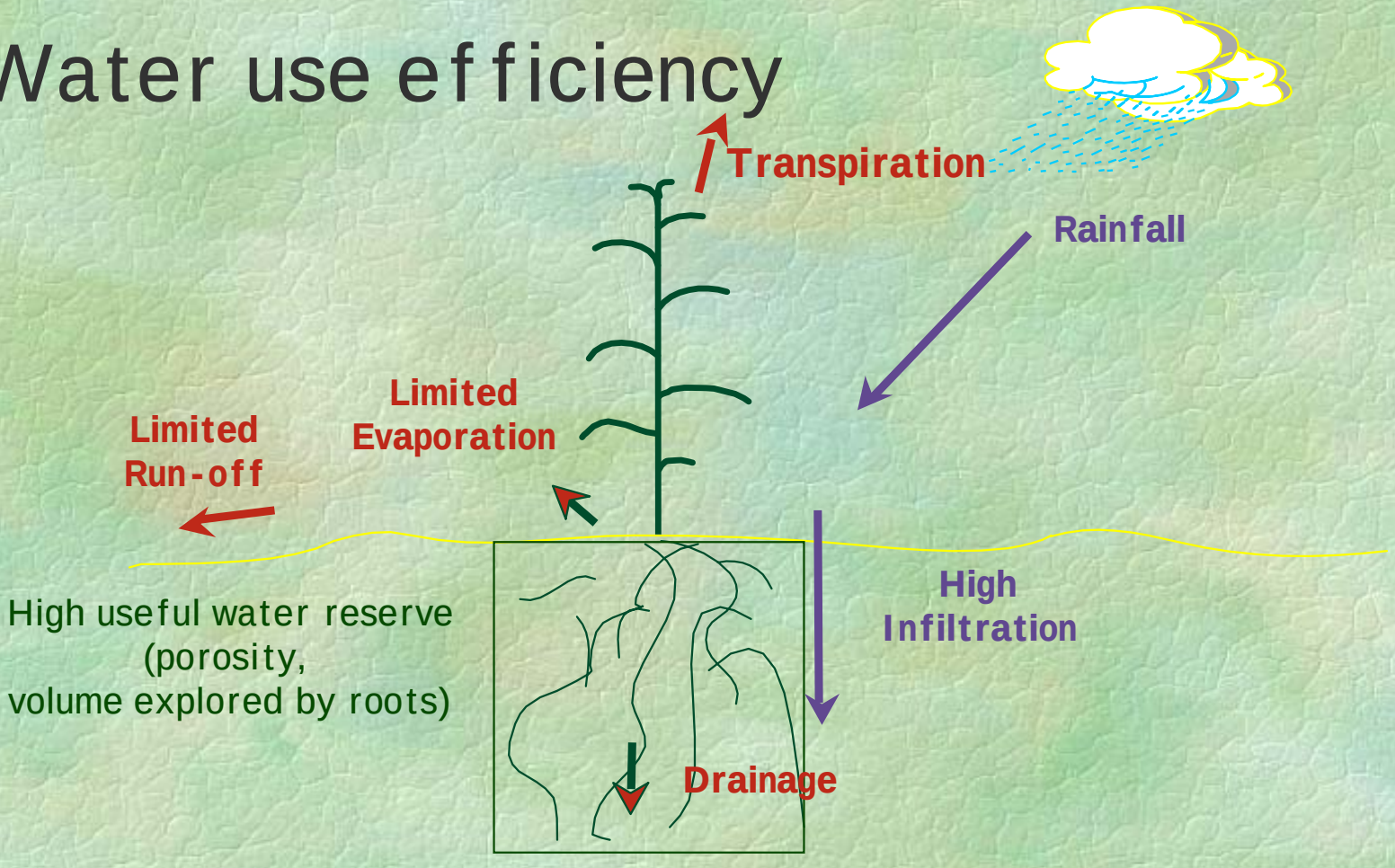
(competition, allelopathy)

Vegetal pests




Advantages

Water use efficiency



Advantages

Biological activity

Creation of humus
Litter mineralisation

(progressive release of nutrients)

Advantages

Biological activity

N fixation
(Legumes)

Advantages

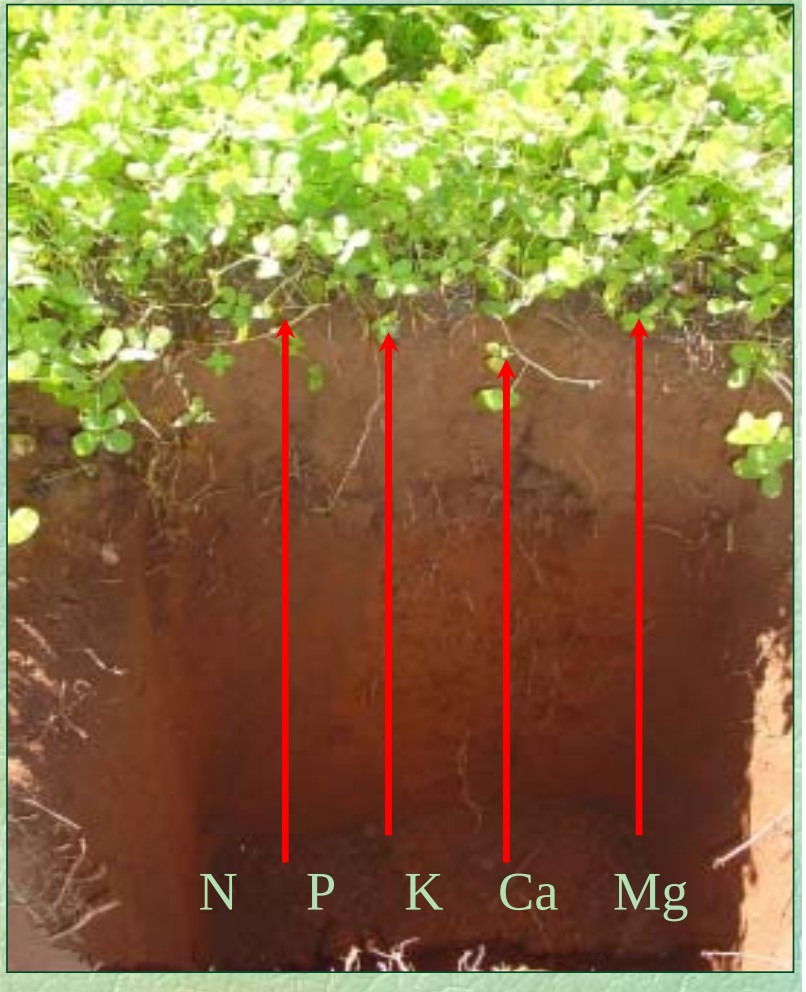
Biological activity

Solubilisation of nutrients by microbs

Advantages

Strong root system

Recycling nutrients
Biological pump



Advantages

Detoxification

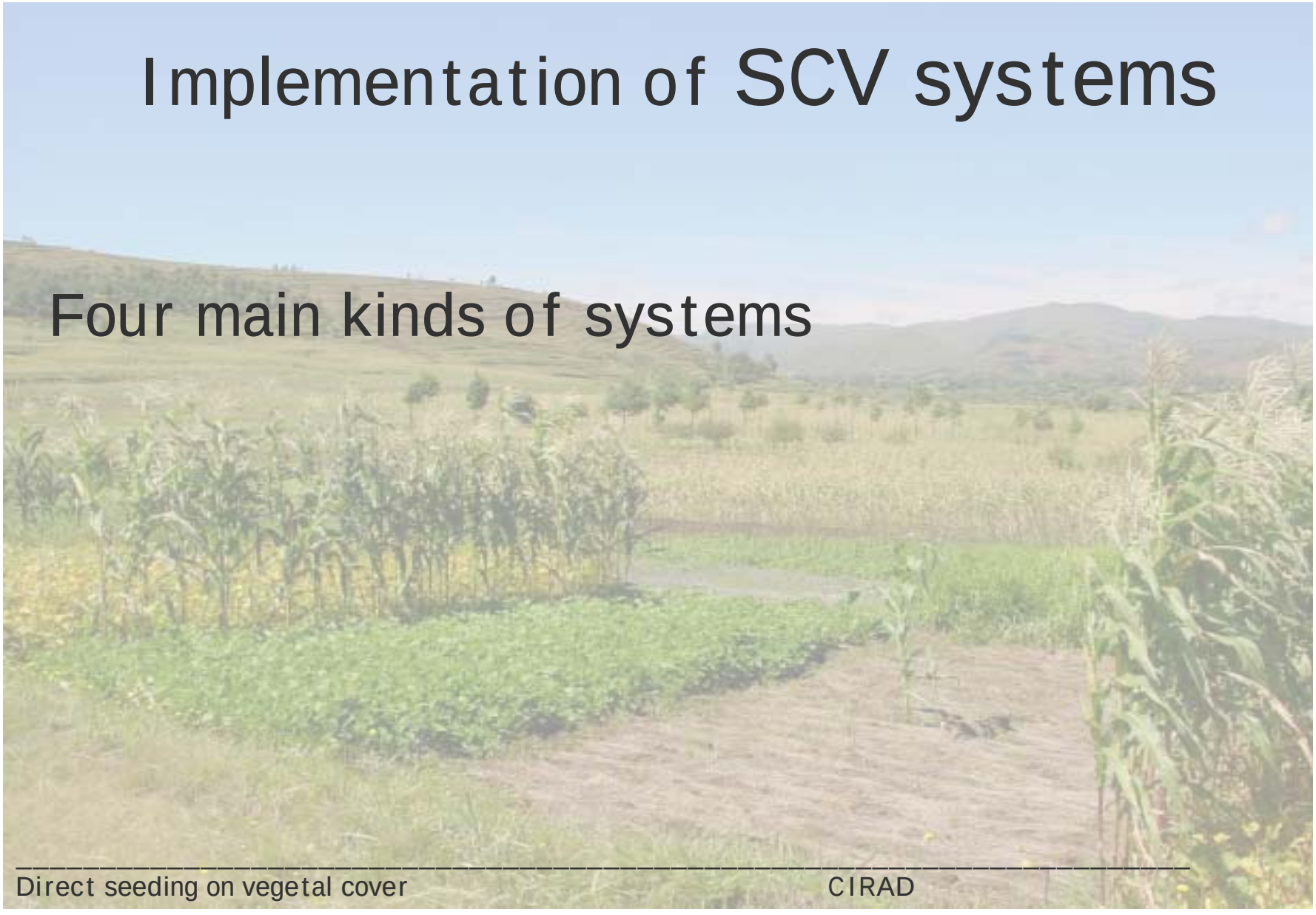
Reduction of Al toxicity:

By increase of pH and organic matter content

Role of organic acids (citric, oxalic, tartric)

Fragmentation of xenobiotics

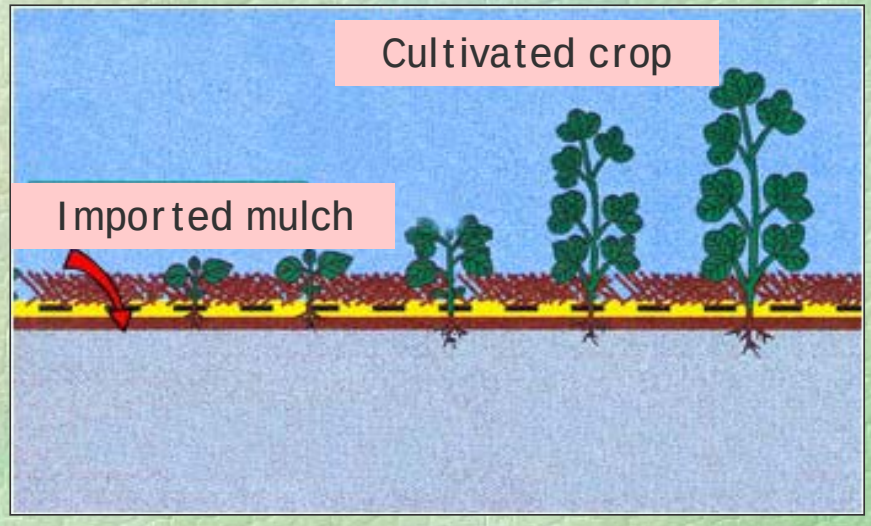
Implementation of SCV systems



Four main kinds of systems

Implementation of SCV systems

1. Mulch is imported from surrounding area




1. Mulch is imported from surrounding area
Northern Vietnam


1. Mulch is imported from surrounding area
Northern Vietnam


1. Mulch is imported from surrounding area
Northern Vietnam

Implementation of SCV systems

1. Mulch is imported from surrounding area

Advantages:

Very simple, doesn't require high technical skills

Usually, farmers adopt this system first

Implementation of SCV systems

1. Mulch is imported from surrounding area

Problems:

Need to have biomass available in the area

Working time to cut and carry the mulch

Implementation of SCV systems

1. Mulch is imported from surrounding area

Performances:

Erosion control: As a function of biomass

Weeds control: As a function of biomass

Plant nutrition: As a function of biomass

Biological activity: As a function of biomass

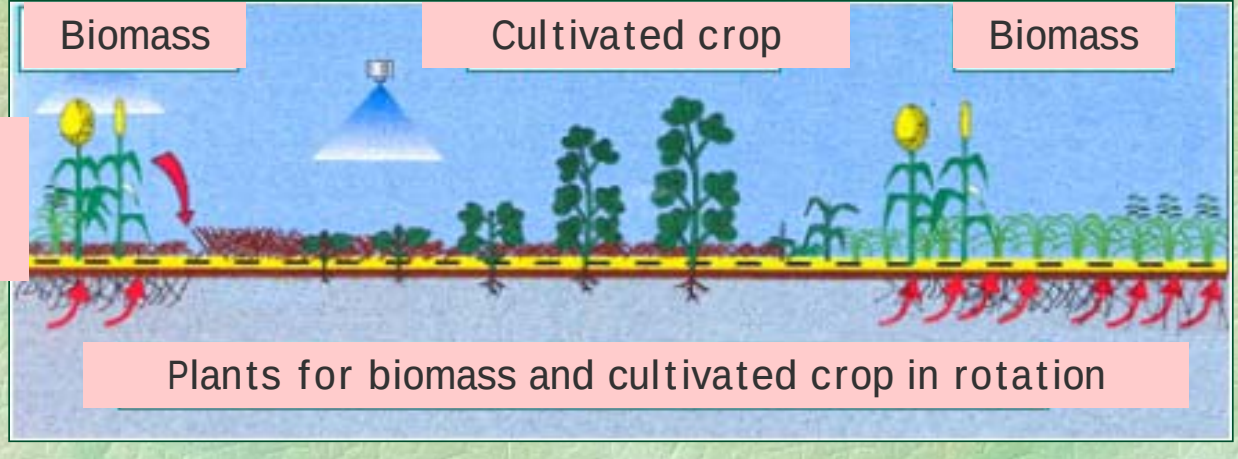
Nutrient recycling: No

Soil structure: Weak, no roots

Slow improvement

Implementation of SCV systems

2. Mulch is locally produced and killed



Implementation of SCV systems

2. Mulch is locally produced and killed

* Natural vegetation or crop residues

* Cover crop grown in the field


2. Mulch is locally produced and killed
Northern Vietnam


2. Mulch is locally produced and killed
Northern Vietnam
7 1 2001


2. Mulch is locally produced and killed
Northern Vietnam

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Northern Vietnam


2. Mulch is locally produced and killed
Northern Vietnam


2. Mulch is locally produced and killed
Northern Vietnam
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Implementation of SCV systems

2. Mulch is locally produced and killed

Advantages:

- Requires limited technical skills
- Reduction of working time, no bottleneck
- Flexibility

Farmer usually adopt when they are used to mulching techniques, to reduce working time

Implementation of SCV systems

2. Mulch is locally produced and killed

Problems:

No crop during the cover crop production (when rains are not reliable)

Implementation of SCV systems

2. Mulch is locally produced and killed

Performances:

Erosion control: As a function of produced biomass

Weeds control: As a function of produced biomass

Plant nutrition: As a function of produced biomass

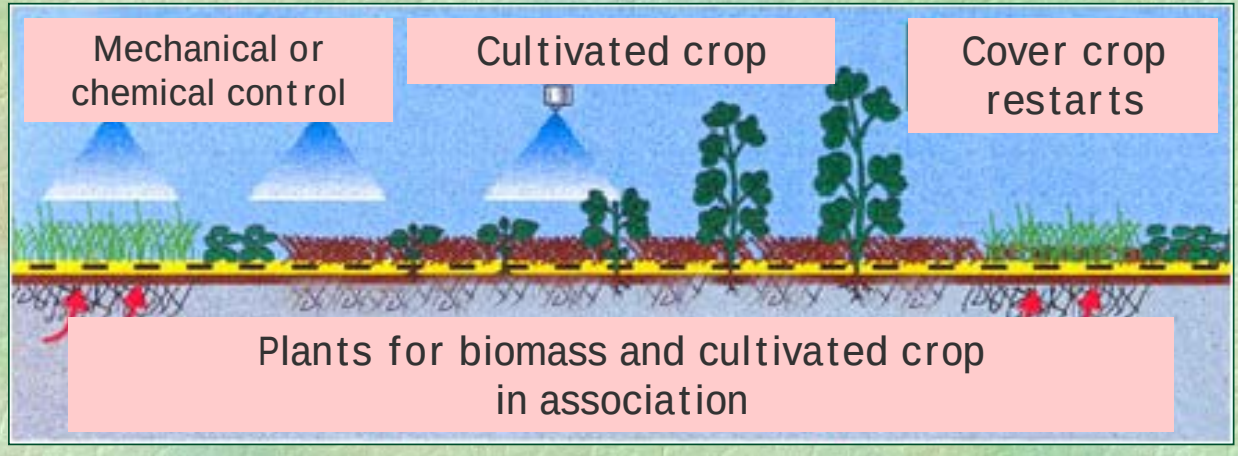
Biological activity: As a function of produced biomass

Nutrient recycling: As a function of produced biomass Soil structure: As a function of produced biomass

Can be good. Medium to fast soil improvement

Implementation of SCV systems

3. Mulch is locally produced and kept alive



3. Mulch is locally produced and kept alive

Maize on trifolium, Madagascar

Implementation of SCV systems

3. Mulch is locally produced and kept alive

Advantages:

Most efficient system

Reduction of working time

Reduction of herbicide doses

Implementation of SCV systems

3. Mulch is locally produced and kept alive

Problems:

Requires high technical skill, no flexibility

Implementation of SCV systems

3. Mulch is locally produced and kept alive

Performances:

Erosion control: Best system

Weeds control: Best system

Plant nutrition: Best system

Biological activity: Best system

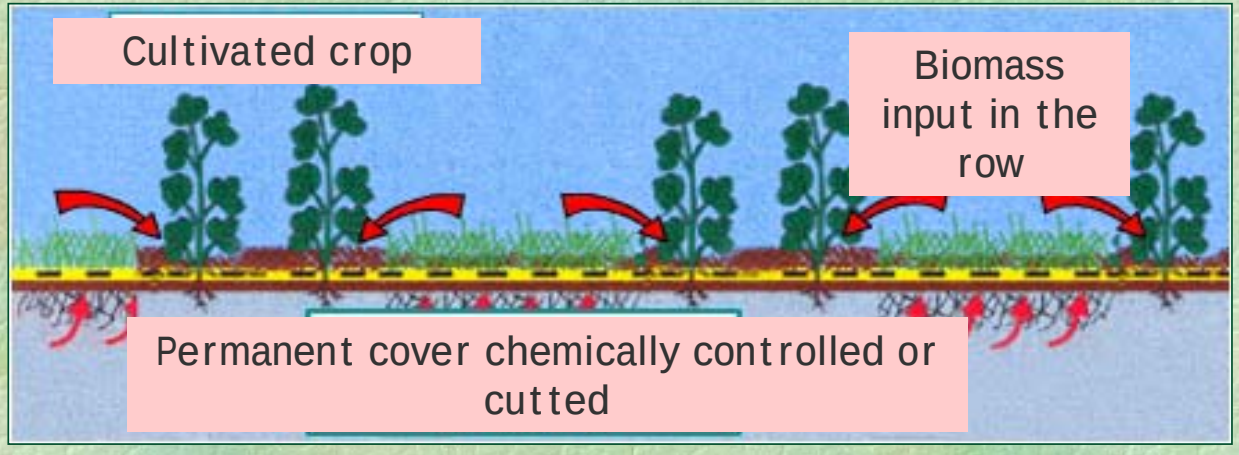
Nutrient recycling: Best system

Soil structure: Best system

Fast improvement, high performances

Implementation of SCV systems

4. Mixed systems



4. Mixed systems

4. Mixed systems

Maize and B. ruziziensis
Northern Vietnam

4. Mixed systems

Implementation of SCV systems

4. Mixed systems

Advantages:

Intermediate system: good performance, medium technical skill required
More flexibility than 3.

Mechanical control (no herbicide) possible.

Implementation of SCV systems

4. Mixed systems

Problems:

Requires some technical skill

Implementation of SCV systems

4. Mixed systems

Performances:

Erosion control: Good if enough biomass produced
Weeds control: Good if enough biomass produced
Plant nutrition: Good if enough biomass produced
Biological activity: Good if enough biomass produced
Nutrient recycling: Good if enough biomass produced
Soil structure: Good if enough biomass produced

Rather fast improvement, good performances

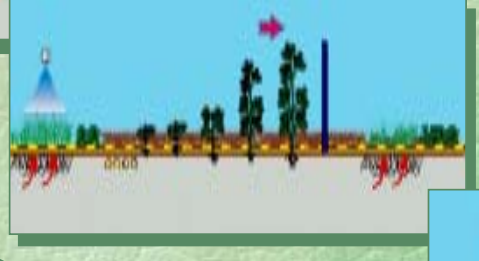
Adaptation and adjustment of DMC systems to local conditions

*** A diversified range of DMC**

Grown mulch

Imported mulch

Perennial cover



Mixt systems

Various technical levels

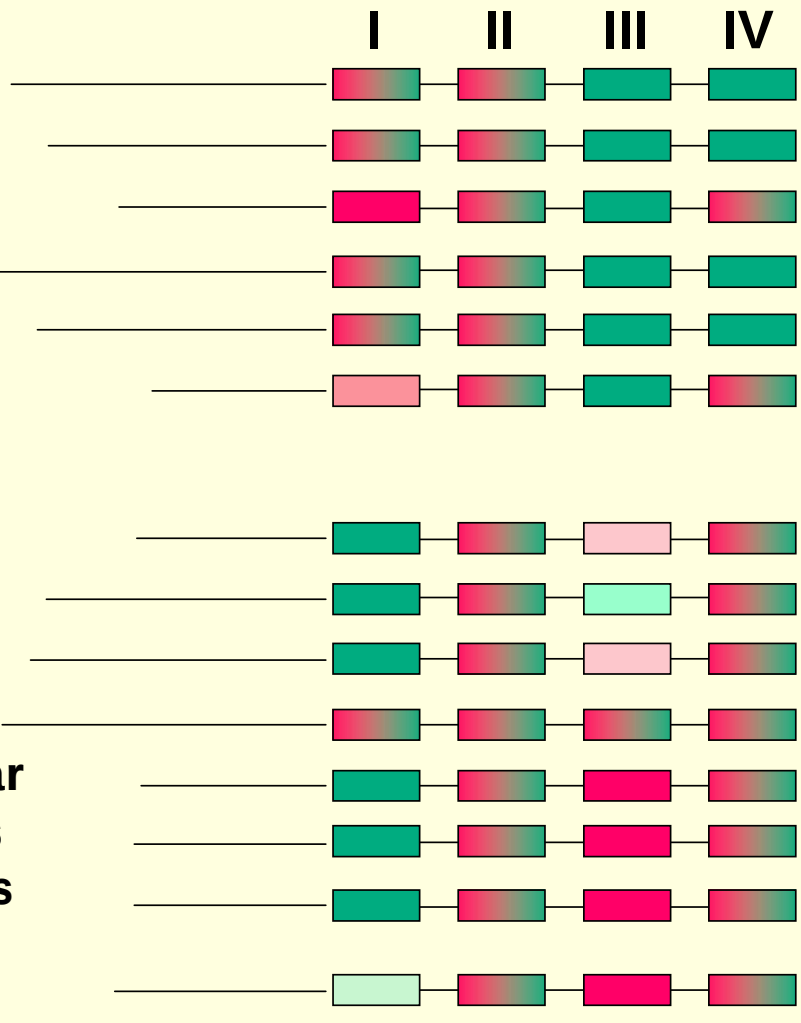
Regulation functions

- Erosion control
- Nutritional function
- Mineral nutrients recycling
- Weed control
- Biological activity
- Soil structure improvement

Technical level required

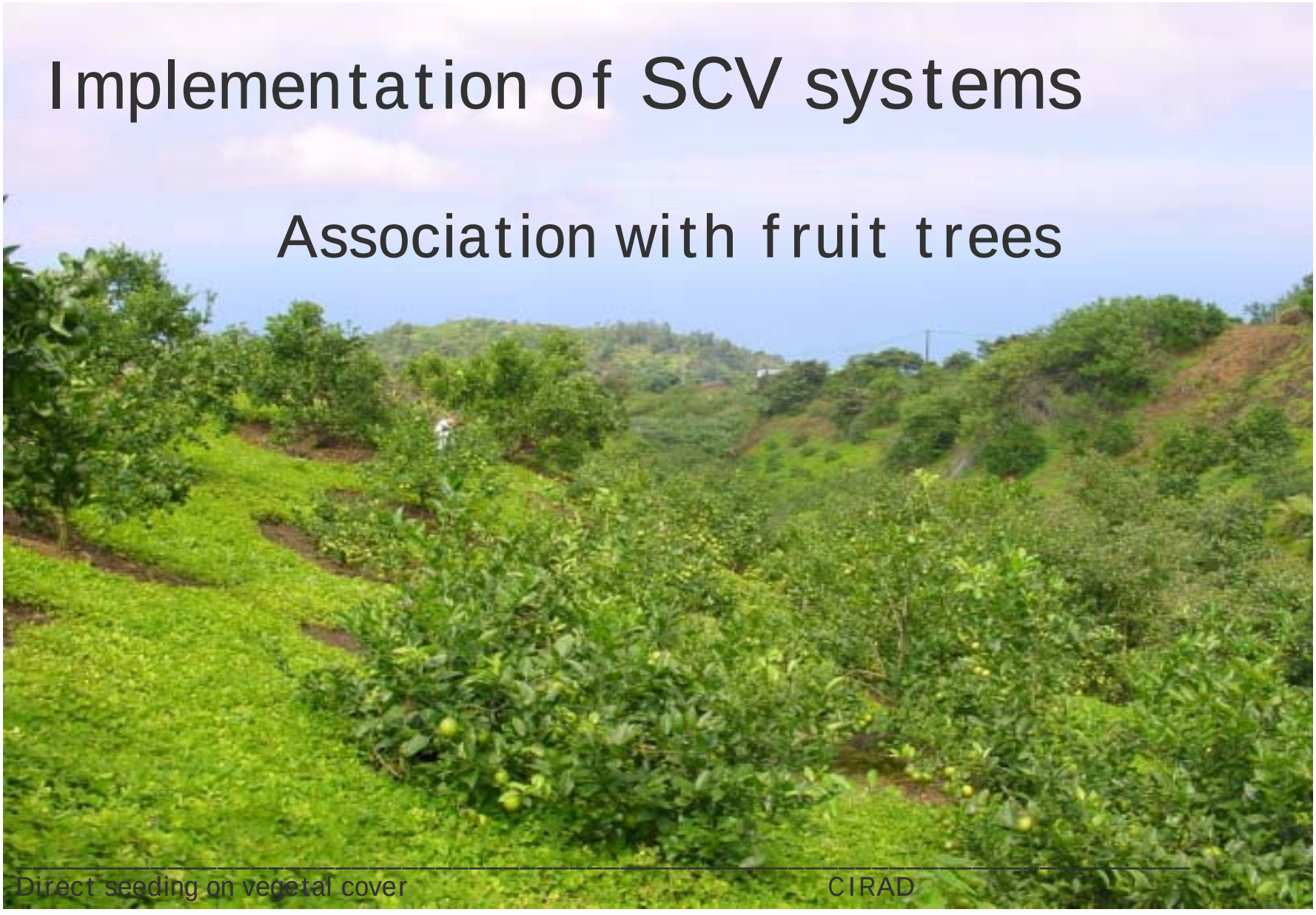
- Establishment of the cover
- Bio-mass production
- Bio-mass control
- Working time
- Respect of cropping calendar
- Choice of active ingredients
- Flexibility of chemical doses

Social adaptability



Implementation of SCV systems

Association with fruit trees



Implementation of SCV systems

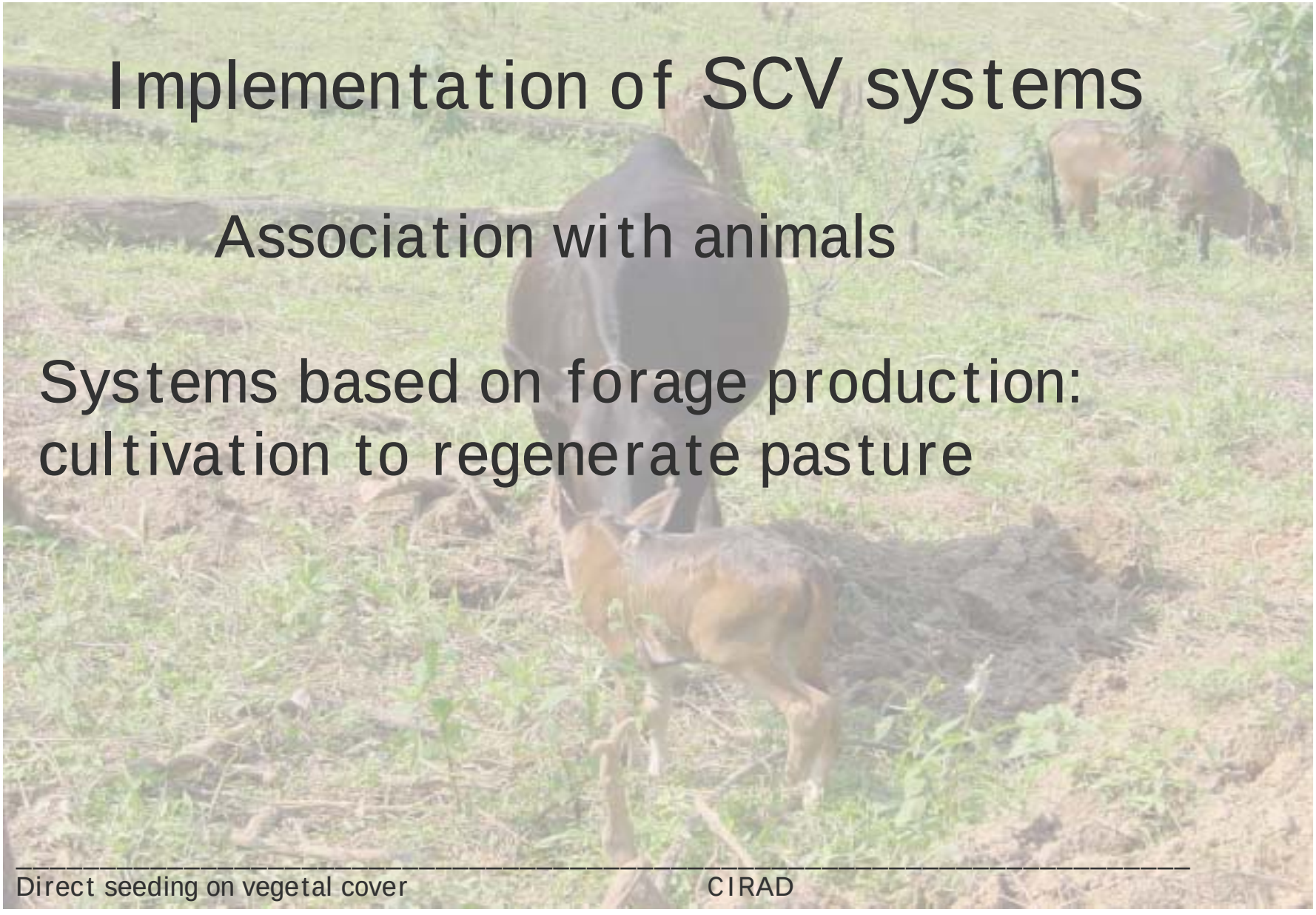
Association with industrial crops

Sugar cane, pineapples and rubber trees
Central Highlands, Vietnam

Implementation of SCV systems

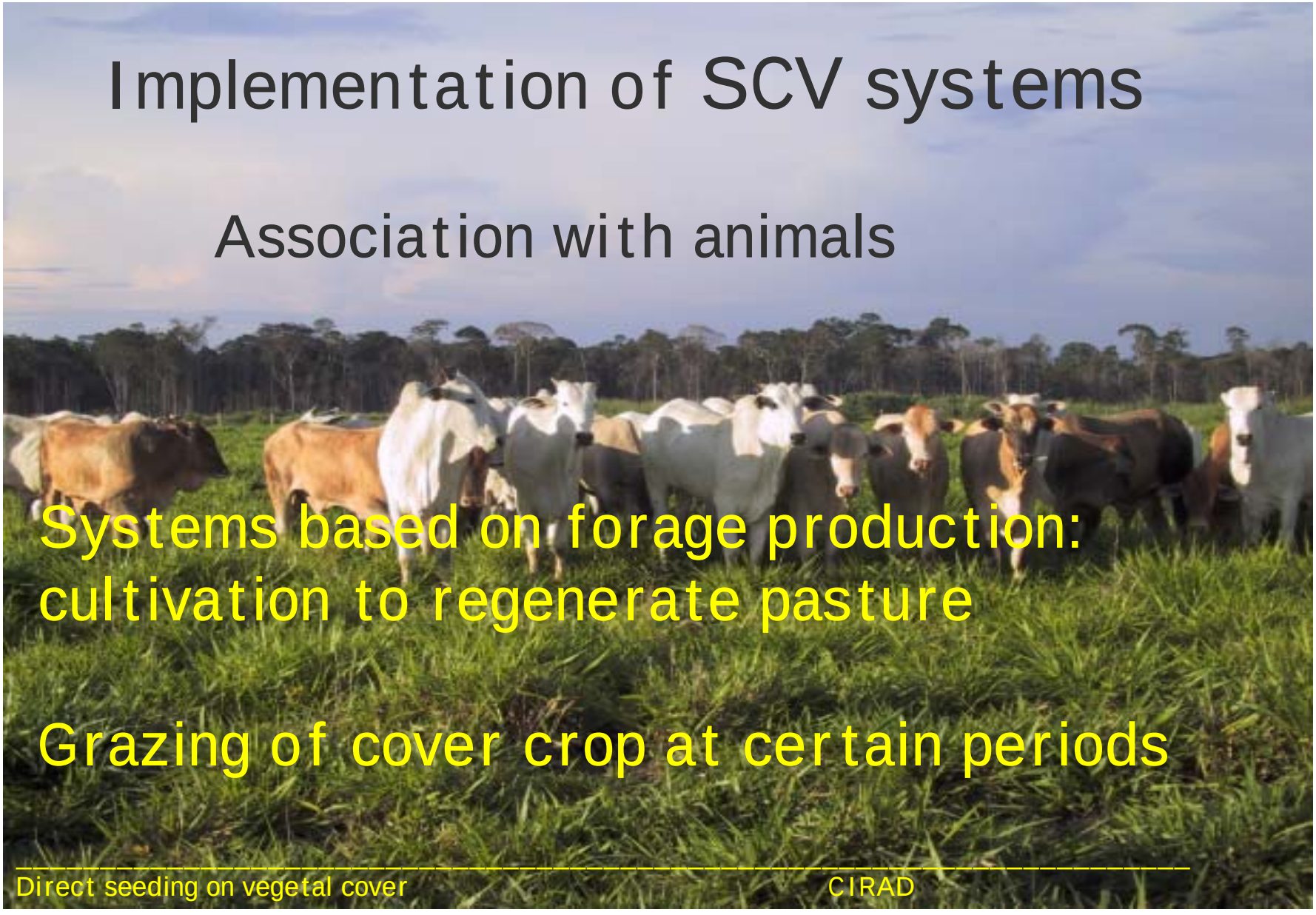
Association with animals

Systems based on forage production: cultivation to regenerate pasture



Implementation of SCV systems

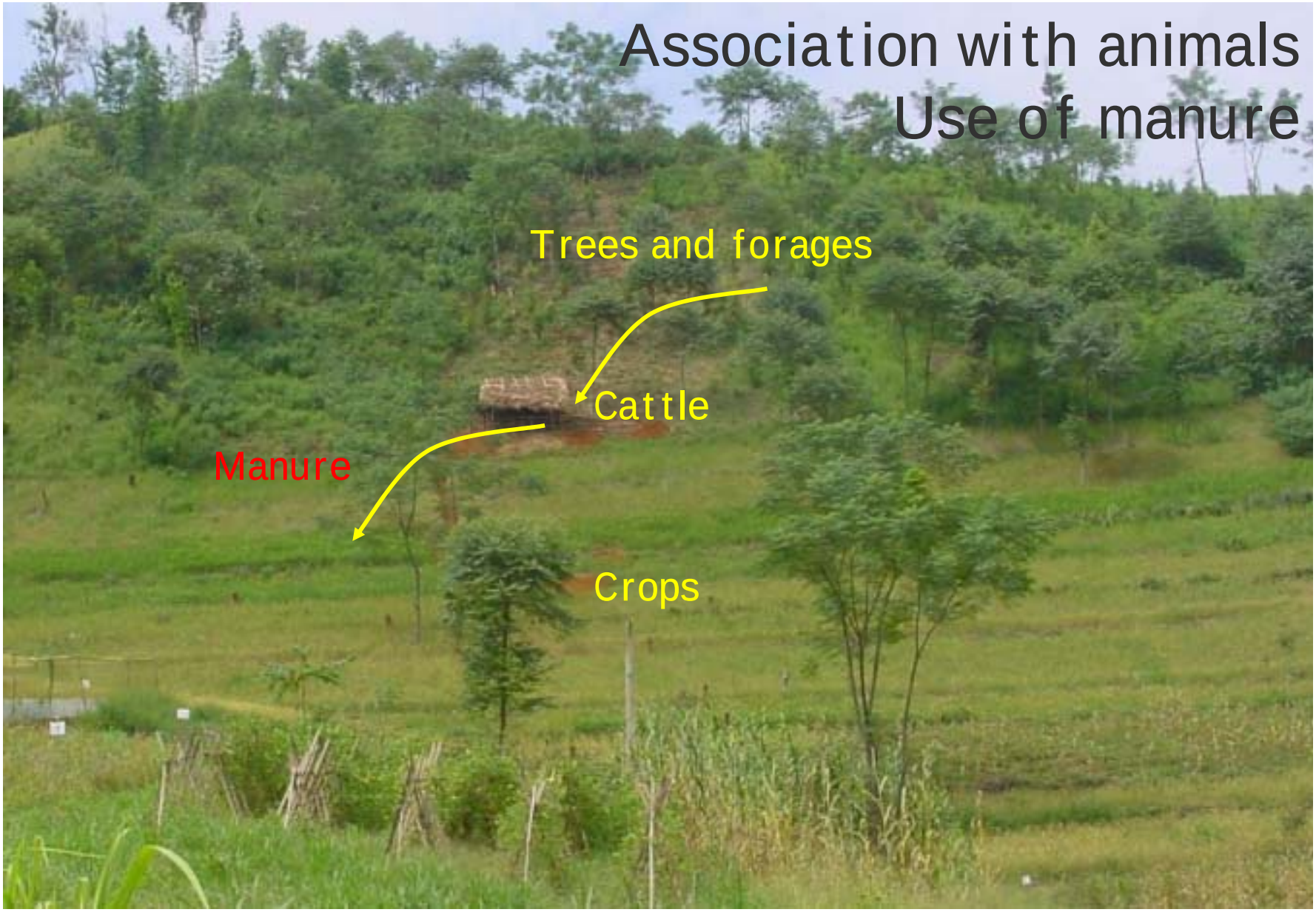
Association with animals



Systems based on forage production: cultivation to regenerate pasture

Grazing of cover crop at certain periods

Association with animals
Use of manure



Implementation of SCV systems Limitations

Needs technical knowledge for good control of cover crop, and planting technique (depth, density)

Needs of fungicide to avoid seeds damages in thick mulch

Seeds and chemicals availability

Very unusual to farmers

Social aspects (land tenure, livestock, tradition)

Implementation of SCV systems
Strengths

Agro-ecological soil and crops management integrates crops, animals and trees production.

Implementation of SCV systems
Strengths

Agro-ecological soil and crops management can be adapted to various bio-physical and socio-economic conditions.
(various level of capital availability)

Implementation of SCV systems
Strengths

Agro-ecological soil and crops management can be adapted to various intensification levels (fertilisation, technical skills, mechanisation, etc...), including without inputs.

Implementation of SCV systems
Strengths

Agro-ecological soil and crops management can be adapted to various intensification levels (fertilisation, technical skills, mechanisation, etc...), including without inputs.

Poorest are not excluded!

SCV: a real breakthrough

Built by L. Séguy and its team in Brazil, over more than 20 years.

SCV: a real breakthrough

Based on the comprehensive understanding of interactions and processes in soil genesis and agronomy (in the widest sense).

Built on identification of universal principles (ease adaptation and extension to other environments)

SCV: a real breakthrough

Extended to millions hectares, under various situations, with unprecedented results

SCV: a real breakthrough

Reclamation of land previously regarded as unfarmable (Madagscar, Vietnam, etc)


SCV: a real breakthrough
Developed in Tunisia (450 mm rainfall/year) or France with stable production while reducing production costs by 30%.

SCV: a real breakthrough

7 to 9 t/ha of upland rice in Brazil

SCV: a real breakthrough

Really new techniques, new paradigm

More than no-tillage, reduced tillage, cover cropping, etc. although some of the principles are the same.

More efficient, higher performences

SCV: a real breakthrough

Economically profitable,
while easily practicable and
environmentally sustainable:

Extension at large scale is limited only by training and diffusion of knowledge, not by economical constraints.

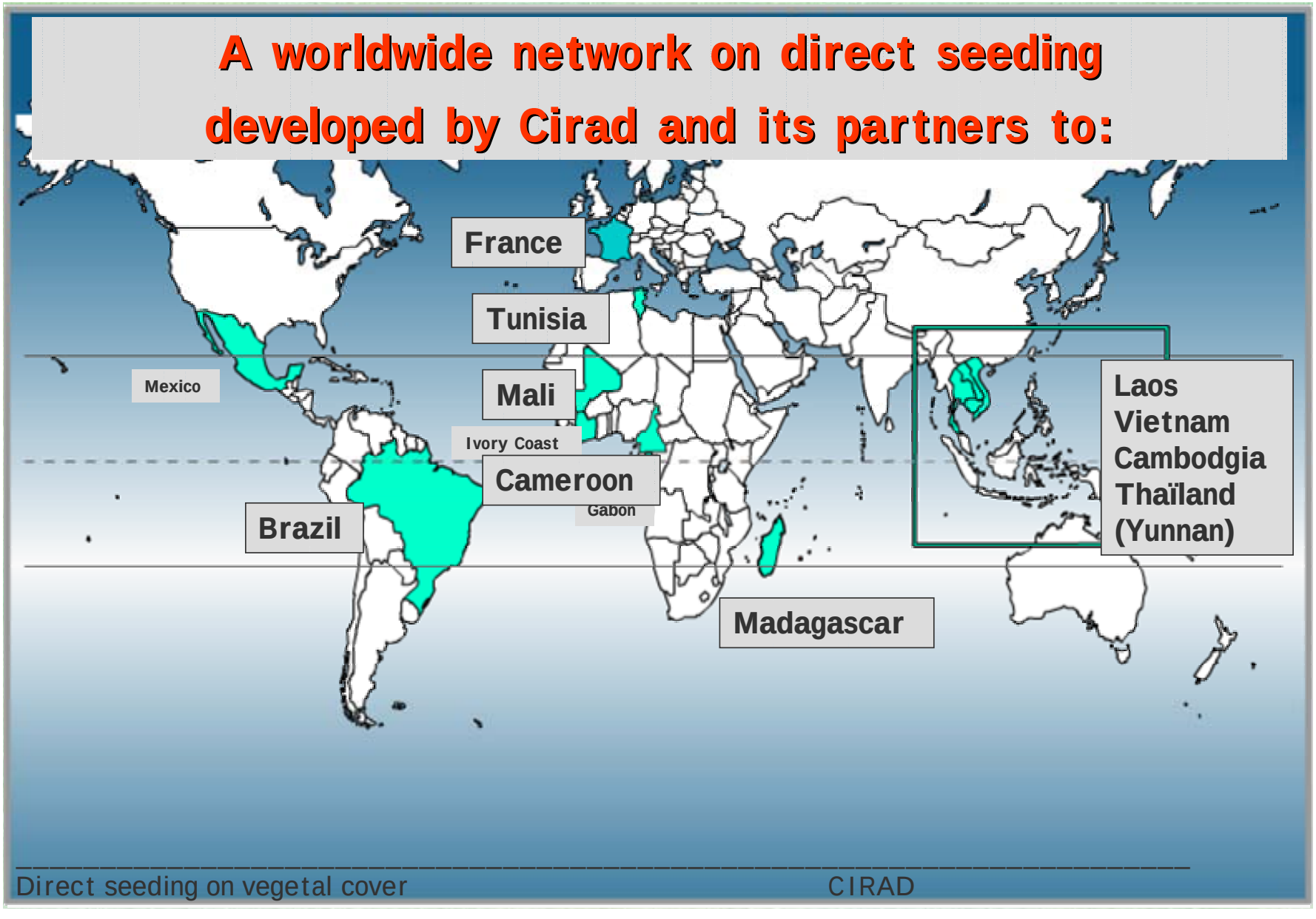
SCV: a real breakthrough

Really new techniques, new paradigm

Not yet included in agronomy schools, training programmes, etc.

Opens new doors (allelopathy, etc), needs revision of traditional agronomic knowledge (e.g. toxicity levels)

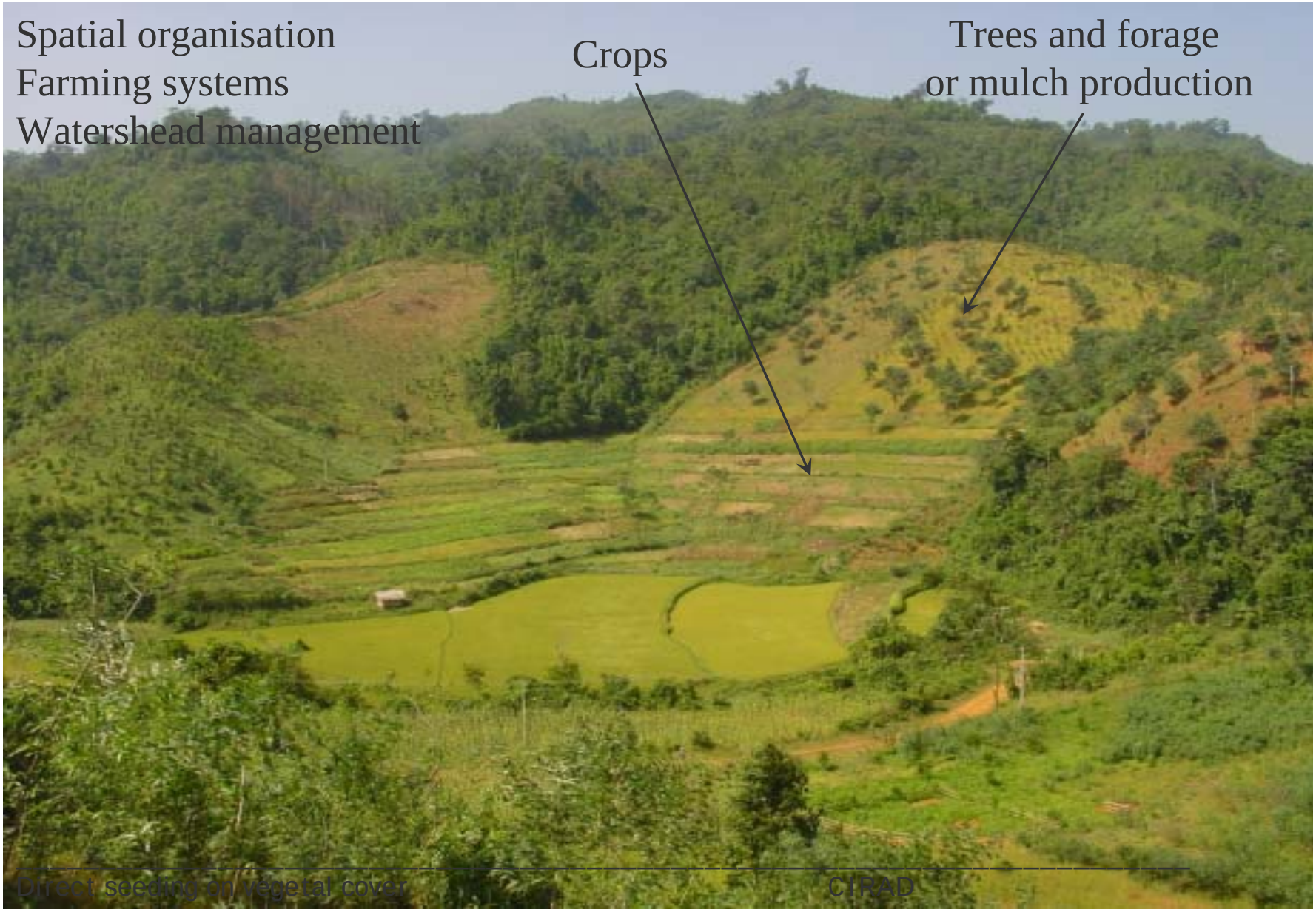
A worldwide network on direct seeding developed by Cirad and its partners to:



A worldwide network on direct seeding developed by Cirad and its partners to:

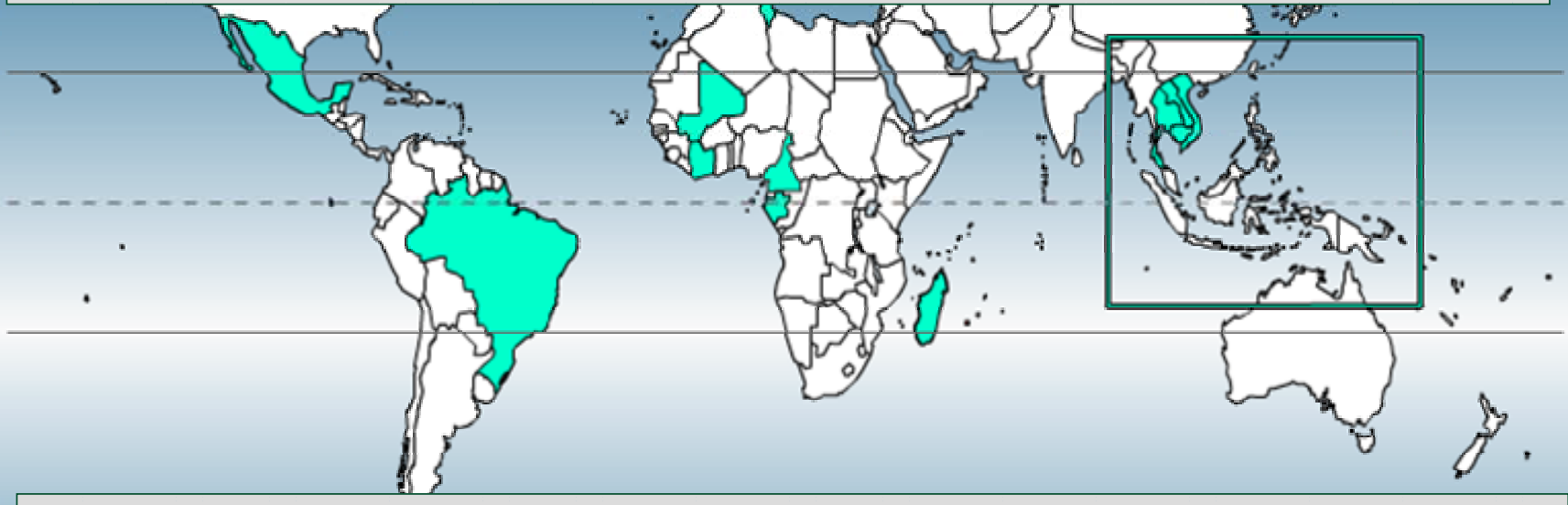
1. Adapt direct seeding techniques to various socio-economics and agro-ecological situations

Creation of systems adapted to local conditions using these « tools », this basement


Spatial organisation
Farming systems
Watershead management
Crops
Trees and forage
or mulch production

A worldwide network on direct seeding developed by Cirad and its partners to:

1. Adapt direct seeding techniques to various socio-economics and agro-ecological situations



2. Develop knowledge on these systems (theoritical and practical)


Thematical trials in Brazil
Direct seeding on vegetal cover
CIRAD
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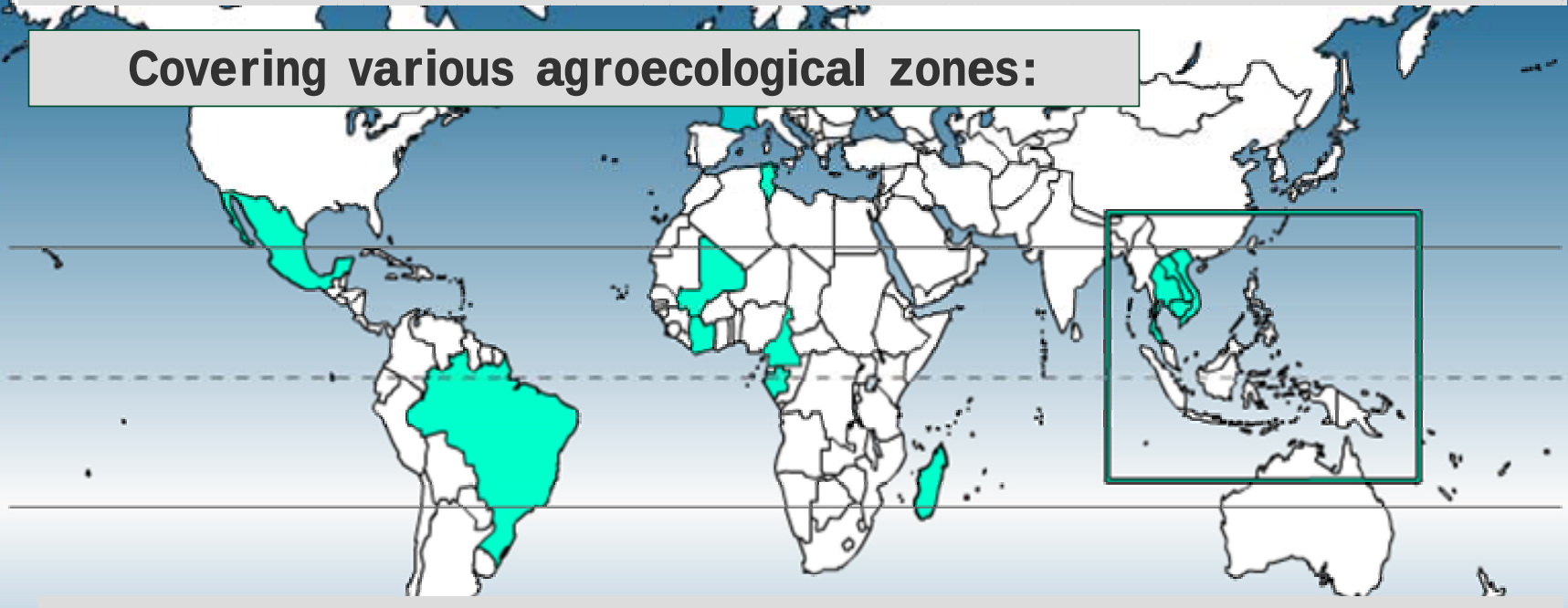
Fundamental researches, PhD, etc. and practical field tests

Soil biology, soil chemistry, weeds.

Carbon sequestration. Worldwide concern.

A worldwide network on direct seeding developed by Cirad and its partners to:

Covering various agroecological zones:



- Humid tropics (Brazil) to arid conditions (Mexico, Tunisia)
- Equatorial (Gabon), tropical (Brazil, Madagascar, etc.),
- Sub-tropical (northern Vietnam) to temperate (France)
- Flat lowlands, gentle slope to steep slope (Northern Vietnam)


Development and test of a wide range of systems
Central highlands
Madagascar


Sayaboury
Laos

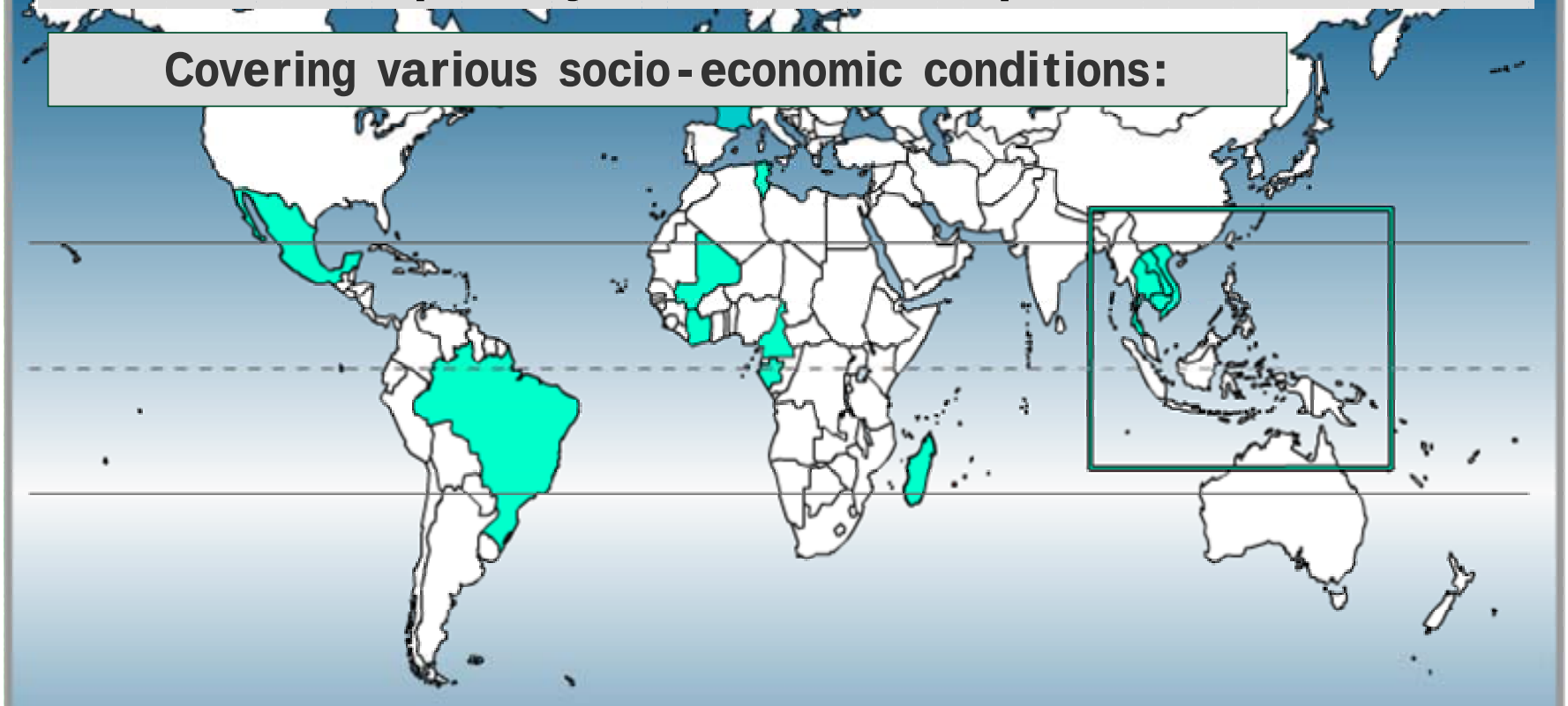
Direct seeding on vegetal cover

CIRAD


Northern mountains
Vietnam

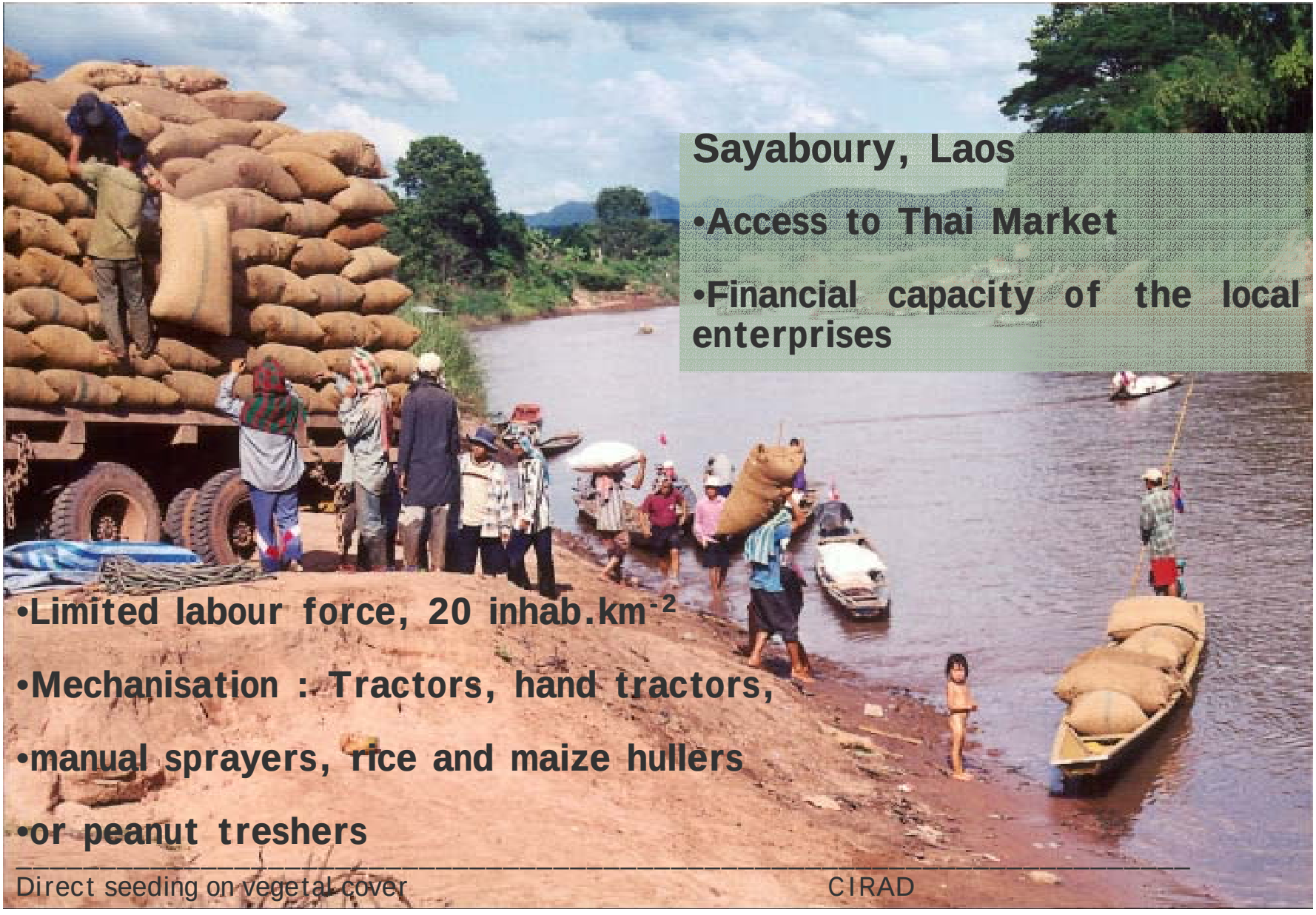
A worldwide network on direct seeding developed by Cirad and its partners to:

Covering various socio-economic conditions:



Population densities, access to market

Open to world market:
Cotton in Brazil (Amazonia)


Sayaboury, Laos
•Access to Thai Market
•Financial capacity of the local enterprises
•Limited labour force, 20 inhab.km-2
•Mechanisation : Tractors, hand tractors,
•manual sprayers, rice and maize hullers
•or peanut treshers


Madagascar:
Various population densities
Poor access to market


Northern Vietnam:
Medium pressure on land, but rapidly increasing
Poor access to market

A worldwide network on direct seeding developed by Cirad and its partners to:

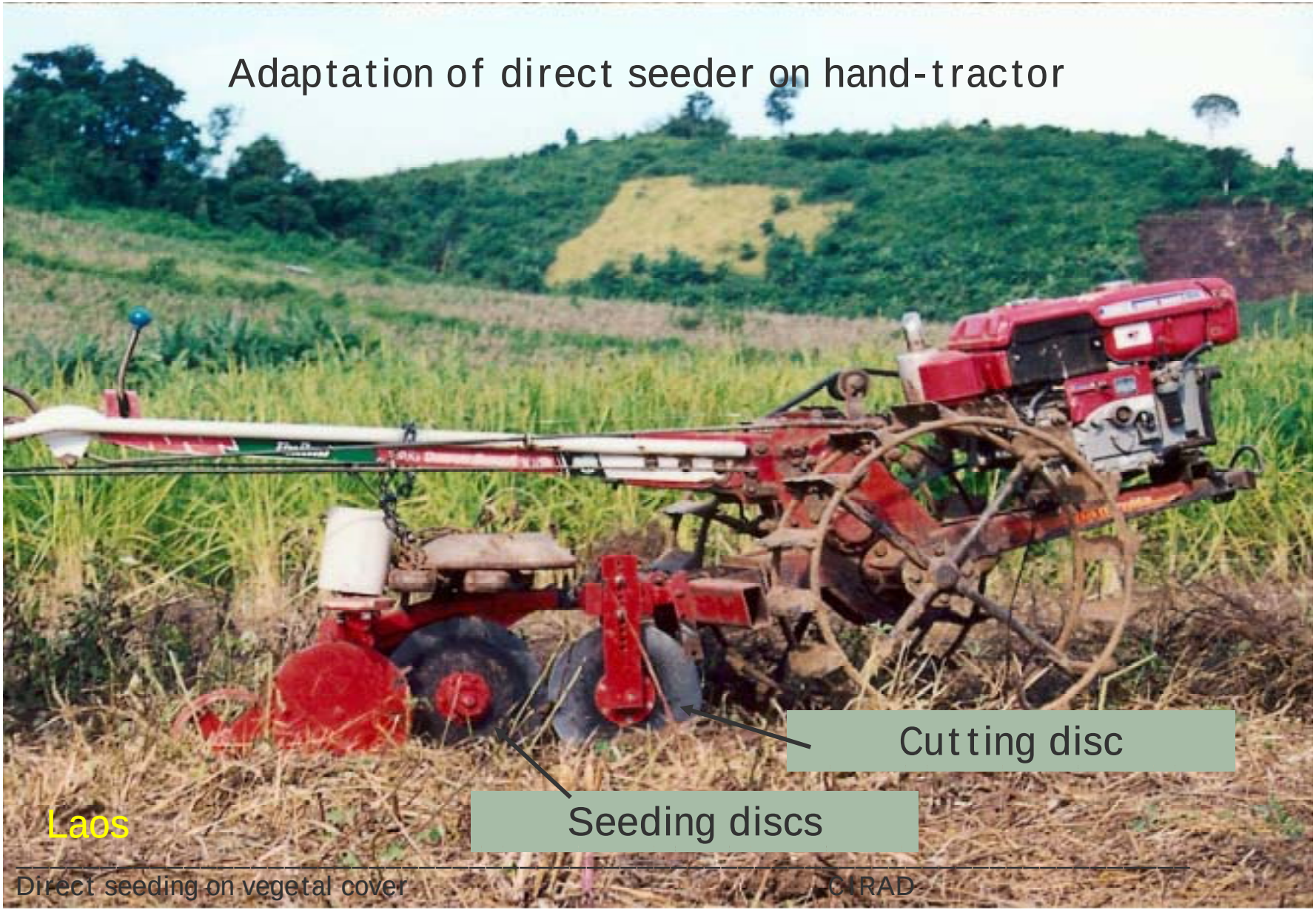
Manual agriculture (Madagascar, Vietnam) to mechanized agriculture (hand tractors, tractors)

Seed drills - Brazil

A double disk cuts the mulch for sowing

Mechanised direct seeding in Tunisia
Arid conditions: 450 mm annual rainfall

Adaptation of direct seeder on hand-tractor



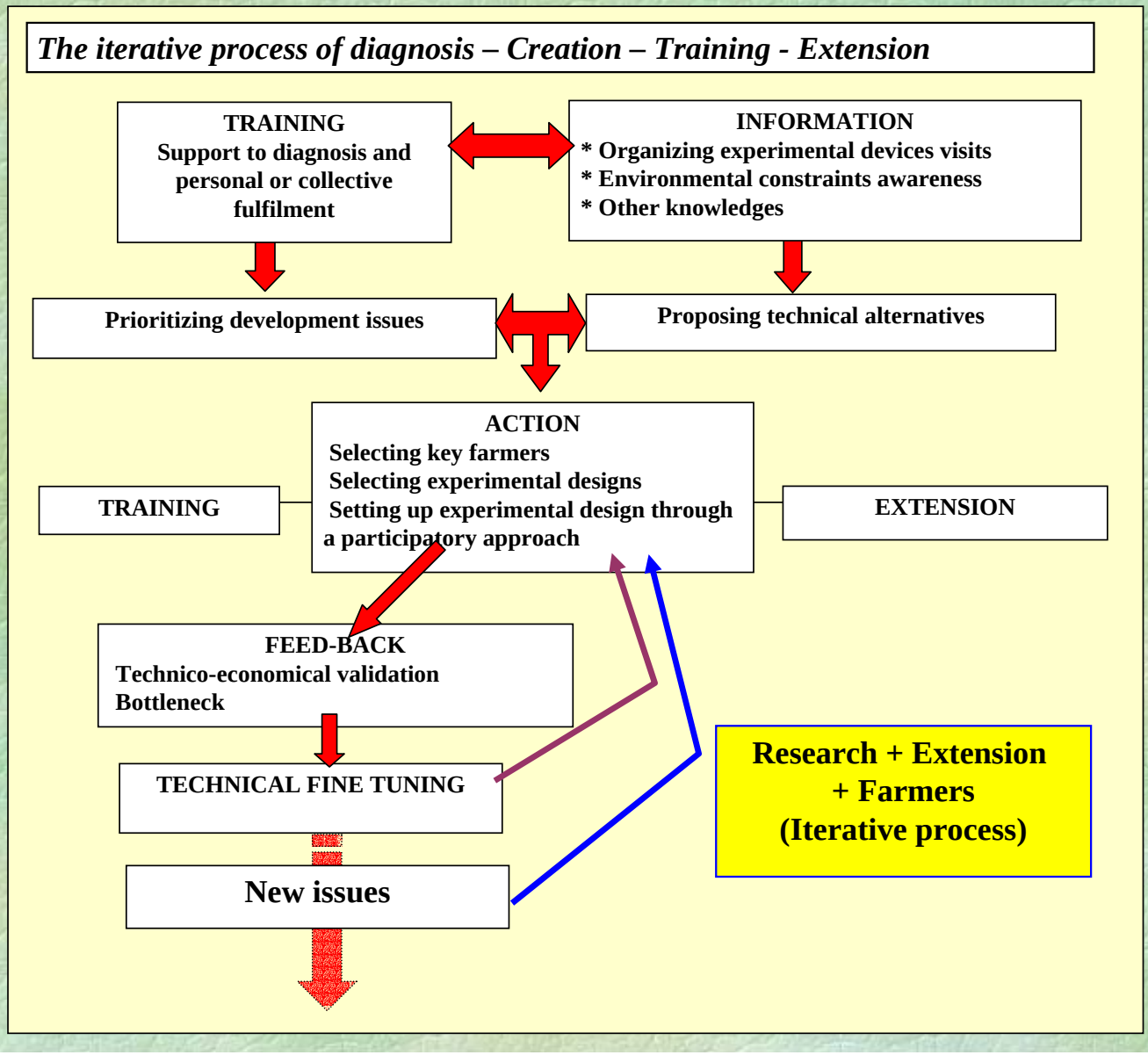
Laos

Rolling injection planters - Madagascar

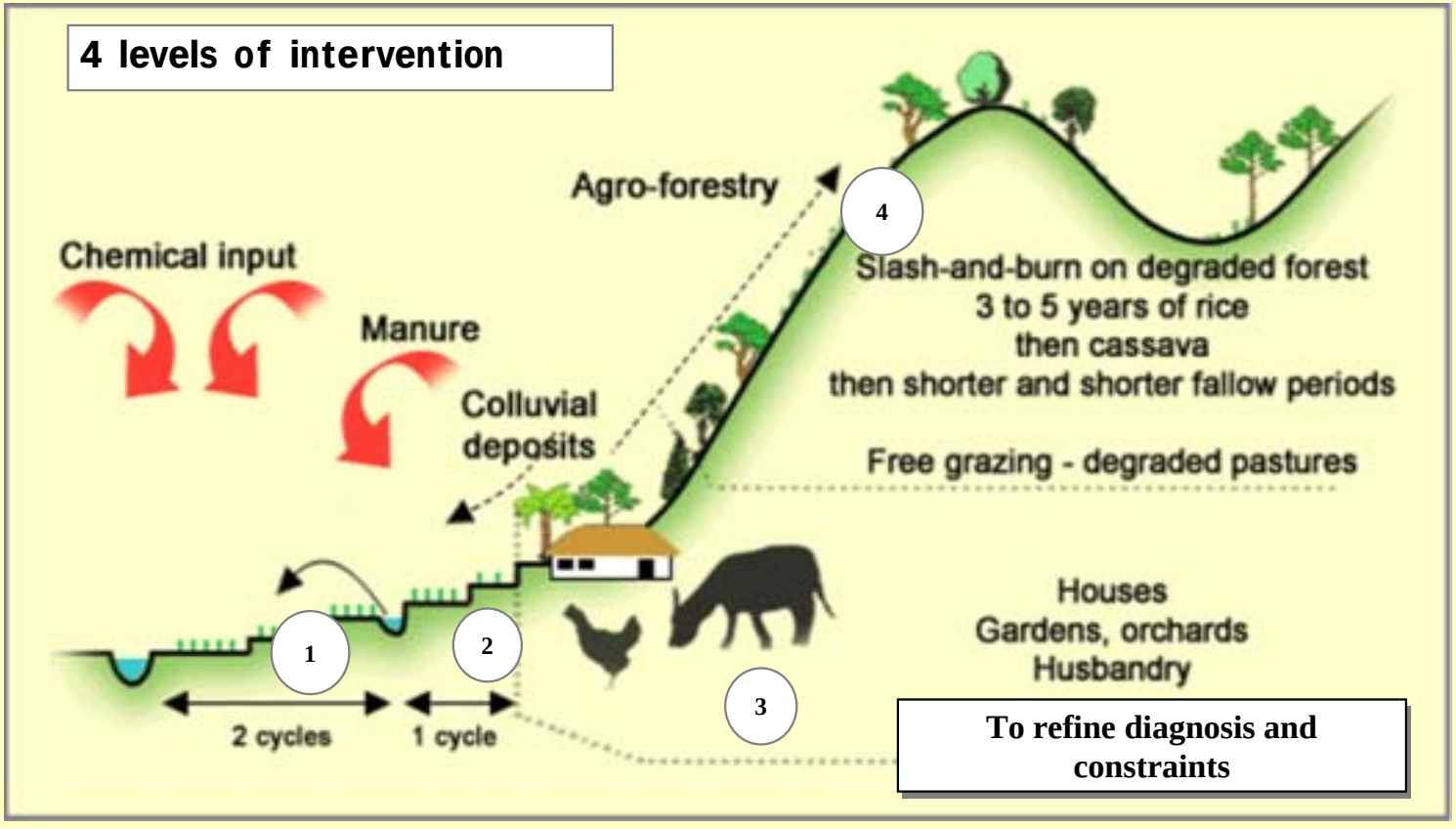
Hand seeder
Madagascar


Simple bamboo stick, Vietnam

Methodology


The iterative process of diagnosis – Creation – Training - Extension
TRAINING
Support to diagnosis and personal or collective fulfilment
INFORMATION
* Organizing experimental devices visits
* Environmental constraints awareness
* Other knowledges
Prioritizing development issues
Proposing technical alternatives
ACTION
Selecting key farmers
Selecting experimental designs
Setting up experimental design through a participatory approach
TRAINING
EXTENSION
FEED-BACK
Technico-economical validation
Bottleneck
TECHNICAL FINE TUNING
New issues
Research + Extension + Farmers (Iterative process)

Land use along the toposequences



1: Paddy with 2 irrigated crops

2: Paddy with 1 irrigated crop

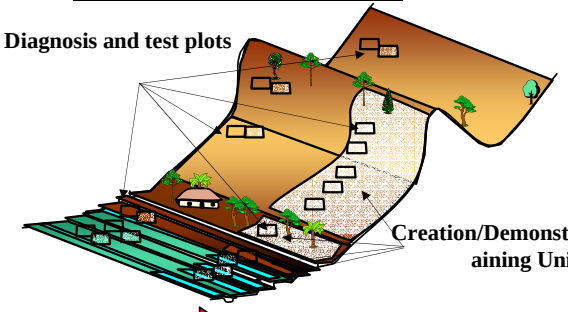
3: Housing, gardens and orchards

4: Crops on slopes

Diagnosis and approach at different scales

1) Cropping system and land level

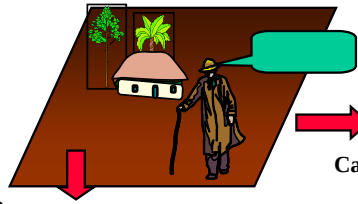
Diagnosis and test plots

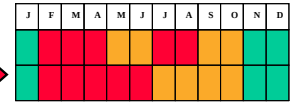


Creation/Demonstration/Training Unit

DMC System: crop/environment interactions

2) Farm level: Surveys





Calendar of labour and cash constraints

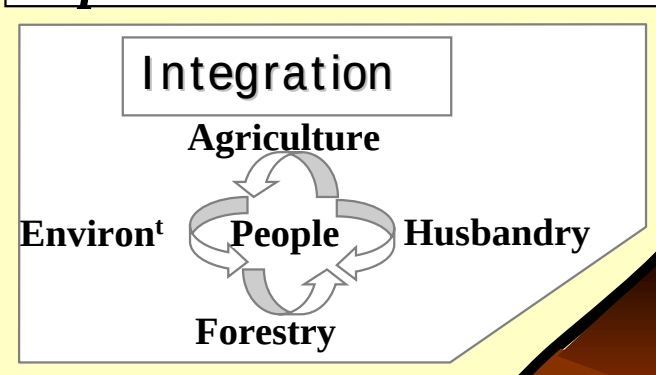
Resources
Dependents
Goals
Access to market and credit
Interactions with other stakeholders
…

Farming system level

Biophysical + socio-economic diversity

- **Identify constraints and farmers'needs**
- **Selecting key farmers**
- **Selecting experimental designs**
- **Setting up experimental design through a participatory approach**

Experimental and demonstration devices



- DMC
- Degraded soils
- Steep slopes
- Hedgerows

- Truck farming
- Orchards
- Small husbandry
- DMC

- Intensification
- Quality of rice
- Calendars
- Quality on practices
- Crop diversification

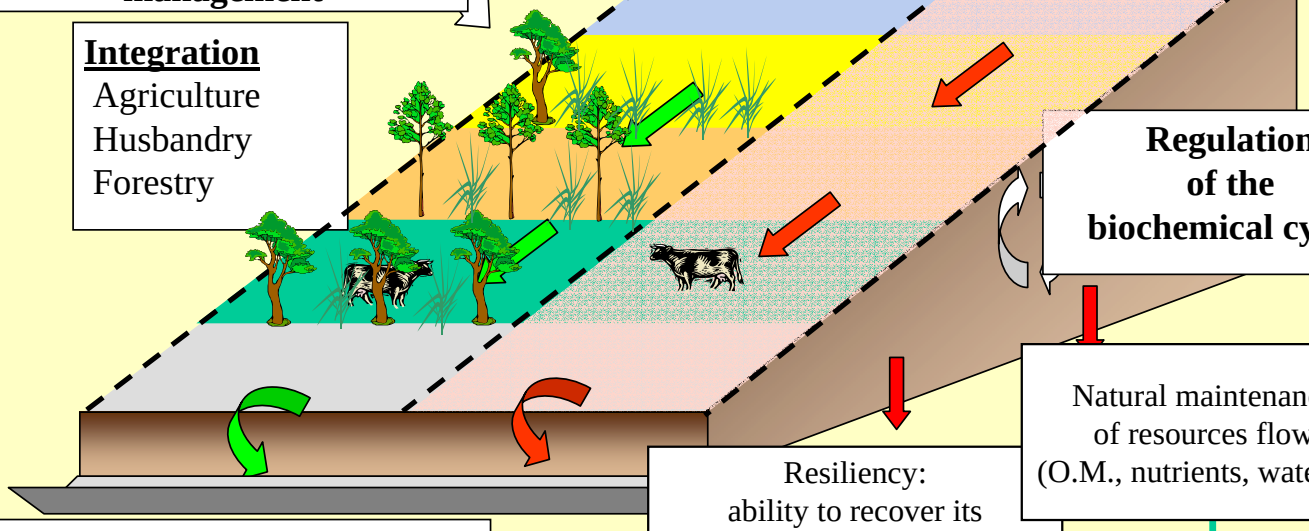
- Water promoting
- Diversification
- Quality on practices and products
- DMC

Main principles to build devices

Rotation and improve fallow management

DMC + Hedgerows + pastures

Traditional systems



Integration
Agriculture
Husbandry
Forestry

Regulation of the biochemical cycles

Natural maintenance of resources flow (O.M., nutrients, water…)

Resiliency: ability to recover its initial state after an external disturbance

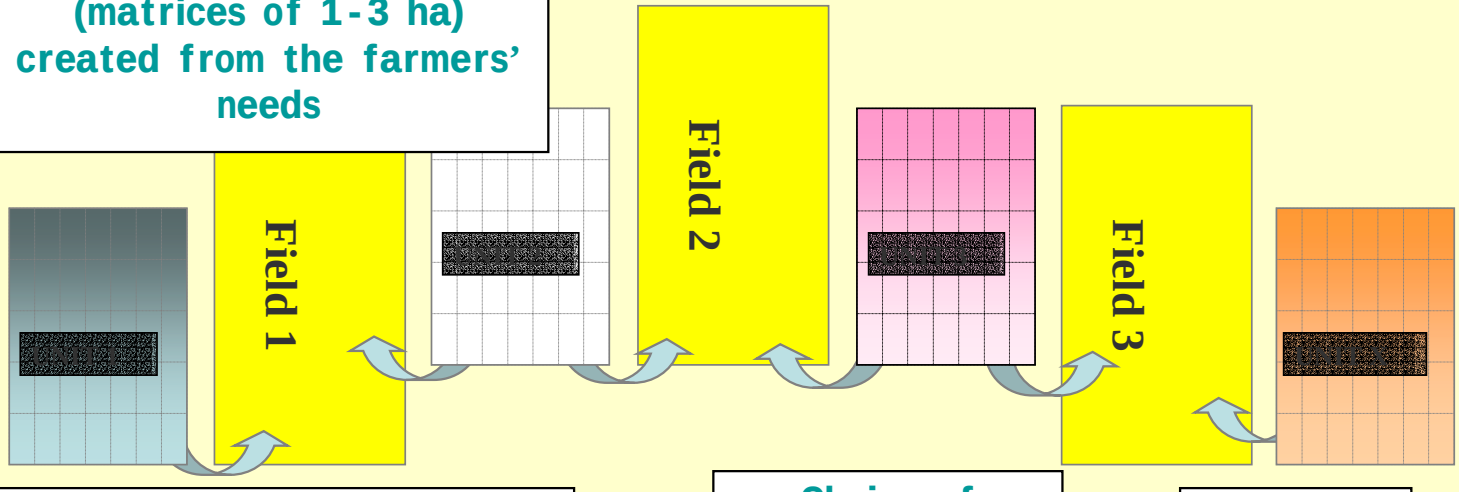
Natural regulation functions

No external effect with negative impact (erosion, over grazing, pollution…)

Externalities
Soil losses by erosion
Water losses by streaming
Pollution factors (pesticides)
Interactions with irrigated crops
Biodiversity

Organization of the tests and demonstrations on slope

Organization around units (matrices of 1-3 ha) created from the farmers' needs



Examples of topics of units

- **Priority food productions**
- **Partial fodder production**
- **Priority fodder production**
- **Priority for Perennial cultures (tea – coffee…)**
- **Priority for trees**
- **Etc…**

Choice of some systems → **Fields**

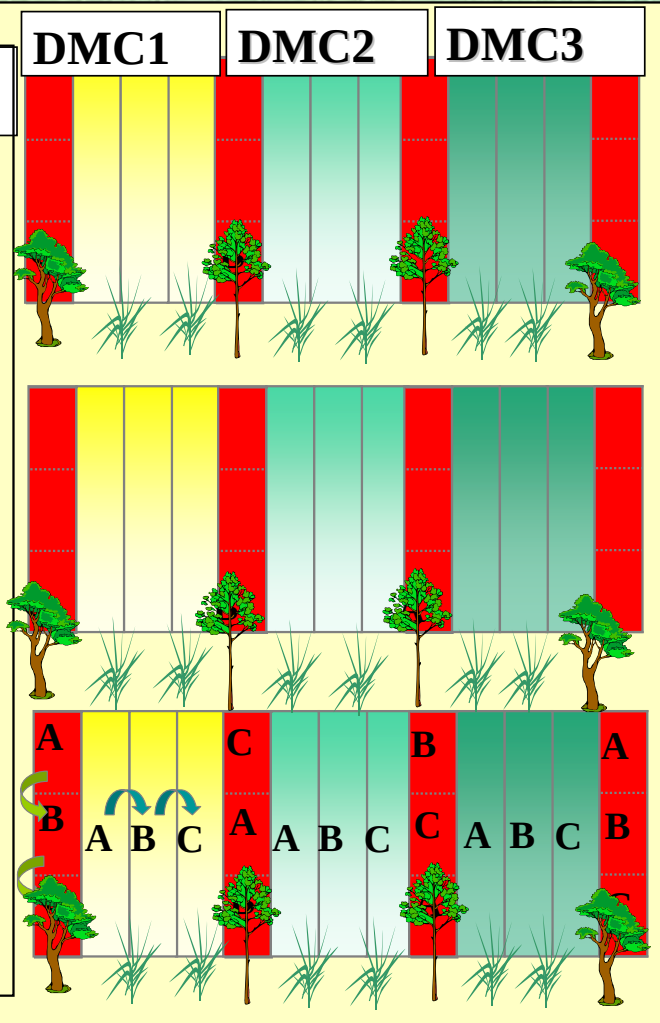
Setting up in fields and according to all the toposéquence by farmers and technicians in training

A range with different levels of intensification

F0 Traditional level of fertilization

F1 Medium level of fertilization

F2 Optimum level of fertilization



A range requiring different skills

Insert control

DMC1 DMC without herbicide on imported mulch

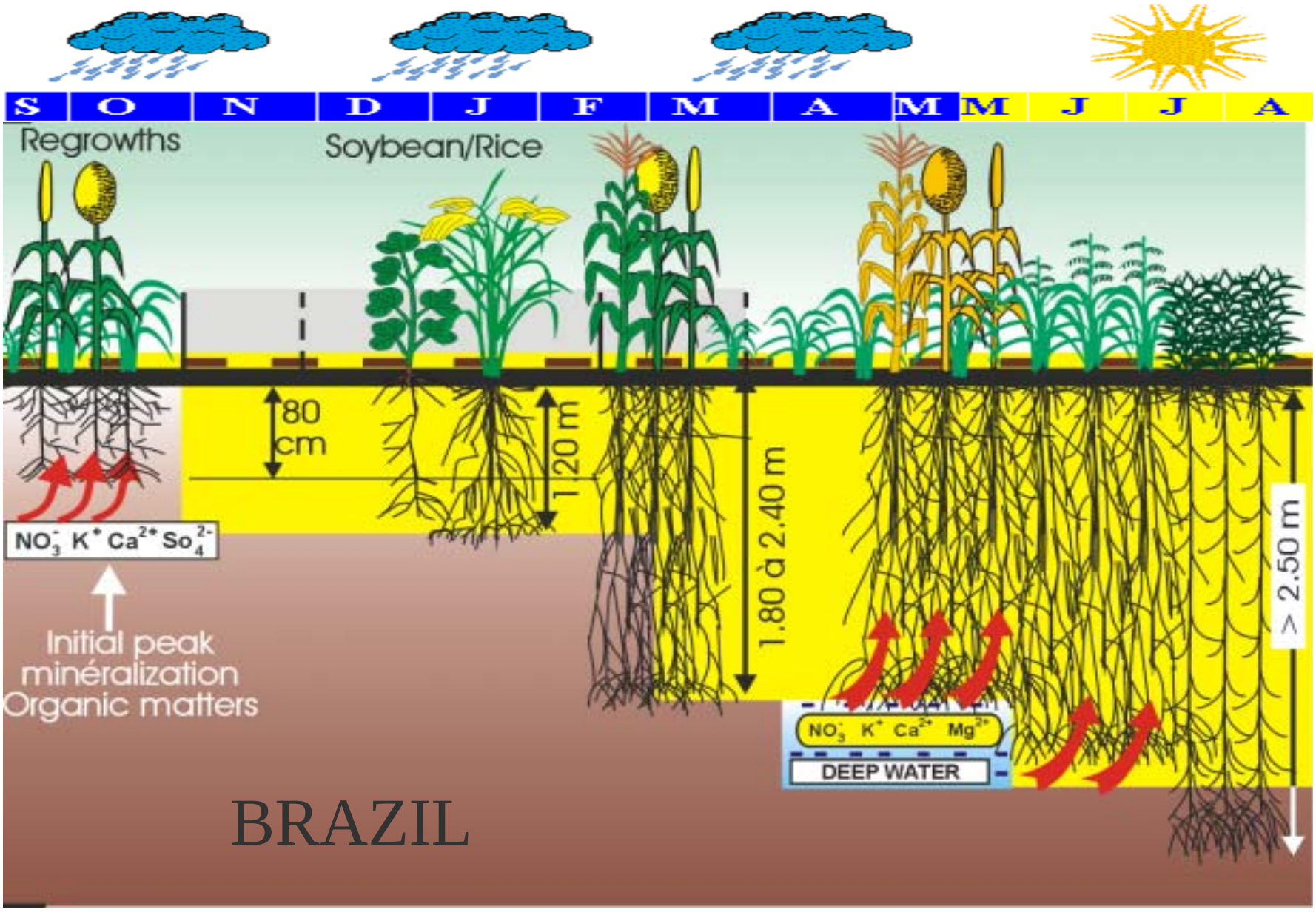
DMC2 DMC on locally produced mulch

DMC3 DMC on living cover

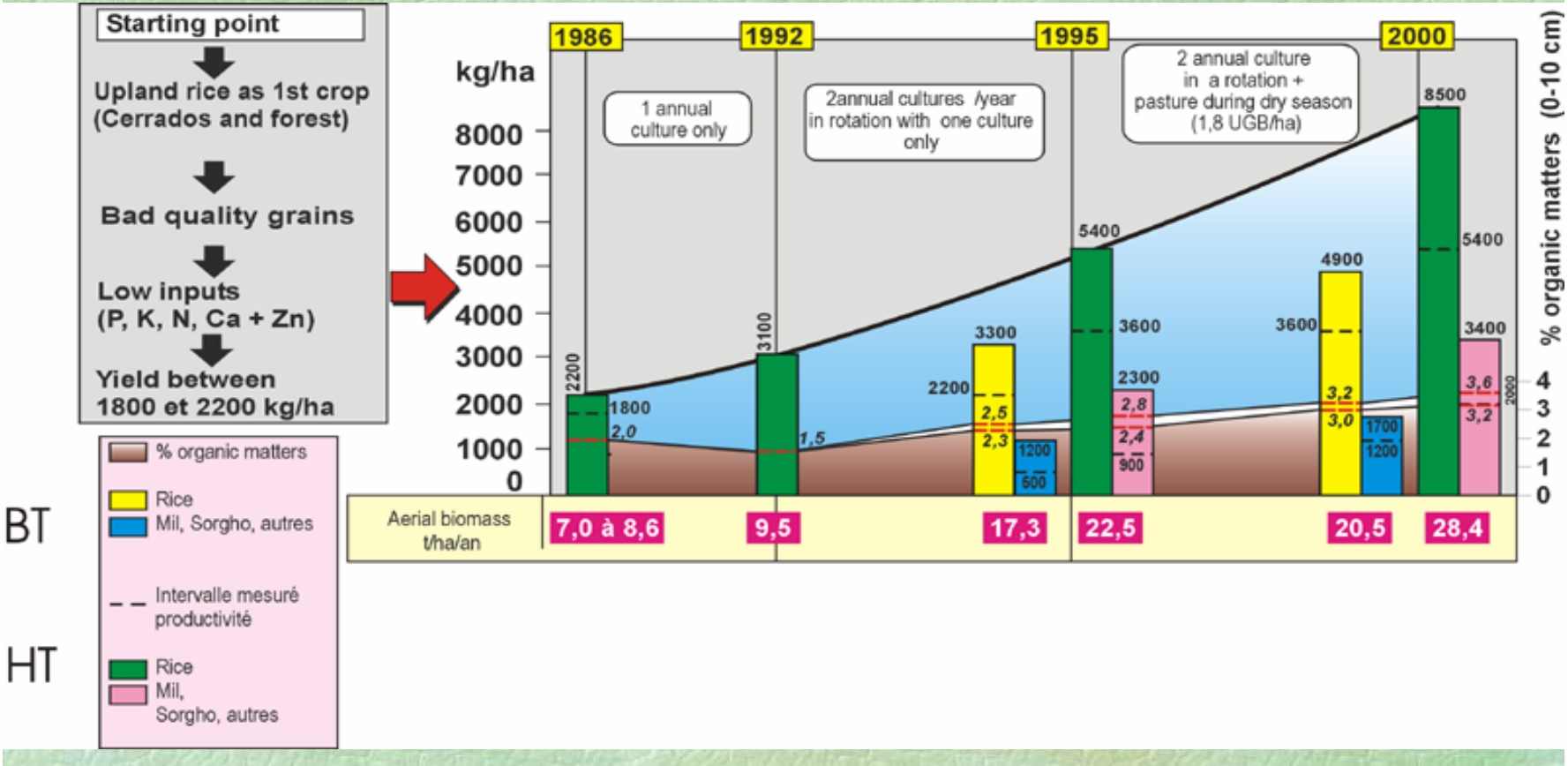
A B C Rotation cash crops

Hedgrows (legumes, grasses)

Examples of results achieved within a few years


S O N D J F M A M M J J A
Regrowths
Soybean/Rice
80 cm
120 m
1,80 à 2,40 m
> 2,50 m
NO_3^- K^+ Ca^{2+} So_4^{2-}
Initial peak
minéralization
Organic matters
NO_3^- K^+ Ca^{2+} Mg^{2+}
DEEP WATER
BRAZIL

Trends of upland rice performance in sustainable cropping systems




Breeding for direct sowing
Upland rice: yield reaching 10 t/ha
Brazil


Madagascar: 10 years
Identification of sets of systems, adapted for the main agroecological conditions
Training and extension phase

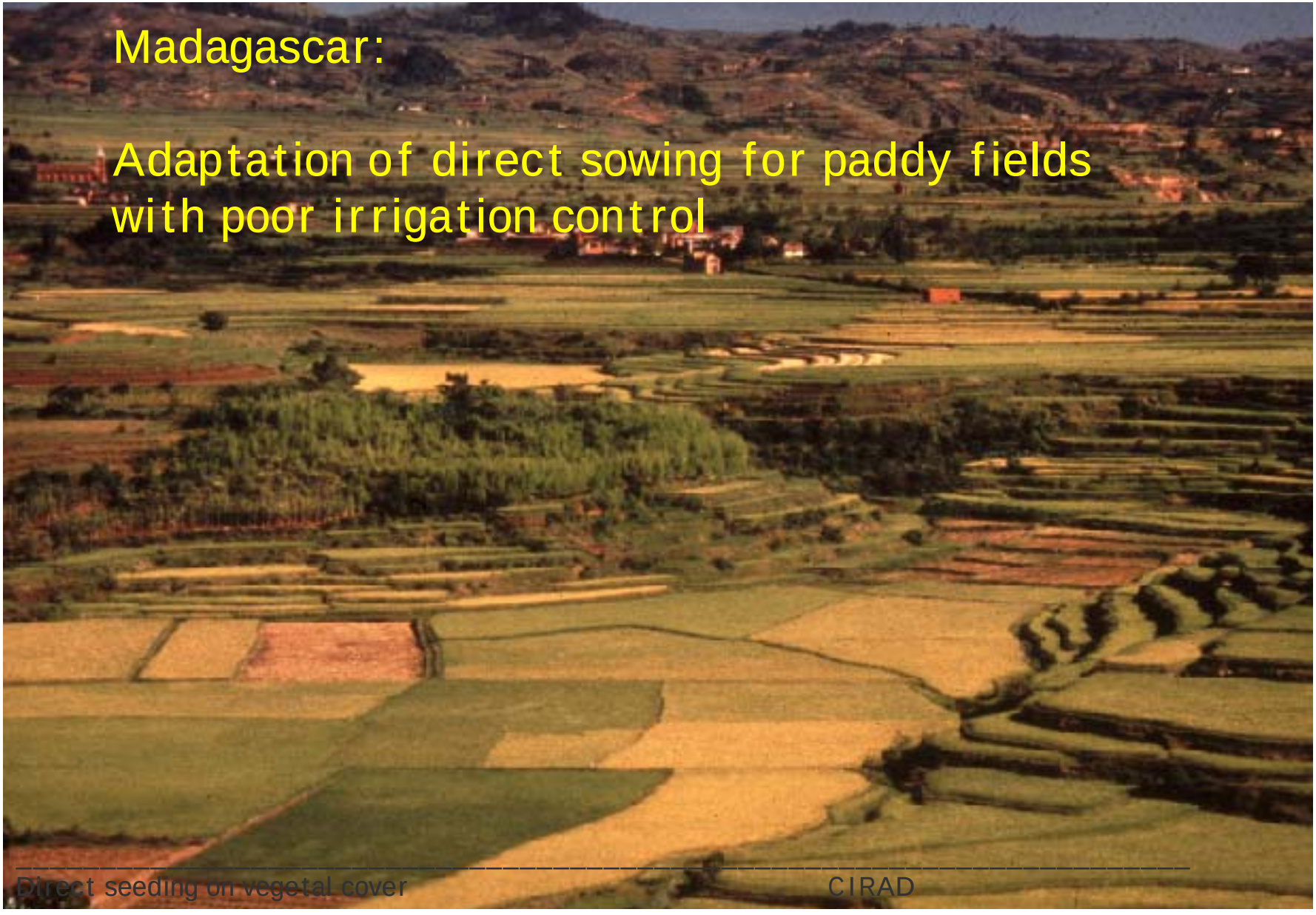

Living mulch of A. pintoi

Maize on living mulch of Desmodium

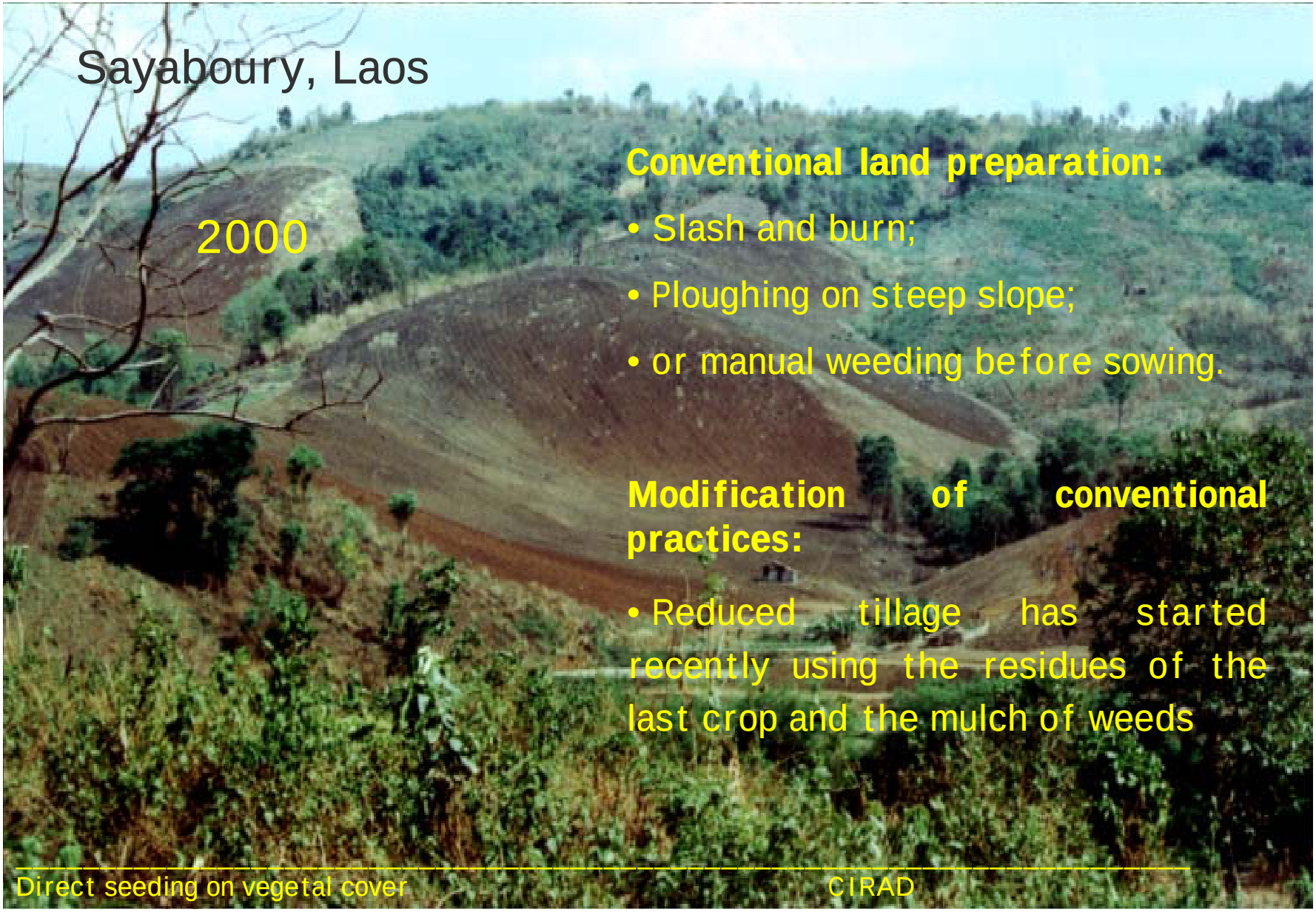
Direct seeding on vegetal cover

CIRAD

Green bean on oats mulch


Madagascar:
Adaptation of direct sowing for paddy fields with poor irrigation control


Madagascar:
Adaptation of direct sowing for paddy fields with poor irrigation control


Sayaboury, Laos
2000
Conventional land preparation:
• Slash and burn;
• Ploughing on steep slope;
• or manual weeding before sowing.
Modification of conventional practices:
• Reduced tillage has started recently using the residues of the last crop and the mulch of weeds

Using crop residues and weeds as mulch

Cover crop of *Mimosa invisa*. Herbicide application of glyphosate (1.5 l/ha) and 2.4-D (1.5 l/ha)

Sorghum, finger millet and millet on the cover of *M. invisa*


Direct seeding of rice on *Mimosa invisa* mulch


Cover crop before the main crop
Direct seeding of cotton on mulch of sorghum and millet

Short duration (90 days) of sesame on three kinds of mulch :

- rice-bean (*Vigna umbellata*) (0.46 t.ha^{-1});
- sorghum (0.52 t.ha^{-1});
- job's tears (0.59 t.ha^{-1})
- weeds (0.56 t.ha^{-1}).

← Importation of rice-bean straws on the site (10 t. ha^{-1} of biomass)

No manual weeding

Association of fruit trees and forage crops (*Stylosanthes guianensis* and *Cassia rotundifolia*)

Brachiaria ruziziensis sowed 25 days after job's tears emergence

Stylosanthes guianensis with maize

Direct seeding on vegetal cover


Rubber trees, coffee
and Stylosanthes guyanensis

Rice and green bean on stylosanthes guyanensis mulch


Rice on Cassia rotundifolia
intercropped with rubber trees


Northern Vietnam
1999


Stylosanthes guyanensis under cassava


Upland rice after Brachiaria ruziziensis

Control of Imperata cylindrica

by Mucuna and mulching


Over 1.7 t/ha
Weeding reduced
No fertilisation


Miniterrasses
with B. ruziziensis


Miniterrasses
with A. Pintoi

Forage production for cattle


Crops diversification
2 crops
Soyabean
Peanuts


Crops diversification
Sunflower
Direct seeding on vegetal cover
CIRAD
© CIRAD/VASI

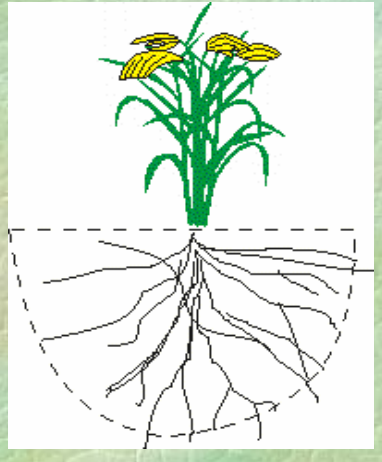

Crops diversification
Winter crops (oats, wheat, barley, forages)


Training
(fruit trees)

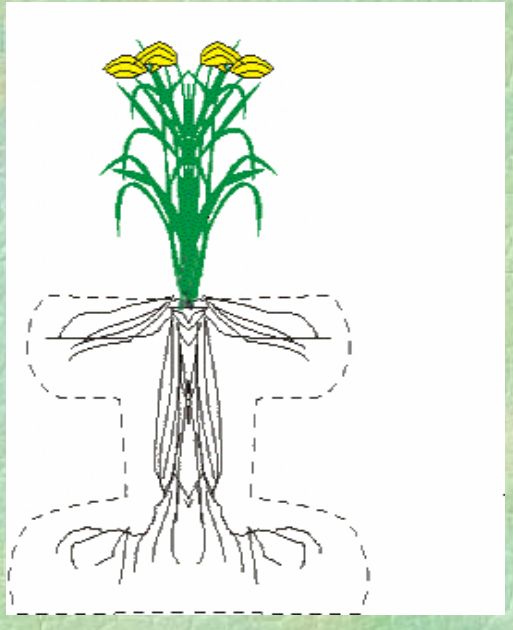

Training by doing
Creation of
a research and training centre
on agro-ecology
30 3 2001

Impact on rice cultivation

By improving the environment, these systems reveal new potentialities for the varietal screening !



Tillage



Direct seeding on plant cover

CIRAD 141

Thousands of ha in Brazil

E-mail- agronorte@terra.com.br
Telefax (65)515-8383

E-mail- anpesq@terra.com.br
Telefax (65)515-8383/531-5263

ARROZ SUCUPIRA

A TECNOLOGIA DA EVOLUÇÃO

- Lançamento Safra 2001/2002
  (Protegida e Registrada)
- Genética Agro Norte
- Dupla aptidão - Terras Altas e Irrigado
- Resistência a Brusone do Pescoço
- Ciclo Curto
- Porte Médio
- Resistência a Acamamento
- Elevado Teor de Amilose
- Grão Longo Fino
- Excelente Aparência de Massa
- Elevada Porcentagem de Inteiros
- Elevado Potencial Produtivo (Até 6.000 KG/HA)**

GLOBALIZANDO A ORIZICULTURA BRASILEIRA

CIRAD 141

Rusticidade e Produtividade

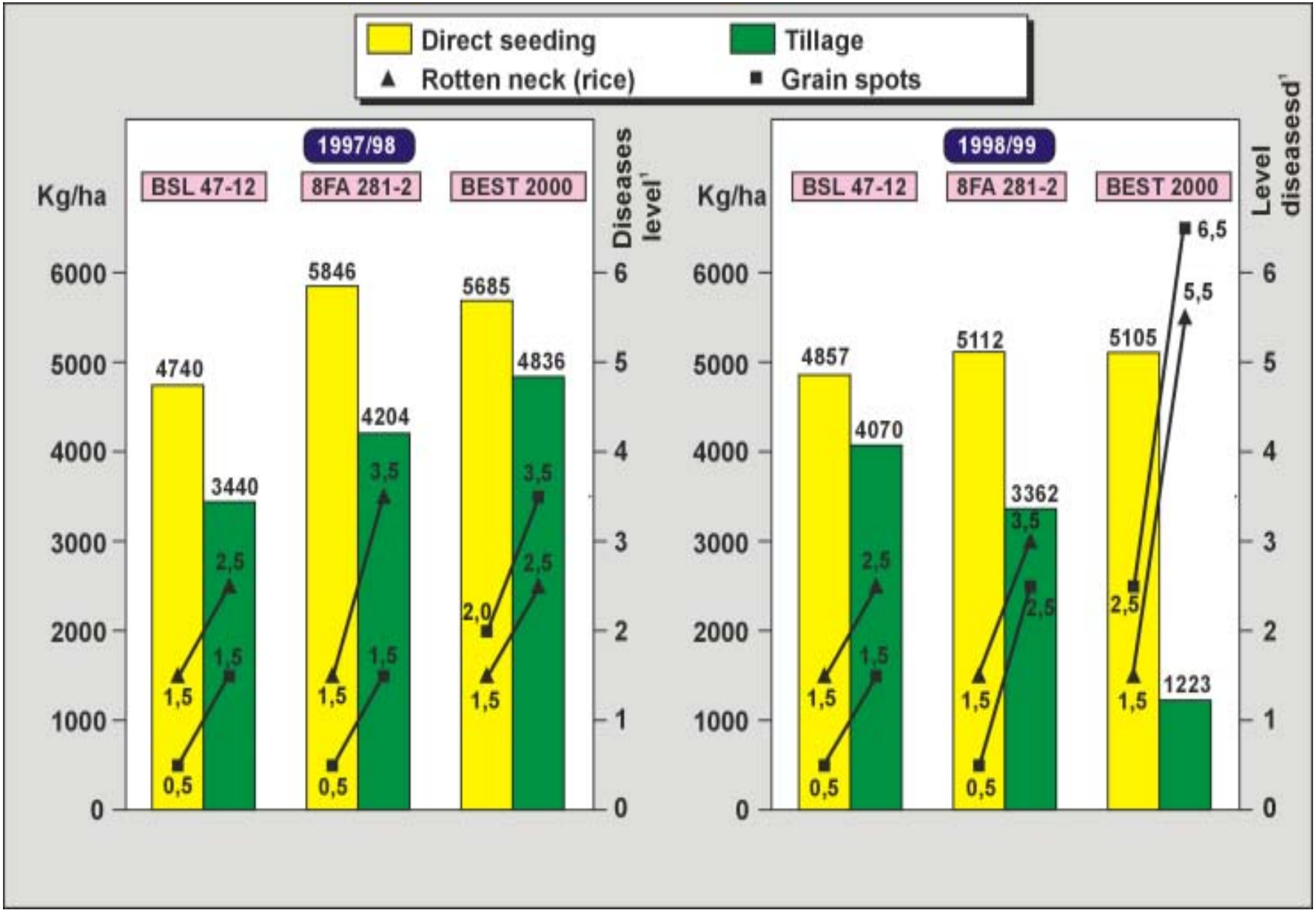
- Genética Agro Norte
- Semente Purificada, registrada e fiscalizada
- Resistência a doenças
- Ciclo Médio
- Resistência a Acamamento
- Classificação Agulhinha
- Excelente Aparência de Massa
- Elevada Porcentagem de Inteiros
- Alto Rendimento de Engenho
- Elevado Potencial Produtivo (até 5.000 Kg/ha)**

** Produtividade variável em função do nível tecnológico empregado

R. Colonizador Ênio Pipino, 993 - Cx. Postal 405 - Sinop-MT CEP 78.550-000

Rice varieties adapted to both upland and irrigated conditions


Upland rice on irrigated plots
Upland rice in direct seeding
Early cultivars


Direct seeding
Tillage
Rotten neck (rice)
Grain spots
1997/98
BSL 47-12
8FA 281-2
BEST 2000
Kg/ha
Diseases level¹
4740
3440
5846
4204
5685
4836
1998/99
4857
4070
5112
3362
5105
1223
Level diseasesd¹
6,5
5,5
0,5
1,5
2,0
2,5
3,5


Selected rice varieties in and for direct seeding on plant cover systems

Imagine with farmers


Accompanying farmers

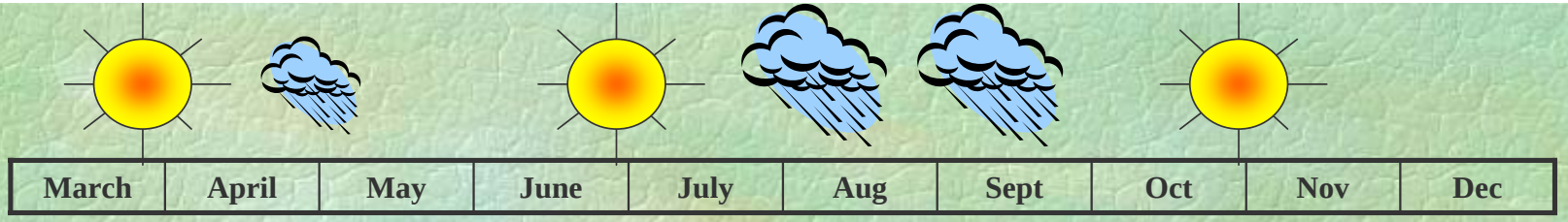

20. 2. 1999

Some useful outputs of agroecology in Cambodia

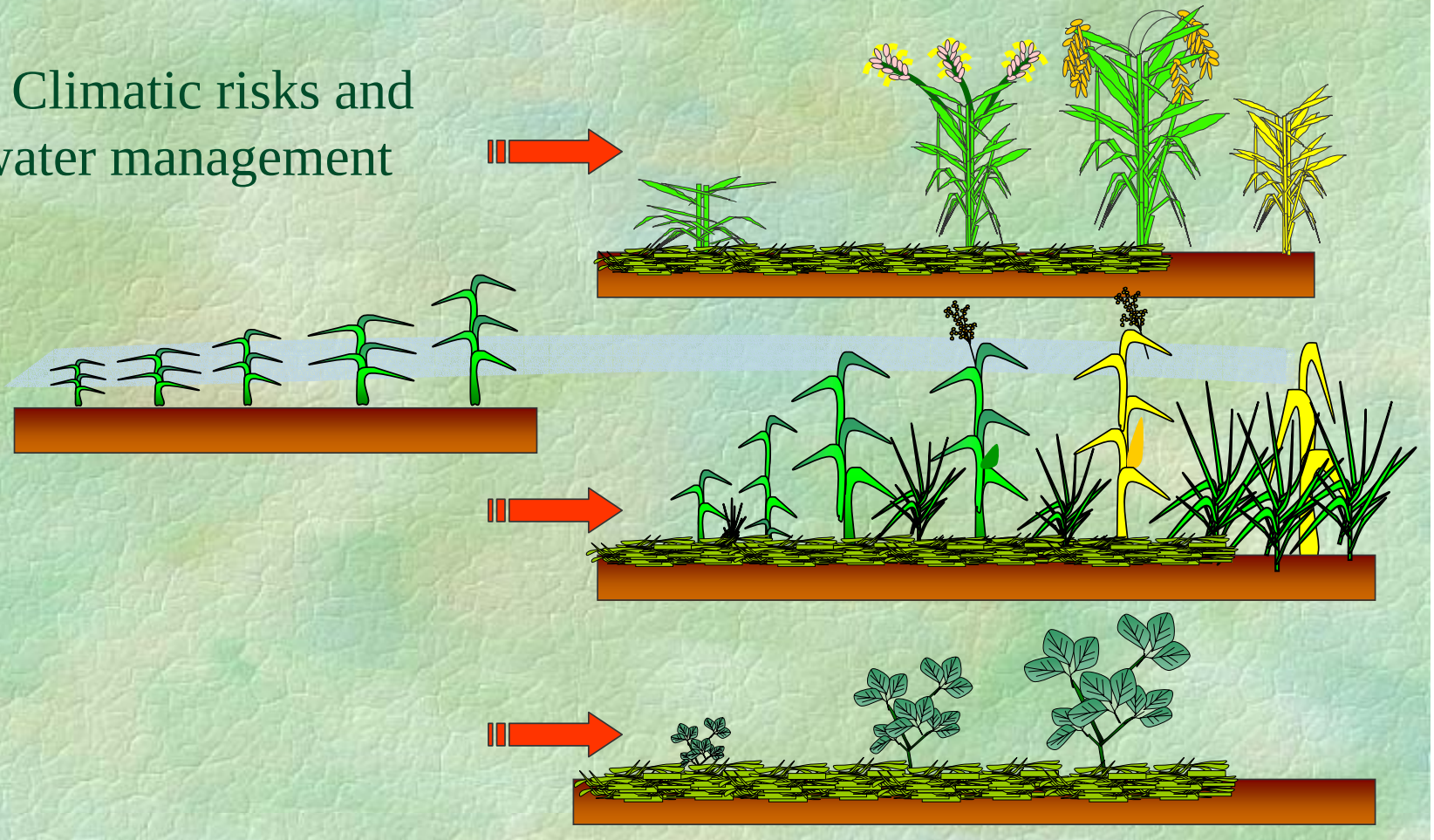
1- Climatic risks and water management for upland and lowland areas

2- Fodder crops associated to grain production in rice based farming systems

3- fixation of cropping systems on poor and/or degraded soils



1- Climatic risks and water management



1- Climatic risks and water management

Biomass production : sorghum and eleusine 50 days after sowing

1- Climatic risks and water management

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1- Climatic risks and water management

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2- Fodder crops associated to grain production in rice based farming systems

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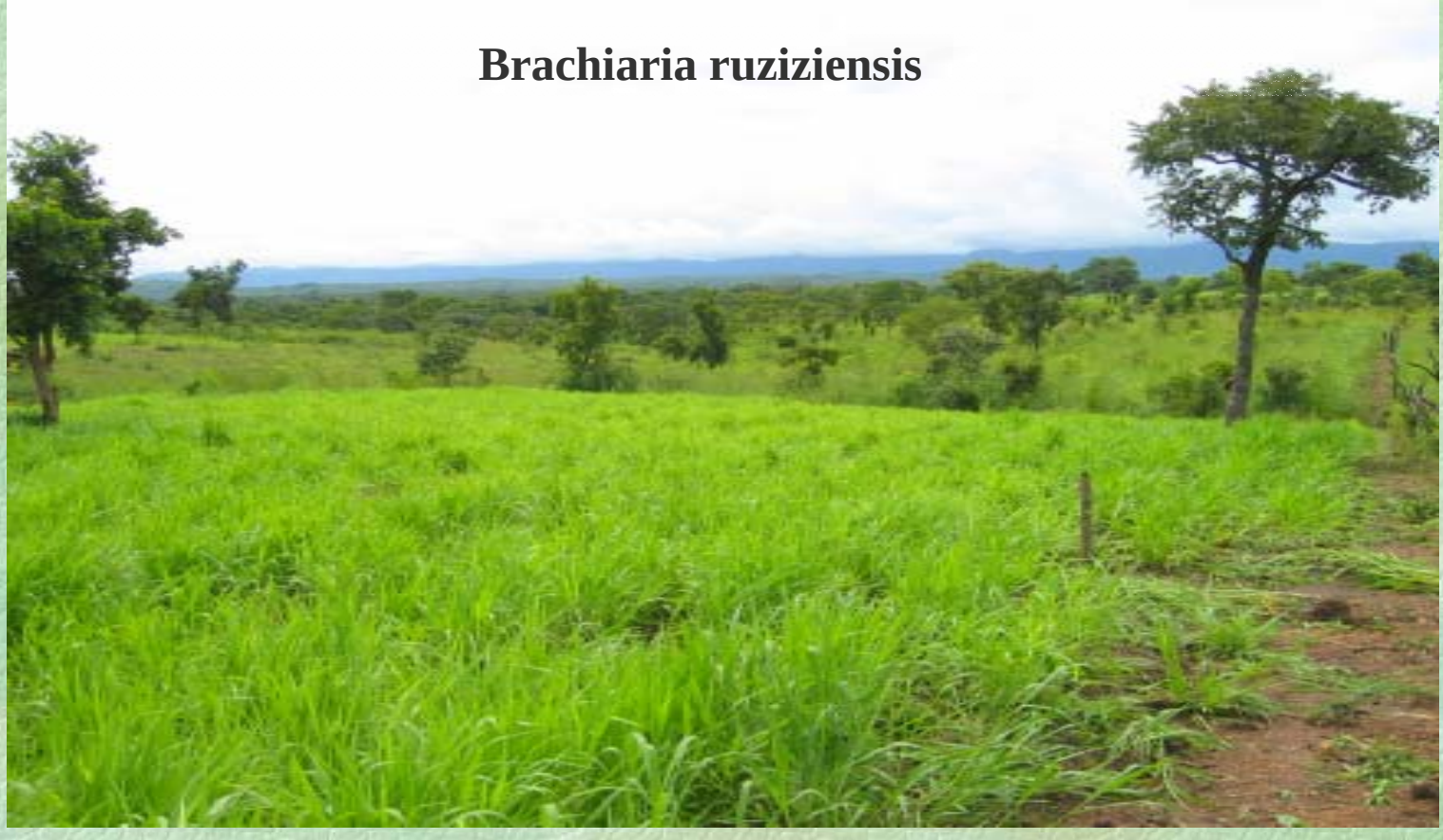
Brachiaria ruziziensis



3- fixation of cropping systems on poor and/or degraded soils

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Thank You for your attention