TROPICAL SOILS
UNDER DIRECT SEEDING,
MULCH-BASED CROPPING SYSTEMS

Madagascar, December, 2007

CONTROL OF SOIL EROSION IN BRAZIL BY THE NO-TILLAGE TECHNIQUE:

IMPORTANT POINTS TO BE CONSIDERED

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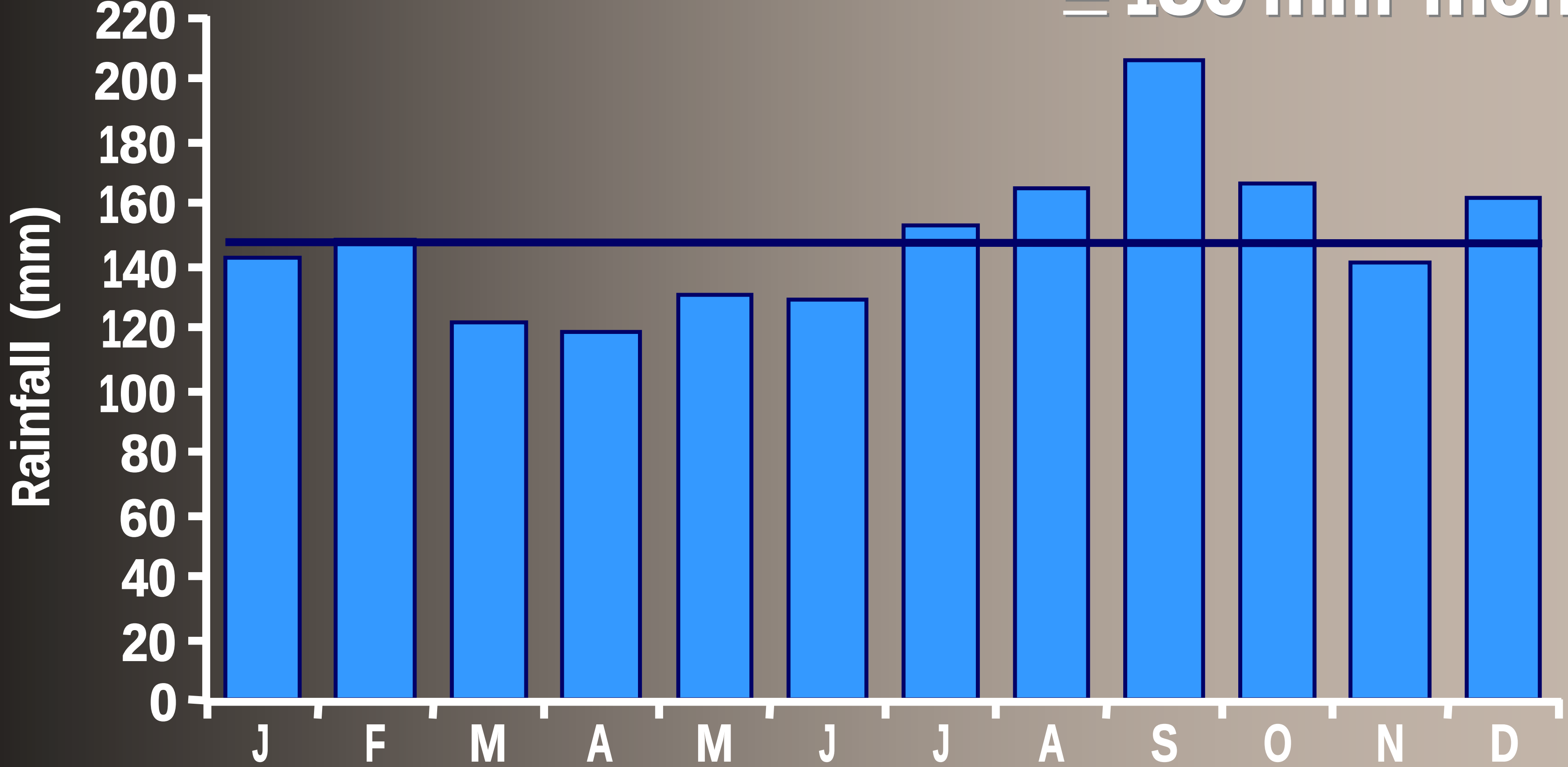
RAINFALL DISTRIBUTION

Subtropical region

- ≅ 1,800 mm $year^{-1}$
- ≅ 150 mm $month^{-1}$



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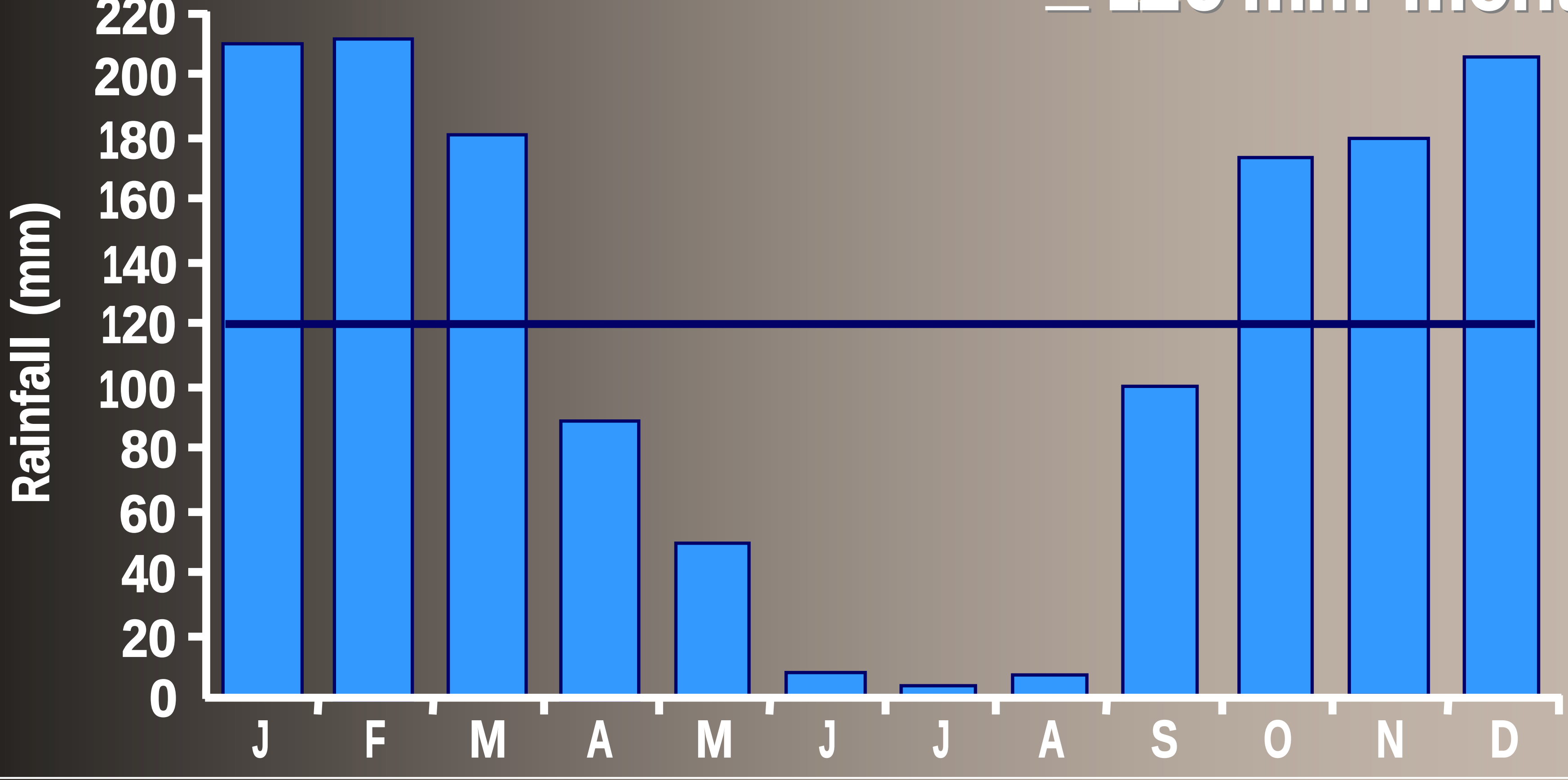
RAINFALL DISTRIBUTION

Tropical region

- ≅ 1,440 mm year^{-1}
- ≅ 120 mm month^{-1}



RAINFALL EROSIVITY

$\cong$ 3,000 to 14,000 MJ mm ha^{-1} hr^{-1} yr^{-1}

- **TROPICAL REGION**

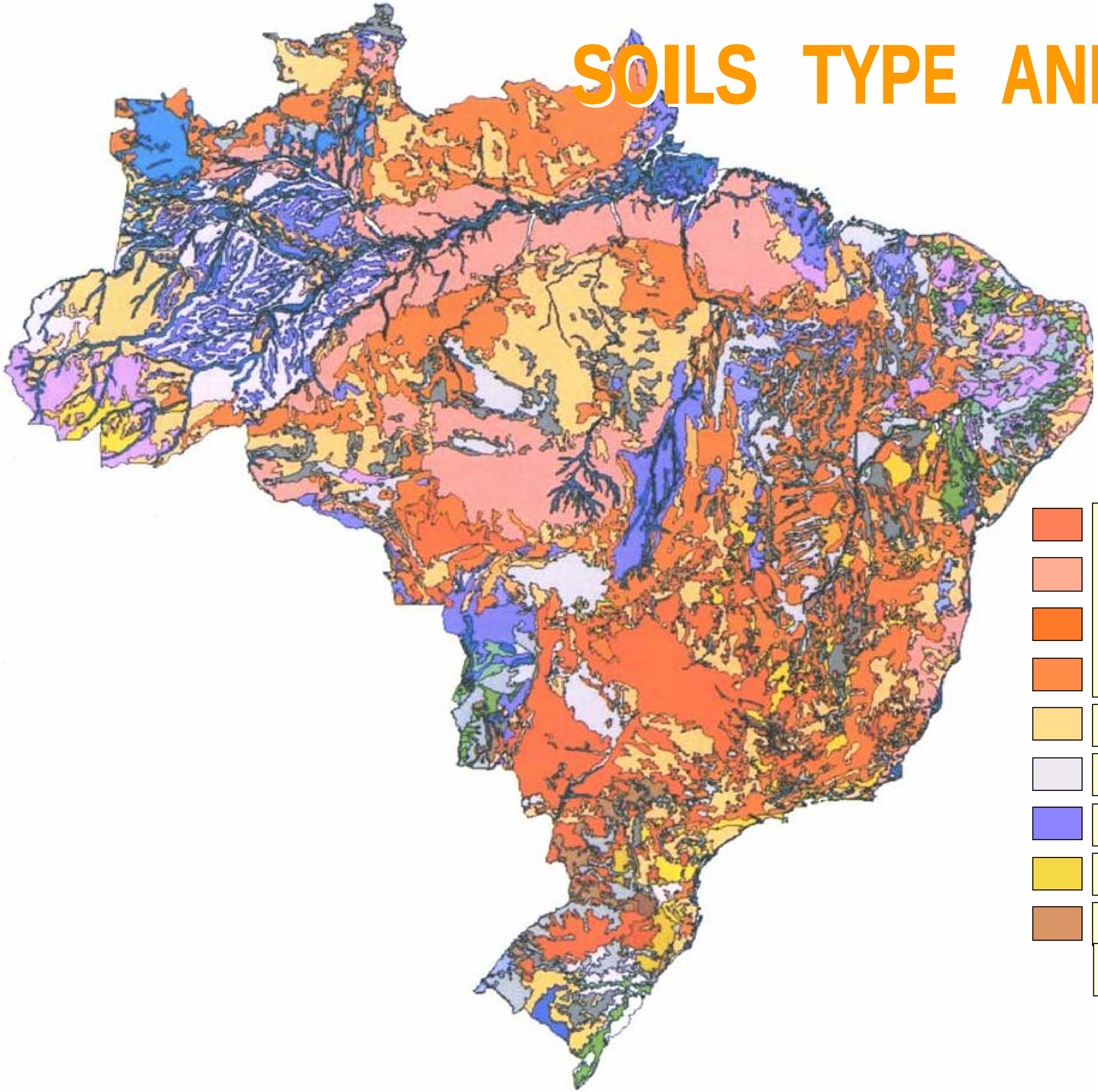
Concentrated in Spring and Summer

- **SUBTROPICAL REGION**

Regularly distributed throughout the year

HIGH RAINFALL-EROSION POTENTIAL

SOILS TYPE AND DISTRIBUTION



Latosol - Red Latosol - Yellow Latosol - Brown Latosol - Red-Yellow		38.7%
Argisol		20.0%
Neosol - sand quartz		14.6%
Plinthosol		6.0%
Cambisol		2.7%
Nitosol		1.4%
Others		16.6%

GENERAL CHARACTERISTICS

Latosols, Argisols, and Nitosols

- Deep
- Well-drained
- Distributed on slightly rolling to rolling landscape

No limitations for mechanization

GENERAL CHARACTERISTICS

Plinthosols, Neosols, and Cambisols

- Shallow
- Poorly-drained
- Presence of stones
- Hilly landscape

Restrictions for mechanization

SOIL ORGANIC MATTER

SOIL TYPE	g 100 g^{-1}
Neosols - sand quartz	< 2
Latosols	< 4
Argisols	< 4
Plinthosols	< 4
Nitosols	< 4
Cambisols	> 4

SOIL MINERALOGICAL CHARACTERISTICS

In general

- Clay fraction
  - 1:1 → (caolinite)
  - oxides → Fe and Al

LOW CONTENT OF WATER–DISPERSED CLAY → HIGH SOIL-AGGREGATE STABILITY

SOIL PHYSICAL CHARACTERISTICS

In general

- Total porosity
  - can exceed 0.60 $m^3 m^{-3}$
  - High soil-aggregate stability

- High permeability to water, air, and roots
- Low to medium susceptibility to water erosion

WATER EROSION SUSCEPTIBILITY

Soil erodibility

SOIL TYPE	ERODIBILITY [1]
Latosols	0.008 to 0.020
Argisols	0.020 to 0.045
Nitosols	0.027 to 0.032

[1] Factor K = Mg ha h MJ^{-1} ha^{-1} mm^{-1}

SOIL CHEMICAL CHARACTERISTICS

In general

- Low pH
- High aluminum
- Low available phosphorus
- Low cation exchange capacity
- Low exchangeable bases
- Dystrophic

Restrictions for plant development

- 2nd HALF OF 1960'S: SOIL FERTILITY IMPROVEMENT (soil acidity and fertility correction)

- increased crop yield
- Improved profitability and competitiveness
- Improved land value

SOIL ANALYSIS LABORATORY NETWORK

- important support for agricultural frontier expansion

AGRICULTURAL FRONTIER EXPANSION

HISTORY

- Beginning : mid 1960's
  - Starting from : forest and pasture lands
- Great changes: 1970 decade
  - Replacement of forest and pasture areas by monoculture (wheat, soybean, maize, rice)

- Conventional tillage
- Limestone and fertilizers

AGRICULTURAL FRONTIER EXPANSION

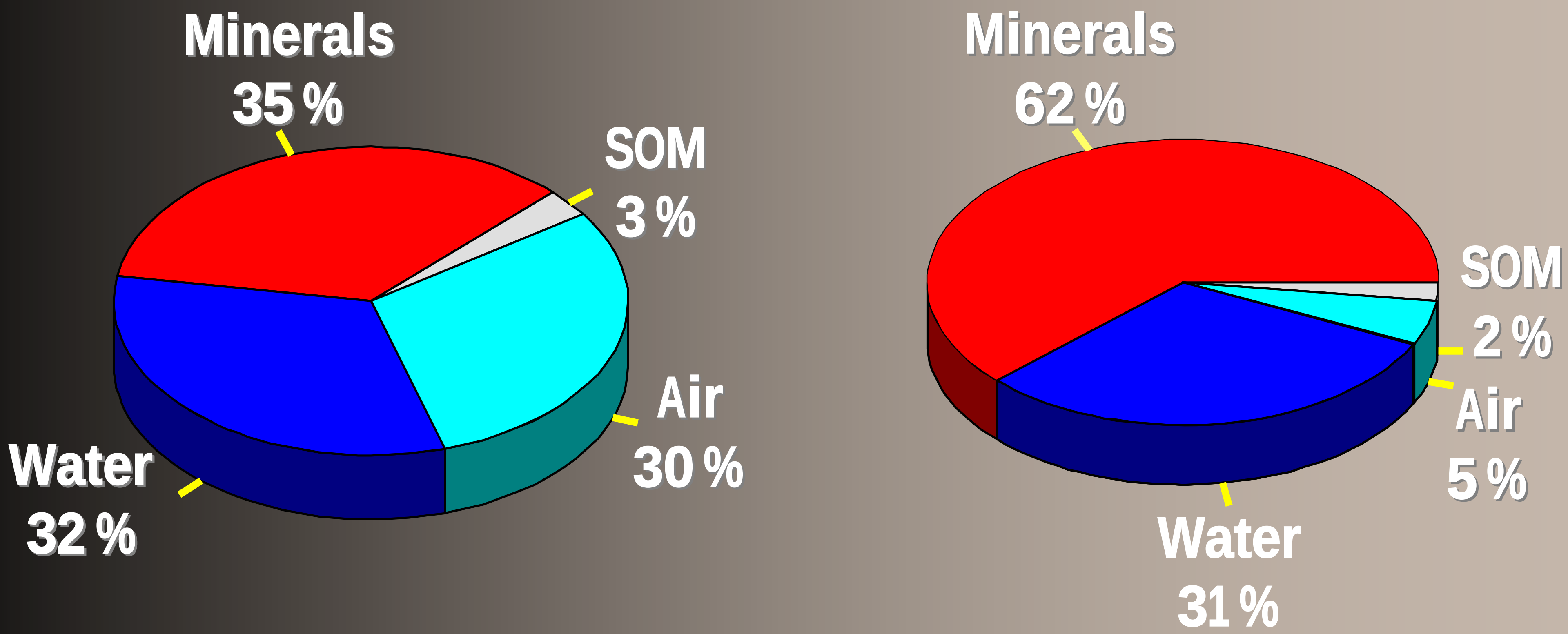
Soil management practices

- Intensive soil mobilization
- Intensive use of lime and fertilizers
- Wheat/soybean or fallow/soybean
- Biomass production lower than SOM decomposition

CONSEQUENCES

- Improvement of soil chemical characteristics
- Degradation of soil structure

DEGRADATION OF SOIL STRUCTURE



LATOSOL UNDER NATURAL CONDITION

LATOSOL UNDER CONVENTIONAL TILLAGE

DEGRADATION OF SOIL STRUCTURE (Latosol, conventional tillage)

Soil layer (cm)	3 years		7 years	
	Soil density (g cm^{-3})	Aggregate stability (%)	Soil density (g cm^{-3})	Aggregate stability (%)
0 - 6	#	#	#	#
6 -14	1.20	78	1.43	48
14 - 23	1.20	79	1.40	58
23 - 30	1.18	78	1.25	56

No aggregates > 4.76 mm.

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AGRICULTURAL FRONTIER EXPANSION

Soil conservation practices

- Contouring
- Terracing

- narrow and medium base (later broad-base), absorption type in Latosols and drainage type in Argisols

THEY WERE SYNONYMS OF SOIL CONSERVATION

- Insufficient to control water erosion

CONSEQUENCES OF POOR SOIL MANAGEMENT PRACTICES

SERIOUS EROSION PROBLEMS

POOR SOIL MANAGEMENT AND EROSION

POOR SOIL MANAGEMENT AND EROSION

POOR SOIL MANAGEMENT, EROSION, AND WATER POLLUTION

WHAT TO DO?

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EROSION RESEARCH

- **The beginning:** 1940 decade

- **Nationwide efforts:** 1970 decade

- **Type:** field runoff-plots, under natural and simulated rainfall

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ROTATING-BOOM RAINFALL SIMULATOR (SWANSON'S TYPE)

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EROSION RESEARCH RESULTS

SOIL LOSSES BY EROSION IN DISTINCT SITUATIONS

Soil	Crop	Exp. time	CBS	CIS	MT	NT
		year	- - - - - - - - - -	Mg ha^{-1} yr^{-1}	- - - - - - - - - -	
Latosol	w/s	6	10.9	3.6	-	1.5
Latosol	w/s	4	-	3.2	-	1.1
Latosol	f/s	6	9.0	6.0	-	5.0
Argisol	w/s	9	-	13.1	3.2	0.5
Argisol	w/s	4	-	5.3	-	1.0
Argisol	w/s	4	51.5	39.5	-	2.2
Nitosol	w/s	11	-	34.0	11.3	8.8
Nitosol	w/s	4	-	6.0	-	0.2

CBS: conventional tillage, burned stubble; CIS: conventional tillage, incorporated stubble; MT: minimum tillage; NT: no-till
W/S: wheat/soybean; f/S: fallow/soybean

EROSION RESEARCH RESULTS

SOIL LOSSES BY EROSION IN DISTINCT SITUATIONS

REGION	SOIL	PERIOD	BS	CBS	CIS	NT	%
			- - - - - - - - - - - - - -	Mg ha^{-1} yr^{-1}	- - - - - - - - - -		
Subtropical	Latosol	Winter	67.5	5.5	1.7	0.7	51
		Summer	65.1	5.4	1.9	0.8	49
Total			132.6	10.9	3.6	1.5	100
Tropical	Latosol	Winter	4.0	0	0	0	5
		Summer	49.0	9.0	6.0	5.0	95
Total			53.0	9.0	6.0	5.0	100

BS: bare soil; CBS: conventional tillage, burned stubble; CIS: conventional tillage, incorporated stubble; NT: no-till

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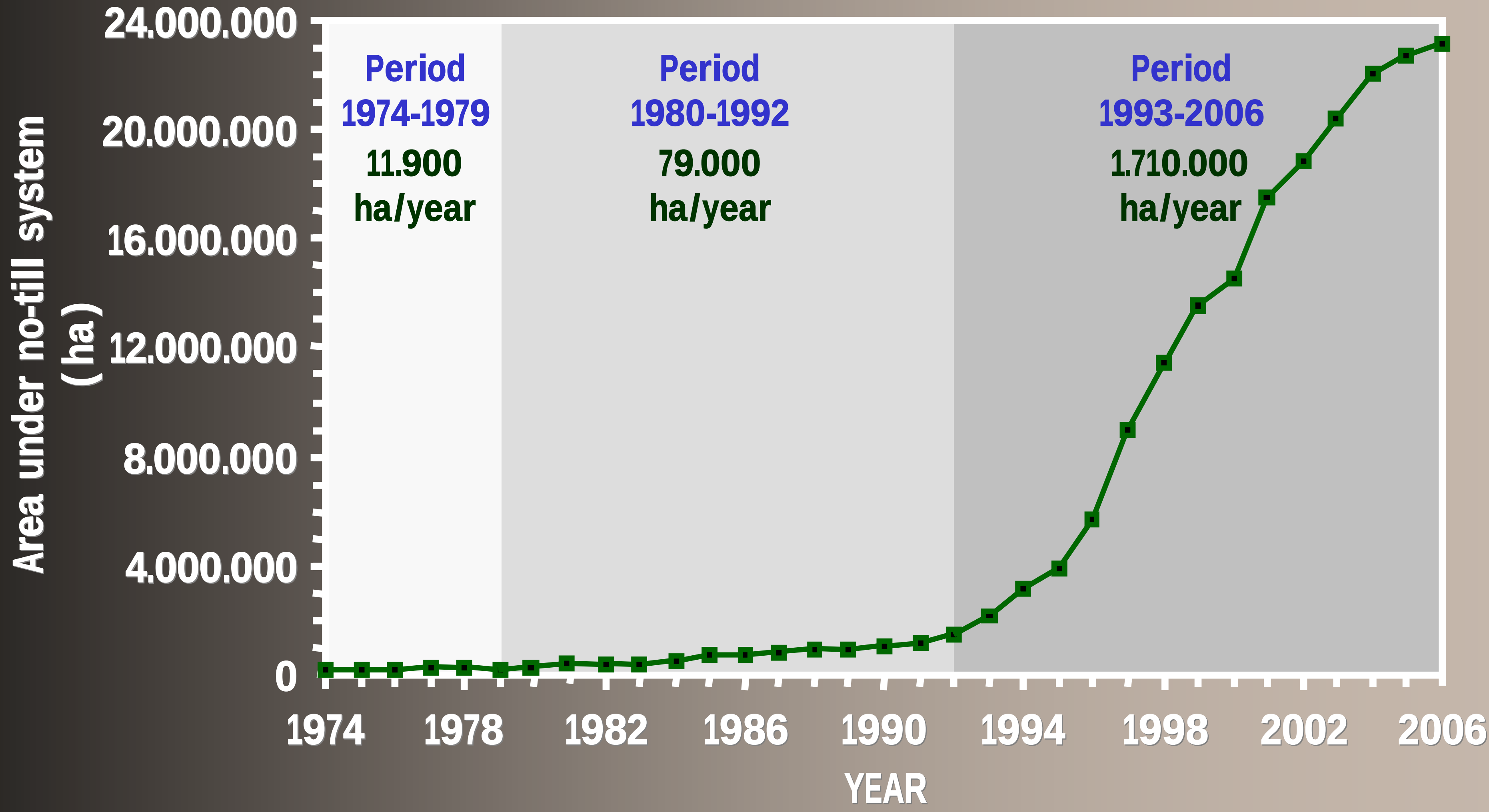
CONSERVATION MANAGEMENT PRACTICES

No-till system

- Concept
  - Complex technology based on species diversification - intercropping or crop rotation -, minimization or suppression of crop-season gap, permanent soil coverage, and mobilization of the soil only in the seed-row.

CONSERVATION MANAGEMENT PRACTICES

Adoption of no-till in Brazil



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NO-TILL SYSTEM IN BRAZIL

Reasons for accelerated adoption

- Effective way for controlling water erosion
- Reduction of time, labor, and costs associated with tillage and seeding operations
- Possibility of implementing agriculture-livestock combination

CONSERVATION MANAGEMENT PRACTICES

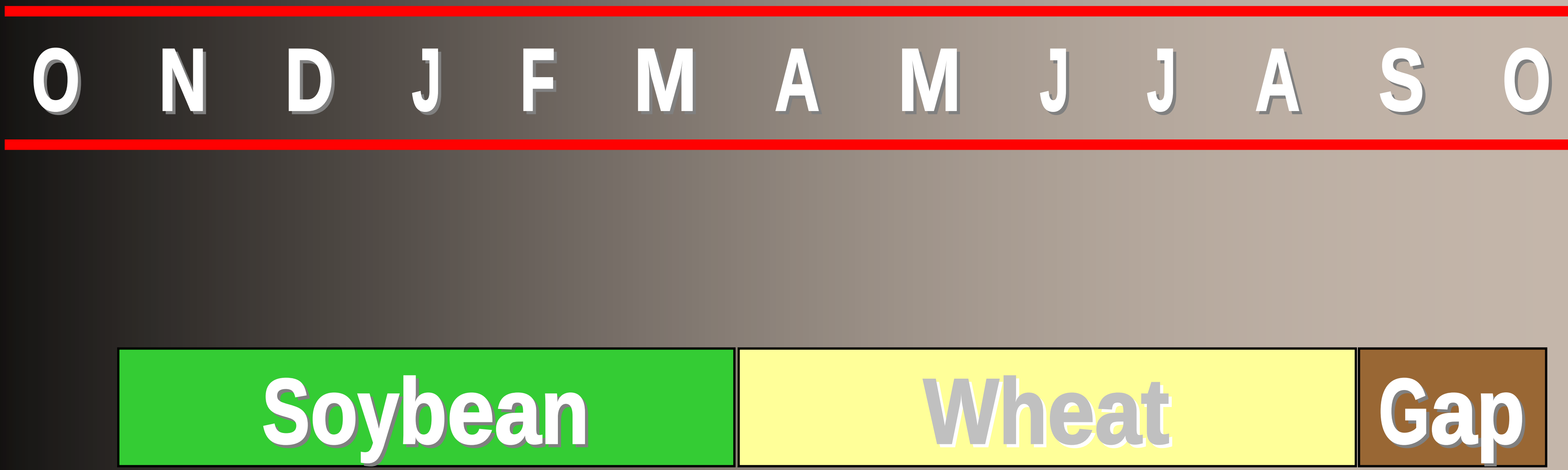
No-till system evolution

- **Different phases, based on temporal and spatial arrangement of species**

1st ➤ wheat/soybean

NO-TILL SYSTEM IN BRAZIL (TROPICAL PORTION)

1st PHASE



CONSERVATION MANAGEMENT PRACTICES

No-till system evolution

- Different phases, based on temporal and spatial arrangement of species

1st ➤ wheat/soybean

2nd ➤ black oats or radish/soybean

NO-TILL SYSTEM IN BRAZIL (TROPICAL REGION) 2nd PHASE

O	N	D	J	F	M	A	M	J	J	A	S	O

Soybean	Black oats	Gap

OR

Soybean	Radish	Gap

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CONSERVATION MANAGEMENT PRACTICES

No-till system evolution

- Different phases, based on temporal and spatial arrangement of species

1st ➤ wheat/soybean

2nd ➤ black oats or radish/soybean

3th ➤ soybean/millet

NO-TILL SYSTEM IN BRAZIL (TROPICAL REGION) 3th PHASE

O	N	D	J	F	M	A	M	J	J	A	S	O

Soybean | Millet | Millet

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CONSERVATION MANAGEMENT PRACTICES

No-till system evolution

- Different phases, based on temporal and spatial arrangement of species

1st ➤ wheat/soybean

2nd ➤ black oats or radish/soybean

3th ➤ soybean/millet

Presently ➤ soybean/maize/brachiaria-livestock combination

NO-TILL SYSTEM AT PRESENT IN BRAZIL (TROPICAL REGION)

O	N	D	J	F	M	A	M	J	J	A	S	O
Soybean												
				Maize								
					Brachiaria & Livestock							

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NO-TILL SYSTEM AT PRESENT IN BRAZIL

- minimization or suppression of crop-season gap (harvest-plant process)

NO-TILL SYSTEM AT PRESENT IN BRAZIL
- minimization or suppression of crop-season gap

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NO-tILL SYSTEM AT PRESENT IN BRAZIL

- minimization or suppression of crop-season gap

NO-TILL SYSTEM AT PRESENT IN BRAZIL

- minimization or suppression of crop-season gap

PROBLEMS ASSOCIATED WITH THE NO-TILL THECNIQUE IN BRAZIL (SUBTROPICAL REGION)

The strong, general impact of no-till

- leads to an erroneous thought ➔

induced by the idea that it would be enough, as isolated practice, to control all the erosion problems

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MISTAKEN INTERPRETATION OF NO-TILL

Consequences

- Terraces were removed
- Contouring was abandoned
- Excessive grazing in the agriculture-livestock combination
- Cropping systems restricted to soybean or maize/voluntary black oat or ryegrass

- **Soil degradation - surface compaction**
- **Low soil coverage - mulch failure**

MISTAKEN INTERPRETATION OF NO-TILL

Effects

Terraces removal

MISTAKEN INTERPRETATION OF NO-TILL

Effects

Contouring abandonement

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MISTAKEN INTERPRETATION OF NO-TILL

Effects

Countouring abandonement

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BREAKDOWN IN PRACTICE EFFECTIVENESS (Wischmeier, 1973)

- " There are critical slope-length limits beyond which the effectiveness of conservation tillage practices diminishes so that C values derived from the regular soil-loss ratio procedure are no longer applicable "
- Also called "mulch failure"

EROSION UNDER CONSERVATION TILLAGE

CRITICAL SLOPE-LENGTH LIMITS IN CONSERVATION TILLAGE

Tillage	Crop residue			Critical length (m)
	Type	Dosage ($Mg\ ha^{-1}$)	Condition	
No-tillage	maize	12	fresh	328 - 483
No-tillage	wheat	4	fresh	106 - 143
No-tillage	soybean	5	fresh	94 - 108
Reduced tillage	maize	12	fresh	147 - 209
No-tillage	maize	5	semi-dec.	87 - 174
No-tillage	soybean	4	semi-dec.	29 - 58

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MISTAKEN INTERPRETATION OF NO-TILL

Effects (mulch failure)

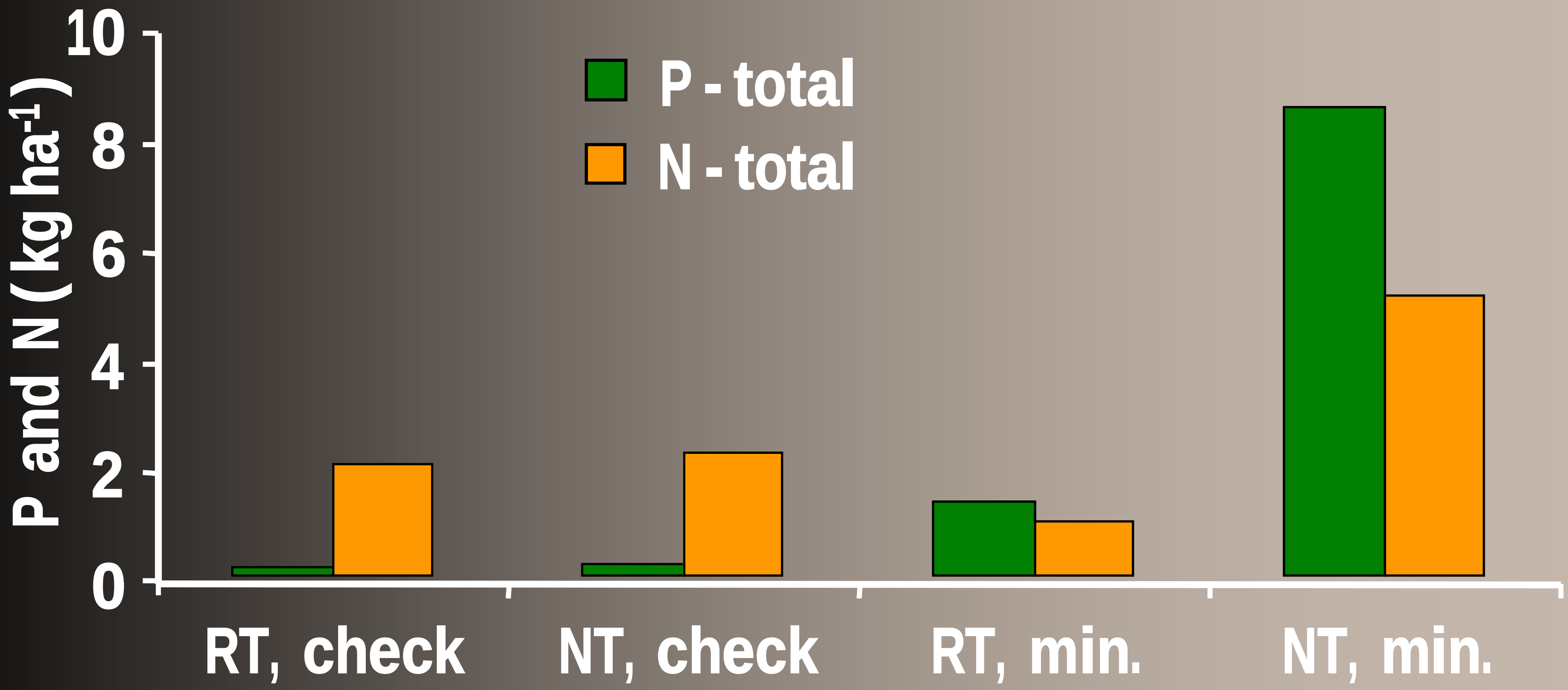
MISTAKEN INTERPRETATION OF NO-TILL

SOIL AND WATER LOSSES IN DISTINCT TILLAGE METHODS

Tillage method	Soil loss	Water loss
	-- $Mg\ ha^{-1}$ --	-- % rainfall --
Bare, conv.-tilled soil	16.40	45.5
Conventional tillage	1.94	11.8
Reduced tillage	0.13	4.6
No-tillage	0.12	9.8

MISTAKEN INTERPRETATION OF NO-TILL

NUTRIENT LOSSES IN SURFACE-RUNOFF



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CONCLUSION

- **The no-till system, built on:**
  - agriculture or agriculture-livestock combination with crop rotation
  - minimization or suppression of crop-season gap
  - use of mechanical and vegetative erosion control practices
  - soil acidity and soil fertility correction
  - precise use of inputs

CERTAINLY CAN BE USED AS AN EFFICIENT TOLL FOR A SUSTAINABLE AGRICULTURE IN TROPICAL AND SUBTROPICAL REGIONS

FINAL CONSIDERATION

- **Usage of no-till as a tool for agriculture development and conservation in the tropics depends on both the QUALITY and the QUANTITY of biomass produced by crops.**

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THANK YOU!