Part 2

The SOM and soil restoration by cropping system associated with conservation tillage

Topics

- The turnover time of C
- C balance in cropping systems associated with tillage management

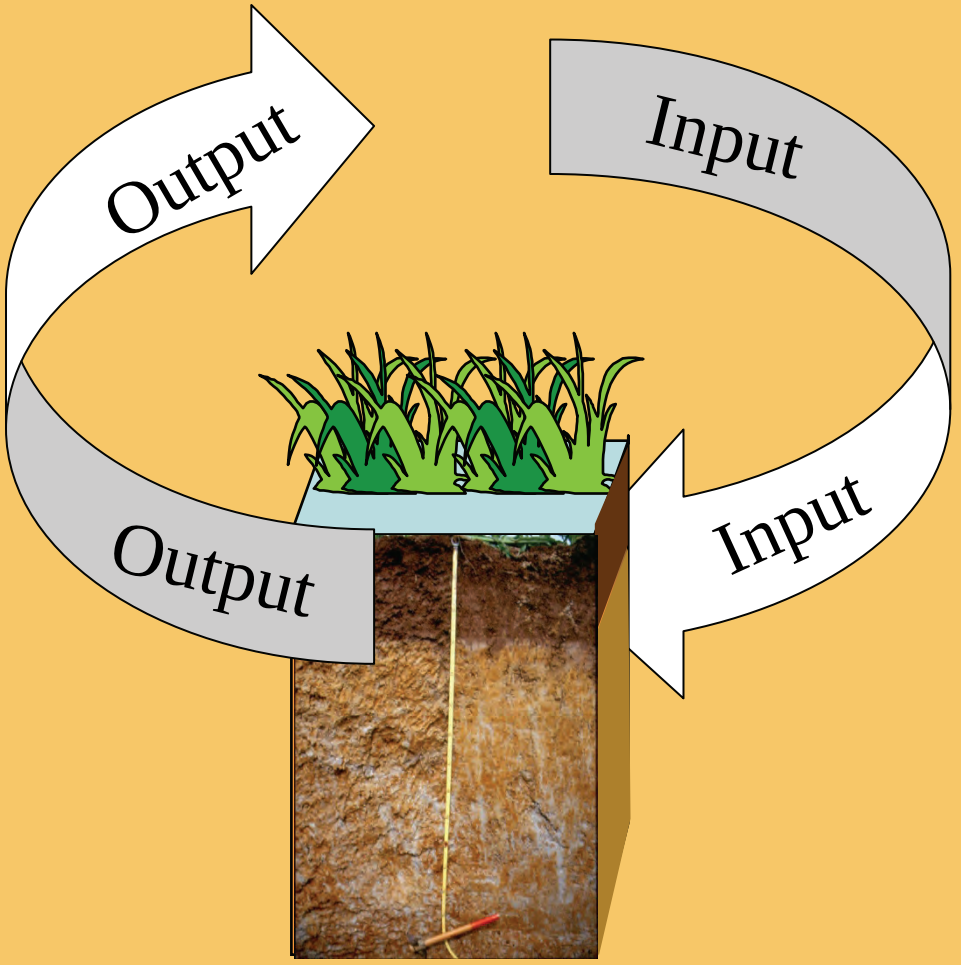
Cropping systems and

Crop residues management

The turnover time of the SOM

Turnover

Process in which the losses and gains proceed simultaneously



Definition

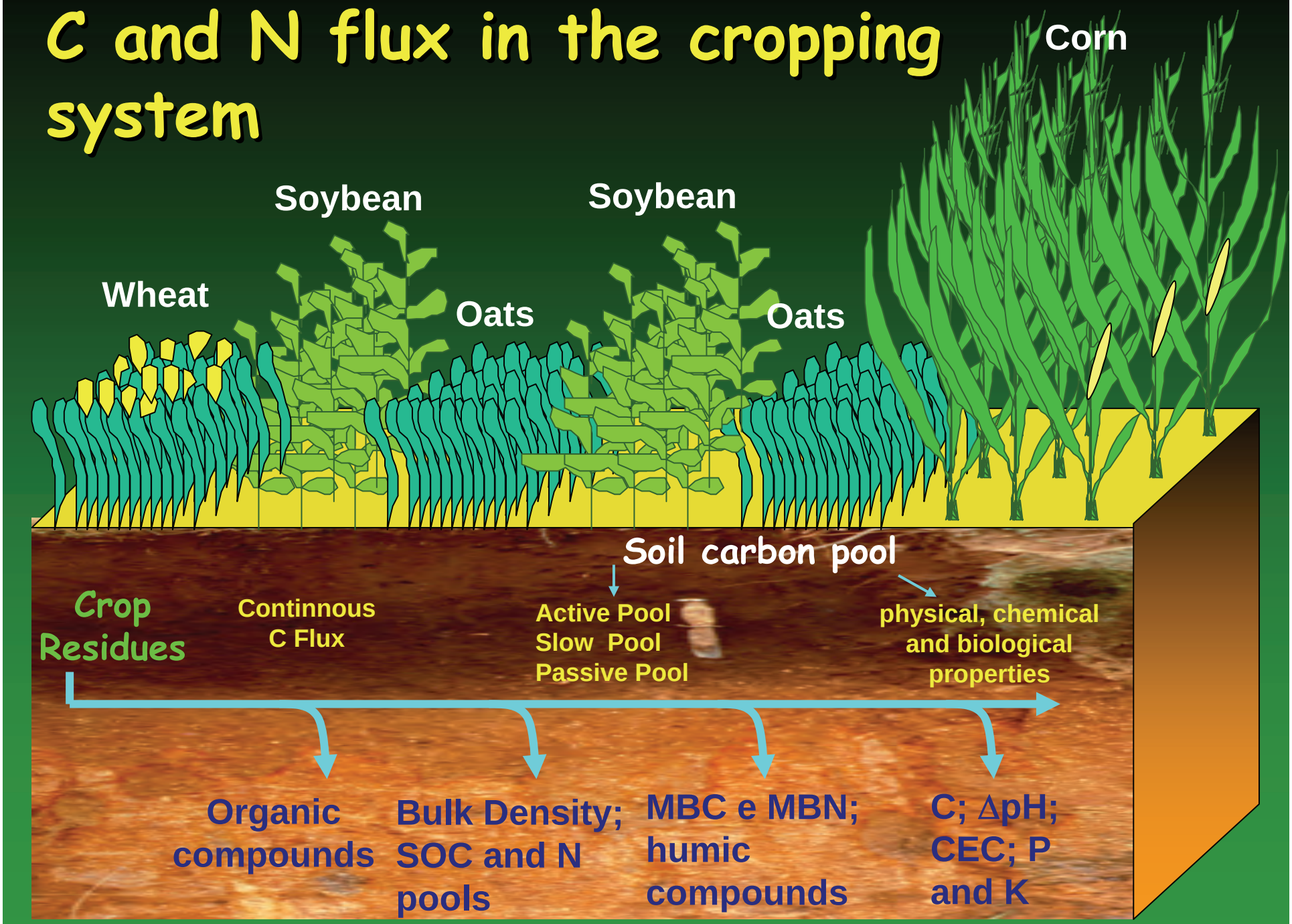
The organic carbon flow through in a know soil volume

Turnover time

"The amount of carbon in a soil system when the balance has been reached, divided by the annual entrance of carbon inside of that system"

Jenkinson & Rayner, 1977

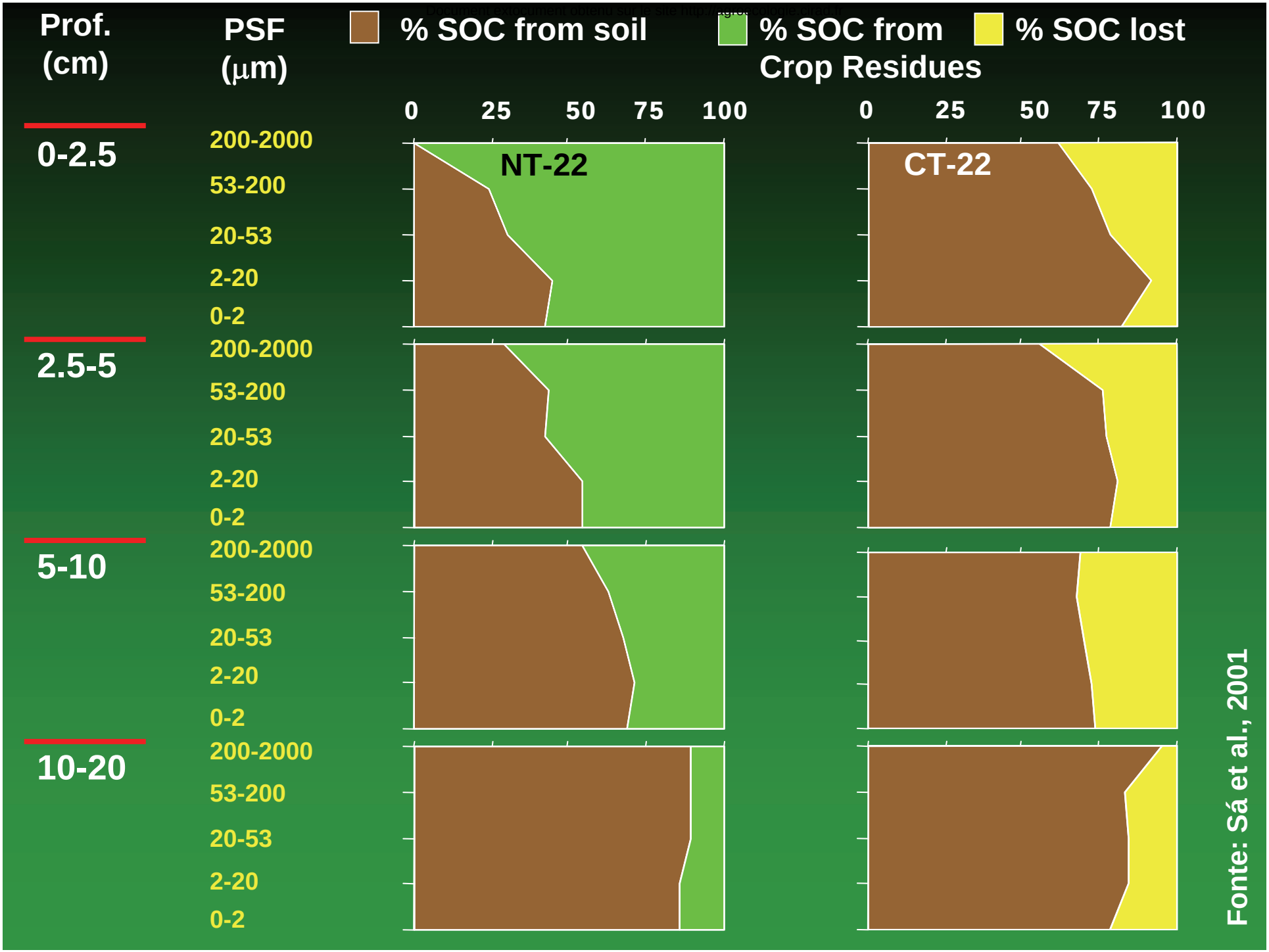
C and N flux in the cropping system



Turnover time of the SOM

Functional compartments	Turnover time	Composition	General name
Metabolic – C	0.2 – 0.5 years	Cells debris, cellulose, sugars, protein	Plant and animal detritus
Active	0.3 – 2 years	Microbial biomass debris, POM, polysaccharides, non humic substances, fulvic acids	Labile fraction
Structural – C	2 – 4 years	Cells wall, lignin, polyphenol, cellulose, wax	Plant detritus
Slow	15 – 100 years	Tissue finaly divided, high lignin	Moderate labile fraction
Passive	500 – 5000 years	Humus physical protected, humin, humic acids	Humic substances, recalcitrant fraction

Source: Blonde, 1991


Prof. (cm)
PSF (μm)
% SOC from soil
% SOC from Crop Residues
% SOC lost
0
25
50
75
100
NT-22
CT-22
0-2.5
2.5-5
5-10
10-20
200-2000
53-200
20-53
2-20
0-2
Fonte: Sá et al., 2001

Associated microaggregates to silt (2-20μm)

+

Microbial and residues lysed

+

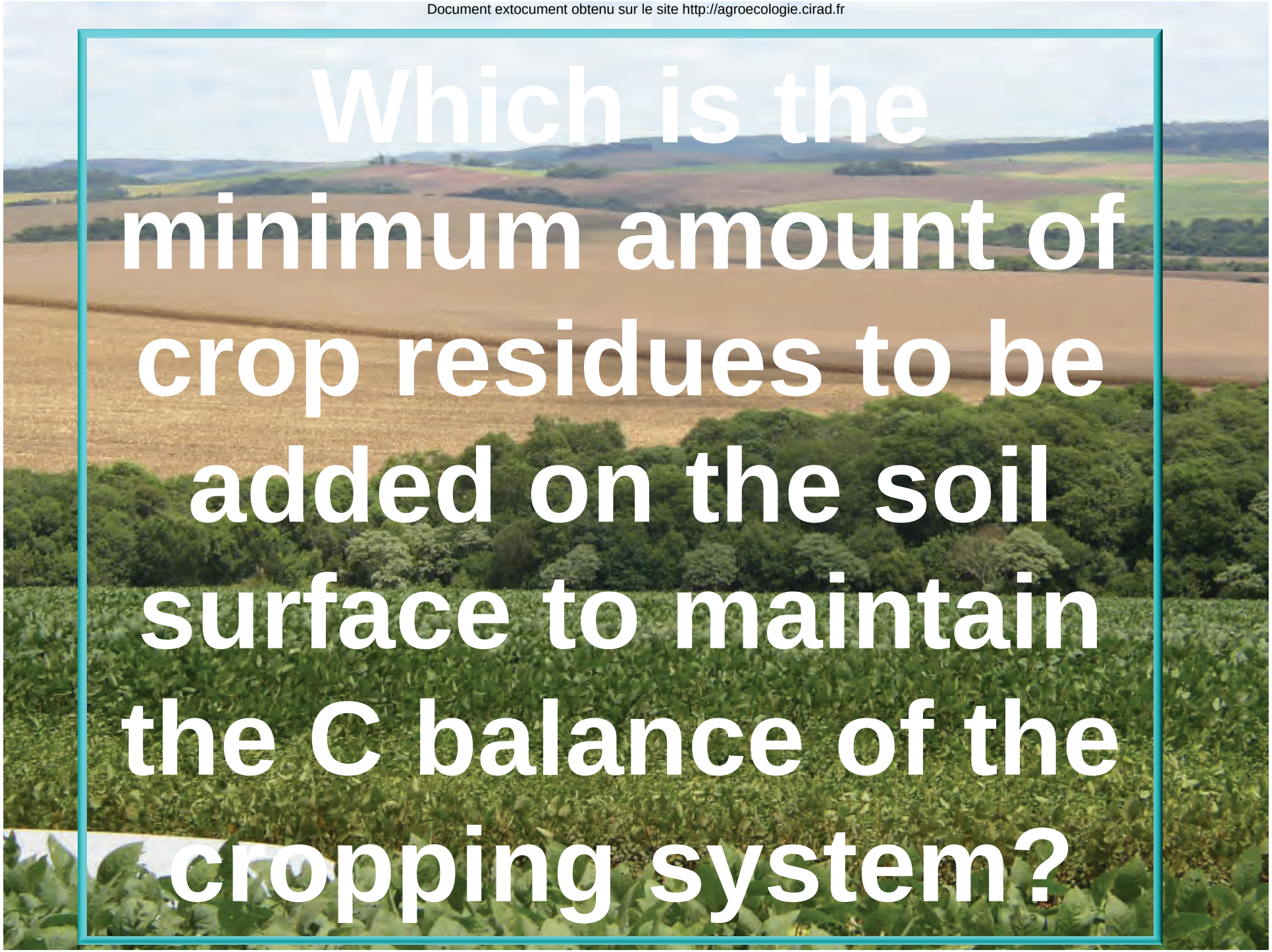
Microaggregates 20-250 μm

Crop residues + Polysaccharides, DOC, microbial C and N + fungi hyphae

Bulk density and rate of O_2 controlled

Microaggregates

Macroaggregates



Uni-compartiment Model

"The soil carbon balance it's strength associate with the equilibrium of the input and output of C from the crop residues "

Henin & Dupuis, 1947

$$dC/dt = -K_2C + K_1A$$

dC/dt It represents the changing rate of soil organic C with the time

A It is the annual addition rate of C (C from de crop residues) for the soil (t ha^{-1})

K_1 Represent the humification coefficient of C derived of the crop residues

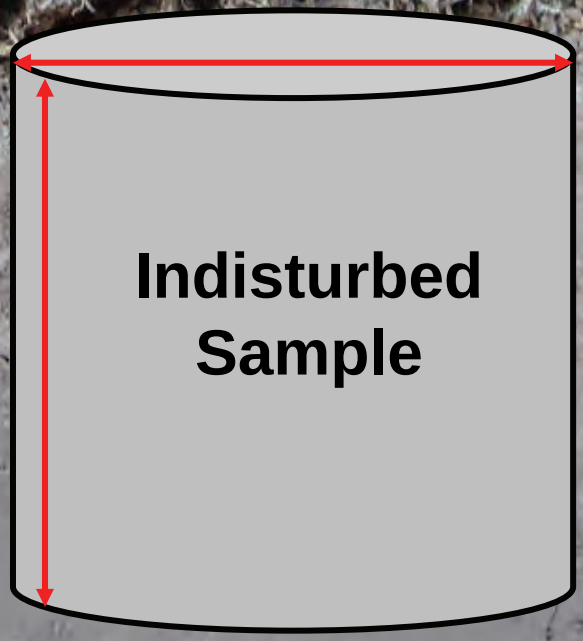
C It is the soil organic carbon stock (t ha^{-1})

K_2 It is the annual oxidation rate of the SOC represented by decomposition of crop residues and the mineralization of the soil organic car(t ha^{-1})

Bd x h = Volume = cm^3, dm^3, m^3

B*d* = Mass/Volume = g/cm^3 = kg/dm^3 = ton/m^3

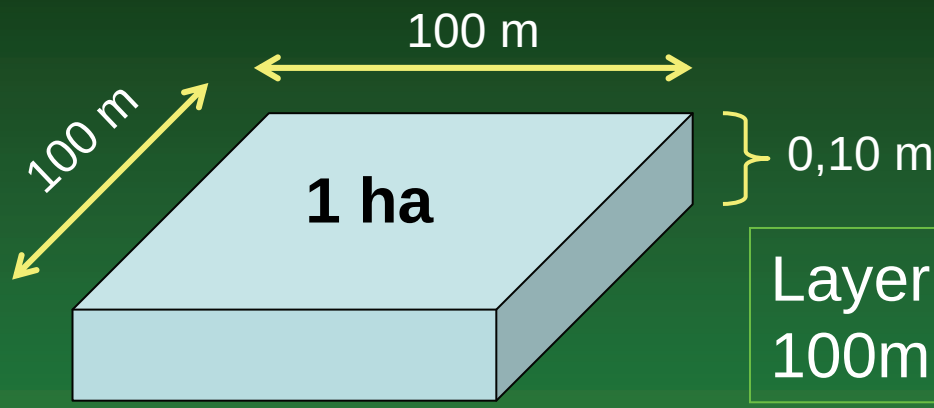
Exemple = Bd = 1.31 ton/m^3



SOC stock calculations (ton/ha)

SOC stock (ton/ha) = C (g/kg) x Bd (ton/m^3) x Volume (m^3)

Soil test Measured Calculed



Layer volume =
100m x 100m x 0.1m = **1000 m^3**

Bd = 1.31 ton/m^3

Soil mass $_{\text{(Layer 0.1m)}}$ = 1.31 ton/m^3 x 1000 = 1310 ton

C = 2.8 % = 28 g/kg = 28 kg/ton de solo (Soil test)

C amount in the Soil mass

28 kg of C → 1.0 ton of soil in 0.1m deep

X → 1310 ton/ha in 0.1m

X = 36680 kg/ha de C
or
X = 36.68 ton/ha

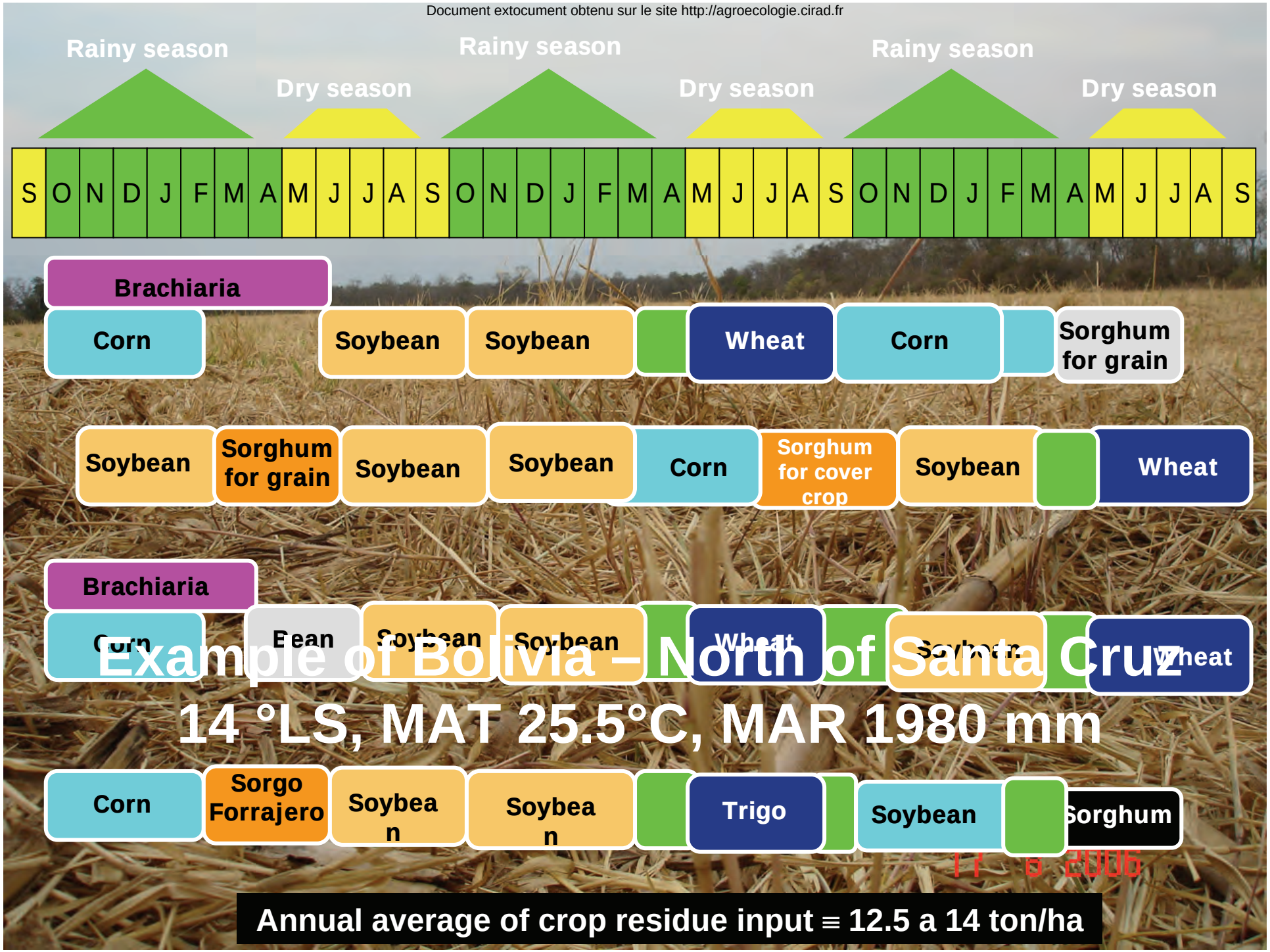
$$dC/dt = -K_2C + K_1A$$

Does it work?

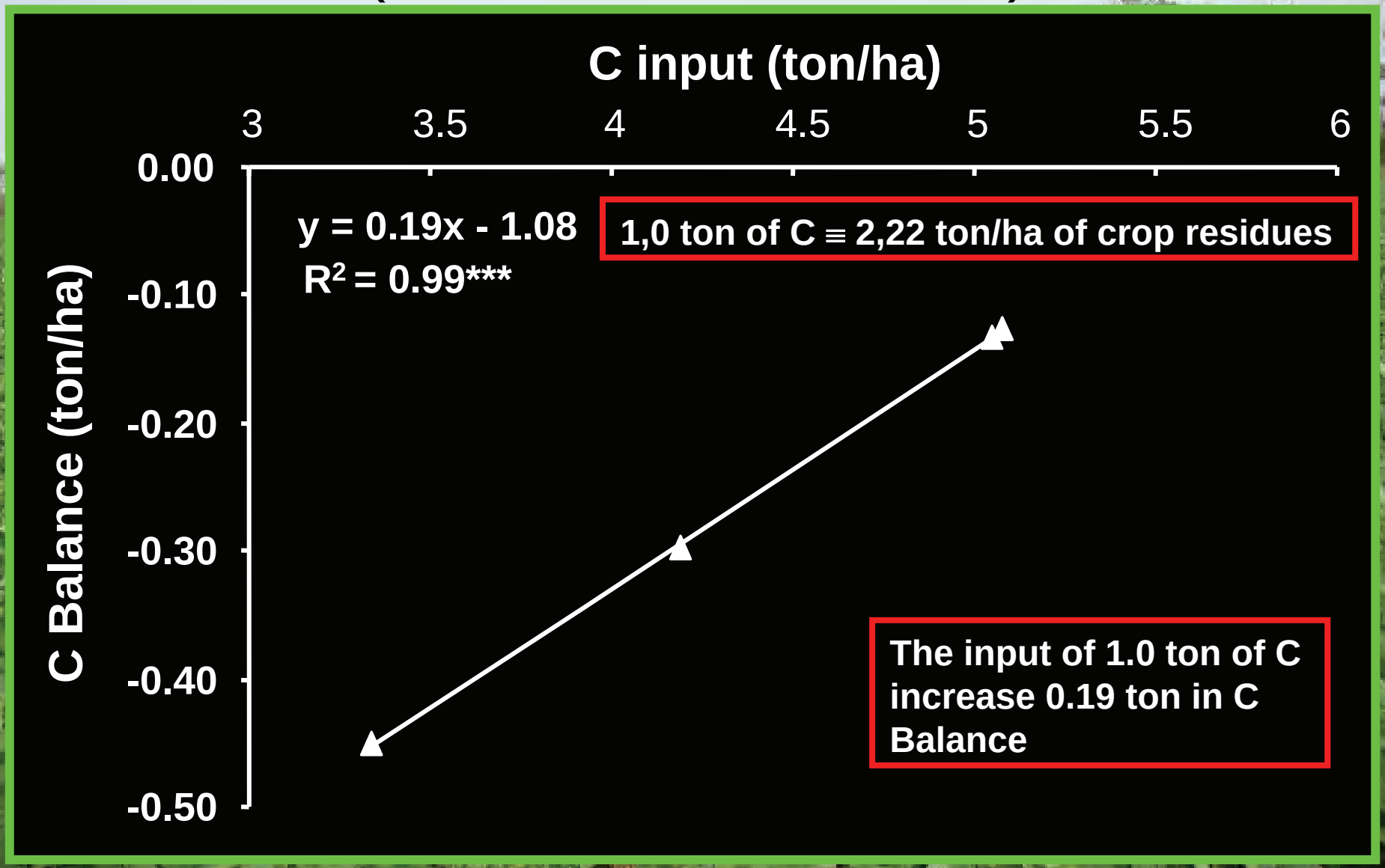
SOM content in soils under forest compared to crop land (> 1800 mm yr^{-1})

Depth	Forest§	Crop Land	SOM Loss in the crop land
(cm)	-- % SOM ---		----- % -----
0 - 5	5.33	2.80	47.42
0 - 20	3.19	2.28	28.63
% of SOM in the 0 – 5 cm	40.1	18.7	

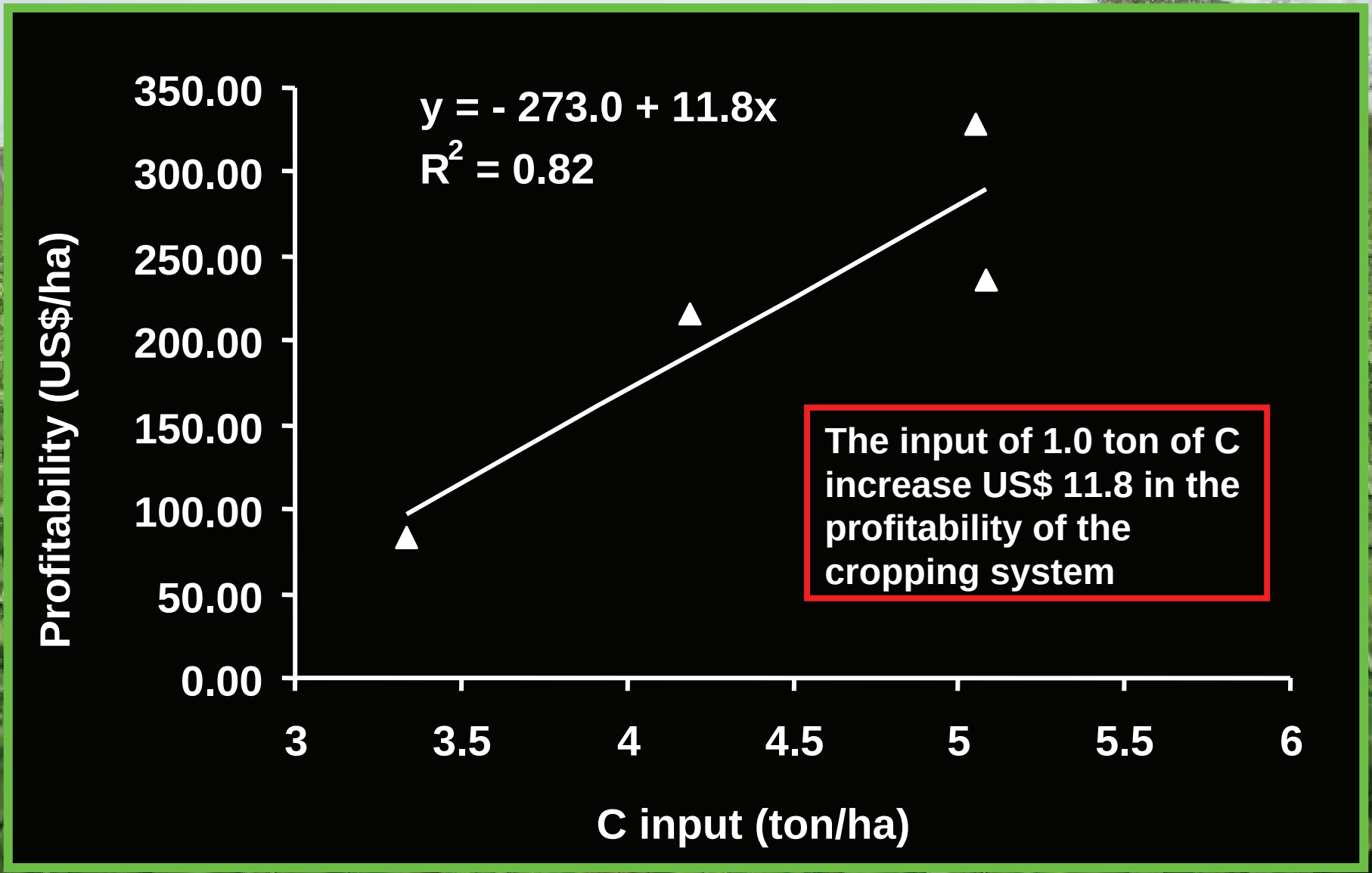
§ Avg = 20 samples



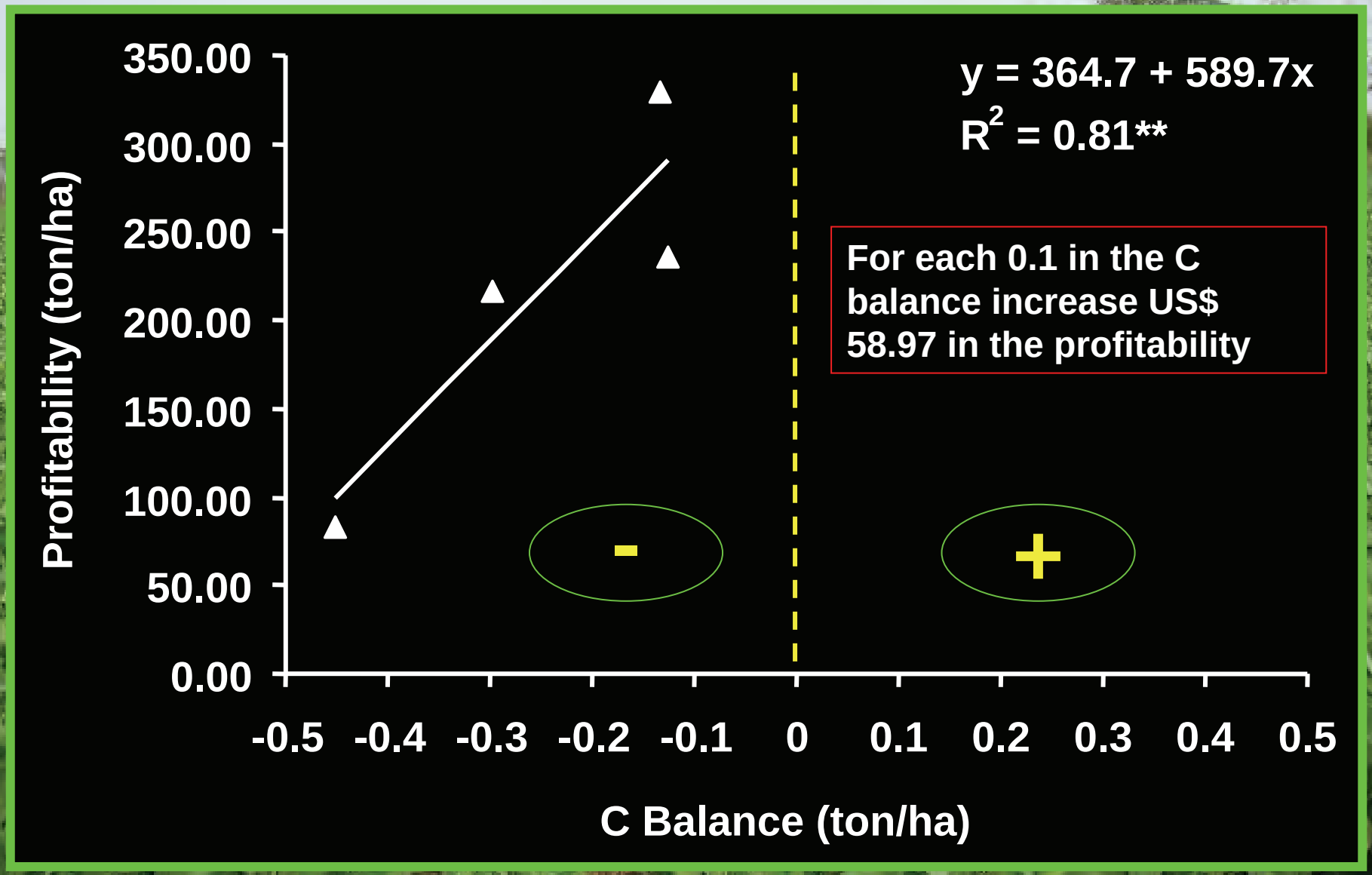
C Balance x Annual C input (Farm assessment)



Farm profitablity x C input



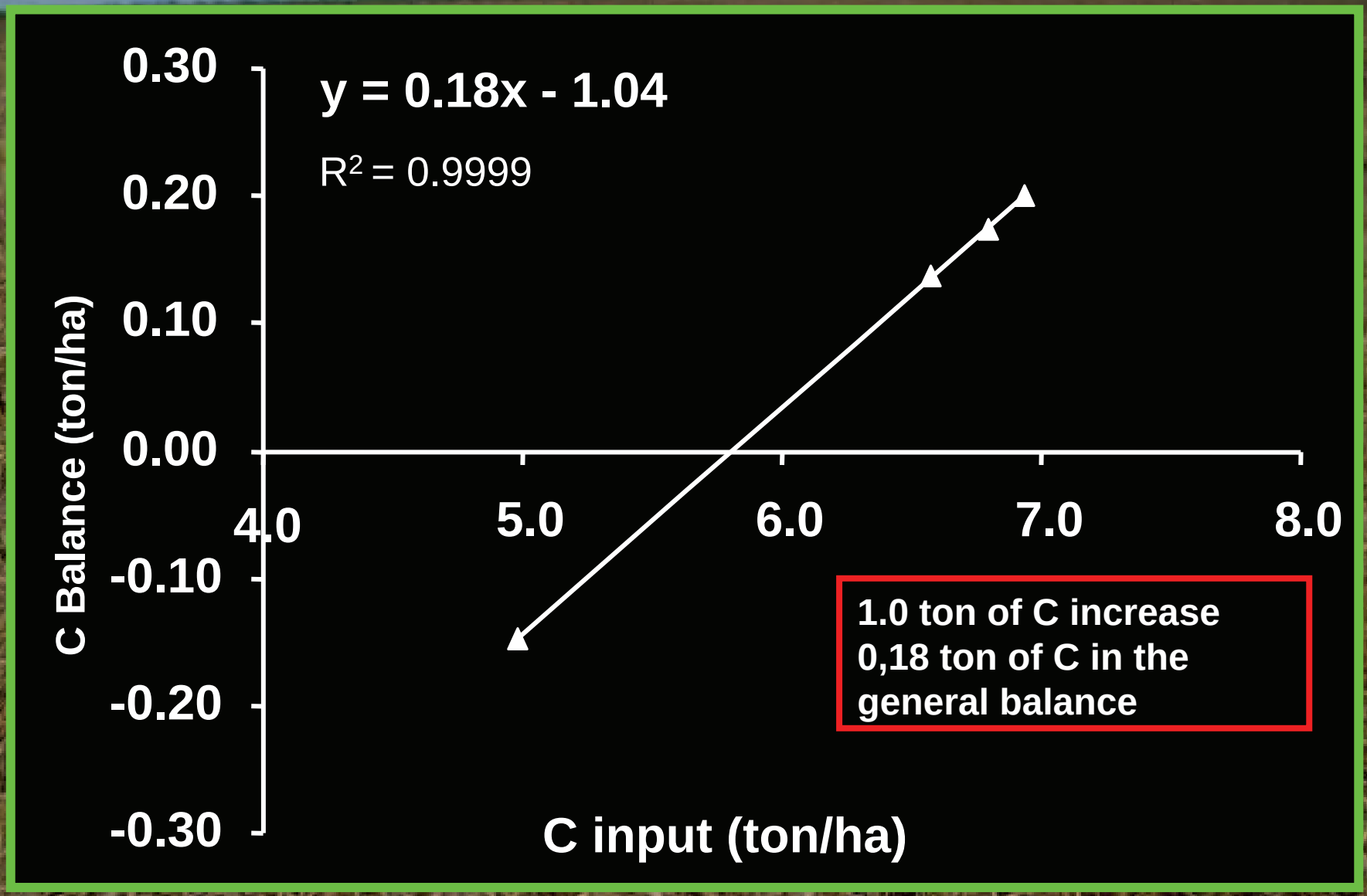
Profitability in the farm sites x C balance



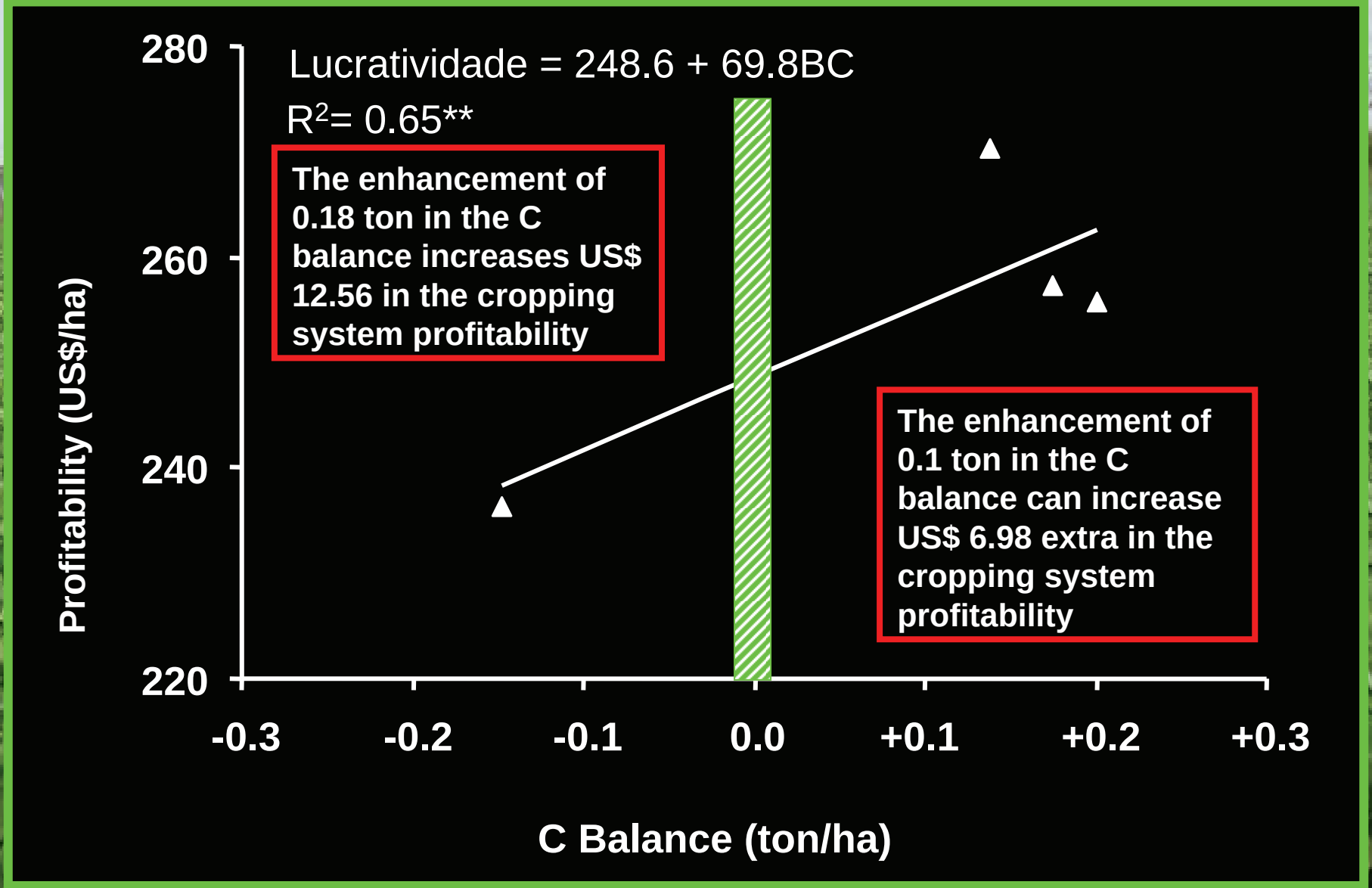
Crop residue input, C input, C balance and Profitability by intensity cropping system under no-tillage

Component	Farms				
	AGP	HDS	5 EST	EL TJ	$\overline{X}$
Crop residue input	14.61	15.10	15.41	11.07	14.05
C input	6.57	6.80	6.93	4.98	6.32
C Balance	+ 0.138	+ 0.174	+ 0.200	- 0.148	+ 0.066
Profitability	270.4	257.3	255.8	236.4	255.0

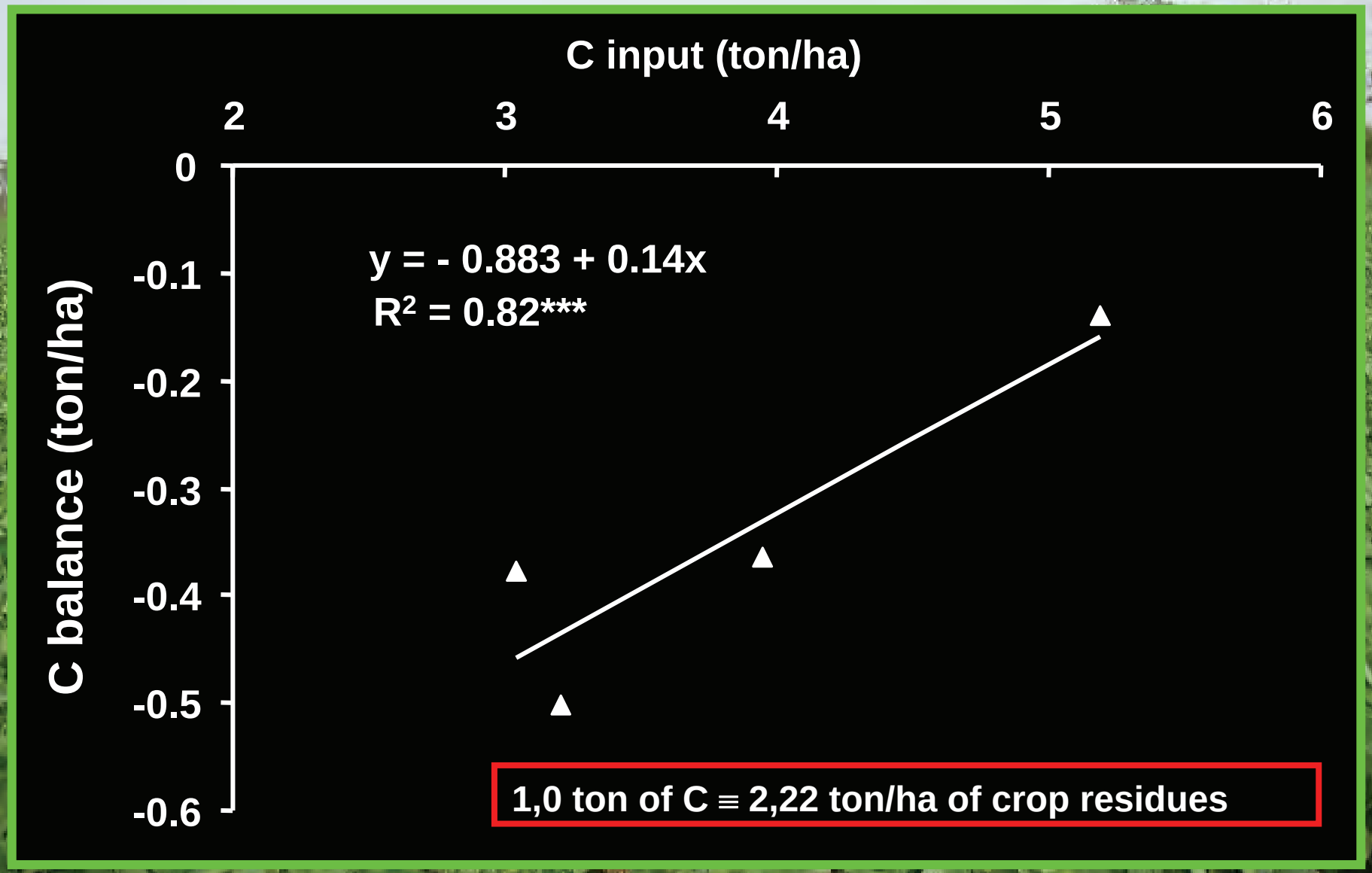
Balanço de C nos sistemas de rotação de culturas em função da adição anual de C - GPN



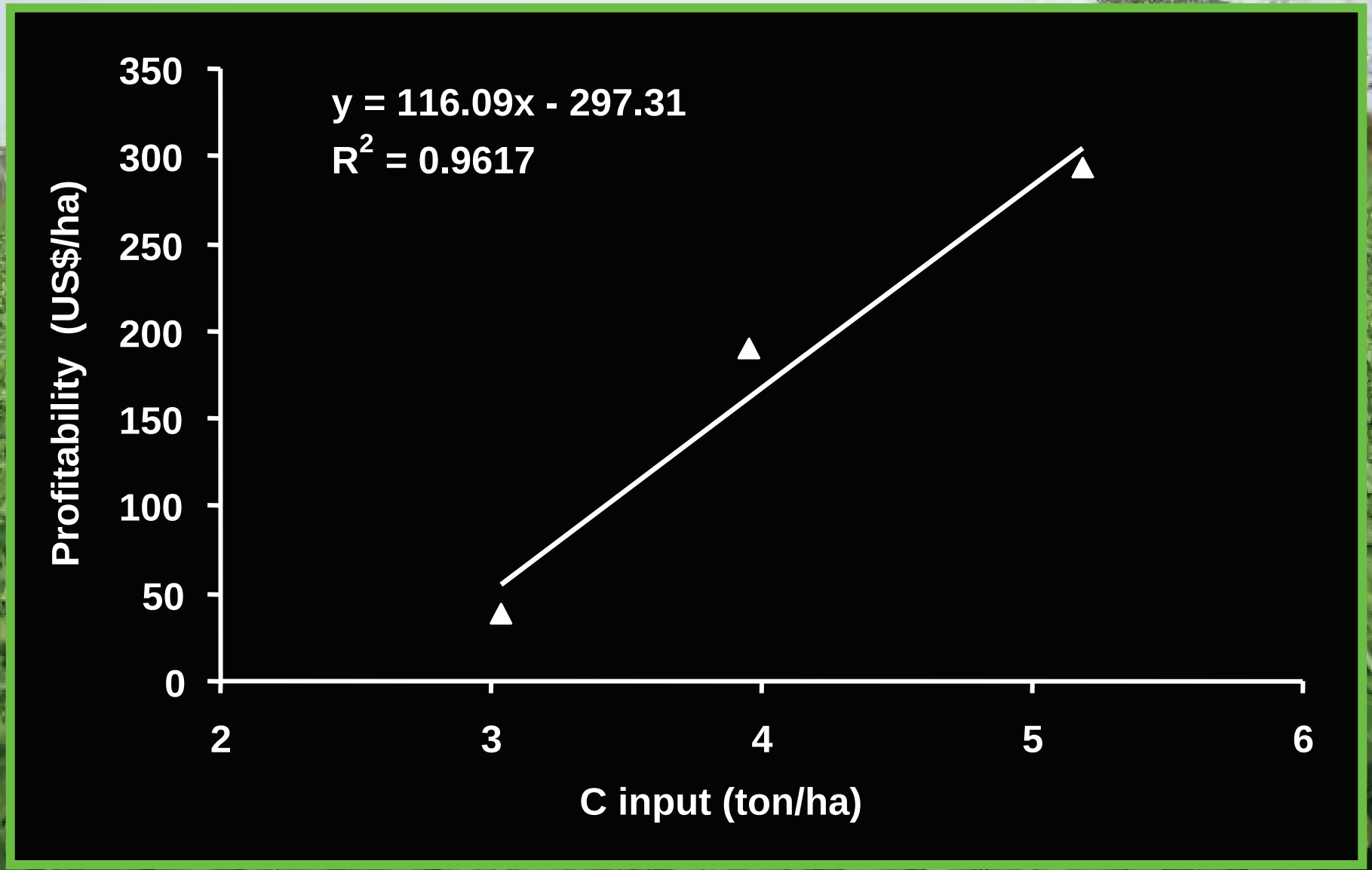
Profitability of the cropping systems with high biomass input



C balance x C input

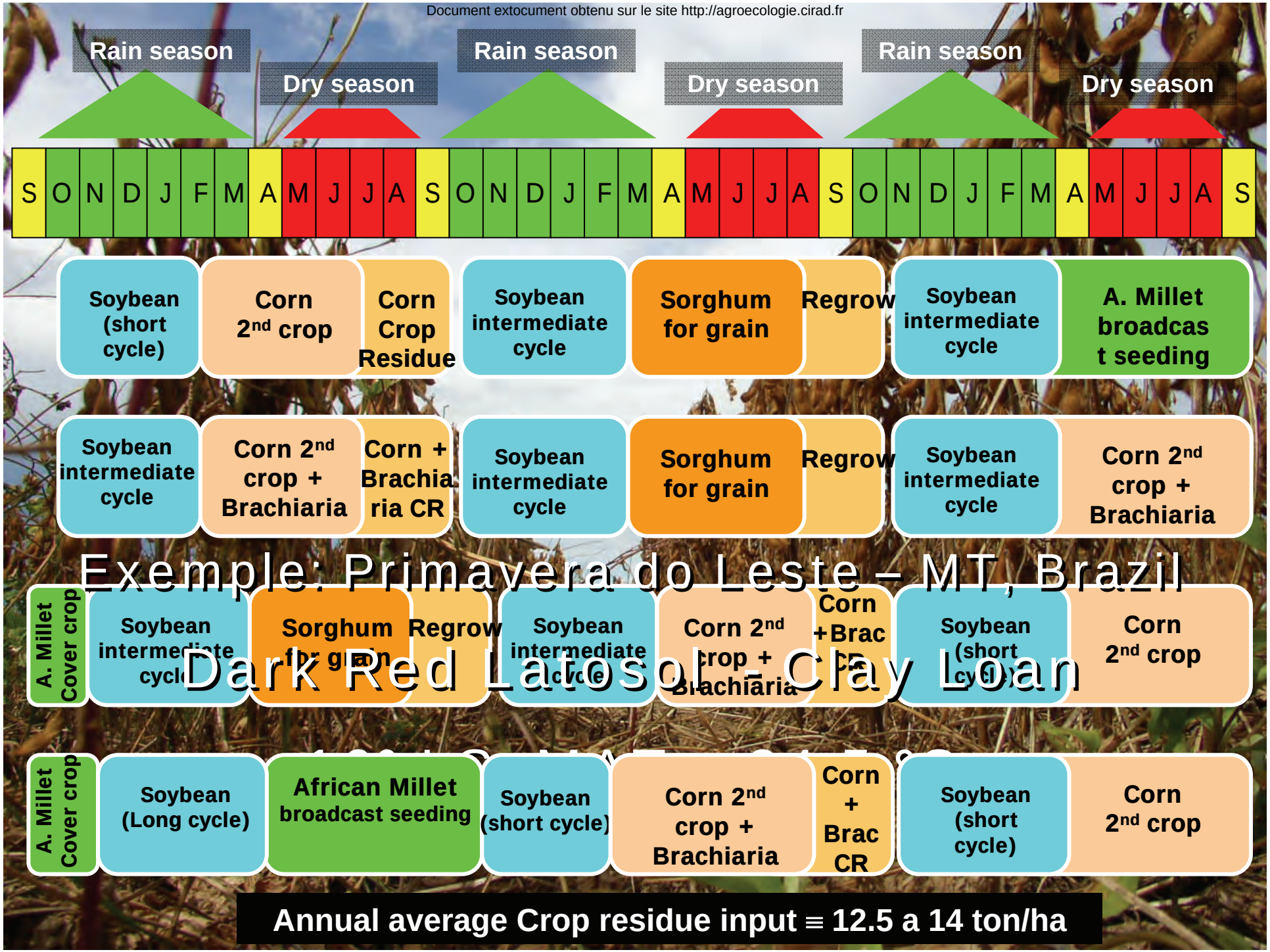


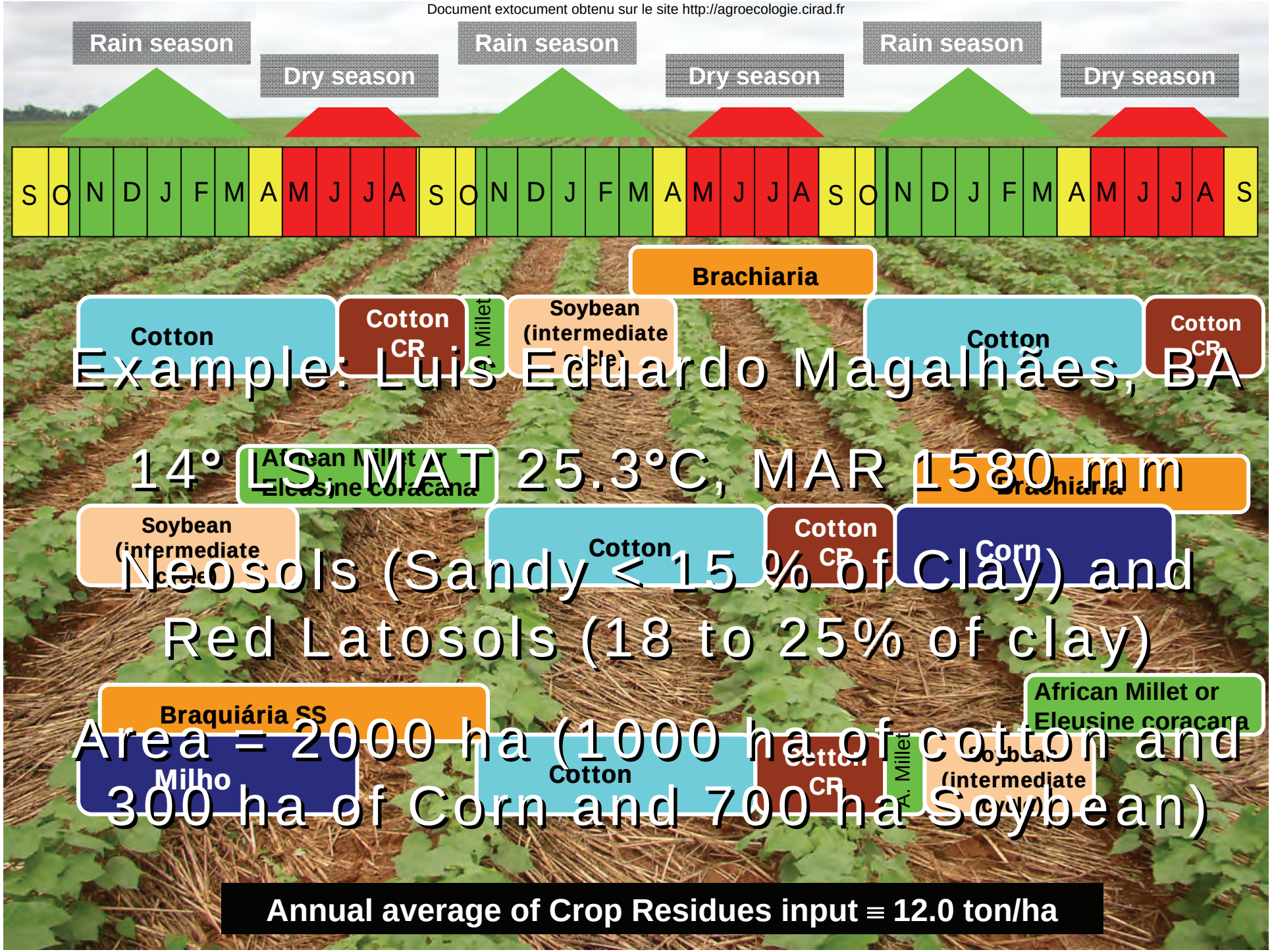
Profitability x C input



Crop Residue input, C input, C Balance and economic return by intensive cropping systems (Sta. Cruz, Bolivia)

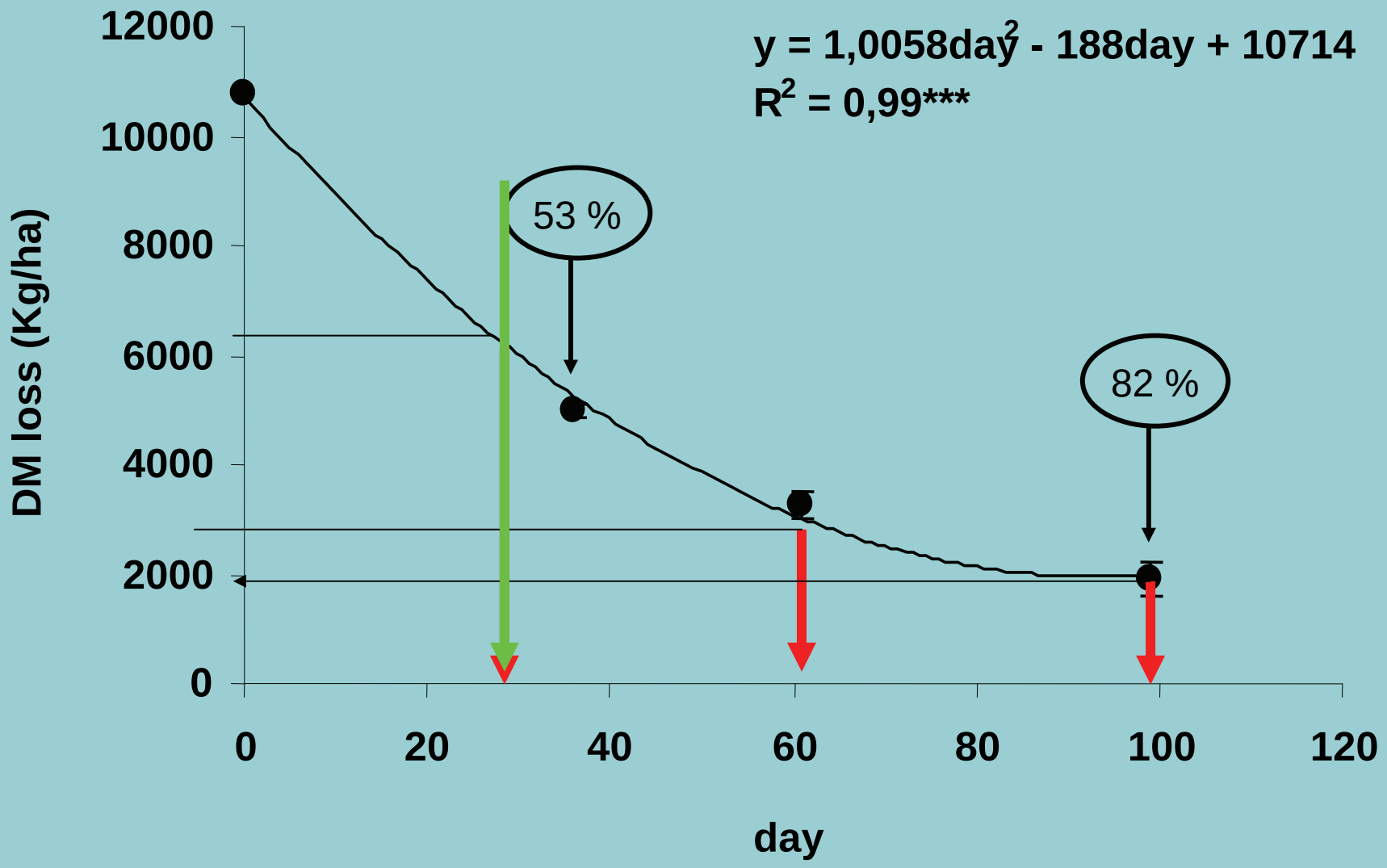
Components	Propriedades				
	Cnt	Estr	Tjbo	SJT	$\overline{X}$
Crop Residue input	13.35	13.75	11.5	11.45	12.51
C input	6.04	6.19	6.52	5.15	5.96
C balance	- 0.010	+ 0.061	+ 0.11	- 0.055	+ 0.026
Profitability	257	307	293	222	262





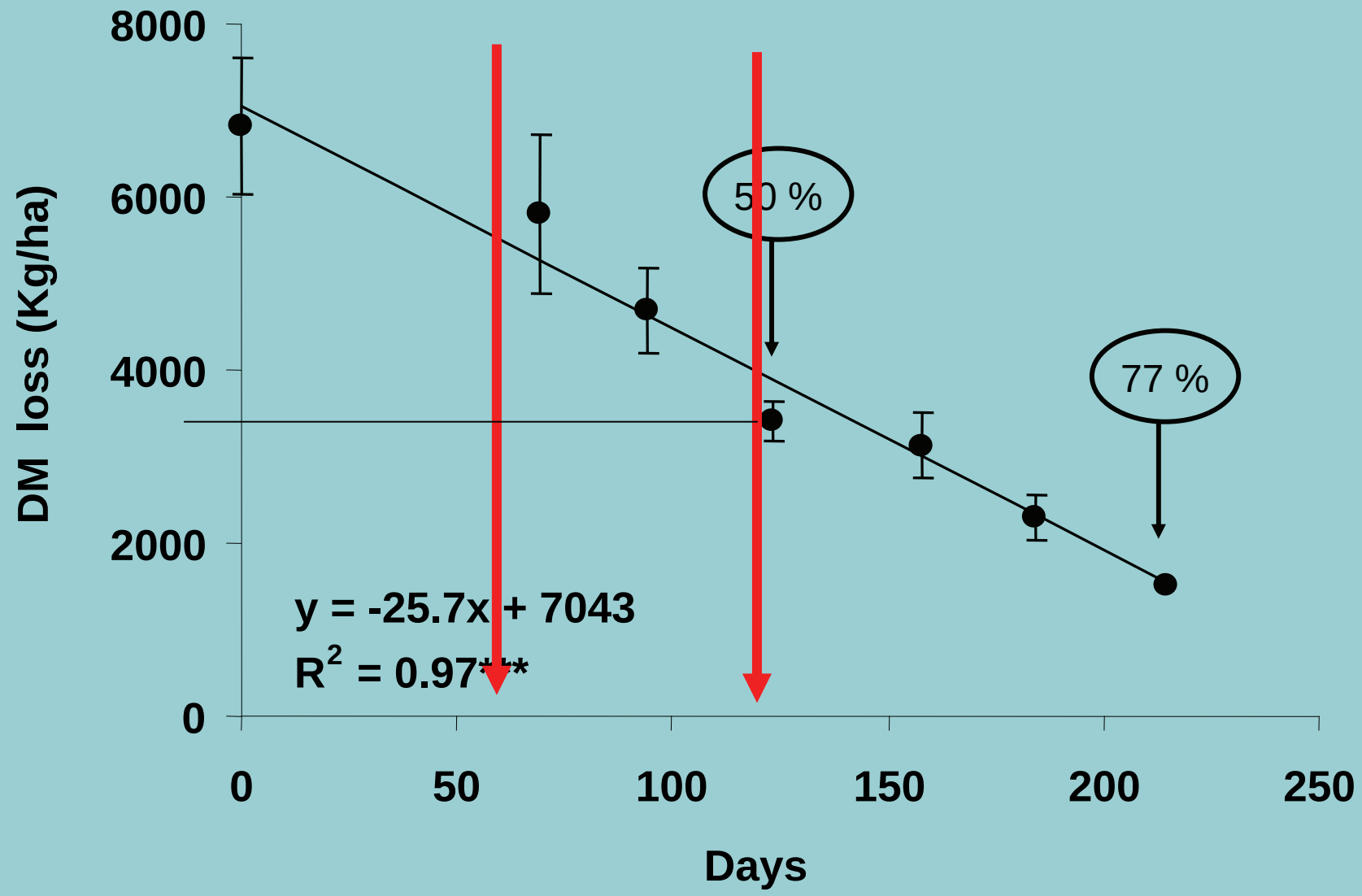
Decomposition rate

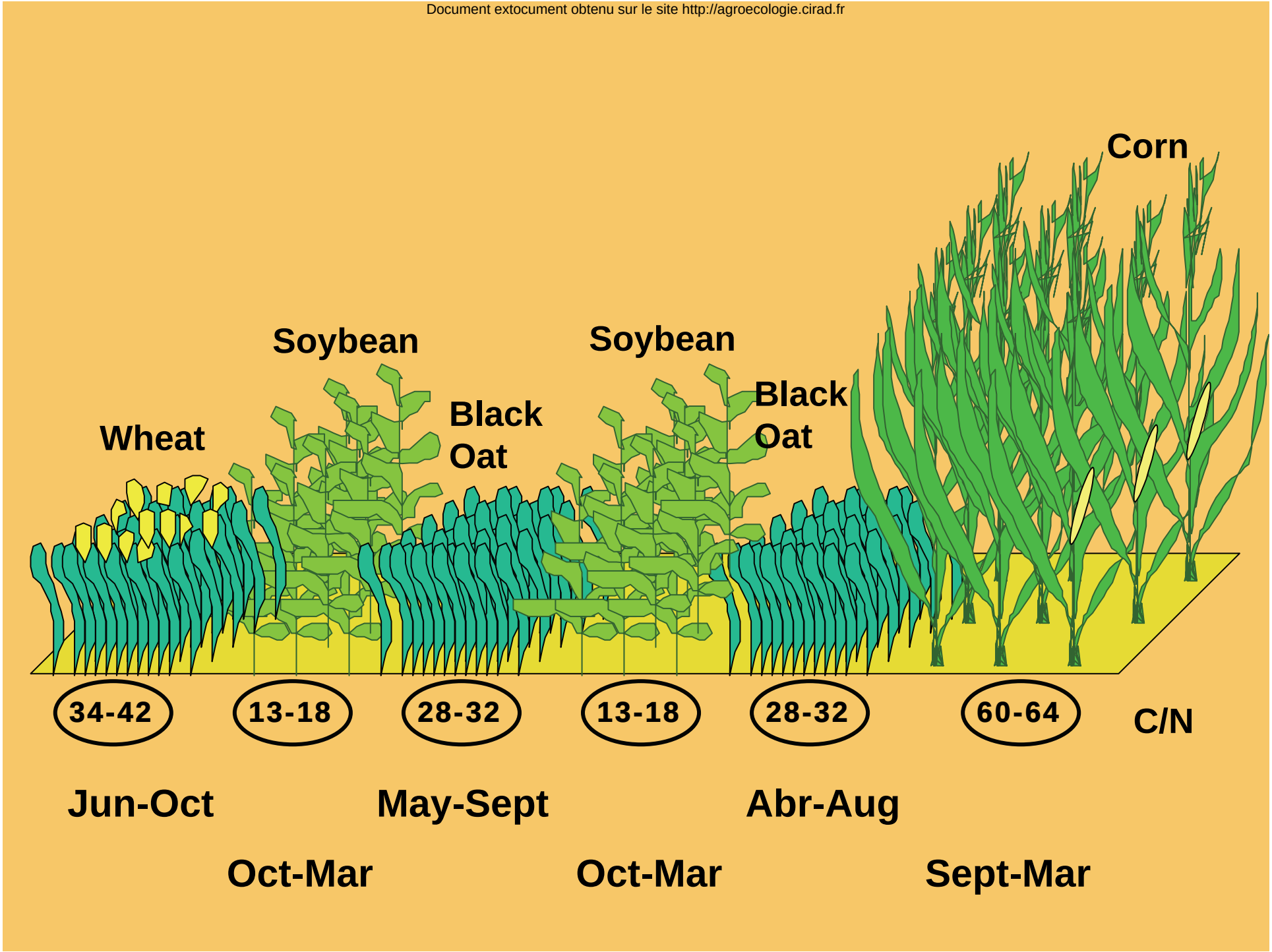
TAJIBO - Plot A (Brachairia decumbens)

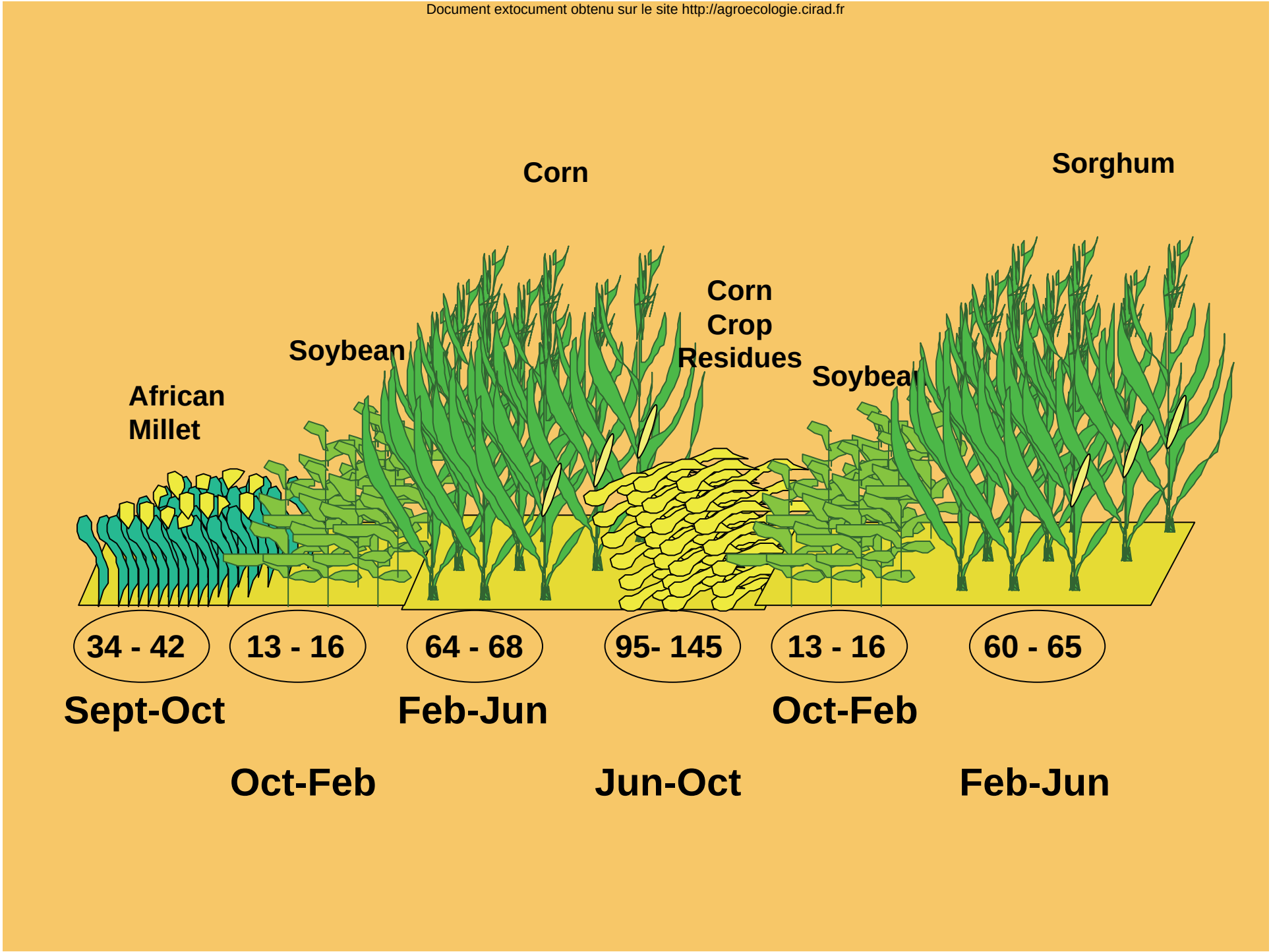


Decomposition rate

TACUARÍ Fram - Plot 37 (Sorghum DK-73)

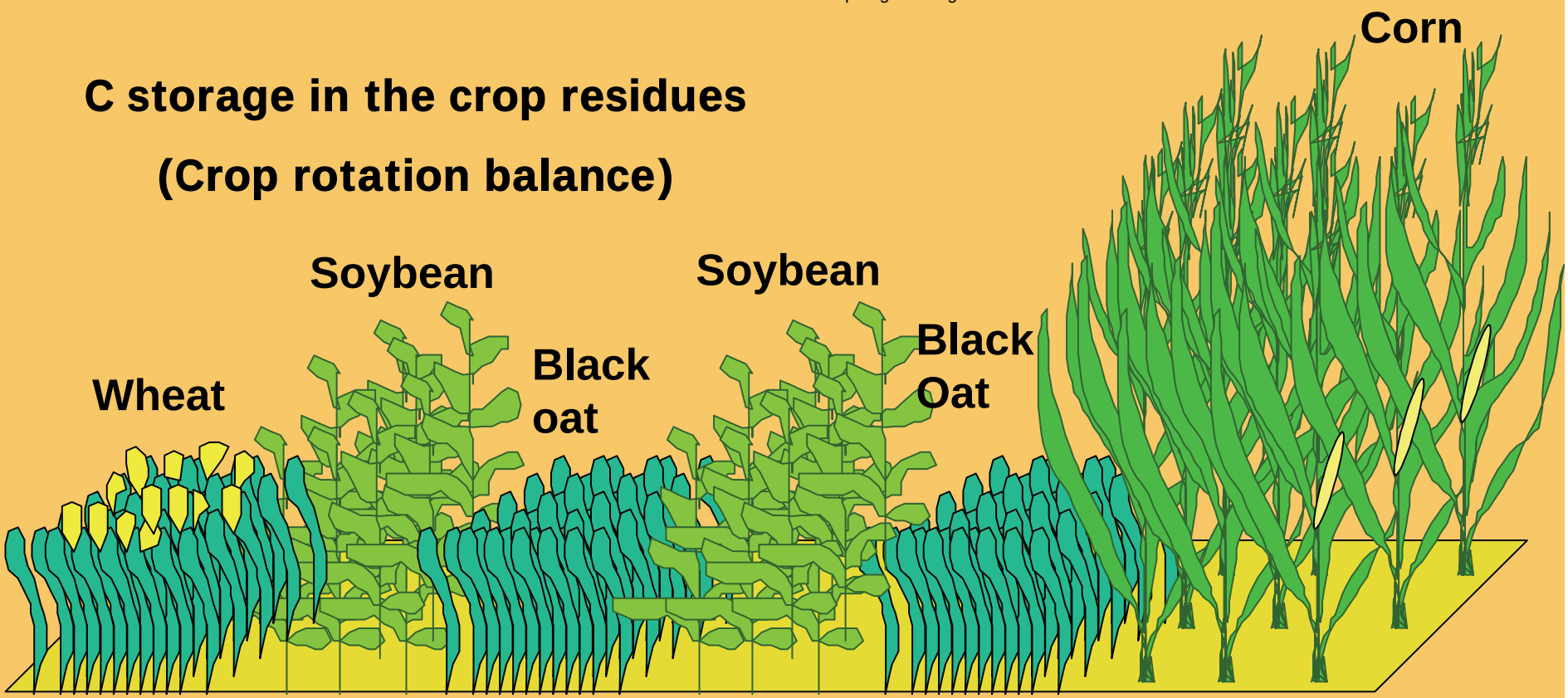






C storage in the crop residues

(Crop rotation balance)



Crop residues input: Above + Belowground(ton ha^{-1})

+ 3.4	+ 3.5	+ 4.35	+ 3.5	+ 4.35	+ 11.2
↓	↓	↓	↓	↓	↓

(C of CR to SOC ton ha^{-1})

+ 0.41	+ 0.42	+ 0.52	+ 0.42	+ 0.52	+ 1.33

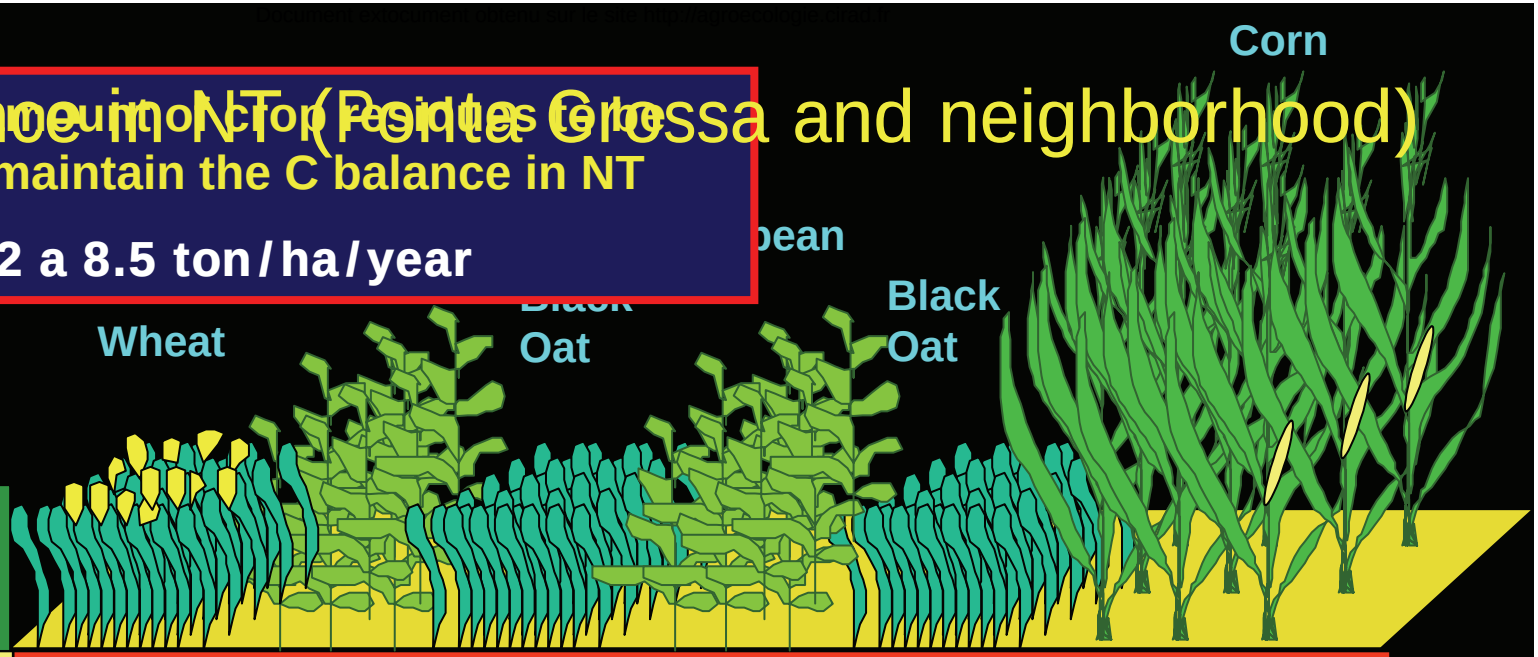
General Balance = + 3.6 ton C ha^{-1} ≈ 1.20 ton ha^{-1} ano^{-1}

Sá, 2002

C balance in NT (Ponta Grossa and neighborhood)

Minimum amount of crop residues to be added to maintain the C balance in NT

7.2 a 8.5 ton / ha / year

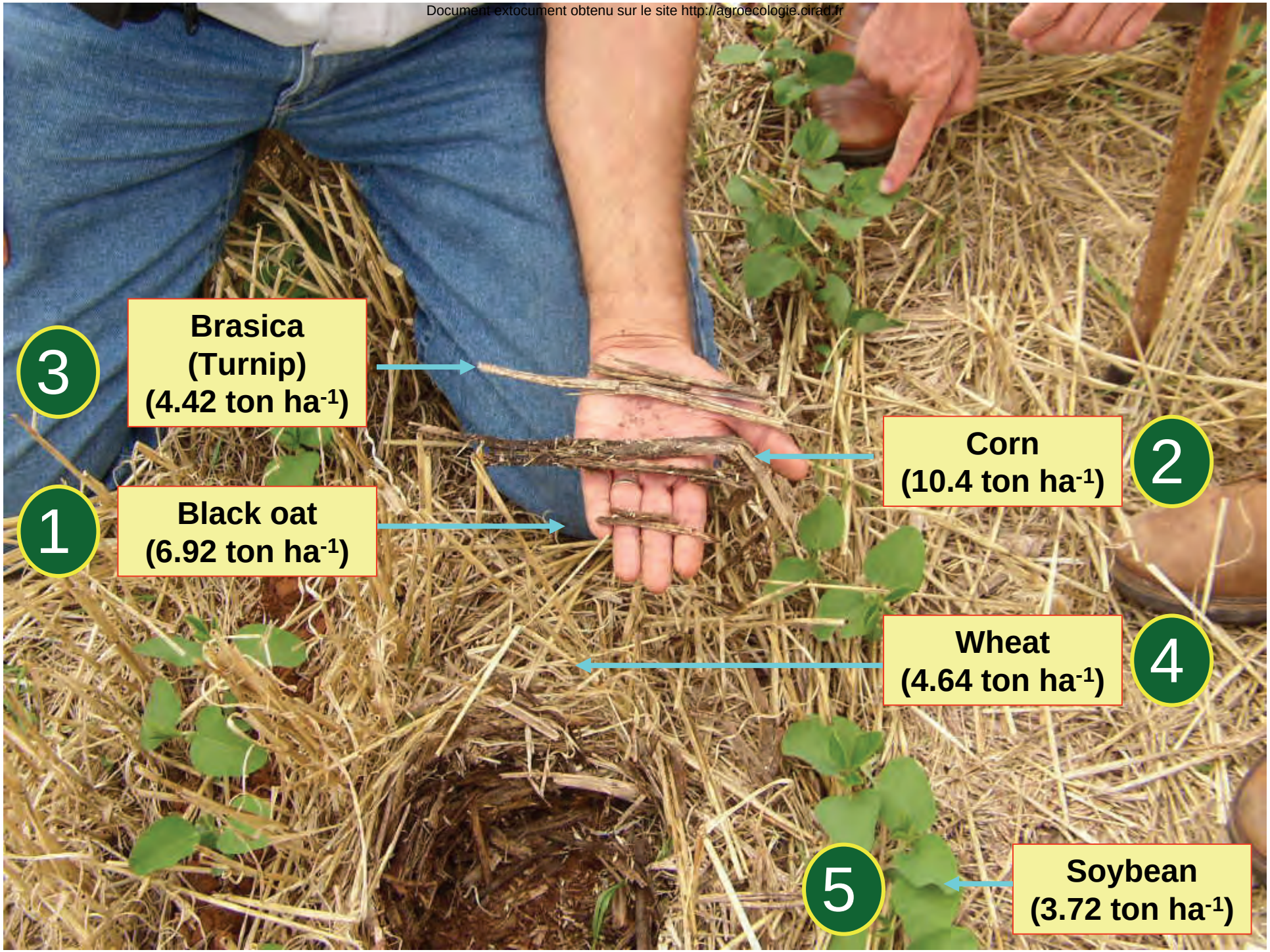


Crop Sequence						
Addition (A)	---------- Mg ha^{-1} ----------					
(DM) W/S	+ 3.40	+ 3.50	+ 4.35	+ 3,50	+ 4,35	+ 11,20
(DM) Annual		+ 6.90		+ 7,85		+ 15,55
C Addition		+ 3.10		+ 3,53		+ 6,99
K_1*A		+ 0.82		+ 0,93		+ 1,85
C stock		58.65		59,58		61,43
K_2*C		- 0.53		- 0,48		- 0,43
dC/dt		+ 0.29		+ 0,45		+ 1,42
Δ C stock	**+ 0.29 + 0.45 + 1.2 = 2.6 Mg ha^{-1} /3 years = 0.72 Mg ha^{-1}**					

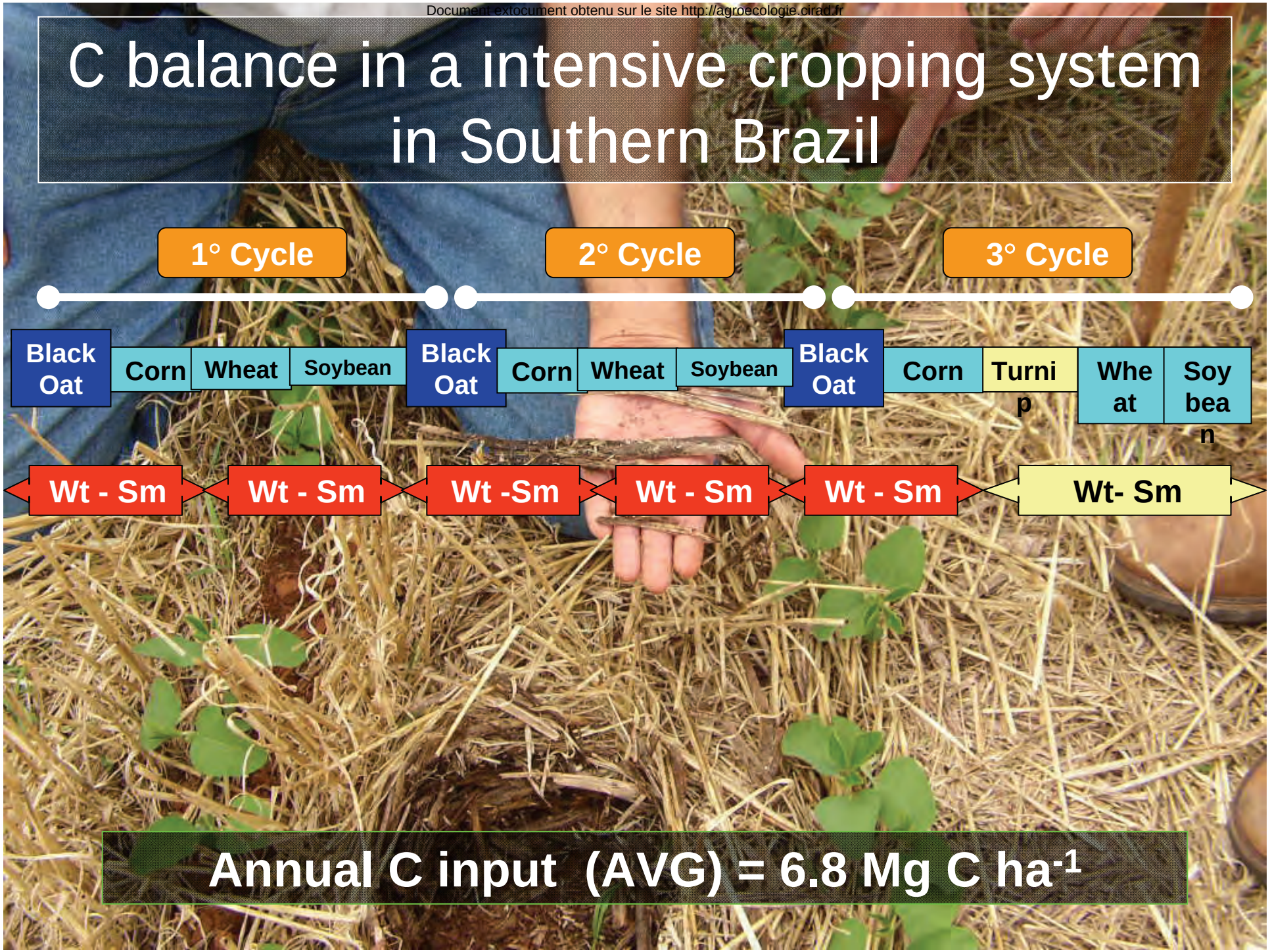
Minimum amount of crop residues to compensate the C oxidation (K_2 = 3 years average) in the steady-state by the tillage sequence in a long term experiment (18 years)

SMS	C*K_2	dC/dt ≠ 0	**Crop residue equivalent**		
			dC/dt = 0	Annual addition (AA)	Δ (AA – dC/dt=0)
			Mg ha^{-1}		
CT	1.67	- 0.20	13.84	12.38	- 1.46
MT	1.14	0.45	10.00	12.62	+ 2.62
CNT	0.99	0.70	9.00	12.99	+ 3.99
PNT	0.84	0.99	8.04	13.12	+ 5.08

(Source: Burkner & Sá, 2006)



C balance in a intensive cropping system in Southern Brazil



Annual C input (AVG) = 6.8 Mg C ha^{-1}

SIMULAÇÃO DO BALANÇO ANUAL DE CARBONO (C) SOBRE 2 ROTAÇÕES EM PLANTIO DIRETO (PDSCV) NA ECOLOGIA DOS LATOSSOLOS DAS FLORESTAS ÚMIDAS DO MATO GROSSO - SINOP/MT - 1998/2002

1 - Sucessão anual contínua: Soja + (*Sorgo + Brachiaria ruziziensis*)

Adições (A)	mg ha^{-1} Adubação mineral		
	Nível baixo[4]	Nível médio[4]	Nível elevado[4]
Matéria Seca (MS) anual (t/ha)	14,5 - 19,2	20,2 - 25,6	22,2 - 28,9
Adição C (t/ha)	6.53 - 8,64	9,09 - 11,52	9,99 - 13,0
K_1 x A ($K_1 = 0,265$)	+ 1,73 - 2,29	+ 2,41 - 3,052	+ 2,64 - 3,445
Estoque C (t/ha)	27,5	27,5	27,5
K_2 x C^2 ($K_2 = 2\%$)	- 0,55	- 0,55	- 0,55
dc/dt simulado	1,18 - 1,74	1,86 - 2,50	2,09 - 2,89
* dc/dt real medido sobre 3 anos mesma sucessão	-	2,73	-
dc/dt[3]=0 Quantidade mínima de resíduos para manter um equilíbrio estável (t/ha)	12 a 14	13 a 15	14 a 17

1 - $K_1 = 0,265$ (Sá et al., 2001)

2 - $K_2 = 2\%$ (*adaptado de Van Veen et Paul, 1981 et Bayer, 1996*) - Solo sempre coberto

3 - Adição de C - dc/dt; transformação de C en M. S. ➡ C x $\frac{100}{45}$

4 - Nível de adubação mineral

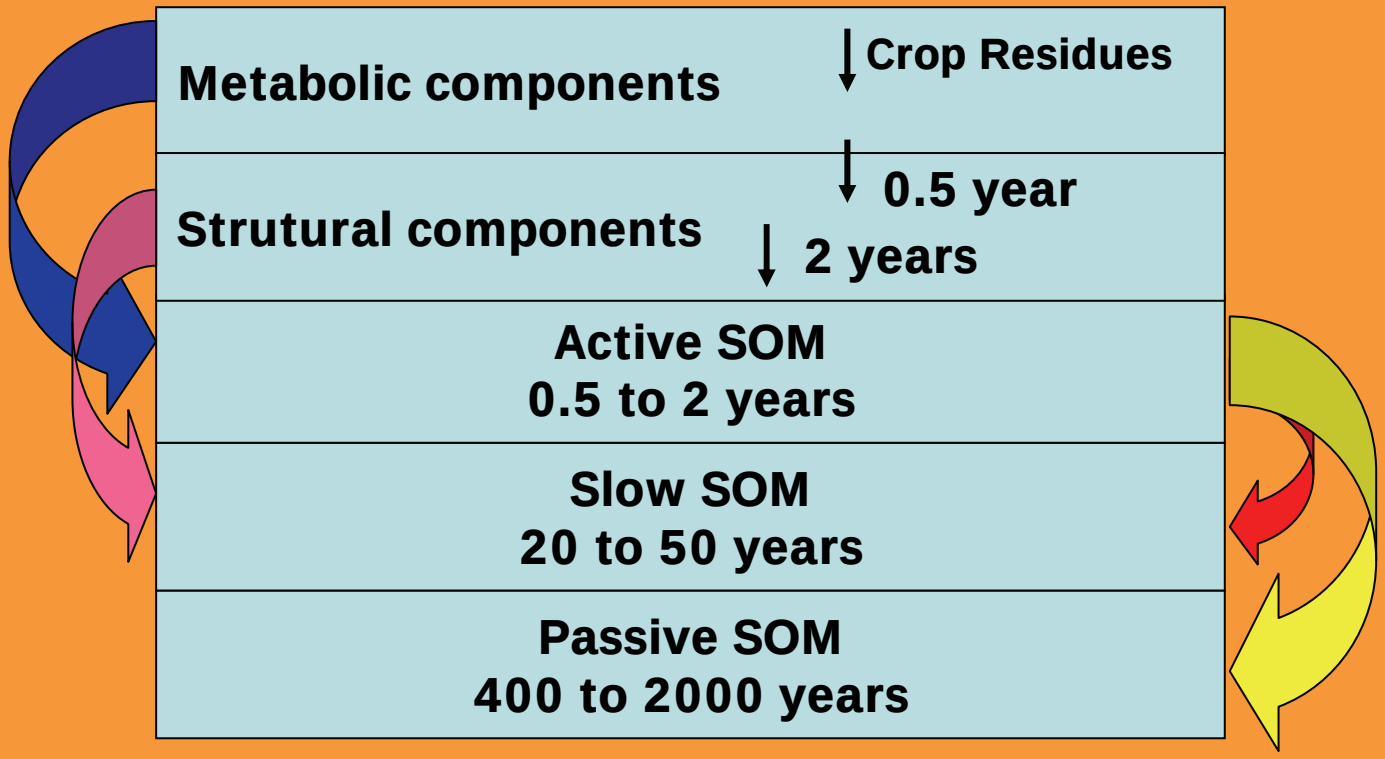
- **Nível baixo** ➡ 33N+38P_2O_5+38K_2O/ha no Arroz; ON+38P_2O_5+38K_2O/ha na Soja — 4N+20P_2O_5+20K_2O na safrinha Sem fungicidas
- **Nível médio** ➡ 65N+75P_2O_5+75K_2O/ha no Arroz; ON+75P_2O_5+75K_2O/ha na Soja — 8N+40P_2O_5+40K_2O na safrinha Com proteção de fungicida no arroz
- **Nível elevado** ➡ 65-85N+157P_2O_5+150K_2O/ha no Arroz; ON+150P_2O_5+150K_2O/ha na Soja — **Com proteção fungicida no arroz**

Fonte: L. Séguy, S. Bouzinac, CIRAD-CA/UR1, A. C. Maronezzi, AGRONORTE, J. C. Moraes de Sá, UEPG - Goiânia-GO, Brasil, 2006

Carbon flow in the organic matter pool's

Crop Residues

Multi-compartment Model
Jenkinson and Rayners, 1977



Multi-Compartments Model's

Nutrient cycling (C, N, P e S) and Green House Gases

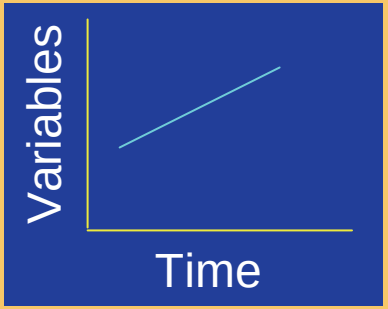
CENTURY	(Parton et. al., 1987)
TEM	(Raich et al. 1991)
DNDC	(Li et al., 1992)
CASA	(Potter et al.,1993)
Roth C	(Polwson et al., 1996)

CENTURY SOM Model

Developed for temperate climate and adjusted for tropical climate

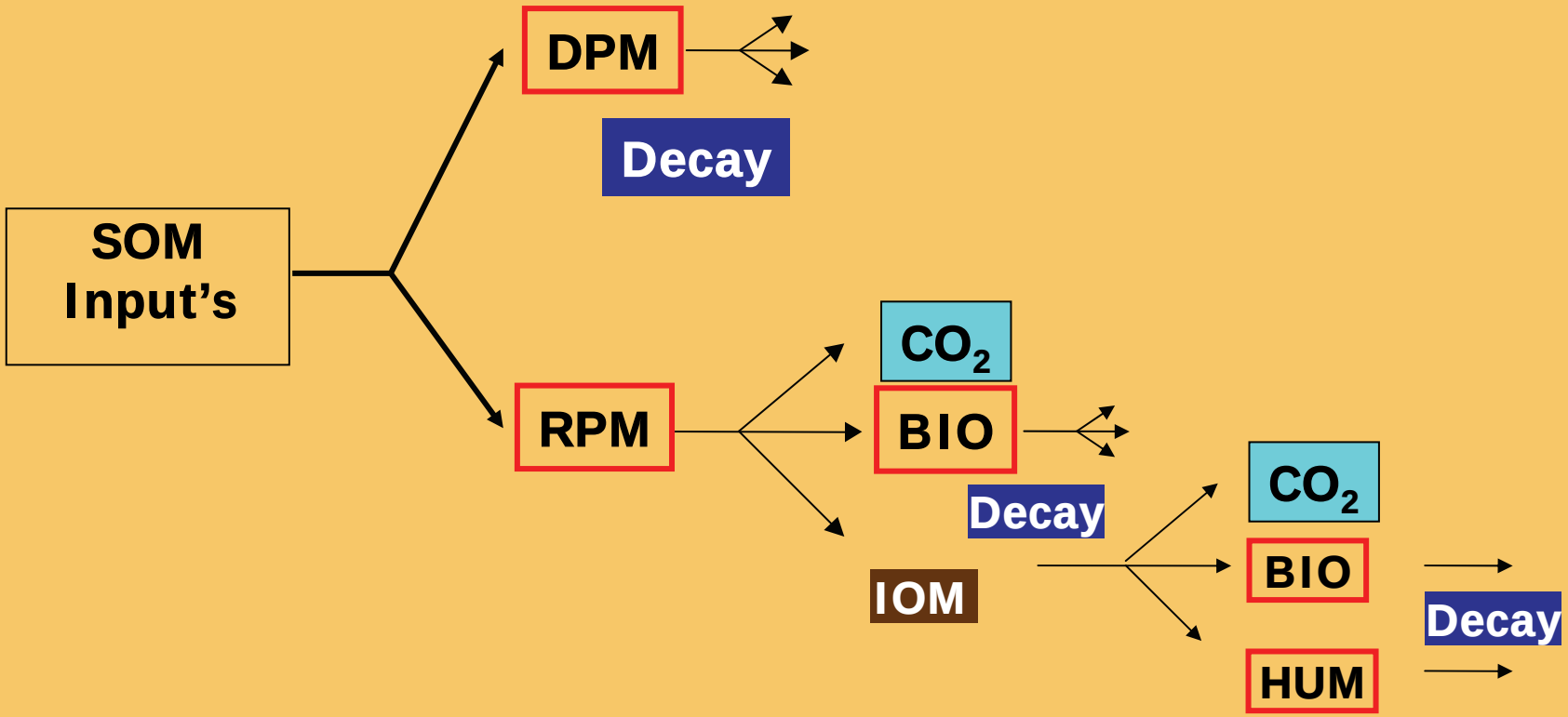
Procedure to use the Mathematical Modelling

Bibliographical review of the Place to be studied → Database (Soil, climate, vegetation… → Model to be used

Model calibration → Simulation with: (# Soil, # vegetation, # fertilizers plots) → 

Validation of the Model
Observed data
Simulated data → Extrapolation of the data for other areas

Diagram of the Roth C Model



DPM: Decomposable plant material

RPM: Resistent plant material

BIO: Microbial biomass

HUM: Humified organic material

IOM: Inert organic matter