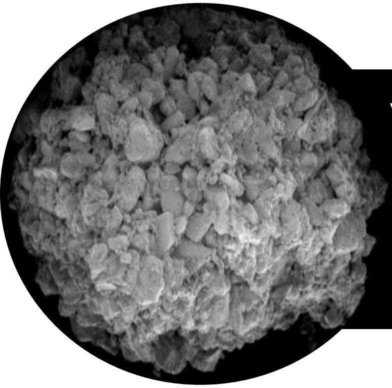
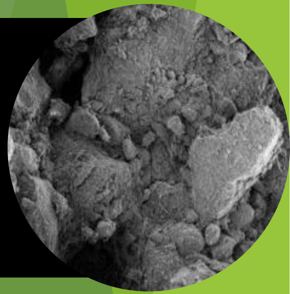


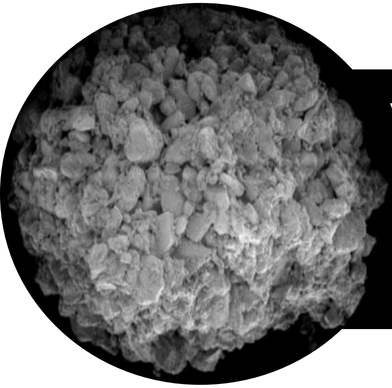
Visiting Soil Structure:

Approaches to understanding the *dynamics of agrochemicals* in the Pampean region of Argentina.



Dr. Filipe Behrends Kraemer, Ing. Agr. Mag. Sc.

- Professor of Soil Management and Conservation – University of Buenos Aires (Agronomy College).
- CONICET Researcher (National Council of Scientific and Techological Research)
- Co-Director of the "Soil Master Programme" FAUBA-EPG



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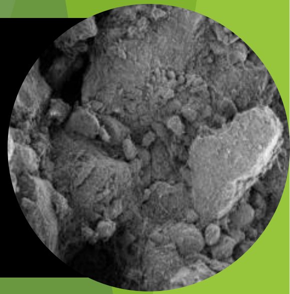

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Contex of studies: ***Soil degradation in the Pampean region***

Visiting Soil Structure in the light of: **"Microbiomes and Glyphosate biodegradation in edaphic and aquatic envirnoments; recent issues and trends"**

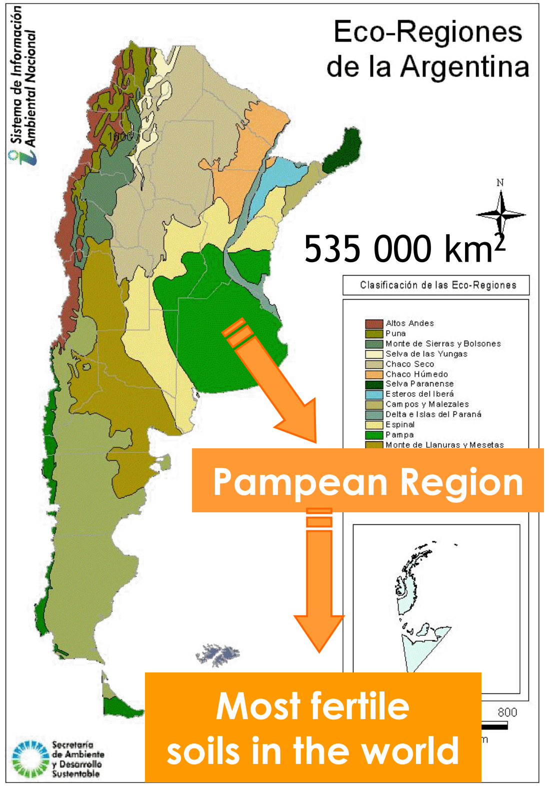
World Journal of Microbiology and Biotechnology (2022) 38:98
https://doi.org/10.1007/s11274-022-03281-w

Land degradation in the Argentinian Pampas

Contex of Studies

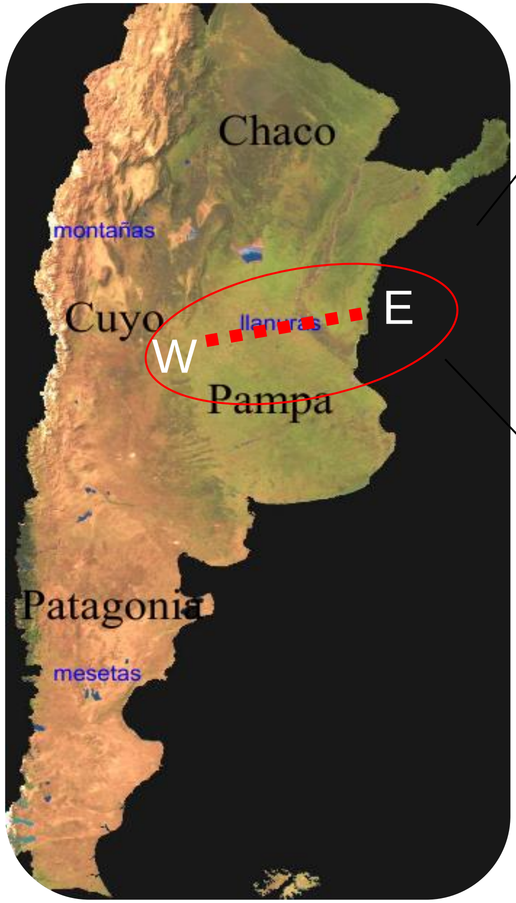
Fragility to soil **physical degradation**

- High silt and very fine sands contents
- Bioliths and volcanic glasses

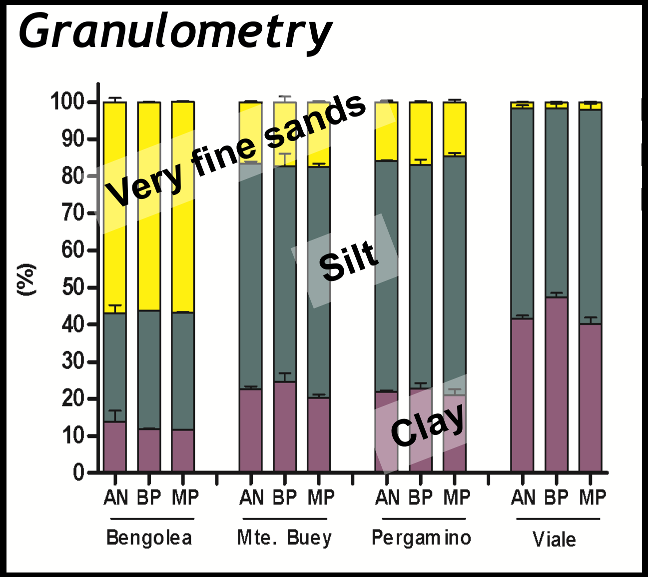


Pampean Region

Most fertile soils in the world

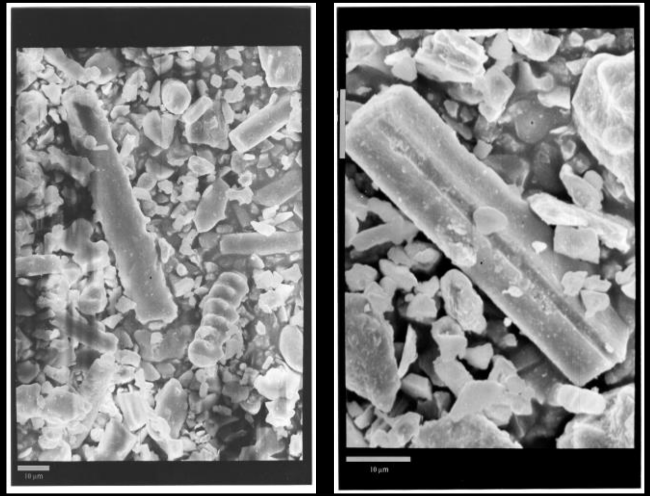


Soil characteristics



Volcanic glasses and bioliths

Silt fraction



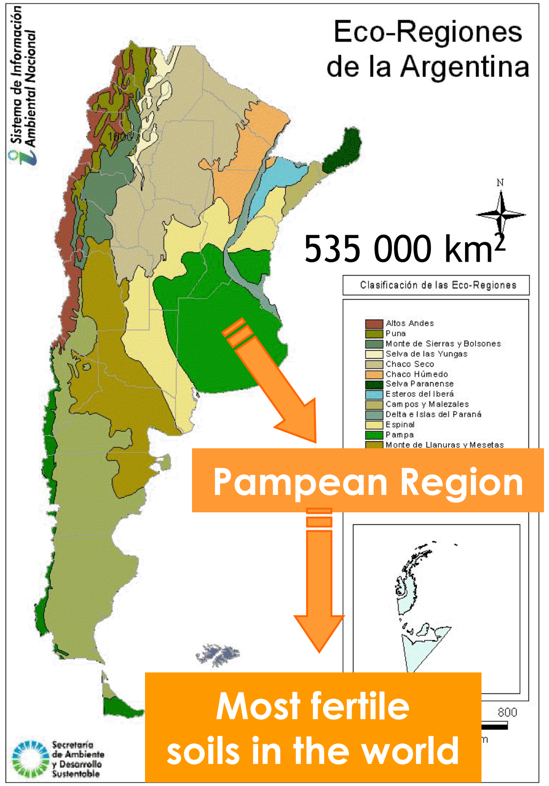
- Easily fractured
- Weak aggregates

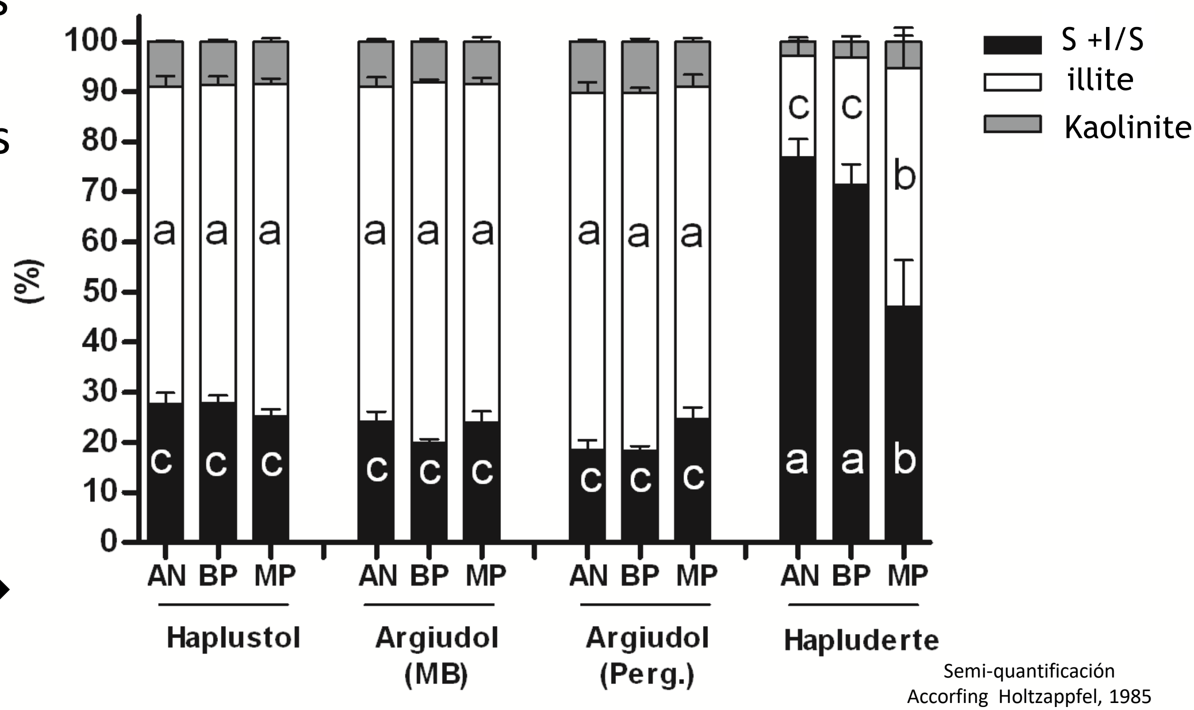
Land degradation in the Argentinian Pampas

Contex of Studies

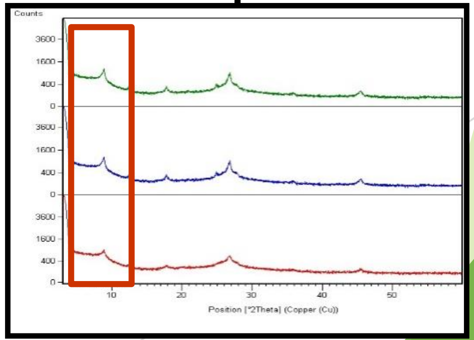
Fragility to soil **physical degradation**

- High silt and very fine sands contents
- Bioliths and volcanic glasses
- Semi-rigid mineralogy





Semi-quantificación
Accorfing Holtzappfel, 1985



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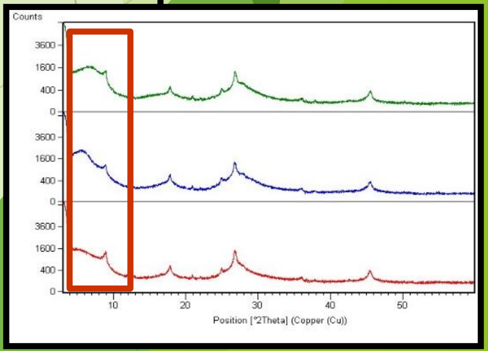


Interestratified S+I/S

Land degradation in the Argentinian Pampas

Fragility to soil **physical degradation**

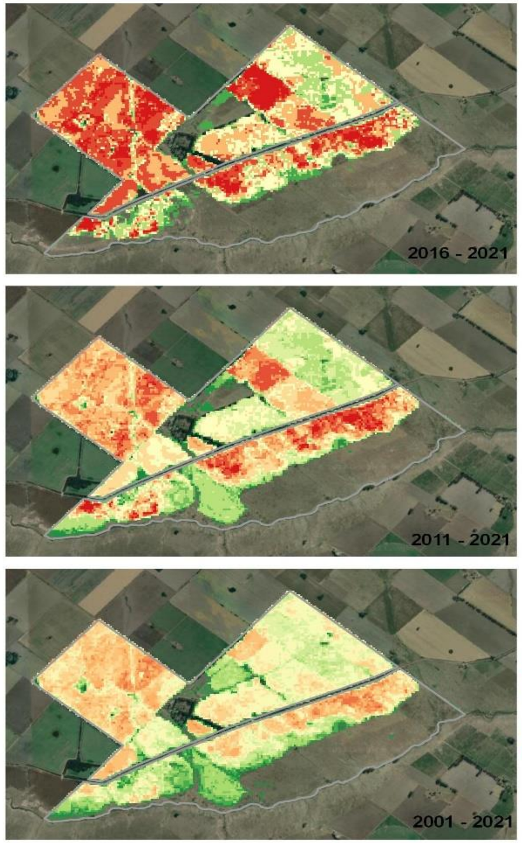
Inadequate land management

Low crop diversification

Tendency to soybean monoculture

Insufficient soil cover

Low winter crops participation



RECURRENCIA DE SUPERFICIE CULTIVADA CON SOJA EN DISTINTOS PERÍODOS EN EL ESTABLECIMIENTO LOS PATRICIOS

La recurrencia de años con cultivo de soja fue elaborada en base al producto Soybean expansion in South America 2001-2021, v1.0 X.-P. Song, M.C. Hansen, P. Potapov, B. Adusei, J. Pickering, M. Adami, A. Lima, V. Zalles, S.V. Stehman, C.M. Di Bella, C.M. Cecilia, E.J. Copati, L.B. Fernandes, A. Hernandez-Serna, S.M. Jantz, A.H. Pickens, S. Turubanova, A. Tyukavina (2021). Massive soybean expansion in South America since 2000 and implications for conservation. Nature Sustainability. https://doi.org/10.1038/s41893-021-00729-z

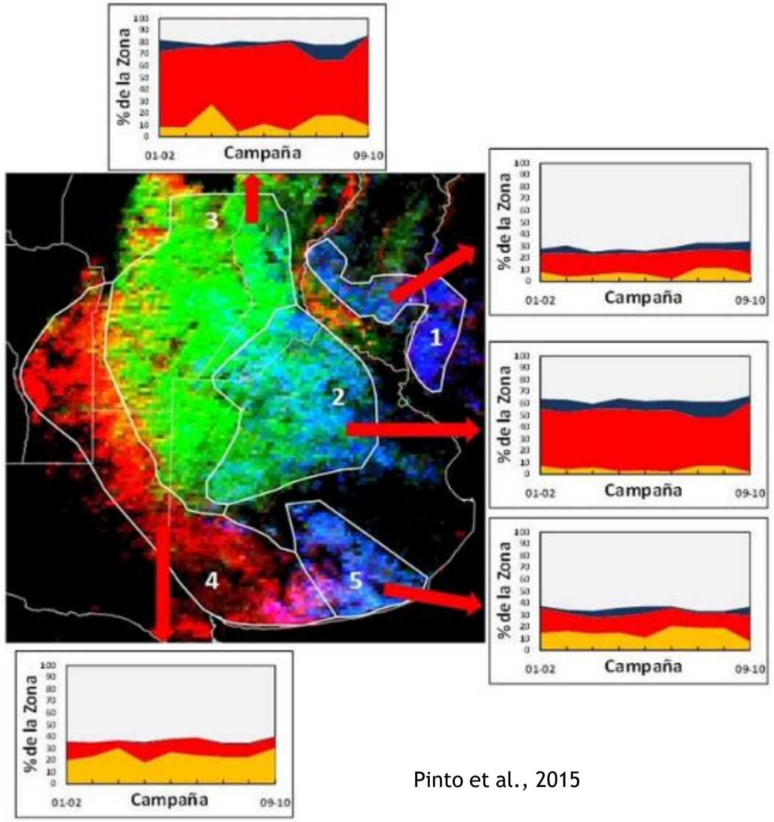
Perímetro Los Patricios - UBA

% campañas de soja

- 10
- 30
- 50
- 70
- 90

Imagen Base - Google

0 0,5 1 1,5 2 km



Pinto et al., 2015

90% No tillage

Contex of Studies

Land degradation in the Argentinian Pampas

Fragility to soil **physical degradation**

+

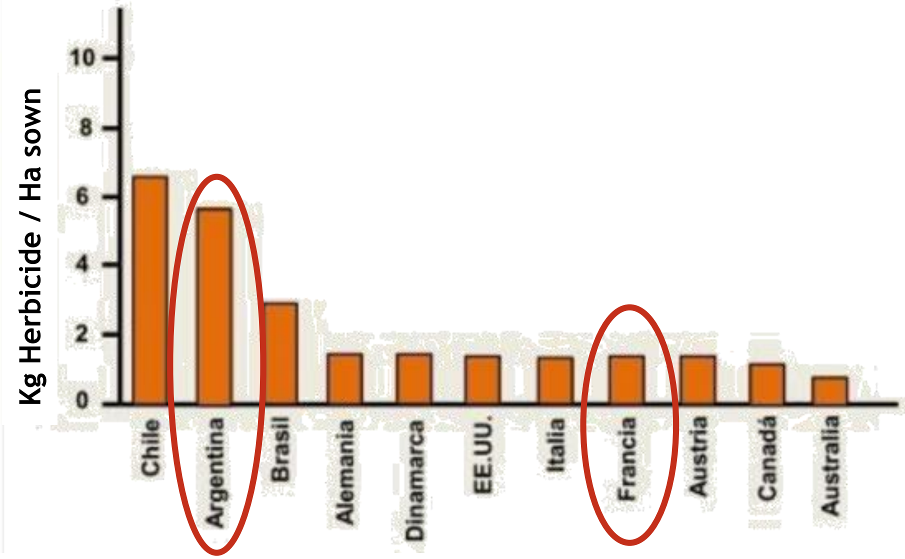
Inadequate land management

Low crop diversification → Tendency to soybean monoculture → Low crop diversification

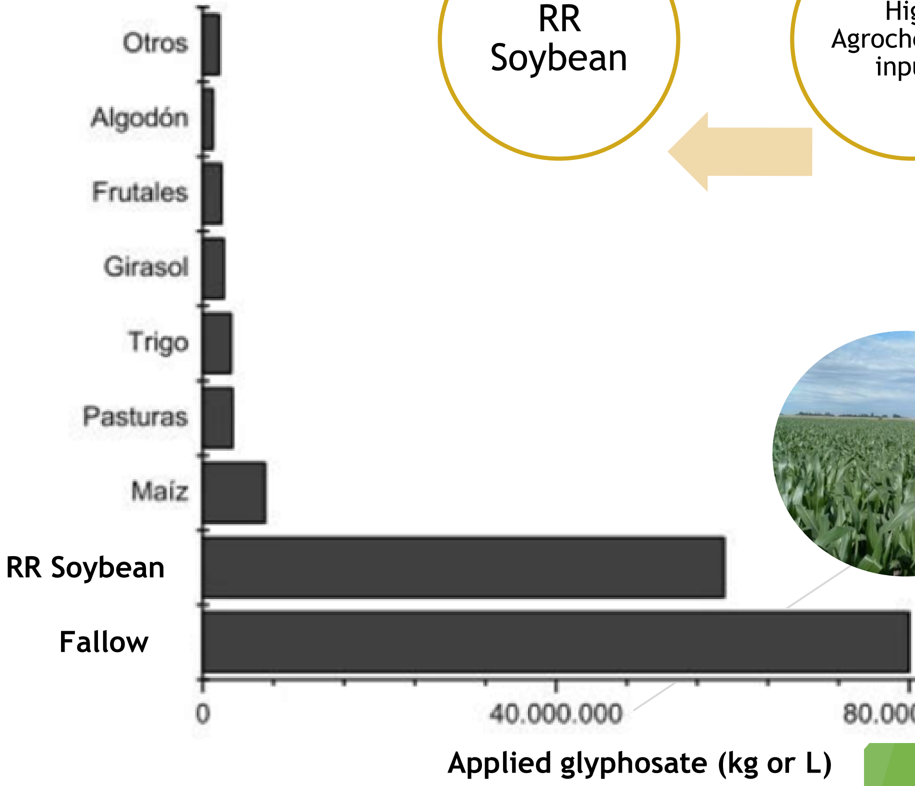
Insufficient soil cover → Low winter crops participation → Insufficient soil cover

RR Soybean → High Agrochemical inputs → RR Soybean

- High agrochemicals inputs (N°2 in the world) ➔65% Glyphosate



(FAO, 2015)



Land degradation in the Argentinian Pampas

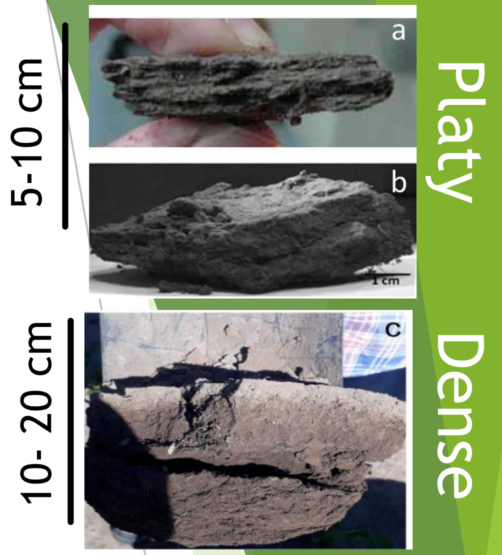
Fragility to soil **physical degradation**

+

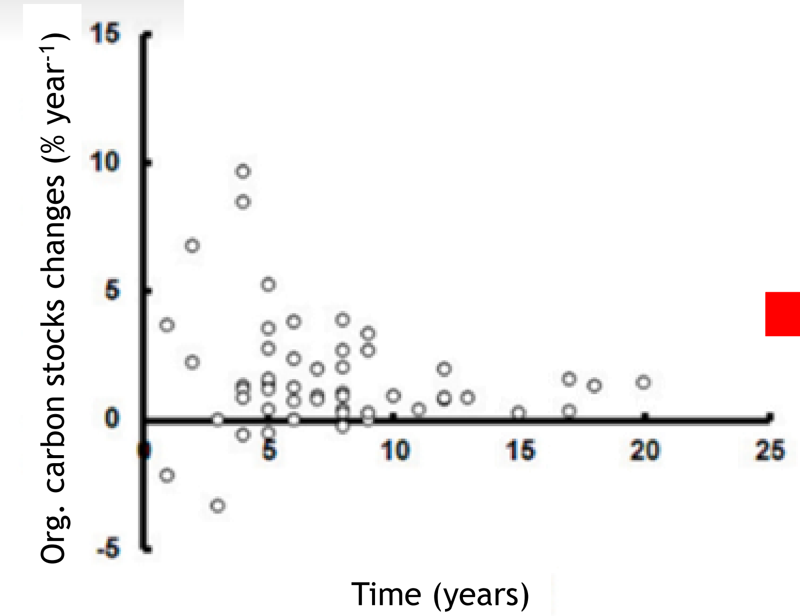
Inadequate land management

=

Land Degradation

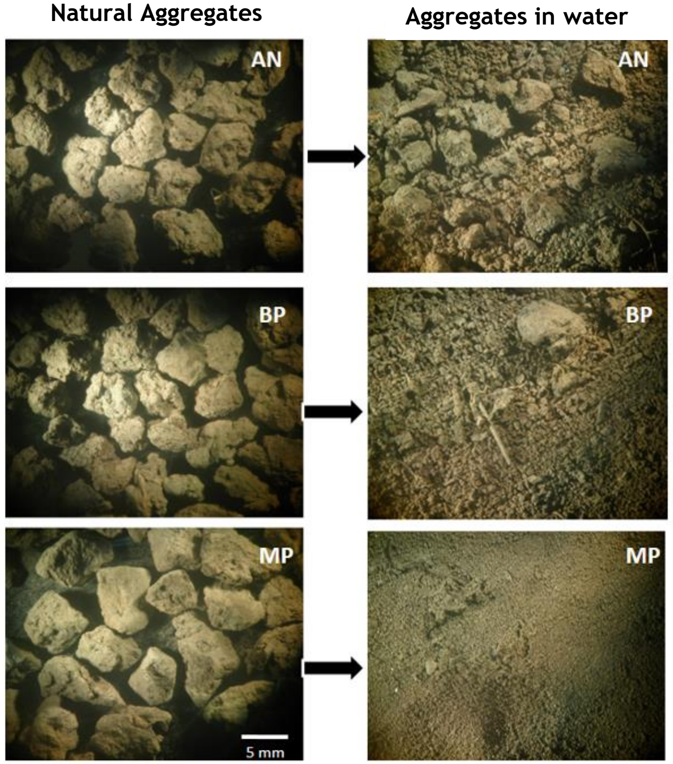


Organic carbon Loss



Alvarez, 2023

Compaction –
Runoff & Soil Erosion



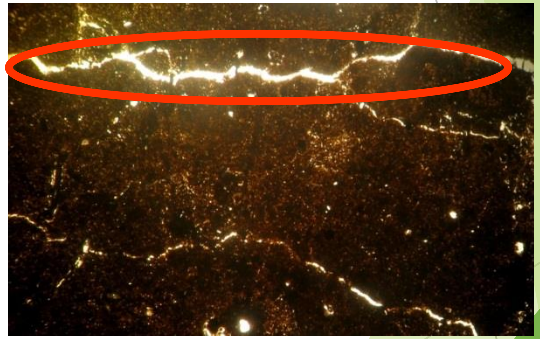
Contex of Studies

Contex of Studies

Soybean Monoculture / Agriculture expansion Heavy transit

High Silt content -Low density Low Swelling-Shrinkage process

physical quality compromised soil structure formation and stability



Synthesis

Degradation processes
Soil structure

- **Runoff – Water excess**
- **Contamination hazards**
- **Productive failures**

- **Sustainable agriculture intensification**
- **Cover crops**
- **Agroecology**

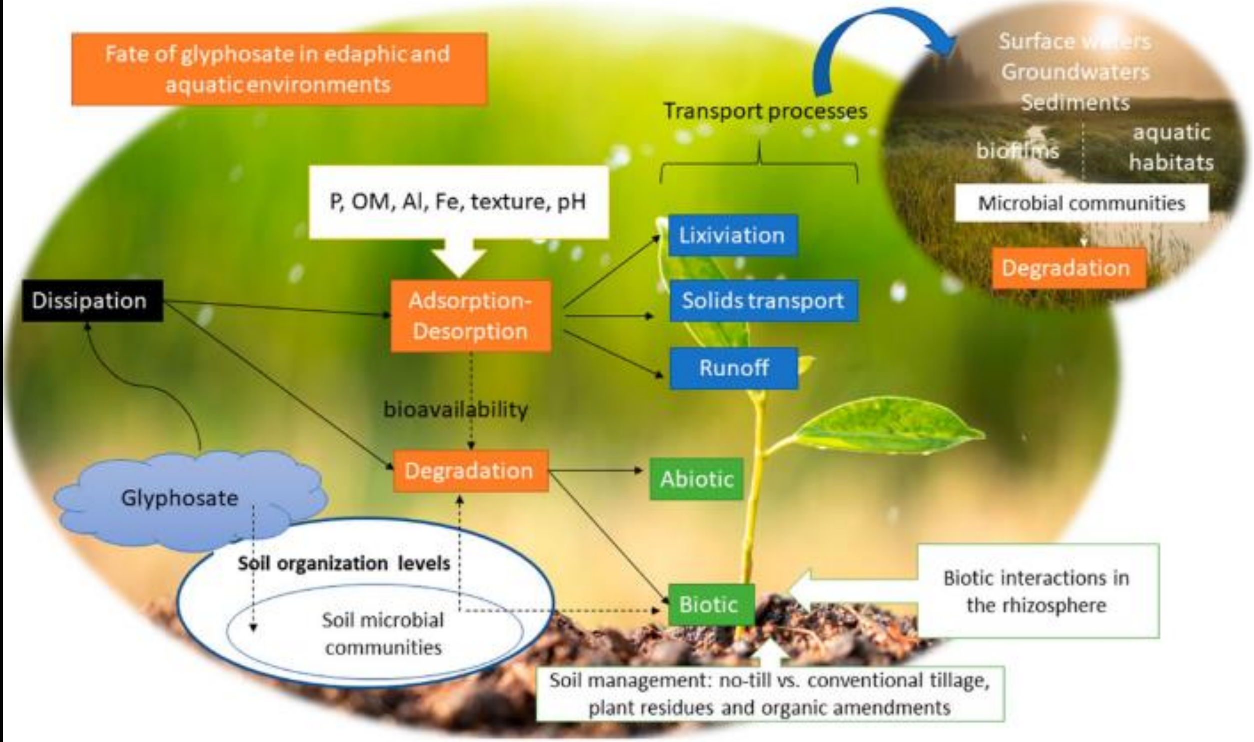
Visiting Soil Structure

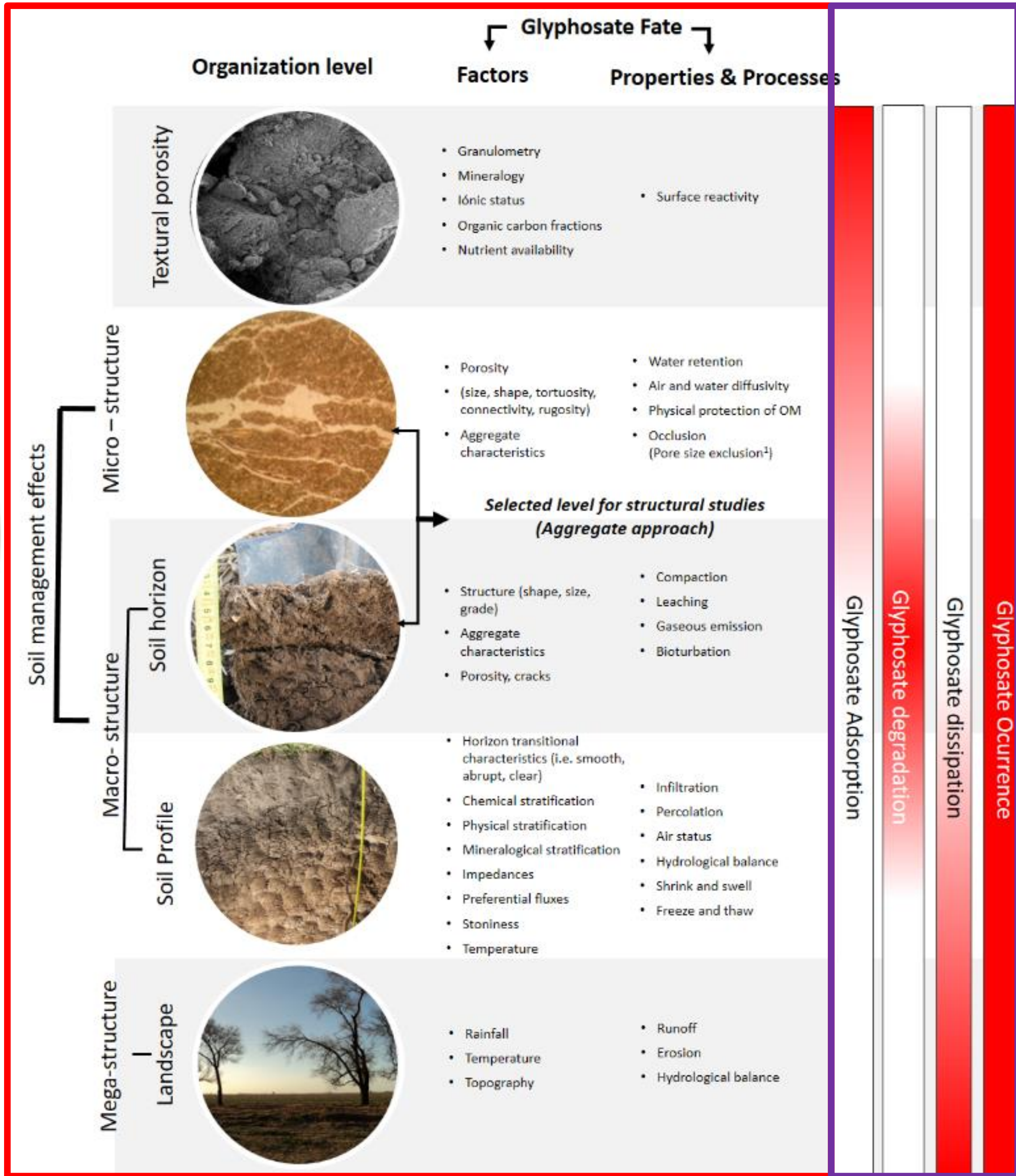
World Journal of Microbiology and Biotechnology (2022) 38:98
https://doi.org/10.1007/s11274-022-03281-w

REVIEW

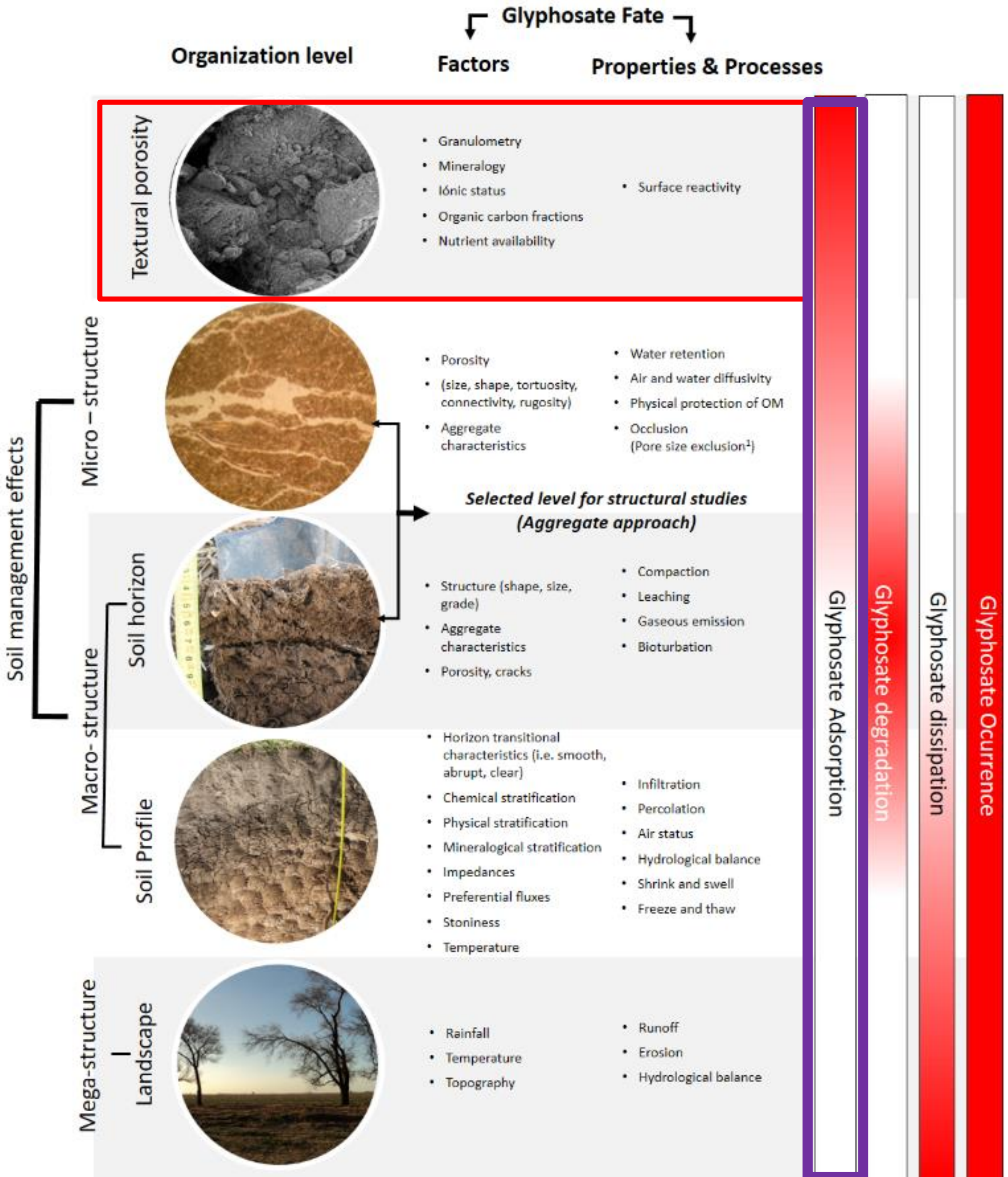
Microbiomes and glyphosate biodegradation in edaphic and aquatic environments: recent issues and trends

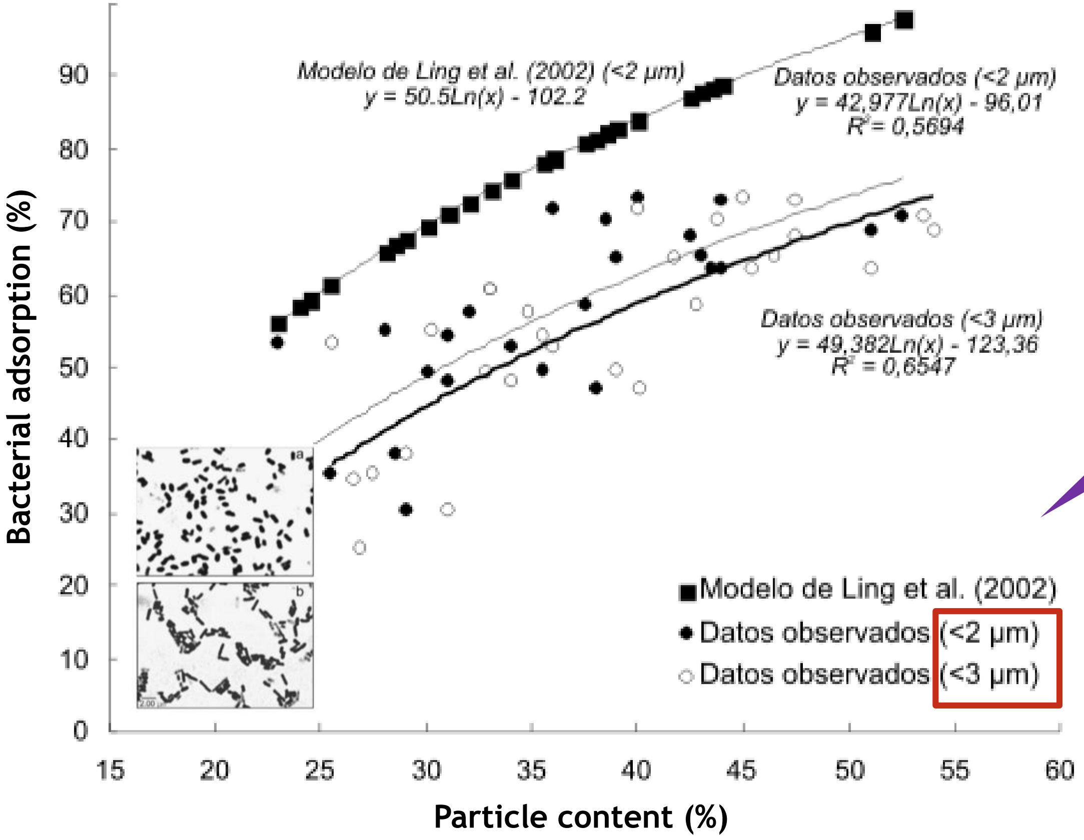
María Celina Zabaloy[1,2] · Marco Allegrini[3] · Keren Hernandez Guijarro[4] · Filipe Behrends Kraemer[5,6] · Héctor Morrás[6,7] · Leonardo Erijman[8,9]



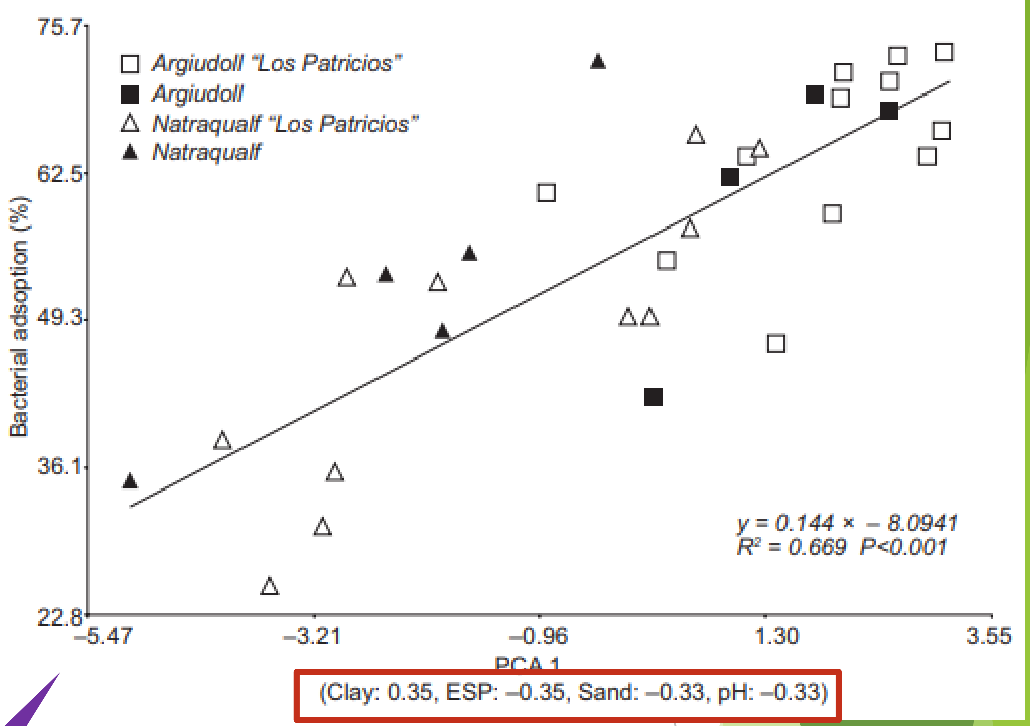


Visiting Soil Structure





Behrends Kraemer et al., 2011a



Behrends Kraemer et al., 2011b

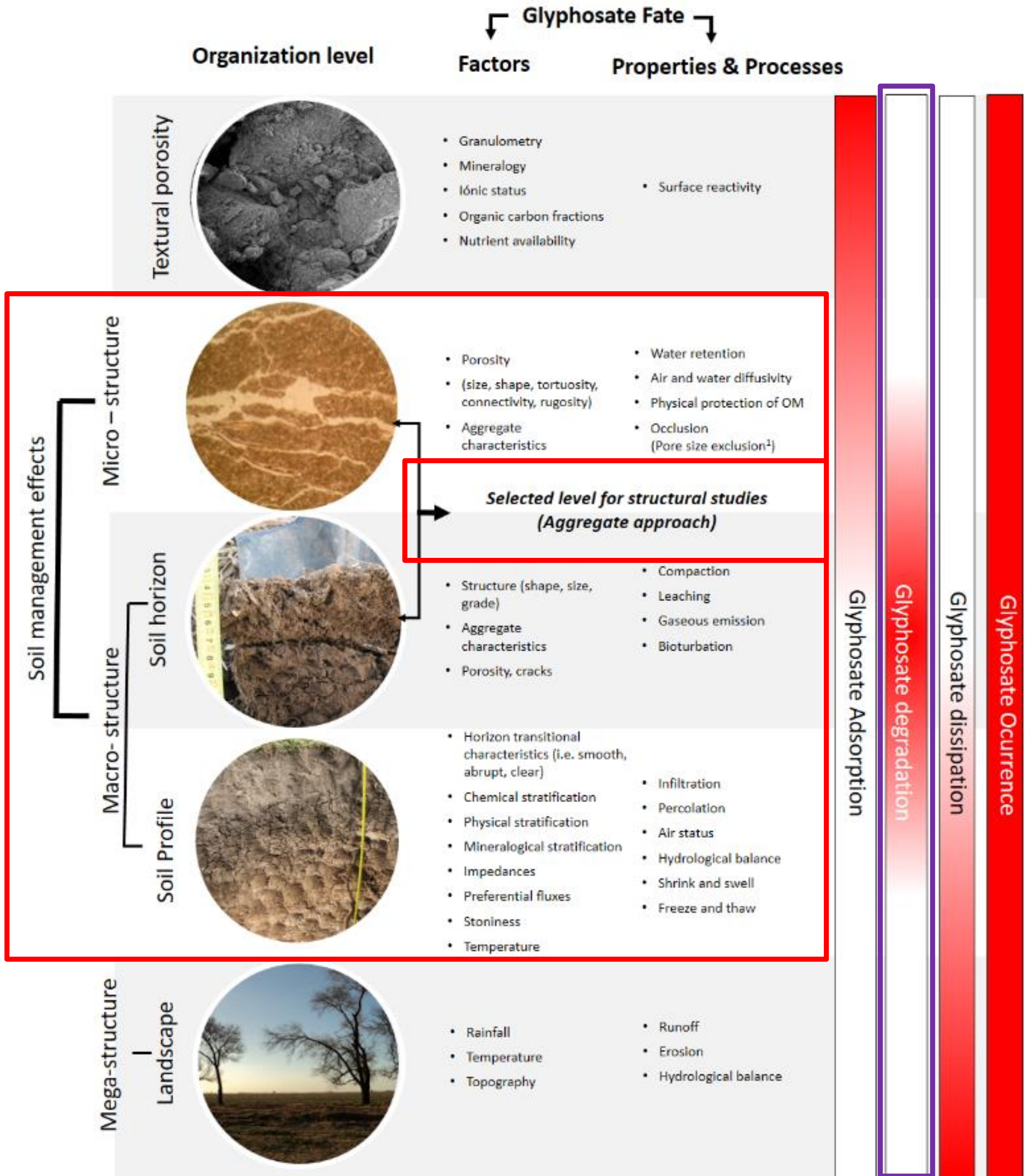
Ground water contamination potential - GWCP - (Glyphosate and AMPA)

(Dalpiaz & Andriulo, 2017)

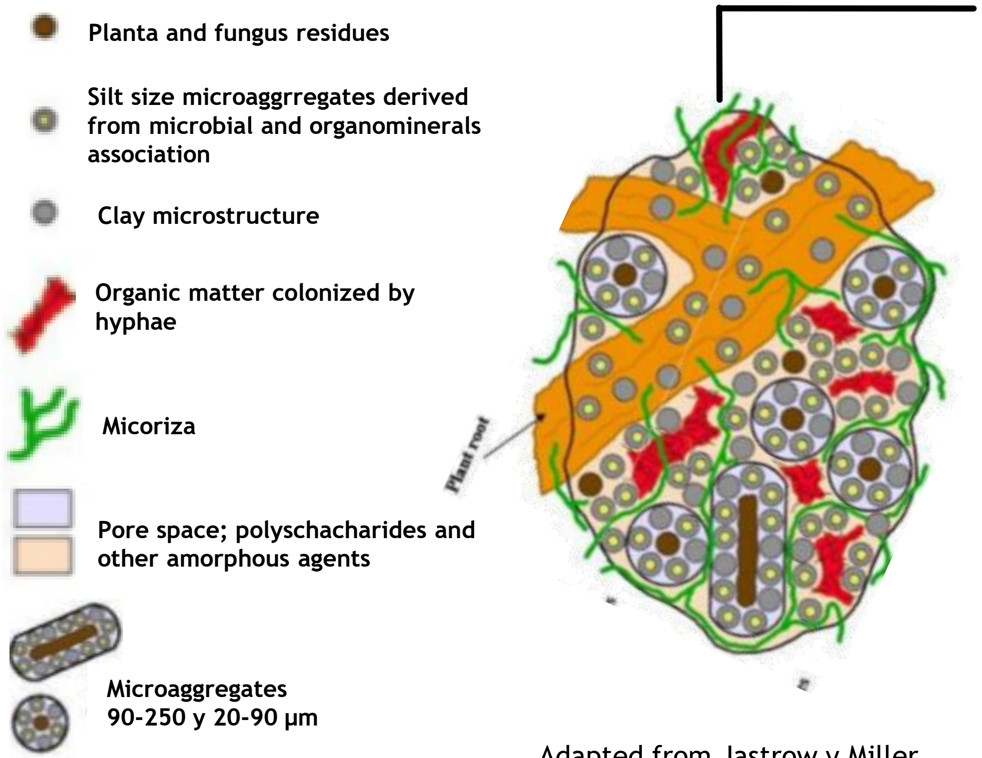
- Soil vulnerability (SLPI)
  - Soil texture, pH, OC content and preferential flux (layers texture ratio)
- Agrochemical lixiviation potential (PLPI)
  - Product half-life, ∑ applications, Koc.

GWCP= SLPI-PLPI *100

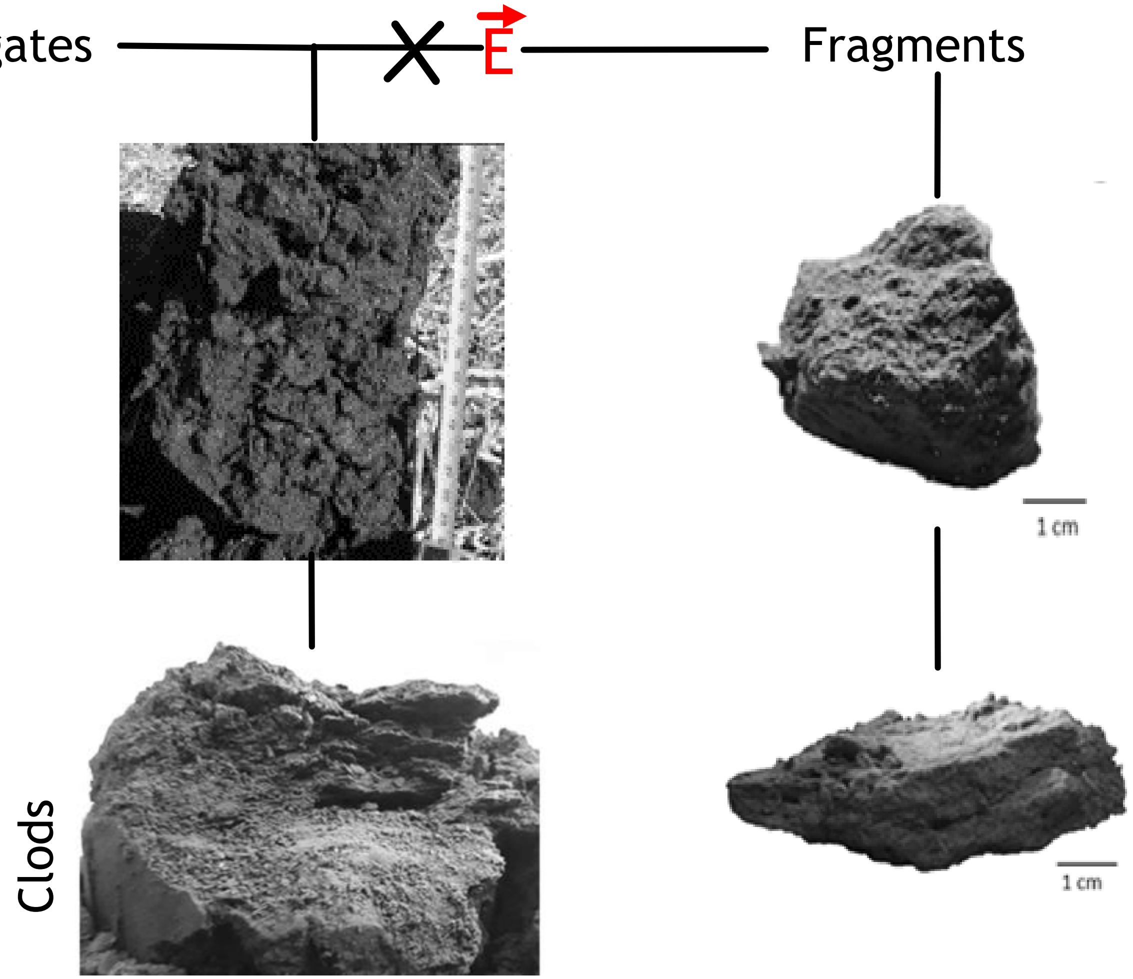
Visiting Soil Structure



Visiting Soil Structure



Adapted from Jastrow y Miller (1998)



Diaz-Zorita et al., 2002

Study approach → Structural arrangement → Structural stability → Structural resilience

Kay, et al. 1990

Contents lists available at ScienceDirect

Soil & Tillage Research

journal homepage: www.elsevier.com/locate/still

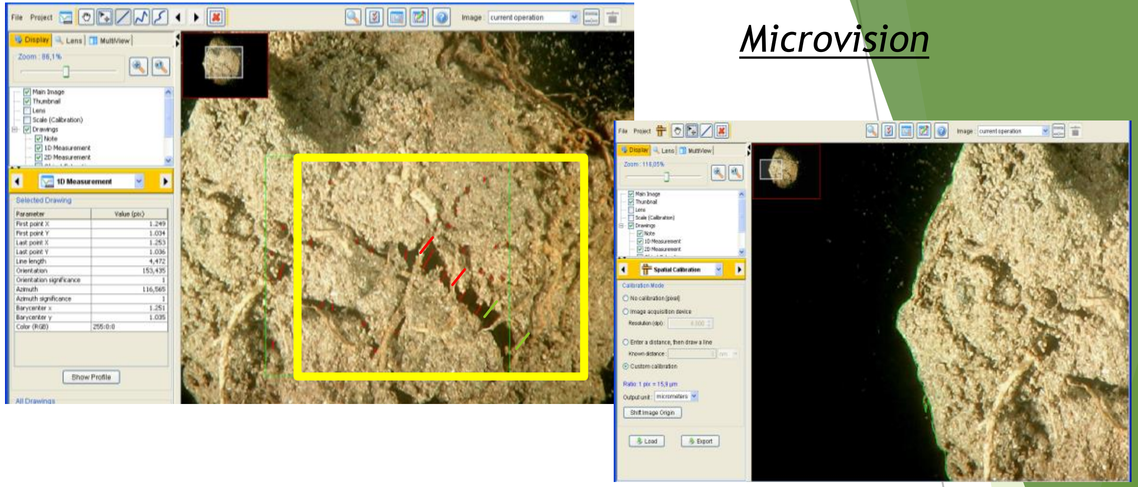
Morpho-structural evaluation of various soils subjected to different use intensity under no-tillage

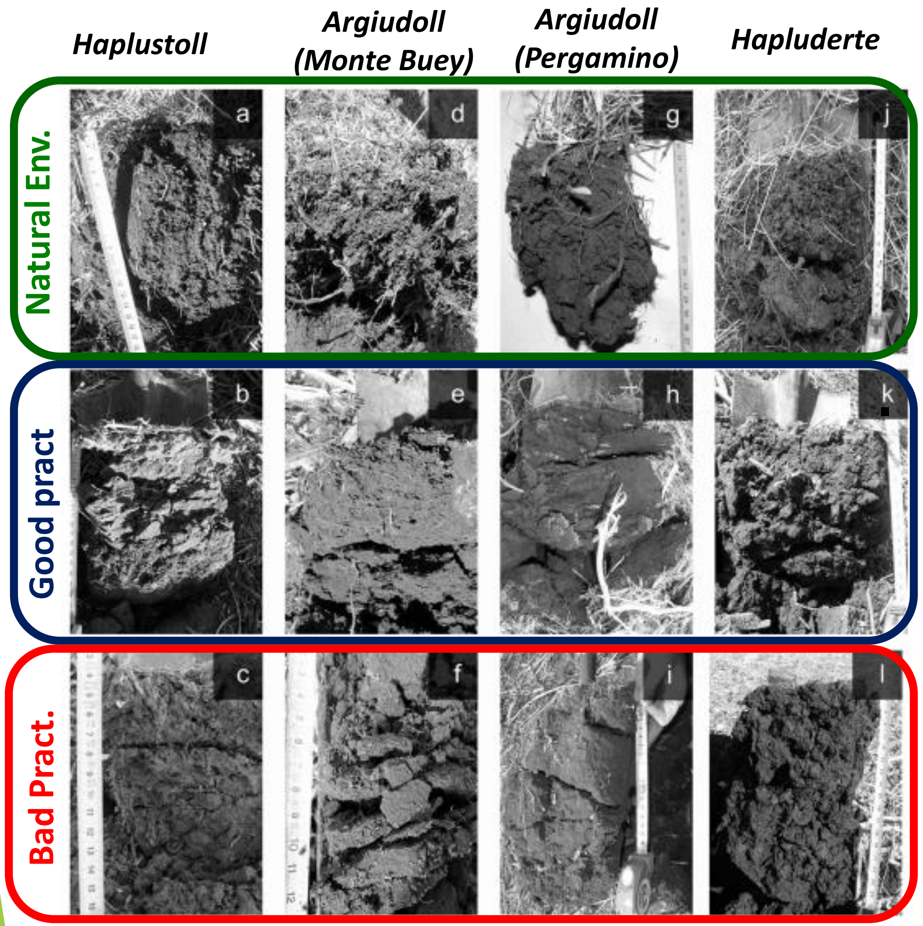
Filipe Behrends Kraemer[a,b,e,*], Marcelo A Soria[c], Mario G Castiglioni[a], Matías Duval[d], Juan Galantini[d], Héctor Morrás[e]

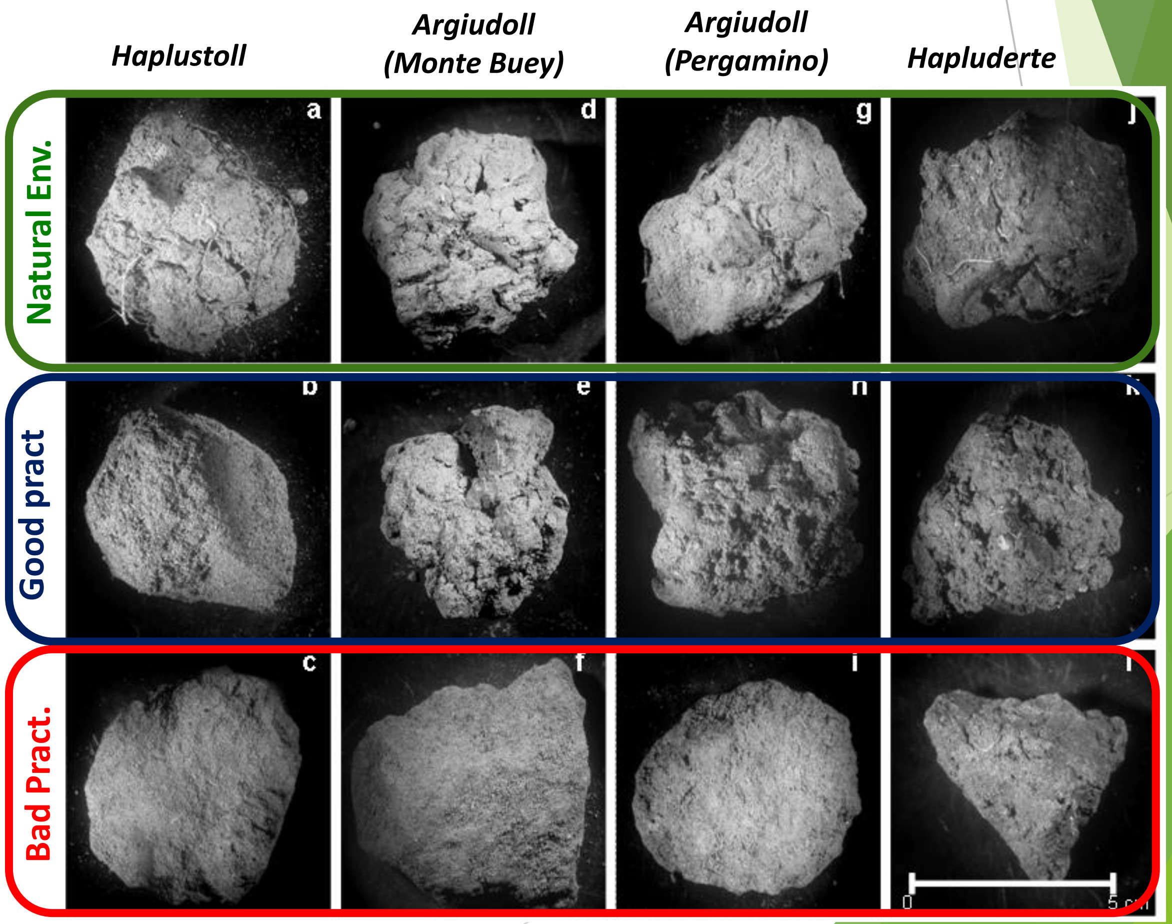
[a] Cátedra de Manejo y Conservación de Suelos, Facultad de Agronomía, Universidad de Buenos Aires, Argentina
[b] CONICET, Argentina
[c] Universidad de Buenos Aires, Facultad de Agronomía, Cátedra de Microbiología Agrícola, INBA-CONICET, Argentina
[d] Comisión Investigaciones Científicas (CIC) CERZOS-Departamento de Agronomía, Universidad Nacional del Sur, Bahía Blanca, Argentina
[e] Instituto de Suelos-CIRN-INTA, Argentina

Microvision

Structural arrangement

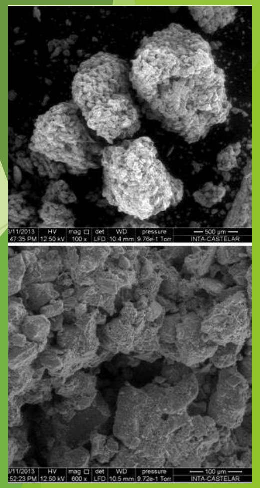






n= 108

Imagen compuesta por 7-10 tomas



Electro scanning Micrcope (gold wahs)

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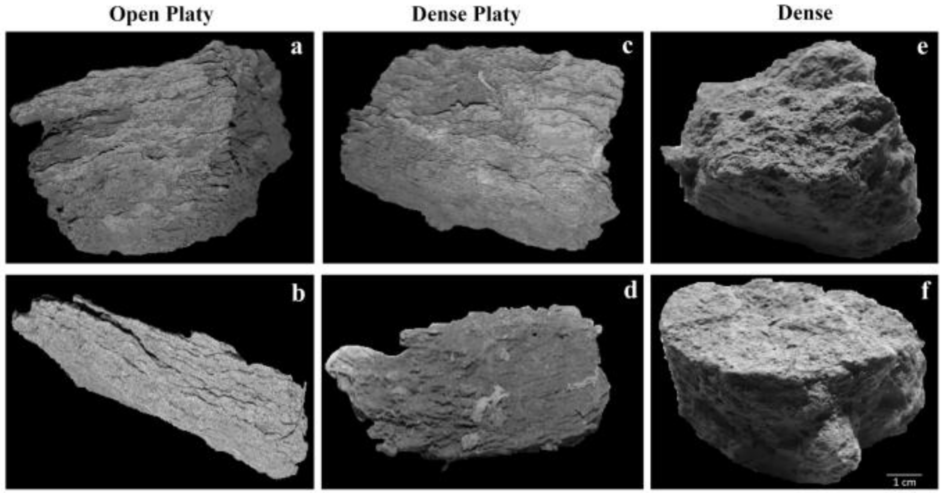
journal homepage: www.elsevier.com/locate/still

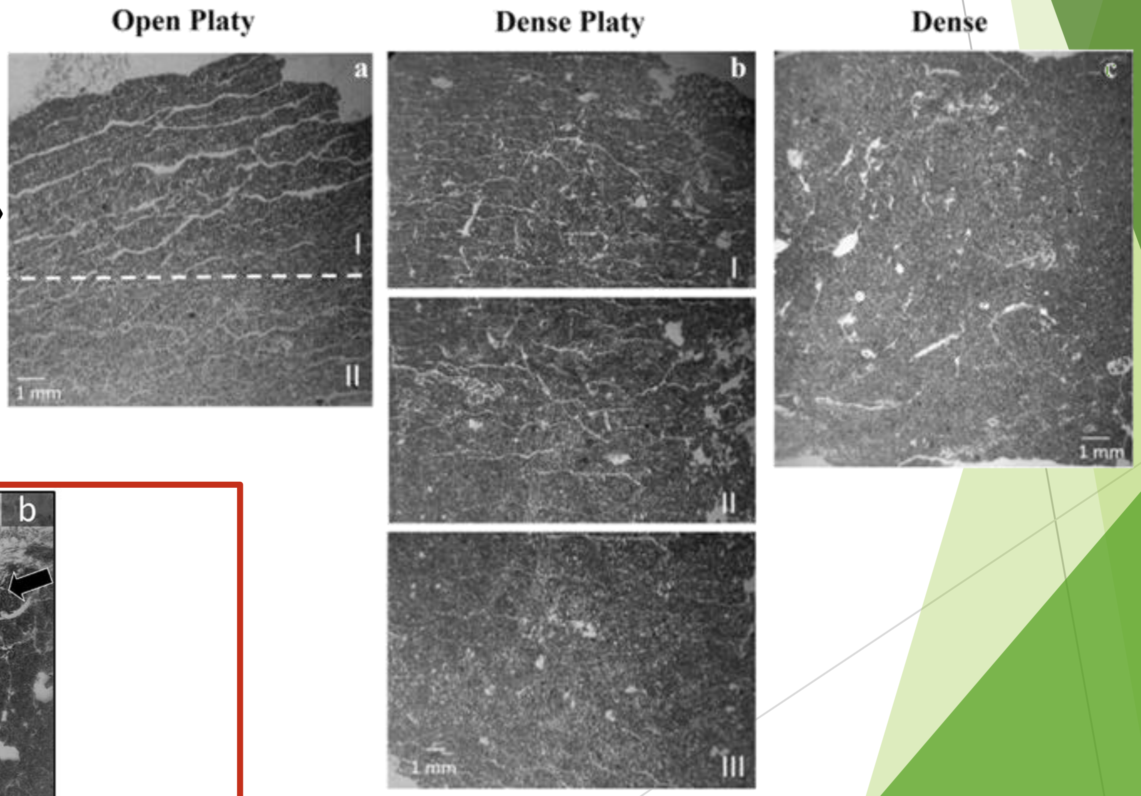
Soil structure and glyphosate fate under no-till management in the Pampa region. I. Soil structural anisotropy and hydro-physical behavior

F. Behrends Kraemer[a,b,*], D. Sainz[a,c], H. Morrás[c], P. Carfagno[c], M. Eiza[d], P. Fernández[b,e], C. Chagas[a]

[a] Cátedra de Manejo y Conservación de Suelos, Facultad de Agronomía, Universidad de Buenos Aires, Argentina
[b] CONICET, Argentina
[c] Instituto de Suelos-CIRN-INTA, Argentina
[d] EEA INTA Balcarce-CERBAS, Argentina
[e] Cátedra de Fertilidad y Fertilizantes, Facultad de Agronomía, Universidad de Buenos Aires, Argentina

- High structural heterogeneity in the first cm of the topsoil
- Ocurrence of dense and platy structures
- Different conformation of these structures (i.e. Biological vs. Mechanical)





Behrends Kraemer et al., 2017

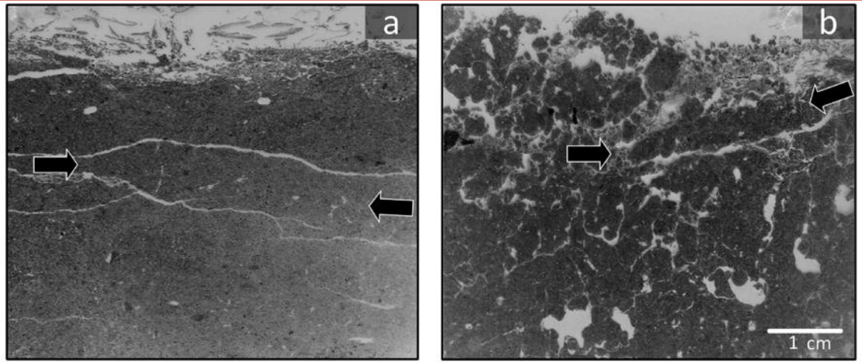
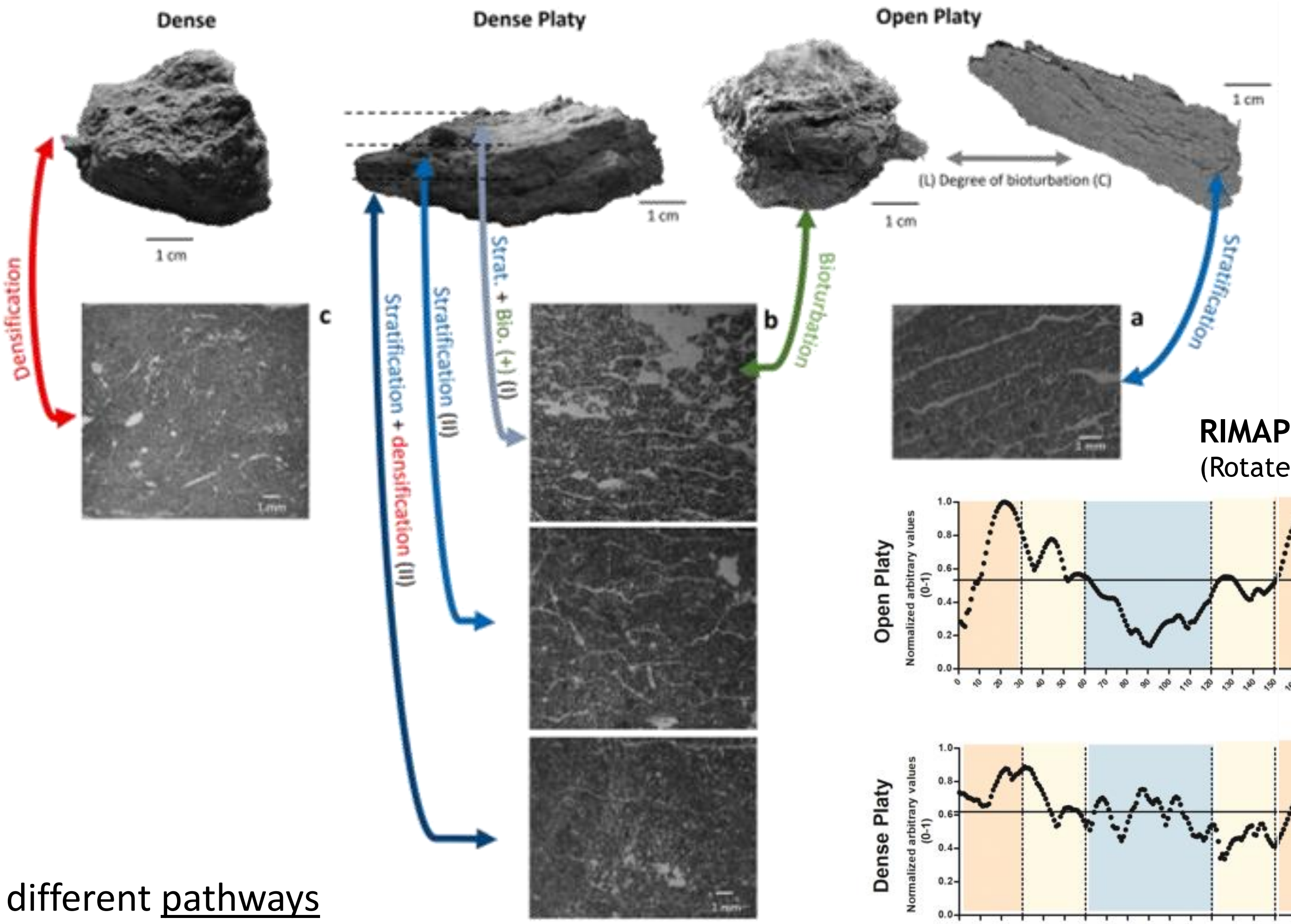


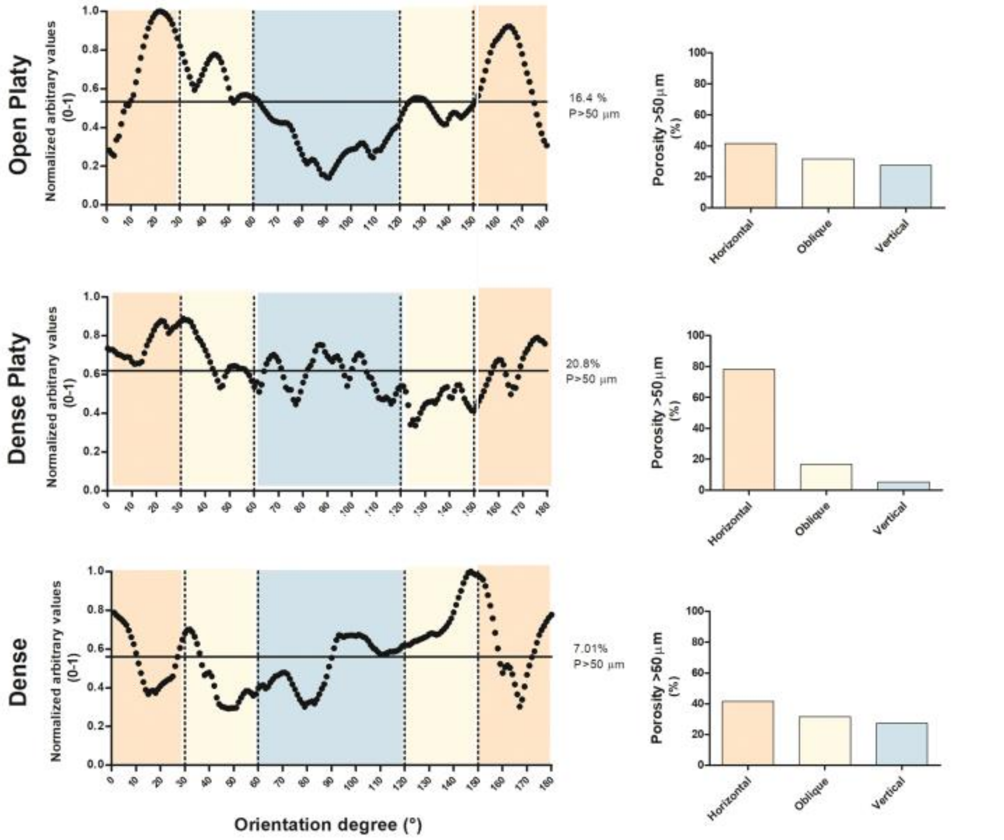
Fig. 7. Thin sections of topsoil (0–6 cm depth) exemplifying different types of platy structures. Area between arrows indicates: a) platy structures from a coarse textured soil matrix (GAP, Haplustoll); b) platy structures from densified and oriented biological aggregates with high internal porosity (GAP, Argiudoll – Monte Buey).

Structural arrangement



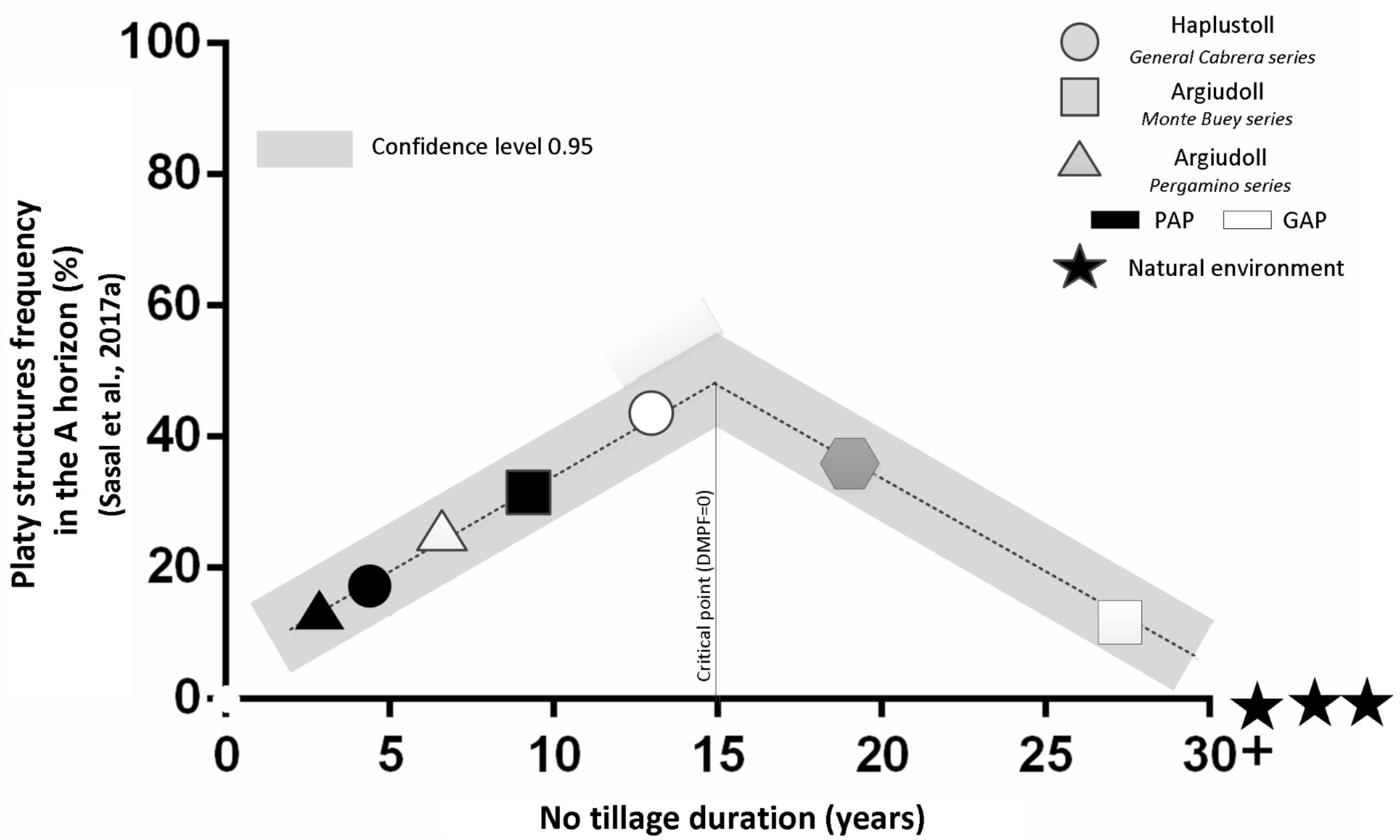
RIMAPS

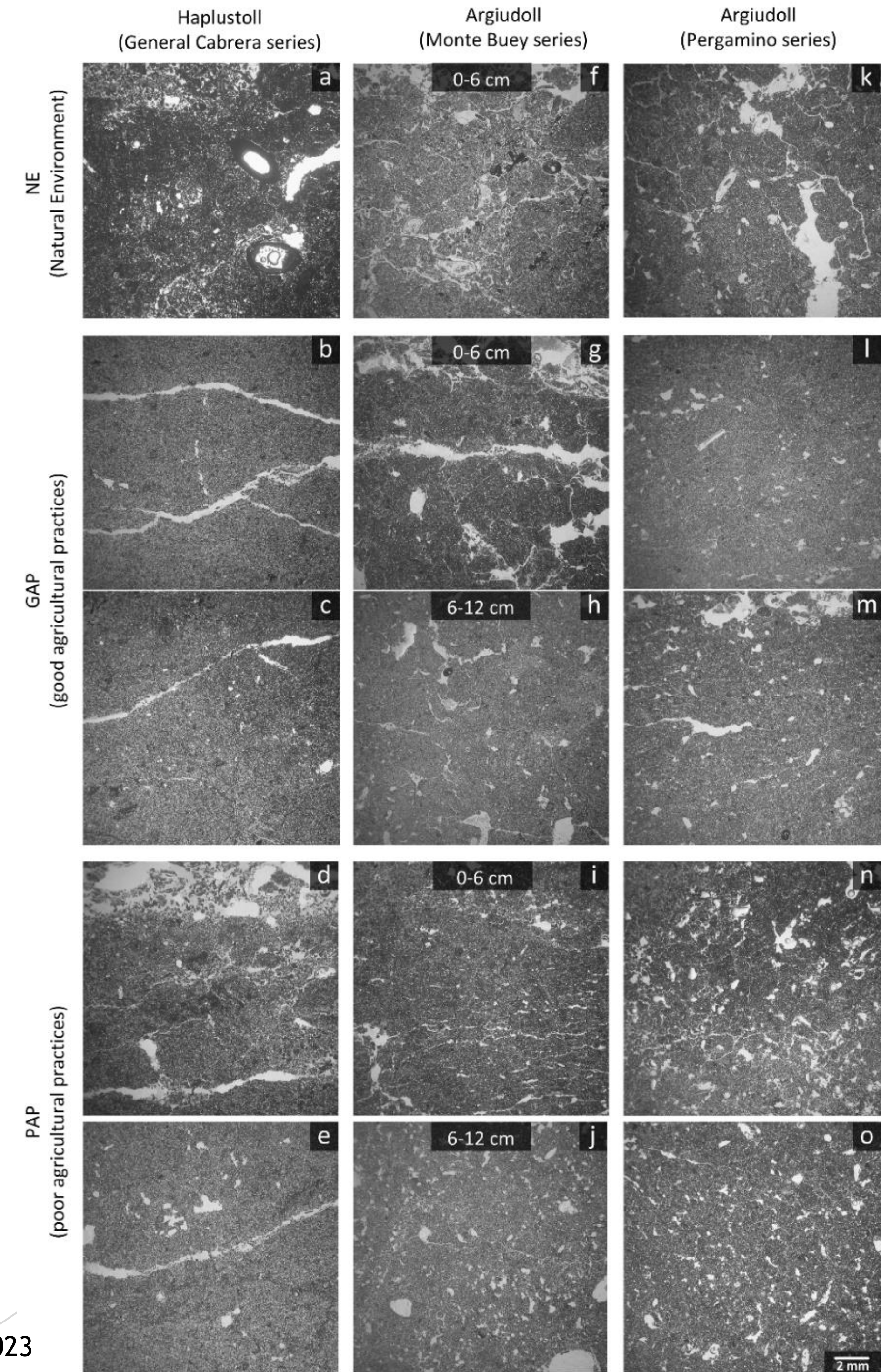
(Rotated Image Average Power Sectrum – Fourier Tr.)



- Propose different pathways
- for **structural differentiation**
- Biology vs Machines
- Deep alteration on *porosity traits* (i.e. volume. continuity and orientation)

Effects of NT convertion on porosity traits and aggregate stability

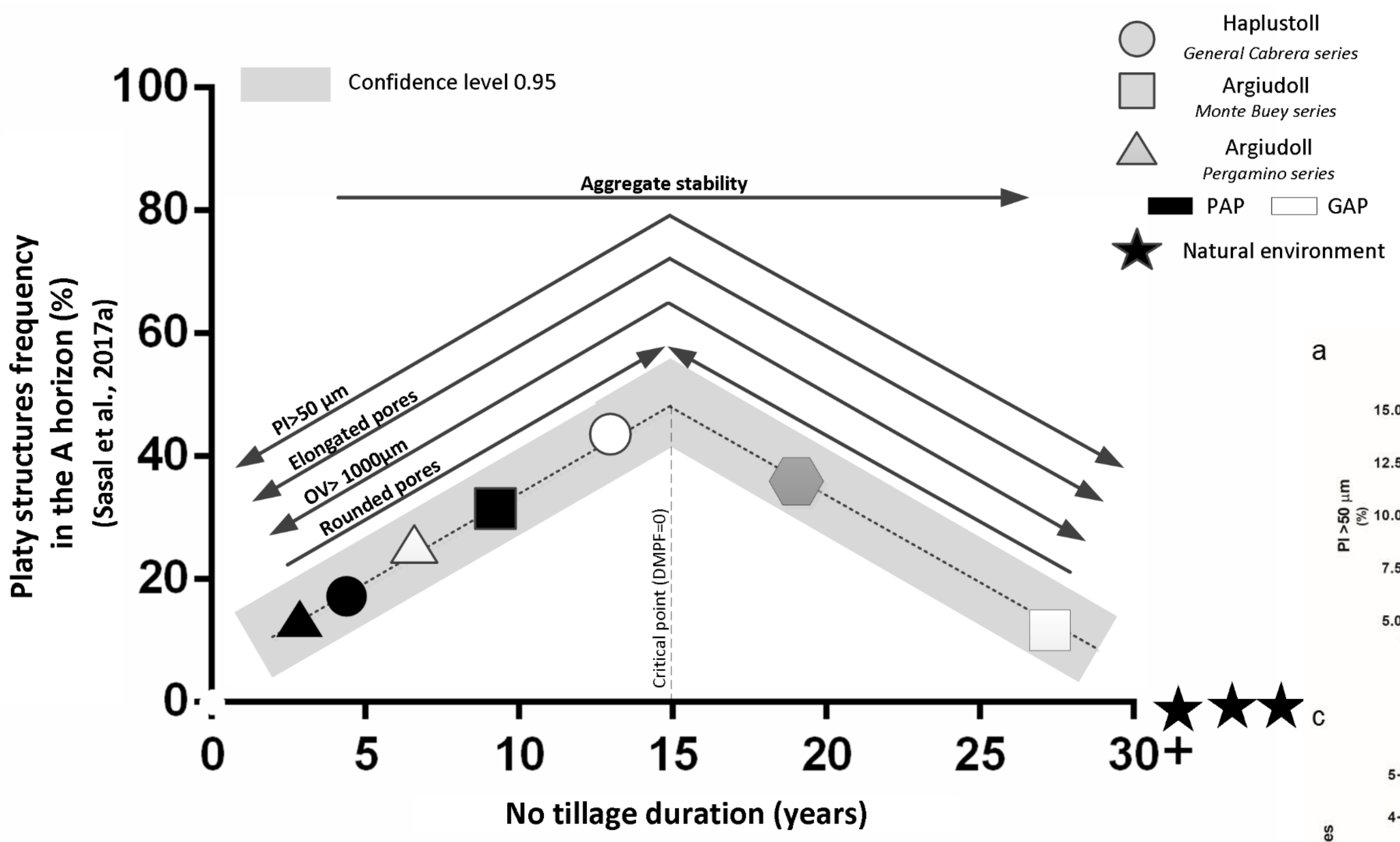


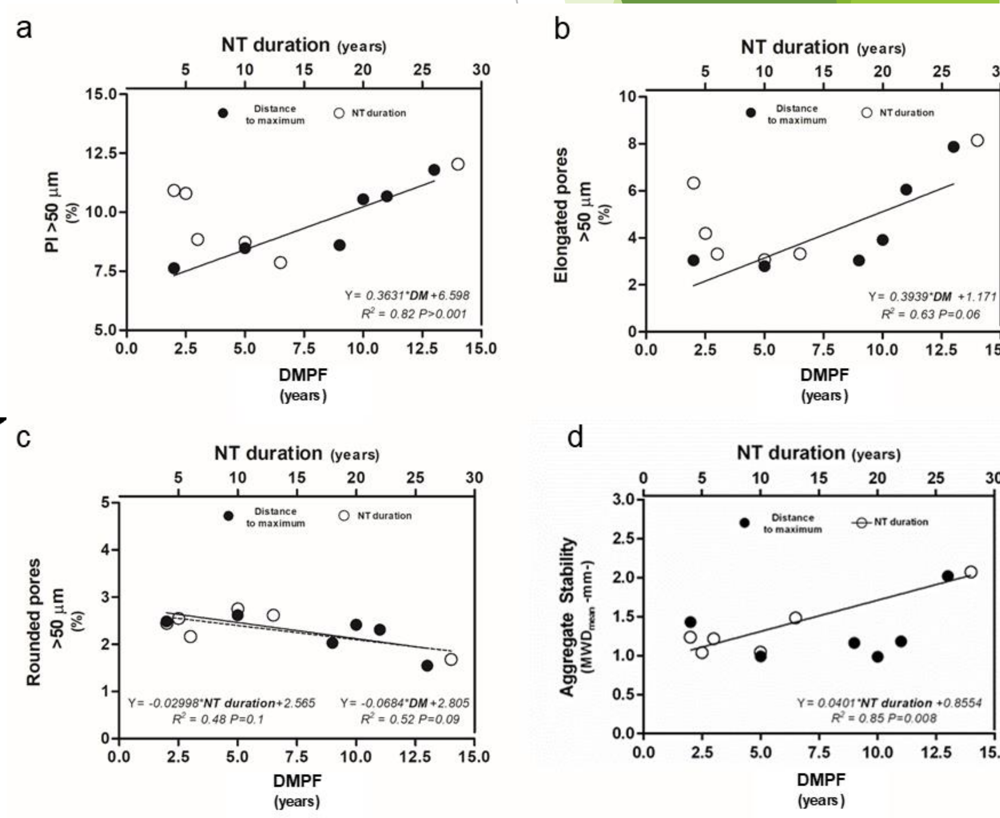


Behrends Kraemer and Morrás, 2023

Effects of NT convertion on porosity traits and aggregate stability

Structural arrangement
Aggregate stabilityt





Visiting Soil Structure

Structural arrangement
Aggregate stability

Visiting Soil Structure

Structural arrangement

Contents lists available at ScienceDirect

Soil & Tillage Research

journal homepage: www.elsevier.com/locate/still

Soil structure and glyphosate fate under no-till management in the Pampa region. II. Glyphosate and AMPA persistence and spatial distribution in the long-term. A conceptual model

H. Morrás[a,*], F. Behrends Kraemer[b,c,**], D. Sainz[a,b], P. Fernández[c,d], C. Chagas[b]

[a] Instituto de Suelos-CIRN-INTA, Argentina
[b] Cátedra de Manejo y Conservación de Suelos, Facultad de Agronomía, Universidad de Buenos Aires, Argentina
[c] CONICET, Argentina
[d] Cátedra de Fertilidad y Fertilizantes, Facultad de Agronomía, Universidad de Buenos Aires, Argentina

Table 1
Glyphosate and AMPA in runoff (rain simulation test) and in the soil (bulk samples). nd: non detected. Runoff rate (volume of water) and crop residues (weight) on the soil surface of each sub-plot. CV: coefficient of variation for each variable.

Sub-plots	Runoff		*Soil*		*Runoff water*	*Crop Residue*
	Glyphosate	AMPA	Glyphosate	AMPA		
	(μg L^{-1})	(μg L^{-1})	(μg Kg^{-1})	(μg Kg^{-1})	L h^{-1}	T ha^{-1}
1	2.14	nd	nd	110.42	2.42	3.23
2	1.97	nd	nd	47.89	1.89	3.08
3	1.62	nd	nd	29.6	1.41	3.88
4	nd	nd	nd	11.31	1.85	4.06
CV (%)	68.4			86.5	21.8	13.5

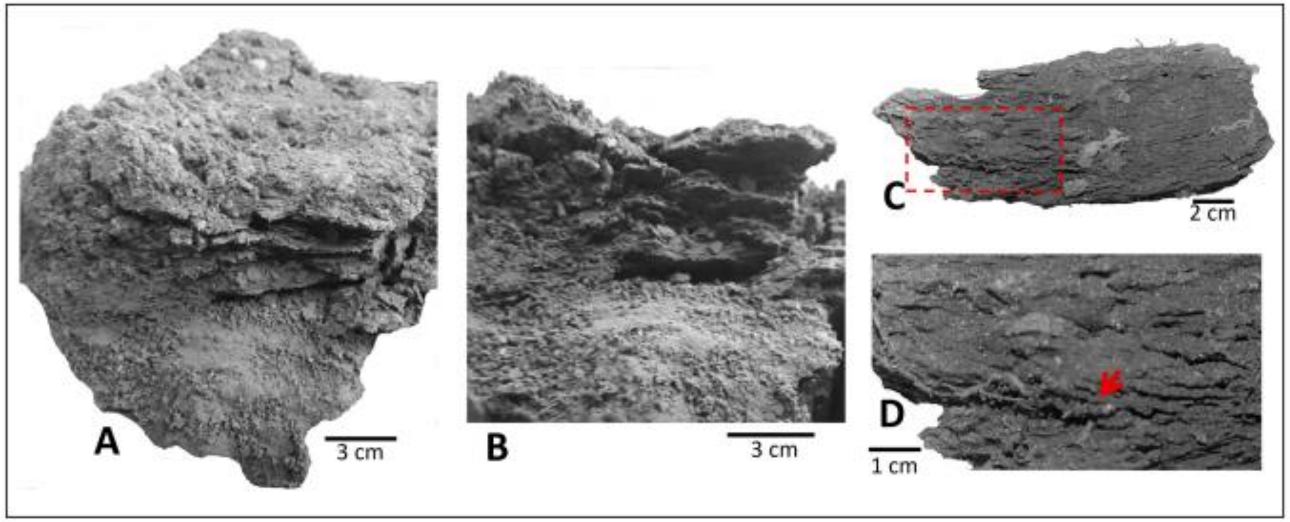


Fig. 1. A and B: monolith extracted from the surface soil horizon. Note the platy structure on top and the compact layer below. C: representative platy aggregate with large horizontal fissures. D: detail of the platy aggregate; note the root developing horizontally along the fissure (arrow).

- High structural anisotropy
- Different results for Glyphosate and AMPA Ocurrence ➔ Runoff or Soil

➔ Results intepretation were complex.

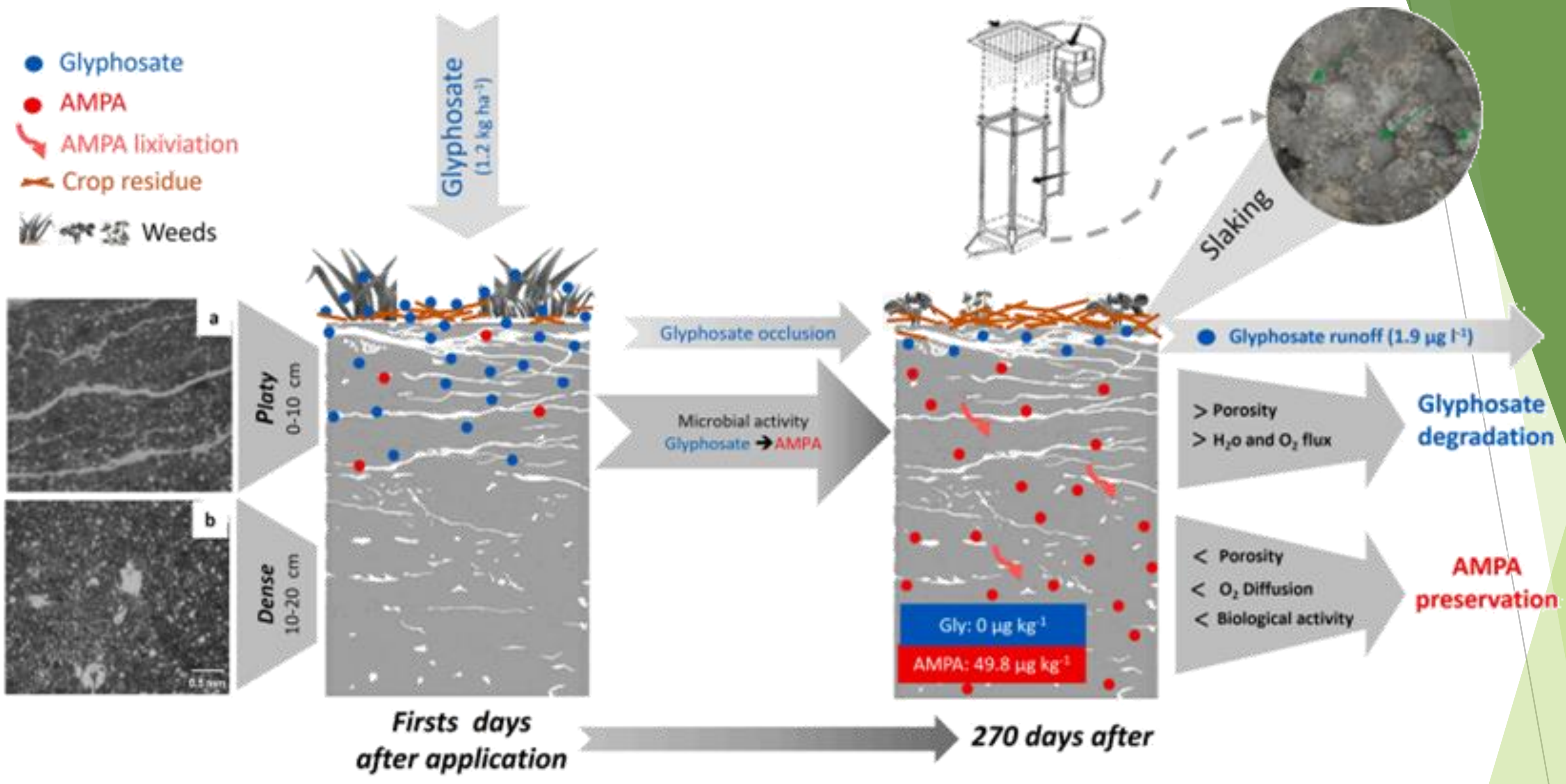
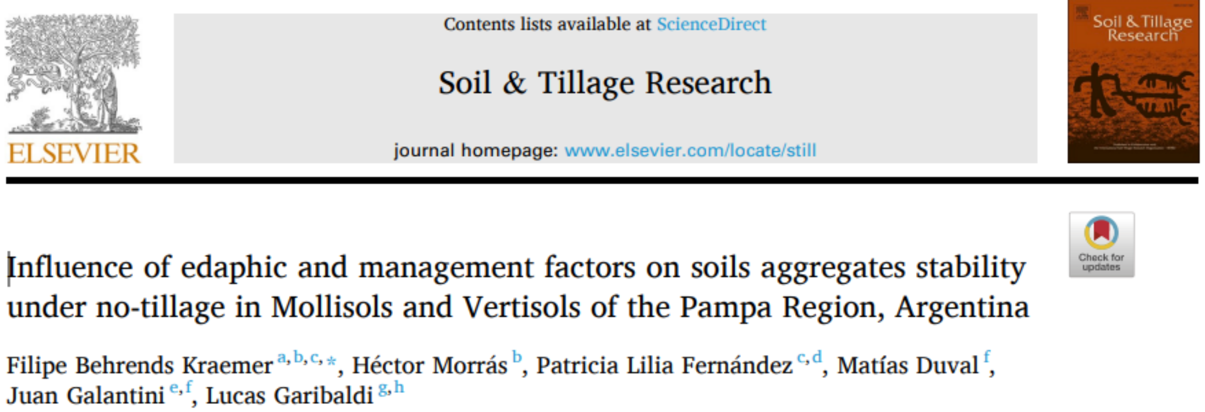


Fig. 2. Graphic representation of the conceptual model on the fate of Glyphosate and AMPA in the surface horizon of the soil under no-tillage. a) Microphotograph of the platy structure (open platy morphotype) in the upper soil layer. b) Microphotograph of the dense structure in the middle and lower part of the A horizon. The photo in the upper right corner shows the effect of raindrops from the simulator on the bare soil surface. In the present work, the tests were carried out with a scarce cover of soybean stubble and weed seedlings, with which the aggregate destruction was less intense than in the image.

- Knowledge of ***structural anysotropy*** let us understand GLY and AMPA dynamics
- Contrasting molecular sizes (GLY and AMPA), occlusion and differential ksat (volumen and orientation), biological activity, etc.

Visiting Soil Structure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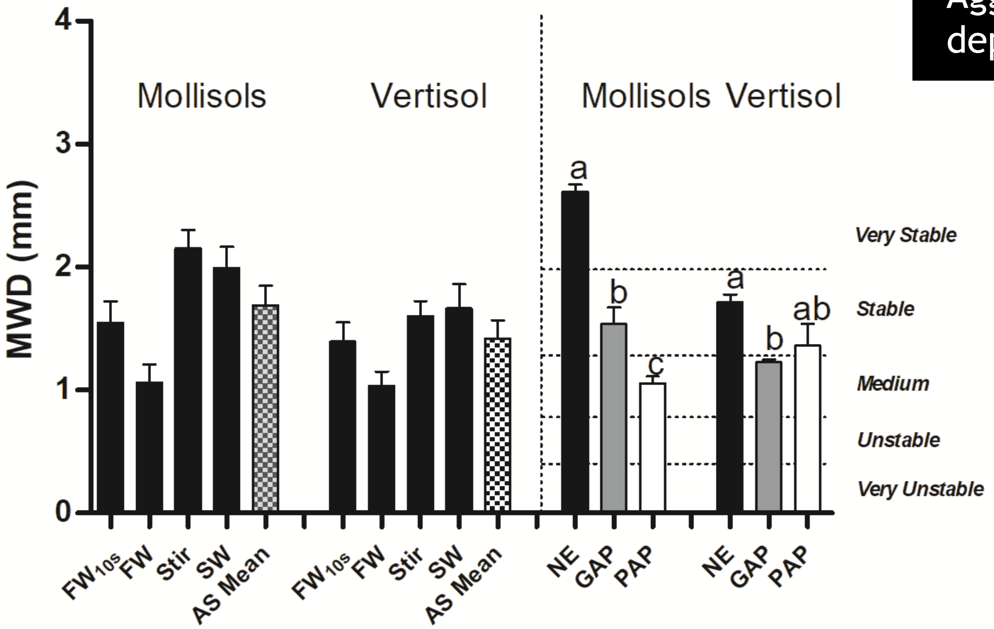
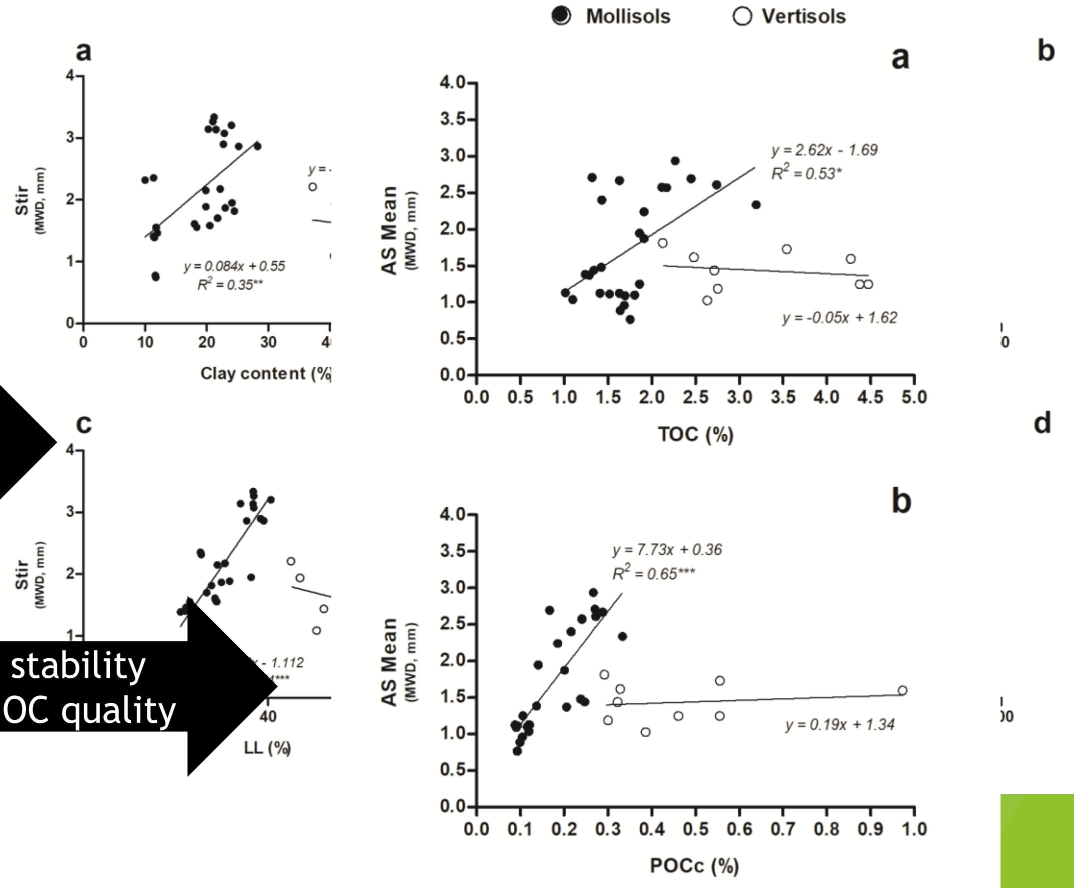
Influence of edaphic and management factors on soils aggregates stability under no-tillage in Mollisols and Vertisols of the Pampa Region, Argentina

Filipe Behrends Kraemer[a,b,c,*], Héctor Morrás[b], Patricia Lilia Fernández[c,d], Matías Duval[f], Juan Galantini[e,f], Lucas Garibaldi[g,h]

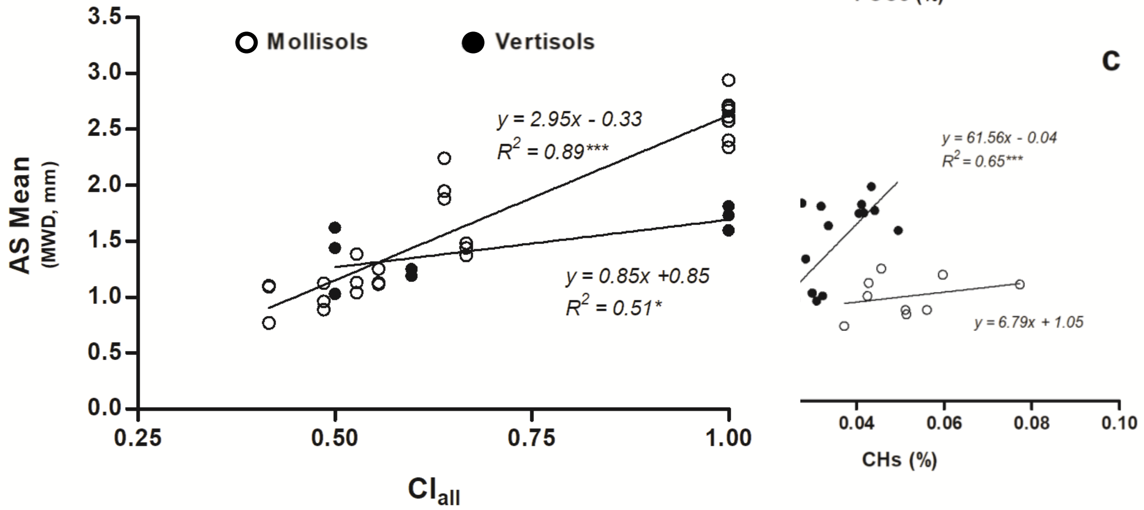


Aggregate stability depend on soil mineralogy



Aggregate stability depends on OC quality

Management effect
> intensif, > AS



Aggregate stability

Contents lists available at ScienceDirect

Geoderma

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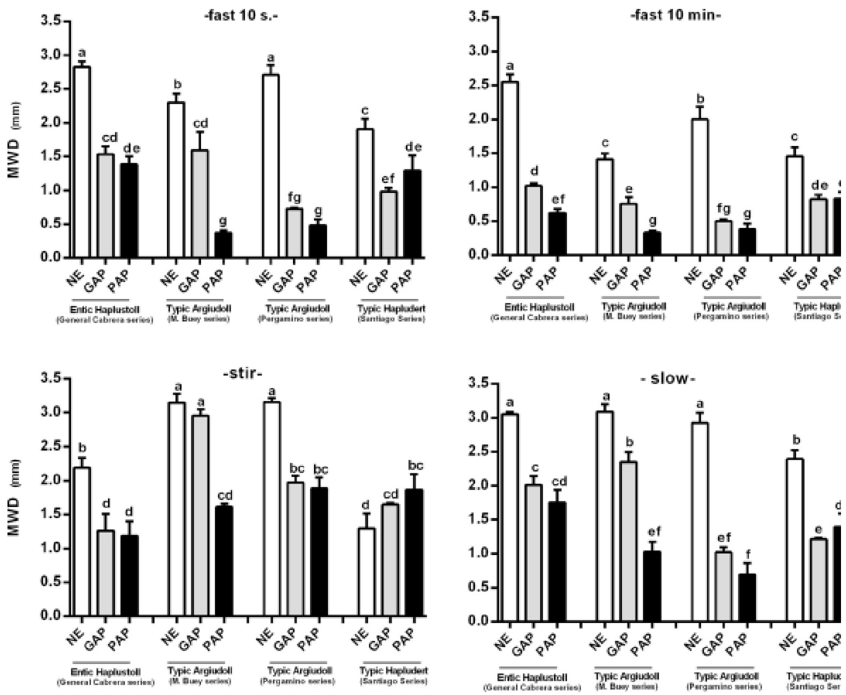
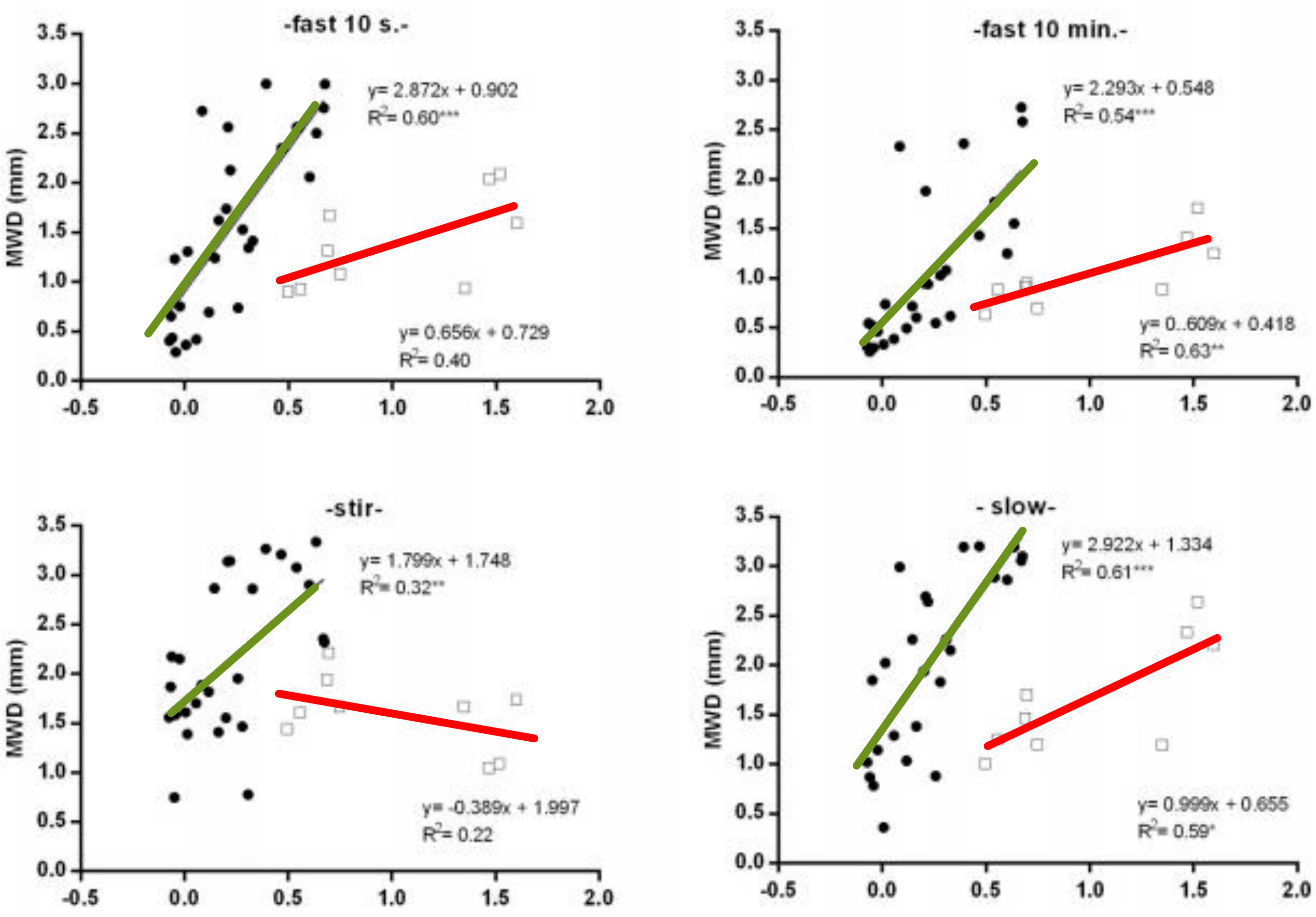
Aggregate stability

Soil stabilisation by water repellency under no-till management for soils with contrasting mineralogy and carbon quality

Filipe Behrends Kraemer[a,b,c,*], Paul D. Hallett[d], Héctor Morrás[b], Lucas Garib... [e,c]
Diego Cosentino[f,c], Matías Duval[g], Juan Galantini[g,h]



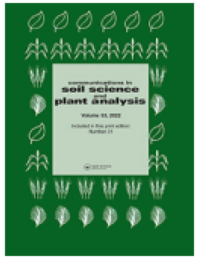
Mollisols ● ☐ Vertisols



Soil Hydrophobicity
(WDPT –Log10 s)

Visiting Soil Structure

Visiting Soil Structure



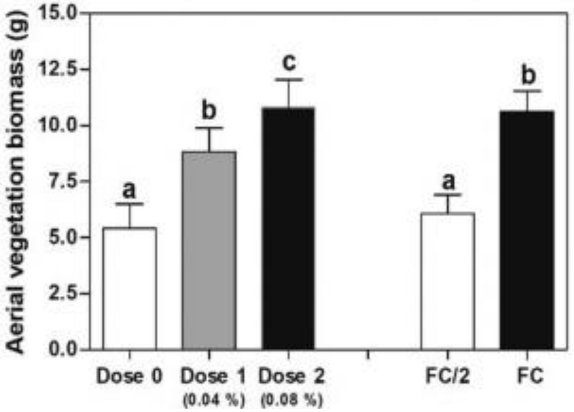
Communications in Soil Science and Plant Analysis

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/lcss20

Superabsorbent Polyacrylamide Effects on Hydrophysical Soil Properties and Plant Biomass in a Sandy Loam soil

P.L. Fernández, F. Behrends Kraemer, L. Sabatté, J. Guiroy & F. Gutierrez Boem

Vegetation



Soil shrinkage

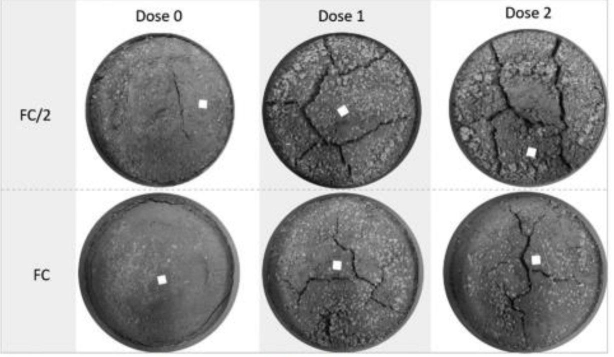


Figure 8. Examples of soil cracks (>400 µm) for different PAM doses (0%, 0.04%, and 0.08%) and water regime (FC: Field capacity; FC/2: Half of field capacity). White square over the soils in the center of the image represents a square centimeter.

Aggregate stability

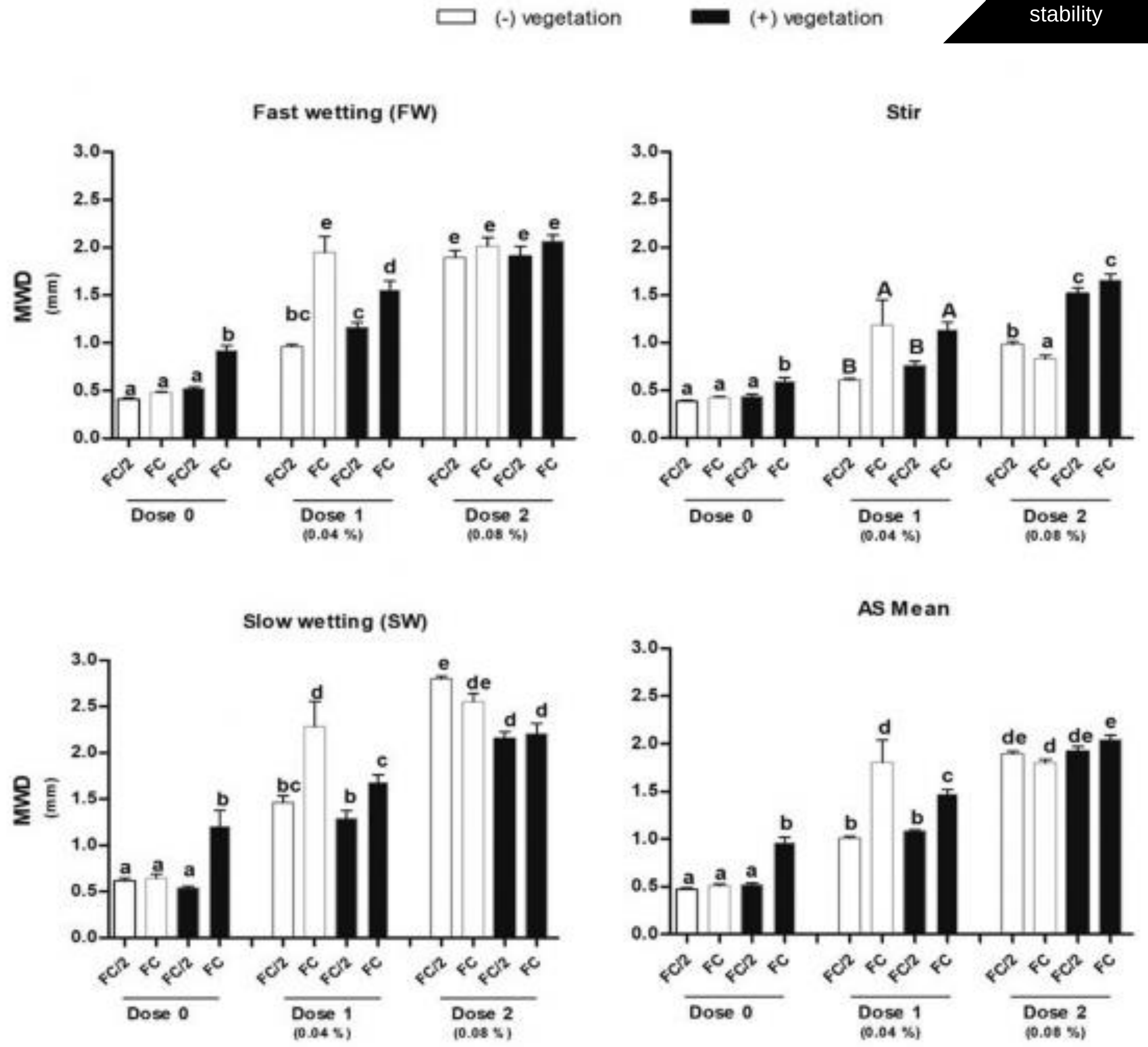


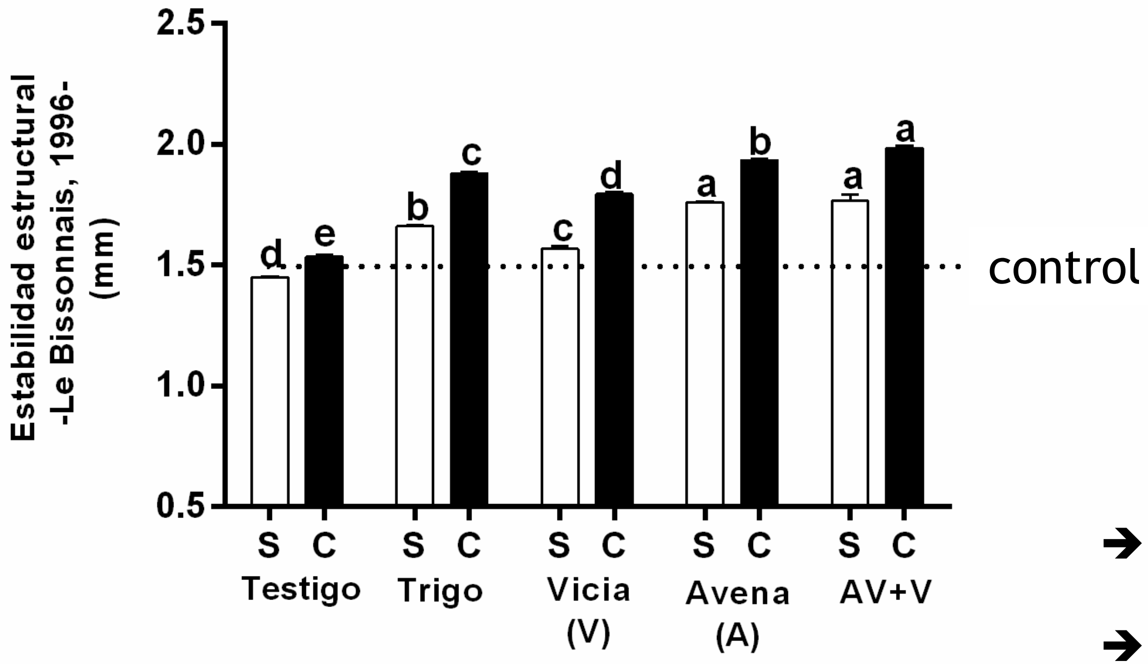
Figure 5. Aggregate stability (mean weight diameter: MWD) according to water regime (FC: Field capacity, FC/2: Half of field capacity), dose (D0: 0%, D1: 0.04%, D2: 0.08%), and vegetation for the different tests: fast wetting (FW), stirring aggregates after ethanol submersion (Stir), slow wetting (SW), and tests average (ASmean). Different small letters indicate significant differences for the triple interaction (P < .05). Capital letters indicate significant differences between water regime for Stir tests.

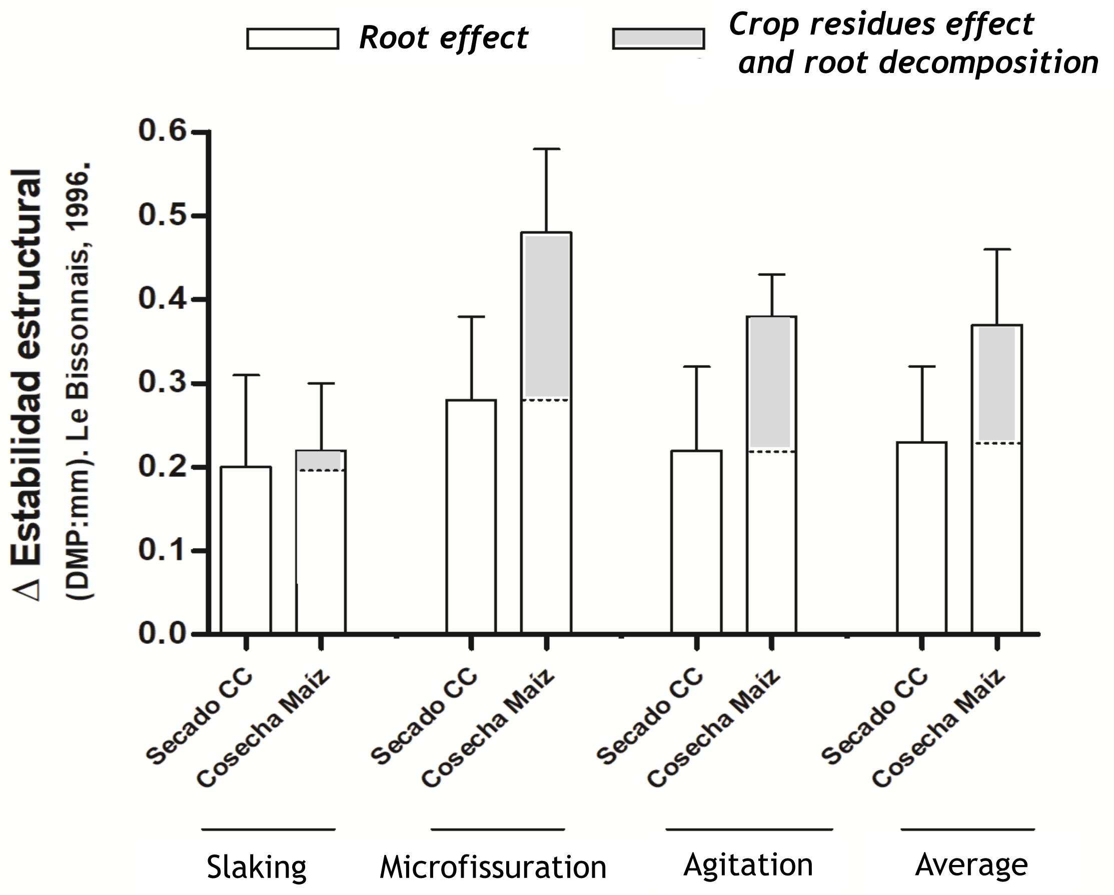
SHORT-TERM EFFECT OF COVER CROPS ON AGGREGATE STABILITY ASSESSED BY TWO TECHNIQUES

MARIO GUILLERMO CASTIGLIONI*[1], FILIPE BEHRENDS KRAEMER[1]

- Non-tillage and Cover crops-
- After CC and after chash crop harvest

- Capitán Sarmiento Series
- San Antonio de Areco, Buenos Aires





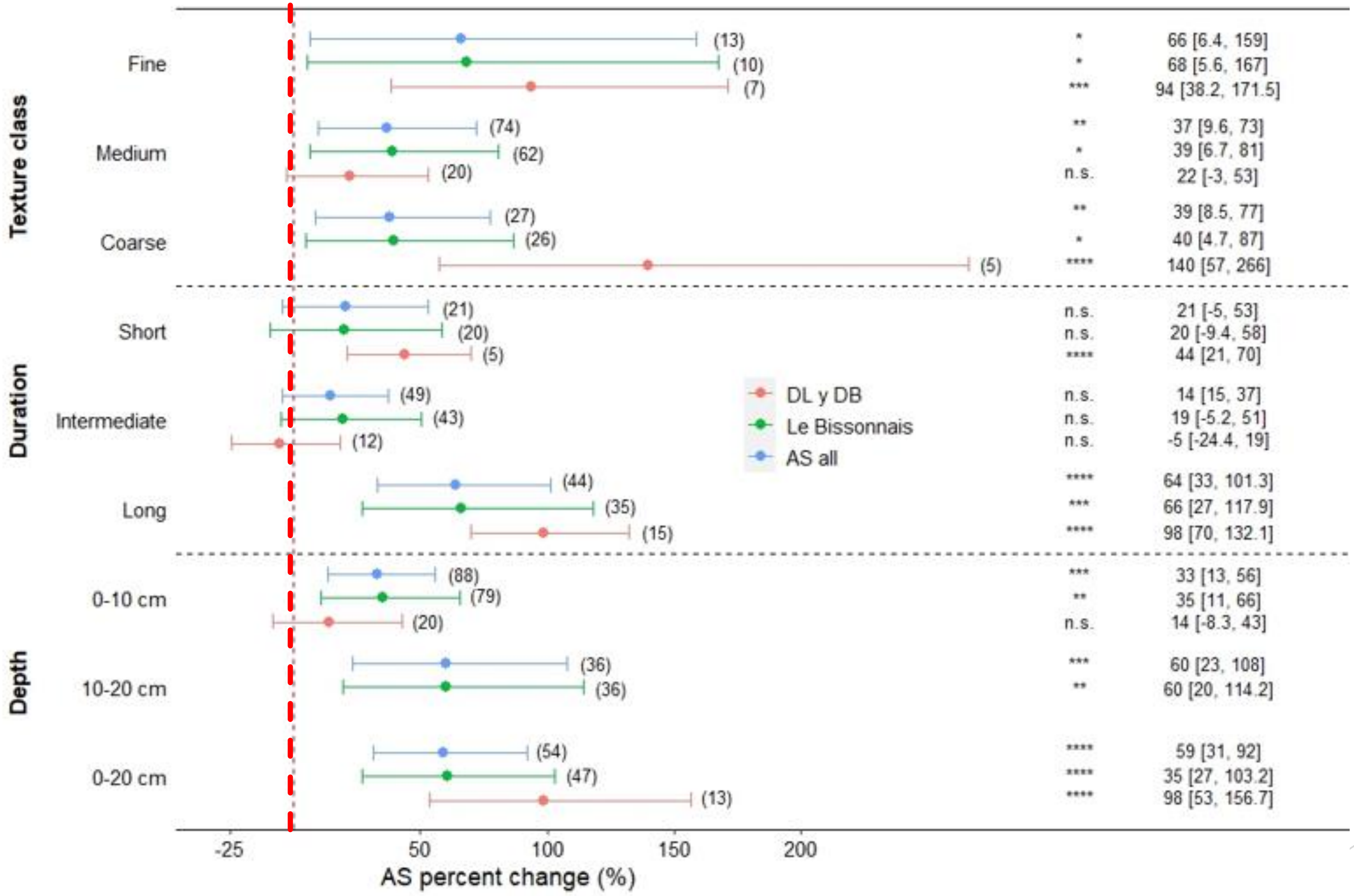
➔Le Bissonnais method ➔ diffents pre-treatments have diferent magnitude and dynamics through time

➔ Mechanistics information

➔ Differential contribution of roots and crop residue + root decomposition

Castiglioni y Behrends Kraemer, 2019

Intensification of the crop sequence improves soil carbon stock and aggregate stability: A meta-analysis of the central-estern of Argentina



>Crop intensification and >aggregate stability

Giustiniani, E.; Behrends Kraemer, F.; Garibaldi, L A, 2023.

Visiting Soil Structure

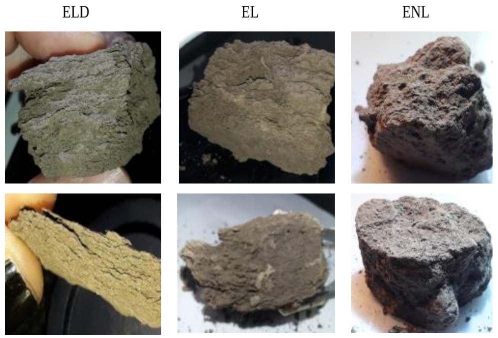
Another approach: *(inspired by Chenu and Horn research)*

Undisturbed soil structure (UnD)

Sieved soil (D)

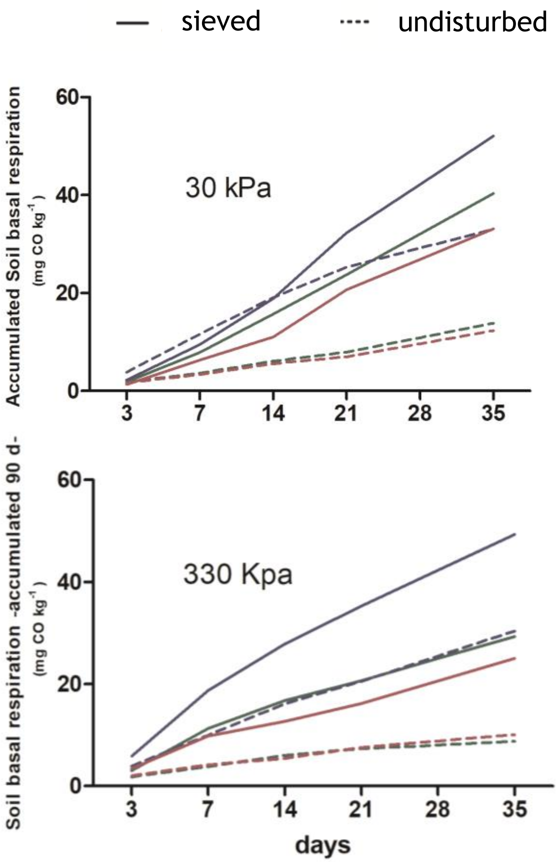
$$\frac{\text{UnD}}{\text{D}} = \frac{ƒ\ \cancel{\text{Adsorption and nutrients}}\ (\text{OC, pH, IF, granulometry})\ \text{and Soil Structure}}{ƒ\ \cancel{\text{Adsorption and nutrients}}\ (\text{OC, pH, IF, granulometry})} = \Delta\ \text{Soil Structure}$$

Effects of different *structural arrangement and* *water regime* on biological activity and glyphosate degradation in mesopores



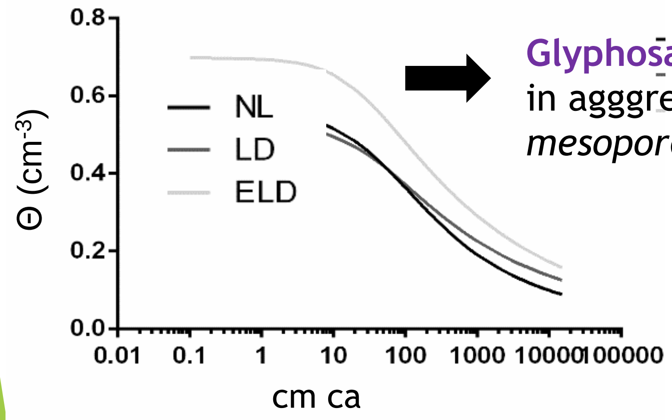
Sieved

Undisturbed

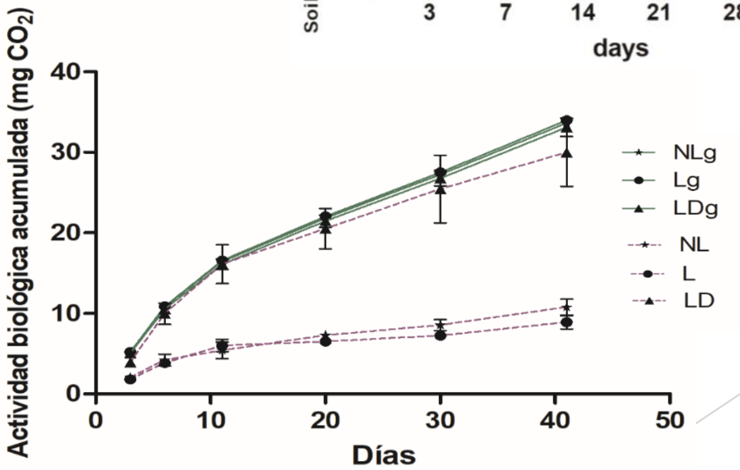


Soil respiration ratio between sieved/undisturbed

	-30 kpa	-300 kpa
Open platy	1,15	1,85
Platy	2,10	1,90
Dense	1,60	1,60



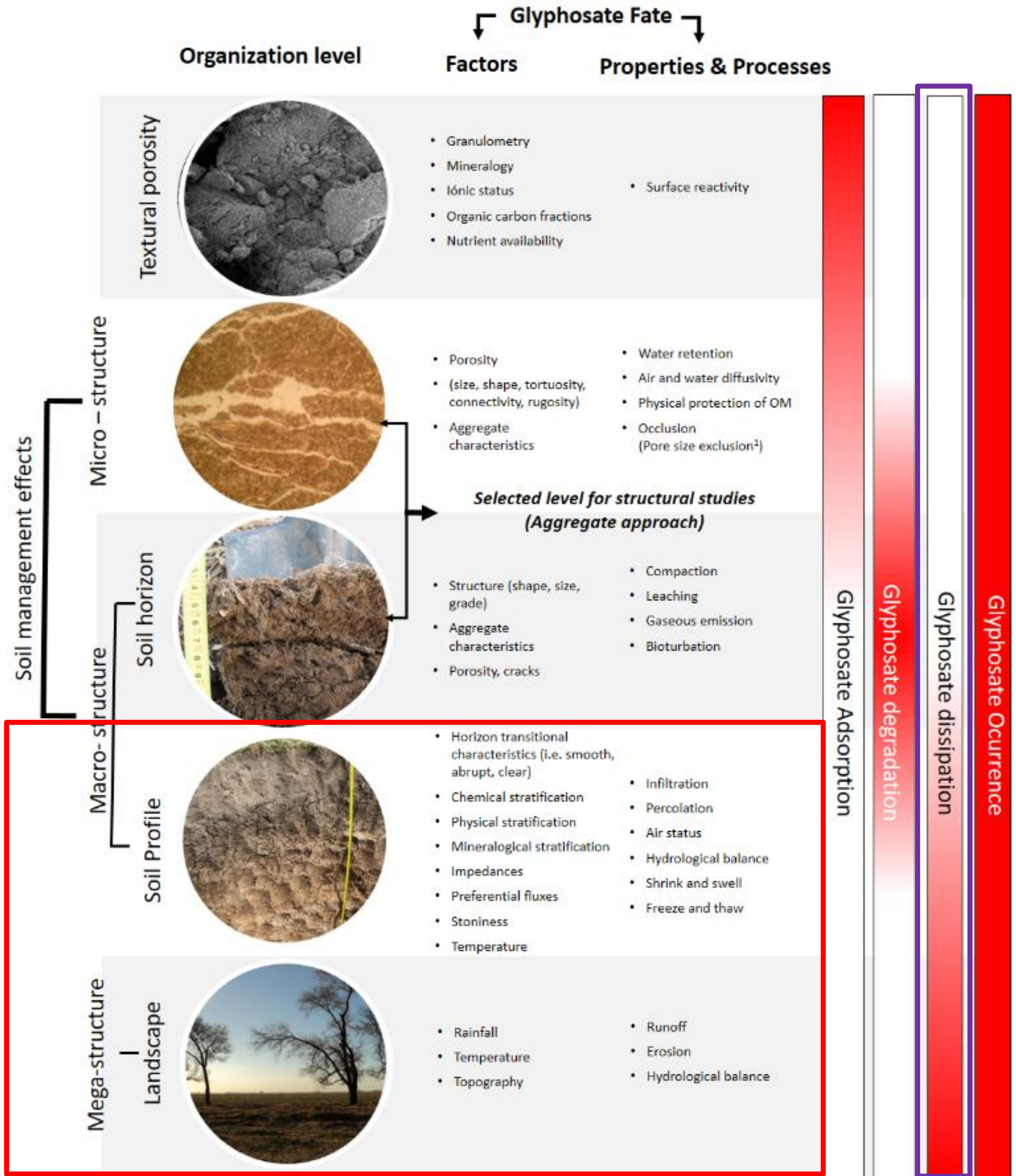
Glyphosate
in agggregates
mesopores



Platy and Dense W/GLY < soil respiration
Glyphosate ➔ equalizes differences
Open Platy ➔ Gly or no Gly =

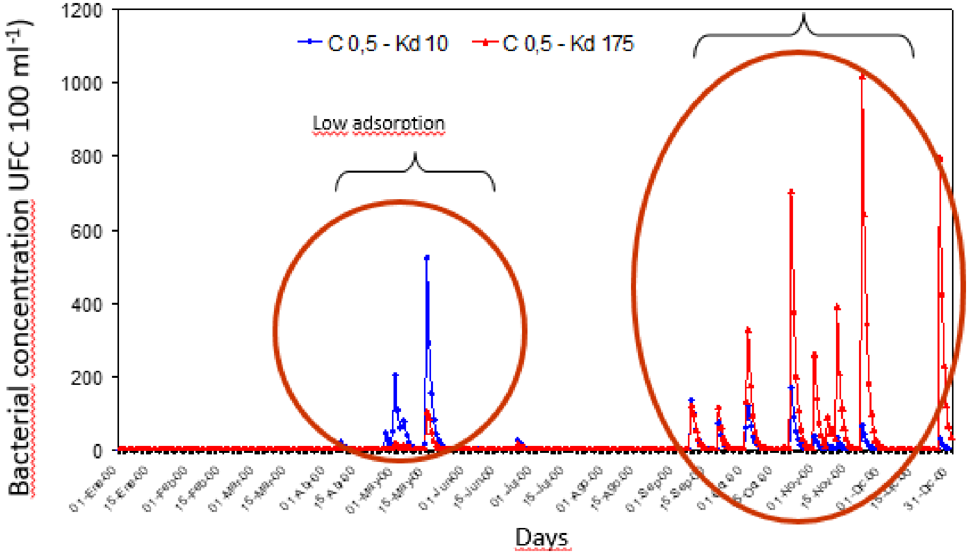
Sainz & Behrends Kraemer, in prep.

Visiting Soil Structure


Glyphosate Fate
Organization level
Factors
Properties & Processes
Textural porosity
Granulometry
Mineralogy
Iónic status
Organic carbon fractions
Nutrient availability
Surface reactivity
Micro – structure
Porosity
(size, shape, tortuosity, connectivity, rugosity)
Aggregate characteristics
Water retention
Air and water diffusivity
Physical protection of OM
Occlusion
(Pore size exclusion[1])
Selected level for structural studies
(Aggregate approach)
Soil management effects
Macro- structure
Soil horizon
Structure (shape, size, grade)
Aggregate characteristics
Porosity, cracks
Compaction
Leaching
Gaseous emission
Bioturbation
Soil Profile
Horizon transitional characteristics (i.e. smooth, abrupt, clear)
Chemical stratification
Physical stratification
Mineralogical stratification
Impedances
Preferential fluxes
Stoniness
Temperature
Infiltration
Percolation
Air status
Hydrological balance
Shrink and swell
Freeze and thaw
Mega-structure
Landscape
Rainfall
Temperature
Topography
Runoff
Erosion
Hydrological balance
Glyphosate Adsorption
Glyphosate degradation
Glyphosate dissipation
Glyphosate Ocurrence

Complexicity

SWAT model



Behrends Kraemer et al., 2014

AACS
ASOCIACION ARGENTINA CIENCIA DEL SUELO

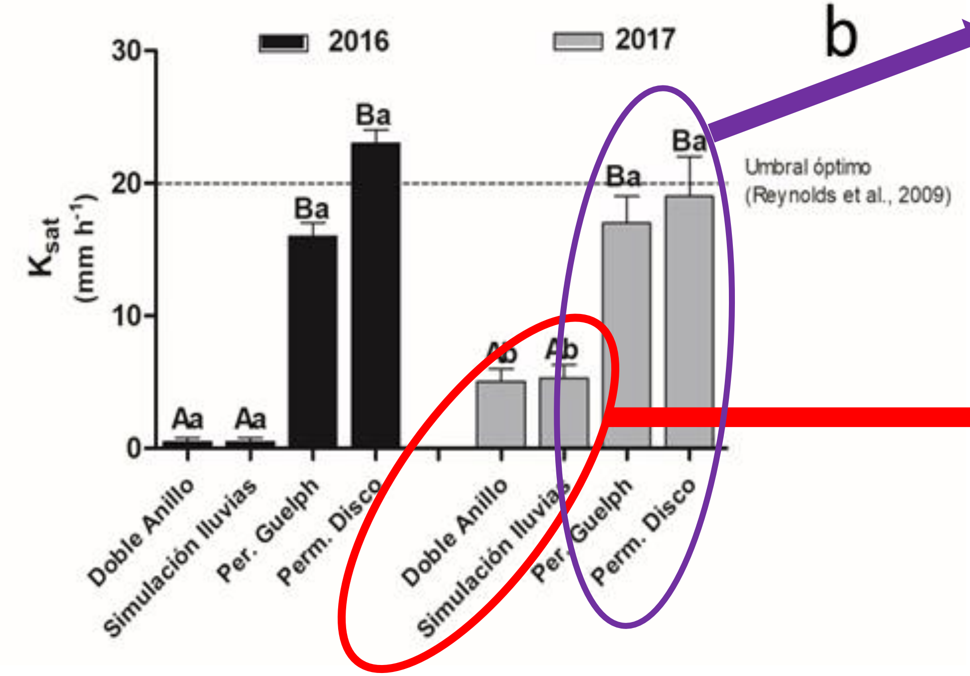
CIENCIA DEL SUELO

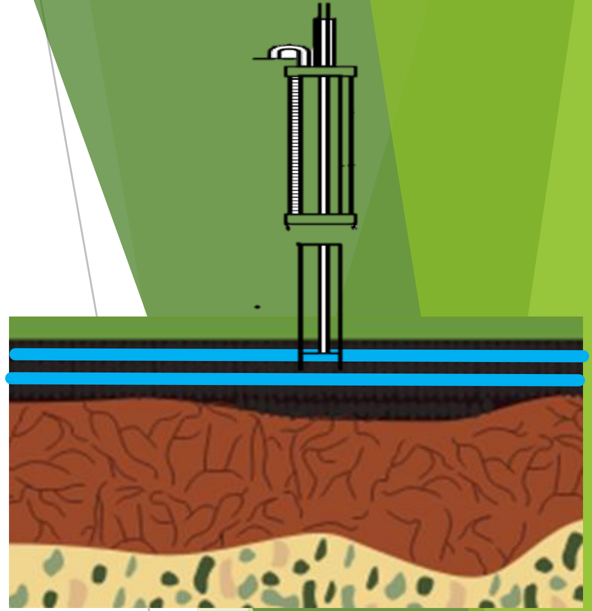
CONDUCTIVIDAD HIDRÁULICA SATURADA DETERMINADA POR DISTINTOS PROCEDIMIENTOS EN SUELOS CON ALTA HUMEDAD INICIAL

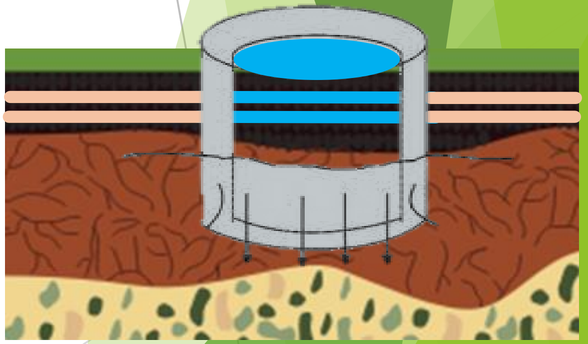
MARIO GUILLERMO CASTIGLION[1]*, FILIPE BEHRENDS KRAEMER[1-2],
JOHN JAIRO MARQUEZ MOLINA[1]

a

b







- Strong effects of platy structures on Ksat
- Runoff - Subsoil lateral water movement

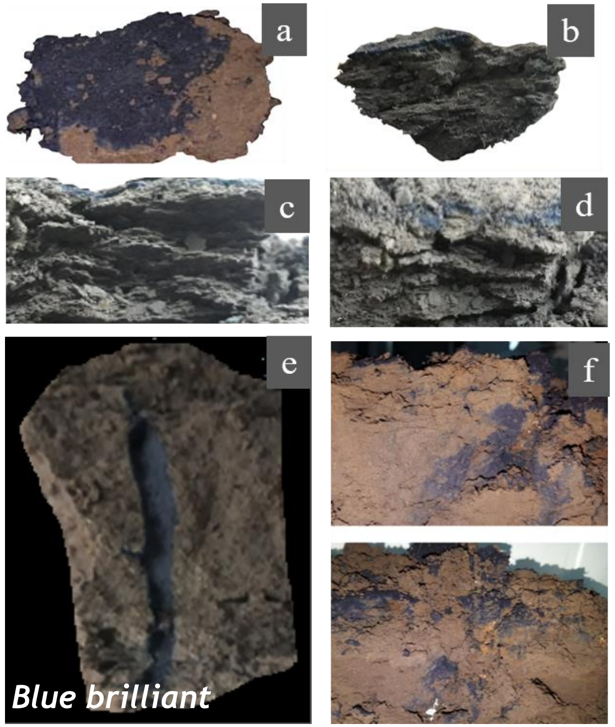
Soil hydro-physical variables and crop residues determinates runoff, soil loss, Glyphosate and AMPA concentration in the aqueous phase under simulated rainfall events

W&D 10 cycles

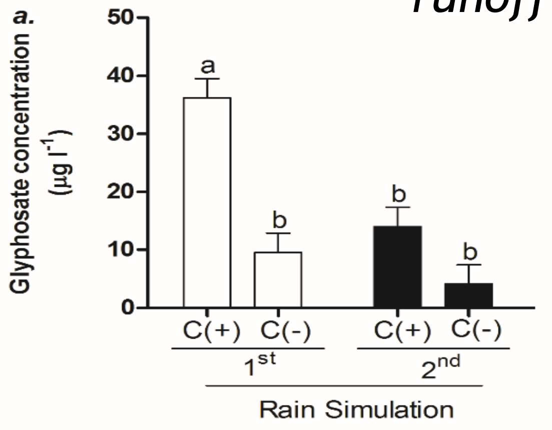
Cover & Bare

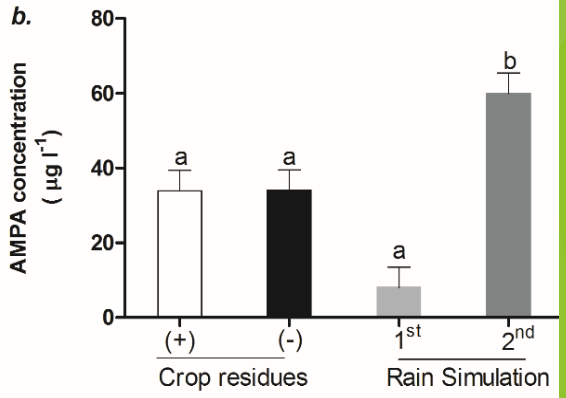
Glyphosate Application (1,8 L ha)

10 samples with different ***platy structure*** ≠ depth and conformation



runoff





Sainz, D., Behrends Kraemer, F., , et al., 2023 (sent Plant and Soil Analyses)

Visiting Soil Structure

Contents lists available at ScienceDirect

Soil & Tillage Research

journal homepage: www.elsevier.com/locate/still

Pesticide dynamics in agroecosystems: Assessing climatic and hydro-physical effects in a soybean cycle under no-tillage

F. Behrends Kraemer[a,b,*], M.G. Castiglioni[a], C.I. Chagas[a], R. De Paula[c], D.S. Sainz[a,d], E. De Gerónimo[e], V. Aparicio[e], D.O. Ferraro[b,f]

[a] Cátedra de Manejo y Conservación de Suelos, Facultad de Agronomía, Universidad de Buenos Aires, Argentina
[b] CONICET, Argentina
[c] Cátedra de Cerealicultura, Facultad de Agronomía, Universidad de Buenos Aires, Argentina
[d] Instituto de Suelos-CIRN-INTA, Argentina
[e] Instituto Nacional de Tecnología Agropecuaria (INTA), Estación Experimental Agropecuaria Balcarce, Argentina
[f] Cátedra de Cerealicultura, Universidad de Buenos Aires, Argentina

Pesticide dynamics:

- Rainfall erosivity
- Cultural Profile
- Ksat and rainfall sim. Ksat
- OC-pH-SWR

Fig. 3. Cultural profiles of the evaluated soils with images analyses of soil structural types (% of the A horizon). Γ: Granular/Subangular; Δ: Compacted with no visible porosity; Φ: near compacted with visible porosity, and P: Platy structures (a=between Block 1 and 2; b= between Block 2 and 3).

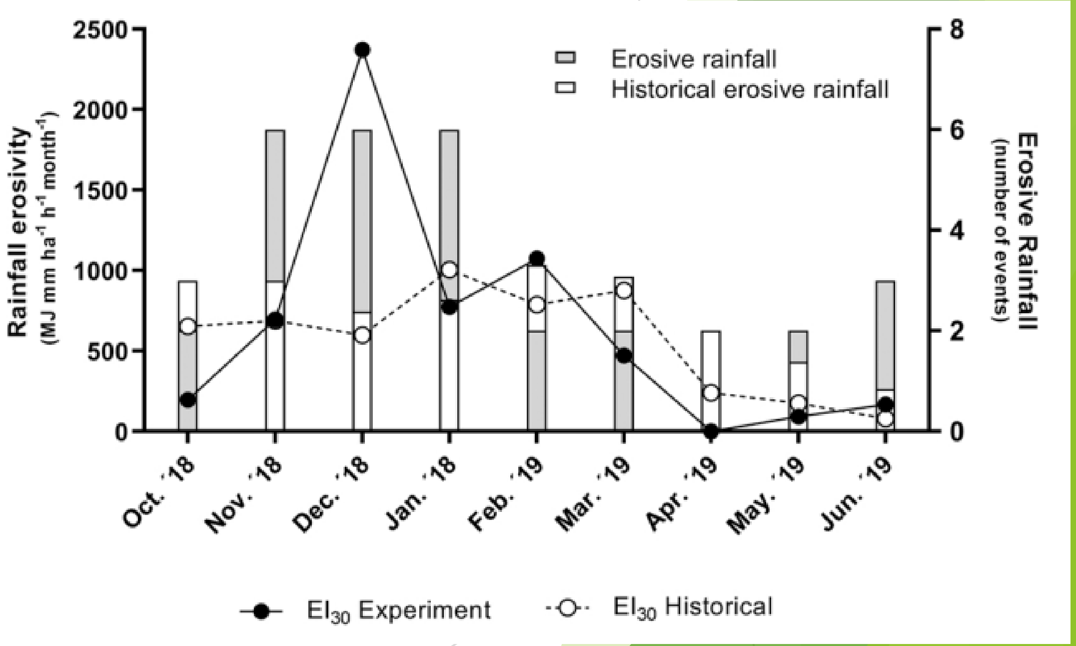
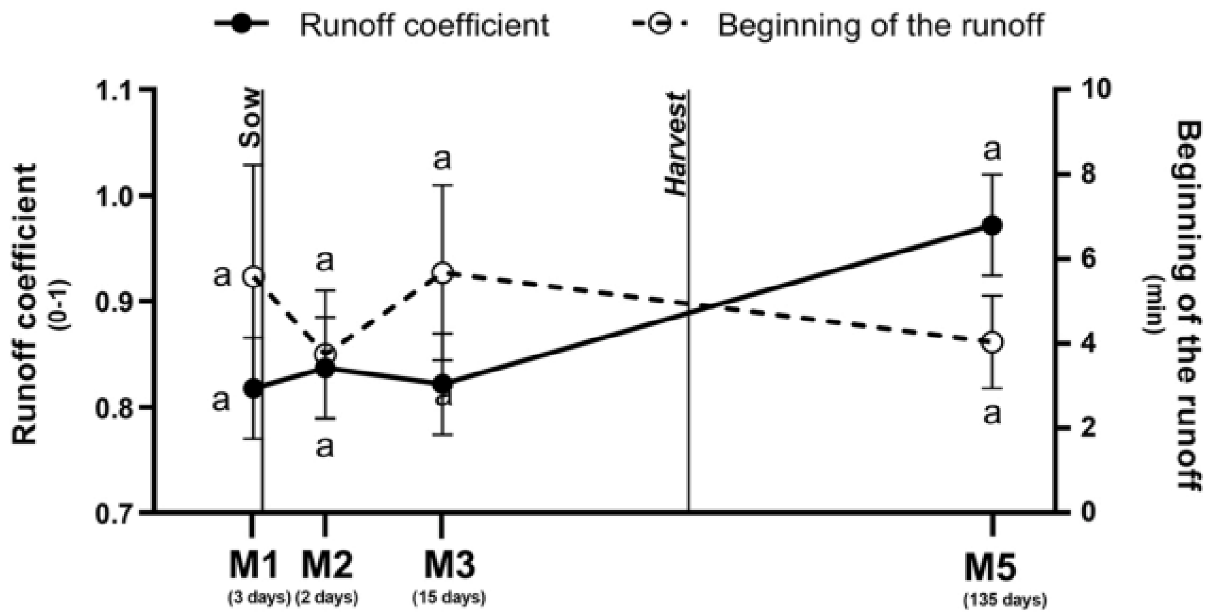
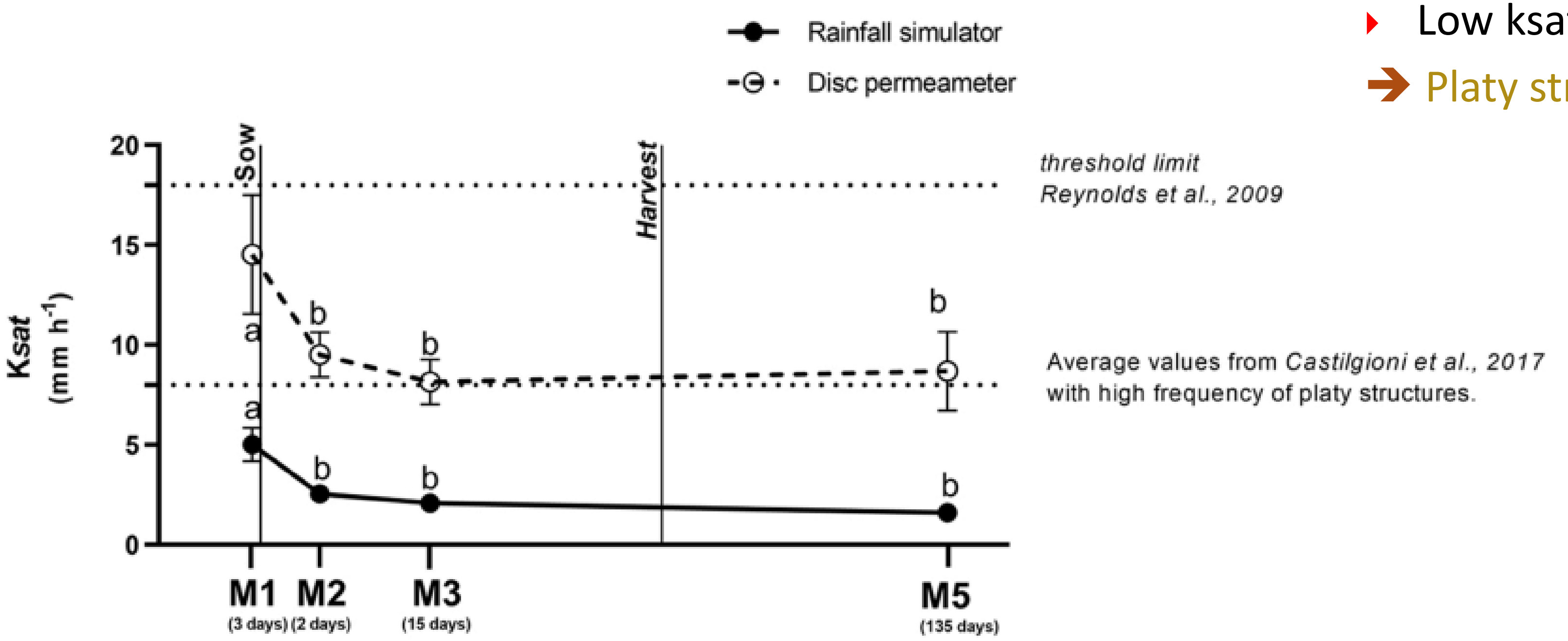


Fig. 2. Monthly rainfall erosivity and number of erosive rainfall events (>13 mm day^{-1}) for historical averages (1999–2017) and for the study period.

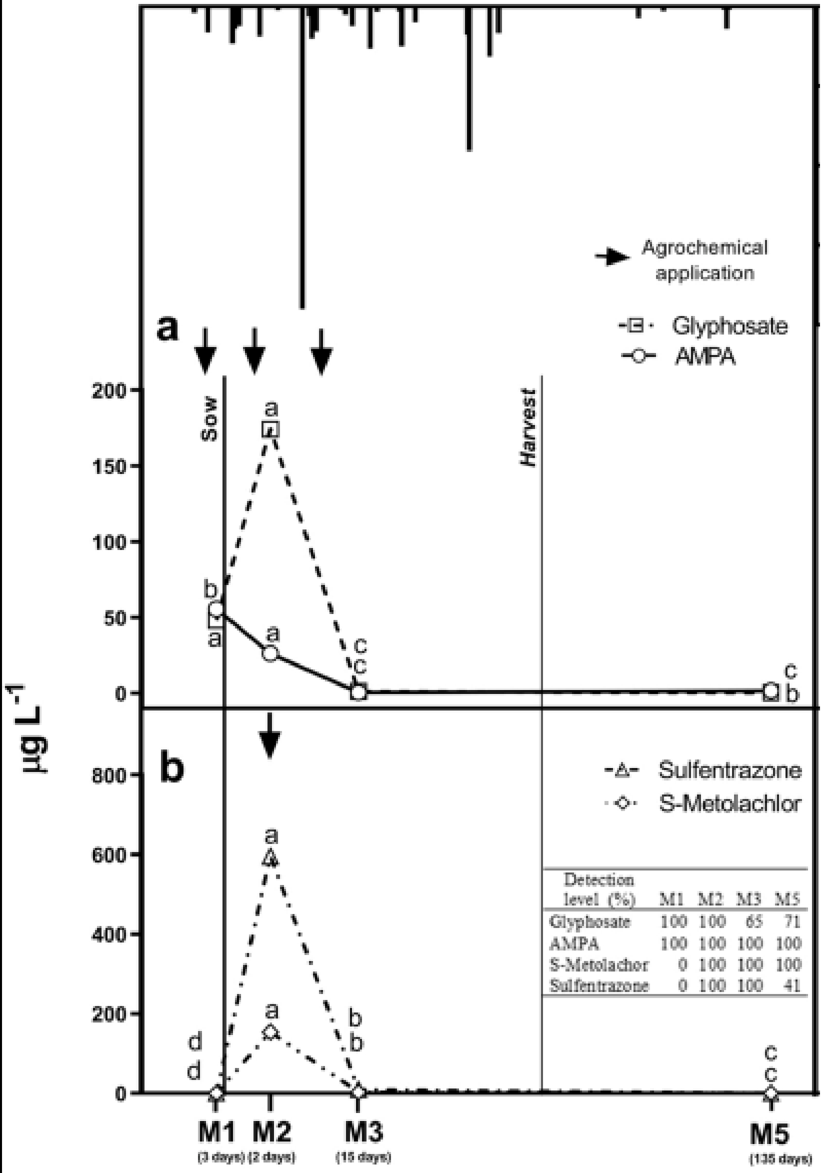




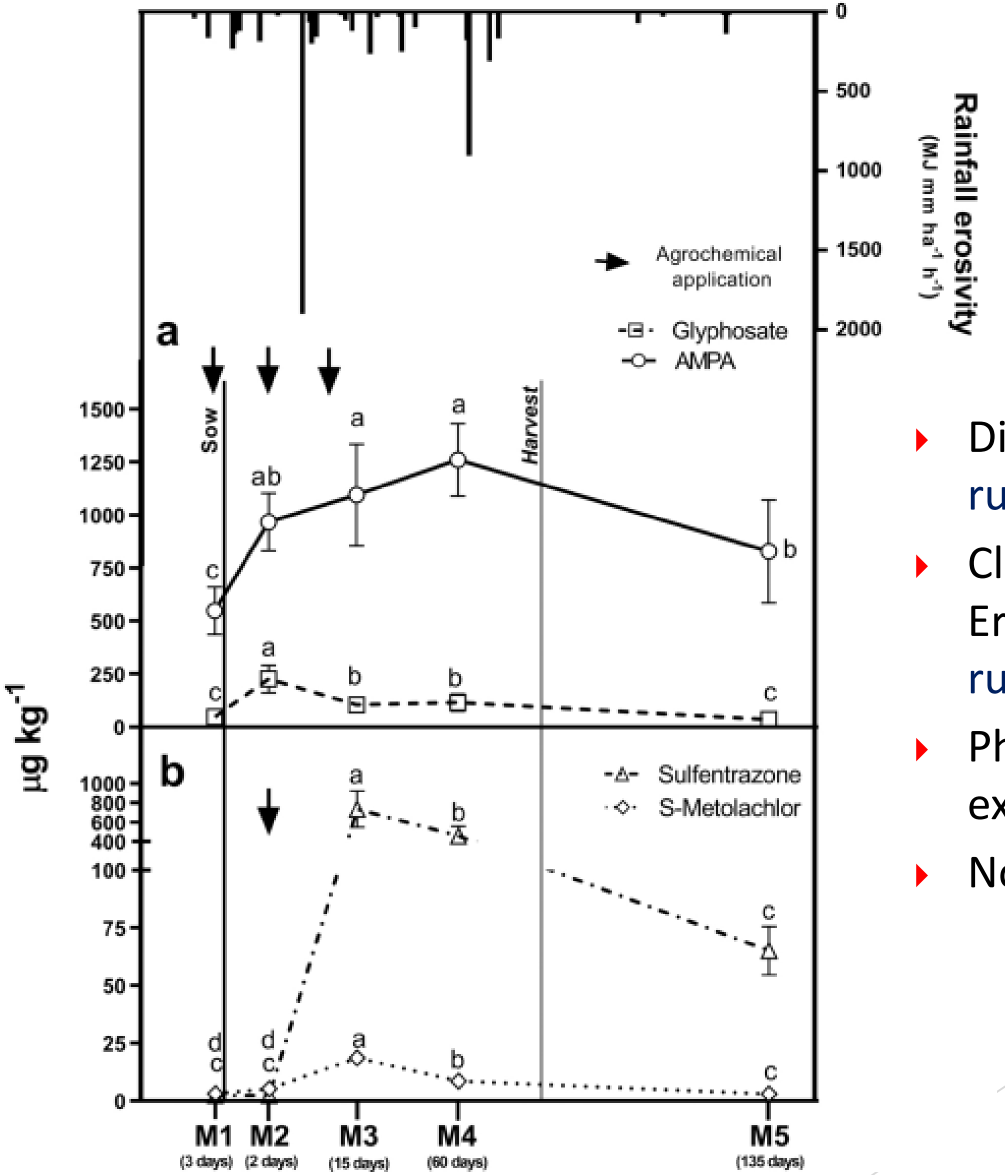
- High runoff coefficient
- Low ksat (lower in rainfall sim)

➔ Platy structure and poor AS

Runoff



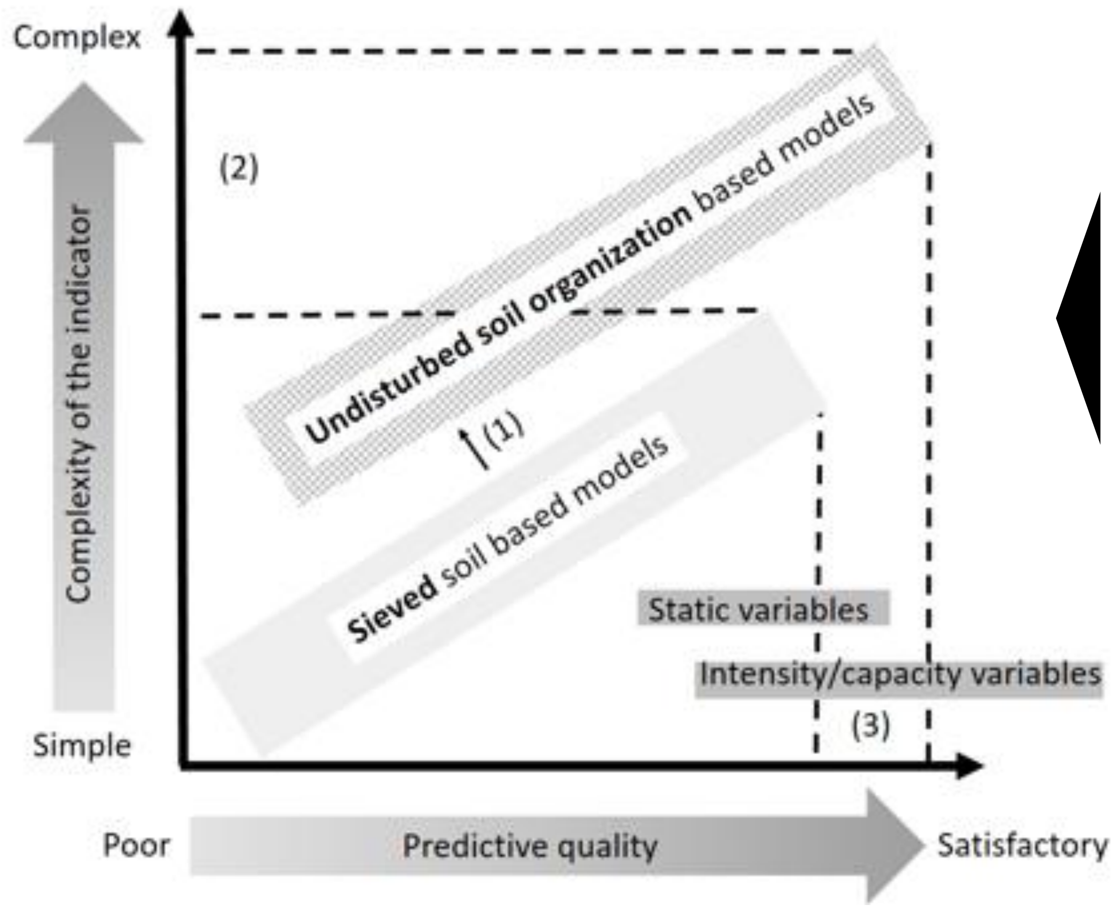
Soil

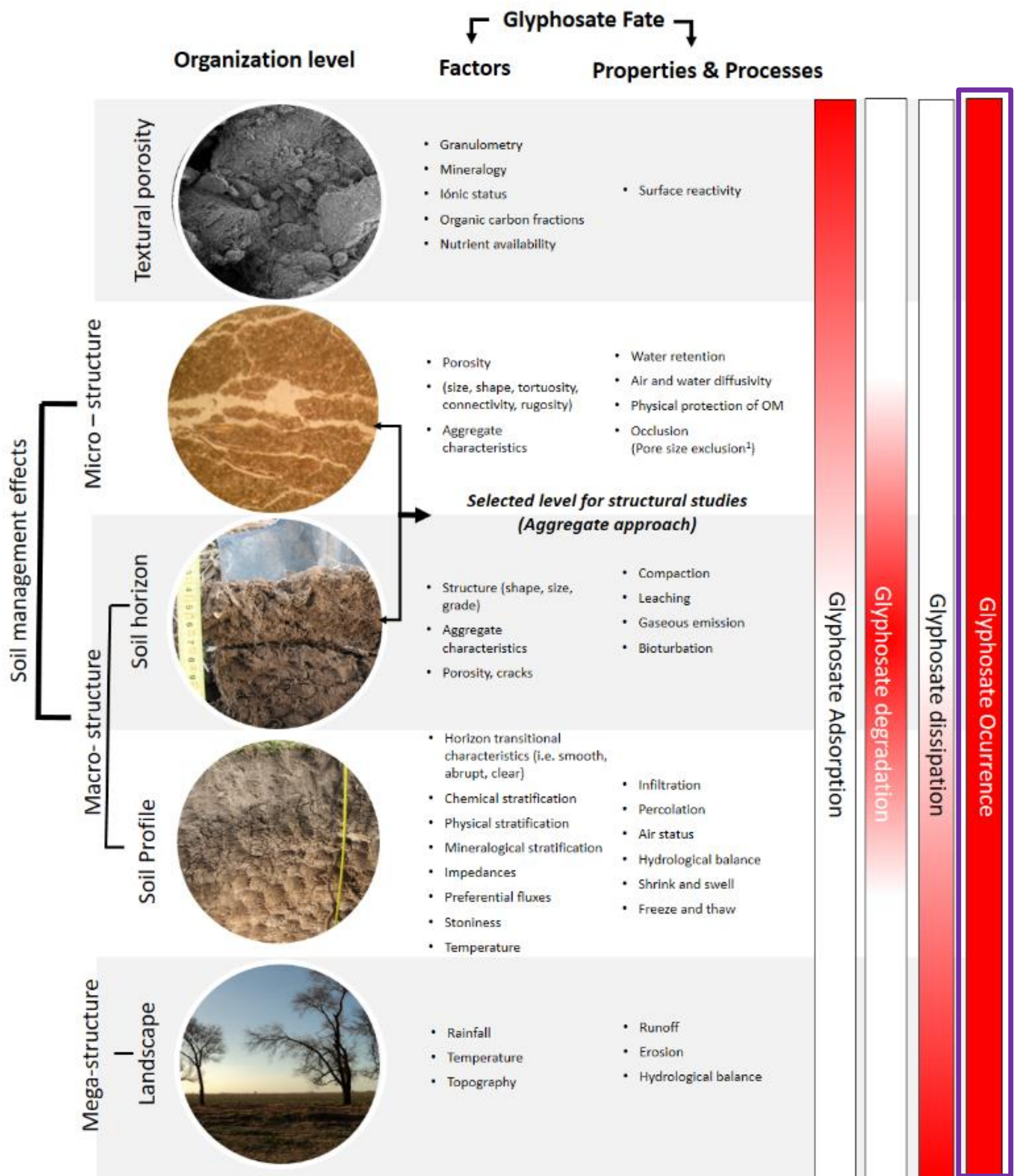


- Different pesticides dynamics in runoff and soil
- Close relationship between Erosivity and Ksat ➔ pesticides in runoff
- Physical and chemical constraints explain pesticide dynamics
- No pesticide acumulation

Ex-situ contamination

Final Remarks





Filipović, V., Coquet, Y., Pot, V., Houot, S., Benoit, P. (2014).

Merci!

filipebk@agro.uba.ar