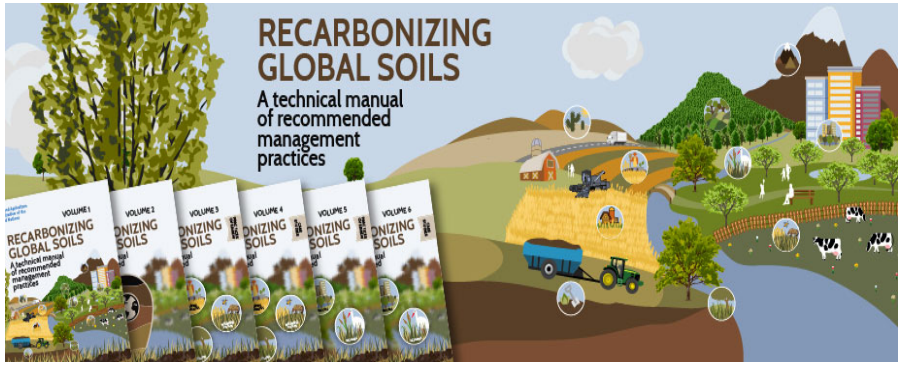
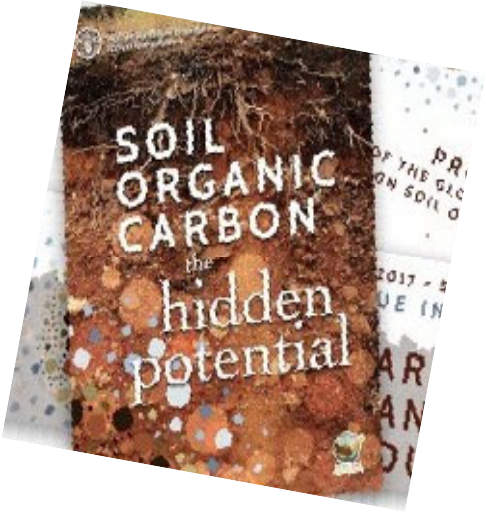




La sostanza organica naturale, fattore chiave per la sostenibilità

(Riccardo Spaccini)

DIPARTIMENTO DI AGRARIA

Caffè Scientifico 18 Settembre 2024

SCUOLA DI AGRARIA E MEDICINA VETERINARIA 2024 — IL caffè SCIENTIFICO

Full Professor Agricultural Chemistry (SSD AGRI-06/B)
DIA-UNINA

Director NMR Research Center CERMANU

Research activities:

SOM management, SOC dynamic

Biomasses recycling, NOM-plant interaction

Bioactive compounds (biostimulant & biocontrol)

Teaching: Organic Fertilizers and Plant Biostimulants

website: https://www.docenti.unina.it/riccardo.spaccini
Orcid: https://orcid.org/0000-0002-9828-1992

A significant extension of the agricultural lands worldwide is moderately or severely degraded, and nearly 2 billion hectares – an area twice the size of China – is seriously degraded, sometimes irreversibly (*FAO Sustainable Soil/Land Management for Climate-Smart Agriculture)*

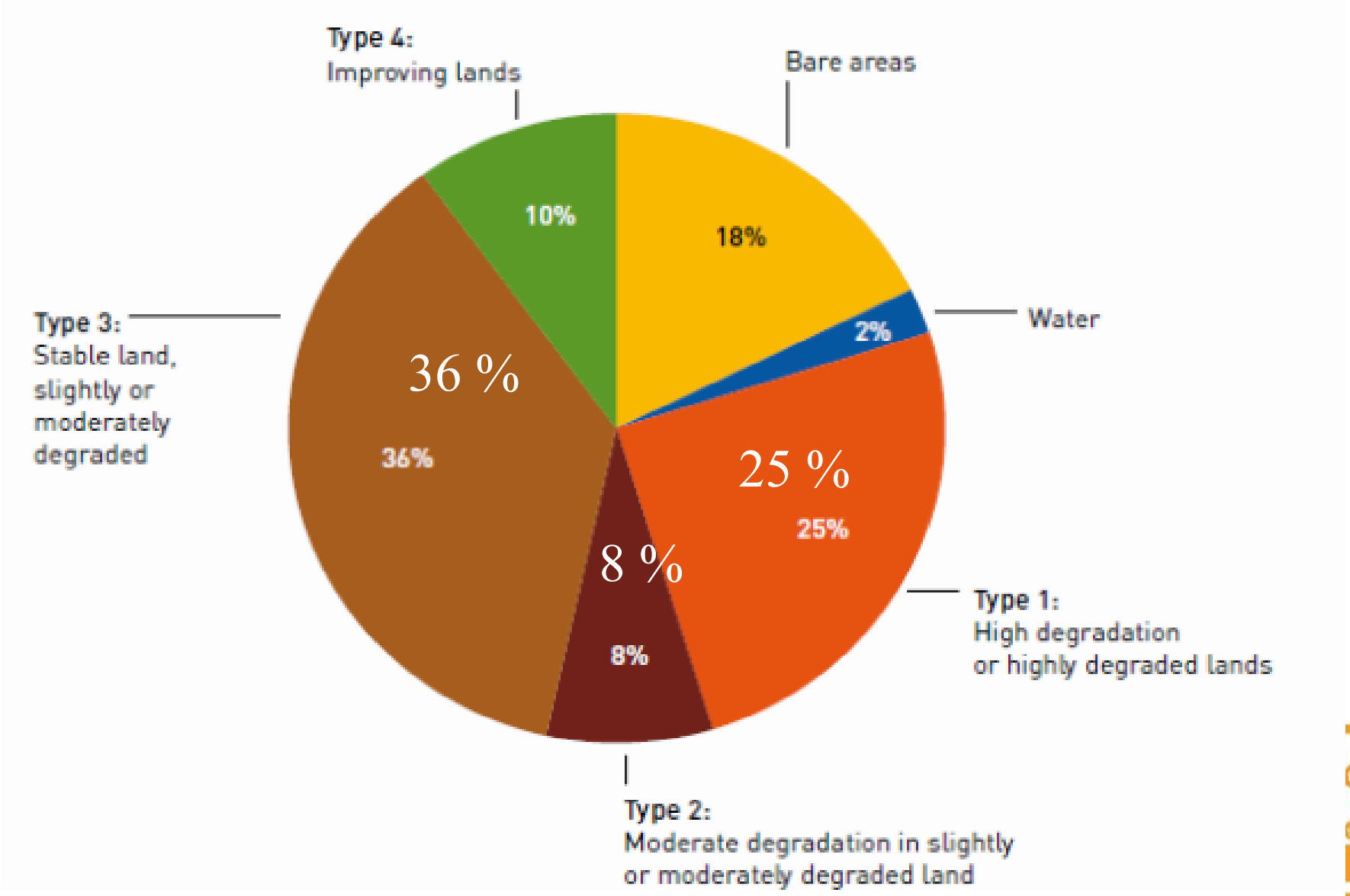
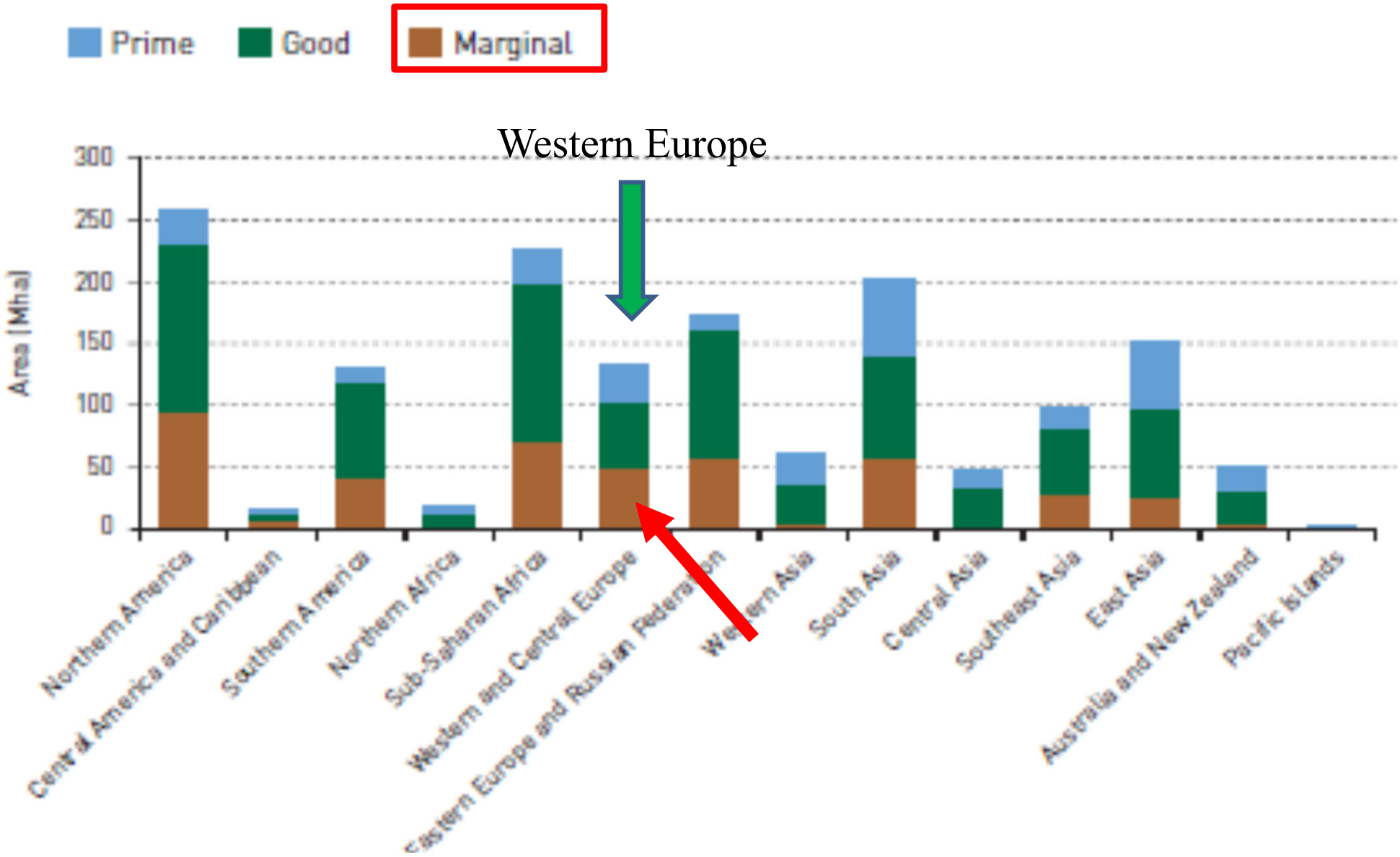
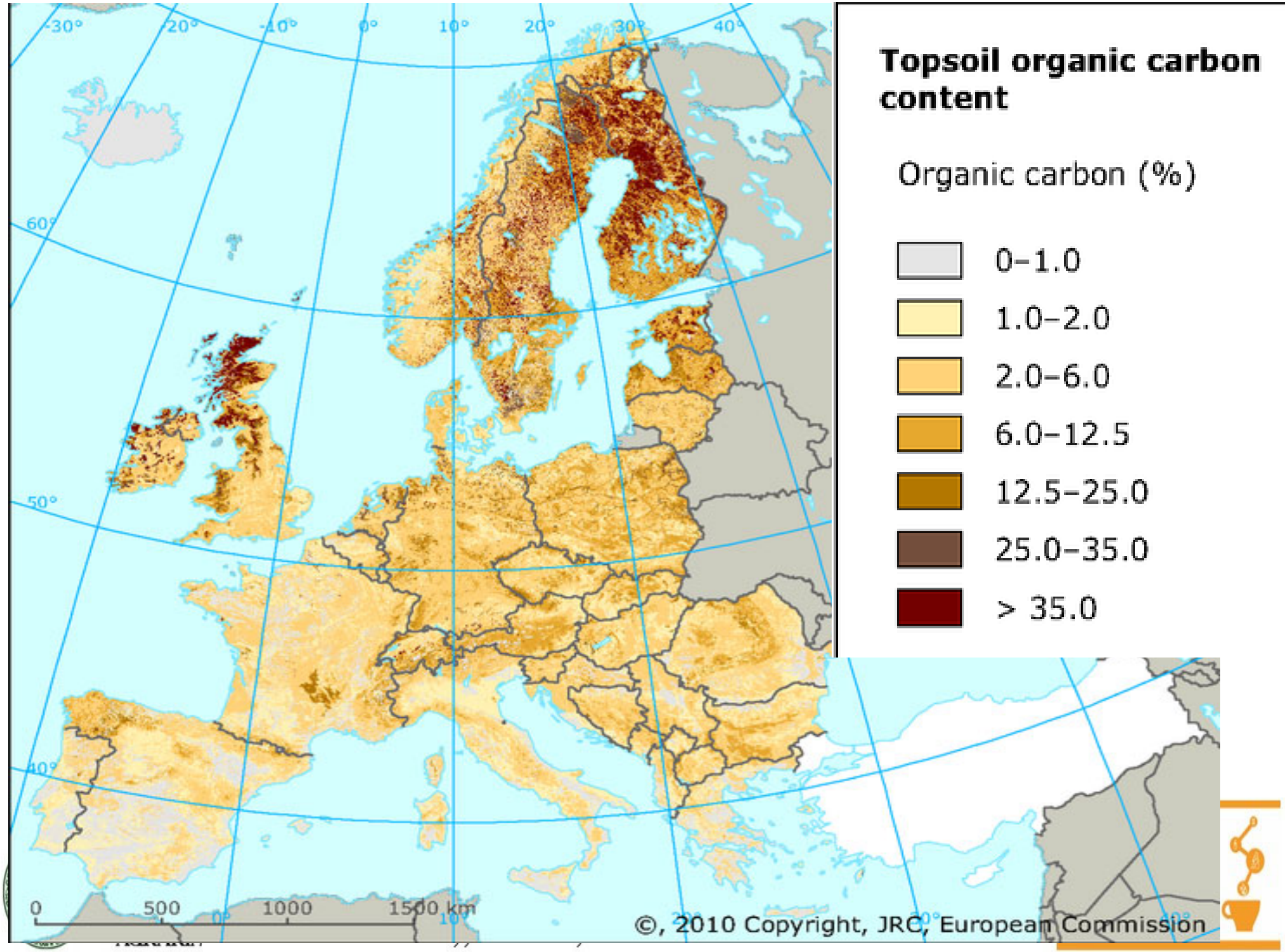


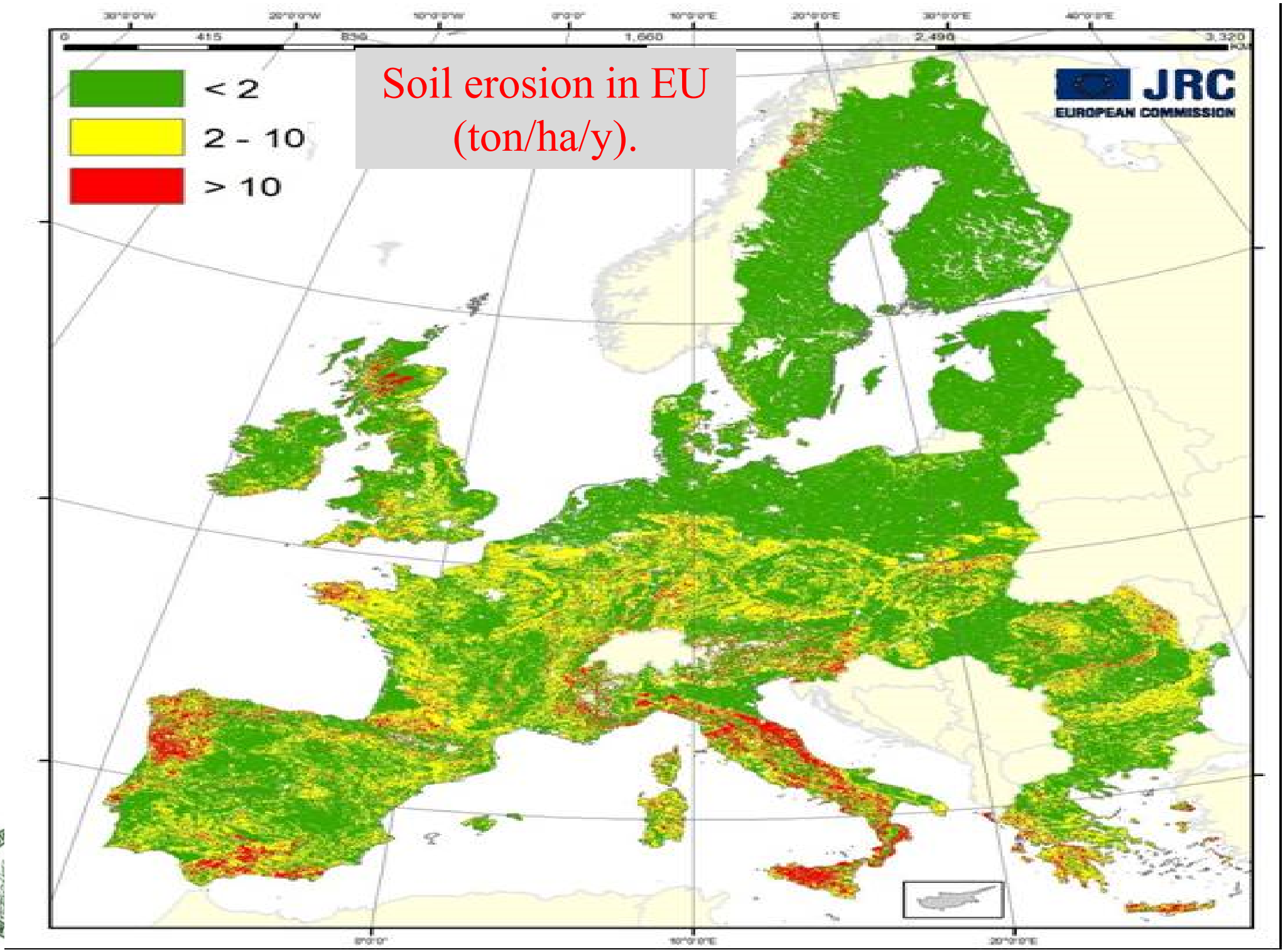
Figure 6: Status and trends in global land degradation

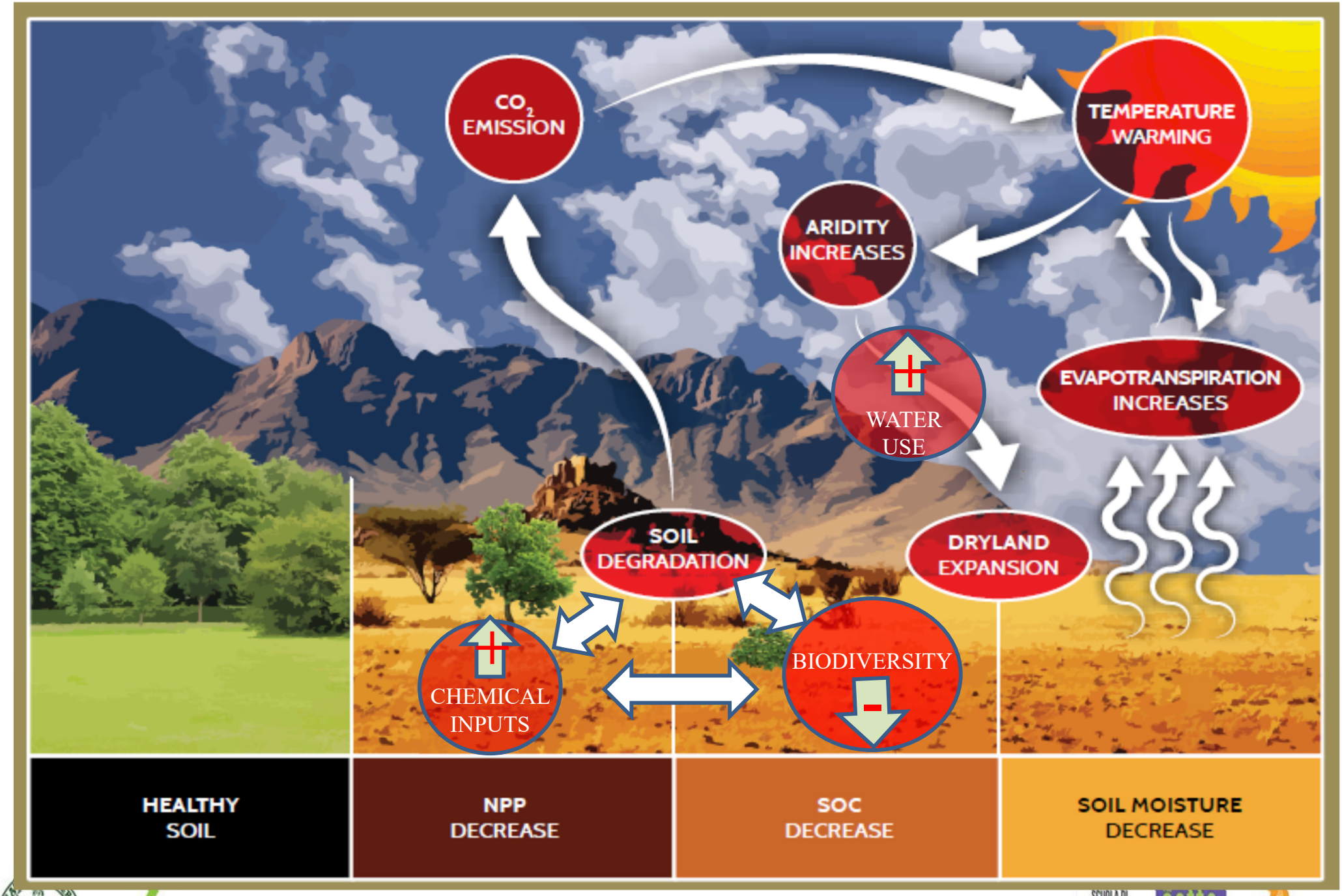
FIGURE 1.3: TOTAL EXTENT OF CULTIVATED LAND BY LAND SUITABILITY CATEGORY FOR EACH GEOGRAPHIC REGION



(*The State of the World's Land ....Resources for Food and Agriculture* FAO 2016)

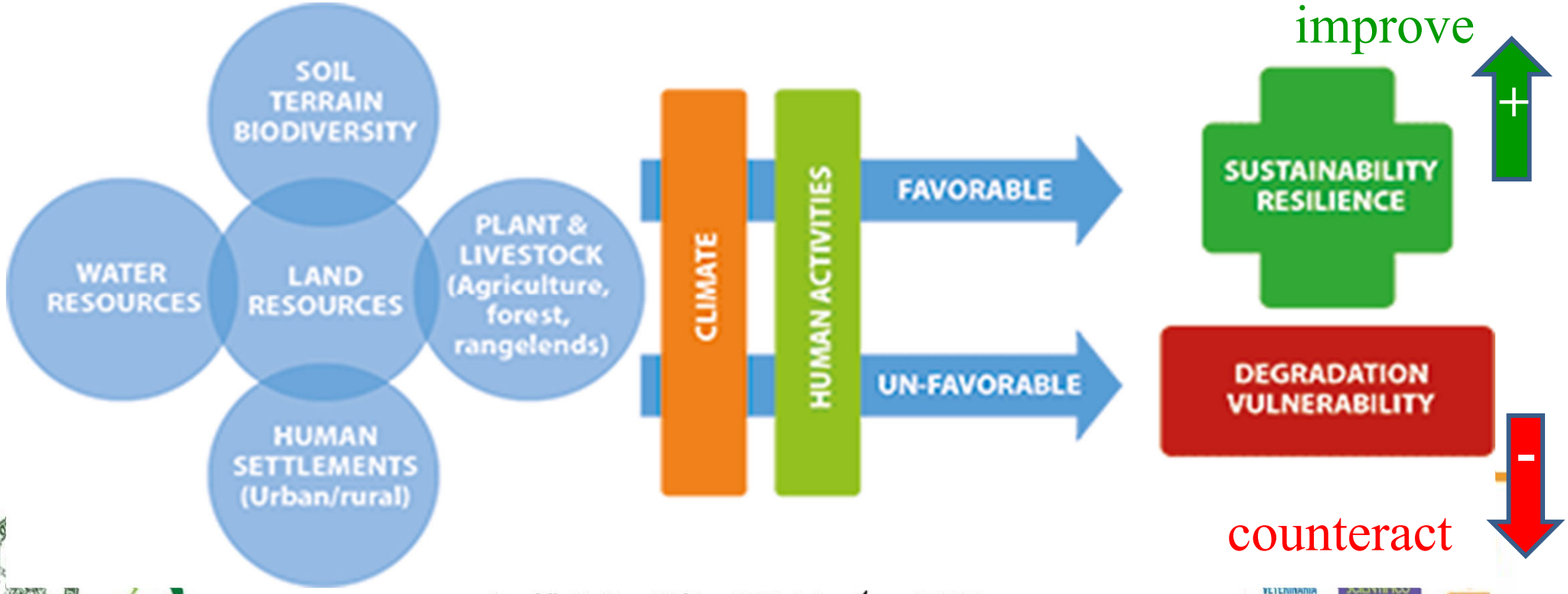

Topsoil organic carbon content
Organic carbon (%)
0–1.0
1.0–2.0
2.0–6.0
6.0–12.5
12.5–25.0
25.0–35.0
> 35.0
-30°
-20°
-10°
0°
10°
20°
30°
40°
60°
50°
40°
0
500
1000
1500 km
© 2010 Copyright, JRC, European Commission


Soil erosion in EU
(ton/ha/y).
< 2
2 - 10
> 10
JRC
EUROPEAN COMMISSION



(SOC the hidden potential FAO 2017 - http://www.fao.org/3/a-i6937e.pdf%20)

The progressive degradation of agroecosystems has promoted an increasing effort to promote the "*adoption of land-use systems that through appropriate management practices enable land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources*" (FAO Sustainable Soil/Land Management for Climate-Smart Agriculture)

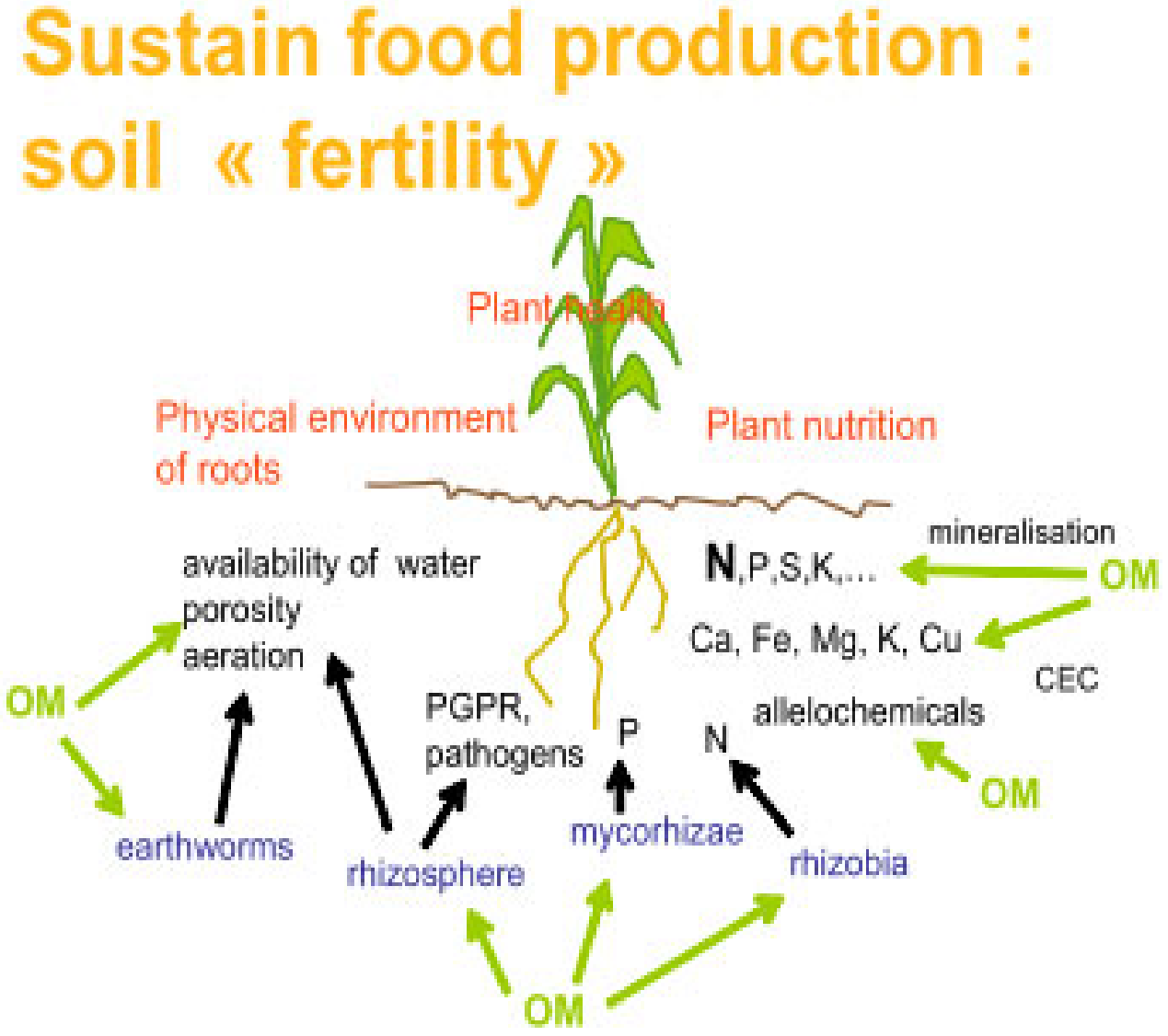


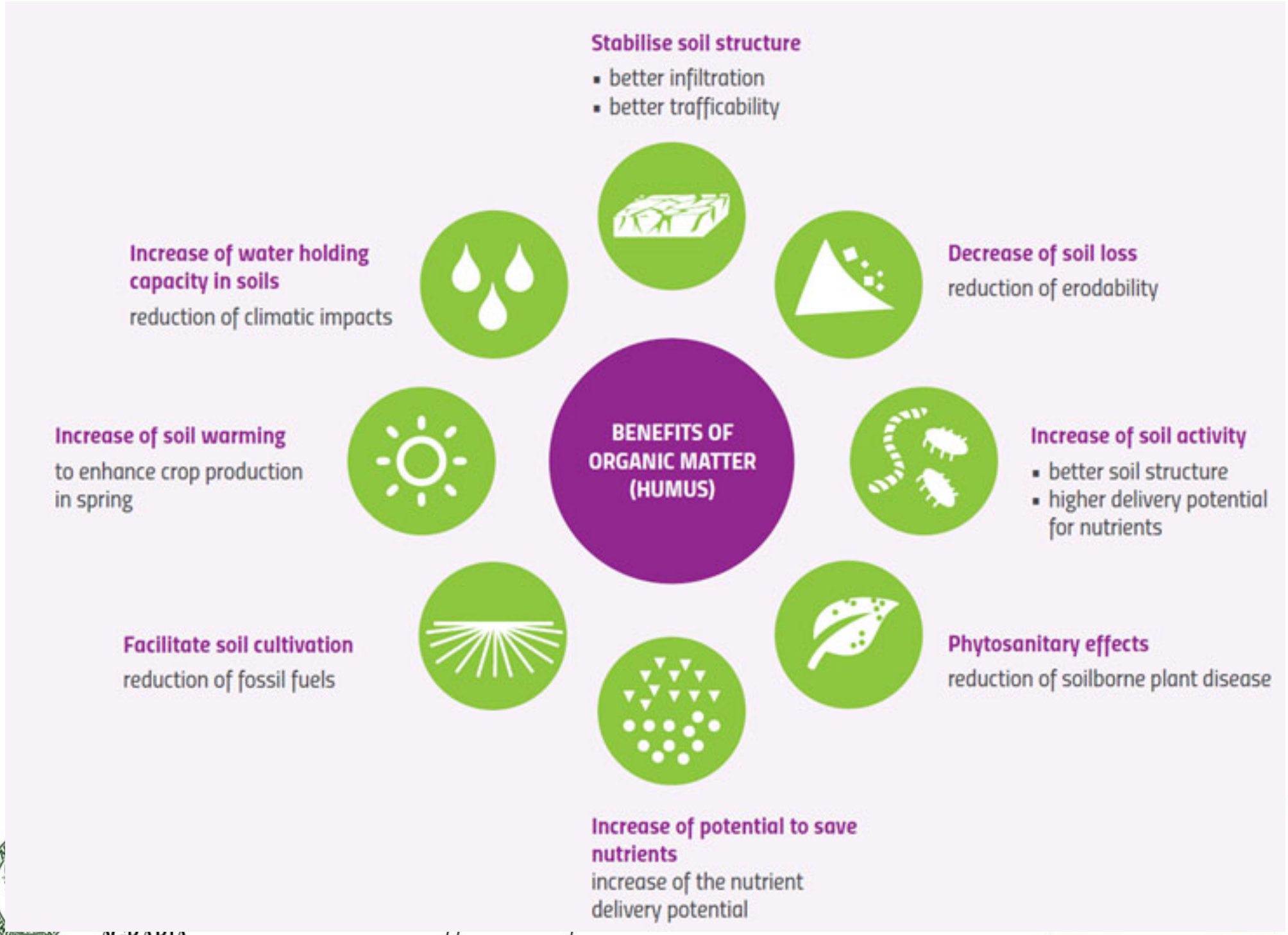
an important role is assigned to the natural organic matter

Soil organic matter is crucial to soil health, fertility and ecosystem services, including food production – making its preservation and restoration essential for sustainable development.

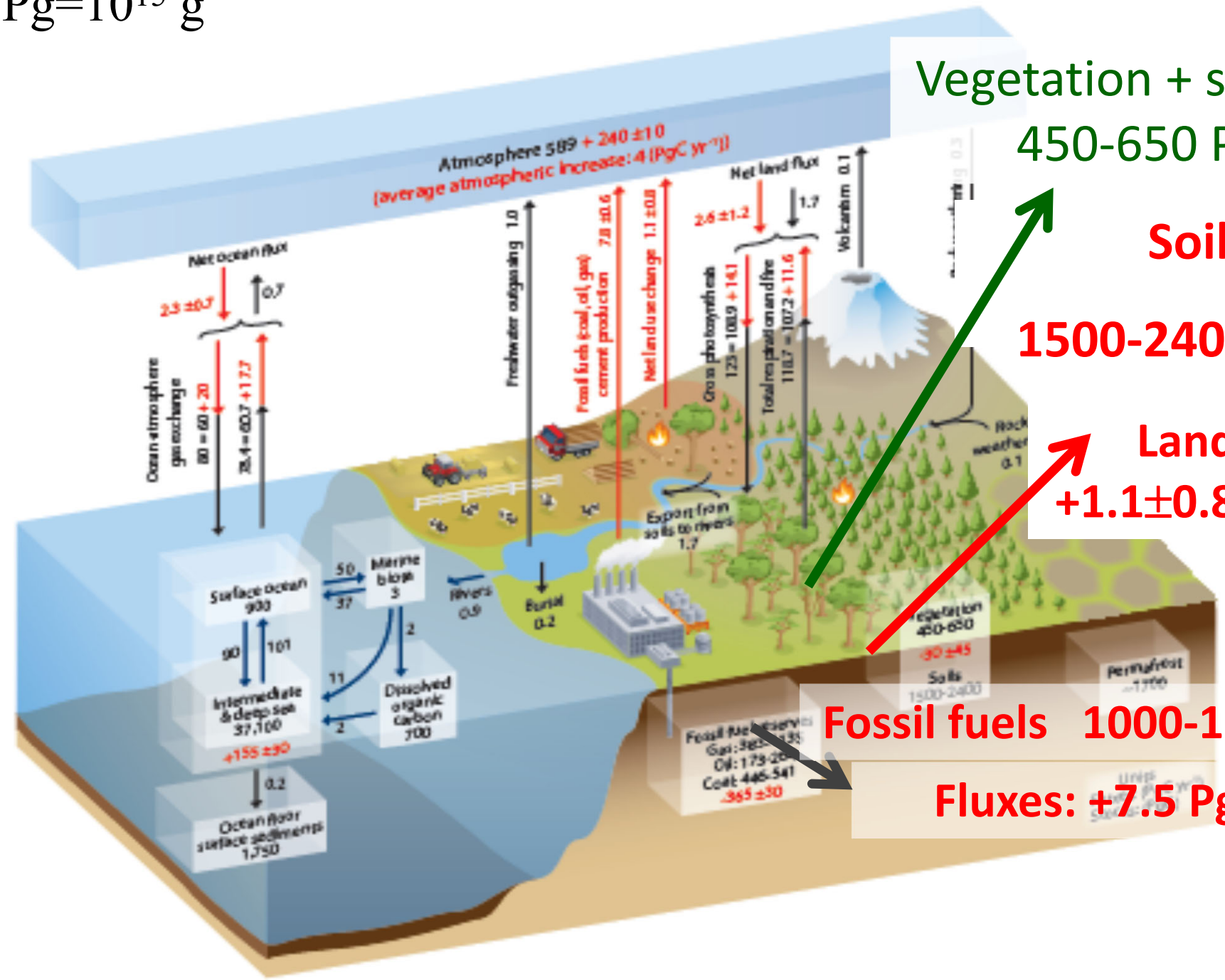
FAO 2017 Global Symposium on Soil Organic Carbon
http://www.fao.org/about/meetings/soil-organic-carbon-symposium/en/)

The soil organic matter (SOM) play a key role for maintenance of the different environmental, productive and biological tasks of agro-ecosystems




Stabilise soil structure
▪ better infiltration
▪ better trafficability
Increase of water holding capacity in soils
reduction of climatic impacts
Decrease of soil loss
reduction of erodability
BENEFITS OF ORGANIC MATTER (HUMUS)
Increase of soil warming
to enhance crop production in spring
Increase of soil activity
▪ better soil structure
▪ higher delivery potential for nutrients
Facilitate soil cultivation
reduction of fossil fuels
Phytosanitary effects
reduction of soilborne plant disease
Increase of potential to save nutrients
increase of the nutrient delivery potential

$Pg=10^{15}$ g



Vegetation + soil biota

450-650 Pg C

Soil

1500-2400 Pg C

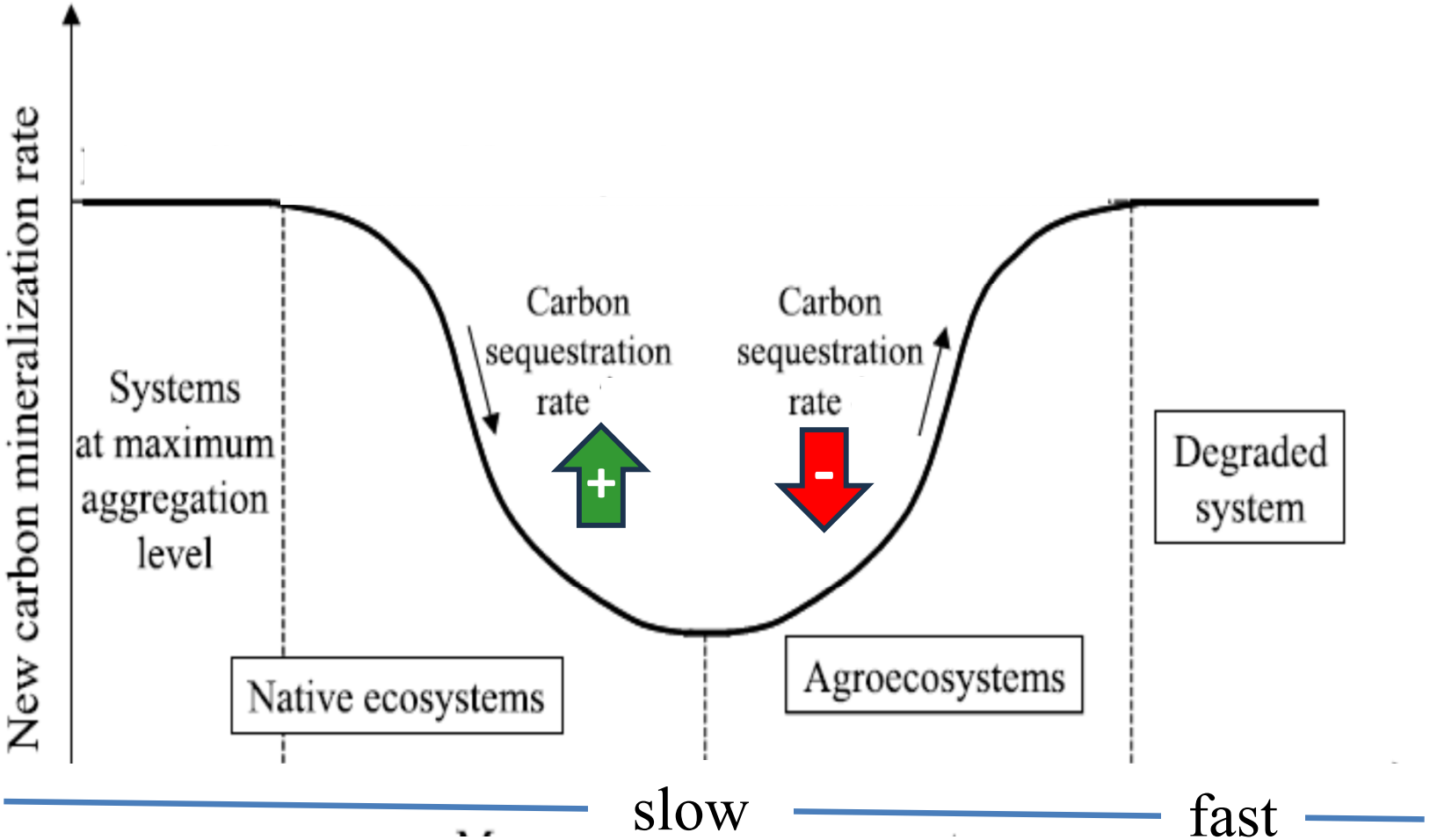
Land use:

+1.1±0.8 Pg C yr^{-1}

Fossil fuels 1000-1800 Pg C

Fluxes: +7.5 Pg C yr^{-1}

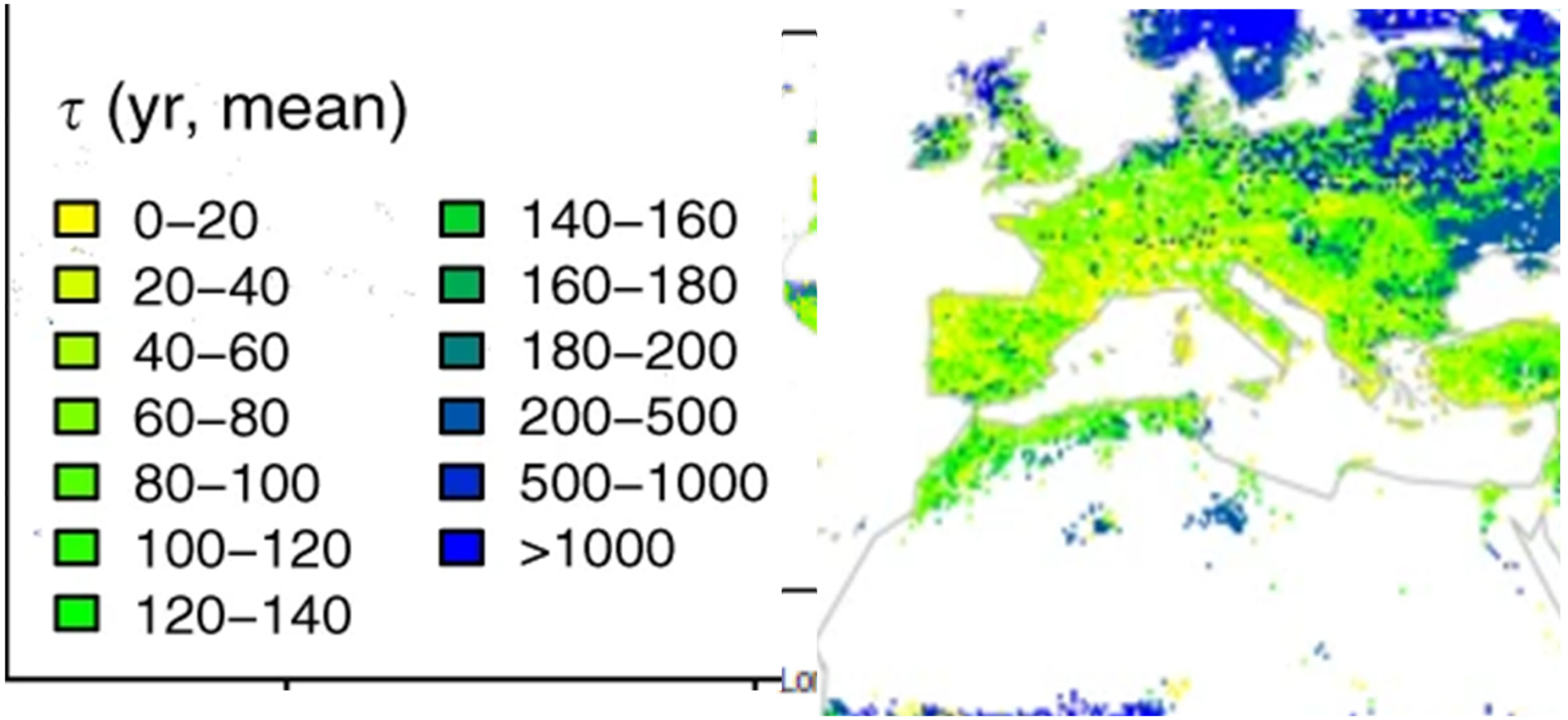
Contribution of SOC to the Sustainable Development Goals.
(SOC the hidden potential FAO 2017)



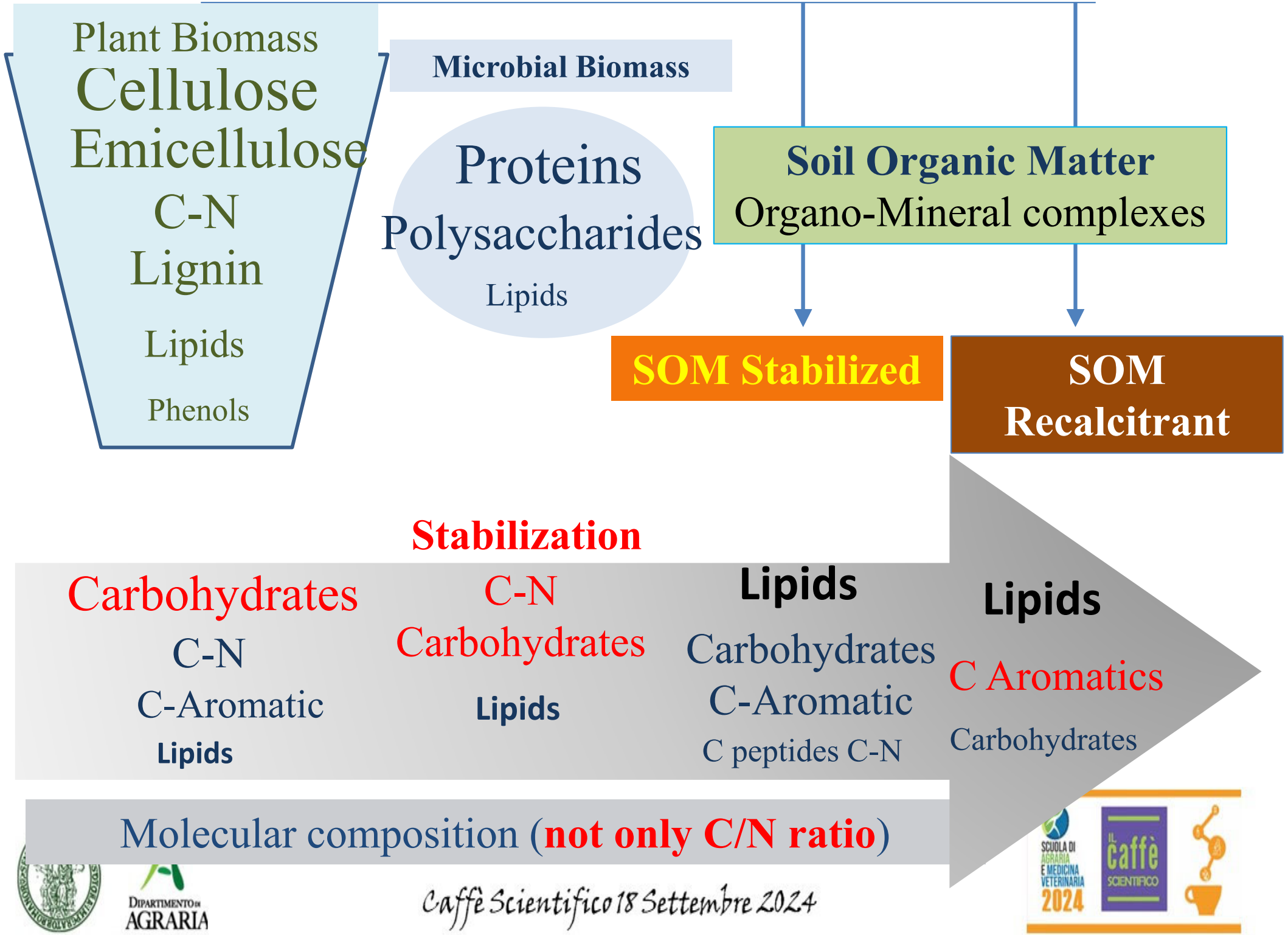
SOM turnover rate

(from Six et al., STR 2004)

Spatial pattern of subsoil organic carbon turnover of subsoil (0.3–1m)



(*Zhongkui et al., 2019 Nature communication doi.org/10.1038/s41467-019-11597-9)*


Plant Biomass
Cellulose
Emicellulose
C-N
Lignin
Lipids
Phenols
Microbial Biomass
Proteins
Polysaccharides
Lipids
Soil Organic Matter
Organo-Mineral complexes
SOM Stabilized
SOM Recalcitrant
Stabilization
Carbohydrates
C-N
C-Aromatic
Lipids
C-N
Carbohydrates
Lipids
Lipids
Carbohydrates
C-Aromatic
C peptides C-N
Lipids
C Aromatics
Carbohydrates
Molecular composition (not only C/N ratio)

Soil Biology & Biochemistry 56 (2013) 40–48

Contents lists available at SciVerse ScienceDirect

Soil Biology & Biochemistry

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

Litter quality assessed by solid state ^{13}C NMR spectroscopy predicts decay rate better than C/N and Lignin/N ratios

Giuliano Bonanomi [a,*], Guido Incerti [a], Francesco Giannino [b], Antonio Mingo [a], Virginia Lanzotti [c], Stefano Mazzoleni [a]

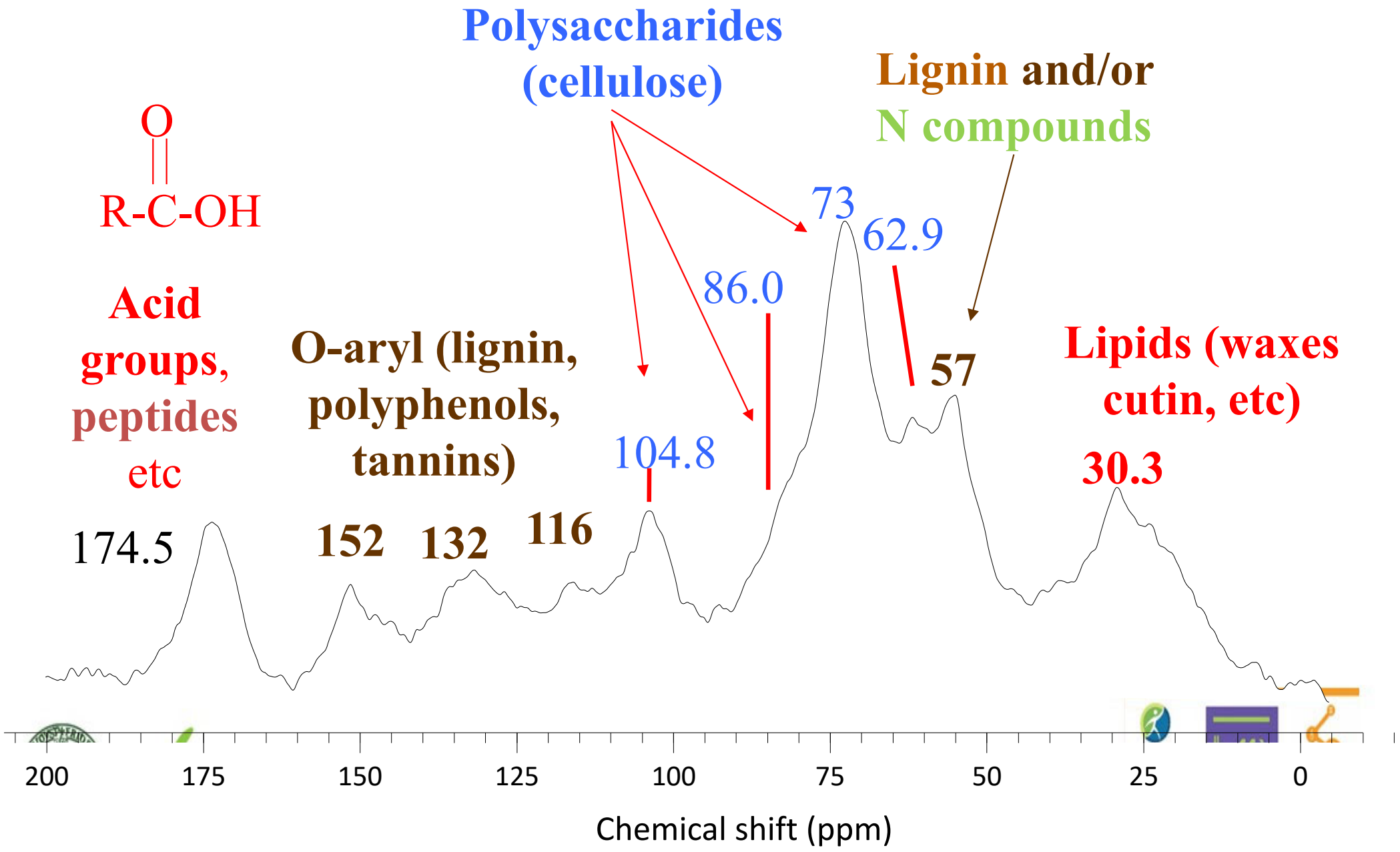
Plant Soil (2019) 441:129–146
https://doi.org/10.1007/s11104-019-04099-6

REGULAR ARTICLE

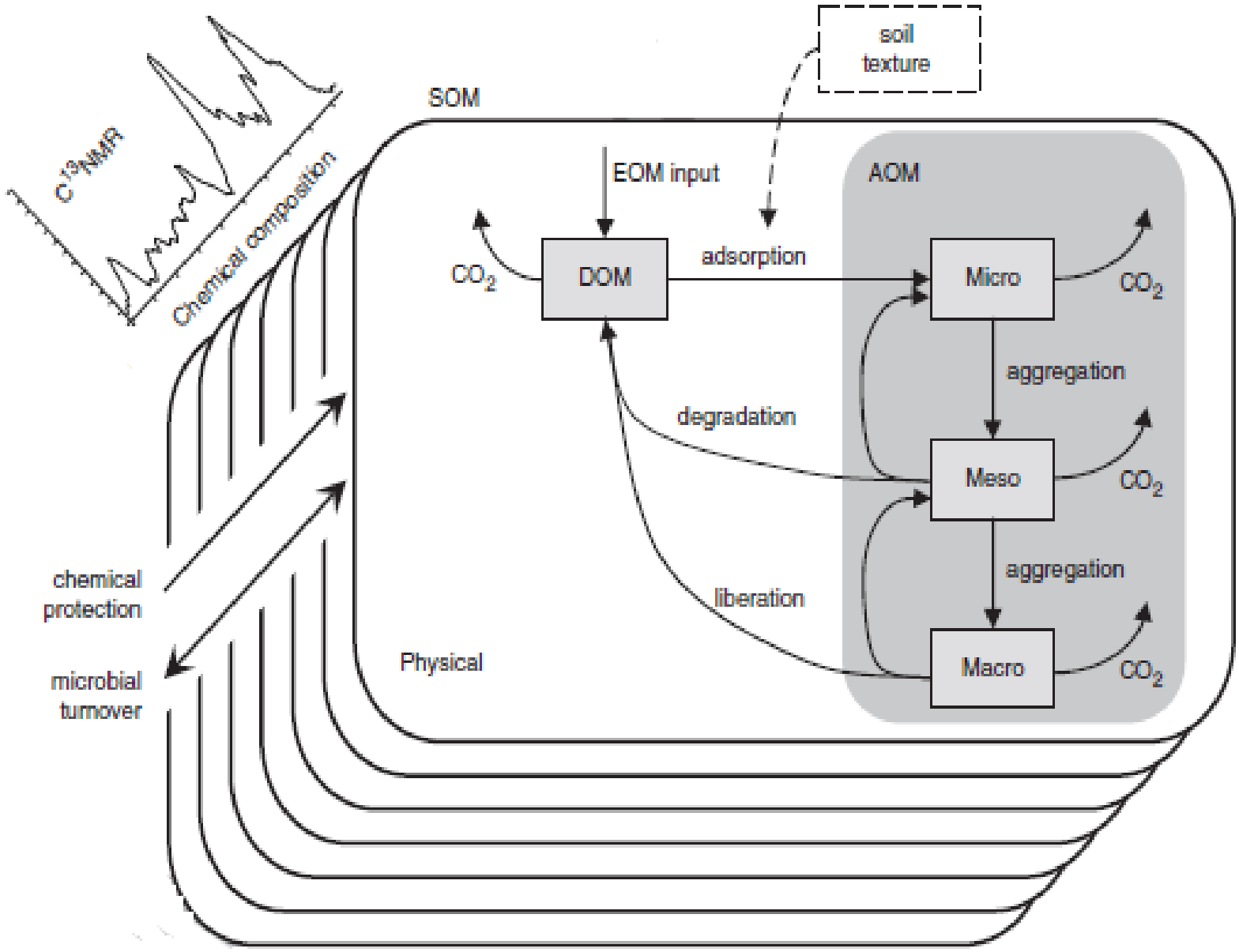
Predicting nitrogen mineralization from organic amendments: beyond C/N ratio by ^{13}C-CPMAS NMR approach

Giuliano Bonanomi · Tushar C. Sarker · Maurizio Zotti · Gaspare Cesarano · Emilia Allevato · Stefano Mazzoleni

13C solid state NMR spectra of green compost



Soil Organic Matter Dynamics (SOMDY)



Plant Soil (2017) 411:377–394
DOI 10.1007/s11104-016-3039-2

REGULAR ARTICLE

OMDY: a new model of organic matter decomposition based on biomolecular content as assessed by ^{13}C-CPMAS-NMR

Guido Incerti · Giuliano Bonanomi · Francesco Giannino · Fabrizio Cartenì · Riccardo Spaccini · Pierluigi Mazzei · Alessandro Piccolo · Stefano Mazzoleni

Soil Biology and Biochemistry 117 (2018) 175–184

Contents lists available at ScienceDirect

Soil Biology and Biochemistry

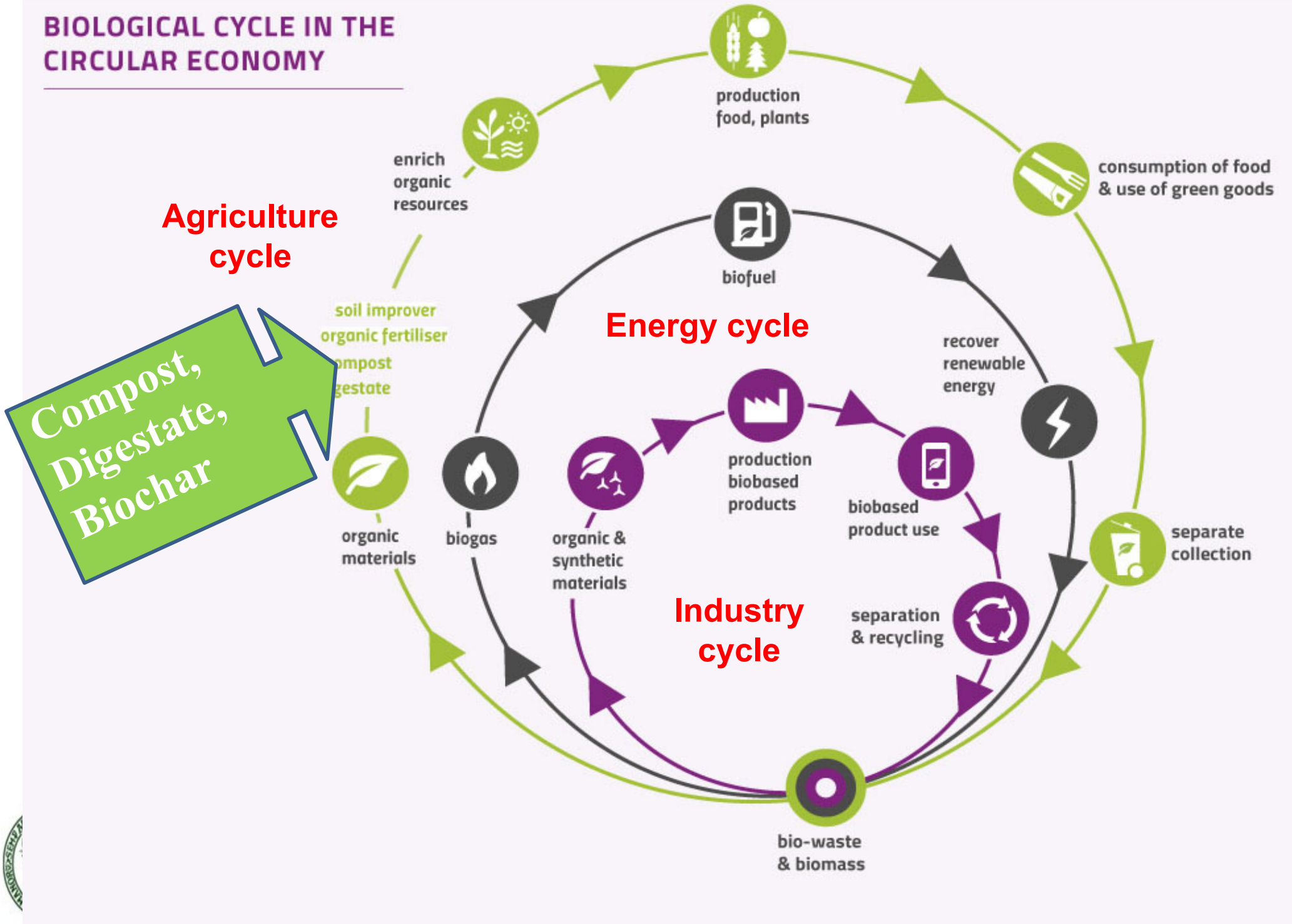
journal homepage: www.elsevier.com/locate/soilbio

Linking organic matter chemistry with soil aggregate stability: Insight from ^{13}C NMR spectroscopy

Tushar C. Sarker[a,*], Guido Incerti[b], Riccardo Spaccini[c], Alessandro Piccolo[c], Stefano Mazzoleni[a], Giuliano Bonanomi[a]

Caffè Scientifico 18 Settembre 2024

BIOLOGICAL CYCLE IN THE CIRCULAR ECONOMY



AGRITECH Spoke 8 - Circular economy in agriculture through waste valorization and recycling

task 8.3.2.: Valorisation and biological regeneration of wastes as resources for organic fertilizers/amendments to improve carbon storage and soil quality

Dept. of Agricultural Sciences – University of Napoli Federico II

Bonanomi Giuliano (AGR/12), Fagnano Massimo (AGR/02), Fiorentino Nunzio (AGR/02), Pindozzi Stefania (AGR/10), Scotto Di Perta Ester (AGR/10), Spaccini Riccardo (AGR/13)

Preliminary test on pilot composting system (**CNR-ISAFOM Perugia**) to optimize the best mixing aimed at the production organic fertilisers based on the combination of **biochar** with organic feedstocks (**buffalo manure, digestate, olive-mill waste)**

AGRITECH SPOKE 8

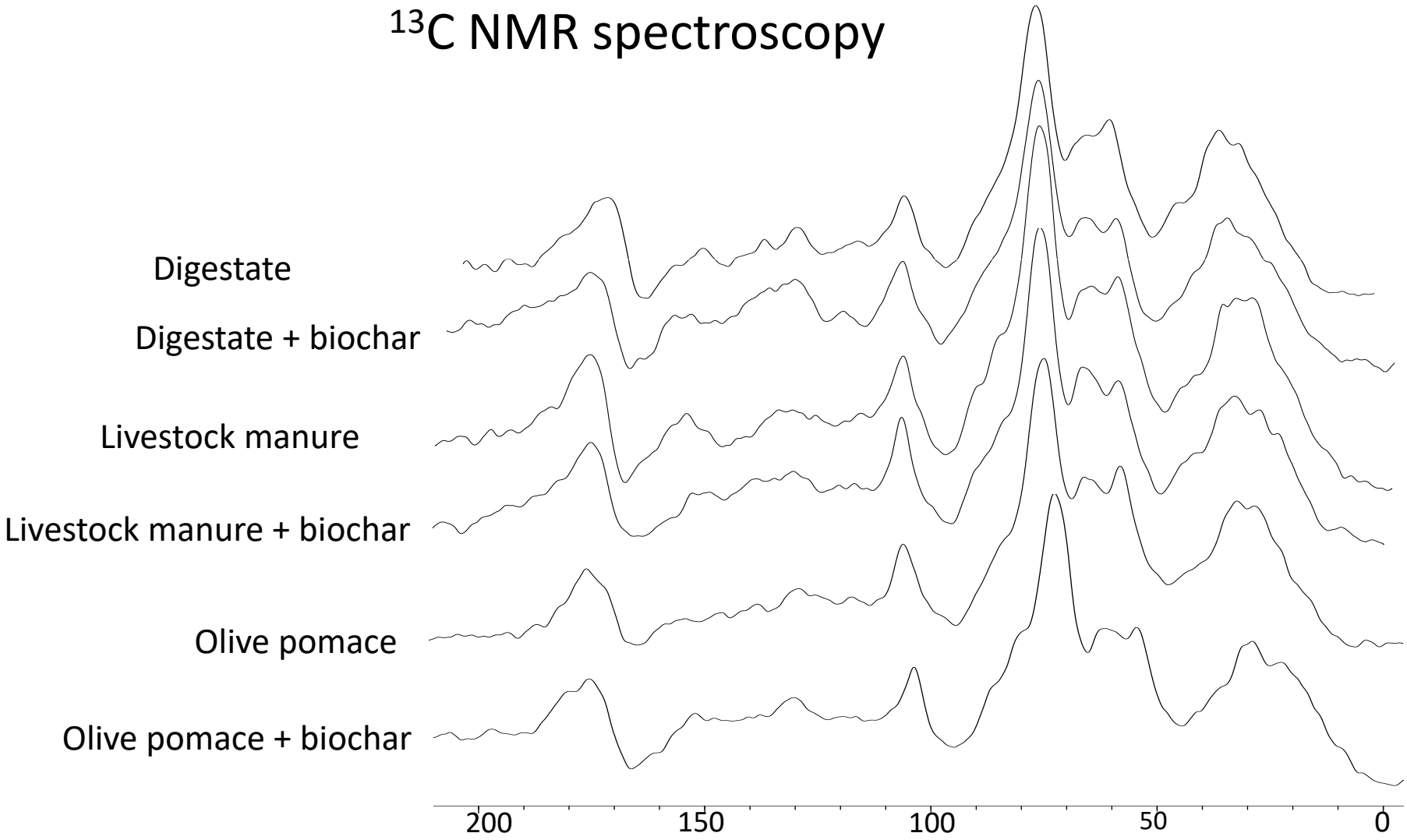
Meeting task 8.3.2.: Valorisation and biological regeneration of wastes as resources, organic fertilizers, or amendments to improve carbon storage and soil quality

Trial #1 – Buffalo manure & biochar -

Spoke 8 - Circular economy in agriculture through waste valorization and recycling

Caffè Scientifico 18 Settembre 2024

^{13}C NMR spectroscopy



AGRITECH SPOKE 8

Meeting task 8.3.2.: Valorisation and biological regeneration of wastes as resources, organic fertilizers, or amendments to improve carbon storage and soil quality

Co-Composting of agro-industrial by-products and biochar

Amendment applied at **four 4 rates of N fertilization: 100% compost, 33%compost-66% urea, 66% compost 33%urea, 2 Ton/Ha compost**

- **C1**: Livestock manure compost
- **C2**: Livestock manure+biochar comp
- **C3**: Livestock digestate compost
- **C4**: Livestock digestate+biochar com
- **C5**: Olive pomace compost
- **C6**: Olive pomace+biochar compost

CNR - ISAFOM

- **CTRL N-:** non-amended control
- **CTRL N+**: 100% urea

DESIGN: Completely randomized:

- ***2 Crops:*** Italian ryegrass *(Lolium multiflorum)*, wild rocket *(Diplotaxis tenuifolia)*
- ***4 Urea rates*** *x* ***6 compost types***
- ***3 replicates***

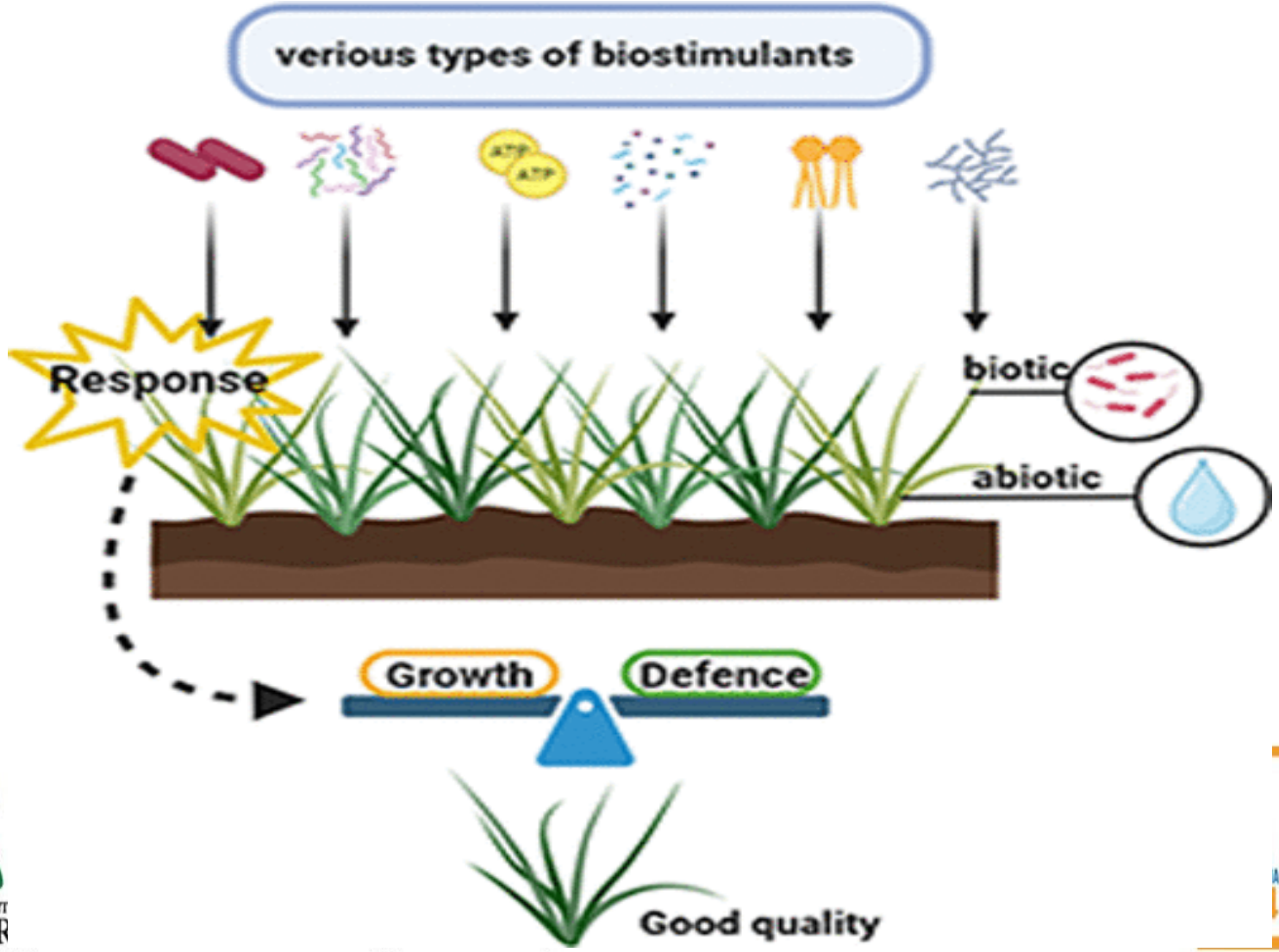
DIPARTIMENTO DI AGRARIA

Caffè Scientifico 18 Settembre 2024

SCUOLA DI AGRARIA E MEDICINA VETERINARIA 2024 — IL caffè SCIENTIFICO

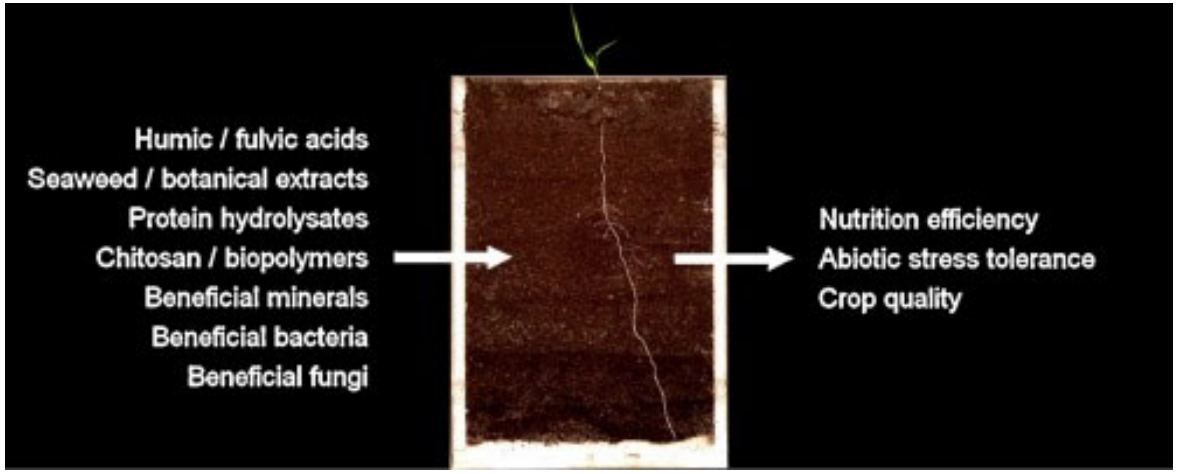
Besides the basic influence on soil fertility the research activities have pointed out that the NOM play a role as mediating agent in the **soil-plant-microbial interaction** thereby acting as natural

biostimulants for plant development

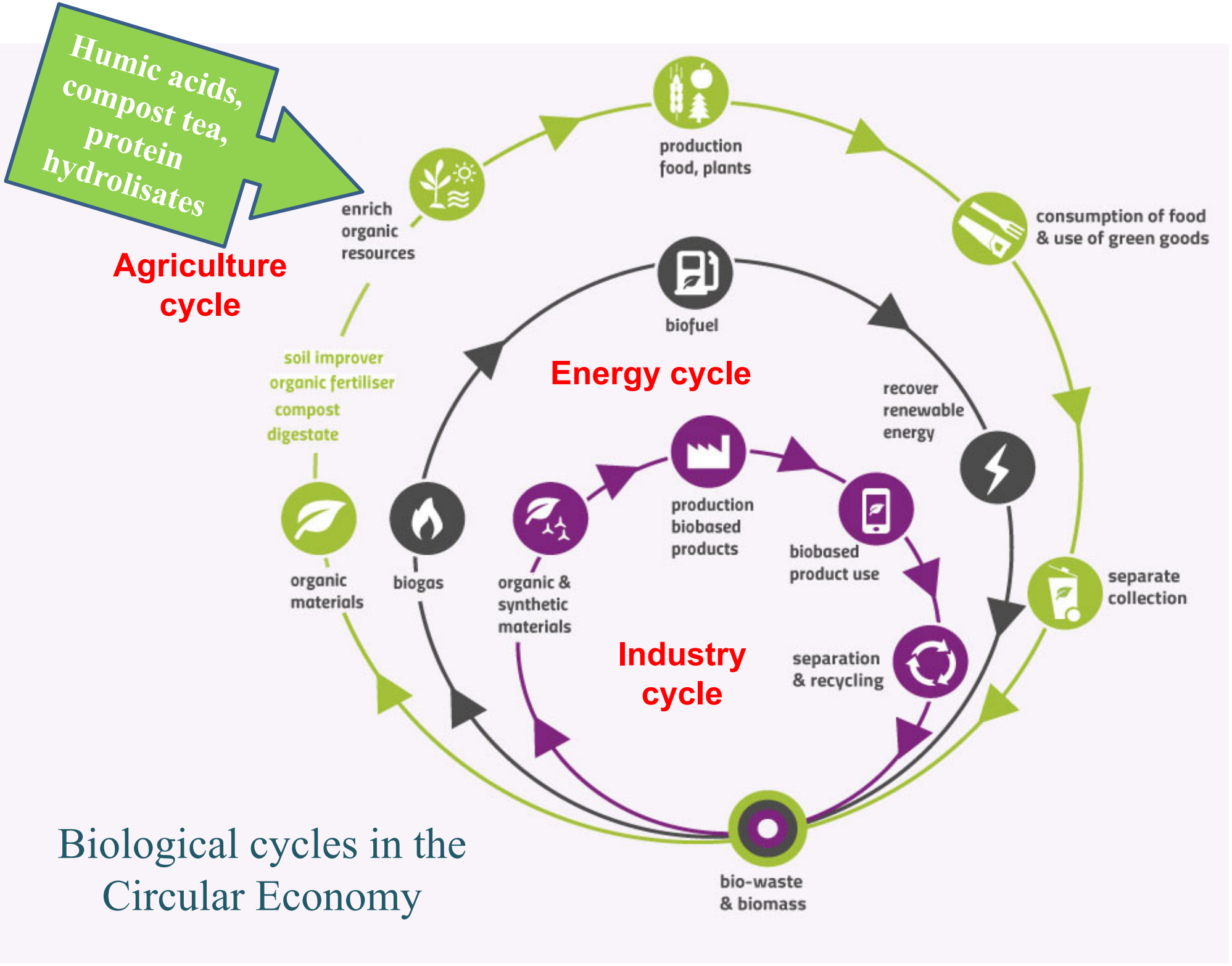


A plant biostimulant is any substance or microorganism applied to plants with the aim to enhance nutrition efficiency, abiotic stress tolerance and/or crop quality traits, regardless of nutrients content.

(Du Jardin 2015 https://doi.org/10.1016/j.scienta.2015.09.021)

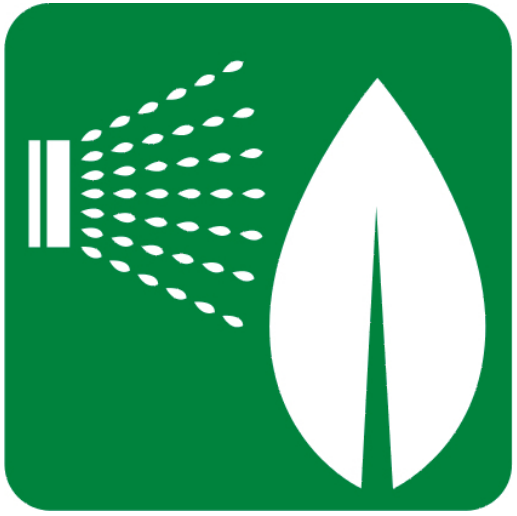


- root mass, branching, elongation of lateral roots
- efficiency of nutrient uptakes (N, P)
- shoot developement
- hormone-like, stimulate biochemical and transcriptional activities
- photosynthetic activity
- yield (quantity and quality)
- improved resilience to deseases and environmentals stresses



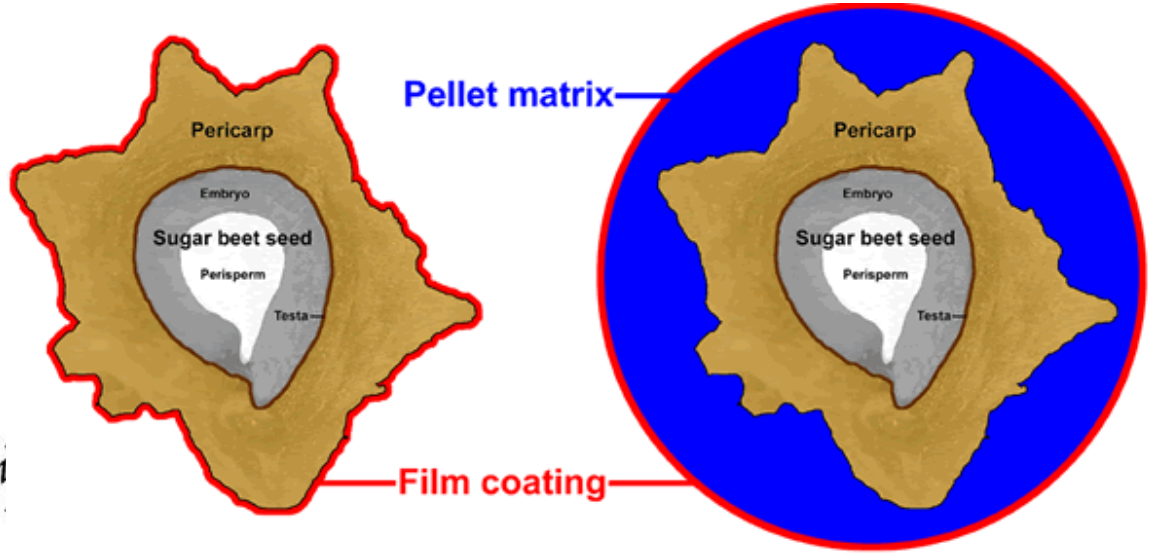
Biological cycles in the Circular Economy

Rhizospheric application (Furrow distribution fertirrigation)



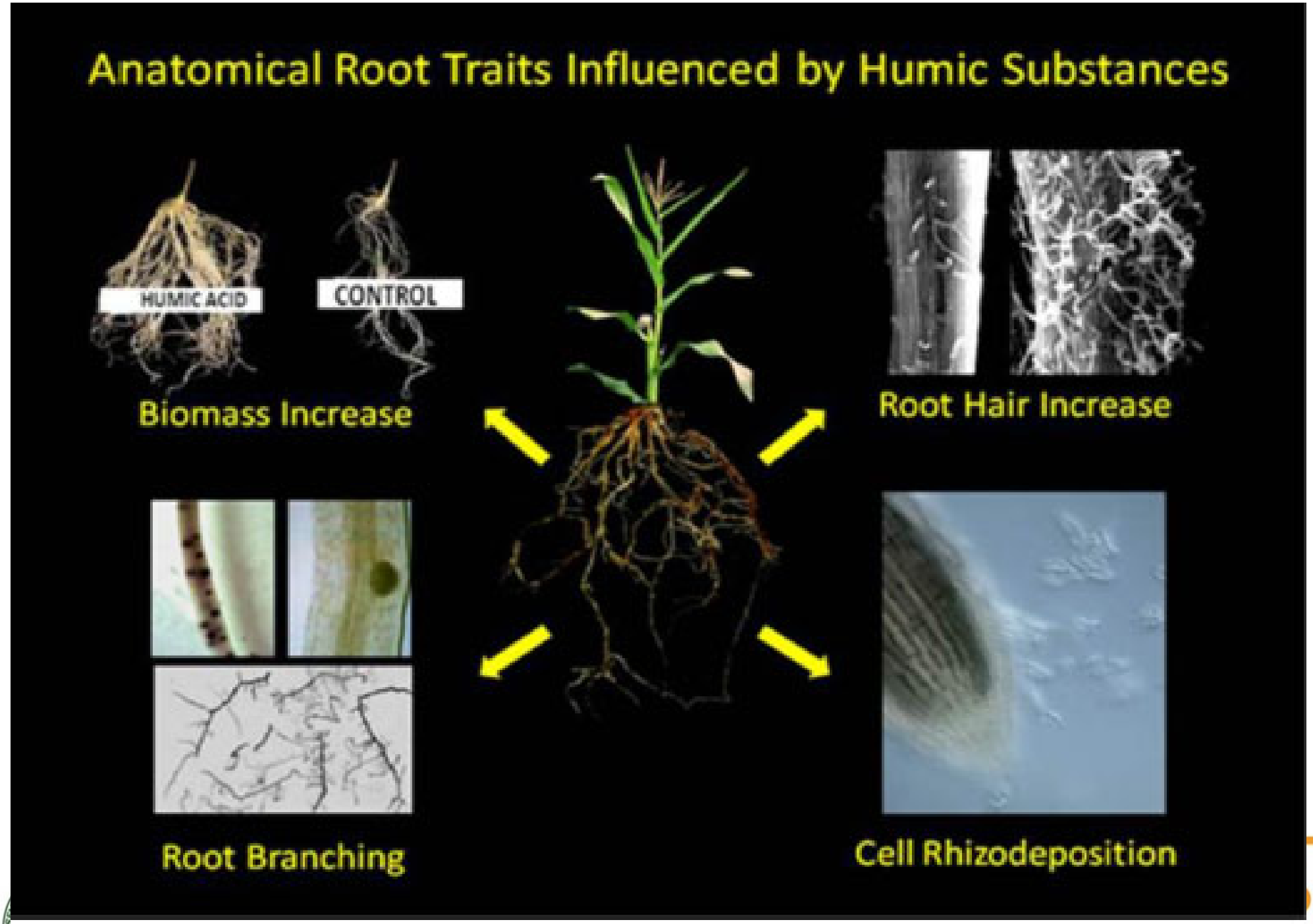
Foliar application

Seed treatments

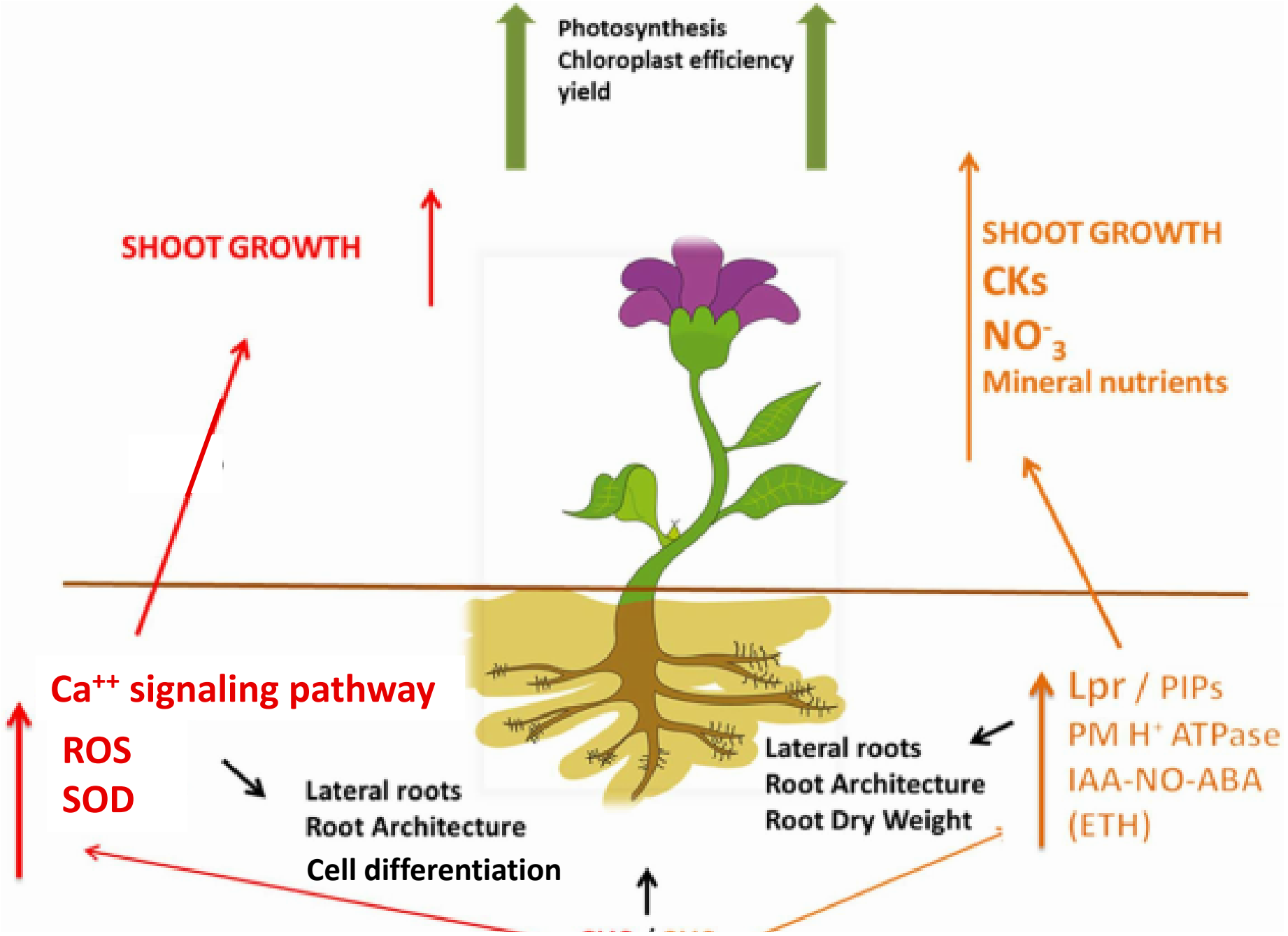


Dipartimento di AGRARIA

Caffè Scienti

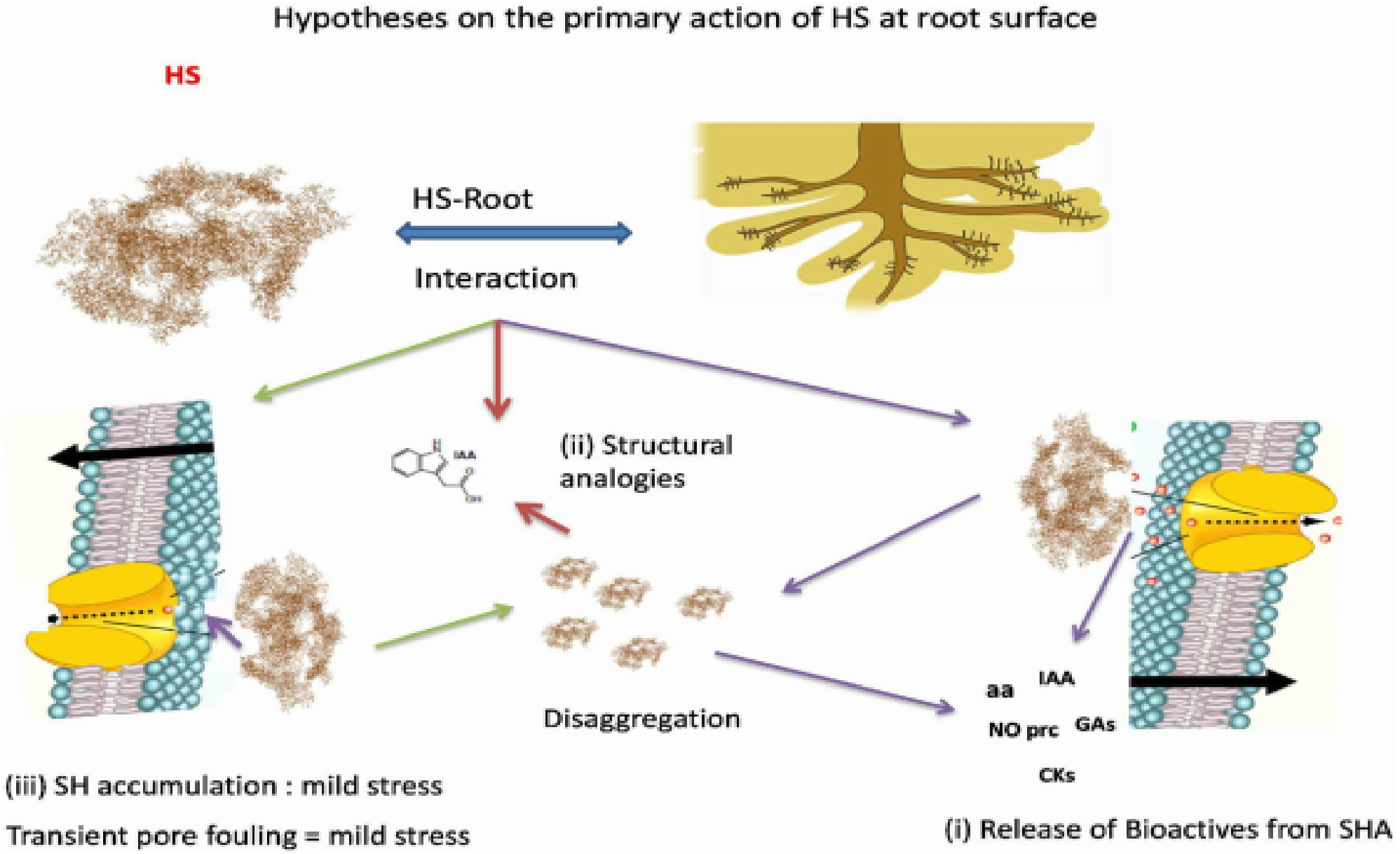


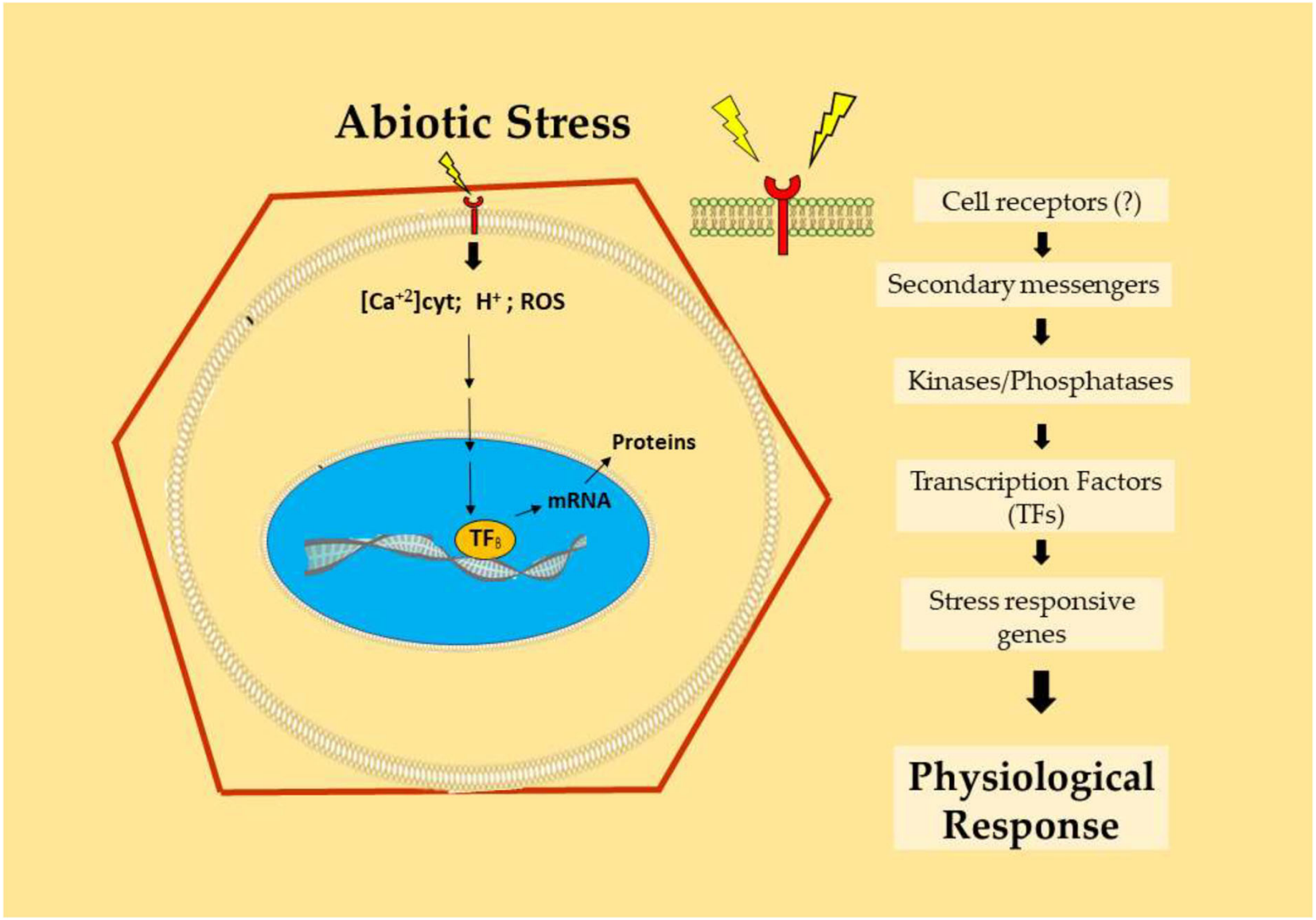
(from *Canellas and Olivares 2014, 10.1186/2196-5641-1-3)*



Root-shoot signalling pathways involved in the promoting action of biostimulants

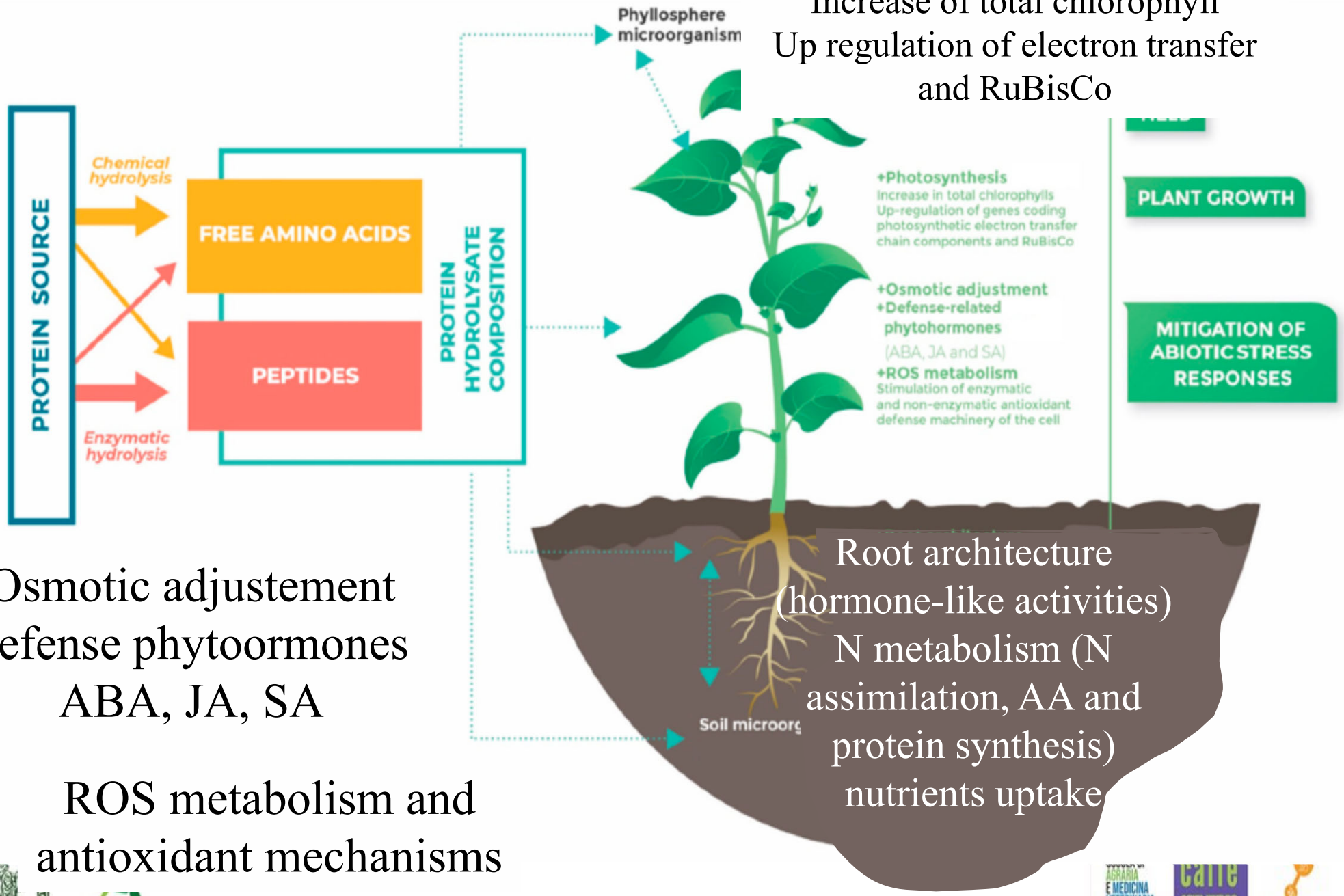
Hypotheses on the primary action of HS at root surface





(from Jindo et al., 2020 *Interaction between Humic Substances and Plant Hormones for Phosphorous Acquisition* Agronomy, 10, 640; doi:10.3390/agronomy10050640)

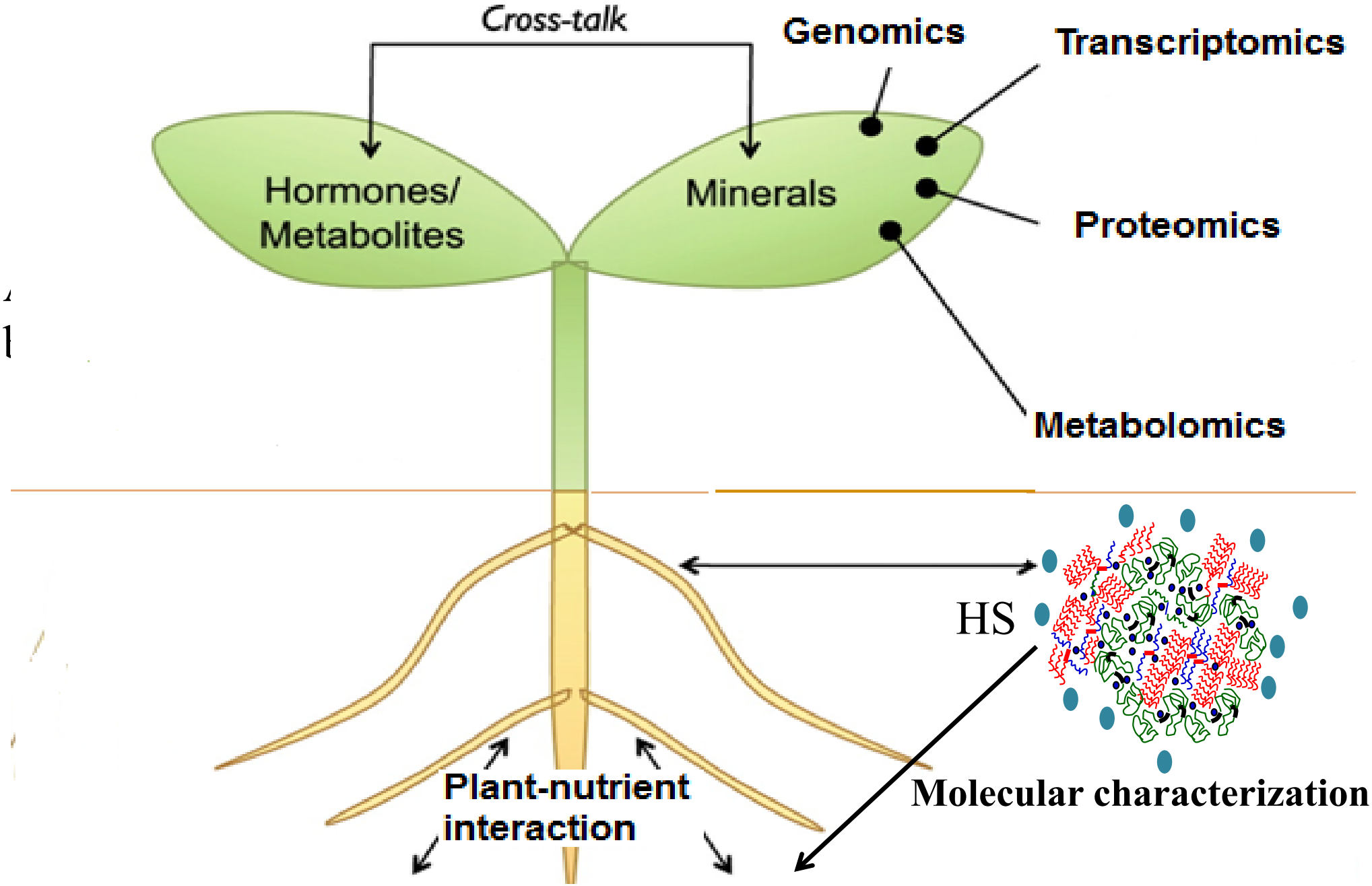
Photosynthesis
Increase of total chlorophyll
Up regulation of electron transfer and RuBisCo



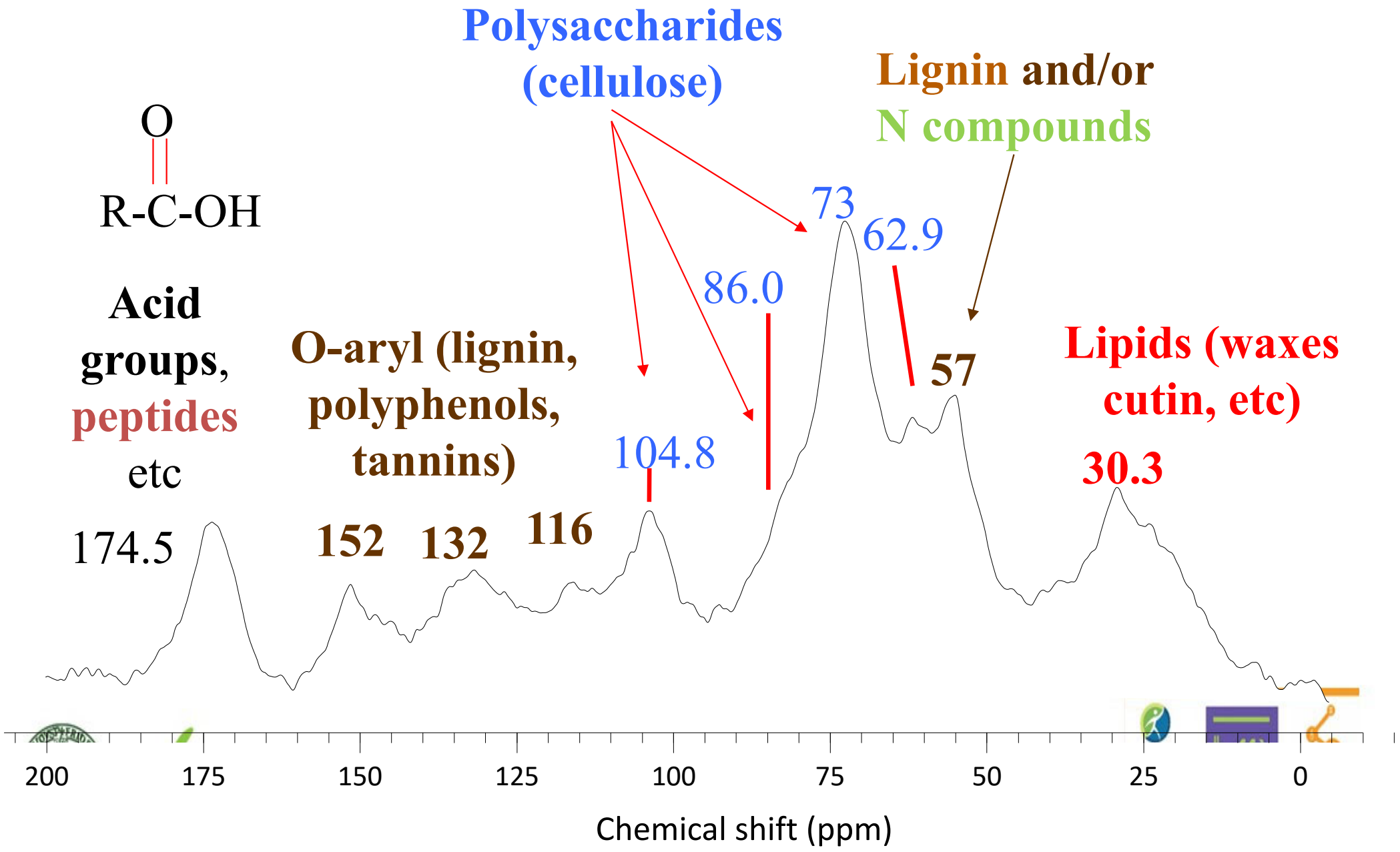
Osmotic adjustement
defense phytoormones
ABA, JA, SA

ROS metabolism and
antioxidant mechanisms

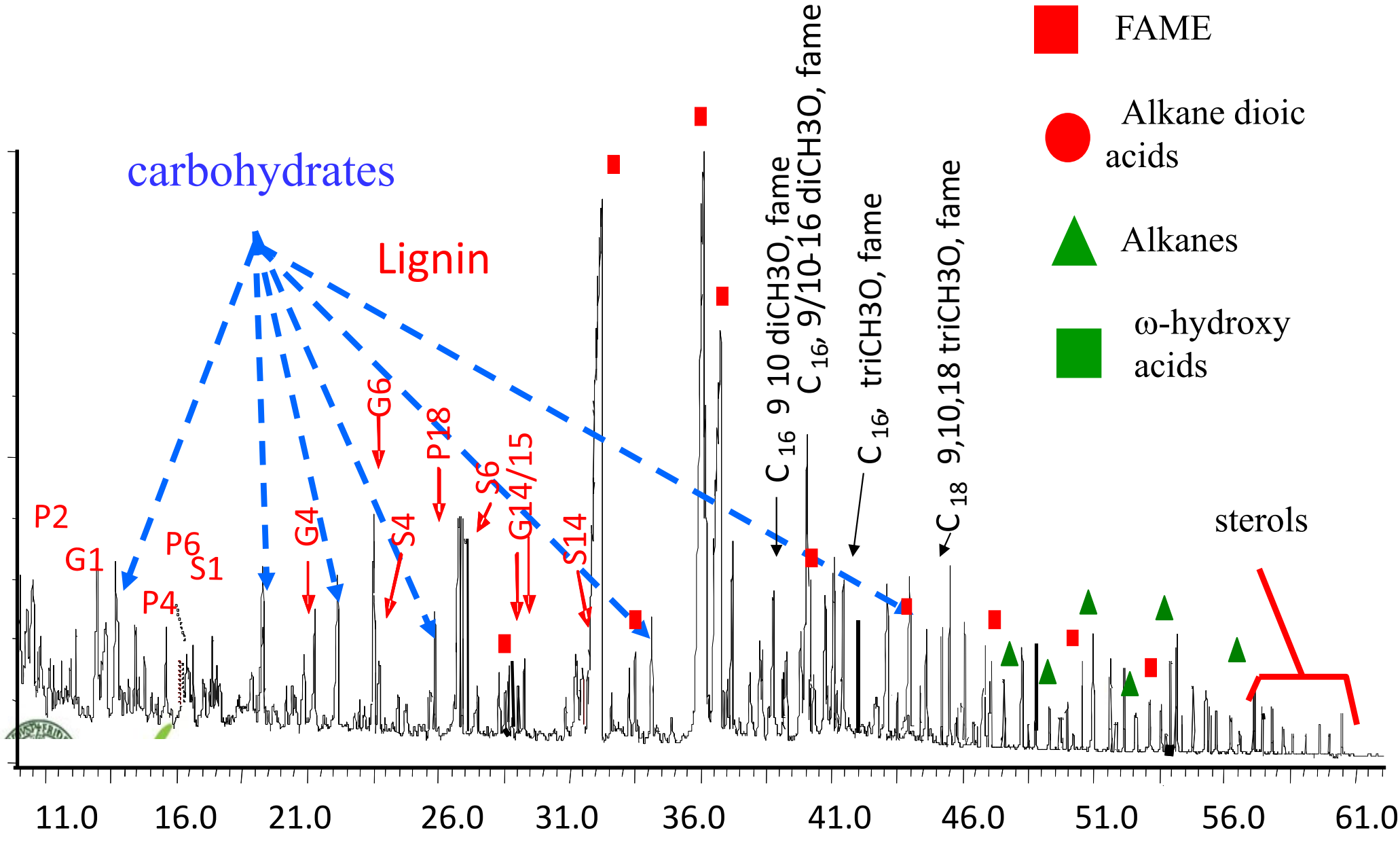
Root architecture
(hormone-like activities)
N metabolism (N
assimilation, AA and
protein synthesis)
nutrients uptake


Cross-talk
Genomics
Transcriptomics
Hormones/
Metabolites
Minerals
Proteomics
Metabolomics
HS
Plant-nutrient
interaction
Molecular characterization
Ca, Mg, Fe, Mn, Zn, Cu
N, P, K

13C solid state NMR spectra of humic acid from green compost



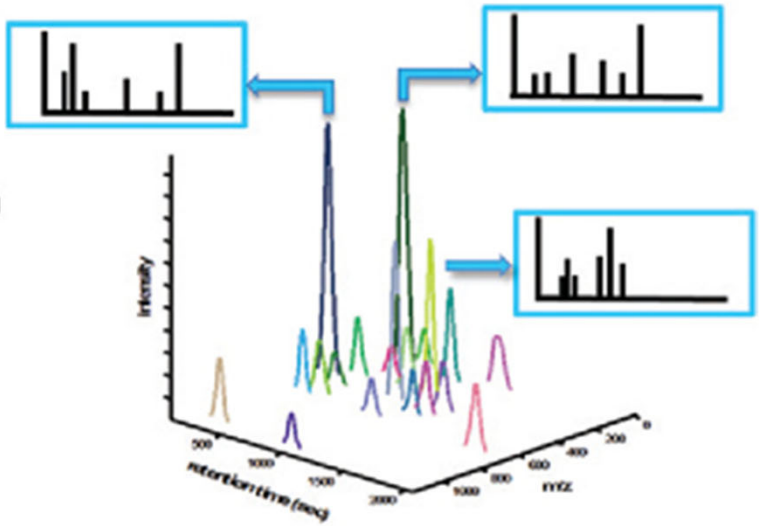
Pyrolysis GC-MS of HS from green compost



Metabolite extraction

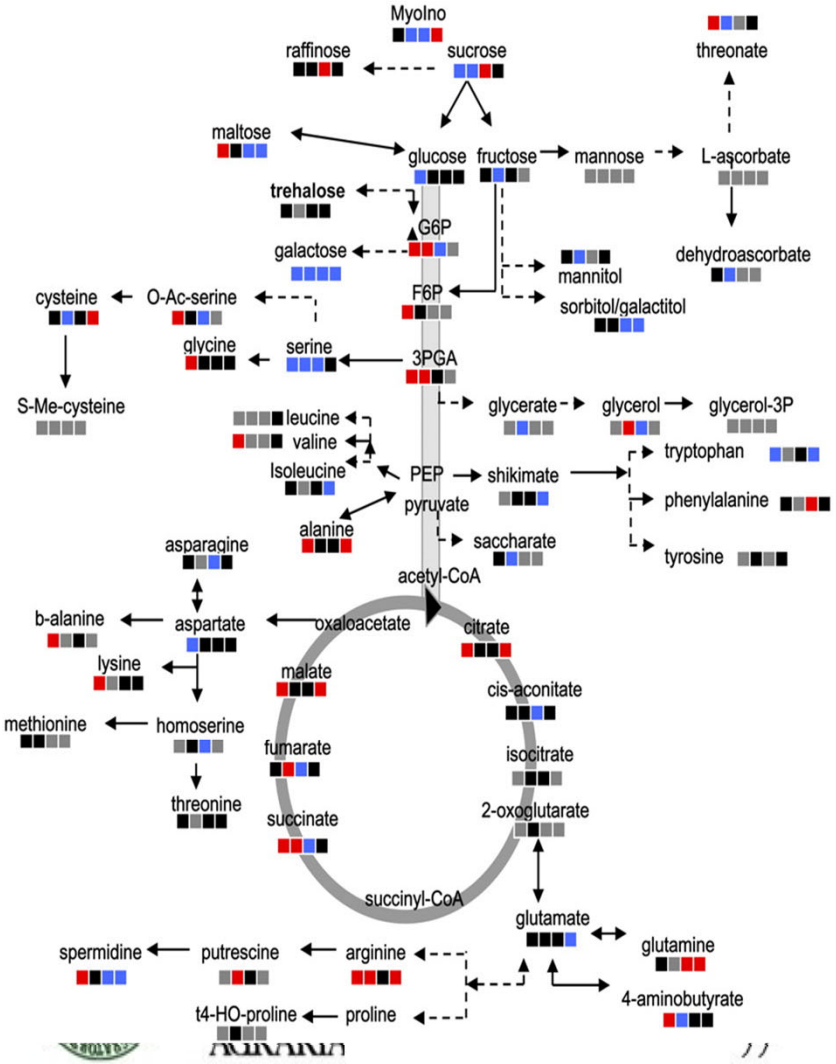
Mass spectrometry

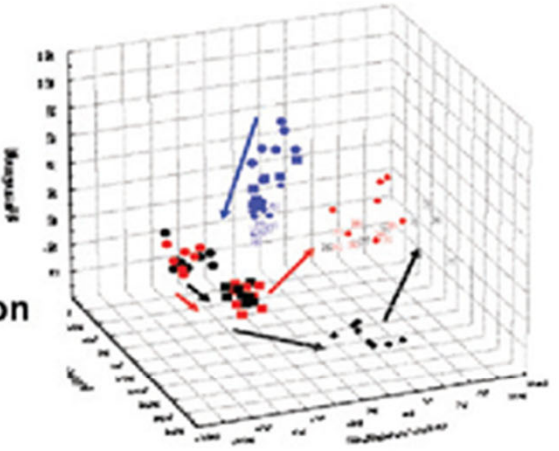
Data acquisition



Features selection

METABOLOMIC





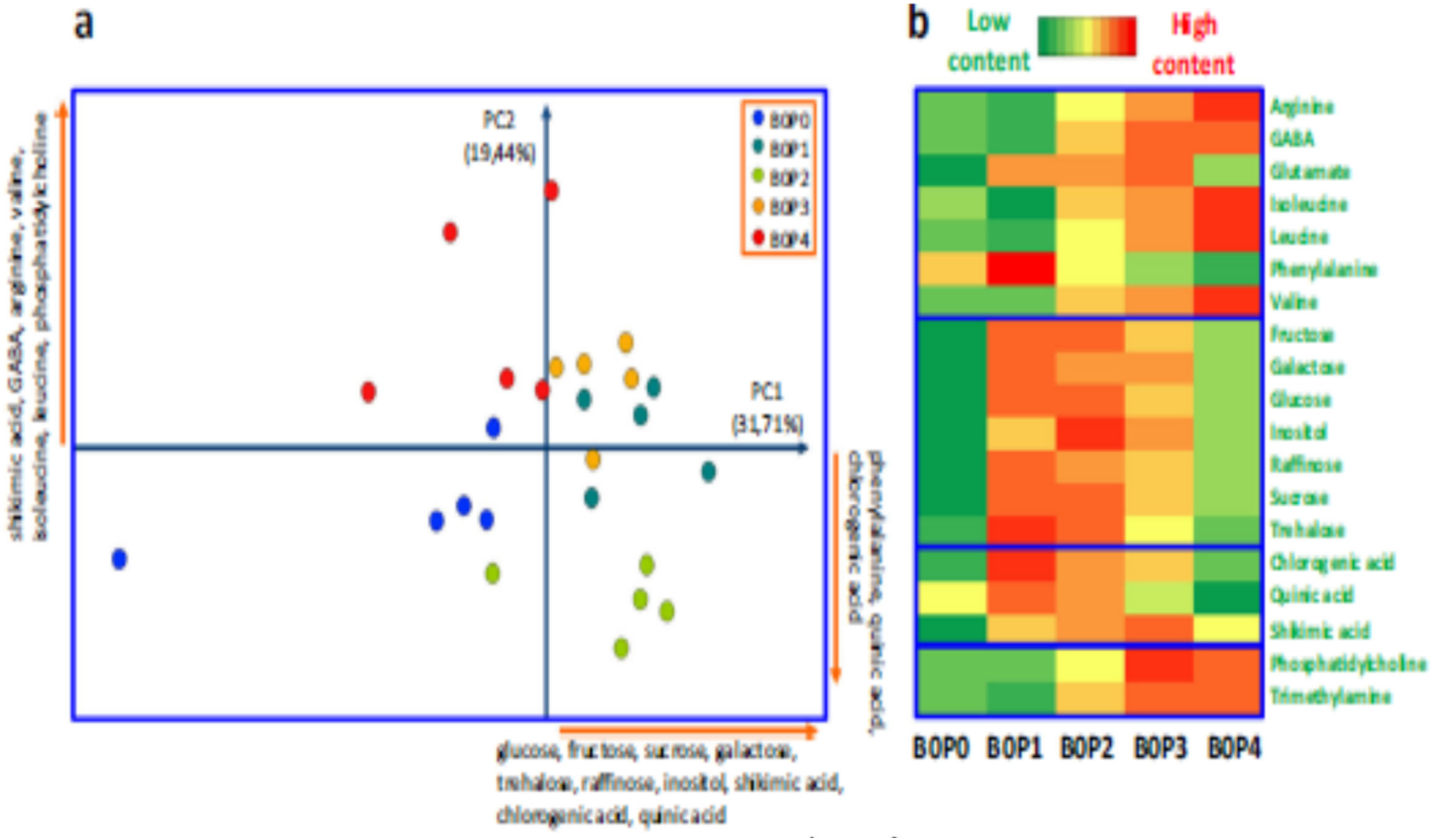
Identification & quantitation of metabolites

- Not significantly different
- Higher in PA2(-) genotypes
- Lower in PA2(-) genotypes
- Not detectable

tembre 2024

SCUOLA DI AGRARIA E MEDICINA VETERINARIA 2024

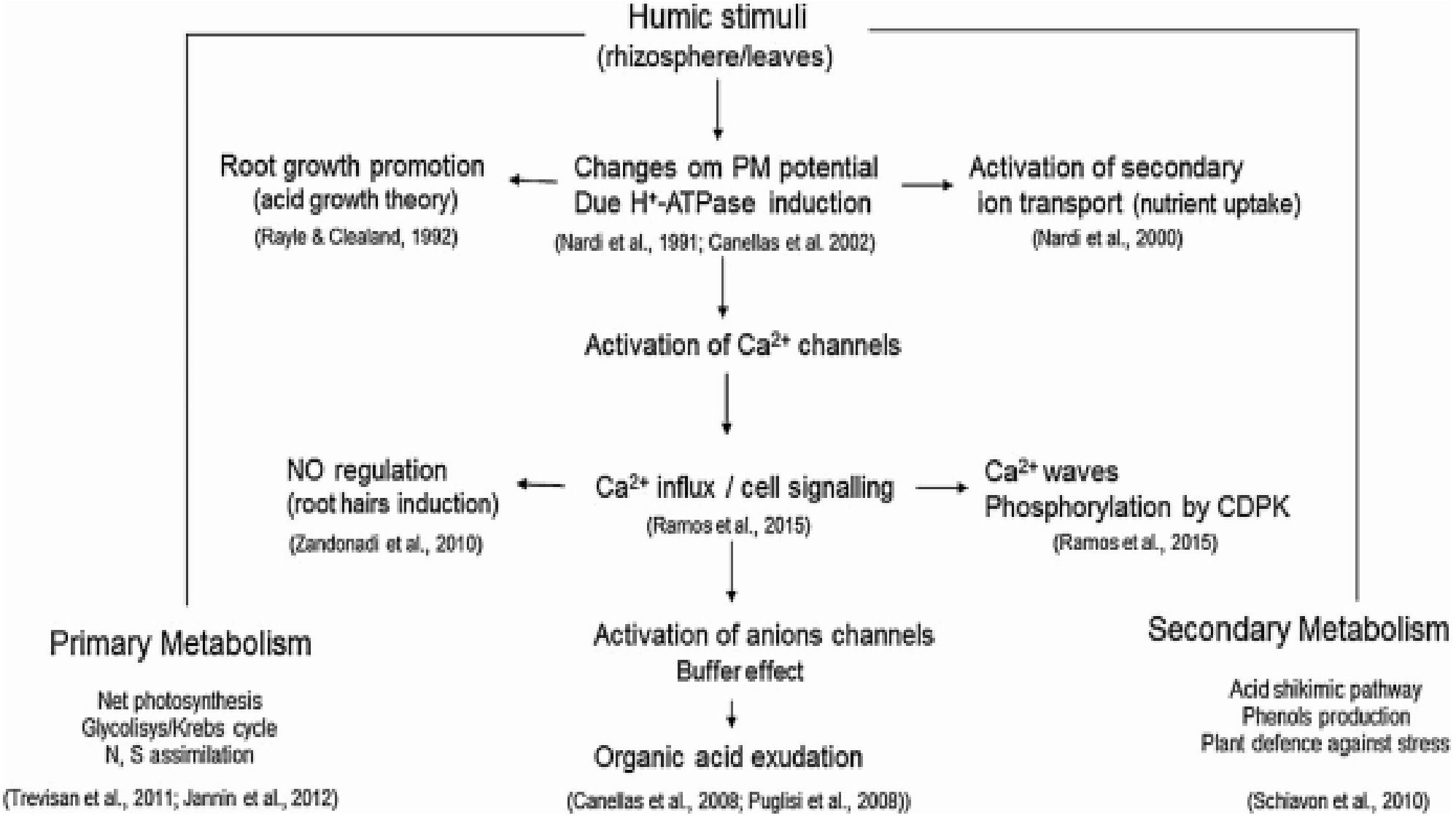
Il caffè SCIENTIFICO



Example of PCA score plot and heatmap of discriminant variables

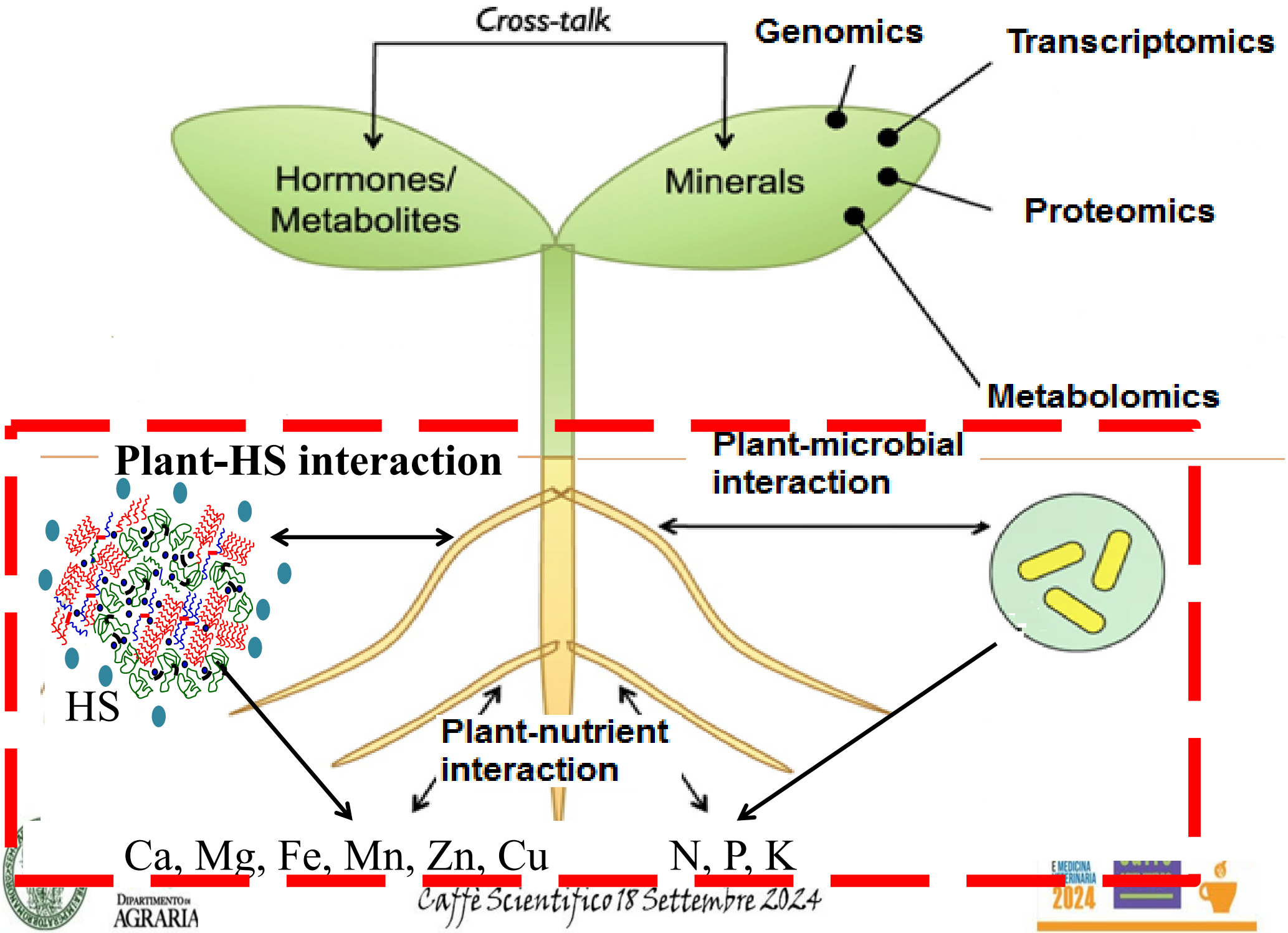
Humic and fulvic acids as biostimulants in horticulture

Scientia Horticulturae 196 (2015) 15–27



Crop	Simplified assay description	Effects	References
Pineapple	HA from vermicompost combined with beneficial microorganisms; pot filled with soil; greenhouse experiment	Improved growth and adaptation of pineapple plantlets to the ex vitro environment	Baldotto et al. (2010)
Potato	Commercial HA and FA applied to the soil or as foliar spray; field experiment	Enhanced nutrient use efficiency, and tuber weight (by 13%) and decreased incidence of hollow heart	Suh et al. (2014)
Potato	Commercial HA applied to soil at different doses; field experiment	Increased yield from 11% to 22%.	Seyedbagheri (2010)
Strawberry	Vermicompost leachates; foliar spray; field experiment	Increased fruit yield (10–14%) and decreased incidence of grey mould	Singh et al. (2010)
Strawberry	HA commercial soluble product; foliar spray at different doses; hydroponic culture under greenhouse	Enhanced yield (33%), fruit firmness and total soluble solid percent	Farahi et al. (2013)
Strawberry	HS combined with N fertilizers; foliar spray	Enhanced fruit quality reducing the number of misshapen and rotten fruits, and increased the sugar content	Neri et al. (2002)
Strawberry	HA at different doses; foliar spray and fertigation; field experiment	Increased nutrient use efficiency	Ameri and Tehranifar (2012)
Tomato	HA and FA from compost at different doses; hydroponic culture; growth chamber	Doses–response curve for shoot and root growth of tomato seedlings; HA were more bioactive than FA	Lulakis and Petsas (1995)
Tomato and cucumber	HA from vermicompost applied to substrate; different doses; pot greenhouse experiment	Increased tomato and cucumber growth	Atiyeh et al. (2002)
Tomato	HA from vermicompost combined with beneficial microorganisms; substrate application and foliar spray; field experiment	Increased fruit yield by 44–80%; decreased incidence of *Phytophora infestans*	Olivares et al. (2015)
Tomato	Different HA from forest soil mixed with nutrient solution; hydroponic culture	Enhanced net photosynthesis by 68–436% during the vegetative stages and increased fruit sugar content	Haghighi and Teixeira da Silva (2
Yellow passion fruit	HA at different doses and times of application as foliar spray	Increased root dry weight by 124% in seedlings	Cavalcante et al. (2013)

An additional valuable approach is the combination of **compost** or **humic substances** with **beneficial microorganisms** such as mycorrhyza, PGPB Plant-Growth-Promoting-Bacteria, *N-fixing bacteria*, *P-solubilising bacteri*a)


Cross-talk
Genomics
Transcriptomics
Hormones/
Metabolites
Minerals
Proteomics
Metabolomics
Plant-HS interaction
Plant-microbial
interaction
HS
Plant-nutrient
interaction
Ca, Mg, Fe, Mn, Zn, Cu
N, P, K

How Humic acid modulate plant-bacteria interaction ?

(1) Chemotaxis
Increase efflux of C-sources in rhizosphere

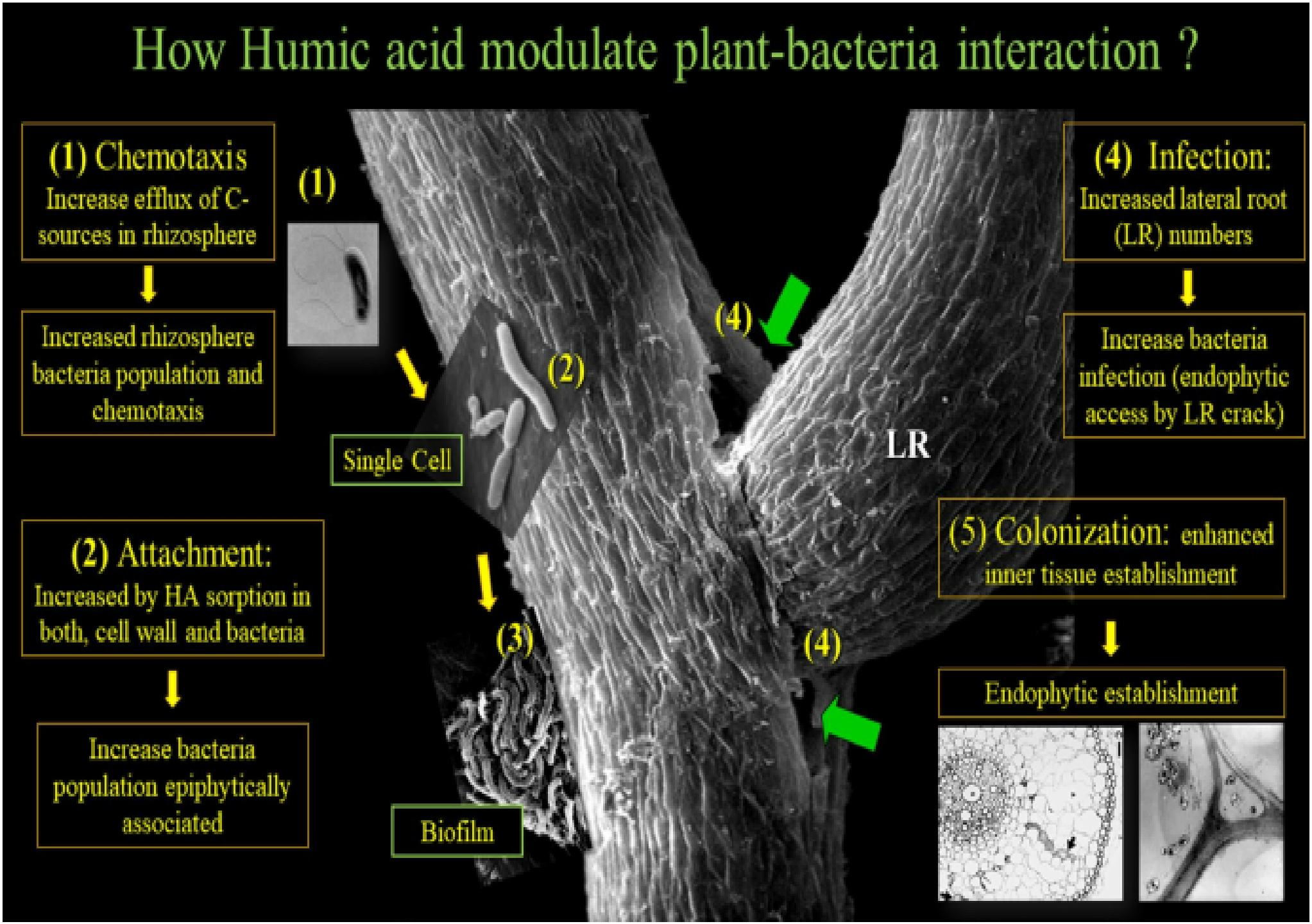
↓

Increased rhizosphere bacteria population and chemotaxis

(2) Attachment:
Increased by HA sorption in both, cell wall and bacteria

↓

Increase bacteria population epiphytically associated



(4) Infection:
Increased lateral root (LR) numbers

↓

Increase bacteria infection (endophytic access by LR crack)

(5) Colonization: enhanced inner tissue establishment

↓

Endophytic establishment

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(Olivares et al. 2017 10.1186/s40538-017-0112-x)

2024

Molecular characteristics of vermicompost and their relationship to preservation of inoculated nitrogen-fixing bacteria

J. Anal. Appl. Pyrol-104 (2013) 540–550
http://dx.doi.org/10.1016/j.jaap.2013.05.015

Phosphorus speciation and high-affinity transporters are influenced by humic substances *J. Plant Nutr. Soil Sci.* 2016, *179*, 206–214 kwwsv=22grl1ruj243143352nsq153483355;

Humic extracts of hydrochar and Amazonian Dark Earth: Molecular characteristics and effects on maize seed germination

Sci. Total Environ.708 (2020) 135000
https://doi.org/10.1016/j.scitotenv.2019.135000

Bioactivity and antimicrobial properties of chemically characterized compost teas from different green composts

Waste Management 120 (2021) 98–107
https://doi.org/10.1016/j.wasman.2020.11.013

Evaluation of Sustainable Recycled Products to Increase the Production of Nutraceutical and Antibacterial Molecules in Basil Plants by a Combined Metabolomic Approach

Plants 2023, 12, 513
https://doi.org/10.3390/plants12030513

Biostimulants Using Humic Substances and Plant-Growth-Promoting Bacteria: Effects on Cassava (*Manihot esculentus*) and Okra (*Abelmoschus esculentus*) Yield

Agronomy 2023, 13, 80. https://doi.org/10.3390/agronomy13010080

Transforming Food Waste Into Sustainable Packaging Materials

Caffè Scientifico 18 Settembre 2024

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SCUOLA DI AGRARIA E MEDICINA VETERINARIA 2024

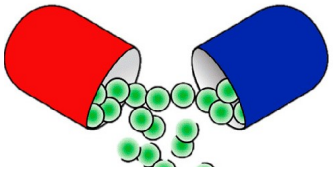
IL caffè SCIENTIFICO

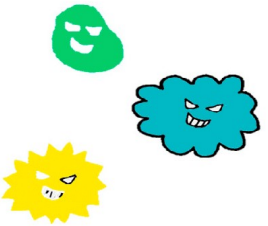
Pharmaceutical Industry

Supplements

Flavoring agent in medicine

Agro-food waste





Against various diseases

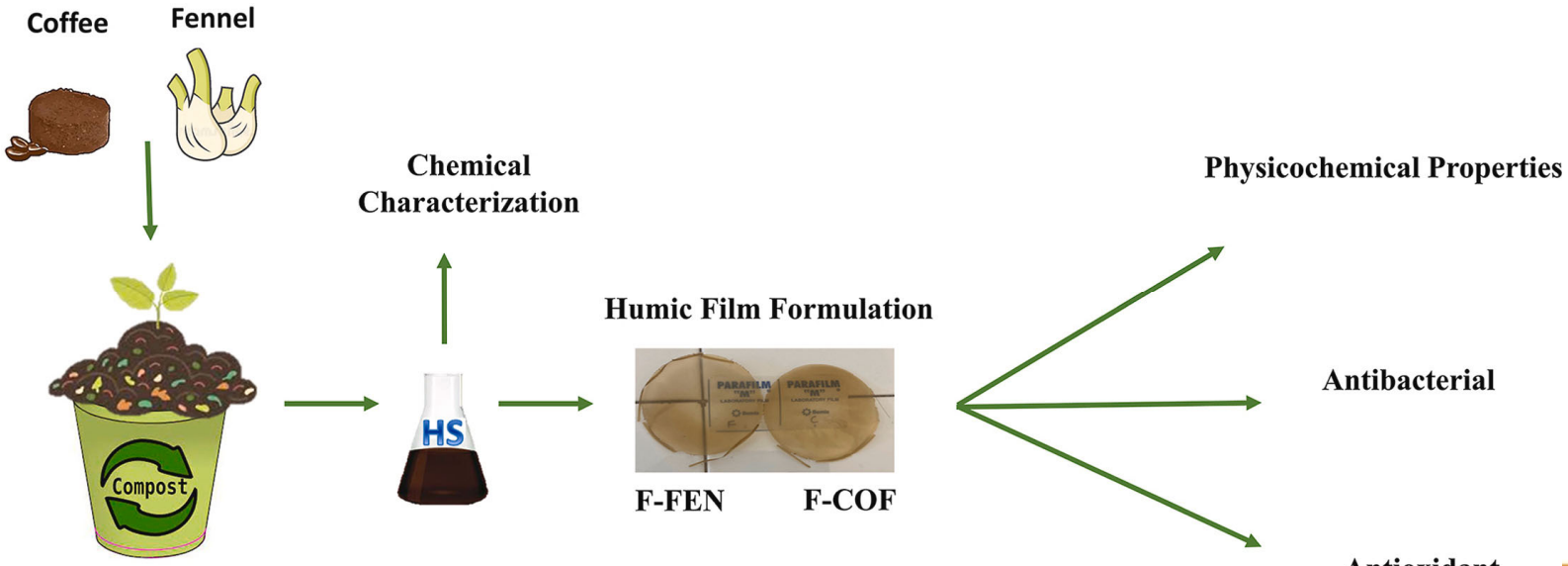
Bioactive extracts

Caffè Scientifico 18 Settembre 2024

Food Bioscience 2023 https://doi.org/10.1016/j.fbio.2023.102757

Valorization of organic biomass through the production of active biopolymer film based on sodium caseinate, guar gum, and beeswax

Mariavittoria Verrillo [a,b,1], Muhammad Rehan Khan [a,*,1], Stefania Volpe [a], Riccardo Spaccini [a,b], Elena Torrieri [a]



Caffè Scientifico 18 Settembre 2024

Biomacromolecules 2023,https://doi.org/10.1021/acs.biomac.3c00143

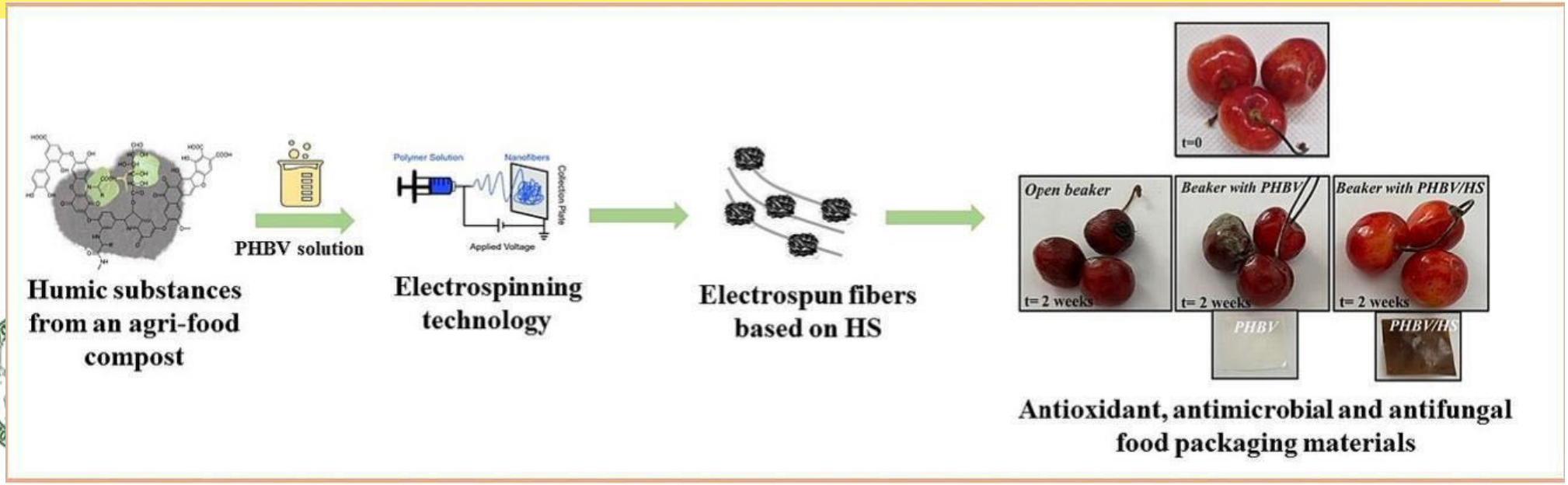
Waste to Wealth Approach: Improved Antimicrobial Properties in Bioactive Hydrogels through Humic Substance–Gelatin Chemical Conjugation

Virginia Venezia, Mariavittoria Verrillo, Pietro Renato Avallone, Brigida Silvestri, Silvana Cangemi, Rossana Pasquino, Nino Grizzuti, Riccardo Spaccini,* and Giuseppina Luciani*

Inter. J. of Biological Macromolecules doi.org/10.1016/j.ijbiomac.2024.130210

Electrospun films incorporating humic substances of application interest in sustainable active food packaging

Virginia Venezia [a,b,*], Cristina Prieto [c], Mariavittoria Verrillo [d], Mattia Grumi [c], Brigida Silvestri [e], Giuseppe Vitiello [a,f], Giuseppina Luciani [a,**], Jose M. Lagaron [c]



PLoS ONE 2023 https://doi.org/10.1371/journal.pone.0281631

Humic substances from composted fennel residues control the inflammation induced by *Helicobacter pylori* infection in AGS cells

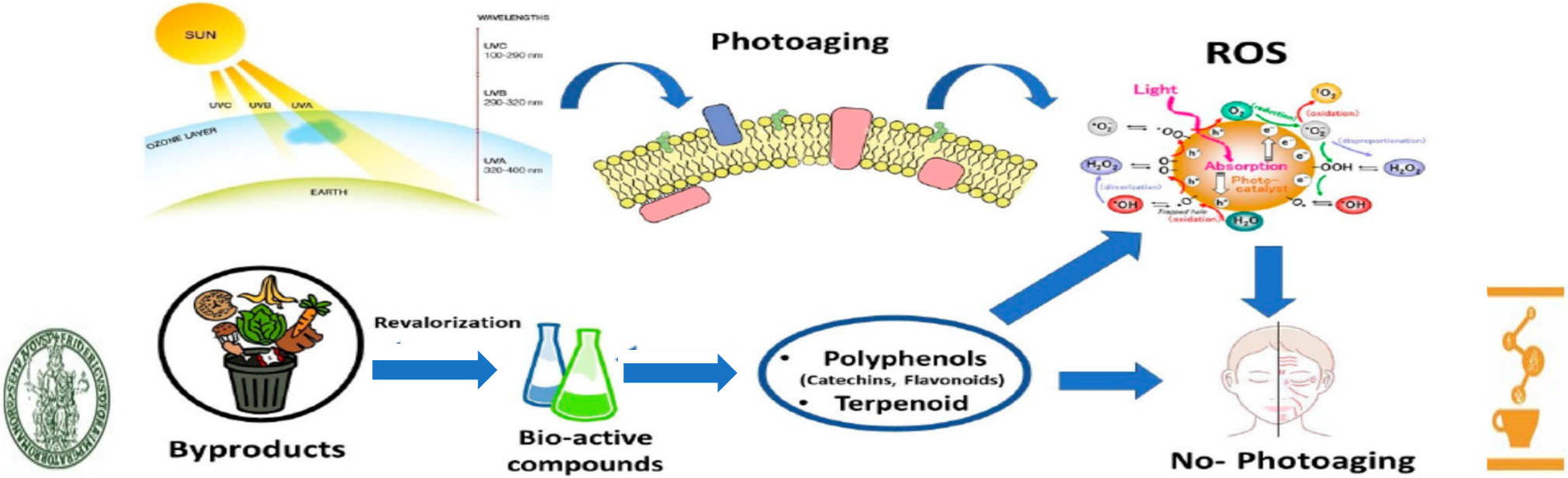
Mariavittoria Verrillo[1,2], Paola Cuomo[2]*, Angela Michela Immacolata Montone[3], Davide Savy[2], Riccardo Spaccini[1,2], Rosanna Capparelli[1,2]*

Plants 2023, https://doi.org/10.3390/plants12040840

Review

Use of Natural Agents and Agrifood Wastes for the Treatment of Skin Photoaging

Melania Parisi [1], Mariavittoria Verrillo [2,3,*], Maria Antonietta Luciano [1], ... Riccardo Spaccini [2,3,*] and Gabriella Fabbrocini [1]



Fondazione VERONESI

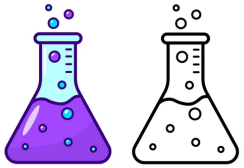
UNIVERSITÀ DEGLI STUDI DI MILANO

UNIVERSITÀ DEGLI STUDI DI PALERMO

UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

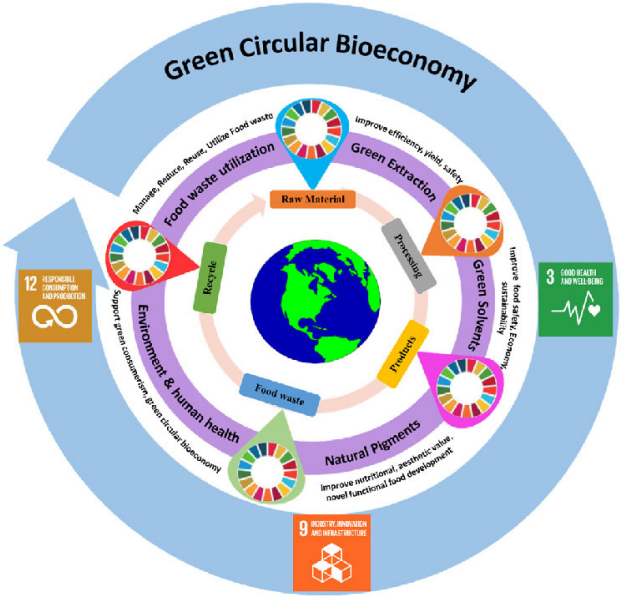
Antitumorigenic activity of BIOproducts extracted by REcycled natural sources (**BIORE**)

Drug delivery, nanoformulation



Antitumorigenic activities

Extraction and characterization of bioactive products



Valorization Agro-food wastes

Social, environmental and economic impacts

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SCUOLA DI AGRARIA E MEDICINA VETERINARIA 2024 — IL caffè SCIENTIFICO

Calendario Caffè Scientifico 2024

16 Ottobre 2024 Nicola Francesco Addeo –
Gli insetti, il cibo del nostro prossimo futuro

6 Novembre 2024 Valentina Iovane – Un approccio integrato nella lotta alle malattie infettive nell'ottica della salute globale

20 Novembre 2024 Monica Isabella Cutrignelli – Quale alimento è giusto per il nostro cane o il nostro gatto?

11 Dicembre 2024 Maria Carmela Ferrante - Le microplastiche: tutt'altro che un "micro" problema…