The mechanism of action of humic substances at the level of soil microparticles

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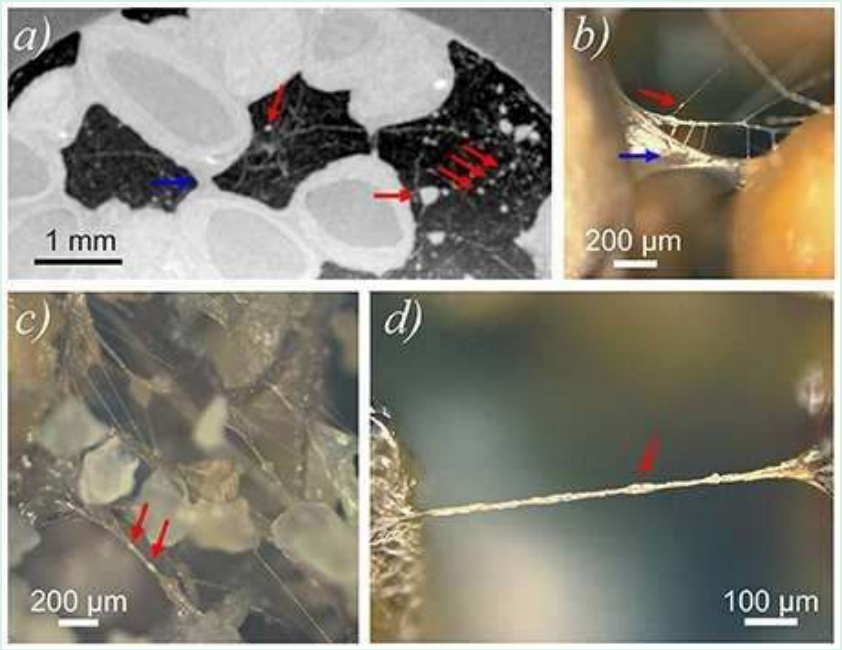
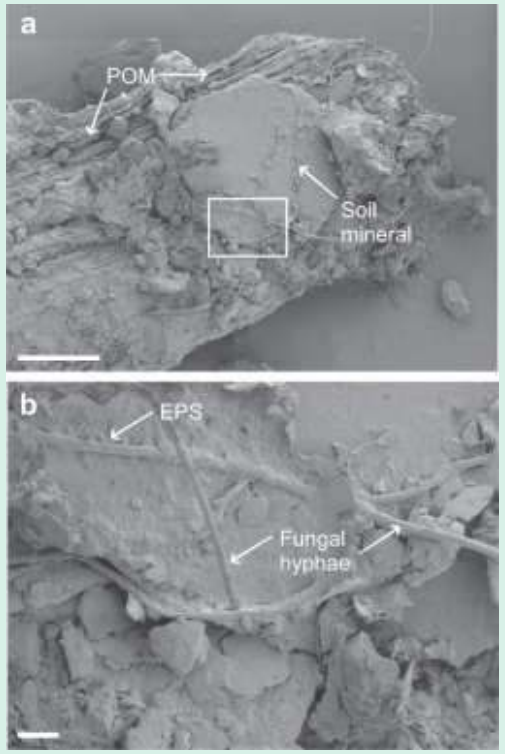
Humic substance is organic matter of special structure

- Source of soil organic matter are root muscilage, microorganisms metabolites and plant residues
- All of these substances are processed by microorganisms and fixed in soil as specific soil organic matter (humus)



https://doi.org/10.3389/fenvs.2018.00032



https://doi.org/10.1038/s41467-021-24192-8

Soil organic matter

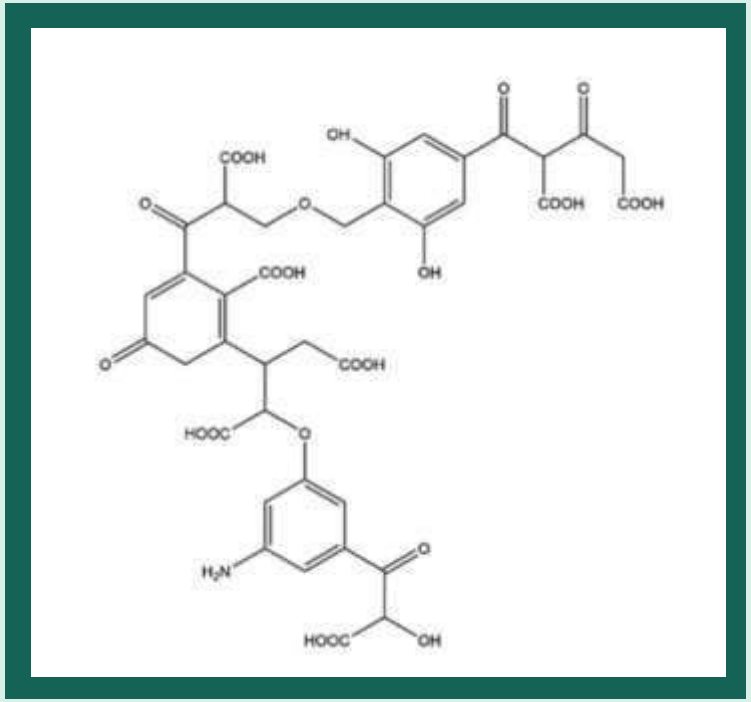
Soil microorganism metabolites

Plant residue

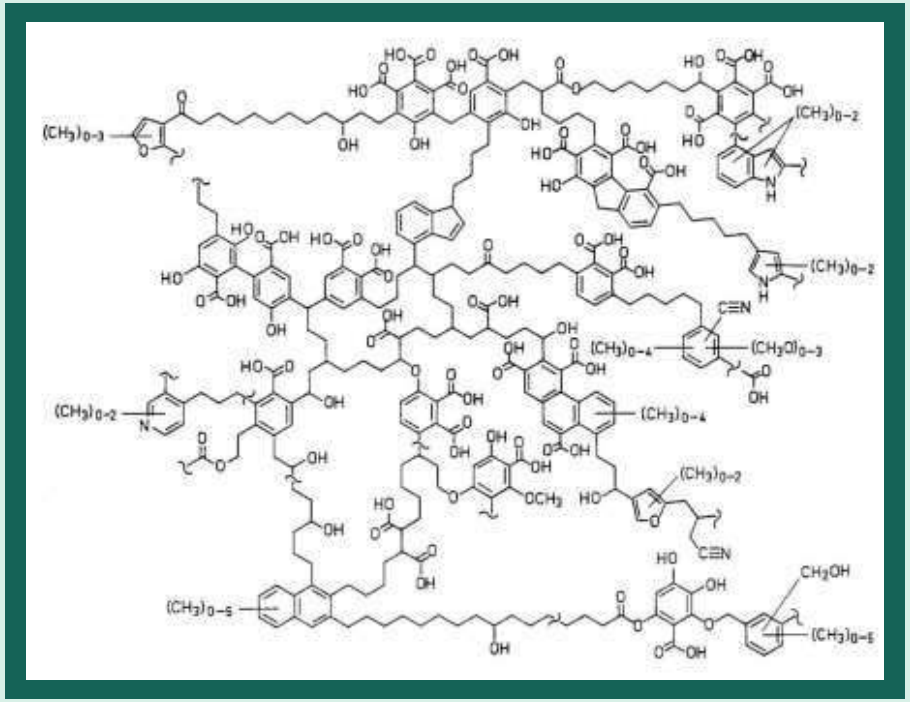
HUMUS

Fulvic acids

Humic acids



DOI:10.1039/C9RA09907G

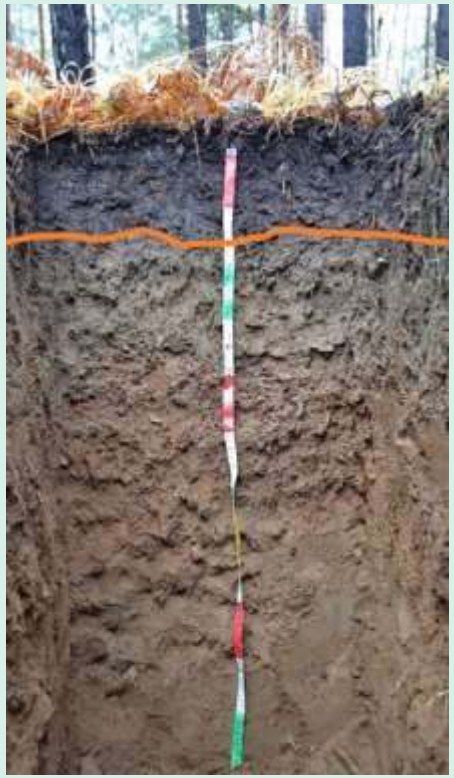


DOI: 10.1007/bf00324293

Soil organic matter better accumulates in conditions of northern forests and steppes, as residues decomposition rate is rather low

Due to high decomposition rate tropical soils have deficit of high quality soil organic matter

	retisol	phaeozem	chernozem	kastanozem	NITISOLS
C org,%	2	4	5-10	2	0,5-1,5
HA, cm	~20	~37	~55	~25	~23



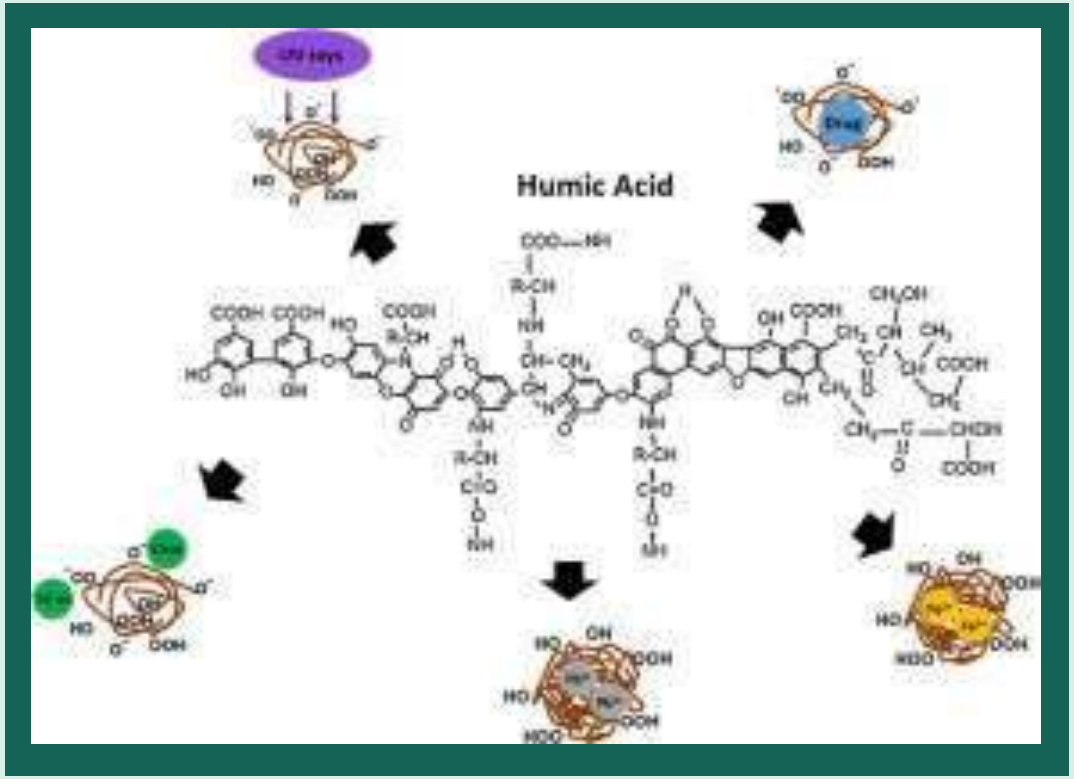
http://photosoil.tsu.ru/

https://www3.ls.tum.de/boku/wrb-working-group/pictures/

Diversity of functional groups of humic substances

Role of functional groups of humic substances

- Humic substances is arena for biochemical interactions
- Trigger for formation of functional microbiological community



Works about role of functional groups (https://doi.org/10.20546/ijcmas.2017.610.213

DOI: 10.1016/j.ecoenv.2018.07.038

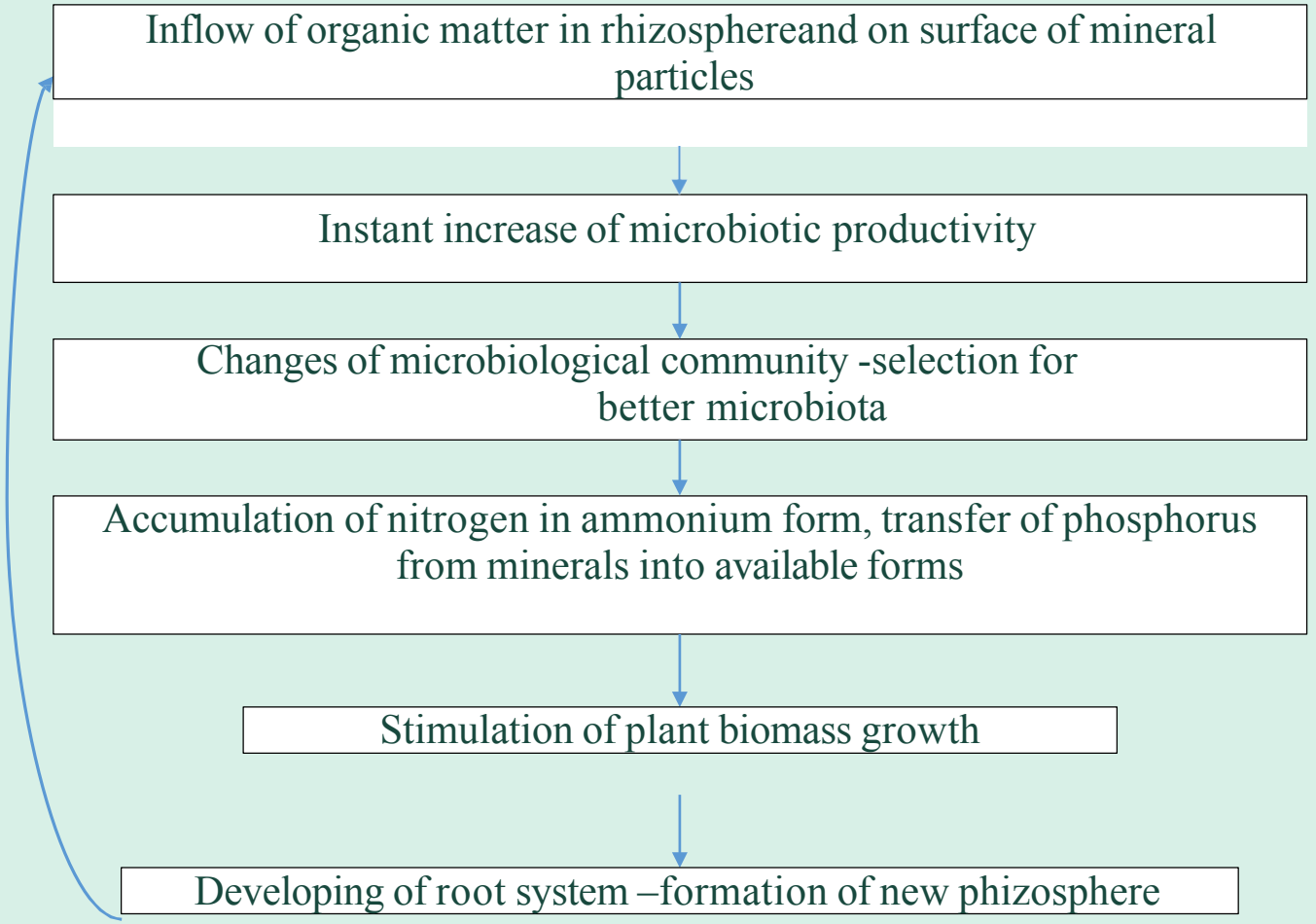
DOI: 10.1016/j.msec.2015.12.001

DOI: 10.3390/agronomy11061067

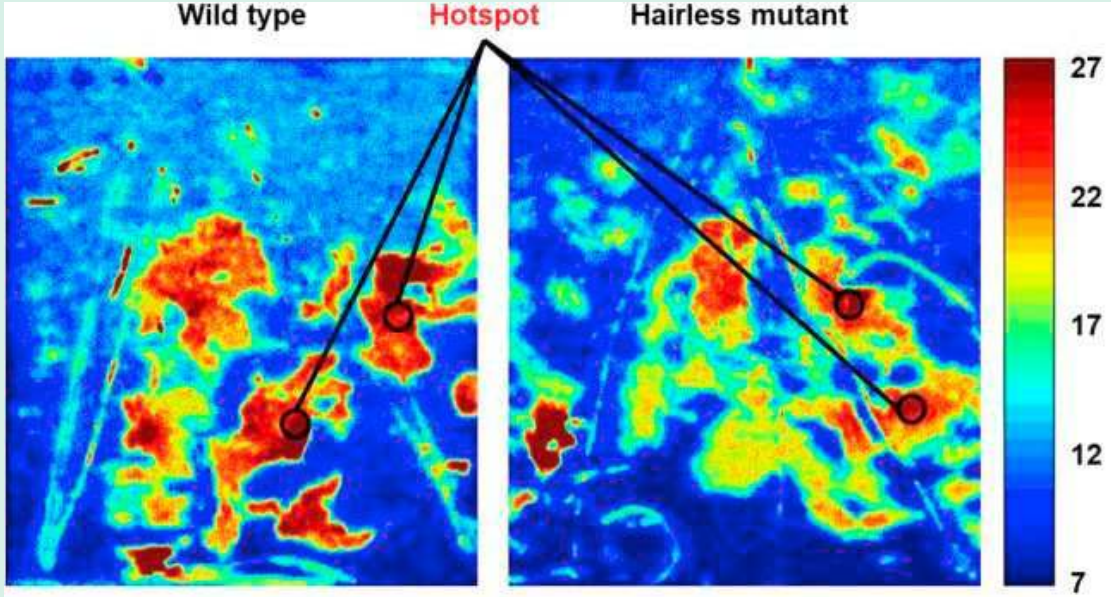
Benefits of humic substance

- Stimulating of microbiota in soils
- Initiation of nitrogen fixation, ammonification leading for higher yields
- Stimulating of self-purification of soils and bottom sediments from dangerous polutants
- Selection of “useful” microbiota in soils and gastrointestinal tract of human and animals
- Stimulation of seed germination
- Increasing plant immunity against plant pathogens
- .....

Scheme of plant-soil-microbiota interaction



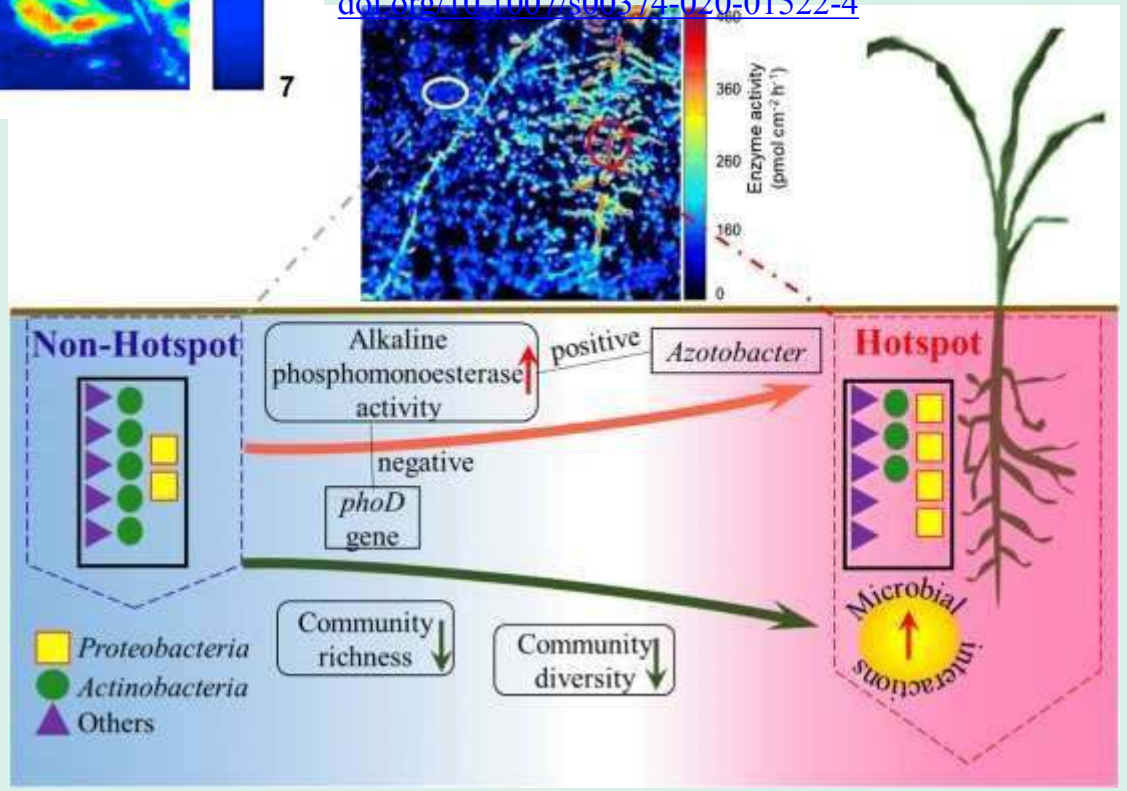
Rhizosphere is arena of plant-soil- microbiota interactions

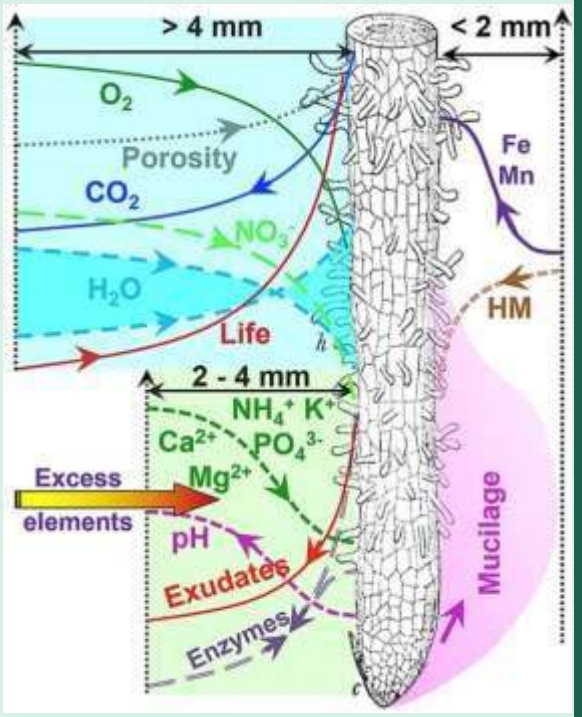


Examples of soil sampling from hotspots of β-glucosidase activity (nmol cm−2h−1) for further analyses (enzyme kinetics, kinetics of substrate- induced respiration and heatp roduction). Small circles: the hotspot soil sampled for further analyses. Left: wild maize type; right: hairless mutant. doi.org/10.1016/j.soilbio.2020.107872

Schematic diagram of ALP activity, *phoD* gene abundance, and microbial community in rhizosphere hotspot and bulk soil non-hotspot. The red arrow indicates an increase and the green arrow indicates a decrease. The diagram showed that the ALP activity generated a hotspot in the rhizosphere and a non-hotspot in bulk soil and was positively related to *Azotobacter* and negatively related to *phoD* gene abundance. The microbial community richness and diversity were lower, but microbial interactions were higher, in the rhizosphere than in the bulk soil

doi.org/10.1007/s00374-020-01522-4





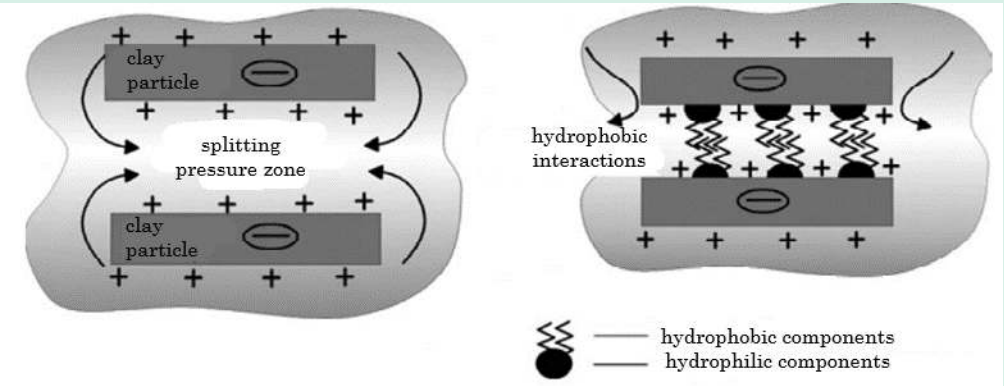
doi.org/10.1016/j.soilbio.2019.05.011

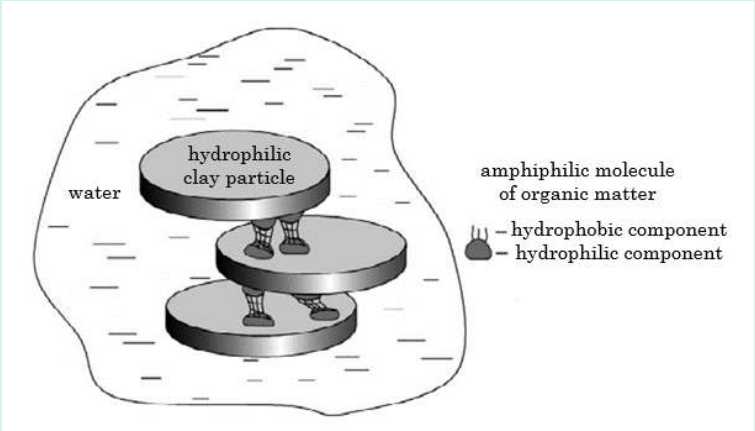
Rhizosphere constrains up to 90% of microbiota biomass

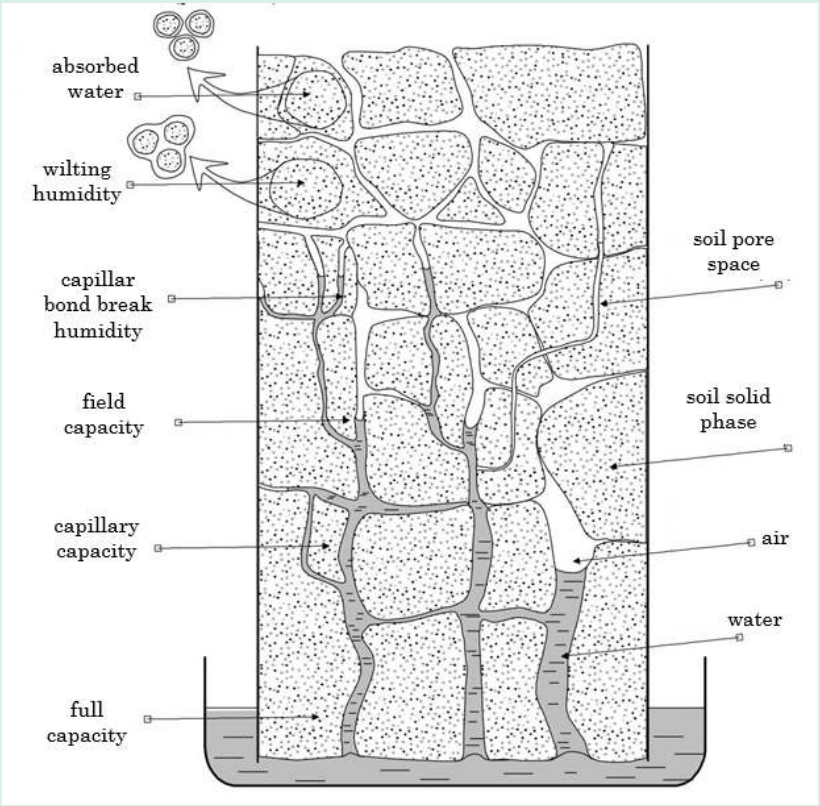
Organic matter changes physical properties of soil

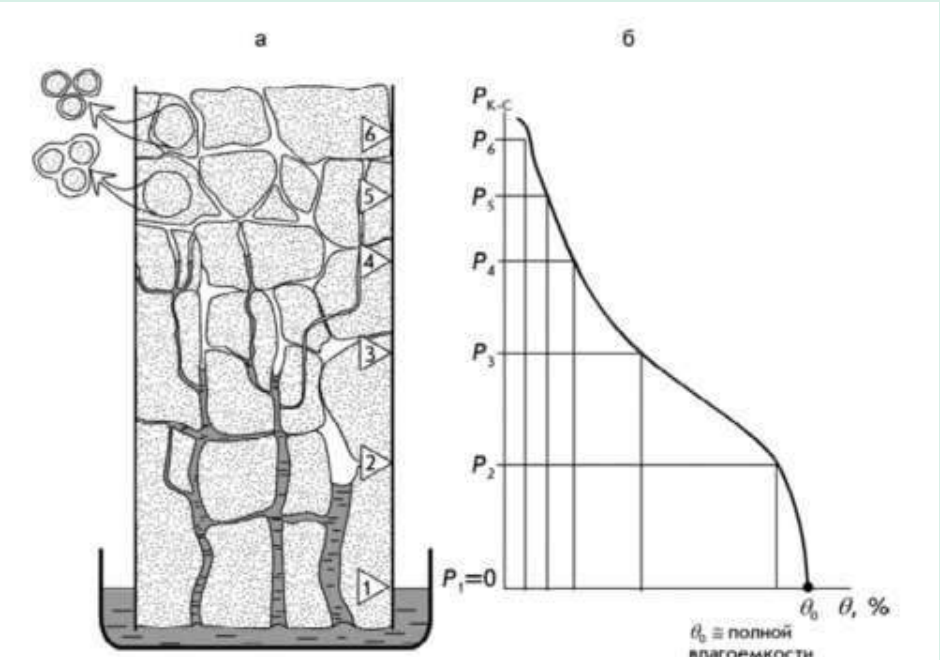
- Organic matter binds soil particles together into aggregates
- Increasing of aggregates size leads to increasing of soil endurance
- Increasing of aggregates size and endurance prevents soil erosion
- Soils with a pronounced agronomically valuable structure can drain excess moisture and have good storage capacity, which makes it possible to optimize water consumption in arid conditions and organize drainage in conditions of excessive moisture.

Organic matter changes physical properties of soil









Water retention curve and forms of water in soil

Conclusion

- Forming of humic substances if a very long process that requires certain conditions.
- Using of humate fertilizers allows you to stimulate the “good" microbiota, which enriches the soil with organic matter, removing restrictions on the conditions of its formation and saving time.
- Such stimulation of soils leads to the initiation of a whole cascade of “good" processes for soil improvement.

Thank you for your attention !

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