Historic and actual awareness of soil fertility in agriculture: Russia – Western Europe – USA: a summary of my survey

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In this paper I present an overview of how scientists in agriculture perceived the soils that produce the crops, and then I try to find out how these perceptions are - more or less consciously - included in agronomy and various related disciplines.

In microbiology the notion of complex soil ecosystems came up in the nineteenth century. Conversion of crop remnants and manure on the one hand and feeding the crops on the other hand, were studied as a balance in time (seasons), of manuring, crop rotation and (minimal) tillage in mixed systems. Therein crop- and livestock production were managed to be in balance.

However, minimalized in the side-line, soil-friendly agriculture survived in organic and biodynamic movements,
in this century enhanced by various similar approaches like agro-ecology.

Coevals of the Russian soil microbiologists

Similar recommendations for sustainable soil management made by Russian scientists as mentioned in my paper can be found by their coevals and successors,
such as the German, British, French and American researchers Rudolf Steiner (1861–1925), Sir Albert Howard (1873-1947), William Albrecht (1888–1974, Hans Peter Rusch (1906-1977) and Masanobu Fukuoka (1913–2008),
who share the perception of soils as living organisms and do apply this perception in agriculture.

But that notion and the experience of
agriculture as the art of ‘managing living soils’
were overruled by an upcoming use of the external inputs of
agrochemicals - fertilisers and subsequently pesticides –
after World War II.

And then the FAO declared the year 2015 as the year of the soil, as the chemical agriculture they had supported for decades, had appeared to be shockingly soil-destructive: causing soil-erosion and subsequently flooding followed by drought.

[See also The Economics of Ecosystems & Biodiversity – TEEB]

Furthermore I present the soil-ecosystem awareness of today in various disciplines such as plant breeding, biosphere & climate, human health, rural development, manuring, phytopathology (including pesticide effects in soil ecosystems).

Here I start by listing the key issues, recommended in one or another way by the cited authors, for sustainable soil management that underlies sustainable agriculture cq agroecology.

In general:
for the manuring, the clue is to feed energy (COH)
to the soil-ecosystem (‘humus’), with all its bacteria, algae, worms and insects, which together break down remnants of plants and manure, thus making nutrients available for the active(!) uptake by plant-root-systems, enlarged by their cooperative fungi (mycorrhiza etc.).
In that perspective:

1. Organic fertilisers cannot be replaced by chemical salts (NPK fertilisers). Depending on crop species, composts as fertiliser eventually brings yield increases of 10 – 50%, as compared to using chemical fertilisers.
2. Mycorrhiza fungi, algae and bacteria exude biotic substances into the soil, such as vitamins, amino acids, auxins, antibiotics, nitrogen compounds, organic (amino) acids and phosphor compounds.
The B vitamins are very important to plants, like vitamin B1, for O2 rich combustion, of B6, B2 B12 PP and H for formation of amino acids and their transamination.
3. Plant roots can take up several organic compounds as such, so complete mineralisation of the organic compounds is not a requirement as often is mistakingly presumed.

Moreover, when bacteria and mycorrhiza fungi are present, phosphorus & other metals and minerals are taken up more easily.

4. Each and every plant species creates its own rhizosphere in the soil, with its own microorganisms. Thereby the soil, climate and management conditions are crucial.
F.e., microorganisms do produce organic metal components (note that plants cannot take up inorganic iron).

5. During crop growth there are mainly non-sporulating bacteria fungi, and algae. When crops ripen the sporulating species, feeding on plant remnants, become most present. The latter can be detrimental to crops as they exude toxic substances:
a monoculture effect that cannot be countered using fertilisers.

6. In fertile soils less harmful microorganisms are found as compared to infertile soils. By adding $CaCO_3$, MgO and NaOH, important improvements of soil quality are accomplished.

On the contrary, by adding KNO_3 and KPO_3, azotobacter, a healthy soil indicator, is killed.
This refers to experiments in podzol soils, that presumably lacked Ca, Na and Mg, and presumably where still rich in K.
7. All micro-organisms have their own antagonists in the soil ecosystems.
To increase their positive effect on plant growth they should be mixed with compost, thus keeping them in a good balance.
8. In addition, although compost amendments applied during transition can improve crop vigour by significantly enhancing soil fertility, their effects on soil-borne diseases are not predictable when the farm is in transitioning to certified organic production.
The shift toward a new balance between breakdown and Uptake needs time to be established.

9. Plants growing in soils treated with manure or compost are found to contain more nutrients, and more antibiotics from the soil. They are usually superior in appearance, size and nutrient density to crops grown with conventional fertility formulations. Their resistance against plant diseases is increased as compared to non-treated plants.
The microbial balances in the soil ecosystem prevent diseases. Killing the living soils by using pesticides works out negatively on the soil fertility.
10. Biotic fertilizers work in a natural manner to rebuild soil acids and soil acid gels that act to hold topsoil in place. This means an end to arable soil erosion and loss of topsoil as it is caused by the use of chemical (conventional) fertilizers, which are easily over applied. Then the result is an imbalance in the carbon/nitrogen ratio in the soil, which accelerates the loss of topsoil.

11. The addition of organic matter such as cover crop, green manure (single and mixed species), seed meals, dried plant material, good quality compost, organic waste and peats can aid in reducing diseases caused by soil-borne pathogens.
12. Organic matter amendments are often very effective in controlling diseases caused by pathogens like Fusarium spp., Pythium spp, Rhizoctonia solani and Sclerotinia spp.

Now, in view of the before said, what can we do?
I suggest to create here and now a working group that is to design an international, multidisciplinary, practice based research program, for soil fertility improving, self sufficient, mixed farming systems (agro-ecological), appropriate for various soil-climate conditions and regional food supply.