DARCOFenews

Newsletter from Danish Research Centre for Organic Farming • June 2005 • No. 2

Articles in this issue

Soil aggregation - a matter of proper management

By **Susanne Elmholt**, **Per Schjønning** and **Lars J. Munkholm**, Danish Institute of Agricultural Sciences

A compact, cloddy soil makes tillage difficult leading to a poor seedbed and poor germination. Furthermore, a compact soil with few macro-pores impedes the transport of water and oxygen to plant roots leading to poor conditions for the soil biota, and nutrient deficiencies.Plants growing in such a soil are more liable to stress, and hence susceptible to pests and diseases.

These problems may become particularly severe in organic farming, where lack of nutrients and attacks by pests and diseases can’t be overcome by the addition of synthetic fertilisers and pesticides.

Interaction between soil constituents and soil life affects soil structure

Soil has to be friable in order to provide a proper seedbed when tilled – it must be able to form 'crumbs' (aggregates). Aggregates are formed by primary particles - clay and sand, which are held together by binding and bonding agents. In Danish agricultural soils, biological agents are the most important. These can be divided into: (1) 'gluing' binding agents (extracellular polysaccharides) formed by plant roots, bacteria and fungi, and (2) 'enmeshing' agents. The latter consist primarily of fungal hyphae, bonding together small crumbs into larger ones. Several inorganic compounds - as well as clay - may also act as binding agents.

The yellow box in **Figure 1** shows how soil microorganisms form binding and bonding agents responsible for soil aggregation. Soil aggregates in turn serve to maintain soil as a suitable habitat for plants, animals and microorganisms.

Studies on aggregate formation

Within the context of DARCOF I and DARCOF II, we have studied some of the binding and bonding agents responsible for the formation of soil structure. The complicated interaction between soil, plants and microorganisms is affected by many management factors. In an attempt to obtain more knowledge on the conditions in commercial farming, one of our studies addressed two pairs of neighbouring fields. Each pair consisted of an organic and a conventional field **(Figure 2)**.

Soil samples were collected in spring. Some measurements were applied to field moist soil ('whole soil'). Others addressed aggregates of different size. We obtained the aggregates by air-drying and sieving 'whole soil' samples. **Figure 3** shows the parameters that were assessed from each of the three boxes listed in **Figure 1**.

Conditions for soil biota poorest in soil from the uniform crop

rotation with synthetic fertilizers

Conditions for soil biota were poorest in soil from the conventional cash crop farm in Field pair 2, which had a higher bulk density and a lower volume of macro-pores than the other three soils **(Figure 4)**. This is probably why the biomass of fungi and bacteria was lower in this soil than in the organic dairy farm counterpart soil **(Figure 5)**. The conventionally cultivated soil also exhibited the lowest content of biological binding and bonding agents.

Both in Field pair 1 and 2, the organically cultivated soil had a higher biomass and contained more biological binding and bonding agents than its conventional counterpart. A reason may be that the crop rotation at both organic farms included leys, while no leys were found at the two conventional farms. Grass is known to favour the growth of microorganisms, especially fungi.

Both farms in Field pair 1 were dairy farms. The conventional field was supplied with large inputs of animal manure – much more than the organic soil in Field pair 2 - and it had a higher content of biomass and biological binding and bonding agents than both soils in Field pair 2 **(Figure 5)**.

A comparison of the two field pairs shows that level of nearly all the biological variables was higher in Field pair 1 than in Field pair 2. The large inputs of animal manure to both soils in Field pair 1 may have stimulated microbial growth and the formation of binding and bonding agents. Besides, the two field pairs were located with 1-2 km distance and differences in soil type may be another reason.

Soil aggregates surprisingly stable in the cash cropped field

Soil aggregates in the field grown for annual cash crops and with addition of only synthetic fertilisers were as stable as those from the organic soil in Field pair 1 **(Figure 4)** despite poor conditions for soil life. This is surprising because the soil contained less binding and bonding agents. What then made aggregates so stable? The answer is clay

Clay as the dominating binding agent leads to clods rather than crumbs

Does it matter for daily farming, whether soil aggregates are held together by clay minerals rather than biological binding and bonding agents – as long as they are held together? Yes it does! When such a soil gets wet, nothing will stabilize the clay, and it will be dispersed into the pore water. The result is an extremely unstable and muddy soil. When drying up, the dispersed clay will form a strong crust resulting in very hard aggregates (clods). Almost like burned bricks! It takes a high input of energy to break these small, hard clods, e.g. a rotary tiller. Subsequently, the soil is very prone to natural and traffic-mediated compaction and crust formation. Compaction may lead to a decreased production of biological binding and bonding agents, i.e. a vicious circle.

The soil aggregates in the conventional cash crop soil of Field pair 2 did actually behave like burned bricks as illustrated by **Figure 6**. In field-moist 'whole soil', the clay was more loosely bound and dispersed more readily in the conventional cash crop soil than in the organic soil. Thus, in the cash crop soil no biologically derived bonding and binding agents helped to withhold the clay in the aggregates.

For the air-dried aggregates, the situation was quite the opposite. Here most clay could be dispersed from the organic soil. In the conventional soil, the loosely bound clay had formed a hard crust during air-drying, and this crust was not soaked within the short dispersal time of 2 minutes as used in the laboratory test. In Field pair 1 we found no difference in the amount of loosely bound clay in soil aggregates. Apparently both the conventional and the organic soil contained enough biological binding and bonding agents to withhold the clay and prevent it from acting as a crusting binding agent.

Conclusions

- The conventionally cultivated soil with cash crops differed from the three dairy farm soils. Less biomass, fewer binding and bonding agents, too hard and compact aggregates. It differed also from the others regarding farming practice. It had a continuous cash crop rotation based on cereals and used exclusively synthetic fertilisers
- Both soils in Field pair 1 had higher levels for most biological variables than the soils from Field pair 2. The large amounts of animal manure in Field pair 1 may have stimulated growth of microorganisms and formation of biological binding and bonding agents
- Both organically cultivated soils had more biomass and a higher content of biological binding and bonding agents than their conventional neighbour. The reason might be that grass was a part of the crop rotation at the organic farms but not the conventional
- When practising continuous cash crop rotations without amendments of organic fertilisers, clay may become the most important binding agent, resulting in soil clods instead of crumbs! This will make soil management difficult. The soil will be perceived as muddy when wet and hard as brick when dry. In the spring, it will take large inputs of energy from a rotary tiller to prepare a seedbed
- Whether you stimulate the formation of crumbs or clods is a matter of proper soil management at the individual farm rather than a question of farming system. Formation of crumbs is primarily stimulated by a diverse crop rotation and organic fertilisers.

About DARCOFenews | **Archives** | **DARCOF** | **Front**