◀주제 2▶

친환경적 토양기능의 유지를 위한 유기농법적 토양보전 기술

안드레아 베스테
(독일유기농업재단)

Soil degradation – threat for the global resources of food production

The soil, like water, air, and energy, is one of our most important resources. Our future living conditions will depend most fundamentally on how well we manage this nourishing resource. A serious endangerment of ecological soil vitality caused by the effects of pollution and high external input management systems in agriculture, can be confirmed at a global level. Besides the contamination of soil, groundwater and drinking water with foreign substances, the rapid decrease of soil biota – biological degradation – and, amplified by this, the high susceptibility of soils for compaction and erosion – physical degradation, represent two more syndromes which have been termed frequently as a serious threat for the global resources of food

production(UNEP/ISRIC 1990, WBGU 1994, FAO 1996, HURNI 1996, BESTE 1999).

Whereas in past times making decisions about agricultural management practices only a small part of the production-functions of soil(mainly the storage and release of extern given nutrients) has been taken into account, today the demanded suitability of management systems depends on the ability to maintain all ecological soil functions for natural and agroecosystems for a long term(HURNI 1996). The source of land(soil) degradation process is an imbalance among the soil functions(DE KIMPE/WARKENTIN 1998).

Ecological soil functions which have to be maintained :

Habitat and living space :	habitat diversity for biota(plants, animals, fungi).
Production and utilisation :	Production of nutrients and biomass.
Ecological regulation :	filtration-, buffering-, restoring-, transformation-capacity for water and organic and inorganic material.

(BESTE, referring WBGU 1994, DE KIMPE/WARKENTIN 1998)

Central objective and indicator of optimal functioning soils are a high biological activity and good soil structure. Both are closely connected (ANDERSON 1991). A loose and crumbly soil with aggregates of high porosity implicates good living conditions for soil biota and the optimal functioning of ecological regulation.

Principles of organic farming sytems

One principle of organic farming is to support a good soil structure and high biological activity. Avoiding artificial fertiliser, production in this management system depends directly on the natural production power of soils. The better all soil functions are balanced the higher is the soil fertility for yield production. There have been gained many experiences how soil fertility can bee supported in many years of organic farming practice. The main principles are the same whether we are in the temperate zones or in the tropics(SIEFERT 1977, MULLER-SAMANN 1986, SCHELLER 1994) :

1. Crop rotation

Monoculture as we know today causes weed problems and susceptibility to diseases. Whereas a high diversity of plants in the crop rotation supports self regulation in the agroecosystem. The techniques to increase diversity in organic agriculture are :

- Changing the main crops as often as possible.
- Using intercrops between the vegetation period of main crops.
- Using the space between the main crop plants for intercrops growing the same time or in the early growing phase of the main crop to protect the soil surface.
- Building up agroforestry systems(mixed cultures of trees and bushes simultaneous with annual or/and perennial plants) (SIEFERT 1977, EGGER 1995, HAMPL 1996).

Apart from the ecological regulation effect of higher diversity there are some definite advances for soil protection and supportion of soil fertility :

- A high diversity of roots offers good food conditions for soil biota as well as increasing porosity and biological stabilisation of soil structure. Both effects support transformation capacity.
- The growing of plants the whole year protects the soil surface against erosion and siltation of aggregates.

2. Manure management

If we use mineral manure, we intend to feed directly the main crop which we will going to harvest and sell. The transmission of nutrients goes mainly over the soil-water. Some processes of the metabolisms which naturally take place in soil(decomposition, transformation etc.) are omitted. Thus for some species of soil biota the vital substances for, their metabolism are missing. Some of these substances(humic substances, colloides) have important stabilising effects on the soil structure(similar as polysaccharides and glycocalyx) So, if we are using mineral manure only, in most cases the diversity of soil biota decreases(which includes a decreasing natural fertility) and we gain less biological stabilisation of soil structure. This leads to the already known current problems of soil compaction, surface sealing and erosion(WBGU 1994, BESTE 1999).

In the system of organic farming manure management aims at feeding the soil biota, supporting a vital and diversified metabolism in the soil.

Transmission of nutrients goes by a large chain of different metabolisms with other closely linked processes. The soil-ecosystem has the chance for self regulation maintaining the natural balance. This causes a well balanced nutrition and less diseases of the main crop(SCHELLER 1993). The techniques of manure management are :

- Organic manure with animal excrements
- Organic manure in the crop rotation with green manure (green fallow, intercrops etc. as mentioned above) which means feeding soil biota with roots.
- Organic manure with harvest residues (mulch effect includes the protection of soil surface at the same time).

• Feeding the main crop by feeding the soil biota with organic manure leads to a high biological diversity and activity in the soil. This supports a good soil structure and natural fertility.

3. Tillage techniques

Every agricultural management, if it is implemented with heavy machines, leads to compaction. Apart from weed regulation and the working in of harvest residues the main purpose of tillage is it to loose the soil periodically to avoid the increase of compaction. So the tillage treatment has to care for a restoration of a soil structure which shows good condition for air and water circulation and habitat conditions for soil biota and their metabolism. Every tillage treatment is an heavy intervention in natural soil

processes. It should not be implemented when soil is wet. Best time to loose the soil technically is after harvest and before sowing an intercrop or a green fallow with good rooting properties to initiate biological loosening of clods and biological stabilisation(with roots and soil biota metabolism products) of the so loosened soil(HAMPL 1996).

Ploughing as a very intensive tillage has many advances in weed control but shows heavy disturbance of biological activity. Non inverting tillage shows more conserving effects on soil biota but has less advantages in weed control. Until now there exists no definite solution for this answer. Some so called rule of thumb says : depth loosening but shallow inverting.

This topic is still open to scientific inquiry(BESTE 1996).

- Tillage should be implemented while soil is dry enough, after harvest and before sowing an intercrop or a green fallow with good rooting properties to initiate biological loosening of clods and biological stabilisation of the so loosened soil.

The best method to prove if soil management leads to good structure conditions and high biological activity is to investigate the soil regularly and look just into it with a so called Spadediagnosis. The practice of the Spadediagnosis, developed by the German J. GORBING about 1930 is to dig a 'soil-brick' with a spade out of the field. This soil brick is immediately examined concerning the condition of soil structure and other parameters. In support of this method the condition of soil structure, size, shape and

arrangement of soil particles and aggregates as well as density, root growth and soil moisture can be examined and estimated with little effort. This comprehensive impression has been proved as very helpful for the judgement of previous management practices(crop-rotations, tillage-treatments...) and appropriate decisions about modifications for future soil management by agricultural consultants and farmers (HAMPL-MATHY 1991, BESTE 1998, BESTE 1996).

References

1. ANDERSON, T.-H. (1991) : Bedeutung der Mikroorganismen für die Bildung von Aggregaten im Boden. Zeitschrift für Pflanzenernährung und Bodenkunde, H. 154.
2. BESTE, A. (1996) : Auswirkungen unterschiedlicher Bodenbearbeitungsverfahren im ökologischen Landbau auf Bodenstruktur und Wasserhaushalt. Diplomarbeit, Geographisches Institut Universität Mainz.
3. BESTE, A. (1998) : Extended Spade Diagnosis. In : Sustainable Land Management. Guidelines for Impact Monitoring. Centre for Development and Environment(cde), Bern(CH) & Gesellschaft für Technische Zusammenarbeit(GTZ), Eschborn, Hrsg..
4. BESTE, A. (1999) : Wie muss Boden bewirtschaftet werden, damit seine ökologische Funktionsfähigkeit langfristig erhalten bleibt? In : Positionen und Vorschläge, 3. Gaytaler Gespräche. Wege zu einer nachhaltigen

Entwicklung in der Region. Die Rolle des Bodens.

5. DE KIMPE, C. & R. WARKENTIN (1998) : Soil Functions and the Future of Natural Resources. In : Blume H.-P.(Hrsg.) : Towards sustainable land use. Furthering cooperation between people and institutions. Selected papers of the 9th conference of the International Soil Conservation Organisation(ISCO). Reiskirchen.
6. EGGER/KORUS (Hg.), 1995 : Öko-Landbau in den Tropen = Alternative Konzepte 86. Bad Durkheim.
7. FAO (Hg.), 1996 : Fighting Hunger and Malnutrition. Rome.
8. HAMPL-MATHY, U. (1991) : Bodengesundung.(= SÖL-Sonderausgabe, 37). Bad Dürkheim.
9. HAMPL, U. (1996) : Gründüngung Grundlage der Bodenfruchtbarkeit. Graz.
10. HURNI, H. with the assistance of an international group of contributors (1996) : Precious Earth : From Soil and Water Conservation to Sustainable Land Management. International Soil Conservation Organisation(ISCO) and Centre for Development and Environment(CDE). Bern.
11. MÜLLER-SÄMANN, K., 1986 : Bodenfruchtbarkeit und Standortgerechte Landwirtschaft in den Tropen.
12. PRIMAVESI, A., 1992 : Agricultura Sustentável. Manual do produtor rural. Nobel-Verlag, Sao Paulo, Brasilien.
13. SCHELLER, E. (1994) : Pflanzenernährung und Düngung im organischen Landbau. In : Springer Loseblatt System Ökologische Landwirtschaft. Pflanzenbau, Tierhaltung, Managenent 1, Lünzer, I. ; Vogtmann, H. (Hg.), Heidelberg, New York, Sektion 02.02, S. 1-21.

13. SIEFERT, E. (1977) : Der organisch – biologische Landbau.(In : Ökologischer Landbau, eine europäische Aufgabe : Agrarpolitik und Umweltprobleme = Alternative Konzepte, 21). Bad Dürkheim Landwirtschaft aus gesamtwirtschaftlicher Sicht. Kiel.
14. UNEP/ISRIC (1990) : The extend of human–induced soil degradation. Annex 5. Wageningen. Netherlands.
15. WBGU (1994) : Die Welt im Wandel – Die Gefährdung der Böden.(= Jahresgutachten 1994). Bonn.