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WIDER BENEFITS OF COMPOSTING: A SURVEY OF THE BENEFICIAL EFFECTS OF THE APPLICATION OF COMPOST AND DIGESTATE

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ABSTRACT

Though MSW-compost has been banned in Switzerland for more than 15 years, and compost may thus be termed a clean product, this has not sufficed to guarantee long-term demand for its products.

A Swiss research project on the benefits of compost and digestate was launched in 2003. Its aim is to assess the beneficial effects of compost and digestate application on plant growth and health, on soil parameters and on the environment in general.

Best known are the fertilising qualities of compost and digestate (P, K, Ca, Mg, S, etc.), though the effects of nitrogen are still little understood. Not enough is known either about how compost affects the soil structure. The main actor here is the organic matter, i.e. the humic compounds. Positive effects are: enhanced soil structure, improved water and air balances, reduced erosion and more earthworms. The intensification of soil microbial activities reduces soil-borne diseases (seedling and foot diseases, etc.). Compost and compost extracts also help to inhibit the appearance of leaf diseases.

During this research project, which will enter its main phase in 2004, the accent will be placed on determining to what degree these beneficial qualities are widespread in composts and digestates and how they can be selectively enhanced.

KEYWORDS

Compost, digestate, benefits, soil imrovement, disease suppressivity, quality standards

1. INTRODUCTION: BIOWASTE MANAGEMENT IN SWITZERLAND

The 7.2 million inhabitants produce an average per capita of 90 kg biowaste which is treated in biowaste treatment facilities. The agricultural use of compost from MSW has been banned in Switzerland since 1986. Only separately collected biowaste can be composted (figure 1). This decision formed a solid basis on which to build the reputation of compost as a harmless product, but obviously was not enough to make a marketing success of it.

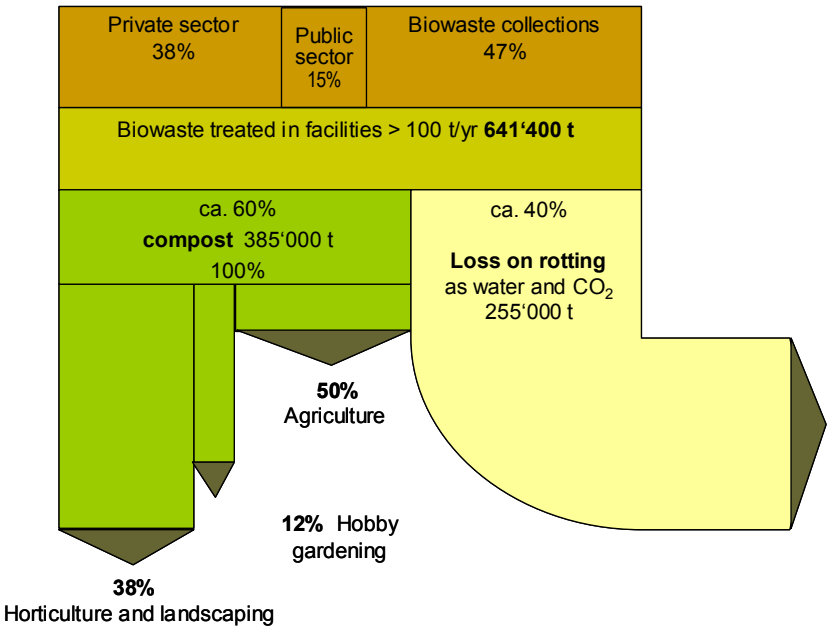

Figure 1. Origin of the biowaste treated in Swiss composting or AD facilities in 2000, and destination of the products.

More than 70% of biowaste is composted in open windrows (figure 2), including field-edge composting. Covered or closed systems, including AD, account for a good quarter of the amounts processed. Only about one eighth is digested anaerobically, most of it in the canton of Zurich, where anaerobic digestion (AD) plants treat of some 30% of the biowaste collected.

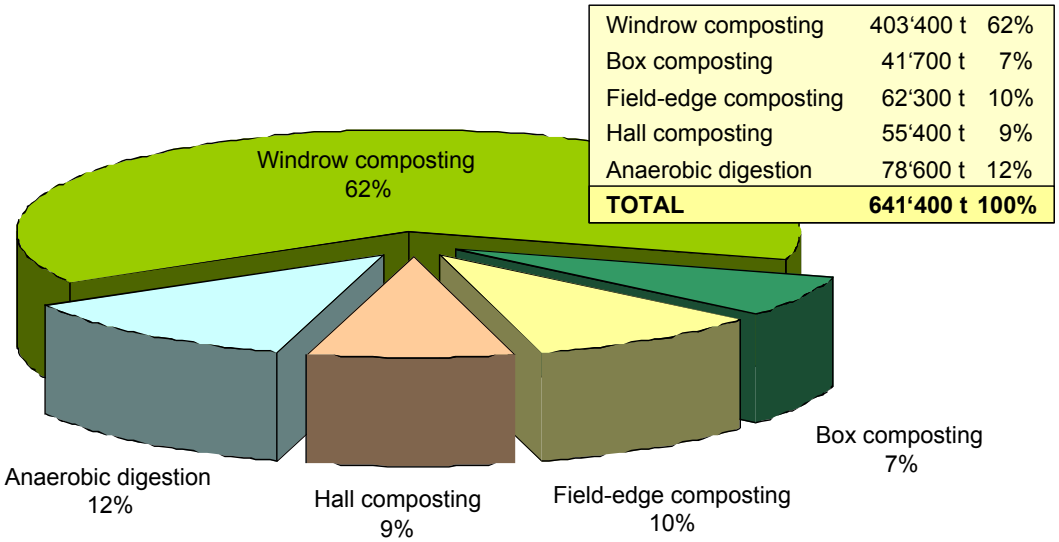

Figure 2. Types of processes used in Switzerland in 2000 (SAEFL 2001)

2. BENEFITS OF COMPOSTS

2.1 Definitions and concepts

Product: a product is something that is put on the market, where it can be inspected, admired, and bought, to be used or consumed, in order to fulfil a desire or a need (Kotler/Bliemel, 1992).

Benefit: a benefit is always buyer- or use-oriented and must be recognisable directly, without any involvement from the producer (all chocolate should be sweet and melt in the mouth). The greater the benefit for the buyer, the higher he will rate the quality of the goods. Therefore the quality of a product is generally assessed from the point of view of the user / customer, who will accept to pay more only if he receives some added value for it. This implies also considering the uses to which the product will be put, since full benefits will be reaped only if the product is used for what it was intended. Products with multiple beneficial uses generally have a harder time establishing themselves on the market than those with a single use (chocolate sweetens your life), since they require a more complex involvement with the product.

The **image** of a product is also very important for many prospective buyers. This is why it is important when one communicates about a product such as compost not only to mention the absence of pollutants or its production from waste, but also to describe its positive qualities (effects on soil life and structure, disease suppressor, fertilising potential, etc.). The producer must therefore shed his role of waste manager for a more commercial attitude, where customer satisfaction with his product becomes of primary importance. This is the only way of ensuring long-term viability for a product.

2.2 Main benefits of compost and digestate

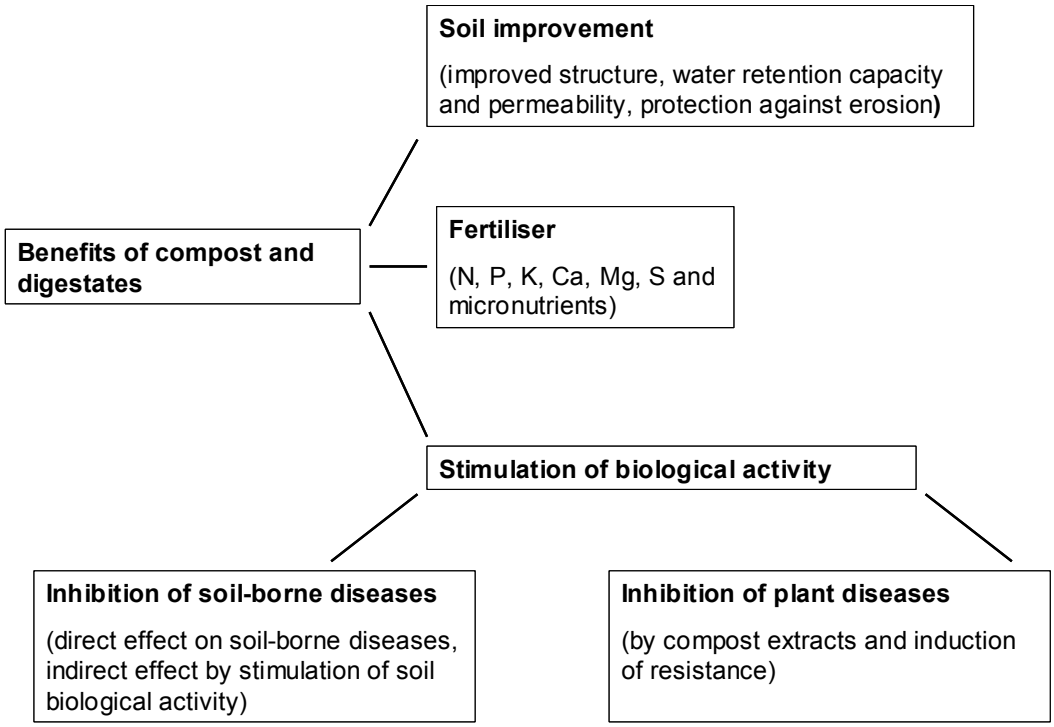

Figure 3 Overview of the benefits of compost and digestate

2.3 Benefits from the nutrients and organic matter of compost

The use of compost is financially interesting. To provide the same quantity of nutrients as contained in 1 m^3 of compost with fertilisers costs about € 6.- in best-practice farming and € 9.- in organic farming. To provide the same quantity of organic matter with peat would cost some € 13.- (this is not allowed in organic farming). Spreading fertilisers costs a further € 1.50. Spreading compost is more expensive and costs between € 6.- and 10.- per m^3.

Up till now the main benefit of compost was considered to reside in its nutrient content, but this is in fact a great oversimplification. When some 50 farmers who had recently applied compost to their land were questioned about its benefits (Schleiss 1999), they awarded a slightly lower value

to the supply of nutrients, compared to that of organic matter. Soil improvement and fertilising value were given about the same weight as transport and spreading costs. Other benefits, such as disease suppressivity were not assessed.

The primary benefit from organic matter is that it feeds the soil biomass. Thus, higher OM contents will sustain larger populations of earthworms and other organisms. Secondly, a more stable organic (humic) fraction improves the cation exchange capacity of the soil and buffers it against possible physico-chemical imbalances.

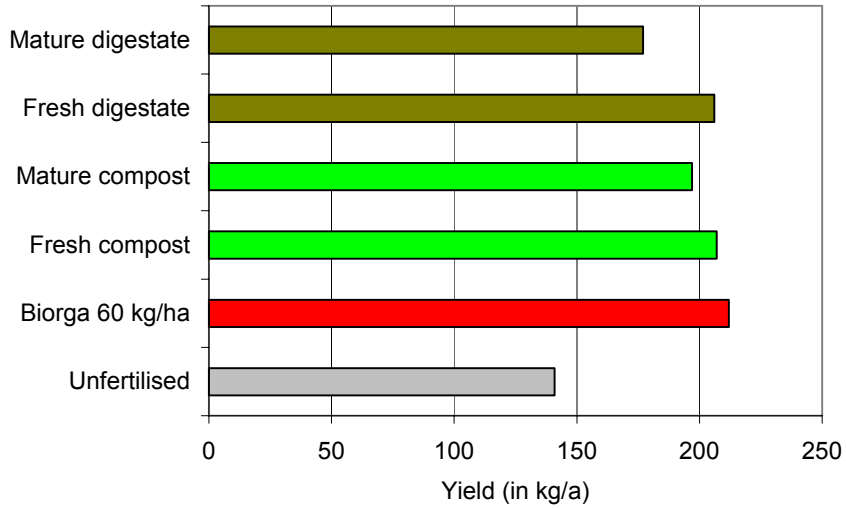

Figure 4 Compost application in a cauliflower culture (4 repetitions, Fremont variety, planting in May, 500 pl./a; harvest in July). Compost application: 63 m^3/ha (corresponds to the phosphorus requirements of 3 years of vegetable culture). Except for the unfertilised plot, all plots received the equivalent of 80 kg N, as Biorga nitrogen pellets). The nitrogen from the compost was not bioavailable, but no symptoms of nitrogen block or of other deficiencies were observed. (Koller et al. 2003).

2.4 Stimulation of biological activity

It is not easy to quantify the inhibition of soil-borne plant diseases and the induction of disease resistance by quality compost. Its benefits as preventive disease inhibitor and the ensuing higher crop yields can easily be some ten-fold that of its use as fertiliser. But concrete demonstrations of these benefits are still lacking. Research has shown the positive influence of humic substances on crop yields (Gerzabek 2002). However assessing the economic value of such effects requires some more time.

2.5 Effects on plant health

Compost will affect plant health indirectly, by providing micro- and macronutrient and by improving the soil structure and water balance. The direct positive effects are less well known. Antagonistic microorganisms, which develop during the maturation phase of quality compost, help to protect plants effectively against diseases. This disease suppressivity can be of practical importance, if the compost is used correctly.

To be of maximum benefit to plant health, composts must be produced from carefully chosen feedstocks and undergo optimal degradation and storage. Only then will the risks of unpleasant surprises from weed germination and contamination with diseases be reduced to negligible levels. Producing this kind of composts requires effort, proper infrastructures and an impermeable work surface.

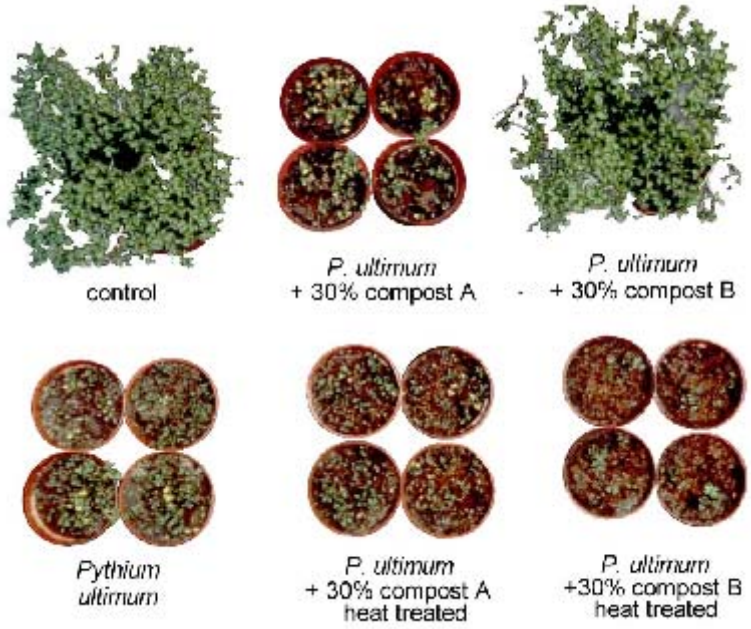

Figure 5 **Compost A** protects cress from seedling diseases, but causes root damage (necrosis and lesions). **Compost B** protects the plants almost completely from disease. This protection is due to **beneficial microorganisms** that are present in numbers in quality compost. If the compost is heat-sterilised before use, it looses its protective virtues, since the microorganisms are destroyed. **The use of sterilised compost is in effect contra productive**, since it offers favourable growth conditions to pathogens. (source J. Fuchs, www.biophyt.ch)

2.6 Use of composts in growth substrates

Figure 6 Influence of storage in plastic bags on the capacity of compost to protect cucumbers plants from foot disease (Pythium) (germination in heat sterilised earth with addition of 20% compost, average of 24 plants). The protection offered by compost fresh off the windrow is good, while compost stored in the anoxic conditions of plastic bags has lost its protective capacity.

Peat-based substrates are microbiologically inactive and are therefore very sensitive to pathogens. They can therefore at times cause heavy losses, in particular in organic gardening, where the use of fungicides is forbidden. Quality compost can act as microbiological buffers in peat-based substrates, drastically reducing the dissemination of pathogens.

2.7 Addition of compost to soil after steaming

Greenhouse soil must be steamed at more or less regular intervals, depending on the type of culture and the intensity of disease pressure. The addition of compost immediately after steaming, increases the soil microbiological activity, thus contributing to degrade phytotoxic substances more rapidly and providing the soil with a biological buffer. This hinders the dissemination of pathogens. Steamed soil to which compost has been added can be replanted faster and the cultures remain healthier. The interval between steamings can also be increased.

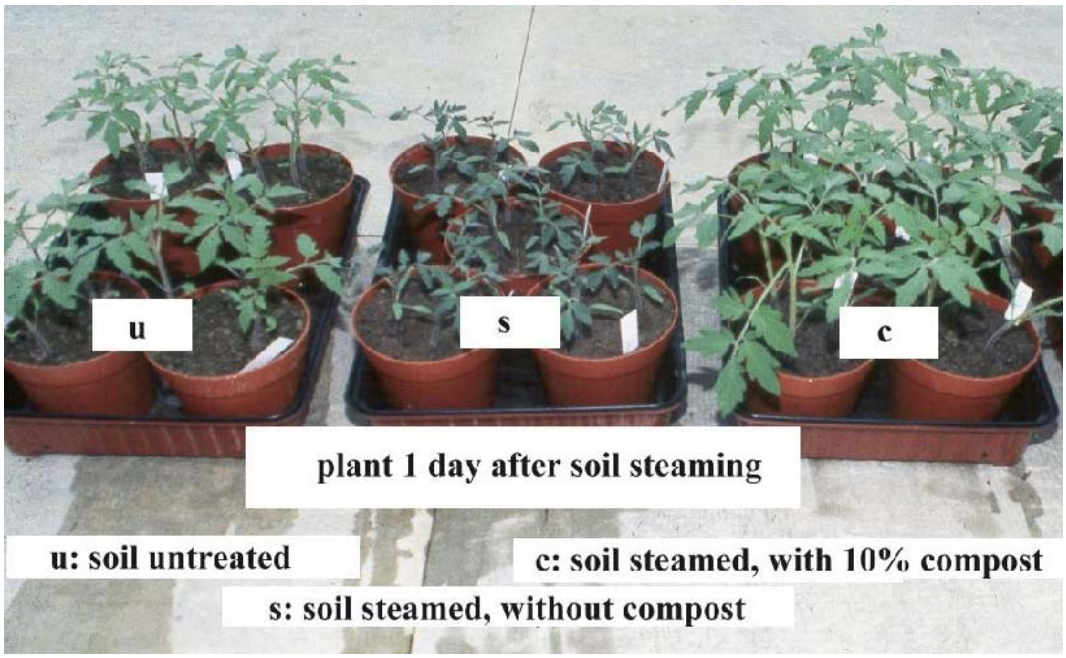

Figure 7 In the new concept of integrated steaming (c), a compost-based soil activator added to the soil immediately after steaming activates it microbiologically. This new concept has several marked advantages. There is no need to wait for the phytotoxic substances, which develop after conventional steaming (s), to degrade. The colonisation by pathogens is inhibited. The result of integrated steaming is the growth of healthier and stronger plants. u: untreated soil, planting 1 day after steaming. (source: J. G. Fuchs, www.biophyt.ch).

2.8 Use of compost in open cultures

Over a period of several years, one side of a field was treated regularly with quality compost. The plants from that half of the field were must less susceptible to seedling diseases than those from the untreated half of the field. The effect of the compost shows itself most clearly in intensively cultivated fields (Fuchs, personal communication).

2.9 Compost and leaf diseases

Composts can help to raise the own defences of the plants (so-called "induced resistance"). Studies have shown that plants cultivated in soils or substrates containing 20% compost suffered fewer leaf diseases than plants grown in unsupplemented soils (Fuchs, personal communication).

3. "EFFECTS OF COMPOSTS AND DIGESTATES ON THE ENVIRONMENT, SOIL FERTILITY AND PLANT HEALTH", A SWISS RESEARCH PROJECT

3.1 Aims of the project

The aim of project described below is to assess the effects of compost and digestate application on plant growth and health, on soil parameters and on the environment in general. This should create a basis to:

i. to assess the sustainability of compost and digestate application from the economic, ecological and social point of view.
ii. to optimize the use of the different products (digestate, fresh compost, mature compost).
iii. to optimise the production processes from a user standpoint (QM-assurance)
iv. to publicise and inform better on the benefits and risks linked to the application of compost and digestate.

The accent will be placed on uses of compost which have practical significance, so as to allow the results of this project to be easily and effectively put into practice.

Project direction: Research Institute for organic farming, Frick, www.fibl.ch
Project coordinator: Dr Jacques Fuchs

3.2 Workshop "Analytical methods for assessing beneficial aspects"

On the 6th of November some 3 dozen specialists met at FiBL to discuss up-to-date analytical and determination methods to assess the positive aspects of compost. After a presentation of a recent literature survey on the subject, three groups discussed the following themes:

- physical methods, including humus determination
- chemical methods, with the emphasis on nitrogen
- biological methods, microbiology and plant tests

About one hundred compost and digestate samples will be analysed in 2004, using the methods that were discussed during the workshop and the results of these analyses will be compared.

4. RESULTS OF THE LITERATURE SURVEY

In the literature there are numerous references about the beneficial aspects of compost, but very few concerning digestate. This is due on the one hand to the very recent appearance of digestate/digestion residues on the market, on the other to the fact that it is mainly the more mature humified forms of compost which have the qualities for soil improvement. Digestion residue have a higher fertilisation potential, comparable to that of manure.

4.1 Conclusions regarding the existing literature

The study of the various publications concerning compost shows that the term "compost" actually covers a very broad spectrum. Many authors do not specify the nature of the staring material or the process parameters. This makes direct comparisons between studies difficult. However, despite these shortcomings, it was possible from the literature to ascertain some general effects of composts on soils and soil fauna, as well as certain trends.

In many countries awareness has grown that no unified criteria exist to judge the qualities of composts, which is increasingly considered to be unsatisfactory. In Europe, Canada, Australia and New Zealand, this question is now being addressed. Since the last SAEFL literature study of 1991, the international opinion has clearly shifted and this will surely influence future research and practices in Switzerland too. It is now generally recognised that "compost" does not in itself have any value if it does not possess certain definite characteristics which have been assessed following specified analytical procedures. These characteristics must possess predictive potential regarding the effects of the compost on food crops and on the soil. Today, there is a broad consensus that the only way of securing the users' trust in the long term is through quality management. This is an essential condition to ensure long-term demand for the products.

The potential beneficial aspects of composts described in the literature are summarised as follows. Composts can sustainably improve the soil properties. Several studies showed that soils to which compost has been added showed higher aggregate stability and increased pore volume. In both cases, these increase the cultural value of the soil. Higher aggregate stability reduces loss of soil structure and increases gas exchange as well as the percolation of rainfall through the upper soil layers. Greater pore volume improves gas exchanges in the deeper soil layers and facilitates the percolation of surface water through these layers.

Composts can be considered globally as soil improvers. Though the importance of nutrient recycling during composting must not be underestimated, the fertilising properties cannot be compared directly with those of mineral fertilisers. Rapid effects can only be expected from special types of composts with a nigh nitrate content of bacterial origin. Most composts are characterised by a high content in lignin (due to a high percentage of wood in the feedstock). If the degradation process is well managed, these compounds will contribute to increase the humus content of the soil. With the exception of peat soils, a higher and more stable humus content is considered generally desirable as it greatly increases both the nutrient storage capacity of the soil and the bioavailabilty of the nutrients for plants. These effects are even more marked in tropical soils, where a good humus management can also prevent aluminium poisoning of the soil. In such soils a lot can be gained by good compost management. This is why it is important to give the user the means of judging the value of the products already on the site of their production. It is therefore essential to define reliable and simple methods of assessing the potential of a compost towards the soil and plants.

It is also no wonder that the addition of organic matter stimulates the soil fauna and flora. Many studies point to the fact that compost application favours earthworms. The importance of earthworms in farming is largely recognised and has been extensively treated elsewhere.

Entirely new dimensions are opened by the suppressive effects on plant diseases and phytonematodes which have been observed in relation to compost applications. In some cases the organisms which develop in compost and are able to suppress soil-borne pathogenic fungi and phytonematodes are even known. However, the conditions under which such beneficial organisms may develop in compost are still only very partially understood. What appears clearly is that the composting process, respectively a proper management of the fermentation stage, consists primarily in directing the evolution of the microbial populations. To progress in this field it will be necessary to research the microbial processes during composting much more closely. In this field, compost still retains much potential for development, and could here acquire a far more prominent place in sustainable farming.

4.2 Open questions

This literature search has revealed existing deficiencies in current knowledge and questions remaining open which should be researched in the interest of further promoting the composting industry.

A lot remains to be discovered concerning well documented long-term studies using well differentiated composts and digestates. As a general rule, future investigations on compost should comprise the definition of uniform quality criteria to characterize the studied composts, as well as trials with and without supplementary reduced fertilisers. The long-term effects of compost application on soil physics, chemistry and microbiology must also more intensively investigated.

The protective mechanisms involved in the use of composts and composts extracts are only partially known. How the quality of a compost affects its disease suppressivity potential is still not well enough understood. If the use of composts and of compost extracts is to develop into a wide-scale practice, more research is indisputably necessary, both to optimise compost production and application, and to ensure that the positive effects can be reliably and constantly guaranteed under strict quality standards.

Practically no research exists on the application of farm or other organic fertilisers besides compost, and on the interactions between these products. However, in Switzerland, this type of

practice is normally the rule. It is therefore difficult to clearly assess the positive effects of compost under these conditions.

In principle, the effects of compost application could also be obtained by other cultural methods, such as crop rotation, fallow, tilling procedures, application of farm fertilisers, etc. For example, the same positive effect could be obtained by methods which preserve the soil and humus, such as direct drilling. It is however also plausible that compost application complements such methods significantly, by reinforcing their positive effects. Research on the interactions between these methods is still lacking, as well as studies quantifying and comparing the effects of compost compared to those of other cultural measures.

4.3 Open questions regarding digestate and compost from digestate

It is difficult to make any definite pronouncements on the effects of digestate and compost from digestate, as hardly any studies have been carried out on the subject. Due to the difference between anaerobic fermentation and aerobic degradation, one can expect variations in physical and chemical soil parameters. Here too, there is a pressing need for further studies.

5. HOW CAN ONE GUARANTEE THE BENEFICIAL EFFECTS OF COMPOST?

During this research project, the accent will be placed on determining to what degree these beneficial qualities are widespread in composts and digestates and how they can be selectively enhanced.

Quality criteria should be defined primarily from a user's perspective (quality is fitness for use). Therefore, the producers must obtain from the their clients information as to which beneficial aspects are important for them. Only after, can production be tailored to the needs and the means of the buyers.

Some of the questions remaining open are directly related to the marketability of these beneficial aspects. For example:

- Which characteristics can be guaranteed yearlong?
- Were can one place the limits of certainty for suppressive effects?
- Which recipes will guarantee product standardisation?
- Which starting materials are favourable and which are unfavourable for the production of high-quality compost and digestate?
- Which storage and haulage practices should be avoided with compost and digestate?

As we have seen, several beneficial aspects of compost and digestate are already well recognised by the scientific community. Cooperation with research is necessary to transfer this know-how over to the producers side and to the users, in particular the farmers.

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