CONCEPT FOR QUALITY MANAGEMENT TO SECURE THE BENEFITS OF COMPOST USE FOR SOIL AND PLANTS

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Abstract

Use of quality compost can have an important positive impact on soil fertility and plant growth and health. For example, it increases soil humus and improves soil structure and suppressivity towards plant diseases. To obtain these positive results, it is important that the adequate compost is used for each use. If used inadequately, the impact of compost can also be negative.

The compost producer should be responsible for the quality of his products, and has to communicate the properties of his composts to the users. But to be successful, the compost users have to communicate to the producers to which culture and under which conditions they want to apply compost. To support compost producers and users in this process, the Swiss producers of compost and digestate published a new quality guideline for compost and digestate in 2010. Five product classes are defined in this guideline: digestate liquid, digestate solid, compost for agricultural use, compost for horticultural use in the open field, and compost for covered cultures. The guideline requires compost producers to establish a quality concept, ranging from collection of green manure to utilization of the products.

Public relation activities are then important to communicate this guideline. Communication between compost producers, compost users and other stakeholders is important to improve the potential of compost use and to develop further application possibilities.

Introduction

Compost is an organic amendment, which can vary greatly in its characteristics. Numerous factors influence its properties: input materials, composting system, management of the processes, maturity, storage, etc. While some composts can have negative impact on the environment or on plant growth, other composts can influence soil fertility and plant health positively. However, a compost is not generally positive or negative. The same compost can be very appropriate for one utilization, and absolutely inappropriate for another use. To obtain positive results, it is therefore important to use the adequate compost for each utilization. Guidelines are important aids to be successful in this; they are useful as well for the compost producer as for the compost user, and represent an important interface between these two actors.

In this paper, some aspects of the impact of compost quality parameters on compost utilization will be discussed, and the Swiss Guidelines 2010 for compost an digestate, based on these results, will be presented.

Materials and Methods

One hundred products representative of the different composting systems and qualities available on the Swiss market were analysed. The products (only from source-separated organic material) were collected according to the guidelines and recommendations with respect to waste fertilizers (FAC 1995). The product description is according to old ASCP Guidelines 2001 (Fuchs et al., 2001). The samples were chosen in such a way that they are representative of the composts produced in Switzerland. The samples were either tested immediately after collection, or stored at 3°C until testing.

Nutrients and heavy metals were analyzed with ICP-AAS according to the official Swiss methods (Schweizerische Referenzmethoden, 2005).

The influence of compost on nitrogen mineralization in soil was determined with the incubation experiment according to the official Swiss methods (Schweizerische Referenzmethoden, 2005). Compost was added to a reference soil, placed in PVC boxes (12 x 10 x 5 cm, with aeration holes), wetted and incubated at 25°C. The mineralized nitrogen (NH_4 and NO_3) in the soil was determined after 0, 2, 4, 6 and 8 weeks.

The phytotoxicity tests were performed according to Fuchs and Bieri (2000). In the open phytotoxicity tests, the growth of cress (*Lepidium sativum* L.) in pots (Ø 10 cm) filled with compost was compared with the growth in reference substrate BRS-200 (Biophyt Ltd, CH-Mellikon). In the closed phytotoxicity test, PVC boxes (1 liter) were half-filled with compost or reference substrate BRS-200, cress sown onto it, and then the boxes were closed hermetically. The growth of the plants in the boxes was then observed.

Results

Chemical characteristics of the Swiss composts

The chemical characteristics of the different products are presented in tab. 1. The values for the different composts varied greatly. The contents of salts, nitrogen, phosphorus, potassium, magnesium and calcium depend predominantly on the materials of origin. The organic matter content and the density are mainly influenced by the maturity of the products. However, high variability was observed for all parameters within a product category. For example, the salt content, which should be low in the composts for covered cultures and private gardening, varied between 328 and 1539 [g KCL equivalent / 100 g fresh matter]. Through a more consistent choice of the materials of origin, the compost producers could obtain a more constant salt content in the final product.

Tab. 1: Chemical characteristics of Swiss composts[1]

	Digestate for agricultural use[2]	Compost for agricultural use[2]	Compost for horticultural use[2]	Compost for covered cultures[2]
salt content[3] [mg KCl/100g FM] median (minimum; maximum)	970 (704; 1384)	862 (361; 1580)	787 (173; 2657)	660 (328; 1539)
pH[3] median (minimum; maximum)	8.5 (8.0; 8.8)	8.2 (7.5; 8.7)	8.1 (7.6; 8.7)	7.9 (7.2; 8.5)
density [g/l] median (minimum; maximum)	468 (321; 631)	556 (412; 851)	609 (434; 836)	715 (631; 904)
dry matter [% FM] median (minimum; maximum)	53.1 (45.4; 75.2)	50.8 (28.2; 73.4)	56.7 (40.8; 71.1)	56.3 (32.2; 64.5)
organic matter [% DM] median (minimum; maximum)	50.3 (28.9; 73.4)	47.7 (17.0; 80.1)	38.1 (23.9; 54.7)	30.6 (20.9; 52.8)
total N [g/kg DM] median (minimum; maximum)	15.3 (9.4; 20.3)	16.6 (8.7; 26.0)	14.6 (9.2; 27.6)	15.1 (8.6; 25.2)
total P [g/kg DM] median (minimum; maximum)	3. 6 (2.0; 8.0)	3.0 (1.7; 6.1)	3.0 (1.3; 12.7)	3.3 (2.1; 8.8)
total K [g/kg DM] median (minimum; maximum)	12.5 (6.4; 20.8)	12.0 (5.7; 25.2)	11.6 (2.2; 20.7)	10.7 (5.5; 27.8)
total Mg [g/kg DM] median (minimum; maximum)	6.8 (3.7; 9.7)	4.8 (3.6; 10.3)	6.5 (4.4; 10.7)	6.5 (4.4; 13.3)
total Ca [g/kg DM] median (minimum; maximum)	46.6 (23.0; 57.8)	53.1 (24.0; 83.7)	64.0 (35.0; 91.5)	44.5 (69.4; 29.5)
Fe [mg/kg DM] median (minimum; maximum)	8.9 (3.7; 12.3)	8.8 (2.9; 16.7)	10.1 (5.4; 14.7)	12.0 (6.1; 15.8)

[1] according to the "Guidelines and Recommendations of the Research Centre for Agricultural Chemistry and Environmental Science with respect to waste fertilisers" (FAC 1995).

[2] product description according to ASCP Guidelines 2001 (Fuchs et al., 2001)

[3] value determined in 1:2 water extract

Influence of digestates and composts on the mineralized nitrogen content of soils

The mineralized nitrogen in soil greatly influences plant growth. The influence of compost on the mineralized nitrogen content in soil depends, beyond the quantity of available nitrogen, also on the microbiological activity of the compost. Normally, digestates contain a high amount of mineralized nitrogen, mainly as ammonia, and they contain relatively low quantities in the form of lignin rich materials. Therefore, nitrogen immobilization is not expected after the utilization of such products. In our experiments, this was not always the case (fig. 1Ds). The reason for the immobilization of nitrogen in soil by some digestates is that these products are not used fresh, but after an inadequate subsequent treatment, during which the digestate has been dry and has lost all the ammonia.

In the other products, the evolution of the nitrogen immobilization risks can be clearly observed (Fig. 1). The composts for agricultural use are mainly young composts rich in undegraded lignin. The degradation of these woody substances in soil leads to a momentary immobilization of the available nitrogen (Fig 1Ca). When the composts were more mature, this risk decreased (fig. 1Ch and 1Cc).

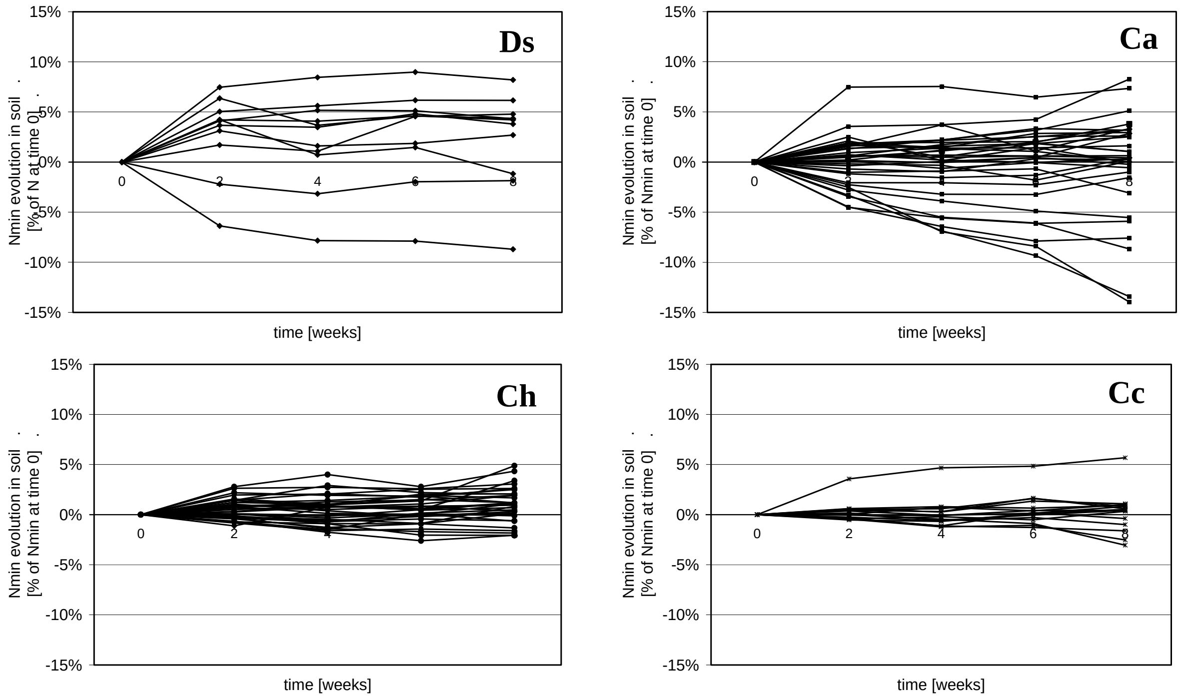

Figure 1. Influence of the addition of different composts to soil on the evolution of its mineralized nitrogen content.

For each compost, the mineralized nitrogen after 2, 4, 6 and 8 weeks are compared to the mineralized nitrogen present in the soil immediately after compost addition. Products according to ASCP Guidelines 2001 (Fuchs et al., 2001): Ds=digestate solid, Ca=compost for agriculture, Ch=compost for horticultural used, Cc=compost for covered cultures and private gardening.

Nitrate content is easy to analyse and allows to predict the risk of nitrogen immobilization. As soon as the nitrification process began and nitrate was present, the composts did not immobilize nitrogen in the soil.

Influence of composts and digestates on plant growth

Plants react on compost or digestate quality as a whole. Sometimes, all of the measured chemical parameters of a compost are good, but plants do not develop well in it for unknown reasons. To assess this risk, the phytotoxicity tests are used. In the closed cress test, the plants are not only in contact with the compost, but are also strongly influenced by the gases which evaporate from the compost; for this reason, this test is therefore very sensitive, and only composts with high plant compatibility allowed a good growth of the cress (fig. 2Ccl). Digestates are generally less compatible with plant growth than composts. In all test systems, an evolution in the plant compatibility was obvious, with the plants growing better in more mature composts (fig. 2). Nevertheless, there was considerable variation within a product class. This fact shows that the management of the composting is at least as important for the biological quality as the advancement of maturation.

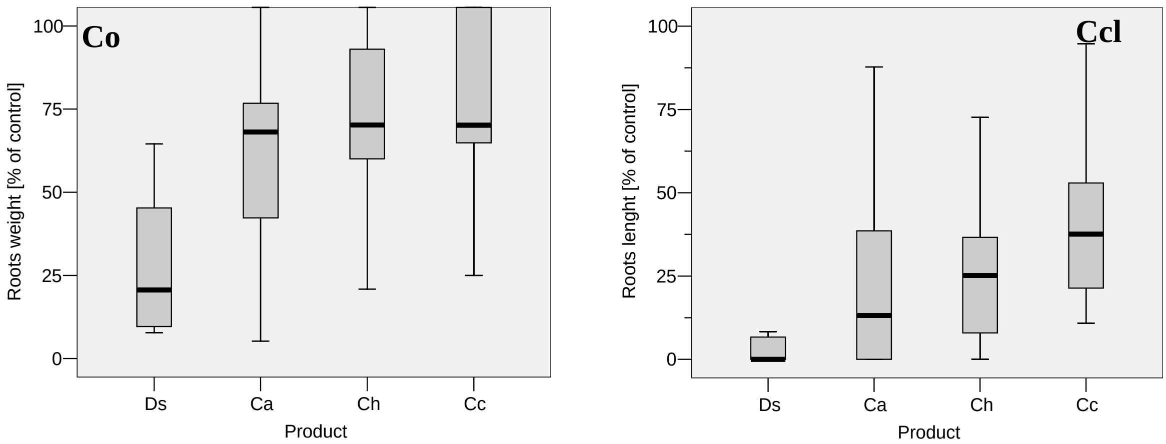

Figure 2. Phytotoxicity of Swiss composts, determined with the open (Co) and closed (Ccl) cress biotest.
The growth of plants in pots filled with compost was compared with the growth of plants in reference substrate (Co, S and B). Products were sampled according to ASCP Guidelines 2001 (Fuchs et al., 2001): Ds=digestate solid, Ca=compost for agriculture, Ch=compost for horticultural used, Cc=compost for covered cultures and private gardening.

Swiss compost and digestate guidelines 2010

For the compost user, the most important factors of compost quality to choose the appropriate product depending on the utilization are its effect on the mineralized nitrogen in the soil and its phytotoxicity. This is especially true for horticultural and vegetable use, where higher quantities of compost are used. To support the compost producer and the compost user, and to avoid undesirable effect on the crops, the sector of green waste management has elaborated the “Swiss compost and digestate guidelines 2010” (Abächerli et al., 2010). They are based on the ASCP Guidelines 2001 (Fuchs et al., 2001) and on the results of a study on the quality of Swiss compost and digestate performed for the Swiss Federal Office for the Environment FOEN (Kupper and Fuchs, 2007).

The products are ordered in five classes (Tab. 2). Three of them concern products for agricultural use (liquid digestate, solid digestate and compost for agriculture), and two classes concern products for horticultural use (compost for field horticulture and compost for covered cultures.

Tab. 2. Summary table of the Swiss compost and digestate guidelines 2010

Criteria	Composts and digestates for agricultural use			Compost for horticultural use	
	Digestate liquide	Digestate solide	Compost	Compost for field horticulture	Compost for covered cultures
	Minimal quality, heavy metals, impurities and hygienization: Complies with minimal quality requirements according to the Swiss Legislation (FAC 1995 and Ordinance SR 814.81 on Risk Reduction related to the Use of certain particularly dangerous Substances, Preparations and Articles)				
P_2O5, K_2O, Mg, Ca[1]	X	X	X	X	X
DM (dry matter) [% FM]	X	X	X	*> 50 %*	*> 55 %*
OM (organic matter) [% DM]	X	X	X	*< 50 %*	*< 40 %*
pH[2]	X	X	X	**< 7.8**	**< 7.5**
Particle size [mm]		X	X	*< 25*	*< 15*
Bulk density	X	X	X	X	X
Coulor of extract[3]		(X)	< 1.0	**< 0.5**	**< 0.2**
Salinity[4] [g KCleq/kg DM]	X	X	X	**< 20**	**< 10**
Total nitrogen[1] [g/kg DM]	X	X	X	*> 10*	*> 12*
C/N ratio	X	X	X	X	X
Ammonium [2] (N-NH_4) [mg/kg DM]	*> 3'000*	**> 600**	**< 600**	**< 200**	**< 40**
Nitrate [2] (N-NO_3) [mg/kg DM]			X	**> 80**	**> 160**
Nitrite [2] (N-NO_2) [mg/kg DM]			(X)	*< 20 mg/kg DW*	*< 10 mg/kg DW*
Nmin. [mg/kg DM]	*> 3'000*	*> 600*	*> 60*	*> 100*	*> 160*
N-NO_3/Nmin.			(X)	**> 0.4**	**> 0.8**
Biotest cress open[5]				**> 50% from control**	**> 75% from control**
Biotest cress closed[5]			(X)	**> 25% from control**	**> 50% from control**
Biotest lettuce[5]				*> 50% from control*	**> 70% from control**

[1]: according to the official Swiss methods (Schweizerische Referenzmethoden, 2005)
[2]: 0.01 M $CaCl_2$-extraction 1:10 (w:w)
[3]: extinction at 550 nm H_2O-extraction 1:10 (w:w)
[4]: H_2O-extraction 1:10 (w:w)
[5]: according to Fuchs and Bieri (2000).
Minimal requirements; *recommendation*; X: has to be mentioned; (X): mention recommended

Digestate and compost differ primarily in their content in ammonium. Digestates are very rich in ammonium, and can therefore serve as effective short time nitrogen fertilizers. But digestate shows an important risk of phytotoxicity, if used in higher quantity. For this reason, they are recommanded only for agricultural and not for horticultural use.

In horticulture, the quantities of compost used are greater, because they are often concentrated near the plant roots, or mixed in the pot. Therefore, the quality requirements are higher for such products with respect to mineral nitrogen, salt content and plant compatibility. Unlike in fields, where the rain can disclocate salts into deeper soil layers, the water evaporation in covered cultures is higher as the water infiltration. For this reason, the salt content of the products used has to be controlled, otherwise the salinity of the upper soil layers can become too high and cause problems to the plants.

Swiss compost and digestate guidelines 2010 in practise

The elaboration of such guidelines is very important to secure the long term use of compost and digestate. However, the guidelines alone are not useful, if they are not applied in practise and recognized by all the actors of the green waste management. The application of the guidelines requires certainly much effort from the compost producer, who has to control and analyze his products more intensively, and to improve his knowledge about product utilization to can advise the compost users in a competent way. The relationship between compost producer and compost user was one of the most important weaknesses in the system in Switzerland. The guidelines are an attempt to stimulate communication between compost producers and compost users, and so to improve the potential of compost and digestate to improve soil fertility and plant growth. To achieve this, an important project at the moment is the implementation of demonstration field trials in collaboration between scientists, compost producers and compost users. It is planned to start 25-35 long term long term field experiments. Under the responsibility of a compost plant, each experiment should have a simple design, with digestate or compost application adapted to the situation. The global concept of all experiment will be the same and supervised by a scientist. So it should be possible on one hand to use these trials as platform for the exchange between the different actors, and on the other hand to collect information to optimize the utilization of the different products under different conditions and in diverse cultures. These experiments are intends as a complement to scientific field experiments.

Conclusions

Digestate and compost have an important potential to improve soil fertility and plant health and growth, if they are used appropriately. The Swiss guidelines should be the basis for good use practice. Together with demonstration experiments under practical conditions, they represent a way to assure in long term the success of the application of these products and to help the plant growers to insure the fertility of his soils.

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