Agricultural humus management using high quality composts

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compost, biowaste, benefit of use, soil fertilizer, plant nutrition, profit

1 The current stage of biowaste evaluation in Germany

Currently about 50% of German households are involved in the separate collection of biowaste (bio-containers). It is neither expected nor is it aspired that all households be connected to the system. The reason for this is that regional corporations make exceptions to the rule of separate collection if self-composting can be proved or if including certain areas in the collecting chain has been proved ineffective due to the quality and/or quantity of the separately collected waste (e.g. in urban inner-city areas). Notwithstanding that the corporations have to date not been able to offer households and commercial enterprises any attractive propositions for separately collecting biowaste. In about 800 composting plants in Germany approx. 8 million tons of biowaste are treated to produce about 5 million tons of compost.

It is assumed that a reasonable potential of an additional 3 million tons for separate collection and material recycling exists. Even though separate collection costs more it will not be more expensive than the combined disposal of biowaste with the residual waste which will be mechanically treated or incinerated eventually. This is because even though separate collection is more extensive, the subsequent treatment (composting) is cheaper than any other process.

2 Benefits of compost

Compost being a „multifunctional product“ has many uses. It is mainly used to improve the soil (soil fertilizer), as plant nutrition (plant fertilizer) as well as a blending compound in the production of substrates (top soils, growing media).

In the following we concentrate on the benefits of using compost as an organic substance for improving the soil and as a fertilizer in agriculture. Other benefits such as using compost for landscaping or top soil production will not be discussed here. Details on these would exceed the limits of this report.

Due to intense competition and specializing in the field of agriculture, large areas of agricultural crop lands are increasingly becoming poor in humus. A balanced humus soil is however the basic requirement for soil fertility and sustainable agriculture.

Suitable measures for producing humus are:
- Crop rotation management
- Crop residues management
- Organic fertilization with manure and soil improvers from separate collected biowaste

Causes for the present humus needs are:
- Intensive crop cultivation (monocultures with humus-depleting plants like maize and sugar beet)
- Export of crop residues (straw for material utilization and burning)
- Increased cultivation of renewable „energy plants“ (such as corn)

A survey of the humus provision in the farmlands of Saxony for example showed that the humus content over the last six years has been decreasing at an average of 0.1 humus units (HE) per hectare and year.
What is really alarming is that 46% of the areas show a negative or strongly negative humus balance. Since changing the cultivation structure or animal stocks is hardly possible, other humus sources such as composts from biowaste or sewage sludges will have to be used more and more.

The humus balance of a crop rotation can be calculated according to a concept compiled by the German Agricultural Investigation and Research Association (VDLUFA). An example of this is depicted in table 1. The span between the extreme values shown here for humus requirement i.e. humus balance result from the specific local factors that influence the humus needs.

### Table 1 Example of the humus balance of a crop rotation

<table>
<thead>
<tr>
<th>Humus requirement</th>
<th>kg Humus-C/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>sugar beet</td>
<td>760 – 1.300</td>
</tr>
<tr>
<td>winter wheat (export of straw)</td>
<td>280 - 400</td>
</tr>
<tr>
<td>winter wheat (export of straw)</td>
<td>280 - 400</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>1.320 – 2.100</strong></td>
</tr>
<tr>
<td>80 t beet leaves</td>
<td>640</td>
</tr>
<tr>
<td><strong>Balance of humus in 3 years</strong></td>
<td><strong>- 680 bis - 1420</strong></td>
</tr>
</tbody>
</table>

The different organic manures are also different in their effectiveness to reproduce humus. This depends firstly on the stability of the organic fractions of the material as well as the application rate which could be given by good practical use.

The application rate of liquid manure from pig sties for example will be limited by its relatively high content of phosphate since all loads connected to this will only have very little humus producing organic substances. (table 2).
Table 2  Humus production efficiency of different materials

<table>
<thead>
<tr>
<th></th>
<th>organic substances 1)</th>
<th>organic carbon 2)</th>
<th>humus-C 3)</th>
<th>humus-C reproduction 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>compost</td>
<td>35 %</td>
<td>20 %</td>
<td>51 %</td>
<td>2 t/ha</td>
</tr>
<tr>
<td>liquid manure</td>
<td>75 %</td>
<td>43 %</td>
<td>21 %</td>
<td>0,2 t/ha</td>
</tr>
<tr>
<td>straw</td>
<td>85 %</td>
<td>49 %</td>
<td>21 %</td>
<td>0,7 t/ha</td>
</tr>
<tr>
<td>sugar beet leaves, green manure</td>
<td>90 %</td>
<td>52 %</td>
<td>14 %</td>
<td>0,6 t/ha</td>
</tr>
</tbody>
</table>

*1) loss of ignition (organic dry matter)
*2) C organic (loss of ignition / 1,742)
*3) percentage of humus reproducible carbon of TOC (reproduction index)
*4) humus reproduction by suitable application rates: compost 21 t DM/ha,
   + liquid manure (pig) 2 t DM (30 m³)/ha, straw 7 t DM/ha, green manure 8 t DM/ha

The humus degraded from husbanded areas will have to be put back into the soil. Agricultural farms will therefore have to compile a humus balance record. If the humus balance is negative after a crop rotation, organic substances will have to be added to the soil. Compost is very suitable for this since it contains a high percentage of stable humus. For soils having insufficient organic substances, humus will have to be added over a longer period of time to regenerate the humus content in it.

The humus state of the soil has also a direct affect on the soil structure: how it can be worked on (e.g. fuel consumption of tractors), its ability to store water (i.e. give up water in the dry periods) and its ability to store plant nutrients. Compost contains alkaline substances that work against soil acidification. This is why compost can be substituted for the maintenance liming commonly used and required in agriculture to regulate the pH-value of the soil.(table 3).

Table 3  Maintenance liming with compost for regulation

<table>
<thead>
<tr>
<th>soil types</th>
<th>Target: pH-value</th>
<th>maintenance liming CaO</th>
<th>compost application1) t dm/ha</th>
<th>Effect of compost liming CaO</th>
</tr>
</thead>
<tbody>
<tr>
<td>sands</td>
<td>5,6</td>
<td>600 kg/ha</td>
<td>15 t TM</td>
<td>675 kg/ha</td>
</tr>
<tr>
<td>clayey sands to silts</td>
<td>6,0</td>
<td>900 kg/ha</td>
<td>20 t TM</td>
<td>900 kg/ha</td>
</tr>
<tr>
<td>strongly sandy clay to clayey silts</td>
<td>6,4</td>
<td>1.100 kg/ha</td>
<td>25 t TM</td>
<td>1.125 kg/ha</td>
</tr>
<tr>
<td>sandy, silty clays to clays</td>
<td>6,8</td>
<td>1.300 kg/ha</td>
<td>30 t TM</td>
<td>1.350 kg/ha</td>
</tr>
<tr>
<td>Silty-clayish clay to clay</td>
<td>7,0</td>
<td>1.600 kg/ha</td>
<td>30 t TM</td>
<td>1.350 kg/ha</td>
</tr>
</tbody>
</table>

1) compost with an average content of 4,5 % effective alkaline matter in dry matter. Application limited to 30 t DM/ha in 3 years.
Compost also contains all important nutrients needed for fertilizing pot soil and could substitute the fertilizing with phosphates and potassium, by normal application rates and by good practical use. (table 4). Due to nitrogen fixation on organic substances, fertilization with this nutrient should be separately calculated.

In the case of phosphate the resources of which will only last for about 90 years, the prime goal should be the recycling and with it the protection of existing raw material reserves. In contrast to “alternative energies”, no “alternative nutrients” are available in the case of plant nutrients. Nutrients cannot be exchanged. Their re-utilization is therefore very important.

<table>
<thead>
<tr>
<th>Crop rotation</th>
<th>N kg/ha</th>
<th>P₂O₅ kg/ha</th>
<th>K₂O kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar beet⁷</td>
<td>180</td>
<td>55</td>
<td>138</td>
</tr>
<tr>
<td>Winter wheat²</td>
<td>200</td>
<td>86</td>
<td>149</td>
</tr>
<tr>
<td>Winter barley⁴</td>
<td>180</td>
<td>48</td>
<td>36</td>
</tr>
<tr>
<td>Sum of humus demand</td>
<td>560</td>
<td>189</td>
<td>323</td>
</tr>
</tbody>
</table>

| Organic fertiliser | | |
|-------------------|---|---|---|
| Compost (30 t dm) | 30 | 198 | 327 |
| Residual humus demand | -530 | +9 | +4 |

1) Sugar beet: expected yields 550 dt/ha, without removal of residual crops
2) Winter wheat: expected yields 80 dt/ha, with straw removal
3) Winter barley: expected yields 60 dt/ha, without straw removal

Nutrient contents of compost on the basis of the medium value from BGK 2004
(P₂O₅ 0,66 %, K₂O 1,09 % dm)

The nitrogen present in compost has a double function. A small part (soluble nitrogen including easily degradable nitrogen) can be used as plant nutrition. The larger part of nitrogen however is organically bonded and is used to a large extent for the production of humus. (Fig. 2). It not only makes compost suitable for enriching degraded soil in humus but can also be a supplementary mineral fertilizer if used timely and purposefully. The value of the nutrients contained in humus itself (N, P, K and lime) amounts to around 6 €/t fresh matter i.e. 230 €/ha (table 5).

![Figure 2 Double function of nitrogen](image-url)
Table 5  Value of plant nutrients in compost

<table>
<thead>
<tr>
<th>Nutrients (N, P, K, Mg, CaO)</th>
<th>€ / t ¹)</th>
<th>€ / ha ²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>compost</td>
<td>5,80</td>
<td>203</td>
</tr>
<tr>
<td>residues from AD</td>
<td>4,50</td>
<td>140</td>
</tr>
</tbody>
</table>

¹) Equivalent costs of mineral fertiliser due to market prices (N 0.6, P₂O₅ 0.51, K₂O 0.62, MgO 0.2, CaO 0.03 €/kg)
²) Equivalent value per hectare for typical application rates (Compost 40 t fm, liquid digestate product 35 m³, 5 % dm)

The value of other nutrients such as magnesium, sulfur and microelements is not added here. Also not included is the value of organic substances used for producing humus. Taking into account that the cultivation of crops with high humus consumption increase and that the demand for crop residues for material or energetic use (straw) is growing, the value of organic substances in compost could clearly exceed the value of nutrients present in it.

The monetary profits of using compost in agricultural crop cultivation are generally on the march if done regularly. This is shown in table 6 on the development of marginal returns from agricultural proceedings from perennial field trials. By regularly nurturing the humus with compost, the monetary profits of the farmer could increase to more than 100 €/ha in the course of the years. The reasons for this increase are mainly better harvests as a consequence to soil improvement and other factors such as reduced fuel consumption when working on soil with optimal humus content.

Table 6  Developing marginal returns in crop market farms regularly nurturing humus with compost

<table>
<thead>
<tr>
<th>compost application</th>
<th>1. year</th>
<th>2. year</th>
<th>3. year</th>
<th>4. year</th>
<th>5. year</th>
<th>6. year</th>
<th>7. year</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 t dm/ha</td>
<td>38 €/ha</td>
<td>48 €/ha</td>
<td>52 €/ha</td>
<td>53 €/ha</td>
<td>54 €/ha</td>
<td>55 €/ha</td>
<td>55 €/ha</td>
</tr>
<tr>
<td>10 t dm/ha</td>
<td>53 €/ha</td>
<td>78 €/ha</td>
<td>90 €/ha</td>
<td>97 €/ha</td>
<td>102 €/ha</td>
<td>106 €/ha</td>
<td>108 €/ha</td>
</tr>
</tbody>
</table>

It becomes obvious that a long term compost management is economically advantageous. The influence of specific market parameters could have bring additional monetary profits. Thus, raising the price of field crops or increasing the price of mineral fertilizers would also increase the monetary profits.

Agriculture uses the most relevant quantity of compost. The sales areas are mainly defined by the marketing strategies of the particular producer as well as the local area structure.

Apart from agriculture (45 %) also landscaping (19 %), market and hobby gardening (10 % and 12 % respectively) as well as the industry producing top soils (14 %) are of relevance.

Compost is used for the following purposes in gardening and landscaping:
- Creating new sites (gardens, parks etc.). The creation of new gardens and greens is often preceded by building works that leave behind disordered broken down surfaces. The soil is often very marred or poor in humus, and has to be recultivated or improved. Subsoil poor in nutrients, or clayey or gravelly should be mixed with compost in order to produce an airy, vegetation friendly layer.
• Tending gardens and parks. Regularly tending with compost helps to keep the soil and plants healthy. The compost used should bear the nutrient needs of the vegetation in mind.

• Producing a topsoil substitute: Topsoil material can be produced from inanimate and nutrient poor soil by adding compost and if needed other blending compounds. This is done by mixing soil/subsoil and compost in the compost plant.

• Production of growing media: Extensive studies have shown many times that ready compost is a good blending compound for growing media. However, compost is not a ready substrate in which plants can be sown directly. Only by mixing it with nutrient poor components can we produce good compost soil.

As mentioned earlier no other specifications pertaining to this area can be made here.

Likewise no specifications will be made here on further questions on the sustainability of recycling the „raw material biowaste“. Such questions however, are of special importance for decision making politicians for evaluating suitable steering measures, who then deduce advantages directly from the objectives shown here.