Beneficial use of compost on agricultural soils – benefits and risks

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Earlier	Now
Compost was produced from agricultural waste by farmers, who also used to be the end-users for compost.	Compost is produced from a variety of municipal organic wastes by urban waste management companies.
The benefits were straight forward, and there were no risks.	Link between the producers and the users is broken, and there is mistrust against using compost on farmland.

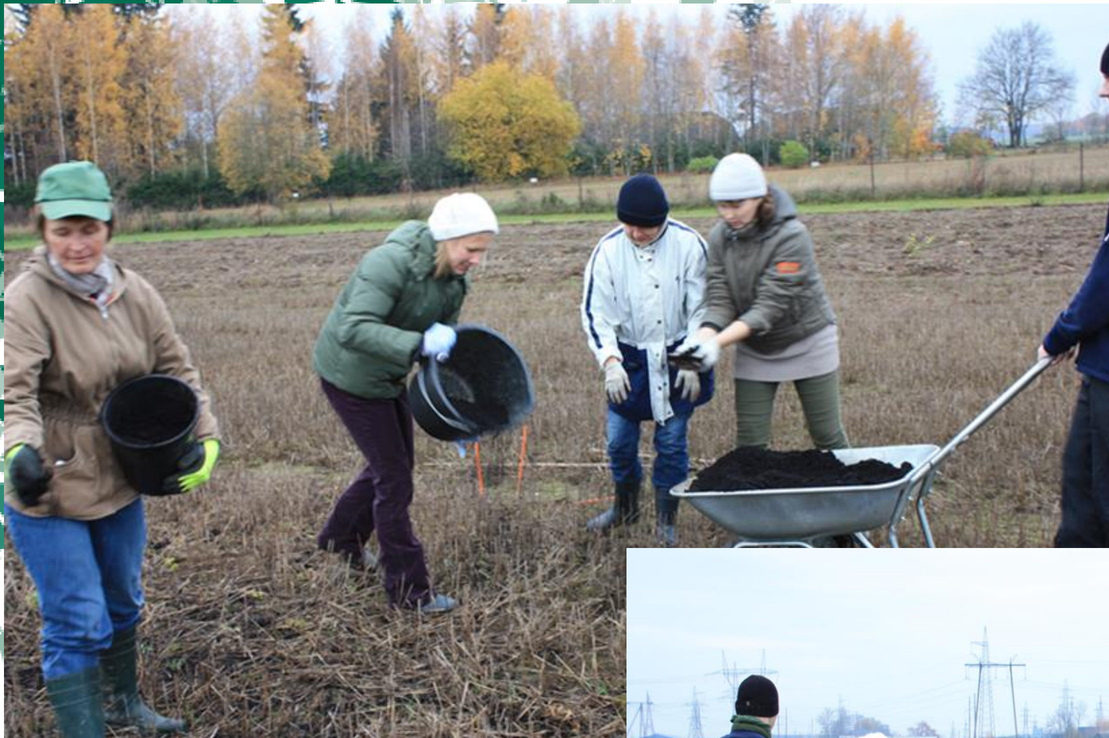
Utilisation of compost

- Is the compost of good quality?
  - … and what is ‘quality’?
- Are there any obvious benefits?
- Are there any risks?

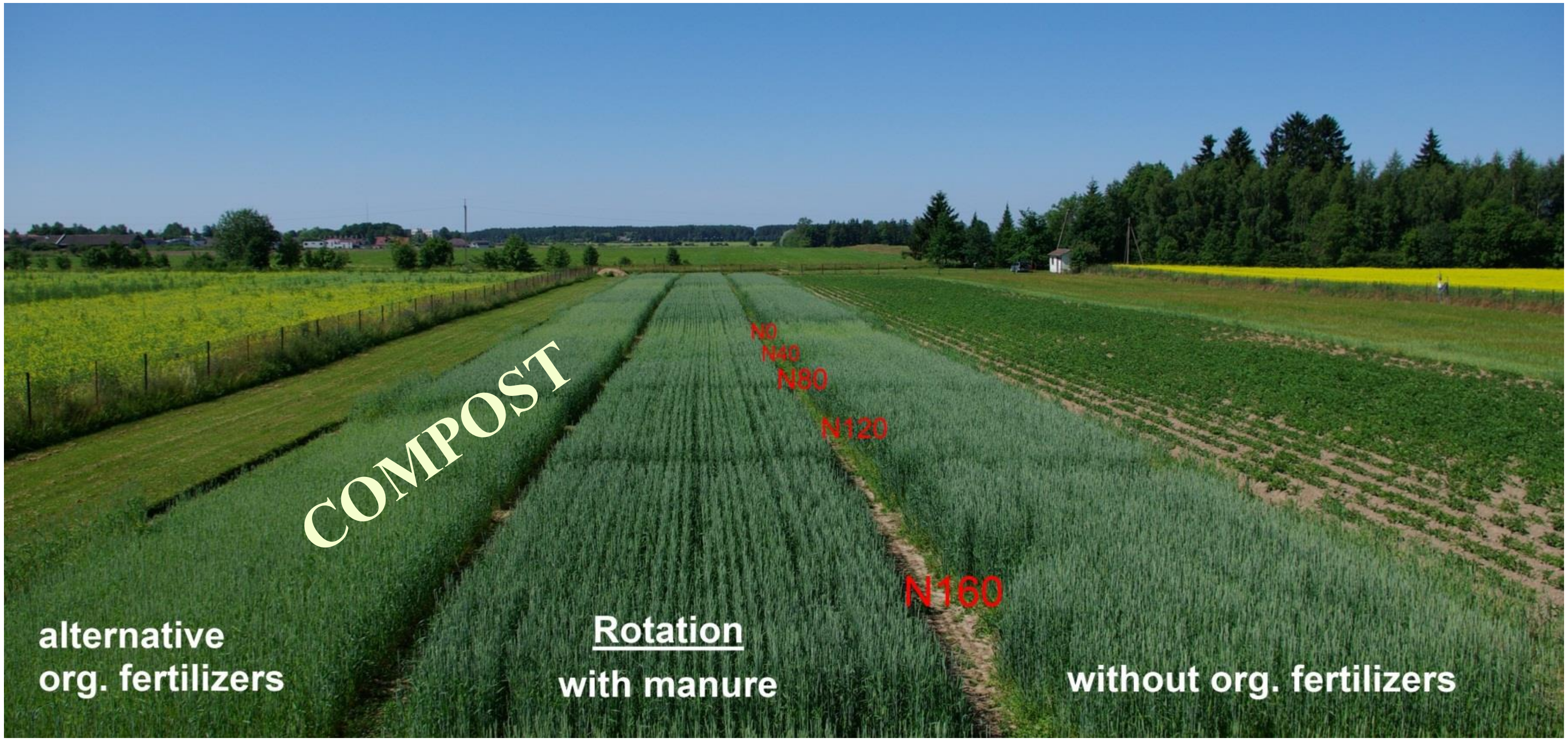
- Does compost meet my needs?
- Does compost replace mineral fertilisers?

Field trials

Field trials



Field trials



Long-term field test

Test location	Region of Baden-Württemberg, Germany
Soils	Intermediate-type and heavy soils, (one location sandy)
Composts	Quality assured biowaste compost (4) + green waste compost (1)
Test period	12 years (3 locations) 9 years (2 locations)
Test parameter	Compost application: 0 (control), 5, 10, 20 t/ha DM/y N-supplementing fertilisation: 0, 50, 100 % of fertilizer optimum
Test design	Randomised block design: 12 alternatives with 4 repetitions, in total 48 test lots
Crop rotation	corn/winter wheat, winter barley

Humus

Annual supply with compost		Compost supplies in t/ha DM 3 year rotation	
		20	30
Organic matter	t/ha DM	2.4 - 2.8	3.6 - 4.0
Carbon (C)	t/ha	1.3 - 1.7	2.0 - 2.4
Thereof C reproducible	t/ha	0.6 - 0.9	1.0 - 1.3
Annual humus demand of soil in t/ha carbon		Humus demand of soil	
		average	high
Humus content	optimal	0.2 - 0.4	0.6 - 0.9
	suboptimal	0.4 - 0.6	1.2 - 1.6

- As a rule the humus content of the soil can be covered to a large extent.
- The **humus balance** is positive, or at least stable.

Humus

- The increasing compost supply caused an extensive linear increase of **humus contents.**
- Even relatively low annual compost supply (5 t/ha) provided measurable increases of humus contents of approximately 0.2 – 0.4 %.
- The increase in humus content in soils can be calculated as 0.1 % per 8 – 9 t/ha DM of organic compost substance.
- The increase of humus contents on sandy soils was slightly lower than on medium to heavy soils.

Humus

- A medium compost dose of 15 – 20 t/ha DM in a 3 year rotation is sufficient to influence the humus balance positively.
  - High compost supply (>20 t/ha) is recommended in soils with extremely low humus content.
- The increase of humus content was registered for <30 cm top soils only – change your tilling habits?!
- No increased degradation of organic carbon in soils was registered – thus a sustainable humus enrichment of soils at a regular compost application was proved.

Soil structure

- The bulk density of the soil was reduced.
- The total pore portion increased (not on heavy soils).
- Drainage and aeration improved.
- Aggregate stability of the soils increased.
  (less obvious – expected on medium and heavy soils, but not on sandy soils)
- Increased workability – reduced fuel consumption.
- Less erosion on slope areas.

Water content

- *Water holding capacity* improved.
  (obvious on medium to heavy soils, smaller on sandy soils)
- *Water content* increased 1 – 2 %.
- *Usable field capacity* increased.
  (more medium-sized and coarse pores)
  - Crops are able to resist longer lasting droughts, mainly on light soils.
  - Farmers observed more rapid drying of soils after heavy rainfall.

Soil biology

- The portions of *microbial biomass* significantly improved.
- The *phytosanitary potential of the soil*, its ability to resist harmful organisms, was improved.

Supply of nutrients

- The medium **nutrient supply** of compost application for crop cultivation is 20 to max 30 t /ha DMevery 3 y.

Annual supplies	Compost doses (t/ha DM) in a 3-years rotation		Assessment
	20 - average	30 - high	
Nutrients in kg/ha	Medium ranges		Average nutrient balance
Nitrogen - N	80 - 110	120 - 160	Slightly negative (medium doses) resp. balanced to slightly positive (high doses), at high removals balanced
Phosphorous - P_2O_5	35 - 55	60 - 80	Predominantly balanced
Potassium - K_2O	60 - 85	100 - 120	Removals medium: positive Removals high: slightly negative to balanced
Magnesium - MgO	35 - 60	60 - 85	Always highly positive

Fertilising efficiency

- *Soluble i.e. plant available* contents in soil – fertilising efficiency.
- The N-mineralisation equilibrium in the soil is moved towards the soluble and thus fertilising effective N-portions.
  (mechanism – the activity of the soil organisms)

Plant availability and fertilising efficiency

- The soluble ‘plant available’ (N & K) fraction of nutrients:
  - Without fertilising (0 compost added) it decreased.
  - With compost application dose of 5 t/ha DM annually reduction was compensated to some extent.
  - With compost application dose of 10 t/ha DM annually reduction was fully balanced.
- Mg evolution due to fertilising with compost did not achieve phytotoxic limits.

Plant availability and leaching

- Soluble phosphorus content were mostly found in the tilled topsoil.
  - Diminishing P content in soil layers of 30–60 cm.
  - P was rarely found in layers of 60–90 cm.
- No measurable potassium and magnesium in deep layers.
- No leaching to groundwaters!

pH

- Lime supply with compost applications in regular intervals serves as *maintenance liming*.
  - Also in deeper soil layers.
- As a magnitude an up-rating of about 0.1 pH-units per 10 t/ha CaO from compost application was determined.
- Compost doses (crop cultivation) of 20 to 30 t/ha DM in a 3-year rotation were positively influencing the lime balance of the soil.
  - Large doses serve as remediation measures.

Possible risks
impacts on soils and harvest products

- Heavy metals.
- Hazardous organic compounds.
- Epidemic and phytohygiene effects.
- Weed seeds.
- Impurities and stones.
- N-mineralisation.

Heavy metals
in soil

- A *positive balance* always remains in the soils.
  - Minimum heavy metal removal by harvested products.
- Metal accumulation in soil can not be excluded, but it was *extremely small* in the study.
  - Accumulation is very slow, analytically determined not before 10–20 y.
- The contents of (Pb, Cd, Cr, Ni, Hg) *did not rise* in soil during the field trials after 9–12 years of compost application (20 t/ha DM annually).
- The contents of Cu and Zn showed a *slightly increasing* tendency (> 10 t/ha DM annually).
  - This took place in topsoil, not in deeper layers.
- Heavy metal *mobility* was generally missing or decreased (Cd, Ni and Zn).

Heavy metals
in plants

- The heavy metal contents in harvest products remained unchanged during the trials compared with control (no compost application).
- The quality of food plants, which are fertilised with compost in regular intervals is not endangered by heavy metals, according to the particular long-term trial.
- Precautionary soil protection is recommended – heavy metal supply with compost must be lowered as much as possible.

Organic pollutants

- Persistent PCB contents were very low, ranging close to the background/analytical detection levels.
- Other organic pollutants (organochlorine pesticides, polycyclic aromatic hydrocarbons, phtalates etc) had no influence not even with an excessive application doses.
- In total there was no indication for an enrichment of organic pollutants in the soils resulting from a compost application.

Impurities and stones

- **Impurities and stones** are no longer a problem when quality assured composts are used.
- The contents of impurities > 2 mm are below a mean value of 0.1 % DM.
- Impurities from plastic foils can massively damage the visual appearance of the compost (reputation of compost!).
- Stones can be classified as a lower-ranking risk.

Hygiene aspects

- 65° C over a period of 7 days eliminates risks from epidemic and phytohygienic pathogen contents.
  - salmonella disappears.
  - coliform bacteria ranged below the harmless guide values.
- High total contents of bacteria and fungi indicates high biological activity of composts, which is desirable.

Weeds

- The number of **germinable weed** in composts show harmless ranges if hot decomposition stage is achieved during composting.
- **Quality assured composts** are virtually free from germinable weed seeds.
- The result of 54 annual ratings of the total weed ground cover degree showed in no case a measurable weed stock which could have been attributed to compost application.
  - Confirmed by farmers.

Conclusions
Compost is a ‘multifunctional product’

- Compost shows many application possibilities.
  - It is mainly used to improve the **soil** (soil fertilizer),
  - And as **plant nutrition** (plant fertilizer).
- Compost is delivers 3 to 4 times higher reproduction rates of humus carbon for soils compared to straw, liquid manures and anaerobic digestion products.
- The humus level of the soil has direct effect for the soil structure and the soils ability to store water and nutrients.
  - improved workability e.g. less fuel consumption of tractors

Conclusions
Fertilizer effect is slow

- The fertiliser effect from application of mineral fertilisers is fast, but the effect is short.
- The fertiliser effect from application of compost is slow.
  - The fertiliser effect arrives in several years, but lasts longer
  - Apply compost regularly over 3 to 10 years
- Soil-improving effect of regular compost application **dominates** (compared to fertiliser effect).

Conclusions
Successful use of compost

- Particularly important are the results of long-term use of compost, which is the key for long-term markets, and trust of customers.
- The success of sustainable use of composts on agricultural soils is depending on:
  - well controlled input material,
  - well maintained composting process,
  - good chemical composition of the compost,
  - application rates.

Acknowledgements

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To be**lieve**, or not to be**lieve **– this is the question.

Thank you!

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