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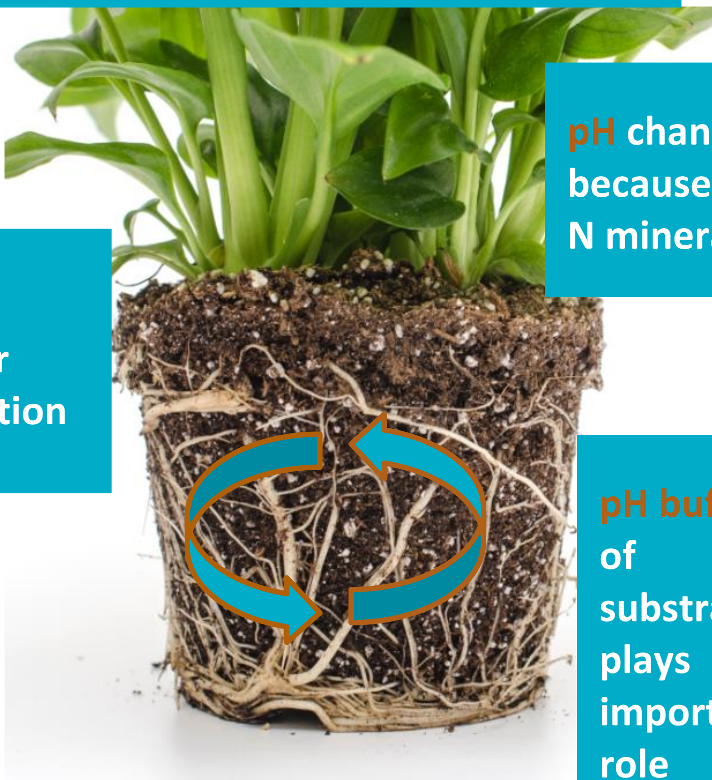
Dynamics around organic fertilizers

1

Organic fertilizers work differently compared to mineral fertilizers



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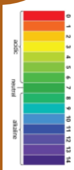
pH changes because of N mineralization



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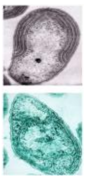

Bacteria necessary for N mineralization

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pH buffer of substrate plays important role

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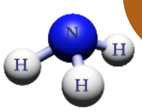

Attention to high ammonia level under certain circumstances

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Mineralization speed depends on circumstances

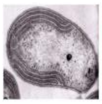
1. Organic fertilizers work differently compared to mineral fertilizers

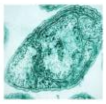
As basic fertilization in substrates organic fertilizers, mineral potting soil substrate components or controlled-release fertilizers (CRF) can be used. However, there are important differences between the composition and effects of these fertilizers.

Just like with mineral fertilizers for the composition of organic fertilizers it is important to look at the levels of especially nitrogen (**N**), phosphor (**P**), potassium (**K**) and magnesium (**Mg**). It is also vital to determine whether the fertilizer contains trace elements (**Fe**, **Mn**, **Zn**, **B**, **Cu**, **Mo**).

Organic fertilizers can also partially contain mineral fertilizers. From a legal point of view, these are mineral-organic fertilizers. Therefore it is important to always check the specifications of the product that is to be applied.

In organic fertilizers **N** and **P** are released because of mineralization. **K** is not bound and is immediately available. The rate at which **N** mineralizes depends on the composition and granular size of the organic fertilizer.





2. Bacteria necessary for N mineralization

The mineralization of organically bound nitrogen (**N**) happens because of bacteria in a dynamic process that follows certain steps. Fundamentally ammonification takes place first, followed by nitrification.

Ammonification

Bacteria make ammonia (**NH_3**) from organically bound nitrogen that immediately binds an **H+** to itself – this is called association – causing ammonium (**NH_4^+**) to be created. Retraction of an H+ causes the pH (acidity) to rise. This process also takes place under anaerobic circumstances, so without oxygen!

$$R\text{-}NH_2 \rightarrow NH_3 + H_2O \rightarrow NH_4^+ + OH^-$$

Dissociation of ammonium

Depending on the pH level, ammonium separates **H+** from itself – this is called dissociation.

$$NH_4^+ \leftrightarrow NH_3 + H^+$$

This process is also influenced by the temperature. More ammonia is created at higher temperatures. For example, at a rise in temperature from 20°C to 30°C the level of ammonia doubles.

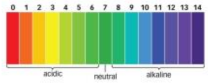
Nitrification in 2 steps

There are two kinds of bacteria that cause nitrification (the conversion of ammonium, which comes from mineralization, to nitrite and then in nitrate). This happens in a twostep process:
1. *Nitrosomonas* converts ammonia to nitrite.
2. *Nitrobacter* converts nitrite to nitrate.

Step 1 : $2NH_3 + 3O_2 \rightarrow 2NO_2 + 2H_2O + 2H^+ + \text{energy}$

Step 2 : $2NO_2^- + O_2 \rightarrow 2NO_3$

This process happens under aerobic circumstances; oxygen is necessary. Raised bog peat does not contain these bacteria naturally, therefore nitrification starts slower in a potting soil mixture consisting of pure raised bog peat. Nitrification is also pH dependent. For nitrification ammonia (**NH_3**) is necessary, which is only created at a higher pH because of the aforementioned dissociation. If the pH is too low, the nitrification stops.

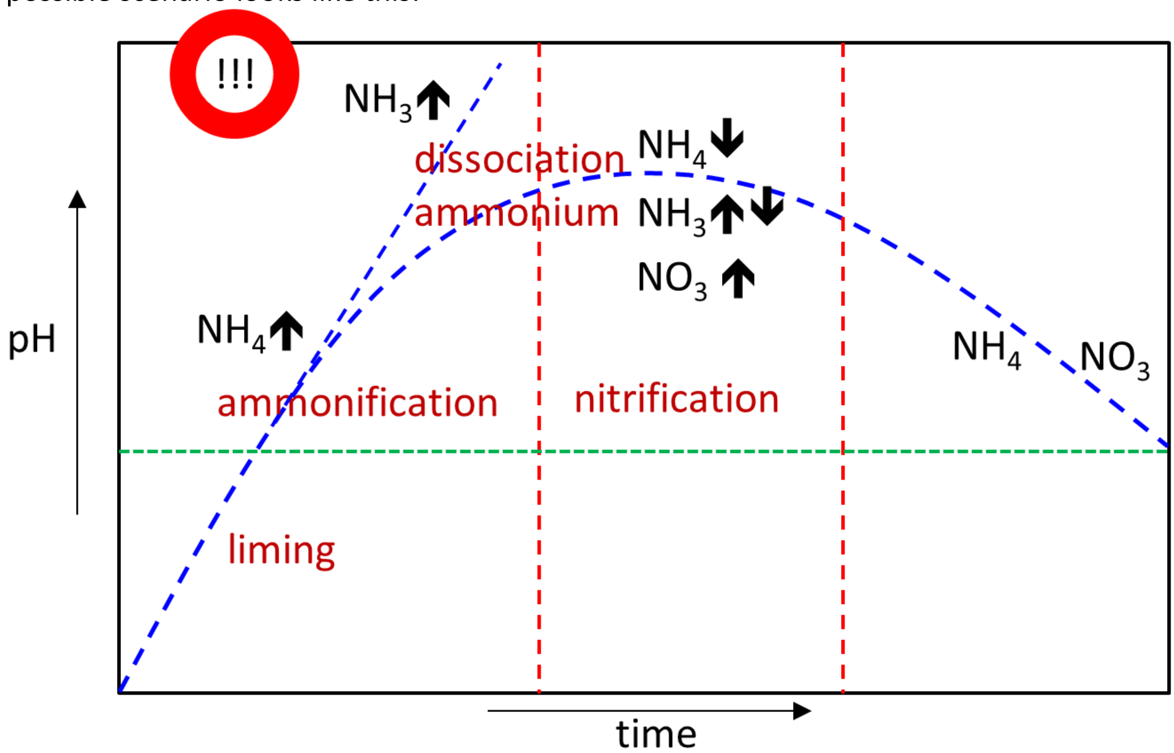


3. pH changes because of N mineralization

During delivery the substrate has a certain pH value. In substrates with organic fertilizers this pH changes because of among others the nitrogen mineralization process.

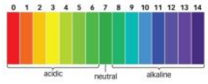
The pH rises because of ammonification. This can start already before the beginning of the culture, even without the presence of oxygen. The higher the pH and the temperature, the more dissociation of ammonium and the more ammonia is created. Under the influence of a pH that is sufficiently high, the presence of nitrifying bacteria and oxygen, nitrification takes place which also causes the pH to decrease again. If nitrification does not happen (quickly enough) then the pH rises, during continuing ammonification, further. Because of this ammonia can rise to levels that are harmful for plants.

A possible scenario looks like this:



The actual process is especially dependent on the amount of added organic nitrogen and the pH buffering capacity of the substrate.

Biological processes – nitrification – can also occur with the application of mineral fertilizers and thus change the pH.



pH fluctuates

When using organic fertilizers the pH will always fluctuate. In general the pH rises in the first weeks of using organic fertilizers and then falls again only to end up with a pH of the mixture of around the same level as it was at the start.

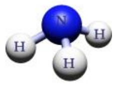
Apart from the use of organic fertilizers and the level of pH buffering of the substrate, there are more aspects that influence the actual pH process in a culture:

- pH and EC at the start of the culture
- EC changes during the culture
- amount of liming
- stage of the crop (vegetative or generative crop)
- use of bicarbonate rich irrigation water
- irrigation system and precipitation, leading to possible rinsing of elements
- additives during the culture, including biological agents

4. pH buffer of substrate plays important role

When using organic fertilizers the pH may initially, because of ammonification, strongly increase and then, because of nitrification, strongly decrease. The substrate can buffer the pH, which causes it to rise and fall less. It also avoids the pH from rising too high and the creation of too much ammonia.

Peat is a raw material with a relatively large pH buffer. Other raw materials, such as bark, coir pith/fibre/chips, wood fibre and perlite have a far smaller pH buffer. If such raw materials form a larger part of the substrate, then the pH buffer of the substrate is lower compared to a peat substrate. pH changes are buffered to a lesser extent and the pH can change faster.




5. Attention to high ammonia level under certain circumstances

Under certain circumstances too much ammonia can also be created for the crop during the mineralization of organically bound nitrogen (**N**).

Ammonification causes the pH to rise. This happens more strongly in a less buffered substrate. The higher the pH and temperature, the more dissociation of ammonium and the more ammonia is created. If subsequently the nitrification does not start (quickly), then under certain circumstances the pH can rise further which may lead to an ammonia level that is too high for the crop.

Uptake by the crop

The extent to which a substrate buffers the pH, determines the effect of ammonification on the pH. In the end the uptake by the crop determines the ultimate pH. It can rise or fall depending on the cation/anion rate. A surplus of ammonium or nitrate can, because of these processes and the crop uptake, again lead to a strong pH change. If the pH remains too low and nitrification does not occur, then the pH can also decrease because of crop uptake.

Sensitivity of the crop

The sensitivity of the crop plays an important role in how it reacts to a high ammonia level. The developmental phase of the crop combined with the stage of the mineralization process also has an effect on the consequences of ammonia on the crop.

6. Mineralization speed depends on circumstances

The mineralization of organically bound nitrogen (**N**) is a dynamic process. Whether or not this process is set in motion, depends on different factors and circumstances.

pH

pH is an important factor for nitrification. This is because nitrifying bacteria convert ammonia that is formed at higher pH values. This goes much slower in a substrate with a low pH.

From substrate production to start of culture

It matters when a mixture is made and when it is used. Ammonification already takes place before the first use of the substrate for sowing/planting cuttings, under anaerobic circumstances (without oxygen) and under the influence of bacteria. This causes the pH to rise. The height of the pH at the start of the culture, has influence on the speed of mineralization. Only at a higher pH value the dissociation of ammonium to ammonia will start.

Moisture level

In freshly produced substrates the moisture level is an important factor. If a substrate is already wet, then mineralization will also take place during transport and storage. This may lead to the loss of nitrogen. For example if nitrification is not set in motion because of a lack of oxygen and ammonia can be created, or if formed nitrates are denitrified because of that.

Temperature

Temperature also plays an important role in the speed of mineralization. Mineralization goes faster at higher temperatures. Higher temperatures also lead to a higher rate of dissociation from ammonium to ammonia.

Amount Nitrosomonas and Nitrobacter

If in a substrate the bacteria *Nitrosomonas* and *Nitrobacter* or other nitrifiers are not present, then nitrification does not occur anyway. For example, these bacteria often do not naturally occur in raised bog peat. If there are few nitrifying bacteria in a substrate, then the nitrification does not happen immediately. This is because *Nitrosomonas* multiplies very slowly (duplication every 24 hours). Aerobically produced composts do contain nitrifying bacteria and can therefore be applied in substrates. In this case a dosage of 5 to 10 % on volume basis suffices.

Oxygen

Because the dissociation of ammonium to ammonia is an aerobic process, it needs oxygen. At the start of the culture this is obviously the case. During storage this is an important point of interest. If mineralization takes place under circumstances without oxygen, it may lead to more nitrogen loss because of the formation of ammonia.

In short, when successfully using organic fertilizers several aspects and their interactions need to be taken into account. Summarized this dynamic around organic fertilizers looks like this: