Terra Preta - Comparative trials with young crops

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Our climate and nature conservation project "Humus per la Biosfera" is about practical experiences with the use of "Terra Preta" in smallholder agriculture on Mount Etna, Sicily, for the purpose of long-term carbon sequestration in the soil. In the trials, we want to test effects on crops and the simplest possible production and application of the product in order to disseminate possible recommendations in the region.

What is Terra Preta? Terra Preta is a particularly fertile soil that originated in the Amazon basin. There, cultivated areas are found with terra preta soils that are up to thousands of years old and have a fertility that is atypical for the location. These black soils were found near ancient settlements - they are remnants of anthropogenically cultivated arable soils that can be visibly distinguished from the light-coloured Ferralsol soils that are common there. Clay shards and pyrogenic carbon (charred substances) were found there. Measurements showed that the humus content is extremely high at 15% (European soils usually have humus contents of 1-6%). The formation can be traced back to the mixing of charred plant parts and organic waste as well as faeces. By burying it, it was presumably fermented under the exclusion of air and developed in the humification process into Terra Preta, which enabled the indigenous culture to achieve high crop yields.

Today, Terra Preta is increasingly in the spotlight, also because of its importance for climate protection.

We are conducting a first series of experiments with freshly mixed "immature" Terra Preta that has not yet undergone a fermentation process. We are investigating the question:

How does Terra Preta affect plant growth and the water retention capacity of the soil?

Assumption: The plants in a Terra Preta soil grow faster and more luxuriantly compared to plants with ordinary topsoil and are more resistant to water stress due to the higher water holding capacity. We assume that the long-term nutrient availability through Terra Preta, which is considered to be higher for plants in this experiment,

has no difference on growth compared to direct fertilisation, since the nutrients in b) and c) are directly available - unless the biochar in c) has stored the nutrients during its "charging" in such a way that they are not available to the plant as quickly as in b). Whether this turns out positively or negatively for the annual crops tomato and lettuce is to be observed.

Experimental set-up:

Three different soil mixtures:

A Ordinary topsoil

B Topsoil with horse manure

C Terra Preta (fresh, not matured) with horse manure

Two different trials per soil mixture

A.1 Irrigation according to plant needs
A.2 Simulation of heavy rain and dry periods as stress test
→ **B + C** correspondingly

Two different crops per soil mixture and irrigation test:

A.1.1 Tomato
A.1.2 Lettuce
A.2.1 Tomato
A.2.2 Lettuce
B + C correspondingly

Description of our procedure:

Wed, 22.06.2022, Terra Preta production. We mixed fresh horse manure in a ratio of 1:5 (1 part biochar, 5 parts manure) into crushed biochar, which had previously been produced from olive tree cuttings in the "Kon-Tiki". We already call this mixture Terra Preta for our trial, although it can be considered too young as far as nutrient storage and release is concerned (it should actually mature for a few months). But at least in the irrigation stress test (not yet carried out), the proportion of biochar should already show effects.

Thu, 23.06.22: Setting up the experimental series in plant pots

A -Topsoil	**B -**Topsoil / horse manure →Ratio 2:1 (2.600ml:1.300 ml) for **tomato*** →Ratio 4:1 (5.200 ml:1.300 ml)for **lettuce***	**C -** Topsoil / Terra Preta →Ratio 2:1 (2.600ml:1.300 ml) for **tomato*** →Ratio 4:1 (5.200 ml:1.300 ml)for **lettuce*** (Addition of 200 ml horse manure, for quantitative compensation between B and C)
A.1.1 tomato	B.1.1 tomato	C.1.1 tomato
A.1.2 lettuce	B.1.2 lettuce	C.1.2 lettuce
A.2.1 tomatounder stress	B.2.1 tomatounder stress	C.2.1 tomatounder stress
A.2.2 lettuceunder stress	B.2.2 lettuceunder stress	C.2.2 lettuceunder stress

*The mixtures of B and C contain the same amount of horse manure per crop. The tomatoes, as nutrient-demanding plant, get twice as much manure as the less demanding lettuces.

<u>Site conditions at the beginning of the experiment:</u>

Maximum temperatures at 34-36 °C; minimum temperature at 20 °C. For further temperatures during the trial, see Excel sheet.

Location in partial shade under a tree in pots with soil contact.

<u>Care</u>:

Water daily and measure the height of the plants at three-day intervals. The two crops are watered with different amounts of water, but within A, B and C each with the same amount of water. The amount of water added per day varies between 150 ml and 200 ml for tomato and 100 ml and 150 ml for lettuce, depending on the weather conditions and plant growth. Orientation is given by the plant condition and the soil moisture in the pot.

Stress test to be carried out in the future: In the stress test, which again takes into account the crops with different needs but is the same in A, B and C, heavy rainfall events and dry periods are simulated. The aim here is to determine whether the plants cope better with the extreme situations in the Terra Preta mixture than in A and B, where the plant biochar with its water and nutrient storage capacity is missing.

Protocol:

Temperature, natural precipitation →see Excel sheet

Observations, intermediate results:

Plant size: see Excel sheet

Health status:

A) Soil only: lush, rapid growth, with no evidence of growth difficulties or other stress.

B) Soil & horse manure: hardly any growth progress noticeable over weeks; partly yellowish withered leaves; no flower formation on tomatoes

C) Soil & Terra Preta: quite similar to the 2nd variant, but grow minimally better in comparison.

25th of July: the majority of the plants were accidentally damaged from feeding by animals. As a result, the stress tests could no longer be carried out.

Results and interpretation of the results:

A) Soil only: The tomatoes and lettuces grew very quickly and luxuriantly in the pure soil without any further fertiliser, indicating that it was fertile soil. This meant that the plants did not need any further fertiliser because there were enough nutrients.

B) Soil & horse manure: In the part of the experiment with horse manure, it can be assumed that the nutrient supply was too high for the young plants. Hardly any growth was observed and the plants made a sickly impression. In general, it is recommended not to use fresh horse manure. Especially for young plants, the fertilisation is too strong in most cases, so that the small sensitive roots "burn". The yellow leaves on the plants were an indicator of the oversupply of nutrients.

It would have made more sense to compost the horse manure for a few months and then use it.

C) Soil & Terra Preta: In this part of the experiment, the horse manure also had a negative effect on plant growth. However, a comparison of this variant showed that the plants grew a few centimetres more towards the end than in variant B). In the Excel file, this can be shown graphically in the diagrams. Note the different scaling. In retrospect, it can be interpreted that the horse manure was also too strong here and

that the difference compared to test part B) could be caused by the biochar. Due to its pore structure, the coal has an enormous surface area (over 300m^2/g) and can thus store large amounts of water and nutrients. It can therefore be assumed that the biocharabsorbed some of the excess nutrients from the horse manure and was thus able to protect the plant somewhat. The observation that, in terms of time, the plants grew better and better at the end suggests that successively more and more excess nutrients could be absorbed by the biochar, so that they did less harm to the plant and it recovered somewhat over time.

However, in order to achieve the usual success with Terra Preta, one has to allow a maturing process that takes several months. With the addition of effective microorganisms, the Terra Preta is fermented in the form of a "stack compost". This takes place for six to eight weeks under exclusion of air, e.g. wrapped in a tarpaulin. For this, the mix of biochar and effective microorganisms is alternately layered with organic material, whereby the correct ratio should be 10:1 [organic material:biochar] in total. After the fermentation process, the digestion process begins under oxygen supply, which takes four to eight months. Finally, a Terra Preta ready for use is produced. The reasons for fermentation are that the overall digestion process is faster, no rotting occurs, germs, pesticides and seeds are broken down and sanitised, bad odours do not occur, few nutrients are lost because temperatures do not rise as much as in a conventional compost and the emission of greenhouse gases such as CO_2 and CH_4 is reduced. In addition, the fermentation process produces valuable enzymes, vitamins and antioxidants, which, last but not least, are transferred to the plants that are eventually planted on the Terra Preta. [Source: Caroline Pfützner; "Natürlich Gärtnern mit Terra Preta"; edition 2019]

The background of this process is the "charging" of the biochar with nutrients, whereby it is "activated". As already described, the biochar is able to absorb the plant nutrients. However, if the Terra Preta has not matured for a sufficiently long time, it draws on the nutrients in the soil that the plants actually need for their growth. As a result, even with an adequate amount of fertiliser, the plants as a whole may not have enough available because the biochar intercepts the nutrients. The soil can also temporarily leach out as a result. Instead of the desired positive effect, there is then a negative effect on plant growth.

This was not the case in our experiment, however, because there was an oversupply of nutrients from the outset, which even the biochar could not intercept sufficiently.

It is often described that charging can also take place immediately: In a rapid process with the addition of liquid available nutrients, such as urine. This was the original idea in our experiment, because by adding fresh horse manure, which has some moisture, and waiting a day until planting, it might have had the same effect. However, it turned out that this was not sufficient. In our approach, not enough time had passed for the biochar to be charged with the nutrients from the horse manure.

Photo documentation:

Figure 1: Mixing the Terra Preta

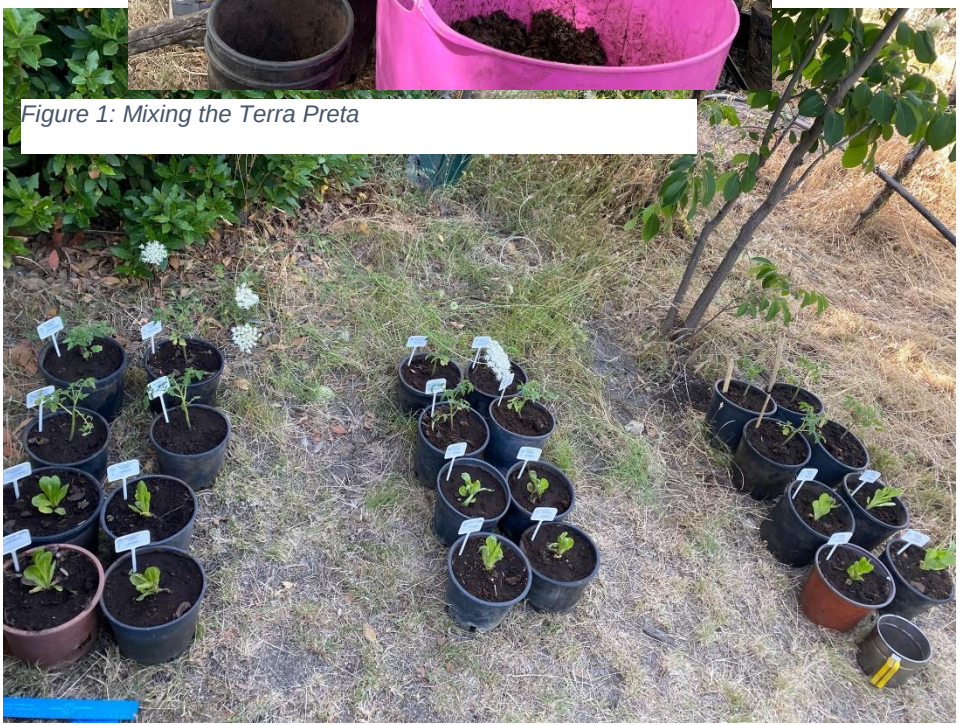

Figure 2: The completed variants right after planting: Left - topsoil only, Middle - topsoil/horse manure, Right - topsoil/terra preta

Figure 3: Regular measurement of growth pro

Figure 4: Enormous differences in growth; below: only soil [18.07.2022]

Abbildung 5Variante Terra Preta - gelbeBlätter