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Biochar in vineyards

Claudio Niggli und Hans-Peter Schmidt

With soil depletion in vineyards often reaching extreme dimensions, the use of biochar seems a very promising way forward. Two years ago the Delinat Institute started the first large-scale biochar experiment in Europe. The results come not only as surprise for sceptics, but also far exceed the expectations of optimists.

Biochar is one of the oldest soil conditioners in the history of agriculture. The Amazon Basin is probably the best example. Here, up to 500 years ago, a highly developed civilisation with a multi-million population was able to feed itself only through the well-conceived use of biochar. Though this is the main example, traditional farmers in most other countries were well aware of biochar's valuable properties. We find evidence of the use of biochar in farming not only in Europe, but also in South Asia, Africa and South America.

In Europe, the discovery and introduction of synthetic fertilisers led to the loss of a great amount of knowledge on traditional soil conditioners. On top of this, charcoal lost its significance as fuel. Yet in many third world countries, knowledge of biochar did not completely disappear. This has meant that, for decades now, a number of large-scale, long-term experiments on the use of biochar have been carried out in Cameroon, Ghana, Bolivia, Belize, Indonesia, India and China [Lehmann, 2009]. In Europe, however, the experiment that begun in 2007 by the Delinat Institute is one of the first and largest on-farm trials. This will, however, change this year, with the 2010 biochar production capacity (350 tonnes) of Swiss Biochar's pyrolysis plant destined for use on field trials throughout Europe.

Preparing of the trial at Mythopia

As there was no biochar available on the market in 2007/2008, 1000 kg of charcoal dust were imported from Germany. Whereas biochar is produced from all kinds of organic materials, charcoal is obtained solely from wood. Conversely, all forms of charcoal are biochar, both being identical with respect to their carbon structure. More important than the organic material used are a) the temperature at which pyrolysis takes place and b) the amount of oxygen in the smoulder chamber. Unfortunately, neither of these parameters were available, so that we had to rely on laboratory analysis and electron microscopy to establish its properties. For this reason, alongside the outdoor field tests, the same substrates were also used for extensive plant-pot tests.

Mythopia test vineyard

70% of biochar lumps were smaller than 2 mm, with the rest measuring up to 15 mm in length. The whole 1000 kg of biochar was mixed with 8 m^3 of compost [La Coulette] to form a biochar-compost (BC) mixture, which was then spread evenly over the vineyard. The BC mixture was left on the surface under the vines, but mixed into the soil between the rows. In addition to the substrate, cover crops with a high leguminous content were sown. These legumes act on the one hand as a green manure for conditioning the soil and on the other hand as a booster allowing a better analysis of nutrient balances.

The whole 3000 m2 test field was subdivided into several plots, thereby enabling the following different compositions to be used several times:

1. BC mixture combined with a leguminous cover crop seed (leg/co/ch) or (LegKPk)
2. Compost combined with a leguminous cover crop seed (leg/co) or (LegKp)
3. Leguminous cover crop seed without biochar or compost (leg) or (Leg)
4. Control plots without cover crop and compost, where plants sprouted of their own accord

Results

1. Growth

Right from the very first year, a significant increase in the vines' nitrogen uptake was found on those plots treated with the BC mixture. As the soil was very eroded, with little humus and a high stone/dust content, the legumes were in the beginning unable to achieve any adequate symbiosis with organisms present in the soil, so that they withdrew a relatively high amount of nutrients from the soil. This were seen in the plots without biochar conditioning, where vine growth took place at a reduced level.

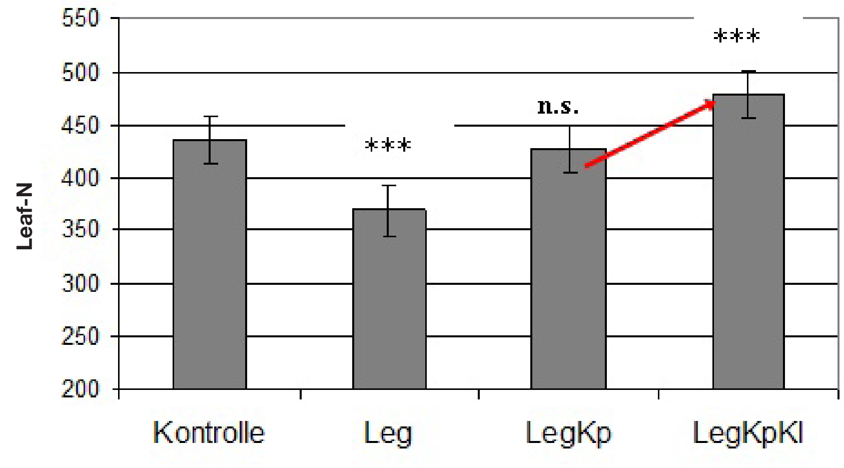
Symbiosis with organisms present in the soil seemed to take place faster on the plots treated with biochar, implying higher nutrient availability levels. This, in turn, led to a more even vine growth, shown not just by a higher leaf nitrogen content, but in particular by achieving ideal conditions suited for Pinot Noir (450-490). Such differences in growth patterns within the vineyard were clearly visible even for non-experts.

Wood growth during the first two years after sowing is significantly lower only in the leguminous cover soil than in the control plot. This effect can, at least, be partly compensated through the addition of biochar with compost but not with compost alone (there is no significant difference between control and the leg/co/ch plots).

2. Significantly higher amino-acid levels in the grapes

Biochar soil treatment led to a higher (up to 300%) amino acid content in the grapes. Alongside carbohydrates, amino acids are the main source of food for yeasts in the fermentation process. A high amino-acid content is also an indication of increased plant and grape resistance to parasites, as these have much greater difficulty extracting nutrients locked in amino acids than from the simply structured ammonium.

The comparison with the control plot is remarkably demonstrated in Fig. 3. The main difference of the variations is apparent in the leguminose-treated plot and not in that with



Leaf nitrogen of Pinot Noir vines during the first year along different soil treatments. (See introductory text for explanation of soil treatments; n.s.= not significant; stars are significance levels at p>0.05; bars are standard deviations,).

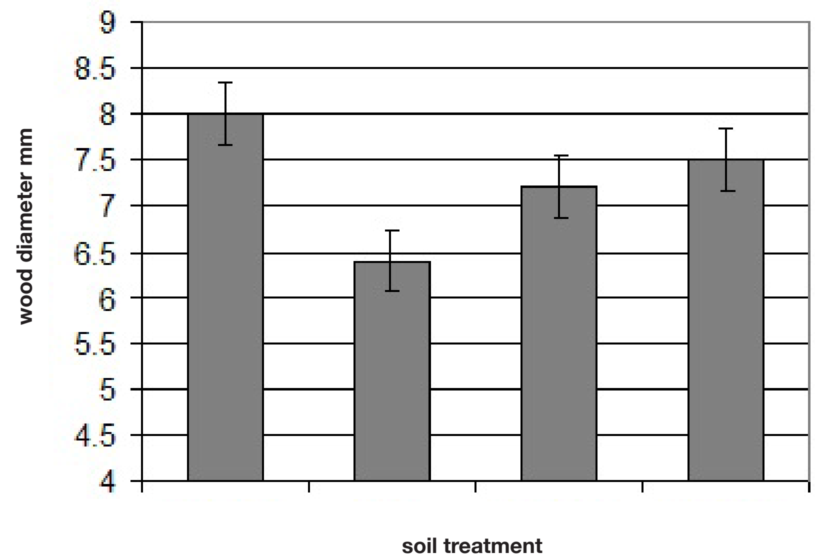


Fig.2. Levels of vine growth as measured in wood diameter (n = 30) on different soil treatments. (See introductory text for explanation of soil treatments. Bars indicate standard deviations.)

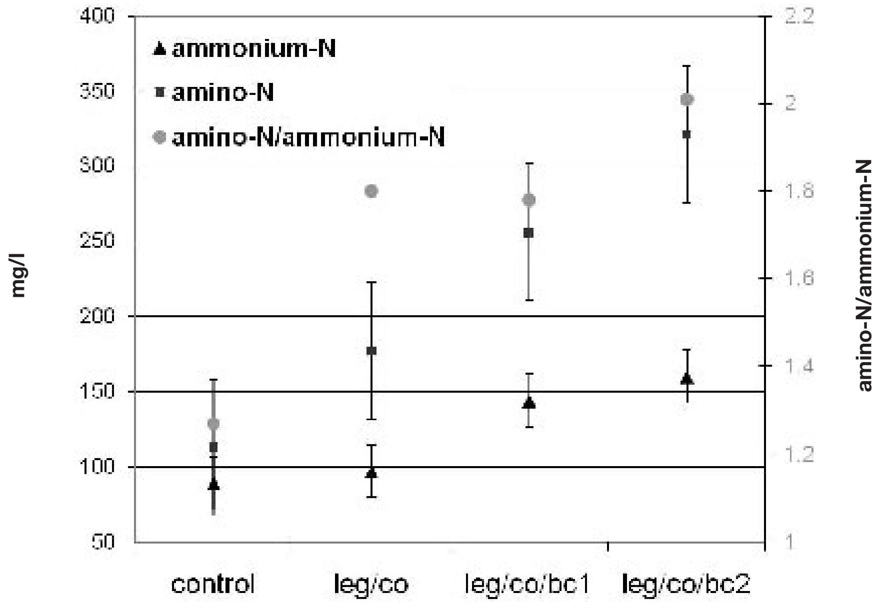


Fig.3. Ammonium and Amino-N contents, as well as the relation of Amino-N to Ammonium (grey) in 50 Pinot Noir grapes at harvest period. (leg/co= legume+compost – leg/co/bc = legume+compost+biochar. See introductory text for explanation of soil treatments. Bars indicate standard deviations.)

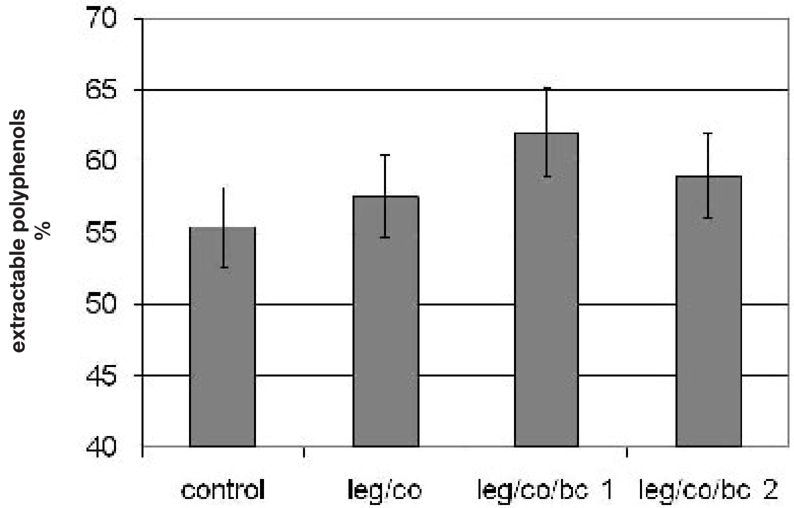


Fig.4. Levels of extractable polyphenols in 50 grapes (Pinot Noir 6 October 2009) harvested from different soil treatments. (Leg/co= legume+compost - leg/co/bc = legume+compost+biochar. See introductory text for explanation of soil treatments. Bars indicate standard deviations).

biochar treatments. Each value was determined from a mash of 300 berries. However, it is not possible to draw statistically reliable conclusions from these data.

3. Improved phenolic maturity

Both tannins and anthocyanins belong to the family of soluble polyphenols. Polyphenols have antioxidant characteristics thought to have a positive effect on health. Tannins are a main source of taste in wine, also contributing to a longer shelf life. Alongside grapes' sugar content (measured using the Oechsle scale), the so-called phenolic maturity is a major determinant of grape quality.

Grapes from biochar-treated plots had a 10% higher polyphenol content. Together with the much higher amino acid content, this was an indication of a greater aromatic quality of the grapes, which is then passed into the wine.

Summary

The experiment took place on a particular soil under specific conditions. The measured values are therefore to be seen only as a sample from a much wider spectrum of important indicators. The positive influence of biochar is, however, unmistakeably and impressively verified by the series of measurements conducted. The results confirm some key hypotheses in the field of biochar research and act as a clear signal to intensify research efforts into biochar and its effects on agricultural soil systems.

See also the results of the laboratory tests conducted with the same soil and the same biochar concomitantly at Zurich University. Here too, considerable insights have been gained into aspects such as water storage capability, nutrient assimilation and growth rates. (Pichler 2010)

2010 is set to be a key year for biochar research, with the area dedicated to outdoor tests increasing 500 times. In the whole of Europe, biochar-compost substrates will be worked into different kinds of agricultural soils and the resulting effects will be subjected to scientific evaluation. In addition, specialists from over 10 European universities and research institutes are now networked together, which will help close the remaining gaps in our knowledge in this field.