Biochar as „negative emission technology and as contribution to achieve the “4 per mille” objective in Austria

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Background

The deployment of negative emission technologies (NETs) is considered indispensable to reach the 2 ° C goal. Compared to other NETs, such as afforestation, bioenergy with carbon capture and storage or direct air capture of CO_2, soil carbon sequestration with biochar (BC) has a smaller, but significant negative emission potential, namely 0.7 Gt C_{eq}/a, but fewer potential disadvantages such as high energy or water consumption or land requirement.

The so-called “4 per 1000” initiative, which was launched by COP21 in Paris, suggests an annual increase of soil organic carbon-stocks (SOC-stocks) of 0.4% of the current stocks in the top 30-40 cm soil of all land covers around the world. The stability of biochar contributes to a much longer residence time of carbon in soil than carbon from compost. Biochar resistance to mineralisation may persist for more than 500 years, with a turnover rate of 0.0046 %/d of 97 % of the BC carbon (Wang et al., 2016).

In order to evaluate the feasibility of reaching the 4 per mille objective in accordance with high stability of carbon stocks and suitable amendment scenarios for the case study of Austria, exemplary analyses of the efficiency of compost and biochar amendments were carried out.

Materials and Methods

The 4 per mille objective was used as a guideline to calculate the theoretically required C sequestration rate for the compensation of anthropogenic greenhouse gas emissions in Austria. A recent report by AGES (Haslmayr et al., 2018) gave an overview of Austrian SOC contents and stocks which served as a basis for estimating potentials for C sequestration in Austrian soils.

Based on studies of different countries on best management practices for C sequestration (Minasny et al., 2017), the sequestration stock boundary to reach the 4 per mille goal was derived as 75-80 t C/ha_{30cm}. Using this SOC stock goal (75 t C/ha_{30cm}), the sequestration potential of each soil type in Austria was calculated by difference of SOC stock and goal.

Results

Table 1 shows the surface areas of different land use forms in Austria, based on a report by Statistik Austria, the corresponding SOC stocks and the calculated or estimated (**) total SOC stocks. This data was used to calculate the total Austrian SOC stock (~631 Mt) in order to determine the necessary 4 ‰ increase overall by multiplication with 0.004 (~2.5 Mt) respectively 0.3 t C/ha annually. Considering that the agricultural area only accounts for ~32% of the total land area, this equals to about 0.9 t C/ha annually.

Deduced from typical BC application rates of 10-50 t/ha and its relatively high price, 10 t/ha can be seen as a realistic goal for the future. Even with the amendment of pure BC, about 2.5 t/ha annually would be demanded for the 4 per mille objective. But due to its recalcitrance this goal could be reached through annual amendment.

Considering that the availability of a compost and BC amendment in sufficient amounts for all Austrian crops, vineyards and orchards is very unrealistic, the rates would have to be even higher to compensate for the not amended areas. Fig.1 shows the costs of scenarios with amendment on all those soils with different BC/compost ratios, in order to give an orientation for further developments of agricultural soil management.

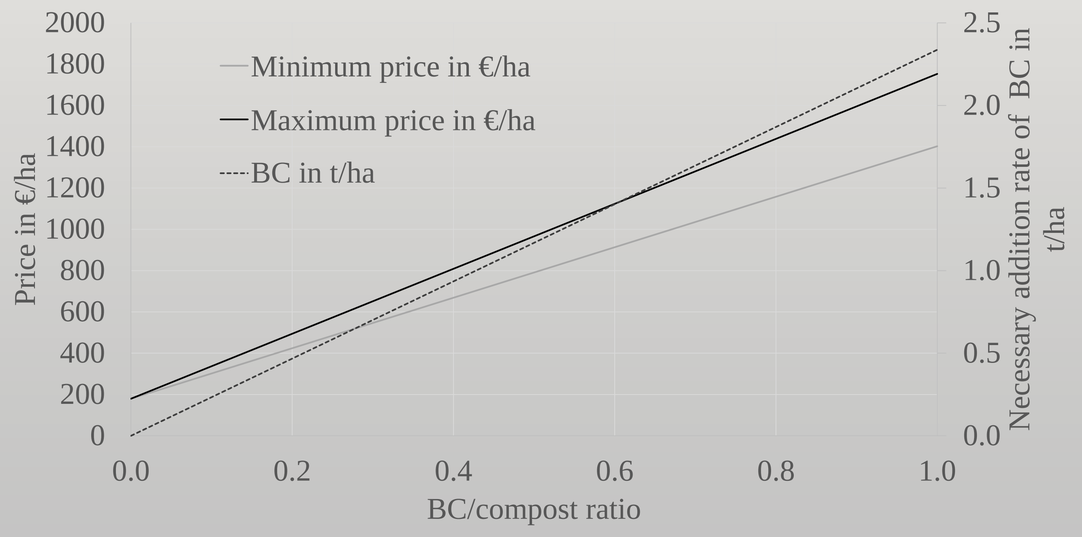

Fig.1. Costs for C-sequestration according to the 4 per mille objective on all Austrian crops, vineyards and orchards with various biochar-compost ratios

Table 1: Area and SOC-stocks of different Austrian land use forms (*..calculated by difference of total Austrian land area and the other land use forms; **..Estimated for the unproductive area of holding: A SOC-stock of 50 t/ha is chosen, since most of that area is fallow land which should have SOC-stocks similar to crops (70t/ha) and the rest are farm or country roads etc. which are lower in SOC.

Land use form		Area in Mha	SOC-stock in t/$ha_{(30cm)}$	SOC-stock in $Mt_{(30cm)}$
agricultural area		**2.66**	**75.0**	**199.8**
	permanent grassland	1.26	72.6	91.4
	crops, vineyards and orchards	1.40	69.1	97.1
	other (urban and sealed area, surface waters, Alpine regions, etc)	1.13*	10**	11.3
forestry area		**3.41**	**106.0**	**361.2**
unproductive area of holding		1.18	50**	59.1
Country area TOTAL		**8.38**	**75.3**	**631.4**
		Required annual increase (4‰)		**2.53**

Conclusions

- **The required annual increase of the SOC-stock to reach the “4 per 1000” objective is about 2.5 Mt SOC (in total for Austrian agricultural areas)**
- **The required amount cannot be reached by compost alone because of limitations in the allowed application rates and in the availability of the required amounts**
- **Although the objective could be reached by biochar applications in theory, this strategy faces limitations because of high costs and too low biochar production capacity**
- **Additional soil management strategies (e.g. ÖPUL-measures) are necessary to complement organic soil amendments as measures to increase SOC**

References:

Wang, J., Xiong, Z., Kuzyakov, Y., 2016. Biochar stability in soil: Meta-analysis of decomposition and priming effects. GCB Bioenergy 8, 512–523.

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