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Potential use of low-temperature gasification biochar as nutrient provider and soil improver – field evaluation

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Introduction

Low-temperature gasification utilises biomass fuels with high ash content, such as straw, with high efficiency. The process can also destroy pathogens and unwanted organic substances in e.g. sewage sludge. This allows developing biochar as valuable soil amendments, also securing safe return of non-renewable resources such as phosphorus (P). The economic feasibility and sustainability of the technology is likewise improved. The objective of the present study was to test the amendment of soil with gasification biochar (GB) products in two experiments in farmer's fields, focusing on 1) soil fertility and carbon sequestration and 2) phosphorus fertilizer value.

Materials and methods

On a temperate sandy loam soil (EXP1) macro-plots (12x100m) were established comparing straw incorporation or removal with straw GB application at rates of 0.5 – 10 tons ha. On a similar soil type, but depleted in P (11 mg P kg^{-1} soil), standard plots (4x10 m) were established comparing two different superphosphate fertilizer levels with alternative P sources from straw GB, straw/sewage sludge GB and raw sewage sludge (EXP2). A number of classical agronomic soil and crop parameters were determined in both experiments.

Close dialogues with the individual farmer involved and other interested stakeholders in workshops were used to evaluate current findings and perspectives.

Results

In EXP1, GB had a positive effect on chemical soil properties without any negative effects on soil biota and crop yields. The application of the highest GB dosage resulted in an increase of soil exchangeable potassium and soil pH. In EXP2, straw GB gave by tendency rise to higher yields compared to straw/sludge biochar at the lower P application rate, however, the overall spring barley yields were not significantly increased even after the addition of 60 kg superphosphate ha^{-1}, which might be attributed to a high P fixing capacity of the soil.

Discussion

Judged by two years experimentation, straw GB as a fertilizer and a soil carbon sequestration agent was regarded as promising, showing the possibility to produce bioenergy from crop residues without negatively affecting soil quality. The relative costs and benefits for the farmers adopting such a new technology are still unclear though. Further research are also needed to verify specific nutrient plant availability in GB when substituting traditional mineral fertilizers. Several farmers raised concern about negative longer term consequences reducing microbial services when incorporating a rather inert material like GB instead of straw.

Conclusion

The use of agricultural residues and urban waste streams for bioenergy and subsequent return of residuals to agricultural soils is an important step towards closing nutrient cycles. Our results indicate that GB can be utilized as a renewable fertilizer and liming agent without any harmful effects on soil biota. However, more demand-driven involvement of farmers is required to bring the practical application of biochar into play.

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