Soil amendment with pyrolysed grape marc residue: a circular economy study

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Introduction

In France, the wine industry leads to the production of 850 000 tons of raw grape marc each year. Among this huge amount of wastes, 25 500 tons come from the Alsace region (north-east of France) where grape marc is mostly valorised by distillation to extract ethanol (IFV, 2013). The residual biomass corresponds to exhausted grape marc, which is usually used as biofuel. An interesting alternative to this issue is to transform this biomass into biochar, after pyrolysis, and to use it as fertiliser. By this way, it is possible to obtain a negative carbon balance, and also to generate carbon sequestration. This study has been done in the frame of a territory circular economy (Jeguirim, 2017), at the level of a region. A batch of exhausted grape marc coming from a distillery was sampled and analysed. The grape pulp and pips fraction was selected to produce a biochar at different temperature. These biochars were used as fertilisers for the growth of ray-grass.

Material and methods

50 kg of exhausted grape marc were collected at the Sigolsheim distillery (France), the grape stem fraction was removed from the biomass before being crushed and sieved. The 250-400 μm fraction was selected to prepare the biochar. The elemental analysis of this biomass is presented in table 1.

Table 1. Elemental analysis of the raw pulp and pips fraction used in this study.

Elemental analysis (dry basis)	% wt	Ash composition (% wt – main elements)	% wt
C	50.76	P	0.257
H	6.41	K	0.677
N	1.17	Ca	0.622
S	1.10		
O	37.8		
Ash	2.76		

2kg of dry biomass was used in a batch pyrolyser to produce three different biochars at 300°C, 400°C and 500°C, at a heating rate of 5°C/min and with a residence time of 1 hour. The elemental analyses of the biochars were carried out. Surface analyses were performed by IR, SEM-EDX and XPS spectroscopy in order to identify the morphology and the homogeneity of the biochars. Ray grass growth was studied in 1 kg of soil fertilised with different amounts of biochar, depending on their K content (same amount of K added to each pot). Two cuts were operated on the different pots after 4 and 8 weeks of growth in order to evaluate the mass yield and the K uptake of the Ray grass cultures.

Results and discussion

The biochar yields obtained after pyrolysis were 78.50, 46.96 and 35.43 %wt at 300, 400 and 500°C respectively. Infrared spectroscopy was used to identify the evolution of the surface groups during the pyrolysis process. Infrared spectra measurements were carried out on the 3 biochars. Results showed that by increasing the pyrolysis temperature the aliphatic band intensity (≈ 2900 cm^{-1}) decreased due to the devolatilization process. The morphology of the biochars was analysed by SEM-EDX. Figure 1 shows the surface of the biochars, with different structures. The more temperature of pyrolysis is high, the more porosity appears. Another very interesting point concerns the presence of thin stick corresponding to tartric acid residue.

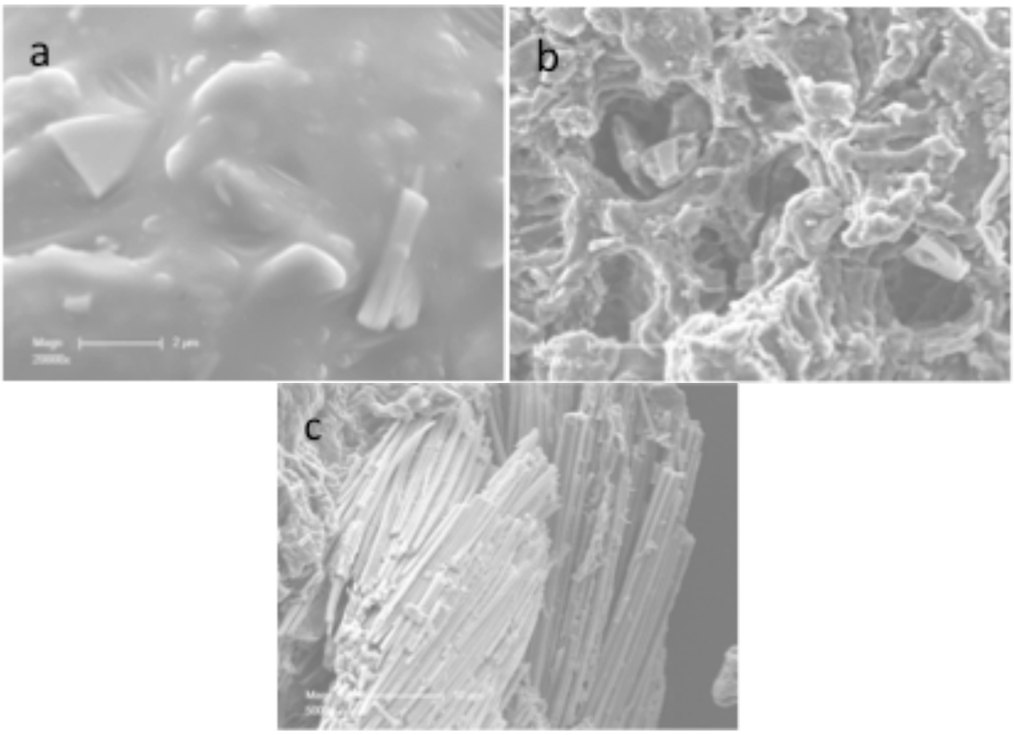

Figure 1. SEM images of the biochars produced at a) 300°C b) 400°C and c) 500°C.

EDX analyses showed that potassium and phosphorous are present everywhere in the biochars (diffuse), while calcium and silicon are located in specific areas. The elemental analyse of the three biochars is reported in table 2. The K content of the different biochars has been selected to calculate the quantity of biochar to add to each pot (200 unities of K_2O/ha), it corresponds to 1.10 %wt, 1.64 %wt and 2.17 %wt for biochars produced at 300, 400 and 500°C respectively.

Table 2. Elemental analysis of the different biochars.

Elemental analysis (dry ash free basis)	Biochar 300°C	Biochar 400°C	Biochar 500°C
C	60.21	67.42	72.91
H	6.04	5.07	3.15
N	2.51	2.71	2.72
S	1.09	0	0
O	30.2	24.8	21.2

The analyse of the different cuts (after 4 and 8 weeks of growing) showed that K and P were bio-available and allowed the plant growth without difference compared to reference samples fed with mineral solution containing KNO_3. The best results were obtained with the biochar produced at 500°C, Ray grass yield was slightly higher than with the different references and the use of this biochar led to soil alkalinisation.

Conclusion

The use of exhausted grape marc biochar as fertilizer showed interesting potential for Ray grass growth. The results showed that a pyrolysis temperature of 500°C was necessary to obtain a positive results compared to conventional fertilizer. This study was carried out at the scale of a small French territory where wine is produced.

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References

Institut Français de la Vigne et du Vin, 2013, www.vignevin.com

M. Jeguirim, P. Dutournie, A. Zorpas, L. Limousy, Olive mill wastewater: from a pollutant to green fuels, agricultural water source and bio-fertilizer, Part 1: the drying kinetics, Energies (10) 1423