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

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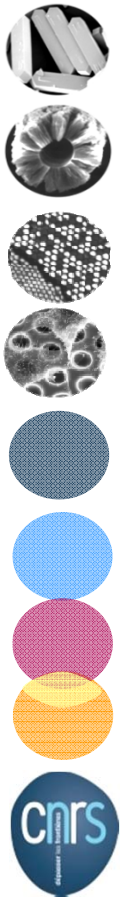
IS2M
Institut de Science des Matériaux de Mulhouse



Outline

1. Introduction - Context
2. Biochar elaboration
3. Soil amendment – Biodisponibility of P and K
4. Conclusion

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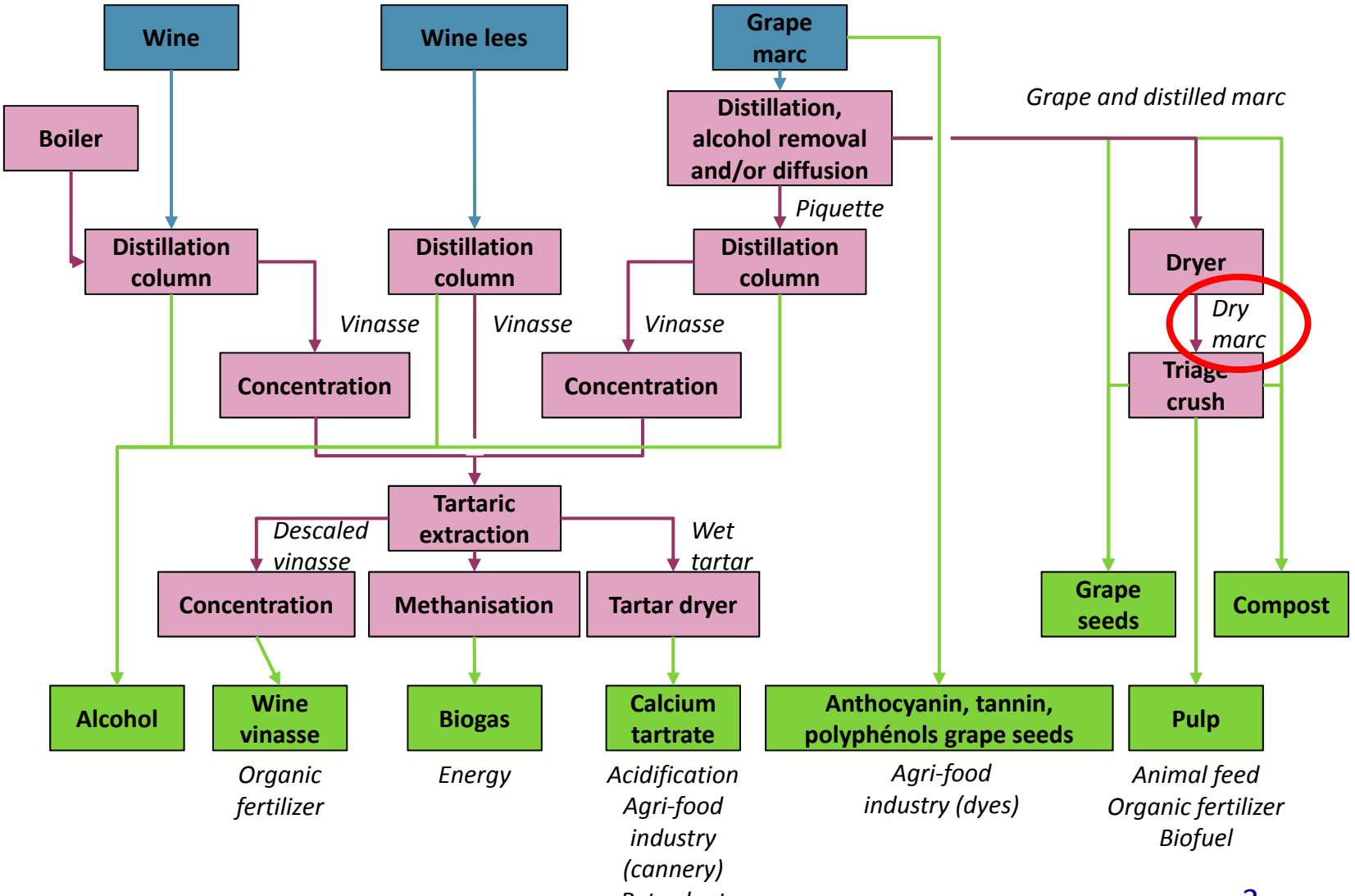
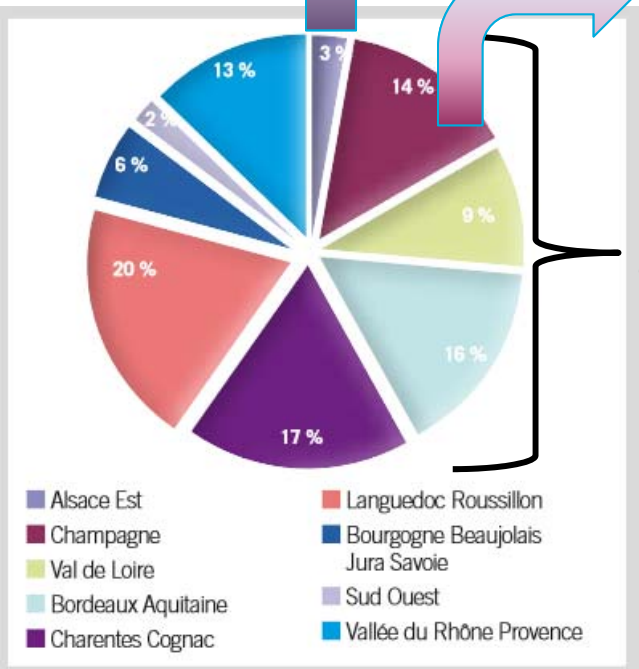
Recovery procedures for GM



Grape marc deposit

Alsace (North-east of France) :
25 500 tons of raw GM/year

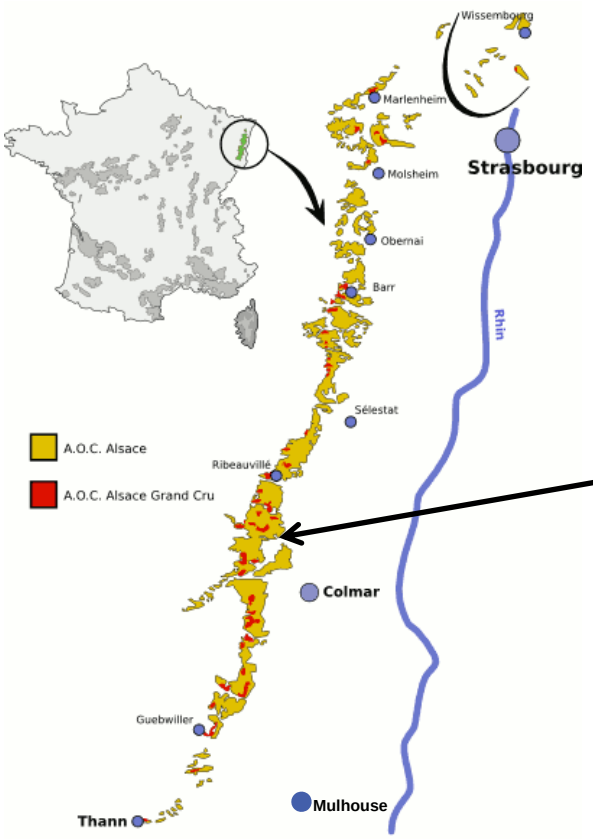
Champagne (North-east of France) :
102 000 tons of GM/year



France :
850 000 tons/year

Distribution of grape marc deposit in France en France (IFV, 2013)

Alsatian vineyard – GM deposit location

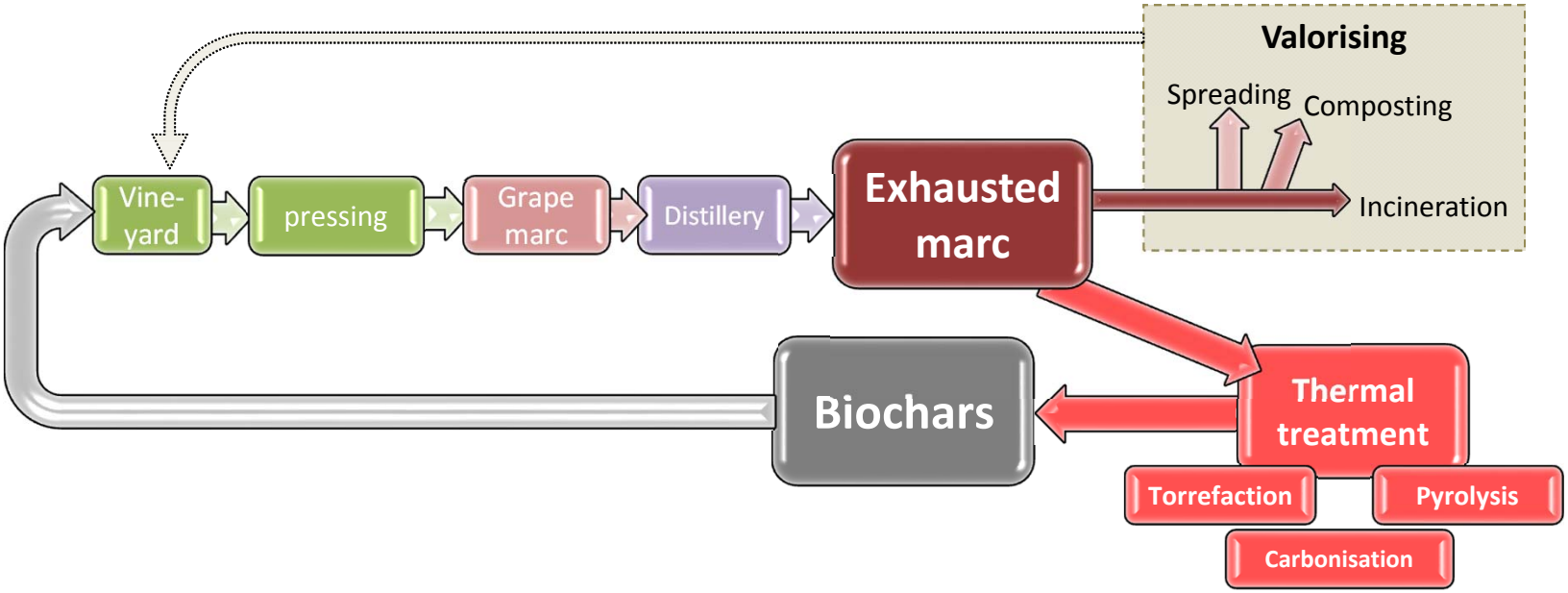


Romann distillery (Sigolsheim)
→ 18 000 tons of raw GM/year

Grape varieties:

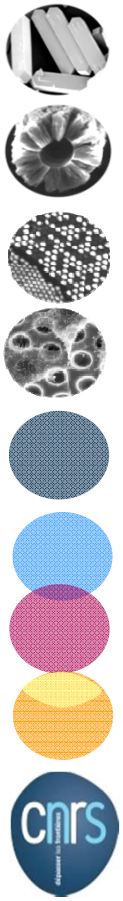
Gewurztraminer, Riesling, Muscat, Pinot Gris, Pinot Noir, Sylvaner, Pinot Blanc

Strategy of the project



- **Benefits :**
  - **Agronomic valorizing of chars**
  - **C sequestration in the soil** (objective 4/1000)
  - **Hygienisation** of grape marc
  - **Volume reduction** for storage and transport
  - **Production of renewable energy** (syngaz, bio-oil).

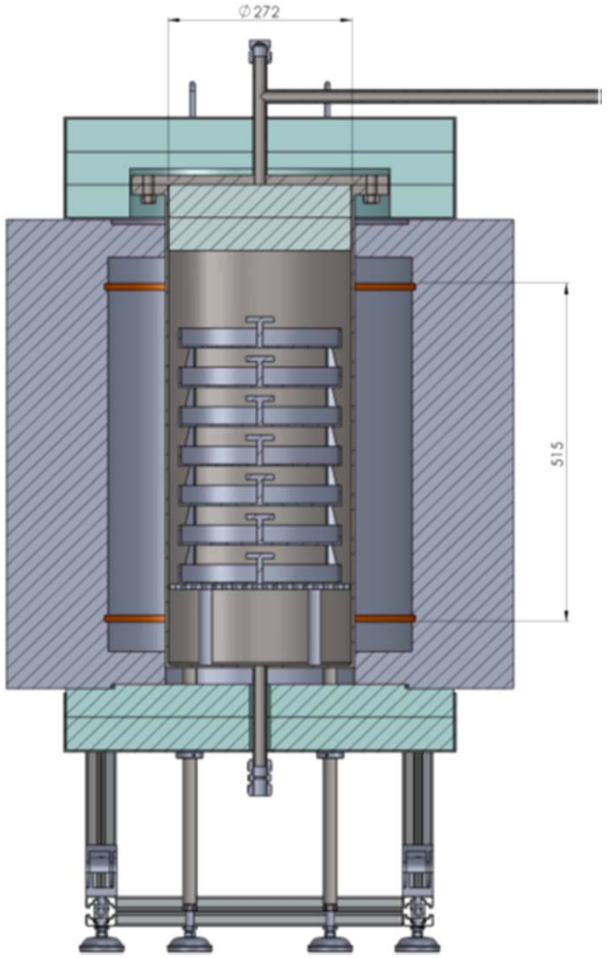
Objectives



- Elaboration of biochars from GM at different temperatures
  → 300° C to 600° C
- Characterization of the different biochars
- Soil fertilisation

Experimental procedure

Pyrolysis tests:

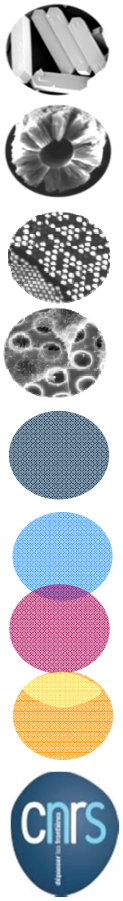


Experimental parameters:

- → 2 kg of raw biomass (250-400 µm)
- → Pyrolysis temperature: 300-400-500-600° C
- → 5° C/min
- → Flow rate (N_2): 25 NL/h
- → Residence time : 1h

Mass yields:

300° C	400° C	500° C	600° C
65.8%	59.1 %	33.8%	32.5%



Chemical analysis:

DB (wt %)	GM 300°C	GM 400°C	GM 500°C	GM 600°C
C	60.21	67.42	72.91	72.13
H	6.04	5.07	3.15	2.16
N	2.51	2.71	2.72	1.71
S	1.09	0	0	0
O deduced	30.2	24.8	21.2	24
Elemental analysis DB (mg/kg)				
Al	554	433	471	326
Ca	7010	10300	13400	17961
Fe	512	771	930	718
K	11000	16400	21700	20095
Mg	1150	1430	1900	2929
Na	199	299	407	422
Ti	19	-	40	-
P	3370	4940	6230	8194
Si	3150	4590	6150	1326
Ni	-	-	-	0
pH	7.23	8.69	9.9	10.08
H/C	0.10	0.08	0,04	0.03
O/C	0.50	0.37	0.29	0.33

Characterization of the biochars:

CO_2 adsorption → textural properties

Temperature (°C)	300	400	500	600
Surface area (m^2/g)	24.8	130.4	204.8	253.4
Microporous volume (cm^3/g)	-	0.03	0.06	0.08

⇒ Stabilization of the biochars properties for pyrolysis temperature higher than 500° C

Biodisponibility of P and K for the plant:

1 kg soil + biochars

Reaping of the air biomass (after 4 and 8 weeks) : **DM, P wt% and K wt%**

Production trials:

Char 300° C → 200 U K_2O/ha (12.5 t /ha → 106 U P_2O_5/ha)

Char 400° C → 200 U K_2O/ha (8.33 t /ha→ 93 U P_2O_5/ha)

Char 500° C → 200 U K_2O/ha (6.25 t /ha → 121 U P_2O_5/ha)

Char 500° C → 100 U K_2O/ha (3.13 t /ha → 60,5 U P_2O_5/ha)

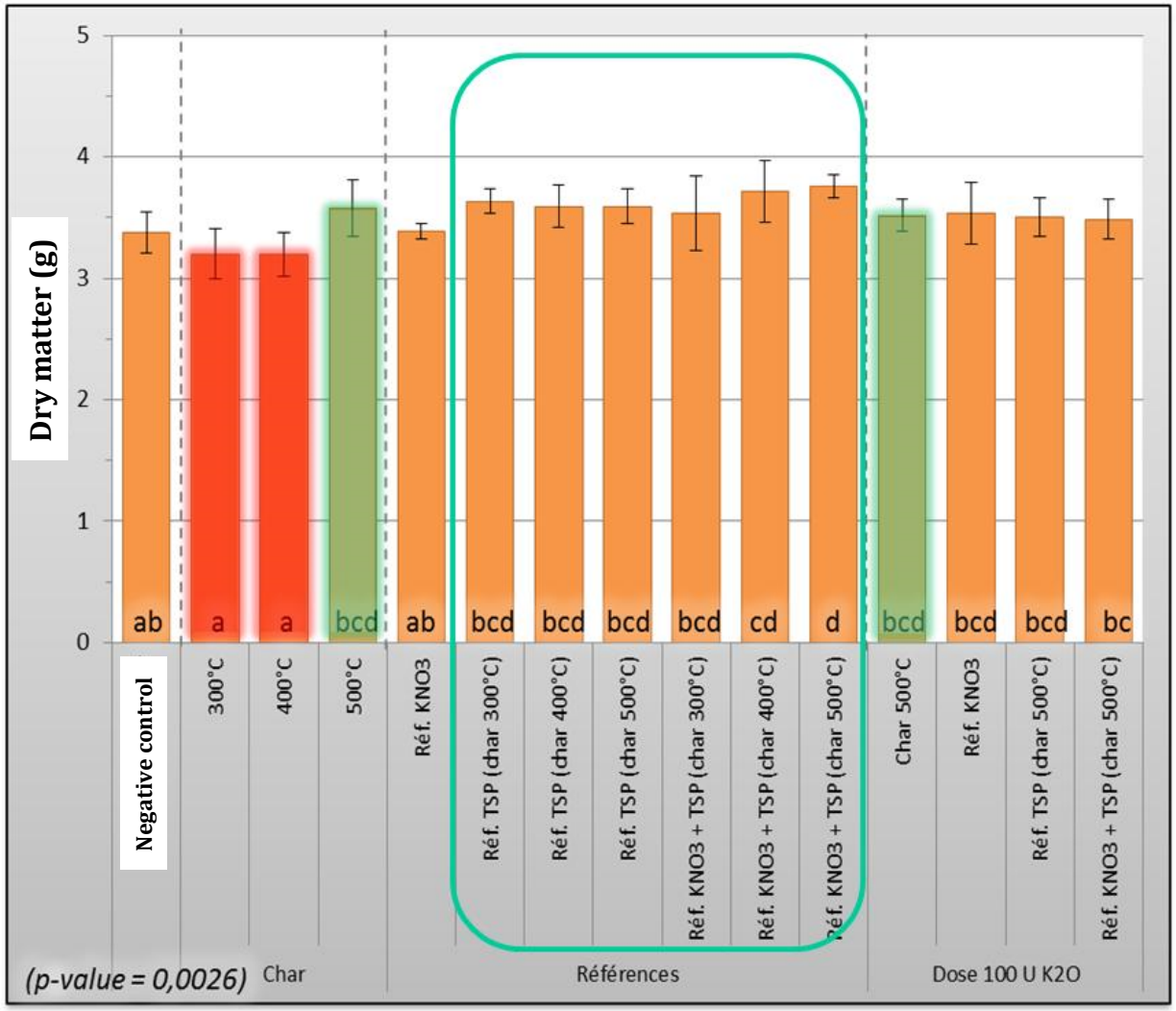
Standards (references) :

KNO_3 → 100 et 200 U K_2O/ha

TSP → 60.5 ; 93 ; 106 et 121 U P_2O_5/ha

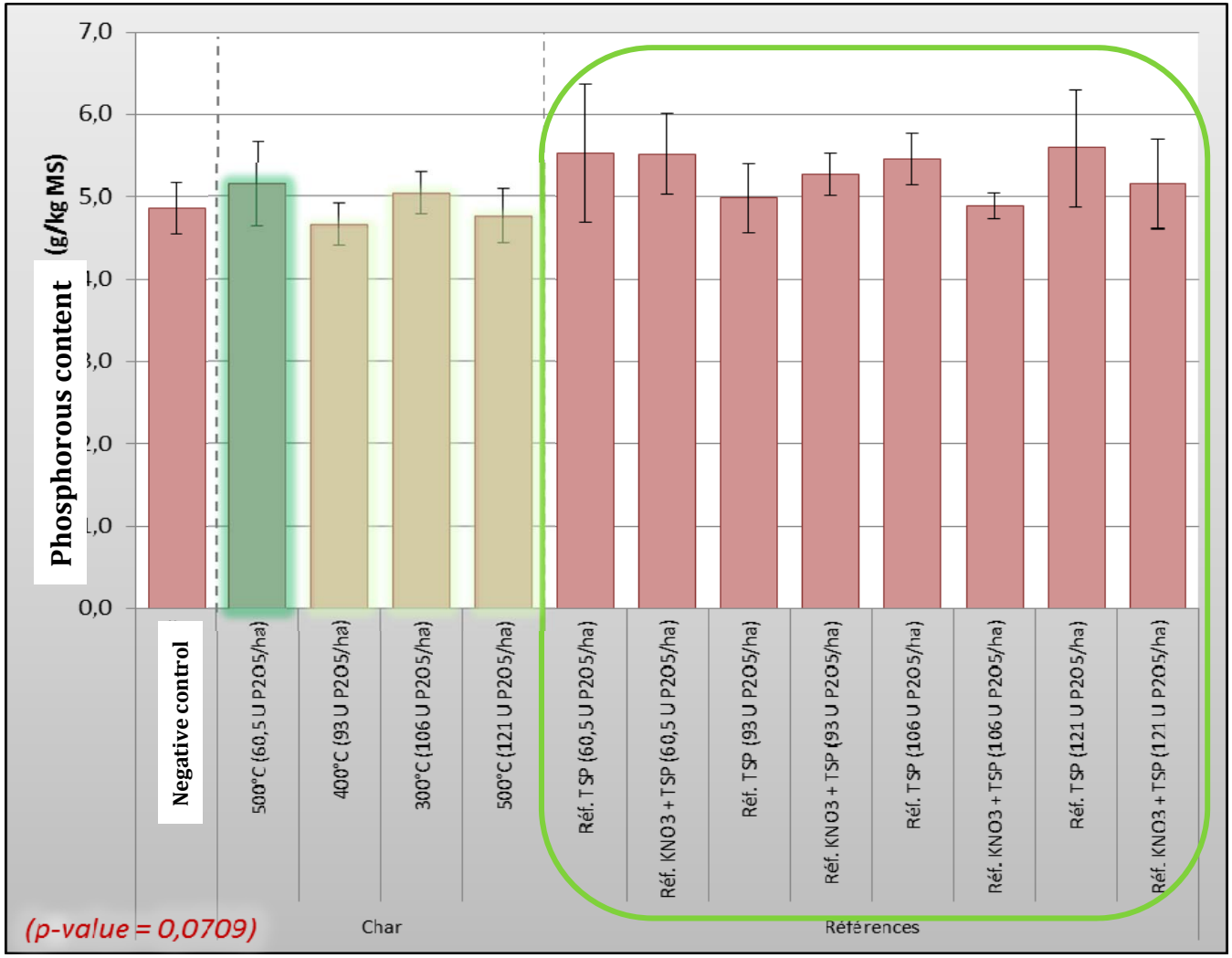
4 repetitions for each trial

Dry matter content:



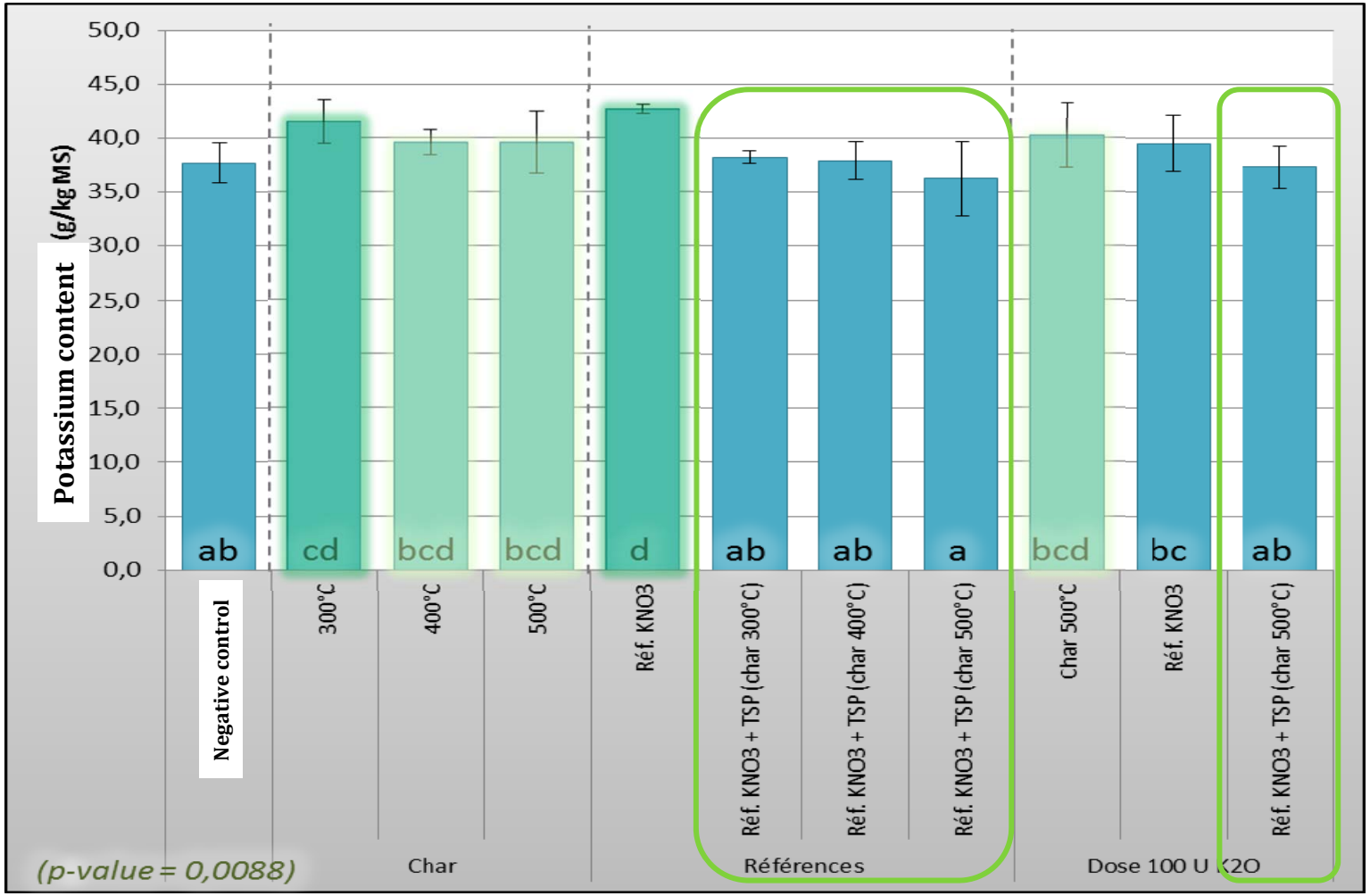
⟹ Best results are obtained with the biochar 500° C → comparable with TSP + KNO_3 references

Biodisponibility of P for the plant:



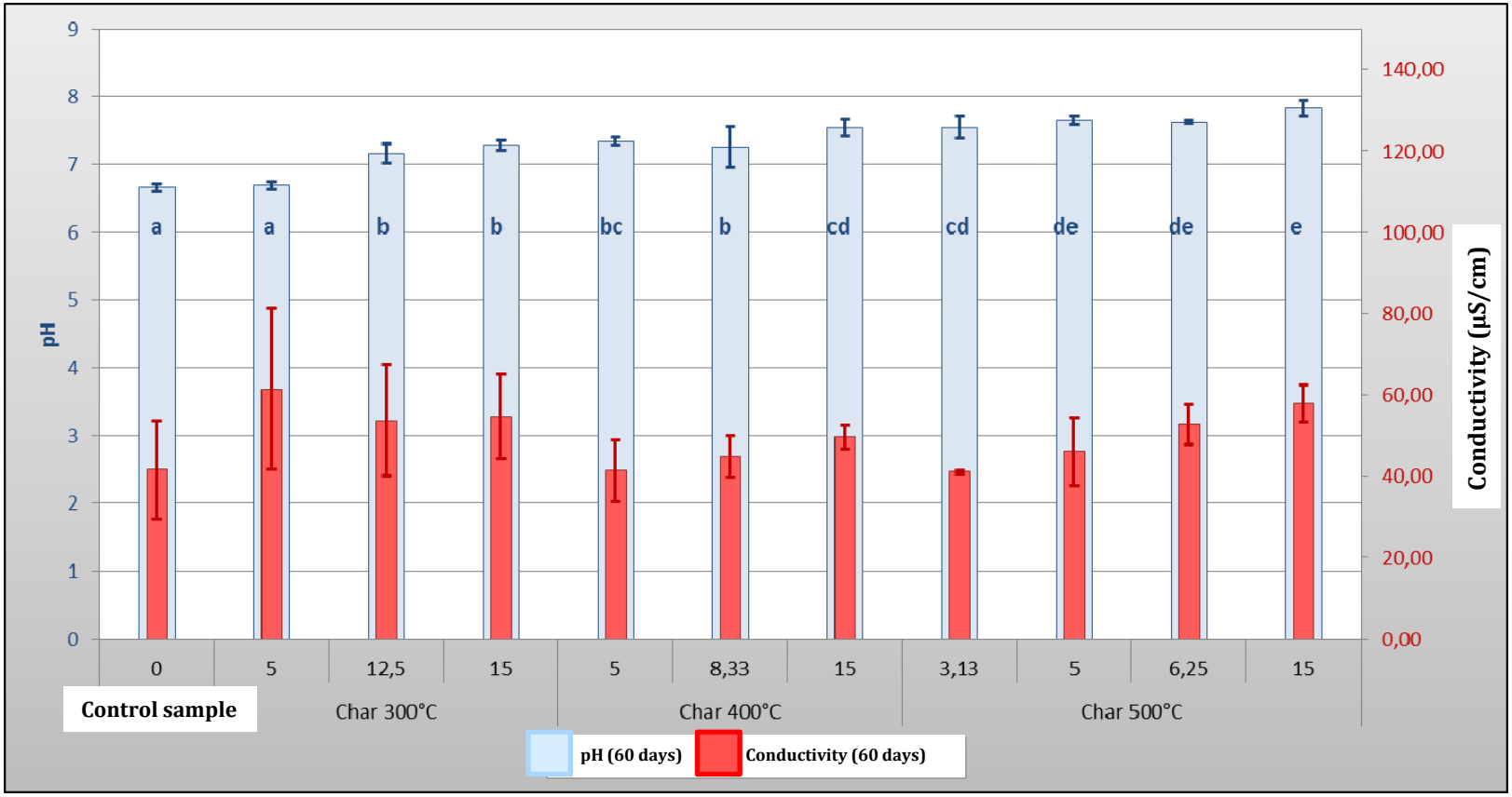
⇒ Biodisponibility of P limited in comparison with the TSP references

Biodisponibility of K for the plant:

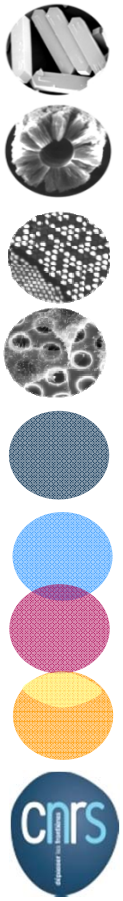


⇒ Good biodisponibility of K especially for the biochar 300° C sample

Effect of the biochars on pH and soil conductivity:



⇨ Increase of soil pH according to the temperature of pyrolysis
Soil conductivity is higher for the biochar 300° C sample



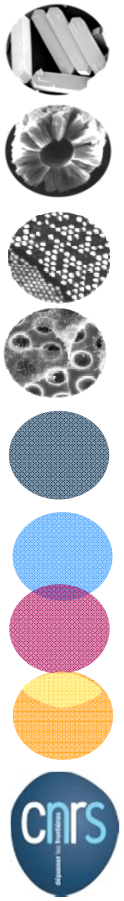
Biochar elaboration and characterization :

- High K and P contents for biochars prepared at 500 and 600° C
- Devolatilization ends at 500° C
- Textural properties of biochars prepared at 500 and 600° C are more favorable for soil application

Efficiency of the different biochars for plant growth:

	300° C	400° C	500° C
Biodisponibility			
DM yield	-	-	+
Phosphorous	-	-	+
Potassium	++	+	+

Effect of biochars on soil structuration, suppresive effect and water retention have to be done



Acknowledgements to

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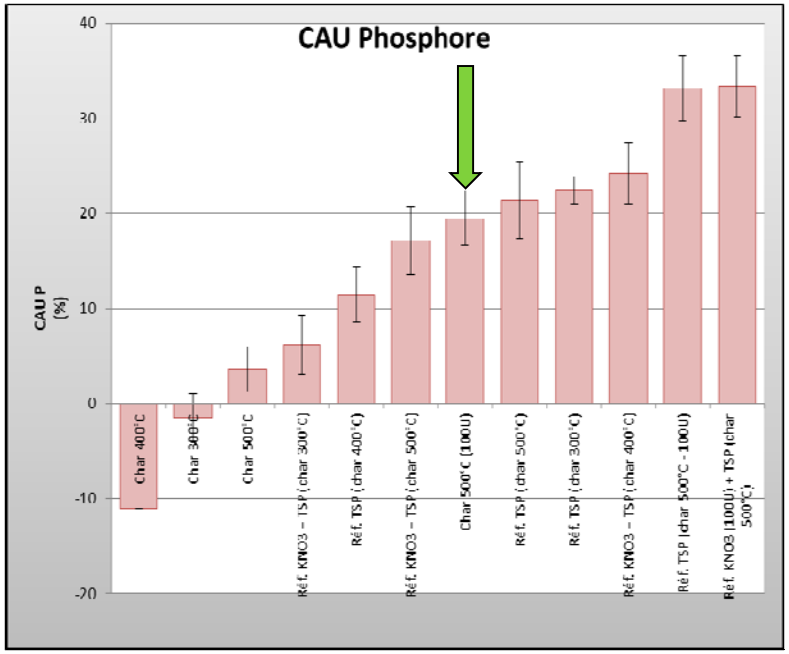
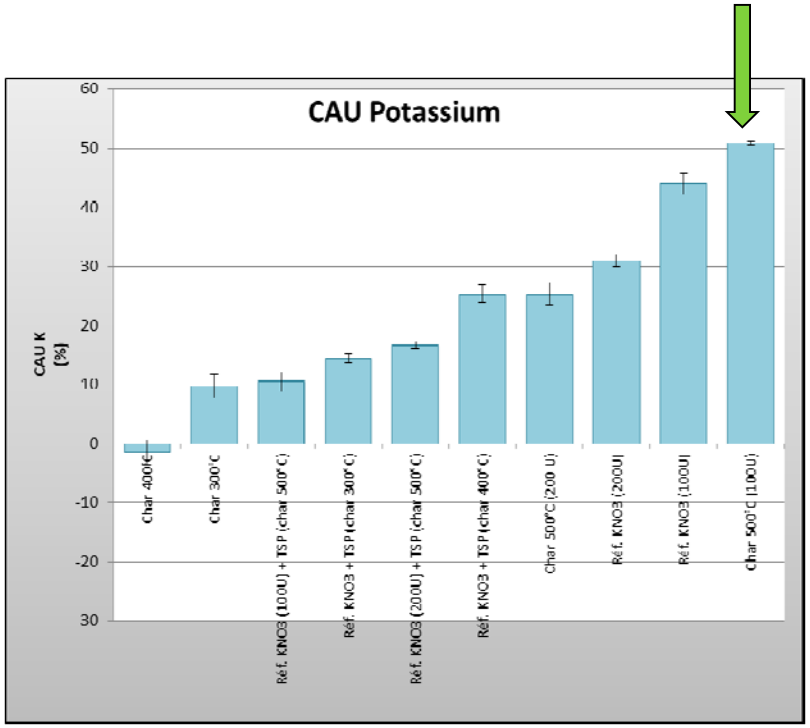
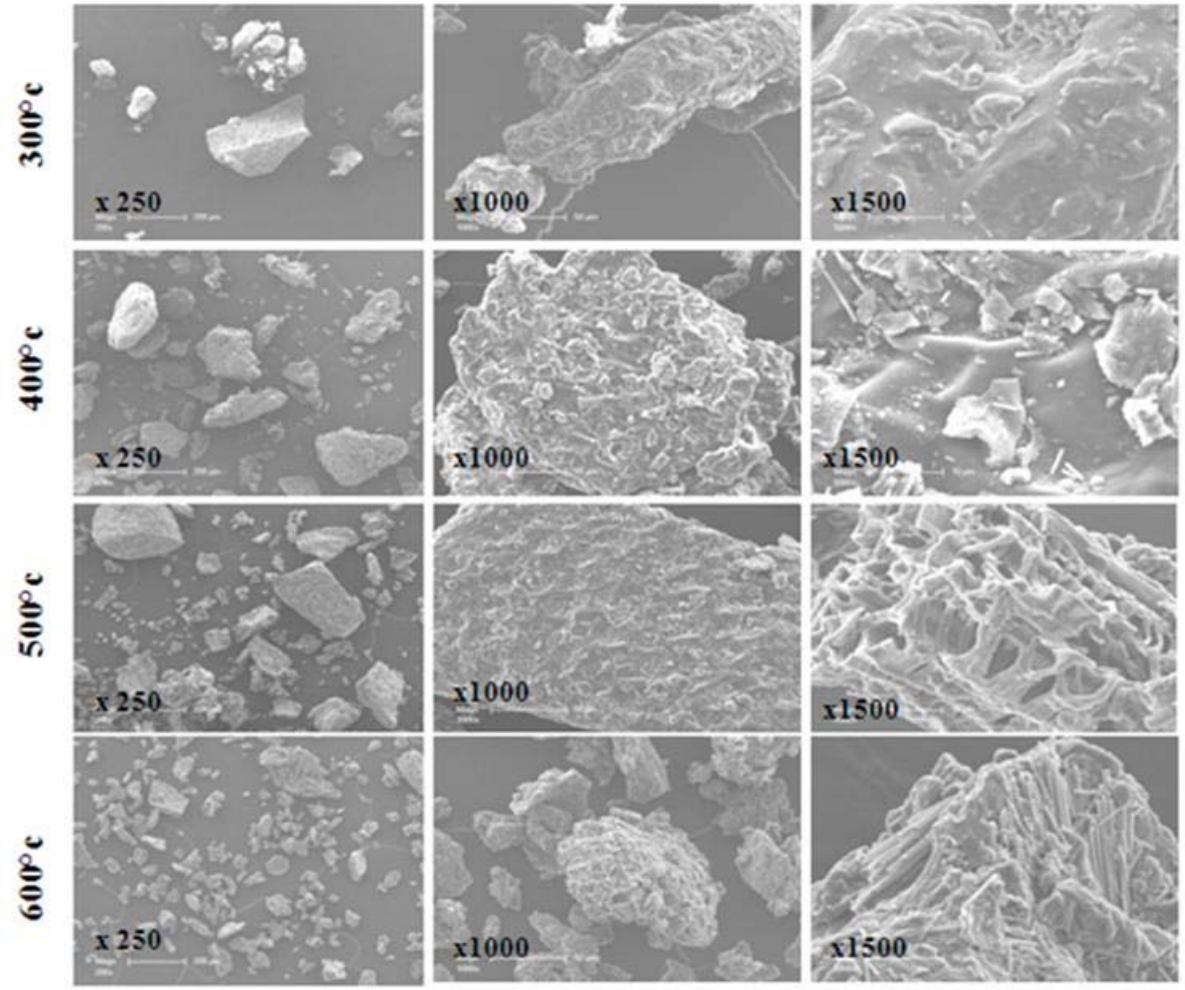
Apparent utilization coefficient:





Characterization of the biochars:

Scanning Electron Microscopy characterization



⇒ Devolatilization seems to be complete from 500° C