RITTMO Agroenvironnement®

INTERREG IVB

Intérêts agronomiques des biochars: Résultats du projet BioenNW

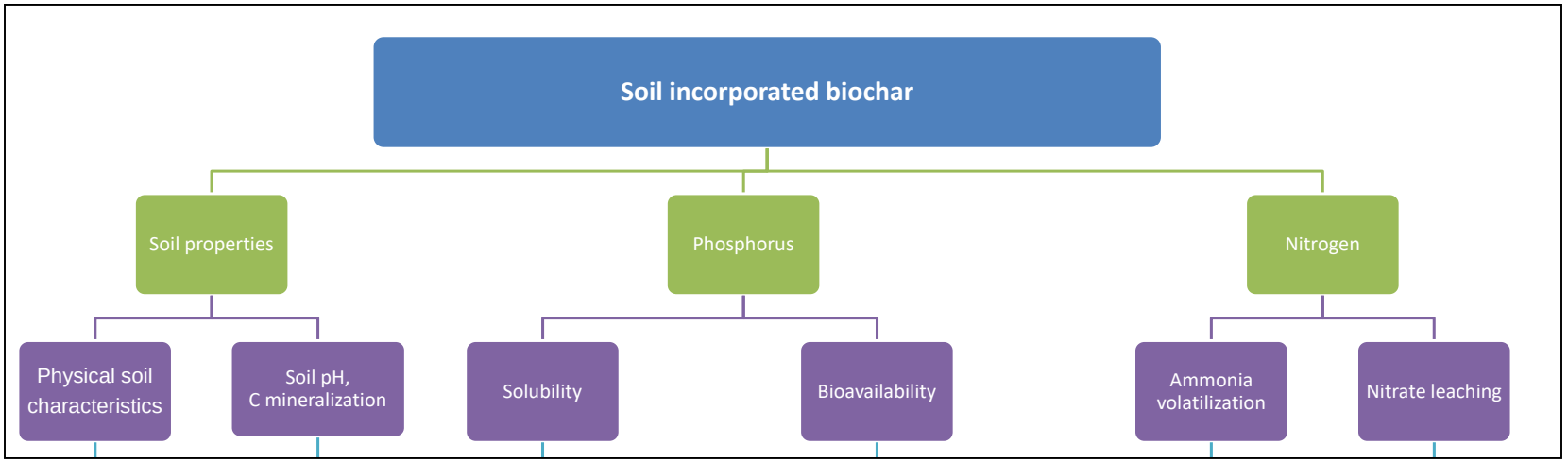
(INTERREG NW European Project)

Mohammed Benbrahim

BioenNW Project

- Support and promote development of Bioenergy
- 11 partners
  - European Bioenergy Research Institute - ASTON Univ : lead-partner
  - **RITTMO in charge of :**
    - Contacting stakeholders and developing a BSC
      - 1st BRIN – 22nd of May 2014
        - » Call for stakeholders interested in testing pyrolysis of their residues and in having their biochars studied
    - **Investigate agronomic interest of Biochars**

• Agronomic interest of Biochars



Interactions Biochars / micro-organismes
Interactions Biochars / Plant growth (root; defense;..)

Studied biochars

- 8 differents biochars :

Biochar Code	Feedstocks	Production Scale	Pyrolysis Temperature (°C)
PmW-BC	Poultry manure and wood	Pilote	500
D1-BC	Digestate of corn	Pilote	500
D2-BC	Digestat (corn silage> 60%, manures)	Industrial	700
W1-BC	Forestry Residues (Branches and tops)	Industrial	650
W2-BC	Forestry Residues	Pilote	500
WC-BCX	Vegetable and forestry wastes; refuse compost	Pilote	500
D3-BC	Digestate cattle manure	Pilote	500
Pig-BC	Pig manure	Pilote	500

Studied biochars

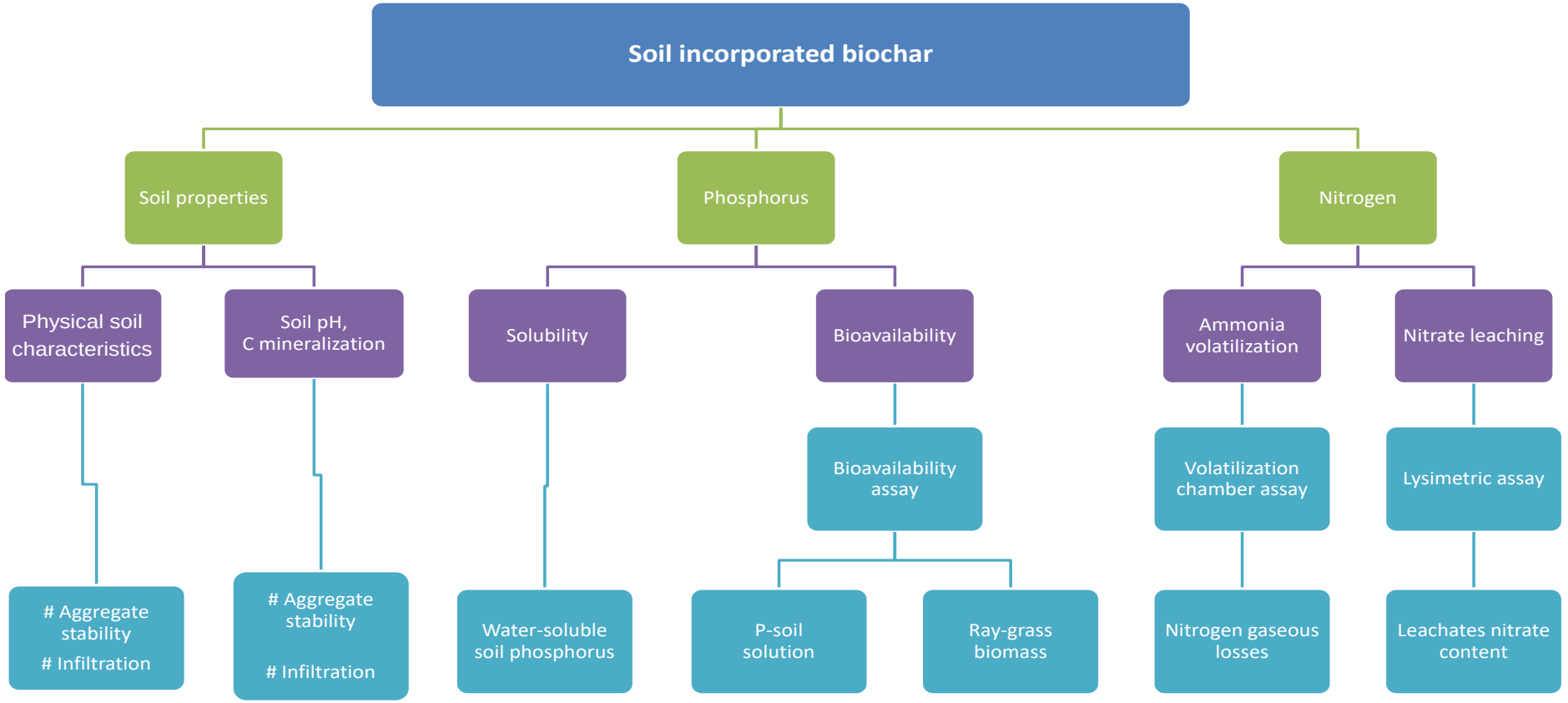
- Mineral and organic content :

Biochar Code	MS % PB	pH	N % PB	P_2O_5 % PB	K_2O % PB	OM % PB
PmW-BC	99.5	10.7	1.59	10.04	6.48	29.4
D1-BC	98	10.6	1.92	5.48	11.28	31.8
D2-BC	99.4	11	0.8	9.64	7.01	52.8
W1-BC	67	9.7	0.41	0.24	0.6	54.4
W2-BC	100	9.1	0.59	0.44	0.8	90.4
WC-BCX	100	11.9	0.87	0.67	1.2	17.4
D3-BC	98.2	11.4	0.99	3.38	5.19	64.4
Pig-BC	100	11.9	1.66	8.74	9.85	37

Agronomic values compared to French Fertilizer Regulation

Biochar	Code	OM (%PB)	$N+P_2O_5+K_2O$ (%PB)	CaO (%PB)	MgO (%PB)	CaO+MgO (%PB)
French Regulation (NF) thresholds		NFU 44-051 >20	NFU 42-001 > 7	--	--	NFU 44-001 > 15
BC1 R1501017	PmW-BC	29,4	18,1	28,66	2,56	31,22
BC2 R1502004	D1-BC	31,8	18,68	5,15	2,19	7,34
BC3 R1504035	D2-BC	52,8	17,45	6,99	4,83	11,82
BC4 R1504036	W1-BC	54,4	1,25	2,55	0,2	2,75
BC5 R1505058	W2-BC	90,4	1,83	19	2,8	21,8
BC6 R1505059	WC-BCX	17,4*	2,74	6,69	0,49	7,18
BC7 R1505060	D3-BC	64,4	9,56	4,5	1,46	5,96
BC8 R1505061	Pig-BC	37	20,25	10,8	6,99	17,79

List of realized assays



List of realized assays

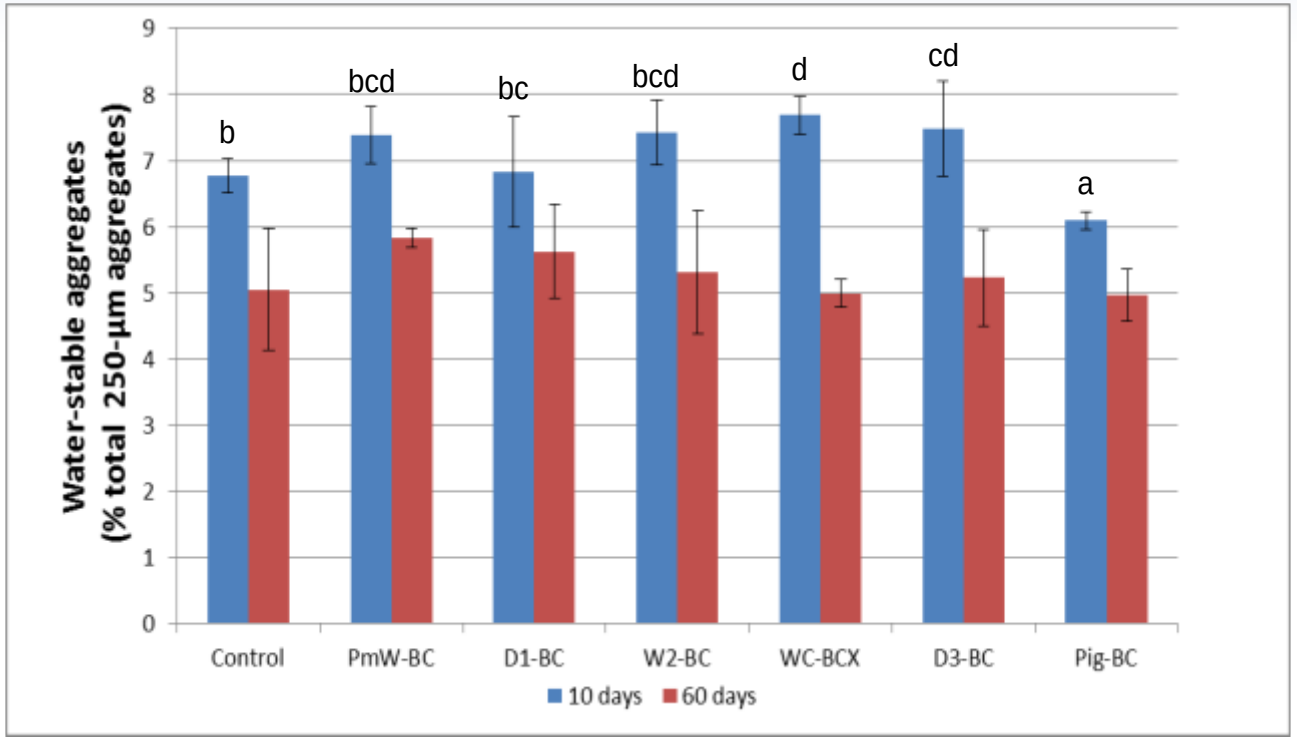
- Feeding doses:
  - 4 T/ha for all the assays (NH_3-Volatilization and NO_3 leacheate, C-mineralization and effect on pH) except phosphorus)
  - For Phosphorus essay: equivalent 4 T/ha for all biochars or 40 T/ha for Wood-based biochars (P-Content)
  - 10 T/ha for Aggregate stability and run-simulator for water infiltration essays

Effects on soil aggregate stability

- Biochar incorporation and soil incubation
  - Biochars incorporated to 500g of soil ;
  - Incubation in greenhouse for 2 months ;
  - After 10 and 60 days of incubation, soil-biochar samples were dried at 40°C and sieved to collect the 1-2 mm fraction for aggregates measurement.

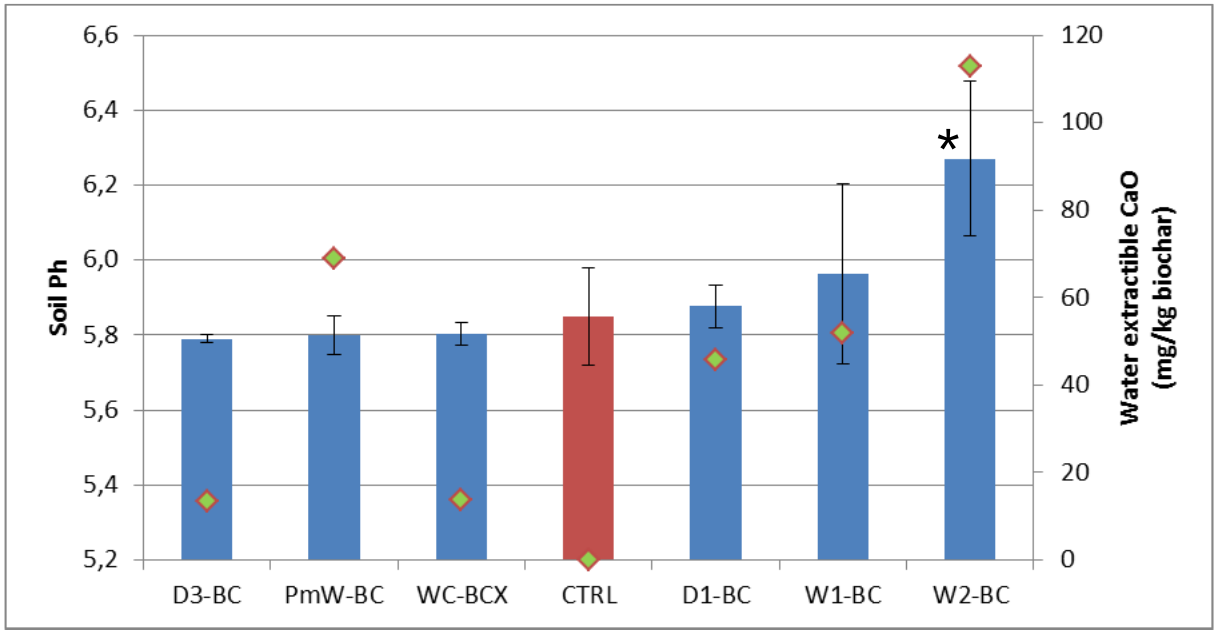
- Water stables aggregates measurements :
  - The dried 1-2mm fractions were sieved at 200 µm sieves two times :
    1. In distilled water to determine the water unstable aggregate
    2. In dispersing solution to determine the water stable aggregate
  - The water stable aggregates are the expressed as percent of the total 200 µm aggregate

Effects on soil aggregate stability



- No tangible effect:
- 10 days after biochar application, only D3-BC and WC-BCX had slightly increased the WAS (+6 – 7 %) whereas the Pig-BC has slightly decreased the WAS (- 11 %) compared to the control
- No effect after 2 months

Effects on the soil pH

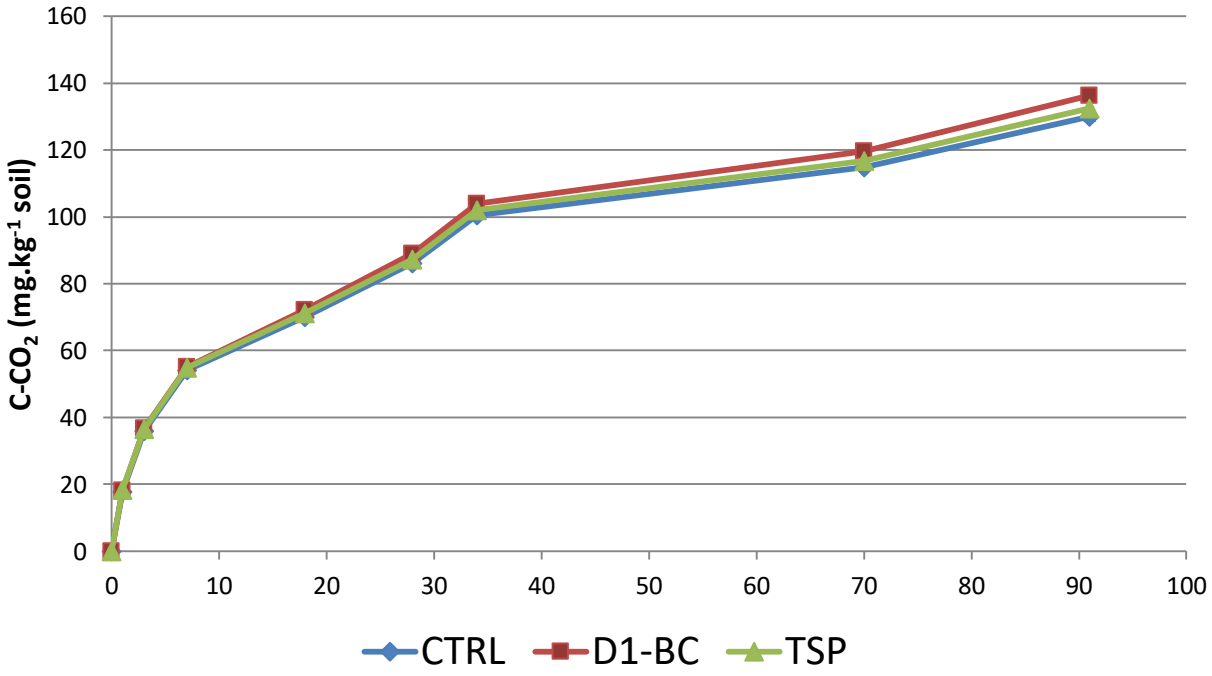


- At a rate of 4 T/ha, only the W2-BC has increased the soil-pH. Effect on soil pH seems to be related to the water extractible Ca rather than a total Ca content.

Effect on carbon mineralization

- **Objective:** Study the mineralization of carbon kinetic in soil during an incubation period of 91 days at 28°C (equivalent to 1,8 years in field)

- **Reference:** «Characterization of organic matter by potential mineralization of carbon and nitrogen.» French Norm XP U44-163



No effect of Biochar on C mineralization

➔ Carbon is stable
Long-term effect ?

Phosphorus biodisponibility of biochars

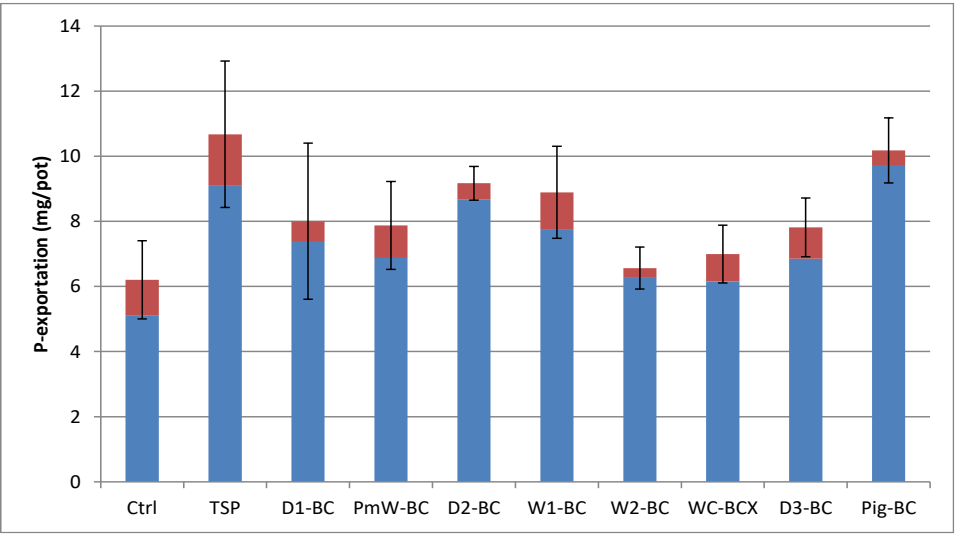
- References:
  - Developed by Chaminade (1960. 1964),
  - Revised by Lemaire (1977),
  - Summarized by Lombaert (1992).

- Ray grass test :
  - Ray-grass culture in green house with biochar application (4 T/ha or 40 T/ha depending on their P-content)
  - Repetitive cuttings of foliar biomass: starting from the 5th week, then all 3 weeks
  - All biomass are dried, weighed and added
  - Analysis of biomass: content and export of P
  - Calculations:
    - Indicator of bioavailability
    - Fertilizing value of P compared to mineral reference
    - Apparent use coefficient of P
- Soil test :
  - Extraction of the soil solution after ray-grass growth
  - Use of ceramic porous for soil solution extraction
  - Measurement of water soil –P content in the soil solution (green malachite dye method)

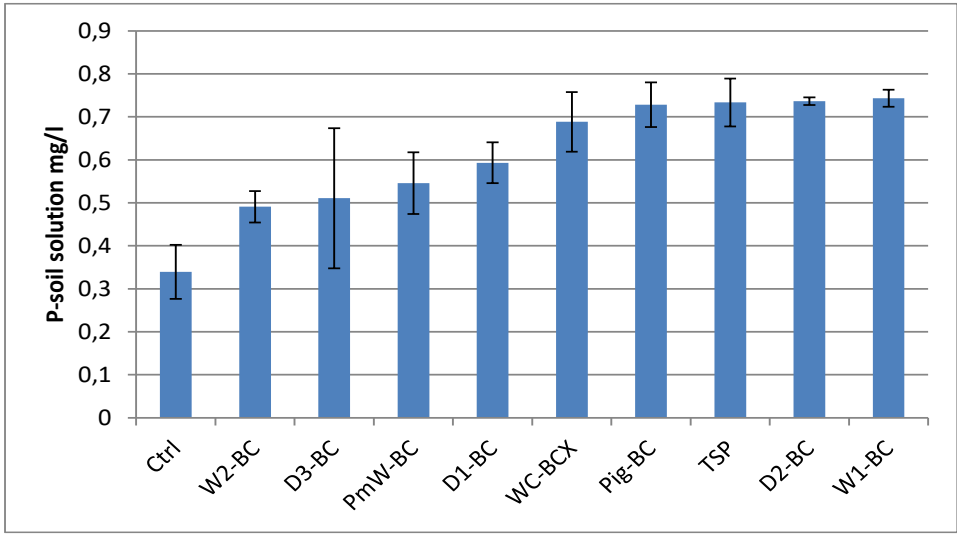
Phosphorus biodisponibility of biochars

- **Results :**

P exportation



P soil solution



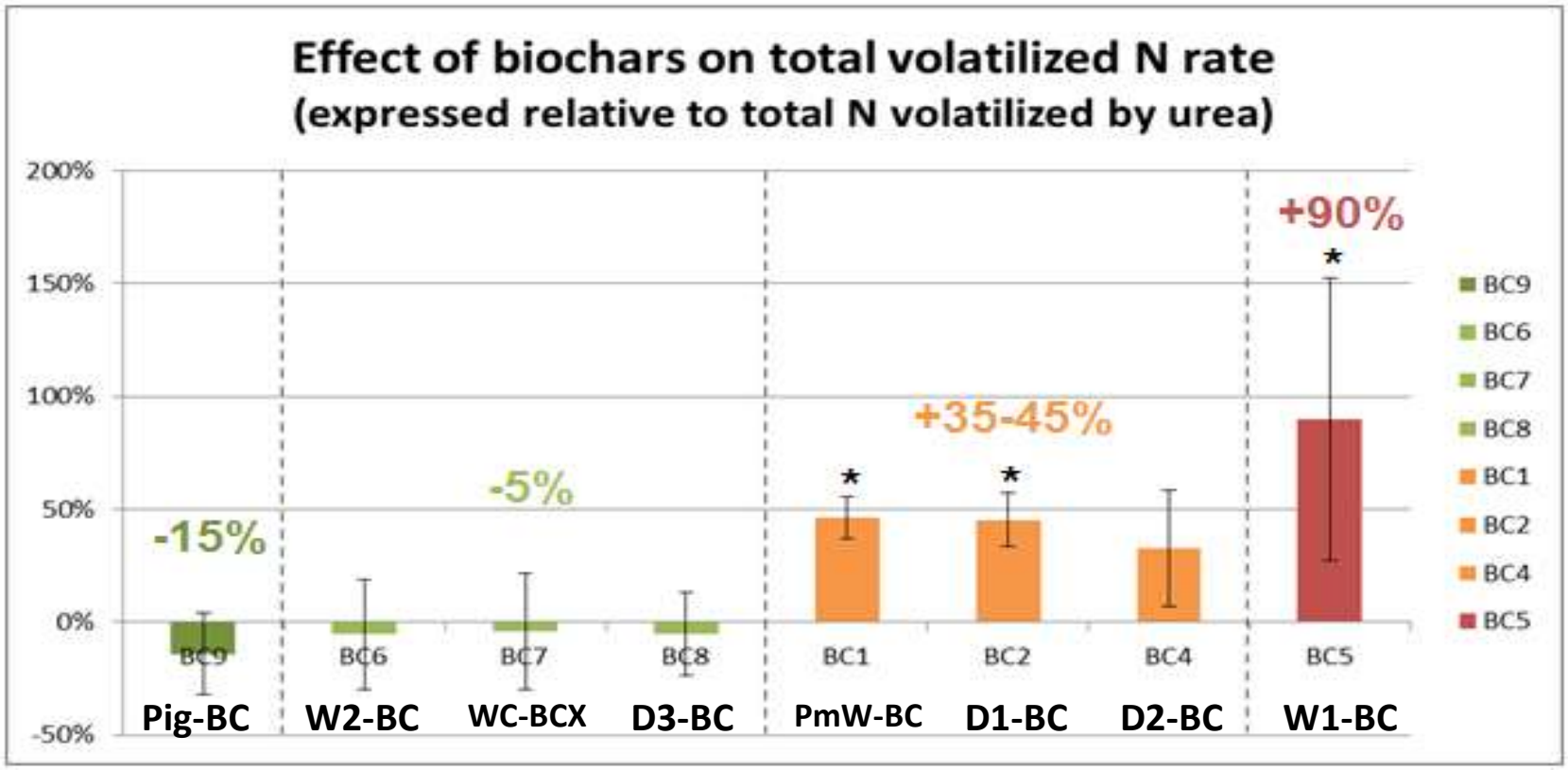
- ✓ Significant **increase of P uptake** for all biochars expected W2-BC and WC-BC compared to the control
- ✓ The **apparent use coefficients** of D3-BC and Pig-BC are **similar to the mineral reference** (TSP)
- ✓ Wooded biochars have less available phosphorus even if used at high rate application
- ✓ **Biochars increased P-soil solution** and confirmed the relative high availability of their P-content

Effects on N volatilization

- Soil incubation method:
  - Volatilization chamber, containing:
    - 150g DM of soil ± biochar (4T DM/ha)
    - Nitrogen fertilizer: urea (240kgN/ha) spread on the surface
    - Incubation in laboratory at 20±3°C, humidity 70%RH
    - Air flow control = 1,25L air/minute /chamber
    - Trapping in sulfuric acid solution (0,05M)
    - Kinetic of volatilization at 1, 2, 3, 6, 10 and 15 days

Effects on N volatilization

- Final results :

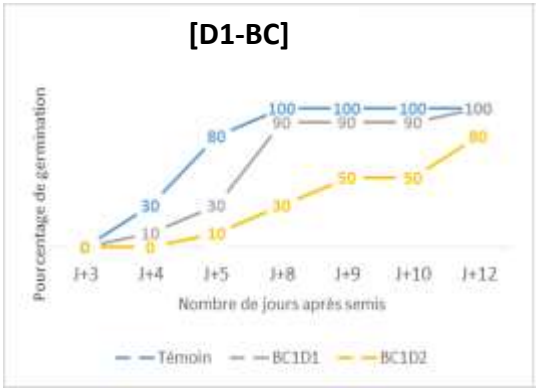


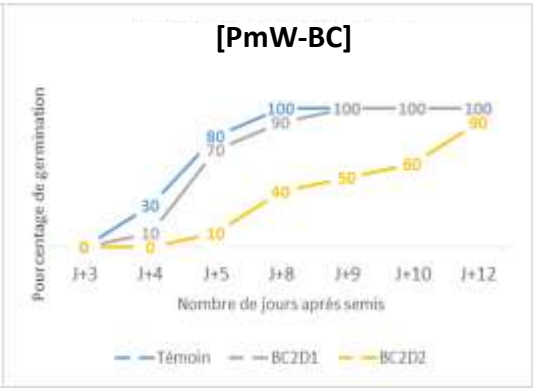
- ✓ 4 biochars increase volatilization (pH effect, N and ammonia content of biochar, ??),
- ✓ 3 biochars have no effect,
- ✓ 1 biochar slightly decreases volatilization.

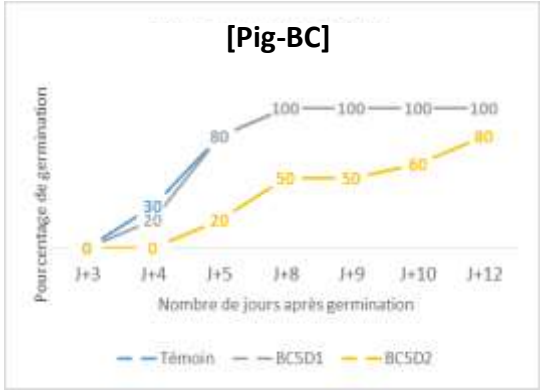
Effects on soil root germination

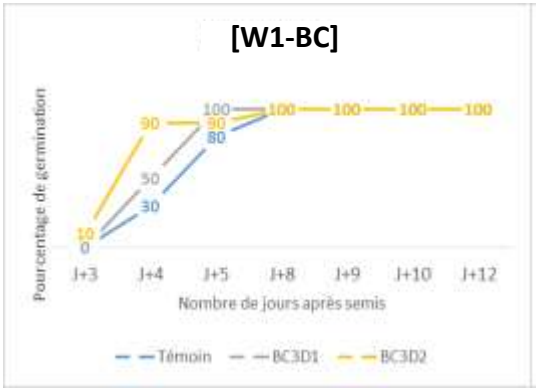
Effects on wheat roots development and growth

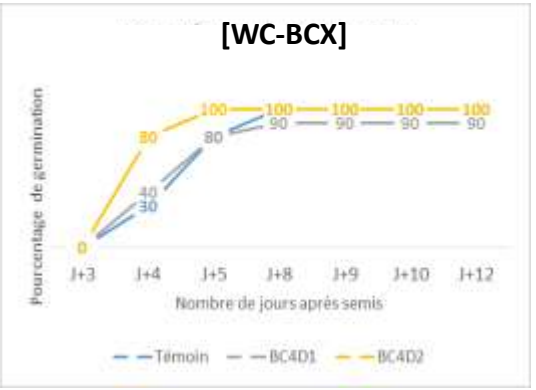
- **XP1 : Effect of biochars on roots of wheat (early stage):**
  - Wheat germination rate :











→ Germination delay in presence of **digestate (D1-BC)**, **poultry manure (PmW-BC)** and **pig manure (Pig-BC) biochars**

→ Precocious germination in presence of **wood (W1-BC)** and **forestry wastes (WC-BCX)** biochars

Suitability test of biochar formulation in growing media

- **Objective :**
  - study biochar potentials to become a feedstock of growing media (notably a sphagnum peat & coir alternative)

- **Applications : soil-free plant productions**
  - Green plants : *Musa acuminata* (dwarf banana tree)
  - Flower plants : *Zinnia angustifolia* (zinnia)
- **Experiment :**
  - 2 types of growing media
  - 3 studied biochars4 incorporation doses
    - 0% (control)
    - 5%, 10% & 20% (v/v) of biochar
  - Fertilization : NPK nutritive solution
  - Harvest : after 2 months of growth

Suitability test of biochar formulation in growing media

- **First observation : Phytotoxicity**

  Very quickly (3 days), seedlings (of the 3 species) of various modalities show **phytotoxicity symptoms, or die.**

Tomate

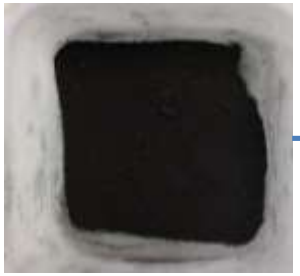
Zinnia

Bananier

Biochars incorporation doses less than 5% (v/v)??

Suppressive effect of biochars in vitro

- Method:



Strirring 24h

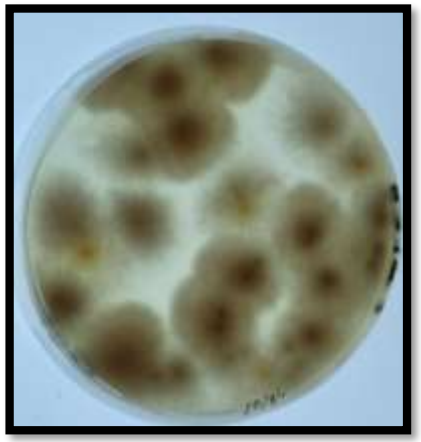
Biochars extracts

Suppressive effect of biochars in vitro

Microbial count

Non sterilized biochar extract

Sterilized biochar extract (filtration or thermic treatment)



INSTITUT CARNOT MICA

BioenNW
Delivering Local Bioenergy to NW Europe

CRT CENTRE DE RESSOURCES TECHNOLOGIQUES

Suppressive effect of biochars in vitro

- Results:
  - % of inhibition in relation to the control (1-D1/D_t) (fresh biochars)

10 days of growth	D1-BC	D2-BC	PmW-BC	W1-BC
Rhizoctonia solani	58,13%	63,41%	67,89%	65,24%
Phytophtora sp.	62,20%	68,70%	69,51%	76,02%
Pythium ultimum	49,17%	72,92%	73,75%	70,63%

10 days of growth	W2-BC	WC-BCX	D3-BC	Pig-BC
Rhizoctonia solani	41,38%	33,99%	44,83%	33,99%
Phytophtora sp.	29,76%	40,49%	41,46%	36,59%
Pythium ultimum	26,06%	34,46%	29,38%	22,60%

Conclusions

www.rittmo.com

Delivering Local Bioenergy to NW Europe

Conclusions for the BioenNW project:

www.rittmo.com

- Ecotoxicological impact :
  - Risks with few kinds of biochars in most critical scenario.
- Agronomic interest :
  - High P bioavailability for plant nutrition
  - Potential alcalinizing effect; Carbon from biochar seem to be recalcitrant
  - Little effect on soil aggregates stability; Potential negative effect on nitrogen volatilisation
- Growing media formulation :
  - Severe phytotoxicity with digestate based biochars : importance of feedstock selection
- Effects on microorganisms :
  - Clearly an effect on soil born microorganisms :
    - Suppressive effect on telluric fungi

New project about biochars 2016-2017

- **CARBOVIT** : Comparative study of valorization of one feedstock by torrefaction, carbonization and pyrolysis.
  - One unique feedstock, transformed by 3 different processes,
  - Evaluation and comparison of agronomic quality of biochars,
  - Introduction of a new solution of valorization for this feedstock.

➢ Alsatian project with local partners

➢ Depending on results, possibility to extend the project at national and international scale

Futur ?

- **NuCy**
- *Mineral recovery from wastes, residues and waste-waters for a more efficient material flow in the circular economy*

- INTERREG V North-West Europe

- Submitted on June 2016

• Mohammed BENBRAHIM: mohammed.benbrahim@rittmo.com

REMERCIEMENTS

Région Alsace

INSTITUT CARNOT MICA

BioenNW
Delivering Local Bioenergy to NW Europe

CRT CENTRE DE RESSOURCES TECHNOLOGIQUES