Agronomic effects of biochars

Agronomic effects of biochars : Biochars studied

Feedstocks and origins:

Biochar	Code	Feedstocks	Production Scale	Pyrolysis Temperature
BC1 R1501017	**PmW-BC**	Poultry manure and wood	Pilot	500
BC2 R1502004	**D1-BC**	Digestate of corn and rye	Pilot	500
BC3 R1504035	**D2-BC**	Digestate from a biogas plant	Industrial	700
BC4 R1504036	**W1-BC**	Forestry Residues	Industrial	650
BC5 R1505058	**W2-BC**	Forestry Residues	Pilot	500
BC6 R1505059	**WC-BCX**	Vegetable and forestry wastes; refuse compost	Pilot	500
BC7 R1505060	**D3-BC**	Digestate from a biogas plant	Pilot	500
BC8 R1505061	**Pig-BC**	Pig manure	Pilot	500

Agronomic effects of biochars : Biochar studied

Agronomic values:

Biochar	Code	MS % PB	pH	N % PB	P_2O_5 % PB	K_2O % PB	OM % PB
BC1 R1501017	**PmW-BC**	99,5	10,7	1,59	**10,04**	**6,48**	29,4
BC2 R1502004	**D1-BC**	98	10,6	1,92	**5,48**	**11,28**	31,8
BC3 R1504035	**D2-BC**	99,4	11	0,8	**9,64**	**7,01**	52,8
BC4 R1504036	**W1-BC**	**67**	9,7	0,41	0,24	0,6	54,4
BC5 R1505058	**W2-BC**	100	9,1	0,59	0,44	0,8	90,4
BC6 R1505059	**WC-BCX**	100	11,9	0,87	0,67	1,2	**17,4**
BC7 R1505060	**D3-BC**	98,2	11,4	0,99	3,38	**5,19**	64,4
BC8 R1505061	**Pig-BC**	100	11,9	1,66	**8,74**	**9,85**	37

Agronomic effects of biochars : Biochar studied

Agronomic values compared to French Fertilizer Regulation :

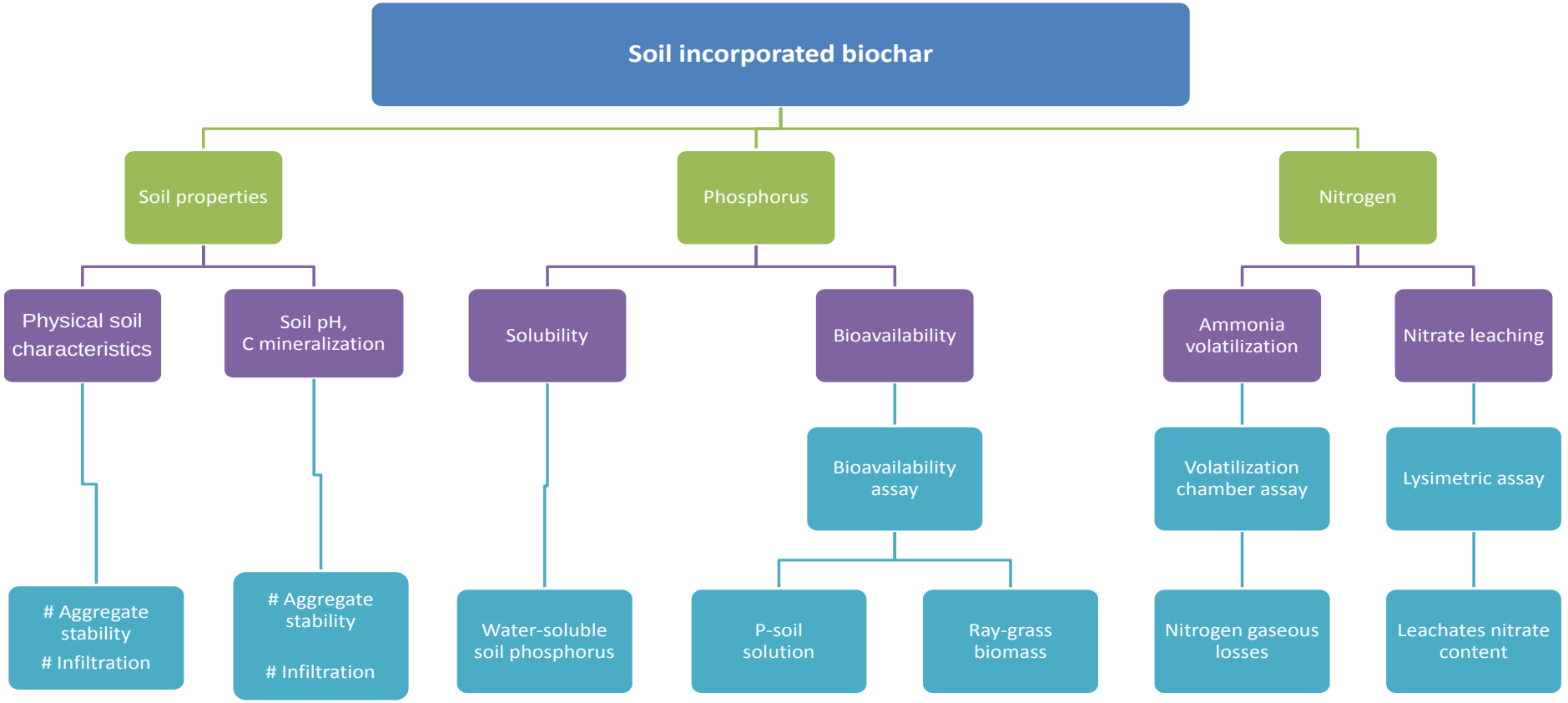
Biochar	Code	OM (%PB)	$N+P_2O_5+K_2O$ (%PB)	CaO (%PB)	MgO (%PB)	CaO+MgO (%PB)
French Regulation (NF) thresholds		NFU 44-051 >20	NFU 42-001 > 7	--	--	NFU 44-001 > 15
BC1 R1501017	**PmW-BC**	29,4	18,1	28,66	2,56	31,22
BC2 R1502004	**D1-BC**	31,8	18,68	5,15	2,19	7,34
BC3 R1504035	**D2-BC**	52,8	17,45	6,99	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

Effects of biochars in agriculture:

Bibliography :

- Feeding doses used in assays are variable
- Not much carbon is mineralized, but biochars could increase mineralization of exogenous organic matter
- Nitrogen is not much available (complex forms hardly degradable)
- Increase of the pH of soil (but not always)
- Important availability of Phosphorus (for almost every biochar)
- Increase of the efficacy of ammoniacal fertilizer (trapping and reduction of nitrogen losses)

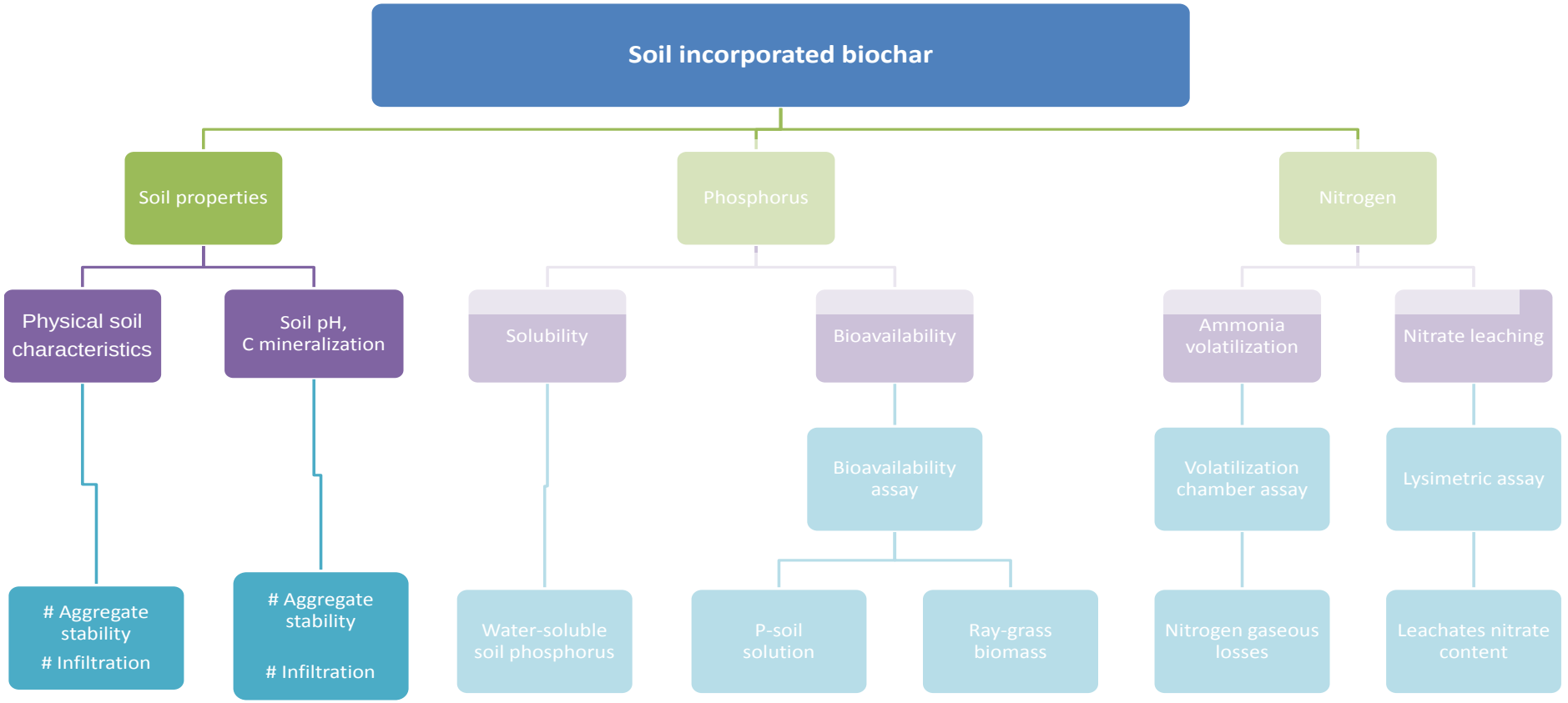
Agronomic effects of biochars : Realized essays:



Agronomic effects of biochars : Realized essays:

- Feeding doses:
  - 4 T/ha for all the assays (NH3-Volatilization and NO3 leacheate, C-mineralization and effect on pH) except phosphorus)
  - For Phosphorus essay: 4 T/ha for all biochars except Wood-based biochars (40 T/ha)
  - 10 T/ha for Aggregate stability and water infiltration essays

Agronomic effects of biochars : Realized essays:



Effects of biochar on the soil aggregate stability : Methods

- ***Biochar incorporation and soil incubation***

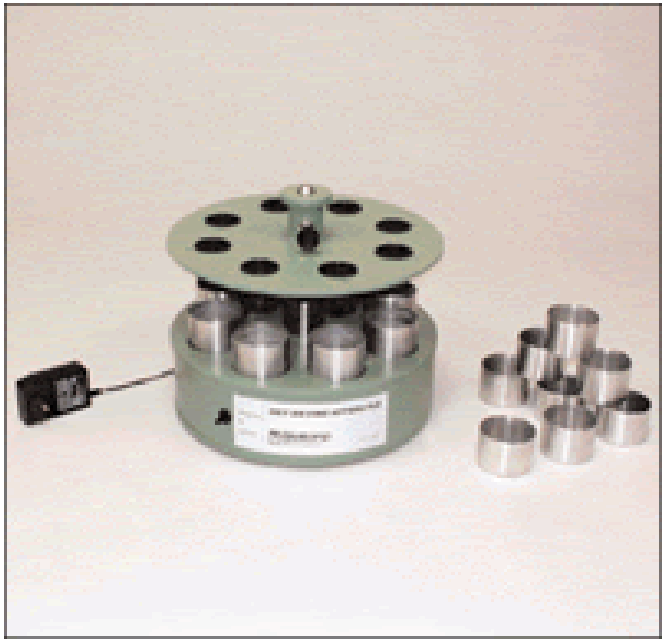
- Biochars have been incorporated to 500g of soil and incubated in greenhouse for 2 months.
- After 10 and 60 days of incubation, soil-biochar samples were dried at 40°C and sieved to collect the 1-2 mm fraction for aggregates measurement

- **Water stables aggregates measurements :**

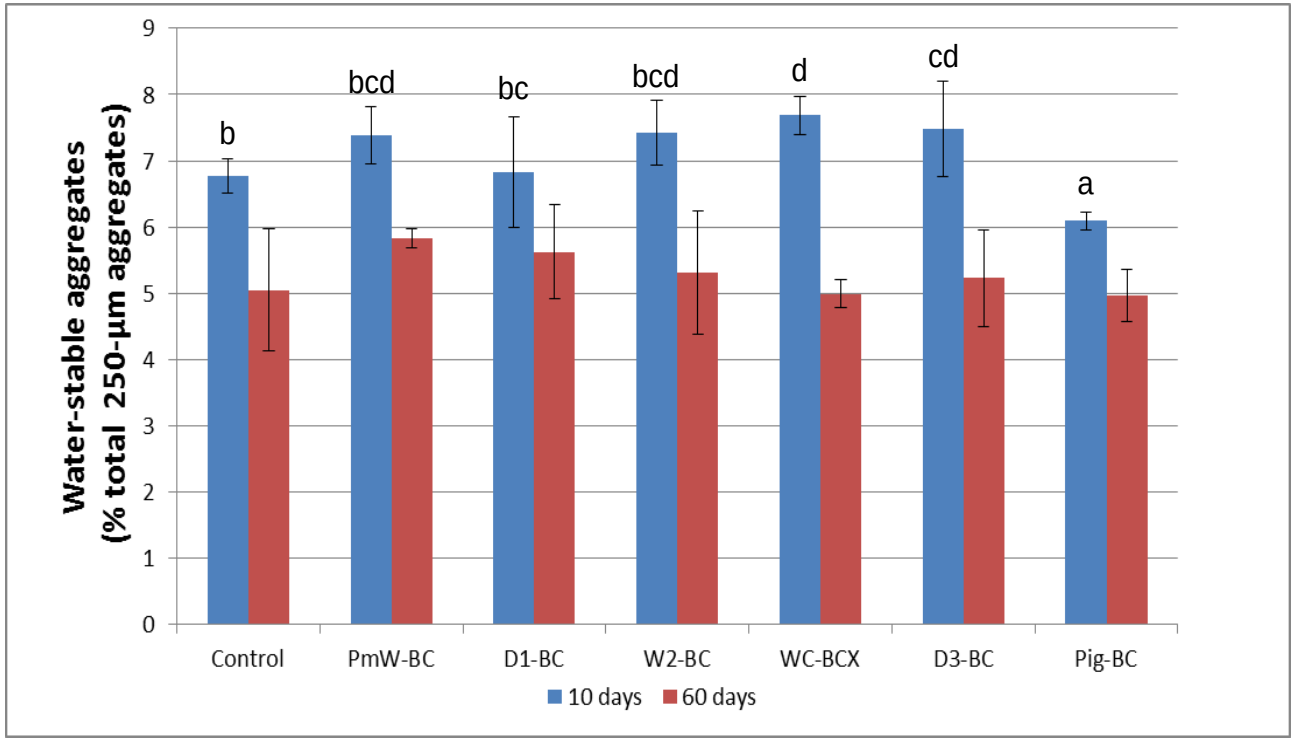
The dried 1-2mm fractions are inserted in the 200µm sieves at sieved two times in :

- Distilled water to determine the water unstable aggregate
- Dispersing solution to determine the water stable aggregate

The water stable aggregates are the expressed as percent of the total 200µm aggregate



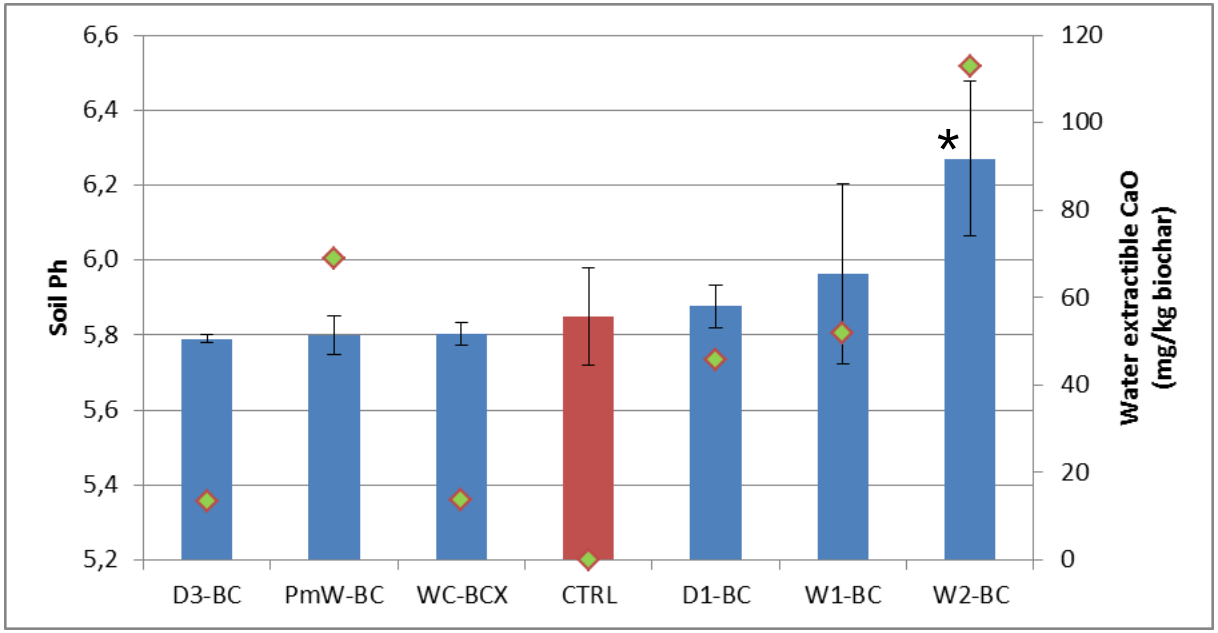
Effects of biochar on the soil aggregate stability : Results



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 of biochar 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.

Carbon mineralization : Methods

- **Objective:**

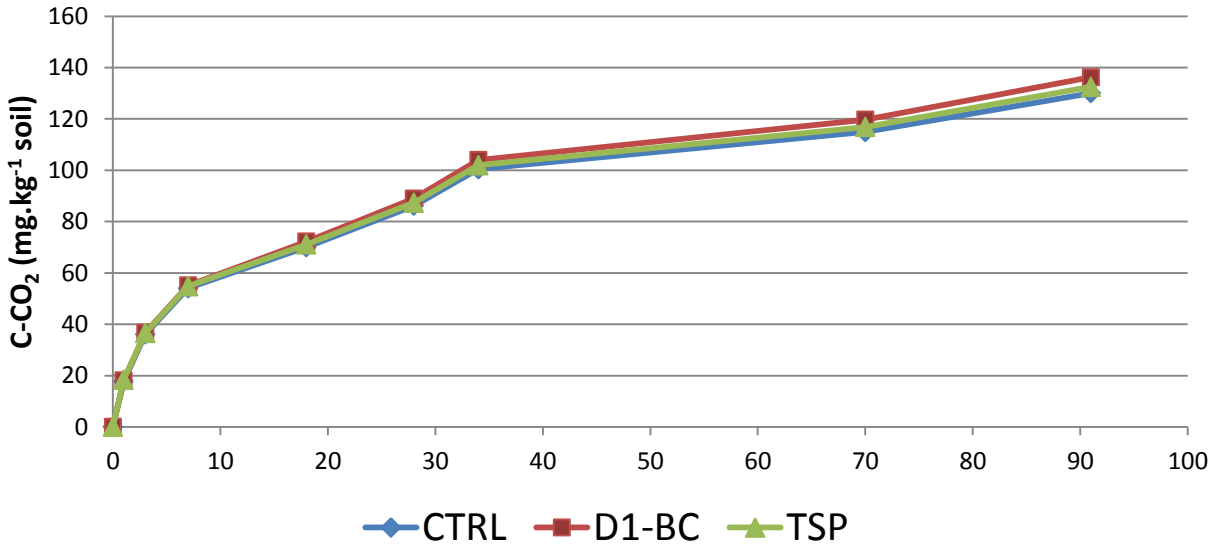
Study the mineralization of carbon kinetic in soil during an incubation period of 91 days at 28°C (equivalent to 1,8 years in field)

- **Reference**

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

Carbon mineralization : Results

- **Results** :

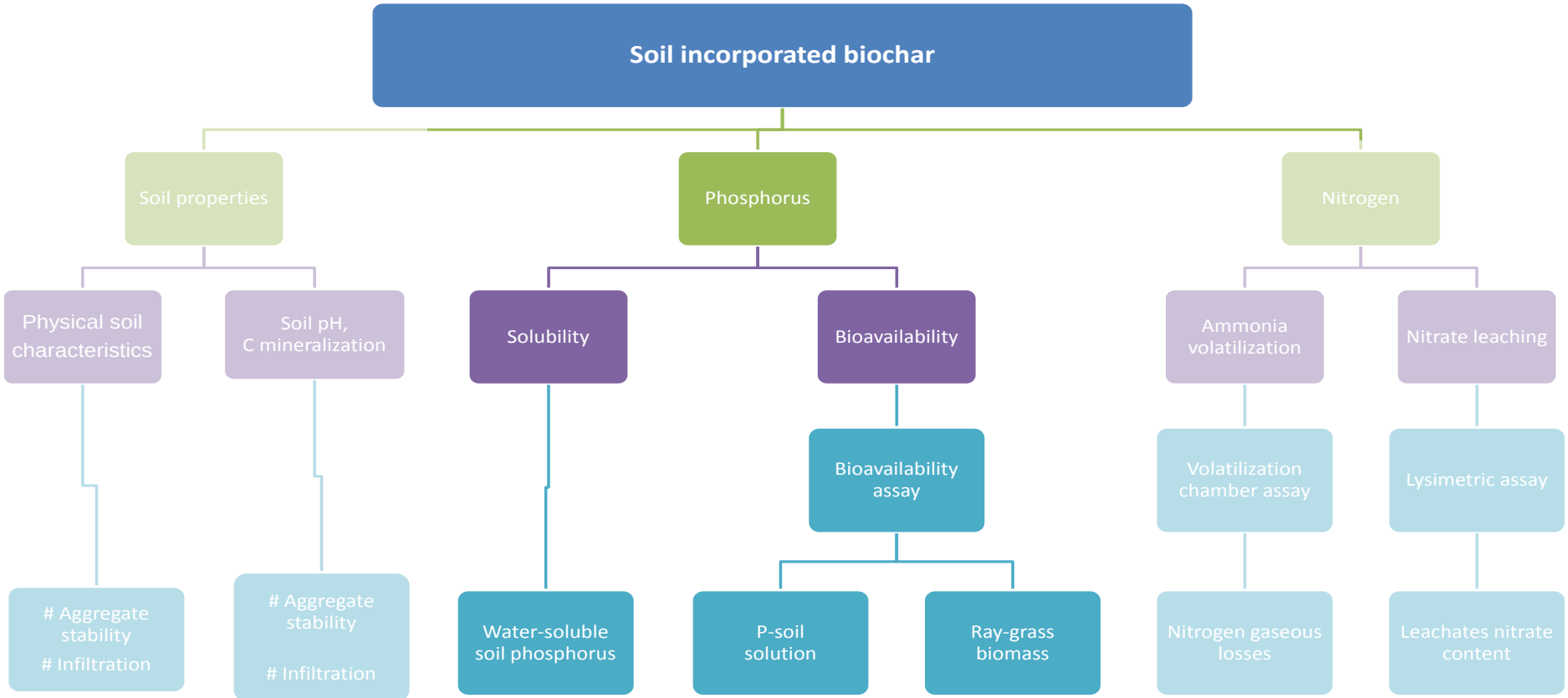


No effect of Biochar on C mineralization

➔ Carbon is stable

Long-term effect ?

Agronomic effects of biochars : Realized essays:



Biodisponibility of phosphorus contained in biochars: Methods

- **1- Plant test :**

✓ **Ref**: technique developed by Chaminade (1960. 1964), revised by Lemaire (1977) and summarized by Lombaert (1992): Ray-grass test

Biodisponibility of phosphorus contained in biochars: Methods

- **1- Plant test :**

  - **Biomass**
    - 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**

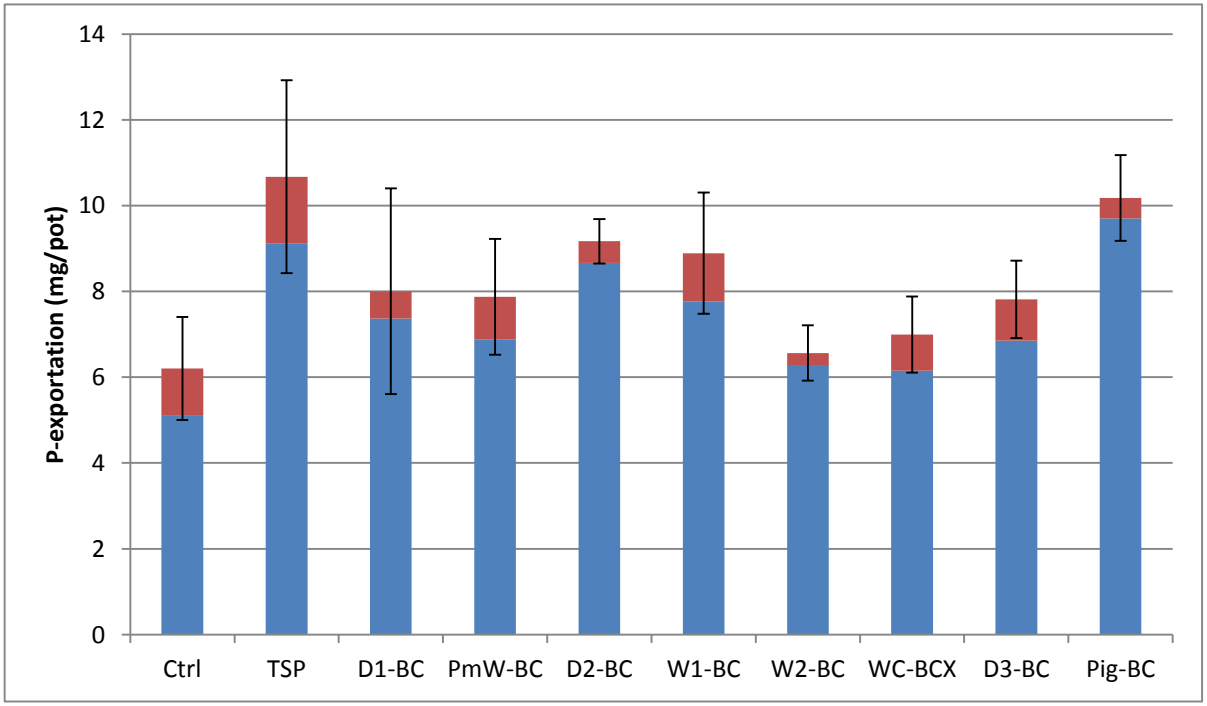
Biodisponibility of phosphorus contained in biochars: Methods

- **2- 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)

Biodisponibility of phosphorus contained in biochars: Result

- **Ray-grass test** :

D1-BC	Digestate
PmW-BC	Poultry manure and wood mix
D2-BC	Fraunhofer
W1-BC	Pyreg
W2-BC	Branches and tops (Forestry Residues)
WC-BCX	Treat vegetable, forestry wastes and refuse compost screenings
D3-BC	Digestate from a biogas plant
Pig-BC	Pig manure

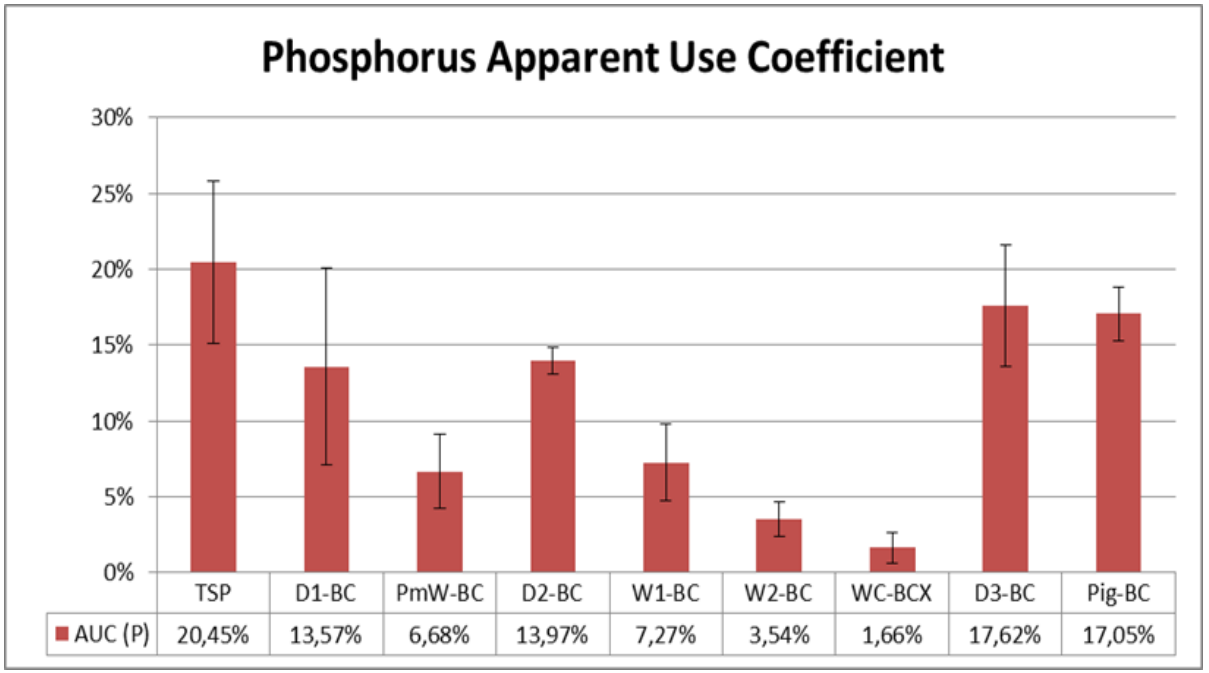


Significant increase of P uptake for all biochars expected W2-BC and WC-BC compared to the control

Biodisponibility of phosphorus contained in biochars: Result

- **Soil test**:

D1-BC	Digestate
PmW-BC	Poultry manure and wood mix
D2-BC	Fraunhofer
W1-BC	Pyreg
W2-BC	Branches and tops (Forestry Residues)
WC-BCX	Treat vegetable, forestry wastes and refuse compost screenings
D3-BC	Digestate from a biogas plant
Pig-BC	Pig manure



- The apparent use coefficients of D3-BC and Pig-BC are similar to the mineral reference (TSP)
- The biochars out of wood feedstocks have less available phosphorus even if used at high rate application

Biodisponibility of phosphorus contained in biochars: Result

- **Ray-grass test** :

D1-BC	Digestate
PmW-BC	Poultry manure and wood mix
D2-BC	Fraunhofer
W1-BC	Pyreg
W2-BC	Branches and tops (Forestry Residues)
WC-BCX	Treat vegetable, forestry wastes and refuse compost screenings
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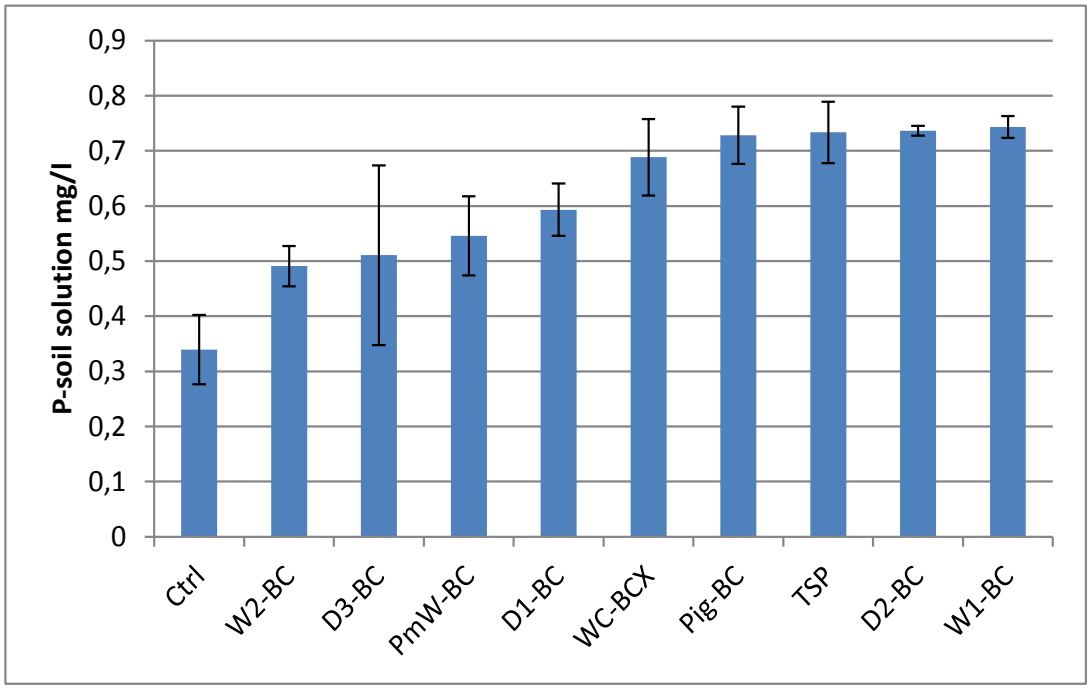


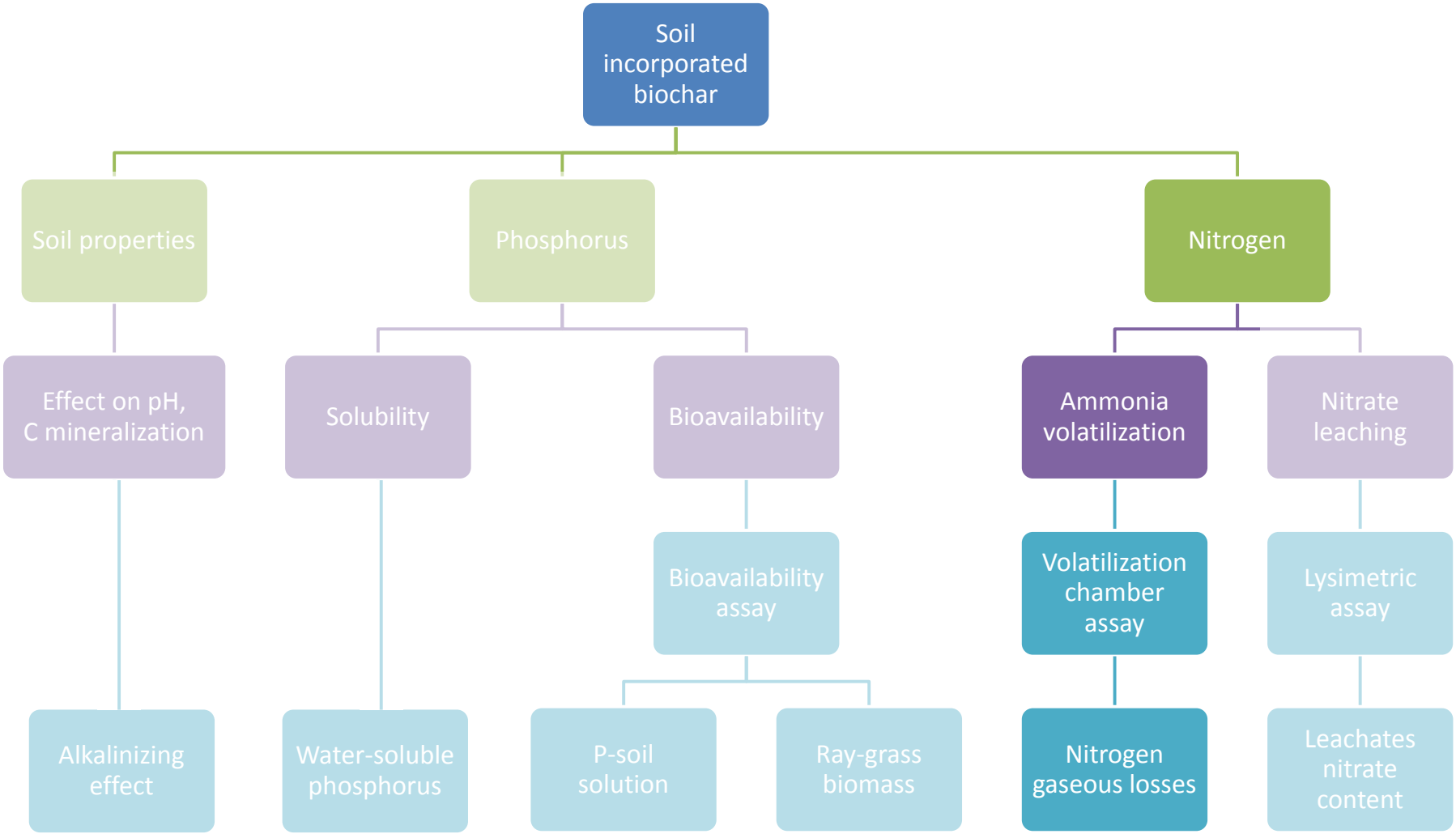
- Biochars increased the P-soil solution and confirmed the relative high availability of their P-content (except for W1-BC)
- P-availability is probably controlled by other factors than Ca and Al contents

Biodisponibility of phosphorus contained in biochars: Result

Code	P_2O_5 % PB
PmW-BC	**10,04**
D1-BC	**5,48**
D2-BC	**9,64**
W1-BC	0,24
W2-BC	0,44
WC-BCX	0,67
D3-BC	3,38
Pig-BC	**8,74**

- Biochar have high P content, except for biochars obtained from wood feedstocks
- Phosphorus from biochars seems to be available for plant nutrition
- Biochars could be an alternative re-use of P from manures

Agronomic effects of biochars : Realized essays:



Effect of biochars on ammonia volatilization : Methods

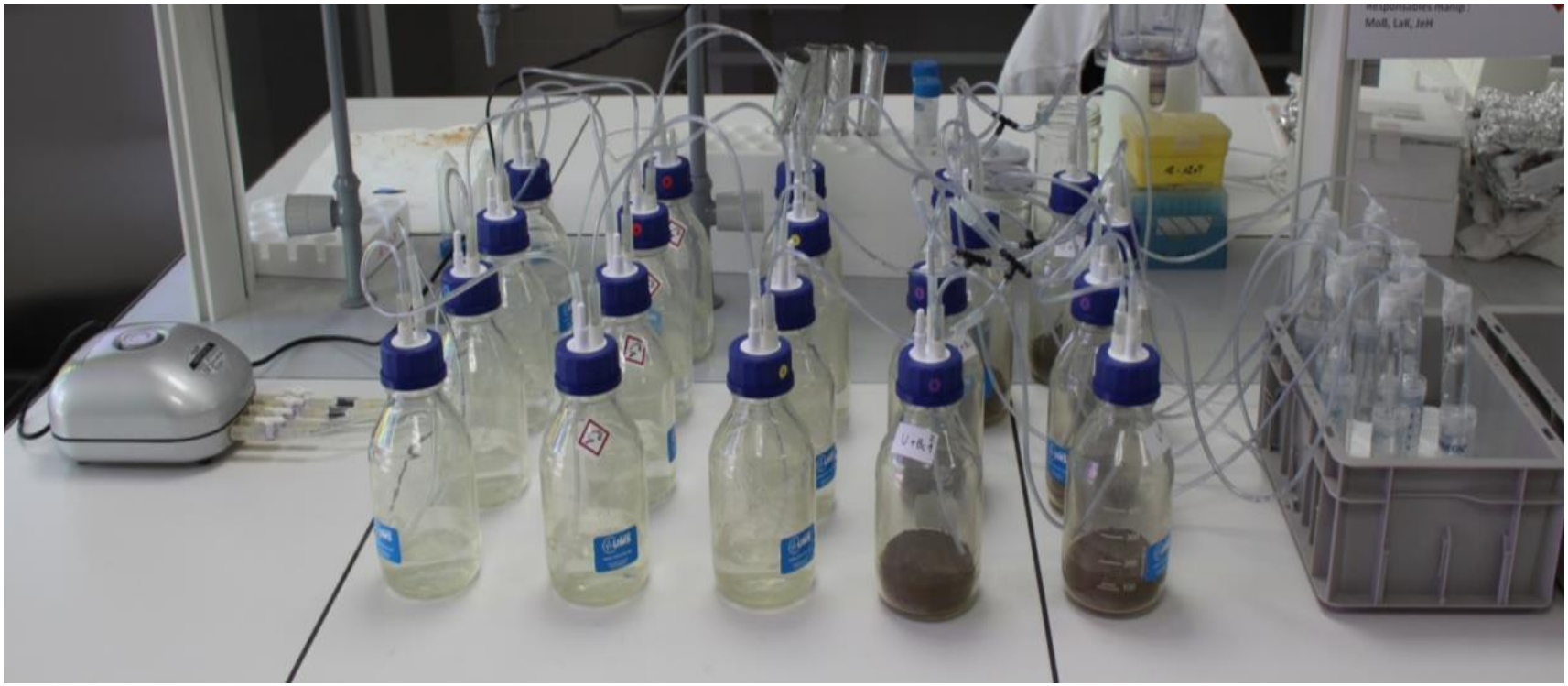
- **Soil incubation method:**

Volatilization chamber, containing:

- 150g DM of soil ± **biochar** (4T DM/ha)
- Nitrogen fertilizer: **urea** (240kg_N/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

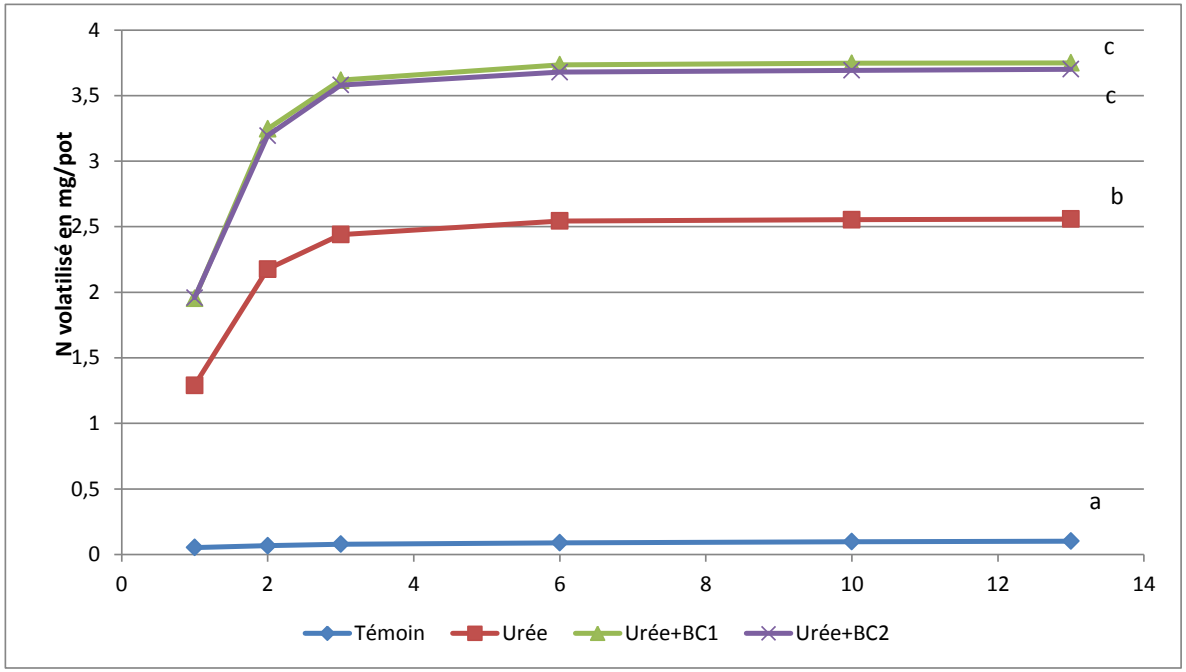
Effect of biochars on ammonia volatilization : Methods

- Volatilization chambers :



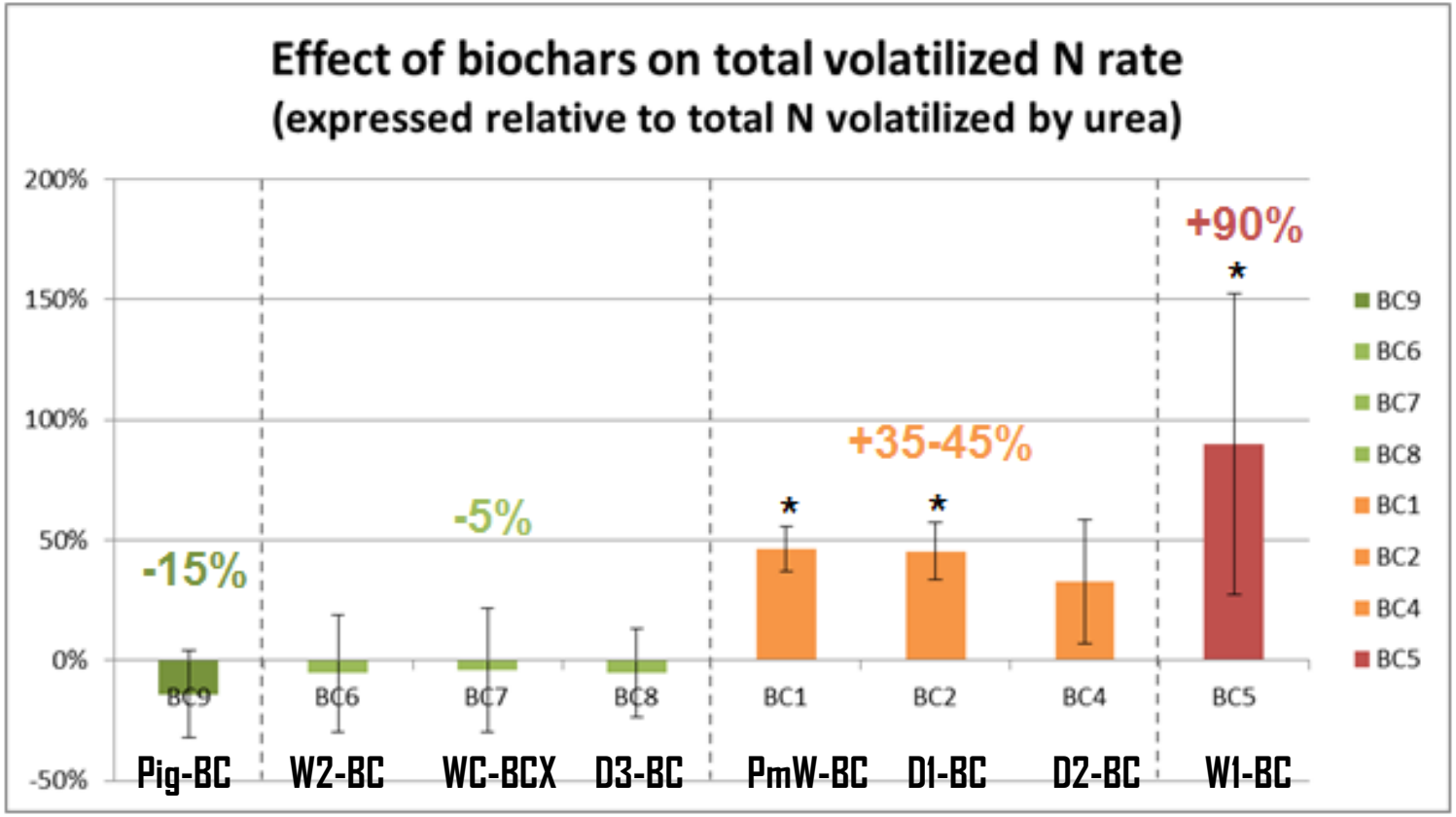
Effect of biochars on ammonia volatilization : Results

- **Example for two biochars compared to the control (soil only) and to soil with urea**



Effect of biochars on ammonia volatilization : Result

- **Final result**:



Effect of biochars on ammonia volatilization : Result

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

Agronomic effects of biochars : Conclusions

- No systematic effect could be generalized for biochars
- Carbon from biochar seem to be recalcitrant
- Biochars have a little effect on Soil-pH, soil aggregate stability, water infiltration and nitrate leaching
- Phosphorus from biochar seems to be available for plant nutrition
- Biochar can increase ammonia volatilization when urea is used as N-fertilizer

Thank you for your attention