Organic growing media and organic fertilizer's chemistry drive microbial catabolic functions in soilless horticulture

[a] EPHor, AGROCAMPUS OUEST, 49045 Angers, France
[b] PREMIER TECH GHA SAS, Le Ciron, 49680 Vivy, France
[c] IRHS, INRA, AGROCAMPUS-Ouest, Université d'Angers, SFR 4207 QUASAV, 42 rue Georges Morel, 49071 Beaucouzé cedex, France

Louise Paillat [a,b] *, Patrice Cannavo [a], Lydie Huché-Thélier [c], Fabrice Barraud [b], René Guénon [a]

CONTEXT

Consumer demand for healthy products as well as concerns over agricultural impacts on the environment encourage the development of sustainable practices by producers. This pressure leads to a diversification of Growing Media (GM) and fertilizers in favor of **sustainable organic materials** [1].

Despite GM being widely used, little is known about microbial communities [2] ; even less about **microbial functions involved into mineralization** of organic fertilizer [3].

Objective

How organic fertilization does affect microbial catabolic functions in growing media ?

GM physical properties associated with fertilizer chemistry (N content and quality) are suspected as key drivers of microbial functions.

EXPERIMENT

Growing Media

- PEAT
- COIR
- BARK

Fertilizers 300 mg N L^{-1}

	C:N	C:P
HORN	3.3	17
Granular F1[a]	5.5	25
Granular F2[a]	13.8	72

[a] plant based granular fertilizers: commercial names are confidential

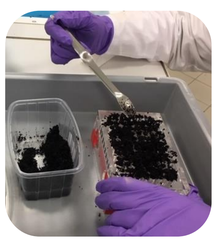
Mixes

INCUBATION (25°C, 60% of water holding capacity)

Toolbox: MicroResp™

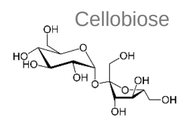
Campbell *et al.* (2003)

1 Filling the Deep-well with the sample

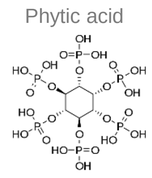


2 C-, N-, P-sources addition

Cellobiose



Phytic acid



C- Sources: from saccharides to aromatics

Monosaccharides: D-Glucose $C_6H_{12}O_6$, D-Galactose $C_6H_{12}O_6$, D-Mannose $C_6H_{12}O_6$, L-Arabinose $C_5H_{10}O_5$, D-xylose $C_5H_{10}O_5$
Diholosides: D-Cellobiose $C_{12}H_{22}O_{11}$, D-Sucrose $C_{12}H_{22}O_{11}$
Acids: DL- malic acid $C_4H_6O_5$, Ellagic acid $C_{14}H_6O_8$
Aromatic compounds: 4-hydroxybenzoïc acid $C_7H_6O_3$, Catechol $C_6H_6O_2$

Catechol

N- Sources: Amino-acids and Urea

L-Lysine $C_6H_{14}N_2O_2$; D-Alanine $C_3H_7NO_2$; Glycine $C_2H_5NO_2$; N-acetyl-D-glucosamine $C_8H_{15}NO_6$; Urea CH_4N_2O

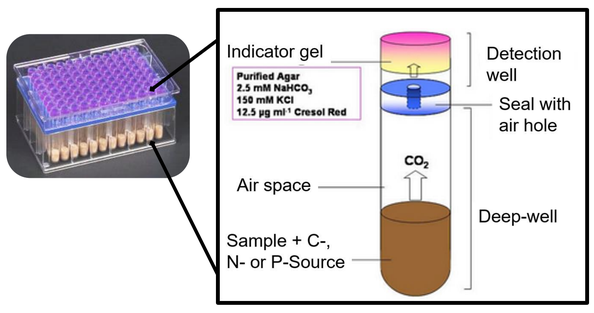
Ellagic acid

P- Sources

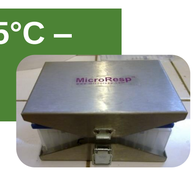
Calcium phosphate (rock phosphate) $CaHPO_4$
Phytic acid $C_6H_{18}O_{24}P_6$

3 Detection plate reading: before and after incubation

4 Assemblage of MicroResp™ device



5 Incubation – 6h, 25°C – of the device sealed by metal clamp



6 Color changes related to % CO_2 produced

Calculation of Substrate Induced Respiration (SIR) rates (mg CO_2–C L^{-1} h^{-1})

RESULTS

N limitation in Growing Media

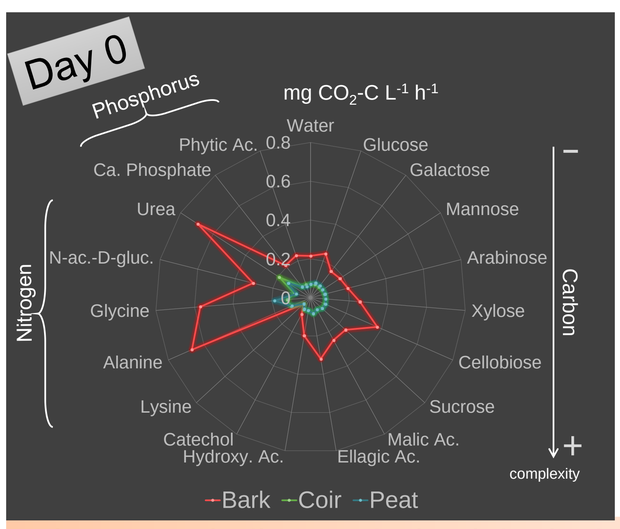


Fig.1: Catabolic Level Physiological Profiles (CLPPs) in different GM, prior to fertilizer addition.

Higher respiration rates:
- ❖ With N-sources
- ❖ Mostly in Bark

Phytic Ac.	Phytic acid
Ca. Phosphate	Calcium Phosphate
N-ac.-D-gluc.	N-acetyl-D-glucosamine
Hydroxy. Ac.	Hydroxybenzoic acid
Ellagic Ac.	Ellagic acid
Malic Ac.	Malic acid

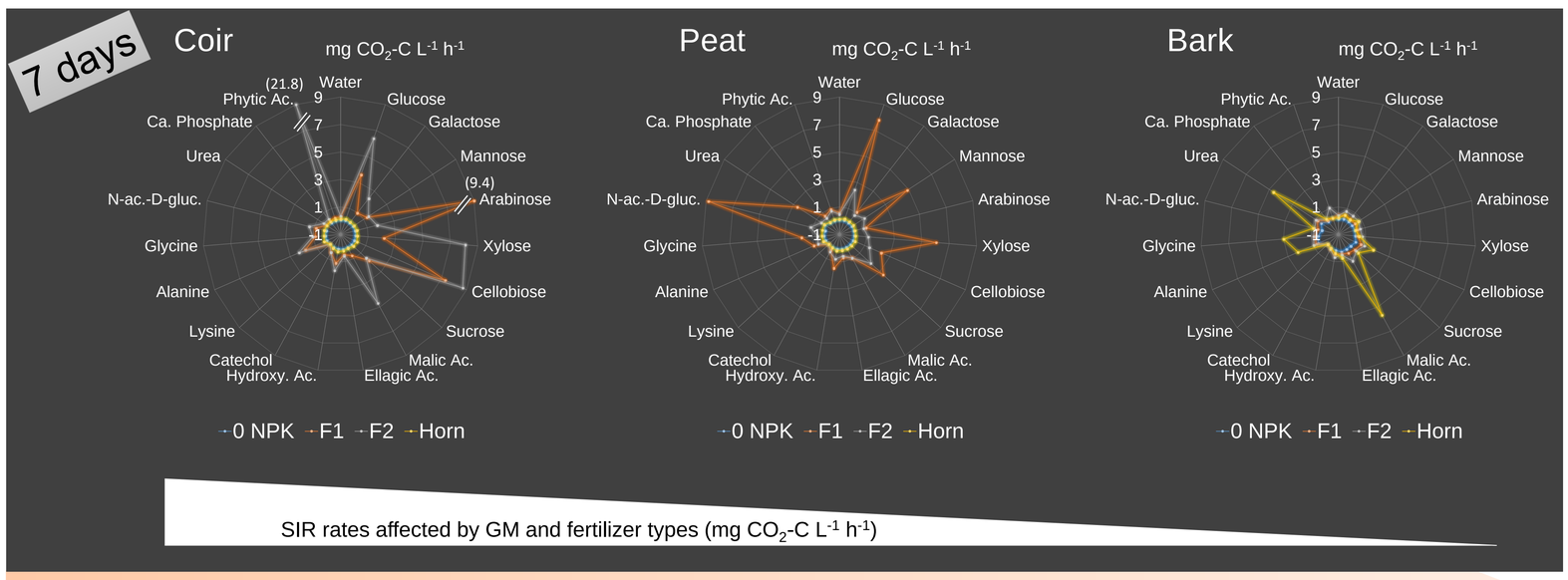


Fig.2: CLPPs after 7 days of incubation

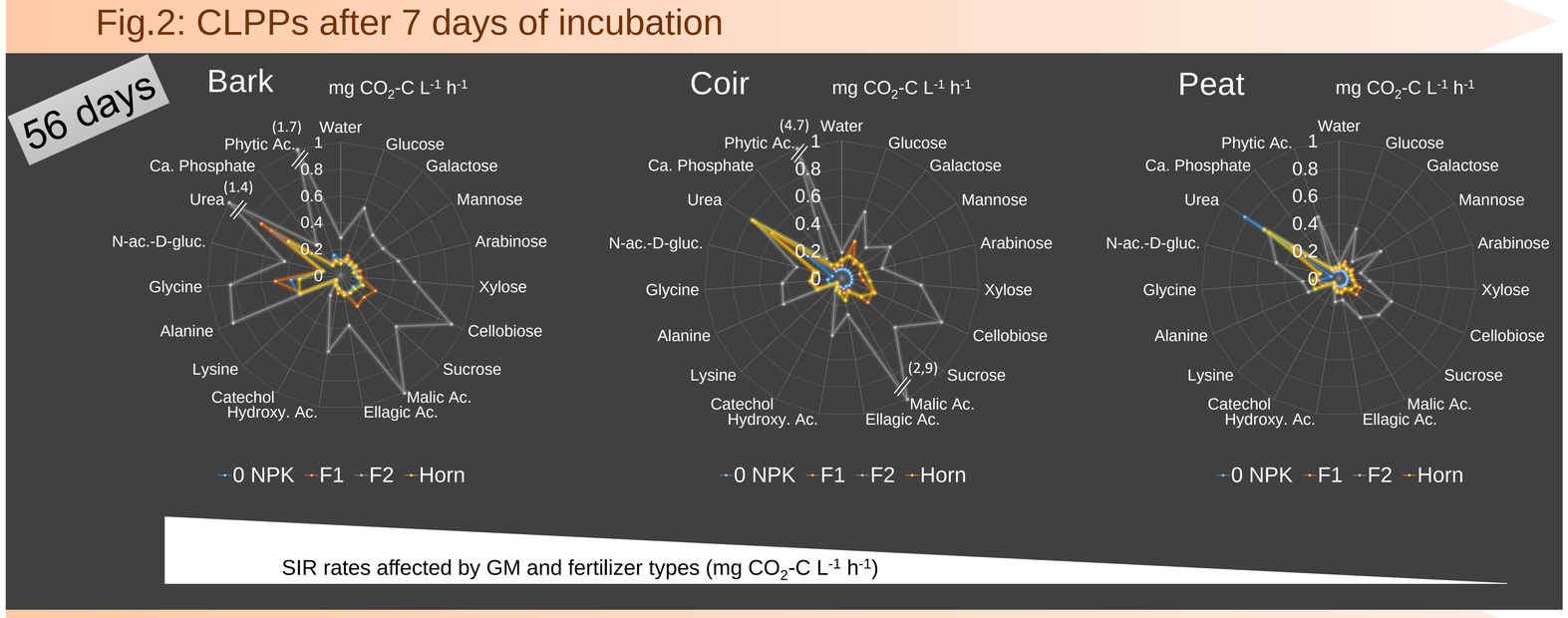


Fig.3: CLPPs after 56 days of incubation

- ❖ SIR rates highly increased after 7 days and slowed down after 56 days: 10 to 1 fold ratio for both coir and peat and 3 to 1 fold for bark
- ❖ SIR rates after 7 days: Coir > Peat > Bark
  - Coir: C induced respiration with F1, C and P induced respiration with F2
  - Peat: C induced respiration with F1 and F2
  - Bark: N induced respiration with Horn
- ❖ SIR rates after 56 days: GM had similar CLPPs but with different intensities (Bark > Coir > Peat)
  - F2 induced highest SIR (C, N and P)
  - Weak effect with both F1 and Horn

Discussion and conclusions

- ❖ Fertilizers turned on microbial activity depending on GM
  - The burst in SIR after 7 days in Coir and Peat indicates a strong C-demand (or C-capacity), especially for simple compounds (saccharides).
  - Microbes in Bark are more prone to degrading recalcitrant C-forms (*e.g.* Horn).
- ❖ CLPPs showed contrasted microbial C, N, P use efficiency depending on fertilizer type
  - Higher SIR intensities with F2: N and P were limited after 56 days (higher C:N and C:P ratios *vs*. F1 or Horn). The need for P was especially high in Coir.
  - After 56 days, fertilization no longer affects CLPPS reflecting a return to the physiological state of microbial communities.

Take-Home

- Community Level Physiological Profiles provide deep information on microbial C, N, P use efficiency
- All GM are initially N-limited (Bark > Coir = Peat)
- F2 Fertilizer induces higher microbial catabolism to get nutrients
- Peat and Coir respond strongly to fertilization
- Bark specifically degrade recalcitrant fertilizer

Corresponding author
Louise PAILLAT
louise.paillat@agrocampus-ouest.fr

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