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drive microbial catabolic functions in soilless horticulture

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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	Fertilizers	300 mg N L ⁻¹	C:N	C:P
PEAT	HORN		3.3	17
COIR	Granular F1 ^a		5.5	25
BARK	Granular F2 ^a		13.8	72

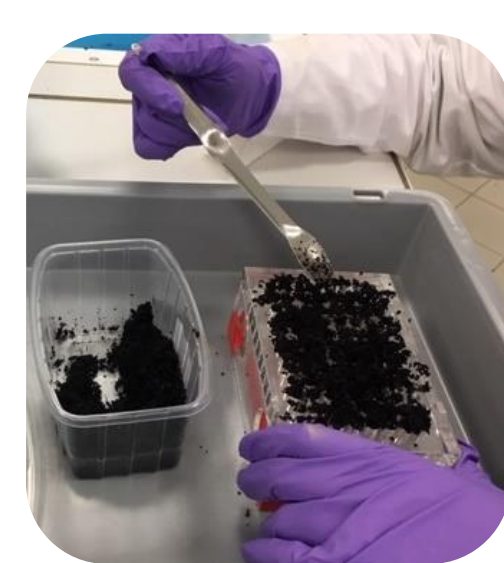
^a plant based granular fertilizers: commercial names are confidential

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

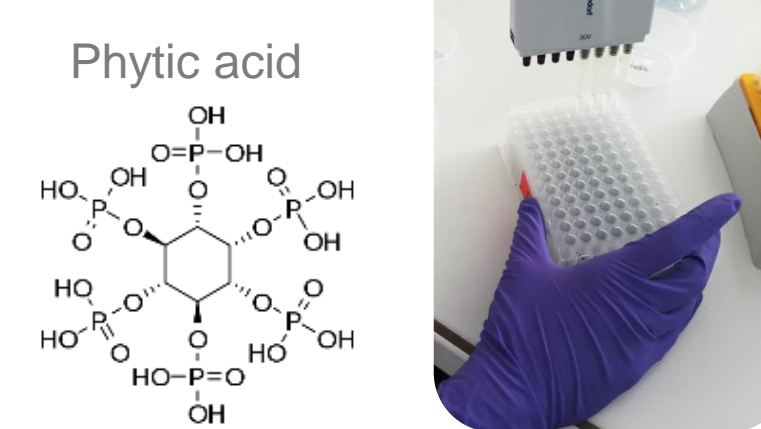
Toolbox: MicroResp™

Campbell et al. (2003)

1 Filling the Deep-well with the sample



2 C-, N-, P-sources addition



C- Sources: from saccharides to aromatics

Monosaccharides: D-Glucose C₆H₁₂O₆, D-Galactose C₆H₁₂O₆, D-mannose C₆H₁₂O₆, L-Arabinose C₅H₁₀O₅, D-xylose C₅H₁₀O₅
Dihydrosides: D-Cellobiose C₁₂H₂₂O₁₁, D-saccharose C₁₂H₂₂O₁₁
Acids: DL-acide malique C₄H₆O₅, acide ellagique C₁₄H₈O₆
Aromatic compounds: 4-Acide hydroxybenzoïque C₇H₆O₃, catéchol C₆H₆O₂

N- Sources: Amino-acids and Urea

L-Lysine C₆H₁₄N₂O₂; D-Alanine C₃H₇NO₂; Glycine C₂H₅NO₂; N-acétyl-D-glucosamine C₈H₁₅NO₆; Urea CH₄N₂O

P- Sources

Calcium Phosphate (rock phosphate) CaHPO₄
 Phytic Acid C₆H₁₀O₂₄P₆

3 Detection plate reading: before and after incubation



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

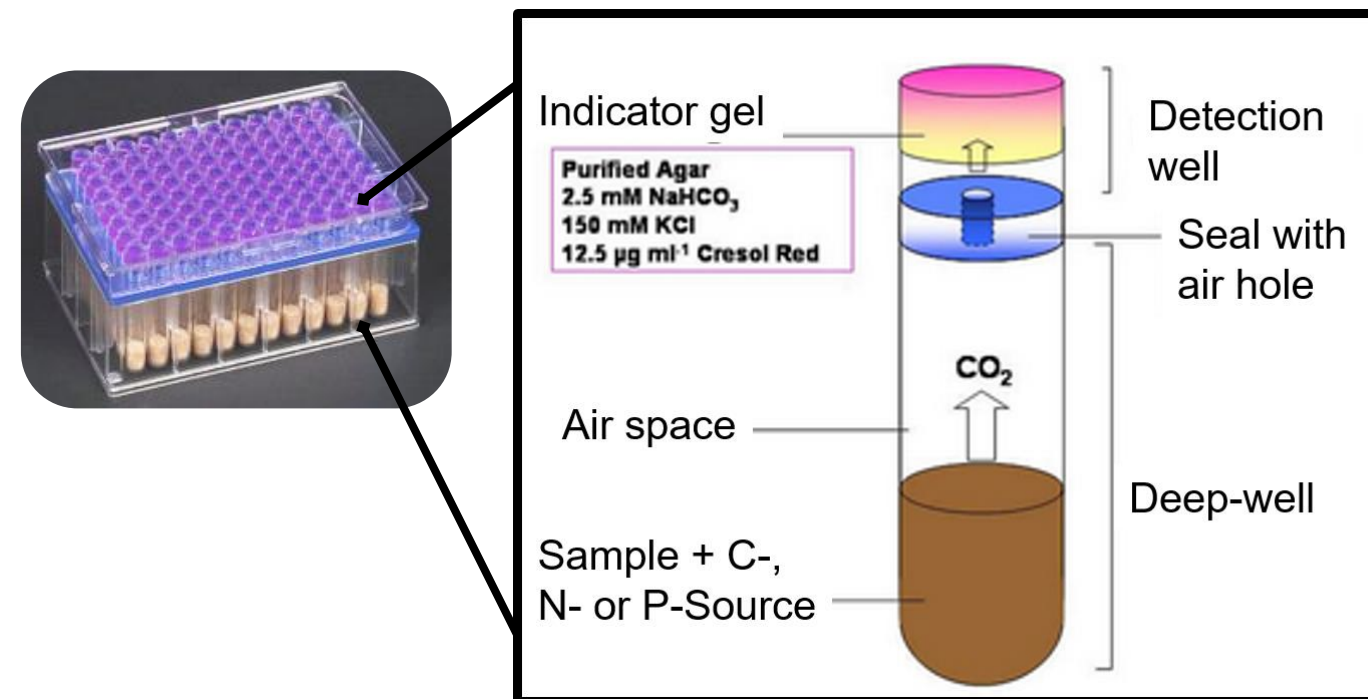


6 Color changes related to % CO₂ produced



Calculation of Substrate Induced Respiration (SIR) rates (mg CO₂-C L⁻¹ h⁻¹)

4 Assemblage of MicroResp™ device



RESULTS

N limitation in Growing Media

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

Phytic Ac.
 Ca. Phosphate
 N-ac.-D-gluc.
 Hydroxy. Ac.
 Ellagic Ac.
 Malic Ac.

Phytic acid
 Calcium Phosphate
 N-acetyl-D-glucosamine
 Hydroxybenzoic acid
 Ellagic acid
 Malic acid

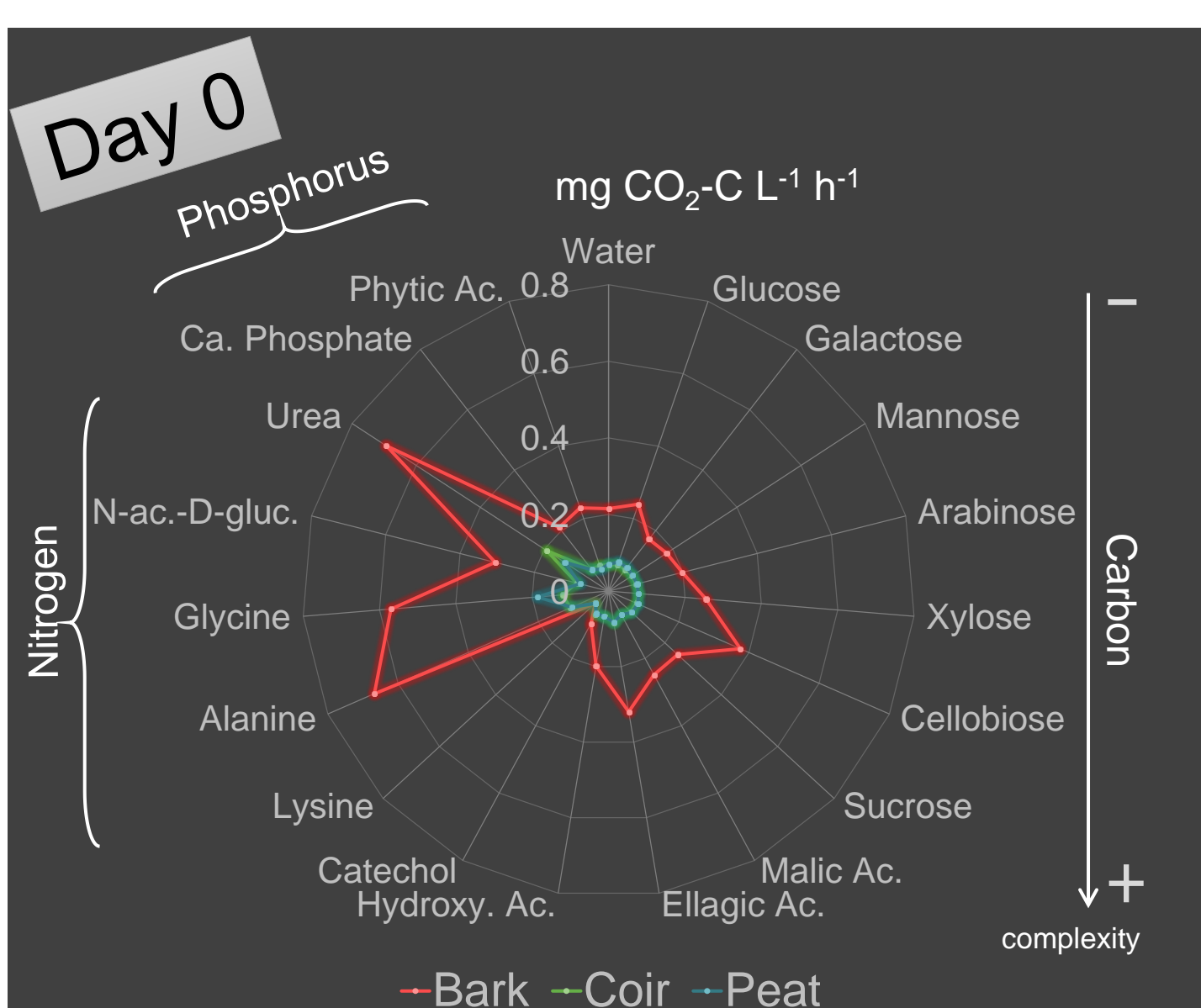


Fig.1: Catabolic Level Physiological Profiles (CLPPs) in different GM, prior to fertilizer addition.

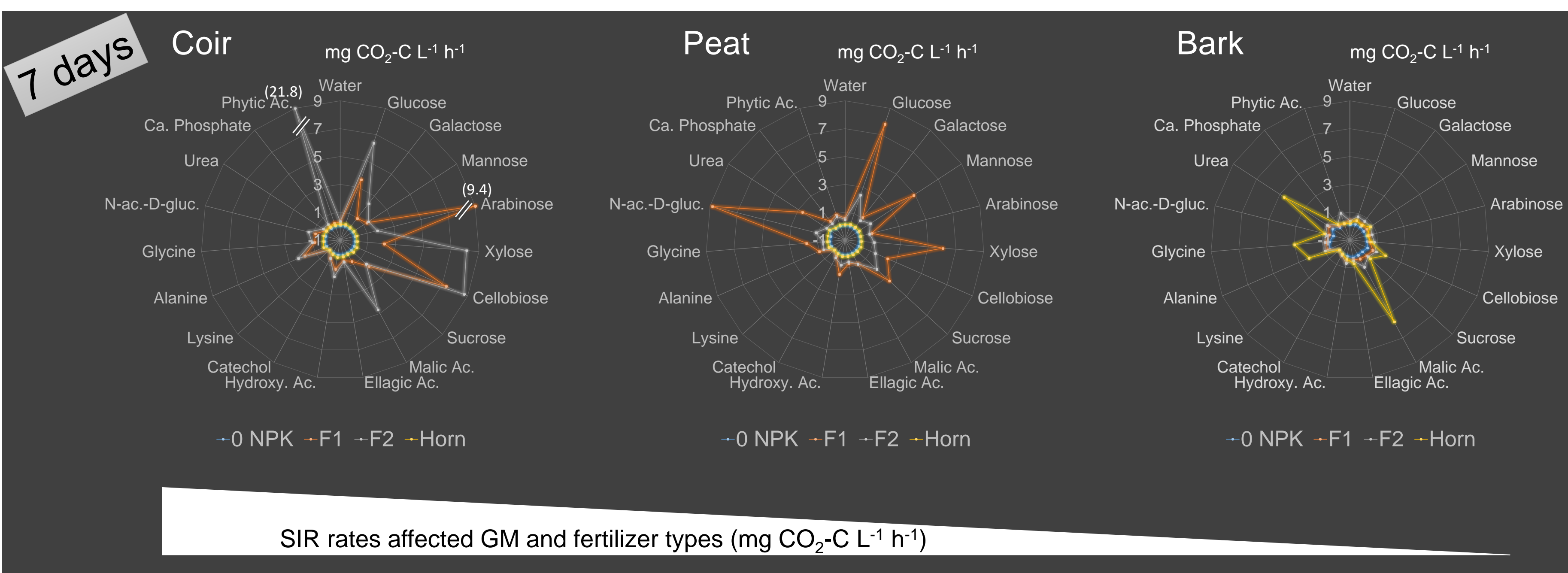


Fig.2: CLPPs after 7 days of incubation

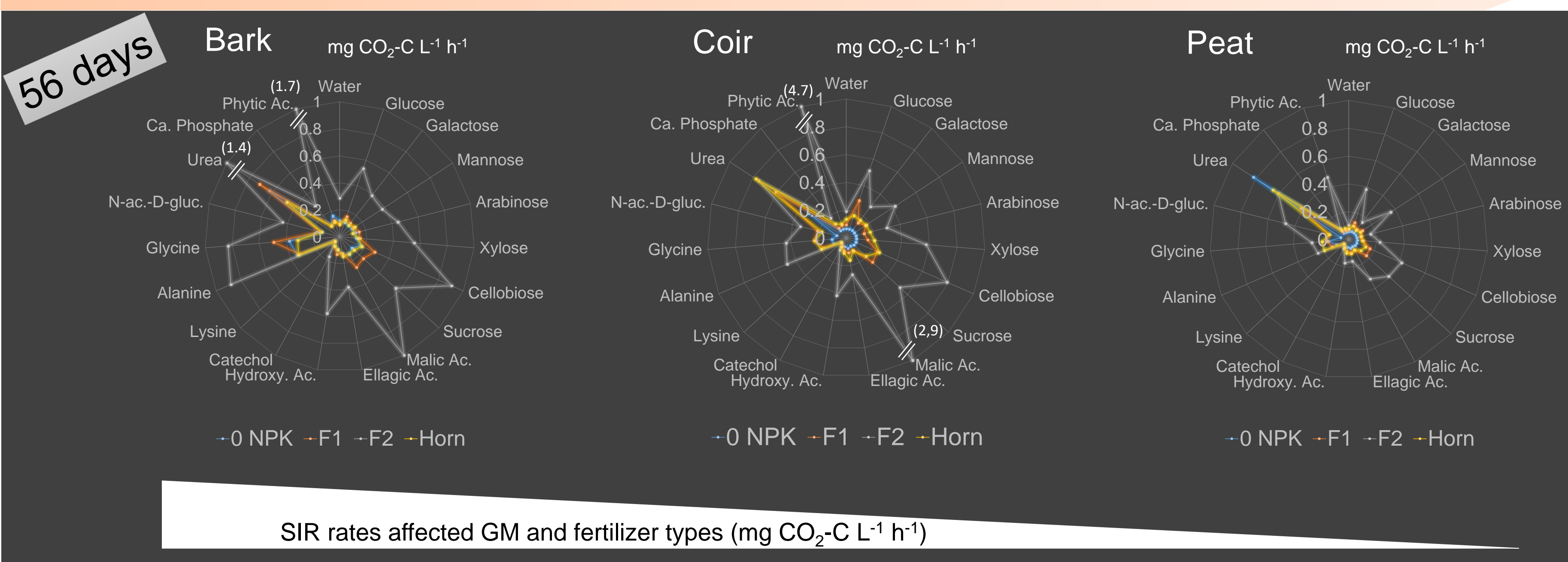


Fig.3: CLPPs after 56 days of incubation

- ❖ 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

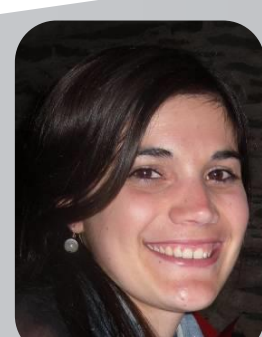
Discussion and conclusions

- ❖ 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

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