BVOC fluxes from maize: flux intensity, pattern, and composition changes from leaf emergence to senescence

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Background

- Biogenic Volatile Organic Compounds (BVOCs) have a profound influence on atmospheric chemistry, climate and ecosystem functioning.
- Few BVOC emission data are available for crop species like maize which is vastly cultivated worldwide.
- Flux measurements at all developmental stages are required to understand plant BVOC production and exchange mechanisms.
- A recent field study on BVOC fluxes from a maize field covering the whole growing season has recently been conducted within the CROSTVOC project (Bachy et al., 2016). However, their ecosystem-scale eddy covariance BVOC flux data did not allow to untangle soil exchanges from plant exchanges as well as fluxes from leaves of different developmental stages (poster A. Bachy et al).
- As a result, information on the underlying BVOC exchange mechanisms, intensity and pattern from maize remains limited.
- The main objectives of the present study were to find out how BVOC flux intensity, pattern, and composition varies over different developmental stages (young, semi-mature, mature, and senescent) of maize leaves.

Materials and methods

- *Zea mays* L. plants
- hs-PTR-MS (Proton Transfer Reaction–Mass Spectrometer)
- LI-7000 non-dispersive infrared gas analyzer
- Dynamic enclosure
- Temperature and light controlled environmental chamber

Young Semi-mature Mature

Figure 1: Maize leaves in the dynamic enclosure.

Results and discussion

m/z 33 (methanol*)

*tentative identification

- Clearly higher methanol fluxes from the young and senescent leaves (during chlorosis)
- Nighttime methanol emissions from the young maize leaves
- Better correlation between methanol emission and PPFD for the semi-mature and mature maize leaves
- Methanol emission continued even after the leaf chlorosis of the senescent leaves

m/z 45 (acetaldehyde*)

- Negative daytime fluxes of m/z 45 from the young, semi-mature, and mature leaves could be entirely related to uptake of CO_2 as a linear correlation was observed between CO_2 concentration in the supply air and obtained m/z 45 signals
- High emission of acetaldehyde was found for the senescent leaves during leaf chlorosis

m/z 59 (acetone*)

- Higher acetone fluxes were observed from the young leaves
- Diurnal emission pattern from the young, semi-mature, and mature leaves
- Transient emission peak in the morning for the semi-mature and mature leaves
- Slight increase of emissions during the leaf chlorosis and emission continued after leaf chlorosis

m/z 61 (acetic acid*)

- Acetic acid emission intensity was higher for the young and senescent leaves
- Persistently high acetic acid emissions from the senescent leaves was noticed during and after the chlorosis period
- During decreasing emission from the senescent leaves, some temporary increasing values were also noticed due to increase of relative humidity in the supply air

m/z 81 (hexenal/monoterpenes*)

- Hexenal emission intensity was maximal during leaf chlorosis for the senescent leaves
- Young leaves also showed high m/z 81 signals which could be due to a mixture of hexenal and monoterpenes (same for the semi-mature and mature leaves) as m/z 137 was also observed simultaneously
- A diurnal emission pattern was noticed for the young, semi-mature, and mature leaves

Transpiration and photosynthesis

- Overall transpiration and photosynthesis rates were noticed to decrease with the age of the leaves (except for the first few days of transpiration measurement from the senescent leaves)
- Transpiration and photosynthesis rates for the senescent leaves decreased with leaf chlorosis and eventually became almost zero

Stomatal conductance and temperature

- As it was for transpiration, stomatal conductance was higher for the younger leaves (except for the senescent leaves)
- Stomatal conductance for the senescent leaves decreased with leaf chlorosis and eventually became almost zero
- Air temperature in the enclosure was similar for all the experiments

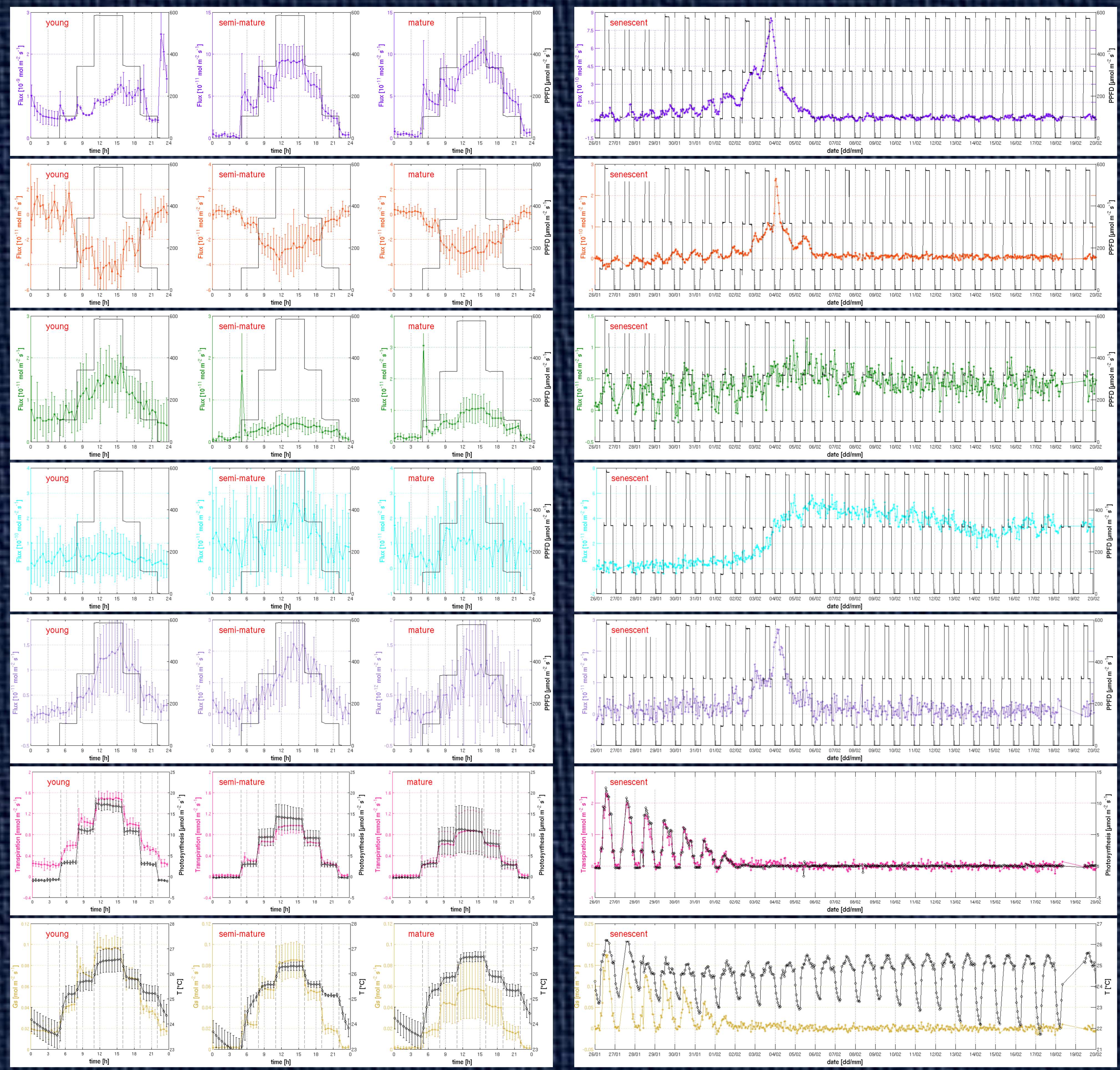

Figure 2: BVOC fluxes, PPFD, transpiration, photosynthesis, stomatal conductance, and temperature for the young, semi-mature, mature and senescent leaves.

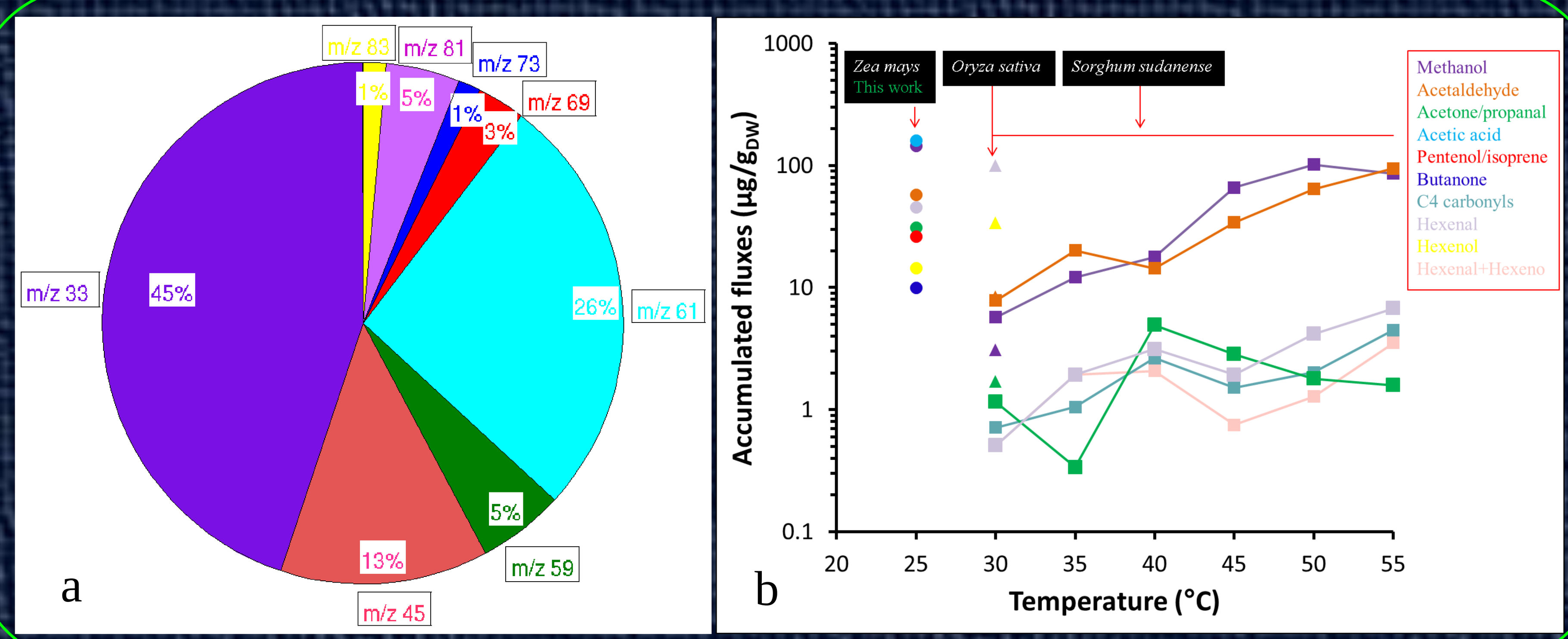

Figure 3: Contribution of the emitted compounds from the senescent leaves to the total accumulated BVOC flux (mole fractions, a) over 25 day following chlorosis and comparison with available literature data (Karl et al., 2005, b) on mass basis.

- Obviously methanol was the maximum emitted compound with 45% of the total accumulated emission.
- Acetic acid was the second most emitted compound with 26% of the total accumulated emission.
- Acetaldehyde, and both acetone and hexenal were the third (13%) and fourth (5%) highest emitted compounds.

Notes: Only compounds which individually make up over 0.5% of the total emission are considered.

- Integrated fluxes over 25 days from the senescent maize leaf which was attached to the plant stem during the whole period (averages over 5 replicates).
- Integrated fluxes over 4-12 hours from the rice and sorghum plants dried in an oven.
- In general, almost all the compounds (except hexenal and hexenol) showed higher integrated fluxes for maize than for rice and sorghum.
- Methanol and acetic acid had the highest integrated fluxes for maize, and hexenal and acetaldehyde had the highest integrated fluxes for rice and sorghum respectively.

Conclusions

- BVOC flux intensity, pattern, and composition changes with developmental ages of maize leaves.
- Investigations should be done on plant leaves at all developmental ages to get a clear understanding of BVOC fluxes.
- Methanol was the highest emitted compound for all the developmental ages.
- Ranks second only to the young leaves, senescent leaves were significant BVOC emitters.
- More investigation on naturally senescing leaves of different plant species are needed.
- Field measurements under natural conditions will be needed for further investigation.

References

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