Maize plasticity characterization through in-field 3D phenotyping

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BACKGROUND & AIM

Identifying architectural traits linked to intra-specific competition.

Plant density and sowing pattern play a key role in light interception and a number of processes that are downstream (canopy photosynthesis, evapotranspiration...). Understanding how maize genotypes can cope with intra-specific competition adapting their architecture to maximize light interception is essential to evaluate the impact of intra-specific competition in biomass production and yield. The objective of this study is to analyse the architectural plasticity of several maize hybrids using indirect high-throughput phenotyping (HTP).

METHODS

Experiment

A field experiment was conducted in Montardon, France. Five commercial maize hybrids were sown at two plant density (6 and 12 plants.m-²) at 0.8 m rows spacing with three replicates.

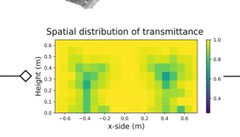
HTP Measurements

I – Ground-based LiDAR at 409 and 642 GDD

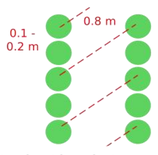
Phe-B tractor
Equipped with 2 LiDARs SICK LMS4000

LiDAR 3D Point Cloud

- Plant clustering *(Wang Di, 2020)* → Leaves segmentation *(Jin et al., 2019)* → Leaves Azimuth | Leaves Length | Width | Leaves Inclination | Curvature
- Scene Voxelisation → Beam counting → 3D Transmittance

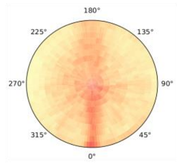


II – Hemispherical photographs at flowering (700 GDD)



Transects in the inter-row
32 photos per replicate

- Leaf | Sky classification *(Serouart et al., 2022)* → Pixel counting per angular sector

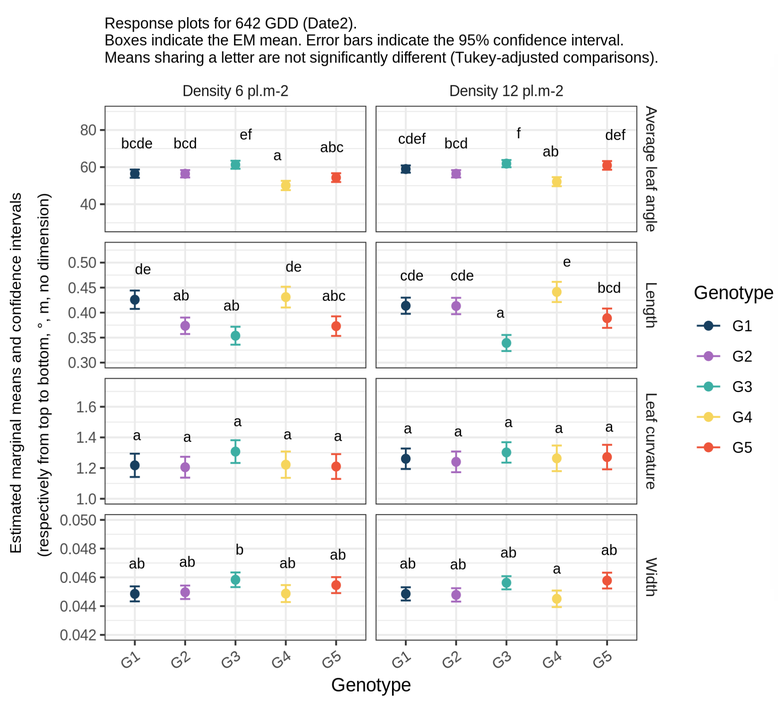


→ Directionnal canopy transmittance

RESULTS

Genotypic differences in maize plant architecture

Leaves dimensions and inclination



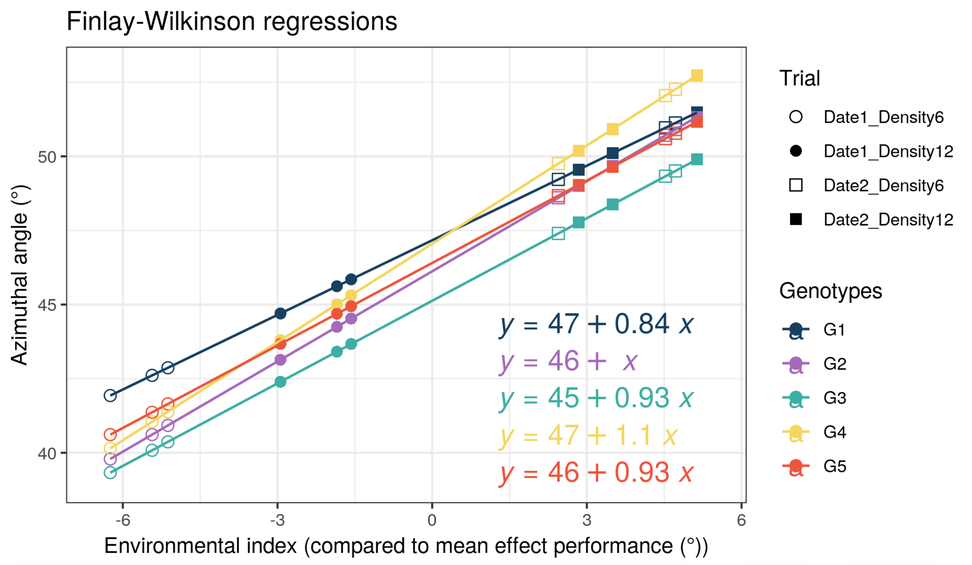
LiDAR-derived traits on leaves dimensions and inclination indicates significant differences among genotypes.

The differences are observed for leaves length and inclination:

G3 presents, systematically, shorter and more inclined leaves compared to all the others.

No significant differences were observed among the genotypes depending on plant density

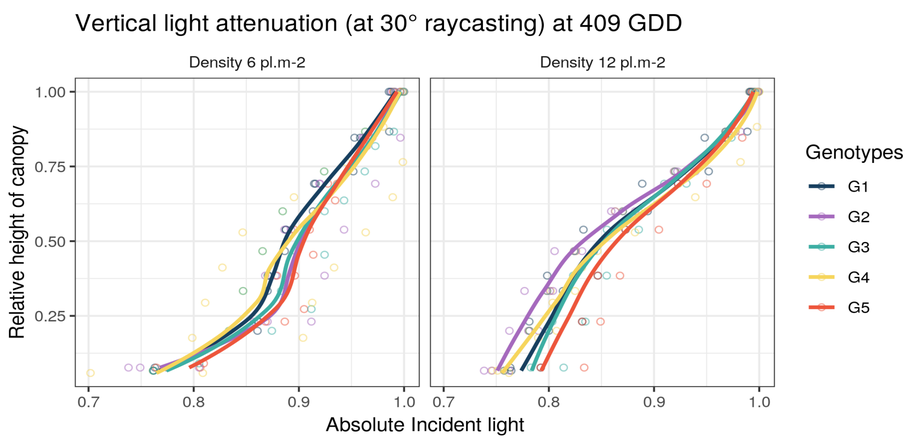
Leaves orientation



An increased proportion towards azimuth angles > 45° as density increases is noted. The G4 genotype has the highest tendency to position itself perpendicular to the row in high density environments. It is also the most sensitive to environmental changes, with the highest 1 + βi value at mean environnement. G3 is the least sensitive of the five genotypes presented to environmental variations. G1 is not as capable of adjusting in competitive environmental conditions.

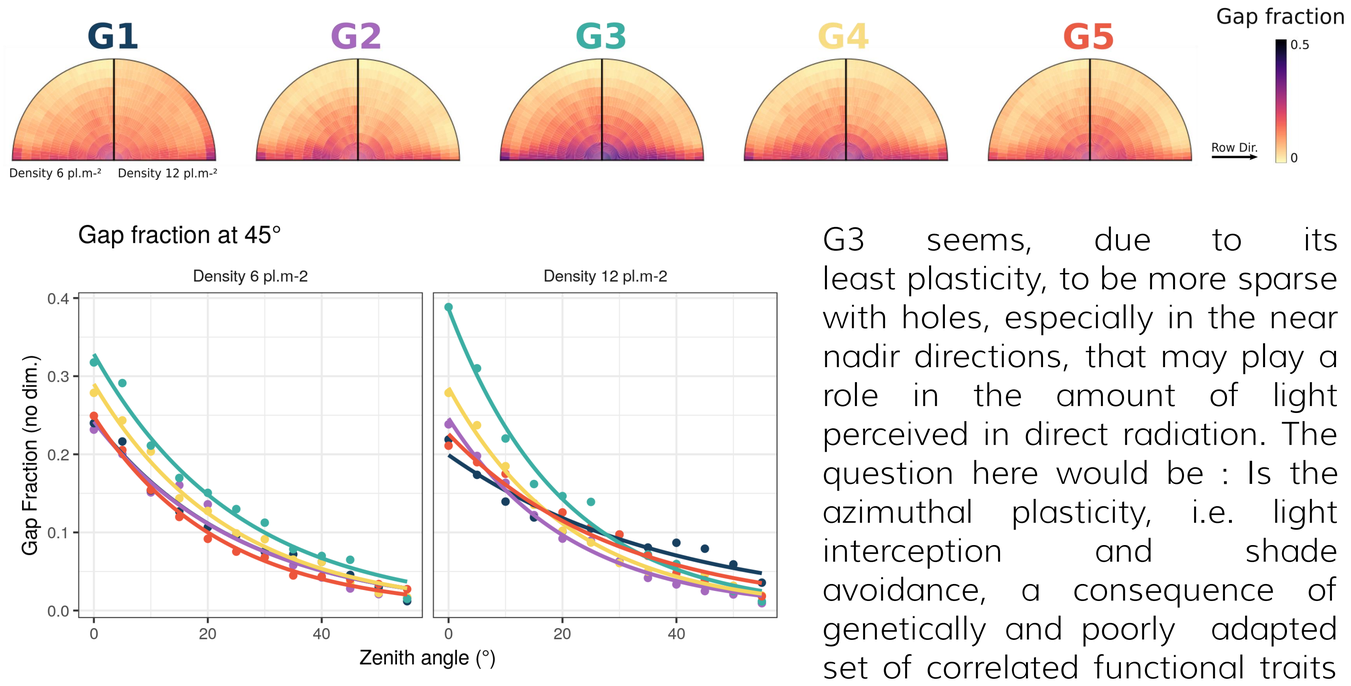
Consequences for canopy transmittance

Vertical profile of light attenuation at stage V8



It can be estimated from LiDAR transmittance, inverting Beer-Lambert law. Thus, vertical light attenuation, i.e. impact of architecture in canopy light distribution, can be computed, also showing up to 5% differences in light perception between genotypes in lower canopy layers at early-medium stage. Further stages should be studied later.

Total canopy gap fraction at flowering



G3 seems, due to its least plasticity, to be more sparse with holes, especially in the near nadir directions, that may play a role in the amount of light perceived in direct radiation. The question here would be : Is the azimuthal plasticity, i.e. light interception and shade avoidance, a consequence of genetically and poorly adapted set of correlated functional traits ?

CONCLUSION

According to GxE interactions traits distributions, we would be able to model realistic canopies and further investigate impact of radiative transfer on yield.

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