Using UAV photogrammetry and spectroscopy for field phenotyping of Cassava traits



Cassava Sink Source Project – Bill and Melinda Gates Foundation



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Cassava consumption

- Robust and withstands droughts
- Growths in poor soils
- Can be harvested between 10 and 30 months ap
- Propagation occurs via stem cuttings
- Serves as "safe" food reserve
- Can be processed to many nutritious products
 - Cooked, fried, baked, fermented, dried, pulp
- But, spoils quickly





However, Cassava yield is lower than that of other countries. Possible reasons are:

- Pathogens
- Bacterial leaf blight
- Fungal diseases
- Insects
- Viruses
- Postharvest losses
- Low fertilizer input
- Physiology



Cassava growth





CASS Project aims





- Understand the source to sink relationships and metabolic processes limiting cassava yield and starch accumulation in storage roots.
- Exploration of the genetic space of total biomass and starch yield in a range of cassava genotypes and especially farmer preferred varieties.
- Engineering source-to-sink relations in transgenic cassava plants to increase total biomass and starch yield.





Field phenotyping – RGB



Example field – nutrient study x 4 cassava varieties

- Falcon-8 octocopter AscTec
- > Flight plan: photo collection at 25m, just before every harvest episode.
- Relate image data to ground measurements.
- Monitor crop canopy growth over time. Can we estimate (root) biomass?
- Information we can add: Canopy structure, canopy height distribution.
- Use thermal camera to estimate crop water stress index differences between the varieties.

Experiment:

> 4 varieties

- TME 419 High starch preferred by industry
- TMS 01-1368 Bio-fortified pro-vitamin A
- TMS 30572 high dry matter, broad adaptation
- TMS980581 drought tolerant, stay green
- Treatments NPK
 - Control 0.0.0
 - ➢ PK 0.20.45
 - NPK 30.20.45



Data analysis – step by step



	Agisoft Photoscan	Cloud Compare	Pix4D	R	
Cloud construction from images	Yes	No	Yes	Not aware	
Create ground 0 model (in case you don't have it)	As geo .tif, ASCII grid or .xyz	No	As geotif, that can only be opened in Qgis and R.	Write what Pix4D does	Agisoft orthophoto
Data extraction from dense cloud	Measure point height, surface area, profile along a line and volume of a polygon.	Distance ground model to canopy surface model	Measure point height, surface area and volume of a polygon.	Once you have geo tif, xyz or similar file, you can calculate anything – raster and rgdal package	
Defining plots	Draw polygon	Cut segment	Draw polygon (cannot copy paste)	Define with extent or draw polygon	Volume measurement in Pix4D
Pros	Constructs a useful cloud	Calculates distance between clouds	Creates good ground model	With a raster loaded you can extract data in any way you want.	
Cons	Ground model not as good as in PIX4D	Slow, user unfriendly	Only exports data per individual object. Does not export a point cloud.	Hard to overlay a ground model from PIX4D to a model from Agisoft.	

Data analysis in R



Example 1: Field structure change in time – surface height



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Data analysis in R

Example 2: 2D profile of a plant row profile



Plot profile

Data analysis in R



m 2.5

2.0

1.5

1.0

0.5

0.0

Example 3: 1 Variety ~ 3 Nutrient treatments (NPK)



Data analysis in R



Example 4: 2 Varieties ~ 1 Treatment





Field phenotyping - Thermal Imaging

Crop Water Stress Index

CWSI = (dT - dTI) / (dTu - dTI)

where,

- dT is the measure difference between crop canopy and air temperature,
- dTu is the upper limit of canopy minus air temperature (nontranspiring crop),

and

dTI is the lower limit of canopy minus air temperature (wellwatered crop).

References

- Wet -> dTu, upper limit in the field a tub with water (and cloth)
- Dry -> DTI, lower limit the same as above without water
- Emissivity -> correct for changing light conditions Aluminum foil

Block design for the next field experiment

Thermal camera fov at 25 m : 22 x 30 m

Spinach trial lessons

- Distortion needs lab calibration
- Background contrast set threshold levels by trial and error





🕨 Block <

Many thanks to our group



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