Estimating and modelling productivity of mango trees from endogenous factors

A methodology set up and validated for African orchards

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INTRODUCTION

- In West Africa, mango (*Manguifera indica L.*) trees are cultivated in a variety of cropping systems (extensive, diversified and intensive). At the tree scale, yield is highly variable as a result of cultivar, variability in tree structures and cropping practices.
- However, heterogeneity of mango productivity depending on endogenous factors has not been described and quantified yet.
- The aim of this study was to quantify the yield of mango trees and study the effects of endogenous factors (cultivar, load index and structure) on tree production. Models for yield estimation from these factors were fitted and validated.

MATERIALS AND METHODS

1. **Sampling of 209 trees** - depicting in-field structure heterogeneity of three main cultivars: 'Kent', 'Keitt' and 'Boucodiékhal' (BDH) - were imaged using RGB camera. Yield (in kg) was estimated using machine vision system coupled with models (*Sarron et al. 2018*). Actual yield was measured in the field on 64 additional trees by mango experts for model validation.

3 classes load index: "low", "medium" and "high"

2. **Tree load index** (area of visible fruits compared to the overall crown area) was evaluated in the field by visual estimation.

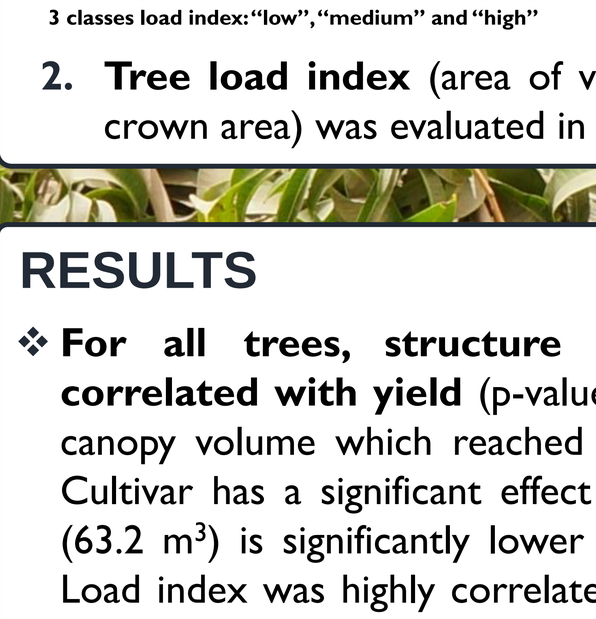
3. **Tree structure** was assessed using12 variables (length, area, vol.)

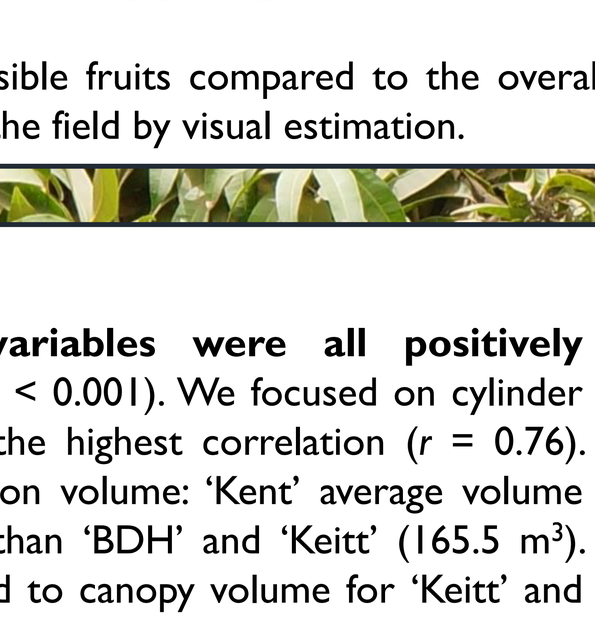
Variable	Assessment
perimeter	In field
tree_height	On images
canopy_height	On images
canopy_width	On images
volume_cylinder area_cylinder	Cylinder model using canopy height and width
volume_sphere_height area_sphere_height	Sphere model using canopy height as radius
volume_sphere_width area_sphere_width	Sphere model using canopy width as radius
volume_ellipse area_ellipse	Ellipse model using canopy width (minor axis) and height (major axis)

4. **Structure effects on yield** were analysed using Pearson correlation tests whereas cultivar and load index effects were analysed using two-way ANOVA with Tukey tests. For each cultivar, model was fitted between yield and independent variables (i.e. load index and structure variable most correlated to yield) and were validated by comparing actual and estimated yield.

RESULTS

- **For all trees, structure variables were all positively correlated with yield** (p-value < 0.001). We focused on cylinder canopy volume which reached the highest correlation (r = 0.76). Cultivar has a significant effect on volume: 'Kent' average volume (63.2 m^3) is significantly lower than 'BDH' and 'Keitt' (165.5 m^3). Load index was highly correlated to canopy volume for 'Keitt' and 'BDH' cultivars.



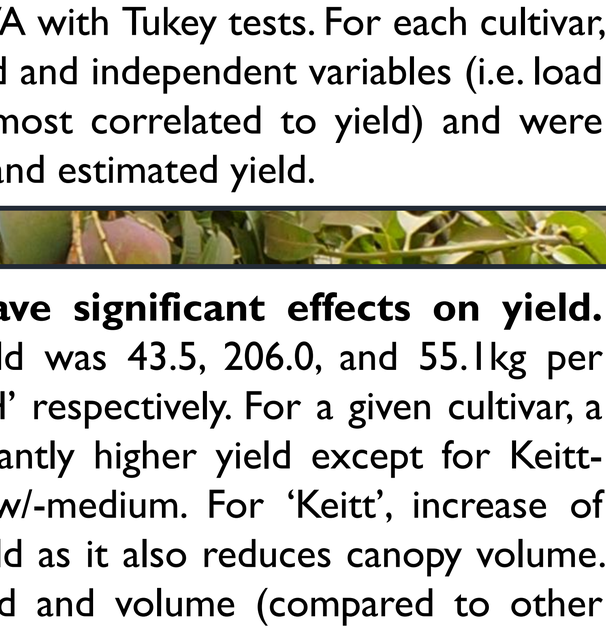


- **Cultivar and load index have significant effects on yield.** Cultivar average estimated yield was 43.5, 206.0, and 55.1kg per tree for 'Kent' 'Keitt' and 'BDH' respectively. For a given cultivar, a higher load index gives significantly higher yield except for Keitt-medium/-high and for Kent-low/-medium. For 'Keitt', increase of load index has no effect on yield as it also reduces canopy volume. 'Kent' trees have too low yield and volume (compared to other cultivars) to display a significant effect of load index.

- Yield predictive models reached R^2 > 0.70. There is no differences between estimated and actual yield (t-test p-value = 0.40).

Performance of built models for yield estimation:

Cultivar	Model variables	R^2	RMSE %
All	*cylinder crown volume, load index*	0.71	0.41
'Kent'	*sphere crown volume, load index*	0.81	0.39
'Keitt'	*canopy height, load index*	0.92	0.32
'BDH'	*cylinder crown volume, load index*	0.90	0.56



CONCLUSION AND PERSPECTIVES

- The yield of three mango cultivars was estimated and the effects of endogenous factors (fruit load, cultivar and structure) on productivity were quantified. Further studies will investigate the effect on yields of other variables (phenological effect, temperature, etc.).
- This work demonstrated that mango tree yield could be accurately estimated from cultivar, load index and one structure variable. Future work will use high resolution UAV cartography to allow a remote measure of tree structure for yield estimation at the orchard scale.

Sarron, J., Sané, C.A.B., Borianne, P., Malézieux, É., Nordey, T., Normand, F., Diatta, P., Niyang, Y., Faye, É. : Is machine learning efficient for mango yield estimation when used under heterogeneous field conditions? In: 30th International Horticultural Congress (IHC), submitted (2018)