

| IRC | 2019 | Berlin |
INTERNATIONAL RAPESEED CONGRESS

PHENOVIA a field experimental platform in Burgundy for WOSR phenotyping under low chemical inputs.

**X.Pinochet, F.Kazemipour-Ricci, P. Marget,
V.Deytieux, F.Salvi, L.Thiery, JL.Lucas**

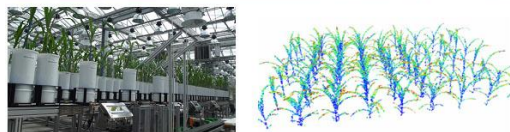




4 controlled
conditions



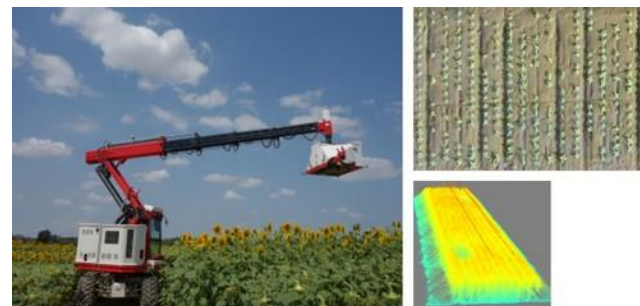
2 Omics



2 field semi
controlled

**National infrastructure
project 2012-2024
11 Infrastructures**

3 field platforms



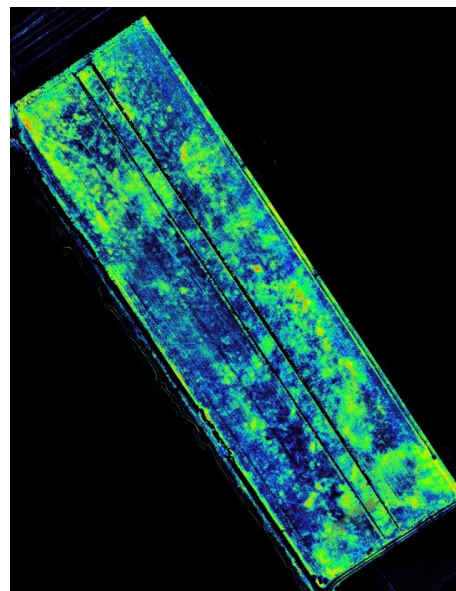
PHENOVIA : one of the field platform near Dijon (Burgundy)

- Located on INRA Farm of Bretenière :



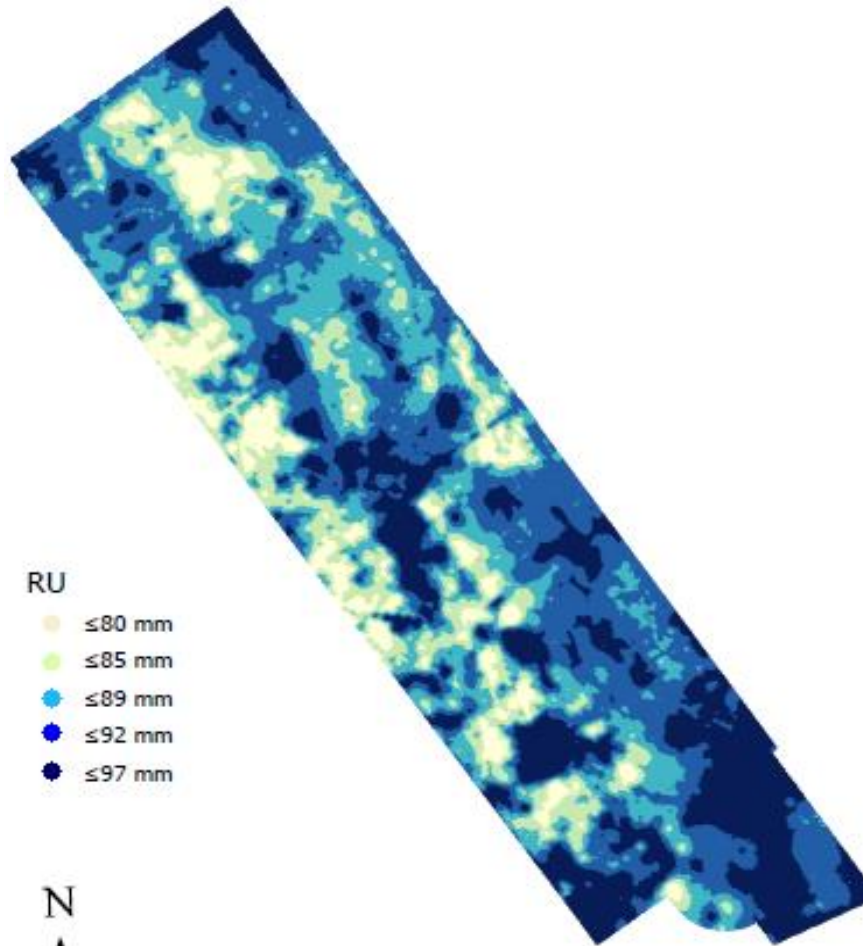
Investments for a performing environment characterization and high throughput phenotyping tools

- **A top level Weather station**
- **Soil heterogeneity maps**
 - Resistivity,
 - Soil water content capacities
 - NDVI on non watered spring crop
 - Yield on non watered spring crop
- **T°, wetness captors**
 - Soil (permanent or movable captors)
 - Canopy
 - Wireless data transmission
- **Irrigation facilities available**



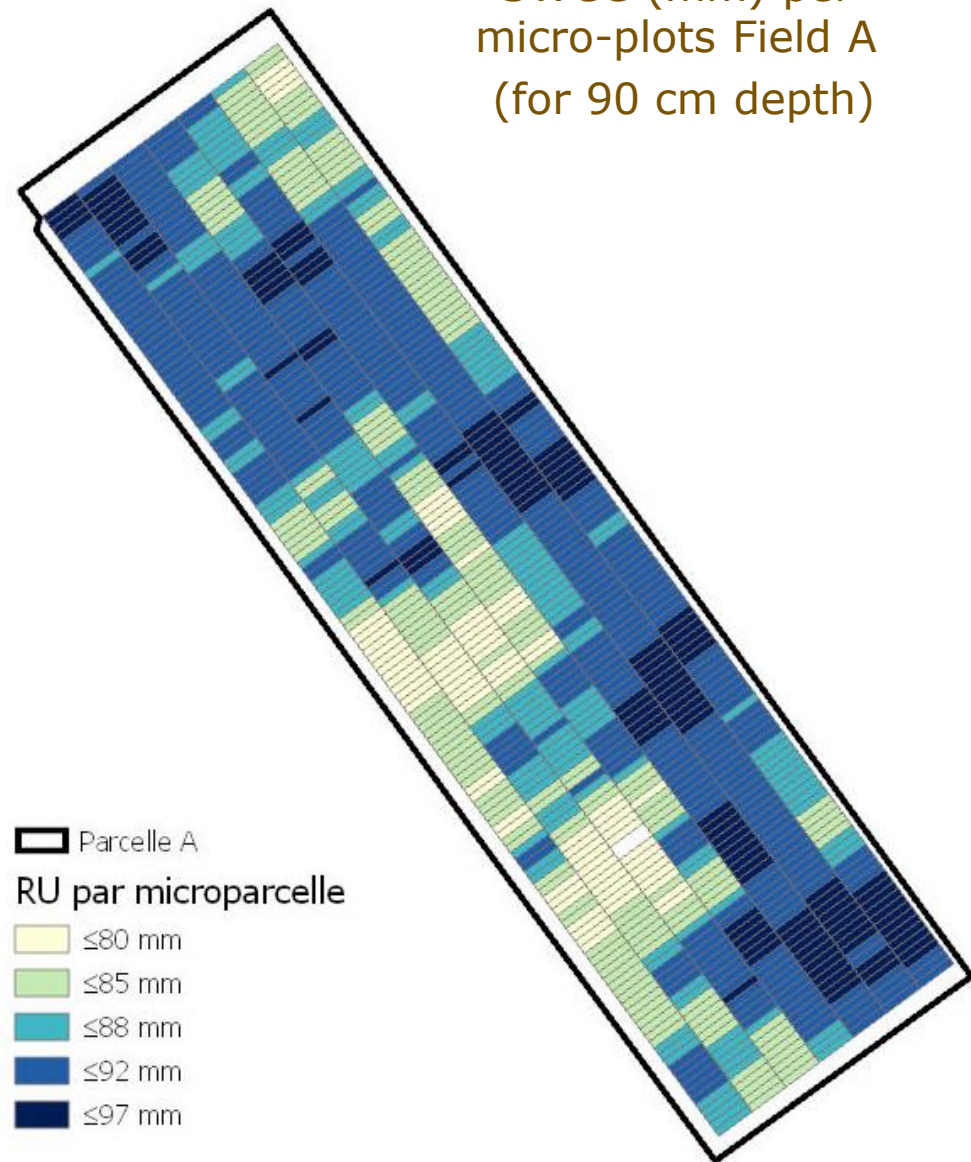
Precise Description of soil water content capacities - Marc Janin (2018)

SWCC (mm) / Phénovia for a root system depth of 90 cm



0 50 100 200 Meters

SWCC (mm) per micro-plots Field A (for 90 cm depth)



Phenotyping tools tested

Multiplex®

GreenSeeker®



ASD® FieldSpec 3



SunScan



RGB Sony



Caméra MS Airphen

Investments for a performing environment characterization and high throughput phenotyping tools



Crop establishment

- ✓ **Vigour**
- ✓ **Speed of Soil covering**
- ✓ **Plant density**



Vegetative phase

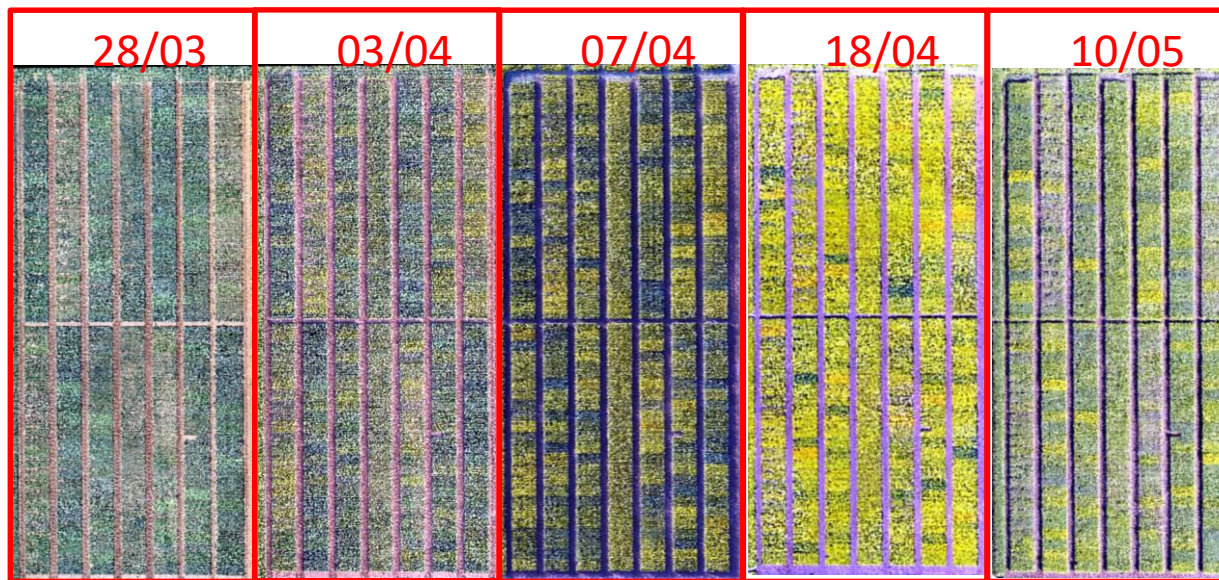
- ✓ **growth**
- ✓ **Biomasse/ LAI**



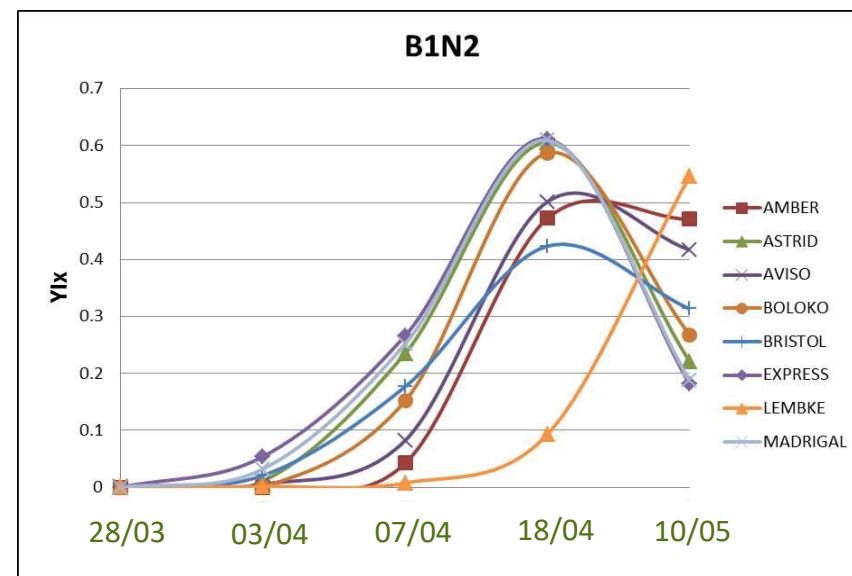
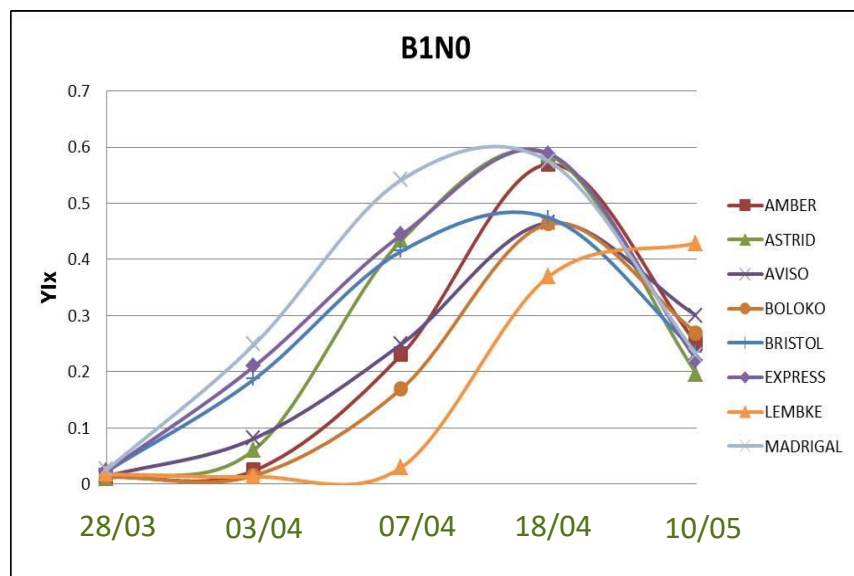
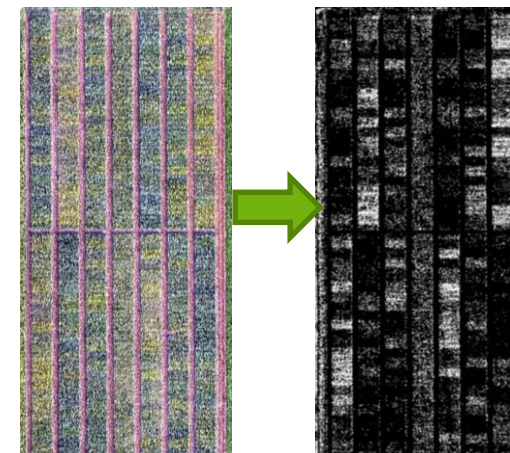
Phenology

- ✓ **Flowering dynamic**





2017



Actually the main challenge is on data storage and processing

Data processing in the framework of RAPSODYN project :

#440



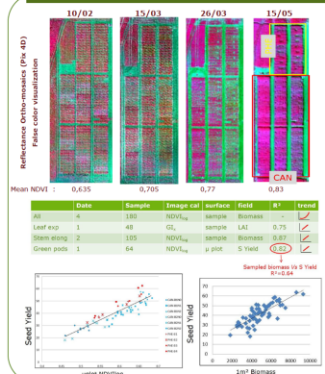
Proxy- and Remote-sensing of oilseed rape crops

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² Agrocampus Ouest, 65 rue de Saint Briec, 35000 Rennes, France

Introduction & objectives

- Winter OilSeed Rape (WOSR):
 - 2nd winter arable crop in Europe and France
 - Different phenological stages requiring continuous field observations and destructive samplings
 - Solution: proxy- and remote- measurements to monitor crop at different growth levels
 - Unlike most other arable crops, only a few number of research subjects about WOSR proxy- and remote- sensing
- Goals: How to deal with crop changing? Sensor? Platform? Precision?

Results



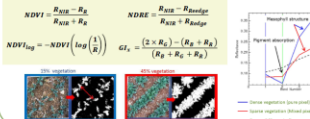
This work has been partly funded by ANR (French National Agency for research) through PHENOME and RAPSODYN projects. This experiment was carried out in Experimental farm of French Agricultural Research Institute (INRA). We would like to thank the experimental teams of INRA and Terres Inovia for field works and also Airinov/AgriDrone for UAV images services.

Materials & Methods

- Experimental program
 - 2 designs: CAN and PHE at INRA experimental farm (near Dijon)
 - Various genotypes (G) and nitrogen supply (N)
 - N applications: February and March



- Data Acquisition and analysis
 - Field Photography
 - ASD VNR field spectrometer
 - UAV multispectral images
 - 4 ch: G, R, Rededge and NIR
 - Pixel size: 6 cm
 - Field observations (biomass, LAI)



Conclusion & perspectives

- UAV images: monitoring WOSR growth and health
 - High spatial resolution
 - Frequency and flexibility of aerial operation
 - Synoptic view
 - ➔ Better consideration of field heterogeneity
- Next step: estimation of agronomic variables
 - Multi-year and multi-site data
 - Data from other Rapsodyn partners
 - Statistical modeling and evaluation

#418



Phenotyping and remote sensing: applying machine learning for Green Leaf Area Index (GLAI) predictive modeling using multispectral drone images.

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BACKGROUND: High through put phenotyping of plant growth and health indicators using non-destructive tools has great interest to characterize crop canopies for agronomic and breeding applications. Green Leaf Area Index (GLAI) and biomass quantifications with non-destructive remote sensing methods are increasingly preferred, with satellite or drone-based multispectral images for their rapidity and inexpensiveness, but still difficult to calibrate for winter oil seed rape. Other methods, e.g. semi-empirical models based on vegetation indices and radiative transfer model inversion method, have shown the value of remote sensing for estimating biophysical variables [1] and have been calibrated on rapeseed [2].

OBJECTIVES: With the rise of computer power, apply machine learning (ML) algorithms [3-4] to provide a robust and ready-to-deploy model to predict green leaf area index (GLAI) of winter oil seed rape (WOSR) canopies using UAV images performed in multi-year context:

- Take into account more predictors, e.g. quantiles to preserve across-variability of all spectral bands instead of vegetation indices values.
- Train and compare well-known ML algorithms.
- Evaluate the performances of the best model on a set of new UAV images to discriminate the GLAI kinetics of several genotypes (G), under contrasting nitrogen conditions (N), in a field context.

METHODOLOGY:

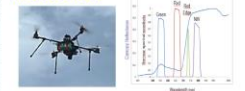


Fig. 1. Drone shadow, characteristics of Phenome Sequoia Multispectral Camera: spatial resolution of 5-7 cm in 4 spectral bands.

Field trials & measurements: several G of contrasted GLAI dynamics have been trialed under 2 N conditions, 2 years (Le Rheu, France).

UAV data: 10 datasets of observed GLAI values, collected during vegetative period and assessed by planimeter LICOR (1m²/sampling plot) vs drone multispectral images (10m² UAV/plot) (Fig. 1 & 2).

ML, variables, train & validation: 8 ML algorithms are tested (support vector machine (SVM), Gaussian process (GP), generalized additive model (Gam), random forest (RF), ...). A double cross-validation is performed. First of all, the calibration of each model is done by cross-validation to determine the parameters to be used. The comparison of the best models of each method is carried out on a second independent data set containing genotypes different from those used to calibrate the model.

RESULTS: Performance of 8 ML algorithms: the best model obtained to predict GLAI presented a RMSE=0.23 (Fig. 3), being more accurate than the best vegetation-index based regression model (RMSE=0.28). Reflectances are more explanatory than vegetation indices, and the NIR band is the most contributor to the GLAI estimate.

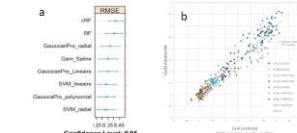


Fig. 2. a) RMSE of the different ML models. b) Measured vs predicted GLAI values (GLAI: radiol model; median & Q2, Q25, Q75, Q95) for 3 dates x 2 years, during 3 periods of vegetative growth for rapeseed (autumn, spring before and after fertilization: N1 or N2).

Agonomic applications: GLAI models allow to establish a dynamic of crop growth and discriminate N and G effects and to investigate S-N interaction more precisely and by providing additional information to that obtained by field observations.

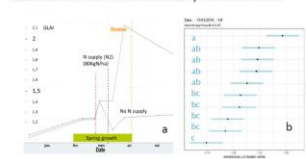


Fig. 3. a) RMSE of the different ML models. b) Measured vs predicted GLAI values (GLAI: radiol model; median & Q2, Q25, Q75, Q95) for 3 dates x 2 years, during 3 periods of vegetative growth for rapeseed (autumn, spring before and after fertilization: N1 or N2).

CONCLUSIONS & PERSPECTIVES: UAV images provide suitable data & application of Machine Learning, coupled with more statistical measures, improves GLAI modeling accuracy and would enable frequent, exhaustive and non-destructive predictions of the overall growth dynamics on both small (m²) and large (ha) areas. Furthermore, deep learning algorithms would be interesting for other high through put phenotyping as: fractional vegetation cover, crop biomass. Also, its ability of pattern recognition could distinguish organ types, plant health status, discriminate canopy architectures or screen genotype variability for various traits. Further studies will focus on the validation of prediction model for new datasets for new genotypes.



➤ Phenovia :

Since 2012...

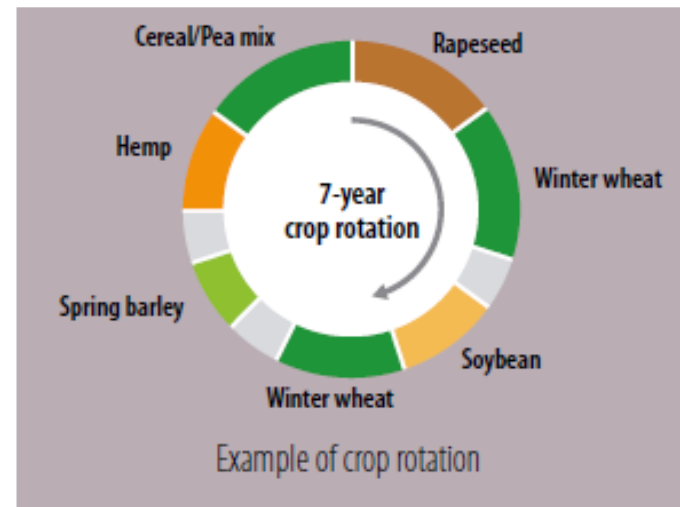
more than 7000 μ plots already done mainly for quantitative genetics

Oilseed rape, Soybean, Pea

2018 : The farm became the CA-SYS platform : Long term experimental platform on **agro-ecology** at various scales

CA-SYS : Co-designed Agroecological-SYSTEM Experiment

- Multi-performant Agro- Systems
- Maximizing biological processes;
- Strong reduction of pesticides
- Longer rotations .



PHENOVIA takes the opportunity to focus on low chemical inputs plant/canopy phenotyping

- **Plant nutrition /fertilization / Biostimulant expérimentations**
- **IPM strategies / Biocontrol of bioagressors tests**
- **Variety testing under low chemical inputs**
- **The platform is open to collaboration**
 - **We would be pleased to welcome your expérimentations**
 - **Open to collaborative projects**
 - **Ready to discuss your protocols**

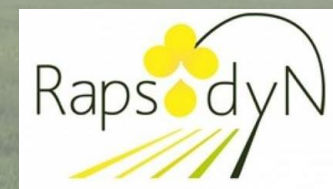
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Many thanks for your attention



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