



LIEN  
DE LA VIGNE  
*VINELINK INTERNATIONAL*  
[www.liendelavigne.org](http://www.liendelavigne.org)

**ASSEMBLEE GENERALE 2017**  
*2017 General Assembly*

**NOUVEAUX OUTILS POUR LE SUIVI DE  
LA QUALITE DES RAISINS :**

**Capteurs, analyse des données, outils  
d'aide à la décision**

*New tools for monitoring  
grapes quality : sensors, data  
analysis, decision*

## Les capteurs de fluorescence FORCE-A

# FORCE-A fluorescence sensors

Zoran G. Cerovic

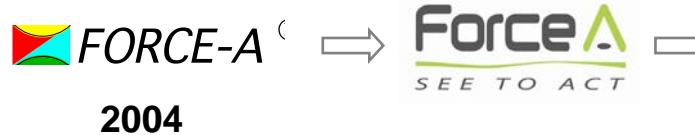
*CNRS, Univ. Paris-Sud, Orsay, France*

[zoran.cerovic@u-psud.fr](mailto:zoran.cerovic@u-psud.fr)



# Abbreviations and acronyms

*Fluorescence and  
Optoelectronics Research for the  
Communication between  
Ecophysiology and Agriculture*



*Dual Excitation*



1 G Lab 1999 & Field 2000



2 G 2003



3 G 2005/06

**Dualex®**



4 G 2009

*Multiple Excitation*



1 G 2005



2 G 2007



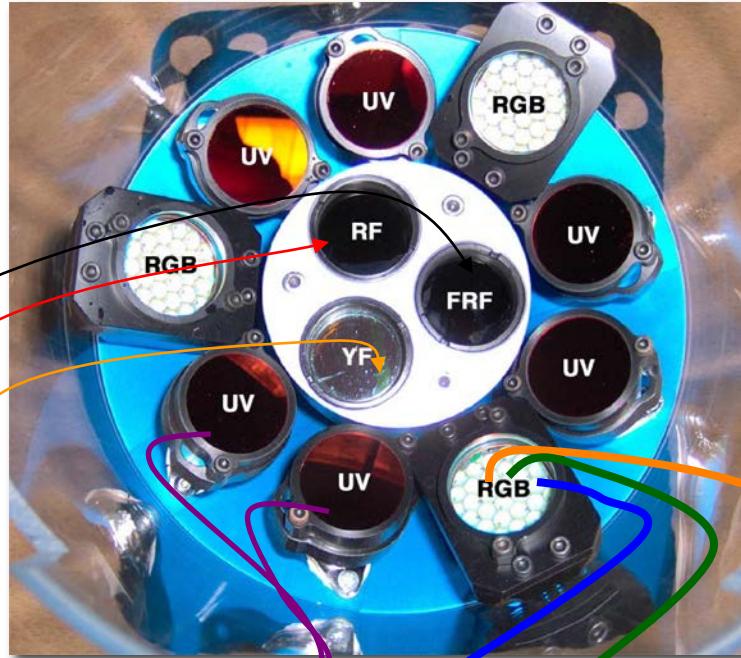
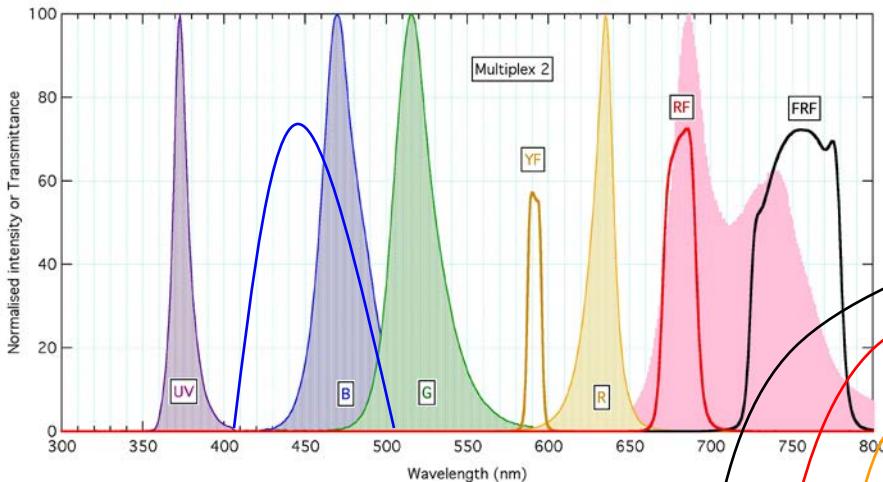
3 G 2008/2009



Mounted 2010

**Multiplex®**

# The Multiplex sensor



40  $\mu$ s flashes  
4 excitations  
3 emission channels  
Repeated 250 times  
3000 measurements  
1 second per sample  
In situ, in the field  
**Under ambient light**

Emission (nm)	Excitation	UV	Blue (B)	Green (G)	Red-Orange (R)
YF (590)	YF_UV	YF_B = R	YF_G = R	YF_R = R	
RF (685)	RF_UV	RF_B	RF_G	RF_R	
FRF (735)	FRF_UV	FRF_B	FRF_G	FRF_R	

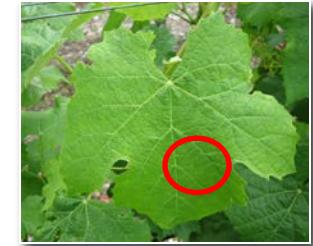


# Two families of sensors for plant constituents

## *Leaf clips*



**Dualex®:**  
Chlorophyll  
Flavonols  
Anthocyanins



## *Proximal sensors: leaves and fruits*



**Multiplex®:**  
Chlorophyll  
Flavonols  
Anthocyanins  
Stilbenes



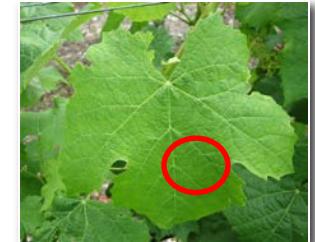
# Type of measurement

Dualex



*hand-held*

leaves



GPS  
inside

Multiplex



leaves

grapes on vine

*hand-held*

harvested grapes



*vehicle-mounted*



harvested grapes



leaves

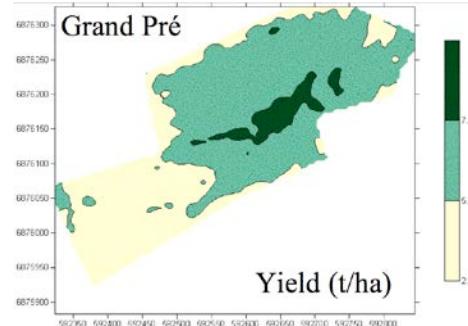
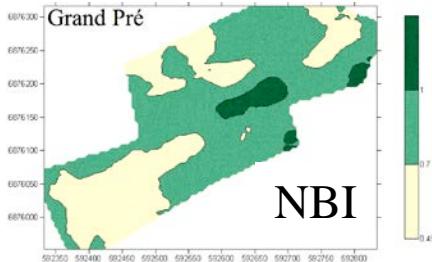
grapes on vines



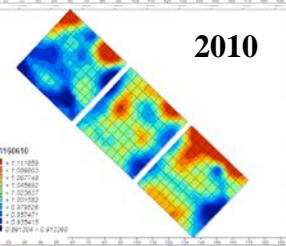
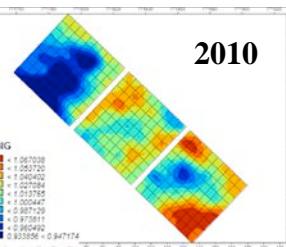
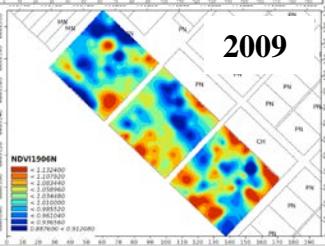
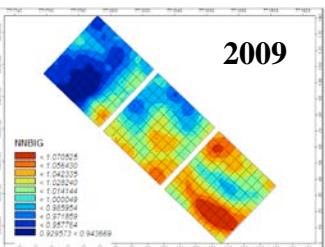
# Precision agriculture: Multiplex NBI mapping



*Martinon et al. (2010)  
10<sup>th</sup> ICPA, Denver*



*Debuission et al. (2010)  
10<sup>th</sup> ICPA, Denver*

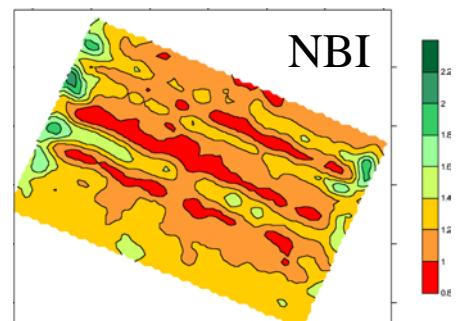
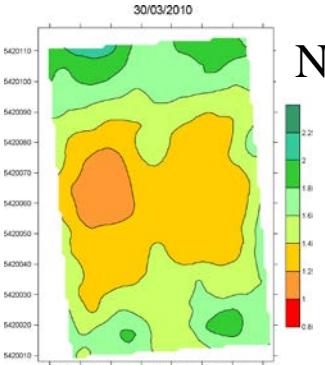


$$NBI \ r^2 = 0.75$$

$$NDVI \ r^2 = 0.11$$



*Lejealle et al. (2010)  
10<sup>th</sup> ICPA, Denver*



# FORCE-A services for viticulture

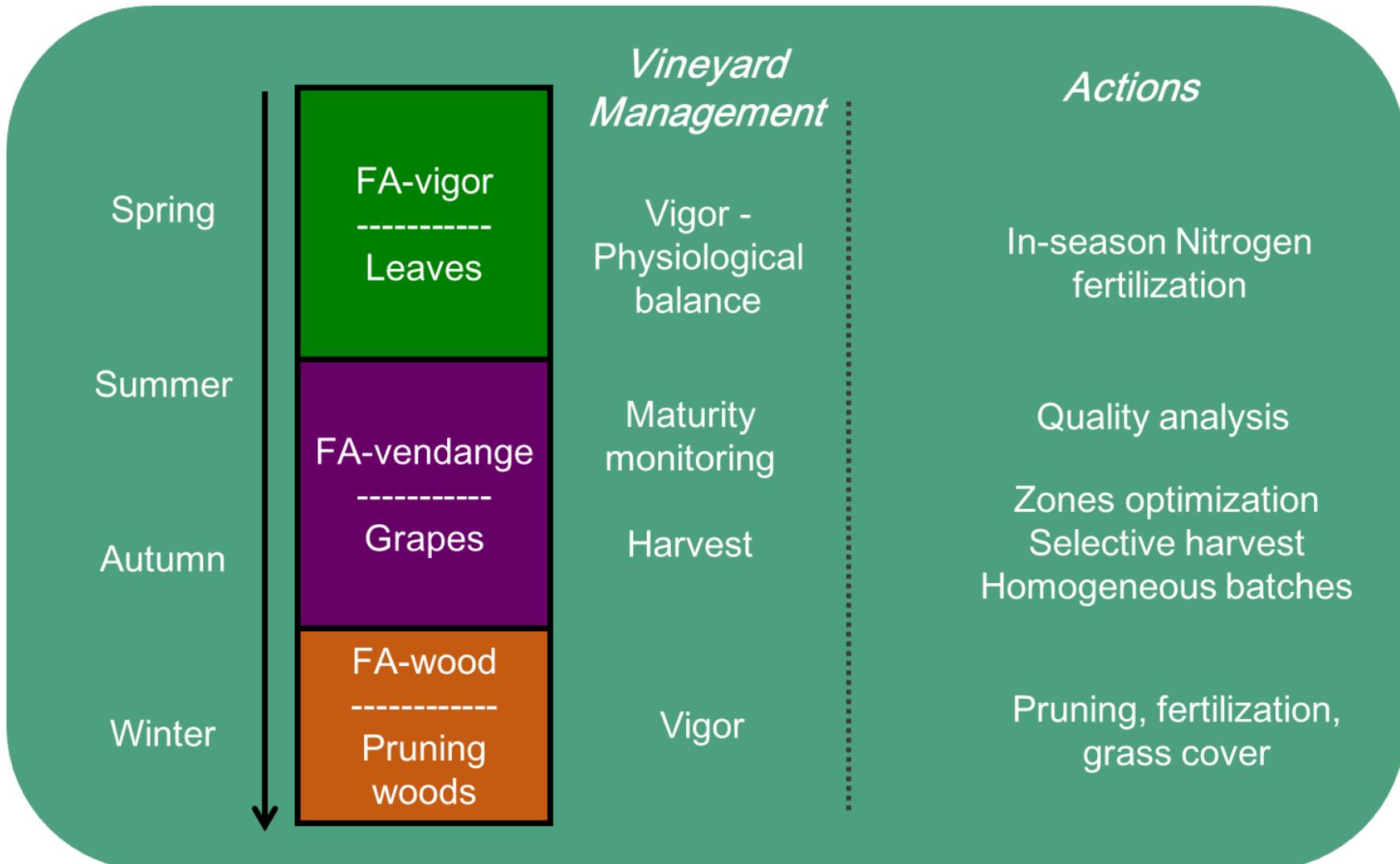


FA-Vigor™

FA-Vendange™

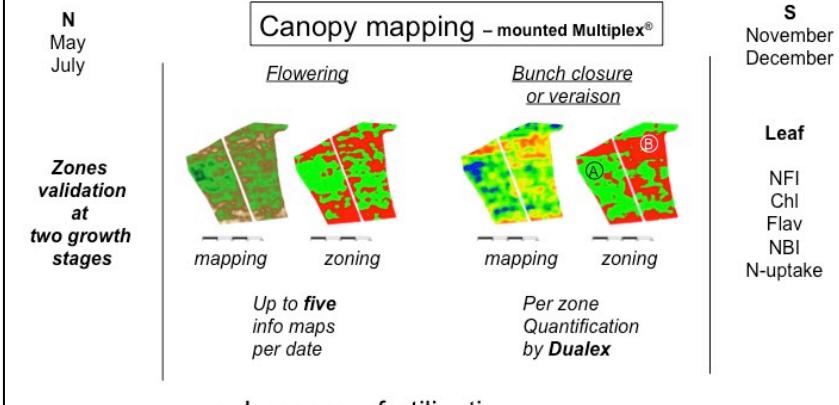


FA-Wood™



# All-year-around vineyard monitoring

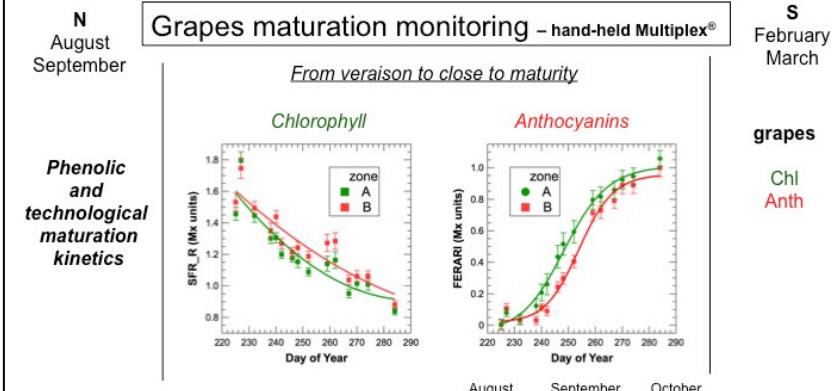
## All-year-around vineyard monitoring – summer



- In-season fertilisation
- Forecast of grape & must nitrogen
- Need for inter-row cover-crop (next year)
- Disease pressure estimation

Cerovic, Orsay, December 11, 2014

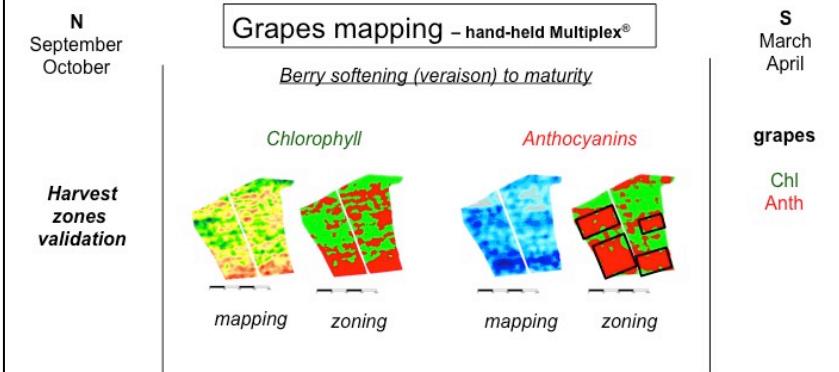
## All-year-around vineyard monitoring – summer



- Precocity zone confirmation
- Harvest date forecast
- Type of wine forecast (rosé vs. red) (premium vs. super-premium)

Cerovic, Orsay, December 11, 2014

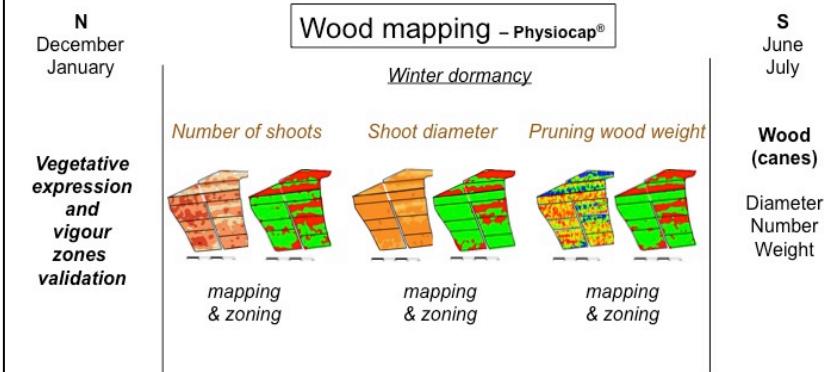
## All-year-around vineyard monitoring – autumn



- Selective harvesting - same date
- Selective harvesting - time delay

Cerovic, Orsay, December 11, 2014

## All-year-around vineyard monitoring – winter



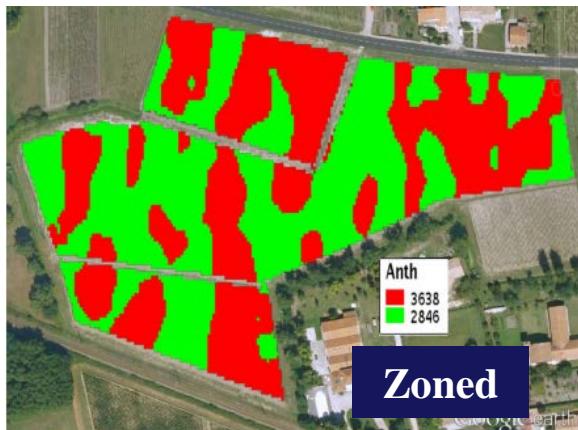
- Pruning planning (Ravaz index)
- Vintage evaluation
- Fertilisation or inter-row cropping
- N reserve estimation

Vinelink International – 31 March 2017

# Advantage of selective harvesting

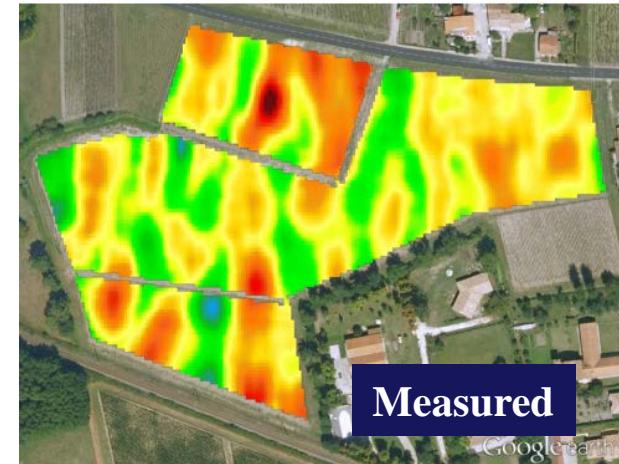


## FA-Vendange™



Wine	First	Second
Tannins (g/L)	5.3	4.6
Anthocyanins (mg/L)	1 506	1 132

+ 40 000 €  
(+23%)



First 20 € | Second 12 €

An increased wine quality that directly improves profitability

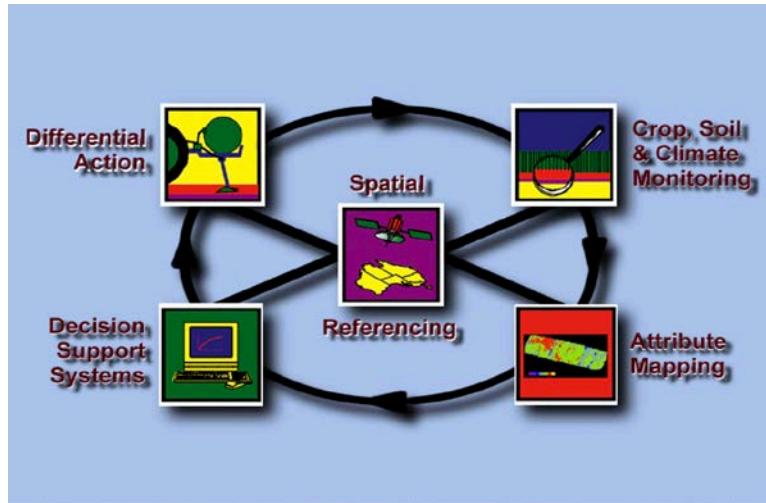


Multiplex® hand-held mapping

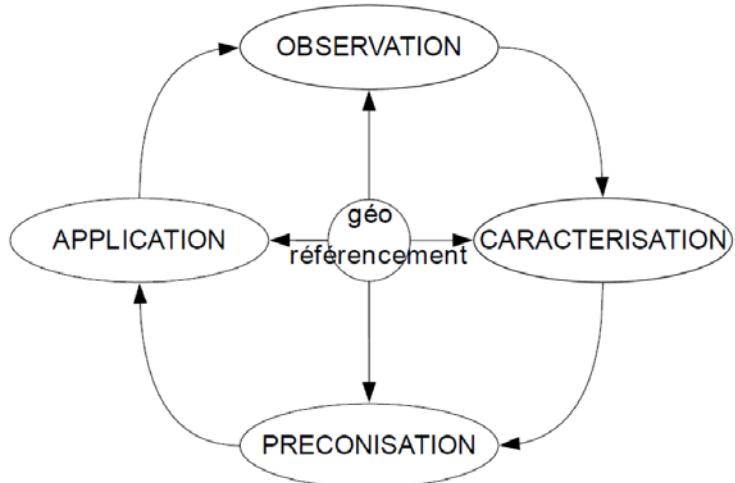
Bottles	First Wine	Second Wine	Sales
Without FA-Vendange	0	14 800	177 600 €
With FA-Vendange	5 333	9 467	220 264 €
cost	1 350 €		

# Advances in precision viticulture concept

## The PV wheel



Australian Centre for Precision Agriculture (McBratney & Taylor, 1999)



Tisseyre (2011)

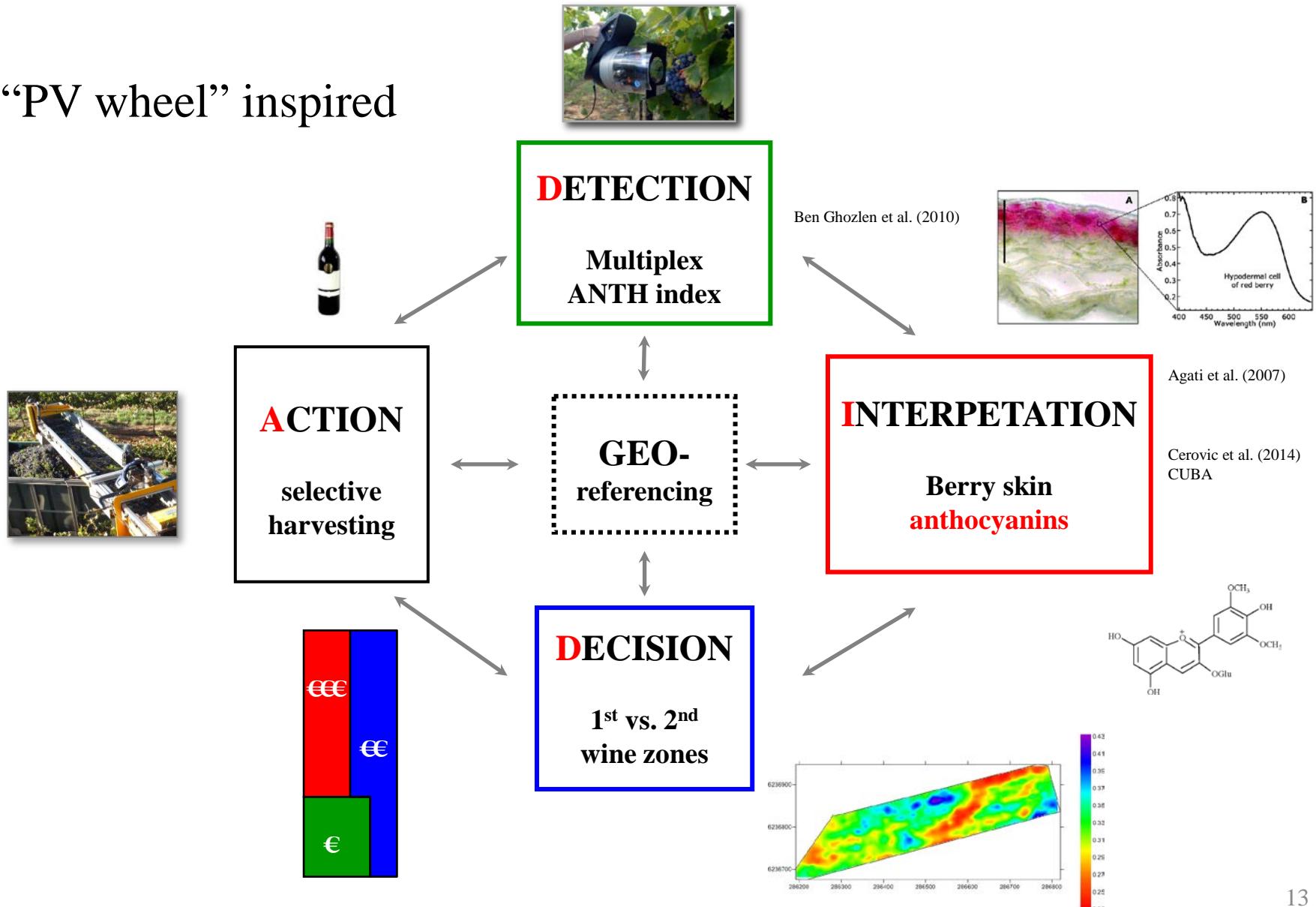


FRUITION SCIENCES

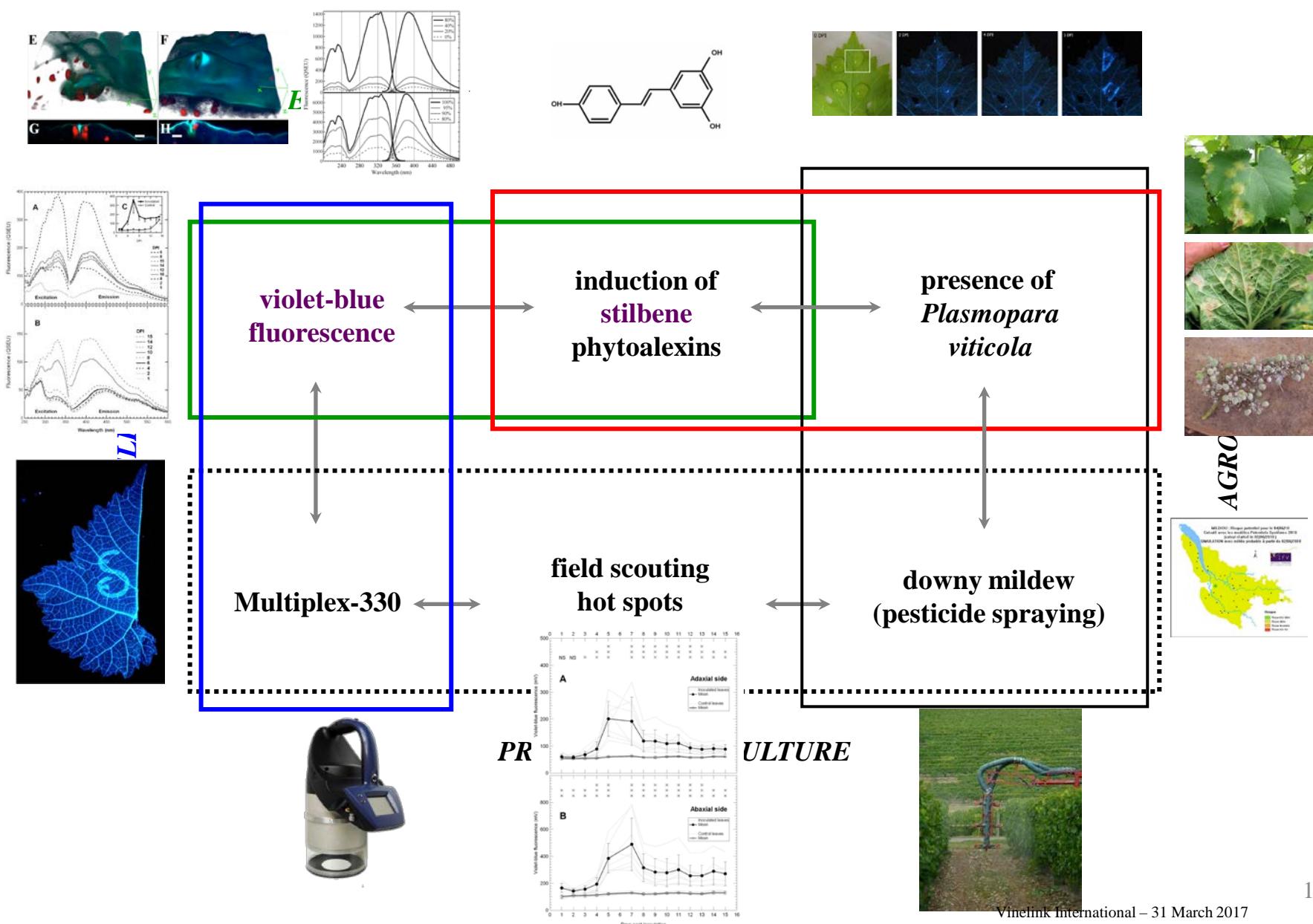


All-year-around practice

“PV wheel” inspired



# Stilbenes as indicators of downy mildew in grapevine



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**SENSORS**

FORCE-A SELLS OPTICAL SENSORS FOR THE RESEARCH IN ECOPHYSIOLOGY AND FIELD PHENOTYPING

**MORE**

**NEWS**

FEBRUARY, 14TH TO 17TH 2017: ENOMAQ  
09/02/2017 > Zaragoza, Spain

JULY, 16TH TO 20TH 2017: ECPA  
30/01/2017  
> Edinburgh, United Kingdom

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YOU WANT A QUOTATION FOR OUR SENSORS

**FA SERVER**

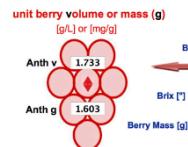
LOAD MY DATA TO GET MY REPORT

<http://www.ese.u-psud.fr/article307.html?lang=en>

Principles and applications of Multiplex and Dualex:  
innovative tools in the service of viticulture and oenology

Principios y aplicaciones del Multiplex y Dualex:  
unas innovadoras herramientas al servicio de la viticultura y la enología

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Converter of Units for Berry Anthocyanins



The other fluorescence.  
Journées de la Société Française de Photosynthèse, Paris, France, 18-19 May 2015.



Using fluorescence in the field to detect crop diseases: How we got there.  
16th International Congress on Photobiology, Cordoba, Argentina, September 8-12 2014.



Seeing the invisible : new proximal optical sensors for precision viticulture. Seminars at Garzón, Uruguay, September 1, 2014; Mendoza, Argentina, September 16, 2014; San Rafael, Argentina, September 17, 2014.



New proximal sensors of vegetation: towards a non destructive quantitative estimation of plant constituents  
Ebernburg-Workshop on "Leaf Optics", Ebernburg, Germany, 10-12 October 2012.



Proximal sensors of vegetation for sustainable agriculture  
Conference NewEnviro 2012, Sremska Kamenica, Serbia, 28-30 May 2012.



Principes et applications de Multiplex et Dualex: des outils innovants au service de la viticulture et l'oenologie

French

English

Principles and applications of Multiplex and Dualex: innovative tools in the service of viticulture and oenology



Principios y aplicaciones del Multiplex y Dualex: unas innovadoras herramientas al servicio de la viticultura y la enología

Spanish

Cerovic Logrono 2011

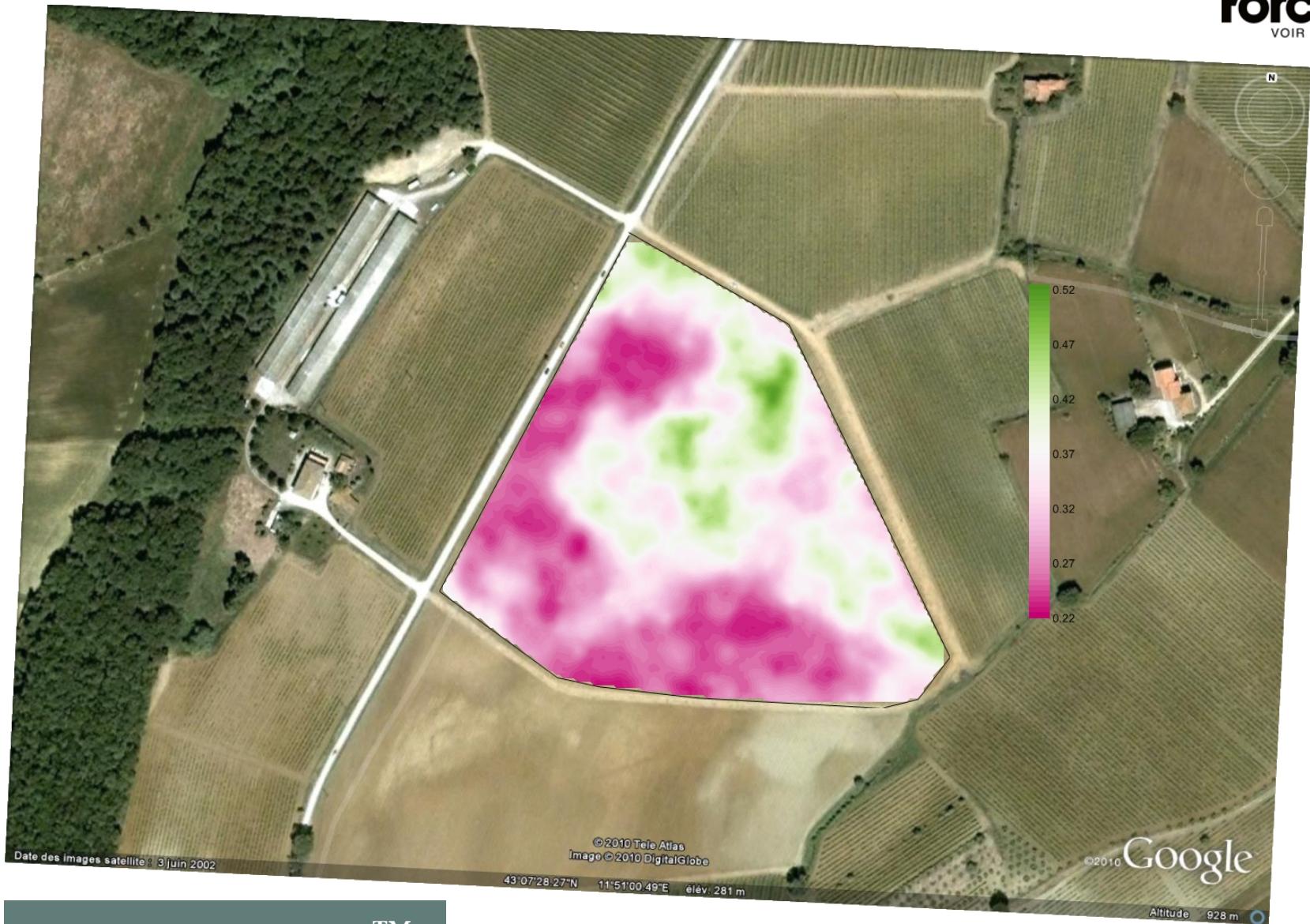
Presented at the first Technical Day of the ICVV, Logrono - Spain, May 3, 2011

# Mapping and real-time assessment of harvest quality



Vinelink International – 31 March 2017

# Grape phenolic maturity for selective harvesting

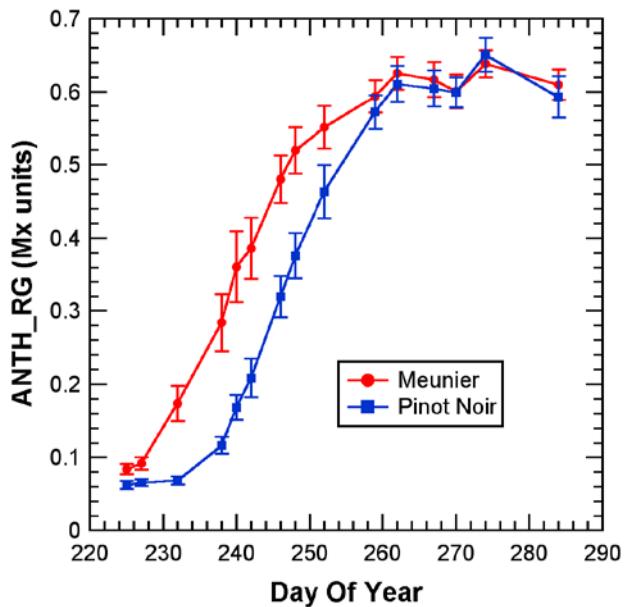


FA-vendange™

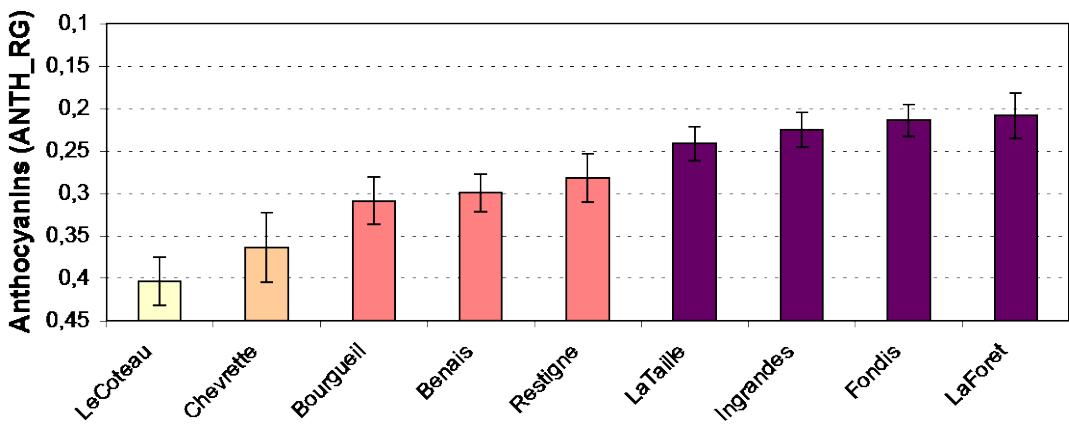
## FA-vendange™

Multiplex® measurement of berry skin anthocyanin content

### Anthocyanin accumulation



### Plots classification



Replaces laboratory analysis on 200-berries samples & avoids berry sampling problems

To optimise harvest logistics