

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

**Force**   
*SEE TO ACT*



## 植物、农作物及精准农业实时光学测量解决方案

**Real-Time Optical Solutions for Plant Science, Agri-food Industry and Precision Agriculture**



Beijing - CHINA  
October 2010

[www.force-a.com](http://www.force-a.com)



- 1、FORCE-A company FORCE-A  
公司介绍
- 2、Our technology main principles  
技术原理
- 3、Our instruments: DUALEX® & MULTIPLEX®  
产品： DUALEX® & MULTIPLEX®
- 4、The different applications on crops  
仪器应用
- 5、Our Research & Development  
研究与开发
- 6、Open questions  
提问

- 1、FORCE-A company FORCE-A  
公司介绍
- 2、Our technology main principles  
技术原理
- 3、Our instruments: DUALEX® & MULTIPLEX®  
产品：DUALEX® & MULTIPLEX®
- 4、The different applications on crops  
仪器应用
- 5、Our Research & Development  
研究与开发
- 6、Open questions  
提问

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

CNRS spin off, University Paris 11.  
法国国家研究中心及巴黎11大学研究成果.

Award-winner in 2002 and 2004 by the French  
government for its project of technology transfer.  
2002&2006法国技术成果转化奖.

More than 15 years of R&D experience in the field  
of Photosynthesis and Optical Remote Sensing.  
15年光合作用及光学遥感研究开发经验.



UNIVERSITÉ  
PARIS-SUD 11



Liberté • Égalité • Fraternité  
RÉPUBLIQUE FRANÇAISE



[www.force-a.com](http://www.force-a.com)



Development  
开发

Manufacturing  
生产

Marketing  
销售

Applications & Services  
应用 & 服务

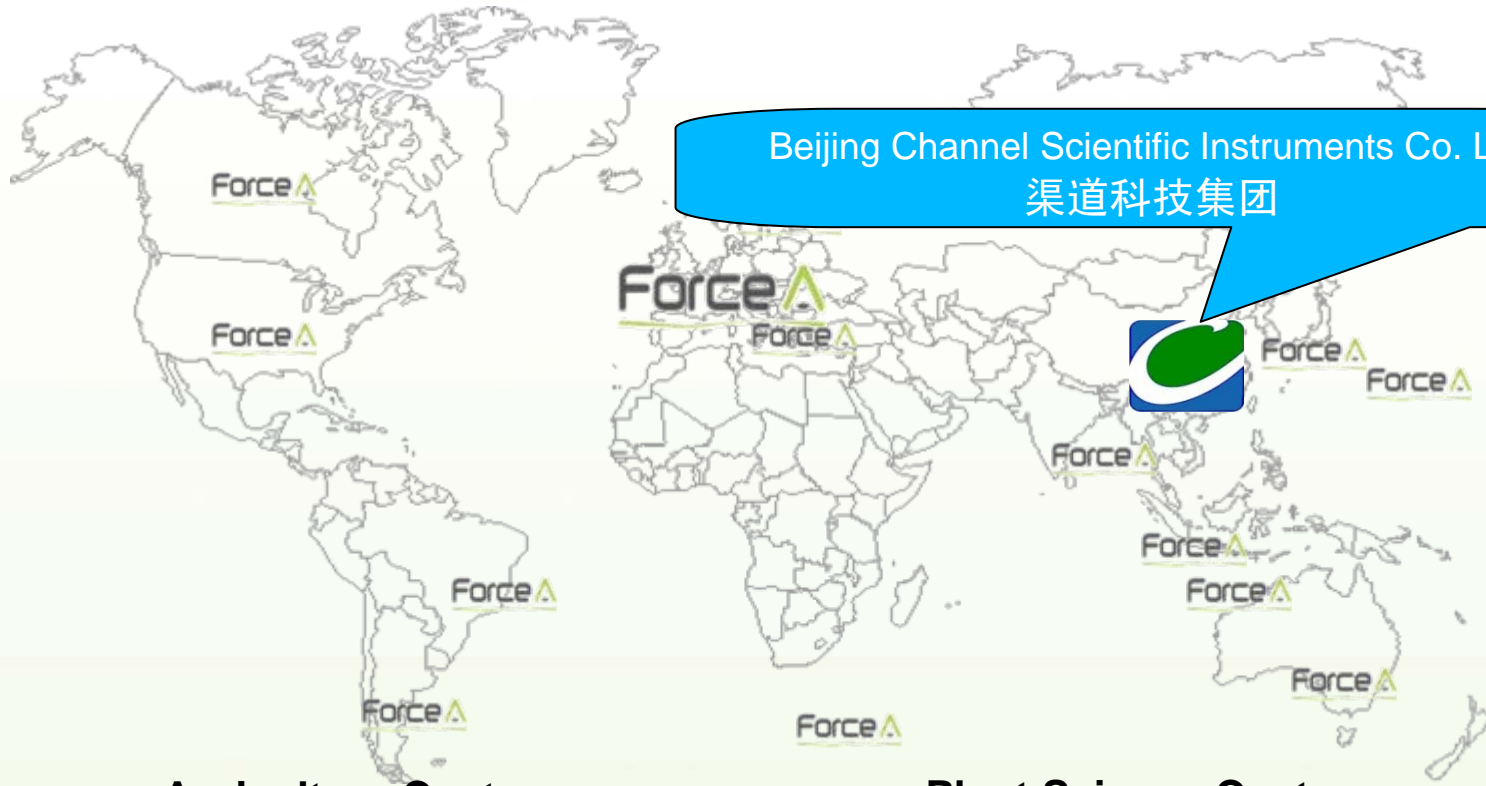




- A twofold purpose:
  - ▶ To increase quality
  - ▶ To optimize input costs

- 两方面目的：
  - ▶ 提高作物质量
  - ▶ 优化资金投入





■ **Agriculture Customers**

- ▶ Direct Sales
- ▶ Distribution Network

■ **农业客户**

- ▶ 直接销售
- ▶ 代理网络

■ **Plant Science Customers**

- ▶ Direct Sales
- ▶ Distribution Network

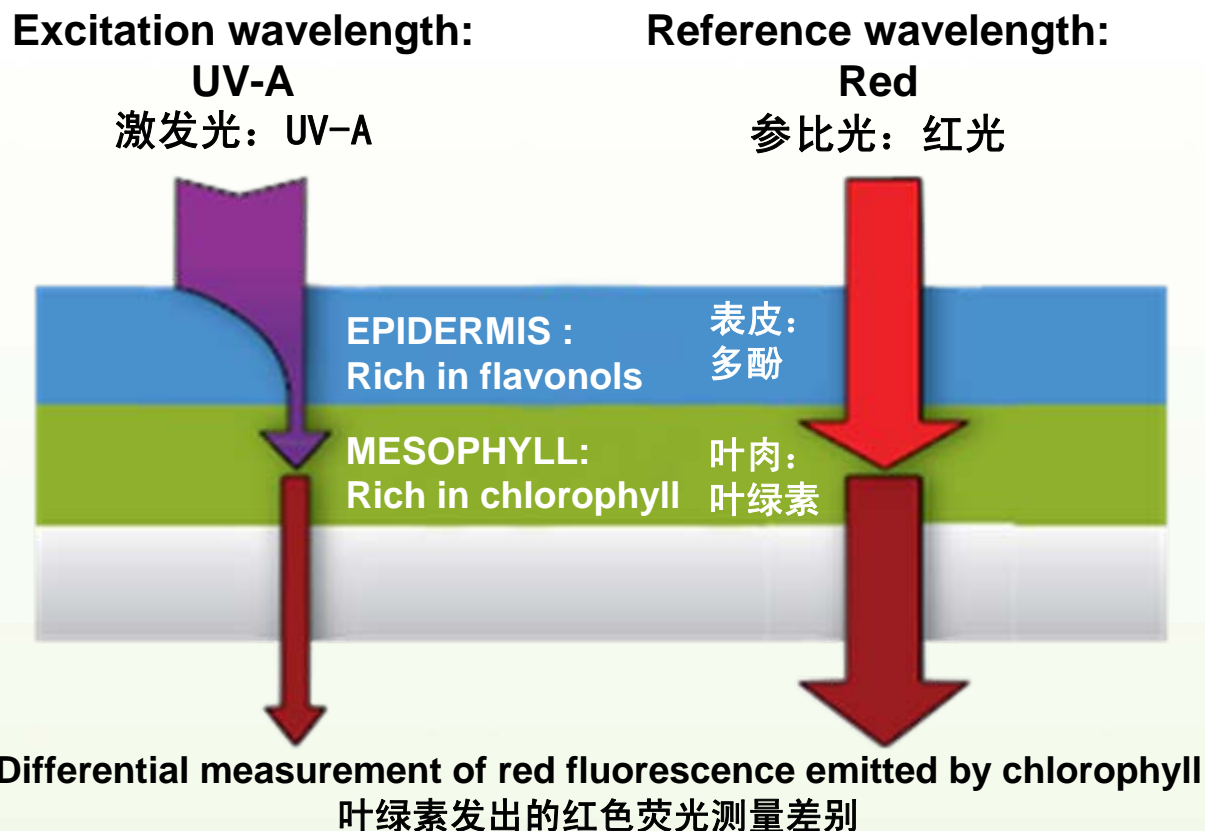
■ **植物研究客户**

- ▶ 直接销售
- ▶ 代理网络



- 1、FORCE-A company FORCE-A  
公司介绍
- 2、Our technology main principles  
技术原理
- 3、Our instruments: DUALEX® & MULTIPLEX®  
产品： DUALEX® & MULTIPLEX®
- 4、The different applications on crops  
仪器应用
- 5、Our Research & Development  
研究与开发
- 6、Open questions  
提问

# Measurement principle 测量原理



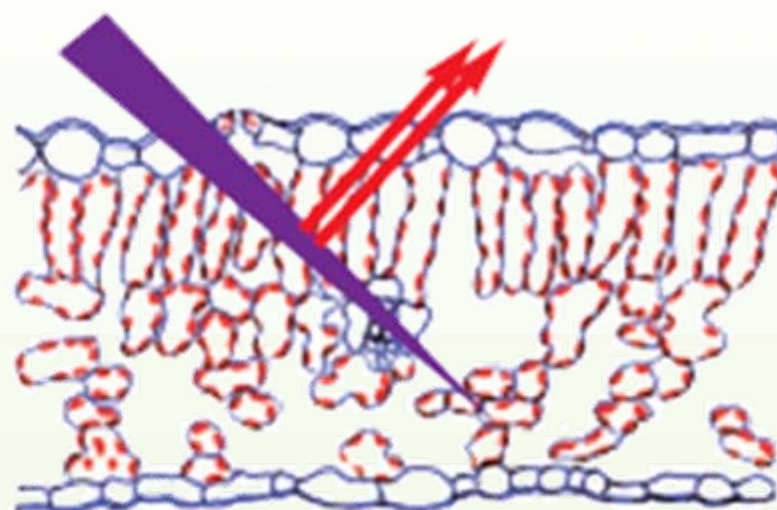
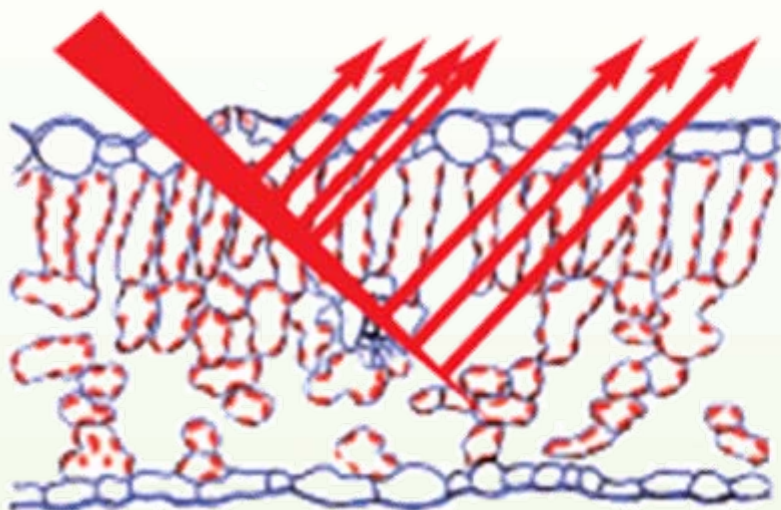
USE OF THE SCREENING EFFECT OF THE  
POLYPHENOLS LAYER OVER THE CHLOROPHYLL  
运用叶绿素周围的多酚层荧光作用测量

Red 红色  
excitation 激发光

Chlorophyll 叶绿素发  
fluorescence 出的荧光

UV 紫外  
excitation 激发光

Chlorophyll 叶绿素发  
fluorescence 出的荧光



USE OF THE SCREENING EFFECT OF THE  
POLYPHENOLS LAYER OVER THE CHLOROPHYLL  
运用叶绿素周围的多酚层荧光作用测量

**DUALEX® ANTH**  
**MULTIPLEX®**  
**DUALEX® SCIENTIFIC**

**High light/UV 高光照/UV**  
anthocyanins 花青素  
flavones 类黄酮  
sinapyl esters 芥子酸  
isoflavonoids 异黄酮  
psoralens 补骨脂素



**DUALEX® HCA**  
**MULTIPLEX®**

**Wounding 物理损伤**  
coumestrol 拟雌内酯  
coumarin 香豆素  
psoralens 补骨脂素  
chlorogenic acid 绿原酸  
ferulate esters 黄烷醇酯  
wall bound phenolic acids 酚酸  
lignin.suberin 木质素.木栓质

**Pathogen attack 病毒入侵**  
ptero carpans 紫檀碱  
isoflavans 异黄酮  
prenylated isoflavonoids 异戊烯基黄酮类  
stilbenes 二苯乙烯  
coumarins 香豆素  
furanocoumarins 呋喃香豆素  
3-deoxyanthocyanidins 3-脱氧花青素  
flavanols 黄烷醇  
aurones 橙酮

**Signaling 信号**  
salicylic acid? 水杨酸?

**MULTIPLEX®**  
**DUALEX® SCIENTIFIC**

**MULTIPLEX®**  
**Low temperature 低温**  
anthocyanins 花青素  
**DUALEX® ANTH**



**Low nitrogen 缺氮**  
flavonoids 类黄酮  
isoflavonoids 异黄酮

**Low phosphate 缺磷**  
anthocyanins 花青素

**Low iron 缺铁**  
phenolic acids 酚-酸

**DUALEX® SCIENTIFIC**  
**MULTIPLEX®**

**DUALEX® ANTH**  
**MULTIPLEX®**

**DUALEX® HCA**



## Forestry 林业

<b>Cell walls</b>	细胞壁
<b>Wood</b>	木质部
Lignin	木质素
Suberin	软木脂
Cutin	表皮素
Ferulic acid	阿魏酸

## Agriculture 农业

<b>Pathogen diseases protection</b>	病原体病害保护
<b>Phytochemicals</b>	植物化学物
Phytoalexins	植物抗病素
Stilbens	二苯乙烯
BGF	蓝绿荧光

<b>Appetite</b>	口味
<b>Forage</b>	储藏
Tannins	单宁酸
Hydrolysable and non-hydrolysabl	水解及非水解产物

<b>Carbon-Nitrogen Balance</b>	碳氮平衡
<b>Nitrogen status</b>	氮状态
Flavonols	类黄酮
Chlorophyll	叶绿素
NBI®	NBI®

## Ecology 生态

<b>Anti-UV Protection</b>	UV防护
<b>Ozone</b>	臭氧
<b>Temperature</b>	温度
Flavonols	类黄酮

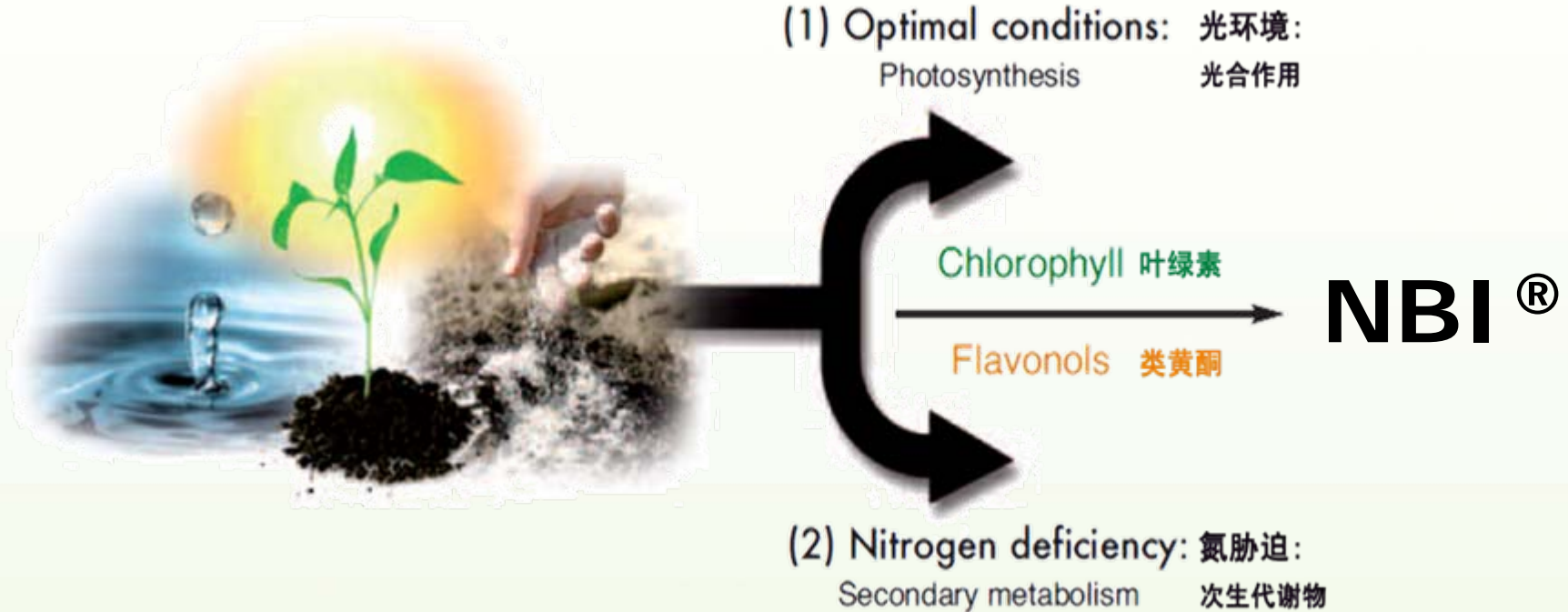
## Health and Agri-food 食品及健康

<b>Secondary metabolites</b>	次生代谢物
<b>Maturity</b>	成熟度
<b>Aroma</b>	香味
Vine, Fruits, Tea	葡萄, 水果, 茶
Anthocyanins	花青素
Flavonols	类黄酮

<b>Anti-oxidants</b>	抗氧化
<b>Health &amp; Care</b>	健康
(Vitamin P)	(维生素P)
Vegetables-fruits	水果蔬菜
Hydroxycinnamic acids	羧基酸
Flavonols	类黄酮
Stilbens (Resveratrol)	二苯乙烯



# NITROGEN BALANCE INDEX (NBI®): The combination of chlorophyll & flavonols 氮平衡指数 (NBI®): 叶绿素及类黄酮综合指标



$$\text{NBI}^{\circledR} = \text{CHL/FLAV (2001)}$$

- 1、FORCE-A company FORCE-A  
公司介绍
- 2、Our technology main principles  
技术原理
- 3、Our instruments: DUALEX® & MULTIPLEX®  
产品： DUALEX® & MULTIPLEX®
- 4、The different applications on crops  
仪器应用
- 5、Our Research & Development  
研究与开发
- 6、Open questions  
提问



❑ **DUALEX® FLAV: flavonols**

类黄酮

❑ **DUALEX® ANTH: anthocyanins**

花青素

❑ **DUALEX® HCA: hydroxycinnamic acids**

羟基酸

## Patented Technology 专利技术

- Portable and ergonomic
- Non-destructive, quick and simple
- No sample preparation
- Any ambient light conditions

人体工程学设计&便携  
无损、快速、简单  
无需准备  
所有光环境下试用



- CHLOROPHYLL  
叶绿素
- FLAVONOLS  
类黄酮
- NBI  
NBI



## Patented Technology 专利技术



- Portable and ergonomic
- Non-destructive, quick and simple
- No sample preparation
- Easy data management
- Any ambient light conditions

人体工程学设计&便携  
无损、快速、简单  
无需准备  
简单的数据管理功能  
所有光环境适用





**DUALEX® 1 Field**  
2000



**DUALEX® 2**  
2003



**DUALEX® 3.2**  
2005



**DUALEX® 1 Lab**  
1999

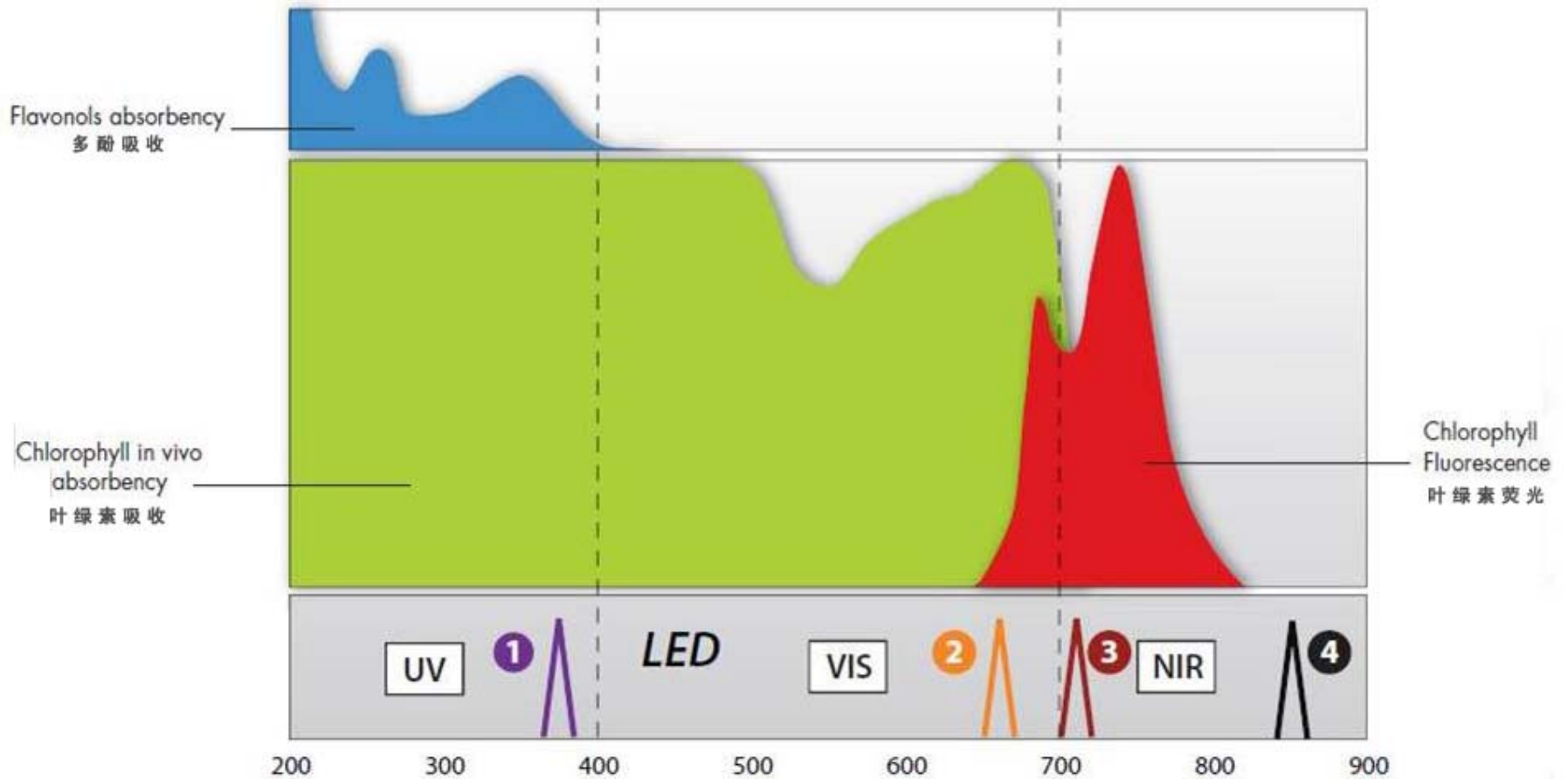


**DUALEX® 4**  
2009



**DUALEX® 3.3**  
2006







- Chlorophyll**  
叶绿素
- Flavonols**  
类黄酮
- Anthocyanins**  
花青素



## Patented technology 专利技术

- Portable and remote  
人体工程学设计&便携
- Multi-wavelengths and real-time  
同时测量多个参数
- Non-destructive, quick and simple  
无损、快速、简单
- No sample preparation  
无需准备
- Any ambient light conditions  
所有光环境适用

- Blue Green Fluorescence (BGF) excited by UV**  
紫外激发的蓝绿荧光



**MULTIPLEX® 1.5**  
2005



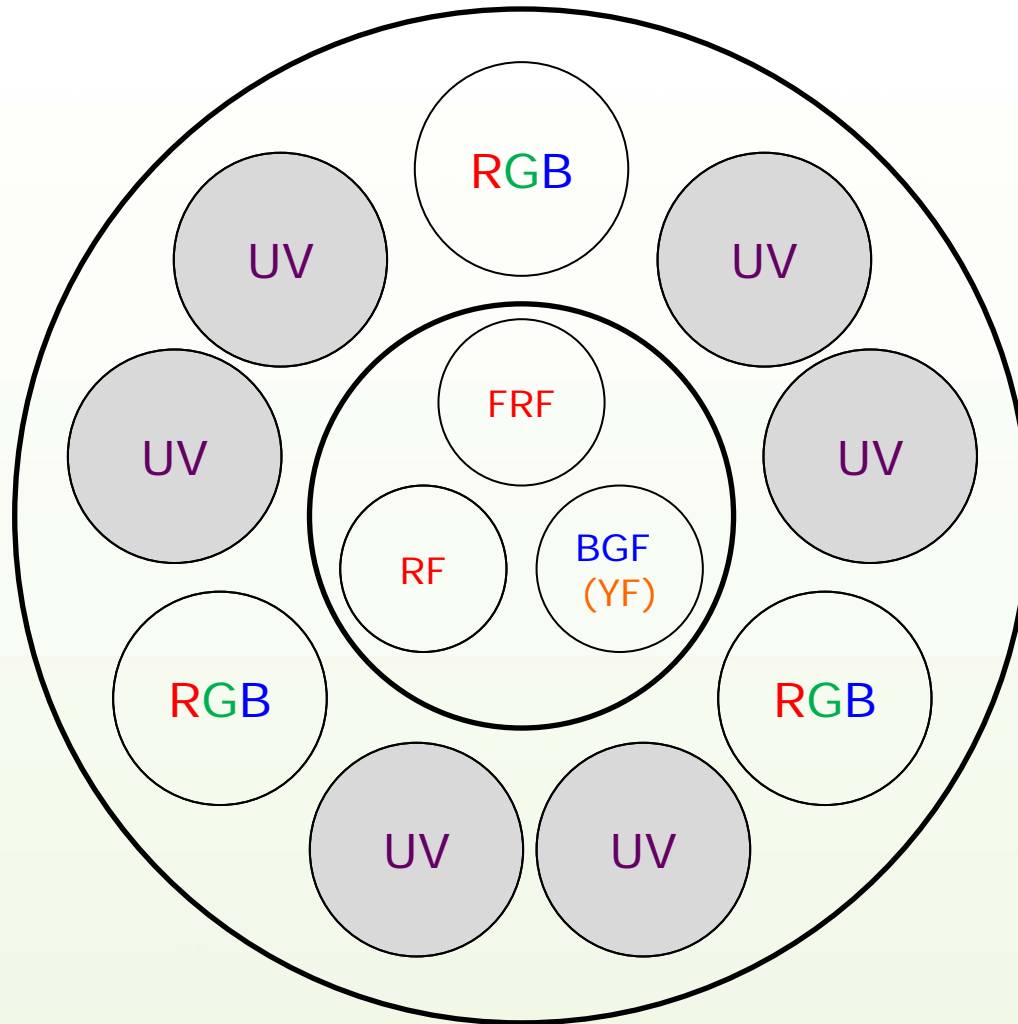
**MULTIPLEX® 1<sup>st</sup>**  
prototype 2004



**MULTIPLEX® 2**  
2007

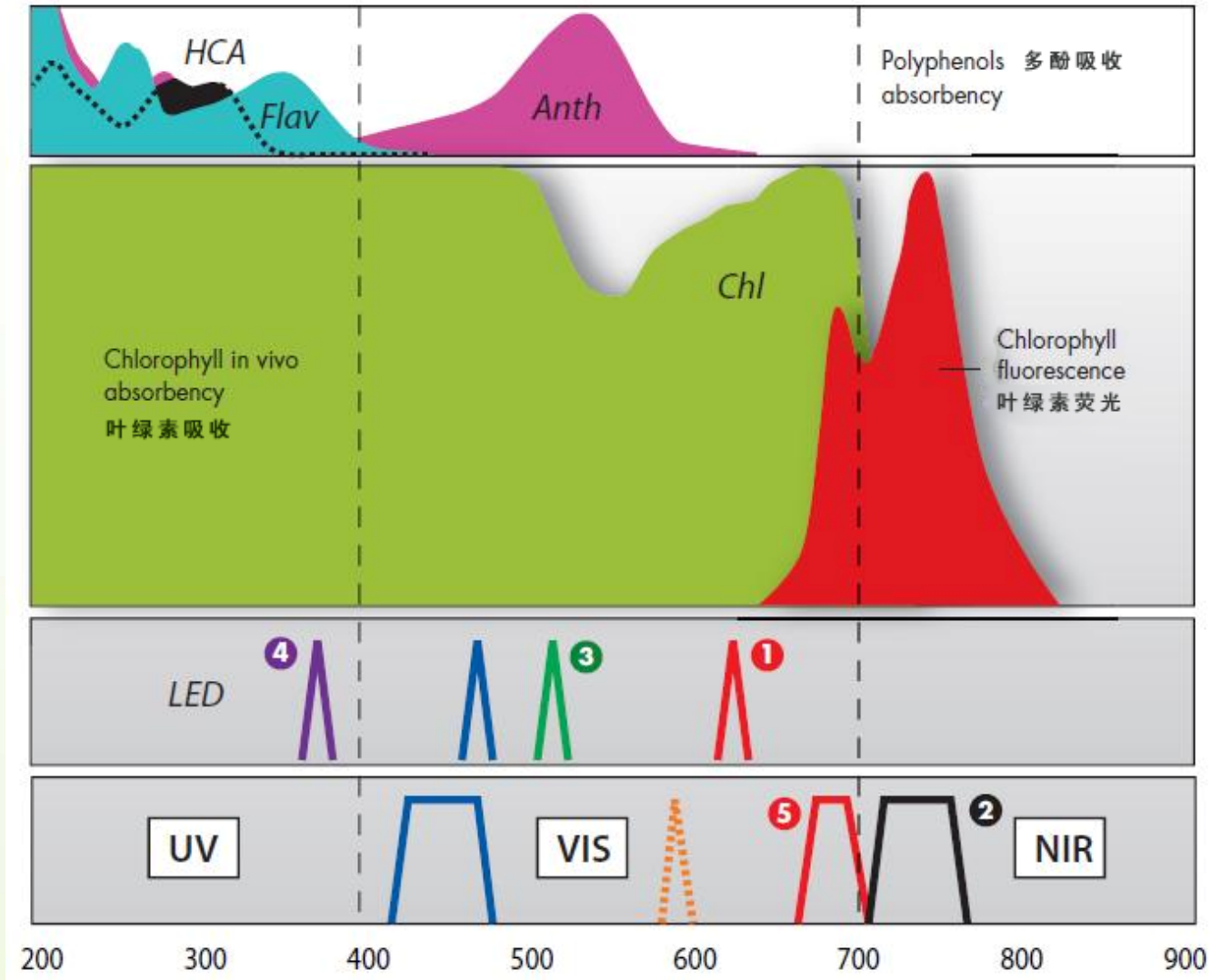


**MULTIPLEX® 3**  
2009



# MULTIPLEX® 3 : Measurement principle

## 测量原理

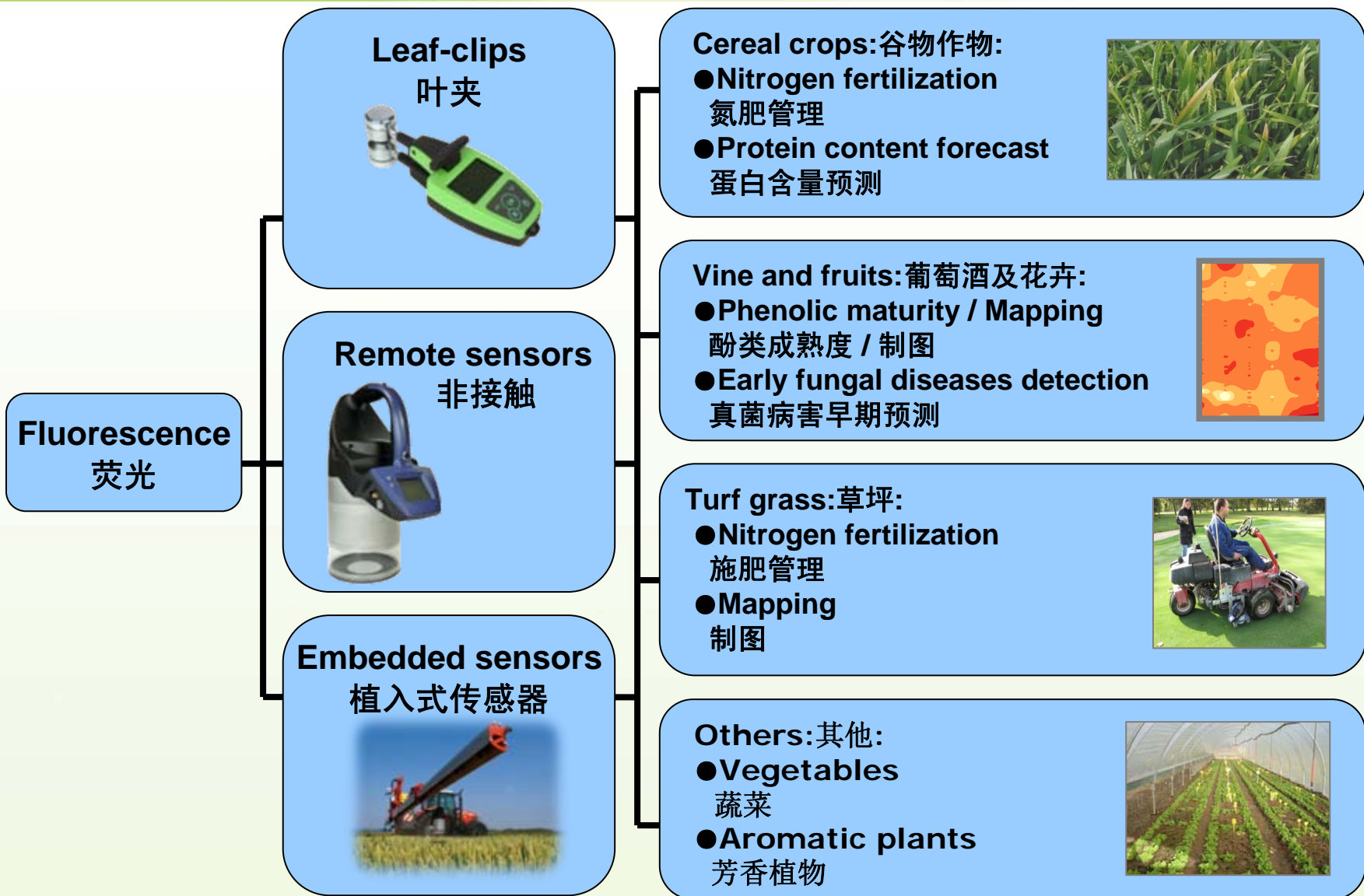




SIGNAL 参数	Emission 释放		Excitation 激发
BGF_UV	Yellow Fluorescence	蓝绿荧光	UV
RF_UV	Red Fluorescence	红色荧光	UV
FRF_UV	Far-Red Fluorescence	远红外荧光	UV
BGF_B	not in use	未试用	Blue
RF_B	not in use	未试用	Blue
FRF_B	not in use	未试用	Blue
BGF_G	Reflected Yellow-Green light	蓝绿反射光	Green
RF_G	Red Fluorescence	红色荧光	Green
FRF_G	Far-Red Fluorescence	远红外荧光	Green
BGF_R	not in use	未使用	Red
BF_R	Red Fluorescence	红色荧光	Red
FRF_R	Far-Red Fluorescence	远红外应该	Red

RATIO参数	Description含义	Formula公式
SFR_G	Simple Fluorescence Ratio (Green Exc.) 简单荧光比率	FRF_G/RF_G
SFR_R	Simple Fluorescence Ratio (Red Exc.) 简单荧光比率	FRF_R/RF_R
BRR_FRF	Blue-to-Red Fluorescence Ratio (UV Exc.) 蓝-红荧光比率	BGF_UV/FRF_UV
FER_RUV	Fluorescence Excitation Ratio (Red&UV Exc.) 荧光激发比率	FRF_R/FRF_UV
FLAV	Flavonols 类黄酮	log(FER_RUV)
FER_BG	Fluorescence Excitation Ratio (Red&Green Exc.) 荧光激发比率	FRF_R/FRF_G
ANTH	Anthocyanins 花青素	log(FER_RG)
NBI_G	Nitrogen Balance Index (SFR_G/FER_RUV) 氮平衡指数	FRF_UV/RF_G
NBI_R	Nitrogen Balance Index (SFR_R/FER_RUV) 氮平衡指数	FRF_UV/RF_R

- 1、FORCE-A company FORCE-A  
公司介绍
- 2、Our technology main principles  
技术原理
- 3、Our instruments: DUALEX® & MULTIPLEX®  
产品： DUALEX® & MULTIPLEX®
- 4、The different applications on crops  
仪器应用
- 5、Our Research & Development  
研究与开发
- 6、Open questions  
提问





# CEREAL CROPS

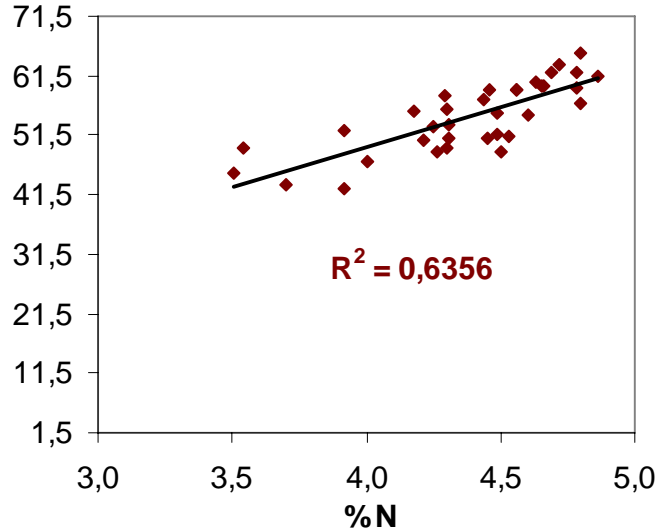
## 谷物作物



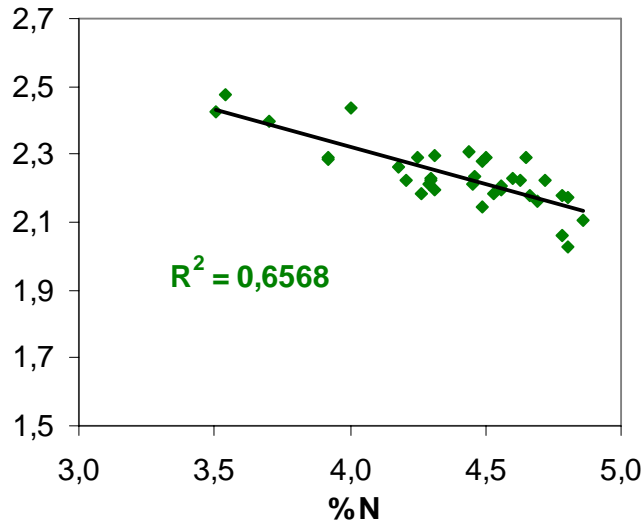
- ◎ Nitrogen fertilisation (Date and Dose: 3rd input)  
氮肥管理 (时间及剂量: 第三次施肥)
- ◎ Grain protein content forecast (wheat and barley): At flowering  
籽粒蛋白含量 (小麦及大麦): 开花期
- ◎ Variety selection (fungal and nutrition deficiency resistance)  
品种选择 (抗真菌、抗氮胁迫)
- ◎ Treatment physiological effects  
生理学处理后植物响应



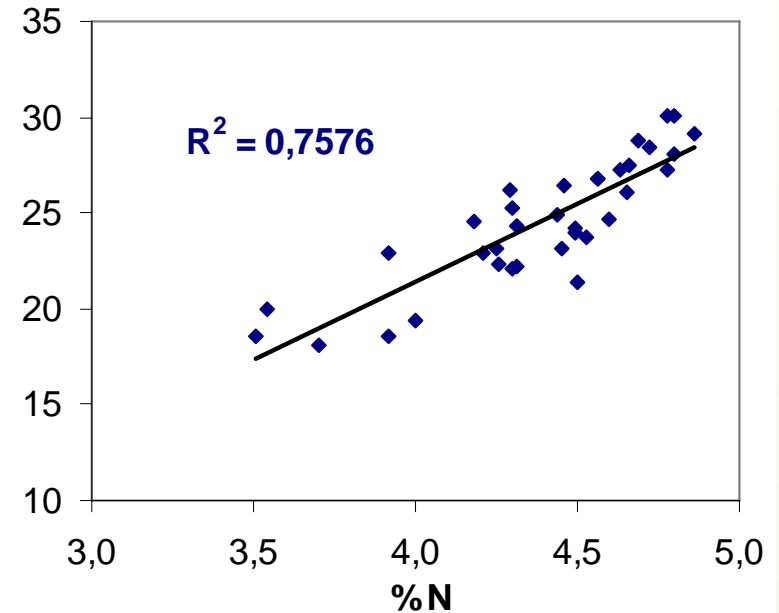
**Chl (Dualex units) 叶绿素 (Dualex 测量单位)**



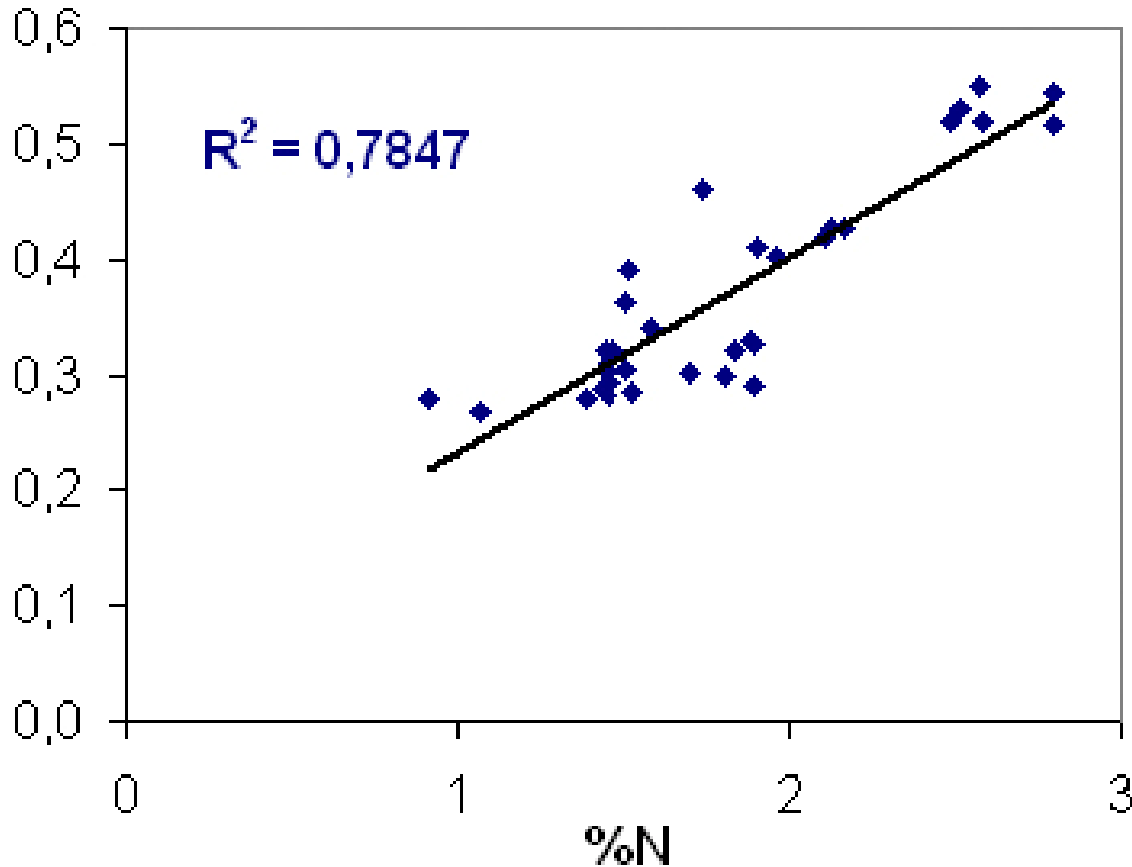
**Flav (Dualex units) 类黄酮 (Dualex 测量单位)**



**NBI (Dualex units) 氮平衡指数 (Dualex 测量单位)**

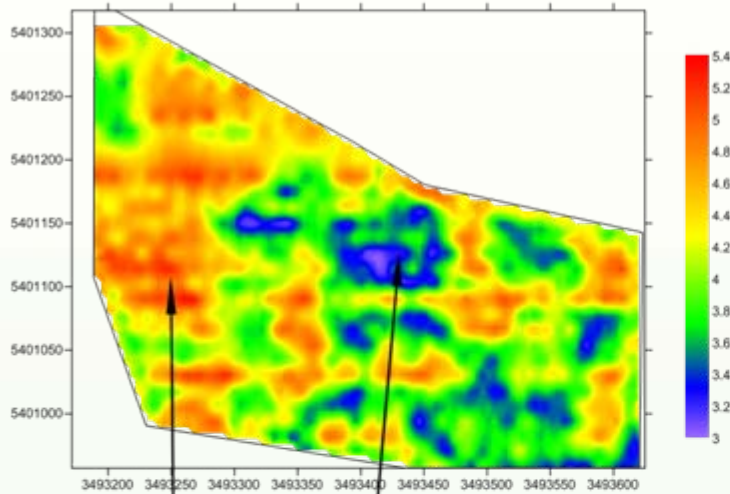


NBI (Multiplex units)  
氮平衡指数 (Multiplex 单位)

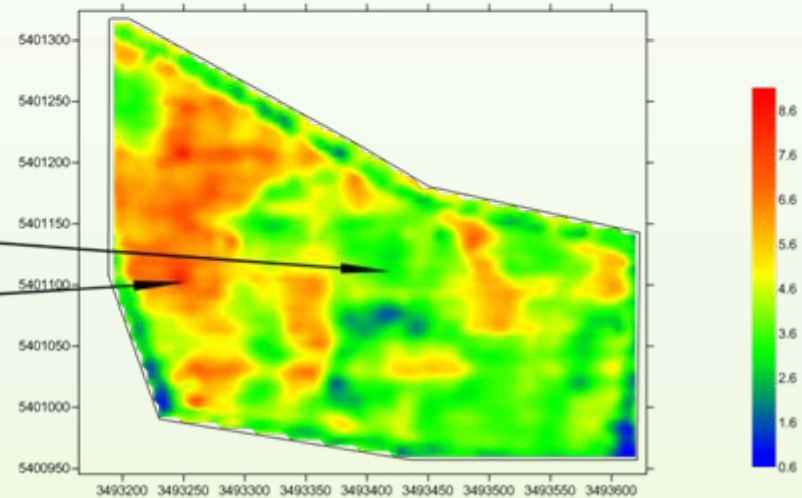


# MULTIPLEX: Wheat (intra-plot management) 小麦 (制图及营养管理)

NBI\_R : Nitrogen status  
氮肥状态



Yield 作物产量



氮肥状况差

氮肥状况好

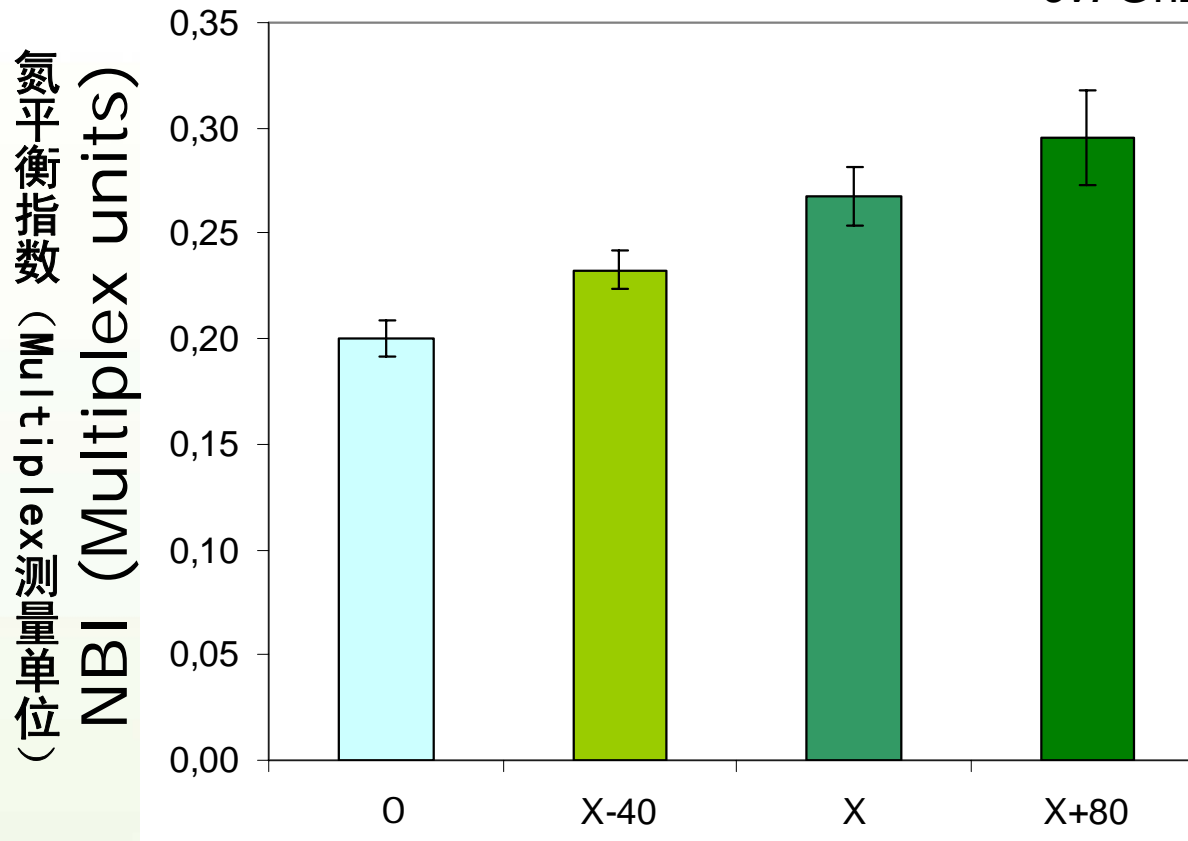


**RAPSEED**

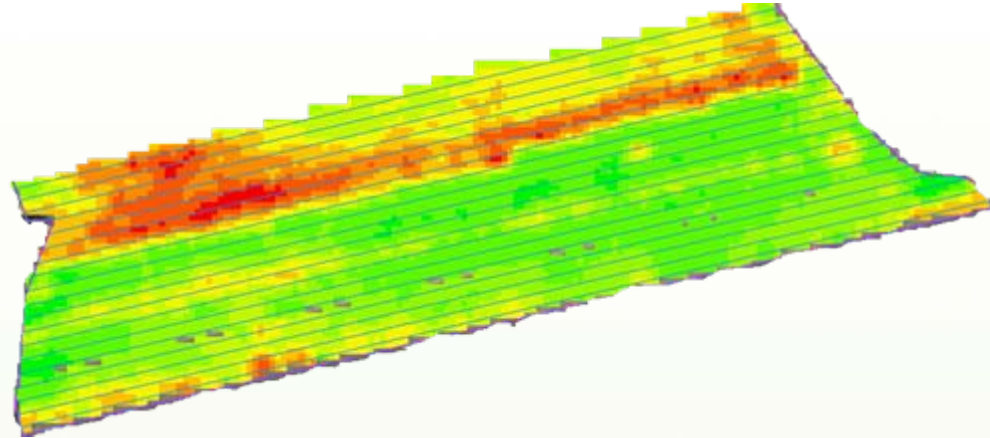
**油菜籽**



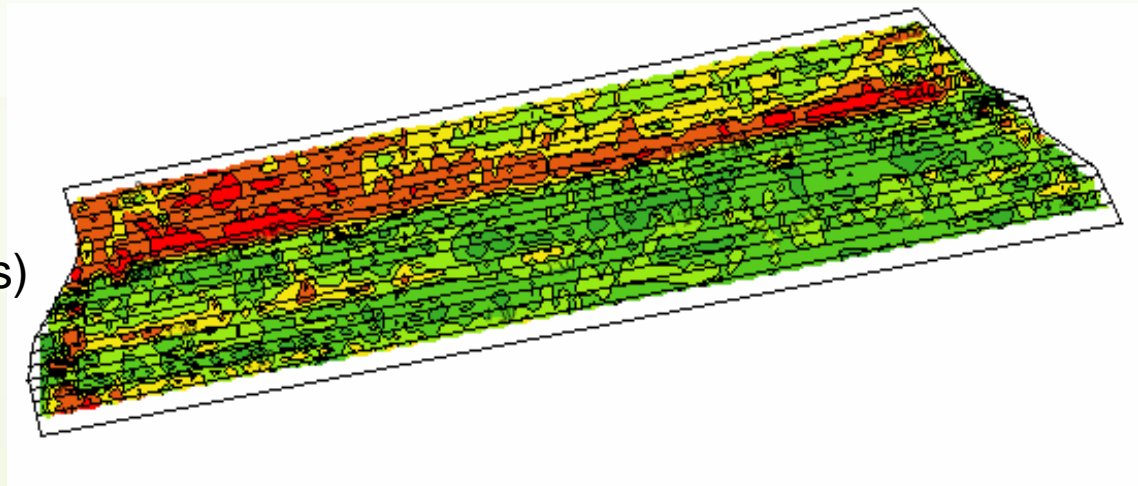
cv. Grizzly, at flowering



Satellite (reflectance)  
卫星图片 (反射)



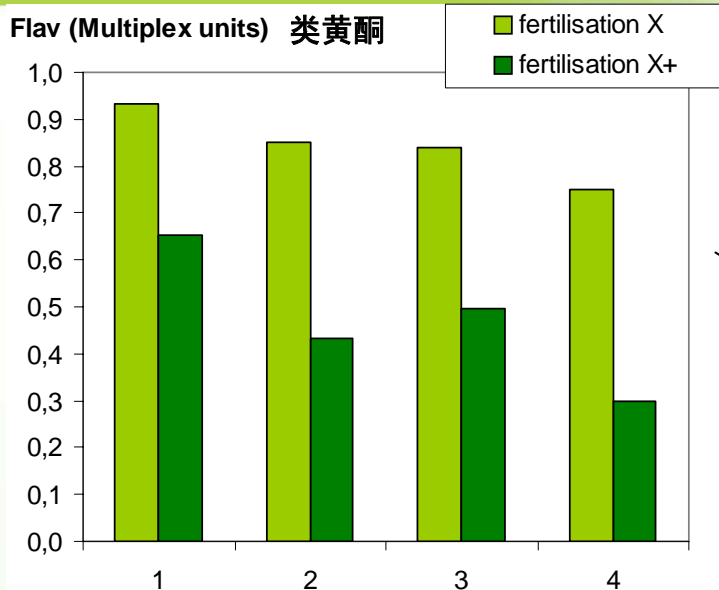
MULTIPLEX<sup>®</sup>(biomass)  
(生物量)



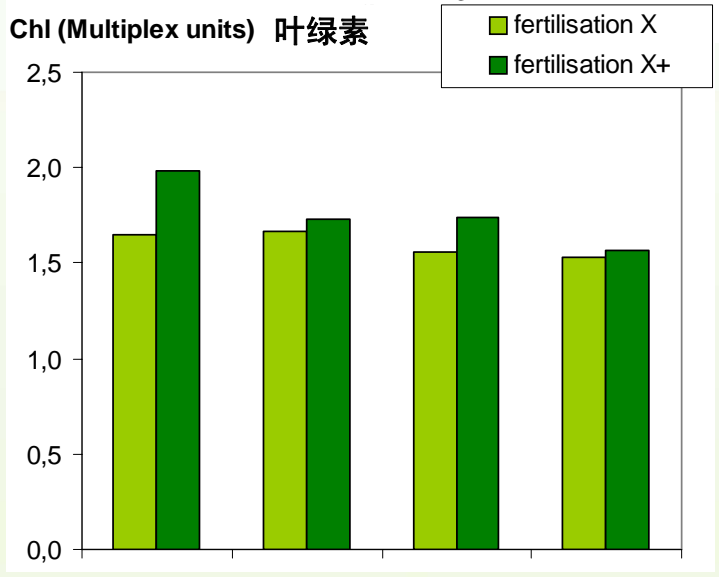


**MAIZE**

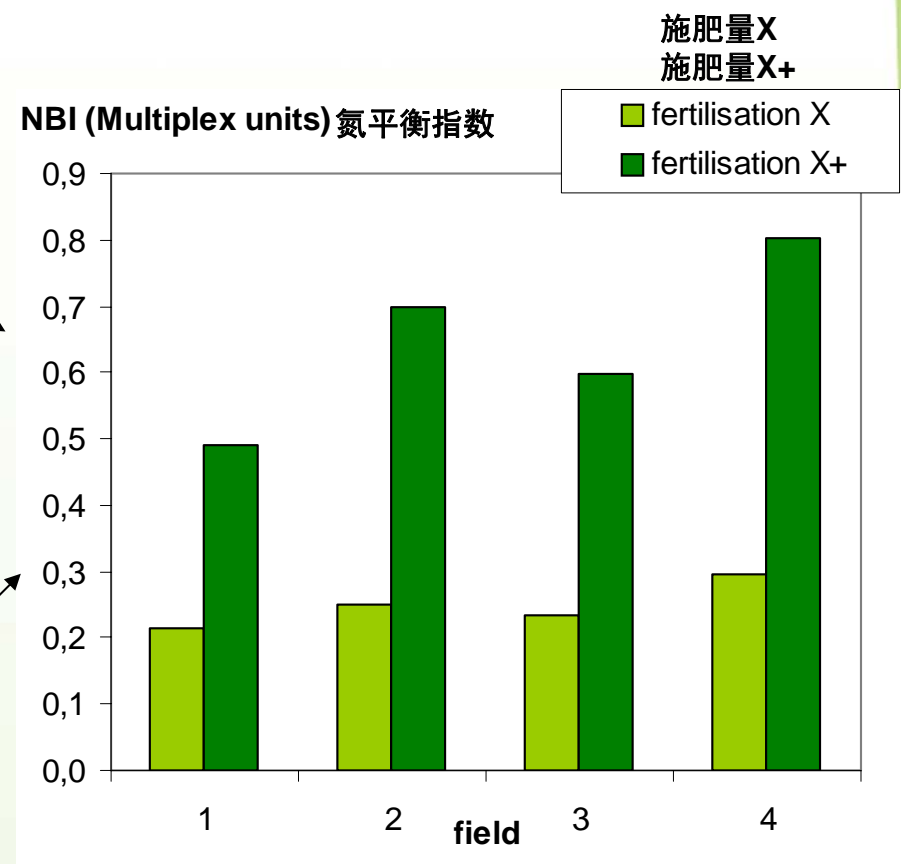
**玉米**



施肥量X  
施肥量X+



施肥量X  
施肥量X+



施肥量X  
施肥量X+

**Maturity stage, 2009**

**2009年，研究成熟**



# TURF GRASS

## 草坪



◎ Nitrogen fertilisation monitoring

施肥指导

◎ Fertiliser quality assessment

氮肥效果评估

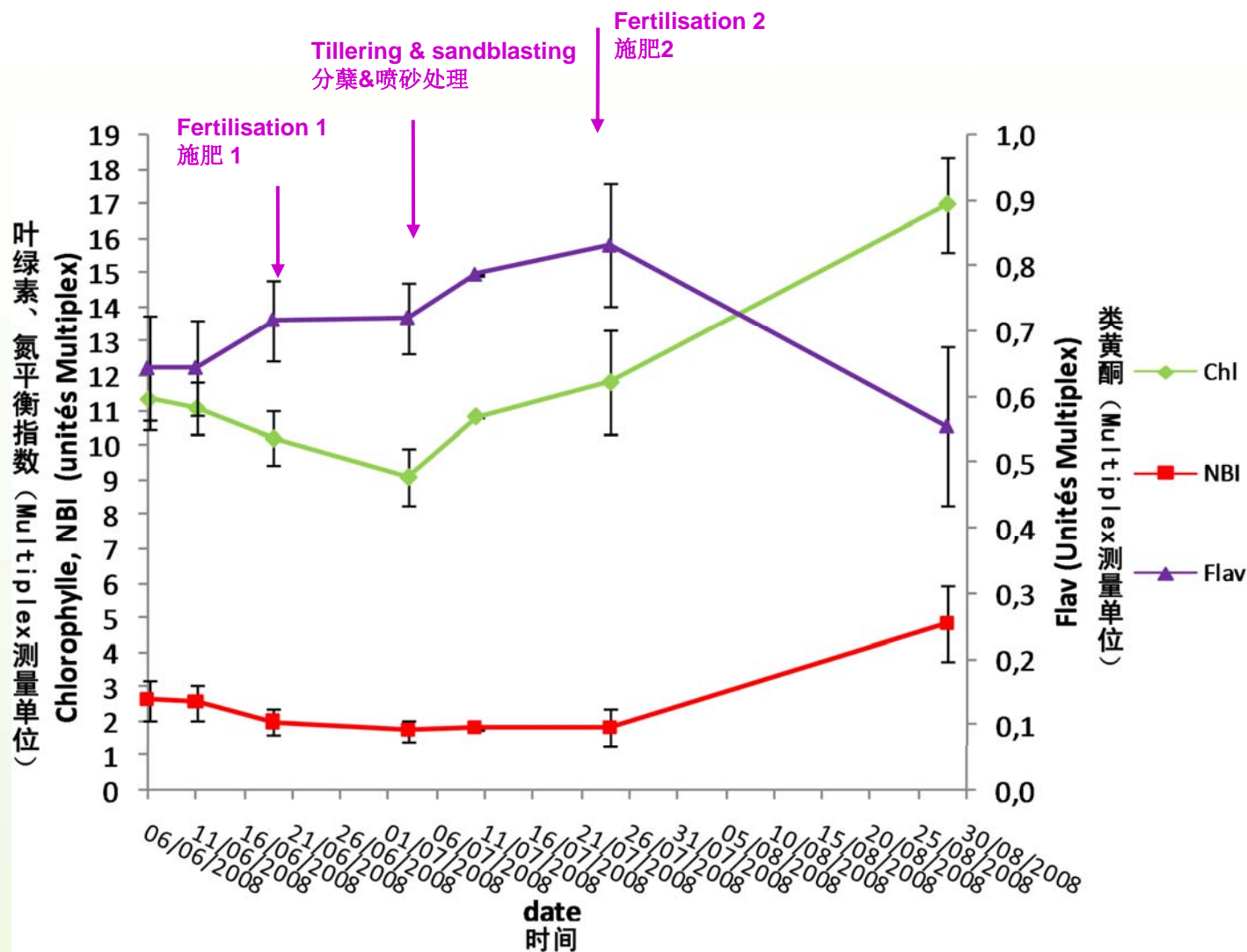
◎ Mapping

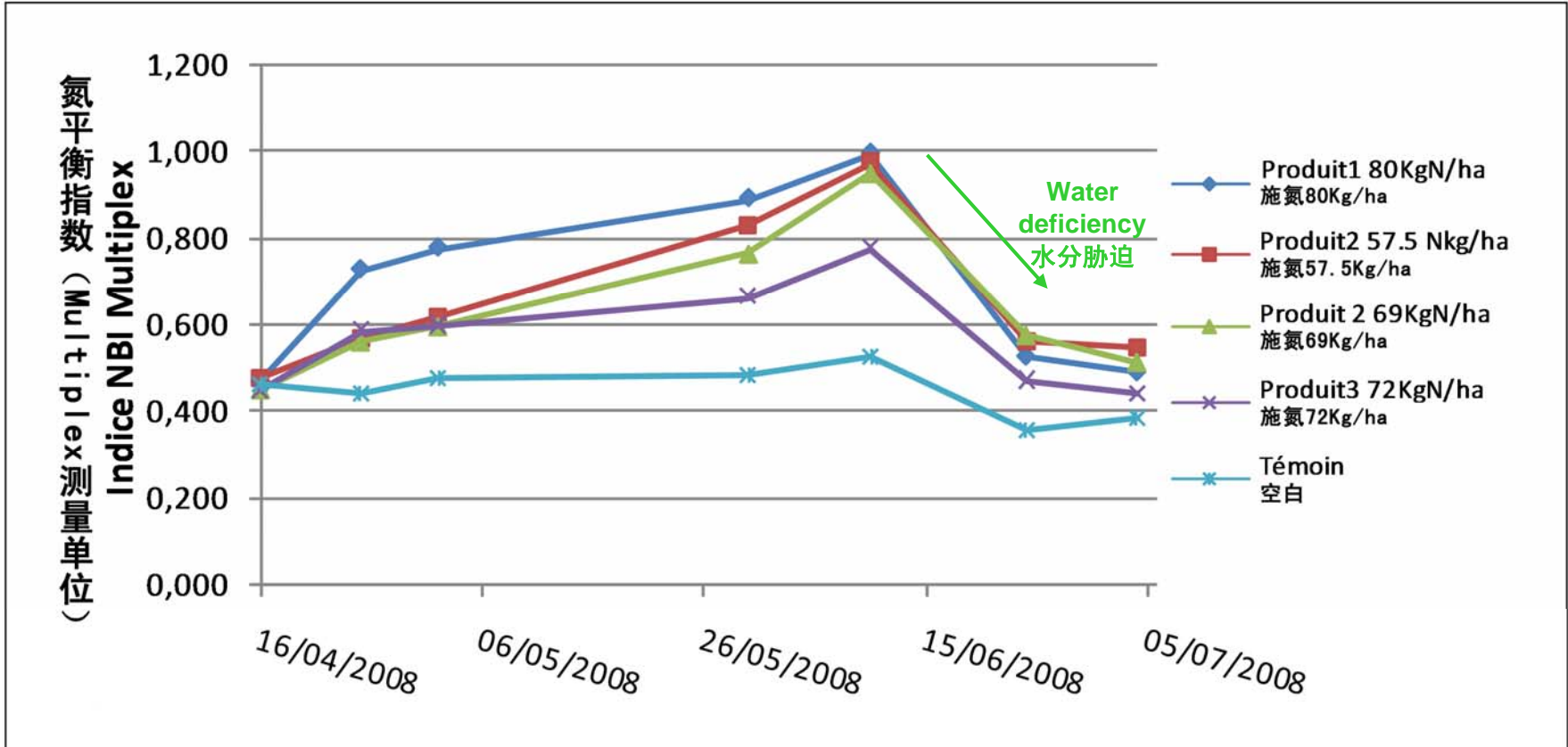
空间格局制图

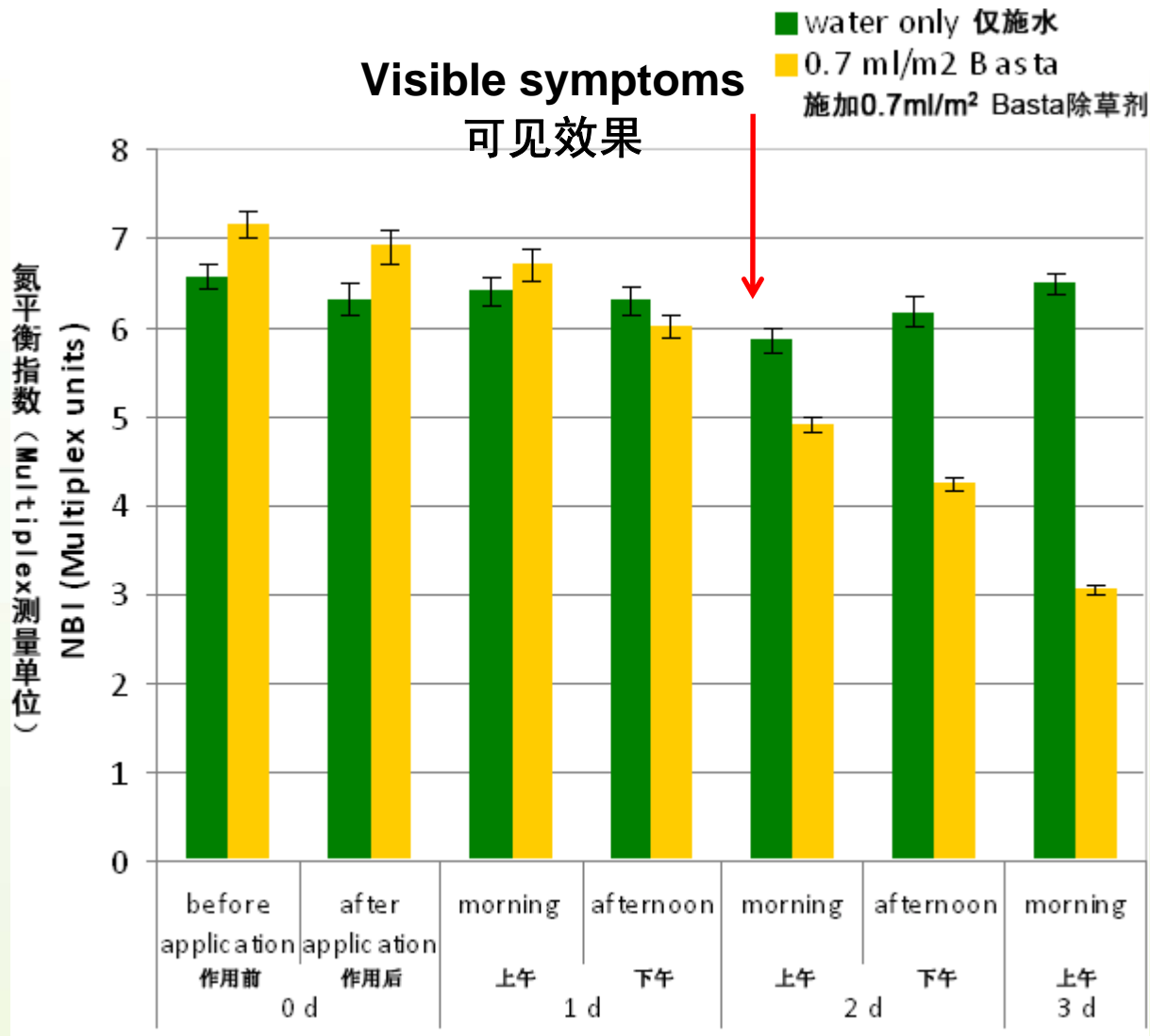
◎ Variety selection

品种选择









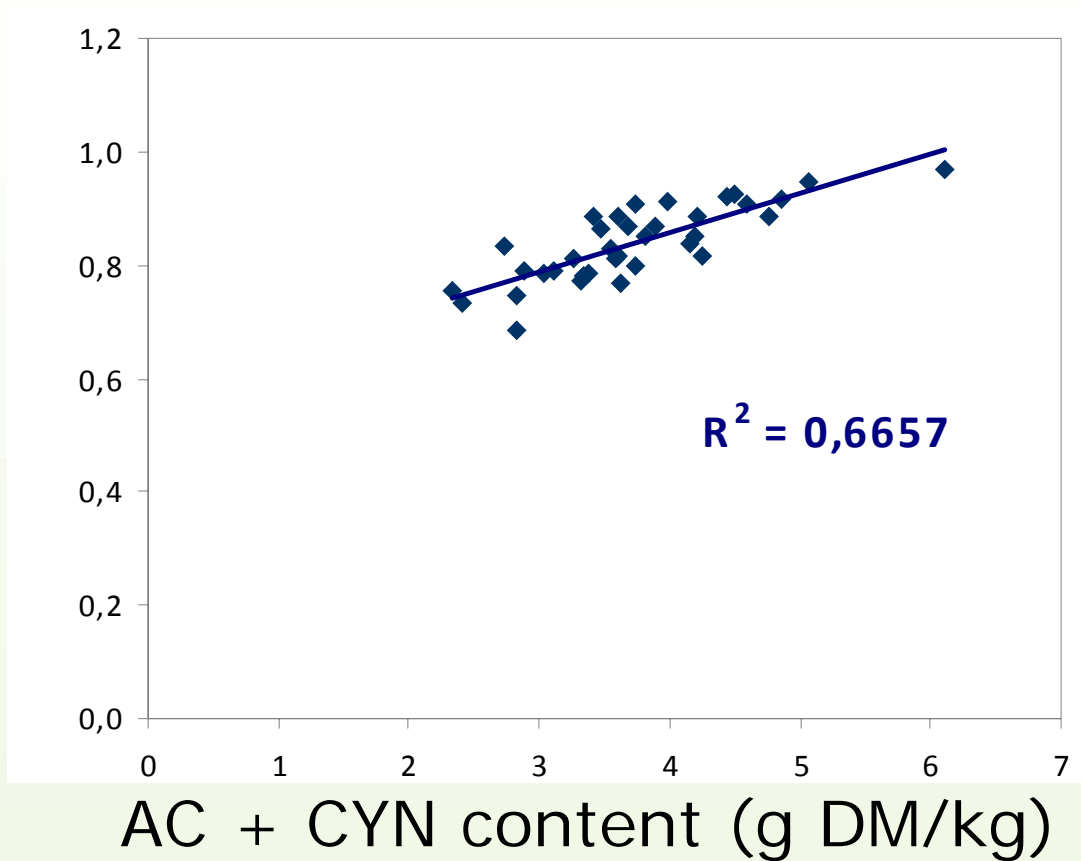


**AROMATIC  
PLANTS  
芳香植物**



FLAV (Multiplex units)

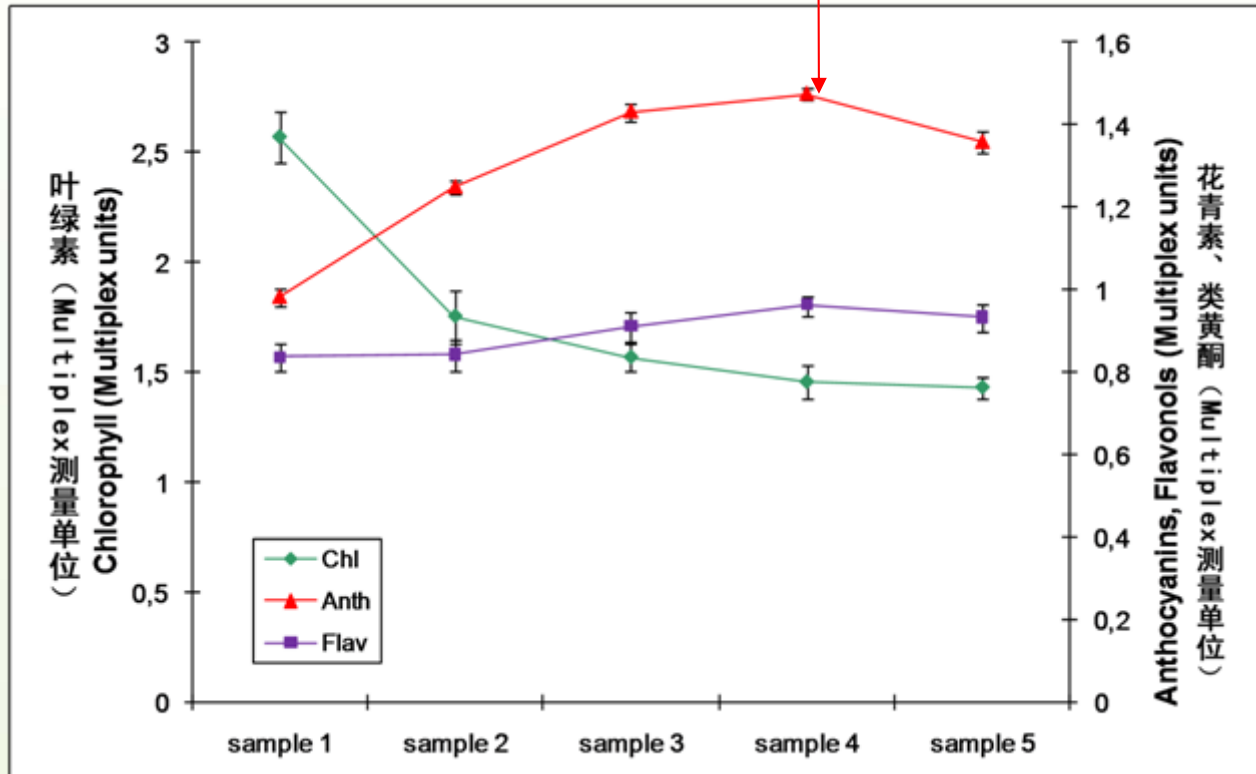
类黄酮 (Multiplex测量单位)





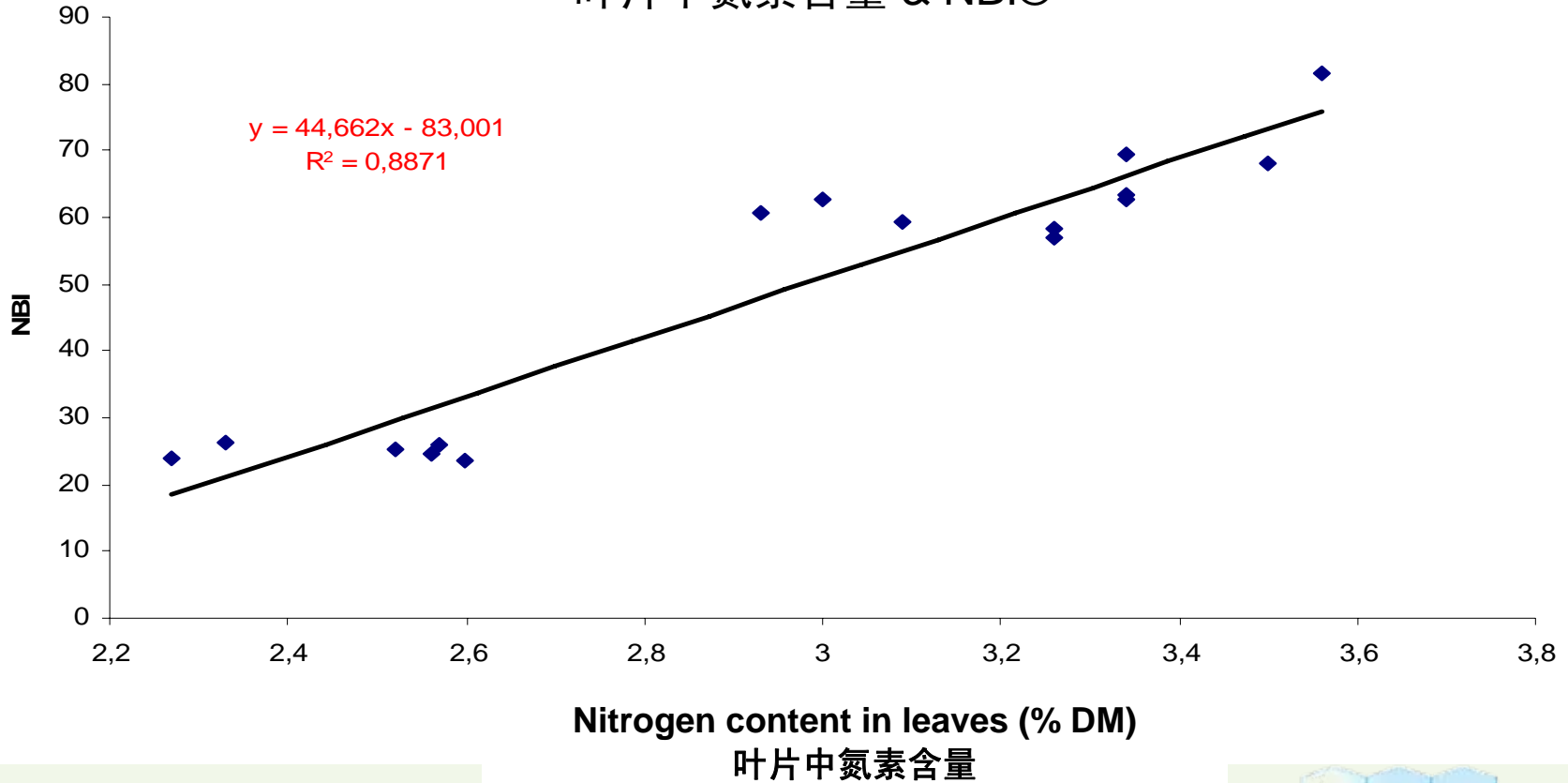
**FRUIT  
BERRIES**  
水果

# MULTIPLEX<sup>®</sup>: Strawberry (maturity monitoring) 草莓 (成熟度测量)



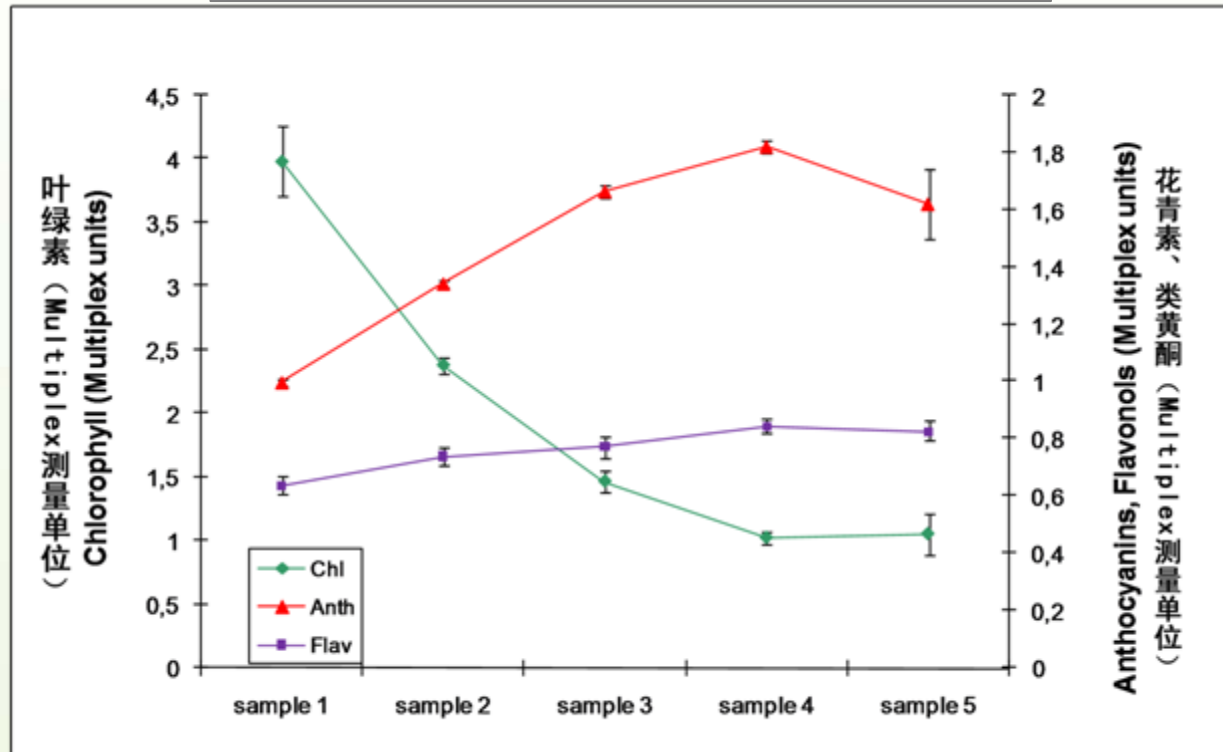
**Chlorophyll, anthocyanins and flavonols measurements**  
叶绿素, 花青素和类黄酮测量

### NITROGEN & NBI<sup>®</sup> 叶片中氮素含量 & NBI<sup>®</sup>



# MULTIPLEX<sup>®</sup>: Raspberry (maturity monitoring)

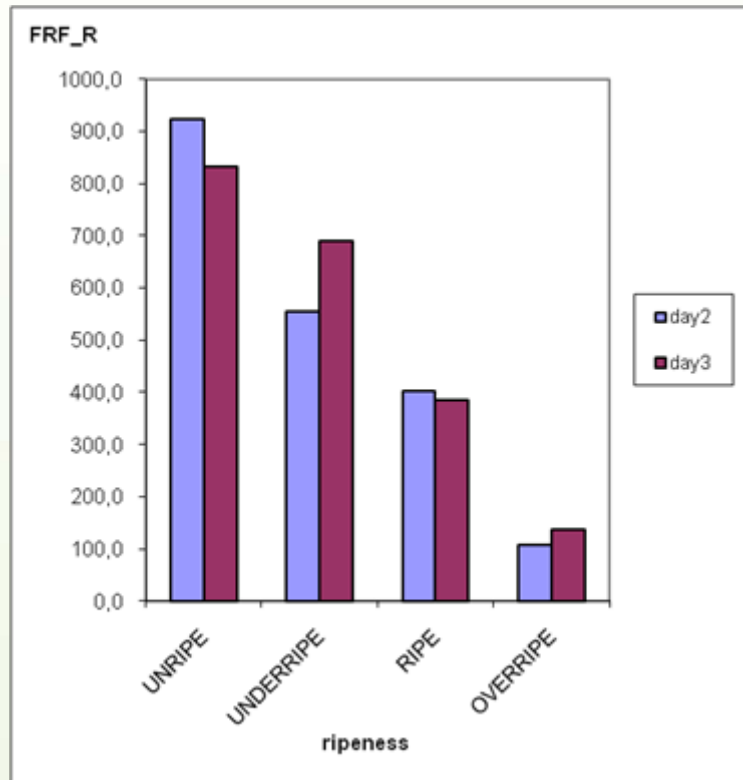
## Raspberry 某种果 (成熟度测量)



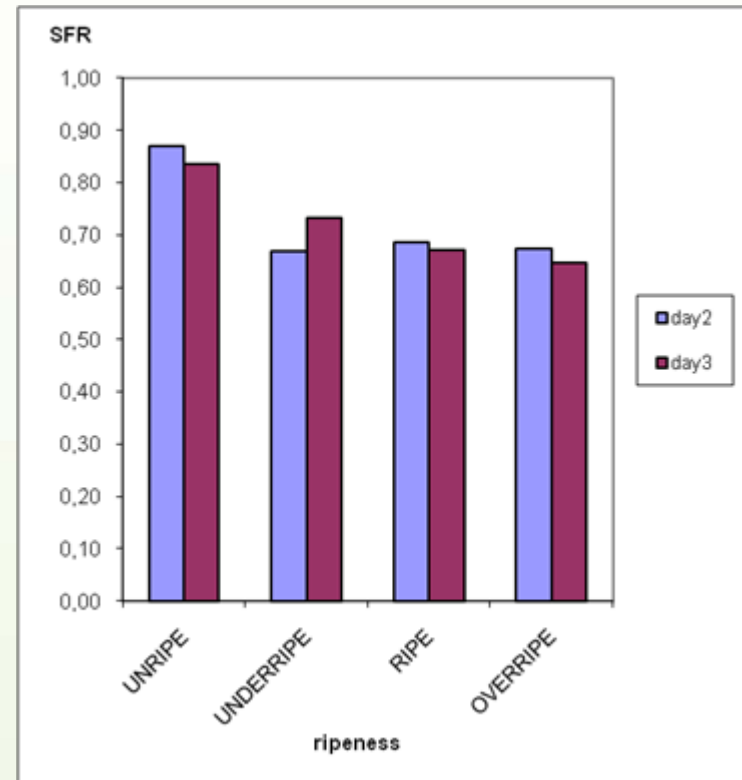
**Chlorophyll, anthocyanins and flavonols measurements**  
叶绿素, 花青素和类黄酮测量



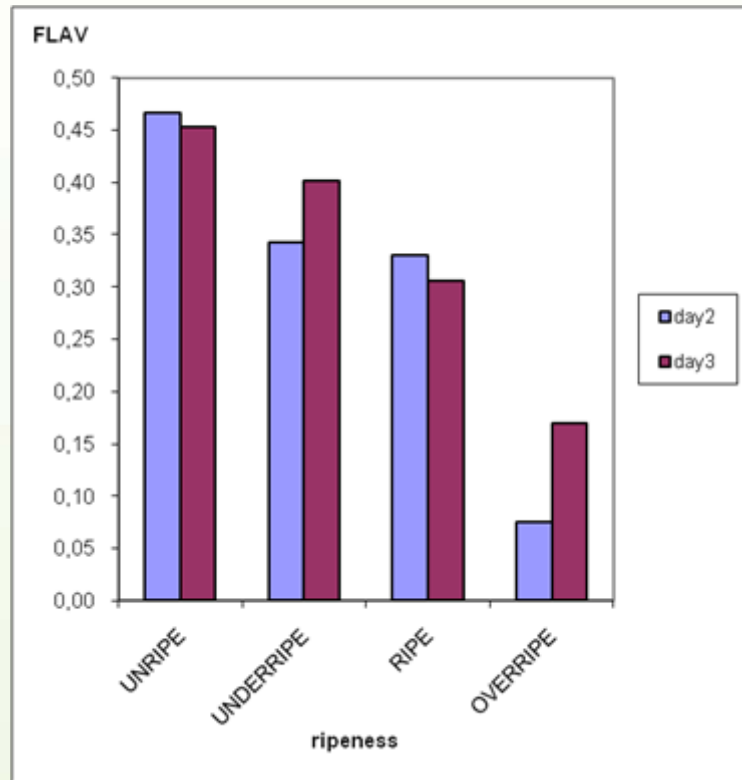
**Alive biomass**  
**存活生物量**



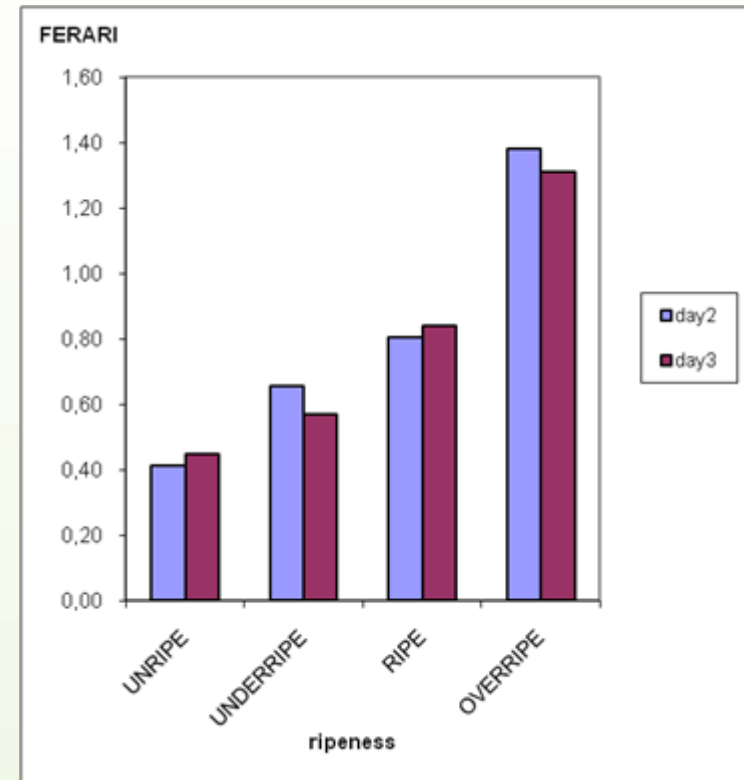
**Chlorophyll**  
**叶绿素**



## Flavonols 类黄酮



## Anthocyanins 花青素





# VEGETABLES

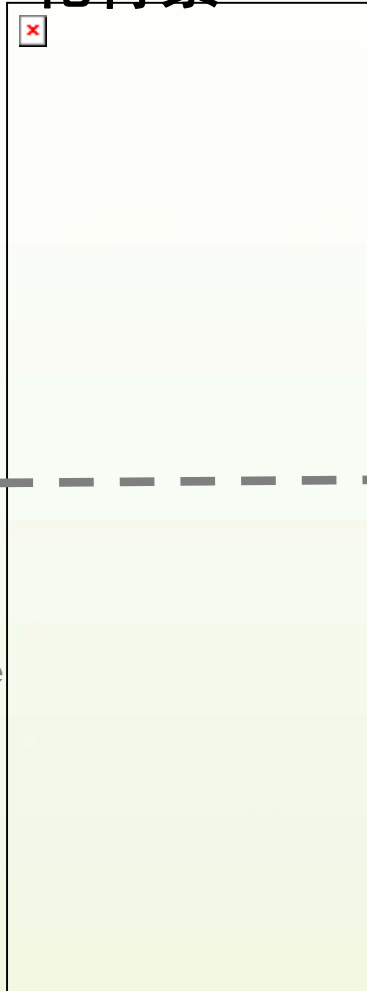
## 蔬菜

Open side  
通气侧



## Anthocyanes

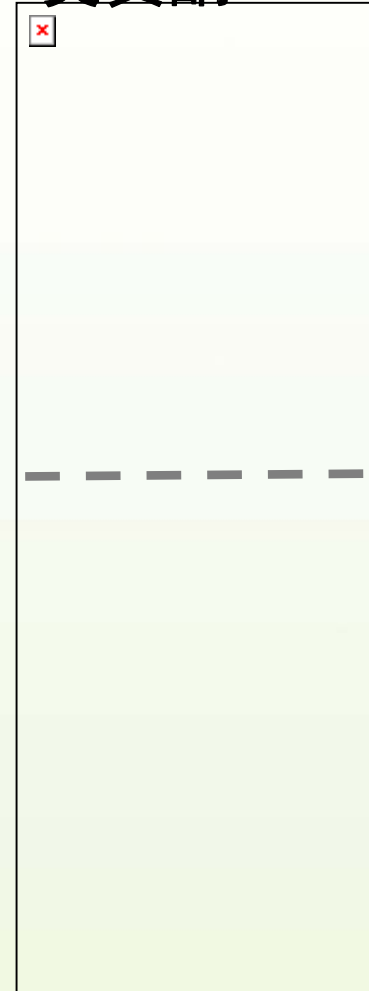
花青素



## Flavonols

类黄酮

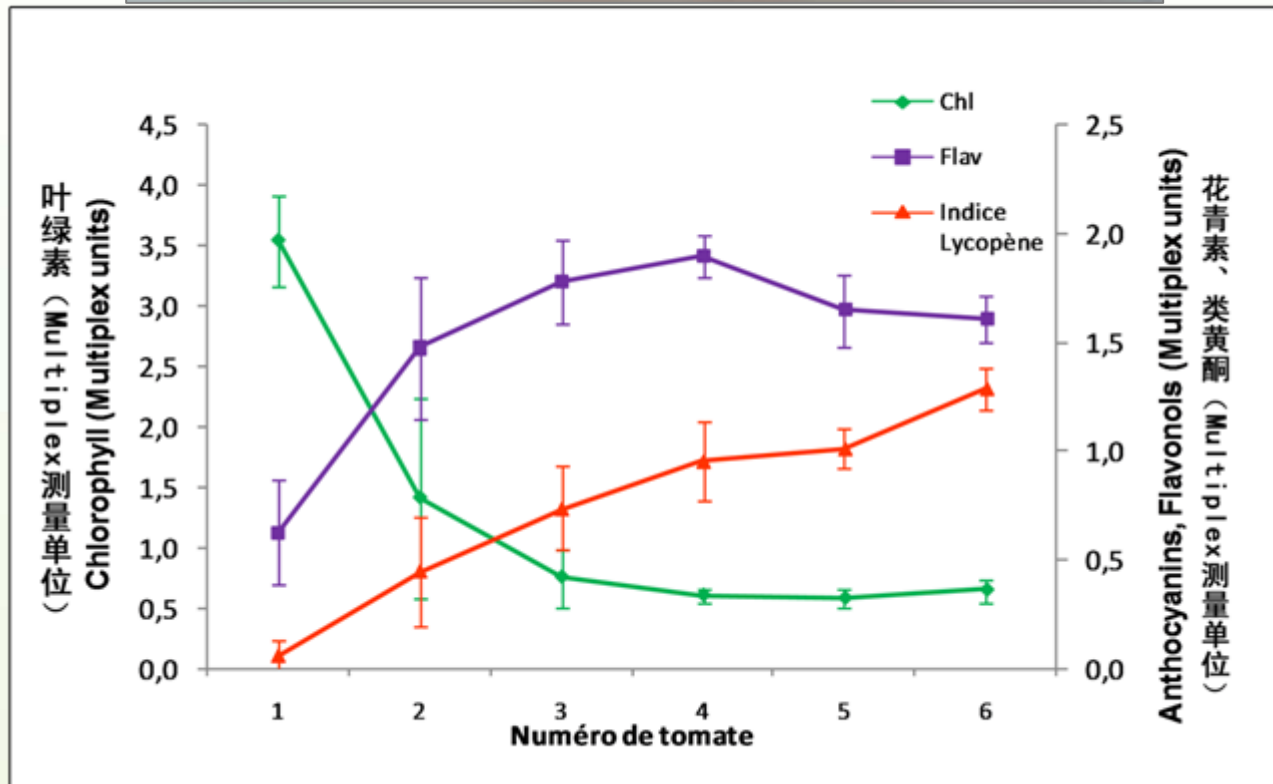
Ctifl



Open side

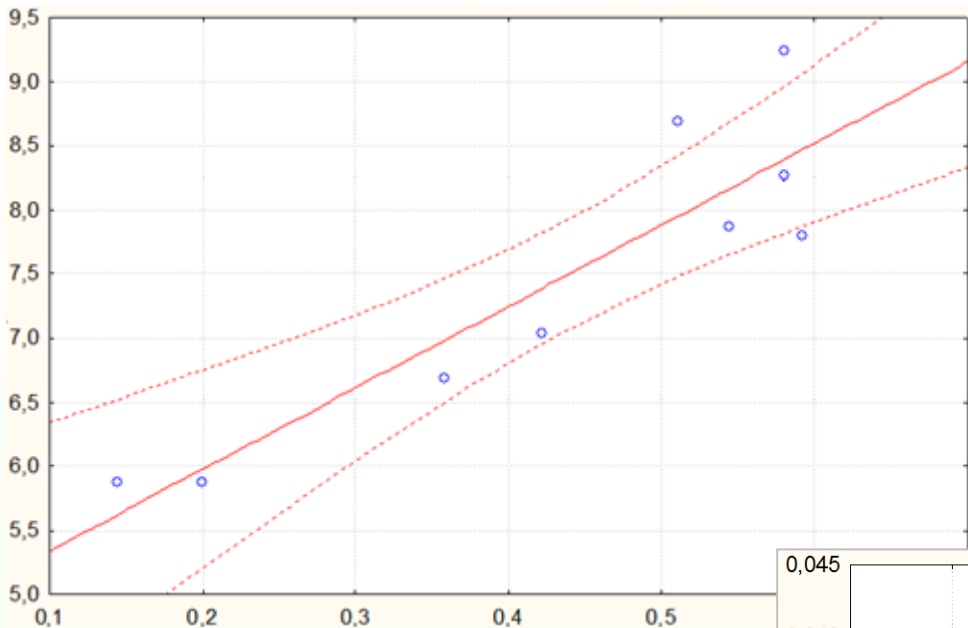
通气侧

# MULTIPLEX<sup>®</sup>: Tomato (maturity monitoring) 西红柿 (成熟度测量)



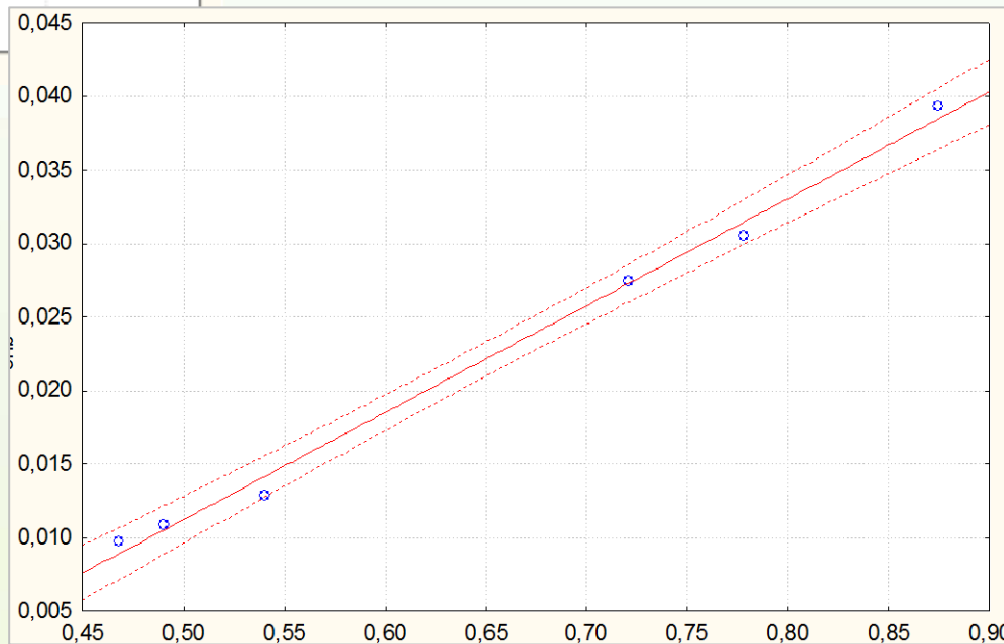
**Chlorophyll, anthocyanins and flavonols measurements**  
叶绿素, 花青素和类黄酮测量





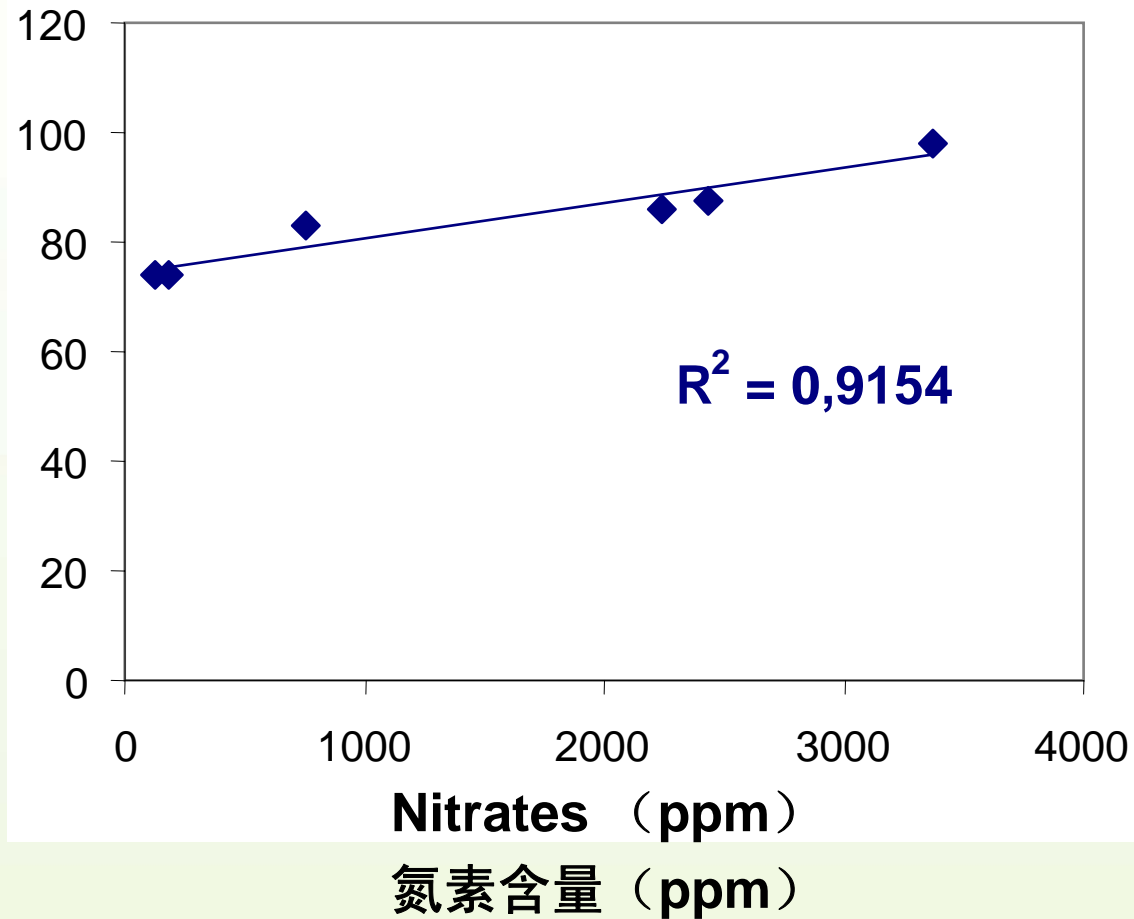
Lycopens:  
番茄红素:  
 $R^2=0.9$

Quercetrin  
槲皮苷  
 $R^2=0.99$

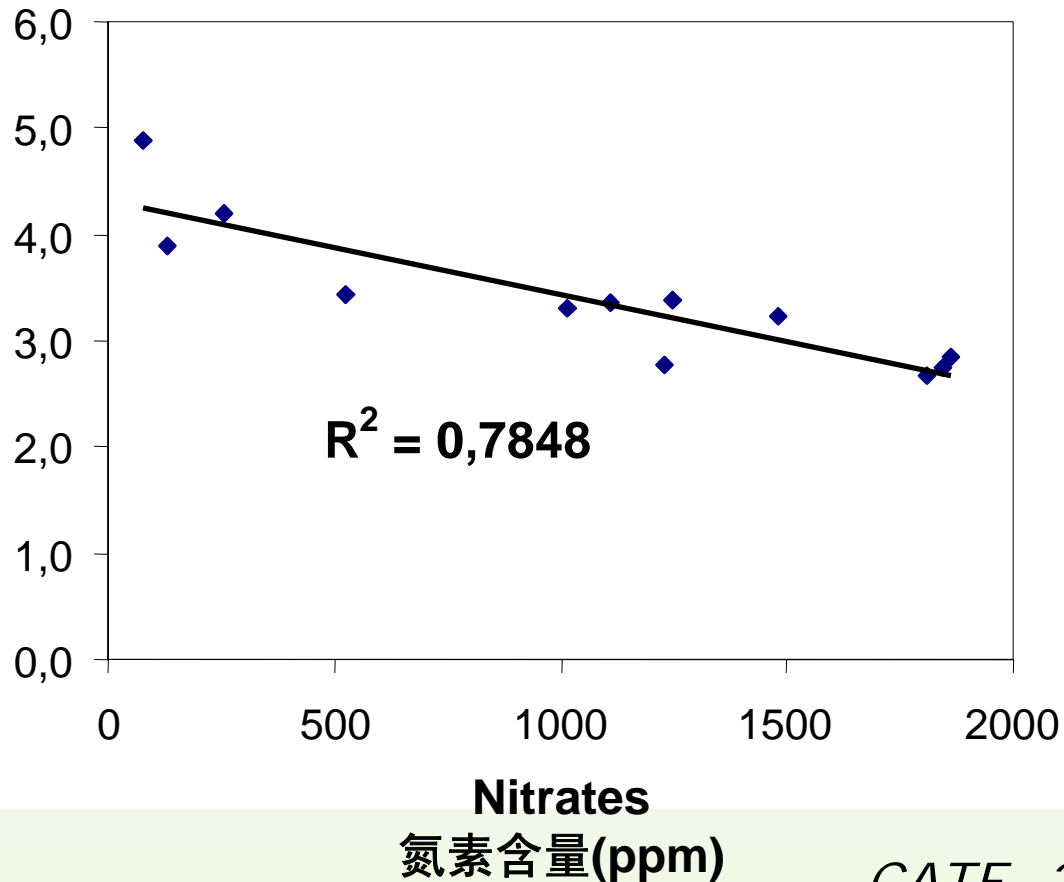


**NBI (Dualex units)**

**NBI ( Dualex 测量单位 )**

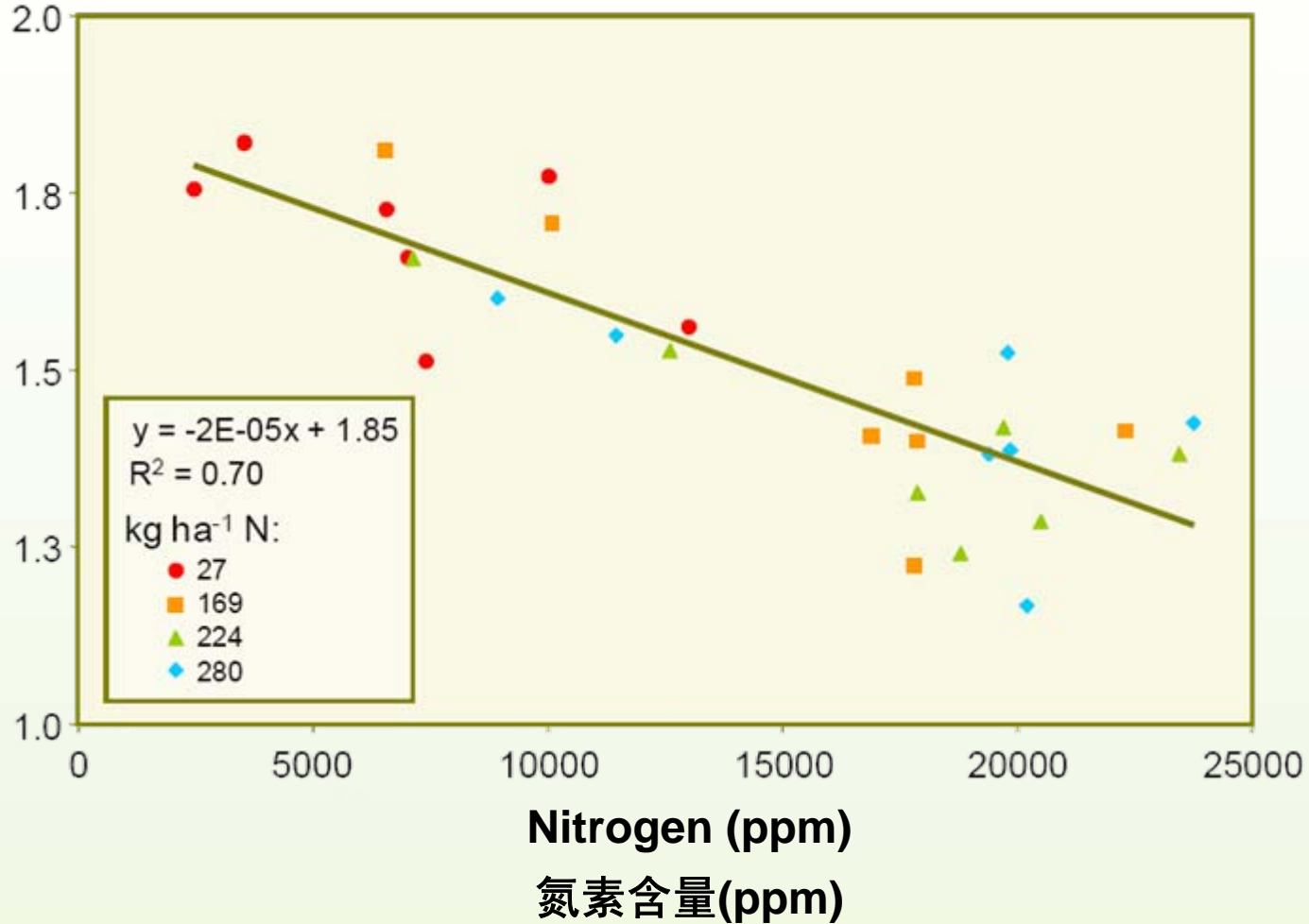


Phen/Chl  
NBI(Multiplex测量单位)



CATE, 2005

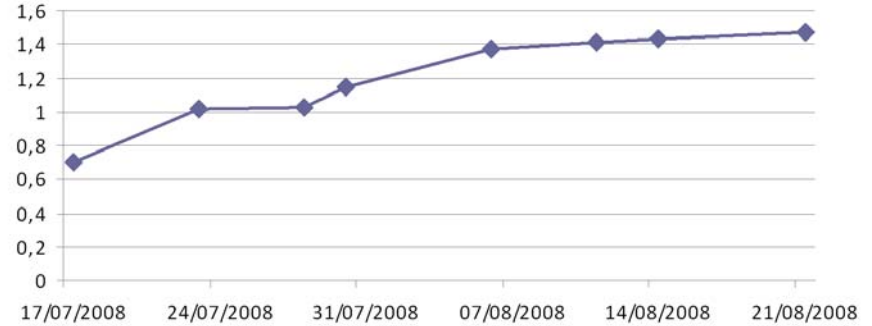
**NBI (Multiplex 测量单位)**



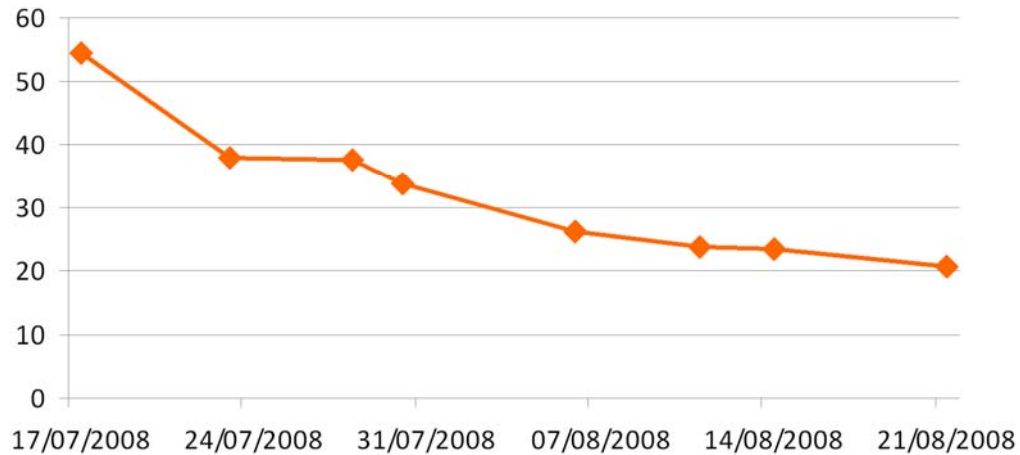
**Chlorophyll (SPAD units) 叶绿素 (SPAD)**



**Flavonoïdes (Dualex units) 类黄酮**



**NBI (Chl/Flav) 氮平衡指数**





**VINE**  
**葡萄**



## Viticulture

### 葡萄栽培



- ◎ Phenolic maturity monitoring  
成熟度测量
- ◎ Impact of vine-growing practices on quality  
质量检测
- ◎ Management of nitrogenous fertilization on leaves  
叶片测量-氮肥管理
- ◎ Early detection of leaf and fruit diseases (*Plasmopara viticola*)  
叶片果实病害早期检测 (霜霉病)

## Oenology

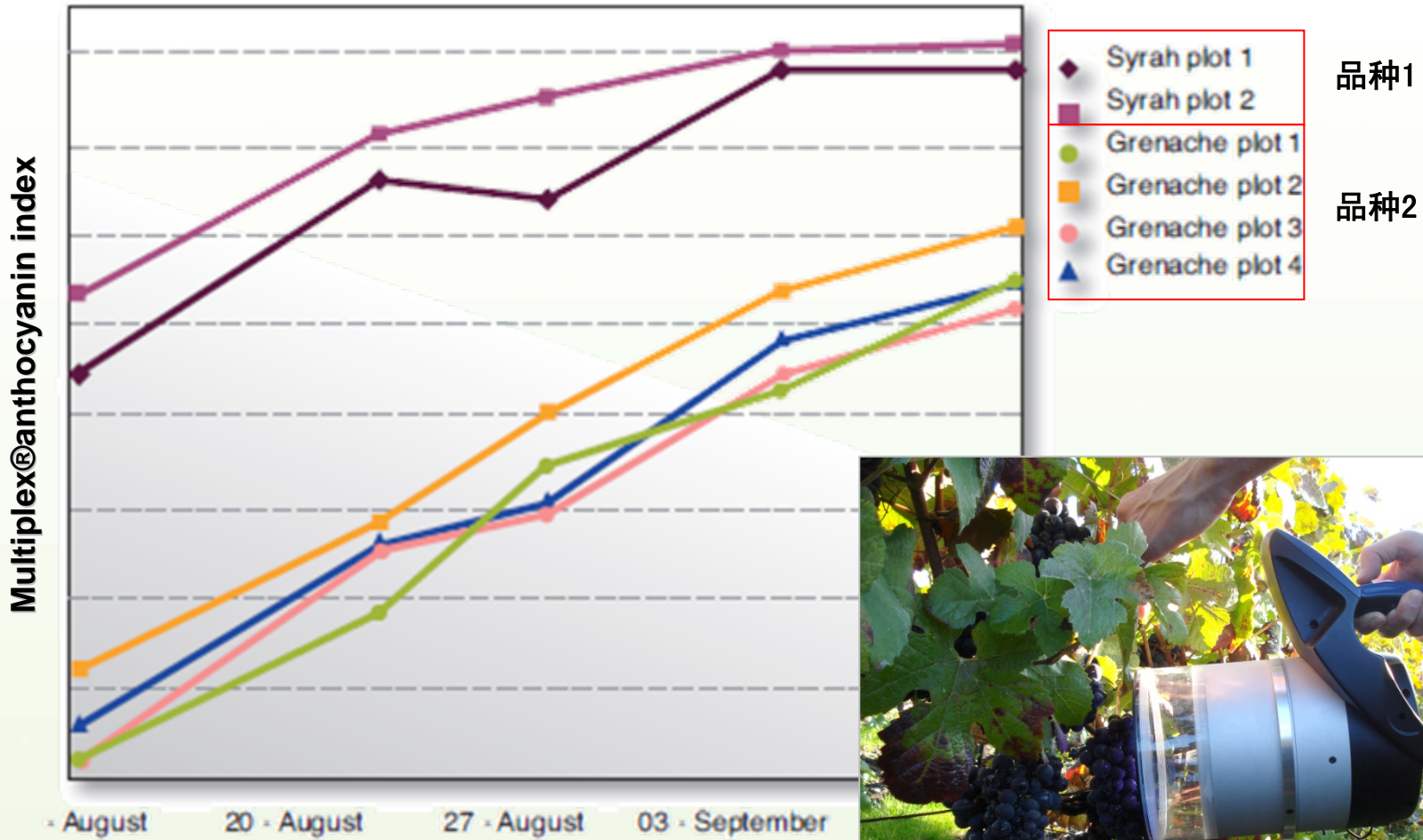
### 酿酒葡萄研究



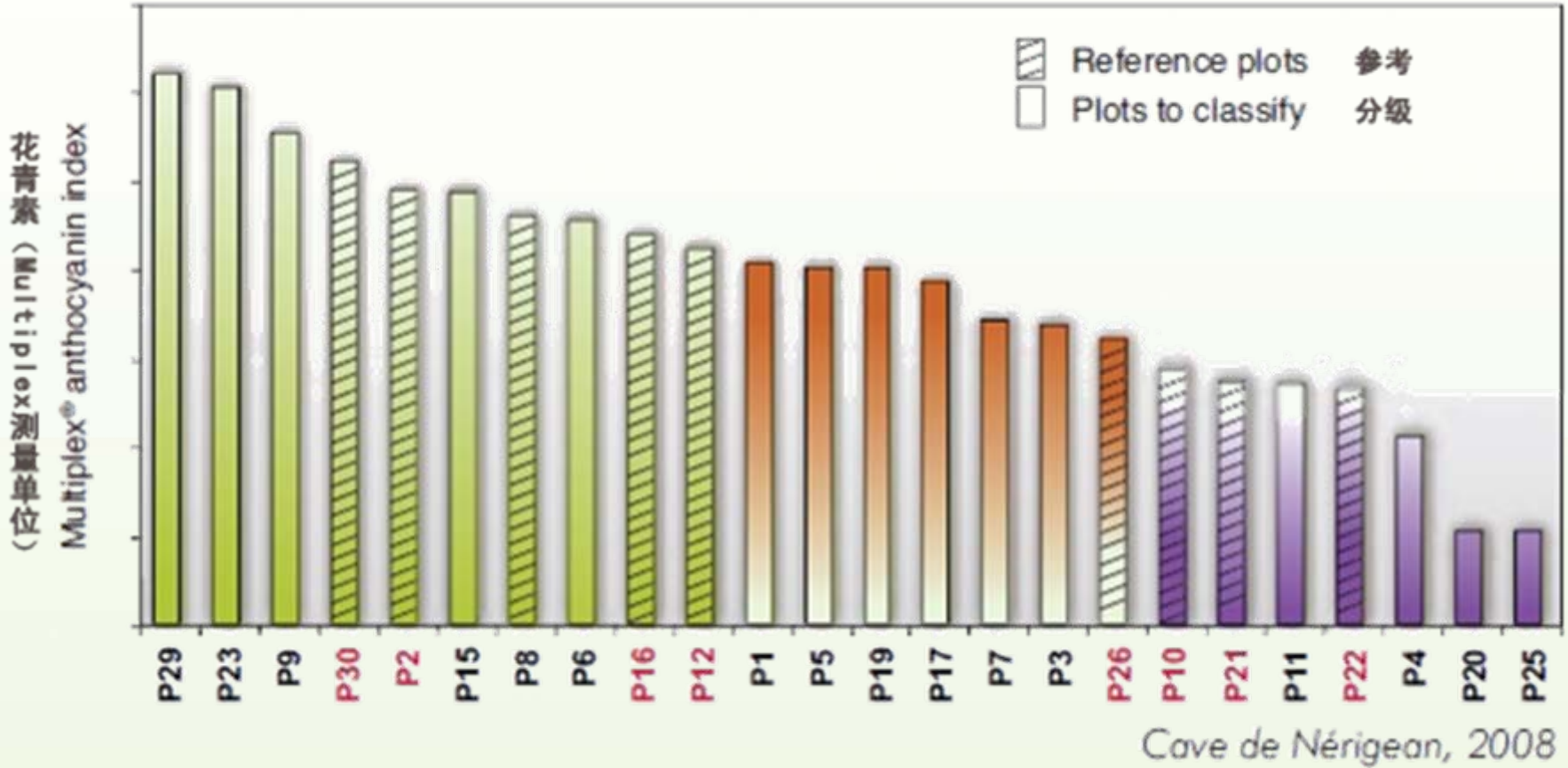
- ◎ Inter-plot management to assemble uniform vats  
葡萄酒的内插值管理
- ◎ Intra-plot grape harvest management  
葡萄成熟度的制图管理
- ◎ Estimation of the available nitrogen potential of the bunches  
氮肥管理

# MULTIPLEX<sup>®</sup>:Vine (maturity monitoring) 葡萄 (成熟度监测)

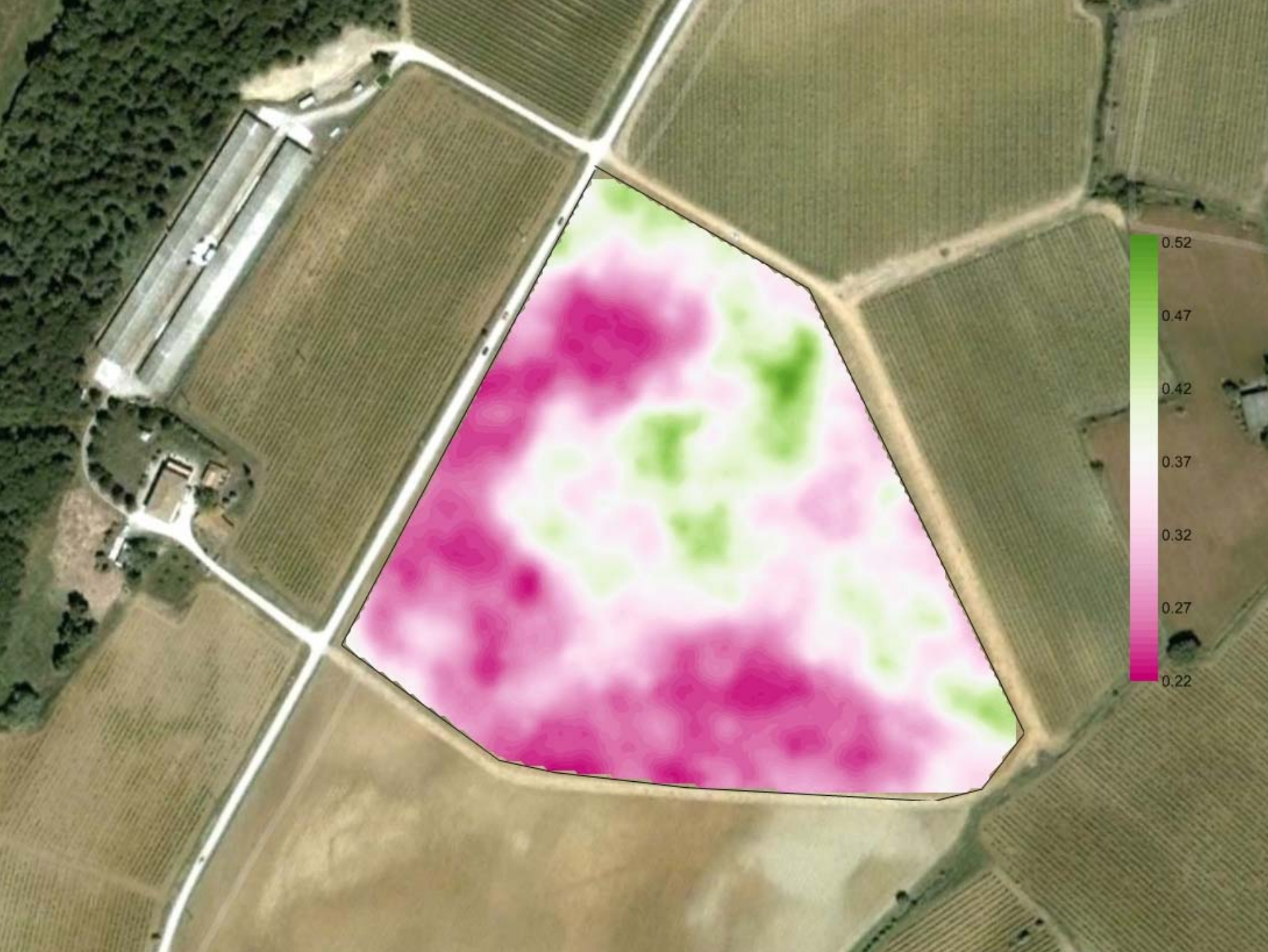
花青素 (Multiplex测量单位)



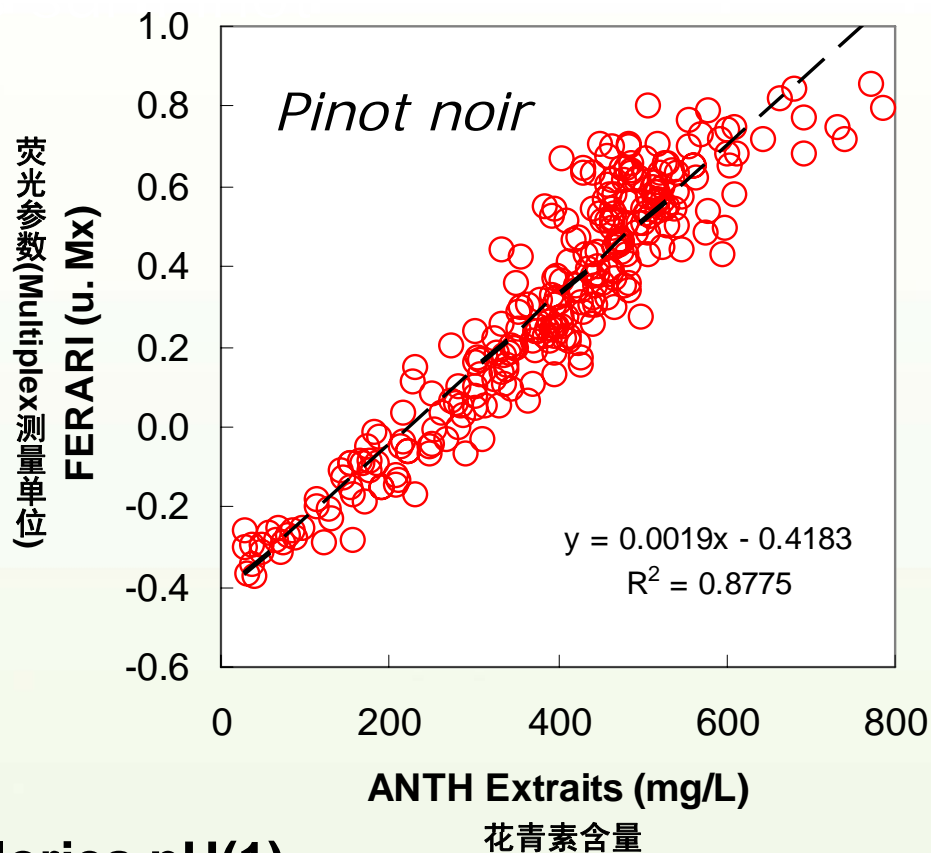
# MULTIPLEX<sup>®</sup>: Vine (inter-plot management) 葡萄 (制图管理)







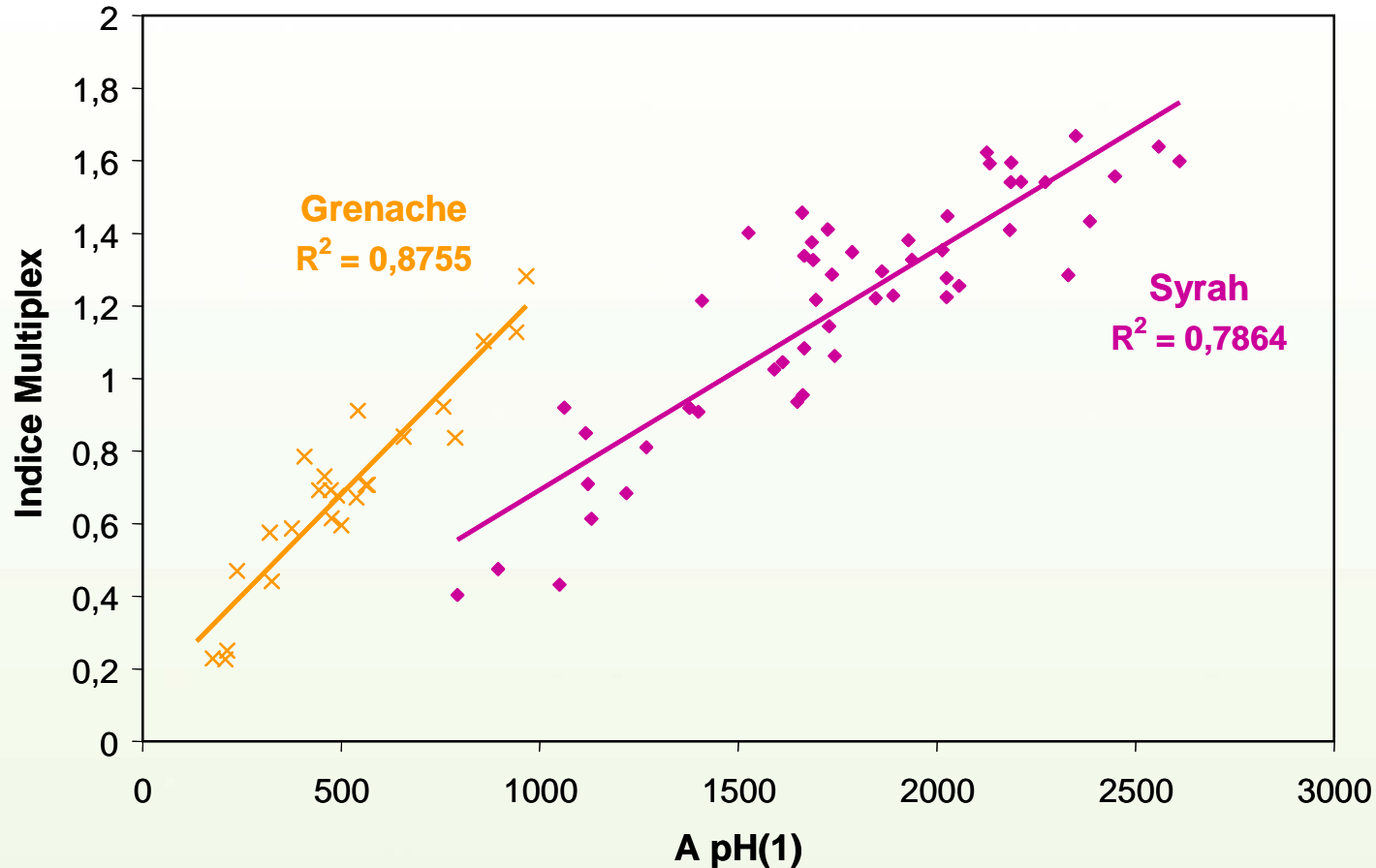
Moët & Chandon - 2008



化学方法: Glories pH(1)

光学方法: MULTIPLEX

ICV - 2008



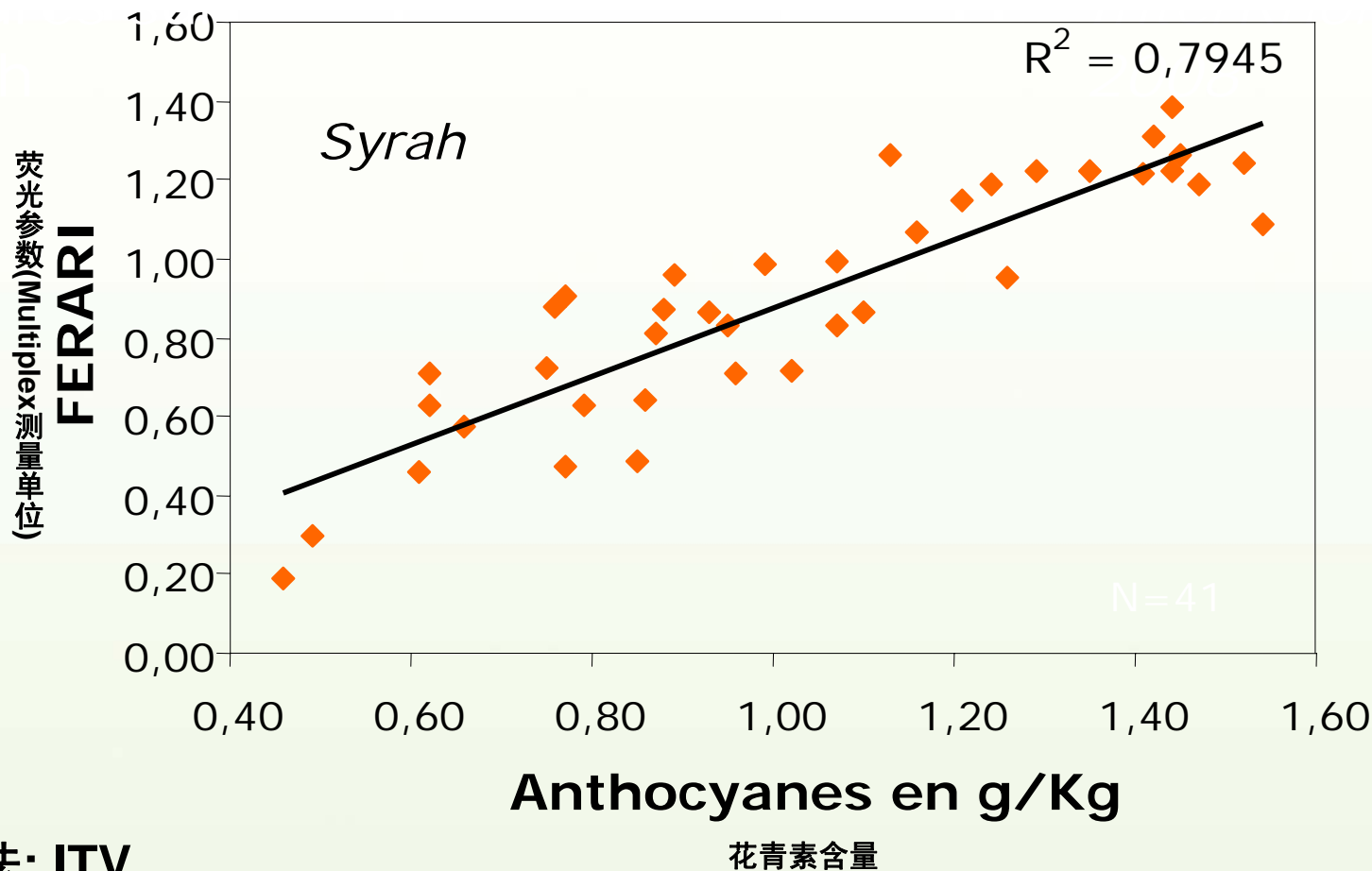
化学方法: Glories pH(1)

光学方法: MULTIPLEX



# MULTIPLEX®:Vine (laboratory calibration) 葡萄 (实验室验证)

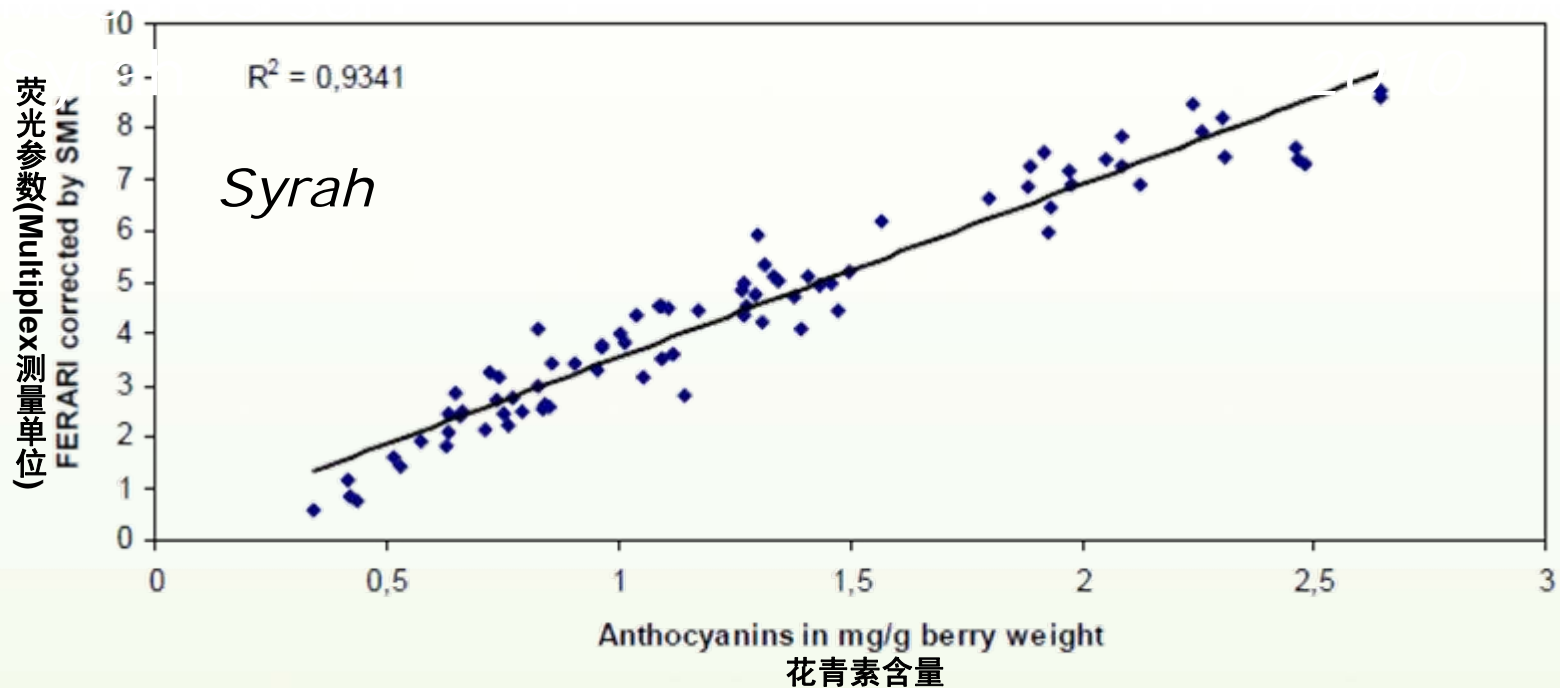
InterRhône - 2008



化学方法: ITV

光学方法: MULTIPLEX

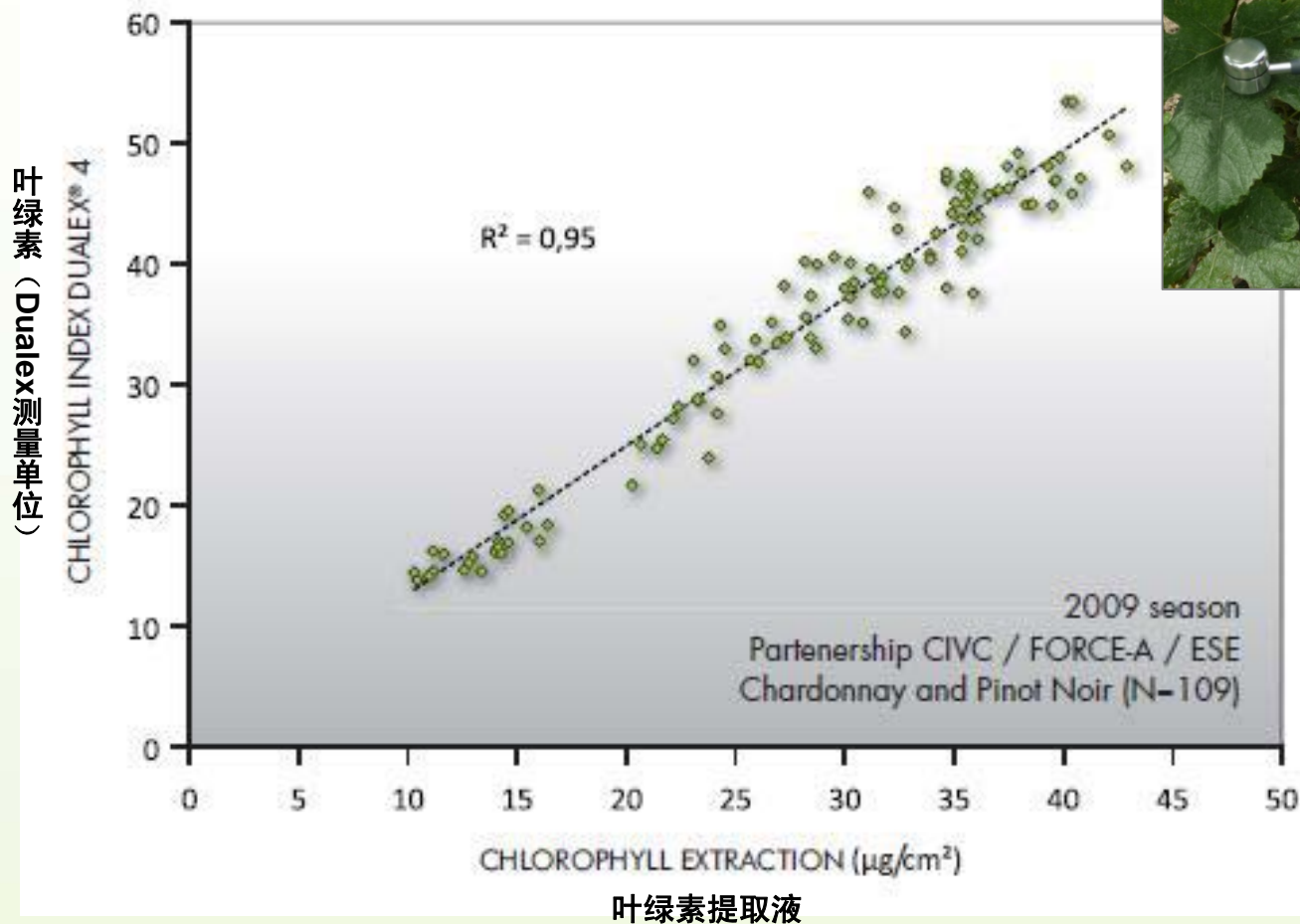
Australie - 2010



化学方法: Hland

光学方法: MULTIPLEX

# DUALEX® 4 : Vine (chlorophyll measurements) 葡萄(叶绿素测量)



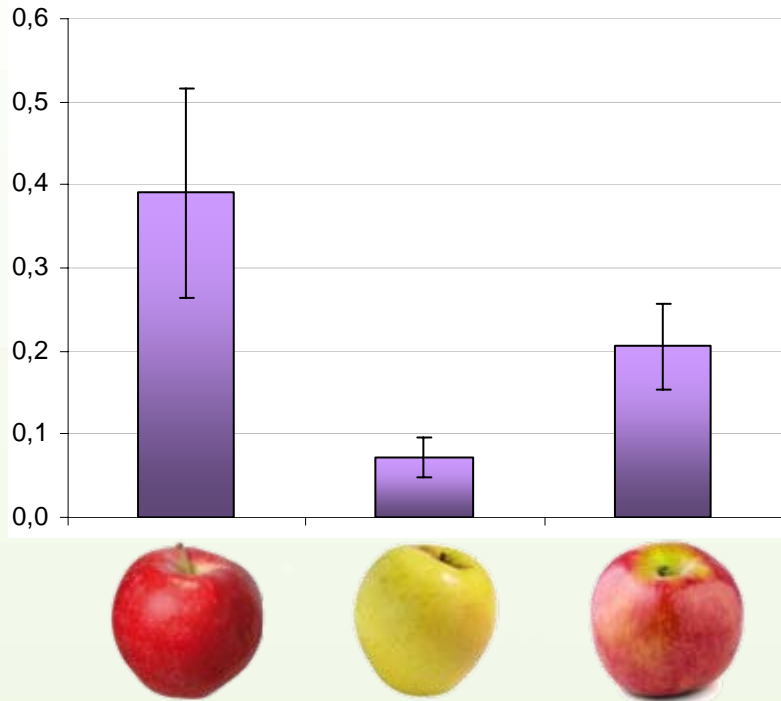


# ARBORICULTURE

## 果树栽培

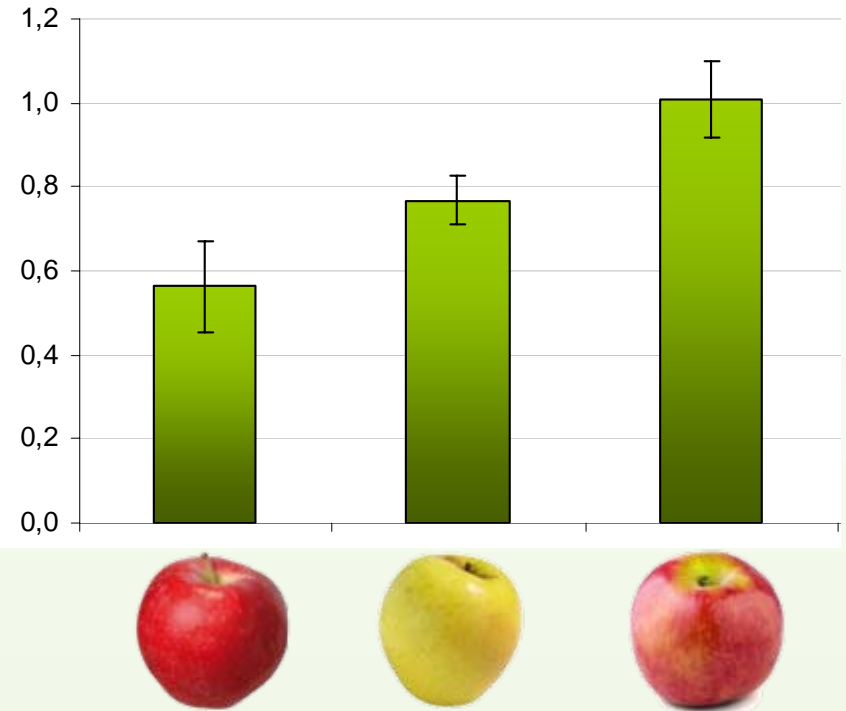
**Anthocyanins Index**  
**花青素指数**

FERARI

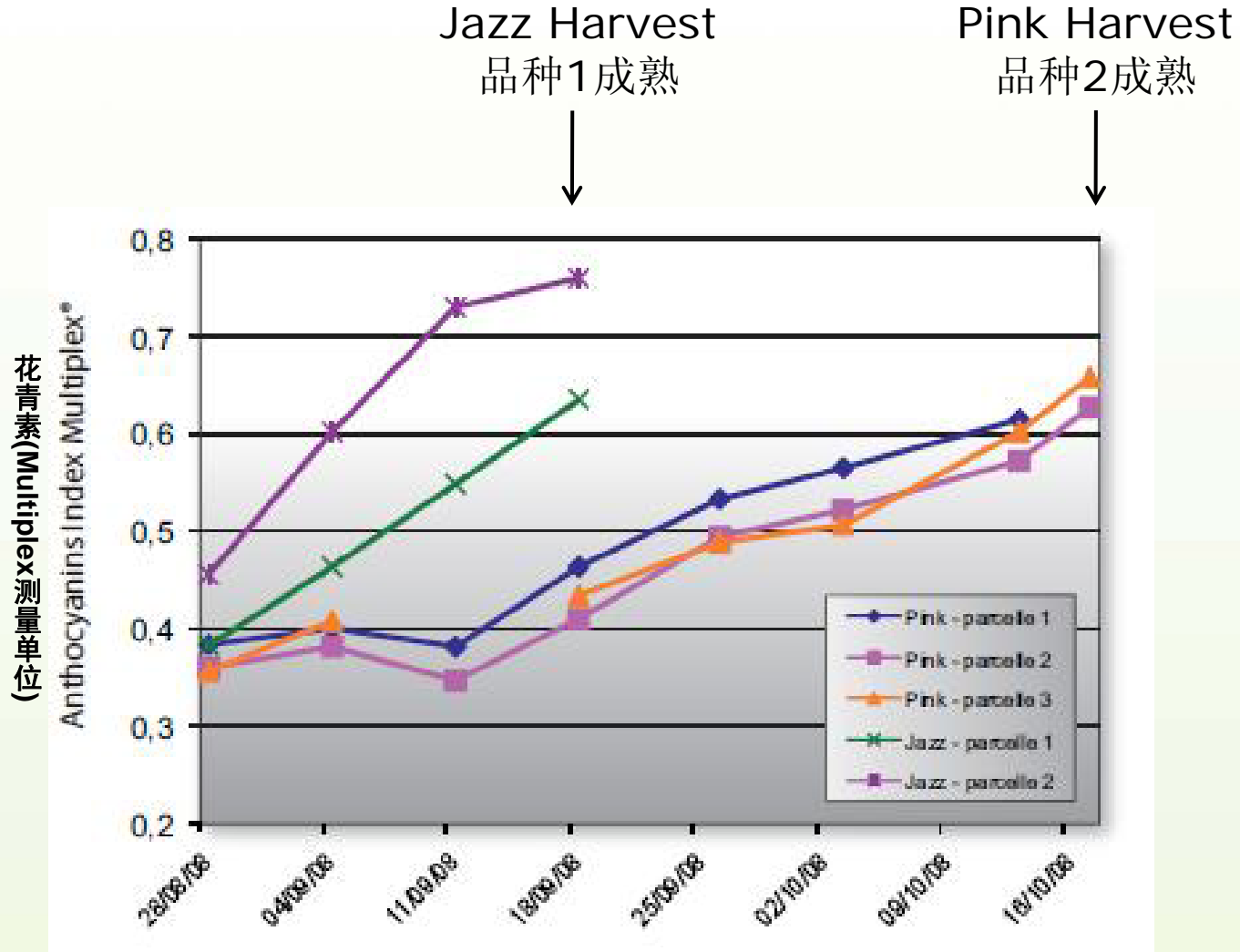


**Chlorophyll Index**  
**叶绿素指数**

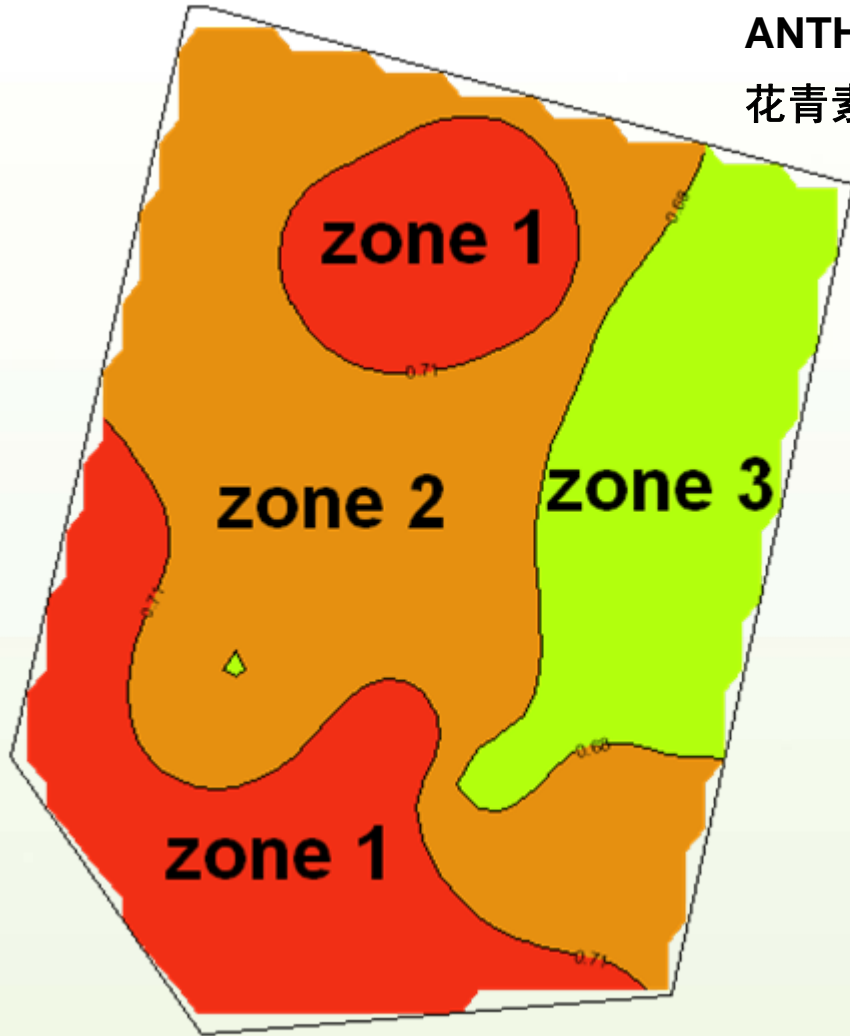
SFR\_G



# MULTIPLEX<sup>®</sup>: Apple (maturity monitoring) 苹果 (成熟度检测)







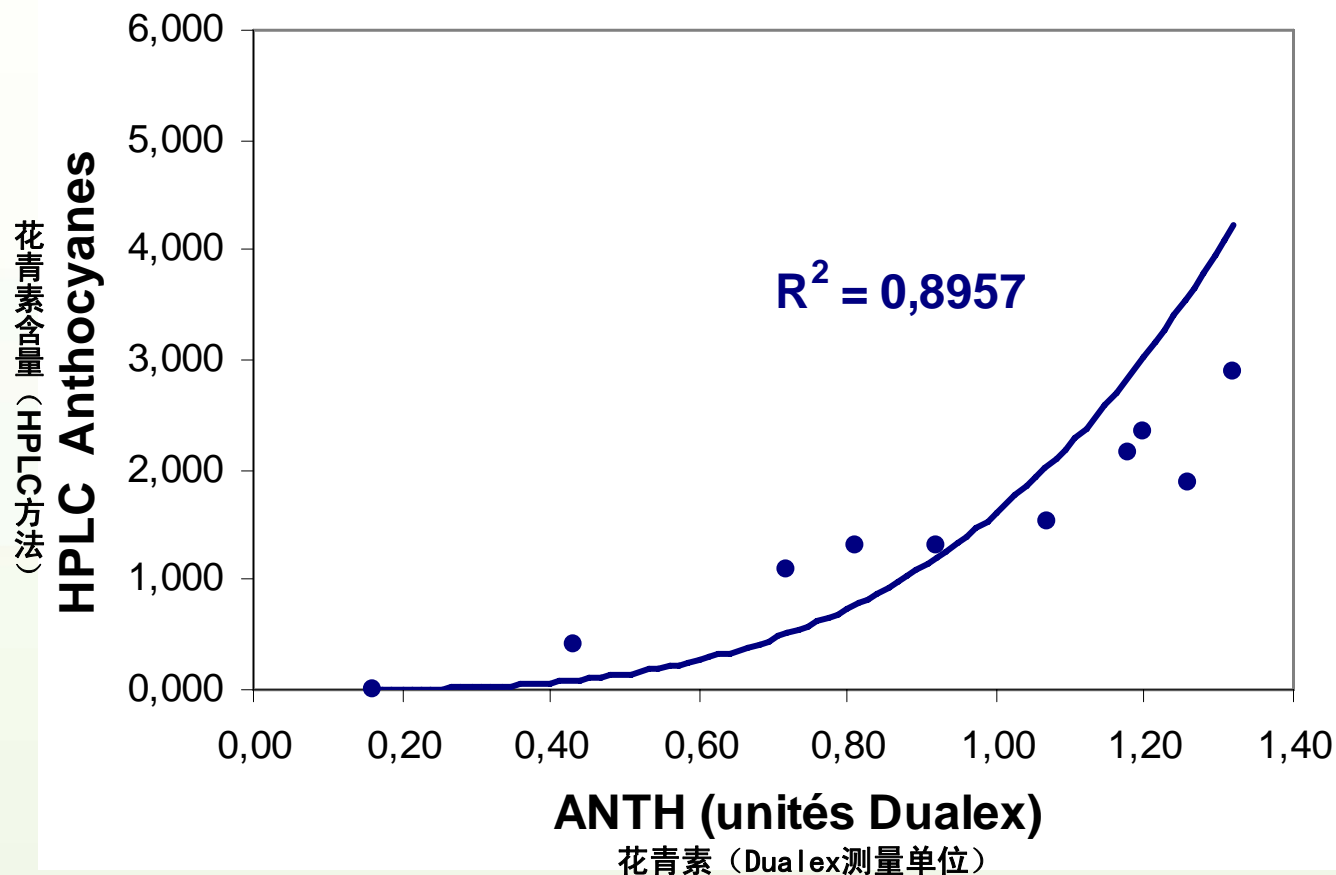
**ANTH (Multiplex units)**

花青素 ( Multiplex测量单位)

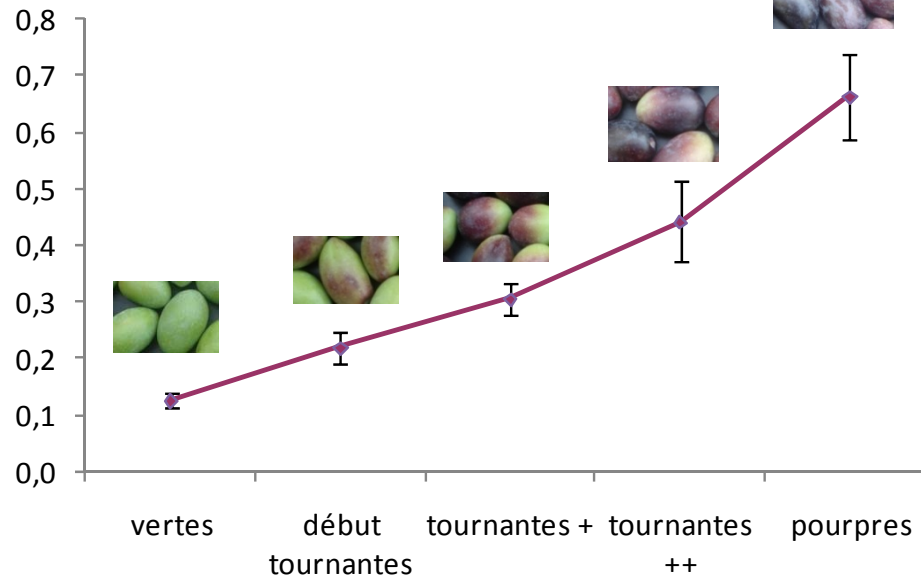
**Selective harvest**  
**成熟度选择**

Chambre d'agriculture  
d'Ile de France

CG Essonne, 2007



## Anthocyanins Index



- 1、FORCE-A company FORCE-A  
公司介绍
- 2、Our technology main principles  
技术原理
- 3、Our instruments: DUALEX® & MULTIPLEX®  
产品： DUALEX® & MULTIPLEX®
- 4、The different applications on crops  
仪器应用
- 5、Our Research & Development  
研究与开发
- 6、Open questions  
提问



# SPRAYING QUALITY

## 喷雾质量管理

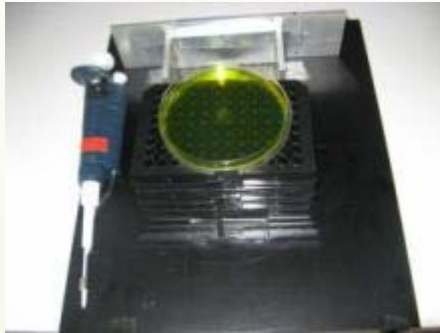
## To quantify the spraying 喷雾质量管理

A partnership with:

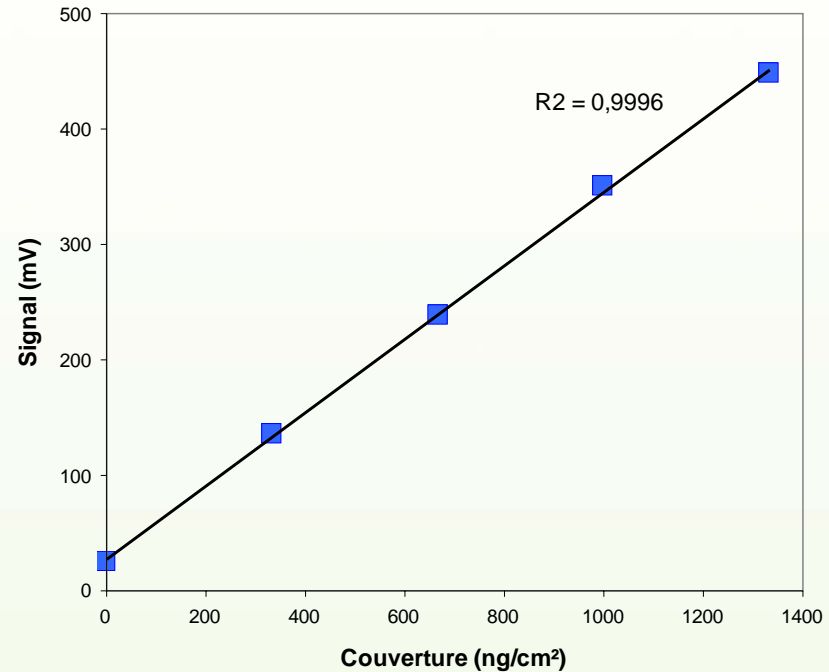




# MULTIPLEX®: QUANTISPRAY project (1<sup>st</sup> results) 喷雾质量实验



## MULTIPLEX calibration



Fluorescent component: 100 g/ha

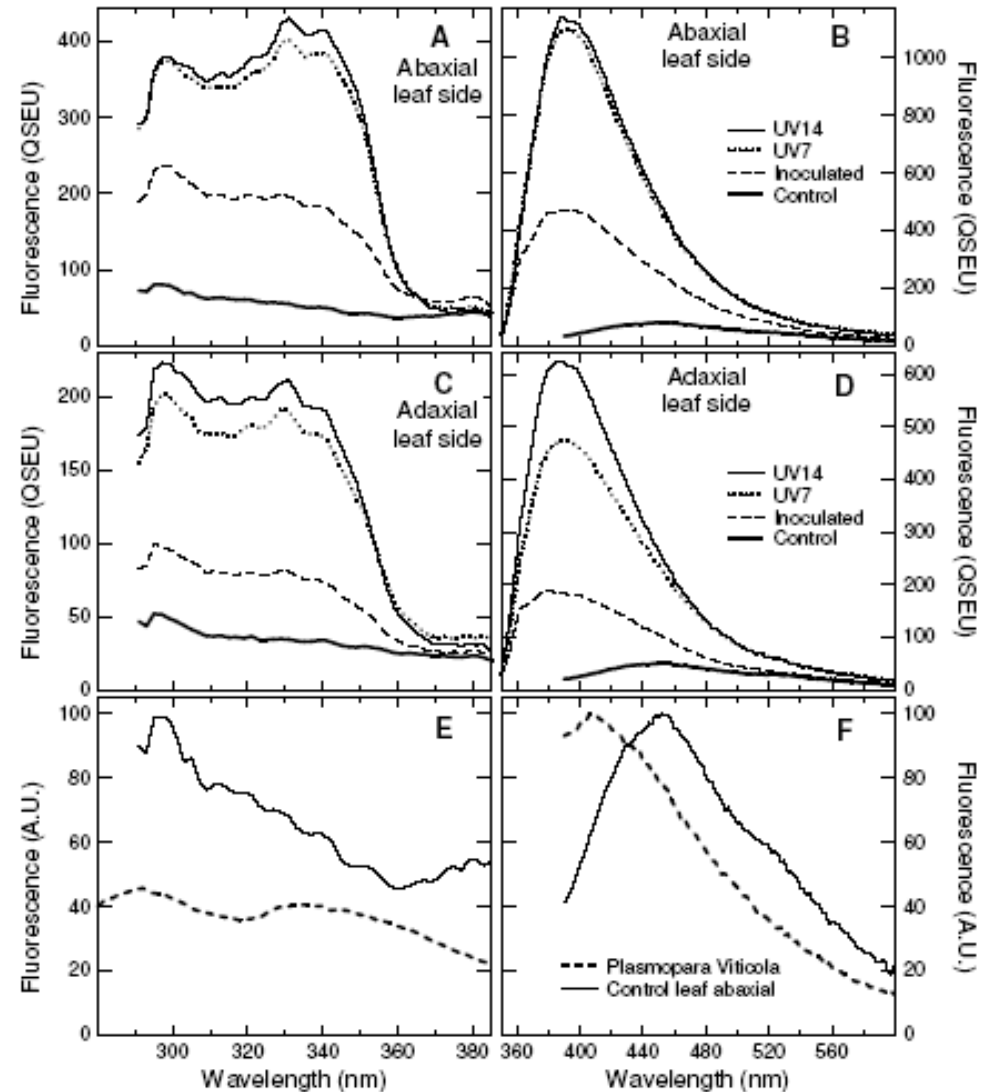
Lowest detected quantity: 0.3 ng/cm<sup>2</sup>

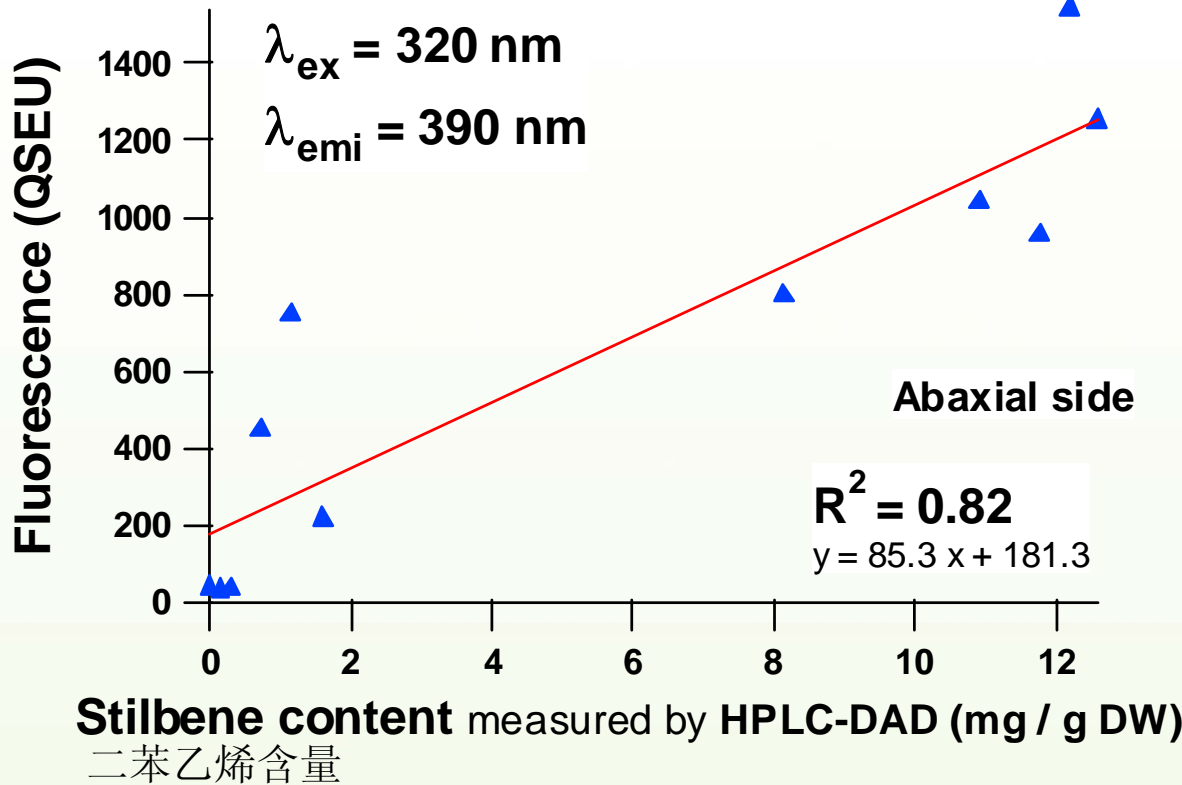


**EARLY FUNGAL  
DISEASES  
DETECTION**  
**早期真菌病害预测**



Poutaraud, Latouche et al. 2007

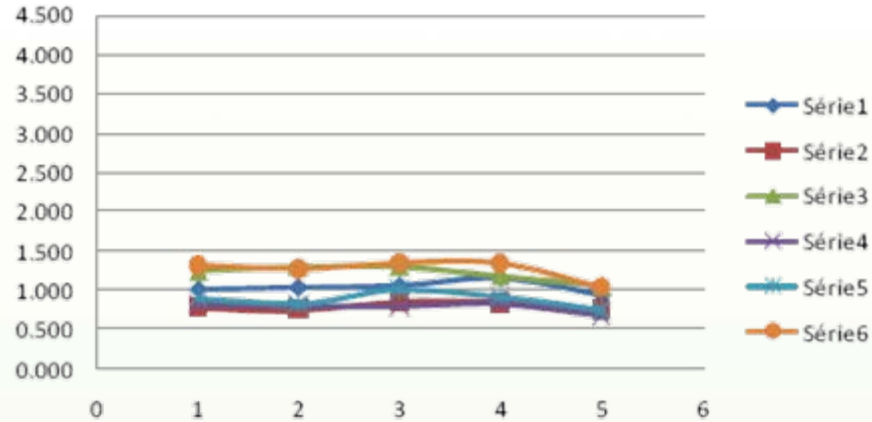




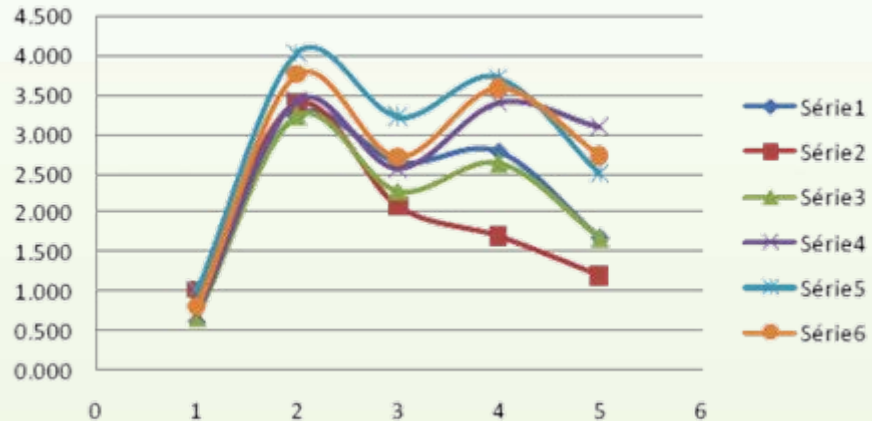
*Poutaraud et al.*  
*J. Agric. Food Chem.* 55 (2007)

In **in vivo** stilben blue fluorescence is used to measure leaf response to *P. viticola* infection  
葡萄叶片活体中二苯乙烯的蓝色荧光可反映出葡萄霜霉病的状况。

Controlled conditions:  
Healthy  
控制：健康



Uncontrolled conditions:  
Infected  
非控制：污染





**SENSORS & MACHINERY**  
**传感器 & 机械**







# Measurements on leaves (Champagne) 叶片测量





# Measurements on grapes (Australia) 葡萄测量







- 1、FORCE-A company FORCE-A  
公司介绍
- 2、Our technology main principles  
技术原理
- 3、Our instruments: DUALEX® & MULTIPLEX®  
产品： DUALEX® & MULTIPLEX®
- 4、The different applications on crops  
仪器应用
- 5、Our Research & Development  
研究与开发
- 6、Open questions  
提问