Advances in Precision Agriculture

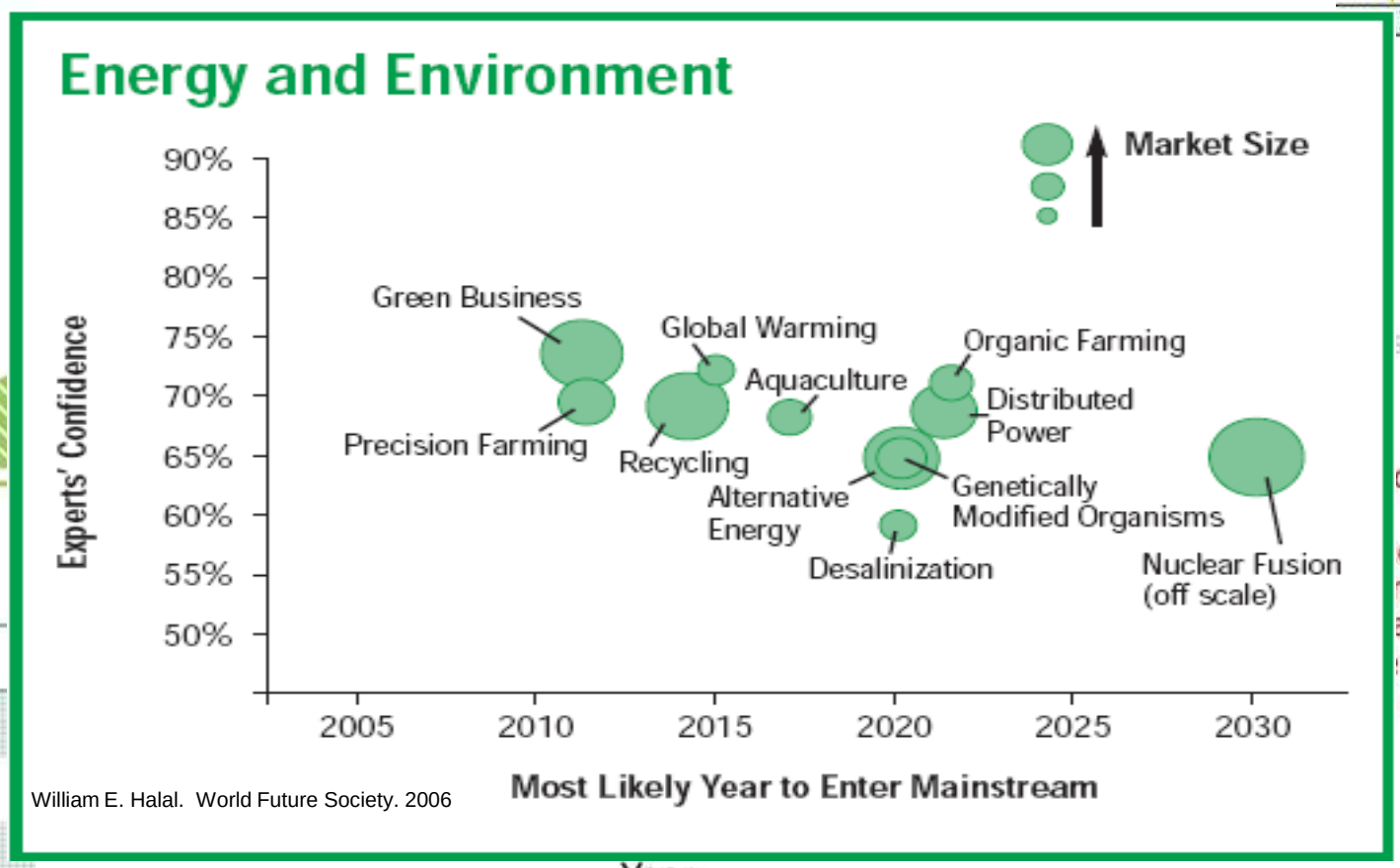
Integrating Chilean Agri-Food Sector to the new millennium

INIA - PRECISION AGRICULTURE PROGRAM

TEAM:

Stanley Best (Director - computer imaging technology, Remote Sensing), Marcelino Claret (Food Safety) Lorenzo León (Non-destructive systems and Data Mining), Rodrigo Quintana (Econometrics, statistics monitoring), Valeska Concha (Computer Science), Faviola Flores (mathematical modeling), Francisco Ferrada (Applied Electronics), Claudio Aliaga (Technical field and developments Workshop Manager).

Actual Problems



Our vision is associated with consumer requirements

Nutritious foods (functional characteristics)
High in antioxidants and other phytonutrients.

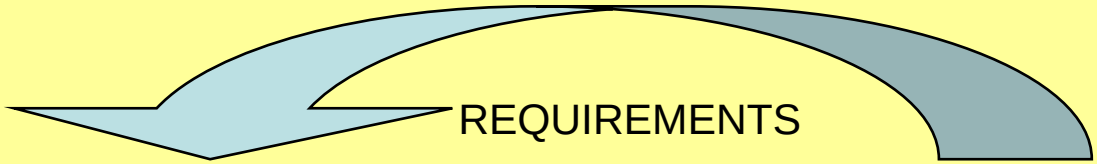
Healthy Food
Chemical waste (reduction -> Effectiveness - Efficiency).
Microbial Health

Good Taste
Taste, maturity, visual characteristics, life, etc.

The technology will influence the way of selling in the short term !!

THE ROAD AHEAD IS THE TECHNOLOGY

Whole Chain Assurance



PRE-FARM GATE

POST FARM GATE

Growers
Farmers

Food Packing and Processing

Retail Stores

Consumers

Key components

- Pre-Farm and Post Farm Gate Standards
- ISO Guide 65
- Traceability
- Risk Assessment
- Residue Monitoring



Increased costs in labor, raw materials and inputs in production processes and energy, encourages the search for regions or field zones of higher productivity and quality.

The necessity of increase the credibility and confidence in national and international level in the quality of some products

Engage and retain customers now costs more!!

Challenges to Latino American Agriculture

- Global markets, Local inputs
- Labor cost & availability
- Trade policies
- Consumer demand stagnant
- Retail consolidation
- Environmental accountability (weather changes)
- Competing uses for farmland, water
- Food safety & biosecurity

Actual Development Trends

Biotecnología

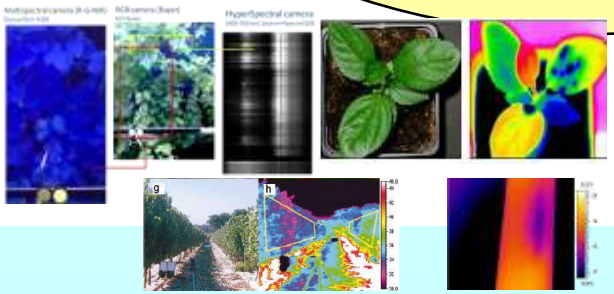
Nanotecnología

Automation and Mechanization Sensors and robotics, mechanical assistance to harvesting and crop management, automatic and remote processing, packing, and shipping.

Plant health, development and production quality

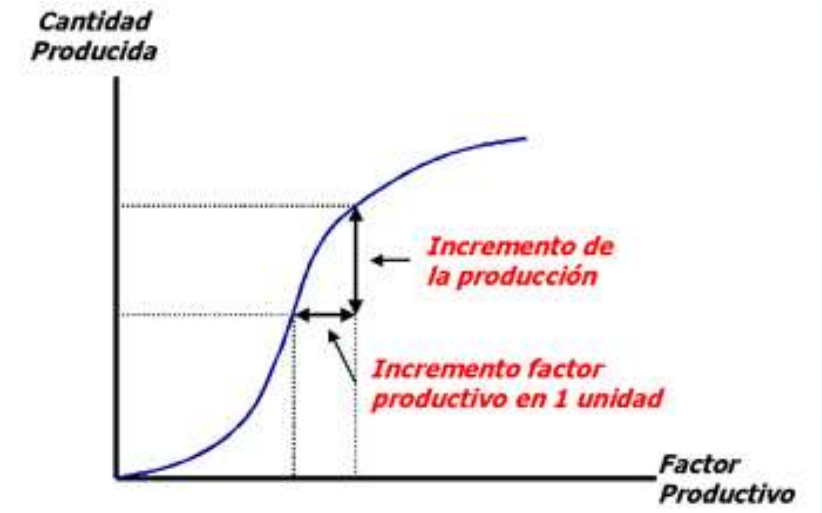
Reducing the use of agrochemicals
Prediction tools
Fruit Quality and Sanity
Water Use Efficient
Fertility management
etc.

ICT´s



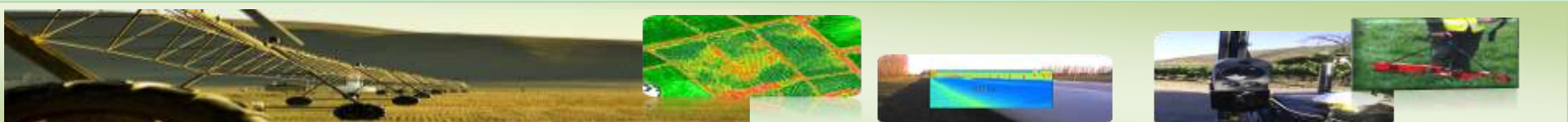
Improve customer satisfaction (The technology will influence the form of selling in the short term?)

Homogeneous management is sustainable?

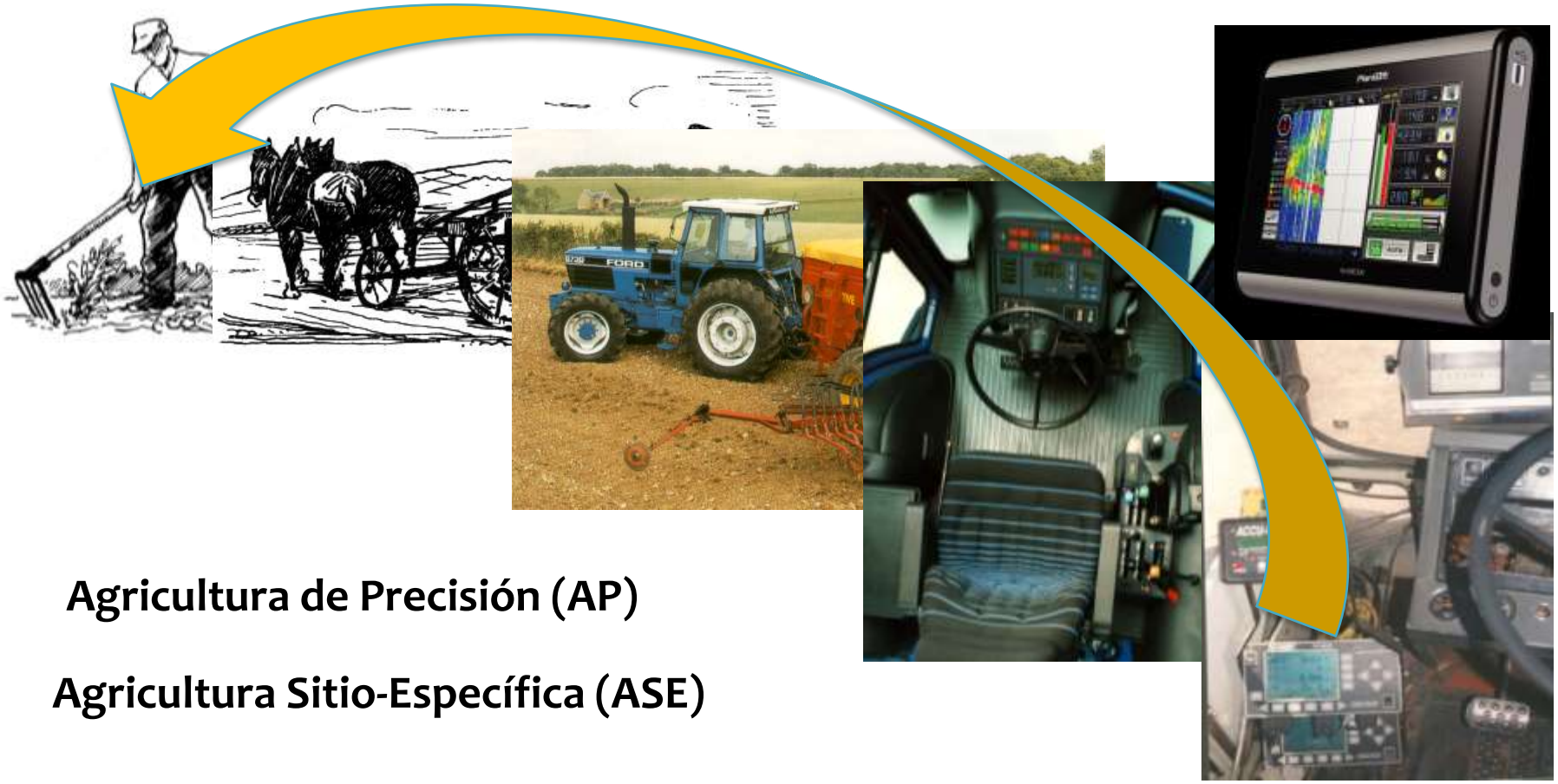


Use technology to achieve greater efficiency and sustainability

PROGAPINIA

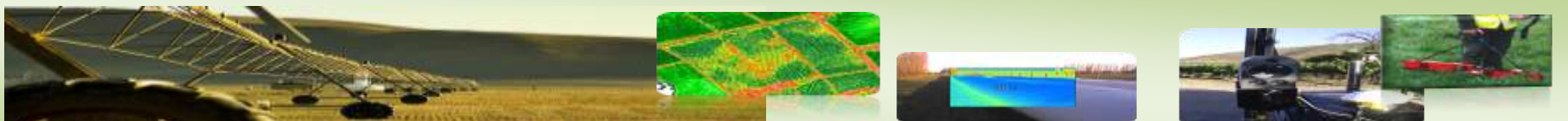


Evolution of Agricultural Technology

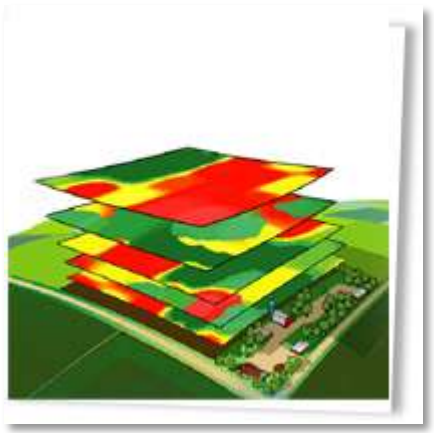


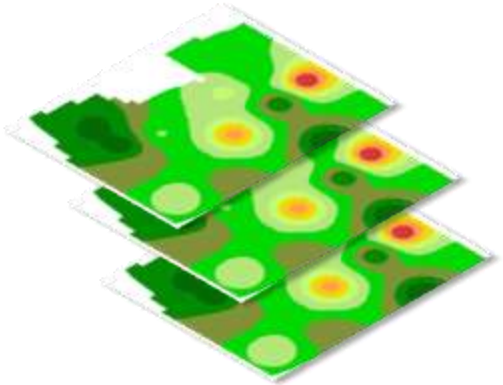
Agricultura de Precisión (AP)

Agricultura Sitio-Específica (ASE)



DEFINITION OF MANAGEMENT ZONES





PF FARM FAIR IN ARGENTINA, BRASIL, CHILE.

PF Adoption of tools in Latin America

Adoption of PF technology v/s other technologies
The Argentinean Case

35

Bolivia

Zona Geográfica	Sector Productivo	Rubro
Europa (Italia – Francia)	1º Cultivos Industriales	Maíz, Trigo, Canola
	2º Frutales	Pomáceas – Olivos
	3º Viticultura	Viñas
	4º Hortalizas	De modo experimental
Latinoamérica (Argentina y Brasil)	1º Cultivos Industriales	Maíz, Soja, Canola, Trigo, Caña de Azúcar
	2º Ganadería Bovina	Lechería
	3º Frutales	Manzano
América del Norte (USA)	1º Cultivos Industriales	Maíz, Trigo, Soja
	2º Frutales	Berries, Pomáceas, Carozos, Frutos de Nuez
	3º Viticultura	Viñas
Australia	1º Cultivo Industriales	Trigo
	2º Viticultura	Viñas
	3º Ganadería	Ovina y Bovina de Carne

adora

Superficie con Dosificación Variable

Superficie con Guia Automática

HERRAMIENTAS

ProgapINIA

Segmentación Zonas homogéneas

Selección de calidad homogéneas

Sensores de monitoreo Del cultivo (herramientas Predicción)

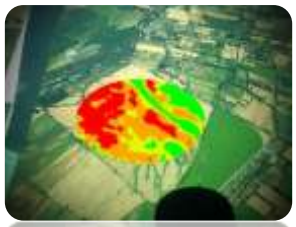
TIC : Trazabilidad de la producción

Automatización y Robótica

ProgapINIA

Actuadores

TRANSFORMING DATA INTO INFORMATION FOR FARM MANAGEMENT



DATA

Raw Sensor Data

Field Data
GPS Data
Computer Vision

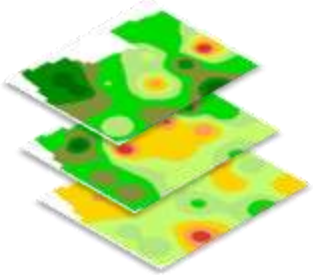
EC Maps and point Monitoring definition

Information

Integrate and Contextualizing Data

Temporal context
Geographic context

3D Compaction and soil Maps



knowledge

Information Application Associated with the Experience

Field Prediction

Agronomiocal Knowledge

Action

Usere Integrates Knowledge:

Knowing how and When to implement a Recommendation.

Variable irrigation

HOW THOSE TECHNOLOGIES TOOLS HAVE BEEN USED IN OUR COUNTRIES

Monitoring Plant Vigor and their asociation with yield.

Homogeneous generation of management zones

Refineingcrops management as required in the different zones

Em-38

Resultados de Ensayo AP: Nivel Comercial

Productor 2

Variedad	Vigor Bajo	medio	alto	
Sun Downer	29.952	39.729	9.004	
ha	1,181	1,128	0,203	
kg/ha	25.362	35.221	44.355	0,4282101

Productor 3

Variedad	Vigor Bajo	medio	alto	
Imperial gala	33.598	52.850	5.244	
ha	0,972	1,128	0,102	
kg/ha	34.566	46.853	51.412	0,32766666

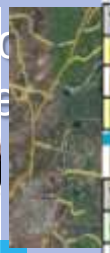
Productor 4

VARIEDAD	Vigor Bajo	medio	alto	
Granny Smith	38.056	232.706	117.772	
ha	1,40	4,88	2,21	
kg/ha	27.183	47.686	53.290	0,4899043
Pink Lady	19.659	105.171	52.982	
ha	1,40	4,88	2,21	
kg/ha	14.042	21.551	23.974	0,41427021

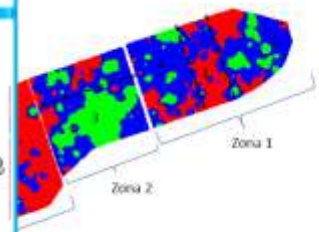
Productor 5

Variedad / Vigor	Vigor Bajo	medio	alto	
Fuji	20.915	87.831	138.601	
ha	0,76	1,20	1,79	
kg/ha	27.520	73.193	77.431	0,64458894

Plant Vigor Segmentation



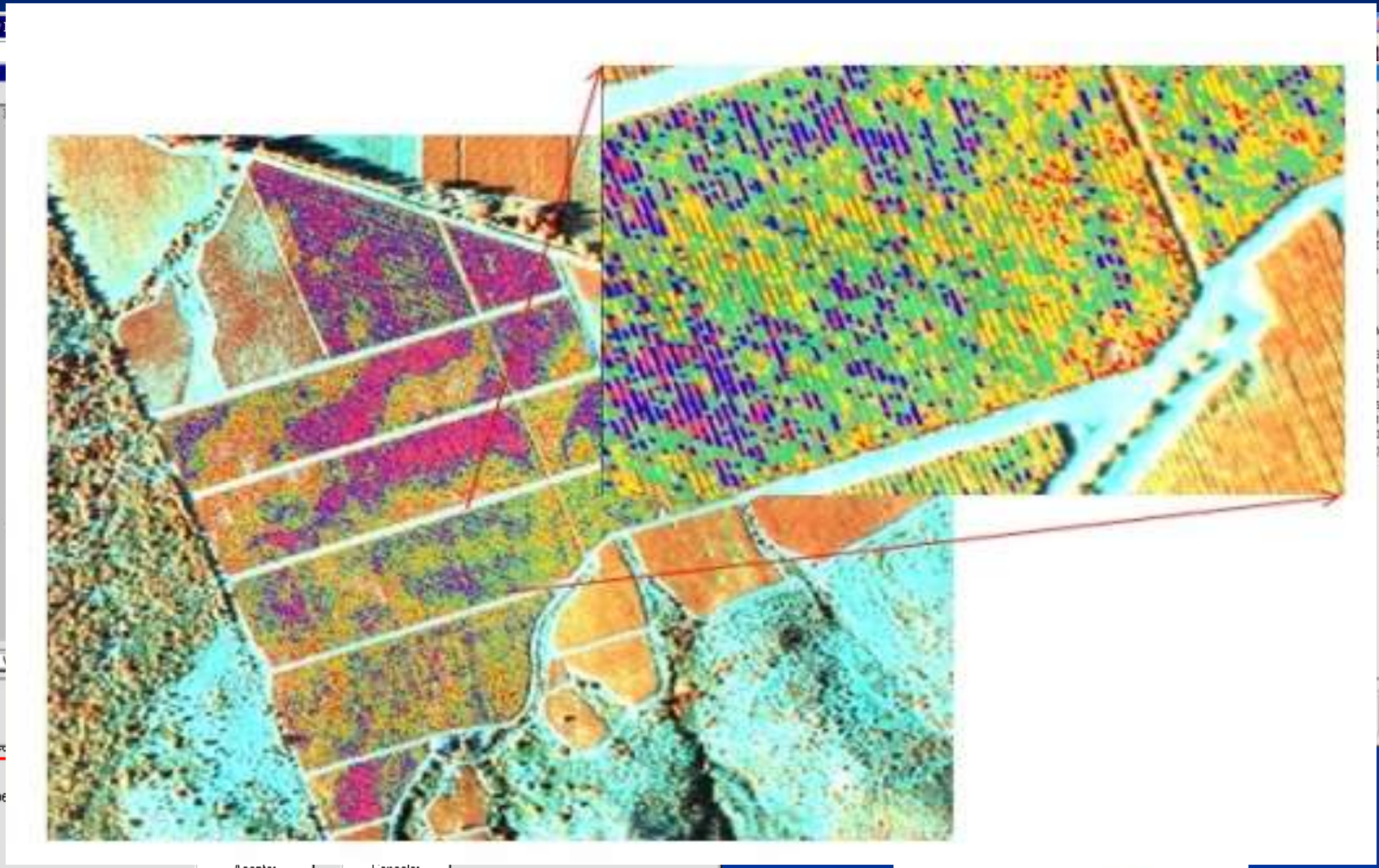
zonas de



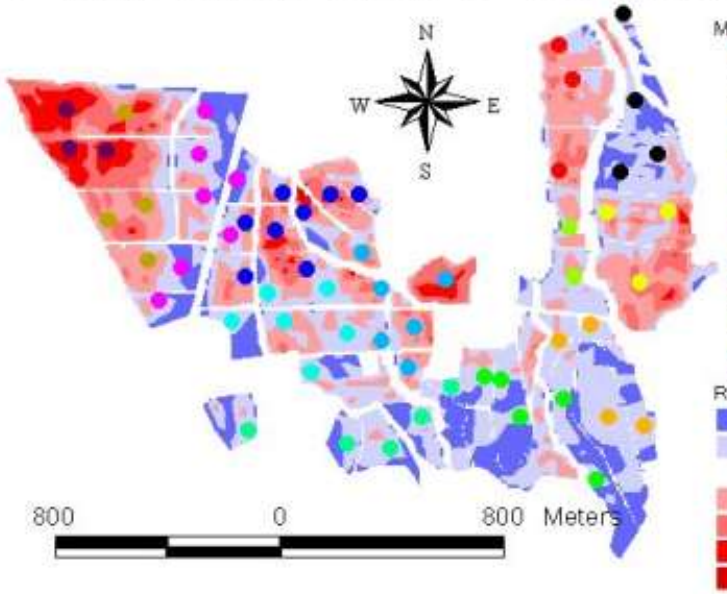
e zonas de

An environment
characteristics a
handling with h

Image Analysis Application and potential use (ICAS)



Planos de Fertilidad

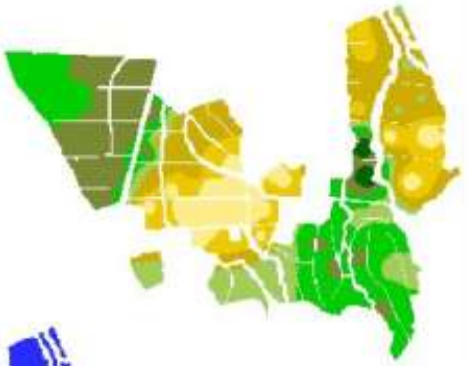


Muestras integradas_ fertilidad - ptos.txt
1
2
3
4
5
6
7
8
9
10
11
12
13

Rfl2008.shp
-0.151 - 0.101
0.101 - 0.354
0.354
0.354 - 0.606
0.606 - 0.859
0.859 - 1.111
1.111 - 1.23

RANGO
ELEMENTO⊓ADECUADO
Nitrogeno total⊓1,5-2,00
Fosforo⊓0,10-0,30
Potasio⊓>0,8
Calcio⊓>1,00
Magnesio⊓>0,10
Hierro⊓>60
Manganeso⊓>20
Zinc⊓10-30
Cobre⊓>4
Boro⊓19-150

Ca/Mg
6.764 - 7.726
7.726 - 8.689
8.689 - 9.651
9.651 - 10.613
10.613 - 11.575
11.575 - 12.537
12.537 - 13.499
No Data



B
25.008 - 32
32 - 38.992
38.992 - 45.984

Mg
0.11 - 0.143
0.143 - 0.177
0.177 - 0.21

Ca
1.29 - 1.49
1.49 - 1.69
1.69 - 1.89

P
0.11 - 0.157
0.157 - 0.203
0.203 - 0.25

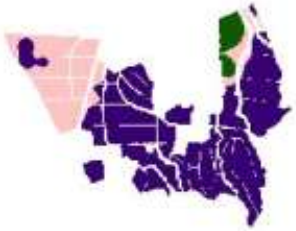
K
0.49 - 0.637
0.637 - 0.8
0.8 - 0.93

N
1.54 - 1.763
1.763 - 1.986
1.986 - 2.21

Mn
17.01 - 28.671
28.671 - 40.332
40.332 - 51.994

Fe
61.001 - 82.998
82.998 - 104.996
104.996 - 126.993

Cu
8 - 11.999
11.999 - 15.998
15.998 - 19.997

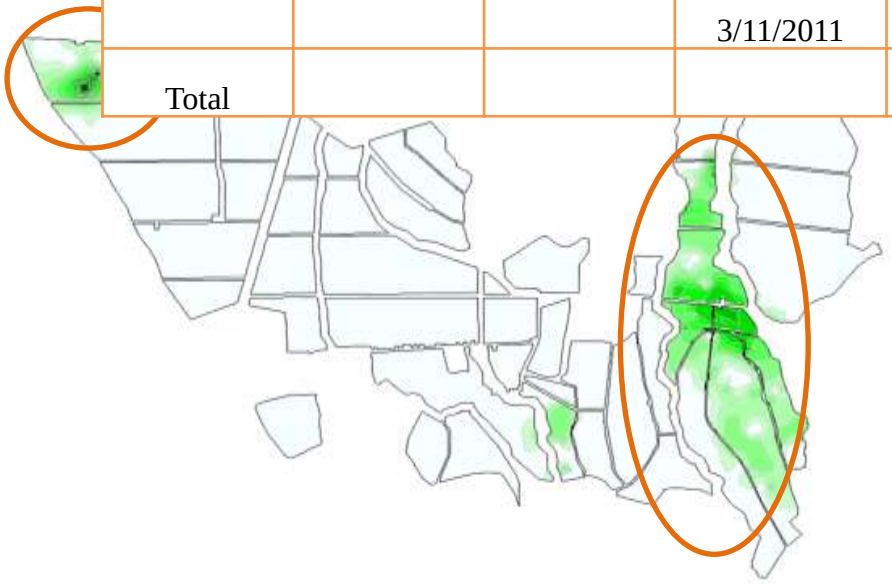


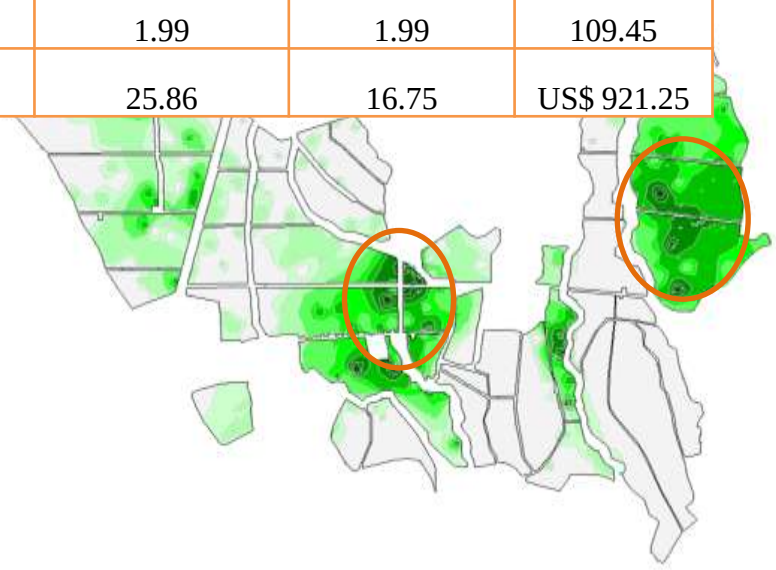
Zn
14.007 - 32.324
32.324 - 50.64
50.64 - 68.957

IDENTIFICACION DE MOSQUITA BLANCA

IDENTIFICACION REPILO

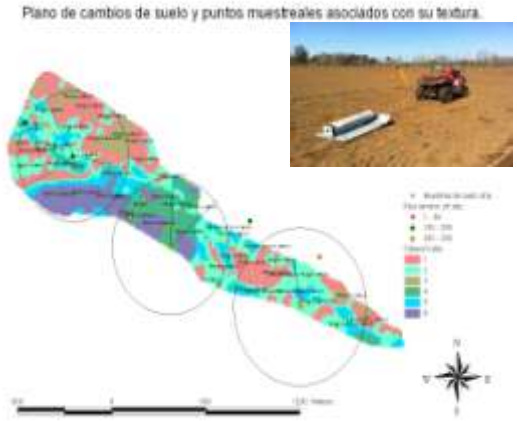
PRODUCTO	PRECIO	DOSIS /HA	FECHA DE APLICACIÓN	CUARTEL	HA CUARTEL	HA APLICADAS	Costo Aplicación US$
Hurrigane	US$220/kg	250 grs	20/10/2011	101-8	9.97	5.59	307.45
			5/11/2011	101-6	7.5	2.77	152.35
			2/11/2011	108-1	1.75	1.75	96.25
			2/11/2011	108-2	0.82	0.82	45.1
			3/11/2011	108-3	3.83	3.83	210.65
			3/11/2011	108-4	1.99	1.99	109.45
Total					25.86	16.75	US$ 921.25

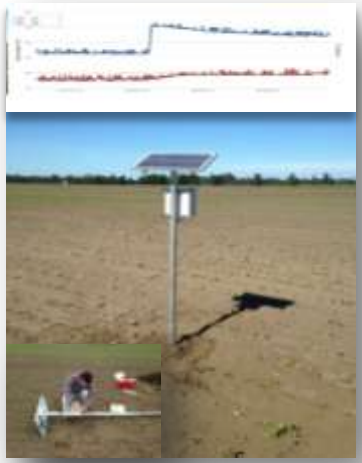




Example of actual use of technology associate to soil physic

Systems Implementation for Soil Moisture Monitoring in real time





Compaction profile (7.5, 35, and 53 cm) Field of Bio Bio Province.

Depth

Compactacion-7.5 cm (KPa)
662.615 - 904.792
904.792 - 1146.969
1146.969 - 1389.145
1389.145 - 1631.322
1631.322 - 1873.
1873.499 -
2115.

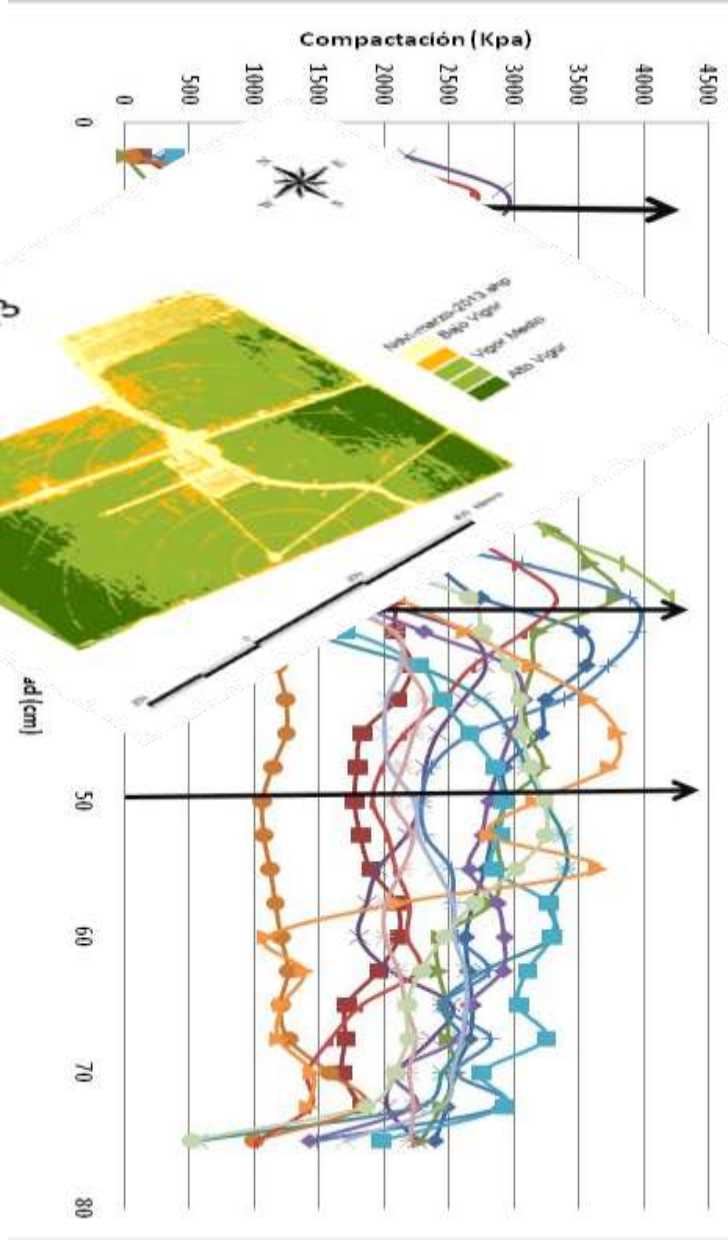
Compactacion 35 cm
568.254 - 974.874
974.874 - 1381.493
1381.493 - 1788.113
1788.113 - 2194.733
2194.733 - 2601.352
2601.352 - 3007.972
3007.972 - 3414.591
3414.591 - 3821.211
3821.211 - 4227.831

Compactacion 53 cm (KPa)
1079.19 - 1335.125
1335.125 - 1591.06
1591.06 - 1846.995
1846.995 - 2102.93
2102.93 - 2358.865
2358.865 - 2614.8
2614.8 - 2870.735
2870.735 - 3126.671
3126.671 - 3382.606

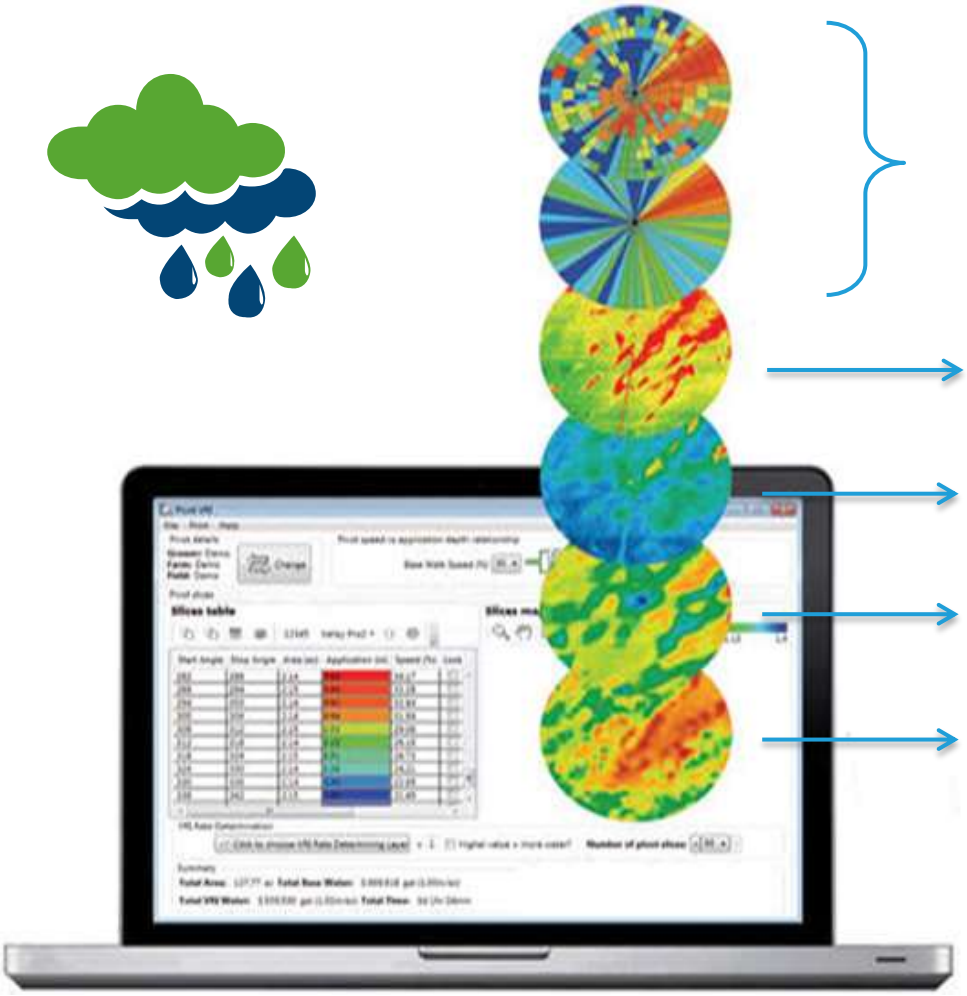
NDVI-Marzo-2013

Compaction curves (KPa)

Field Province Bio Bio



Variable Rate Irrigation



Variable irrigation strategy

Soil Infiltration capacity

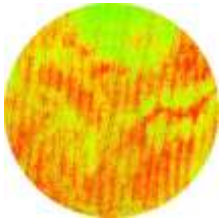
Compaction

Topography

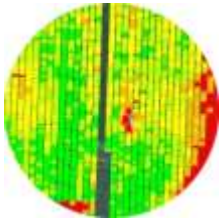
Soil Texture

Input Data

Soil Spatial Variability



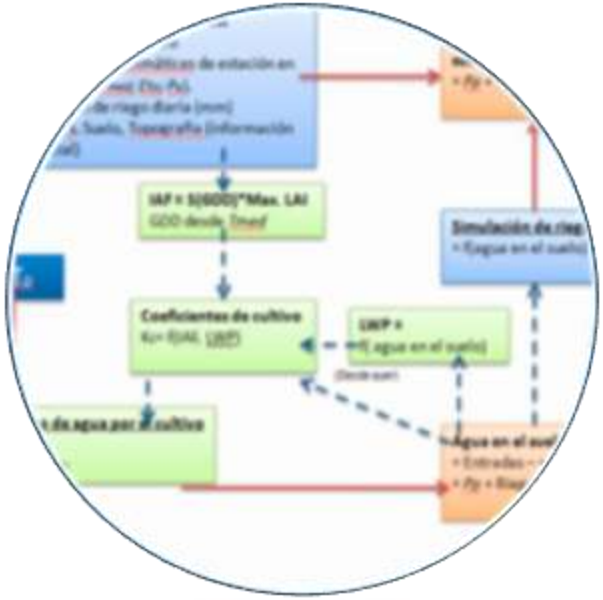
NDVI and IAF Maps



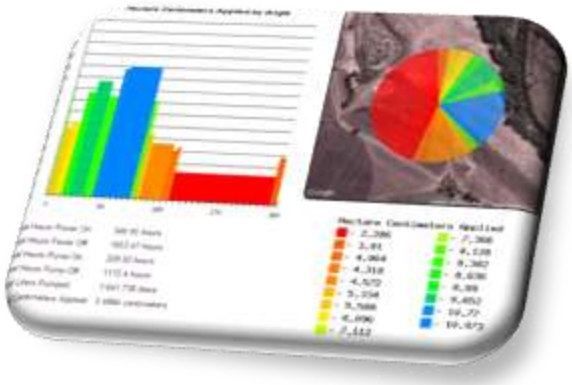
Etr Maps (Metrics)

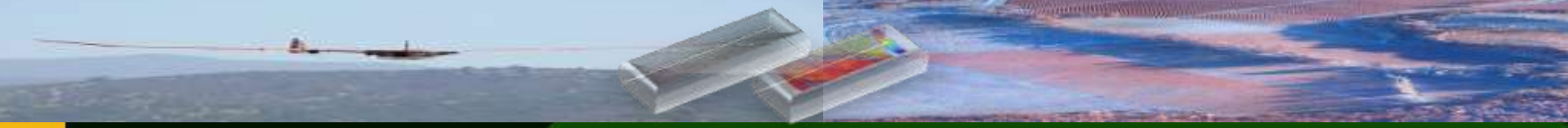
Soil TAW and Soil Moisture Sensors Location

SPATIAL AND TEMPORAL WATER STRESS MODEL

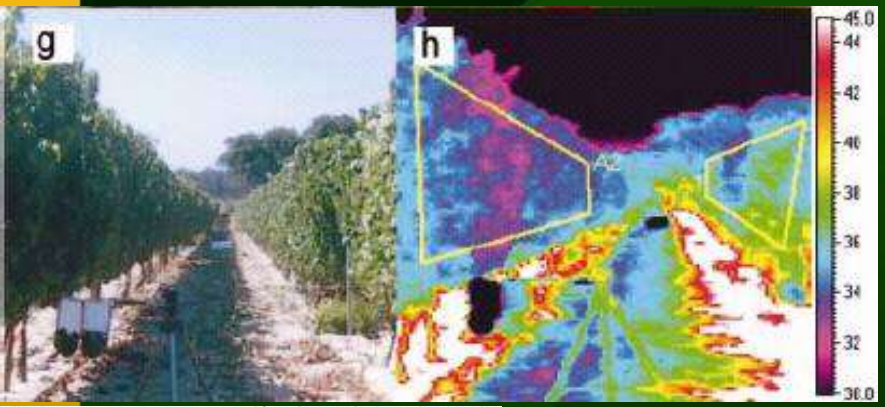


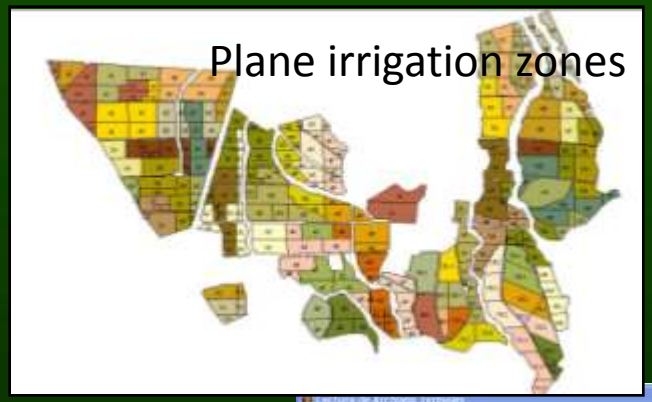
IRRIGATION DEFICIT MAPS

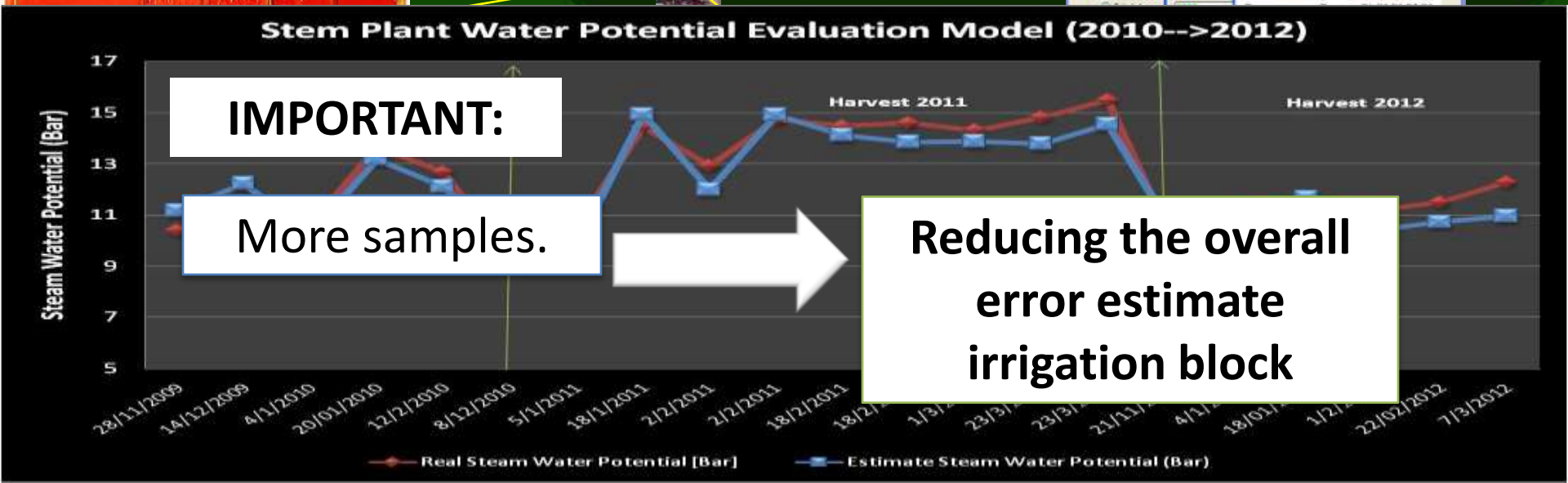




Evaluation of water deficit





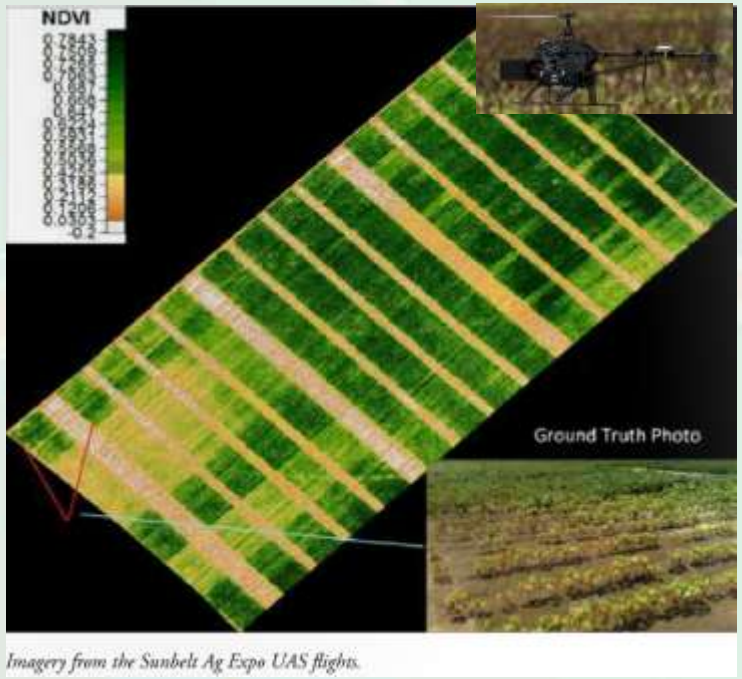


IMPORTANT:

More samples.

Reducing the overall error estimate irrigation block

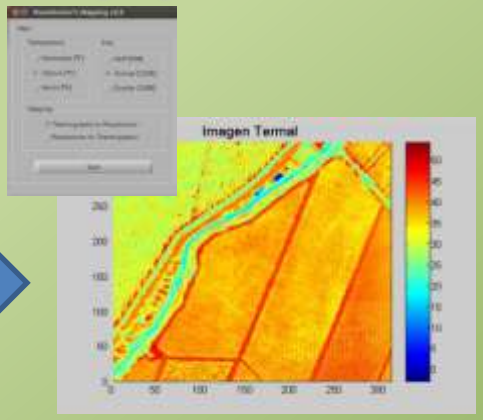
UAV Applications



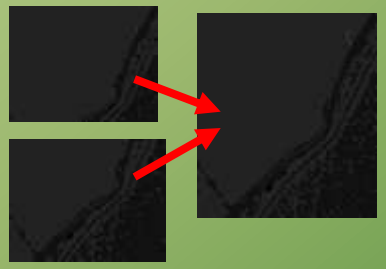
Imagery from the Sunbelt Ag Expo UAS flights.

Thermal GIS Application Development

Thermal Images Capture



Processing of thermal images into RAW format image



Integration of Thermal Images for Mosaic development

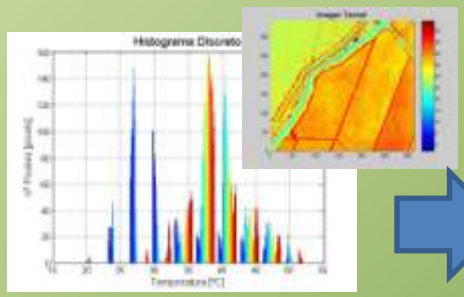
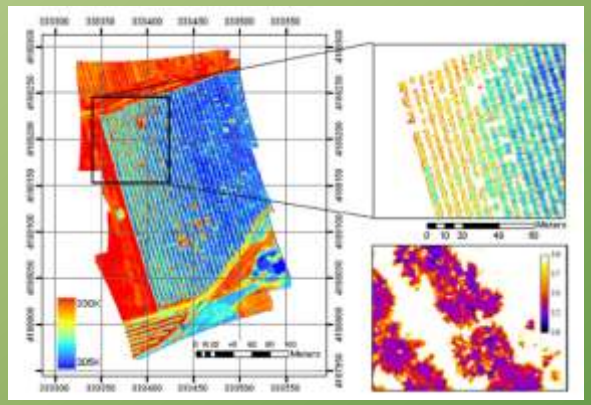
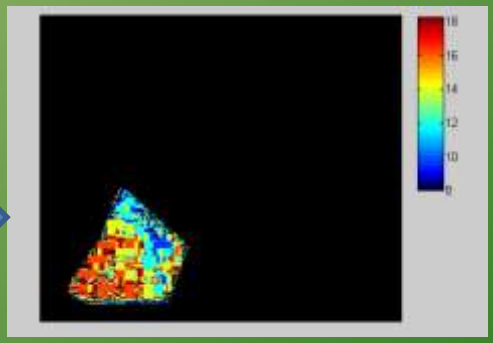


Image filtering

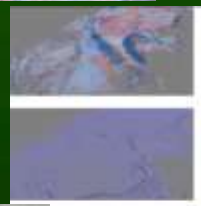


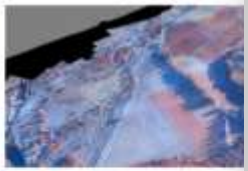


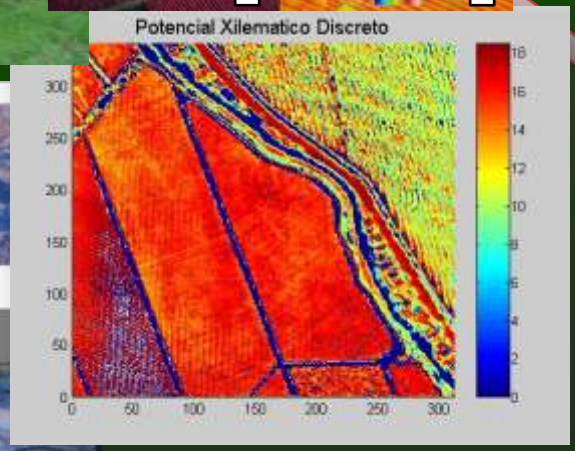
Maps Development of

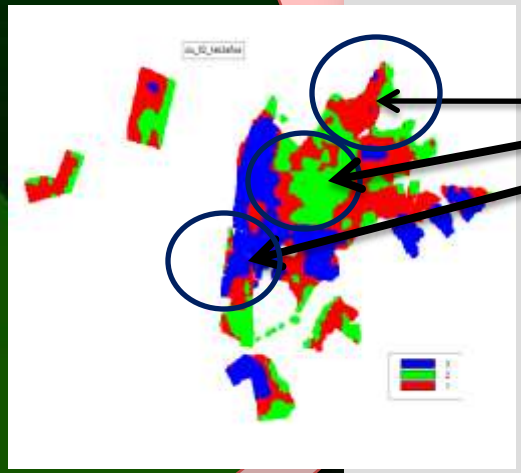
Cuartel	692-4	697-1B1	636-5	662-1	667-3
Pot Xil Prom Real (Bar)	11,38	12,14	9,7	9,80	12,35
Numero de Puntos en terreno	33	21	33	36	21
Pot Xil Prom Est (Bar)	11,27	12,62	10,61	10,84	13,19
Error Prom Estimación (Bar)	0,1	-0,5	-0,9	-1,0	-0,8

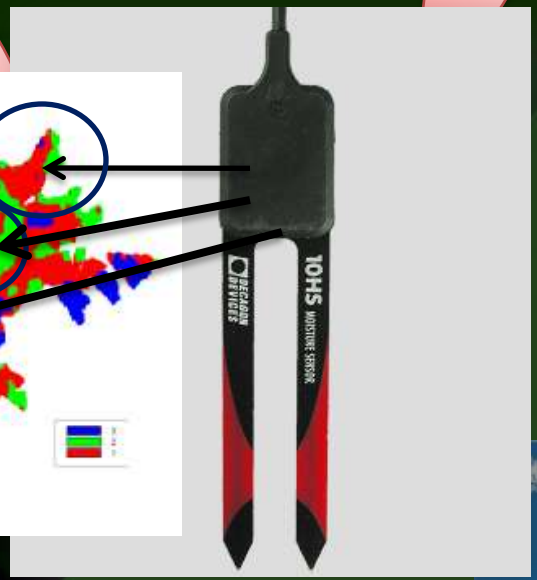
Irrigation



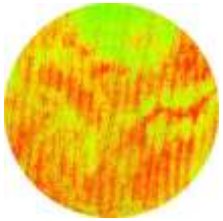



Potencial Xilematico Discreto
300
250
200
150
100
50
0
0
50
100
150
200
250
300
16
14
12
10
8
6
4
2
0

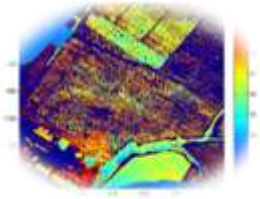



10HS
MOISTURE SENSOR
RECHARGE DEVICES

Soil Spatial Variability



NDVI and IAF Maps



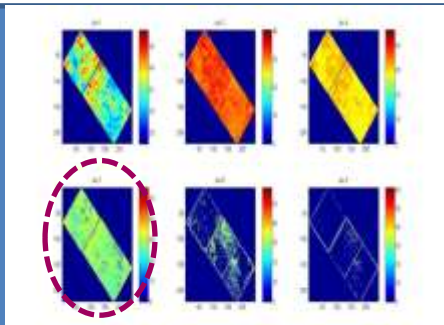
Stem Water Potential Maps

Soil TAW and Soil Moisture Sensors Location

SPATIAL AND TEMPORAL WATER STRESS MODEL

SYSTEM DELIVERY

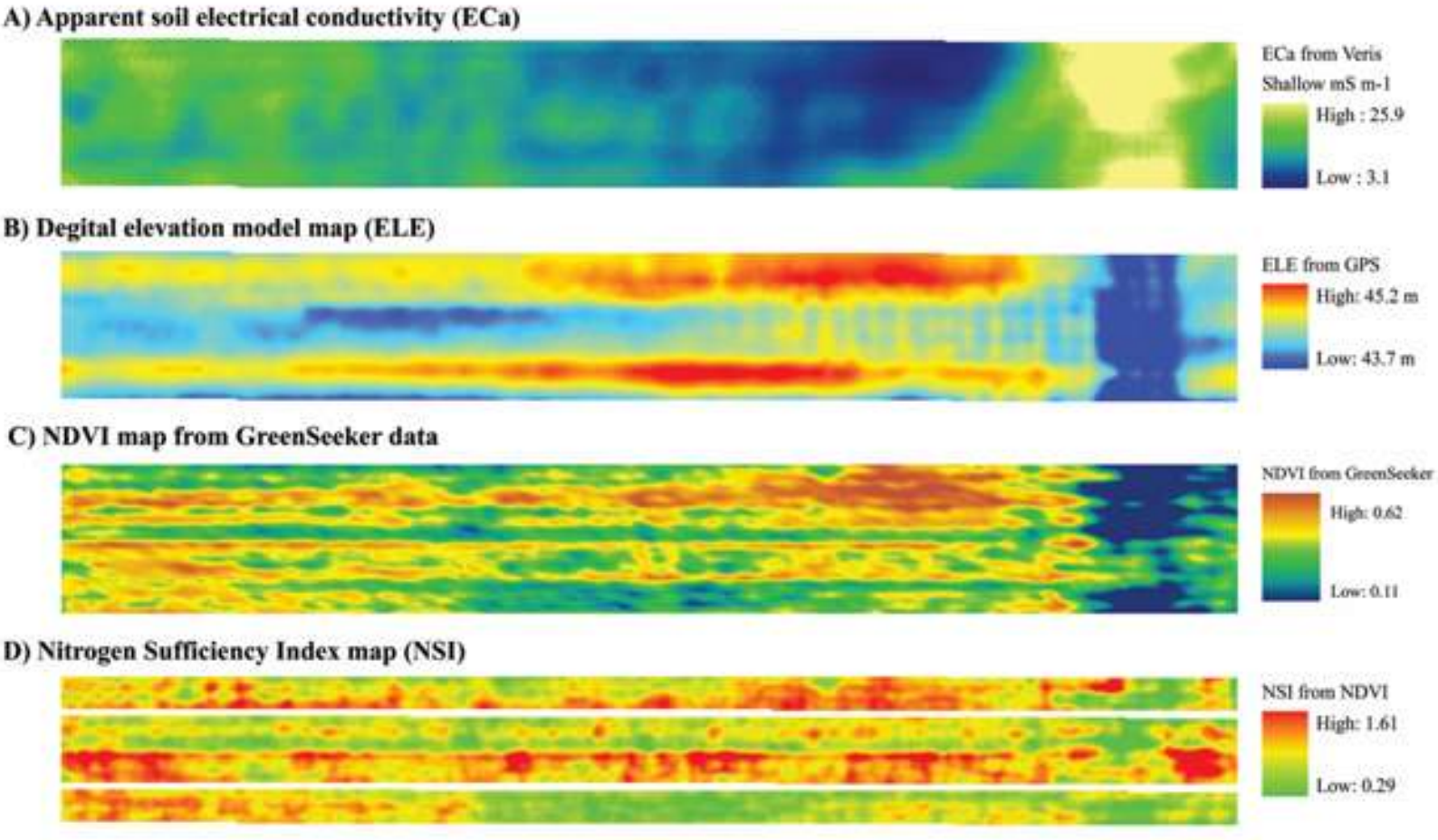
DAIRY IRRIGATION NECESITIES MAPS



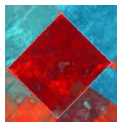
FERTILITY PROBLEMS

PROGAPINIA

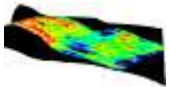
Input and output







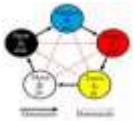

Manejo Sitio Específico*



identificar

diferenciar

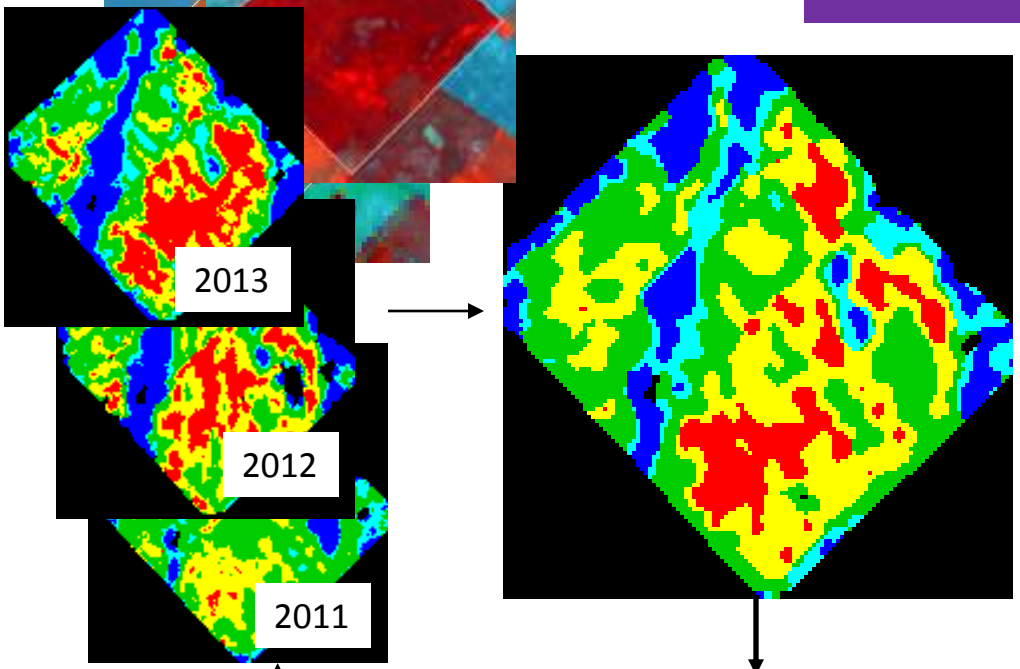
interactuar

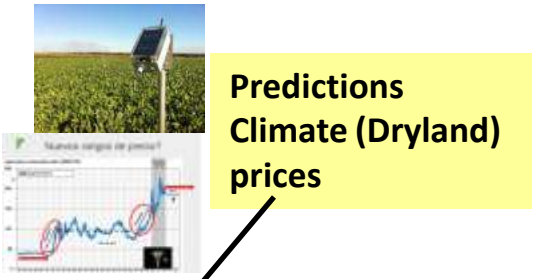


personalizar

EFFICIENT PRODUCTION MANAGEMENT OUTLOOK

Digital Diagnosing of "explanatory factors" and monitoring spatial-temporal variability



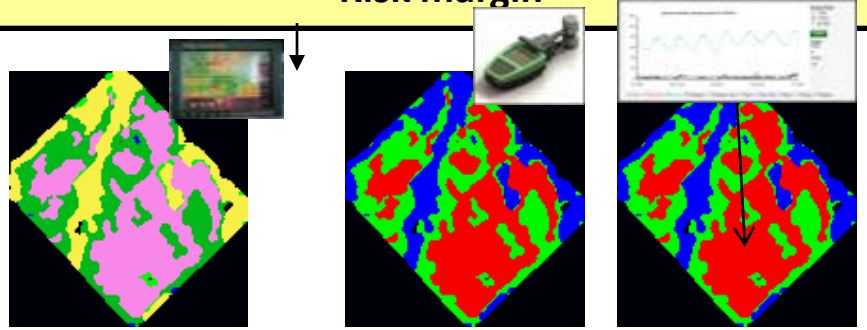


Predictions
Climate (Dryland)
prices

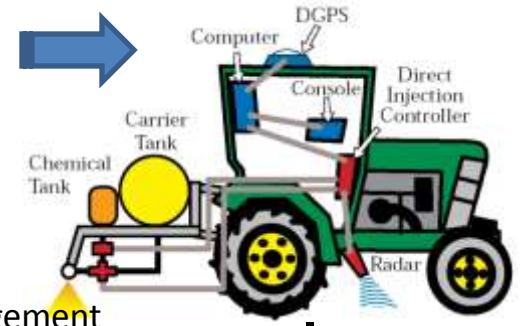
OPTIMIZER

Risk margin

Differentiation of harvest areas and assessment of land management



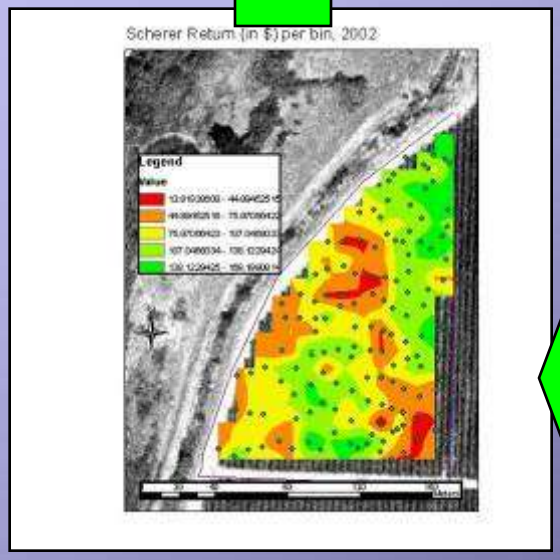
Plant Density | Fertilizer dose | Irrigation management



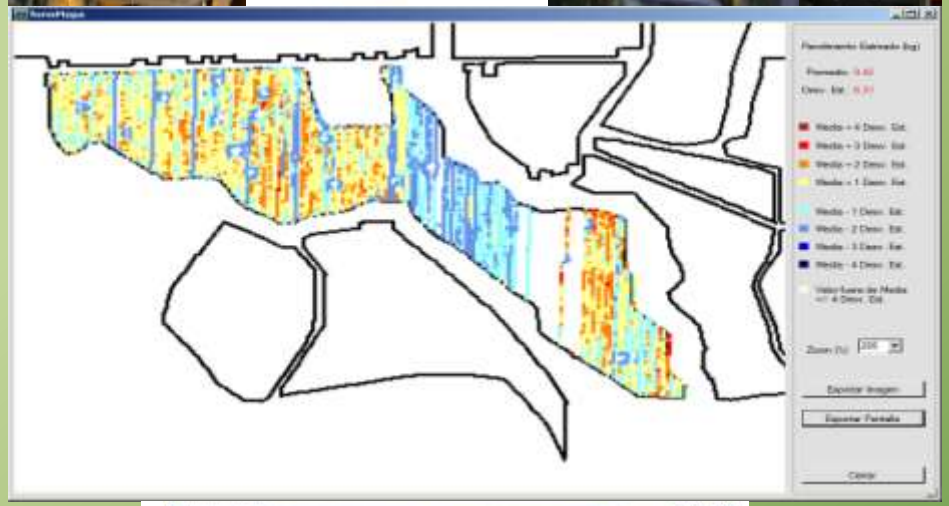
Acquire Process

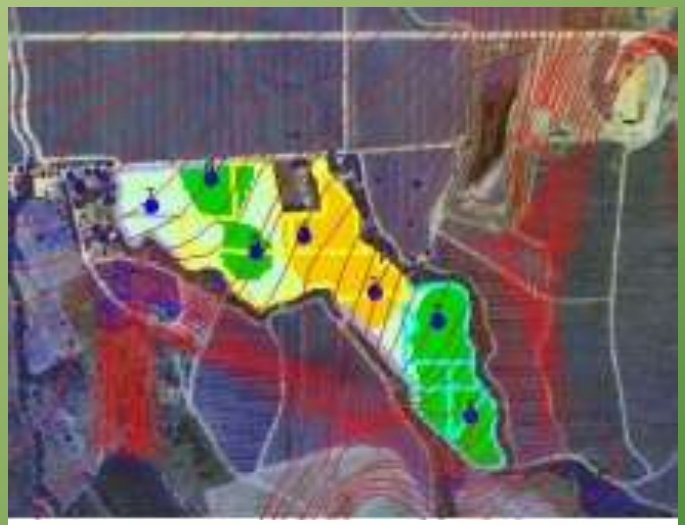
Analyze Understand

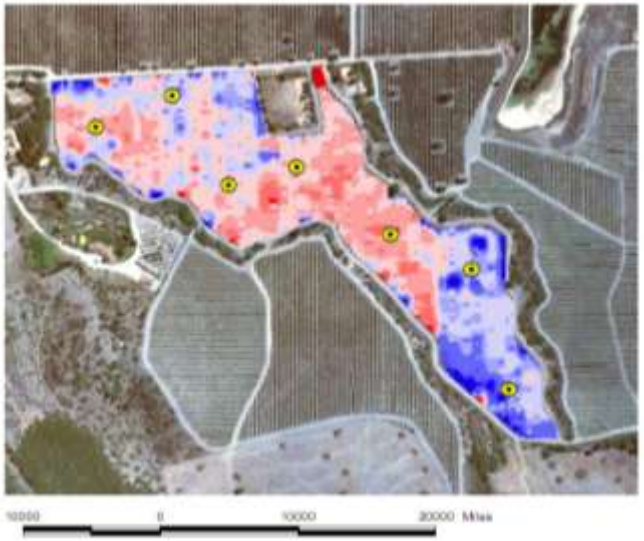
Tunrover Maps



Relationship Yield Map and fruit size at harvest

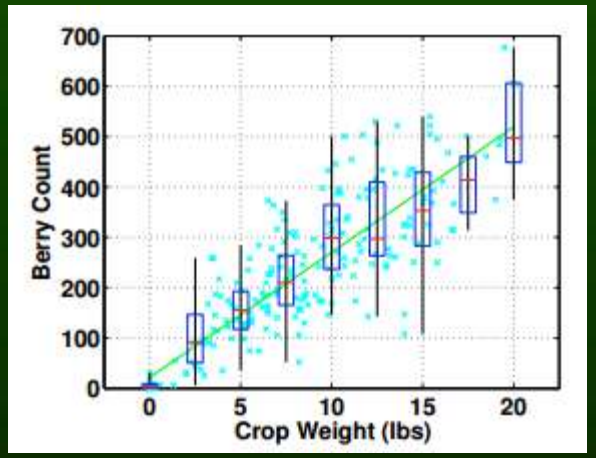


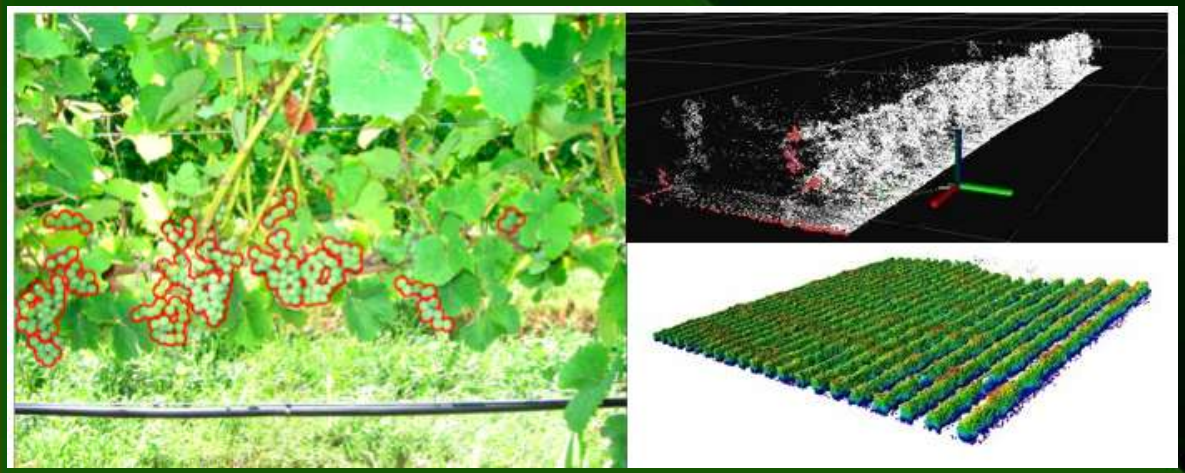




Fi gura 4. Pantalla de finalización de proceso (ver sección log ejecución) del software de monitor de rendimiento.

Vineyard Yield Estimation (EEUU).





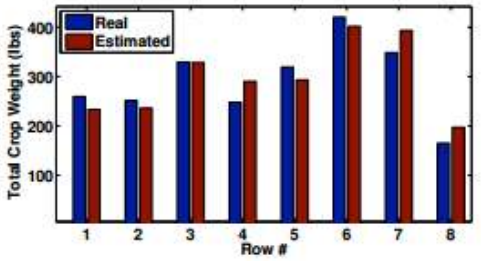
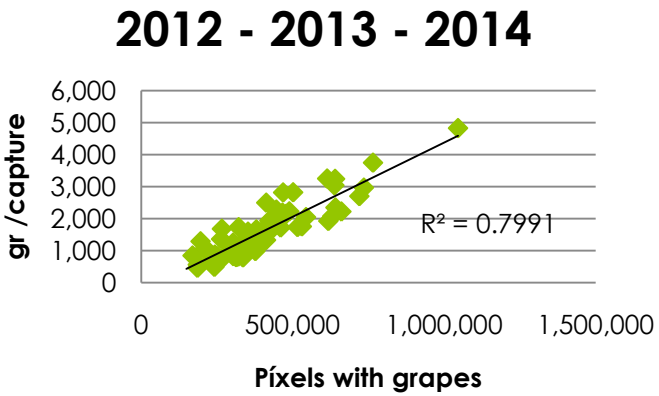
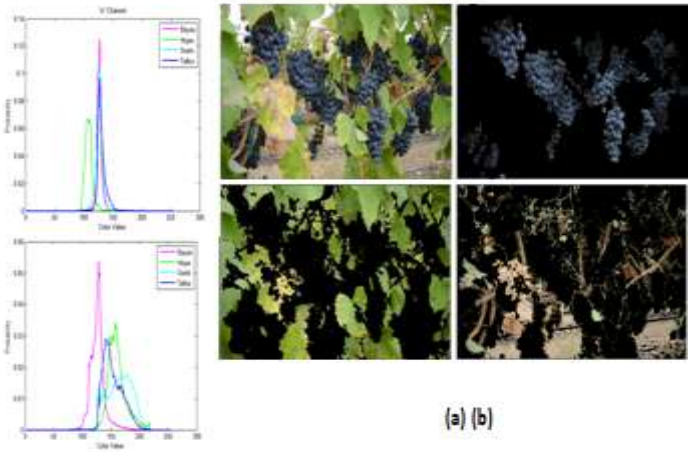


Fig. 6. Graph showing our predictions of the harvest weight of rows in a vineyard. Rows 1 to 4 have 24 Traminette vines each. Rows 5 to 8 have 32 Riesling vines each. Predictions are generated from the functions mapping berry count to crop weight that were calibrated on data from other rows. Our yield estimates have a mean error of 9.8% of the weight of the row. Producing yield predictions at this accuracy at the resolution of single row surpasses the coarse sampling approaches currently used in vineyards.

INIA

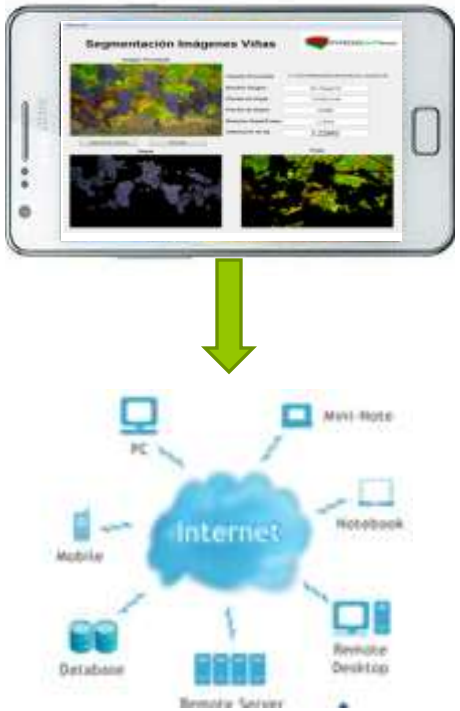
Movil Application (APP)



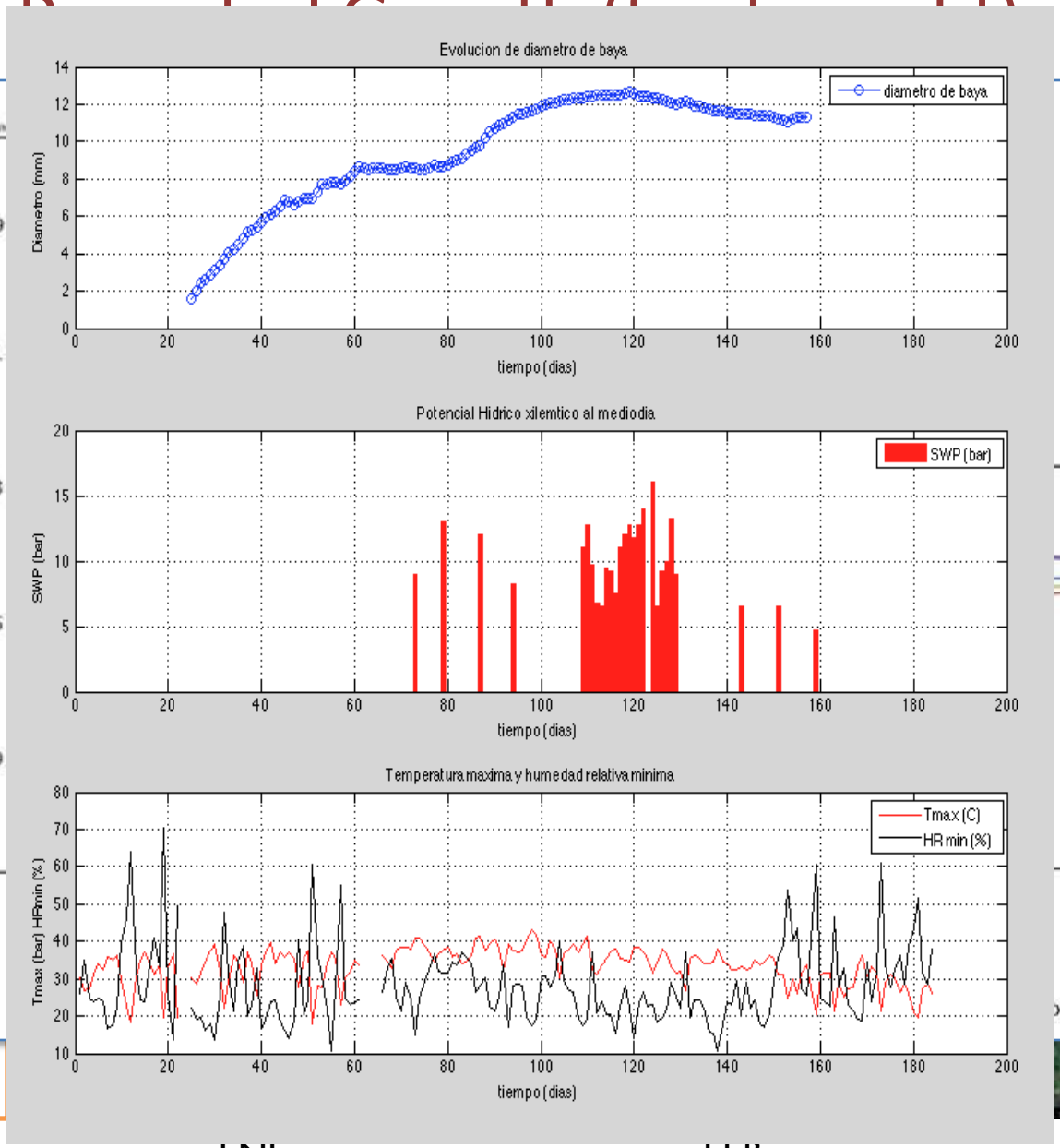


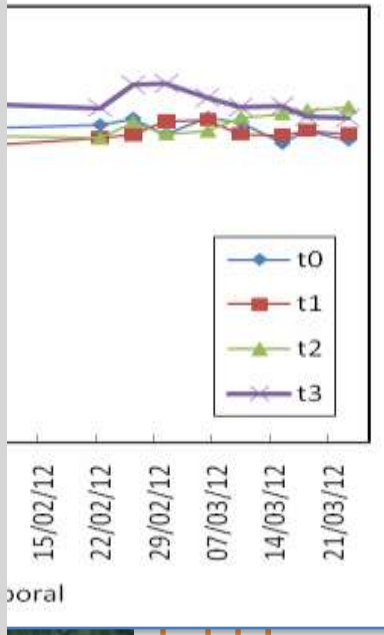
(a) (b)

Figura 17.(a) Histograma de canales "a" y "b" sobre el espacio de color CieLab. **(b)** Segmentación de imagen a partir del espacio de color CieLab.



Tracking the evolution of fruit?





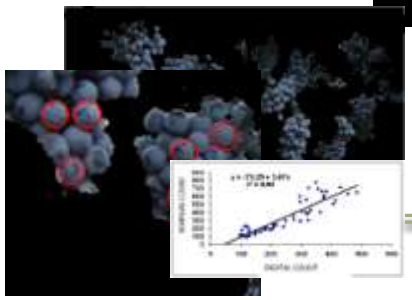
DIC ENE FEB MAR

AUTOMATIZATION

WEATHER SENSOR

TIME LAPSE CAMERA

MICROPROSESOR

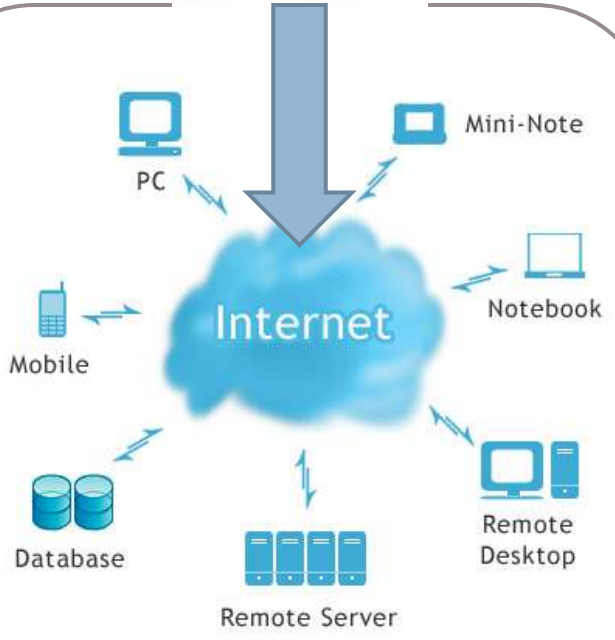


SOIL SENSOR

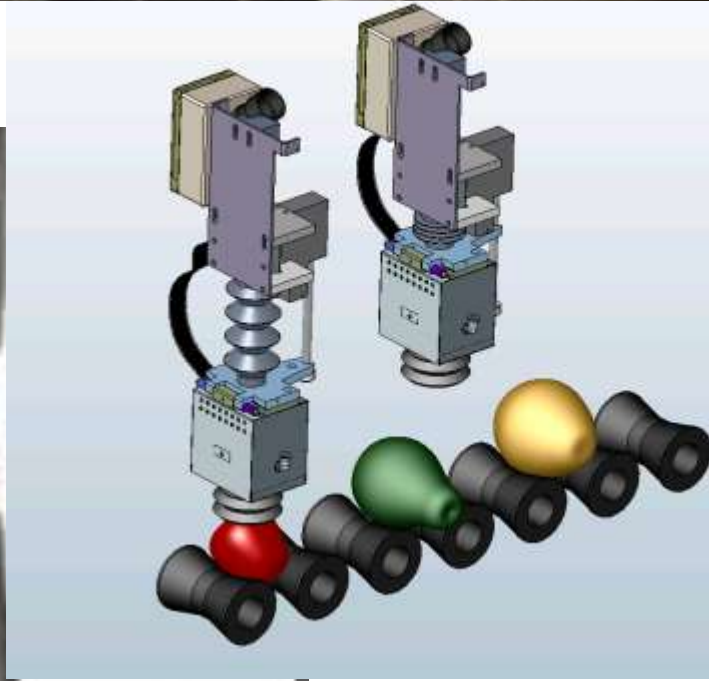
TRANSMISSION DATA

GPRS

DATALOGER



Quality

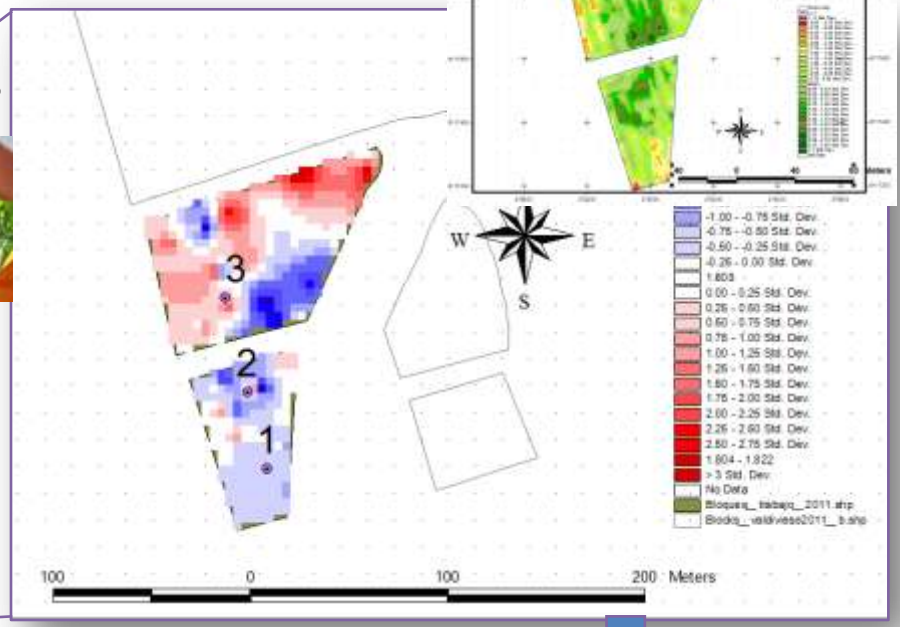


Quality Management of Fruits

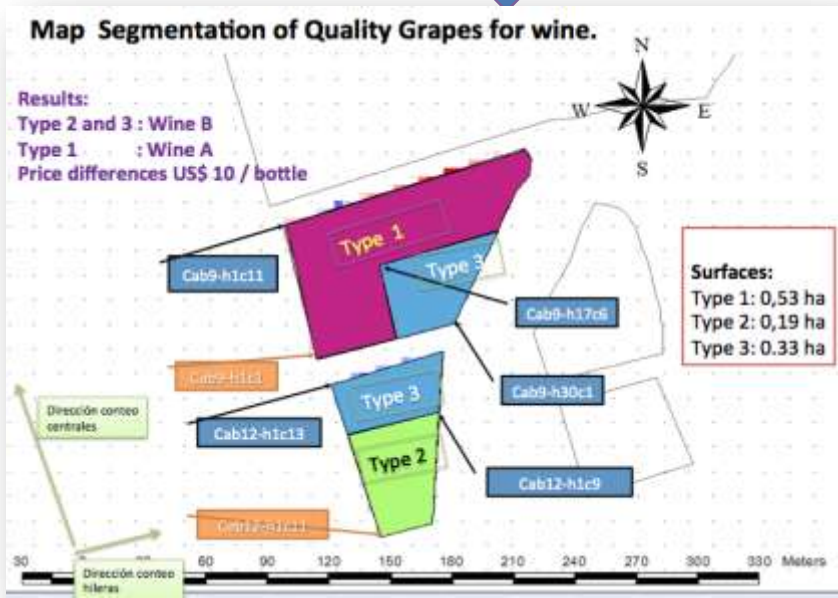
Mar-4-2011

Calidad de uvas

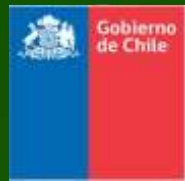
Ferari Index



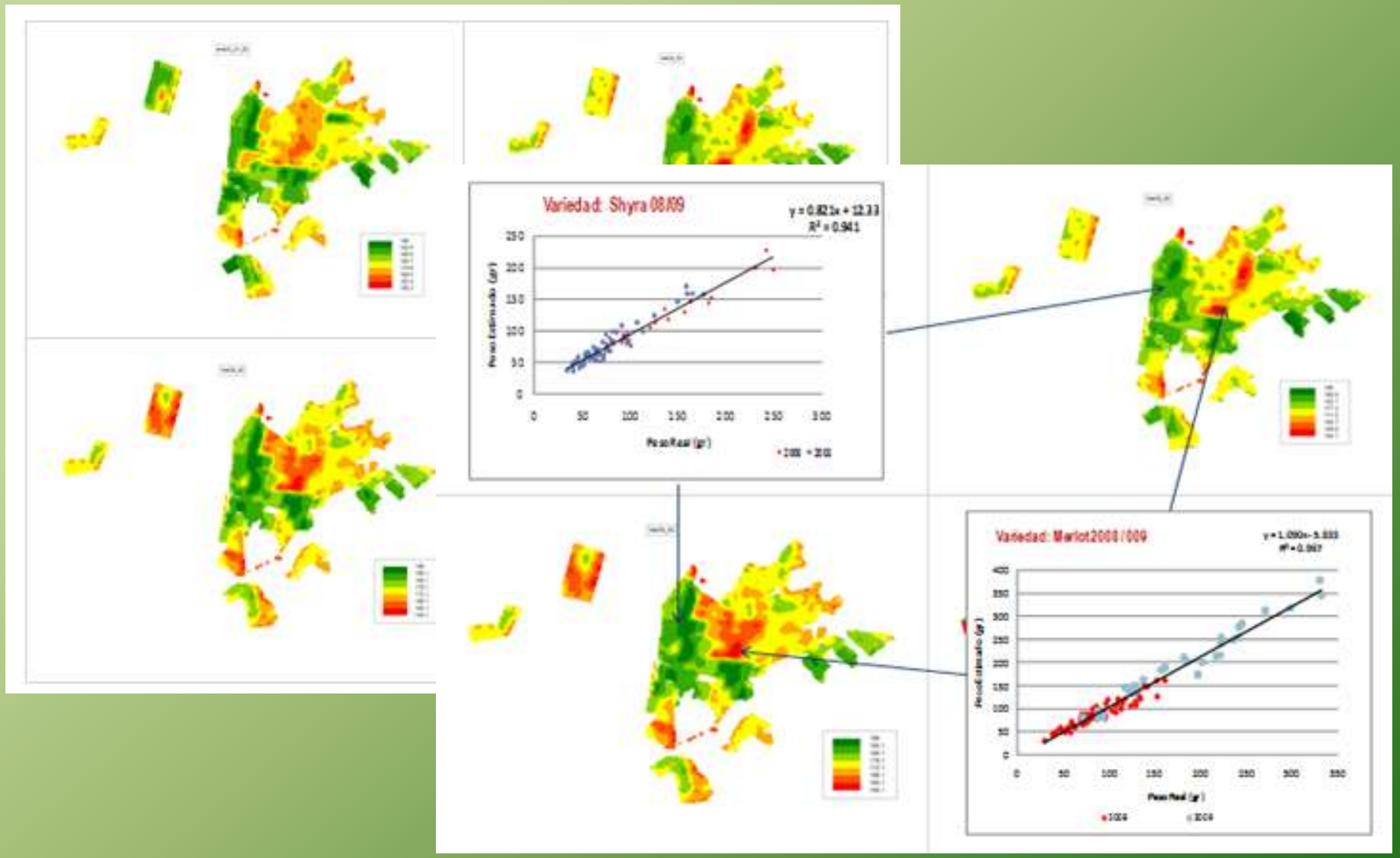
Winemaker evaluation



“Digital Terroir”: Progress and Understanding the Problem



NDVI seasonal changes



Seasonal Changes and Effect on production and quality

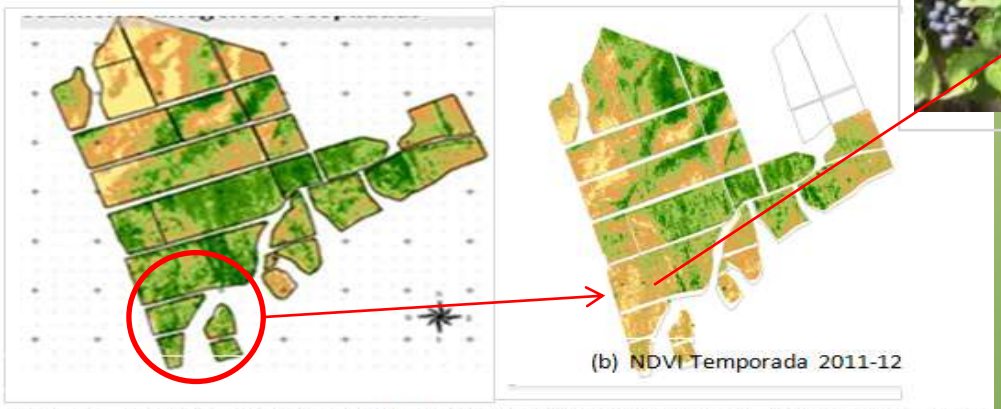
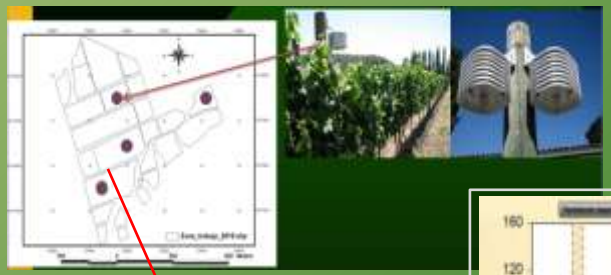
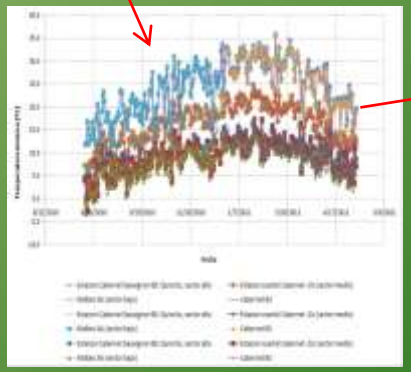
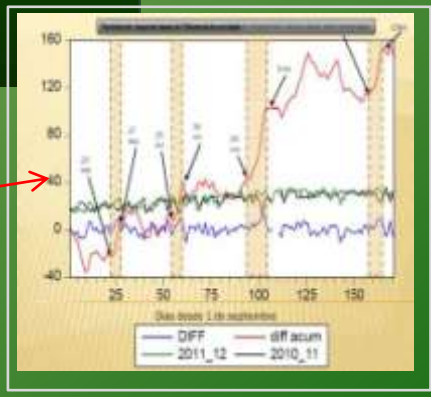


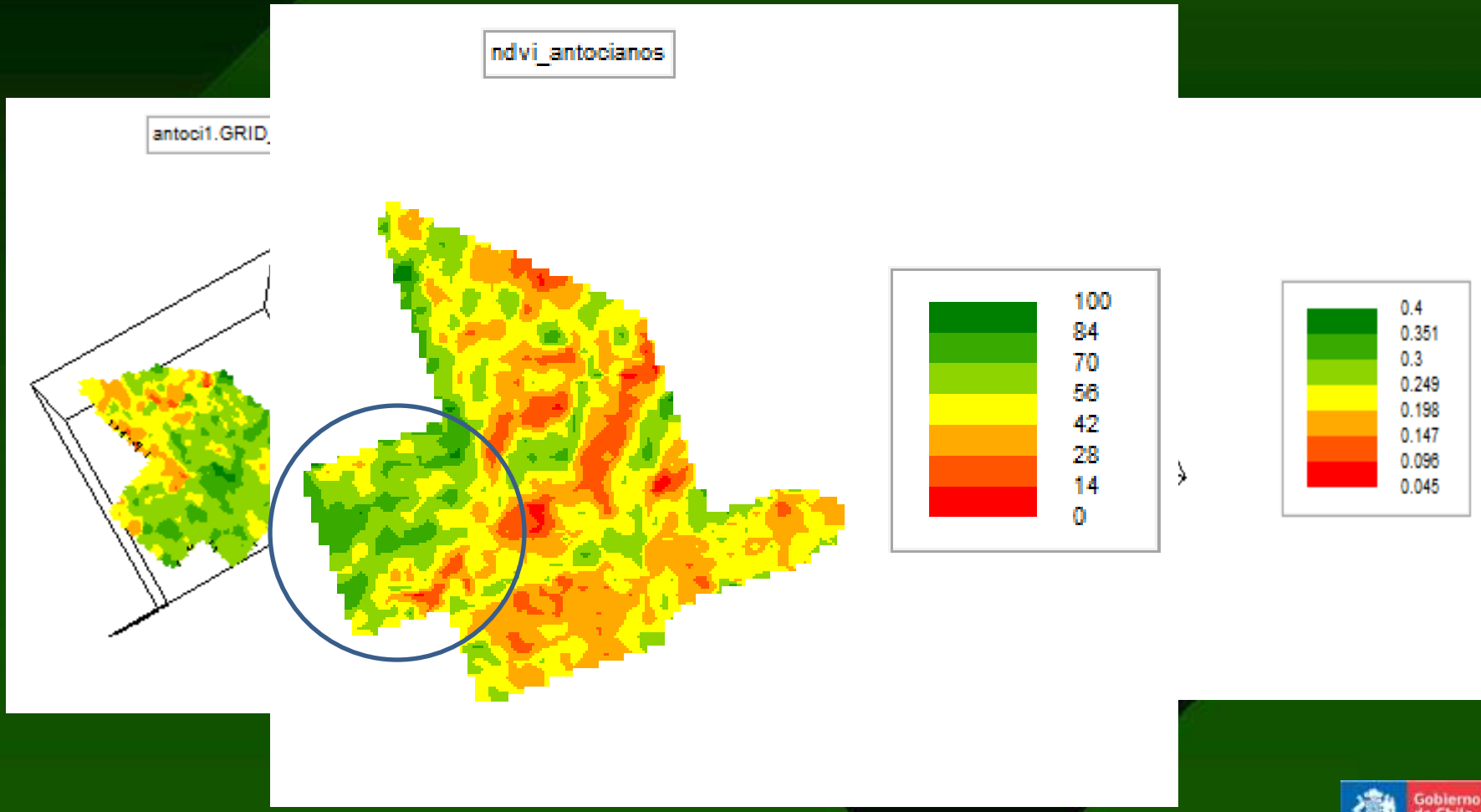
Figura 6. Variación de índice NDVI para (1) análisis integrado de 3 temporadas para segmentación de predio en zonas de comportamiento similar (informe nov. 2011) y (2) análisis de NDVI para temporada 2011-12





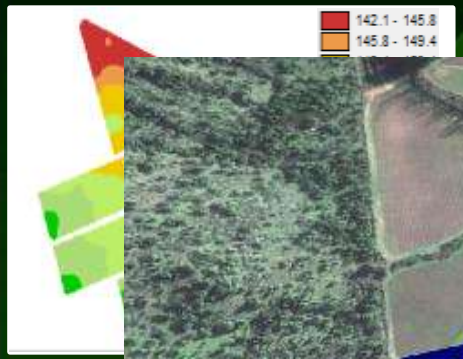


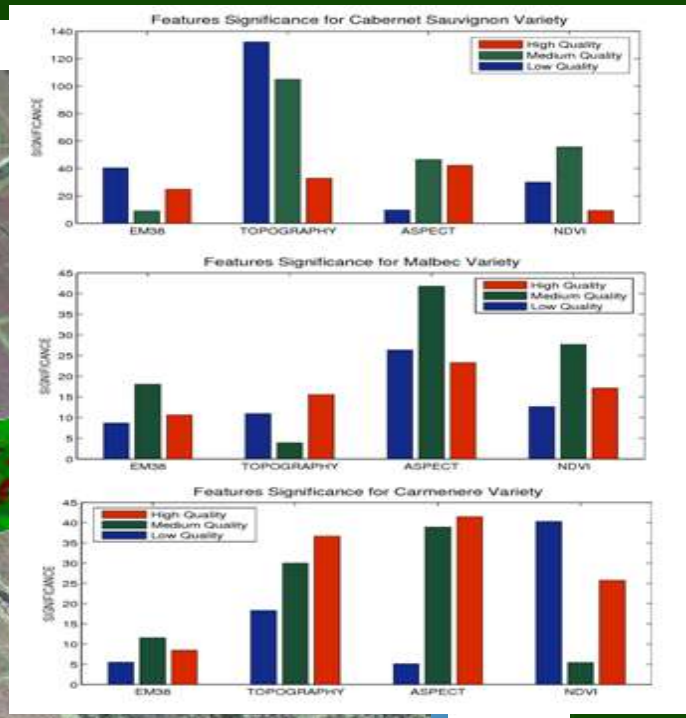
Comparative of Grapes Chemical Quality characteristics and NDVI map

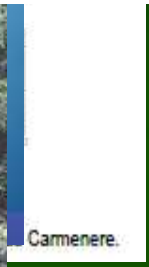


Association of soil and plant variables with grapes chemical quality characteristics

Topography NDVI Maps Exposure Maps CE Maps (EM38)

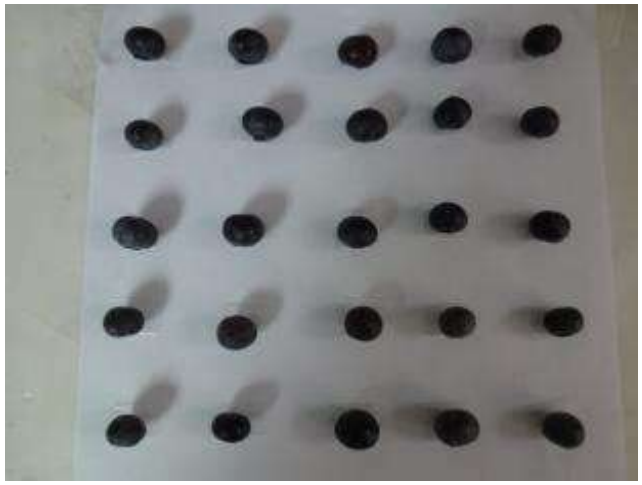






Variety	High Quality	Medium Quality	Low Quality
Cabernet Sauvignon	7,01%	10,81%	2,21%
Malbec	1,89%	5,63%	3,57%
Carmenere	4,97%	6,38%	1,03%

Characterizing differential maturity



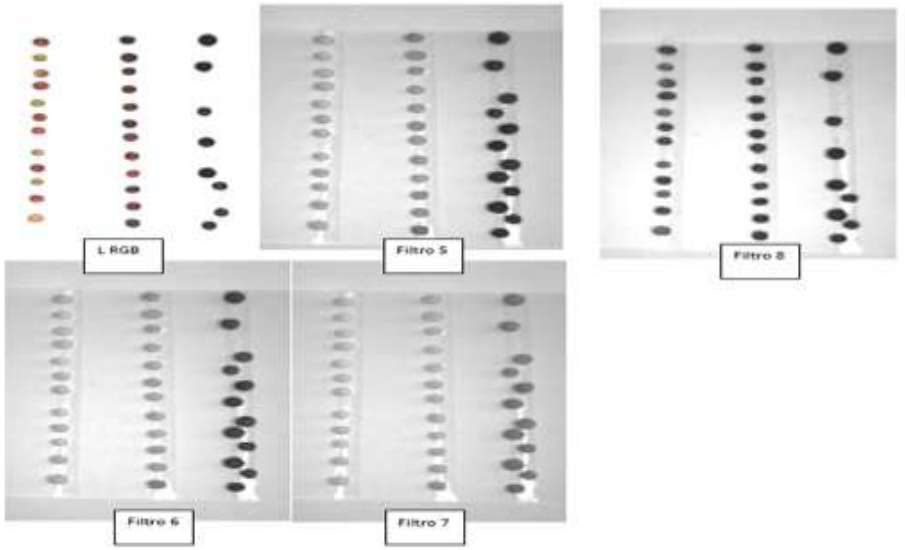
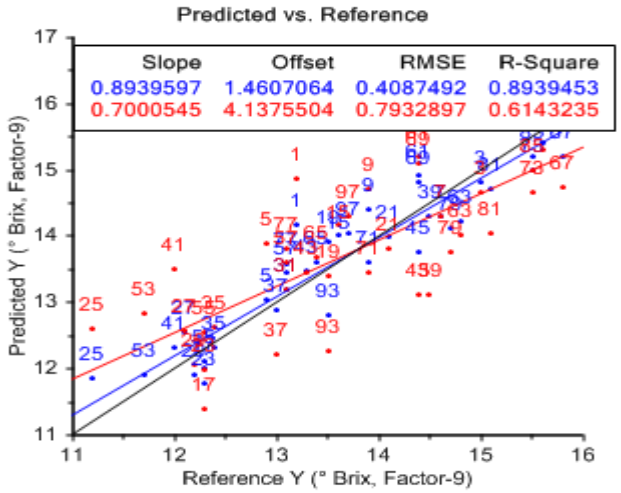
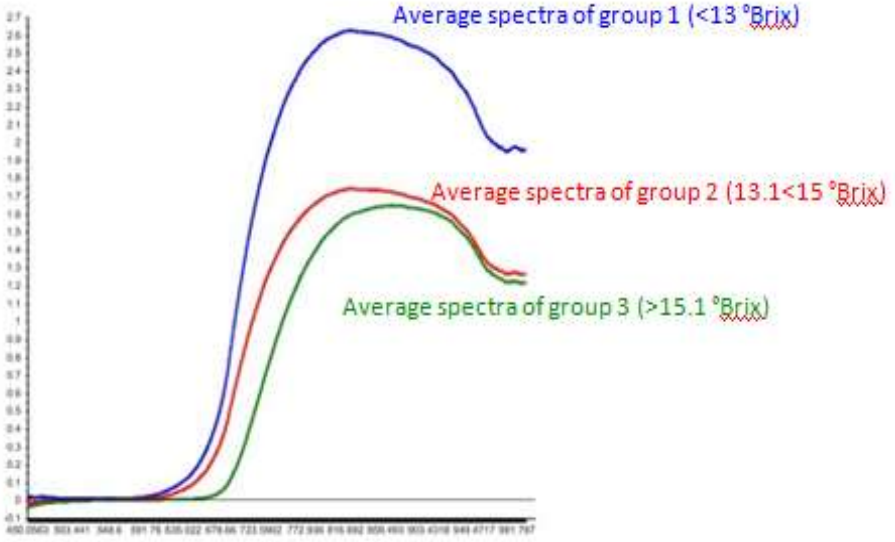


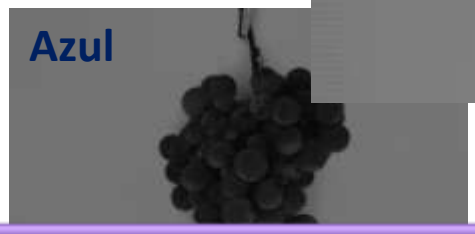
Figura 8. Imagen RGB (Superior Izquierda) de arándanos en diferentes estado de madurez y toma de la misma imagen en otras bandas espectrales.

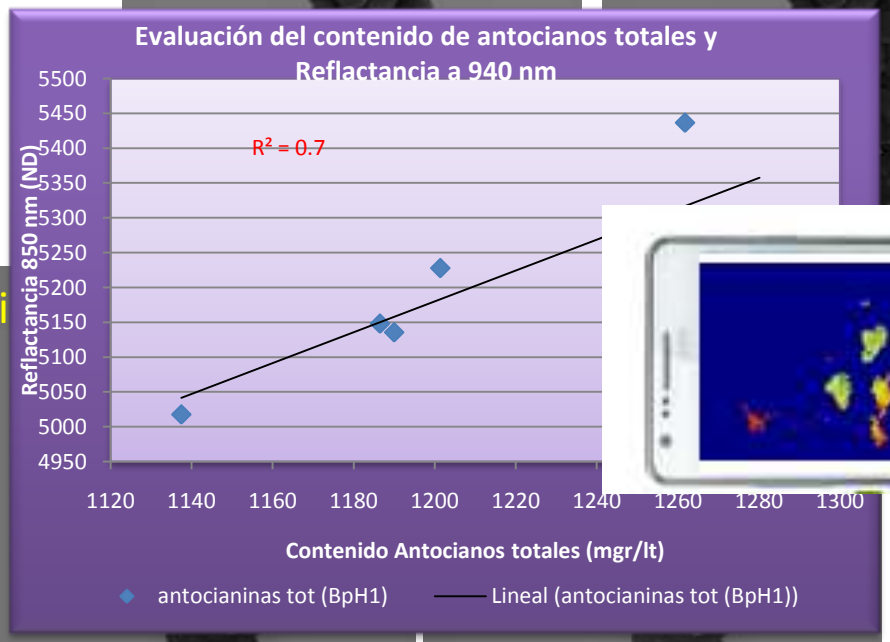


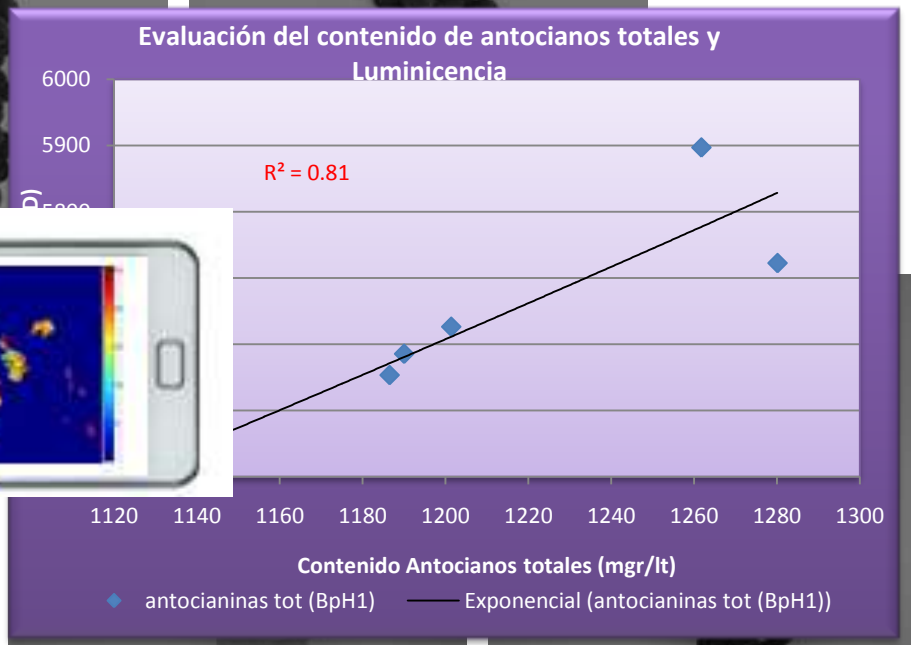


Laboratory analyze

(under controlled lighting conditions)



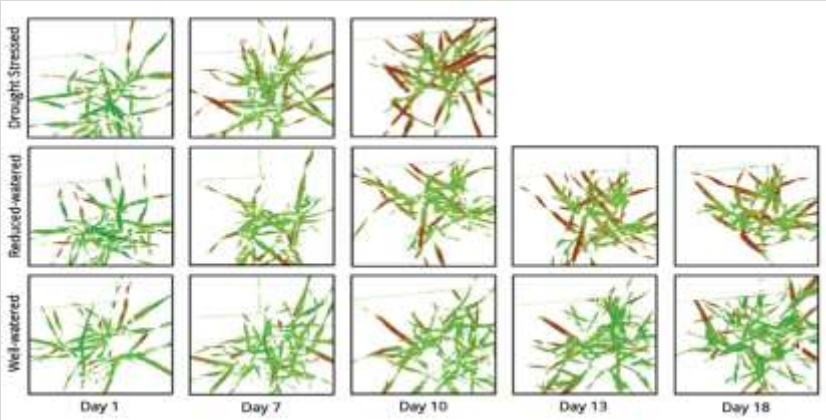


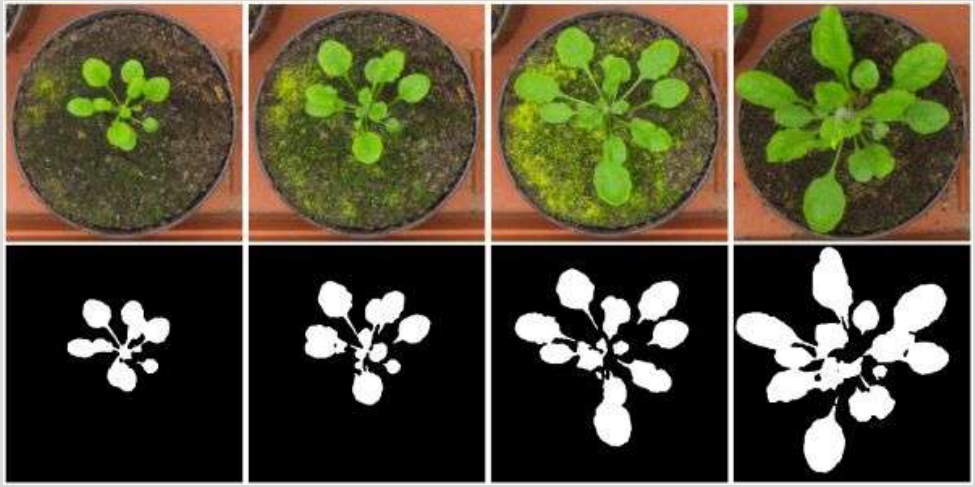


Advances in Detection and Control of Weeds, Pests and Diseases

Weed Control

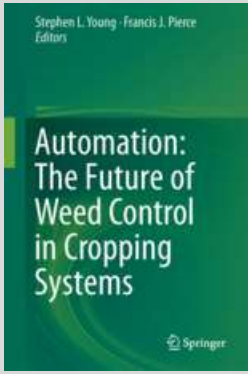
- Screening of weed detection
- Digital morphological characterization (resistance)





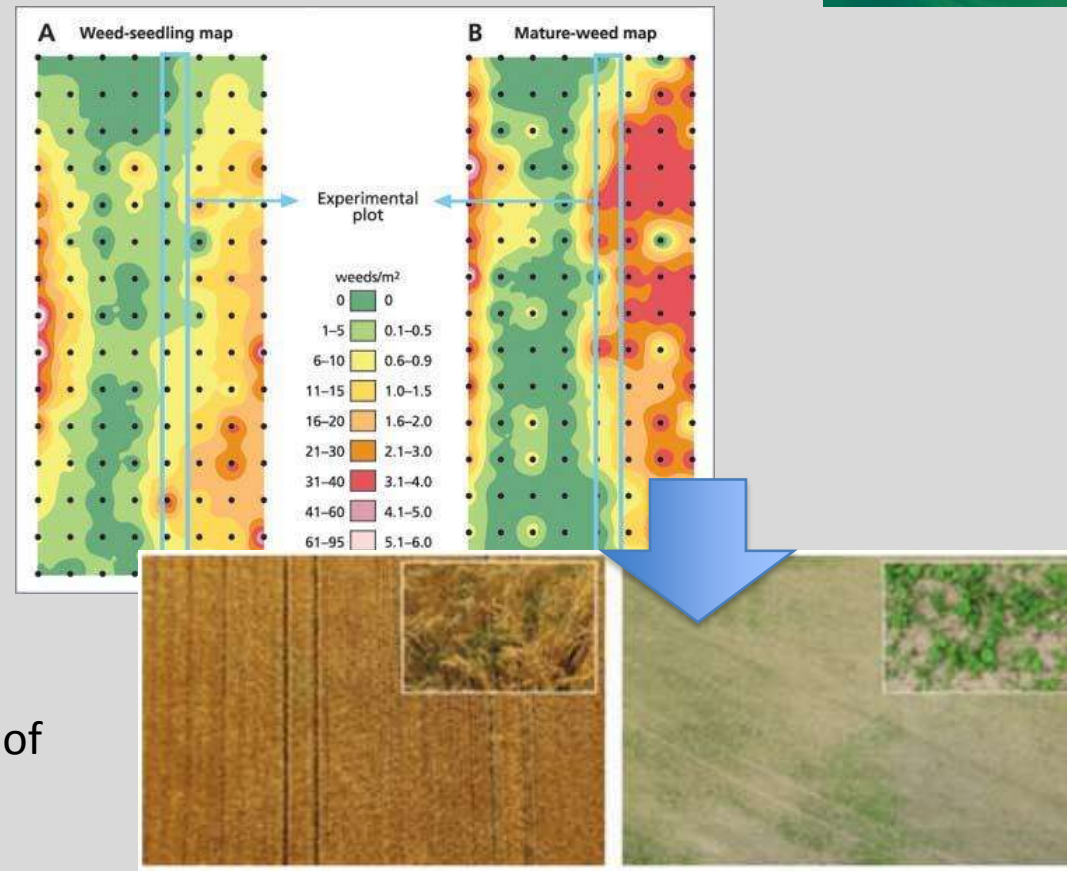
Recognition and dimamica growth species by "image technoloy"

Weed Control



– Poor assessment of time and place of application

Evaluating the objectives by UAV technology in combination with multi-and hyperspectral survey

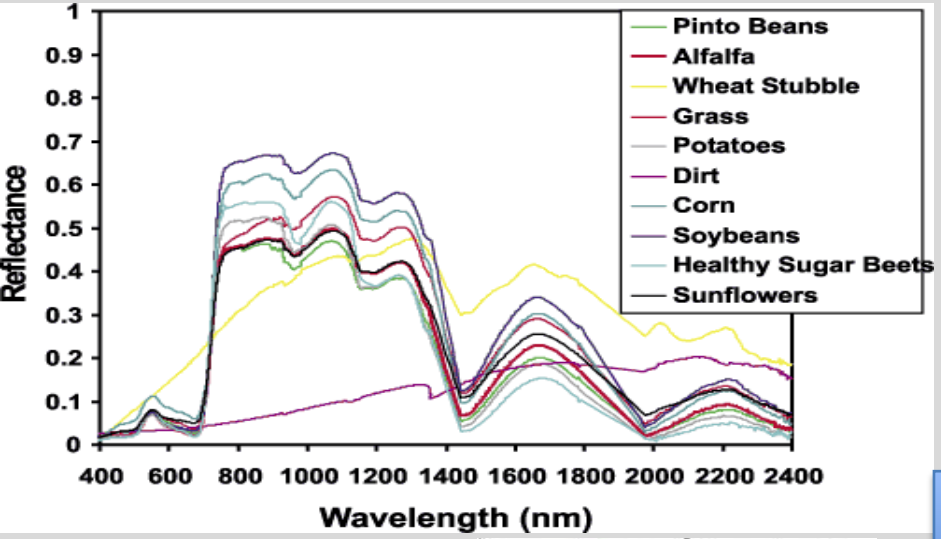


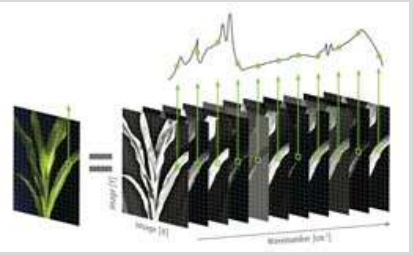
Using UAV equipment for determination of zones of varying degrees of infestation.

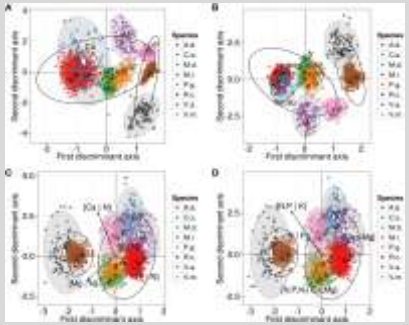
Weed Control

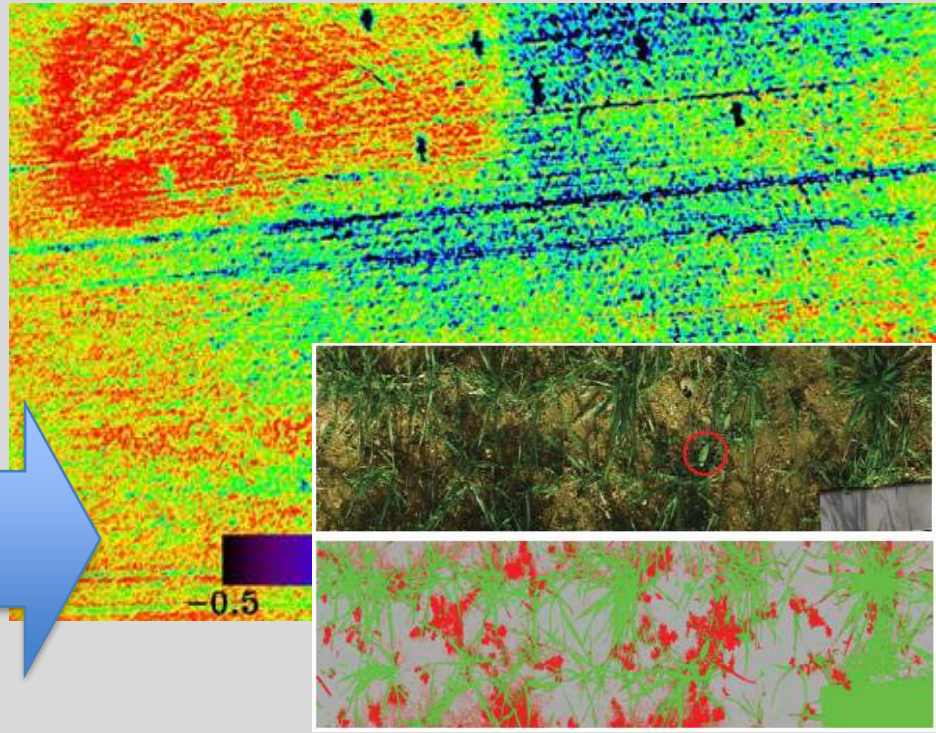
- Screening of plant resistant

  - Spectral characterization "fingerprinting"



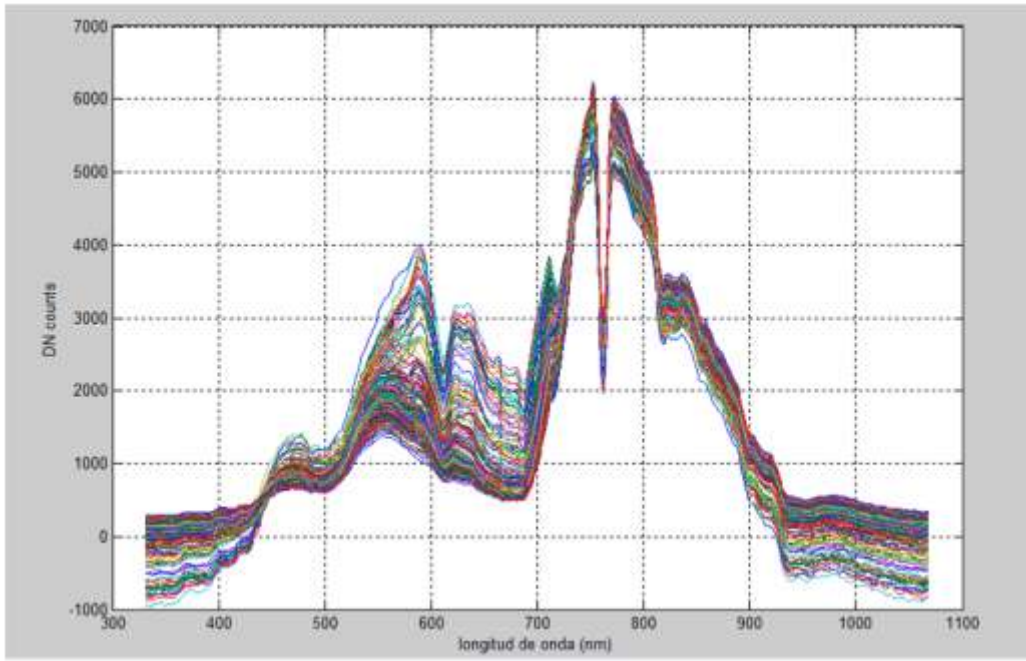




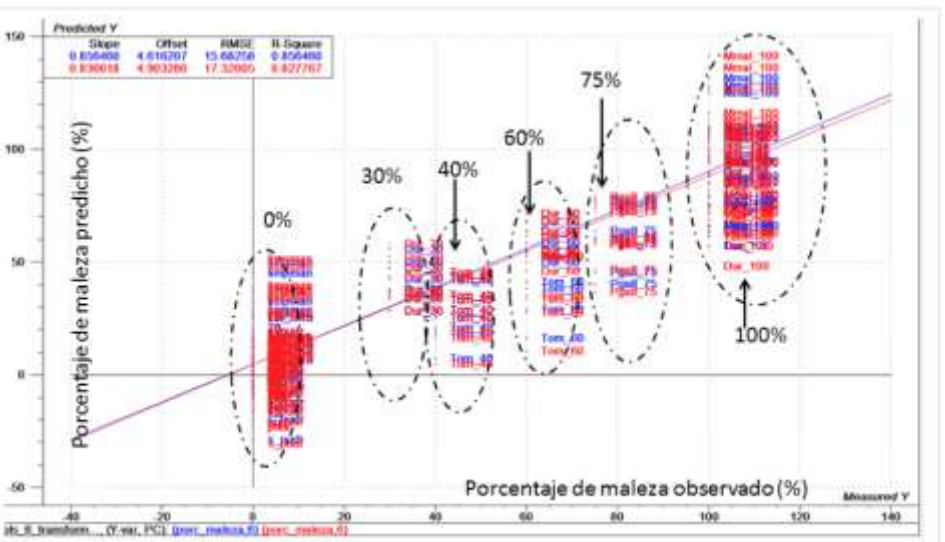


Weed spatial discrimination by spectral information

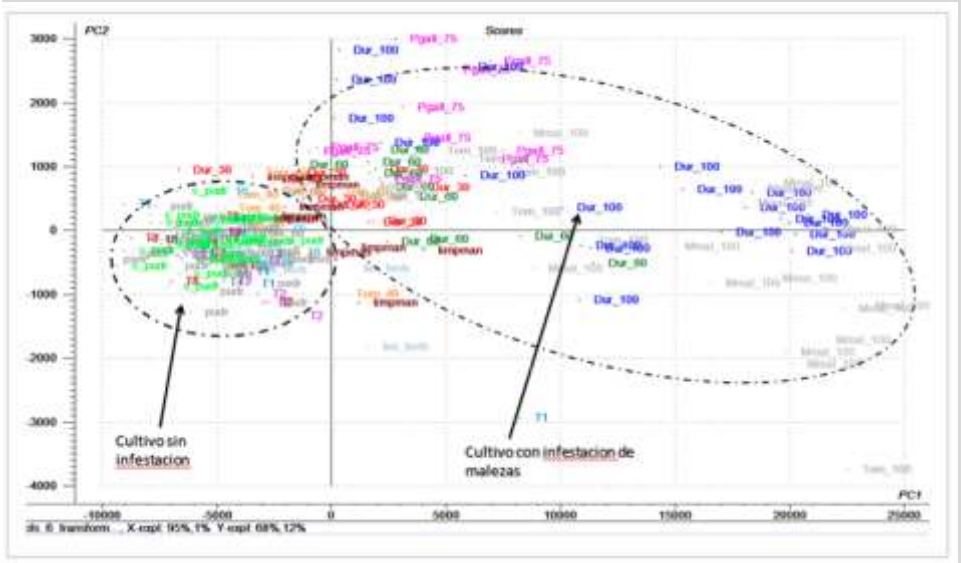
a) Niveles de infestación considerados



b) Firmas espectrales capturadas



c) Infestation levels of spectral correlation confirms



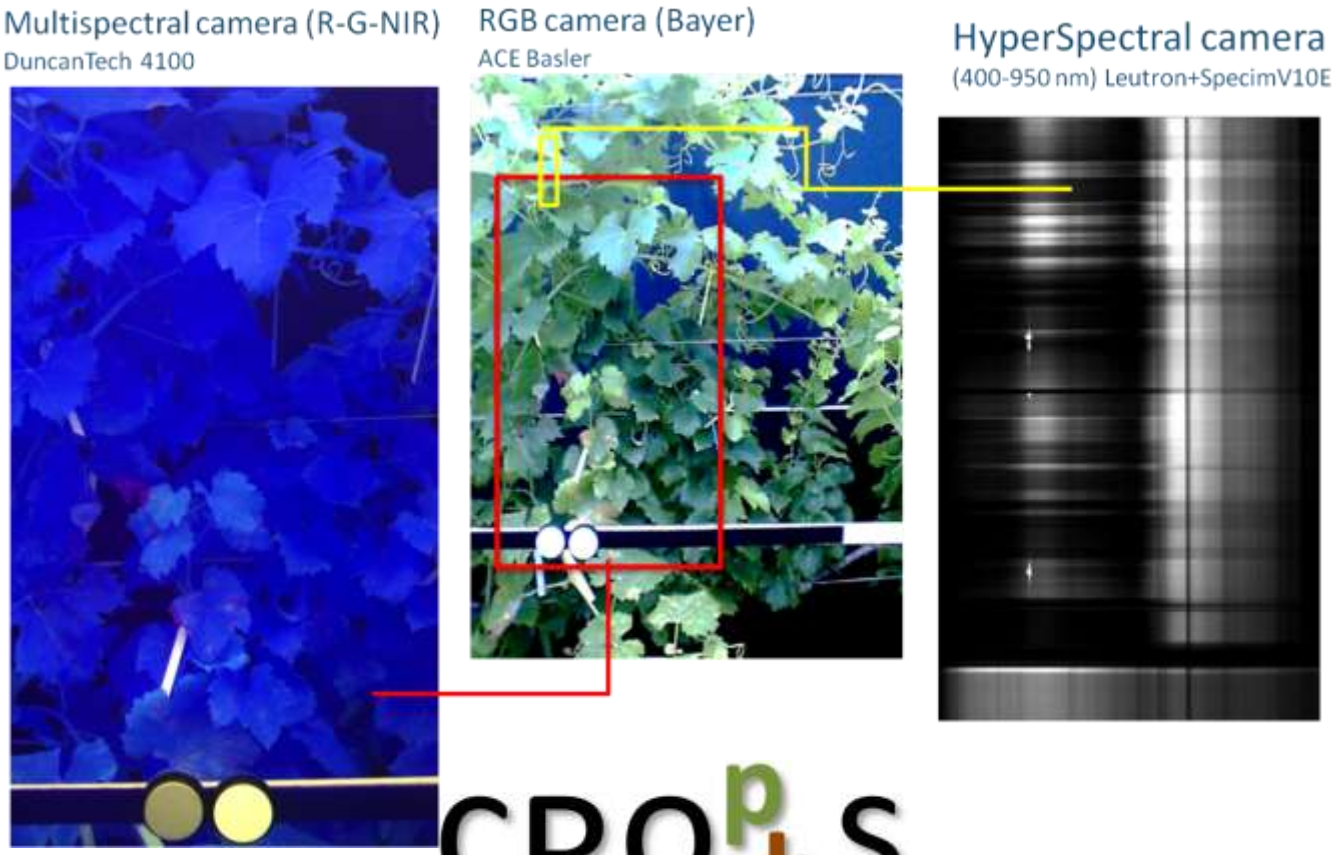
d) Discrimination weed-crop

Detection system for diseases in field crops

2011	2012						2013				
14	16	18	20	22	24	26	28	30	32	34	36

FORCE-A, KULEUVEN, CSIC, INIA

Example of multicamera sensing in vineyard conditions



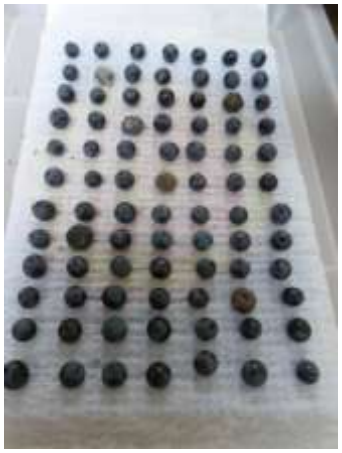
CROPBS

Monitoring of Botrytis on bunches before harvest (pre-harvest)

Bunch disorders and diseases can be detected at early stages by measuring optical changes in tissue and berries.

The changes in properties of juice and berry matrix (as water, sugar, acids content) can induce modifications of reflectance-transflectance spectra and activity.

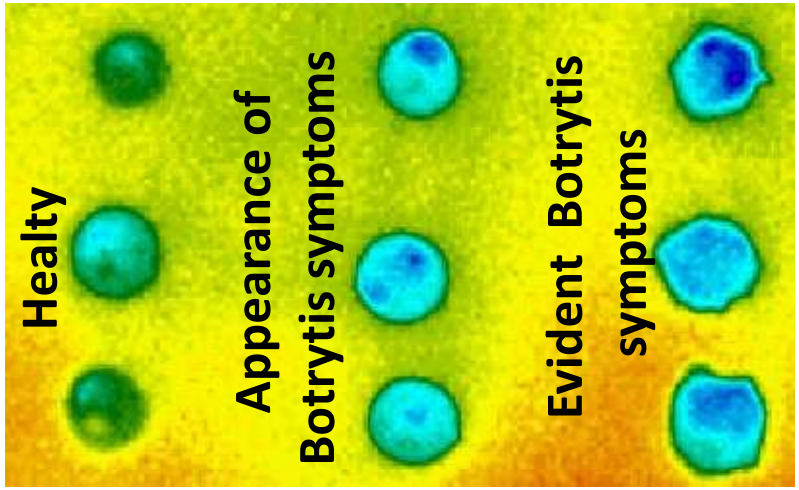
At early stages these effects are not visible to the human eye.



Botrytis inoculation and monitoring developed

IN LABORATORY

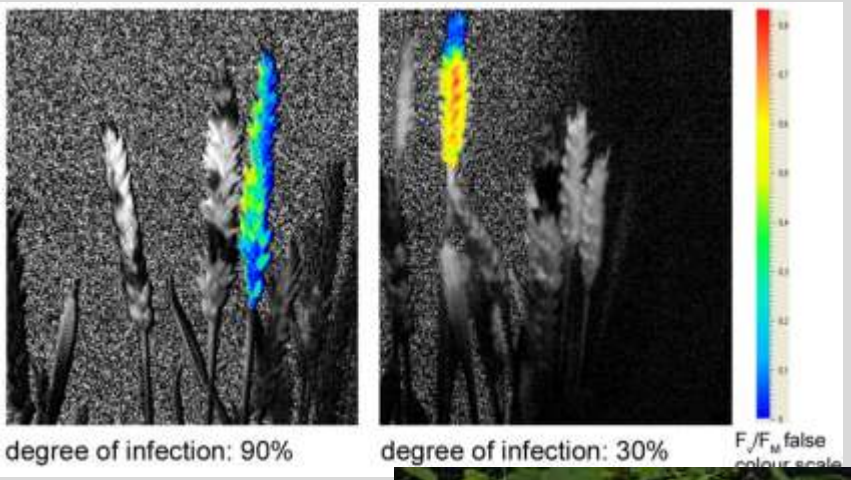
Thermal camera



Point-wise spectral reflectance in visible and NIR range

Disease control

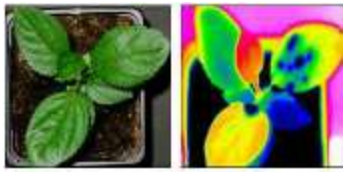
- Plant Disease detection and control

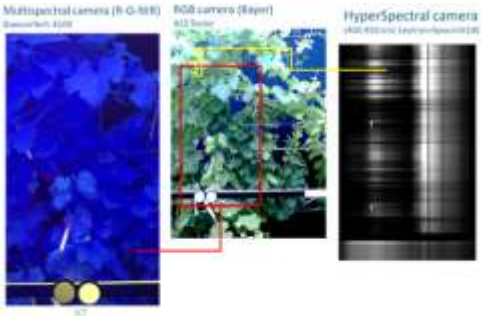


a) Discrimination of susceptible plants to diseases by use hyperspectral imagines; b) Robotic pesticide application (source: crops Project INIA-EEC)

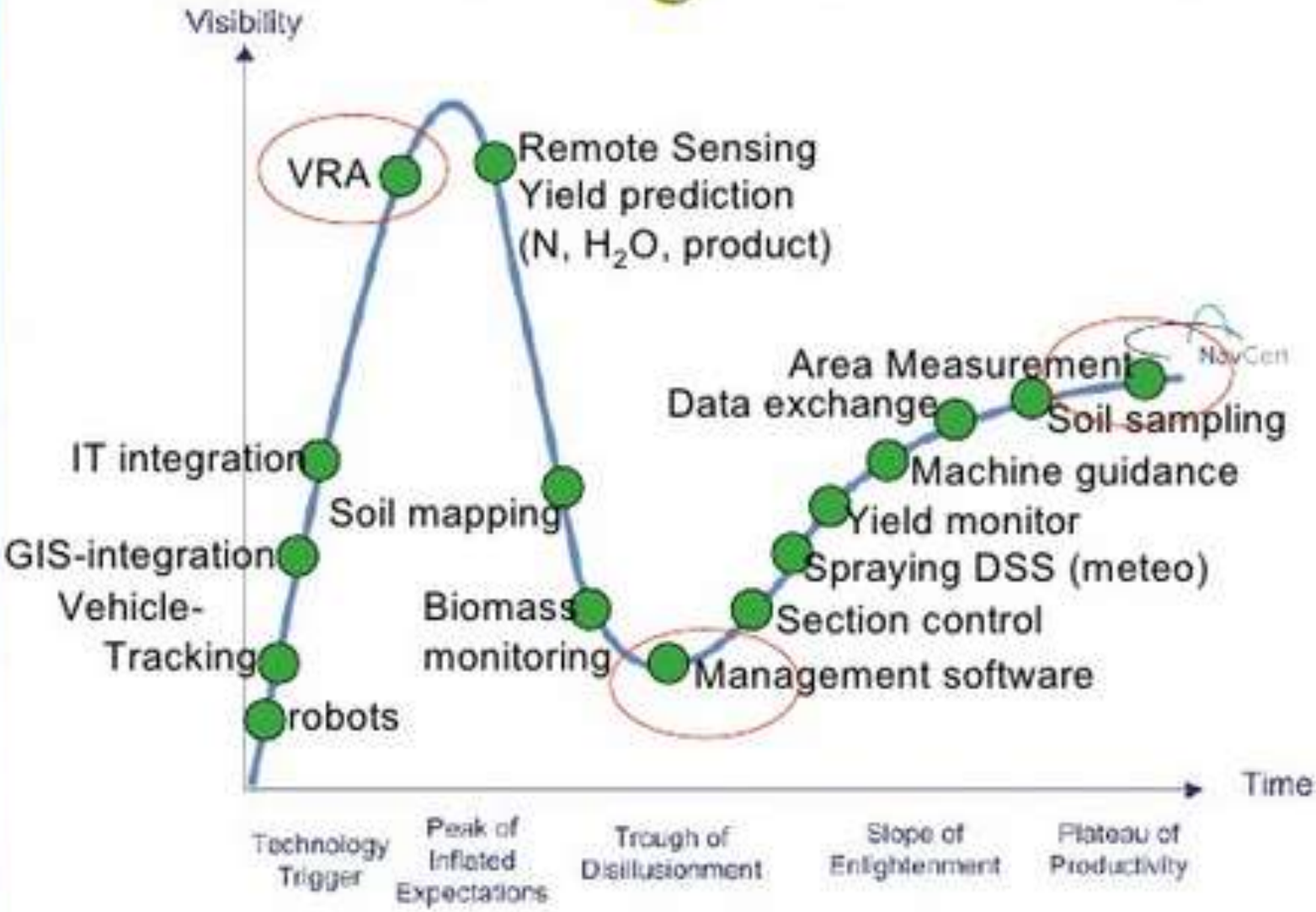
Applications

- Crop Monitoring
- Quality control
- Automating processes
- Anomaly Detection
- others





Precision Agriculture 'monitor'



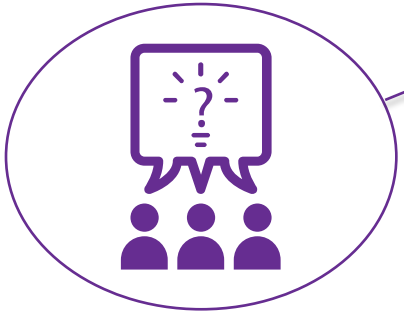
Different PrecAg applications placed on Gartners Hype Cycle curve.
Variable Rate Application (VRA) is promising but must prove itself. Too many uncertainties still.

Current situation of the production system in Chile and in many parts of the world

Agribusiness companies without further support to the productive sector and low answer to producers.

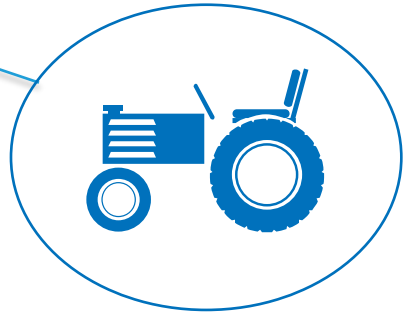
Producers with low technical level support means brief and very suspicious.

Business in technology services with low technical level and not in the opportunity time required. Sales data and not information.



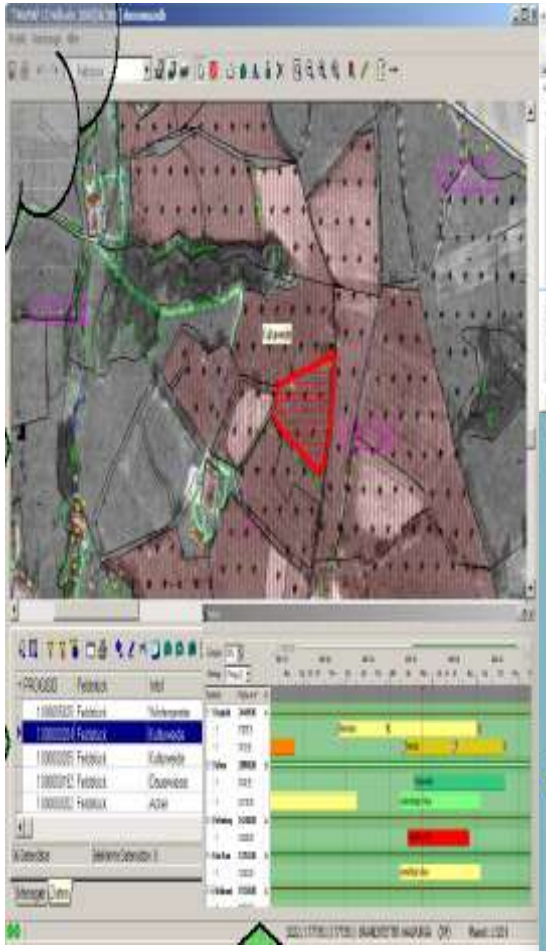
Sector I + D + I without greater linkage to producers.

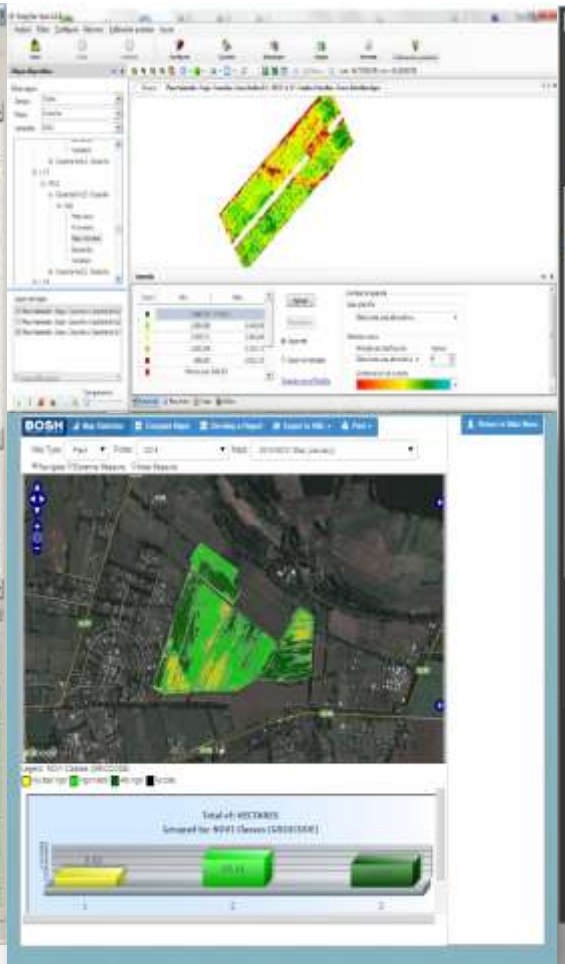
Agrochemical sales companies without real support (most of the time recipes) and sales of higher margin product.

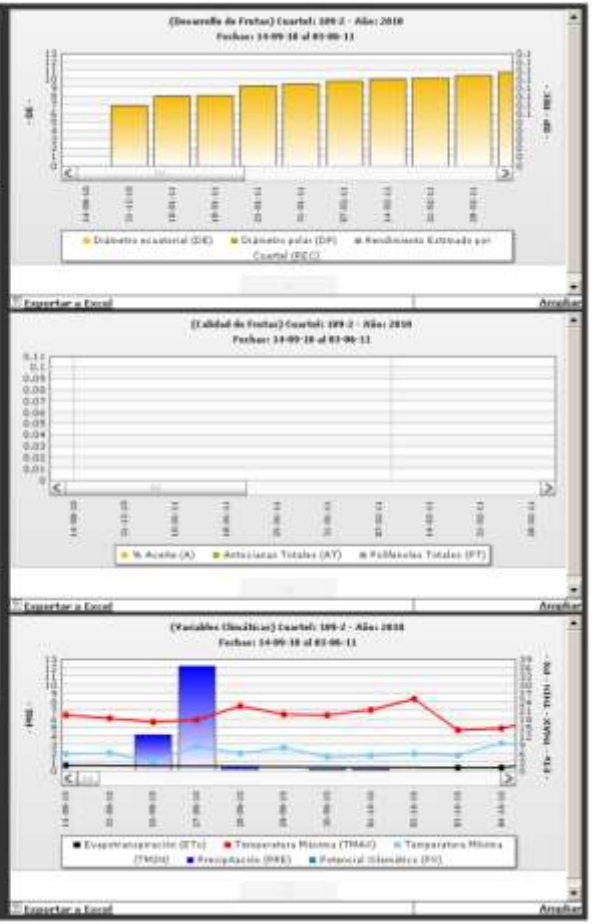


Machinery Service firms without much modernization and low efficiency in the support to the producers.

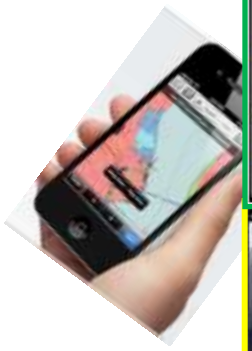
Lost a lot of information in each season. Inadequate records (files, paper). No spatial information management. Poor Management of Resources

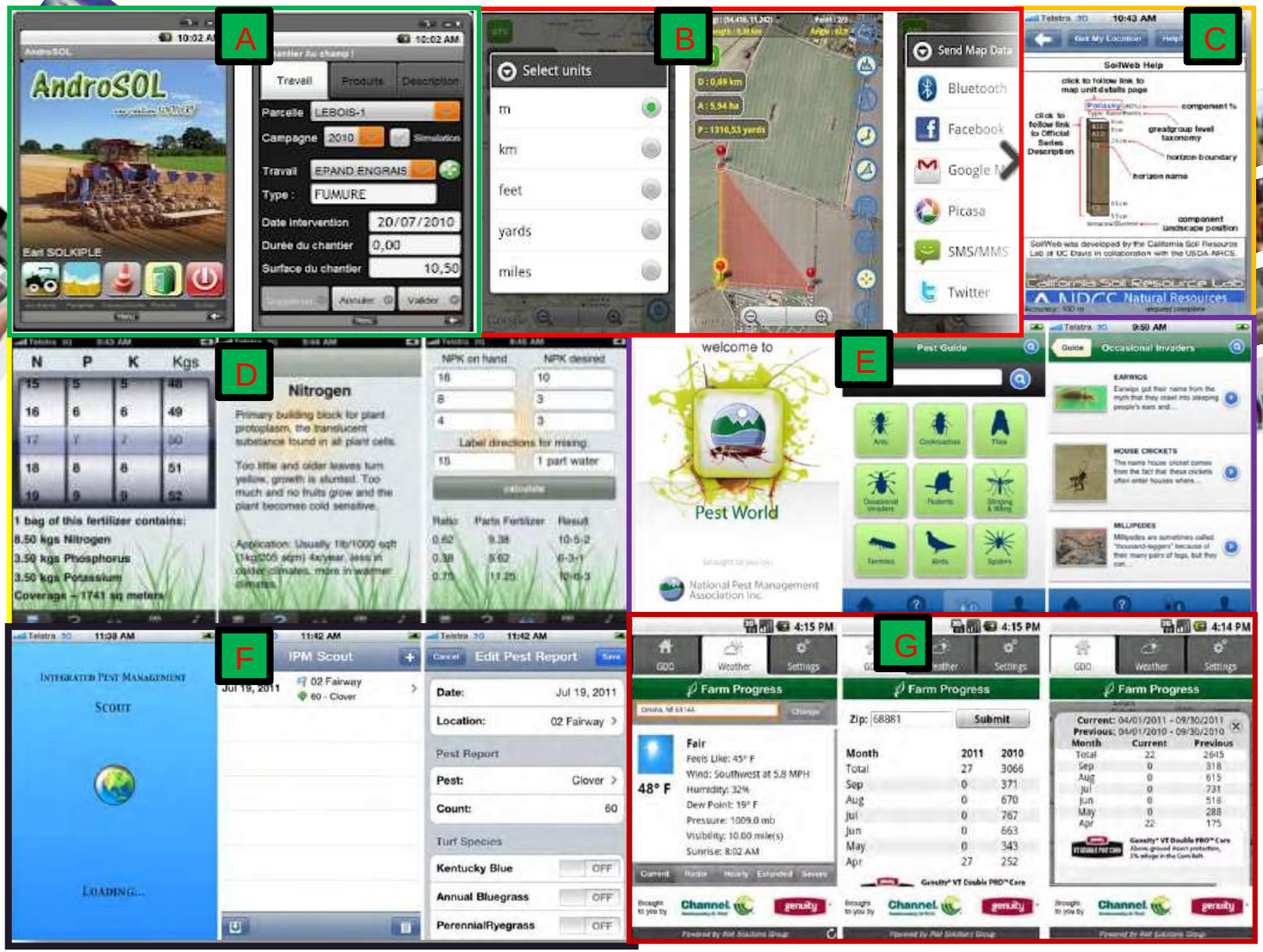


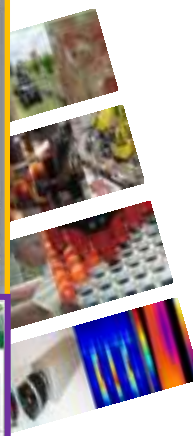




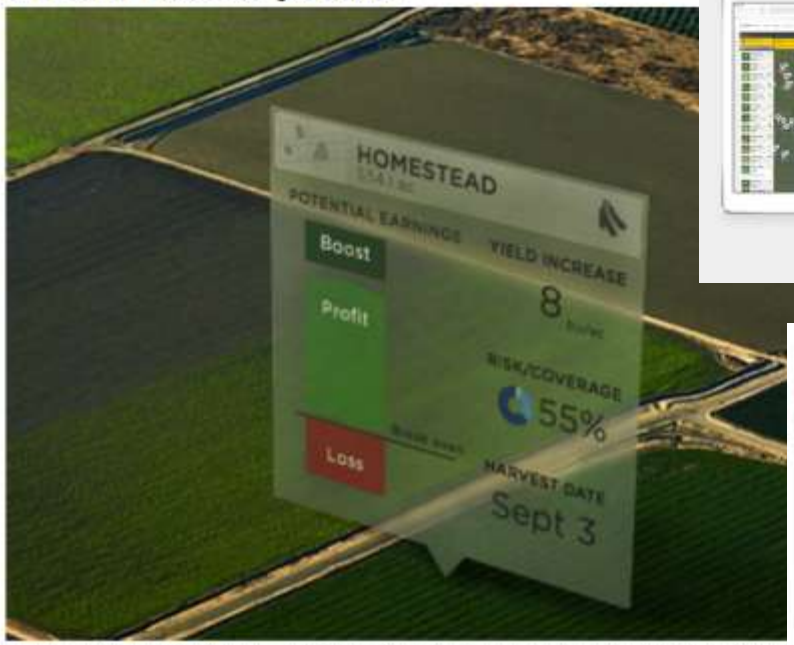
Developing and integration







1. The Climate Corporation

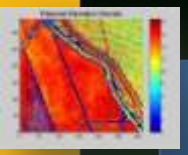


Courtesy of The Climate Corporation


Wearable tech for farmers: Google Glass

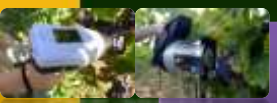
Imágenes relacionadas:

Future of Crops Monitoring and Management (Vineyard Example)



Irrigation

Remote Sensing



Quiality

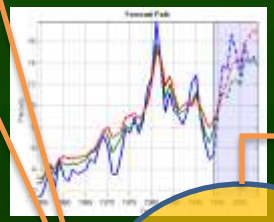
Yield

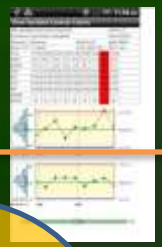
Soil

wheater

Close Monitoring

Integrated Vision



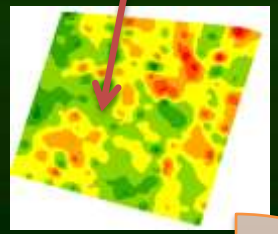


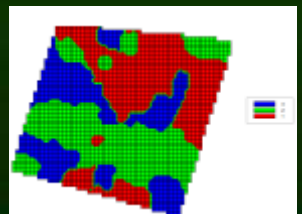
Spatial Predictive Models

Pre-Harvest Map

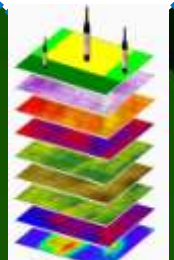
Harvest Map

Variation of management based monitoring (alert)/prediction. All in a interactive platform

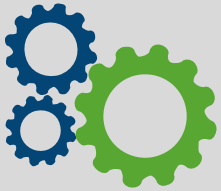




Winemaking and Viticulturist diagnosis



Expected Benefit



Diferenciation

Service quality obtained

Better Market Opportunities

Trazability

Sustentability

Savings for better management and efficiency

Future Expectations in Agriculture
Growth in Robotics

Multi-robot system

Intelligent robot
integrating with PF

Autonomous vehicle

Automatic Guidance system
（Deere: AutoTrack, etc.）

Navigation system
（Deere: Pararel track, etc.）

Effect on labor shortage

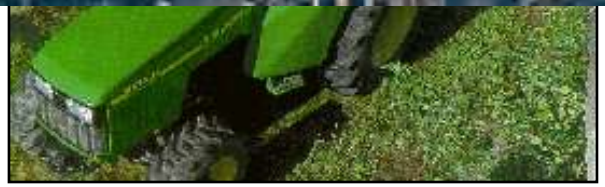
2000 2007 2014 2021

VeBots
Laboratory of Vehicle Robotics

Automated Orchard Systems?

Orchard De

Irrigation



Aut. System Monitoring

Robotic Aplications

Mechanical Harvester

The age of new technological convergences

The PF as a macro technological convergence

New technological, Economical and organizational paradigm :

- We need to change from homogenizer logic into diversity logic.
- Mutual empowerment. Advances in some technology drastically accelerate others.
- The different technologies must be "enabled" to work with others.
- "Synergistic combination" of two or more generic technologies in the search for common goals.
- It clear that ICT integrated into the internet cloud will be the way to pull down the different technologies in the hand of the final user but, those development must integrate a **social and technology** issues, in order to full fit the goal of real introduction.

www.aidic.it/frutic

Frutic Italy 2015

FRUTIC ITALY 2015

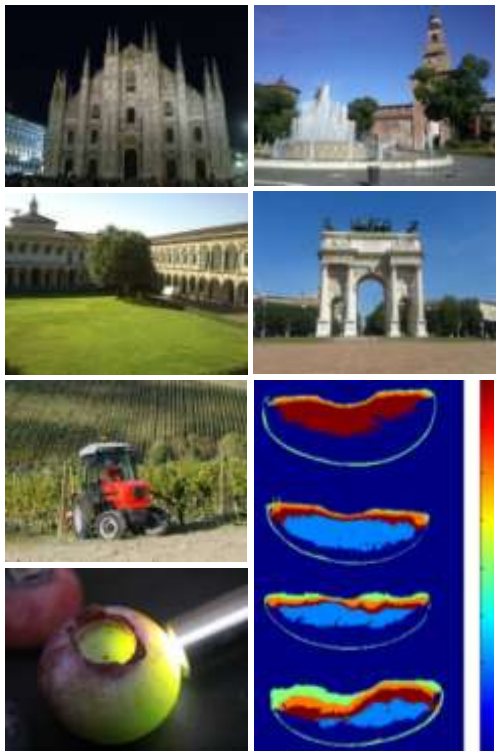
The 9th Fruit, nut and vegetable production engineering symposium

19-22 May, 2015 - Milano, Italy

http://www.aidic.it/frutic/

frutic@aidic.it

The conference will be held in **Milan**, during the **Expo Milano** 2015 (**www.expo2015.org**) and **IPACK – IMA** (**www.ipack-ima.it**), which present for the first time **FRUITECH** (**www.fruitech.it**), an exhibition focused on processing, packaging, preservation, and transportation technologies for fruit and vegetables.



Topics

- **Precision Agriculture in the orchard**
- **Sensors and Automation for orchards and transformation processes**
- **Logistics in the harvest and post-harvest**
- **Technologies for the pre- and post-harvest**
- **The measure of quality**
- **The equipment for packaging**
- **Sustainability in fruit and vegetables cultivation**


Thank you very much for your attention