Precision Horticulture

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Greece

Presentation Layout

1. Horticultural crops
2. Horticultural market
3. Specificities
4. Technology issues
5. Applications on orchards
6. Applications on vegies
7. Specific questions
8. Conclusions

Horticultural crops

Tree fruit (*orange, lemon, apple, banana, cherries, etc.*)

Tree nuts (*cashew, walnut, pistachio, etc.*)

Other fruit (*strawberry, pineapple, watermelon, blueberry, etc.*)

Vine fruit (*table grapes, kiwi fruit*)

Fruit considered as vegetables (*avocado, tomato, egg plant, squash, pumpkin, etc.*)

Source: FAO Agricultural Services Bulletin 76

Horticultural crops

Vegetables derived from seeds and flowers *(broccoli, pea, bean, lentil, chickpea, etc.)*

Leaf and stem vegetables *(lettuce, spinach, leek, asparagus, etc.)*

Root vegetables *(onion, potato, radish, carrot, etc.)*

Herbs *(parsley, mint, basil, etc.)*

Spices *(ginger, black pepper, chilli pepper, etc.)*

Flowers

Synonymous to High Value Crops or Specialty Crops

Source: FAO Agricultural Services Bulletin 76

Specificities in Precision Horticulture

PERENNIAL VS ANNUAL CROPS

Temporal stability for tree crops and spatial stability for vegetables

TABLE VS PROCESSING CROPS

Quality is important for table fruits and vegetables and quantity for processing crops (as arable crops)

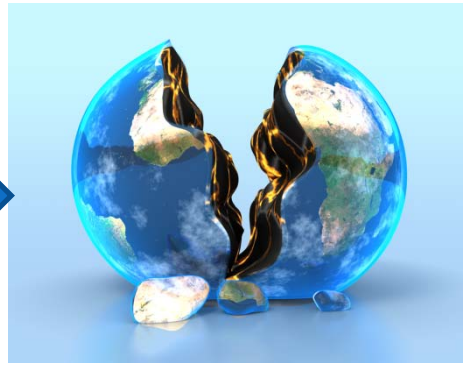
Specificities in Precision Horticulture

- Many **manual operations**
- **Hand harvested**
- **Quality control** of products is very important issue more than any other culture
- As the majority deals with perennial crops (orchards), **temporal stability** is very important
- **Planting densities and time** of planting is different and this may cause problems with RS
- **Field size** is generally smaller

European Horticultural market

Fruit & vegetables market had total revenues of **124 billion Euros in 2010**

Consumption was about **92.9 million tons** in 2010



Annual growth rate of 3.4% for the period spanning 2006-2010

Annual growth rate expected to be of 5.2% for the period 2011-2015 to reach **160 billion Euros**

Source: http://www.copa-cogeca.be

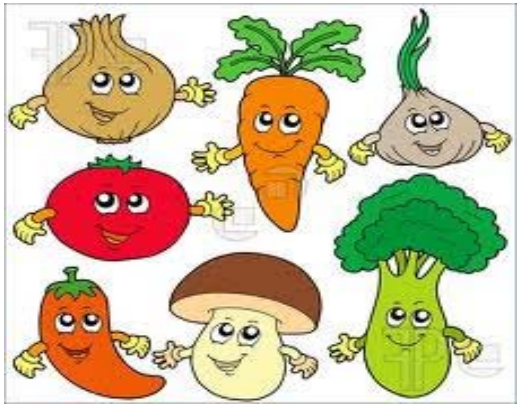
European Horticultural market

Europe is the world **second largest producer** of fruit and vegetables

EU has a **deficit** in fruit and vegetables (8 billion Euros) and is the second largest importer

Source: http://www.copa-cogeca.be

Social Impact of Horticultural crops



Contain vitamins, minerals, phytochemicals. Help to protect the body against diabetes, stroke, heart disease, some cancers and high blood pressure.

Many people do not eat enough fruit and vegetables

Attention against food scarce and food scandals, which are more frequent in recent years.

Traceability systems for fruits and vegetables are important.

Machinery and PA technologies available for trees and vegetables

Orchard machinery - equipment

Mechanical Harvester
for Citrus - Oxbo, USA

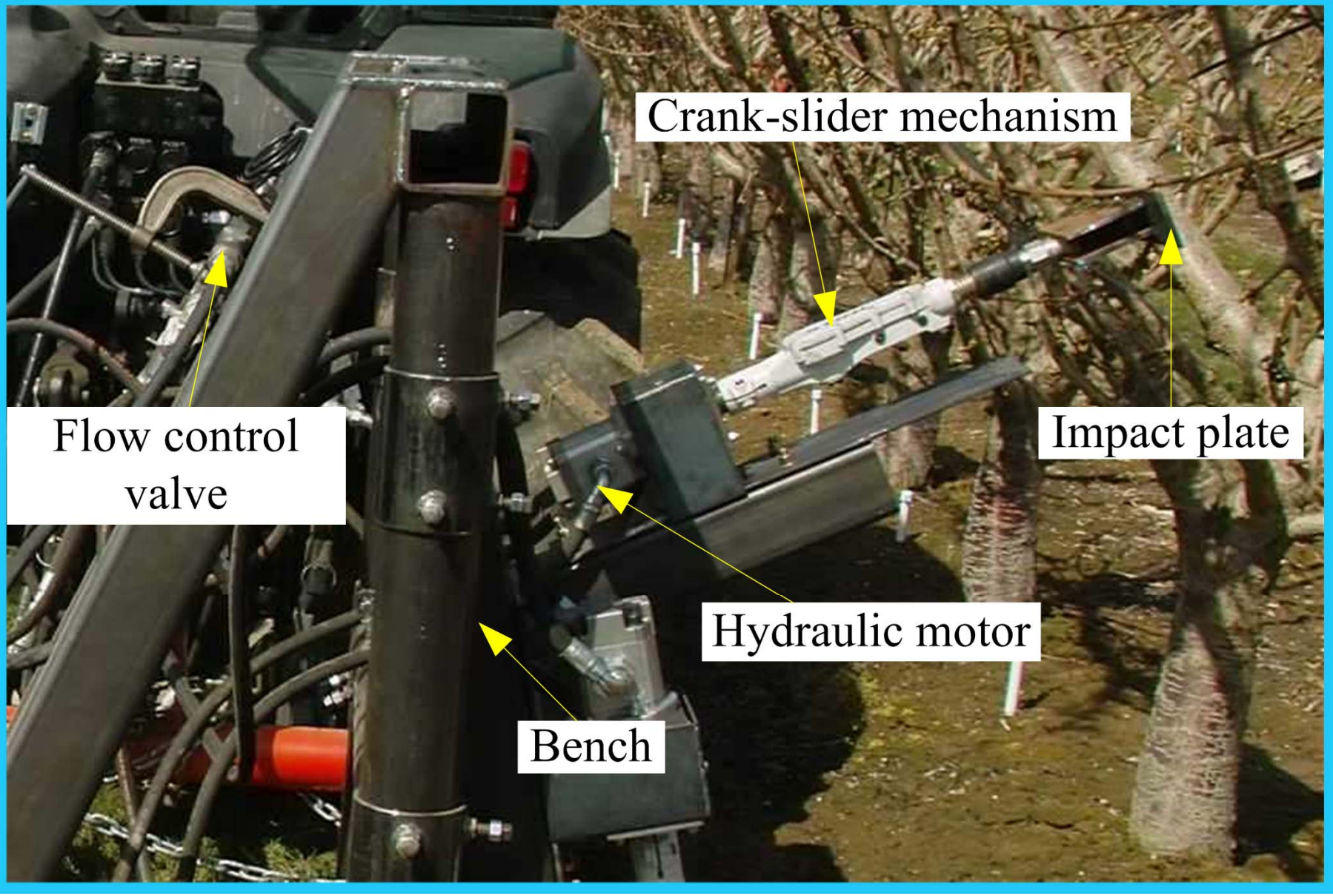
Orchard machinery - equipment

Vacuum Apple Harvester,
Phil Brown Welding, USA

Orchard machinery - equipment

Prototype Mechanical Harvester for Sweet Cherries (PickerTech - WSU)

Mechanical Harvest of Stem Free Cherry



Mechanical Harvest for Olive trees

Mechanical Harvest for Olive trees

Traditional Harvesting for Olive trees

Challenges in Mechanical harvesting

- **Interaction** between Orchard System and Machine compatibility
- Fruits are not matured at the **same time**
- Need for **crop load uniformity**
- **Range** of orchard systems
- **Market size** is not big and is regionally segmented
- Assist systems **do not replace large numbers of employees**
- **Capital investment** is required

Precision Horticulture technologies

Smart Monitoring

3D Machine Vision for Improved Apple Crop Load Estimation-WSU

Pollination Solutions

PollenPlus™QuadDuster – New Zealand

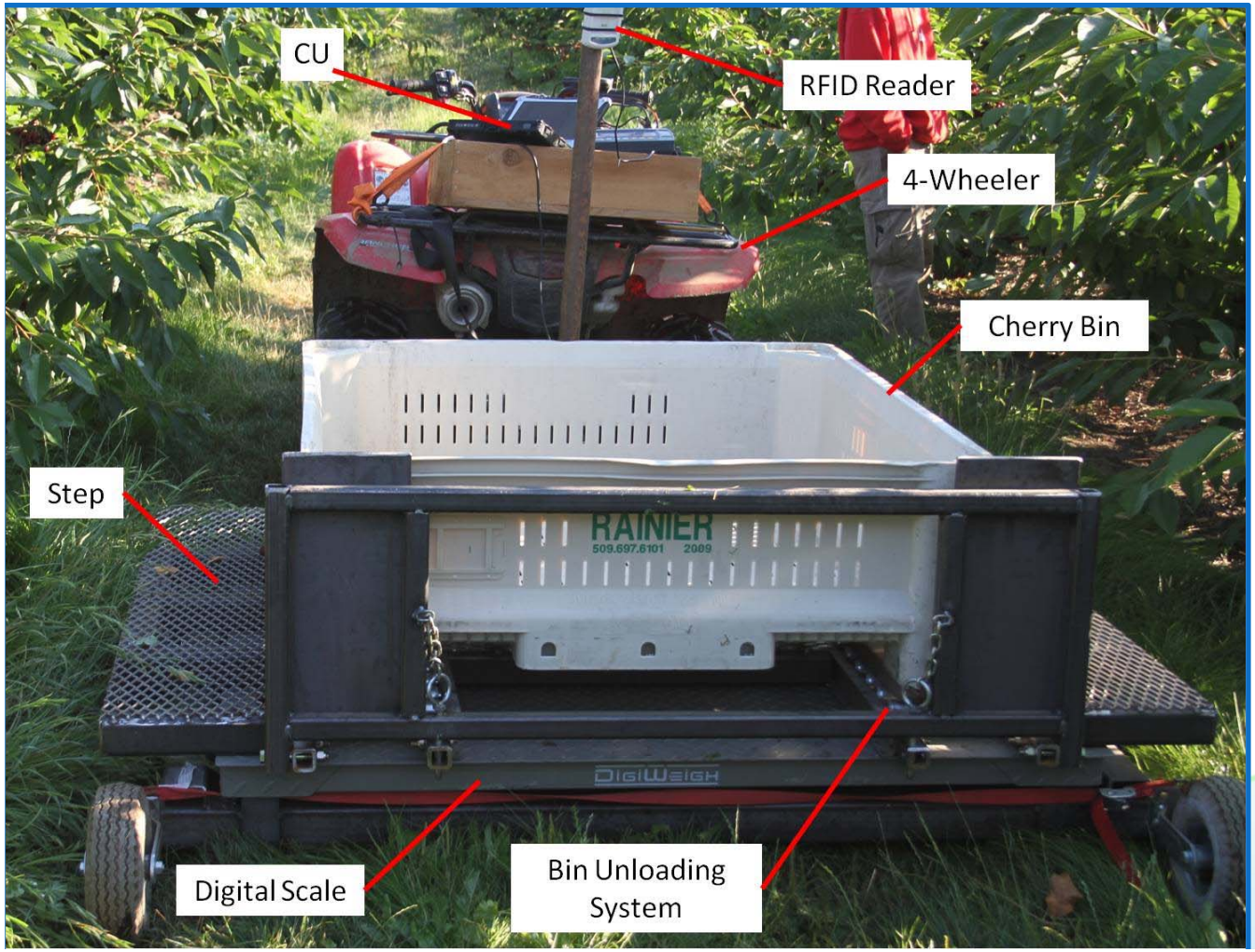
Precision horticulture technologies

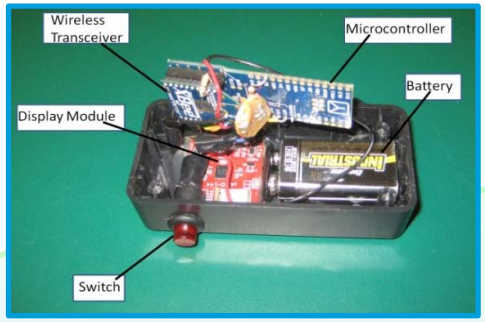
Yield mapping for peaches based on RFID tags

Ampatzidis et al.(2009)

Precision horticulture technologies

Labor Monitoring System, LMS

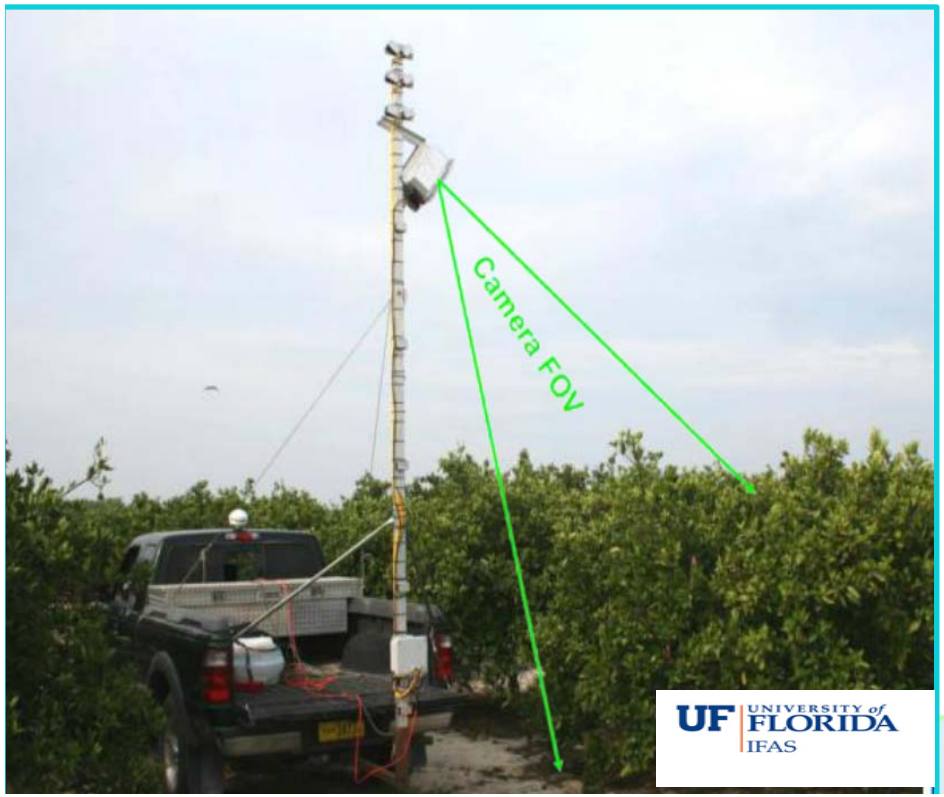




Ampatzidis et al.(2012)

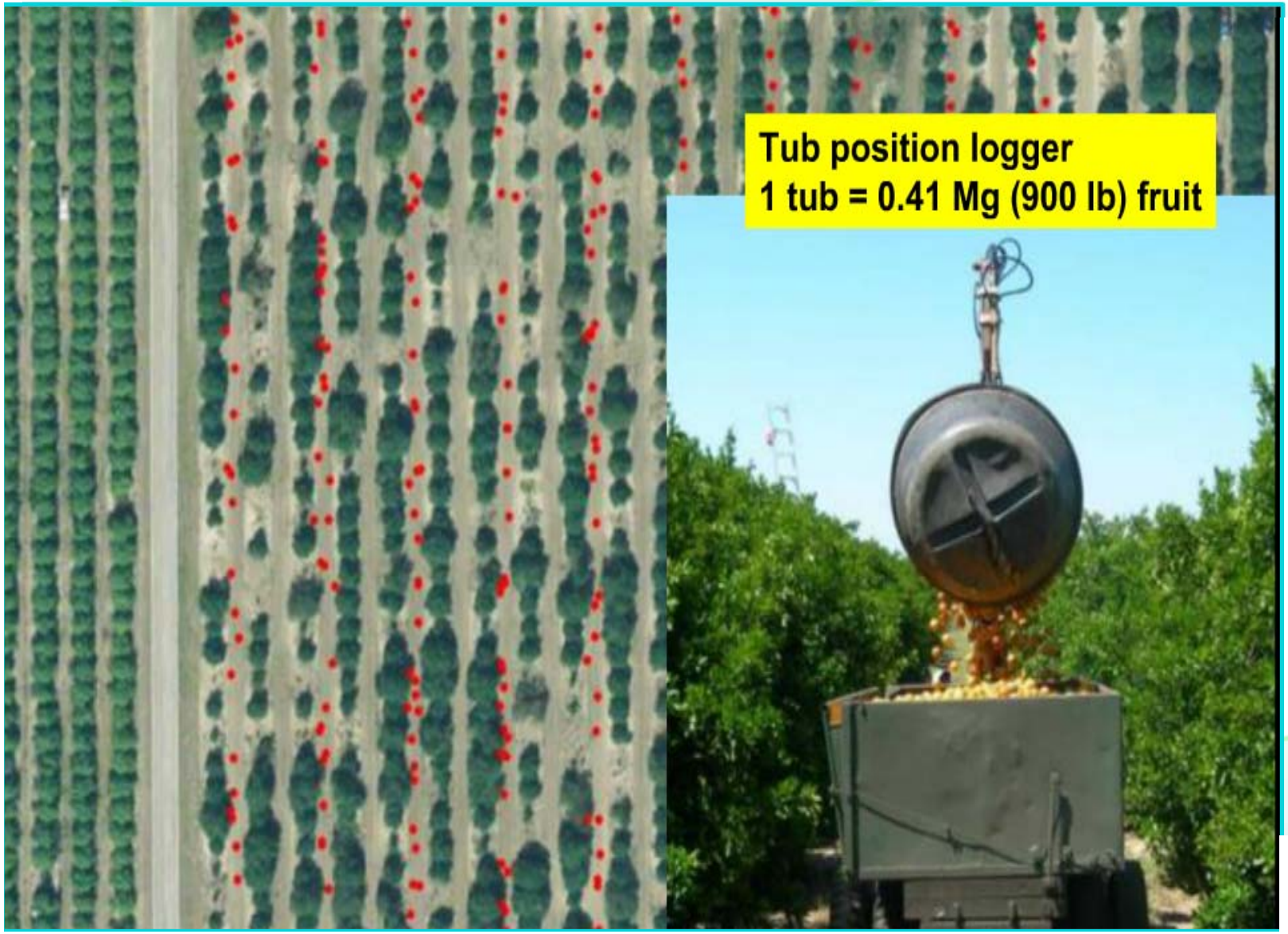
Precision horticulture technologies

Digital photography



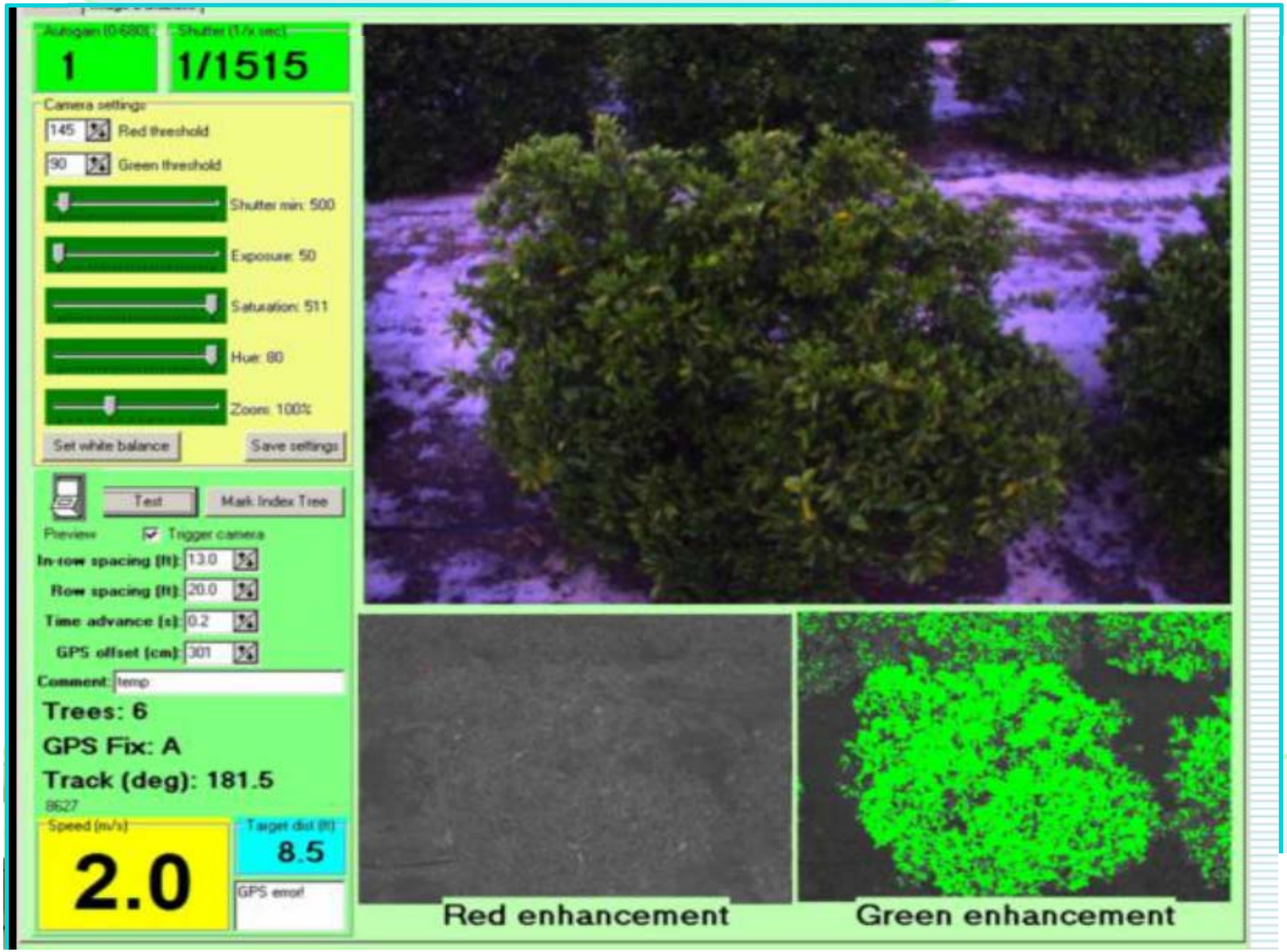
Ultrasonic canopy volume estimation

Precision horticulture technologies



Yield mapping with tree positions

Precision horticulture technologies



Automatic colour image acquisition

UF UNIVERSITY of FLORIDA IFAS

Precision horticulture technologies

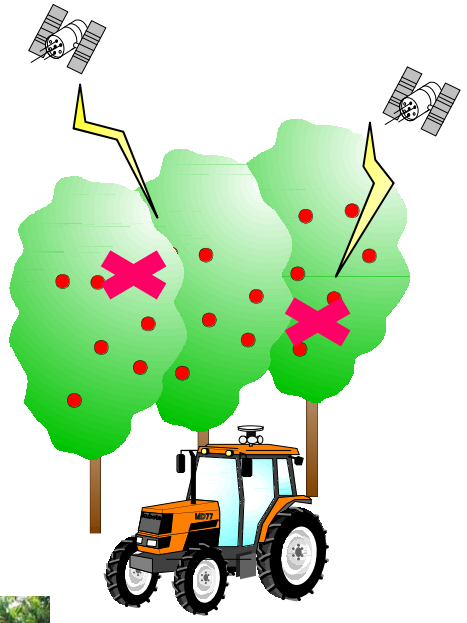
NIR digital photography

Section control (on/off) spraying

www.maxcharge.com

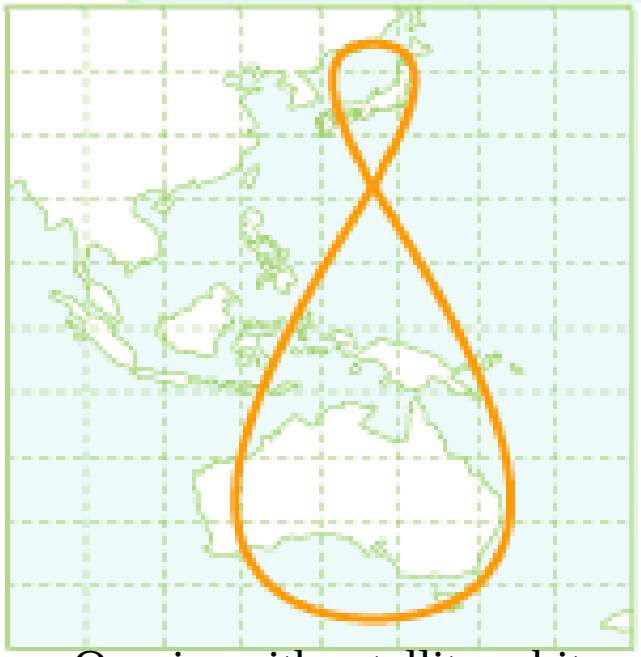
GPS navigation on orchards

Current GPS cannot be used in any time and any places



- **Low reliability due to limited number of SVs**
- **Acquisition of correction signal for RTK has problems**

QZSS for enhancing precise positioning



Quasi-zenith satellite orbit

The Quasi-Zenith Satellites System (QZSS) uses multiple satellites that have the same orbital period as geostationary satellites with some orbital inclinations (their orbits are known as “Quasi-Zenith Orbits”).
The system makes it possible to provide high accuracy satellite positioning service covering close to 100% of Japan, including urban canyon and mountain terrain.

QZSS enhances GPS services in the following ways:

1) Availability enhancement (improving the availability of GPS signals)
2) Performance enhancement (increasing the accuracy and reliability of GPS signals).

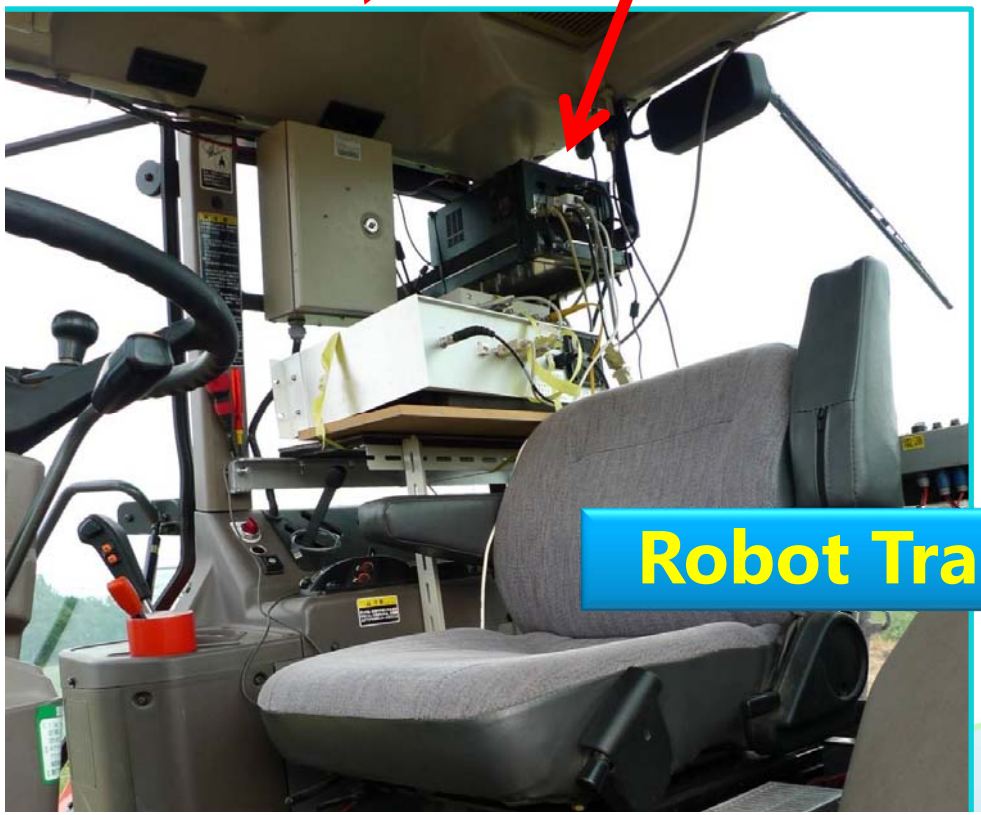
FACULTY OF AGRICULTURE HOKKAIDO UNIVERSITY
Vehicle Robotics Laboratory
RESEARCH FOR THE FUTURE...

Experiment system for QZSS

Robot controller

QZSS receiver

Antenna of QZSS



Robot Tractor

Travel accuracy using signal by QZSS

	Lateral error (m)	
Path #	QZSS	Base-station
1	0.035	0.088
2	0.027	0.072
3	0.036	0.085
4	0.031	0.094

Vis/NIRS: Commercialized equipment

RESEARCH

ATB, 1999

EU-Project 1998

COMMERCIAL

NIR Gun, Japan
A-Force, France
Nirvana, Australia

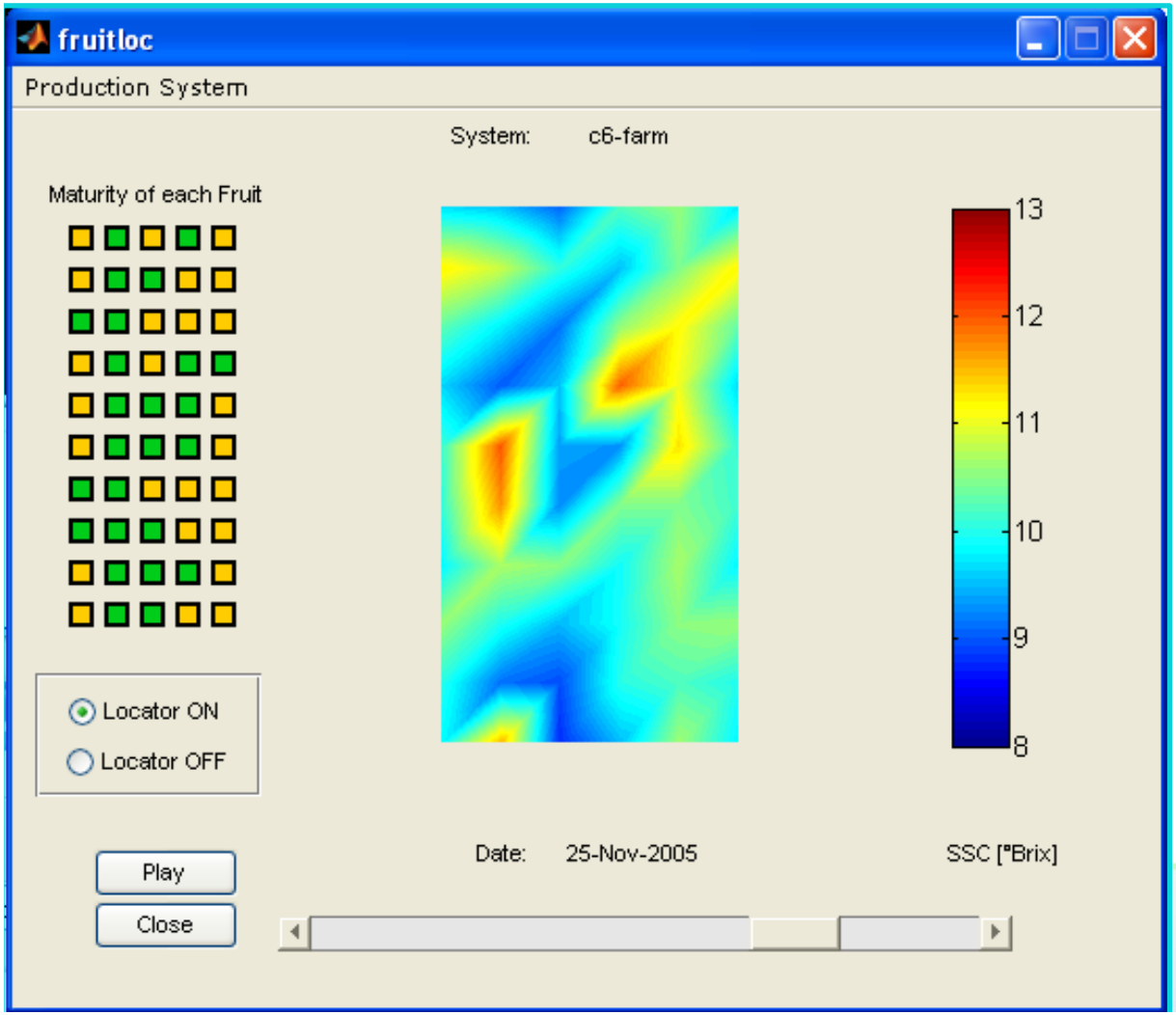
DA-Meter,
Sintéleia, 2009, Italy

Pigment Analyzer, CP,
2003, Germany
beratung@cp-info.de

Fruit phenolic maturity,
A-Force, France

Zude, M. (ed.). 2009. Optical Monitoring of Fresh and Processed Agricultural Crops. CRC Press.

DSS for citrus harvest management



Zude et al. (2008).
Biosystems Engineering 99: 455-459

Integration: Precision Fruticulture based on ICT and robotics

www.atb-potsdam.de/3D-MOSAIC

ICT-AGRI project "3D-Mosaic – Advanced Monitoring of Tree Crops for Optimized Management Contact: project coordinator Manuela Zude

Precision horticulture technologies

Efficient spatial sensing and sampling for the fruit export industry

- Yield forecasting at block scale in apples, olives, kiwis, cherries, cucumber seed
- In-time evaluation of pruning for labour recruitment and quality control
- Block management based on economic and agronomic factors

PRONOFRUT

by Dr. Dvoralai Wulfsohn

Pronofrut Yield Forecast System

8

CON MINIHELICÓPTERO PREDICEN LAS COSECHAS

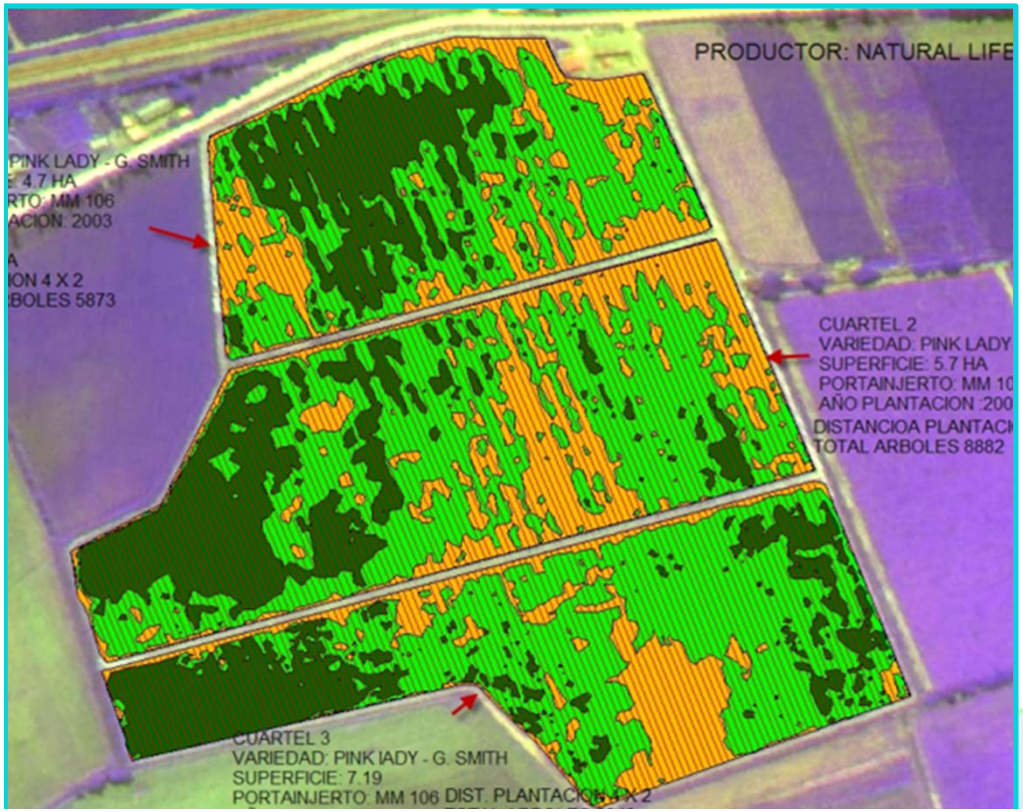
¿Vehículos voladores no tripulados en la agricultura? Pronofrut los usa, pero nada tienen que ver ni con extraterrestres ni con ciencia ficción. Es pura ciencia y surgida en regiones, más precisamente en San Fernando, la que logró desarrollar un sistema de pronósticos de cosecha que usa pequeños helicópteros para captar imágenes y datos, y que dice tener un muy bajo margen de error.

Y es que la estimación temprana de la cosecha es uno de

Oktocopter en pleno vuelo. Demora un día en muestrear 50 hectáreas.

Universidad de California-Davis, de Estados Unidos, quien en Florida trabaja en el desarrollo de vehículos voladores no tripulados aplicados a la agricultura, específicamente para los huertos de cítricos. Ha estado detrás del helicóptero no tripulado con que cuenta Dayenu para tomar imágenes de gran precisión y recabar otros datos de los campos que sobrevuela.

Otro de los investigadores con gran expertise es la británica Dvora-Laio Wulfsohn, poseedora de un Ph.D. en ciencias, también otorgado por



PRON Imagen Sampler FRUT

by Dr. Dvoralai Wulfsohn

Results of commercial scale trials

Year	Company	Species	Variety	Area (ha)	Forecast Error (kg)	Forecast Error (%)
2010	Monsanto	Cucumber	Hybrid (seeds)	18.5	140	4.0
2010	Monsanto	Cucumber	Hybrid (seeds)	12.2	65	3.2
2011	Greenvic	Apple	Granny Smith	11.3	-18 261	-4.9
2011	Greenvic	Apple	Granny Smith	8.6	22 001	4.4
2011	Frusan	Apple	Fuji Raku Raku	7.6	4 853	1.8
2011	Undurraga	Winegrape	Carmenere	10.2	-543	-1.2
2012	Undurraga	Winegrape	Cabernet Savignon	50.2	1 279	0.4
2013	Undurraga	Winegrape	Cabernet Savignon	50.2	-21 078	-3.3
2012	Sta Emiliana	Winegrape	Carmenere	3.1	-1 771	-7.6
2012	Frusan	Cherry	Bing	3.6	-120	-0.9
2012	Palo Alto	Cherry	Korda	2.2	-1 702	-10.2
2012	Palo Alto	Cherry	Lapins	2.4	311	0.5

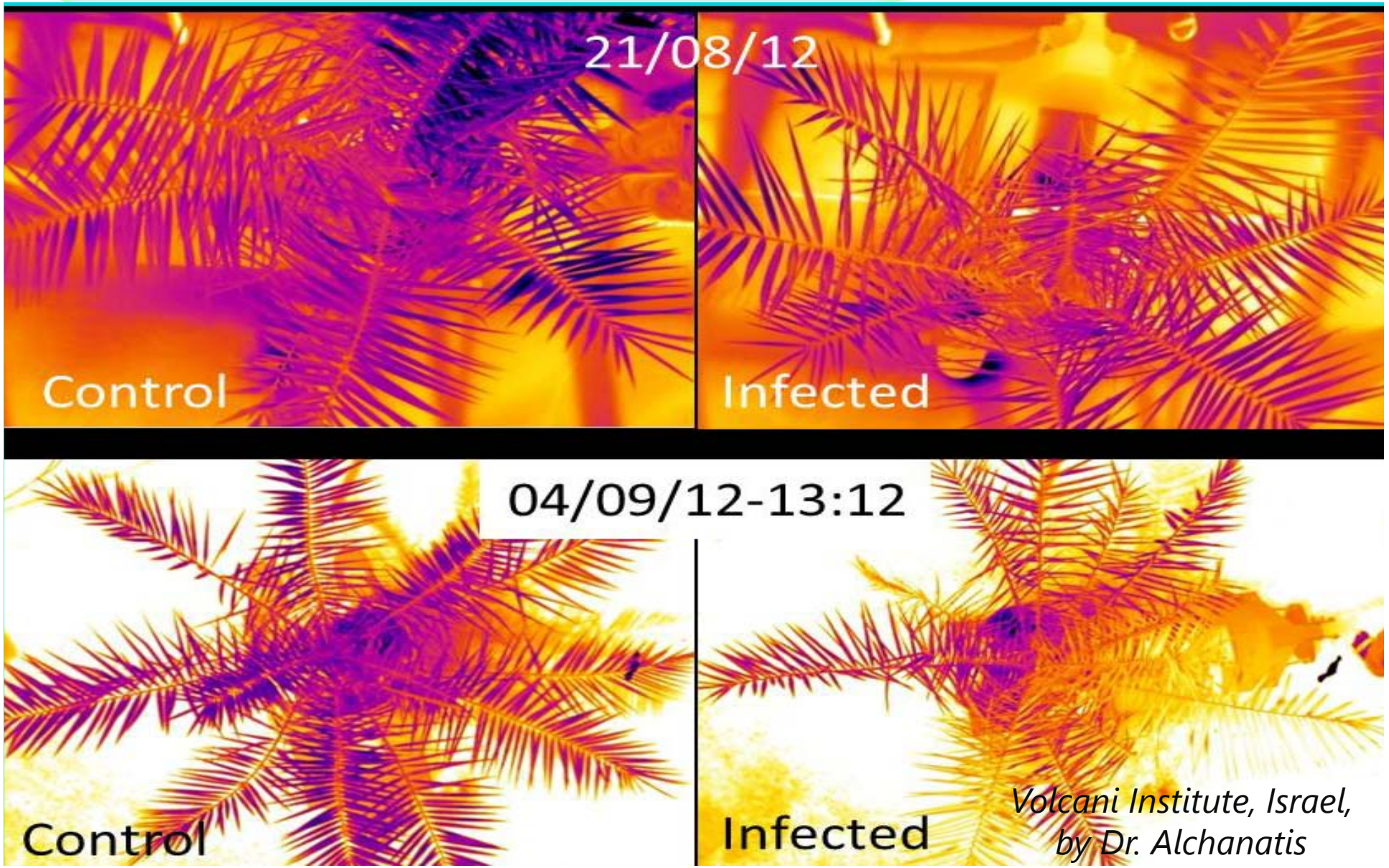
Remote Sensing for Precision Horticulture

cameras (FLIR + RGB or AOTF)
and a Tether interface

The system is
remotely controlled

Volcani Institute, Israel, by Dr. Alchanatis

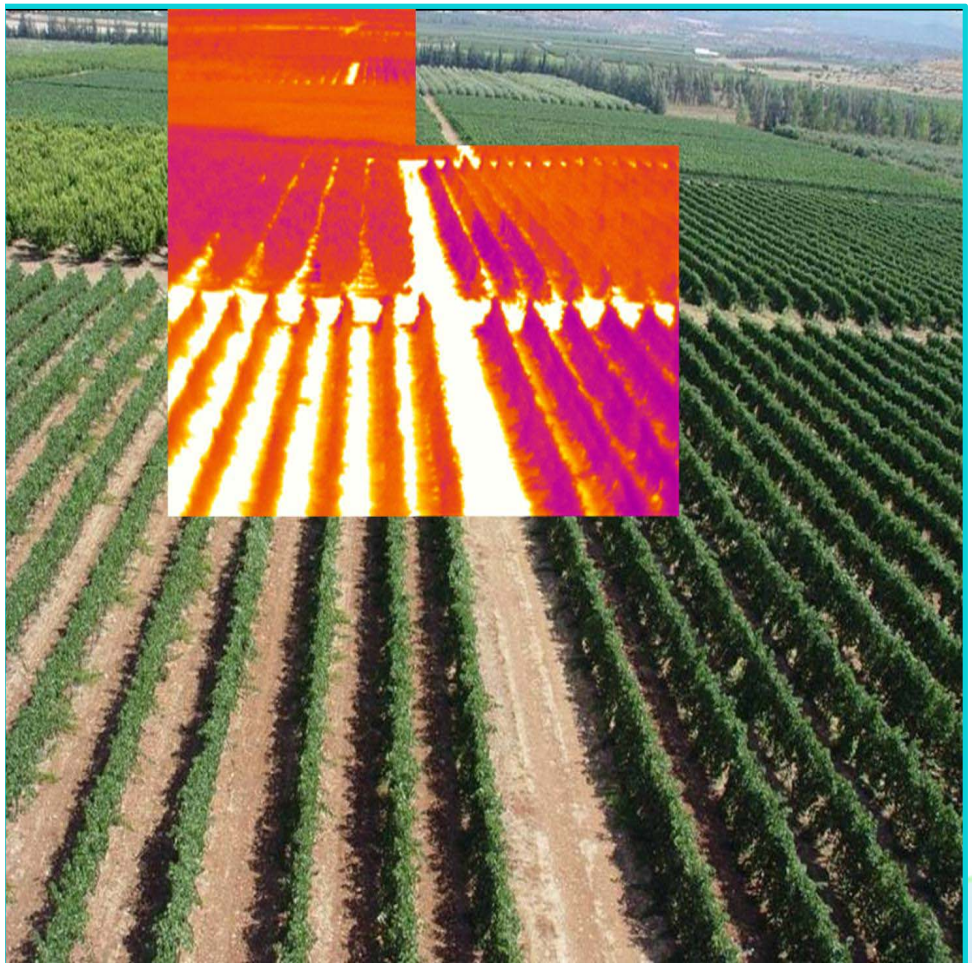
Detection of trees with Red Palm Weevil



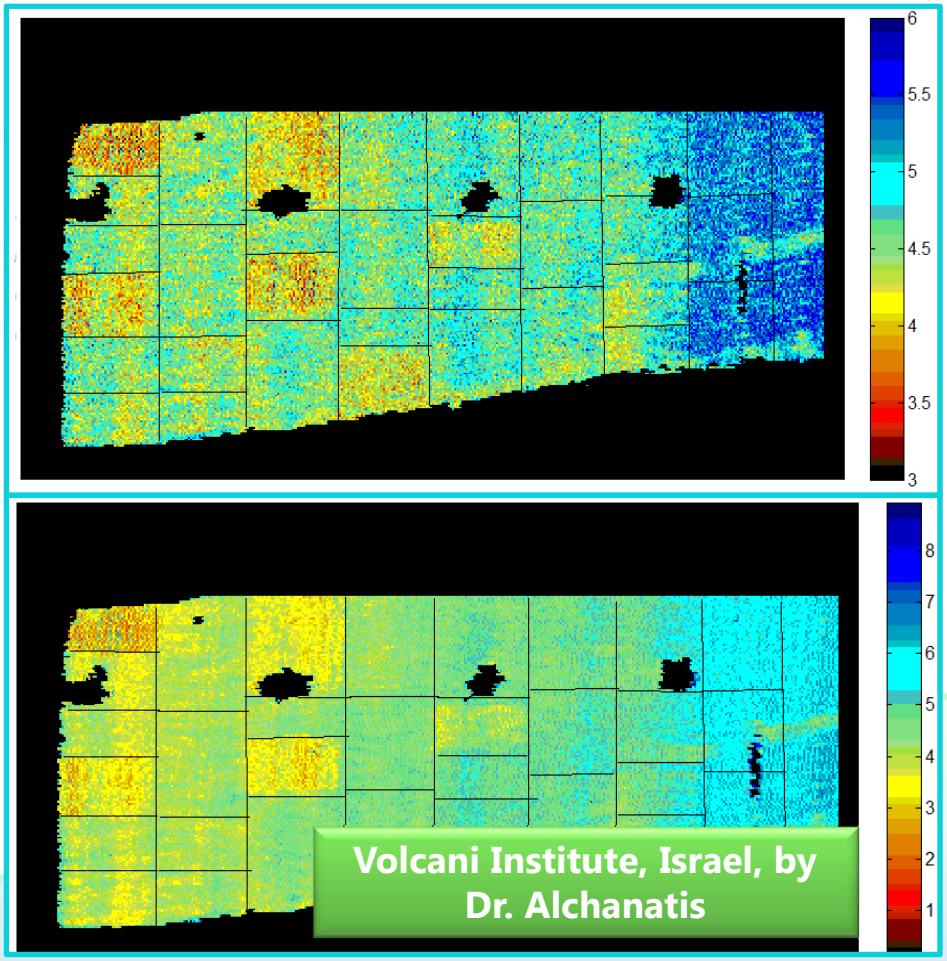
Volcani Institute, Israel, by Dr. Alchanatis

Detection of water & nutrient stresses

Detection of irrigation malfunctions



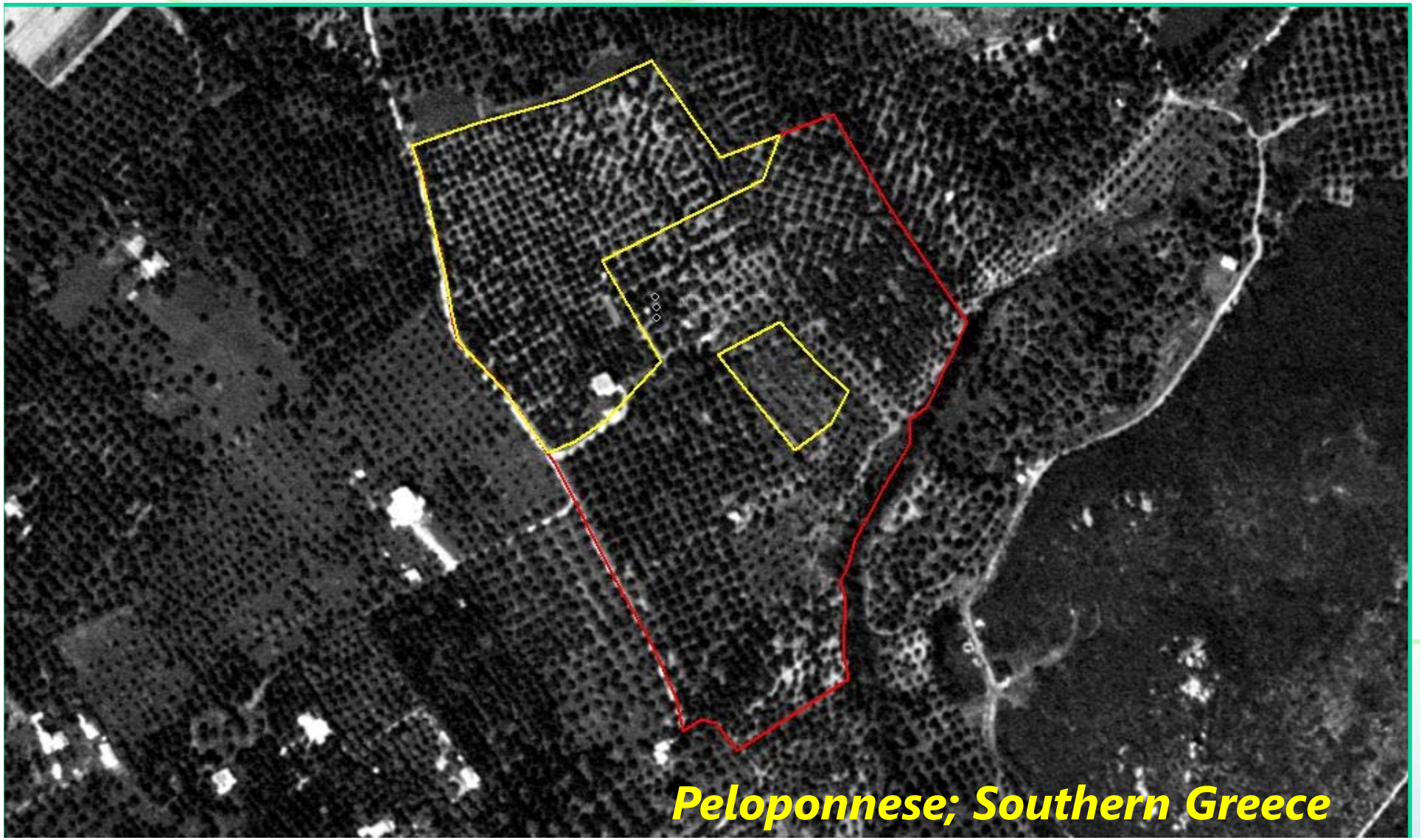
Leaf Nitrogen content in potato



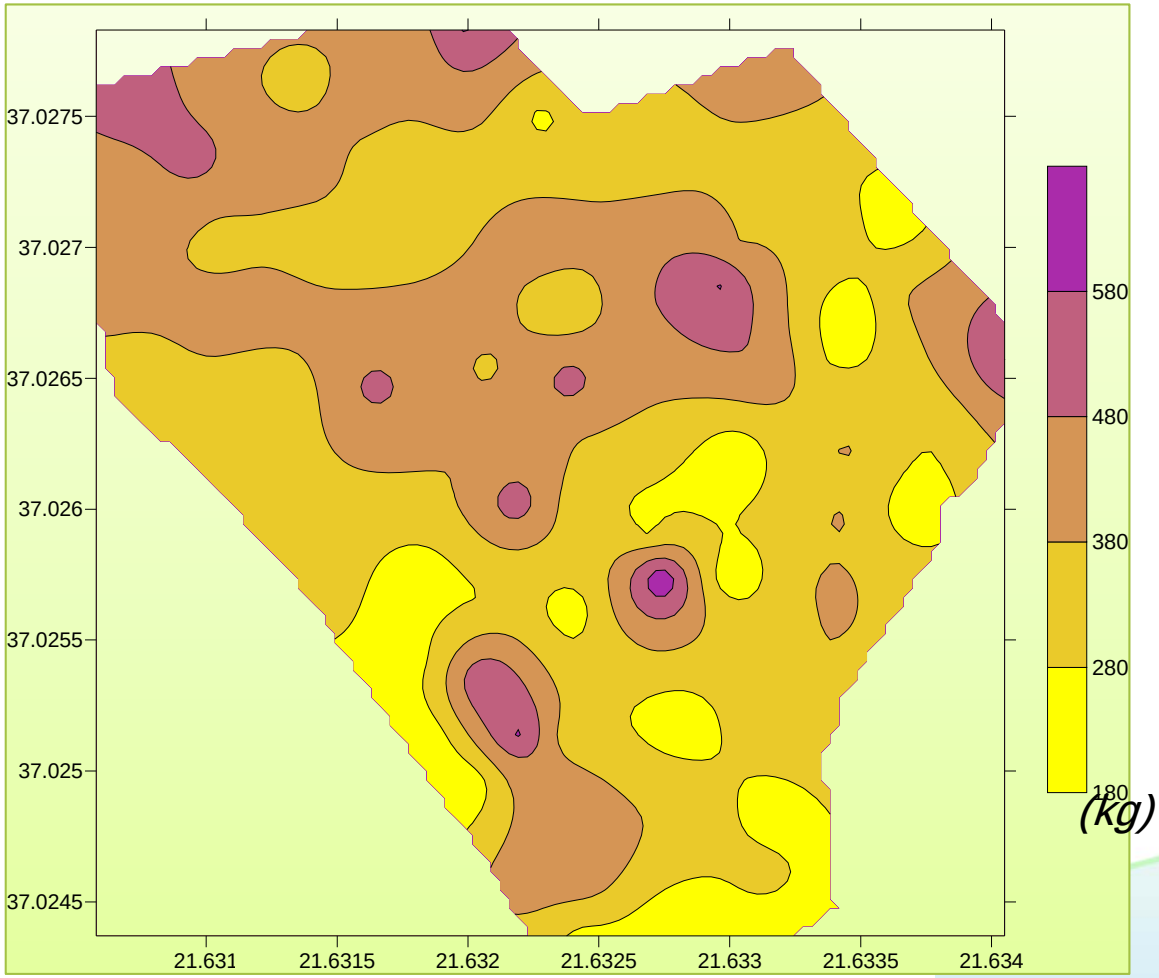
Spatial management for orchards and vegetables in small fields

Precision Agriculture in olive trees

9.1 ha olive tree plantation – 1700 trees



Yield mapping

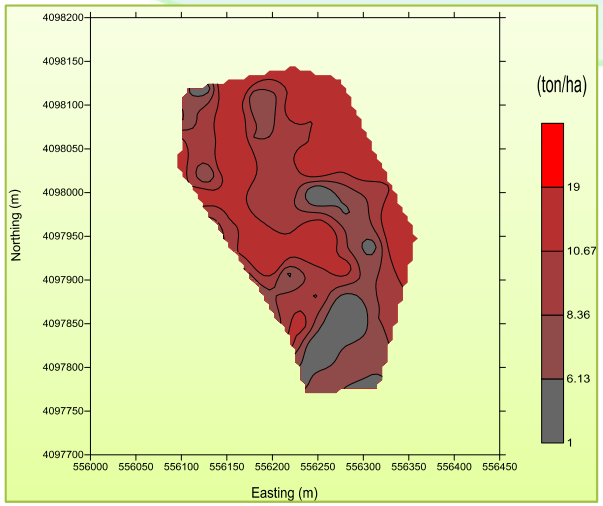


Challenge:
It is a very time consuming process to record GPS positions for the farmers

Fountas et al. (2011)

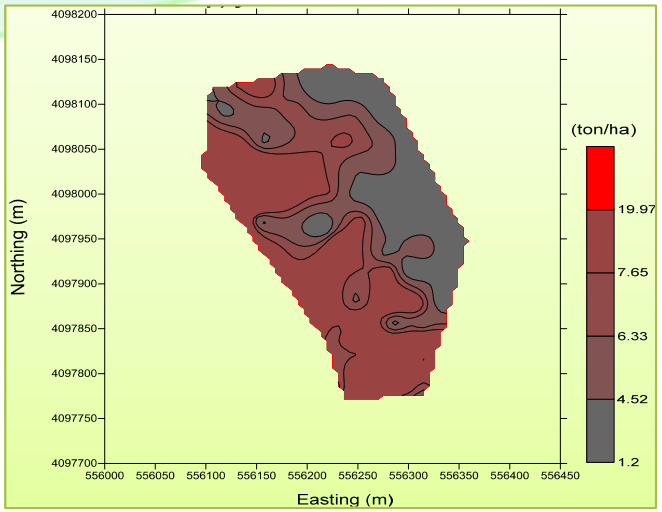
Alternate bearing effect on olive trees

Yield 2007



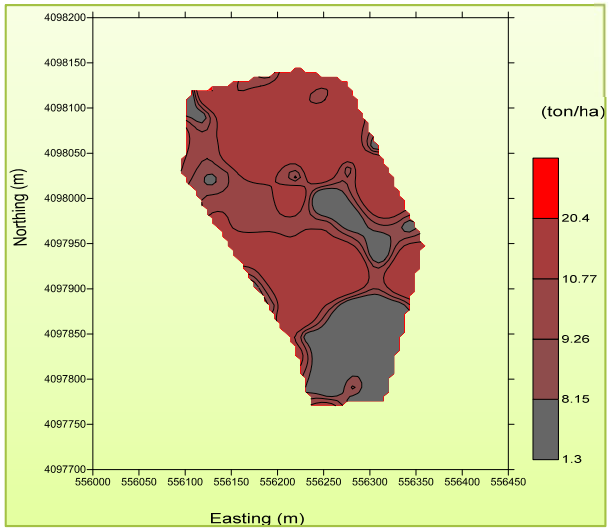
Mean Yield: 7 ton/ha

Yield 2008



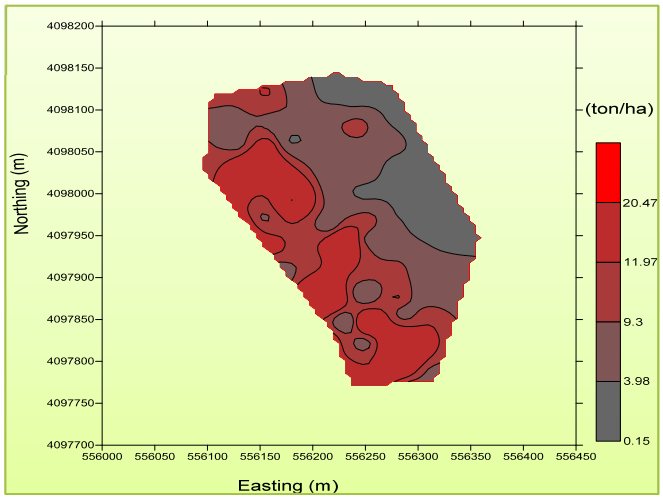
Mean Yield: 10 ton/ha

Yield 2009



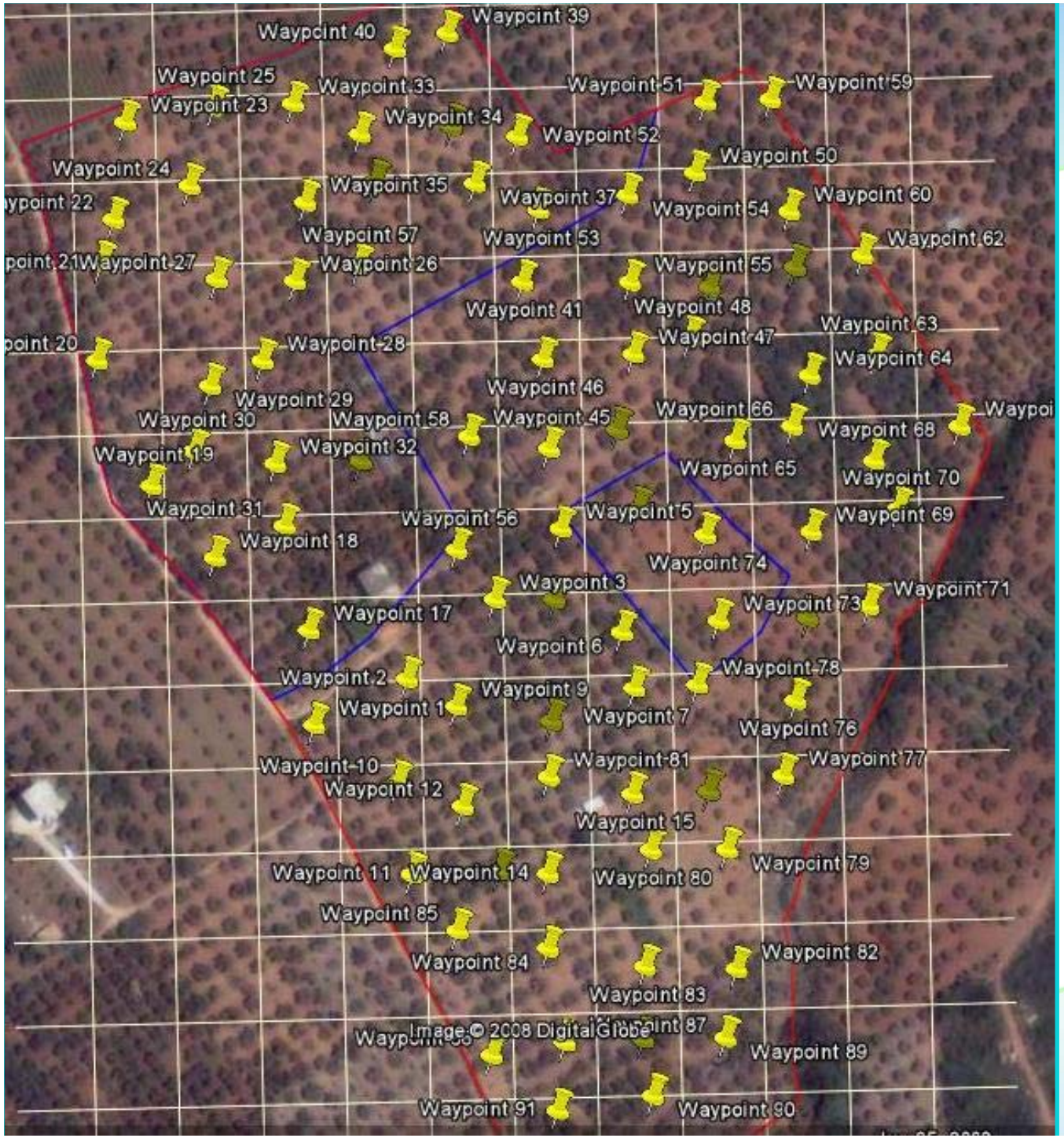
Mean Yield: 8 ton/ha

Yield 2010



Mean Yield: 10 ton/ha

Challenge:
How many years of yield data are required to have safe results of spatio-temporal?



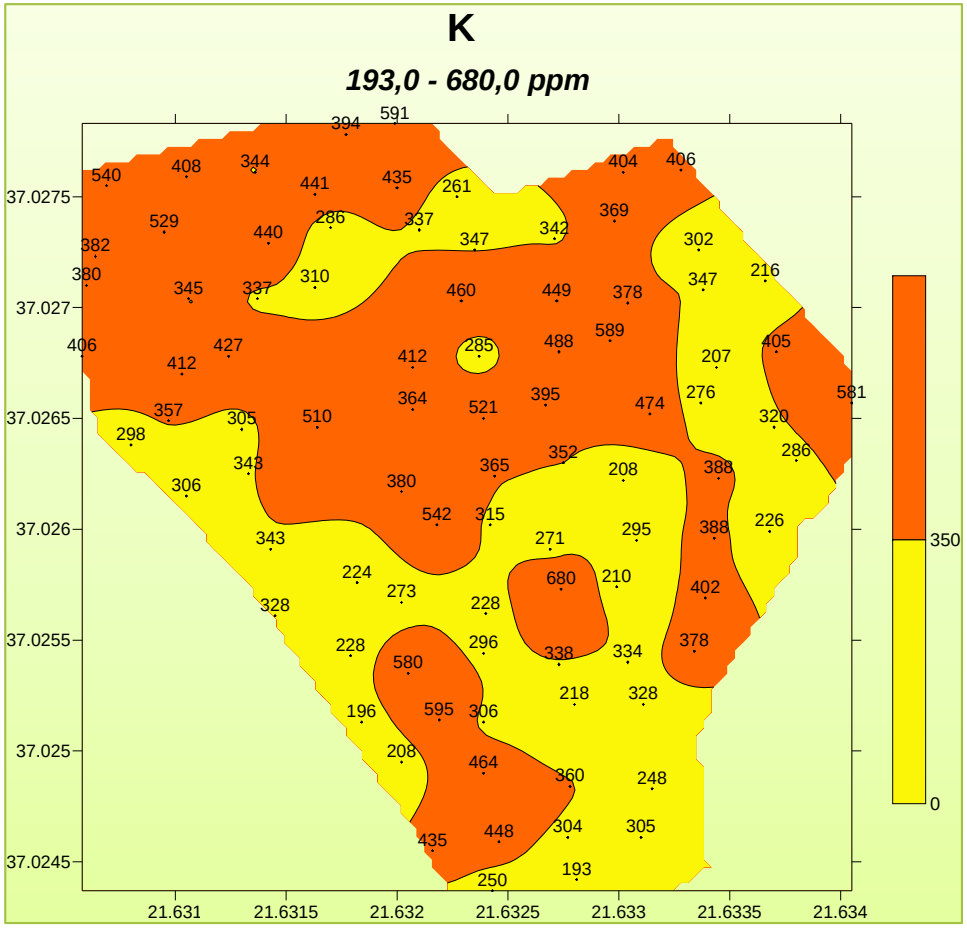
Soil sampling

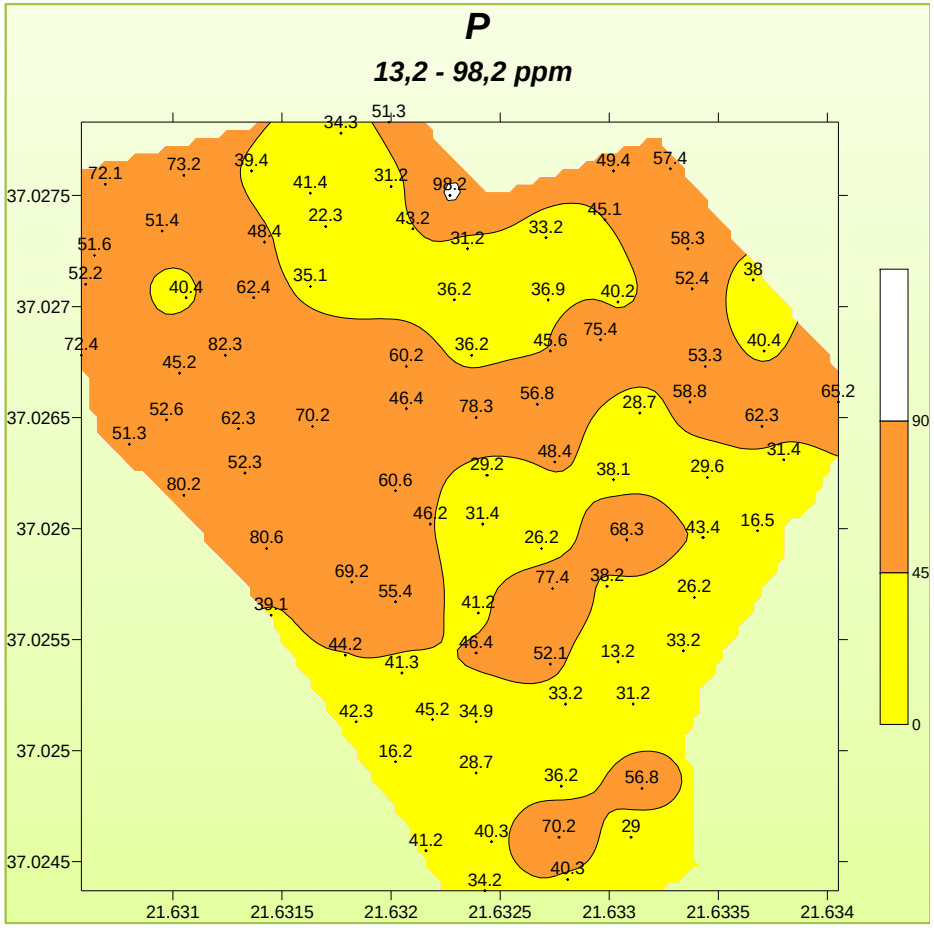
91 samples:
1 sample/0.1 ha

Challenge: How many samples should we take per ha?

Management zones for P & K

Challenge: How to persuade farmers to fertilise less ?





VR fertilizers for P, K & lime

Challenge: How do we variably apply fertilizers in orchards ?

Precision Agriculture in Apples

1 hectare orchard

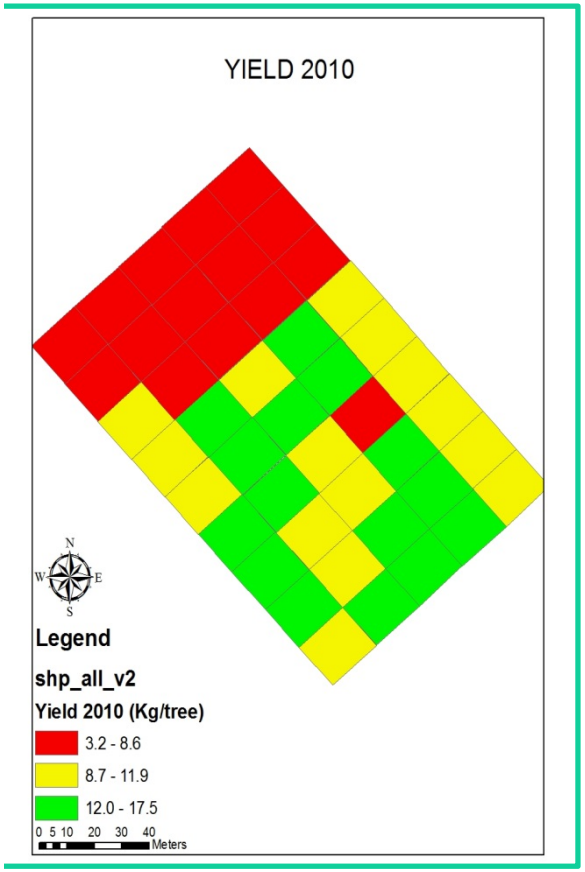
Main variety :Fuji

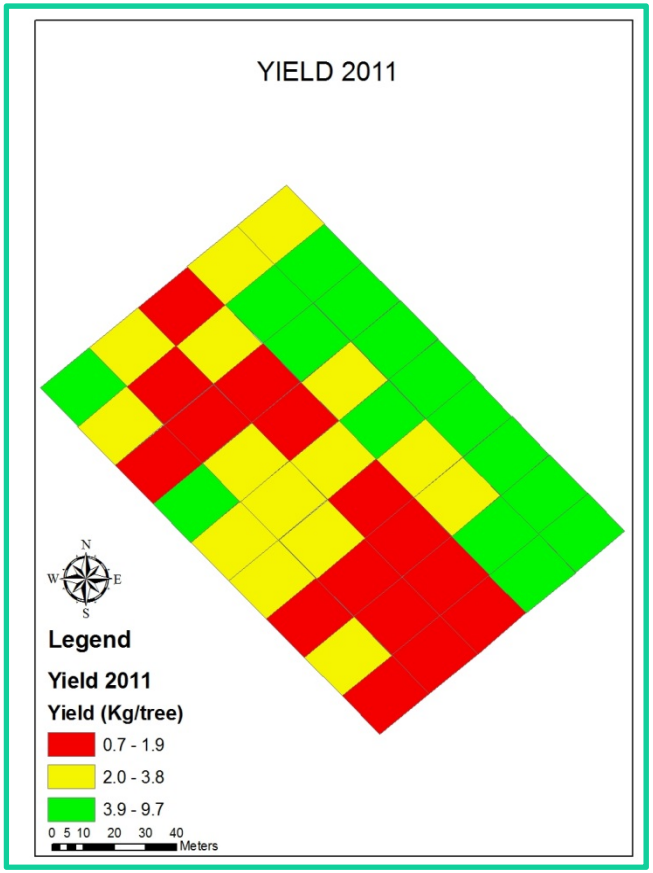
Pollinator: Red Chief

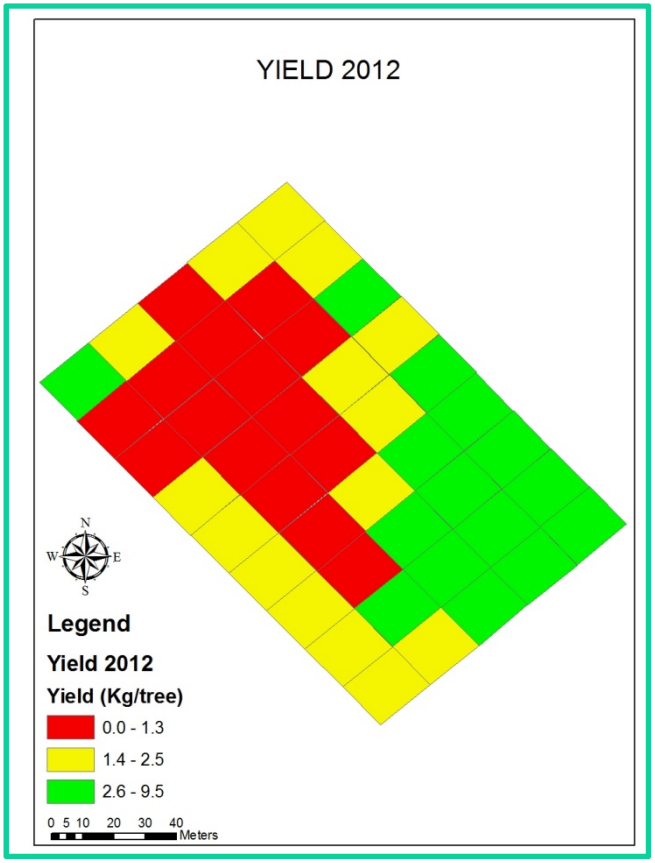
PhD dissertation by Liakos, V. (2013)

Yield mapping

Challenge: How many years of yield data are required to have safe results of spatio-temporal?

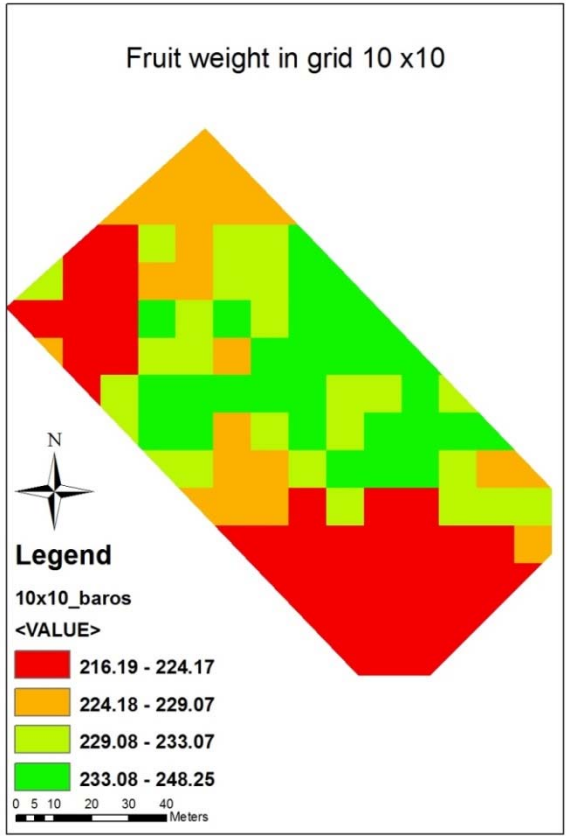


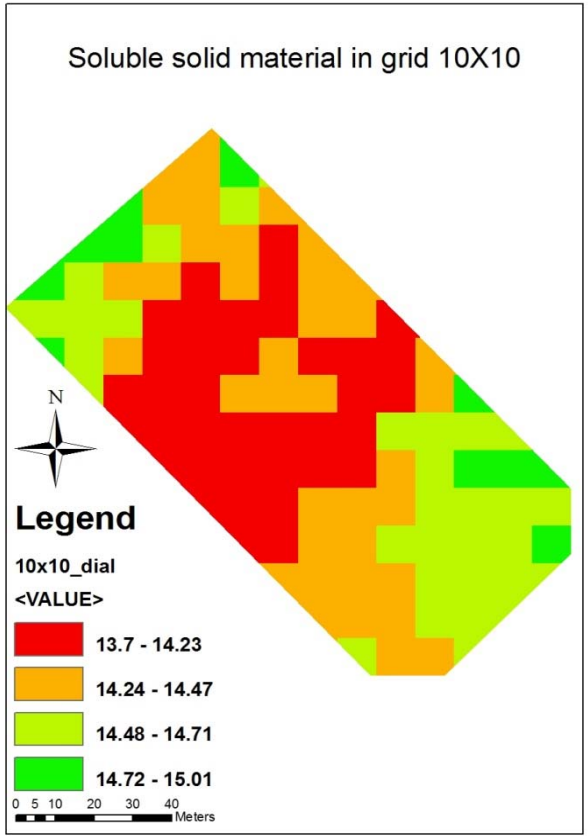


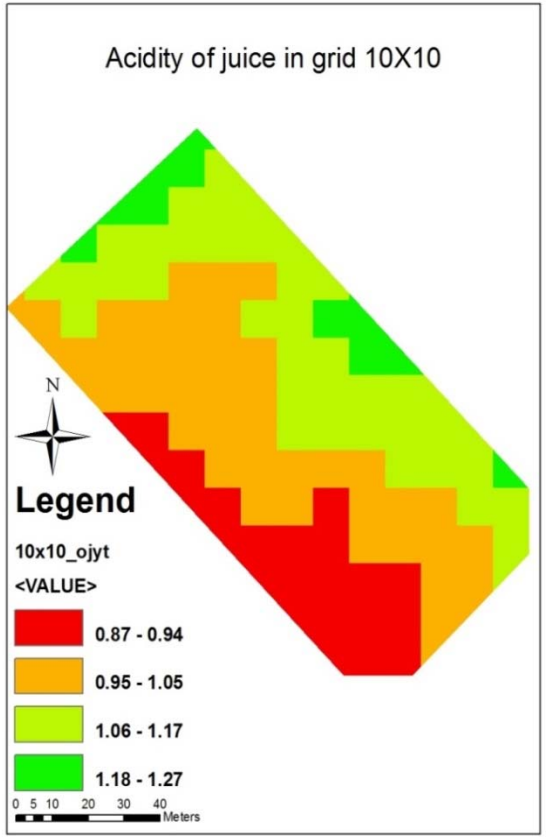


Quality of apples

Challenge: Which parameters should be better measured and at which sampling pattern?



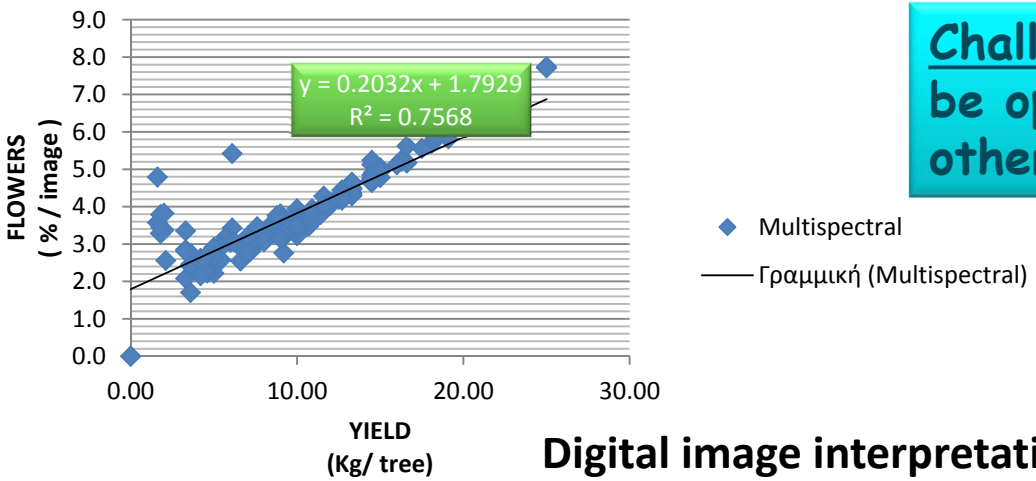




Measurements of flowers

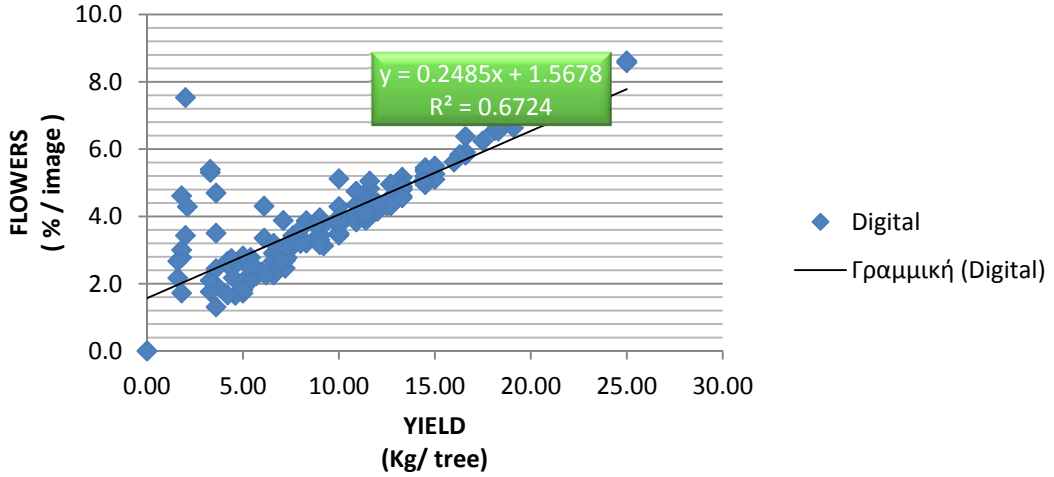
Measurements of flowers

Multispectral image interpretation



Challenge: The process should be operated and transferred to other tree crops.

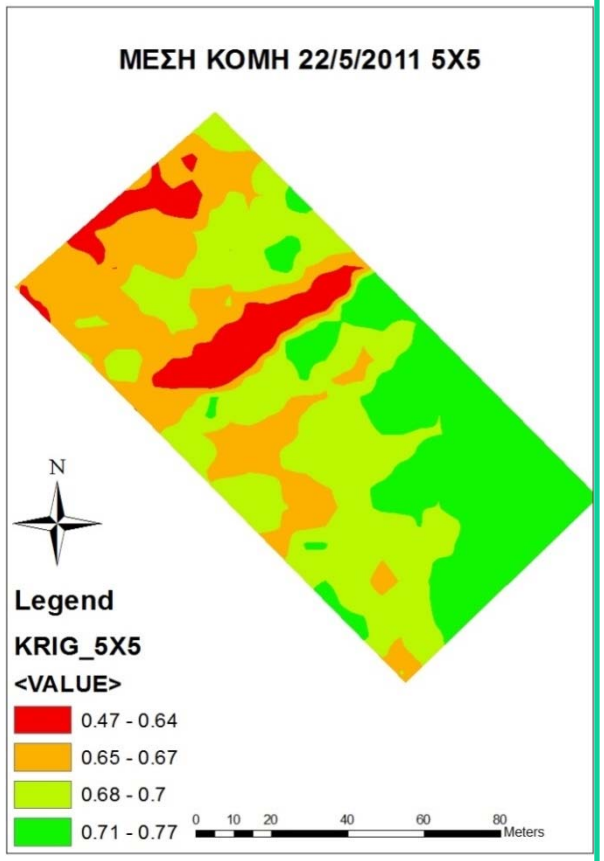
Digital image interpretation



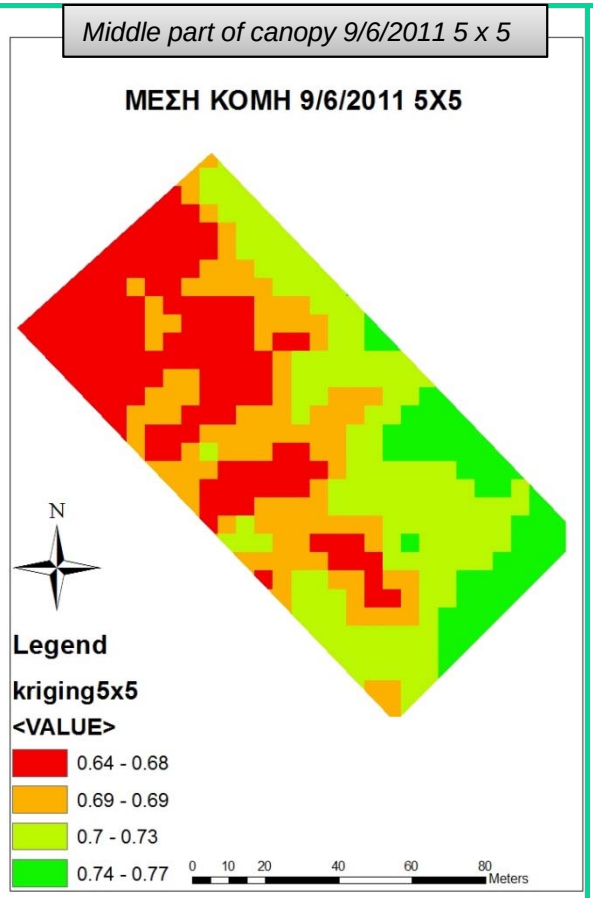
NDVI measurements

Challenge: When is the best period to acquire NDVI maps? From the side or the top? From satellite or ground sensors?

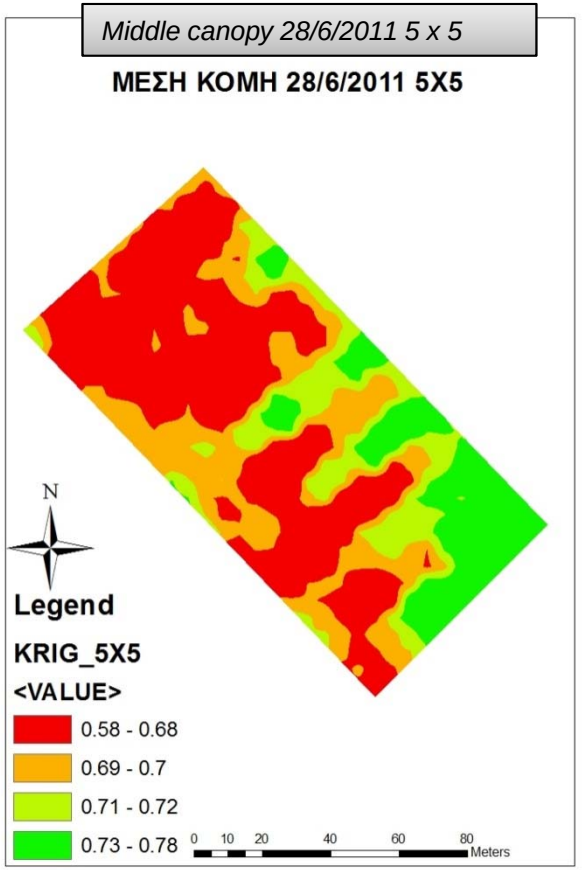
Middle part of canopy 22/5/2011 5 x 5



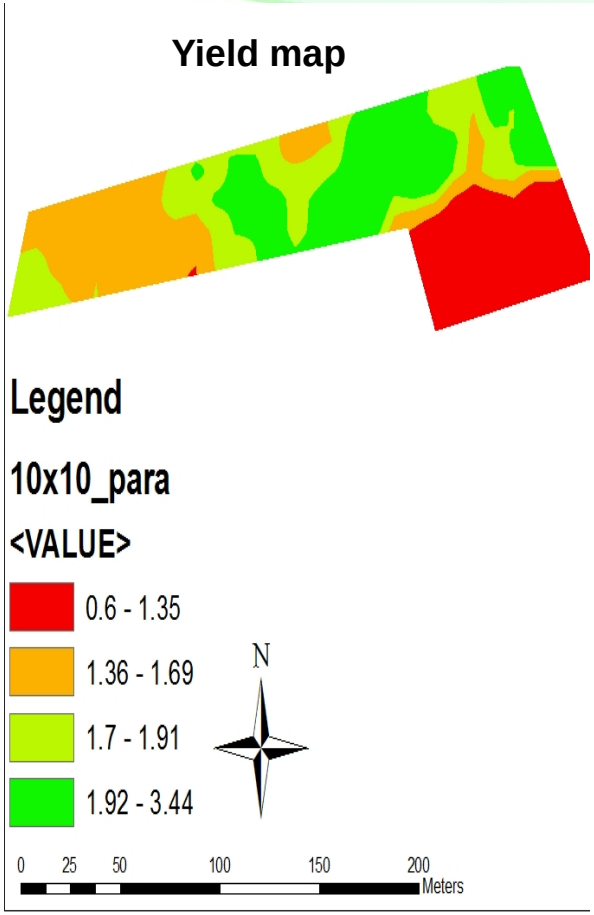
Middle part of canopy 9/6/2011 5 x 5

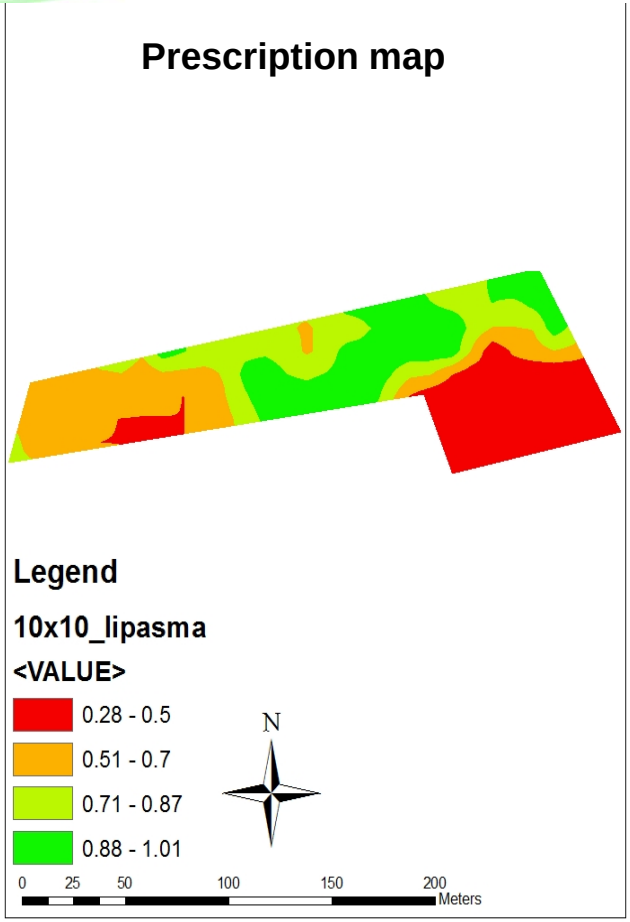


Middle canopy 28/6/2011 5 x 5



VR Fertilizers in apples



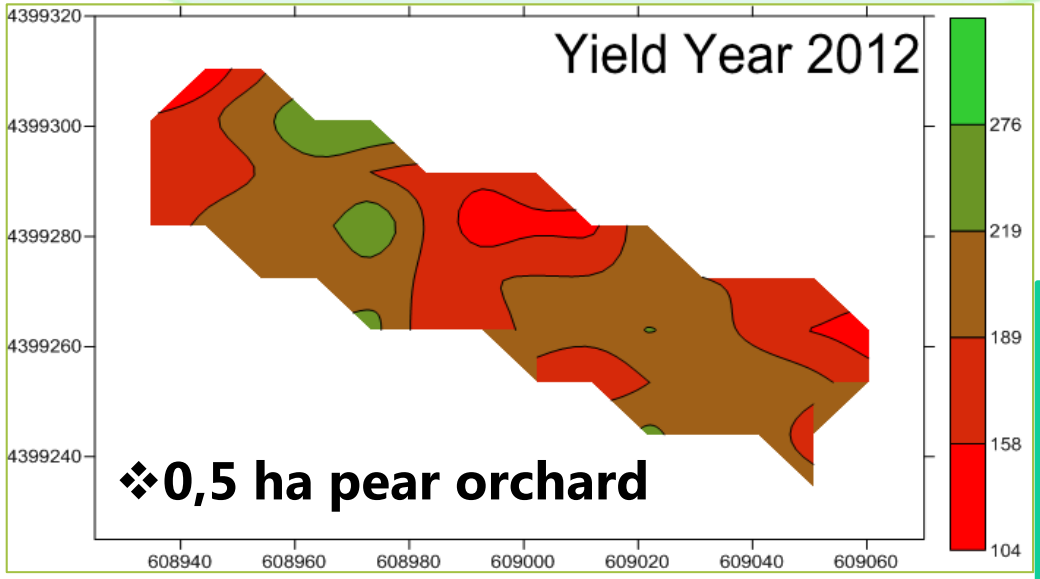


Challenge: Is replenishment the right strategy for VR Nitrogen application in apples? Automated machinery to apply?

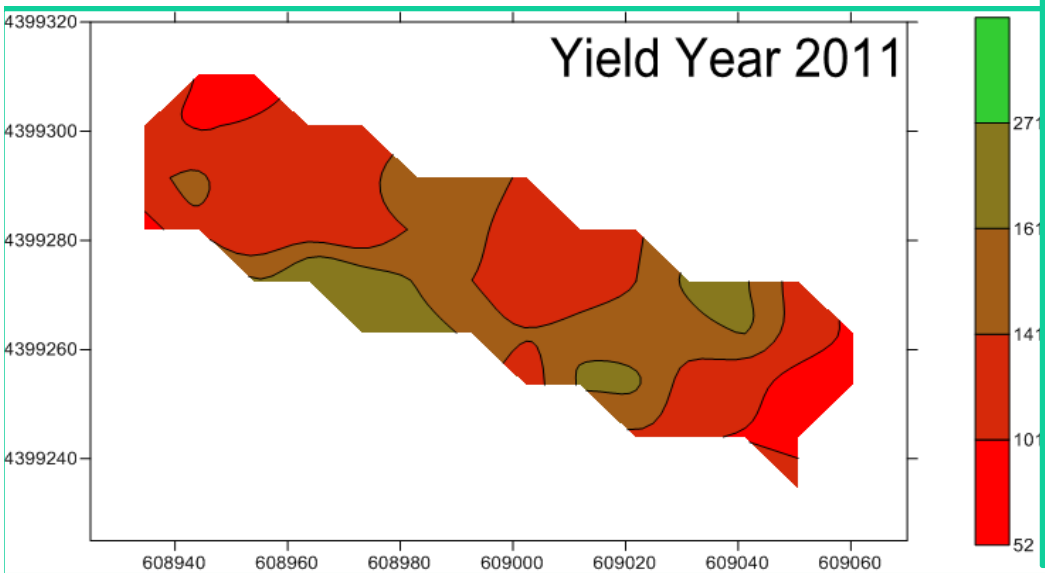
Calibration of scoop for: 1Kg, 0.7Kg, 0.5 Kg, 0.3 Kg of N

Liakos, V. (2013)

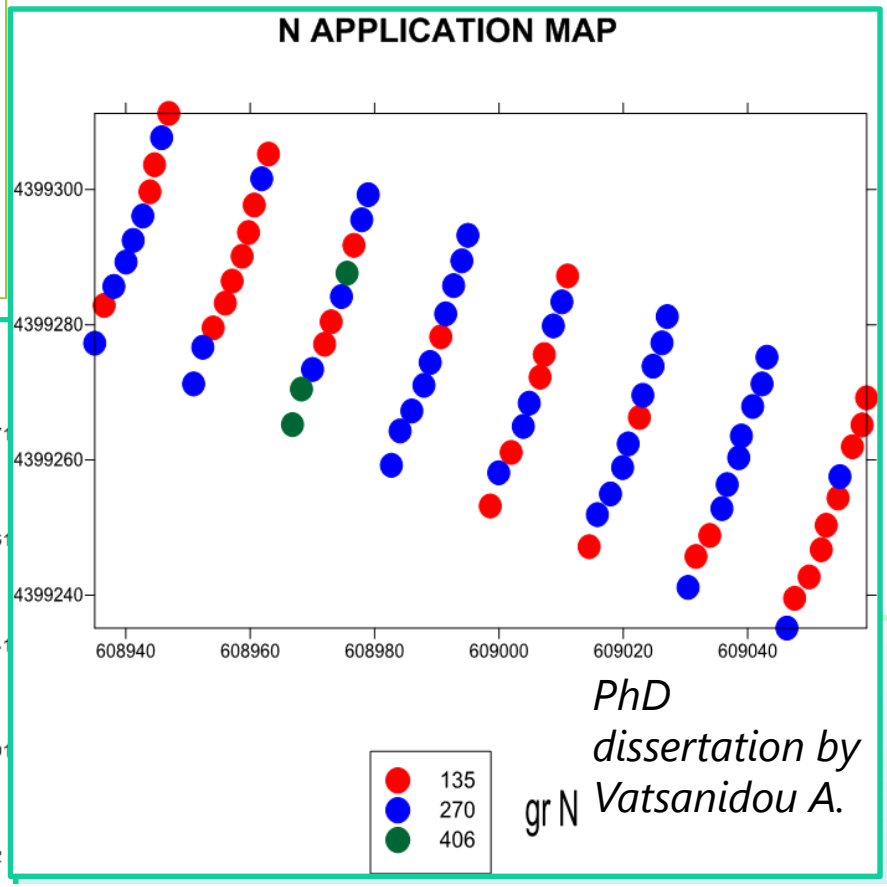
Precision Agriculture in pears



❖0,5 ha pear orchard



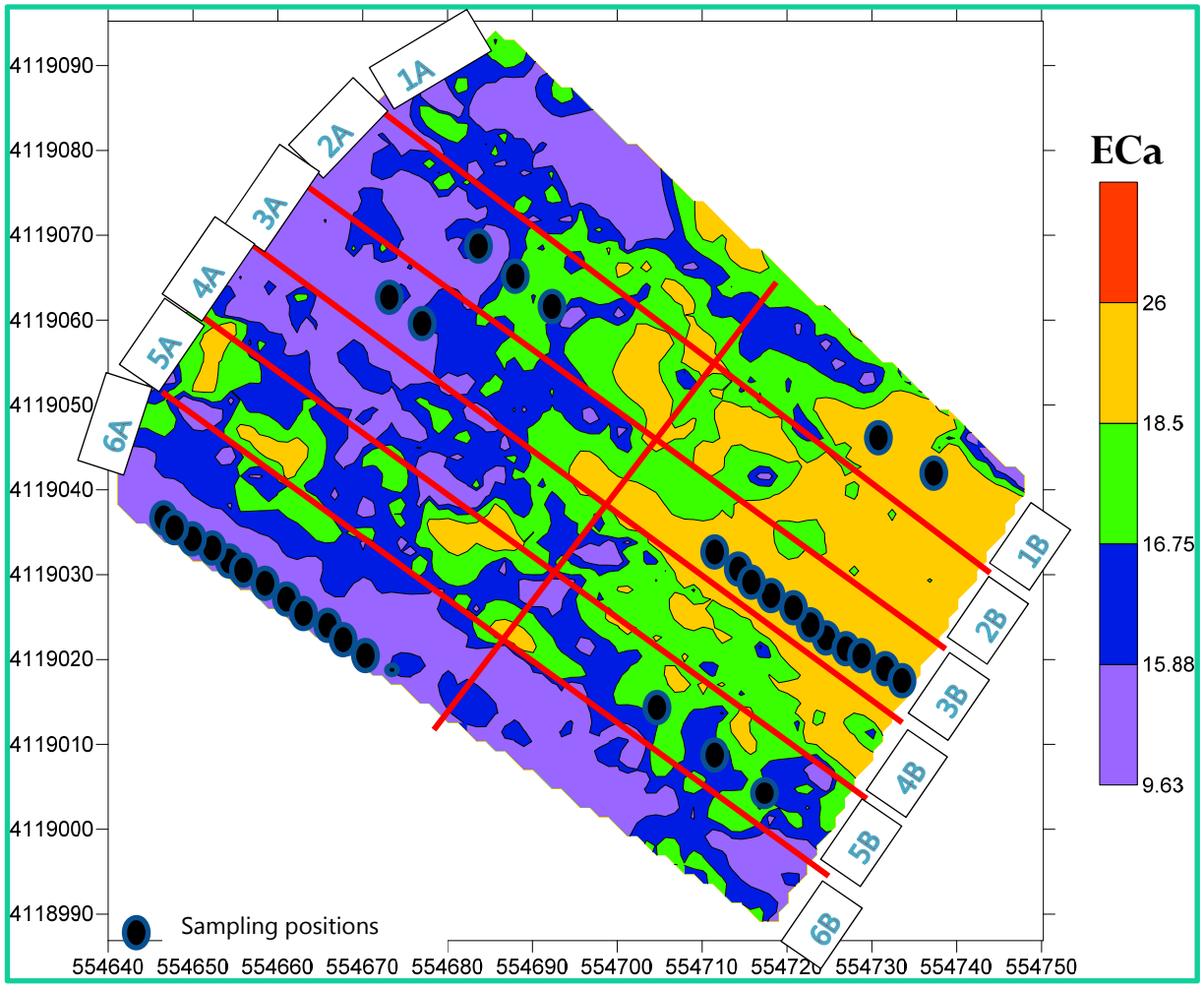
Challenge: Is replenishment the right strategy for VR Nitrogen application in pears? Easy machinery to apply?



PhD dissertation by Vatsanidou A.

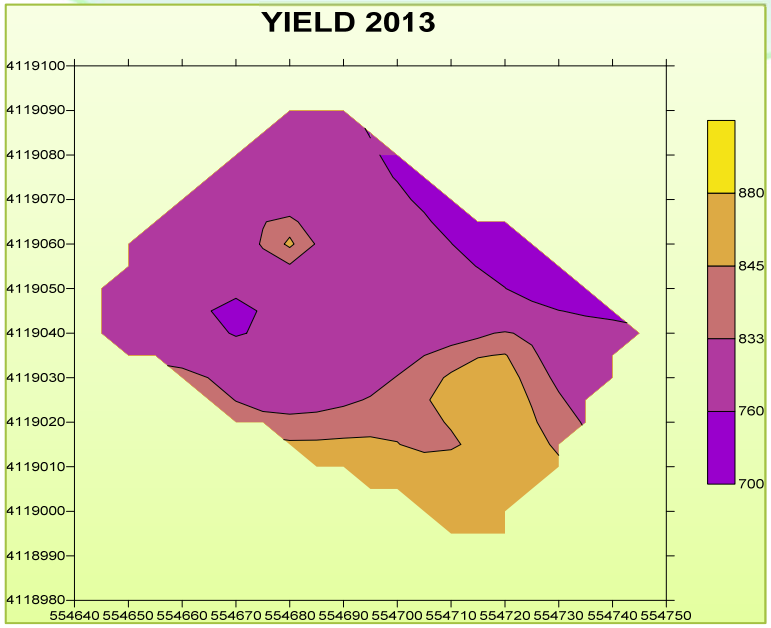
Watermelon application

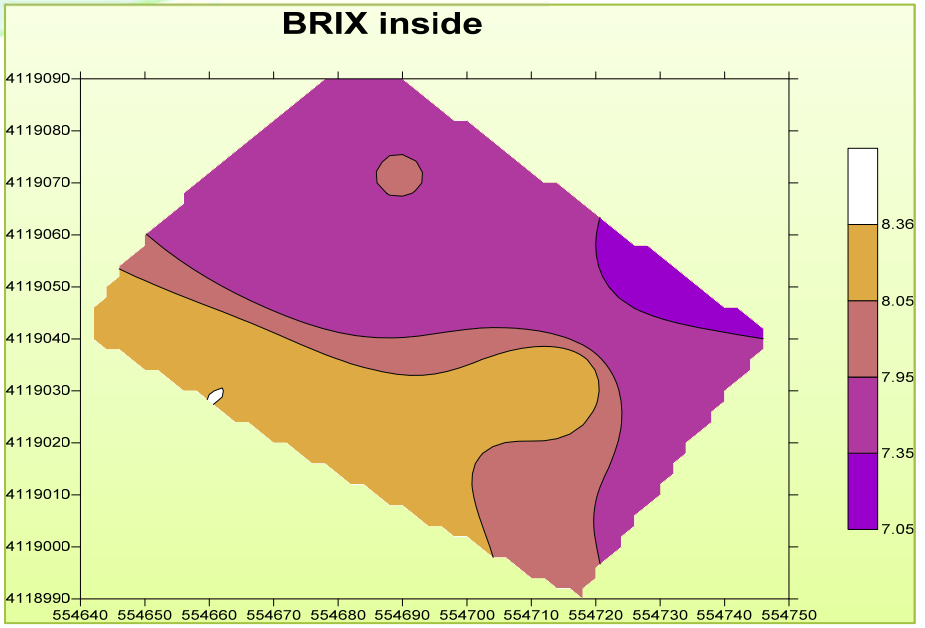
Watermelon application

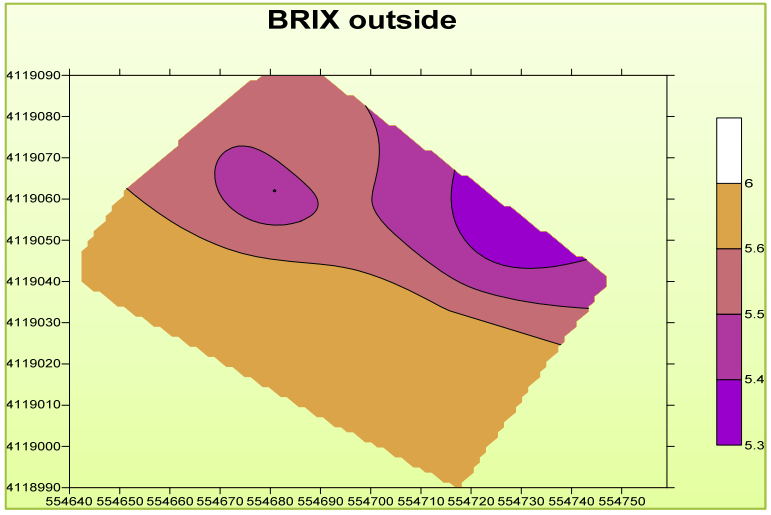


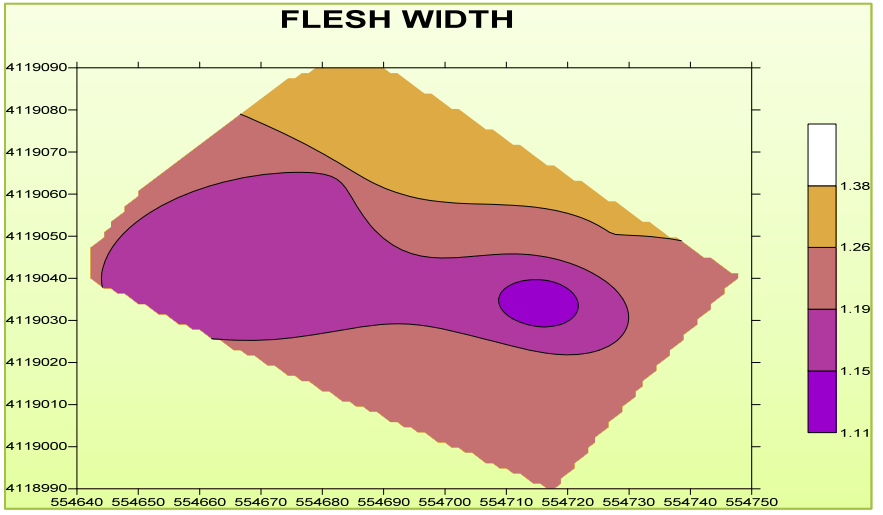
Challenges: Many!!
Very high production (70 ton/ha).
Hard to measure yield per row, while per block the average yield cancels out

Watermelon application

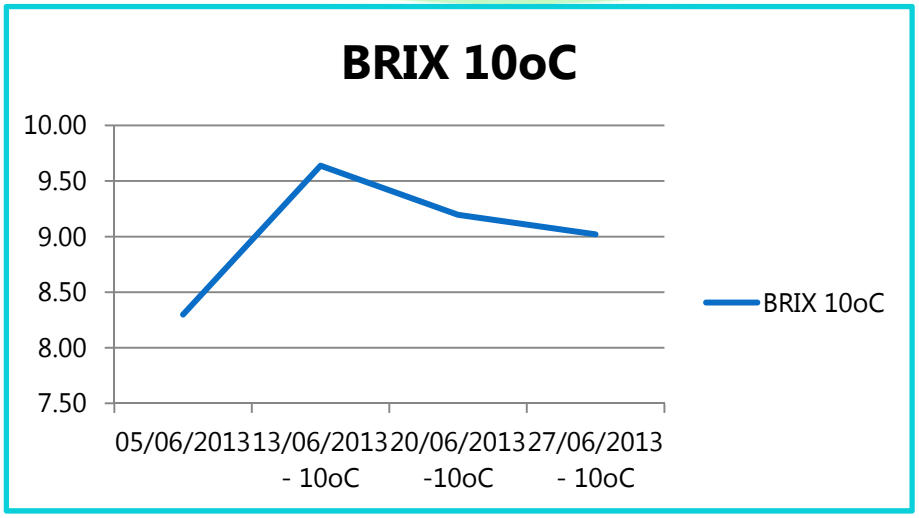


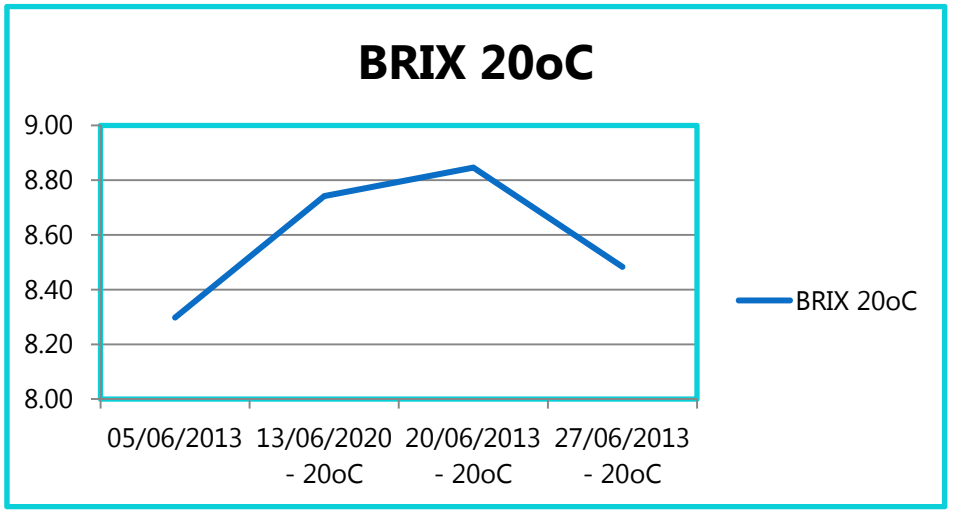


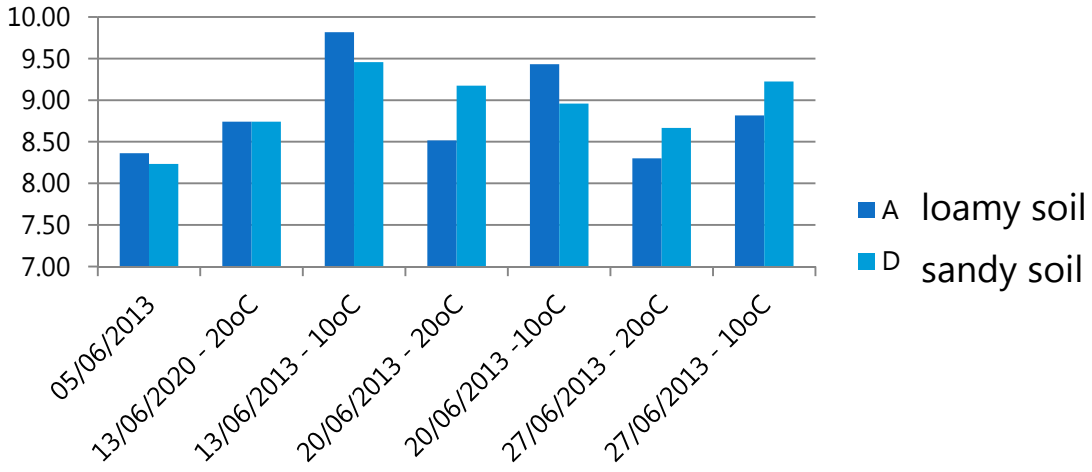




Storability for 3 weeks at 10 & 20oC







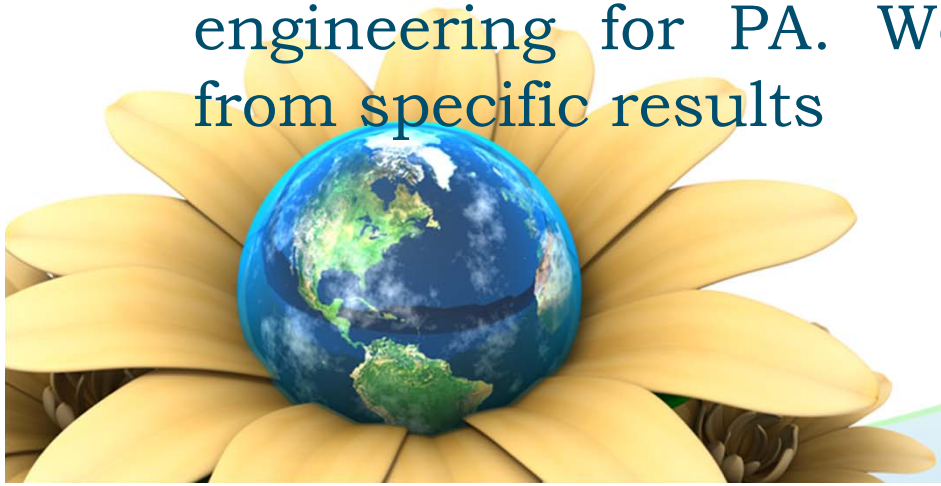
Challenge: We have to find correlations between spatial data at pre and post-harvest for targeted treatments focusing on quality.

Aerial estimation of yield mapping

Challenge: Great potential for early estimation of yield for export purposes one month prior to final yield

Conclusions

- Bringing PA down to plant level, sub-block level or block level
- PA equipment and models do not transfer nicely to other countries
- Designs and management should be adapted to local conditions
- Not only PA prescriptions be site-specific, but also engineering for PA. We can't promise generality from specific results



Conclusions

- The majority of fruit and vegetable operations will continue to be done by hand due to limited technology available
- Operations to be done automatically will be spraying with on/off machines, which need to be affordable and usable
- Fruit quality is by far very important at all stages, as shipping to destination could take by to 40 days
- Climate change will play a significant role and change management strategies and practices

Conclusions

- Many years of yield and soil data are needed to explore the alternate bearing effect and generate management strategies
- Quality mapping linked to post-harvest operations should be studied
- Management strategies and practices for applying PA technologies for small scale horticultural farmers is needed

Conclusions

High value crops ----->

Economic benefits of PA pay off!

PA is not only about technology…

Prof. Bahhtin Akdemir, Turkey 2009

Thank you..

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