10th European Conference on PRECISION AGRICULTURE

July 12-16, 2015

Voclani Center, Beit-Dagan, Israel

PROGRAM AND ABSTRACTS

TABLE OF CONTENTS

Dear Colleagues and Friends,

It is a great pleasure and privilege to welcome you to Israel and to the 10th European Conference on PRECISION AGRICULTURE. The conference is being held under the auspices of the International Society of Precision Agriculture (ISPA) and the venue is ARO (The Volcani Center) – the largest agricultural public research center in Israel. ARO's six institutes are responsible for Plant Sciences, Animal Science, Plant Protection, Soil, Water and Environmental Sciences, Agricultural Engineering, and Postharvest and Food Sciences. ARO also operates four research stations, in various parts of the country, and serves as a testing center for agricultural produce and equipment. Israel's Gene Bank for Agricultural Crops is also located on the ARO - Volcani Center campus.

The meeting will provide the necessary platform on which researchers from all over Europe and other continents to meet in order to present the state of the art in the rapidly evolving field of Precision Agriculture. The latest research will be discussed and debates on crucial topics will be conducted by eminent scientists.

The Scientific Program includes presentations covering new developments in all aspects of precision agriculture, as well as basic and translational research relevant to the field. This conference's theme is "Precision agriculture for efficient resources management under changing global conditions". The scientific sessions will be an excellent opportunity to intensify the cooperation between our professional groups.

The program is complemented with a professional exhibition and a professional tour. The professional tour will expose the participants to the activities of precision agriculture in Israel and have the opportunity to explore part of Israeli scenery.

We look forward to welcoming you to Israel, for what we hope will be a stimulating and inspiring scientific, social and cultural event.

Victor Alchanatis
Conference Chair

Yafit Cohen
Conference Chair

GENERAL INFORMATION

VENUE
Scientific sessions will take place at the Volcani Center campus, located close to Tel-Aviv.

LANGUAGE
The Conference will be conducted in English.

REGISTRATION / HOSPITALITY / INFORMATION
A registration and hospitality desk will operate on the Volcani Center campus outside the session halls during session hours.

NAME BADGE
Your name badge is included in the material which you received upon registration. Please wear your badge to all conference sessions and events.

DAILY SHUTTLE SERVICE
A daily shuttle service will operate between the Hotels in Tel Aviv and Volcani Center campus. Times are available at the reception of each hotel or at the registration desk at Volcani Center.

SPEAKER PRESENTATIONS
Computer projection is available in all halls. Presentations, in PowerPoint or PDF format, should be uploaded to the system, the latest during the break before the session. Please see the assisting crew in the library (adjacent to Harris Hall) before the beginning of your session.

POSTERS
Posters will be on display in the exhibition tent for the duration of the conference. Presenters are requested to refer to the program book to find the board number assigned to them. Posters should be mounted on July 13 morning and must be removed by the end of the conference. Please note that the organizers cannot be held responsible for posters that are not removed on time.

EXHIBITION
An exhibiton will take place during session hours.

GENERAL INFORMATION (Continued)

INTERNET ACCESS

Internet access is available throughout the conference area situated on Volcani Campus. The network name is **ARO_Guest**.

PROFESSIONAL TOUR, THURSDAY, JULY 16

All participants that are entitled to attend the professional tour will receive an exchange voucher in their registration kit. Please take this voucher to the onsite registration desk to receive your ticket to the tour.

CONFERENCE ORGANIZERS

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SOCIAL EVENTS

GET-TOGETHER RECEPTION
SUNDAY, JULY 12, 2015 at 19:30

An informal get-together to renew acquaintances and meet new colleagues will take place on the roof top of the Marina Hotel in Tel Aviv.
All registered participants are invited to join.

EVENING TOUR OF NEVE ZEDEK
MONDAY, JULY 13, 2015

Directly after sessions at Beit Dagan, take the conference shuttle to Tel Aviv. Buses will stop near the David Intercontinental Hotel. Meet guides for a walking tour of the neighbourhood of Neve Tzedek, which is one of the first neighborhoods built in the “new” city of Tel Aviv, back in 1887. Early in the 20th century, Neve Tzedek was the home for many artists and writers. Proceed to Rothschild Boulevard, which was built in 1910 and was initially called Rehov HaAm, "street of the people”. Many of the historic buildings were built in the eclectic and Bauhaus Architectural styles, forming part of the White City of Tel Aviv. Duration of the tour is approximately 1.5 hours and at the end of the tour return to your hotels on your own and/or enjoy the neighboorhood bars and cafes that the city offers.
All registered participants are invited to join.

CONFERENCE DINNER (OPTIONAL)
TUESDAY, JULY 14, 2015

The dinner will take place in Jerusalem. Buses will leave directly from sessions. Dinner will be followed by a special night tour of Jerusalem. The cost of a ticket is 70 euros and entry is by ticket only.
A transfer service has been arranged to bring registered accompanying persons from Tel Aviv to the Volcani Center in order to join the buses to Jerusalem.
Return after the dinner to conference hotels in Tel Aviv.

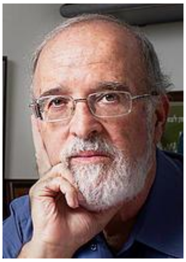
KEYNOTE SPEAKERS

Dr. Manuela Zude-Sasse
Germany

Mr. Jim Watt
Germany

Prof. Sheizaf Rafaeli
Israel

Prof. Svend Christensen
Denmark



Prof. Isaac Ben-Israel
Israel

Dr. Erik Andrejko
USA

EXHIBITORS

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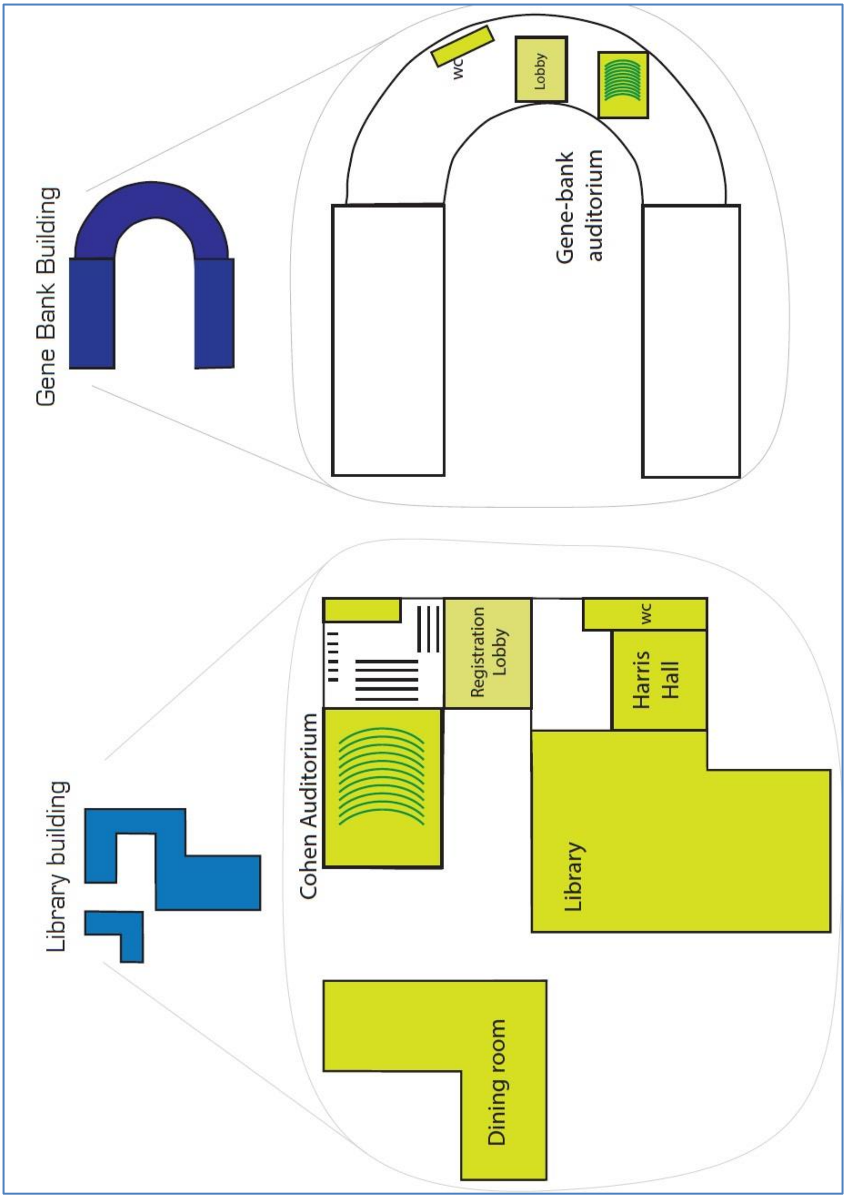
MAP OF VOLCANI CENTER CAMPUS

MAP OF SESSION HALLS



SCIENTIFIC PROGRAM

SCIENTIFIC PROGRAM

SUNDAY, JULY 12, 2015

16:00	Registration at *Marina Hotel, Tel Aviv*
19:30	Welcome Reception at *Marina Hotel, Tel Aviv*

MONDAY, JULY 13, 2015

07:30	Registration Opens at *Volcani Center, Beit Dagan*

08:15 – 08:30 **OPENING GREETINGS** *Cohen Auditorium*
Chair: **V. Alchanatis,** Israel

Prof. S. Harpaz, Deputy Director for R&D, ARO, Israel
Dr. K. Sudduth, President of ISPA, USA

08:30 – 10:00 **PLENARY SESSION 1** *Cohen Auditorium*
Chair: **A. Hetzroni,** Israel

08:30	VIEWS ON PRECISION HORTICULTURE **M. Zude-Sasse,** Germany
09:15	GUTENBERG TO ZUCKERBERG: HOW TECHNOLOGY CHANGES THE RULES **S. Rafaeli,** Israel
10:00	*Coffee, Poster Viewing and Visit the Exhibition*

10:20 – 12:20 *TECHNICAL SESSION T1-H* *Harris Hall*

ADVANCES IN PRECISION VITICULTURE

Chair: **Y. Netzer,** Israel

10:20 INTEGRATION OF OPERATIONAL CONSTRAINTS TO OPTIMIZE DIFFERENTIAL HARVEST IN VITICULTURE
B. Tisseyre, N. Briot, C. Bessiere, P. Vismara, France

10:40 "ON-THE-GO" MULTISPECTRAL IMAGING SYSTEM TO CHARACTERIZE THE DEVELOPMENT OF VINEYARD FOLIAGE
M.A. Bourgeon, J.N. Paoli, C. Gee, S. Villette, M. Morlet, S. Debuisson, G. Jones, France

11:00 WITHIN-VINEYARD ZONE DELINEATION IN AN AREA WITH DIVERSITY OF TRAINING SYSTEMS AND PLANT SPACING USING PARAMETERS OF VEGETATIVE GROWTH AND CROP LOAD
C. Miranda, J.B. Royo, L.G. Santesteban**,** Spain

11:20 TEMPORAL STABILITY OF WITHIN-FIELD VARIABILITY FOR TOTAL SOLUBLE SOLIDS IN FOUR IRRIGATED GRAPEVINES CULTIVARES GROWING UNDER SEMI-ARID CONDITIONS
N. Verdugo Vásquez, C. Acevedo-Opazo, H. Valdés-Gómez, B. Ingram, I. García de Cortázar-Atauri, B. Tisseyre, Chile

11:40 NDVI-BASED VIGOUR MAPS PRODUCTION USING AUTOMATIC DETECTION OF VINE ROWS IN ULTRA-HIGH RESOLUTION AREAL IMAGES
J. Primicerio, P. Gay, D.R. Aimonino, L. Comba, A. Matese, S.F. Di Gennaro, Italy

12:00 DEVELOPMENT OF AN ARTIFICIAL VISION PROGRESSIVE LOCAL METHOD FOR AUTO TRACKING OF THE VINE ROWS
B. Benet, R. Lenain, M. Berducat, France

10:20 – 12:20 **TECHNICAL SESSION T1-C** *Cohen Auditorium*
CROP AND SOIL PROXIMAL SENSING 1
Chair: **Y. Miao,** China

10:20 OBTAINING EFFECTIVE HIGH RESOLUTION SOIL INFORMATION FOR PRECISION FARMING: REQUIREMENTS, CAPABILITIES AND LIMITATIONS
J. Taylor, Newcastle University, UK *(Invited)*

10:40 3D SOIL MOISTURE SENSING AND IMAGING
I. Gravalos, A. Georgiadis, D. Kateris, O. Haralampous, T. Gialamas, P. Xyradakis, Z. Tsiropoulos, E. Bompolas, E. Manolakoudis, Greece

11:00 POTENTIAL OF USING PORTABLE X-RAY FLUORESCENCE SPECTROSCOPY FOR RAPID SOIL ANALYSIS
R. Gebbers, Germany

11:20 LONG-TERM MONITORING OF SOIL ORGANIC CARBON PATTERNS IN A PERENNIAL PASTURELAND
J.M. Serrano, S. Shahidian, J.M. da Silva, R. Wallach, Portugal

11:40 SPATIAL VARIABILITY OF SOIL PHOSPHORUS, POTASSIUM AND PH: EVALUATION OF THE POTENTIAL FOR IMPROVING VINEYARD FERTILIZER MANAGEMENT
J.M. Serrano, J.M. da Silva, S. Shahidian, L. Silva, A. Sousa, F. Baptista, Portugal

12:00 COMBINING ACTIVE OPTICAL SENSORS, INFRARED THERMOMETERS AND ULTRASONIC HEIGHT SENSORS FOR PROXIMAL SENSING IN IRRIGATED COTTON
K.F. Bronson, J. White, A. French, M. Conley, J. Mon, E. Barnes, USA

12:20 – 13:15 **POSTER FLASH TALKS** *Cohen Auditorium*
Chair: **A. Karnieli,** Israel

MONDAY, JULY 13, 2015 (Continued)

13:15	*Lunch, Poster Viewing and Visit the Exhibition*	
14:40 – 16:00	***TECHNICAL SESSION T2-H*** **ADVANCES IN PRECISION HORTICULTURE** Chair: **B. Tisseyre,** France	*Harris Hall*
14:40	ESTIMATION OF APPLE ORCHARD YIELD USING NIGHTTIME IMAGING **R. Linker,** E. Kelman, O. Cohen, Israel	
15:00	COMPUTER VISION SYSTEM FOR INDIVIDUAL FRUIT INSPECTION DURING HARVESTING ON MOBILE PLATFORMS **J. Blasco,** S. Cubero, S. Alegre, N. Aleixos, Spain	
15:20	USE OF NDVI TO PREDICT YIELD VARIABILITY IN A COMMERCIAL APPLE ORCHARD **V. Liakos,** A. Tagarakis, S. Fountas, G. Nanos, Z. Tsiropoulos, T. Gemtos, USA	
15:40	SAMPLING STRATIFICATION USING AERIAL IMAGERY TO ESTIMATE FRUIT LOAD AND HAIL DAMAGE IN NECTARINE TREES **C. Miranda**, I. Urretavizcaya, L.G. Santesteban, J.B. Royo, Spain	

14:40 – 16:00	***TECHNICAL SESSION T2-C*** **CROP AND SOIL PROXIMAL SENSING 2** Chair: **R. Gebbers,** Germany	*Cohen Auditorium*

14:40	OPERATIONAL CHARACTERISTICS OF COMMERCIAL CROP CANOPY SENSORS FOR NITROGEN APPLICATION IN MAIZE **K. Sudduth,** S. Drummond, N. Kitchen, USA
15:00	PRECISION NITROGEN MANAGEMENT STRATEGY FOR WINTER WHEAT IN THE NORTH CHINA PLAIN BASED ON AN ACTIVE CANOPY SENSOR **Y. Miao,** Q. Cao, F. Li, D. Lu, China
15:20	UNDERSTANDING HAND-HELD CROP SENSOR MEASUREMENTS AND WINTER WHEAT YIELD MAPPING **M. Perez-Ruiz,** L. Quebrajo, J. Agüera, A. Rodriguez-Lizana, Spain
15:40	PROXIMAL NITROGEN SENSING BY OFF-NADIR AND NADIR MEASUREMENTS IN WINTER WHEAT CANOPY **M.L. Gnyp,** M. Panitzki, S. Reusch, Germany
16:00	*Coffee, Poster Viewing and Visit the Exhibition*

16:20 – 18:20	***TECHNICAL SESSION T3-H*** **ADVANCES IN PRECISION OLIVICULTURE** Chair: **R. Linker,** Israel	*Harris Hall*

16:20 A MOBILE TERRESTRIAL LASER SCANNER FOR TREE CROPS: POINT CLOUD GENERATION, INFORMATION EXTRACTION AND VALIDATION IN AN INTENSIVE OLIVE ORCHARD
A. Escolà, J.A. Martínez-Casasnovas, J. Rufat, A. Arbonés, R. Sanz, F. Sebé, J. Arnó, J. Masip, M. Pascual, E. Gregorio, M. Ribes-Dasi, J.M. Villar, J.R. Rosell-Polo, Spain

16:40 MAPPING OLIVE-TREE GEOMETRIC FEATURES FROM 3D MODELS GENERATED WITH AN UNMANNED AERIAL VEHICLE
J.M. Peña, J. Torres-Sánchez, F. López-Granados, Spain

17:00 USING DEPTH CAMERAS FOR BIOMASS ESTIMATION – A MULTI-ANGLE APPROACH
D. Andujar, A. Escolà, J.R. Rosell-Polo, Á. Ribeiro, C. San Martín, C. Fernández-Quintanilla, J. Dorado, Spain

17:20 NUMERICAL SIMULATION OF SOIL WATER DYNAMICS AS A DECISION SUPPORT SYSTEM FOR IRRIGATION MANAGEMENT IN DRIP-IRRIGATED HEDGEROW OLIVE ORCHARDS
G. Egea, A. Díaz-Espejo, J.E. Fernández, Spain

17:40 AUTOMATED DETECTION OF MALFUNCTIONING IN DRIP-IRRIGATION SYSTEMS USING THERMAL REMOTE SENSING IN VINEYARDS AND OLIVE ORCHARDS
A. Dag, I. Zipori, V. Alchanatis, Y. Cohen, M. Sprinstin, A. Cohen, T. Maaravi, A. Naor, Israel

18:00 CHARACTERIZATION OF SALINITY-INDUCED EFFECTS IN OLIVE TREES BASED ON THERMAL IMAGERY
R. Rud, Y. Cohen, V. Alchanatis, I. Beiersdorf, R. Klose, E. Presnov, A. Levi, R. Brikman, N. Agam, A. Dag, A. Ben-Gal, Israel

16:20 – 18:20	***TECHNICAL SESSION T3-C*** **CROP AND SOIL PROXIMAL SENSING 3** Chair: **E.M. Pena-Yewtukhiw,** USA	*Cohen Auditorium*

16:20 USING AN UNMANNED AERIAL VEHICLE TO EVALUATE NITROGEN VARIABILITY AND DISTANCE EFFECT WITH AN ACTIVE CROP CANOPY SENSOR
B. Krienke, R.B. Ferguson, B. Maharjan, USA

16:40 IMPROVING ESTIMATION OF RICE YIELD POTENTIAL USING ACTIVE CANOPY SENSOR CROP CIRCLE ACS 430 IN NORTHEAST CHINA
Y. Miao, J. Lu, J. Shen, Q. Cao, China

17:00 NDVI MEASURMENTSAS A PREDICTOR OF MISCANTHUS X GIGANTEUS BIOMASS
E.M. Pena-Yewtukhiw, J.H. Grove, C. Griffin, K. Fetter, USA

17:20 USE OF CROP HEIGHT AND OPTICAL SENSOR READINGS TO PREDICT MID-SEASON COTTON BIOMASS
R.G. Trevisan**,** N. de Santana Vilanova Jr., G. Portz,
M.T. Eitelwein, J.P. Molin, Brazil

17:40 REMOTE SENSING FOR CROP WATER STRESS DETECTION IN GREENHOUSES
T. Bartzanas, N. Katsoulas, A. Elvanidi, K.P. Ferentinos, C. Kittas, Greece

18:00 EMBEDDED STEM WATER POTENTIAL SENSOR
M. Meron, S.Y. Goldberg, A. Solomon-Halgoa, G. Ramon, Israel

(Immediately after sessions) *Walking Tour of Neve Zedek*

TUESDAY, JULY 14, 2015

08:00	Registration
08:30 – 10:00	**PLENARY SESSION 2** *Cohen Auditorium* Chair: **H. Eizenberg,** Israel
08:30	UAVs HIGH RESOLUTION IMAGING FOR PRECISION AGRICULTURE **S. Christensen,** Denmark
09:15	MICRO AND NANO SATELLITES FOR EARTH OBSERVATION AND PRECISION AGRICULTURE **I. Ben-Israel,** Israel
10:00	*Coffee, Poster Viewing and Visit the Exhibition*

10:20 – 12:20 *TECHNICAL SESSION T4-H* *Harris Hall*
PRECISION CROP PROTECTION 1
Chair: **P.K. Jensen,** Denmark

10:20 AUTOMATING SITE, PLANT AND LEAF-SPECIFIC WEED CONTROL IN FIELD CROPS
A. Murdoch, Reading University, UK *(Invited)*

10:40 AN IMAGE-BASED DECISION SUPPORT METHODOLOGY FOR WEED MANAGEMENT
C.A. Franco, S.M. Pedersen, H. Papaharalampos, J.E. Ørum, Denmark

11:00 PRECISION HARROWING WITH A FLEXIBLE TINE HARROW AND AN ULTRASONIC SENSOR
G. Peteinatos, V. Rueda-Ayala, D. Andujar-Sanchez, R. Gerhards, Germany

11:20 WEED DETECTION BY AERIAL IMAGING: SIMULATION OF THE IMPACT OF SOIL, CROP AND WEED SPECTRAL MIXING
M. Louargant, S. Villette, G. Jones, N. Vigneau, J.N. Paoli, C. Gée, France

11:40 OPERATIONAL UNMANNED AERIAL VEHICLE ASSISTED POST-EMERGENCE HERBICIDE PATCH SPRAYING IN MAIZE: A FIELD STUDY
F. Pelosi, **F. Castaldi,** R. Casa, Italy

12:00 FUSED INERTIAL MEASUREMENT UNIT AND REAL TIME KINEMATIC-GLOBAL NAVIGATION SATELLITE SYSTEM DATA ASSESSMENT BASED ON ROBOTIC TOTAL STATION INFORMATION FOR IN-FIELD DYNAMIC POSITIONING
D.S. Paraforos, H.W. Griepentrog, J. Geipel, T. Stehle, Germany

10:20 – 12:20 ***TECHNICAL SESSION T4-C*** *Cohen Auditorium*
UAV, AERIAL AND SATELLITE SENSING 1
Chair: **J. Vangeyte,** Belgium

10:20 VEGETATION INDICES FROM UNMANNED AERIAL VEHICLES - MOUNTED SENSORS TO MONITOR THE DEVELOPMENT OF MAIZE (ZEA MAYS L.) UNDER DIFFERENT N RATES
J.A. Martínez-Casasnovas, M. Ariza-Sentís, Á. Maresma, E. Martínez, J. Lloveras, Spain

10:40 ESTIMATION OF ABOVE-GROUND DRY MATTER AND NITROGEN UPTAKE IN CATCH CROPS USING IMAGES ACQUIRED FROM AN OCTOCOPTER
A.K. Mortensen, R. Gislum, R. Larsen, R.N. Jørgensen, Denmark

11:00 A FULLY AUTOMATIZED PROCESSING CHAIN FOR HIGH-RESOLUTION MULTISPECTRAL IMAGE ACQUISITION OF CROP PARCELS BY UAV
G. Rabatel, S. Labbé, France

11:20 FIELD TRIAL DESIGN USING SEMI-AUTOMATED CONVENTIONAL MACHINERY AND AERIAL DRONE IMAGING FOR OUTLIER IDENTIFICATION
M.S. Laursen, R.N. Jørgensen, M.W. Brandt, T. Schmidt, R. Larsen, M. Nørremark, H.S. Midtiby, Denmark

11:40 EVALUATING SOIL AVAILABLE NITROGEN STATUS WITH REMOTE SENSING
J. Meng, X. You, Z. Chen, China

12:00 HIGH RESOLUTION REMOTE AND PROXIMAL SENSING TO ASSESS LOW AND HIGH YIELD AREAS IN A WHEAT FIELD
F.A. Rodrigues Jr., I. Ortiz-Monasterio, P.J. Zarco-Tejada, U. Schulthess, B. Gérard, Mexico

12:20 – 13:15	**SPONSOR SESSION** Chair: **K. Benish,** Israel	*Cohen Auditorium*
	KIDUM	
	AGAM ADVANCED AGRONOMY	
	EFOS & TRAPVIEW	
	FORCE-A	
	GEOMETRICS	
	RSIP VISION	
	TRIMBLE	
	SENSILIZE	
13:15	*Lunch, Poster Viewing and Visit the Exhibition*	
14:40 – 16:00	***TECHNICAL SESSION T5-H*** **PRECISION CROP PROTECTION 2** Chair: **R. Casa,** Italy	*Harris Hall*
14:40	CROP HEALTH CONDITION MONITORING BASED ON THE IDENTIFICATION OF BIOTIC AND ABIOTIC STRESSES BY USING HIERARCHIAL SELF-ORGANIZING CLASSIFIERS **D. Moshou,** X.E. Pantazi, R. Oberti, C. Bravo, J. West, H. Ramon, A.M. Mouazen, Greece	
15:00	USING SENSORS TO ASSESS HERBICIDE STRESS IN SUGAR BEET **G. Peteinatos,** J. Roeb, R. Gerhards, Germany	
15:20	PROXIMAL SENSING OF BARLEY RESISTANCE TO POWDERY MILDEW **M. Kuska,** M. Wahabzada, S. Thomas, H.W. Dehne, U. Steiner, E.C. Oerke, A.K. Mahlein, Germany	

14:40 – 16:00	***TECHNICAL SESSION T5-H*** **Continued**	*Harris Hall*

15:40 — VARIABLES ASSOCIATED WITH THE SPREAD OF BACTERIAL CANKER AND WILT CAUSED BY CLAVIBACTOR MICHIGANESIS SUBSP. MICHIGANESIS IN TOMATO GREENHOUSE
L. Blank, Y. Cohen, M. Borenstein, R. Shulhani, M. Lofthouse, M. Sofer, D. Shtienberg, Israel

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14:40 – 15:20 ***TECHNICAL SESSION T5-C*** *Cohen Auditorium*
UAV, AERIAL AND SATELLITE SENSING 2
Chair: **J.A. Martínez-Casasnovas**, Spain

14:40 — REMOTE ESTIMATION OF GROSS PRIMARY PRODUCTIVITY IN MAIZE AND SOYBEAN
A.A. Gitelson, Y. Peng, D. Rundquist, A. Suyker, S. Verma, Israel

15:00 — YIELD PREDICTION FOR PRECISION TERRITORIAL MANAGEMENT IN MAIZE USING SPECTRAL DATA
V.P. Rueda-Ayala, S.S. Kunapuli, G. Benavides, A. Córdova-Cruzatty, A. Cabrera, C. Fernández, J. Maiguashca, Ecuador

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15:20 – 16:00 ***TECHNICAL SESSION T5-C***
ECONOMICS AND PRACTICAL ADOPTION *Cohen Auditorium*

15:20 — ADOPTION AND PERSPECTIVES OF AUTO-GUIDANCE IN NORTHERN EUROPE
S.M. Pederson, Denmark

15:40 — PROMOTING PRECISION FARMING IN SOUTHEAST EUROPE: EXAMPLES FROM SITE-SPECIFIC MANAGEMENT CLUSTERS IN NORTH GREECE
T. Alexandridis, G. Galanis, E. Kalopesa, I. Cherif, A. Chouzouri, A. Patakas, T. Thomidis, G. Zalidis, A. Dimitrakos, C. Kalopesas, I. Navrozidis, Greece

16:00 *Coffee, Poster Viewing and Visit the Exhibition*

16:20 – 17:40 ***TECHNICAL SESSION T6-H*** *Harris Hall*
PRECISION CROP PROTECTION 3
Chair: **J. Blasco,** Spain

16:20 EARLY DETECTION OF TWO-SPOTTED SPIDER MITE DAMAGE TO PEPPER LEAVES BY SPECTRAL MEANS
I. Herrmann, M. Berenstein, A. Karnieli, T. Paz-Kagan, A. Sade, Israel

16:40 DETECTION OF RED PALM WEEVIL INFECTED TREES USING THERMAL IMAGING
O. Golomb, V. Alchanatis, N. Levin, Y. Cohen, Y. Cohen, V. Soroker, Y. Livne, Y. Nakash, Israel

17:00 SITE-SPECIFIC DETECTION AND TREATMENTS OF MEDFLY IN ORCHARDS
O. Mendelsohn, L. Blank, S. Aidlin-Harari, M. Silberstein, V. Orlov, T. Dayan, R. Fishman, Israel

17:20 AN AUTOMATIC SYSTEM FOR MEDITERRANEAN FRUIT FLY MONITORING
E. Goldshtein, **Y. Cohen**, D. Timar, Y. Grinshpon, L. Rosenfeld, Y. Gazit, A. Hofman, A. Mizrach, A. Hetzroni, V. Alchanatis, Israel

16:20 – 17:20	***TECHNICAL SESSION T6-C*** **MANAGEMENT, DATA ANALYSIS AND DSS 1** Chair: **D. Moshou,** Greece	*Cohen Auditorium*

16:20 COMBINING CROP SENSING AND SIMULATION MODELING TO ASSESS WITHIN-FIELD CORN NITROGEN STRESS
V. Zanella, B.V. Ortiz, K. Thorp, F. Morari, G. Mosca, G. Hoogenboom, Italy

16:40 THE USE OF COMPUTER SIMULATION MODELS IN PRECISION NUTRIENT MANAGEMENT
F. Plauborg, K. Manevski, Z. Zhou, M.N. Andersen, Denmark

17:00 YIELD MAPPING METHODS MANUALLY HARVESTED CROPS
A.F. Colaco, R. Trevisan, F. Karp, J. Molin, Brazil

Evening *Conference Dinner (Optional)*

WEDNESDAY, JULY 15, 2015

08:30	Registration	
09:00 – 10:30	**PLENARY SESSION 3** Chair: **A. Escolà,** Spain	*Cohen Auditorium*
09:00	DECISION SUPPORT IN AGRICULTURE - BRIDGING THE GAP **E. Andrejko,** USA	
09:45	PRECISION TO DECISION **J. Watt,** Germany	
10:30	*Coffee, Poster Viewing and Visit the Exhibition*	

11:00 – 13:00	***TECHNICAL SESSION T7-H*** **ADVANCES IN PRECISION IRRIGATION** Chair: **K.F. Bronson**, USA	*Harris Hall*

11:00 A DECISION SUPPORT TOOL FOR MANAGING PRECISION IRRIGATION WITH CENTER PIVOTS
V. Liakos, G. Vellidis, M. Tucker, C. Lowrance, Xi Liang, USA

11:20 A SMARTPHONE APP FOR PRECISION IRRIGATION SCHEDULING IN COTTON
G. Vellidis, V. Liakos, C. Perry, M. Tucker, J. Andreis, K. Migliaccio, C. Fraisse, USA

11:40 OPTIMAL IRRIGATION OF COTTON IN NORTHERN GREECE USING AQUACROP: A MULTI-YEAR SIMULATION STUDY
R. Linker, I. Tsakmakis, G. Sylaios, Israel

12:00 IRRIGATION CONTROL IN COTTON FIELDS USING GROUND THERMAL IMAGING
O. Rosenberg, Y. Cohen, V. Alchanatis, Y. Saranga, A. Bosak, S. Mey-Tal**,** Israel

12:20 A COST-EFFECTIVE CANOPY TEMPERATURE MEASUREMENT SYSTEM FOR PRECISION AGRICULTURE DECISION SUPPORT – FIRST YEAR STATUS UPDATE
M. Perez-Ruiz, **J. Martinez**, G. Egea, L. Perez, J. Agüera, Spain

12:40 IS THERE VARIABILITY IN SOIL WATER CONTENT OF LEVELED FIELDS?
L. Longchamps, R. Khosla, R. Reich USA

11:00 – 13:00	***TECHNICAL SESSION T7-C*** **SPATIAL VARIABILITY AND MAPPING** Chair: **D. Kalivas**, Greece	*Cohen Auditorium*

11:00 THE ACCORD BETWEEN PRECISION AGRICULTURE AND GEOSTATISTICS
M. Oliver, University of Reading**,** UK *(Invited)*

11:20 AN APPROACH TO DELINEATE MANAGEMENT ZONES IN A DURUM WHEAT FIELD: VALIDATION USING REMOTE SENSING AND YIELD MAPPING
G. Buttafuoco, A. Castrignanò, G.Cucci, M. Rinaldi, S. Ruggieri, Italy

11:40 IMPROVING N USE EFFICIENCY BY INTEGRATING SOIL AND CROP PROPERTIES FOR VARIABLE RATE N MANAGEMENT
L. Longchamps, R. Khosla, USA

12:00 A MULTIVARIATE SPATIAL CLUSTERING METHOD FOR PARTITIONING TREE-BASED ORCHARD DATA INTO HOMOGENOUS ZONES
A. Peeters, M. Zude, J. Käthner, M. Ünlü, R. Kanber, A. Hetzroni, R. Gebbers, A. Ben-Gal, Israel

12:20 SOIL MANAGEMENT DETERMINES SAMPLING DENSITY/SPATIAL DEPENDENCE OF DYNAMIC SOIL PROPERTIES
J.H. Grove, E. Pena-Yewtukhiw, USA

12:40 PRECISION AGRICULTURE IN WATERMELONS
S. Fountas, G. Xanthopoulos, G. Lambrinos, E. Manolopoulou, S. Apostolidou, D. Lentzou, E. Anastasiou, Z. Tsiropoulos, Greece

11:00 – 13:00	***TECHNICAL SESSION T7-G*** **ROBOTICS FOR PA 1** Chair: **W.S. Lee,** USA	*Gene Bank Auditorium*

11:00	THE LATEST TRENDS IN CONTROLLED TRAFFIC FARMING **S. Peets,** Harper Adams, UK *(Invited)*
11:20	A FLEET OF AERIAL AND GROUND ROBOTS: A SCALABLE APPROACH FOR AUTONOMOUS SITE-SPECIFIC HERBICIDE APPLICATION **A. Ribeiro**, C. Fernandez-Quintanilla, J. Dorado, F. Lopez-Granados, J.M. Peña, G. Rabatel, M. Pérez-Ruiz, J. Conesa-Muñoz, P. Gonzalez-de-Santos, Spain
11:40	EFFECTIVE SEGMENTATION OF GREEN VEGETATION FOR RESOURCE-CONSTRAINED REAL-TIME APPLICATIONS **S.M Krishna Moorthy Parvathi,** B. Boigelot, B. Mercatoris, Belgium
12:00	AUTONOMOUS FIELD NAVIGATION FOR DATA ACQUISITION OF WIRELESS SENSOR NETWORKS **D. Reiser,** D.S. Paraforos, H.W. Griepentrog, M.T. Khan, Germany
12:20	ADVANCED SENSOR PLATFORM FOR HUMAN DETECTION AND PROTECTION IN AUTONOMOUS FARMING **P. Christiansen,** M. Kragh, K. Arild Steen, H. Karstoft, R.N. Jørgensen, Denmark
12:40	A ROBOTIC MONITORING SYSTEM FOR DISEASES OF PEPPER GREENHOUSE **N. Schor**, S. Berman, A. Bechar, Israel
13:15	*Lunch, Poster Viewing and Visit the Exhibition*

14:15 – 15:35	***TECHNICAL SESSION T8-H*** **VRA FOR PA** Chair: **C. Gee,** France	*Harris Hall*
14:15	IMPORTANCE OF MEASURING TILLAGE IMPLEMENT FORCES FOR REDUCED FUEL CONSUMPTION AND INCREASED EFFICIENCY WITHOUT AFFECTING TILLAGE DEPTH **Z. Tsiropoulos,** S. Fountas, I. Gravalos, A. Augoustis, S. Arslan, P. Misiewicz, T. Gemtos, Greece	
14:35	SLURRY TANKER RETROFITTING WITH VARIABLE RATE DOSING SYSTEM: A CASE STUDY **M. Brambilla,** A. Calcante, R. Oberti, C. Bisaglia, Italy	
14:55	COMPARISON OF DIFFERENT SPREAD PATTERN DETERMINATION TECHNIQUES S.R. Cool, **J. Vangeyte**, J. Van Damme, B. Sonck, J.G. Pieters	
15:15	MEASURING THE DYNAMIC MASS FLOW FROM A CENTRIFUGAL FERTILIZER SPREADER S.R. Cool, **J. Vangeyte,** J. Van Damme, J. Voet, J.G. Pieters, K.C. Mertens, B. Sonck, Belgium	
14:15 – 15:15	***TECHNICAL SESSION T8-C*** **MANAGEMENT, DATA ANALYSIS AND DSS 2** Chair: **S. Fountas**, Greece	*Cohen Auditorium*
14:15	REMOTEAGRI: PROCESSING ONLINE BIG EARTH OBSERVATION DATA FOR PRECISION AGRICULTURE **K. Karantzalos**, A. Karmas, A. Tzotsos, Greece	
14:35	PREDICTING PRE-HARVEST AFLATOXIN CORN CONTAMINATION RISK WITH A DROUGHT INDEX **D. Damianidis,** B.V. Ortiz, G.L. Windham, B.T. Scully, P. Woli, USA	
14:55	HOW TO DEFINE THE SIZE OF A SAMPLING UNIT TO MAP HIGH RESOLUTION SPATIAL DATA? **B. Tisseyre**, V. Geraudie, N. Saurin, France	

14:15 – 15:35	***TECHNICAL SESSION T8-G*** **ROBOTICS FOR PA 2** Chair: **A. Bechar,** Israel	*Gene Bank Auditorium*

14:15 THE DEVELOPMENT OF ROBOTICS IN AGRICULTURE
S. Wane, Harper Adams, UK *(Invited)*

14:35 ORCHARD TREE DIGITIZATION FOR STRUCTURAL-GEOMETRICAL MODELING
S. Vougioukas, R. Arikapudi, T. Saracoglu, USA

14:55 LOW-COST ROBOTICS FOR HORTICULTURE: A CASE STUDY ON AUTOMATED SUGAR PEA HARVESTING
M.F. Stoelen, K. Kusnierek, V.F. Tejada, N. Heiberg, C. Balaguer, A. Korsaeth, UK

15:15 TASK CHARACTERIZATION AND CLASSIFICATION FOR ROBOTIC MANIPULATOR OPTIMAL DESIGN IN PRECISION AGRICULTURE
V. Bloch, A. Bechar, A. Degani, Israel

15:35 Coffee, Poster Viewing and Visit the Exhibition

16:00- 17:00	***TECHNICAL SESSION T9-C*** **MANAGEMENT, DATA ANALYSIS AND DSS 3** Chair**: J.P. Molin,** Brazil	*Cohen Auditorium*
16:00	FARM MANAGEMENT INFORMATION SYSTEM FOR FRUIT ORCHARDS **Z. Tsiropoulos,** S. Fountas, Greece	
16:20	SOME CONSIDERATIONS ABOUT THE DEVELOPMENT AND IMPLEMENTATION PROCESS OF A NEW AGRICULTURAL DECISION SUPPORT SYSTEM FOR SITE-SPECIFIC FERTILIZATION **C. Lundström,** J. Lindblom, M. Ljung, A. Jonsson, Sweden	
16:40	PALMSCOT: A COTTON LANDSCAPE MODEL FOR A PRECISION AGRICULTURE SCALE **R.J. Lascano**, USA	

16:00- 17:00	**TECHNICAL SESSION T9-G** **ROBOTICS FOR PA 3** Chair: **S. Vougioukas,** USA	*Gene Bank Auditorium*
16:00	ROBOWEEDSUPPORT: WEED RECOGNITION FOR REDUCTION OF HERBICIDE CONSUMPTION **M. Dyrmann,** H. Midtiby, R.N. Jørgensen, Denmark	
16:20	AN APPROACH TO LASER WEEDING SYSTEM FOR ELIMINATION OF IN-ROW WEEDS **W.S. Lee,** R. Shah, USA	
16:40	DETECTION OF PLANT AND GREENHOUSE FEATURES USING SONAR SENSORS **R. Finkelshtain,** Y. Yovel, G. Kosa, A. Bechar, Israel	

WEDNESDAY, JULY 15, 2015 (Continued)

17:10	**CLOSING PLENARY SESSION** Chair: **Y. Cohen,** Israel	*Cohen Auditorium*
	Conference conclusion Poster competition and prize winner's announcement Best papers award Announcment of next ECPA location	

THURSDAY, JULY 16, 2015

ALL DAY	**Professional Tour**
07:00	Departure from Tel Aviv to Ramat-Hanadiv
08:30	Tour in Ramat Hanadiv at the southern end of Mount Carmel
11:30	Field demonstrations in Kibbutz Megiddo
14:00	Lunch at Kibbutz Dalia
15:30	A tour to the Muhraka on the SE tip of Mount Carmel
19:30	Arrival to Tel Aviv

POSTER PRESENTATIONS

1. THERMAL REMOTE IMAGING FOR EVALUATION OF WATER CONDITION IN GRAPEVINE FOR IRRIGATION NEEDS
   A. Alon, V. Alchanatis, R. Rud, Y. Netser
   Sensing Systems, Information and Machinery Engineering, Institute of Agricultural Engineering, Aro, Israel, Rishon Le Zion, Israel

2. A LIDAR-BASED SYSTEM TO ASSESS POPLAR BIOMASS
   D. Andujar, A. Escolà, J. R. Rosell-Polo, S. Ricardo, F. Q. Cesar, D. José
   Centro De Automatica Y Robotica,
   Csic. Institute for Agricultural Sciences, Madrid, Spain

3. INTEGRATION OF A HYDROLOGICAL MODEL WITH GEORCHAEOLOGICAL INFORMATION THROUGH GIS TO ESTIMATE RUNOFF WATER YIELD FOR ANCIENT AGRICULTURAL TERRACES AND CISTERNS IN THE NEGEV HIGHLANDS
   H. Bithan- Guedj, T. Svoray, H. Bruins
   Department Of Geography and Environmental Development, Ben Gurion University of the Negev, Beer Sheva, Israel

4. DRIVING OLIVE FLY POPULATION MODEL WITH SATELLITE DATA: TOWARDS A SYSTEM OF PRECISE PEST CONTROL IN AGRICULTURE
   M. Blum, I.M. Lensky, P. Rempoulakis, D. Nestel
   Geography, Bar Ilan University, Ramat Gan, Israel and Department of Entomology, Agriculture Research Organization, Volcani Center, Beit Dagan, Israel

5. PRECISION NUTRIENT MANAGEMENT FOR TARGETED YIELDS OF MAIZE (ZEA MAYS L.) IN ALFISOLS OF KARNATAKA
   Hanumanthappa D.C, **S. Channabasappa**, Nagaraju DR., Seshadri T, Mudalagiriyappa DR., Channabasave Gowda R
   Agronomy Department, University of Agricultural Sciences, Bangalore, India

6. ADVANCES IN PRECISION IRRIGATION
N. Douglas
Trimble Ag, Trimble, Westminstaer, USA

7. PERFORMANCE OF SPECTROMETERS TO ESTIMATE SOIL PROPERTIES
M. T. Eitelwein, J. A. Melo Demattê, R. G. Trevisan, A. A. Anselmi, J. P. Molin
Biosystems Engineering, Universidade De São Paulo, Piracicaba, Brazil

8. AUTOMATIC ACTIVITY MONITORING SYSTEM SUPPORTING INFORMED DECISION MAKING IN AN EXTENSIVE LIVESTOCK OPERATION - GRAZING BEEF CATTLE
R. Gabrieli
Agricultural Extension Service, Ministry of Agricultuer and Rural Development, Rishon Le Zion, Beit Dagan, Israel

9. DETECTION OF STABLE CROP PATTERNS IN A CHANGING CLIMATE BY COMBINING SATELLITE IMAGES AND GROUND MAPS IN A MULTI-TEMPORAL APPROACH
C. Georgi, D. Spengler, S. Itzerott, E. S. Dobers
Section 1.4 Remote Sensing, Gfz German Research Centre for Geosciences, Potsdam, Germany

10. SPECTRAL ASSESSMENT OF LEAF POTASSIUM CONCENTRATION IN UN-STRESSED PEPPER GROWN IN NET HOUSE
I. Herrmann, A. Karnieli, U. Yermiyahu
The Remote Sensing Laboratory, Jacob Blaustein Institutes for Desert Research, Ben Gurion University of the Negev, Sede Boker Campus, Israel

11. EPHEMERAL GULLY SPACE-TIME DYNAMICS IN AN AGRICULTURAL CATCHMENT
D. Hoober, T. Svoray, S. Cohen
Geography and Environmental Development, Ben Gurion University of the Negev, Beer Sheva, Israel

12. POTENTIAL TO GRADUATE THE DOSE ACCORDING TO CROP BIOMASS WHEN DESICCATING POTATO CROPS
    P. K. Jensen, B. Nielsen
    Agroecology, Aarhus University, Slagelse, Denmark

13. DEVELOPMENT AND APPLICATION OF A SPATIAL DECISION SUPPORT SYSTEM IN NITROGEN FERTILIZATION AT FIELD SCALE
    A. Papadopoulos, S. Theocharopoulos, **D**. P. Kalivas, S. Stamatiadis
    Natural Resources Management and Agricultural Engineering, Agricultural University of Athens, Athens, Greece

14. MAPPING THE WEEDS SPATIO-TEMPORAL APPEARANCE IN BREWERY BARLEY AT FIELD SCALE
    D. P. Kalivas, G. Economou, I. Thomopoulos
    Natural Resources Management and Agricultural Engineering, Agricultural University of Athens, Athens, Greece

15. EVALUATION OF APPLE FLOWERING INTENSITY USING COLOR IMAGE PROCESSING FOR TREE SPECIFIC THINNING
    O. Krikeb, V. Alchanatis, O. Krein, A. Naor
    Institute of Agricultural Engineering, Agricultural Research Organization, the Volcani Center, Bet Dagan, Israel and Faculty of Agriculture, The Hebrew University in Jerusalem, Rehovot, Israel

16. ESTIMATION THE LEAF PHOSPHORUS CONTENT OF LITCHI AT DIFFERENT GROWTH STAGES BY CANOPY LEAF REFLECTANCE
    D. Li
    National Engineering and Technology Center for Information Agriculture, Guangzhou Institute of Geography, Guangzhou, China

17. A MULTI-TOOL APPROACH FOR ASSESSING FRUIT GROWTH, PRODUCTION AND PLANT STATUS OF A PEAR ORCHARD
L. Manfrini, P. Losciale, B. Morandi, E. Pierpaoli, M. Zibordi, S. Anconelli, F. Galli, L. C. Grappadelli
Department of Agricultural Sciences, University of Bologna, Bologna, Italy and HK, Horticultural Knowledge Srl, Bologna, Italy

18. INFLUENCE OF THE YEAR OF IMAGE ACQUISITION AND ITS SOURCE (SATELLITE VS. AIRBORNE) ON VINEYARD REMOTE CHARACTERIZATION THROUGH MULTISPECTRAL IMAGES
I. Urretavizcaya, A. Urzáiz, **C. Miranda,** J.B. Royo, L. Gonzaga Santesteban
Crop Production, Public University of Navarre, Pamplona, Spain

19. EFFECT OF GLYPHOSATE RESISTANT WEEDS ON THE ADOPTION OF SITE-SPECIFIC FARMING METHODS IN THE UNITED STATES
T. C. Mueller
Plant Sciences, University of Tennessee, Knoxville, TN, USA

20. USING REFLECTANCE PROFILING (REMOTE SENSING) TO OPTIMIZE CROP INPUT MANAGEMENT AND REDUCE CROP SUSCEPTIBILITY TO PESTS
C. Nansen
Insect Ecology and Remote Sensing, Department of Entomology and Nematology, CA, USA

21. CLIMATE SENSITIVITY ANALYSIS OF MAIZE YIELD ON THE BASIS OF DATA OF PRECISION CROP PRODUCTION
A. Nyéki, J. Kalmár, G. Milics, A. J. Kovács, M. Neményi
University of West Hungary Faculty of Agricultural and Food Sciences, Institute of Biosystems Engineering, Mosonmagyaróvár, Hungary

22. MULTI-SENSOR PLATFORMS FOR DETAILED CHARACTERIZATION OF PLANT CANOPIES DURING THE ENTIRE GROWING SEASON
S. Paulus, T. Dornbusch
Lemnatec, Gmbh, Aachen, Germany

23. PERCEPTION OF PRECISION FARMING IN NORTHERN EUROPE
K.M. Lind, T.W. Tamirat, **S.M. Pedersen**
Department of Food and Resource Economics, University of Copenhagen, Copenhagen, Denmark

24. PRECISION NUTRIENT MANAGEMENT - 4R STEWARDSHIP
S. Phillips
North America Program, International Plant Nutrition Institute, Norcross, USA

25. MEASUREMENT OF MAIZE STALK DIAMETER TO ESTIMATE YIELD
J. S. Schepers, K. Holland, D. Francis
Agronomy and Horticulture, University of Nebraska Lincoln, Lincoln, USA

26. GEOSTATISTICAL TOOLS FOR THE STUDY OF INSECT SPATIAL DISTRIBUTION: PRACTICAL IMPLICATIONS IN THE INTEGRATED MANAGEMENT OF ORCHARD AND VINEYARD PESTS
A. Sciarretta, P. Trematerra
Department of Agricultural, Environmental and Food Sciences, University of Molise, Campobasso, Italy

27. CHALLENGES TO IMPLEMENTATION OF PRECISION IRRIGATION WITH SPRAYERS
S. Shahidian, **J. Serrano**, R. Wallach, R. Hakimi
Rural Engineering, Icaam/ Universitof Evora, Evora, Portugal

28. DEVELOPMENT AND SIMULATION OF A ROBOTIC CONTROLLER BASED ON FUZZY BEHAVIOURS FOR GUIDANCE OF MOBILE ROBOT IN ORCHARDS
R. Vieira de Sousa, R. Tabile, P. Pereira, R. Inamasu
Department of Biosystems Engineering, University of São Paulo, Pirassununga, Brazil

29. THEORETICAL BOUNDARIES OF PRECISION IRRIGATION OF COTTON CULTIVATION IN NORTHERN GREECE
    I. Tsakmakis, **G. Sylaios**, R. Linker
    Department of Environmental Engineering, Democritus University of Thrace, Xanthi, Greece

30. DECISION SUPPORT FOR IRRIGATION MANAGEMENT: CASE OF APPLE ORCHARD IN SWITZERLAND
    T. W. Tamirat, K. Nielsen, S. M. Pedersen, C. Franco
    Department of Food and Resource Economics, Faculty of Science, Copenhagen University, Frederiksberg C, Denmark

31. OPPORTUNITY OF AIRBORNE IMAGES TO IDENTIFY MISSING VINE PLANTS: APPLICATION TO CV. SYRAH AND VERTICAL SHOOT POSITIONING TRAINING SYSTEM
    M. Córdoba, N. Sarurin, H. Ojeda, **B. Tisseyre**
    Montpellier Sup Agro/Irstea, Inra, Gruissan, France

32. DESIGN OF AN ENERGY EFFICIENT AND LOW COST TRAP FOR OLIVE FLY MONITORING USING A ZIGBEE BASED WIRELESS SENSOR NETWORK
    B. Alorda, F. Borja, M. del Mar Leza, L. Almenar, J. Feliu, M. Ruiz, M. A. Miranda, **F. Valdes Crespí**
    Physics, Illes Balears University, Palma, Spain

33. PRELIMINARY DEVELOPMENT OF AN AUTONOMOUS ORCHARD TRACTOR
    S.O. Wane, S. Blackmore, L. Biggs
    Engineering, Harper Adams University, Telford, United Kingdom

ABSTRACTS:
POSTER PRESENTATIONS

THERMAL REMOTE IMAGING FOR EVALUATION OF WATER CONDITION IN GRAPEVINE FOR IRRIGATION NEEDS

Asaf Alon[1], Victor Alchanatis[2], Ronit Rud[2], Yishai Netser[3]
[1]Sensing Systems, Information and Machinery Engineering, Institute of Agricultural Engineering, Aro, Israel, Rishon Le Zion, Israel, [2]Sensing Systems, Information and Machinery Engineering, Institute of Agricultural Engineering, Aro, Rishon Le Zion, Israel, [3]Department of Vineyard Wine, Mountain R&D, Israel, Ariel, Israel

Wine vineyards irrigation, plays an important role in viticulture and has both short and long term impact on the quality of the fruit and the trees. Monitoring the water status today is done in several ways: 1) Soil water status, 2) Plant water status (Indices like Stem Water Potential (SWP), and Leaf Water Potential (LWP) etc.), 3) Remote sensing, made mainly by thermal imaging. In vineyard thermal remote sensing, a lot of studies investigated relationships between plant water status indices and CWSI (Moller, et al., 2006)(Grant, et al., 2007)(Jones, et al., 2002)(Pou, et al., 2014), and there were attempts to create a spatial map of CWSI from a UAV(unmanned aerial vehicle) (Bellvert, et al., 2013)(Baluja, et al., 2012). In addition, there was an attempt of thermal imaging by a moving vehicle in the vineyard (Dhillon, et al., 2012).

The objective of this study was to assess various aspects of thermal remote sensing with an emphasis on thermal image acquisition from the side of the vineyard, as a tool for water status monitoring. An additional objective was to create a spatial map of CWSI using this methodology of photography. Thermal images were acquired from the center of the row, when the camera was placed: (1) horizontally: the camera was placed at the height of the center of the canopy, directed towards the center of the canopy, (2) at an inclination angle of about 45º, about 1m above the canopy, directed towards the center of the canopy. A tripod was secured on the back of a pickup truck. Two cameras (thermal and RGB) were mounted on the tripod head, looking at the center of the vines. The cameras were connected to a computer along with a GPS receiver.

The computer acquired the images from the two cameras and logged the location when the images where acquired. A meteorological station placed in the field acquired data every minute.

A number of different irrigation treatments were applied, that resulted to a wide range of SWP throughout the season. Thermal images of pre-marked trees were acquired, in which SWP was also measured. Image processing algorithms were developed to (1) separate vegetation from various objects in the image (soil, sky etc.). This was accomplished using the typical vegetation temperature range around air temperature at the time of image acquisition. (2) exclude parts of the image that were mistakenly classified as vegetation, (3) extract canopy temperature in different methods. Automatic data acquisition was performed, according to a predetermined schedule while traveling between vineyard rows. Dedicated software was developed that first coordinated between all the acquired data: thermal images, meteorological data and location, and then calculate CWSI for all the traveled locations. Linear regression models where built between CWSI and SWP to generate a seasonal model, using information from side and oblique images. It was found that the oblique images (when the cameras were placed at an angle of 45 degrees to the canopy) resulted to higher correlations. Spatial map of CWSI was created from the automatic data acquisition by the software data analysis.

A LIDAR-BASED SYSTEM TO ASSESS POPLAR BIOMASS

Dionisio Andujar[1], Alexandre Escolà[2], Rosell-Polo Joan Ramon[2], Sanz Ricardo[2], Fernández-Quintanilla Cesar[3], Dorado José[3]
,[1]Centro De Automatica Y Robotica Csic. Institute for Agricultural Sciences, Madrid, Spain, [2]Research Group on Agro Ict & Precision Agriculture, Universitat De Lleida, Lleida, Spain, [3]Crop Protection, Institute for Agricultural Sciences, Csic, Madrid, Spain

This study evaluates the capabilities and accuracy of a LiDAR-based system for the characterization of poplar trees for biomass production. The precision of the system was assessed by analyzing the relationship between the distance records and biophysical parameters. The terrestrial laser scanner (TLS) system mounted a 2D time-of-flight LiDAR sensor, a gimbal to dynamically stabilize the sensor and a RTK-GPS to georeference its location and, subsequently, the sensor data. The sensor and its stabilizer were fixed, facing downwards, in a metal frame designed for this purpose and placed on an All-Terrain Vehicle performing 2D scans in planes perpendicular to the travel direction. Distances between the sensor and the surrounding objects had a high spatial resolution, providing high density 3D point clouds. The results on the reliability of LiDAR system to estimate plant height showed a significant relationship between the records provided by the sensor and actual data on the height of the poplars.

INTEGRATION OF A HYDROLOGICAL MODEL WITH GEORCHAEOLOGICAL INFORMATION THROUGH GIS TO ESTIMATE RUNOFF WATER YIELD FOR ANCIENT AGRICULTURAL TERRACES AND CISTERNS IN THE NEGEV HIGHLANDS

Hodaya Bithan- Guedj[1], Tal Svoray[1], Hendrik Bruins[2]

[1]Department Of Geography and Environmental Development, Ben Gurion University of the Negev, Beer Sheva, Israel, [2]Department Of Man in the Desert, Ben Gurion University of the Negev, Beer Sheva, Israel

The average annual rainfall in the Negev Highlands is about 100 mm. Rainfall alone is obviously not sufficient for agricultural production of cereal grains or fruit trees. However, there are many archaeological data concerning the widespread existence of terraced wadi fields in the region (Bruins, 2012), which clearly indicate that agriculture was practiced here in ancient times. Indeed the agronomic and hydrological research by Evenari et al. (1982) of reconstructed ancient farm systems near Shivta and Avdat showed that stone terrace walls captured the flow of runoff water, in order to increase soil moisture in the loessial soils, thus facilitating agriculture in the desert.

Our research project focusses on simulations of runoff water generation and flow in relation to three terraced wadis at the rural archaeological site of Horvat Haluqim (Cohen, 1976; Bruins, 1986, Bruins and Ore, 2009). The site contains various Iron Age building remains and is situated on the Haluqim hill range, not far from Kibbutz Sede Boker. The runoff simulations are based on selected rainfall data during the 30 year period 1980-2010, a digital elevation model (DEM) of the site based on LiDAR data, geographic information system (GIS) geomorphic surface data and a topographic-hydraulic GIS model. An earlier version of the GIS model was used by Ackermann et al. (2008) in a less detailed approach.

Concerning the input of rainfall into the model, we selected a typical year with average rainfall amounts (1989-1990), a severe drought year (1998-1999) and a very wet year (1991-1992). Climatic mapping was carried out for the Negev by Bruins (2012) for the decadal average during 1990-2000, and also for the above severe drought year and very wet year. It is obvious that runoff amounts will be different for the selected climatic scenarios, while the ancient farmers had to cope with such climatic variability.

We calculated the runoff amounts for each individual rainfall event during the three distinguished rainy years (average year, drought year, wet year). The first 2-3 mm of each nonconsecutive rainfall event was deducted from the respective rainfall amounts, because runoff will only begin after the geomorphic surface is saturated (Shanan and Schick, 1980).

We calculated runoff yields by utilizing the LiDAR DEM data, the archaeological data for the terraced fields and cisterns, and the D-Infinity (Tau-Dem) algorithm, a multiple flow direction algorithm that identified the steepest downward slope on planar triangular facets on a block-centered grid (Tarboton 1997). In addition, we used orthophotography to map and categorize the ground cover of the catchment areas by GIS, in order to assign weighted runoff coefficients for each mapping unit, based on the literature (Yair and Kossovsky 2002).

For validation of our hydrological GIS model we made comparisons with the Avdat experimental farm, where actual runoff yields were measured with a hydrograph (Shanan and Schick, 1980; Evenari et al., 1982). We selected eight rainfall events and the respective measured runoff yields for each of the eight catchment areas in the Avdat area. Then we calculated the runoff yields for these rainfall events with our GIS model based on a DEM of the Avdat area. The results of the validation are quite satisfactory with $R^2 = 0.87$ and NRMSE = 0.12.

Concerning the Horvat Haluqim site, the runoff yields were calculated for each terraced field, both in terms of sideward runoff flow from the hill sections above each terrace and from the through-flow in the wadi. The height of the terrace walls above the soil surface of the terraced fields also determines how much runoff water is captured and retained by each field. Therefore, we used three different scenarios of terrace wall heights above the respective fields: 10 cm, 20 cm and 30 cm. .

We evaluated the runoff yields for each terraced field, including the three studied heights of the terrace walls above the soil surface, in terms of suitability for the possible growth of different crops, *i.e*. barley, wheat, grapevines and olive trees. The detailed results are shown in the poster. We conclude that taking into account the three different climatic scenarios (average year, drought year, very wet year), it seems most efficient to use a terrace wall height of 10 cm above each field in order to distribute the captured runoff water most efficiently over all the terraced fields. Moreover, wheat seems the most suitable crop to grow at Horvat Haluqim. Our GIS model findings are supported by archeological evidence, including the discovery of grain silos in the eastern valley of Horvat Haluqim, as well as sickle blades (Bruins, personal communication, to be published).

References:

Ackermann, O., Svoray, T., Haiman, M., 2008. Nari (calcrete) outcrop contribution to ancient agricultural terraces in the Southern Shephelah, Israel: insights from digital terrain analysis and a geoarchaeological field survey. *Journal of Archaeological Science* 35: 930-941.

Bruins, H.J., 1986. Desert Environment and Agriculture in the Central Negev and Kadesh-Barnea during Historical Times. Published Ph.D. Dissertation, Wageningen University, Stichting Midbar Foundation, Nijkerk.

Bruins, H.J. (2012) Ancient desert agriculture in the Negev and climate-zone boundary changes during average, wet and drought years. *Journal of Arid Environments* 86: 28-42.

Bruins, H.J., Ore, G., 2009. Runoff from loess or bedrock? Hillslope geoarchaeology of ancient runoff farming systems at Horvat Haluqim and Har Eldad in the central Negev desert. *Israel Journal of Earth Sciences* 57 (3-4): 231-247.

Evenari, M., Shanan, L., Tadmor, N.H., 1982. *The Negev: The Challenge of a Desert*, 2nd revised edition. Harvard University Press, Cambridge MA.

Yair, A., Kossovsky, A., 2002. Climate and surface properties: hydrological response of small arid and semi-arid watersheds. *Geomorphology,* 42(1–2), pp. 43-57.

Shanan, L., Schick, A. P.,1980. A Hydrological Model for the Negev desert highlands: Effects of infiltration, runoff and ancient agriculture. *Hydrological Science Bulletin*, Vol.25, pp. 269-282.

Tarboton, D.G., 1997. A new method for the determination of flow directions and upslope areas in grid digital elevation models. *Water Resources Research,* 33(2), pp. 309-319.

DRIVING OLIVE FLY POPULATION MODEL WITH SATELLITE DATA: TOWARDS A SYSTEM OF PRECISE PEST CONTROL IN AGRICULTURE

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Simulation of insect pest populations in agricultural and forest ecosystems is an important and useful tool for integrated pest management (IPM). Insect population models are mainly driven by environmental temperature data, which are usually collected from agrometeorological stations or derived from geographic statistical extrapolations. Our main aim was to demonstrate the use of satellite-acquired information for modelling biological and ecological phenomena. As a case study we used the olive fruit fly (Bactrocera oleae (Gmelin)). As a first step, we developed a method to estimate olive canopy temperature using Moderate Resolution Image Spectro-Radiometer (MODIS) data at 1 km resolution. Land Surface Temperature (LST) and Normalized Difference Vegetation Index (NDVI) from MODIS onboard NASA TERRA satellite, together with in-situ canopy temperature were used. The satellite based estimation of canopy temperature measurements in different regions and olive orchard environments was found to be more accurate than using air temperature form the nearest meteorological station. The estimated canopy temperatures were used as input for an olive fly population model. Eleven years (2001-2012) of olive fly populations were simulated for three different geographic locations, representing different geo-climatic conditions (Nablus, Lahav, Shaar-hagai). The model successfully simulated the seasonal population fluctuations throughout the 11-year period and did a good job of connecting all of the life stages of the insect. To evaluate the validity of these findings, we compared them with adult olive-fly trapping data. We observed a high degree of correlation between the trapping data and our model’s predictions. We demonstrate that satellite thermal data can be used to make insect pest population predictions that can be used for IPM. The study also advances some new modeling concepts such as the "window of opportunity" which links physiological development with chronological age.

PRECISION NUTRIENT MANAGEMENT FOR TARGETED YIELDS OF MAIZE (ZEA MAYS L.) IN ALFISOLS OF KARNATAKA

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A field experiment was conducted at Zonal Agricultural Research Station, University of Agricultural Sciences, G.K.V.K, Bangalore during kharif 2014 on Precision nutrient management for targeted yields of Maize (Zea mays L.) in alfisols of Karnataka. The experimental site is located at 13o 05’ 22” N latitude, 77o 34’ 04” E longitude and an altitude of 933 m above MSL. Totally thirty six grids of size 9.0 m x 9.0 m each were prepared, soil samples from each grid were collected and analysed to know the spatial variability. The initial pH of the soil ranged from 4.63 to 4.95 with an electrical conductivity of 0.08 to 0.12 dS m-1. Available nitrogen, phosphorous and potassium varied between 168 to 206, 7.1 to 8.6 and 226 to 308 kg ha-1 respectively. The treatments comprised of three methods of fertilizer application (M1: UAS (B) package of practice, M2: Drip fertigation in 12 equal splits at weekly interval, M3: Drip fertigation in 6 equal splits at fortnightly interval with targeted yield levels of 75, 90, 105 q ha-1 including recommended dose of fertilizer as control. The experiment was laid out in split plot design with three replications. The fertilizers required for each targeted yield was calculated based on the soil available nutrient status using the formulae F.N = 3.84 T - 0.42 S.N (KMnO4-N), F. P2O5 = 1.57 - 1.18 S. P2O5 (Bray’s P2O5), F. K2O = 1.15 T - 0.11 S. K2O (Ammonium acetate K2O). Where, T= Targeted yield, F.N= Fertilizer nitrogen requirement, F. P2O5 = Fertilizer phosphorous requirement, F. K2O = Fertilizer potassium requirement, S.N/ S. P2O5/S. K2O = Nitrogen/ phosphorus/potassium content in soil. The results showed that the application of fertilizers as per package of practice taken only 47 days to produce 50 % tassels which was one week earlier than the treatments which received drip fertigation in 6 equal splits at fortnightly interval and drip fertigation in 12 equal splits at weekly interval which were produced 50% tassels 54 days after sowing. Significantly higher plant height of 47.5 cm and 188.0 cm was recorded with

the fertilizers applied for different targeted yields as per UAS (B) PoP. Among different yield levels, targeted yield of 105 q ha-1 recorded significantly higher plant height of 40.9 and 201.5 cm at 30 and 60 DAS respectively. The same trend was observed with respect to number of leaves per plant, leaf area index, stem girth, internodal length and dry weight per plant. At 30 DAS chlorophyll content (26.0) was significantly higher with the application of fertilizers as per UAS (B) PoP over rest of the treatments. Among different yield targets, targeted yield of 105q ha-1 recorded significantly higher chlorophyll content of 20.8 and 44.5 at 30 and 60 DAS respectively. Based on the performance of above parameters the yield targets of 90 and 105 q ha-1 could be achieved with the précised supply of 317:156:89 and 275:131:75 NPK kg ha-1 respectively.

ADVANCES IN PRECISION IRRIGATION

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Agriculture has a growing requirement to deliver the right amount of water and nutrients to the crop during the growing cycle. The need to produce higher volumes and greater quality of crops is driving the development of new irrigation and fertigation technologies.
Each crop has a differing set of requirements throughout its growing cycle, and each crop will have a differing irrigation regime depending on soil type, planting density and land topography. All of these combined makes delivering the optimal amount of water and nutrients to the root zone a challenging task for the farmer.
Water as a resource is going to become scare and farmers are aware of this, soon legislation will start to dictate and control the amount of fresh water that can be used for irrigation. The cost of pumping water and the cost per acre for irrigation is likely to rise over the next decade as this resource becomes more valuable.
Farmers have become more technologically savvy and the use of web based and cloud driven services are enabling farmers to better manage their production. Farmers are looking for ways to improve and optimize their irrigation techniques through better delivery systems, both to the farm and to the crop. On a large scale irrigation is generally managed using either Linear or Pivot irrigators, and until recently these systems had little or no control over where the placed the water or nutrients they dispensed. It is the control of these irrigators that will allow the farmer to better manage crop production and deal with the restrictions gradually being introduced around water management and nutrient loss/leaching. The ability to precisely control what the irrigator is applying, to what depth, for how long and when the irrigation events took place will become a significant tool for the farmer to use.
Technology is now available to allow the farmer to manage these irrigation events through their irrigators by equipping them with VRI technology. This is the practice of fitting solenoid controlled valves to each sprinkler on the irrigator and then using smart control systems and web based software solutions to better regulate how water is applied.

These new systems are allowing farmer to effectively turn what is a wide and indiscreet watering system in to an “ink jet printer”. This is binge accomplished by creating areas under the irrigator, which can be soil based, crop based or topography based and then regulating the amount of water applied by switching individual sprinkler off and on to reduce the application rate of the irrigator.

Studies have shown that applying water at the correct amount during the growing cycle, can increase yield, reduce disease and provide greater uniformity of the crop. This is being achieved by monitoring the soil moisture and controlling the application rates of water from the irrigator to maintain the soil moisture at optimal plant uptake. In addition to this farmers are taking advantage of a more precise application of water to prevent the nutrients they apply being washed past the root zone, thus maximizing plant nutrition.

This technology has only been available in the last 5 years for large scale irrigation, but studies have suggested significant increase in crop yield can be expected, form better water management, less waste in nutrients and the ability to mix different hybrids, greater crop density or by having mixed crop types under the same irrigator.

The net result to the farmer is greater productivity, greater control and a significant return on investment.

PERFORMANCE OF SPECTROMETERS TO ESTIMATE SOIL PROPERTIES

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The objective of this work was to compare soil spectral reflectance readings obtained by two spectrometers and evaluate their potential to predict soil attributes. A total of 261 samples were used which were collected in the depth ranges 0-0.2, 0.4-0.6 and 0.8-1 m. The samples were sent to a laboratory to determine soil granulometry (particle size distribution); soil organic matter (SOM) and chemical elements (K, Ca, Mg and H + Al) to calculate CEC. Two instruments were used for the spectral readings. The comparison of sensor readings from both spectrometers using Pearson linear correlation was good in the range 400 – 1900 nm. The predictions of soil attributes using partial least squares regression (PLSR) exhibited significant possibilities for determining soil physicals characterists, such as sand and clay. This is an ongoing study and a third instrument will be used for new comparisons.

AUTOMATIC ACTIVITY MONITORING SYSTEM SUPPORTING INFORMED DECISION MAKING IN AN EXTENSIVE LIVESTOCK OPERATION - GRAZING BEEF CATTLE

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Beef cattle breeding is an extensive operation, carried out in vast pastures. Herd management and data collection are carried out manually due to the lack of applicable technology. Prolonged production cycle based on natural resources and a lack of online information result in a cause - consequence knowledge gap which inhibits the breeders' ability to address varied, transient physiological events affecting production. Once production results are revealed, management modifications have no effect on the current production cycle. Furthermore, this time gap between a production result and the causing event hinders educated data analysis and conclusion making, thus leaving unknown negative factors undealt with in any other way but culling cows. Culling is a costly measure that often has a negative effect on genetic merits for weight gain, especially in hot climates. Cows that are superior in growth qualities may not concept due to lack of adequate feeding, breeding or grouping management. Monitoring individual cow's activity continuously can provide online information concerning these aspects and facilitate proper treatment of defined problems and addressing individual needs.
Previous attempts to apply electronic monitoring systems in open pastures have failed due to transmission limitations. Sampling activity at fixed times and locations, such as obligatory passage points, have resulted in irregular identification and data reception, due to the irregular behaviour patterns of grazing beef cows. This irregularity was reflected in fluctuated activity graphs which masked specific activity patterns expressing physiological or behavioural phenomena.
This paper presents an innovative approach for informed management decision making in a commercial, extensive beef cattle herd, based on a long range wireless pedometric system for continuous online monitoring cows' activity. The system was modified to serve as a standalone station in the 300 ha pasture plot.

Fifty multiparous nursing cows were tagged, out of which twenty five were open. Oestrus observations were carried out to verify detection by the system.
The system comprises of three components: 1. A central receiving unit: PC, Eco-herd software, RS485 communication box, UHF receiver + high gain antenna. 2. battery- powered UHF transceivers + high gain antenna units based in the pasture, mounted on a 4-10 metre pole and 3. UHF transmitting tags (ENGS, Rosh Pina, Israel). The tags are strapped to the distal lateral aspect of the front metacarpus. The tag had a rigid plastic housing (length 68.76 mm; width 26.53 mm; height 50.72 mm; weight 75 g). It measured acceleration (*g*) in the x, y and z-axes at a frequency of 1000 Hz. The device transmitted data wirelessly every 15 minutes to a computer with software provided by the manufacturer (ENGS, Rosh Pina, Israel) which converted on-line *g*-force readings into standing, lying and walking behaviour (*i.e.* number of steps).
Data recording by the tags performed at hourly intervals, in each case logged for 12 hours with an hourly resolution, thus ensuring stable activity graphs for each cow reaching the antenna range at least once every twelve hours.
Individual physiological and behavioural events and group events were observed and recorded for validation of the system data collection. Data analysis resulted in definition of typical distinct deviation patterns from individual average activity.
Defined patterns discussed here include oestrous and lameness.
Oestrus was expressed in an activity deviation, averaging 281%±35% from average activity during the seven pre- and seven post-oestrus days, coupled with reduced lying period averaging -58%±28%. Peak activity time ranged between four to twelve hours with great individual variability. Out of the twenty five open tagged cows, eighteen (72%) showed two oestrus events within 61 days ± 36 after calving. Cessation of oestrus events in the activity graphs was interpreted as conception. The cows were tested for pregnancy by palpation forty five days after the last oestrus event. All cows were pregnant. This result is considered good and implied an adequate bull and feeding management. The other seven cows remained cyclic and revealed a variety of physiological problems. Four cows were treated and conceived later during the breeding season. Three cows were culled.

Estimated economic value of culling three cows approximately six months prior to the possibility without online data, and addressing physiological problems facilitating conception of the other four during the current breeding season, equals seventeen thousand ILS, or an additional 20% to the profit for the group of fifty tagged cows.

Lameness was characterised by a continuous declined activity and elevated lying periods, the extent depending upon the severity of the case. In the case of abdominal pain (bloat), lying bouts increased and lying periods decreased. During the trial period thirteen cases of illness occurred, including tick fever, EHV, bloat, embryonic death, mastitis and abscess. All cases were detected by the system and the herdsman was informed the following day. In three cases the herdsman noticed at the same time as the system did. In the ten other cases he failed to notice and approached the cow following system's alert. Out of these ten cases, seven cows were not treated by him, suspecting a false alarm. Three of them healed spontaneously and four died. Three were treated and recuperated. These results were analysed accordingly: three false alarms, seven true and beneficial alarms, three true and non-beneficial. The added value for the farmer by lameness detection by the system equals the value of seven average producing cows which is approximately sixty thousand ILS, or an additional profit of 14% to the group of fifty tagged cows.

Online continuous activity monitoring holds a great potential for increasing profit in extensive beef operations, by providing a management supporting tool.

The main challenges to be addressed are improving the farmer's trust in the lameness data detection by the automatic system from one side, and learning how to define and ignore true alarms concerning health problems that are spontaneously resolved and need no human intervention.

DETECTION OF STABLE CROP PATTERNS IN A CHANGING CLIMATE BY COMBINING SATELLITE IMAGES AND GROUND MAPS IN A MULTI-TEMPORAL APPROACH

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Precision Agriculture (PA) is the emerging practice that can combine the drive for intensification and the reduction of environmental impact. Optical remote sensing can be an important component of the monitoring and mapping approach of PA, enabling the gathering of information about plant and soil properties through spectral characteristics on a rather large scale.
Variations in these properties lead to in-field differences in plant growth and vitality, which can be detected by remote sensing data. These spatial patterns are often directly related to yield differences. The detection of temporal stable spatial vegetation patterns requires multi-temporal data analysis in combination with repetitive ground truth data. Mapping out reoccurring crop patterns can indicate different yield potential areas within a field. By combining these spatial patterns with complementary GIS data mainly based on point data the farmer is able to optimize his cultivation strategy.
The goal of this project is the development of an automatic mapping algorithm for the detection of recurrent spatial crop patterns that affect yield and determine the cause for those heterogeneities. This process chain is divided in two steps: segmentation of the remote sensing data for detection of stable spatial patterns, and classification of the segmented objects.
The presented work is focused on the first part of the automatic mapping algorithm. This segmentation is based on multi-temporal multi-spectral RapidEye data of a 120 hectare field, on which the cultivated crops are primarily winter wheat, canola and sugar beet. From a set of 43 cloud-free scenes just six could be selected for final segmentation.
Images that show bare soil situations, fully-developed vegetation with high biomass and dense coverage, or strongly visible tram lines have been omitted for pattern recognition. The most suitable images for segmentation were found in early (emerging/tillering) and late growth stages (middle to late ripening).

The main criteria for the automatic selection is the mean NDVI of the field subset. A range of 0.25 up to 0.4 mean NDVI suits well for selecting images during the desired phenological time frame.
The segmentation itself has been achieved through a simple unsupervised classification over the selected images. For this purpose suitable images have been split up into five bands. Each band has been averaged with the corresponding bands of the other dates. On this artificial scene, k-means clustering has been performed and delivers very good results on identifying stable spatial patterns. The result shows stable and quite compact clusters that can be transformed into vector-segments. Neither k-means clustering of single-year yield data, nor single satellite scenes produce this conclusive result due to temporal influences like tram lines.
With this automatic selection and clustering, the segmentation of spatial vegetation patterns can presumably be done independent of crop type and phenology. It is a simple approach that does not require commercial software and delivers more confident results than working on point-based GIS data.
This initial test site is located within the TERENO (Terrestrial Environmental Observatories) test site in Northern Germany and shows various heterogeneities in crops under differing conditions and management. Most spatial crop patterns are due to spatial variability of soil quality and/or relief. However, nutrient deficiency of soil within one field can also cause differences seen from above.
The presented work gives an overview about the methods used and outlines the first results for a single test field. The results will be discussed in terms of accuracy of segmentation, comparability of the result with yield map information and transferability to other test fields.

SPECTRAL ASSESSMENT OF LEAF POTASSIUM CONCENTRATION IN UN-STRESSED PEPPER GROWN IN NET HOUSE

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Potassium (K) is an essential element for plant development and appears in plant as an ion K^+. Additional fertilization was applied by irrigation in four levels: 0, 50, 100 and 150 ppm K to pepper plants grown in net house. Canopies as well as specific leaves were spectrally measured by a field spectrometer with bare fiber and integrating sphere, respectively. Leaves were measured for reflected and transmitted radiation and the absorbance was calculated. These leaves were dried and grinded and spectrally measured with a contact probe. K and nitrogen (N) concentration in dry matter were obtained from leaf powder. Plants from the four treatments have shown no significant difference between treatments for the average height while for average biomass (fresh and dry) some treatments were separated from others but it was not in agreement with the increasing K treatment. The yield was also the same for all four K treatments. Therefore, it is assumed that the plants were not K stressed.
The spectral data were analyzed by correlating it to K concentration and applying partial least squares regression (PLS-R) for K concentration as well as PLS discriminant analysis (PLS-DA) for classification of the four K treatments. The K concentration range of values was 1.7-6.3%, therefore, in fresh leaves, with water content of 80%, the concentration is less than 1.5%. The averaged K concentrations as well as K to N ratio are significantly different per K treatment and increasing in agreement with K treatments. K and N concentrations were poorly correlated. The K concentration were correlated to each of the wavelengths of canopy spectral data and resulted in low correlation coefficients ($r<0.2$) that are non- significant ($p<0.05$). For the data reflected from leaves the correlation coefficients were higher ($r<0.4$) mostly significant ($p<0.05$). The leaves powder resulted in higher correlation coefficients ($r<0.5$) mostly highly significant ($p<0.01$). The ratio of K to N resulted in correlation coefficients, per wavelength, similar to those of the K concentration but with more significant values ($p<0.05$).

There is some resemblance of the correlation coefficient per wavelength line to the spectral relative intensity, therefore, it is assumed that the intensity of radiation measured had a leading role in setting the correlation to K concentration. In several cases red-edge bands were better correlated and significant than their adjacent wavelengths. The PLS-R r^2 values were peaking for the leaf powder with values of 0.80, 0.74 and 0.71 for calibration, cross validation and prediction, respectively. The variable importance in projection (VIP) line was similar to the spectral reflectance of leaf powder except for 720nm and 760nm wavelengths, therefore it can be said that also in the case of PLS-R the intensity of the spectral data has almost absolute influence (Figure 1). The analyses presented in the current study have resulted in similar values as presented in the literature in case of K concentration analyses by spectral means in the range of 400-2500 nm or similar. PLS-DA for four treatments, by leaf spectra resulted in total accuracies not higher than 50%. In most of the cases, (canopy, leaf as well as leaf powder) the producer and or user accuracy of treatment 0 ppm K resulted in the highest values relative to the rest of treatments. Therefore it is assumed that in case of K stress the separation will be better.

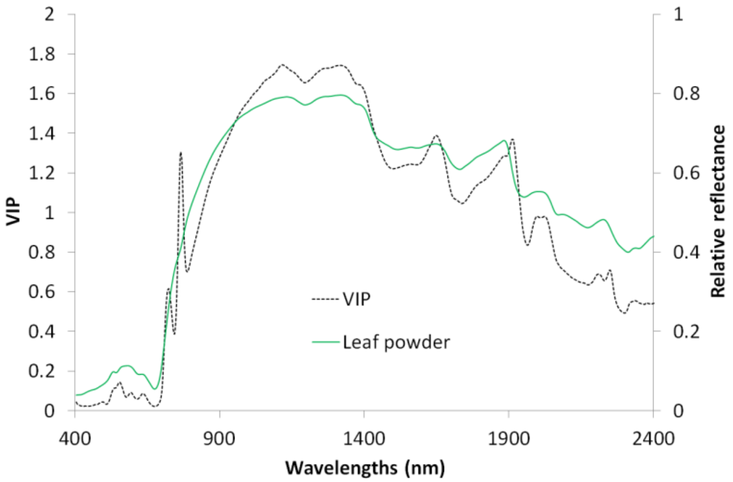

Figure 1- VIP output from the PLS-R model obtained for the leaf powder in relation to potassium (K) content and the averaged spectra of the leaf powder.

It is concluded that:

- Studies exploring spectral assessment of K content are gaining lower results than studies examining spectral assessment of K stress.
- Spectral data of leaf powder was better correlated as well as regressed than the spectral data of canopy or fresh leaves.
- Although the intensity of spectral data is the major contributor to the correlation and the PLS-R models to k content, the red-edge region shows importance that is not intensity related.
- In most of the cases the 0 ppm K treatment was better classified than the other three treatments. Therefore it is assumed that in case of K stress applying PLS-DA might allow identification of stressed plants.

These results for leaf K concentration assessment does not seem to be applicative, therefore, it is suggested to explore early K stress identification by spectral means with high spatial resolution or to look for alternative methods of K concentration assessment. Further research is needed in order to check for leaf K concentration influence over leaf N concentration in low K concentrations as well as for spectral assessment in lower K concentrations.

EPHEMERAL GULLY SPACE-TIME DYNAMICS IN AN AGRICULTURAL CATCHMENT

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Water driven soil erosion is a major cause of land degradation worldwide resulting in considerable financial and food security repercussions. In many cases, it is manifested as ephemeral gullies, induced by concentrated surface flow, which typically develop every year due to repeated tillage operations. Ephemeral gullies are considered key contributors to agricultural catchment soil loss and sediment yield. Despite their crucial impact, quantifying and understanding their dynamics is often challenging. Landscape Evolution Models (LEMs) can simulate soil processes driven by water-based erosion. Although few attempts have been made to integrate soil formation processes at the hillslope scale within LEM framework, none have practiced ephemeral gully simulation. Nevertheless, these three-dimensional landscape evolution models have great potential in ephemeral gully evolution modeling. Here we investigate the space-time dynamics of ephemeral gullies, simulated within the physically based landscape evolution model CEASAR-LISFLOOD (CL). CL simulates geomorphological landscape evolution and landforms alteration on a cell-basis data model. Each cell is attributed with an elevation value, together forming a numerical landscape representation (i.e. DEM). The alteration process is achieved by routing runoff across the DEM whilst changing cell elevations according to erosion and deposition mechanics originating from a set of fluvial and diffusive rules. The alteration is performed as part of cellular automata concept, in which iteration mechanics are introduced and apply the same set of rules, repeatedly, onto the cellular framework. Consequently, the topography is altered each time step (predefined by the user; usually, according to the rainfall input data). In this study, ephemeral gullies evolution was simulated in a small (0.37km^2) agricultural plot adjacent to Revadim settlement in the center of Israel, in a semi-arid climate. The area is characterized by a planar landscape with large swales and low hills.

A database was complied, consisting of five main datasets: (i) a 2X2 m DEM, interpolated from 655 Total station survey readings, representing the initial topography; (ii) Hourly rainfall data (December 2013 to June 2014), spatially uniformed along the basin; (iii) Soil grain size distribution conducted on six spatially random soil samples up to 30 cm deep, (iv) a bedrock depth file representing the maximum depth for which the soil cannot be eroded further and a (v) GPS recordings if the spatial location and depth value of each gully throughout the basin in intervals of ~2 meter. As part of input (iii), A Particle Size Analysis (PSA) was conducted to implement a numeric input of soil description. Soil texture consists of average: 17% Clay, 58% Silt and 25% Sand (Silt-Loam). Soil type is dark-brown Grumusol. To assess the evolution process, we based our calibrations on previously published values with fine-tuning for our field site using a parametric study of key model parameters. Consequently, elevation difference output maps at each time step were compared visually and numerically. Results show that CL yields a satisfactory spatial fit to observed gullies. Temporally, ephemeral gully evolution is divided to two main stages: initial rapid development occurring after the first two weeks and stable thereafter. Further, gullies tend to develop at the lower part of the basin first and develop upwards later. The dynamics found in this research also exhibits known processes such as headcut migration and discontinuous growth. Depositional areas are found to coexist with excavation of material indicating of micro meandering activity. Moreover, mean depth of observed gullies compared to mean depth of predicted gullies shows great correspondence (12.56 cm and 14.9 cm, respectively). This study demonstrates the viability of using a reduced complexity model such as CEASAR-LISFLOOD (CL) to incorporate short temporal and spatial scale to simulate super unstable transient phenomenon such as ephemeral gullies, in what is considered as a long-term oriented LEM. The work presented here has significant and practical implication in helping solve the problem of soil degradation and its devastating repercussions as a rise in determining the prone areas subjected to soil erosion is ever high.

POTENTIAL TO GRADUATE THE DOSE ACCORDING TO CROP BIOMASS WHEN DESICCATING POTATO CROPS

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When arable crops are cultivated on fields with heterogeneous soil types there can be large differences in crop development, density and biomass. The study presented here was part of a larger project investigating whether the applied pesticide dose should be varied according to crop density/biomass when the purpose is to achieve the same biological efficacy. The theory was that the biological efficacy is dependent on a constant pesticide dose rate per leaf area index or crop biomass. Potato crops are often desiccated before harvest in order to obtain a certain tuber size and an easier harvest. In the study it was tested whether the dose response relationship desiccating potatoes with diquat was dependent on the development of the potato crop. Three levels of nitrogen fertilization were applied in order to obtain different levels of biomass/crop development representative of the variation in potato crops grown in fields with heterogeneous soil conditions. In order to establish a dose response relationship each level of nitrogen fertilization was combined with three dose rates of the desiccant. Crop development was monitored just prior to desiccation and desiccation of the potato crop was assessed with visual evaluation of desiccation and electronic monitoring of vegetation index. The experiment was replicated two years. In the first study year differences in crop development and biomass were relatively limited. As a consequence the dose response curve obtained when the crop was desiccated was independent on the nitrogen level applied. In the second study year larger differences in crop development were obtained but still differences that are seen in normal potato cultivation. The larger differences in crop development were reflected in the dose response obtained following the experimental desiccation treatments. The dose response followed the expectation with a larger dose requirement at the high nitrogen rate in order to obtain the same biological efficacy as in the low nitrogen treatment. The differences in dose response between nitrogen levels reflected the differences in crop development and biomass found at the time when the desiccation treatment was carried out.
The results can be used as input in algorithms used to apply the desiccant site-specific in uneven developed potato crops. The results can further be used to calculate the potential of a site-specific crop density/biomass dependent adaptation of the herbicide dose in different scenarios where the variability of the crop development is assessed.

DEVELOPMENT AND APPLICATION OF A SPATIAL DECISION SUPPORT SYSTEM IN NITROGEN FERTILIZATION AT FIELD SCALE

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Modern farming practices depend largely on chemical inputs such as fertilizers and plant protection products in order to achieve high yields. However, conventional agriculture considers any field as a homogenous unit to manage, resulting in ignoring significant spatial variations that exist within the boundaries of a field. The development of modern technologies of sensors along with the use of field - laboratory methods and the application of geographical information systems (GIS) in agriculture combined with expert systems have enabled not only the accurate monitoring of spatial variations that affect and drive crop production but also the evolution of agricultural decision making.
The research area is focused on site specific nitrogen fertilizing management. The objective of the work integrates spatial information of soil fertility and cotton plant nutrition levels within the limits of a field, with the decision-making process of nitrogen fertilizer application. The methodology used in this work is summarized into data acquisition, processing of collected data under GIS environment, built and evaluation of the spatial decision support system and production of site specific fertilizing application maps.

The sites that were chosen for the experimentation and the application of the spatial decision support system concerns two cotton fields in the plain of Chaironeia (Viotia Prefecture), central Greece. The first one is a 3.4 ha flat field while the second is a 5.3 ha sloped field. The specific fields were selected according to their macroscopic soil heterogeneity after *in situ* visual inspection of various other fields in the area.

Data acquisition is accomplished with both traditional field and laboratory work and with the use of new sensing technologies. Field work refers to dense grid soil sampling and analysing basic physicochemical properties of surface soil. Further, cotton leaf samples are analysed at two cotton growth stages for nitrogen concentration quantification. Finally, before harvesting, yield will be sampled and measured at representative locations inside the limits of the two fields.

A sensing technology integrated in the research work is a multispectral groundbased sensor (Crop circle ACS-430, Holland Scientific). The main function of this sensor is based on a transmitter which emits radiation in the visible and infrared wavelength and on its corresponding light sensitive receiver, which records the radiation reflected from scanned background. Through the sensor, transmittance values of the scanned background, having point reference, are logged in near infrared, red, and red-edge wavelengths. Additionally, the sensor delivers direct measurements of the indices Normalized Difference Vegetation Index (NDVI) and red-edge NDVI. Scanning work is planned in a four phase schedule. One prior to seeding at bare ground, two at according representative cotton growth stages directing sensor upon cotton plants and a final one just before cotton harvesting again targeting cotton crop.

At the same four stages the ground sensed area is also aerially monitored with the use of an unmanned aerial vehicle. The vehicle is a quadcopter (Phantom 2, DJI) underneath which a specially modified camera is mounted. The modification includes the substitution of the camera's lens with a 4.4 mm flat lens with 71^{o} angle of view. Moreover, the infrared cut (IR-cut) filter was properly removed from the new lens. Instead, two removable filters (IR-cut and IR-longpass) are used in order to capture aerial photographs in visible and in near-infrared wavelengths. Spectral indices are again calculated from aerial photography products and are set in comparison with groundbased sensor's readings. The use of ground and aerial multispectral sensors combined with laboratory soil and leaf analyses targets the quantification of soil fertility, nutritional status of cotton crop and the assessment of final yield. Additionally, data coupled with historical fertilizing records and expert knowledge are further stored in a geodatabase and analysed through spatial modelling procedures under GIS environment.

With the use of model builder toolbox (ArcGIS, ESRI Inc.) a spatial system is built delivering nitrogen fertilizing application maps at management zones within the experimental fields. The system comprises of three modules; a data input and management module; an analysis module and a layout module. Values of state variables after entering the system and receiving proper harmonized raster formats will be further proceed to the solution of algorithms which specifically link spectral indices to proposed fertilizing doses. The layout module delivers site specific fertilizing recommendations in the form of map representations. The evaluation of the system is an automated spatial decision procedure, retaining transparency over its block elements; allowing its designer and manager to dynamically control its parameters.
The methodological steps followed and proposed in this work, in essence, establish a Spatial Decision Support System for nitrogen fertilizing at field scale, which concerns producers, agronomists and extension agronomic services. Moreover, the project seeks to broader disseminate Precision Agriculture principles to all stakeholders, mainly to local producers, demonstrating the practical use of certain soil and crop monitoring means, that are employed in this work and can potentially improve integrated farming practices.
Keywords: precision agriculture, multispectral sensors, unmanned aircraft, spatial decision support system, nitrogen fertilization.

MAPPING THE WEEDS SPATIO-TEMPORAL APPEARANCE IN BREWERY BARLEY AT FIELD SCALE

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Barley is a versatile and useful crop with applications ranging from feed and food production to brewery industry. It was one of the first cultivated cereal grains and right now belongs to the most grown crops worldwide. Although barley is widely known for its high allelopathic potential, weeds can in several cases cause strong competition, which may result reduced yield and lower seeds size and protein content, undesired quality traits for malting production. The record of the spatial dynamics in weed populations as well as their spread rate within the cultivated fields may help to develop methods which could be used for site specific weed management.

In order to analyze the growth and the spatial variability of weeds, an experiment was carried out in a field (1000 m^2) cultivated with brewery barley, without herbicide applications, in the AUA's experimental station (Spata), for three consecutive years (2012 - 2014). The field was divided in 48 sampling units of $1m^2$ separated by 3m following a regular grid sampling of 12 rows and 4 columns. Also water sensors were installed to monitor the soil water content. During each growing period recordings of the weeds' density and frequency were logged over the course of 15 days. Furthermore meteorological data were taken into account such as total precipitation and mean temperature. The Inverse Distance Weighting spatial interpolation method was applied and weed density maps for each sampling period for the three years were realized.

The recordings of the weeds' density varied strongly between the three subsequent years. In the first growing season, the following weeds have been recorded in diminished rank, taking into account their densities (weeds m^{-2}): *Malva sylvestris* L. (2.8), *Chamomilla recutita* L. (1.8), *Sinapis arvensis* L. (1.3), *Chrysanthmum coronarim* L. (0.5), *Sillybum marianum* L. (0.4), *Cardaria draba* L. (0.4) and *Papaver rhoeas* L. (0.2).

In the second growing period the composition of weed flora changed with the emergence of *Avena sterilis* L. and *Convolvulus arvensis* L. while the rank of the recorded weeds modified in terms of their densities.

Particularly, the weeds were recorded in diminished rank as follows; *C. recutita*, *Avena sterilis* L., *P. rhoeas*, *C. draba*, *M. sylvestris*, *C. coronarium and Convolvulus arvensis* L. at densities 3.3, 1.3, 0.9, 0.9, 0.8, 0.6, and 0.6 weeds m^{-2}, respectively. Finally, in the third growing period we noticed the appearance of a new weed, *Lolium rigidum* L*.,* occurring in the higher densities (2.7 weeds m^{-2}), compared to the other occurred weeds, which were recorded at the following rank, *A. sterilis*, *C. recutita*, *C. coronarium*, *P. rhoeas*, *C. arvensis* and *M. sylvestris* at the rates of 1.5, 1.4, 1.3, 0.7, 0.6 and 0.5 weeds m^{-2}, respectively. The shift in weed flora composition and the differentiation in the ranking of the weed density between the three cultivated periods may be correlated to the quite dissimilar climatic conditions of each year.

The spatio-temporal distribution of the recorded weeds was not uniform. *C. coronarium* and *M. sylvestris,* two of the most important species in this study, is a great example of different patchiness. Specifically *C. coronarium* appeared in the same part of the field, whereas *M. sylvestris* was equally distributed.

In general weed populations appeared to develop a patchy distribution within the field. In this experiment the temporal weeds' patchiness which at first was observed and then highlighted by interpolated maps (Fig. 1), indicates that the weed appearance could have been affected by the seed bank. Moreover the spatial weed appearance was more significant in the section of the field neighbouring to uncultivated field margins indicating the side effects of the naturally occurring weed populations. The monitoring of the weeds' populations dynamics is represented in weed maps. These maps may provide the necessary data for a successful site-specific weed management in precision agriculture.

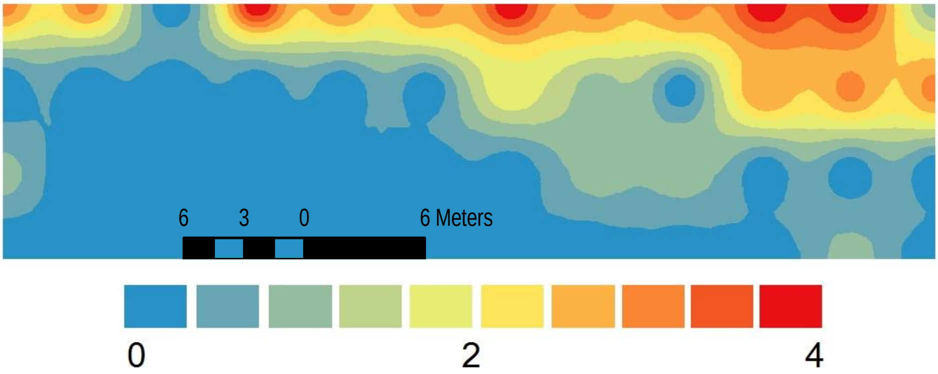

Figure 1. Interpolated map (IDW method) of *Sinapis arvensis* density (weeds m^{-2}) in 6-4-2012.

EVALUATION OF APPLE FLOWERING INTENSITY USING COLOR IMAGE PROCESSING FOR TREE SPECIFIC THINNING

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Thinning in apple orchards is a commonly used technique for improving yield, size to quantity, regularity and fruit quality. Chemical thinning is performed in the flowering stage and the ripening stage. A number of effective chemical thinning agents are available. Nevertheless, thinning is still mostly carried out through expensive manual labor due to the fear of over thinning. Moreover, for tree-specific thinning management, individual evaluation of trees is necessary.

The objective of this work was to develop an agricultural tool based on color images of the trees, which identifies the level of bloom for individual trees in the orchard in order to estimate the time for the peak of the bloom and its intensity.

The research was carried out in an experimental orchard of the ARO at Matityahu farm in the Western Galilee area. The orchard was 680 meters above sea level. A plot with Golden Delicious apple trees was selected, with rows in N-S direction. Flower clusters at full bloom time on ‘Golden Delicious’ are similar to other apple cultivars with 4–6 individual flowers in the cluster that open gradually throughout the bloom period. The distance between rows was 3 m and the interval between trees in the row was 1.5 m. The trees were between 1.90 to 3 m high. Two rows were selected for measurements and image acquisition, which contained about 70 trees.

Image acquisition campaigns were conducted at the beginning of April 2014, starting when the first signs of blooming appeared, until two days past the bloom peak. This resulted to a period of 10 days. During this time period RGB images of each tree were acquired daily to estimate the number of flowers. A Canon 6D stills camera was used (20.2 megapixels) with Canon's 24mm prime lens. The camera was place on a tripod, about 1.5m away from the trees and was directed towards them. The optical setup enabled to include the whole tree in one frame, with a resolution of about 1 mm per pixel.

Each day, 70 trees were measured, and their geographical location was recorded. The blooming intensity of each tree was also manually and visually evaluated: buds were marked on selected branches and the number open flowers were recorded every day. In addition, the blooming intensity of each tree was estimated by an experienced expert during the same period.

The RGB images were processed using Matlab. Different algorithms were developed and applied on the images in order to detect the flowers. First, the buds and flowers on each tree were segmented from the rest of the objects (sky, soil, branches) and their number was estimated. A comparison between the manual count and visual estimation of blooming intensity to the automatic estimation is currently conducted, and the results will be presented in the paper. In addition, the developed algorithms will separate between open flowers and buds. Comparing the number of buds to the number of open flowers on each tree will serve as a measure to determine the peak of the bloom. This information will serve as an input to a decision support system that determines the thinning policy for each individual tree. This policy can be applied with site specific sprayers who have today the capability to apply chemicals in a tree specific manner.

ESTIMATION THE LEAF PHOSPHORUS CONTENT OF LITCHI AT DIFFERENT GROWTH STAGES BY CANOPY LEAF REFLECTANCE

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This study aims to quantify litchi leaf phosphorus content (LPC) from canopy spectra at five different growth stages. The band iteration was used to optimize the ratio vegetation index (RVI) and ratio of band difference index (RBDI). The correlation analysis, linear regression and cross validation were used to analyze the relationship between spectral data and LPC and construct the robust estimation model for LPC. The correlation curves based on canopy reflectance spectra (R) and the processed spectra by Standard Normal Variate (SNV) showed that the relationship between spectral data and LPC were inconsistent at different growth stage. Although the variation of LPC across the growth stages is large (Coefficient of Variation, C.V. =50.40%), it is difficult to estimate the LPC by the general model. The partial least square (PLS) model by the first derivative spectra of the synthetic dataset failed to construct the robust model for LPC (R2c=0.61, RMSEc=0.08, R2cv=0.49, RMSEcv=0.10). The correlation analysis based on the dataset at each growth stage showed that the band optimization can improve the relationship between spectral data and LPC. And the wavebands selected by the band iteration were mainly located in blue, red, near infrared and shortwave infrared region, which were partly related to the absorption of anthocyanin, protein, starch et al.. The estimation model by RBDI (905, 965, 1005) at fruit maturation stage had the best performance (R2cv>0.95). The best estimation model at flowering stage was calibrated by RVI (925, 1025) with the R2cv of 0.66. The linear model by RBDI (1525, 2105, 2225) presented the R2cv of 0.75 at autumn shoot maturation stage. And the RBDI (815, 1475, 2135) and RBDI (2005, 2095,2375) had the best performances at flower spike growing stage and flower bud differentiation stage with the R2cvs of 0.68 and 0.63, respectively. The results indicated that it is available to estimate LPC by canopy reflectance spectra. Besides it is necessary to estimate the phosphorus content of litchi based on the growth stages.

A MULTI-TOOL APPROACH FOR ASSESSING FRUIT GROWTH, PRODUCTION AND PLANT STATUS OF A PEAR ORCHARD

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There is very little in the literature concerning seasonal information relating fruit growth to plant water status to yield in horticultural crops. This paper analyses information recorded in 2014 from the end of cytokinesis (early July) on Abbè Fetel trees grafted on four different rootstocks (Farold, Sydo®, MH and MC) grown in the Fratelli Navarra Foundation Experimental Farm, in Ferrara, Italy. Measurements of leaf chlorophyll fluorescence following the procedure described by Losciale et al, (2015) were undertaken allowing to calculate the I_{PL} index strongly and linearly correlated to net photosynthesis thus giving a quick and clear idea of the plant status. Fruit maximum equatorial diameter was measured on 30 fruit on each selected trees. Data were recorded by a Calibit (Manfrini et al. 2015), a digital calliper fitted with an on-board datalogger. Since the diameter of the fruit has been shown to be strongly related to the mass of the fruit (De Silva et al, 1997) this information can be used to predict fruit weight by the equation: $\boldsymbol{W = a * D(mm)^b}$ where W is the fruit weight in grams, D is the fruit diameter expressed in millimetre and a and b are parameters specific to Abbé Fetel. The fruit harvest was scheduled for one date (strip pick on August 29th) following the commercial strategy of the orchard. Measurements taken allow to calculate the single tree crop load both expressed in weight (kg/tree) and in number of fruit per tree (fruit/tree), the average fruit weight (g/fruit), the fruit production (t/ha) and commercial production (t/ha) each treatments. An ANOVA of variance of all the parameters was performed to compare the means. All the data collected refers to a single tree basis. A total of 216 trees were georeferenced with a stand alone Garmin GPSII plus (GPS) receiver.

Maps of crop production and plant status parameters were generated by punctual kriging with a global variogram using the Vesper freeware (Minasny et al, 2005) on a common grid as described by Manfrini et al, 2009. Maps were created in QGIS

Results and discussions

Differences can be found in the physiological and productive behaviors of diverse pear rootstock (table 1). The clonal rootstock Farold differs from the quinces MC, MH and Sydo showing a clear example of slow initial fruit bearing. Farold has developed the biggest average diameter together with MH. This structural development is not followed by an increase of production as for MH rootstock. The Farold plant production is higher than the other rootstocks but the planting density and the average fruit size did not supply the productive gap with the MC, MH and Sydo.

Indeed if the I_{PL} index is indicating a higher plant activity, statistically different form the others quinces, that is not followed by an increase of yield implying the photosynthates are mainly used for plant perennial structures storage. MH shows a statistically equal size trunk diameter as Farold coupled with a high production. Farold commercial production results the 50% circa of the total production compared to the 90% circa of the MH. MC result the more productive followed by MH.

Considering the commercial production the places of MC and MH result inverted underlining the bigger average size of MH fruit. The fruit size obtained at harvest could have been predicted with the measurements along the season: comparing the trend reported in the fruit weight with the forecast diameter, MH and Sydo results the biggest, MC results slightly smaller while Farold is the smallest.

The generated maps completed the information from non-spatial statistics providing the distribution of the crop parameters within the orchard.

The zones characterized by a higher crop load is dependently related to the lower average fruit weight corresponding to Sydo and MH rootstocks. This productive behavior normally correspond to high productivity in term of yield if the orchard plant density is maintained all over the field. West side of the orchard correspond to Farold rootstock, still characterized by a juvenile behaviour where the most part of the resources are addressed to the reserve organs.

The Farold is also, among the four considered rootstocks, the lower planting density thus should take into account the major plant development and consequently the higher plant activity (higher I_{PL} index). The maps areas in which the MFW is higher correspond to the higher fruit diameter size of figure 2B underling that the forecast described in table 1 was well indicating the fruit development of the four different rootstocks. The production and commercial production maps result of similar shape underling a low production in the Farold zone.

Conclusions

This work permit to analyze the behavior of four different pear rootstocks both with traditional and spatial statistics. The goal of the analysis illustrate a) how pear rootstocks behavior can vary within the orchard b) the variability is possible to be defined by spatial analysis, c) quick and easy tool for the measurement of plant and fruit performance parameter can drive thought knowledge and decision for a better orchard management.

INFLUENCE OF THE YEAR OF IMAGE ACQUISITION AND ITS SOURCE (SATELLITE VS. AIRBORNE) ON VINEYARD REMOTE CHARACTERIZATION THROUGH MULTISPECTRAL IMAGES

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The Normalized Difference Vegetation Index (NDVI) is a widely used parameter in Precision Viticulture research, and it is usually obtained from multispectral images acquired from satellite or airborne multispectral sensors. NDVI is a good estimator of the vegetative development of the vineyard and allows the delineation of zones with different vegetative development within the vineyard, or to classify vineyards according to their variability. However, the widespread use of multispectral images by wineries is conditioned by several factors such as weather conditions that may hinder their acquisition or by their cost. Therefore, it would be interesting to learn to which extent the year of image acquisition and the source type (satellite vs. airborne) limit the usability of multispectral images.

The aims of this work were 2; (i) to evaluate the temporal stability of NDVI images acquired in different years, to learn if an image can be used for several years, and (ii) to evaluate the influence of the acquisition source (satellites or airborne).

The study was carried out in 14 cv. Tempanillo fields in Gumiel de Mercado area (Ribera de Duero, Spain), using multispectral images that gave information on red (R), green (G), blue (B) and infrared (IR) reflection.. At each field, NDVI was obtained individually in two steps. First, R and IR layers were combined and then a filter was applied to delete the inter-rows. For the first objective airborne images obtained in 2008 and 2010 were compared, whereas for the second one airborne images obtained in years between 2008 and 2010 were compared to satellite images acquired in 2010.

For each image and field, mean NDVI and some variability-related parameters such as the coefficient of variation (CV), the aeral coefficient of variation (CVa) and the opportunity zoning index (Oi) were calculated. Then, the values obtained for all the fields were compared through regression analysis.

The results showed a low correlation when temporal stability was analyzedin terms of NDVI mean value comparison. However, a high relation was observed when the stability of spatial variability was studied for CV, CVa and Oi. Something similar happened when images obtained from different sources were compared. NDVI mean value was not stable, but variability estimating parameters were relatively well correlated. In conclusion, we may state that for some of the utilities multispectral images have in viticulture, neither acquiring the image, the same year nor its source are critical.

EFFECT OF GLYPHOSATE RESISTANT WEEDS ON THE ADOPTION OF SITE-SPECIFIC FARMING METHODS IN THE UNITED STATES

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The adoption of Site Specific farming in the USA has been encouraged by improvements in technology. Yield monitors on combines and cotton pickers coupled with GPS hardware and software now allow producers to manage their fields in increasingly smaller production areas. Farmers will typically “stack” different geo-spatially referenced layers such as soil type, various soil nutrient levels and previous crop yield, for example.

Historically, weed populations changed slowly over time in many US agronomic fields. The weeds present in a given field were relatively constant over time. These relatively-constant weed populations could theoretically be managed by various means, including soil-applied preemergent herbicides that would inhibit the germination of the weeds, and thus reduce their later growth. If the weed population was variable within a field, then site-specific herbicide applications could be made. Another potential use of site specific herbicide application would be to alter the soil-applied herbicide rate to match changes in soil parameters, such as texture, organic matter or pH. In some soils, widely divergent soil properties (sometimes referred to as “sand blows”) can result in herbicide injury to the crop in those areas. An application of a lower herbicide dosage in that sandy soil area could still provide good weed control with reduced crop loss.

The landscape of production agriculture in the United States was radically altered by the near-universal adoption of transgenic glyphosate-tolerant agronomic crops. Independent of one’s belief on the technical and ecological merits of this technology, there is no doubt that the coupling of crop safety traits to a broad-spectrum herbicide that kills annual and perennial weeds that are both monocots and dicots was a near-panacea for those producers that used them. Unfortunately, very few farmers practiced good stewardship of this new technology, and the resulting selection pressure on hundreds of millions of hectares has resulted in multiple weedy species that are now essentially immune to glyphosate and that have no meaningful fitness penalty. What effect does the glyphosate resistance (GR) have on precision farming adoption? The first effect can be the much more rapid change in weed species present in a given field. In the past, weed species shifts would take several years.

Now, a GR weed population can become established and within 2-3 years can significantly reduce crop yields. The previous data layer containing weed maps of species present and their relative density is largely irrelevant.
A second effect of GR is that many farmers now manage all their fields as if they already have GR weeds. A combination of practices may include cover crops, altered tillage systems, herbicide diversity with multiple modes of action, and mechanical removal by equipment or by hand labor. GR weeds have complicated weed management in the United States, and has discouraged the adoption of site-specific farming on broad hectare production areas.

USING REFLECTANCE PROFILING (REMOTE SENSING) TO OPTIMIZE CROP INPUT MANAGEMENT AND REDUCE CROP SUSCEPTIBILITY TO PESTS

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It is widely accepted that many arthropod pest outbreaks occur in crops initially being exposed to abiotic stress, such as drought or fertilizer deficiency (Amtmann et al. 2008, West and Nansen 2014). In other words, a given arthropod pest outbreak may be considered a symptom or consequence of a priori sub-optimal management, and it suggests that management of crop inputs can be used to minimize the risk of pest outbreaks. Such a strategy was originally proposed more than 60 years ago (Haseman 1950), and it has later been highlighted in several papers on arthropod pest management (Culliney and Pimentel 1986, Altieri and Nicholls 2003, Zehnder et al. 2007, Zehnder and Hunter 2008).
Different types of remote sensing technologies are creating new ways to automate detection of subtle physiological changes in crops, such as nutrient composition, and this is markedly improving our abilities to develop and deploy preventive pest infestation tactics. The concept of "preventive medicine" is normally applied to human health but may also be of relevance to innovative crop management (Nansen et al. 2013), especially due to growing concerns about the current reliance and dependence on pesticide applications in arthropod pest management (Nansen and Ridsdill-Smith 2013). Careful management of crop inputs may affect crop plant suitability directly by affecting: 1) levels of readily digestible nutrients (host plant nutrient value), 2) thickness of leaf cuticle and cell walls (host plant digestibility), and/or 3) levels of constitutive and inducible defense compounds (host plant resistance), or it may affect crop plant suitability indirectly through the ability of infested crop plants to recruit natural enemies via emissions of visual and olfactory cues.
This poster discusses the fundamental concept of "preventive medicine" when deployed to crop management, and a series of examples are briefly described. As an example, we have demonstrated that both spider mites and aphids prefer host plants, which had been subjected to experimental levels of abiotic stress (Nansen et al. 2013, Lacoste et al. 2015).

And we have demonstrated that exposure to experimental levels of abiotic stress not only increased crop susceptibility but also caused significant and detectable changes in leaf reflectance features.

The same concept of studying the combination of nutrient composition of plants and reflectance features may also be used to improve the performance of insects as biological control agents of aquatic weeds. That is, water nutrient levels affect growth and reflectance of water hyacinth plants, and from laboratory bioassays we have demonstrated that plant nutrient levels also affect both preference and performance of a weevil species (*Neochetina eichhorniae*) used to control water hyacinth. Thus, we have data supporting the working hypothesis that: airborne remote sensing technologies can be used to characterize spatio-temporal variations in water hyacinth nutrient composition and therefore to optimize augmentative releases of the biological control agent, water hyacinth weevil, *Neochetina eichhorniae*. That is, airborne remote sensing technologies can be used to find patches of water hyacinth with high susceptibility/suitability to the weevils, and those patches should be targeted for releases of weevils and for in-depth ecological studies of the impact of the natural enemy.

References

Altieri, M. A., and C. I. Nicholls. 2003. Soil fertility management and insect pests: harmonizing soil and plant health in agroecosystems. Soil & Tillage Research 72: 203-211.

Amtmann, A., S. Troufflard, and P. Armengaud. 2008. The effect of potassium nutrition on pest and disease resistance in plants. Physiologia Plantarum 133: 682-691.

Culliney, T. W., and D. Pimentel. 1986. Ecological effects of organic agricultural practices on insect populations. Agriculture, Ecosystems & Environment 15: 253-266.

Haseman, L. 1950. Controlling insect pests through their nutritional requirements. Journal of Economic Entomology 43: 399-401.

Lacoste, C., C. Nansen, S. Thompson, L. Moir-Barnetson, A. Mian, M. McNee, and K. C. Flower. 2015. Increased susceptibility to aphids of flowering wheat plants exposed to low temperatures. Environmental Entomology: 1-9.

Nansen, C., and T. J. Ridsdill-Smith. 2013. The performance of insecticides – a critical review, pp. 195-232. *In* S. Trdan (ed.), Insecticides. InTech Europe, Croatia.

Nansen, C., A. J. Sidumo, X. Martini, K. Stefanova, and J. D. Roberts. 2013. Reflectance-based assessment of spider mite "bio-response" to maize leaves and plant potassium content in different irrigation regimes. Computers and Electronics in Agriculture 97: 21-26.

West, K., and C. Nansen. 2014. Smart-use of fertilizers to manage spider mites (Acari: Tetrachynidae) and other arthropod pests. Plant Science Today 1: 161-164.

Zehnder, C. B., and M. D. Hunter. 2008. Effects of nitrogen deposition on the interaction between an aphid and its host plant. Ecological Entomology 33: 24–30.

Zehnder, G., G. M. Gurr, S. Kühne, M. R. Wade, S. D. Wratten, and E. Wyss. 2007. Arthropod pest management in organic crops. Annual Review of Entomology 52: 57-80.

CLIMATE SENSITIVITY ANALYSIS OF MAIZE YIELD ON THE BASIS OF DATA OF PRECISION CROP PRODUCTION

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We have predicted the maize yield in precision crop production technologies using six different climate change scenarios (Ensembles Project) for 21th century with the Decision Support System for Agrotechnology Transfer (DSSAT) plant dynamic physiological model. The critical climate factors and soil parameters were studied. Based on our results we can state that the small scale (field-level, management zone level) climate impact research is mandatory for large scale modelling.
Keywords: sensitivity analysis, climate models, maize yield, site-specific soil data

Agricultural Ecological Zone (AEZ- FAO) modelling method integrates precision agriculture processes adapting and enlarging them to regional, national and global scale in order to be able to evaluate the impact of climate change on the agroecological systems (Fischer et al.; Thian et al. 2012). We believe that the agro-ecological zones, precision agriculture and the investigation of effects of climate change on agriculture are inseparable from each other in the future. One of the used sensitivity analysis method is rather appropriate for collection of local information and the other one is rather able to predict the impact of climate change in larger areas. It is important to note that there are different levels of decision making. The first type of analyses provides information for farmers and county leaders and the second one rather for national politicians.

The method presented here can be a useful further step in the field of climate change impact on plant production.

Materials and Methods

For the sensitivity analyses we used the Biome- BioGeoChemical Cycles model (Newlands et al. 2012). It focuses on forest and agricultural production concerning carbon-water-nitrogen and energy balance. The yield prediction was carried out by DSSAT v. 4.5.0. CERES-Maize. We have taken 13 different soil parameters and three soil texture types (loam, silt loam, sandy loam) into consideration. The applied global climate models were C4I-HadCM3, DMI-ARPEGE, KNMI-ECHAM5, ETZH-HadCM3Q, MPI-ECHAM5 and SMHI-BCM. Eight different meteorological parameters were used for yield predictions: daily maximum and minimum temperatures, wind speed, amount of precipitation, relative humidity, potential evaporation, duration of sunshine, and surface radiation until 2100 (except C4I-HadCM3 which provides data only until 2075). The sensitivity test ranked different soil types and parameters, CO_2 concentrations, minimum and maximum temperatures and precipitation change for agricultural response. Focusing on the impact of change in CO_2, minimum and maximum temperatures and precipitation climate parameters is compatible with the concept of AgMIP (Rosenzweig et al., 2013). Out of the six applied models, SMHI-BCM and ETZH-HadCM3Q predicted the extreme maximum and minimum results, respectively.

Results and Discussion

According to the sensitivity analysis the largest effect on the maize yield were P_2O_5, Cu, NO_2-NO_3-N and Na under the conditions of the test field in loam, sandy loam and silt loam soil types. Concerning yield - in the model predicting most critical changes - 5.22 mm precipitation compensates for 1ppm CO_2 increase, or 1 degree temperature maximum increase compensates for 2.18 degrees temperature minimum increase, or 18.56 ppm CO_2 increase is compensated by 1 degree temperature minimum increase.

Conclusions

Base simulation as well as sensitivity tests showed the same results: the ETZH-HadCM3Q model has the highest negative effect and the SMHI-BCM model has the lowest negative effect on maize yield. The other four climatic models have very similar (moderate) negative effect on yield in the case of loam, silt loam and sandy loam soils.

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Precision agriculture technology is focusing on the homogeneous units (management zones) of a given field. This provides the possibility to evaluate the responses of the plants in these units for the micro-environmental changes as well as climate change.

We used the Decision Support System for Agrotechnology Transfer (DSSAT, CERES-Maize) plant dynamic model. For each investigated management zones in our research field about 50 input data are provided. By this method we carry out site-specific modelling. The AEZ (Agricultural Ecological Zone) FAO modelling method integrates the precision agriculture processes adapting and enlarging them to regional, national and global scale in order to be able to evaluate the impact of climate change on the agroecological systems. (Fischer et al. 2005: Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990-2080. Phil. Trans. R. Soc. B. 360, pp. 2067-2083; Thian et al. 2012: Estimating the potential yield of wheat production in China based on cross-scale data-model fusion. Front. Earth Sci. 6(4), pp. 364-372).

Based on our results we can state that the small scale (field-level) climate impact research is mandatory for large scale modelling. In our work we have predicted the maize yield in PA according to six different climate change scenarios (Ensembles Project) for 21th century DSSAT model. Sensitivity analyses were carried out.

The focusing on impact of change of CO_2, minimum and maximum temperature and precipitation climate parameters is compatible with the concept of AgMIP (The Agricultural Model Intercomparison and Improvement Project: NASA, Goddard Institute). Based on the sensitivity analysis we have concluded that the impact of the factors can be numerically defined, i.e. 5.22 mm precipitation compensates for 1ppm CO_2 increase.

According to the sensitivity analysis the parameters exercising the largest effect on the maize yield were P_2O_5, Cu, NO_2-NO_3-N and Na under the conditions of the test field.

MULTI-SENSOR PLATFORMS FOR DETAILED CHARACTERIZATION OF PLANT CANOPIES DURING THE ENTIRE GROWING SEASON

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In recent years, digital phenotyping has increasingly been recognized as an important tool in plant breeding and plant physiology to better understand plant-environment interactions. In this regard, one of the most important phenotyping goals is to search for high-yielding yet resistant and resource-efficient cultivars suitable for future climatic conditions.

Especially on laboratory and green-house scale, high-throughput phenotyping approaches have been established, whereas applications in the field are more difficult to implement. Therein, the variability of environmental conditions throughout the year represents a major problem. To date phenotyping approaches use various sensors (e.g. RGB or IR cameras), which are carried by using unmanned aerial vehicles, tractors or other handhelds devices. Acquired data is used to get information on leaf area index, chlorophyll content, germination rates, water stress or growth kinetics. This phenotypic data is used to evaluate the performance of a crop in a given environment.

High precision crop phenotyping over an entire growing season is challenging, because sensors need to be positioned at the same location with high repeatability to monitor small regions in the field. Therefore a high degree of automation for temporally high-resolved measurements is essential. Here, we present a multisensor phenotyping platform mounted on rails. The prototype covers 1500m² (15m in wide and 100m in length) and is equipped with a multisensory platform containing: RGB, NIR and fluorescence camera, IR thermography and a laser scanner.

Traits like LAI in 2D (from camera) are complemented by 3D height information (laser scanner). Especially traits derived from 3D have risen interest in the past years, because they provide possibilities for more detailed description of plants and even of individual organs. By using multi-sensor platforms the generation of multi-dimensional field maps is possible.

PERCEPTION OF PRECISION FARMING IN NORTHERN EUROPE

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In recent years, the development of precision farming systems has gained increasing interest among farmers in Europe as a technology to improve profit and pursue environmentally sustainable farming practices. The aim of this paper was to present the results of a farm survey and statistical analyses about farmers' perception and market segments for Precision farming in Northern Europe.

Based on survey data collected from Germany, Finland and Denmark, see Lawton et al (2011), this study analyses on the relationship and adoption patterns among farmers. The paper presents the results of the surveyed population, demography, farm structure with crop production characteristics and farmers' use of different farming systems. Based upon review of previous studies about adoption, we is hypothesized that farm size, farm structure, education, degree of specialization, time spend on learning new procedures and farmers' age could have an impact on the adoption pattern.

More specifically, it is expected that large farmers adopt more precision farming systems compared to small sized farms because of relatively large investments in GPS systems, variable rate spreaders and site-specific mapping of the field. It is also expected that specialized farms and young farmers are more likely to adopt the systems relative to other farmers because it will reduce the costs for investing in many different crop specific systems.

It is expected that farms with a high number of employees adopt more precision farming systems compared to small sized farms because of large production units. Furthermore, it is expected that farms with a high degree of specialization are more likely to adopt precision farming systems which again is related to a focused inevestment strategy. Farmers who spend more time for learning new procedures and participating at workshops and exhibitions are also expected to be more interested in adopting precision farming systems compared to other farmers.

Finally, it is expected that farmers with longer education are more likely to adopt precision farming systems compared to farmers with a shorter education because of relative advanced information management systems that are related to the implementation and management.
To investigate these hypotheses, a cluster analysis was used to delineate market segments of farmers that have adopted precision farming systems in these countries.
A hierarchical cluster analysis of the farmers in the dataset is produced. Statistical tests suggest that 7 clusters are a reasonable taxonomy of the farmers. Subsequently, a hierarchical cluster analysis with 7 clusters is generated. The seven clusters form a taxonomy of the surveyed farmers where the characteristics of the farmers in each cluster identify a segment with similar attitudes towards precision farming.
Cluster one contains five farmers that have large farms are fairly young and are highly educated. They have implemented precision farming on around a quarter of their land. Cluster 2 consists of 10 farmers that do use precision farming. Farmers in this group have relatively small farms, they are relatively young and have little education. Cluster 3 is made up of 17 farmers that use precision farming technology on about a quarter of their land. They have farms of moderate size, have few employees and are among the youngest in the sample. Cluster 4 consists of only 2 farmers that have the largest farms in the sample, they have many employees and spend a lot of time in the office. These two farmers have implemented precision farming on around half their land, the highest adopters in the sample. Cluster 5 contains the most farmers with 287. They barely use precision farming technology and have the smallest farms in the sample. They spend very little time on administrative work, have the fewest employees and have little education. Cluster 6 consists of only one farmer, the oldest in the sample, with a large farm and 4 employees. This farmer has not adopted precision farming technology. Cluster 7 comprises 16 farmers who have adopted precision farming on more than a third of their land. They have fairly large farms and many employees although the spend very little time on administrative work.
Findings from this study indicate that farm size and farmers interest in farm planning and knowledge sharing has an impact on farmers’ adoption of precision farming systems. Results of the cluster analysis suggest that farm size is important for adopting precision farming techniques.

The larger the farm perhaps the more beneficial precision farming becomes in for instance reducing pesticide and fertilizer application. Age does not seem to be correlated very clearly with precision farming adoption, and equally the amount of administrative work is only loosely indicative of adoption. On the other hand, the more employees the higher the willingness to adopt the analysis indicates perhaps somewhat counterintuitively. Generally, higher education suggests higher willingness to adopt precision farming technology.

Results from statistical analyses of precision farming adoption such as this cluster analysis should be taken into consideration in designing targeted policies for a further diffusion of precision farming technology.

Lawson LG , Pedersen SM , Sørensen CAG, Pesonen L, Fountas S, Werner A et al .2011: A four nation survey of farm information management and advanced farming systems: a descriptive analysis of survey responses. Computers and Electronics in Agriculture 77(1):7-20

Key words: Adoption, precision farming, farm management

PRECISION NUTRIENT MANAGEMENT - 4R STEWARDSHIP

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Precision agriculture is focused on getting it right by incorporating as much local information as possible in the management decision-making process and employing the appropriate tools and technologies in the farming operation to get it done. 4R Nutrient Stewardship is a precision approach to nutrient management that simultaneously considers, and equally weights, the principles of nutrient source, rate, timing, and placement when making fertilizer management decisions. 4R Nutrient Stewardship is always practiced in a site-specific manner depending on the context of the cropping system and the end result is whole farm management of a sustainable agricultural system. One recently developed precision management tool that is being used to accomplish this is the decision support tool, Nutrient Expert. The objectives of this presentation will be to discuss the experimental development of the Nutrient Expert decision support tool; explain how the principles of precision agriculture and 4R Nutrient Stewardship are being employed in small-holder agricultural systems using Nutrient Expert; and show results from NE field-testing in several countries.

The International Plant Nutrition Institute has developed Nutrient Expert (NE), nutrient decision support software, which is based on the principles of 4R Nutrient Stewardship. Nutrient Expert enables crop advisors to develop fertilizer recommendations that are tailored to a specific field or growing environment, taking into account important factors affecting nutrient management recommendations and uses a systematic approach of capturing information to develop location-specific recommendations. Nutrient Expert does not require a lot of data nor very detailed information as in the case of many sophisticated nutrient decision support tools, which can overwhelm the user. Nutrient Expert allows the users to draw the required information from their own experience, the farmers' knowledge of the local region, and the farmers' practices. NE can use experimental data, but it can also estimate the required site-specific parameters using existing site information.

NE provides fertilizer recommendations that are based on the relationship between the balanced uptake of nutrients at harvest and grain yield, called internal nutrient efficiency, which are predicted using the quantitative evaluation of the fertility of tropical soils (QUEFTS) model. The fertilizer requirement for a field or location is estimated from the expected yield response to each fertilizer nutrient, which is the difference between the attainable yield and the nutrient-limited yield.

With NE, several site-specific parameters can be estimated using proxy information, which allows crop advisors to develop fertilizer guidelines for a location without data from field trials.

Field-testing of NE with farmers in South Asia has demonstrated yield gains in grain crops by as much as 1.7 t/ha and increased profits of several hundred USD/ha. Depending on the local situation, the increased production and profitability occurs in different manners. For example, data from India will shoe significant decreases in fertilizer nitrogen (N) and phosphorus (P) resulting in increased grain yield due to improved nutrient balance, while trials in Philippines recommended increased rates of N, P, and potassium (K) over the local farmer's practice, but the result was a significant yield increase leading to greater profitability for the farmer. A third example is in Indonesia, where some nutrients were increased and others decreased, again to provide more appropriate nutrient balance resulting in higher grain yield.

MEASUREMENT OF MAIZE STALK DIAMETER TO ESTIMATE YIELD

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INTRODUCTION - Maize yields vary from plant to plant for various reasons such as plant spacing, date of emergence, soil compaction and nutrient availability. Variability in grain weight per plant determined at harvest prompts questions like when the differences were initiated and why. An undergraduate field scouting exercise conducted at the R3 growth stage indicated an apparent relationship between stalk diameter and yield potential (ear length and diameter measurements). The goal of this study was to follow up on the student in-season observations by repeating the measurements at harvest with the hypothesis that maize stalk diameter is significantly correlated with grain weight.

APPROACH - A preliminary study was initiated in 2014 with sprinkler-irrigated maize on three fields in Nebraska, USA. For the first study, a representative length of row in the field used by the students was harvested plant-by-plant. Stalk diameter and distance between the plants was measured, as were the rows of kernels per ear and grain weight per plant. Two other fields were selected, but in these cases plants representing a more diverse range in spacing was selected.

RESULTS - Grain weight per maize plant at harvest across the three locations was well correlated with stalk diameter (average $r^2 = 0.66$). These relationships were linear and parallel, which is largely attributed to hybrid and plant population differences (Figure 1). Stalk diameter was also significantly correlated with kernel number per ear (Table 1). However, stalk diameter had little or no influenced on the number of rows of kernels per ear or kernel weight.

Table 1. Coefficient of determination between maize stalk diameter at harvest, grain weight per ear, number of kernels per ear, weight per kernel, number of rows of kernels per ear, and inter-plant distance for three irrigated fields in Nebraska, USA.

Comparison	Oswald	Stubblefield	Gangwish
stalk diameter vs. grain wt.	0.620	0.659	0.696
stalk diameter vs. # kernels	0.725	0.655	0.759
stalk diameter vs. # rows	0.154	0.028	0.001
stalk diameter vs. kernel wt.	0.015	0.019	0.002
grain wt. vs. # kernels	0.729	0.702	0.928
grain wt. vs. kernel wt.	0.213	0.209	0.054
grain wt. vs. # rows	0.135	0.027	0.011
distance vs. stalk diameter	0.015	0.012	0.004
distance vs. grain wt.	0.007	0.011	0.004
distance vs. # rows	0.037	0.008	0.148
distance vs. kernel wt.	0.004	0.036	0.329

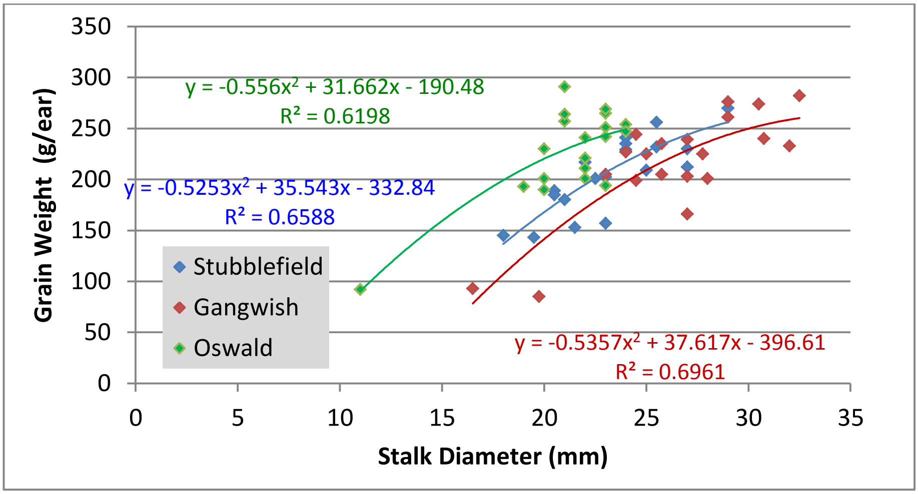

Figure 1. Relationship between maize stalk diameter at harvest and grain weight per ear for three irrigated fields in 2014 in Nebraska, USA.

Grain yield per ear was largely influenced by the number of kernels per ear (average r2 = 0.79), with lesser influence by kernel weight and number of rows of kernels Table 1). These observations confirm that maize plants have several ways to compensate for cultural practices and local growing conditions.

The challenge is to determine the reason(s) for differences in stalk diameter and yield per plant. Plant population and interplant distance are obvious factors that influence yield per plant. However, in the case of this study, plant spacing was relatively uniform and only varied between 7 and 20 cm. As such, plant spacing did not have a significant effect on stalk diameter, rows of kernels per ear, kernel weight, or grain weight per ear. All of the data shown in this study were obtained from a single row in each field to minimize the effect of row-to-row variability associated with cultural practices.

CONCLUSION - Efforts to achieve uniform plant spacing are probably over-emphasized. Rather, emphasis should be placed on determining when differences in stalk diameter are first observed during the growing season and what cultural practices, weather factors, or genetic differences could contribute.

GEOSTATISTICAL TOOLS FOR THE STUDY OF INSECT SPATIAL DISTRIBUTION: PRACTICAL IMPLICATIONS IN THE INTEGRATED MANAGEMENT OF ORCHARD AND VINEYARD PESTS

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Spatial heterogeneity in agricultural systems is recognized as an important source of variability to be investigated. In the evolution of Integrated Pest Management (IPM), patterns and processes that influence spatio-temporal dynamics in insect populations tends to assume more importance compared to the classical theory. Geostatistics represent a valuable tool to investigate the spatial pattern of insect populations and to support pest control. An overview of practical applications in managing pests, focusing on fruit orchards and vineyards was here provided . The utility of geostatistical tools is illustrated with examples taken from field studies, with attention to the analysis of spatial patterns, monitoring schemes, use of traps, scale issues, precision targeting and risk assessment maps. Potential approaches in the context of IPM are discussed in relation to future perspectives.

CHALLENGES TO IMPLEMENTATION OF PRECISION IRRIGATION WITH SPRAYERS

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Precision irrigation technology provides crops with the exact amount of water through differential management of application rate and/or irrigation duration. Nonetheless, the field implementation of precision irrigation with the associated water saving potential, requires equipment that can deliver the necessary precision in terms of uniformity pattern and irrigation depth. The purpose of this study is to evaluate the performance of eight typical sprayer nozzles used for fixed irrigation sets, under optimal conditions. Variable arc as well as fixed arc nozzles from two leading manufacturers were studied. The results indicate that the actual application rate of variable arc nozzles can be 200% of the rated catalogue application rate, thus requiring additional flow capacity of the water delivery system. These nozzles can have low values of uniformity, with Christiansen´s uniformity coefficient, CU, of between 0.31 and 0.70, making it difficult to obtain good uniformity even under a back-to-back setting. On the other hand, the fixed arc nozzles, provide reasonable distribution curves, with CU values of 0.61 to 0.81. The optimum spacing of the fixed arc nozzles was found to be smaller than the manufacturer's recommendation. It can be concluded that for precision irrigation, it is preferable to use fixed arc nozzles, after actual field evaluation.

DEVELOPMENT AND SIMULATION OF A ROBOTIC CONTROLLER BASED ON FUZZY BEHAVIOURS FOR GUIDANCE OF MOBILE ROBOT IN ORCHARDS

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Robotic control architectures supported by intelligent computational behaviors are being investigated for navigation and operation of autonomous vehicles and mobile robots for agricultural applications. Executing complex tasks in the field requires the combination of specific behaviors and demands the research for the development of control architectures for those machineries. In this work is proposed a method based on fuzzy logic that applies agricultural contexts to generate robotic behaviors to perform the guidance actions for a safe locomotion of a mobile robot between rows of crop. A robot, a controller and a virtual crop of an orange orchard are modelled, programmed and simulated using commercial software for prototyping and simulation of mobile robots. It was developed a fuzzy controller designed to use a sensor Light Detection and Ranging (LIDAR) and a receiver GNSS (Global Navigation Satellite System) equipped on a robot model available in the software library. The fuzzy controller uses as input the linguistic variables distance and angle between the robot and the trees identified in the orchard, and as output of the guidance angle (steering). Also, an arbiter based on fuzzy classifier was created in order to identify preview contexts that are commonly found in the agricultural scenarios and use these contexts to classify and coordinate the behaviors activation. The linguistic variables and the heuristic rules for which behavior and the classifier were generated according typical morphology of orchard environment. A robotic platform based on a compact tractor available in the software was adapted to simulate and support the experiments of the proposed architecture and the sensors were mounted on the virtual platform according the previously identified needs for the robot perception system. The 3D agricultural environment was built with rows of trees, where both tree height and the distance between them can be adjusted in order to allow the simulation of different types of orchard. Experiments based on the simulation are carried out for analysis of the activation of which behavior according the contexts presented during

the navigation on the virtual field. Also, it is evaluated the operational ability of the navigation comparing the path performed by the agricultural robot with the ideal path on the middle of the crop rows. The results show the viability of the proposed method and allow the composition of a complex navigational behavior resulting by the combination of the simple behaviors for mobile robot locomotion between rows of crops. The combination of the simple behaviors based on fuzzy arbiter implements a hierarchical coordination of the behaviors in a practical way. In the same way, the modularity of the proposed controller simplifies the implementation of the robotic system due to the using of decentralized behaviors based on agricultural contexts. The navigation system evaluated by simulation met its goal to allow safe navigation of the robot between tree rows in the orchard.

THEORETICAL BOUNDARIES OF PRECISION IRRIGATION OF COTTON CULTIVATION IN NORTHERN GREECE

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Although water is essential for all known forms of life it's resources are not infinite. Nowadays heavy exploitation and contamination of available fresh water resources, caused by human activity, as well as the adverse impact of the accelerating climate change put stress on available fresh water resources. Irrigation has a significant contribution in the total annual global fresh water abstraction. According to 2009 European Environmental Agency report, irrigation accounts for roughly 60% of the total water consumption in Southern European countries, while this portion is approximately 40% in Eastern and Western Europe. Precision Irrigation (PI) is worldwide a new concept in irrigation, having the potential to increase both the water use and its economic efficiency. As a tool for improving water use efficiency, the Food and Agricultural Organization (FAO) has developed AquaCrop, a water driven model which simulates the yield production for a variety of cultivars given a soil profile, a meteorological data set and an irrigation schedule plan. In order to determine the theoretical water productivity improvement through precision irrigation in Northern Greece, Aquacrop model was used. Cotton was selected as the target crop, since it is a common cultivar in Greece and it has increased water requirements. According to Greek legislation, the proposed water quantities for cotton seasonal irrigation fluctuate between 54.1 and 65.9 m3/ha. Considering the impact of weather conditions in agriculture, a year of moderate (2009) and of limited (2007) precipitation was simulated. Several simulation runs were conducted to examine the impact of different amounts of irrigation on the harvested cotton biomass, the plant harvest index (H.I.) and the final seed cotton yield for both years. Results were satisfactory as they showed that a better cotton yield can be achieved by implementing a precision irrigation strategy in contrast to the yield simulated when the proposed by Greek legislation amounts of water were applied for both 2007 and 2009, while at the same time 20% and 50% less water was irrigated in 2007 and 2009 respectively.

DECISION SUPPORT FOR IRRIGATION MANAGEMENT: CASE OF APPLE ORCHARD IN SWITZERLAND

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This study concerns an apple orchard farm in Switzerland which is a demonstration field site for EU-funded USER-PA[1] project. In this study, the primary focus is developing decision support system (DSS) for irrigation management. DSS literature shows not only that DSS development has not kept pace with the advances and application of modern sophisticated technologies in precision agriculture but also less emphasis has been given to irrigation. Focusing on operational decisions related to irrigation management; fuzzy logic approach is employed the objective function being optimizing harvest quality of fruit and farmer net return.

According to Crop Science literature, orchard productivity mainly concerns the management of inherent tree growth mechanisms to which water is a crucial ingredient. Therefore, well designed and managed irrigation is critical for increased productivity as well as improved fruit quality. Sound irrigation management requires optimal integration of several biological, physical, chemical and environmental factors. Moreover, it has become more evident that implications of farm decision making go beyond the farm boundary implying that societal, environmental and regulatory issues have to be considered as well. The growing phenomenon of big data also brings both potentially exploitable value and challenges for the farm manager. Hence, Decision Support Systems (DSS) are needed to fine-tune farm management using a wide set of qualitative and quantitative data, generating plausible recommendations for the situation at hand as well as evaluating alternatives to choose the preferred ones.

Interview with the farm manager reveals that so far historical farm data has not been utilized in a meaningful way. Rather, much of the decision is based mainly on farmer judgment and guess work. In addition, the manager states that it is less likely that the current practice would be optimal. Concerning irrigation, it was found that the farmer generally irrigates too much with the notion that more water is at least as good as less of it. The generally adequate supply of cheap water in Switzerland may explain part of the over-irrigation so far. Combining farmer experience and judgment with quantitative as well as qualitative analysis of data would result in optimal management of water in a way that optimizes production and results in high fruit quality. Hence, with appropriate use of information following the DSS, we expect increased farm productivity and farmer net return, increased water saving, and improved fruit quality without compromising environmental sustainability. Historical and real time weather data from SwissMeteo, farm data from farm owner, USER-PA field data and lab analyses, fruit price data from Fenaco[2] are the main data inputs for the study.

[1] USER-PA stands for USability of Environmentally sound and Reliable Techniques in Precision Agriculture.
[2] Fenaco is an agricultural cooperative in Switzerland to which the farmer of this case-study farm is a member. All the produce is sold to this cooperative.

OPPORTUNITY OF AIRBORNE IMAGES TO IDENTIFY MISSING VINE PLANTS: APPLICATION TO CV. SYRAH AND VERTICAL SHOOT POSITIONING TRAINING SYSTEM

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In the last decades remote sensing has been widely implemented in the agricultural sector and recent advances in image sensors has led to a wide range of applications using remotely sensed imagery in Precision Viticulture (PV). In addition to common applications (i.e. zones delineation, harvest quality management) dedicated to the management of the vineyard, remote sensing images of high spatial resolution (HSR) could be very helpful to identify missing vine plants (MP). Indeed, monitoring MP is of interest for management purposes (i.e. yield estimation) but also to verify compliance with origin denomination standards with limited rate of MP. Previous studies have already shown the potential of HSR images to detect MP with a training system where vine plants are individualized (Gobelet). However, to our knowledge, detection of MP with HSR images has never been tested in the peculiar conditions of vertical shoot positioning (VSP) systems and with a variety like cv. Syrah. Two reasons justify to focus on these conditions: VSP is the most common training system worldwide and Syrah is a variety subjected to a high rate of mortality. The latter condition requires offering fast and easy methods to identify and count the MP. This study case lead to difficulties: vines are not individualized and cv. Syrah is known for making long shoots which may extend to one or more contiguous plants along the row. Both these conditions are extreme situations to identify MP on remote sensing images. This paper addresses the issue of MP detection from HSR airborne images in these adverse conditions. It aims at testing the best possible image resolution to identify MP. The experiment was carried out on a field of approximate 1 ha in the experimental vineyard of Pech-Rouge (INRA-Gruissan) located in southern France. The field was established in 1990 with 1 m spacing between vine and 2.5 m between rows, with the vines trained in VPS. The total planted plants were 3900. To perform the experiment a subplot of 0.1 ha and 437 plants was chosen.

Three Multi-spectral airborne images were acquired at three different elevations in order to have three spatial resolutions (10 cm, 20 cm and 40 cm). Images were acquired at a stage corresponding to full vine canopy expansion period (August 2013). This stage was chosen in order to highlight the within-field variability and to consider differential harvest by the wine industry. The spectral regions contained in the images were blue, green, red and near-infrared. The Normalised Difference Vegetative Index (NDVI) was derived for each image. Field data collection aimed at identifying MP and their location over the whole field. This was done by a systematic manual inspection of each vine. MP were tagged with a specific label and their coordinates were recorded with a submetric DGPS. Tests of MP detection on images were performed by two approaches. The first approach is based on the knowledge of three experts who had prior knowledge of the ecophysiology of the vineyard and were previously trained to perform visual detection and manipulation of images. This approach was undertaken in order to determine whether experts were able to define location of MP by visual inspection of the images. Another purpose of this approach was to identify optimal image resolution for the development of a future MP detection algorithm. The second approach was performed in order to test the potential advantage of an automatic classification of MP and healthy vines. The analysis was conducted only on the image of 0.1 m resolution. For this evaluation, parameters values (mean, maximum, minimum and the standard deviation) of NDVI as well as each spectral band available were extracted from each site of the grid corresponding to an individual vine. Later, the parameters were used as the inputs of a Factorial Discriminant Analysis (FDA). Knowing the ground truth (from field data), the FDA was used to predict group membership for newly sampled data based upon a group of observations, whose memberships are already identified. The data base was divided in a learning set corresponding to 60 % of the data available on the subplot and a validation set corresponding to 40 % of the available data. Once calibrated, error of prediction of the factorial discriminant analysis was computed on the validation set. The subplot represents 11 % of the vines of the fields among which 24% of MP. The detection rate of MP performed by the three experts and three spatial resolutions was 102% and the percentage of MP detected correctly was only 42%. This result highlights the extreme difficulty that the experts had to identify the MP on images in our specific conditions. The error is mainly explained by a confusion between healthy plants and MP plants. However, in 18% of cases, healthy plants are also considered as MP by experts. In the analysis by resolution, the MP detection rate was 113%, 104% and 88%, respectively for 0.1 m, 0.2 m and 0.4 m image resolution. This result suggests that an image with a resolution of 0.2 m would be the best information source to identify MP in our conditions. However, regardless of the resolution of the images, the confusion between MP and healthy plants remains high in average for the three experts; it is of 48 %, 61 % and 64 % respectively for 0.1 m, 0.2 m and 0.4 m image resolution. The higher resolution the better MP detection. Results of classification of the FDA do not performed better than expert's analysis. It improves slightly the percentage of MP detected correctly (57 %) compared to experts (52 %). This error leads to an overestimation of the total number of detected MP of 121 %. The results showed that under our conditions the detection of MP from HSR images showed a low performance whatever the resolution considered. If the goal is to obtain a global percentage of MP percentage, this could be obtained with errors around 10% in average. However, it was not possible to obtain accurate detection of MP. This result is confirmed by the difficulty of the experts to identify properly MP and the results from the classification analysis. This study does not mean that the precise detection of MP is impossible with high-resolution images. Other investigations need to be explored, especially the study of the optimal phenological stage to perform this type of estimation. This study aimed to study the potentiality of images usually used by the wine industry to consider selective harvest. These images would have done an interesting information source for MP at a low cost since no specific image acquisition would have been required. Other stages of vine development such as flowering may be more appropriate to estimate MP accurately. Further studies are required to consider this point.

DESIGN OF AN ENERGY EFFICIENT AND LOW COST TRAP FOR OLIVE FLY MONITORING USING A ZIGBEE BASED WIRELESS SENSOR NETWORK

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Integrated pest management system requires an adequate monitoring of the target pest population, as well as a precise record of environmental parameters such as temperature and humidity. Olive fruit fly Bactrocera oleae (Gmelin) is a major pest of olive production. Losses due to this pest could reach the 100% of the production in years were climatic conditions favour the development of this tephritidae. Therefore, the development of a system able to collect field information is crucial for a sound management of this pest. In this sense, the Wireless Sensor Network (WSN) technology has been introduced in precision agriculture to obtain accurate real time field information. This work shows the design of a real time automatized low cost Olive fly trap as part of a wireless sensor network within the framework of the ENPI European project FRUITFLYNET. The automatized trap proposed is provided of a photographic camera for counting adults of the Olive fly, a solar-based power system and an additional temperature sensor. The network topology is based on mesh capabilities and distributed data storage to increase the WSN robustness. The data collected in the field is transferred to a cloud GIS server using a gateway node with 3G connection. The cloud server will allow historical data analysis, optimal preventive pest management and evaluation of pest application. The overall flytrap architecture, hardware and software components are described. The photographs and sensor data are transmitted to a real-time monitoring application, which incorporates the farm GIS model. The trap testing has been done firstly in the laboratory, to validate its functional requirements, the networking solution and the power consumption estimation. Finally, the coverage and real-time measurements have been obtained from an olive grove. The results reveal the feasibility of the proposed trap and the benefits of using ZigBee standard communication protocol allowing the interoperability with different kinds of sensor nodes.

Keywords: Olive fruit fly, Pest Management, ZigBee, Sensor network, Fruitflynet.

PRELIMINARY DEVELOPMENT OF AN AUTONOMOUS ORCHARD TRACTOR

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A John Deere tractor (model 3720) was converted to be controllable from a vehicle PC so it would be capable of autonomously moving through orchards even during a loss of GPS signal. It is designed to carry thermal cameras to monitor irrigation status and multispectral cameras for nutrient status.

This paper presents the design, build, interfacing, software, and implementation of the autonomous mobile vehicle, which was selected due to the following advantages: a hydrostatic continuously variable transmission (CVT), electrical control of CVT, roll bar at 2.4 metres suitable for mounting canopy sensors, minimal electronic control unit (ECU) allowing for modifications to be safely completed, turning circle of less than six metres in diameter, within budget.

We are currently integrating the Software Architecture for Agricultural Robots (SAFAR) into this system, which has been previously developed at Harper Adams University, and incorporating seven layers of safety that has been found necessary when operating in such an environment.

The various electronic systems of the vehicle were connected via CAN bus but we have recently upgraded to using an Ethernet bus to allow greater flexibility and follow a standard communication protocol allowing transparency and easy integration of hardware components.

The vehicle has been tested in an orchard using a wireless joystick control and is being developed to become an autonomous system.

INDEX