Program & Abstracts Book

EurAgEng 2021 Conference

New Challenges for Agricultural Engineering towards a Digital World

July 5 – 8, 2021
University of Évora, Évora, Portugal

Organized by:

UNIVERSIDADE DE ÉVORA
ESCOLA DE CIÊNCIAS E TECNOLOGIA
DEPARTAMENTO DE ENGENHARIA RURAL

Under the Aegis:

EurAgEng

Contents

Welcome

The University of Évora is very pleased to organise the AgEng2021 - New Challenges for Agricultural Engineering towards a Digital World.

As you know due to the pandemic situation AgEng2020 became AgEng2021. It was our goal to organize AgEng2021 in the University of Évora and in the beautiful city of Évora! However, COVID-19 pandemic still has big impact on travelling conditions and we had to accept that it is not be possible and so AgEng2021 is an ONLINE conference. It includes invited speakers, oral and poster presentations, special sessions, workshops and industry exhibition.

The pandemic situation brought to all of us into an unusual, unexpected situation, that changed our lives, showed the importance of health systems, but also the science, the technology and the agriculture. As agricultural engineers, scientists, technicians, academics and industry it is our obligation to not stop and to contribute to improve food and feed production systems as also the distribution channels in sustainable and safety conditions.

AgEng2021 is an opportunity to bring together engineers, scientists, technicians, academics and industry people to exchange knowledge, ideas, to present innovations and to discuss the state of the art and future perspectives for agricultural engineering as a motor for the sustainable future of agriculture. More than ever the **AgEng2021** conference focus on **New Challenges for Agricultural Engineering towards a Digital World** makes all the sense and it is a great pleasure to host this conference.

We wish you an interesting and fruitfull conference of the European Society for Agricultural Engineers.

Take care and stay safe!

Organizing Committee

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Maria do Rosário Cameira, *ISA, Universidade de Lisboa, Portugal*
Martin Kremmer, *John Deere European Technology Innovation Center, Germany*
Melynda Hassouna, *INRAE, France*
Miguel Angel Muñoz Garcia, *Polytechnic University of Madrid, Spain*
Nikolaos Katsoulas, *University of Thessaly, Greece*

Invited Speakers

Prof. Dr. Teresa Pinto Correia

Évora University, Portugal

Title of speech: Science for sustainability in a fast changing context: progress through interdisciplinarity

Teresa Pinto-Correia, Geographer, Professor at the University of Évora and Director of the MED - Mediterranean Institute of Agriculture, Environment and Development (www.med.uevora.pt), with 175 senior researchers. Coordinator of the team LABscape - an internationally competitive team of 15 researchers including 7 experienced post-docs - with expertise in rural geography, remote sensing, landscape ecology and management, and transdisciplinary processes. The team research focus is on rural landscapes in the Mediterranean context, with a dynamic systems approach where the natural, social and cultural factors are combined. Teresa research aims to provide novel conceptualization and evidence of the uniqueness and complexity of transition processes affecting Mediterranean rural landscapes today, as well as the validation of specific management models out of maintstream path-dependency and towards novel sustainability solutions. Involved in 6 H2020 projects, coordinating one of them, SALSA, on small farms role in sustainable food and nutrition security. More than 100 per-reviewed publications, including a book in Cambridge University Press, 2018, “European Landscapes in Transition: implications for policy and practice”. Member of the EC-Horizon Europe Mission Board on Soil Health and Food, since September 2019.

Prof. Dr. Martin Kremmer

John Deere GmbH & Co. KG, European Technology Innovation Center, Germany

Title of speech: Disruptive Innovations and Future Tech in Agricultural Engineering

Martin Kremmer, born 1972, is an Agricultural Engineer, working in industry for John Deere, global manufacturer of agricultural, turf and construction equipment since 2002 in different functions in Germany and in the U.S. in Tractor Design Analyses, Concept Design, Design, Implement Integration and Automation and Innovation Strategies. In 2019, Kremmer was named a John Deere Fellow and, since 2020, he is the Manager Small Ag&Turf Production Systems Solution Engineering at the European Technology Innovation Center in Kaiserslautern, Germany. Kremmer is a member of the Executive and Board of the European Society of Agricultural Engineers (EurAgEng) and member of the Advisory Council of the Max Eyth Society of Agricultural Engineering of the Society of German Engineers (VDI-MEG). He represents John Deere in other advisory and technical boards in the VDMA (German National Machinery Association) and CEMA (European Agricultural Machinery Association). He is a named inventor of more than 40 patents and patent applications and numerous publications in the field of Agricultural Engineering and has been teaching at the Karlsruhe Institute of Technology (KIT) since 2006 where he was promoted to an Honorary Professor in February of 2019.

Ing. Daniel Azevedo

Copa and Cogeca, Brussels, Belgium

Title of speech: The importance of Research and Innovation for the future of Farming

Daniel Azevedo, is Director in the Commodities and Trade team of Copa and Cogeca, an agricultural lobby representing almost 70 national farm organizations and cooperatives in Europe. He is a natural resources engineer graduated in the University of Évora (Portugal) currently the coordinator of Copa and Cogeca Task Force on agricultural technology. He has previously been working for DG Agriculture and Rural Development after specializing on agro-environmental measures in SLU University (Sweden). Mr. Azevedo comes from a family producing wine and olive oil in Vila Real (Douro Region) in Portugal.

Dr. Doris Marquardt

European Commission, Brussels, Belgium

Title of speech: Horizon Europe research program for agriculture

Doris Marquardt works for the European Commission, in the Directorate-General for Agriculture and Rural Development since July 2019 focussing on the digitalisation of the agricultural sector and rural areas and at Research and Innovation. She completed her PhD in agricultural policies at the Martin-Luther University, Halle-Wittenberg, Germany and holds a diploma (Msc) in Environmental Planning from the Technical University of Munich, Weihenstephan. She held positions at the European Environment Agency, the German Permanent Representation, the German Federal Ministry of Food and Agriculture, the European Network for Rural Development Contact Point, the Germany-based Leibniz Institute for Agricultural Development in Central and Eastern Europe, the Center of Rural Economy in Newcastle, United Kingdom, and the European Academy in Bolzano, Italy. She has experiences in the implementation of the Common Agricultural Policy in several EU Member States, including Romania, Italy and Germany. She served as expert in policy design, agriculture, and rural and regional development in the wider European region in projects commissioned by, e.g. the World Bank, UNEP and FAO.

Program at a glance

Date/ hour	July, 5					Date/ hour	July, 6					Date/ hour	July, 7					July, 8
10:00 CET						10:00 CET	Room 1	Room 2	Room 3	Room 4	Room 5	10:00 CET	Room 1	Room 2	Room 3	Room 4	Room 5	Online Precision Agriculture Course 10-12:00 CET
							CE 1	AI 4	ISF 4	SF 4	SPFB 4		PH 1	E 1	SFARM 1	SF 11	SF 14	
11:00 CET	Opening Session						Break (10 min)						Break (10 min)					
	EurAgEng Awards					11:10 CET	CE 2	AI 5	SF 5	SF 6	SPFB 5	11:10 CET	PH 2	E 2	SFARM 2	SF 12	SF 15	
12:00	Invited speakers						Break (30 min)						Break (30 min)					
CET						12: 30 CET	CE 3	A 1	SW 1	SF 7	SPFB 6	12: 30 CET	-	-	SFARM 3	SF 13	SF 16	
13:30 CET	Lunch (1 h)					13:30 CET	Lunch (1 h)					13:30 CET	Lunch (1 h)					
	Room 1	Room 2	Room 3	Room 4	Room 5													SIMTAP Webinar 14-17:00
14:30 CET	NATM 1	AI 1	ISF 1	SF 1	SPFB1 - LivAGE	14:30 CET	CE 4	A 2	SW 2	SF 8	SPFB 7	14:30 CET	Biosystems Engineering Publishing Workshop	CIGR Section II Meeting	-	-	-	
	Break (10 min)						Break (10 min)						Break (10 min)					
15:40 CET	NATM 2	AI 2	ISF 2	SF 2	SPFB 2	15:40 CET	EB 1	A 3	SW 3	SF 9	SPFB 8	15:40 CET	WG	WG	WG	WG	WG	
16:30 CET	Break (30 min)					16:40 CET	Break (20 min)											
17:00 CET	NATM 3	AI 3	ISF 3	SF 3	SPFB 3	17:00 CET	EB 2	A 4	SW 4	SF 10	SPFB 9	17:00 CET	Break (30 min)					
18:00 CET	Break (15 min)											17:30 CET	Closing Session					
18:15 CET	Virtual Welcome Reception																	

AI - Artificial Intelligence
A - Automation, Robotics and Sensors
CE - Circular Economy
E - Education and Rural Development
EB - Energy and Bioenergy
ISF - Integrated and Sustainable Farming Systems
NATM - New Application Technologies and Mechanization
PH - Post Harvest Technologies
SF - Smart Farming / Precision Agriculture
SW - Soil, Land and Water Engineering
SPFB - Sustainable Production in Farm Buildings

Information

Opening Ceremony
11:00 CET Monday, July, 5.
Room 124 CES, University of Évora

All participants are invited to attend the Opening Ceremony, with real time transmission.

The ceremony will have 4 distinct moments:

1. **11:00 – 11:30 CET** - Official opening with the presence of Évora University Rector, Prof. Ana Maria Freitas, the President of EurAgEng, Prof. Peter Groot Koerkamp and the City Mayor, Dr. Carlos Pinto Sá.

2. **11:30 – 12:00 CET** - EurAgEng Awards ceremony
   Recognition Award: Prof Bill Day
   Award of Merit – Scientific understanding: Prof Richard John Godwin

3. **12:00 – 12:10 CET** - Organizing Committee, Conference logistics

   5 minutes break

4. **12:15 – 13:30** – Invited Speakers
   Prof. Teresa Pinto-Correia, Science for sustainability in a fast changing context: progress through interdisciplinarity

   Prof. Martin Kremmer, Disruptive Innovations and Future Tech in Agricultural Engineering

   Ing. Daniel Azevedo, The importance of Research and Innovation for the future of Farming

   Dr. Doris Marquardt, Horizon Europe research program for agriculture

Virtual Welcome Reception
18:15 – 19:30 CET Monday, July, 5

Online wine tasting with Q&A
Ing. Duarte Lopes, Fundação Eugénio de Almeida

What to look for in a wine tasting?
And other relevant curiosities around wine!
If you want to follow the wine tasting we recommend you to have a bottle of wine and a glass!

Closing Ceremony

17:30 CET Wednesday, 7July

Room 124 CES, University of Évora

All participants are invited to attend the Closing Ceremony, with real time transmission. The ceremony will have 5 distinct moments:

1. EurAgEng Awards ceremony
   Young Engineers Best Paper Award
   EurAgEng Innovation and Development Award

2. EurAgEng presidency – hand-over

3. AgEng2021 Reporting

4. AgEng2021 Goodbye

5. AgEng2022 Berlin

Special sessions:

Special session on *ammonia and GHG emission from livestock housing By Cost Action CAL16106, LivAGE*

5 July, 14:30 (CET), Room 5

LivAGE (Ammonia and Greenhouse Gases Emissions from Animal Production Buildings) is a COST action (www.cost-livage.eu) aimed to is to enhance international discipline cooperation for exchanging ideas and knowledge, sharing good practices, assess technologies that could result in reducing the emissions of GHGs and ammonia from livestock buildings and thus to lead to a more environmental friendly and sustainable livestock production. This special session will provide a forum for discussing the state-of-the-art and on-going research projects of ammonia and GHG emission measurements as well as measuring methods, modelling and reduction techniques. The session will also provide an opportunity to share research experiences and to promote networking among those attendees.

SFARM Workshop - ERASMUS+ KA2 project "SFARM" - the development of MSC programmes in the field of sustainable agriculture in asian countries

7 July, 10:00-13:30 (CET), Room3

The SFARM project is an Erasmus+ project, started in October 2017 with the participation of 3 Program Countries (Greece, Portugal and Italy) and 4 Partner Countries (Vietnam, Laos, China and Indonesia). SFARM aims in advancing the skills of academic staff, students and agricultural extension staff in Higher Education Institutes (HEI) of Laos, Vietnam, China and Indonesia, through the development of new curricula and a MSc programme that integrate in a practical way the latest developments in agricultural applied research.

Webinar: *integrated multi-trophic systems for sustainable fish and crops production results from the pilots and experiments of the PRIMA project "SIMTAP"*

7 July, 14-17h (CET)

Organized by the PRIMA project "Self-sufficient Integrated Multi-Trophic AquaPonic systems for improving food production sustainability and brackish water use and recycling – SIMTAP"

The participation is open and free for everybody (even if not registered to the EurAgEng Conference). **REGISTRATION:** https://forms.office.com/r/sYUHTSEH7x.

The webinar will be held on the Teams platform. After registering you will receive the link to join the webinar. For more info: daniele.torreggiani@unibo.it.

Publishing workshop from the editors of biosystems engineering
7 July, 14:30-15:30 (CET), Room 1

The editors of the official journal of EurAgEng considered it important to engage with the scientists working in our research area to help them improve the effectiveness of manuscripts submitted to peer-reviewed journals in our discipline and remain up to date with the publishing process and the ethical background to scientific publishing.

This workshop will be led by Dr Steve Parkin, Editor-in-Chief, and will consist of 30 mins allocated to a presentation on what editors are looking for in quality submissions followed by 30 mins allocated to a question and answer session.

CIGR Section II meeting
7 July, 14:30-15:30 (CET), Room 2

https://teams.microsoft.com/dl/launcher/launcher.html?url=%2F_%23%2Fl%2Fmeetup-join%2F19%3Ameeting_MjlmMzBhYTEtNjU2Yi00NDEwLWIwZDYtY2EzYmFkYTY4NWNl%40thread.v2%2F0%3Fcontext%3D%257b%2522Tid%2522%253a%25223973589b-9e40-4eb5-800e-b0b6383d1621%2522%252c%2522Oid%2522%253a%25227dd91f29-050e-4b9e-9d70-ceca10ce160f%2522%257d%26anon%3Dtrue&type=meetup-join&deeplinkId=22889bc5-f5ed-4cb8-851c-6f7511413524&directDl=true&msLaunch=true&enableMobilePage=true&suppressPrompt=true

On-line precision agriculture course: *application of remote sensors in agriculture*
8 July, 11:00 CET

Organized by AgroInsider
Registration:
https://docs.google.com/forms/d/1ztEBhtbSImgXMfDzRbHnJbSQTgZlfzAeT8ZjT5k6Q-c/prefill

EurAgeng 2021

Scientific programs

Scientific Program, July, 5

12:15 – 13:30 CET – Invited speakers

Science for sustainability in a fast changing context: progress through interdisciplinarity

T. Pinto-Correia
MED – Mediterranean Institute for Agriculture, Environment and Development, Évora University, Portugal

Disruptive innovations and future tech in agricultural engineering

M. Kremmer
John Deere GmbH & Co. KG, European Technology Innovation Center, Germany

The importance of research and innovation for the future of farming

D. Azevedo
Copa and Cogeca, Brussels, Belgium

Horizon europe research program for agriculture

D. Marquardt
European Commission, Brussels, Belgium

14:30 – 15:30 CET – New Application Technologies and Mechanization 1 – Room 1

Chair: L.A. Conceição

Oral Presentations

ID: 2812

A discrete element approach for modelling the breakability of crop stems

B. Verschaeve, S. Vanmaercke, T. Bangels, W. Saeys
KU Leuven, Division of Mechatronics, Biostatistics and Sensors (MeBioS)

ID: 4788

Dynamics assessment of carbon and energy fluxes from eddy covariance time series in three different european ecosystems

V. Cicuendez, J. Litago, V.S. Girón, L. Recuero, C. Saénz, A.P. Orueta
Universidad Politécnica de Madrid, Spain

14:30 – 15:30 CET – Artificial Intelligence 1 – Room 2

Chair: D. Tinker

Oral Presentations

ID: 2783

Occlusion-robust temporal pose estimation of dairy cows in videos

H. Russello, R.V.D. Tol, G. Kootstra
Wageningen University and Research

ID: 2566

How machine learning can improve models of gas emission from a naturally ventilated dairy barn

S. Hempel[1], J. Adolphs[1], N. Landwehr[1,2], D. Willink[1], D. Janke[1], T. Amon[1,3]
[1]Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), [2]University of Potsdam, [3]University of Berlin

14:30 – 15:30 CET – Integrated and Sustainable Farming Systems 1 – Room 3

Chair: D. Monarca

Oral Presentations

ID: 2575

Damages produced to citrus fruits during detachment using a high amplitude and low frequency shaker

C. Ortiz, E. Orti, A.T. Mira
Universitat Politècnica de València, Spain

ID: 4736

Comparison of a light-weight experimental shaker and an orchard tractor mounted trunk shaker for fresh market citrus harvesting

C. Ortiz
Universitat Politècnica de València, Spain

ID: 4716

Suitability of citrus mechanical harvesting methods from the fresh market to industrial transformation

S. Real [1], C.O. Sánchez [2], R.R.S. Guirado [3], J A G. Ribes [1], S C. García [1]
[1]Escuela Técnica Superior de Ingeniería Agronómica y de Montes, Universidad de Córdoba, [2]Departamento de Ingeniería Rural y Agroalimentaria, Universitat Politècnica de València, [3]Escuela Politécnica Superior, Universidad de Córdoba

Poster Presentations

ID: 3080

The team matters: mechanical apple harvest platform efficiency and yield quality depends on the individual picker's assignment and team size

Y. Salzer [1], E. Yonai [2], S. Kfir [3], Y. Yechezkely [4], A. Naor [3]
[1]Agricultural Research Organization - Volcani Center, [2]Beresheet Corporation, [3]Northern Agriculture R&D Organization, Israel, [4]Agricultural Extension Service of Israel - Shaham, Israel

14:30 – 15:30 CET – Smart Farming / Precision Agriculture 1 – Room 4

Chair: R. van der Tol

Oral Presentations

ID: 4812

Innovation in behavioral indicators of pig welfare: total number of visits to the feeder and proximity index

V.F. Cruz[1], R. Charneca[1] C. Martins[2], T. Morgado[1]
[1]MED, Universidade de Évora, [2]Universidade de Évora

ID: 4813

Awartech project: a new tool of precision livestock farming for growing-finishing pigs

V.F. Cruz[1], F. Baptista[1], J.C. Rico[1], T. Morgado[1], D. Botas[2], D.R. Coelho[2]
[1]MED - Universidade de Évora, [2]Universidade de Évora

ID: 4765

Characterizing lactating sow posture in farrowing crates utilizing automated image capture and wearable sensors

A. Macon, T.B. Brandl, B. Lee, E. Markvicka, R. Sharma
University of Nebraska-Lincoln

ID: 4615

Estimation of ammonia concentration through indoor environmental variables in weaned piglet farms

M.R. Rodriguez [1], T. Arango [1], R. Besteiro [1], J.A. Ortega [2], M.D. Fernández [1]
[1]University of Santiago de Compostela, [2]Xunta de Galicia

14:30 – 15:30 CET – LivAGE Special Session – Room 5

Chair: S. Schrade and T. Bartzanas

Oral Presentations

ID: 2733

Effect of acacia mearnsii supplementation in forage-based diets on dairy cows ruminal methane emissions measured by the greenfeed

G. Lazzari [1], A. Münger [2], L. Eggerschwiler [2], M. Zähner [2], M. Kreuzer [3], S. Schrade [2], F.D. Meier [2]
[1]Agroscope - ETH Zürich, [2]Agroscope, [3]ETH Zürich

ID: 2688

NMVOc emissions of a silage-based and a silage-free diet for dairy cows on a practical scale

S. Schrade [1], S.A. Wyss [2], M. Zähner [1], M. Hill [2], J. Mohn [2], K. Zeyer [2], S. Reimann [2], F. Dohme-Meier [1]
[1]Agroscope, [2]Empa

ID: 3028

Ammonia emission, pen hygiene and pig behavior in a fattening pig house with partly slatted floor during warm conditions

K.H. Jeppsson [1], A.C. Olsson [1], A. Nasirahmadi [2]
[1]Department of Biosystems and Technology, Swedish University of Agricultural Sciences, [2]Department of Agricultural and Biosystems Engineering, University of Kassel

15:40 – 16:30 CET – New Application Tecnologies and Mechanization 2 – Room 1

Chair: L.A. Conceição

Oral Presentations

ID: 2545

Lateral stability performance of narrow-track tractors

B. Franceschetti, V. Rondelli, E. Capacci
University of Bologna, Italy

ID: 2715

Development of a test methodology that evaluates the efficiency of an idle-stop device for agricultural tractor

M. Varani, M. Mattetti, G. Molari
Università di Bologna, Italy

ID: 4668

Development of an optimization tool for three-point hitch geometry

L.A. Fernández, M. Maraldi, M. Mattetti
DISTAL – Department of Agricultural and Food Sciences, University of Bologna, Italy

Poster Presentations

ID: 3316

Innovative tractor hitched prototype design from the demand side

F.J. Castillo-Ruiz[1], [2], S. Peña Valero[1],[3], G.L. Blanco-Roldán[1], F.M.L. del Río[1], J.A. Gil-Ribes[1]
[1]University of Cordoba, Spain, [2]University of La Rioja, Spain, [3]Construcciones Mecánicas Alcay, Spain

15:40 – 16:30 CET – Artificial Intelligence 2 – Room 2

Chair: D. Tinker

Oral Presentations

ID: 4699

Early disease detection in apple and grape using deep learning on a smart-camera

G. Polder [1], P. M. Blok [1], T. V. Daalen [1], J. Peller [1], N. Mylonas [2]
[1]Wageningen University and Research, [2]Agricultural University of Athens

ID: 3182

Detection of tomato fruit from RGBD images using colorspaces and geometry

M. Afonso [1], H. Fonteijn [1], A. Mencarelli [1], D. Lensink [2], M. Mooij [2], N. Faber [2], G. Polder [1], R. Wehrens[1]
[1]Wageningen University and Research, [2]Enza Zaden

ID: 4674

Boosting plant-part segmentation of cucumber plants by enriching incomplete 3D point clouds with spectral data

F. Boogaard, G. Kootstra, E.Van Henten
Wageningen University and Research

15:40 – 16:30 CET – Integrated and Sustainable Farming Systems 2 – Room 3

Chair: D. Monarca

Oral Presentations

ID: 4768

Traditional apple picking vs. Harvest-platforms: combinations of methods compared for quality, productivity, and workload

N. Cohen [1], N. Halali [1], E. Yonai [2], S. Kfir [3], Y. Salzer [1]
[1]Agriculture Research Organization - Volcani Institute, [2]Beresheet Inc., [3]Northern Agriculture R&D

ID: 4750

Estimating costs of a chestnut mechanical harvester

A. Almeida [1], A. Borges [2]
[1]Instituto Politécnico de Bragança, [2]Geosil - Empreendimentos Agrosilvícolas - Rebordainhos, Portugal

ID: 4695

Towards integrated mechanised management of olive farms

S.B. Tejero [1], F.A. Rodríguez [1], J.A.G. Ribes [1], G.L.B. Roldán [1], S.C. Castro [1], R.R.S. Guirado [1]
[1]Unversity of Cordoba

Poster Presentations

ID: 4797

Effect of frequency irrigation on yield and biometrics characteristics of table olives (olea europaea l., cv. Negrinha de Freixo) under full and sustained deficit irrigation

D. Barreales [1], A. Monteiro [2], S. Capitão [2], D.C. Oliveira [2], R.A. Lack [2], T.T. Grabowski [2], A.F. Silva [3], A.C. Ribeiro [1]

[1]CIMO, ESA, Instituto Politécnico de Bragança, [2]ESA, Instituto Politécnico de Bragança, [3]CITAB, Universidade de Trás-os-Montes

15:40 – 16:30 CET – Smart Farming / Precision Agriculture 2 – Room 4

Chair: R. van der Tol

Oral Presentations

ID: 4648

Idea: digitally connected model farm (digimo) with agriculture and fodder farming, dairy farming

A. Foerschner, H. Nussbaum
LAZBW Aulendorf

ID: 2640

Automated assessment of rumen fill in dairy cows using 3D vision

X. Song[1], R. van der Tol[2], E. Bokkers[3], P.W.G. Groot Koerkamp[2]
[1]Smart Components Department, Lely Industries NV, [2]Farm Technology Group, Wageningen University & Research, [3]Animal Production Systems Group, Wageningen University & Research

ID: 4673

Evaluation of a sensor-based system for monitoring rumination in dairy cows with access to pasture

L. Schmeling [1], G. Elmamooz [2], D. Nicklas [2], E. Rauch [3], S. Thurner [1]
[1]Bavarian State Research Center, Institute for Agricultural Engineering and Animal Husbandry, [2]University of Bamberg, Chair of Mobile Systems, [3]LMU Munich, Chair of Animal Welfare, Ethology, Animal Hygiene and Animal Husbandry

15:40 – 16:30 CET – Sustainable Production in Farm Buildings 2 – Room 5

Chair: S. Schrade

Oral Presentations

ID: 2702

Reduction of ammonia emission from dairy floors by urease inhibition

A. Aarnink, D.P. Rodriguez
Wageningen Livestock Research, Wageningen University and Research

ID: 2683

Wind tunnel investigations for a direct measurement of volume flow and emissions of a naturally ventilated dairy barn

D. Janke, Q. Yi, S. Hempel, T. Amon
Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)

ID: 2699

Influence of different ventilation systems on the activity and lying behavior of lactating dairy cows under heat load

J. Heinicke, G. Hoffmann, C. Ammon, T. Amon
Leibniz Institute for Agricultural Engineering and Bioeconomy e.V.(ATB)

17:00 – 18:00 CET – New Application Technologies and Mechanization 3 – Room 1

Chair: L.A. Conceição

Oral Presentations

ID: 4619

Development and evaluation of a subsoil management system to increase yield capacity of arable land

O. Schmittmann, A. Christ, P.S. Lammers
Institute of Agricultural Engineering, Germany

ID: 4717

Suitability of citrus mechanical harvesting methods from the fresh market to industrial transformation

S. Real
Universidad de Córdoba, Spain

17:00 – 18:00 CET – Artificial Intelligence 3 – Room 2

Chair: D. Tinker

Oral Presentations

ID: 2794

5G connected spot sprayer enables autonomous control of volunteer potato

J. Booij [1], W.P. Dirks [1], T. Ruigrok [2], B. Veldhuisen [1], K.V. Boheemen [3], A. Vroegop [4], A. Nieuwenhuizen [3], J. Kamp [1]
[1]Wageningen University and Research - Field Crops, [2]Wageningen University and Research - Farm Technology Group, [3]Wageningen University and Research - Agrosystems research, [4]Wageningen University and Research - Greenhouse Horticulture

ID: 4700

UAV-SFM 4D mapping of landslides activated in a steep terraced agricultural area

L. Mauri [1], E. Straffelini [1], S. Cucchiaro [2], P. Tarolli [1]
[1]University of Padova, [2]University of Udine

17:00 – 18:00 CET – Integrated and Sustaible Farming Systems 3 – Room 3

Chair: D. Monarca

Oral Presentations

ID: 2526

On-farm dry matter monitoring system - silage sampler, dry matter measurement and mobile app for feeding adjustment

T. Kallio [1], M. Härkönen [2], J. Komulainen [1], M. Tanner [3], V. Sutinen [1], P. Kilpeläinen [1], V. Virtanen [1]
[1]University of Oulu, Kajaani University Consortium, Unit of Measurement Technology, [2]Bittium Wireless Ltd, Kajaani, FINLAND, [3]ProAgria Rural Advisory Services of Eastern Finland

ID: 2655

Effects of planter attachments on corn emergence and corn yield

M. Demmel, H. Kirchmeier
Bavarian State Research Center for Agriculture

ID: 4732

Particulate matter emissions from soil preparation activities as influenced by minimum and strip tillage practices

J. Maffia, M. Blandino, L. Capo, E. Padoan, L. Rollé, P. Balsari, E. Dinuccio
University of Torino

17:00 – 18:00 CET – Smart Farming / Precision Agriculture 3 – Room 4

Chair: R. van der Tol

Oral Presentations

ID: 4676

M2M communication in a dairy barn - identifying farmers' needs and requirements

J. Poteko, P. Lübke, J. Harms
Bavarian State Research Center for Agriculture, Institute for Agricultural Engineering and Animal Husbandry

ID: 4647

Low power gps-based systems to support herd management in extensive livestock systems

S.M.C. Porto, F. Valenti, G. Cascone
Department of Agriculture, Food and Environment, University of Catania, Italy

ID: 2751

Heat recovery system for milk cooling units

S. Markus, L. Annett, A. Thomas
Agroscope

17:00 – 18:00 CET – Sustainable Production in Farm Buildings 3 – Room 5

Chair: T. Bartzanas

Oral Presentations

ID: 4629

The 'manure shuffle': a system for frequent removal of fine manure particles from the foraging area of poultry barns

A.P. Bos, Y.S.M. Goselink
Wageningen Livestock Research

ID: 3492

CFD numerical study of the effect of airflow velocity on the dust releasing process from a poultry litter bed

S.M. Derakhshani, N.W.M. Ogink, A.P. Bos, P.W.G. Groot Koerkamp
Wageningen University and Research

ID: 2656

Comparing direct and indirect measurements of ammonia emission (case study: poultry litter)

P. Neysari [1], N. Ogink [2], J. W. De Vries [3], P.W.G. Groot Koerkamp [4]
[1]Wageningen University and Research, [2]Wageningen Livestock Research, Wageningen University and Research, [3]Van Hall Larenstein University of Applied Science, [4]Farm Technology Group, Department of Plant Sciences, Wageningen University and Research

Scientific Program, July, 6

10:00 – 11:00 CET – Circular Economy 1 – Room 1

Chair: T. Batista

Oral Presentations

ID: 4777

Potential of slurry from intensive dairy cattle farms for paulownia and populus trees, as organic fertiliser: i. Effect on production

R. Menino [1], S. A. Pereira [2], H. Moreira [2], A. C. Branco [1], A A. Gomes [1], A. Rodrigues [1], J. Cunha [2], P. Castro [2], A. Vega [2], E. Cardoso [2], M. J. Machado [3], R. Alves [4], F. Cardoso [5], F. Lopes [5], R. Guedes [3]
[1]National Institute for Agrarian and Veterinarian Research, [2]Universidade Católica Portuguesa, [3]Aveleda, S.A., [4]forestis, [5]fenalac

ID: 4811

Livestock effluents: strategic approach towards agronomic and energetic valorization of flows in the farming activity

O. Moreira[1], V. F. Cruz[2], D. Murta[3], H. Trindade[4], R. Fragoso[5], E. Duarte[5]
[1]INIAV, [2]MED - Universidade de Évora, [3]Entogreen, [4]UTAD, [5]ISA-Universidade de Lisboa

ID: 4814

Traditional compost and bsf-biodigested compost in the organic fertilization of ryegrass

R. Menino[1], A.C. Branco[1], J. Semedo[1], P.S. Campos[1], D. Murta[2], C. Nestler[3], O. Moreira[1], V.F. Cruz[4]
[1]INIAV, [2]Entogreen - Ingredient Odyssey, [3]SIRO, [4]MED – Universidade de Évora

Poster Presentations

ID: 4688

A smart fertilization model: a study of multidisciplinary methods in monitoring fertilization in turfgrass

J.F. Marin [1], S. Yousfi [2], L. Parra [3], G.D.L. Horra [1], P.V. Mauri [2]
[1]AREA VERDE, [2]IMIDRA, [3]UPV IMIDRA

10:00 – 11:00 CET – Artificial Intelligence 4 – Room 2

Chair: R. Brunsch

Oral Presentations

ID: 4692

Implementation techniques of pre-trained deep learning networks for plant disease classification

A. Bhujel [1,2], W.I. Kim [3], H.J. Jin [3], H.T. Kim [1]

[1]Gyeongsang National University, Republic of Korea, [2] Ministry of Communication and Information Technology, Nepal, [3] Gyeongsangnam-do Agricultural Research and Extension Services, Republic of Korea

ID: 2672

Fast delivery of insect pest management information using a real-time insect pest monitoring system

D. J.A. Rustia [1], C.Y. Lu [1], J.J. Chao [1], L.Y. Chiu [1], Y.F. Wu [2], J.Y. Chung [2], T.T. Lin [1]

[1]Department of Biomechatronics Engineering, National Taiwan University, Taiwan, [2]Tainan District Agricultural Research and Extension Station, Council of Agriculture, Taiwan

10:00 – 11:00 CET – Integrared and Sustainable Farming Systems 4 – Room 3

Chair: J.R. Silva

Oral Presentations

ID: 3538

A new paradigm in biosystems engineering: technology-4-ecology based farming

P.W.G. Groot Koerkamp [1], W.J. Schouten [2], E.J. van Henten [1], A.P.H.M. Janssen [1], N.P.R. Anten [1], A.P. Bos [3], M.K. Matters-Kammerer [4], H.A. Khan [1], T. Keviczky [5], D.M. Brouwer [6], A.R.H. Fischer [1], J.A. Dieleman [7], J.A.L.M. Kamp [7], Y. Haas [8]

[1]Wageningen University, [2]TiFN, [3]Wageningen University & Research, [4]Eindhoven University of Technology, [5]Delft University of Technology, [6]University of Twente, [7]Wageningen Plant Research, [8]Wageningen Livestock Research

ID: 4728

A functional design framework for successional agroforestry systems in different bio-physical contexts

A. Janssen [1], D. Gasparro [2]

[1]Wageningen University, [2]Leiden University

ID: 4775

Analysis of mixing efficiency in the vertical livestock manure compositing system using dem

B. Oh [1], I. Seo [1], D. Lee [2]
[1]jeonbuk national university, [2]rural development administration

10:00 – 11:00 CET – Smart Farming / Precision Agriculture 4 – Room 4

Chair: A. Balafoutis

Oral Presentations

ID: 4630

A vision-based road detection system for the navigation of an autonomous tractor

S. Saha, R. Ospina, N. Noguchi
Hokkaido University, Japan

ID: 4631

Development of electrical vehicle robot for orchard application

Y. Yamasaki [1], T. Hizatate [1], N. Noguchi [2]
[1]Graduate School of Agriculture, Hokkaido University, Sapporo, Japan, [2]Research Faculty of Agriculture, Hokkaido University, Sapporo, Japan

10:00 – 11:00 CET – Sustainable Production in Farm Buildings 4 – Room 5

Chair: N. Katsoulas

Oral Presentations

ID: 3292

Evaluation of floating cooling fins for emission reduction in fattening pig barns

L. Wokel, E. Gallmann
University of Hohenheim - Institute of Agricultural Engineering

ID: 4743

Correlation between ammonia emission factors and pig farming system

H. Jeong [1], J. Park [2], S. Lee [1], S. W. Hong [3], L. Choi [1]
[1]Chonnam National University and Education and Research, [2]AgriBio Institute of Climate Change Management, Chonnam National University, [3]Chonnam National University

ID: 3367

Numerical approaches for the integrated analysis of large datasets collected in the dairy cattle sector

S. Benni, M. Bovo, D. Torreggiani, A. Barbaresi, E. Santolini, M. Agrusti, P. Tassinari
University of Bologna, Italy

Poster Presentations

ID: 6001

Enabling smart livestock farming technologies for environmental sustainability using blockchain

T. Bartzanas[1], V. Anestis[1], Z. Tsiropoulos[2], V. Anastasiou[2]
[1] Agricultural University of Athens, Greece, [2] Agricultural and Environmental Solutions – Agenso, Greece

11:10 – 12:00 CET – Circular Economy 2 – Room 1

Chair: T. Batista

Oral Presentations

ID: 4779

Carbon footprint of commercial greenhouse crops in greece: a case study of poinsettia and geranium in attica region

V. Anestis, L. Andris, T. Bartzanas
Agricultural University of Athens, Greece

ID: 4618

A gis-based model analysis for assessing tomato peels as suitable biomasses for producing biomethane within the context of circular economy

F. Valenti [1], R. Selvaggi [2], B. Pecorino [2], S.M.C. Porto [2]
[1]Department of Agriculture, Food and Environment, University of Catania, Via Santa Sofia, Catania, Italy,
[2]Department of Agriculture, Food and Environment, University of Catania, Via Santa Sofia, Catania, Italy

ID: 4638

Planning the integrated management of organic waste flows and agricultural residues for a circular economy

C. Manniello [1], D. Statuto [1], A. D. Pasquale [2], P. Picuno [1]
[1]University of Basilicata, [2]INNOVA Consorzio per l'Informatica e la Telematica srl, Matera, Italy

11:10 – 12:00 CET – Artificial Intelligence 5 – Room 2

Chair: R. Brunsch

Oral Presentations

ID: 4611

Deep learning technique and uav imagery dataset for paddy rice panicle detection at early stage

H. Wang[1], S. Lyu[2], Y. Ren[3]
[1]Beijing Research Center of Intelligent Equipment for Agriculture, [2]Graduate School of Agriculture, Hokkaido University, [3]Beijing Research Center for Information Technology in Agriculture

ID: 2489

Deep learning and iot technology applied to monitor the growth of tea trees indoors under artificial lighting

C.C Huang, H.W. Chen, C.L. Chang
Dept. Biomechatronics Engineering, National Pingtung University of Science and Technology

ID: 4713

Random forest models based on biological activity of whole plants to predict the yield of tomato fruits in a greenhouse

N. Fujiuchi[1], K. Inaba[2], S. Oh[1], S. Okajima[3], Y. Asai[3], H. Nishina[1], K. Takayama[4]
[1]Ehime University, Japan, [2]PLANT DATA Co., Ltd., Japan, [3]Asai Nursery Inc., Japan, [4]Toyohashi University of Technology, Japan

11:10 – 12:00 CET – Smart Farming / Precision Farming 5 – Room 3

Chair: J.R. Silva

Oral Presentations

ID: 4693

Comparison of the different growing substrates for the vegetative and reproductive growth of strawberry plants

B.G.K. Madhavi, A. Bhujel, N.E. Kim, H.T. Kim
Gyeongsang National University, Republic of Korea

ID: 4726

Early prediction of protein content and grain yield of rice (oryza sativa l.) Using multispectral imagery

K. Kang [1], C.S. Ryu [1], Y.S. Kang [1], S.H. Jang [1], J.W. Park [1], T.Y. Kim [1], J.W. Nam [2], S.T. Lee [2], D.K. Seung [2]
[1]GyeongSang National University, [2]Gyeongsangnam-do Agricultural Research & Extension Services

ID: 2630

Map based site-specific seeding of seed potatoes by fusion of proximal and remote sensing data

M.A. Munnaf, G. Haesaert, M.V. Meirvenne, A.M. Mouazen
Ghent University

Poster Presentations

ID: 2719

Analysis of camelina sativa cultivation through on-field sensors and remote sensing

D. Mostaza [1], L. Díaz [2], A. García [2], P.V. Mauri [1], A. Capuano [3]
[1]IMIDRA, [2]Universidad de Alcalá, [3]Camelina Company Spain

11:10 – 12:00 CET – Smart Farming / Precision Farming 6 – Room 4

Chair: A. Balafoutis

Oral Presentations

ID: 2795

Discrete event simulation shows potential for small autonomous potato harvester

J. Booij [1], P.V. Dalfsen [1], B.V. Ooster [2], M.V.D. Voort [1], B. Veldhuisen [1], A. Nieuwenhuizen [3], J. Kamp [1]
[1]Wageningen University and Research - Field Crops, [2]Wageningen University and Research - Farm Technology Group, [3]Wageningen University and Research - Agrosystems Research

ID: 2534

Virtual mwir spectra for improved pls calibration of fuel mixtures

M.D.S. Maldonado-Gil[1], P.Barreiro-Elorza[2], B. Diezma-Iglesias[2], G. Vergara-Ogando[3]
[1]LPF_TAGRALIA, UPM CEI Moncloa, [2]LPF_TAGRALIA, UPM-CEI Moncloa, [3]Near Infrarred Technologies Europe

ID: 4598

Simulation for variable-rate nitrogen fertilization with different application schemes

A. Guerrero, A.M. Mouazen
Ghent University

ID: 2664

Automated imaging system for remote monitoring of insect pests in mango orchards

D.J.A. Rustia [1], C.Y. Lu [1], W.C. Lee [1], J.J. Chao [1], Y.F. Wu [2], P.Y. Shih [2], S.K. Chen [2], J.Y. Chung [2], T.T. Lin [1]
[1]Department of Biomechatronics Engineering, National Taiwan University, Taiwan, [2]Tainan District Agricultural Research and Extension Station, Taiwan

11:10 – 12:00 CET – Sustainable Production in Farm Building 5 – Room 5

Chair: N. Katsoulas

Oral Presentations

ID: 4769

Monitoring of particulate matter to working environment in the broiler house

H. Jae-Seo, I. Hwan-Seo, J. Ho-Cha
College of Agriculture, Life Sciences Jeonbuk National University

ID: 4785

Influence of animal-related parameters on emissions of ammonia and methane from an open-sided free-stall barn in hot mediterranean climate

P.R. D'Urso, C. Arcidiacono, G. Cascone
University of Catania, Italy

ID: 4723

Development and testing of an innovative system to acidify animal slurry with powdery sulphur before mechanical separation

E. Dinuccio, J. Maffia, L. Rollè, F. Gioelli, G. Airoldi, P. Balsari
Department of Agriculture, Forest and Food Science (DISAFA) - University of Turin, Italy

12:30 – 13:30 CET – Circular Economy 3 – Room 1

Chair: V.F. Cruz

Oral Presentations

ID: 4636

Floridia soil-based adobes: an exploration on flexural and compressive strength

M. Parlato, S. Porto, G. Cascone
University of Catania, Italy

ID: 4698

Use of near infrared spectroscopy for the assessment of waste wood quality to energy use

M. Mancini [1], Å. Rinnan [1], G. Toscano [2]
[1]University of Copenhagen, [2]Università Politecnica delle Marche

ID: 4794

Plastics in agriculture: the problem and one potential solution

B. Tita [1], A. Ilhéu [1], T. Batista [2], L. Metrogos [3], I.P.P. Cansado [4], P.A.M. Mourão [4], J.M.V. Nabais [5], J. Castanheiro [4], C. Borges [6], G. Matos [6]
[1]Empresa de Desenvolvimento e Infraestruturas de Alqueva (EDIA,SA), [2]CIMAC and MED, IIFA, Universidade de Évora, [3]Comunidade Intermunicipal do Alentejo Central (CIMAC), [4]dLAQV-REQUIMTE, IIFA and D. Química, ECT, Universidade de Évora, [5]Comprehensive Health Research Center (CHRC), Dep. Ciências Médicas e da Saúde, ES, UÉvora, [6]GESAMB

12:30 – 13:30 CET – Automation, Robotics and Sensors 1 – Room 2

Chair: R. Brunsch

Oral Presentations

ID: 3488

Monitoring and analysis of the daily behaviour of individual laying hens by using motion sensors and machine learning

S.M. Derakhshani, T. Romme, T. van Niekerk, I.C. Jong, P.W.G. Groot Koerkamp
Wageningen University and Research

ID: 4672

Instance segmentation and pose estimation of chicken legs in a cluttered environment

F. Kemp, D. Rapado-Rincón, R. Raja, G. Kootstra
Farm Technology Group, Wageningen University and Research

ID: 4764

Pose estimation of tomato peduncle using deep keypoints detector with point cloud

X. Wang, Jianchao, A.K. Burusa, D.R. Rincón, G. Kootstra
Wagningen University and Research

12:30 – 13:30 CET – Soil, Land and Water Engineering 1 – Room 3

Chair: J.R. Silva

Oral Presentations

ID: 2935

Monitoring the water distribution in the lis valley irrigation district, Portugal

M. Nunes [1], S. Ferreira [1], R. Eugénio [2], H. Damásio [2], J.M. Gonçalves [1], M. Teixeira [3]
[1]Instituto Politécnico de Coimbra, ESA, [2]Associação de Regantes e Beneficiários do Vale do Lis, [3]Direção Regional de Agricultura e Pescas do Centro, Portugal

ID: 2936

Water saving in on-farm rice irrigation in the lis valley, Portugal

J.M. Gonçalves [1], R. Eugénio [2], M. Nunes [1], S. Ferreira [1], H. Marques [1], I. Duarte [1], M.N. Araújo [1], P. Amador [1], O. Filipe [1], H. Damásio [2], A. Jordão [3]
[1]Instituto Politécnico de Coimbra, ESA, Portugal, [2]Associação de Regantes e Beneficiários do Vale do Lis, Leiria, Portugal, [3]Direção Regional de Agricultura e Pescas do Centro, Portugal

ID: 4772

Orchard level assessment of irrigation performance and water productivity of an irrigation community in eastern Spain

H. Puerto [1], M. M. Gómez [2], B. R. Merino [3], C. R. Osorio [1], J. M. Cámara-Zapata [1], R. A. Sánchez [1]
[1]Centro de Investigación e Innovación Agroalimentaria y Agroambiental CIAGRO-UMH, Miguel Hernández U., [2]MOVAL Agroingeniería S.A. Spain, [3]Instituto de Investigación para la Gestión Integrada de Zonas Costeras, UPV.

12:30 – 13:30 CET – Smart Farming / Precision Agriculture 7 – Room 4

Chair: A. Balafoutis

Oral Presentations

ID: 2496

Differentiated management center-pivot travel speed based on soil apparent electrical conductivity and remote sensing

J. Serrano[1], S. Shahidian[1], C.M. Rodrigues[1], S. Garcia[2], J. Noéme[2], J. Palha[3]
[1]University of Évora, [2]Terrapro, [3]Pereira Palha Agricultura

ID: 2578

Predicting the evolution of pasture quality by nirs: perspectives for real-time pasture and grazing management

J. Serrano[1], S. Shahidian[1], E. Carreira[1], J. Bueno[2], A.E. Rato[1]
[1]University of Évora, [2]Universidad de Sevilla

ID: 4761

Benefit of the variable rate technology in a top-dressed fertilization of a fodder crop in a nitrate vulnerable area

L.A. Conceição [1], L. Silva [2], S. Dias [2], L. Loures [1], B. Maças [3]
[1]VALORIZA—Research Center for Endogenous Resource Valorization, Polytechnic Institute of Portalegre,, [2]Polytechnic Institute of Portalegre, [3]Research Unit of Biotechnology and Genetic Resources (INIAV), Portugal

12:30 – 13:30 CET – Sustainable Production in Farm Buildings 6 – Room 5

Chair: N. Katsoulas

Oral Presentations

ID: 4746

Structural design and analysed methodology for a flat-roof nethouse in greece

S. Antonodimitraki [1], A. Giannoulis [2], G. Dougka [1], D. Briassoulis [2], I. Vayas [1]
[1]Institute of Steel Structures, National Technical University of Athens, [2]Department of Natural Resources & Agricultural Engineering, Agricultural University of Athens

ID: 4721

A full-scale experimental analysis of the microclimate in two neighbouring insect-proof nethouse tunnels

A. Giannoulis, D. Briassoulis, A. Mistriotis
Agricultural University of Athens

ID: 4718

Structural design methodology for insect proof nets of nethouses under snow load

K. Adamakos [1], D. Briassoulis [2]
[1]School of civil engineering, Institute of steel structures, National Technical University of Athens, [2]Department of Natural Resources & Agricultural Engineering, Agricultural University of Athens

Poster Presentations

ID: 2686

Evaluation of the effects of antidrip and uv transmission properties of polyethylene films on a greenhouse strawberry crop

N. Katsoulas, A. Bari, T. Georgopoulou, C. Papaioannou
University of Thessaly, Greece

14:30 – 15:30 CET – Circular Economy 4 – Room 1

Chair: V.F. Cruz

Oral Presentations

ID: 2685

Effect of ph on schizochytrium limacinum production grown using crude glycerol and biogas digestate effluent

S. Bouras, D. Antoniadis, G. Kountrias, I.T. Karapanagiotidis, N. Katsoulas
University of Thessaly, Greece

ID: 4677

Development of a simulation model for macronutrients concentration estimation in a lab-scale aquaponic system

M. Aslanidou, E. Tsoumalakou, A. Elvanidi, E. Levizou, E. Mente, N. Katsoulas
University of Thessaly, Greece

ID: 2731

Mechanical behavior of biochar: influence of pyrolysis operating conditions on dust production, shear and compression resistance

M. Videgain [1], J.J.M. Cervelló [1], M.V. Cortés [1], E.C.C. Hernando [2], B.D. Iglesias [2], F.J.G. Ramos [1]
[1]Escuela Politécnica Superior - Universidad de Zaragoza. Spain, [2]ETSI Agronómica, Alimentaria y de Biosistemas. Universidad Politécnica de Madrid. Spain

14:30 – 15:30 CET – Automation, Robotics and Sensors 2 – Room 2

Chair: G. Kootstra

Oral Presentations

ID: 2473

Detecting spectral signals in imaging for disease detection in apple, grape, and carrot

J. Peller[1], P. Blok[1], G. Polder[1], I. Malounas[2]
[1]Wageningen University and Research, [2]Agricultural University of Athens

ID: 4798

Evaluation of spectral imaging cameras for disease detection in tomato plants

A. Banakar[1], G. Polder[2], J.L. Ruizendaal[2], J. Balendonck[2]
[1]Tarbiat Modares University, [2]Wageningen University & Research

ID: 2732

Evaluation of integrated optical devices for monitoring grape (vitis vinifera l.) Ripeness

A. Tugnolo[1], V. Giovenzana[1], R. Beghi[1], A. Casson[1], R. Guidetti[1], H. Oliveira[2], A. Geraldes[2], C. Marques[2], J. Piteira[2], P. Freitas[2], C. Fernandes[3], A. Graça[3], N. Fontes[3]
[1]Department of Agricultural and Environmental Sciences (DiSAA), Università degli Studi di Milano, [2]INL, International Iberian Nanotechnology Laboratory, Portugal, [3]Sogrape Vinhos S.A., Portugal

14:30 – 15:30 CET – Soil, Land and Water Engineering 2 – Room 3

Chair: J.M. Gonçalves

Oral Presentations

ID: 2597

Assessment of emitter clogging with different sand media filter underdrain designs using reclaimed effluent

C. Solé-Torres, J. Puig-Bargués, M. Duran-Ros, G. Arbat, J. Pujol, F.Ramírez de Cartagena
University of Girona, Spain

ID: 2598

Hydraulic performance of a wand-type underdrain in a sand media filter for a drip irrigation system

T. Pujol, J. Puig-Bargués, G. Arbat, M. Duran-Ros, C. Solé-Torres, J. Pujol, F. Ramírez de Cartagena
University of Girona, Spain

ID: 3308

Experimental investigation of sustainable water production by PV-RO desalination systems for crop irrigation

E. Dimitriou [1], C.S. Karavas [1], A. Balafoutis [2], D. Manolakos [1], G. Papadakis [1]
[1]Agricultural University of Athens, [2]bInstitute for Bio-Economy Agro-Technology, Centre of Research & Technology Hellas

14:30 – 15:30 CET – Smart Farming / Precision Agriculture 8 – Room 4

Chair: A. Comparetti

Oral Presentations

ID: 4787

Tracking grow-finish pigs across large pens using multiple cameras

A. Shirke, A. Saifuddin, A.G. Miller, I. Condotta, A. Kotnana, O. Kocabalkanli, N. Ahuja, R.N. Dilger, M. Caesar
University of Illinois at Urbana-Champaign

ID: 4681

Design and evaluation of two new seed chutes for a stanhay webb precision seed drill using discrete element modelling

D. White, W. Hook
Harper Adams University

ID: 4682

Understanding the barriers to uptake of precision livestock farming (PLF) in the uk sheep industry

D. White, A. Boothby
Harper Adams University

14:30 – 15:30 CET – Sustainable Production in Farm Buildings 7 – Room 5

Chair: A. Aarnink

Oral Presentations

ID: 4670

Ammonia and greenhouse gas emissions from norwegian cattle buildings

R.K.Tabase [1], G. Næss [1], Y. Larring [2]
[1]Nord Universitet, [2]SINTEF

ID: 4671

CFD model development of winter thermal environment and gas concentrations in a suckler cow building

R.K.Tabase[1], G. Næss[2], Y. Larring[3]
[1]Nord universitet, [2]Nord Universitet, [3]SINTEF

ID: 4697

AmmoniaN2K: ammonia emissions and ecological impacts in Ireland

D. Kelleghan [1], E.T. Hayes [2], M. Everard [2], T.P. Curran [1]
[1]University College Dublin, [2]University of the West of England

15:40 – 16:40 CET – Energy and Bioenergy 1 – Room 1

Chair: G. Papadakis

Oral Presentations

ID: 3365

Very shallow geothermal system to improve the energy efficiency in dairy barns

A. Barbaresi, F. Tinti, K. Strpic, M. Bovo, S. Benni, D. Torreggiani, E. Santolini, P. Tassinari
University of Bologna, Italy

ID: 4705

Methane emissions from cattle farms: comparison of measured emissions and inventories estimates

N.T. Vechi, C. Scheutz
Technical University of Denmark – DTU

ID: 3275

Electricity production based on an agrivoltaic system. A study case for etsiaab in UPM

G.P. Moreda, I. Molina López, M.A. Muñoz-García
UPM, Spain

Poster Presentations

ID: 4711

Agrofossilfree - strategies and technologies to achieve a european fossil-energy-free agriculture

A. Balafoutis [1], M. Moraitis [1], K. Vaiopoulos [1], C. Soerensen [2], D. Manolakos [3], A. Koutsouris [3], G. Papadakis [3], M. Borzecka [4], V. Bisevac [5], D. Creupelandt [6], J. Roman [7], F. Oudshoorn [8], D. Rossi [9], M. Prochniak [10], Z. Tsiropoulos [11], H. Brinks [12], B. Caslin [13], M. Voulgaraki [1], F. Colmorgen [14], J. Sneil [15], M. Zarranz [16]
[1]Center for Research and Technology Hellas, [2]Aarhus University, [3]Agricultural University of Athens, [4]IUNG-PIB, – State Research Institute, [5]CEMA - European Agricultural Machinery Industry Association, [6]RESCOOP.EU, [7]ECAF - European Conservation Agriculture Federation, [8]Landbrug Fodevarer F.m.b.A – L&F (SEGES), [9]CONFAGRICOLTURA, [10]LODR - LUBLIN AGRICULTURAL ADVISORY CENTER IN KONSKOWOLA, [11]AGENSO - AGRICULTURAL AND ENVIRONMENTAL SOLUTIONS, [12]DELPHY BV, [13]TEAGASC - AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY, [14]WIP - WIRTSCHAFT UND INFRASTRUKTUR GMBH & CO PLANUNGS KG, [15]TTA - TRAMA TECNOAMBIENTAL, [16]INI - INICIATIVAS INNOVADORAS

15:40 – 16:40 CET – Automation, Robotics and Sensors 3 – Room 2

Chair: G. Kootstra

Oral Presentations

ID: 2610

A nanoplasmonic sensing device for on-site detection of diclofenac molecules in water treatment plants

N. Steinke [1], R. Wuchrer [2], M. Rio [3], C. Schuster [2], G. Gerlach [4], T. Härtling [2]
[1]Fraunhofer Institute for Ceramic Technologies and Systems IKTS / Technische Universität Dresden, [2]Fraunhofer Institute for Ceramic Technologies and Systems IKTS, [3]Fraunhofer Portugal Research Center for Smart Agriculture and Water Management AWAM, [4]Technische Universität Dresden

ID: 2716

Effect of vis-nir wavelength range on the estimation of three aggregate stability indices

E. Afriyie, A. Verdoodt, A.M. Mouazen
Ghent University

ID: 4754

Remote sensing applications to improve pomegranate irrigation in Vega Baja del Segura area (Alicante, Spain)

J. Solano, H. Puerto, C. Rocamora, S. Rodriguez, J.M. Cámara- Zapata
University Miguel Hernández, Spain

ID: 4675

Robotic cultivation of pome fruit: a benchmark study of manipulation tools – from research to industrial standards

G. Schouterden, R. Verbiest, E. Demeester, K. Kellens
KU Leuven

15:40 – 16:40 CET – Soil, Land and Water Engineering 3 – Room 3

Chair: J.M. Gonçalves

Oral Presentations

ID: 3289

VSIM model adaption to qualified denomination of origin rioja soil and weather conditions

J.M. Peña, J. Arbizu, A. Tascón, F.J. Castillo-Ruiz
University of La Rioja, Spain

ID: 3290

Assessment of three different deficit irrigation strategies in super-high density olive orchard in La Rioja

J. Arbizu, F.J. Castillo-Ruiz, A. Tascón, J.M. Peña
University of La Rioja, Spain

ID: 4738

Calibration of crop coefficients of vitis vinifera l. Cv. Loureiro using simdualkc

S. Silva [1], M.I. Valín [1], S. Mendes [1], C.A. Paredes [2], J.J. Cancela [3]
[1]Instituto Politécnico de Viana do Castelo. CISAS, [2]Instituto Politécnico de Viana do Castelo. PROMETHEUS, [3]GI-1716 Projects and Planification. Agroforestry Engineering Department, EPSE

15:40 – 16:40 CET – Smart Farming / Precision Agriculture 9 – Room 4

Chair: A. Comparetti

Oral Presentations

ID: 4704

Challenges for agriculture through industry 4.0

H. Bernhardt [1], M. Bozkurt [2], R. Brunsch [3], E. Colangelo [4], A. Herrmann [2], J. Horstmann [5], M. Kraft [6], J. Marquering [7], T. Steckel [8], H. Tapken [9], C. Weltzien [3], C. Westerkamp [9]
[1]Technical University of Munich, [2]VDI, [3]Leibniz-Institut für Agrartechnik und Bioökonomie e.V., [4]Fraunhofer-Institut für Produktionstechnik und Automatisierung, [5]Maschinenfabrik Bernard KRONE GmbH & Co. KG, [6]Johann Heinrich von Thünen-Institut, [7]Jade Hochschule Wilhelmshaven, [8]CLAAS E-Systems GmbH, [9]Hochschule Osnabrück

ID: 2764

What makes the difference? State-of-the-art and new perspectives on precision- and task-oriented drones for agricultural use

F. Bakhshande, D. Söffker
University of Duisburg-Essen

ID: 4608

Outline of a regenerative agriculture system at scale: definition of required outcomes

P.W.G. Groot Koerkamp, W.J. Schouten [2], J. van Dijk [3]
[1]Wageningen University, [2]Top Institute of Food and Nutrition, [3]Utrecht University

Poster Presentations

ID: 4678

Unmanned ground vehicles in agriculture: a bibliometric review

J. Waked [1], G. Todde [1], G. Sara [1], M. Polese [1], G. Hassoun [2], F. Gambella [1], M. Caria [1]
[1]Department of Agricultural Sciences, University of Sassari, [2]Department of Agricultural Engineering and Veterinary Medicine, Lebanese University

15:40 – 16:40 CET – Sustainable Production in Farm Buildings 8 – Room 5

Chair: A. Aarnink

Oral Presentations

ID: 2657

Thermal analysis for an unrefined sugar cane processing factory in colombia by using CFD

J.D. Alvarez, R.O. Hernández
Universidad Nacional de Colombia

ID: 3334

Effect of photoconversion greenhouse films used as 'double covers' on tomato crop in Almeria (Spain)

F.D. Molina-Aiz [1], M.A. Moreno-Teruel [1], S. Lemarié [2], D.L. Valera [1], F. Peilleron [3], A. López-Martínez [1]
[1]Univeristy of Almería, [2]INRAe-IRHS, [3]Centre d'Affaires Emergence

ID: 3363

The effect of envelope features on the energy efficiency of agricultural buildings under different environmental control settings

D. Torreggiani, A. Barbaresi, M. Bovo, E. Santolini, S. Benni, P. Tassinari, D. Torreggiani
University of Bologna, Italy

Poster Presentations

ID: 4745

Influence of chromatic plastic mulches on soil temperature and yield in a tomato crop inside greenhouse

D.L. Valera, F.D. Molina-Aiz, M.A. Moreno-Teruel, A. López-Martínez, A. Peña, P. Marín-Membrive
Univeristy of Almería, Spain

17:00 – 18:00 CET – Energy and Bioenergy 2 – Room 1

Chair: G. Papadakis

Oral Presentations

ID: 2641

Evaluation of the cost-effectiveness of renewable energy sources in wineries

J.L. Garcia, C.J.P. Prieto, F.R. Mazarrón, A. Perdigones
Universidad Politécnica de Madrid, Spain

ID: 2737

Description of a pilot scale test station for measurement of static and dynamic loads in silos under different conditions

R.M. Gandia[1], W.C. Paula[2], F.C. Gomes[2], P.J. Aguado Rodriguez[3]
[1]Federal University of Lavras (Brasil), [2]Federal University of Lavras (Brazil), [3]University of Leon (Spain)

ID: 2740

Experimental and numerical study of silo filling using pellets

R.M. Gandia[1], A.R. Padin[2], G.H. Rodrigo[2], L.H. Ortega[2], A.T. Vegas[3], P.J. Aguado Rodriguez[2]
[1]Federal University of Lavras (Brazil), [2]University of Leon (Spain), [3]Universidad de La Rioja (Spain)

Poster Presentations

ID: 2701

Study of agronomic characteristics of 11 clones of ulmus pumila l. For use as an energy crop

I. Bautista, M.C. Amorós, J.R. Fernández, D. Mostaza, P.V. Mauri
IMIDRA

17:00 – 18:00 CET – Automation, Robotics and Sensors 4 – Room 2

Chair: G. Kootstra

Oral Presentations

ID: 4623

Mobile robot weeder prototype for cotton production

J.M. Maja[1], M. Cutulle[1], E. Barnes[2], J. Enloe[1], J. Weber[1]
[1]Clemson University, [2]Cotton Incorporated

ID: 3214

Cityveg: a robotic platform for urban vegetable production

M. Moraitis, K. Vaiopoulos, A. Balafoutis
Centre for Research and Technology Hellas, Greece

ID: 4759

Single plant fertilization using a robotic platform in an organic cropping environment

C. Valero[1], A. Krus[1], C.C. Ulloa[2], A. Barrientos[2], J. D. Cerro[2], J.J. Ramírez[1]
[1]Universidad Politecnica de Madrid, [2]Centre for Automation and Robotics (UPM-CSIC)

17:00 – 18:00 CET – Soil, Land and Water Engineering 4 – Room 3

Chair: J.M. Gonçalves

Oral Presentations

ID: 4737

Influence of irrigation and nitrogen fertilization on kiwifruit production

R. Pinto [1], M.I. Valín [2], L.M. Brito [3], R. Rego [1], C. Cardoso [1], N.M. Ponte [4], I. Mourão [3], R. Rodrigues [2], L. Moura [2]
[1]Instituto Politécnico de Viana do Castelo., [2]CISAS, Instituto Politécnico de Viana do Castelo, [3]CIMO, Instituto Politécnico de Viana do Castelo, [4]LAQV-REQUIMTE, Faculty of Science (FCUP), University of Porto

17:00 – 18:00 CET – Smart Farming / Precision Agriculture 10 – Room 4

Chair: A. Comparetti

Oral Presentations

ID: 4603

Detection of leek rust and white tip disease under field conditions using hyperspectral proximal sensing and supervised machine learning

S. Appeltans, J. Pieters, A.M. Mouazen
Ghent University

ID: 3213

Optima - optimised integrated pest management for precise detection and control of plant diseases in perennial crops and open-field vegetables

A. Balafoutis [1], M. Moraitis [1], N. Mylonas [2], S. Fountas [2], D. Tsitsigiannis [2], P. Balsari [3], M. Pugliese [3], E. Gil [4], D. Nuyttens [5], G. Polder [6], F. Freire [7], J.P. Sousa [7], M. Briande [8], V.l. Clerc [8], J.P. Douzals [9], A. Caffini [10], L.T. Berger [11], Z. Tsiropoulos [12], D. Eberle [13], S. Bellalou [14], M. Roth [15]
[1]Centre for Research and Technology Hellas, [2]Agricultural University of Athens, [3]University of Turin, [4]University Polytechnic Cataluna, [5]Instituut voor Landbouw-, Visserij-en Voedingsonderzoek, [6]Wageningen University & Research, [7]University of Coimbra, [8]Agrocampus Ouest, [9]INRAe, [10]CAFFINI, [11]FEDE Pulverizadores, [12]AGENSO, [13]Terre da Vino, [14]INVENIO, [15]European Crop Protection Association

ID: 4720

Effect of plant-growth stage on the performance of a weed-detection system

T. Ruigrok, J. Blom, G. Kootstra, E.V. Henten
Wageningen University and Research

17:00 – 18:00 CET – Sustainable Production in Farm Buildings 9 – Room 5

Chair: A. Aarnink

Oral Presentations

ID: 3216

Novelties in the revised eurocode 1994, part 4: actions on silos and tanks

F. Ayuga, E. Gallego, J. M. Fuentes
Universidad Politécnica de Madrid, BIPREE research group, Spain

ID: 3342

Differences in yield and water consumption in a tomato crop irrigated with desalinated seawater blended with well water

P. Marín-Membrive, D.L. Valera, F.D. Molina-Aiz, A. Peña, A. López-Martínez, M.A. Moreno-Teruel, J. Reca
University of Almería, Spain

Scientific Program, July, 7

10:00 – 11:00 CET – Post Harvest Technologies 1 – Room 1

Chair: P. Barreiro

Oral Presentations

ID: 2542

Prediction of flavour of tomatoes using non-destructive sensors

J.L. Ruizendaal, G. Polder, C.W. Labrie, R.R. de Jong
Wageningen University and Research

ID: 3180

Prototype plant operating at very low temperatures for quick freezing

A. Biglia[1], P. Barge[1], M. Bilardo[2], L. Comba[1], E. Fabrizio[2], D. Ricauda Aimonino[1], C. Tortia[1], P. Gay[1]
[1]DiSAFA – University of Turin, [2]DENERG – Politecnico of Turin

10:00 – 11:00 CET – Education and Rural Development 1 – Room 2

Chair: F. Ayuga

Oral Presentations

ID: 4607

State of the art on degree study programs in agricultural/biosystems engineering in EU

A. Comparetti, P. Febo
University of Palermo, Italy

ID: 2736

Attitude of spanish agriculture students towards education in sustainable precision agriculture

A. Krus [1], J. Karouta [2], J.J.R. Montoro [1], A. Michailidis [3], D. Andújar [2], C. Valero [1]
[1]Universidad Politécnica de Madrid, [2]Consejo Superior de Investigaciones Científicas, [3]Aristotle University of Thessaloniki, Greece

10:00 – 11:00 CET – SFARM 1 – Room 3

Chair: V.F. Cruz

Oral Presentations

ID: SFARM 1

Sustainable farming

G. Papadakis, E. Dimitriou
Agricultural University of Athens, Greece

ID: SFARM 2

Sustainable farming – SFARM – an ERASMUS+ KA2 project: capacity building in the field of higher education

E. Dimitriou[a*], G. Papadakis[a], P. Lourenço[b], V.F. Cruz[b], F. Baptista[b], P. Picuno[c]
[a]Agricultural University of Athens, Greece; [b]MED - Universidade de Évora, Portugal; I[c]University of Basilicata, Italy

ID: SFARM 3

Training and learning needs for MSC programs in sustainable agriculture

P. Lourenço[1], F. Baptista[1], V.F. Cruz[1], L.L. Silva[1], J.R. Silva[1], A. Sousa[1], E. Dimitriou[2], P. Picuno[3], G. Papadakis[2]
[1]MED - Universidade de Évora, Portugal, [2]Agricultural University of Athens, Greece, [3]University of Basilicata, Italy

10:00 – 11:00 CET – Smart Farming / Precision Agriculture 13 Room 4

Chair: W. Júnior

Oral Presentations

ID: 4727

Linking soil nitrate-nitrogen and crop nitrogen uptake by means of sensor support

F. Argento[1], T. Anken[1], F. Liebisch[1], M. Simmler[1], C. Ringger[1], A. Walter[2]
[1]Agroscope, [2]ETH Zürich

ID: 4714

New approaches for improving nitrogen efficiency based on clustering algorithms

P. Kastenhofer, P. Prankl, P. Riegler-Nurscher, J. Prankl
Josephinum Research

ID: 4610

Study on deployment of a truecolor sensor array for dual use - weed detection and n-fertilizer application

A. Christ, O. Schmittmann, P.S. Lammers
Institute of Agricultural Engineering - University of Bonn

Poster Presentations

ID: 4689

Granulometric parameters of solid blueberry fertilizers and their suitability for precision-fertilization

T. Lillerand, I. Virro, J. Olt
Estonian University of Life Sciences

10:00 – 11:00 CET – Smart Farming / Precision Agriculture 14
Room 5

Chair: J.R. Silva

Oral Presentations

ID: 2770

State machine-based model for estimation and prediction of above ground biomass in corn during vegetative stage

L. Owino, D. Söffker
University of Duisburg-Essen

ID: 2779

Modeling and prediction of corn growth during vegetative phase

L. Owino, D. Söffker
University of Duisburg-Essen

ID: 4622

The effect of image patch size on cnn-based just-in-time biomass yield estimators

P. O'Byrne [1], P. Jackman [1], D. Berry [1], T. Lee [1], M. French [2], R.J. Ross [1]
[1]Technological University Dublin, [2]Tanco Autowrap

11:10 – 12:00 CET – Post Harvest Technologies 2 – Room 1

Chair: P. Barreiro

Oral Presentations

ID: 4722

A comparative study on existing interventions for tackling post-harvest losses in developing countries

W. Ereku, M.L. Franco-García, M.A. Heldeweg
University of Twente

ID: 4729

Potential of nirs technology for the determination of cannabinoid content in industrial hemp (cannabis sativa l.)

C. Jaren, P.C. Zambrana, C. Perz-Roncal, A. Lopez-Maestresalas, A. Abrego, S. Arazuri
Universidad Pública de Navarra, Spain

11:10 – 12:00 CET – Education and Rural Development 2 – Room 2

Chair: F. Ayuga

Oral Presentations

ID: 1886

Analysis to map invasive plant species along roads: performance of different obia software

P. Lourenço [1], N. Sillero [2], A.C. Teodoro [3]
[1]MED, - University of Evora, [2]CIGGE - University of Porto, [3]University of Porto

ID: 3165

Acquisition of knowledge through creativity and leadership in a multidisciplinary environment

M.A. Muñoz-Garcia, L-O Guanaga Arrieta, S. Benito-Hernandez, G. Moreda Cantero, A. Moya Gonzalez
UPM, Spain

ID: 4751

Curriculums on smart greenhouses in the framework of the neghtra project

J.M. Cámara- Zapata [1], C. Rocamora [1], H. Puerto [1], J.A.S. Molina [2], F. Rodríguez [2], E. Schettini [3], G. Vox [3], A. Kavga [4], F. Baptista[5]
[1]University Miguel Hernández, [2]University of Almería, [3]University of Bari, [4]University of Patras, [5] MED, University of Evora

11:10 – 12:00 CET – SFARM 2 – Room 3

Chair: E. Dimitriou

Oral Presentations

ID: SFARM 4

An exploration of case method in cultivating innovation ability of agricultural postgraduates

L Huang, F Xiong, A.M Ni

Three Gorges University, China

ID: SFARM 5

The accreditation as quality assurance of higher education program

M. Melati, E. Santosa, I.Z. Siregar, D.P. Hapsari

IPB University, Indonesia

ID: SFARM 6

Description and scope of the accreditation process masters program of agroecotechnology, Universitas Syiah Kuala - Indonesia

Samadi, R. Sriwati, Zaitun, Syafrudin, Hasanuddin

Universitas Syiah Kuala, Indonesia

11:10 – 12:00 CET - Smart Farming / Precision Farming 12 – Room 4

Chair: W. Júnior

Oral Presentations

ID: 2675

A practical iot based tool to help farmers identify silage spoilage: a case study

I. Pölönen [1], G. Hattingh [1], A. Suokannas [2], O. Koskela [1], R. Laine [3]

[1]Hamk University of Applied Science, [2]Natural Resources Institute Finland, [3]HAMK University of Applied Science

ID: 4749

Simulation of variable rate manure application under different schemes

J. Zhang, A. Guerrero, A.M. Mouazen

Faculty of Bioscience Engineering, Ghent University

ID: 4799

Bluetooth low energy (BLE) and passive RFID integration for obstacle avoidance and autonomous vehicles management in agriculture

D. Monarca [1], P. Rossi [1], P.L. Mangiavacchi [1], M. Pirozzi [3], L. Di Donato [3], L. Tomassini [3], P. Febo [2], F. Cossio [1], M. Cecchini [1]
[1]Universita degli Studi della Tuscia, [2]Università di Palermo, [3]INAIL - Laboratorio Macchine e Attrezzature di Lavoro

11:10 – 12:00 CET - Smart Farming / Precision Farming 15 – Room 5

Chair: J.R. Silva

Oral Presentations

ID: 4789

Yield estimation in tablegrape using the pronofrut it-supported methodology

D. Wulfsohn [1], I. Zamora [2]
[1]Geco Enterprises, [2]Dayenu Ltda

ID: 4790

Pronofrut sampler: smartphone application for sampling and yield estimation of specialty crops

D. Wulfsohn [1], J.E. Gardi [2], I. Zamora [2]
[1]Geco Enterprises, [2]Dayenu Ltda

ID: 4617

The effect of laser radiation for selective blossom thinning in Apple

P. Netsawang [1,3], L. Damerow [1], M. Blanke [2], P. Schulze Lammers[1]
[1]Institute of Agricultural Engineering, University of Bonn, Germany, [2]Institute of Crop Sciences and Resource Conservation (INRES), University of Bonn, Germany, [3]Faculty of Engineering, Rajamangala University of Technology Lanna, Thailand

12:30 – 13:30 CET – SFARM 3 – Room 3

Chair: P. Lourenço

Oral Presentations

ID: SFARM 7

Master of science in sustainable agronomy programme in Champasack University

T. Sychanh, S. Southavong, K. Khamphila, N. Phounsavath
Champasack University, Laos

ID: SFARM 8

Master program development on sustainable farming in savannakhet university (SKU), Laos

S. Khemmarath
Savannakhet University, Laos

ID SFARM: 9

Impact evaluation of SFARM project in hue agriculture and forestry (HUAF) university and tay nguyen university (TTN), in Vietnam

D. Nguyen[1], A. Do[1], N.V. Nam[1], L.T.T. Hang[2]
[1]Tay Nguyen University, Vietnam, [2]Hue Agriculture and Forestry University, Vietnam

12:30 – 13:30 CET – Smart Farming / Precision Agriculture 15 – Room 4

Chair: W. Júnior

Oral Presentations

ID: 4707

ICT-agri-food fosters the digital transformation towards sustainable and resilient agri-food systems

J. Pfeifer, E. Saggau
German Federal office for agriculture and food (BLE)

ID: 3759

Encouraging the adoption of precision fertilization technologies: steps from theory to practice

M. Cutini, C. Bisaglia, E. Romano, M. Brambilla, A. Assirelli
CREA Research Centre for Engineering and Agro-Food Processing

ID: 4756

Spatio-temporal study of tree volume in response to soil eca using mobile lidar laser scanner in sweet cherry orchard

K.K. Saha, N. Tsoulias, M.Z. Sasse
Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)

12:30 – 13:30 CET – Smart Farming / Precision Agriculture 16
Room 5

Chair: J.R. Silva

Oral Presentations

ID: 2738

Unsupervised semantic interpretation of 3D point clouds of vineyards for precision agriculture

L. Comba [1], A. Biglia [1], S. Zaman [1], D. R. Aimonino [1], F. Dabbene [2], P. Gay [1]
[1]University of Turin - DiSAFA, [2]Institute of Electronics, Computer and Telecommunication Engineering (IEIIT)

ID: 4612

Estimating soybean yield spatial variability within-field scale through google earth engine in northeast Italy

A. Zanchin, M. Sozzi, F. Marinello, A. Kayad
University of Padua, Italy

ID: 4719

Data fusion modeling of visible, near infrared and mid infrared spectra

S.H. Javadi, A.M. Mouazen
Ghent University

Poster Presentations

ID: 4683

Evaluation of smart glasses for augmented reality: technical advantages on their integration in agricultural systems

G. Sara, G. Todde, M. Polese, M. Caria
Department of Agricultural Sciences, University of Sassari

EurAgeng 2021

Poster Virtual Room

AI - artificial intelligence

ID: 2774

Prediction of ambient temperature for agricultural applications using anns: a case study in Castile and León, Spain

L.M. Navas-Gracia [1], F.J. Diez [1], A. Martínez-Rodríguez [1], A.C. Guimaraes [1], L. Chico-Santamarta [2]
[1]University of Valladolid, [2]Harper Adams University

ID: 4709

Characterization of floating waste by means of artificial intelligence. Preliminary results

C. Rocamora, A. Codes, H. Puerto, R. Abadía
Universidad Miguel Hernandez, Spain

ID: 4730

Flower monitoring in a hedge almond orchard with image analysis

A.B. Dias [1], A.C. Gonçalves [1], P.L. Donno [2]
[1]MED, Universidade de Évora, [2]Torre das Figueiras Soc. Agrícola Lda

A - Automation, Robotics and Sensors

ID: 2909

Capacity and limitations of colour image processing to detect tetranychus urticae in citrus leaves

M.G. González-González, P. Chueca, S. Cubero, J. Blasco
Instituto Valenciano de Investigaciones Agrarias (IVIA), Spain

ID: 4632

Potential of vis-nir hyperspectral imaging to detect automatically tetranychus urticae in citrus leaves

M.G. González- González, P. Chueca, S. Cubero, J. Blasco
Instituto Valenciano de Investigaciones Agrarias (IVIA), Spain

ID: 6000

Towards a phenotype classification of agricultural robots

G. Anacoreta, M. Medici, M. Canavari
University of Bologna, Italy

CE - Circular Economy

ID: 2537

Modelling the remaining value of grape harvesters according to asabe and comparison with other statistical approaches

P. Barreiro[1], W.V.C. Neto[2]
[1]UPM, [2]UniPampa, Campus Dom Pedrito

ID: 2816

The circular economy in the street food sector through the reuse of a naval shipping container

A. Casson, V. Giovenzana, A. Tugnolo, R. Beghi, A. Pampuri, R. Guidetti
Università degli Studi di Milano, Italy

ID: 4755

Environmental impact assessment of a aquaculture production systems using the life cycle approach

A. Vatsanidou, V. Anestis, I. Skoufos, A. Tzora, T. Bartzanas
Agricultural University of Athens

ID: 4782

The mediterranean diet potential – how do specific dietary choices can affect the portuguese nitrogen footprint?

S. Cruz [1], J. Marinheiro [1], C.M.S. Cordovil [1], A. Leach[2], J. Galloway[3]
[1]Instituto Superior de Agronomia, [2]University of New Hampshire, [3]University of Virginia

ID: 4688

A smart fertilization model: a study of multidisciplinary methods in monitoring fertilization in turfgrass

J.F. Marin [1], S. Yousfi [2], L. Parra [3], G.D.L. Horra [1], P.V. Mauri [2]
[1]AREA VERDE, [2]IMIDRA, [3]UPV IMIDRA

E - Education and Rural Development

ID: 2705

Study of the use of mobile devices in the classroom within agricultural engineering

J.L. Garcia[1], A. Perdigones[1], F.R. Mazarrón[1], C.J.P. Prieto[1], I. Cañas[1]
Universidad Politécnica de Madrid, Spain

ID: 4634

Diagnosis and assessment of visual impacts for aesthetics improvement of jerte valley municipalities (Spain)

J.H. Blanco, M.M.J. Martín, J.G. Velarde, M.J.M. Parejo
University of Extremadura, Spain

EB - Energy and Bioenergy

ID: 2701

Study of agronomic characteristics of 11 clones of ulmus pumila l. For use as an energy crop

I. Bautista, M.C. Amorós, J.R. Fernández, D. Mostaza, P.V. Mauri
IMIDRA

ID: 3765

A simplified algorithm for the optimal setting of the factors affecting agricultural tractor fuel consumption during heavy drawbar tasks

M. Cutini, C. Bisaglia, M. Brambilla, D. Pochi, R. Fanigliulo
CREA Research Centre for Engineering and Agro-Food Processing

ID: 4711

Agrofossilfree - strategies and technologies to achieve a european fossil-energy-free agriculture

A. Balafoutis [1], M. Moraitis [1], K. Vaiopoulos [1], C. Soerensen [2], D. Manolakos [3], A. Koutsouris [3], G. Papadakis [3], M. Borzecka [4], V. Bisevac [5], D. Creupelandt [6], J. Roman [7], F. Oudshoorn [8], D. Rossi [9], M. Prochniak [10], Z. Tsiropoulos [11], H. Brinks [12], B. Caslin [13], M. Voulgaraki [1], F. Colmorgen [14], J. Sneil [15], M. Zarranz [16]
[1]Center for Research and Technology Hellas, [2]Aarhus University, [3]Agricultural University of Athens, [4]IUNG-PIB, – State Research Institute, [5]CEMA - European Agricultural Machinery Industry Association, [6]RESCOOP.EU, [7]ECAF - European Conservation Agriculture Federation, [8]Landbrug Fodevarer F.m.b.A – L&F (SEGES), [9]CONFAGRICOLTURA, [10]LODR - LUBLIN AGRICULTURAL ADVISORY CENTER IN KONSKOWOLA, [11]AGENSO - AGRICULTURAL AND ENVIRONMENTAL SOLUTIONS, [12]DELPHY BV, [13]TEAGASC - AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY, [14]WIP - WIRTSCHAFT UND INFRASTRUKTUR GMBH & CO PLANUNGS KG, [15]TTA - TRAMA TECNOAMBIENTAL, [16]INI - INICIATIVAS INNOVADORAS

ISF - Integrated and Sustainable Farming Systems

ID: 3080

The team matters: mechanical apple harvest platform efficiency and yield quality depends on the individual picker's assignment and team size

Y. Salzer [1], E. Yonai [2], S. Kfir [3], Y. Yechezkely [4], A. Naor [3]
[1]Agricultural Research Organization - Volcani Center, [2]Beresheet Corporation, [3]Northern Agriculture R&D Organization, Israel, [4]Agricultural Extension Service of Israel - Shaham, Israel

ID: 4735

Effect of mechanical pruning on olive yield in a high density olive orchard – an account of 14 years

A.B. Dias [1], J.M. Falcão [2], A. Pinheiro [1], J.O. Peça [1]
[1]MED, Universidade de Évora, [2]Torre das Figueiras Soc. Agrícola Lda

ID: 4783

Innovative agricultural technologies - decreasing the nitrogen footprint of tomato production

S. Cruz [1], C.M.S. Cordovil [1], C. Carrasqueira [1], J.S. Silva [2], T. Ribeiro [3]
[1]ISA, Universidade de Lisboa, [2]Centro de Competências para o Tomate Indústria, [3]Benagro

ID: 4786

Sustainable agricultural practices on vineyard production – portuguese wine of low nitrogen footprint

C. Cordovil [1], S. Cruz [1], C. Rego [1], P. Baptista [2], S. Martins [3], A.M. Santos [4]
[1]ISA, Universidade de Lisboa, [2]Fundação Eugénio de Almeida, [3]Lusovini Distribuição, S.A., [4]Reguenguinho Sociedade Agrícola Lda

ID: 4797

Effect of frequency irrigation on yield and biometrics characteristics of table olives (olea europaea l., cv. Negrinha de Freixo) under full and sustained deficit irrigation

D. Barreales [1], A. Monteiro [2], S. Capitão [2], D.C. Oliveira [2], R.A. Lack [2], T.T. Grabowski [2], A.F. Silva [3], A.C. Ribeiro [1]
[1]CIMO, ESA, Instituto Politécnico de Bragança, [2]ESA, Instituto Politécnico de Bragança, [3]CITAB, Universidade de Trás-os-Montes

NATM - New Application Technologies and Mechanization

ID: 2624

Laboratory scale dewatering analysis of poultry manure via cylinder-piston batch separator

P. Neysari [1], M.H. Kianmehr [2], A. Arabhosseini [2]
[1]Wageningen University and Research, [2]University of Tehran

ID: 3316

Innovative tractor hitched prototype design from the demand side

F.J. Castillo-Ruiz[1], [2], S. Peña Valero[1],[3], G.L. Blanco-Roldán[1], F.M.L. del Río[1], J.A. Gil-Ribes[1]
[1]University of Cordoba, Spain, [2]University of La Rioja, Spain, [3]Construcciones Mecánicas Alcay, Spain

ID: 3793

Mechanical compression strength analysis in jabre paths stabilized with cement. Comparison cem I 42.5R with cem II A-V 42.5N

C. Gilarranz[1], S. Laserna, J.E. Gómez[2], J. Montero[2]
[1]Universidad Politécnica de Madrid, [2]Universidad de Castilla-La Mancha

ID: 4731

Development of a machine to remove by-products with brown spot disease inoculum from pear orchards

A.B. Dias, M.C. Martins, C. Rasteiro, A. Garcia, S. Isaque, R. Gomes, M.J. Batista, R. Antunes, J. Azevedo, J.P. Luz, C. Amaro
[1]MED, Universidade de Évora, [2]Centro Operativo e Tecnológico Hortofrutícola nacional (COTHN), [3]Coopval - Cooperativa Fruticultores Cadaval, [4]Frutus - Estação Fruteira de Montejunto, CRL, [5]CPF Central Produção e Comercial Hortofrutícola, Lda, [6]Cooperativa Agrícola do Bombarral, [7]Frutoeste - Cooperativa Agricola de Horticultores do Oeste, [8]Associação dos Produtores Agrícolas da Sobrena (APAS), [9]Escola Superior Agrária do Instituto Politécnico de Castelo Branco

ID: 4685

Aerodynamic properties of chopped rye grass

B. Alizadeh, T. Leblicq, W. Saeys
KU Leuven

PH - Post Harvest Technologies

ID: 2535

First results of the spectral analysis of cantina oils

P. Barreiro, L. Lleó
UPM, Spain

ID: 2815

Shelf life evaluation of fresh cut valerianella locusta l. Through packaging by visible/near infrared spectroscopy

R. Beghi, A. Tugnolo, A. Pampuri, A. Casson, R. Guidetti, V. Giovenzana
Università degli Studi di Milano, Italy

ID: 3830

Discrimination of common defects on 'algerie' loquat fruit using hyperspectral imaging and machine learning techniques

S. Munera [1], A. Prieto [1], J. G. Sanchis [2], N. Aleixos [3], J. V. Francés [2], S. Cubero [1], E. Soler [4], G. Colelli [5], J. Blasco [1]
[1]Centro de Agroingeniería, Instituto Valenciano de Investigaciones Agrarias, [2]Departamento de Ingeniería Electrónica, Universitat de València, [3]Departamento de Ingeniería Gráfica, Universitat Politècnica de València, [4]Cooperativa de Callosa d'en Sarrià, [5]Departament of Science of Agriculture, Food and Environment, University of Foggia

ID: 4644

Prediction of internal quality properties of pomegranate fruits using hyperspectral imaging

S. Munera [1], A. Prieto [1], F. Hernández [2], N. Aleixos [3], S. Cubero [1], J. Blasco [1]
[1]IVIA, [2]UMH, [3]UPV

ID: 4646

Study on ultraviolet light-induced fluorescence of citrus fungal decay in different citrus varieties

A. Prieto [1], G. Ancillo [1], L. Palou [1], S. Munera [1], S. Cubero [1], N. Aleixos [2], J. Blasco [1]
[1]IVIA, [2]UPV

SF - Smart Farming / Precision Agriculture

ID: 2719

Analysis of camelina sativa cultivation through on-field sensors and remote sensing

D. Mostaza [1], L. Díaz [2], A. García [2], P.V. Mauri [1], A. Capuano [3]
[1]IMIDRA, [2]Universidad de Alcalá, [3]Camelina Company Spain

ID: 2769

Development of the technical structure of the "cow energy" concept

H. Bernhardt [1], J. Stumpenhausen [2]
[1]Technical University of Munich, [2]University of Applied Scienes Weihenstephan-Triesdorf

ID: 2570

Design and implementation of dust organic treatment in vines to prevent fungal infections

T. Diaz-Riquelme[1], A. Morante-Diaz[2], A. Rabasco-Gata[3], M.V. Serrano-Sanchez[4], F. Gonzalez-Rodríguez[2], J. Anchuelo[5], P. Barreiro-Elorza[3], F. Cabello-Sanz[1]
[1]IMIDRA, [2]Farmer, [3]LPF_TAGRALIA, UPM-CEI Moncloa, [4]farmer, [5]UPA Madrid

ID: 2573

Determining critical points in order to reduce fruit damages in fresh stone fruit packing lines

C. Ortiz, R. Mahiques, A.T. Mira
Universitat Politècnica de València, Spain

ID: 3691

Innoseta – innovative spraying equipment training advising

E. Gil [1], M. Moraitis [2], A. Balafoutis [2], S. Fountas [3], P. Balsari [4], D. Nuyttens [5], S. Codis [6], V. Bisevac [7], M. Roettele [8], N. Peric [9], J. M. Roche [10], D. Donkers [11], Z. Tsiropoulos [12], D. Rossi [13], E. Nilsson [14], P. Mazur [15]
[1]Universitat Politècnica de Catalunya (UPC), [2]Centre for Research and Technology Hellas (CERTH), [3]Agricultural University of Athens (AUA), [4]Università degli Studi di Torino (UNITO), [5]Instituut voor landbouw- en visserijonderzoek (ILVO), [6]Institut Français de la Vigne et du Vin (IFV), [7]European Agricultural Machinery Association (CEMA), [8]European Crop Protection Association (ECPA), [9]European Farmers and Cooperatives Association (COPA-COGECA), [10]Unión de Pequeños Agricultores (UPA), [11]ZLTO, [12]Agricultural & Environmental Solutions (AGENSO), [13]Confagricoltura, [14]VISAVI, [15]ZODR

ID: 3778

Smart agricultural monitoring and management of barley based on the use of NDVI satellite images and close detection sensors

J. F. Palma [1], M. Sampaio [1], A. Tomaz [2], J. Dôres [1], M. I. Patanita [1], I. Guerreiro [1], J. Penacho [1], M. Patanita [2], M. Regato[1]
[1]IPBeja - Escola Superior Agrária, [2]IPBeja - Escola Superior Agrária / GeoBioTec. FCT-Nova, Universidade Nova de Lisboa

ID: 4678

Unmanned ground vehicles in agriculture: a bibliometric review

J. Waked [1], G. Todde [1], G. Sara [1], M. Polese [1], G. Hassoun [2], F. Gambella [1], M. Caria [1]
[1]Department of Agricultural Sciences, University of Sassari, [2]Department of Agricultural Engineering and Veterinary Medicine, Lebanese University

ID: 4683

Evaluation of smart glasses for augmented reality: technical advantages on their integration in agricultural systems

G. Sara, G. Todde, M. Polese, M. Caria
Department of Agricultural Sciences, University of Sassari

ID: 4689

Granulometric parameters of solid blueberry fertilizers and their suitability for precision-fertilization

T. Lillerand, I. Virro, J. Olt
Estonian University of Life Sciences

ID: 4741

Evaluation of livestock vehicle disinfection systems using aerodynamic simulations

L. Choi [1], J. Park [2], S. Lee [1], H. Jeong [1], SW. Hong [3]
[1]Department of Rural and Biosystems Engineering, Chonnam National University and Education and Resear, [2]AgriBio Institute of Climate Change Management, Chonnam National University, [3]Chonnam National University

ID: 4802

Remote sensing-based agri-environmental indicators for a cost-effective monitoring and assessment of agroecosystems

A. Gil[1], P. Lourenço[2]
[1]Instituto de Investigação em Vulcanologia e Avaliação de Riscos (IVAR), Universidade dos Açores, [2]AgroInsider

SW - Soil, Land And Water Engineering

ID: 2842

Characterization of floating waste in the Vega Baja del Segura district

C. Rocamora, H. Puerto, R. Abadia, M. Brugarolas, L.M. Carrasco, J. Cordero
Universidad Miguel Hernandez, Spain

ID: 4770

Analysis of the effects of reducing fine dust and fugitive dust by crop cultivation in reclaimed land

S.W. Lee, I.H. Seo, E.A. Sun
Jeonbuk National University

SPFB - Sustainable Production In Farm Buildings

ID: 2686

Evaluation of the effects of antidrip and uv transmission properties of polyethylene films on a greenhouse strawberry crop

N. Katsoulas, A. Bari, T. Georgopoulou, C. Papaioannou
University of Thessaly, Greece

ID: 3343

Influence of different cooling systems on the photosynthetic activity and yield of greenhouse tomato crops

D.L. Valera, F.D. Molina-Aiz, M.A. Moreno-Teruel, A. López-Martínez, A. Peña, P. Marín-Membrive
University of Almería, Spain

ID: 4712

Modeling atmospheric dispersion of particulate matters emission from livestock using aermod

S. Lee [3], J. Park [1], H. Jeong [3], L. Choi [3], S.W. Hong [2]
[1]AgriBio Institute of Climate Change Management, Chonnam National University, [2]Chonnam National University, [3]Chonnam National University and Education and Research

ID: 4633

The D5 Silo of Manganeses de la Lampreana (Zamora): history, construction characteristics and technology

V. Marcelo, J.B.Valenciano, F.J. Lopez, P. Pastrana
Universidad de León, Spain

ID: 4742

A preliminary study for measuring pesticide spray drift by aerial application

J. Park [1], S.W. Hong [2], S. Lee [3], H. Jeong [3], L. Choi [3]
[1]AgriBio Institute of Climate Change Management, Chonnam National University, [2]Chonnam National University, [3]Chonnam National University and Education and Research

ID: 4745

Influence of chromatic plastic mulches on soil temperature and yield in a tomato crop inside greenhouse

D.L. Valera, F.D. Molina-Aiz, M.A. Moreno-Teruel, A. López-Martínez, A. Peña, P. Marín-Membrive
Univeristy of Almería, Spain

ID: 4747

Effects on the microclimate of the use of low tunnels inside greenhouses

A. López-Martínez A.[1], F.D. Molina-Aiz [1], D.L. Valera [1], A. Peña [1], M.A. Moreno-Teruel [1], P. Marín-Membrive [1]
[1]*CIAIMBITAL, University of Almería*

ID: 4748

Effect of photoconversion films used as greenhouse double roof on the development of cucumber fungal diseases in Spain

E. Ávalos-Sánchez [1], A. López-Martínez [1], F.D. Molina-Aiz [1], S. Lemarié [2], F. Peilleron [3], M.A. Moreno-Teruel [1], D.L. Valera [1]
[1]*CIAMBITAL, University of Almería,* [2]*INRAe-IRHS Campus du Végétal,* [3]*Centre d'Affaires Emergence*

ID: 4753 - LivAge

Ammonia and GHG emissions from livestock buidlings – LivAGE cost action

A. Aarnink, G. Arsenos, T. Bartzanas, S. Calvet, P. Demeyer, M. Hassouna, S. Ivanova, Ş. Gülzari, K. Kamila, S. Schrade, G. Zhang
Agricultural University of Athens, Greece

ID: 6001

Enabling smart livestock farming technologies for environmental sustainability using blockchain

T. Bartzanas[1], V. Anestis[1], Z. Tsiropoulos[2], V. Anastasiou[2]
[1] *Agricultural University of Athens, Greece,* [2] *Agricultural and Environmental Solutions – Agenso, Greece*

Online Workshop

Integrated Multi-Trophic systems for sustainable fish and crops production Results from the pilots and experiments of the PRIMA project "SIMTAP"

7 July 2021, 14-17 h (CEST – Italian time)

Organized by the PRIMA project "Self-sufficient Integrated Multi-Trophic AquaPonic systems for improving food production sustainability and brackish water use and recycling – SIMTAP"

14.00 Welcome

Introduction: improving sustainability and circularity in fish and crop production
- Alberto Pardossi, SIMTAP project Coordinator

Integrated Multi-Trophic systems: the SIMTAP pilots and results
- The SIMTAP project - Alberto Pardossi (University of Pisa, Italy)
- Concept of the SIMTAP prototype in Italy: objectives, design, and preliminary results - Carlo Bibbiani (University of Pisa, Italy)
- New diets for SIMTAP application: preliminary experiments and results in Italy - Baldassare Fronte (University of Pisa, Italy)
- Interaction of aquatic species in coastal pond IMTA: a case study in Charentes (France) - Joël Aubin, Christophe Jaeger, Vincent Gayet (INRAE, France)
- Concept of the SIMTAP prototype in Turkey: objectives, design, and studies - Mehmet Ali T. Kocer (Mediterranean Fisheries Research Production and Training Institute, Antalya, Turkey)
- Fish growth in a SIMTAP prototype and dietary inclusion potential of polychaetes meal in terms of self-sufficiency - Hüseyin Sevgili (University of Applied Sciences, Isparta, Turkey)
- Smart monitoring and control, energy efficiency and optimal location of SIMTAP - Daniele Torreggiani, Alberto Barbaresi (University of Bologna, Italy).
- General approach and methodology for the assessment of SIMTAP sustainability - Giuseppe Coppola, Jacopo Bacenetti (University of Milano, Italy)

16.30-17.00: Q&A and Discussion

The participation is open and free for everybody (even if not registered to the EurAgEng Conference). REGISTRATION: https://forms.office.com/r/sYUHTSEH7x. The webinar will be held on the Teams platform. After registering you will receive the link to join the webinar. For more info: daniele.torreggia ni@unibo.it.

University of Bologna · University of Milano · Korolev GmbH · INRA UMR SAS Sol Agro et hydrosystème Spatialisation · Lycée de la Mer et du Littoral · Ministry for the Environment, Sustainable Development & Climate Change · Mediterranean Fisheries Research Production and Training Institute · University of Pisa

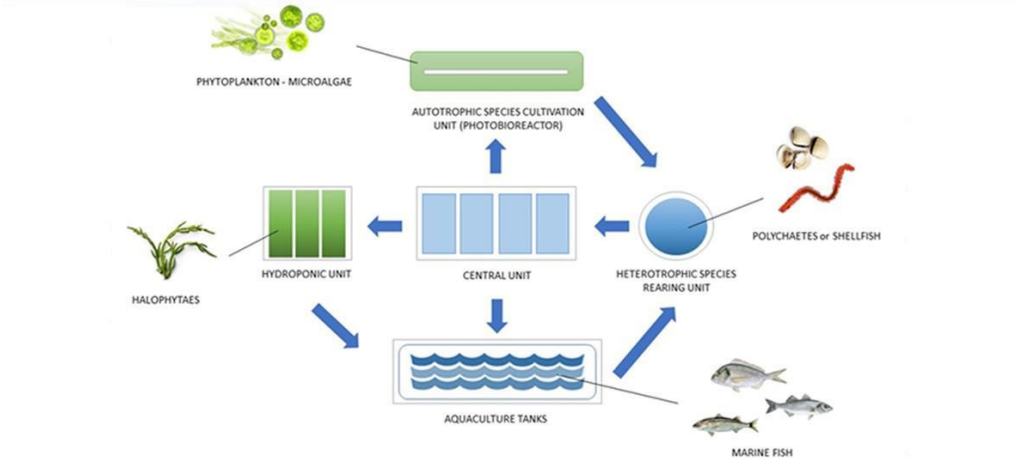
The SIMTAP project at a glance

The SIMTAP project, funded by the PRIMA program (Partnership for Research and Innovation in the Mediterranean Area), started in June 2019, and is aimed at designing, developing and testing a water-recirculating closed-cycle multitrophic system for the production of marine fish and crops for fresh consumption or the extraction of active ingredients for nutraceuticals, functional foods or medicinal use. The project aims at boosting the sustainability of marine aquaculture, further developing and challenging the aquaponics concept: the integrated multitrophic chain auto-produces fish feed ingredients (filter/feeders organisms) achieving also a fish waste bioremediation, thus reducing pressure on wild fish stocks and environment. Moreover, SIMTAP systems can exploit the effluents from greenhouse soilless cropping systems to enhance the production of filter/feeders organisms.

The project is the result of the joint work of several academic, public and private partners from the Mediterranean region: University of Pisa (project coordination), University of Bologna, University of Milan, INRAE - UMR SAS Sol Agro et hydrosystème Spatialisation, Lycée de la Mer et du Littoral, Malta Ministry for Agriculture, Fisheries, Food And Animal Rights, Turkish Mediterranean Fisheries Research Production and Training Institute, Korolev GmbH.

The keynotes and the presentations of the project partners will highlight the main challenges and opportunities for sustainable aquaculture and aquaponics,and will present the results of the ongoing project and the experiments which are being carried out in the pilot plants realized in Italy, France and Turkey.

Attendees are welcome to listen to the presentation and participate actively in the Q&A and discussion sessions.



For more info, visit the project website: www.simtap.eu

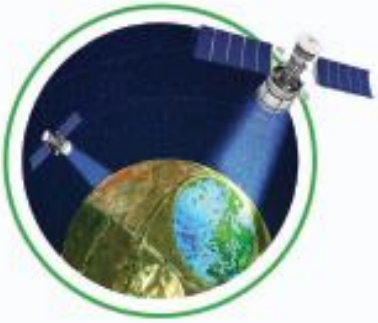
AGROINSIDER

ONLINE PRECISION AGRICULTURE COURSE

Application of remote sensors in agriculture

2h, max 23 person per course, 50€

PROGRAM



1 – Introduction to satellites and remote sensing. Emphasis will be putted in radar and optical satellites (Sentinel 1 & 2) managed by the European Satellite Agency.

2 - Crop monitoring through satellite data: high production costs; excessive use of inputs; water shortage; climate change; pest and diseases.

3 – Agromap platform: what is it and how to use it?

4 - SmartAG reports platform (Crop alerts).

5 - Exercise: use your farm limit* and we show you how is working.

* a) The attendees should send the production units (parcels) they want to study before the beginning of the course;

b) If the attendees are researchers, they can also send their research plot limits;

c) If the attendees are none of the above, they can send us the limits of any interesting region they are interested in observing (e.g., Rice in Vietnam, Coffee in Brazil, Pineapple in Costa Rica, Potatoes in Germany, etc.);

d) A video will be sent to the attendees explaining how they should vectorize their farm observation units.

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JOHN DEERE

John Deere is a world leader in providing advanced products and services. The company's innovative technology is key to serve the growing worldwide population. Higher standards are necessary to meet the world's dramatically increasing need for food, fuel, shelter and infrastructure.

More than 69.600 employees worldwide generate a turnover of 35 Billion US-$ with agricultural equipment, as well as lawn and grounds care equipment and construction and forestry equipment. In 2017 the company acquired the Wirtgen Group, the leading manufacturer of road construction equipment.

John Deere runs more than 80 manufacturing facilities in 19 countries and the products are sold in 160 countries worldwide. The company has a strong presence in Europe, CIS, Africa and Near & Middle East. With nearly 19.000 employees John Deere is the largest employer in Europe.

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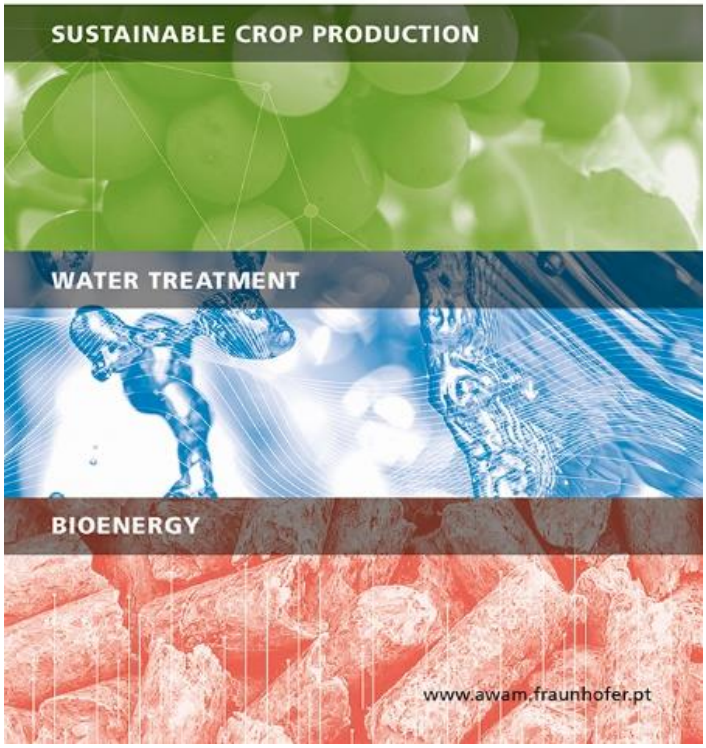
Fraunhofer Center for Smart Agriculture and Water Management - AWAM



EurAgeng 2021

Oral Presentations Abstracts

Automation, robotics and sensor technologies

ID: 2473

Detecting spectral signals in imaging for disease detection in apple, grape, and carrot

J. Peller[1], P. Blok[1], G. Polder[1], I. Malounas[2]
[1]Wageningen University and Research, [2]Agricultural University of Athens

Downy mildew, Apple scab, and Alternaria leaf blight are endemic diseases that affect crops across Europe. These diseases can respectively cause severe losses in grapes, apples, and carrots in particular when not detected in an early stage. The EU Horizon 2020 OPTIMA project intends to address this by including early detection as part of an integrated pest management (IPM) system, as this would be enormously beneficial to not just the farmer but also to the wider environment. A state-of-the-art decision support system (DSS) will be developed to determine the risk of a disease outbreak. In this research, we investigated the early detection of these three diseases using spectral images, as input to the DSS, in order to precisely localize and quantify the infection, so that appropriate plant protection product type, dose, timing, and location will be recommended. Spectral image sensing was explored to see whether it outperforms standard RGB colour imaging due to its extended wavelength range and more detailed reflection over the spectrum. Image data was acquired in the fields and greenhouses of Greece, the Netherlands, Italy, and France using a research based IMEC Snapscan spectral camera with high spectral resolution (200 bands, 470-900nm), and later a commercially available SILIOS spectral camera (8 bands, 560 nm - 836 nm). Annotation was performed by experts in the field and used to extract spectra from healthy and diseased parts of the plants. These spectra were used to train a linear discriminant classifier to separate between healthy and infected plant parts. The weights from the classifier highlights the wavelengths most discriminative for each disease type. Using this information, the SILIOS camera was selected to create high contrast images of plant disease on the plant. Preliminary results from a deep learning algorithm show that classification of the spectral images from the SILIOS camera outperform classification based on RGB data.

ID: 2610

A nanoplasmonic sensing device for on-site detection of diclofenac molecules in water treatment plants

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The detection of hormones and pharmaceuticals at trace concentrations is of growing interest due to their presence in the aquatic environment (in the range of ng/L to µg/L) and potential toxic effects on nature and wildlife. Remarkably high concentrations at the effluent of waste water treatment plants are measured e.g. from the nonsteroidal anti-inflammatory drug diclofenac. Current detection methods such as GC-MS or LC-MS/MS are realized by representative sampling, which is time-consuming and costly. To overcome these problems the monitoring of pharmaceuticals needs to be done on-site, e.g. directly at the effluent of water treatment plants. This leads to a demand of small, sensitive and robust biosensors allowing continuous monitoring of molecule concentrations in complex matrices. Particularly suitable for this purpose are surface plasmon resonance (SPR) sensors allowing a label-free and sensitive detection of biomolecules. By means of an indirect, competitive assay with a monoclonal anti-diclofenac antibody we were able to detect diclofenac concentrations in the range of 1 µg/L. However, classical SPR sensors are designed for use in laboratory environment, which is why we directed our study towards the development of a plasmonic sensor system for the fast on-site detection of diclofenac molecules. For this, a nanostructured gold surface fabricated by nanoimprint lithography plays a key role and serves as plasmonic transducer. We set up a compact and robust optical transmittance configuration which relies on a novel photocurrent-based read-out approach to further minimize the optical unit and sensor size. The entire system was included into a measurement device for on-site molecule detection and tested in a water treatment container operated at the effluent of a municipal water treatment plant. In this contribution we present selected results of this study to demonstrate the sensitivity and the on-site operation of the holistic plasmonic sensor system.

ID: 2716

Effect of vis-nir wavelength range on the estimation of three aggregate stability indices

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Soil aggregate stability (AS) is a principal indicator of soil erosion. Standard laboratory procedures for determining AS are time consuming and laborious. Recently, visible and near-infrared diffuse reflectance spectroscopy (vis-NIR) has provided a rapid and inexpensive means of predicting various soil properties. Because AS is associated with soil organic carbon, clay content,

and calcium carbonates, which have direct response in NIR spectroscopy, vis-NIR was identified a potential for the estimation of AS index. However, sensitivity and accuracy of vis-NIR spectrophotometers vary due to varying technical parameters (e.g., spectral range, spectra resolution, and detector type). This study compared the performance of two commercially available vis-NIR spectrophotometers [one having a diode array detector with a short wavelength range (SWR, 350 – 1700 nm) and the other having Fourier transform scanning detector with a full wavelength range (FWR, 350 – 2600 nm)] for the estimation of three AS indices, namely, mean weight diameter under fast wetting (FW), slow wetting (SW) and mechanical breakdown (MB). Partial least squares regression was used to build calibration models for the three indices. Results showed that the larger spectrum range of the FWR instrument did not provide improved accuracy in the estimation of SW and MB. In the case of FW, a superior prediction performance was recorded with the FWR model over that of the SWR. This was attributed to the significant spectral feature evident around 2200–2300 nm for the FWR spectrophotometer, which could be associated with hydrophoby-inducing organic matter constituents. Therefore, the FWR is recommended for the measurement of FW AS index, whereas the SWR or FWR spectrophotometers can both be equally successful used for measurement of the SW and MB indices, using vis-NIR spectroscopy.

ID: 2732

Evaluation of integrated optical devices for monitoring grape (Vitis vinifera I.) Ripeness

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Monitoring the grape ripening until the harvest is a crucial issue since berry quality is closely related to it. The research for non-destructive methods, which could explore many samples and give a rapid and comprehensive overview of ripening is helpful. Anyway, monitoring large areas requires the collection of several data derivable from the grape which would be useful for a local scale mapping of the ripening and for multi-year management of the grapevine. Although the literature reports different works regarding optical hand-held systems able to check the status of the grape, these instruments are incompatible with the data necessary for large monitoring campaigns. In this context, a stand-alone and cost-effective optical device was designed, built and tested with the goal to support growers in planning the optimal harvest date and to improve the vineyard management, following a viticulture 4.0 concept. Hence, a first prototype version of a fully integrated optical device incorporating different components (photodiodes, LEDS and electronics) was developed by INL under the scope of i-Grape consortium. Each module is equipped with four detection channels for optical measurements in the Vis and SW-NIR ranges. The optical data were collected on grape berries in a commercial vineyard owned by Sogrape, using the prototype and one commercial handheld spectrometer which works among 400 and 1000 nm, with a resolution of 0.3 nm. As reference values, the common technological and phenolic parameters were analysed on each sample. The correlation between the optical data and the parameters was explored, and a

comparison among prediction deriving from prototypes and from the commercial vis/NIR device was also performed. Results were encouraging underlining a small loss of information for the MLR models employing the prototypes compared to the PLS models calculated using the commercial spectrometer.

ID: 3214

Cityveg: a robotic platform for urban vegetable production

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Urbanization worldwide changes fresh food supply chain to a supermarket-driven system. Urban agriculture is a production system that can improve food systems for city supply. Urban farmers span from low income citizens spending 60-85% of their income for food and produce for own consumption, until high income professionals seeking quality homemade fresh vegetables, but have limited time for gardening. The latter category is becoming larger and is willing to invest in automated systems installed in houses or offices to satisfy this need. The purpose of this study is to suggest an automated solution by providing a robust, permanent robotic platform that can be tailored for each urban garden parcel and can maintain vegetable production after seeding/planting until harvest. CityVeg has 3 main parts: (i) 2 rails, (ii) an aluminium frame with a pi (Π) shape that runs on the rails and (iii) the 'actuation' component that runs on the Π frame and also moves upwards/downwards. A camera is set above the parcel and 4 electric motors are used to mobilize its 3 moving parts that are actuated by a microcontroller. All functions depend on a software implementation that is hosted on a cloud service, which processes data related with the growth conditions of the parcel's plants. A neural network identifies the crops and differentiates them from weeds, measuring their size and vigour and using unique algorithms based on Normalised Difference Vegetation Index (NDVI) to quantify water to be purred (irrigation, fertigation) or sprayed (foliar fertilization, weeding) according to plants' needs and growth stage. CityVeg provides minimum water supply based on crop size and growth stage, fertilizes directly to each plant with reduced nutrients and applies PPPs on the weeds when they just appear. The work is in progress and the description of the performance of CityVeg will be provided in the full paper.

ID: 3488

Monitoring and analysis of the daily behaviour of individual laying hens by using motion sensors and machine learning

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Poultry farmers have to monitor their chickens regularly to ensure their health and welfare. Welfare-oriented regulations enforce farmers to shift to more welfare-friendly systems with larger groups of hens and more complex hen behaviour. As a result, the monitoring of each individual

chicken by traditional methods is impossible. In this study, a wireless accelerometer sensor was mounted on the chicken body to monitor the behaviour of chickens, which was divided into three classes of static, semi-dynamic and dynamic behaviours. Static behaviour consisted of standing, sitting and resting, and semi-dynamic behaviour included pecking, eating, drinking, scratching, stretching, head shaking, preening and foraging activities. The dynamic class consisted of walking, jumping, flying, body shaking, wing flapping and dust bathing activities. The experiment was conducted for five days in a laying hen house and the behaviour of two chickens was continuously recorded on video in addition to the tracking by the sensors. The data were analysed by machine learning classification algorithms to classify the three classes of chicken behaviours. All recorded behaviours over time were assigned to one of the defined classes. Only in case, the behaviour was not present in the video recordings, the data was filtered out at the beginning of the process, e.g. when the chicken was in the laying nest. The overall accuracy of the class detection by the machine learning model was 91%. The precision for static, semi-dynamic, dynamic classes were 94%, 89%, and 80%, respectively. The main reason for the lower precise prediction of the model for the dynamic class was due to the relatively low number of data for training the model for that particular class. The accelerometer sensor seems to be a useful tool to track individual chicken activities and further development of the algorithms is therefore advised.

ID: 4623

Mobile robot weeder prototype for cotton production

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Cotton producers have little options to address weeds due to, limited herbicide options, high technology fees for herbicide-resistant varieties, and labor shortage for hand weeding. This paper will first present the navigations and obstacle avoidance technique, its implementation on our mobile robot and present the weeder prototype developed for cotton and the field test results in 2019 and early 2020. The autonomous mobile platform used a Robot Operating System (ROS) version kinetic and runs in Ubuntu 16.04. Two different weeder modules were designed, built, and tested. The first design has six individual prongs on each side, where each prong measured approximately 15 cm. The prong was designed to penetrate about 3.8 cm. into the soil. Two wheels were used to ensure the prongs would be kept at a constant depth into the ground. The second design was based on a cultivator with a harrow disk. A randomized complete block with three replications was used to test the mobile robot platform's speed with the weeder prototype, where half of the test was irrigated (drip), and the other half was non-irrigated. The preliminary field test showed that the average time of the mobile robot's travel only has a minimal difference between the two irrigated rows (10% saturation and 65% saturation) but has a significant difference between irrigated and non-irrigated. Approximately, 10%~15% weed control was observed on one of the test plots and 80% weed control was observed in the second test plot.

ID: 4672

Instance segmentation and pose estimation of chicken legs in a cluttered environment

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Agricultural food products, like chicken meat, are soft and deformable, which causes a large variation in appearance. This makes automatic processing challenging, especially if the objects are piled up and occluding each other. That is the case in a bin picking situation, where one chicken piece at a time must be removed from a pile in a crate. To pick a single piece, its position and orientation have to be known. A modular algorithm is developed that performs both instance segmentation and 6D pose estimation of chicken legs in such a situation, using a single RGB-D image as input. First, a Mask R-CNN implementation is used to perform instance segmentation, classifying each separate chicken piece as one of five classes, being fully visible or partly visible, with the top or bottom side facing up, or a strongly tilted piece. As fully visible pieces are the easiest to pick, only the masks of these pieces are used in the second step and applied to the depth image, to yield a point cloud per piece. After that, principal component analysis (PCA) is used to find the midpoint and the three principal axes of a piece. The classification of a piece as top or bottom, and the geometry of the piece are then used to correct the axis directions. The determined midpoint and axes together form a coordinate frame, which is used to calculate the translation and rotation with respect to the camera. This approach makes the pose estimation independent of training or 3D models. The achieved mAP@0.5 on instance segmentation is 0.87, with an inference time of 190 ms per image. AP@0.5 for fully visible pieces is 0.96. Pose estimation takes 20 ms, while estimating principal axes with 95% accuracy. Rotation of chicken legs around their normal is estimated with an error of 1.5 ± 2.2 degrees. The proposed algorithm seems effective for both instance segmentation and pose estimation of chicken legs.

ID: 4675

Robotic cultivation of pome fruit: a benchmark study of manipulation tools – from research to industrial standards

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Within the cultivation of pome fruit, apples and pears need to be harvested, sorted and handled in various processes. Currently, the majority of these processes require a vast amount of manual labour. Combined with a structural shortage of seasonal workers, innovation in this field is crucial. Transition to automated processes could provide a solution wherein the search for an appropriate gripping tool will be key. While other researchers already present a set of customized grippers for fruit harvesting, a wide variety of tools is available in robotic industry, ranging from standardized general-purpose grippers to optimized soft grippers. In this paper, nearly all relevant gripping

principles are primarily tested and compared to each other based on their gripping success as well as on their ability of not damaging the manipulated fruit. Other parameters, such as energy consumption and general feasibility, are evaluated as well. Concluding from the tests, these grippers are rated as usable for harvesting, usable for fruit processing or not usable for fruit industry at all. The performed benchmark study showed that the customized foam gripper scores the overall best for all test scenarios at the cost of being the most susceptible to wear and the least energy efficient. These test scenarios being the harvesting and other processing of both apples and pears. On the other hand, the majority of the other gripping principles and related tools excelled at certain specific tasks rather than being generally deployable. Impactive gripping tools are better suited for harvesting at low energy consumption, while astrictive suction cup grippers are more suited for sorting tasks constricted by the available space. A remarkable result was that not all commercially available soft grippers are capable of handling more sensitive fruits such as pears without causing damage.

ID: 4754

Remote sensing applications to improve pomegranate irrigation in vega baja del segura area (Alicante, Spain)

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Enabling digital technologies have great potential to improve crop management. In this regard, remote sensing is a tool that can provide with certain vegetation indices values, such as NDVI and MSAVI that help ameliorate irrigation management. Currently there are commercial platforms that generate this information using satellite images from different sources, endorsed with weather station data. Furthermore, open access satellites, like SENTINEL-2, provide images that can be processed with open access applications such as QGIS. Using these two methods, it is possible to improve irrigation management in certain herbaceous crops that show high homogeneity and are stablished in large plots. However, in the case of fruit trees stablished in small plots, remote sensing information based on satellite images may prove to be insufficient due to interferences such as soil not covered by the crop, adventitious plants, or due to image resolution. This paper aims to suggest improvements in pomegranate irrigation based on low-cost remote sensing tools. For this purpose, the trend of five commonly used vegetation indices during one crop cycle is analyzed. The plots studied were irrigated using two different methods, traditional and drip irrigation, and were situated in Vega Baja del Segura area (Alicante, Spain). The values of these vegetation indices were determined making use of a commercial platform and open access software QGIS, using SENTINEL-2 images. The results obtained show a better predictive behavior when these indices are used in plots irrigated by drip irrigation, although the correlation between vegetation indices values and crop coefficient used in irrigation scheduling proves to be insufficient.

ID: 4759

Single plant fertilization using a robotic platform in an organic cropping environment

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The increasing demand of organic vegetables has driven conventional farmers to change their businesses in order to develop organic methods for cultivation. In some cases, to enhance biodiversity and soil fertility, crops are established in a mixed pattern called 'strip cropping' where single or dual lines of a given species are alternated with a second compatible species, with the aim to enhance resilience, system sustainability, local nutrient recycling, and soil carbon storage. To counteract the additional labour of a multi-crop system, one of the main objectives of the 'Sureveg' European project is to evaluate the benefits of growing in alternate rows for the production of organic vegetables and includes the use of robots as a tool to facilitate the automation of the process, allowing the individual treatment of organic fertilization at plant level. Within the project framework a modular proof-of-concept version has been produced, combining several sensing technologies (3x LiDAR, plus a multispectral RGB-NIR camera) with actuation in the form of a robotic arm operating upside down. The present work describes a method to develop fertilization tasks with recycled organic waste in strip-cropping farms, based on detection of plant species (cabbage) using and liquid fertilizer application with a robot. In order to detect autonomously each single plant, point clouds of the LiDAR units were combined, soil was removed applying a threshold, and plants were identified using clustering and convolutional neural network methodologies. To trigger the actuation system, the decision on which plant had to be sprayed with the liquid fertilizer was taken according to: 1) the estimated volume of every single plant, and 2) the multispectral indexes calculated using the RGB-NIR camera. The prototype is fully functional, and further tests are needed to quantify its performance.

ID: 4764

Pose estimation of tomato peduncle using deep keypoints detector with point cloud

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In recent years, to reduce the labor dependence and improve harvesting efficiency, the concept of using harvesting robots to take place human laborers has been widely investigated. To harvest tomatoes, accurately estimate the pose of the peduncle relative to the main stem is very important to reduce collisions, therefore improving harvesting success rate. Pose estimation has been widely used in human cases, such as skeleton joints detection, facial interest keypoints detection, and some animal cases, but the studies on plants are scarce. Meanwhile, estimating the pose of peduncle in complex greenhouse environments is a big challenge and is hindered by changing lighting,

occlusions, and irregular shapes and size of plants. In this paper, it developed a deep learning-based framework to combine a deep keypoints detector with point cloud to estimate the pose of peduncles. The whole framework is split into three phases of (1) 2D keypoints detection, (2) point cloud projection, and (3) pose estimation. In the first phase, a trained keypoints detector is employed to localize pre-defined keypoints on color images, then the 2D keypoints are projected to 3D point cloud with the utilization of point cloud data acquired from RGB-D camera, and finally the peduncle pose is estimated. This paper evaluate the model's performance from three perspectives, namely object detection, keypoints detection, and angle evaluation. The object 3D position is hard to evaluate and therefore not involved in our research. According to the result, the algorithm achieves *AP50* at 91.74%, *AP75* at 79.74% of, and *AP50:95* at 71.53% in terms of object detection. For keypoints detection, the joint point and the peduncle point achieve *PDJ* at 94.29% and 88.57% respectively when taking fraction *f* equals to 0.1. For angle estimation, we obtained the mean absolute errors at 5.61°-6.04° and mean relative errors at 5.41%-6.93%.

ID: 4798

Evaluation of spectral imaging cameras for disease detection in tomato plants

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Plant diseases are one of the major causes of food production losses, having adverse effects on the economics of any country. In order to investigate a disease in any growth stage, imaging spectroscopy is widely applied for detecting the changes in physiology or biochemistry of plants, caused by the diseases. This paper evaluates the suitability of four different types of spectral imaging cameras to detect powdery mildew in tomato plants. The cameras evaluated are a fast filter wheel eight band (multi) spectral camera (SpectroCam, Ocean Optics/ Pixelteq, USA), a push-broom 224 band line scan (hyper) spectral camera (FX10, Specim, Spectral Imaging Ltd., Finland), a 200 band (hyper) spectral semi snapshot camera (IQ, Specim, Spectral Imaging Ltd., Finland) and a 200 band (hyper) spectral semi snapshot camera (SnapScan, Imec, Belgium), all operating in the Vis-NIR range (400-1000 nm). An experiment was set-up with 120 tomato plants grown in pots. In total 60 plants were inoculated with powdery mildew and the others were used as control treatments. Images of all plants were taken, two weeks after inoculation and were analysed using perClass Mira (perClass BV, Delft, the Netherlands). Plants were classified into healthy and diseased groups, based on the diseased area. By analysing the spectral data of all cameras it was possible to identify diseased areas at a high level of accuracy. Based on the spectral data acquired with the FX10 the best detection result was reached with an accuracy level of 89% in classifiying healthy and diseased areas in plants. It was possible to detect the diseased areas in plants at an accuracy level of 93% while accuracy levels of SpectroCam, SnapScan and IQ were 91%, 80% and 75%, respectively. Data form the FX10 gave also superior results in identifying the healthy plants and the position of the diseased area on the leaves.

Artificial intelligence, data processing and management

ID: 2489

Deep learning and iot technology applied to monitor the growth of tea trees indoors under artificial lighting

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This research proposes a multiple sensing and control system based on the artificial intelligence of things (A-IoT), which is applied to the cultivation and management of indoor tea seedlings with LED lighting. The system includes multi-sensor modules, environmental control devices, and feature of tea leaves recognition devices. Among them, multiple sensors are used to collect environmental parameters of different cultivation areas. The environmental control device includes an atomization device and circulating fans, which is utilized to adjust the temperature and humidity of each cultivation area. The recognition device is used to identify the traits of tea trees, including the number of leaves and the diseases of tea leaves. An image processing algorithm based on morphological operations is employed to identify three types of tea disease characteristics, including brown blight, white scab, and algal spot disease. The samples of tea leaves disease are provided to the YoLov3 network model for training. The recognizer has been implemented in an embedded device, where the average recognition rates of the number of tea leaves and diseases are 94% and 83%, respectively. The performance of the proposed system has been verified during the cultivation of two different varieties of tea plants. The obtained environmental data, number of tea leaves and diseases of tea can be used to analyze and evaluate the health of tea plants during seedlings cultivation. These data can also be displayed in the application (APP) interface of the mobile phone. Early warning information about the environment and the growth status of tea trees can also be displayed in this interface. The system can provide tea factory producers with a reference template for designing smart plant factories.

ID: 2566

How machine learning can improve models of gas emission from a naturally ventilated dairy barn

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Effective mitigation of pollutant gas emission requires profound understanding of emission processes. Measurement and analysis strategy must permit to accurately extrapolate emission values. We systematically analyzed the added value of applying modern methods of supervised machine learning in the process of monitoring and projecting emissions from naturally ventilated

livestock buildings to the atmosphere. We considered long term measurements of ammonia and methane concentrations obtained with hourly resolution from a naturally ventilated dairy cattle building in Germany. We compared model predictions in a cross-validation setup using multiple measures of model accuracy and different regression approaches including ordinary multilinear regression, neural networks and ensemble methods. The error of the predicted emission value mimicking different measurement protocols was on average well below 20% even using small training samples of only 3 times 24 hours. The sensitivity of the prediction on the selected training dataset was the worst for the ordinary multilinear regression. Particularly in combination with short model training periods (e.g., 24 hour periods), without exhaustive outlier removal the method frequently failed to provide a reasonable emission estimation. Modern supervised machine learning methods, particularly the ensemble methods (i.e., random forest and gradient boosting) provided much more robust emission value projections, accompanied by slightly smaller model errors. Among the modern supervised machine learning methods the artificial neural networks were particularly sensitive to the selection and preprocessing of training data. Besides the general trend, the exact ranking of the regression approaches depended on the mimicked measurement protocol, the accuracy measure and the considered gas.

ID: 2672

Fast delivery of insect pest management information using a real-time insect pest monitoring system

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For crop production management both in open fields or greenhouses, excessive and inappropriate pesticide application are one of the main causes of economic loss and health risks. By guiding farm owners with a proper data-driven tool, pesticide application and pest management can be optimized and scheduled accordingly. Therefore, the losses of agricultural crops can be reduced. This paper presents, I^{2}PM, a mobile application and information platform developed for monitoring the density of insect pests and providing concise and reliable information for improving insect pest management. The mobile application uses data from a remote monitoring system that is used to send sticky paper trap images to the information platform for counting and identification of insect pests using a deep learning based insect detection and recognition algorithm. The monitoring system is also used for recording environmental data such as temperature, humidity, and light intensity. The insect counts and environmental data are shown in the mobile application in real-time and are also presented in forms of historical data analyses. Most importantly, the insect counts are transformed into several information such as alarm, hotspots, flight probabilities, and outbreak forecasting using modeling approach. Open data from the government and research institutes are connected to the backend information platform. Together with the pest monitoring data, useful information and recommendation to guide the farmers in decision making can be delivered in time. The integration of the automated monitoring system with the fast delivery

information system will play an important role in reshaping future intelligent and integrated pest management (I^2PM) practices in agriculture.

ID: 2755

Multiple pass deep neural network for early detection of bacterial and fusarium wilts of tomato in hyperspectral imagery

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Bacterial and fusarium wilts are big pathogens to tomato plants. Both would infect the vascular tissues to cause symptom of wilt beginning from lower leaves and ending up the whole plant. More importantly, infection of bacterial and fusarium wilts have devastating lethality to host plants. Early detection is critical to reduce their damage. Unfortunately, their symptom at early stage could be very similar to many other causes form human eyes to further prevent early detection, such as lack of water, and hot weather, etc. Recently, due to rapid advances of sensor technology, the hyperspectral imagery has achieved considerable success in many agriculture applications. Its merit is to collect a wide range of electromagnetic spectrum covering visible and non-visible wavelengths in fine spectral resolution for identification of targets. The fine spectral information of hyperspectral imagery sheds light on early detection of symptoms caused by bacterial and fusarium wilts. This paper designed a time series experimental study to collect more than 1,000 health and infected tomato plants by a hyperspectral sensor with wavelength from 900 to 1700 nm. Deep neural network (DNN) was utilized to extract spectral features for classification of healthy and infected plants. Nevertheless, it is normally challenging to provide reliable training samples, especially for infected samples, which play an important role in accuracy of DNN. To overcome this dilemma, this paper proposed a multiple pass DNN to cascade the results of DNN as the training samples of the next one until its performance is stable. According to experimental results, multiple pass deep neural network provides superior performance by detecting fusarium wilts few days earlier than human eyes. Eventually, Grad-CAM would be applied to present spectral characteristics of both wilts learned by DNN.

ID: 2783

Occlusion-robust temporal pose estimation of dairy cows in videos

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Lameness is a significant welfare issue in dairy farms and is characterized by an abnormal gait of the cow. In biomechanical research, the gait is typically assessed by analyzing the kinematics of

markers placed at anatomical landmarks. Video-based pose estimation can be used for markerless tracking of anatomical landmarks in videos. Recent advances in Deep Learning (DL) have shown great potential for pose estimation of animals. Current animal pose estimation models are static, that is, videos are processed frame by frame and do not use any temporal information. In this work, a static DL model for animal pose estimation was extended to a temporal model that includes information from past frames. We compared the performance of the static and temporal pose estimation models. The data consisted of 1082 samples of 4 consecutive frames extracted from videos (30 fps) of 30 different dairy cows walking through an outdoor passageway. The models were trained on a random set of 80% of the samples, and tested on the remaining 20%. As farm environments are prone to occlusions, we tested the robustness of the static and temporal models by adding artificial occlusions to the videos. Experiments showed that, on non-occluded data, the temporal approach achieved a Percentage of Correct Keypoints (PCKh@0.2) of 99% and 98% for the static approach. On the occluded data, the temporal approach performed 21% better than the static one. These findings show that deep-learning-based pose estimation can accurately detect anatomical landmarks of cows in videos, and that using temporal information increases the detection rate, especially when occlusions occur. In future work, these anatomical landmarks will be used to compute kinematic gait features such as stride length, velocity, step-symmetry and arched-back. Such features are commonly used for gait assessment and could be used in future work for scoring the gait of dairy cows.

ID: 2794

5G connected spot sprayer enables autonomous control of volunteer potato

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Dutch arable farmers face big challenges with unwanted volunteer potatoes. Hot and dry summers result in lower potato yields and more small tubers to be left in the field during harvest. Surviving mild winters, these tubers grow into unwanted potato plants in the next crop in the rotation, like sugar beet or onion, are like a weed and moreover increase soil-borne diseases as potato cyst nematodes or can introduce pests like potato blight. Most effective control method for volunteer potato is the manual application of glyphosate, which requires about 15-20hours/ha of manual labor resulting in costs of €300-€400 per hectare. Decreasing labor availability and increasing labor prices force farmers to look for alternatives. A proof of concept was demonstrated with an autonomous mobile field platform equipped with a spot sprayer and artificial intelligence to recognize potato plants. The spot sprayer consists of four RGB cameras supplemented with artificial light, capturing images of the sugar beet and volunteer potato plants. The images are sent by a 5G connection to a cloud based server about 200 km off site. The server hosts a deep learning algorithm trained to recognize the sugar beet and potato plants in the images. In real-time, the

locations of the potato plants are sent back to the spot sprayer in the field. One of the nozzles at a spraying boom with 29 nozzles, spaced 10 cm apart, applies glyphosate on the identified spot of the potato plant. The cycle of capturing images, sending it to an edge server, processing of the images, sending instructions back to the robot in the field and spraying, took 250ms. About 95% of the volunteer potato plants were sprayed and only 4% of the sugar beet were hit. In the presentation we elaborate on the demonstrated proof of concept, the results achieved in the field, advantages of using cloud based edge solutions and discuss future work and perspectives.

ID: 3182

Detection of tomato fruit from RGBD images using colorspaces and geometry

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Detection of fruits using computer vision is an important step in automating tasks like harvesting, phenotyping, and yield prediction. This kind of image analysis is being used increasingly in agriculture since it is quick, non-destructive, and can avoid time-consuming and labor-intensive manual measurements. Segmenting tomatoes from images taken in a production greenhouse is difficult, a.o., because of occlusions, overlap of the fruit color with other plant parts, and illumination variations. Recent approaches to detecting fruits mostly focus on supervised and deep learning methods, in which a large number of images need to be annotated to train the algorithm to be able to decide what is a fruit. While these methods have the advantage of not having to hand-craft discriminative features, annotating hundreds of images to obtain a workable training set is very labor intensive. This work develops a method for detecting tomatoes, which does not require a training dataset containing labelled fruits. We used an Intel RealSense™ D435 camera which provides pixel registered depth and color images, mounted on a trolley that autonomously navigates through the greenhouse and images all plants at regular intervals. First, the depth is used to extract the front row plants from the RGB image. The intensity of fruit pixels is then enhanced by grayscale transforms. The fruit pixels are then segmented by thresholding. Next, the watershed algorithm is applied to separate contiguous regions. Finally, regions above a certain size and whose perimeters approximately fit a circle are selected as individual fruit instances. Experimental results over 123 images acquired in a greenhouse show that this approach could detect tomatoes with a recall of 0.8 and a precision of 0.6. In addition to being applicable in a practical context in itself, this approach has potential for use as a tool to generate data to train supervised (deep) machine learning methods.

ID: 4611

Deep learning technique and uav imagery dataset for paddy rice panicle detection at early stage

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Accurate panicle segmentation is a key step in paddy field phenotyping. Deep learning methods based on high spatial resolution images provide a potential solution to increase the throughput as well as the accuracy of panicle identification. The quality and volume of the dataset are crucial to training an accurate and robust deep learning model. Panicle segmentation tasks require particularly costly annotations. However, few public datasets are available for rice panicle phenotyping. We present a semi-supervised semantic segment model training process, which greatly assists the annotation and refinement of training datasets. A Mask RCNN model with ResNet101 as the backbone learns the panicle features with limited annotations and localizes more positive samples in the datasets. After the refinement process, the number of annotations increased by 40.6%. In addition, the average pixels per annotation decreased by 18.3%. It indicates that the annotation generated by the DNN model is more precise than the manual label. Finally, the research result is publicly available for all the users to develop and benchmark rice panicle identification models. It contains 400 images with 4096×2160 resolution and 50730 pixel-level annotations. We trained and tested modern deep learning models, including EfficientDet-D7, Mask RCNN, U-Net, and DeepLab v3+, to show how the dataset is beneficial to both rice panicle detection and segmentation tasks.

ID: 4674

Boosting plant-part segmentation of cucumber plants by enriching incomplete 3D point clouds with spectral data

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Plant scientists require high quality phenotypic datasets. Computer-vision based methods can improve the objectiveness and the accuracy of the phenotypic data. In this work, we focus on point clouds for measuring plant architecture of cucumber plants, using multispectral data and deep learning. A first step is to segment the point cloud, such that for each point it is known to which plant part (e.g. leaf or stem) it belongs. Based on hand-labelled training data, a neural network can be trained to segment the data. As a first experiment, we hand-labelled all data twice and assessed the label quality by measuring the intra-operator variability on the two datasets. The training data was used to train a neural network (Pointnet++) to segment the point clouds into plant parts. In the second experiment, we tested the effect of how many distinct plant parts have to be recognized. Finally, we tested if the performance of the segmentation can be increased by adding spectral data (RGB and NIR). The performance of the network and the intra-operator variability are both reported as the intersection-over-union (IoU). The IoU between the two hand-labelled datasets was on average 0.77, ranging from 0.49 (node) to 0.99 (leaf) and showing significant differences between the two sets. Second, the mean IoU of the automatic segmentation improved from 0.74 to 0.86 when underrepresented classes such as flower and node were not considered.

Finally, it was shown that the IoU for all plant parts increased when spectral data was added to the training data. In conclusion, the best performance can be obtained by using geometric and spectral data to train the network. When labelling the data, it is important to consider the number of classes distinguished. Future work will involve a more in-depth analysis of how the uncertainty, resulting from differences in labels, can be used to further improve the performance.

ID: 4692

Implementation techniques of pre-trained deep learning networks for plant disease classification

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Deep convolutional neural network (CNN) has been supplanting the conventional computer vision technique due to its state-of-art performance, specifically in the complex and large number of datasets. However, the design of a network and its training and implementation from scratch necessitate having expert knowledge, high-performance hardware, and large and diverse datasets. Recently, various deep learning networks, designed and trained by experts with a million images, are available in open-source, which can be re-use via knowledge transferring technique. In this study, different knowledge transfer techniques were studied in plant disease classification problems. Moreover, the efficacy of those transfer learning techniques was evaluated comprehensively. For this, image datasets of 16 distinct plant diseases from 4 different plant species were collected (from greenhouse and public databases) and applied to some widely used pre-trained. Three transfer learning techniques (customized output layer, feature extraction, and weight initialization) were applied, and observed their performances. The output layer of a pre-trained model was replaced in the customized output transfer learning technique, in contrast to the coupling of a new fully-connected network (FCN) in feature extraction and weight initialization techniques. Then the modified model was fine-trained in two ways, fine-tuning of later added layers only and fine-tuning of added layers with some deep layers of the base network. The results suggested that the fine-tuning of some deep layers with added layers provides higher accuracy (98.23%) than others with taking more resources. However, the customized output transfer learning took less training time (almost one-tenth), producing the least classification accuracy (78.46%). Therefore, the pre-trained deep learning network can effectively apply in phytopathology.

ID: 4699

Early disease detection in apple and grape using deep learning on a smart-camera

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Downy mildew (*Plasmopara viticola*) and Apple scab (*Venturia inaequalis*), are endemic diseases that affect crops worldwide. The diseases can cause severe losses in grapes, and apples, when it is not detected in an early stage. The EU Horizon 2020 OPTIMA project intends to address this problem by including early detection as part of an integrated pest management (IPM) system. In this research, we investigated the early detection of these two diseases using deep convolutional neural networks on RGB color images. Detections serve as input to the DSS, to precisely locate and quantify the infection, so that appropriate plant protection product, dose, timing, and location can be recommended. Two deep learning algorithms were developed: EfficientNet-B5 and YOLOv5. The first algorithm is an image classification algorithm that worked on images of 545x545 pixels. The second algorithm is an object detection algorithm that worked on images of 640x640 pixels. Because the DSS and the sprayer can only work with one decision per image, we combined the detections of YOLOv5 into a single decision for each image. For real-time implementation on the sprayer a smart-camera with RGB sensor and NVIDIA Jetson TX2 edge-processing unit was used. TensorRT was used to significantly speed-up the image analysis for both algorithms. The average inference time for acquiring a 1.9 MP image (1600x1200 pixels) and doing the deep-learning analysis was 0.30 seconds for EfficientNet-B5 and 0.15 seconds for YOLOv5s. Without TensorRT these inference times were respectively 1.5 seconds for EfficientNet-B5 and 0.20 seconds with YOLOv5s. Results showed a false detection rate of less than 1.2% for both algorithms. For 327 images of grape vines and 63 of apple trees, with a data split of 70% for training, 15% for validation and 15% for testing, the accuracy of the algorithms was in the range of 90-97%.

ID: 4700

UAV-SFM 4D mapping of landslides activated in a steep terraced agricultural area

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The presence of roads is frequently linked with the activation of land degradative phenomena such as landslides. In this connection, recent developments in digital photogrammetry (e.g., Structure from Motion, SfM) paired with Uncrewed Aerial Vehicles (UAV) systems increased our possibilities to realize low-cost and recurrent topographic surveys. This can lead to the development of multi-temporal (4D) high-resolution Digital Elevation Models (DEMs), so as to analyze specific geomorphological features and quantify processes at the fine spatial and temporal resolutions. This research proposes a multi-temporal comparison of geomorphometric indicators (i.e. profile

curvature, maximum curvature, and roughness index) describing a landslide-prone terraced vineyard so as to assess the observed high-steep slope failures. The investigation of the evolution of landslides' geomorphic features in a steep agricultural system through a high-resolution and 4D comparison of such indicators is still a challenge to be explored. The dynamics of the landslides were firstly monitored by repeated DEMs comparison. The road participation in superficial water flows alterations was proved by the elaboration of the Relative Path Impact Index (RPII). Finally, the multi-temporal comparison of indicators and features extraction underlined the geomorphological changes affecting the study area. The accuracy of features extraction was analyzed through the Quality Index computation, which confirmed the usefulness of high-resolution and 4D UAV-based SfM surveys to investigate landslides triggering due to the presence of roads at hillslope scale in agricultural systems. This work could be a useful starting point for further studies of landslide-susceptible zones on a wider scale to preserve the quality and the productivity of affected agricultural areas.

ID: 4713

Random forest models based on biological activity of whole plants to predict the yield of tomato fruits in a greenhouse

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Predicting the yield of horticultural crops is required to meet the expectations of retailers and consumers. Recent attempts to predict the yield have focused on modeling the yield based on measured environmental conditions and predicted biological activities such as photosynthesis and assimilates partitioning. We developed an open-chamber system to monitor net photosynthetic rate and transpiration rate of whole plants with high time resolution. Using this system, measured net photosynthetic rate can be used as an explanatory variable of the yield models of horticultural crops. Here, we developed and evaluated random forest (RF) models based on net photosynthetic rate of whole tomato plants to predict their fruit yields. The open-chamber systems were placed over cherry tomato plants, which were hydroponically grown with a high-wire system in a greenhouse in Japan. Daily photosynthesis (DP) [molCO_2 d^{-1}] was calculated by integrating over the day the net photosynthetic rate of the plants. Variables of environmental conditions (EC) including daily solar irradiation [MJ m^{-2} d^{-1}], averaged air temperature during the daytime [°C], that during the night [°C], averaged atmospheric water vapor deficit during the daytime [g m^{-3}], and that during the night [g m^{-3}] were also measured in the greenhouses. RF models for the prediction of the yield in a week later were developed by using only DP (Model 1), only EC (Model 2), or DP and EC (Model 3) as explanatory variables. For the prediction of tomato yield, mean absolute percentage errors of the prediction by Model 1, 2, and 3 were 7.8%, 7.6%, and 7.3%, respectively. These results indicate that the models using DP as an explanatory variable have high accuracy in yield prediction. We believe that the use of measured net photosynthetic rate in modeling the yields opens new venues for accurate yield prediction.

Circular economy

ID: 2685

Effect of ph on schizochytrium limacinum production grown using crude glycerol and biogas digestate effluent

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Micro-algae are a promising alternative source of nutrients in fish feeds, especially as rich sources of omega-3 fatty acids that are scarce in nature and have beneficial effects in human health. This study examined the effect of different waste products derived from the biofuel industry, crude glycerol and liquid digestate from agriculture crop residues, as potential alternative organic carbon and nitrogen sources respectively, on the growth and lipid accumulation of the strains Schizochytrium limacinum. Experiments were conducted in laboratory scale batch cultures utilizing in the growth medium different concentrations of carbon and nitrogen sources, under different cultivation conditions. The results showed that crude glycerol and liquid digestate can be effectively used to produce high quantities of microalgae biomass that is appropriate to replace part of the conventional aquafeed. The work is carried out in the frame of the Alga4FuelAqua project that aims to exploit the biofuel industry's liquid waste by cultivating micro-algae to produce high nutritional feed and food with clear environmental benefits and minimize industrial wastes to the environment. The project is divided into 3 phases: a) wastewater treatment as a nutrient medium for heterotrophic micro-algae, pilot construction of culture systems and pilot production of micro-algae, (b) utilization of produced micro-algae biomass to produce biodiesel and fish feed, study of bio-diesel production efficiency and fish growth from the use of micro-algae and (c) overall assessment of products and processes through feasibility study, Life Cycle Analysis and Sustainability Indicators calculation, and dissemination of project results. «Acknowledgment: This research has been co-financed by the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE – INNOVATE (project code:T1EDK--01580).

ID: 2731

Mechanical behavior of biochar: influence of pyrolysis operating conditions on dust production, shear and compression resistance

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Biochar is the carbon-rich, solid product obtained from the carbonization (or slow pyrolysis) of biomass, which is commonly heated up to temperatures between 300° to 1000 °C under low (preferably zero) oxygen concentration. Biochar can be used as an organic amendment with different agronomic benefits. Because biochar characteristically has low bulk density and high porosity, the material is susceptible to atmospheric release via natural or mechanical disturbance. Nevertheless, the mechanical properties of produced biochar have not been studied in depth, despite the influence of particle size on its behavior on the soil and the potential impact of generated dust on human health. The specific aim of this study is to investigate the influence of pyrolysis conditions and physicochemical properties of biochar obtained via pyrolysis of different feedstocks on its mechanical behavior. Biochar from two different feedstock was studied: vine shoots (*Vitis vinifera* L.) and oak (*Quercus Ilex* L.). Two final pyrolysis temperatures for both types of biomass were adopted (400 and 600 °C). The mechanical behavior was analyzed through different ways: a physical characterization was carried out on the raw biochar, describing particle size, density and form coefficient. This characterization was repeated after the biochar was mechanically processed through an automatic agitation system, reproducing the product movement in a regular fertilizer spreader. A food texture analyzer was also set-up to analyze the shear and compression resistance of biochar particles. Results showed a significant influence of temperature on dust production. In relation to the resistant properties, the compression resistance varied significantly depending on the feedstock and the pyrolysis temperature.

ID: 4618

A gis-based model analysis for assessing tomato peels as suitable biomasses for producing biomethane within the context of circular economy

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It is well known that climate change is undoubtedly the most imminent environmental issue the world is facing today. There is a consensus that global warming is due to the anthropogenic emission of greenhouse gases. Renewable resources will play a crucial role in the current CO2-

mitigation policy. The biomass is seen as one of the most dominant future renewable energy sources. In detail, agro-industrial by-products represent a cheap, renewable, and abundant feedstock useful for several new products, including biochemical, biomaterials, and above all biogas that in Italy is taking on an ever-increasing role. In this context, the tomato chain was analysed with the aim to estimate the amount of processed tomato and the related waste production (tomato peels) as new suitable resource for producing biofuel (biomethane) as new frontier within the context of circular economy. Due both the importance of tomato industry, that is one of the most important sectors of the world food industry and can display an enormous potential since it produces huge amounts of wastes and given the uncertainty of data relating to biomass quantities, this research aims at filling the gap in the knowledge of the production and yield of these by-products useful as biomasses for energy. This aim is relevant to plan the development of biomethane sector in a sustainable way in terms of reduction of both soil consumption for dedicated energy crops and GHG emissions derived from biomasses logistic supply. Furthermore, tomato peels if are considered as wastes determine a negative impact on the sustainability of all food industry, since their disposal represents one main issue in terms of environmental and economic impact. The developed GIS model allowed to select those territorial areas highly characterised by this kind of biomass, which could play a key role for future policies and strategies aimed at sustainable developing biomethane sector.

ID: 4636

Floridia soil-based adobes: an exploration on flexural and compressive strength

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Raw earth, with wood and stone, has a place among the oldest building materials used in the world. Nowadays, on a circular economic context, researchers' interest in raw earth-based building materials has been growing because they are highly available and environmentally friendly. The use of this traditional material has positive environmental consequences, especially in traditional rural building reuse and in rural landscape preservation. In fact, raw earth is locally available and totally recyclable and, thanks to its perfect integration into the landscape, it improves site visual perception. Often, in order to increase mechanical performances and durability of earth materials additives and/or chemical stabilizer agents (i.e., Portland cement) are used to produce raw earth-based building components. This production process reduces the environmental sustainability of the base material and causes a relevant increase on the embodied energy. This research work aimed at investigating how to improve the mix-design of earth-based building materials in order to increase their mechanical properties without addition of chemical agents. A physical stabilization was performed on an original texture soil, through the addition of different particle sizes. Mechanical tests have been carried out on five different soil mixes by changing soil composition, aggregates, and water. Specimens realized with the mix-design 5 showed best results of flexural and compressive strength values with 1.65 MPa and 6.74 MPa, respectively. Mix 3 obtained the lower

linear shrinkage rate (6.04%). Since raw earth-based materials are highly sensitive to soil composition and aggregates, the attempt of this study is to obtain a repeatable process to produce semi-industrial adobes by the optimization and control of different natural materials (i.e., soils, aggregates, and water).

ID: 4638

Planning the integrated management of organic waste flows and agricultural residues for a circular economy

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In the recent years, the production, management and disposal of both organic waste and agricultural residues has become significantly difficult in Italy, due to the lack of suitable facilities. Very often, indeed, within the different regions, there are no treatment plants for the organic fraction of municipal solid waste or agricultural residues treatment centres, so as to give them a second life in the perspective of the circular economy. The lack of proximity treatment centres, forces local administrations to send these flows to plants outside their territorial area, with a consequent increase for treatment and transport costs. This paper, with reference to the study area of Matera municipality (Basilicata region - Southern Italy), taking into consideration the organic waste flows of non-domestic users from separate collection and agricultural residues - especially those coming from the wine production chain - provides a state-of-the-art analysis of the problems related to their collection, management and disposal. Subsequently, an alternative model feasibility study - called "*proximity composting*", aimed at a more sustainable management of these flows based on their "zero kilometers treatment" – has been implemented. The results obtained have demonstrated that the proposed scenario is much more sustainable when compared to the current situation, both from an economic and environmental point of view. Indeed, thanks to the use of calculation tools, the economic (€/year) and environmental (Kg CO_2 avoided/year) advantages due to the save of transport and disposal of flows outside the region have been quantified with consequent reduction of waste tax for citizens (€/year). In addition, the implementation of maps using a Geographical Information System (GIS) has demonstrated a better optimization of the system. Finally, it was highlighted the social utility of the proposed model, because citizens become an active part in the process and self-produce soil fertilisers.

ID: 4677

Development of a simulation model for macronutrients concentration estimation in a lab-scale aquaponic system

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Aquaponics is an innovative, sustainable food production system that integrates fish culture with hydroponic crops cultivation by recycling water. Aquaponics has a key role to play in food provision since it provides a high nutrient food and it tackles global challenges such as reductions in energy use, food security and water scarcity. The fluctuation of nutrients in one-loop aquaponic systems depends mainly on fish effluents and plant absorption. In this work a model to estimate nutrient concentrations into a laboratory-scale aquaponic system was developed and validated. The model estimates the concentration of NO_3^-, PO_4^{-2}, NH_4^+, K^+, Ca^{+2} in the different parts of the system (fish tank, plant grow bed). To evaluate the model efficiency, a lab scale aquaponic system was used with a combination of a lettuce crop and tilapia breeding. The fish tank water was recirculated constantly from the fish tank to the grow bed and back to the fish tank. Measurements were performed during a cultivation cycle of the lettuce crop with lasted 40 days. The model predicted with high accuracy the nutrient concentrations from the two main parts of the system: before and after the grow bed. The model will be further used as a part of a designing tool for aquaponic systems dimensioning. This research has been co-financed by the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE – INNOVATE (project code:T1EDK--01153).

ID: 4698

Use of near infrared spectroscopy for the assessment of waste wood quality to energy use

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Wood is a highly exploited resource in several sectors, but it is also limited. For this reason, waste wood (WW) is becoming an appealing alternative material since nowadays a large amount remains unused. The great interest in WW is related to the possibility to use it for the production of panel board or as a bioenergy feedstock, mitigating greenhouse gasses emissions and contributing to meet the European energy targets. This is also in line with the Waste Framework Directive that favors the reuse and recycle over the landfill. The identification of the best-suited application and the definition of the possible end-users is directly linked to the assessment of the WW quality characteristics. In fact, it is well known that WW is a very heterogeneous material, and its quality classes definition and degree of contamination also change according to the countries and to their different laws. Consequently, the determination of WW composition is the focal point for choosing its best reuse and avoids expensive landfills, and reduce risks for human health and the

environment. In this study, a set of WW samples have been characterized in order to investigate its heterogeneity. The samples have been collected during a sampling plan in a panel board industry located in northern Italy. All of the samples have been analyzed by means of near infrared spectroscopy directly at the company and later in the lab. The most important chemical and physical properties have also been assessed. Multivariate data analysis has been used to evaluate the variation in sample properties and investigate the optimal sampling and analysis procedures. In addition, Partial-Least Squares regression models have been developed and the results indicate that spectroscopy could be used as a tool for the rapid evaluation of WW parameters for energy applications. The project leading to this application has received funding from the EU's Horizon 2020 (GA 838560).

ID: 4777

Potential of slurry from intensive dairy cattle farms for paulownia and populus trees, as organic fertiliser: i. Effect on production

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Intensive dairy cattle breeding have a relevant social and economic impact in Portugal, particularly in the northern region. This activity generates a high flow of livestock effluents (slurry), rich in important nutrients for plant growth, which can be introduced into forest production systems. These effluents can provide a good alternative to mineral fertilizers, not only from an economic perspective, but also from the point of view of environmental protection. In the present study, the effect of increasing doses of slurry on tree growth, either with or without mycorrhizal arbuscular fungi and plant growth-promoting bacteria inoculation, was evaluated in clones of *Paulownia CoT2* and *Populus i214*, as they are genotypes that have a high efficiency in the mobilization of soil nutrients (namely N) and in the capture of CO_2 from the atmosphere, as well as high biomass calorific value. For this purpose, a demonstration field trial was installed, occupying an area of 14 607 m^2, where the trees were planted with the compasses of: 2.5 x 1.5 m and 2.5 x 0.75 m, respectively for *Paulownia* and for *Populus*. Prior to transplantation to the field, some plants were inoculated with mycorrhizal arbuscular fungi and plant growth-promoting bacteria. In the field, the following treatments were performed: T0 - no fertilization, either mineral or organic, T1 - amount of slurry equivalent to 85 kg of N ha^{-1}, T2 - amount of slurry equivalent to 170 kg of N ha^{-1}, T3 - amount of slurry equivalent to 340 kg of N ha^{-1}, both with and without inoculation Results revealed a significant and positive effect of the slurry application, both in the diameter at breast height (DBH) and total stand height, showing its high fertilizing potential and, thus, providing an alternative to chemical fertilization and to uncontrolled disposal of highly polluting waste.

ID: 4779

Carbon footprint of commercial greenhouse crops in greece: a case study of poinsettia and geranium in Attica Region

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The objective of this paper is to estimate the carbon footprints (CF) of two potted Poinsettia products (**EP3G**: 3l PP pot, 2016m^2 glasshouse, **EP0.68P**: 0.68l PP pot, plastic greenhouse 1051.2m^2) and one potted Geranium product (**PZ2.2P**: 2.2l PP pot, same plastic greenhouse), all grown on a commercial nursery farm located in Attica Region, Greece. For all plants, fertigation using an open hydroponic system and peat as a substrate was applied. A LCA method was conducted using two reference flows at the point of sale: a) one pot and b) 1kg of net plant biomass, using the SimaPro v. 8.5.2 PhD software for the simulation of the three supply chains. The potential CF estimates when expressed per pot were equal to 3.41, 0.90 and 0.76kg CO_2eq for EP3G, EP0.68P and PZ2.2P, respectively, while when expressed per kg of plant biomass equal to 2.98, 3.16 and 0.97kg CO_2eq for EP3G, EP0.68P and PZ2.2P, respectively. CO_2 emission due to the combustion of heavy fuel oil for greenhouse heating in the nursery farm was the major contributor to the total CF for both EP3G and EP0.68P while fossil CO_2 emissions from peat production and its transport to the nursery farm the major contributors to the total CF for PZ2.2P. The results indicate that the choice of reference flow could be misguiding regarding the relative CF performance of EP0.68P. The higher CF per kg of plant biomass for EP3G and EP0.68P can be mostly attributed to the use of heating by burning heavy fuel oil. The difference in the CF per kg of biomass between EP0.68P and EP3G is connected to the higher GHG emissions both from the nursery farm and the inputs for greenhouse climate control (mostly heavy fuel oil production) for the EP0.68P. A less fossil fuel dependent on-farm heating system and a less GHG emitting substrate alternative would be required for the improvement of the CF performance of the studied systems.

ID: 4794

Plastics in agriculture: the problem and one potential solution

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In the last decades agricultural production and food quality rules have forced the use of plastics in various activities. Currently, the plastic waste that results from agricultural activity is recycled outside of Portugal which increases the ecological footprint associated with the life cycle of these materials. It is crucial to consider new models for their valorisation at local and regional level and in a circular economy perspective. In the scope of the Placarvões project (from plastic waste to

activated carbons) it was elaborate the study of the types and quantities of plastics used in one of the biggest irrigated areas in Portugal, the Alqueva dam irrigation area. The methodology establish a reference plot of 700 x 700 meters (49 ha) with is 90% irrigated land and detailed, for each crop, the types of plastic used throughout the culture cycle. Currently the agricultural plastic volume in the Alqueva irrigation area is 1.880 ton per year, and with the expected growth of the irrigated area, it can reach to 3.500 ton per year. The plant protectors represents 56% in the total of plastic waste, followed by the plastic film. These 2 types of plastic represent 85%. The crops that use most plastic are intensive olive groves, almond (plant protectors) and table grapes (plastic film) and represents more than 91% of the total plastic wastes of this agricultural area. The Placarvões solution involves the production of activated carbons (AC) from plastic wastes derived from agriculture, disposable plastics and the fraction rest that results from the mechanical/biological treatment of municipal solid wastes (CDR). The AC were produced by physical and chemical activation. The AC were tested as adsorbents for the removal of 2,4-D and MCPA from liquid phase. This solution may be applicable in the water waste treatment in the region, contributing to the circular economy in the territory.

ID: 4811

Livestock effluents: strategic approach towards agronomic and energetic valorization of flows in the farming activity

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Livestock production is concentrated in specific regions, some without enough area for land spreading valorisation of effluents. Therefore, in order to be competitive and comply with legal requirements, the sector should promote a circular economy, pursuing new alternatives for effluents management. This project aims to valorise the livestock effluents as a resource, focusing on the production and integrated management of the different flows generated as well as to optimise effluents use as secondary raw materials, recovering energy and nutrients, improving farm nutrient balances and promoting sustainable management. The core activities to achieve these objectives relate with the four main routes: manure processing/composting, bioenergy production in a livestock farm, biodegradation by Black Soldier Fly (BSF) larvae and agronomic efficacy studies. Preliminary results of some of the activities developed within the project will be presented: characterization of the Portuguese intensive livestock sector (poultry, pigs and dairy cows), biochar valorization, anaerobic digestion and biodegradation by BSF larvae of manure. The main goal of the project is the application of an established roadmap, including technology portfolio, for effluents management and testing the weak and strong points to promote common advances in the nexus biowaste/bioenergy/bio-fertilizer, closing the nutrients' cycle towards a sustainable bioenergy economy, creating a positive balance between manure production and manure valorisation due to its add-value use. Besides the results will support decision-making on centralized/decentralized solutions and also contribute to sustainable livestock intensification and landscape planning, to face climate change and resources scarcity.

ID: 4814

Traditional compost and BSF-biodigested compost in the organic fertilization of ryegrass

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The present study is a contribution to evaluate the agronomic potential of two different organic products (cattle effluents, either composted or digested by Black Soldier Fly larvae) as organic fertilizers, through the measurement of the photosynthetic activity of ryegrass (Lolium multiflorum L.), growing in a sandy soil, treated with different doses of those products. Within this aim, an experiment was conducted in a semi-controlled greenhouse with ryegrass plants cultivated in pots, with ten treatments: four different treatments of composted material, four different treatments of digested material, a zero control (without any type of fertilization), and a mineral control (using the recommended rate of mineral fertilizer for ryegrass). Gas exchanges were measured in adult expanded leaves of 6 weeks old plants, using an infrared gas analyser (LI6400, Li-Cor), prior to the first plant cut. Under the experimental conditions, the results showed a significant effect of both organic composts, also perceived through overall photosynthetic activity of ryegrass plants and biomass production. This work was funded by PRD2020 through the FEADER, Project GOEFLUENTES (PDR2020-101-031831).

Education and rural development

ID: 1886

Analysis to map invasive plant species along roads: performance of different obia software

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Invasive plants can have devastating impacts in the economy, human health, biodiversity and ecosystem functionality, and they should be early detected for efficient management. Roads and roadsides represent a dispersion channel for many invasive plants. Remote sensing arises as an important tool for ecological studies to assess and monitor the dynamics of invasive plant species along roads, gathering information in a quick, efficient, continuous, consistent and repeatable way over large areas. In this study, we explore the potentialities of object based image analysis (OBIA) methods to map invasive plant species along roads using very high spatial resolution (VHSR) imagery. We aimed to compare the performance of OBIA methods implemented in open source software (OTB/Monteverdi) against those available in two proprietary softwares (eCognition and ArcGIS). First, we classified vegetation and non-vegetation classes using the classification algorithms nearest neighbour, maximum likelihood classifier and support vector machine through a segmentation process using the algorithms multiresolution segmentation and mean shift segmentation algorithm in 15 study sites. These sites, representative of the habitat diversity of the study area, were selected based on the location of the individuals of invasive plants recorded during the field survey. We performed a second segmentation and classification, both using the same algorithms of previous processes, on cropped images representing only the vegetation classes, to distinguish invasive plant species from other dominant species.Overall, the proprietary software eCognition presented the best accuracy assessment (OA_{1st} = 95.7%, OA_{2nd} = 92.8%) for mapping invasive plant species, while the open source software OTB/Monteverdi presented medium values (OA_{1st} = 87.0%, OA_{2nd} = 63.3%) and the proprietary software ArcGIS showed the lowest values (OA_{1st} = 84.32%, OA_{2nd} = 45.7%).

ID: 2736

Attitude of spanish agriculture students towards education in sustainable precision agriculture

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The principles of Sustainable Precision Agriculture (SPA) have been around for decades, and due to technological advancements in recent years, the commercial market for SPA has expanded

substantially. Adoption rates by farmers have however been lacking behind their prediction since the beginning. These days, a farmer has to possess a wide variety of skills, which aren't all covered in common agronomy curricula. The Erasmus+ Project "Sparkle" aims to complement traditional agronomist education with entrepreneurial skills and SPA knowledge, through a mixed format of online courses and face-to-face learning. To develop the contents of this proposed course the perception of agronomy students first had to be assessed, to be able to pinpoint their interests and their perceived knowledge gaps. This paper presents survey results of 192 students at the agronomy faculties of 4 universities across Spain, 48% bachelor and 52% master students. The findings are summarized and interpreted, and correlations between answers are identified using principal component analysis (PCA). Students perceive a lack in knowledge in all skill types included in the questionnaire. They are consistent in rating their own knowledge, and are interested in learning more on all proposed topics, regardless of age or study level. Generally, they prefer on-site or face-to-face teaching, and interactive teaching methods over passive communication. When combined with other studies that are being carried out within the project, the results of these questionnaires will provide the basis for the agri-entrepeneurial Sparkle course.

ID: 3165

Acquisition of knowledge through creativity and leadership in a multidisciplinary environment

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The training of the agronomic engineer increasingly requires multidisciplinarity and the acquisition of transversal skills that help him in his working life and in the interaction with the rural environment. This work addresses the acquisition of knowledge through work in multidisciplinary teams in which the student is an active part of learning. Strengthen the skills and competencies necessary for learning the subjects as useful in the subsequent exercise of the profession. The skills to work are: CT1: Oral and written communication; CT2: Analysis / synthesis and critical reasoning; CT5: Respect for the environment: Promoting the inclusion of the SDGs; CT6: Organization and planning; CT8: Teamwork; CT10: Leadership and decision making; CT12: Creativity. The proposal includes the realization of projects in groups of students from different subjects and degrees taught at the ETSIAAB. The projects will integrate teams of several subjects that must carry out the analysis of a problem and the proposal of a solution comprising knowledge of three of the subjects involved. One of the subjects, related to technical issues of energy, another with calculation of facilities and one more with issues of planning and economic management, which gives it an interdisciplinary nature. The competences require the reinforcement not only of the teacher but also of the classmates themselves, who would be both competitors, students and jurors when assessing the results of the rest of the students. Each group will be involved in the evaluation of the solution provided by the rest of the groups, as well as, partially, of their own. The latter drives the critical spirit of the alumnus. The work, developed will allow evaluating before and after the capabilities

through self-assessment tests, which will allow obtaining measurable results on the goodness of the method.

ID: 4607

State of the art on degree study programs in agricultural/biosystems engineering in EU

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The process of international harmonisation of the degree study programs in Agricultural/Biosystems Engineering (ABE) was started by Prof. Giuseppe Pellizzi during CIGR 1989 Conference and was continued by Prof. Pierluigi Febo in EU, within EurAgEng SIG RD12 - Education and Communication, and also within CIGR WG1 - Agricultural Engineering University Curricula Harmonization. Then, four thematic networks were effective: 1) USAEE-TN (University Studies of Agricultural Engineering in Europe - A Thematic Network), comprising 31 HEIs (Higher Education Institutions) from 27 countries, from 2002 to 2006; 2) Consortium POMSEBES (Policy Oriented Measures in Support of the Evolving Biosystems Engineering Studies in USA - EU), comprising 8 EU and 4 USA HEIs, from 2006 to 2008; 3) ERABEE-TN (Education and Research in Biosystems Engineering in Europe - A Thematic Network), comprising 35 HEIs from 27 countries, from 2007 to 2010; 4) Consortium TABE.NET (Trans-Atlantic Biosystems Engineering Curriculum and Mobility), comprising 4 EU and 2 USA HEIs, from 2009 to 2013. Some examples of significant changes relevant to ABE degree study programs occurred in EU after the end of ERABEE-TN project: they are the curricula established by the HEIs of 7 countries. The aim of this work is to show the state of the art on ABE degree study programs in EU 20 years after the last overview, presented during AgEng2000 Conference. Even if the monitoring of ABE degree study programs in EU is still in progress, the Universities of some countries (e.g. Czech Republic, France, Germany, Lithuania, Netherlands, Norway and Portugal) offer BSc. and MSc. curricula in this area, while the HEIs of other countries (e.g. Austria, Denmark, Finland and Italy) offer BSc. and MSc. curricula including subjects related to Agricultural Engineering and Applied Agricultural Engineering as at least 30% of the total ECTS study load.

ID: 4781

How well do agricultural engineering curricula fit the examination requirements of the agricultural engineers corps?

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Access to the corps of Agricultural Engineers in Spain and in the Valencian Regional Government, is carried out through a public examination. Each public examination has a defined content for each of its exercises and usually encompasses a broad range of knowledge in the field of current agronomic engineering. In this work, the variation in contents of the competition syllabus for the State Agricultural Engineers and Valencian Regional Government Agricultural Engineers is analyzed and compared with the academic curricula of the agronomic engineering schools that teach the qualifying Master's degree in Agronomic Engineering in the Valencian Community. This comparison is analyzed taking into account the trends in agriculture that are projected for the next future and recommendations are given for the review of the teaching content of the subjects that are related to the content of the competitive examinations.

Energy and bioenergy

ID: 2641

Evaluation of the cost-effectiveness of renewable energy sources in wineries

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The objective of this study was to analyze the viability and cost-effectiveness of renewable energy sources in wineries. The alternatives were compared by evaluating costs over their useful life. Photovoltaic (PV) and geothermal heat pumps have been evaluated. The factors studied were as follows: solar radiation, the cost of installation, the prices in the public electricity grid, the size of the winery, and the seasonality in the consumption of energy. In a winery without seasonality, with the mentioned factors at the usual levels in Europe, the PV installation evaluated is profitable, with values of payback between 10 years (southern Spain) and 18 years (northern France). Seasonality is key in the profitability of the PV system for self-consumption, related to the optimum power to be installed. The values of payback of geothermal heat pumps are worse than those of PV.

ID: 2737

Description of a pilot scale test station for measurement of static and dynamic loads in silos under different conditions

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There are few full-scale experimental stations to study the mechanical behavior of the stored materials in silos, therefore there are few data to validate the theoretical models, what are essential to design these structures. The work aims to describe the experimental station built at the Federal University of Lavras (Brazil) according to the methodology described in the project of Pieper Schütz [1]. This model contributed to support DIN 1055-6 [2]. The station consists of two silos, one fully instrumented to perform the tests (pilot silo) and the other to store the test product (storage silo). These silos are connected by a bucket elevator to transport the product, enabling filling and discharging. The pilot silo is metallic and 6 meters high with a diameter between 0.69 and 0.71 depending on the wall to be used. The pilot silo is instrumented with a total of 59 sensors to measure lateral pressures and friction forces on the wall. With these test facilities is possible to obtain different configurations such as: 12 height / diameter ratios, 8 hoppers (changing concentricity, eccentricity and angles), 3 different silo body wall roughness, consolidation time, discharge flow and different materials. The experimental station developed by the authors is capable of obtaining horizontal and friction pressures in the silo body, vertical pressures, normal hopper pressures, as well as contributing experimentally in the silo action field due to the stored product and in the future also contributing to the validation of finite element models. In addition, it can be obtained different

parameters at a real scale, which have been demonstrated are different to those obtained in laboratory tests, for example the lateral to vertical pressures ratio (K), friction coefficients and the Poisson ratio.

ID: 2740

Experimental and numerical study of silo filling using pellets

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At present, different biological materials, agricultural crops or forest products are susceptible to be industrially transformed to be used as solid biofuels. The most common presentation for these materials is in the form of pellets, whose storage is carried out mainly in hoppers, silos or bunkers. However, there is an important lack of knowledge about the mechanical behavior of these stored materials, what causes difficulties in the structural silo design. Numerical models have proved to be a useful tool to analyze this phenomenon and even for the design of silos. However, numerical models need parameters that must be experimentally obtained and finally they must be validated by experimental assays. The objective of this work is to present a finite element model developed by the authors to simulate the mechanical behavior of pellets that have been stored in a silo. This model has been compared with the experimental results obtained using a real scale silo test. The experimental analysis was performed at the experimental station located at the University of León, designed and built by Couto, Ruiz Aguado [1] and Ruiz, Couto Aguado [2]. The parameters such: specific weight, modulus of elasticity, internal friction angle, wall friction coefficient, angle of repose and Poisson's ratio were determined experimentally. The numerical model was made in 3D, using Ansys 19.2 software. For simulate the filling stage all nodes placed at the hopper shell of the silo were totally restricted. The behavior of the pressures in the silo and hopper were verified, as well as the displacement of the grains and the directions of the main stresses. The authors thank the University of Leon financing this research via the project ULE - UXXI2016/00124 "Logística y seguridad en instalaciones agroindustriales y domésticas de biomasa sólida con origen agroforestal".

ID: 3275

Electricity production based on an agrivoltaic system. A study case for etsiaab in UPM

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The land dedicated to crops is affected by photovoltaic solar plants (PVSP), leading to a fight for land. PVSP need large space for its operation what compete with agricultural lands. Agrivoltaic systems can fix this problem whith the combination of both. The term "agrivoltaic" is defined as the use of a land for both agricultural crop and electricity production. Photovoltaic panels will be placed in posts and in between rows posts, it will be positioned crops in a way that radiation can fall over

along the day. In addition, the spaces between posts rows and high ones will be appropriated to mechanize crops. Several scientific works confirm the benefits that a combined system of photovoltaic panels and crop provide. According to Marrou, Dufour et al. (2013), crops increase their yield under the shade of photovoltaic panels, since evapotranspiration is reduced by 10-30% when available sunlight is 50-70%. Also, efficiency in water using is increased, because varieties that have a greater coverage of the soil contribute to capture of sunlight being considerable and decrease the evaporation of the soil. In the Escuela Técnica Superior de Ingeniería Agronómica, Alimentaria y de Biosistemas (ETSIAAB), in Universidad Politécnica de Madrid (UPM), there are 16.5 ha for Experimentation and 6.7 ha are experimental crops . The annual electricity consumption of the Experimental area is very high (1100 MWh/year). An agrivoltaic system is proposed to reduce electricity cost and the carbon footprint. First, it should be analysed what crop is suitable to be under shadow of solar panels. Then, the installation of 48 kWp of photovoltaic power panels will produce 67.2 MWh/year. This will supply 6% of the current electricity demand. The annual saving would be 10080 €, since the price of the energy is 0.15 €/kWh after taxes. With a cost for the installation of 72000 €, the payback time would be between 7 and 8 years.

ID: 3365

Very shallow geothermal system to improve the energy efficiency in dairy barns

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In cow barns, milk cooling is a crucial activity to guarantee the product safety. This operation is performed at every milking and is highly energy consuming. A few farms in the Mediterranean region installed pre-cooling systems taking advantage of free heat exchange between the milk and the low-temperature water taken from well or aqueducts and used for cow drinking and soaking. Ideally, this system can both reduce the milk temperature before the refrigerator intake and at the same time rise the water temperature. This latter aspect plays an important role, avoiding health risks and production losses, since low temperatures often discourage the animals from drinking. Since milking is performed twice a day in limited time in barns equipped with milking parlor, the system shall face two main goals to be effective: to avoid water waste and to keep water temperature between milking. This work presents a system integrating water-milk heat exchangers with a very shallow geothermal system. A newly developed geo-exchanger, designed with double circuit spirals, can exchange the milk heat partially with the ground and partially with a second fluid (cow drinking and soaking water). Moreover, it can keep the water at the proper temperature for hours taking advantage of ground thermal characteristics. The study shows that the proposed system enhances the milk-water free cooling performance, rises and keeps the water temperature, and, if properly sized, avoids water wasted. The study is applied on a case study barn located in Bologna countryside (Italy) and based on experimental data achieved from a thermal response test campaign carried on a shallow geothermal system in the University laboratories.

ID: 4705

Methane emissions from cattle farms: comparison of measured emissions and inventories estimates

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Monitoring and mitigation of methane (CH_4) emission is a crucial step to reduce climate change impacts, and agriculture is one of the most significant CH_4 sources and therefore needs consideration. The bottom-up and top-down comparisons of agricultural methane emission have shown disagreement, which motivates investigation, especially in regions where this has not been done yet. Several studies have quantified CH_4 emissions, most of them focus on either manure or enteric emission and different factors affecting sources strength. The emissions from the whole-facility were here quantified using the tracer gas dispersion method. The method consists of using a tracer gas with a known release to simulate the farms' emissions, combined with downwind measurements of the target and tracer gas, besides, the uncertainty of this technique is estimated as lower than 20%. Nine Danish cattle farms with different manure management, housing systems, animal breed, and production type (Dairy and Beef) were quantified during a whole year approximately six times. The emissions ranged from 1 to 28 kg/h, which corresponded to an averaged emission factor of 22 ± 9 g_{CH4}/LU/h. The differences between dairy and beef farms' emissions factors were one of the most significant among the different management studied. Comparison of measured emissions with national and international inventories (IPCC 2006, IPCC refinement 2019, and Danish National Inventory) shown an underestimation by the models of approximately 30%, the national model on average performed worst. Although, for most of the measured facilities (66%), model and measurements difference were within their uncertainties limits. Furthermore, this type of study can be used to point at some of the factors that might need revision by the inventory models, and the impact of management strategies on methane emissions.

Integrated and sustainable farming systems

ID: 2526

On-farm dry matter monitoring system - silage sampler, dry matter measurement and mobile app for feeding adjustment

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Proper feeding is important for cattle wellbeing and productivity of dairy farms. Maximizing milk yield requires regular monitoring of silage quality. The amount of concentrated feed fed depends on the dry matter content of silage. Economic impact can be significant if too dilute or concentrated TMR is fed resulting in milk yield reduction or extra bought-in feed costs. Still, in general, the process of adjusting TMR recipes requires several steps and operators and cannot be done on a daily or a lot-by-lot basis. Smartfeed EIP-AGRI project developed silage quality monitoring enhancing time management by combining work tasks and providing tools to measure dry matter and edit feeding on site. The developed system was piloted at farms and user feedback was collected. In the project, a new silage sampler attached to a bale gripper was designed. The sampler consists of a sampling tube and a support spike attached to a pivotable adapter allowing the probe to be folded down for other work tasks. A sampling bag can be fastened to the end of the sampling tube to collect the samples. A moisture analyzer was tested for on-farm DM measurement of silage (n=84) and TMR (n=36) samples. Suitable methods were selected and compared to oven drying (60 °C). Intra-method variation was 2-3 % depending on sample type (reference 2 %) and reproducibility was good (3 %). The method for silage samples gave systematically slightly lower values compared to oven (average deviation -4.8 %). The difference can be corrected by a coefficient (1.05x) that is valid at least for timothy-fescue grass, clover grass and whole crop silage. An Android application was designed to adjust TMR recipes. The application calculates the changes in the amounts of different components of a TMR recipe in situations where the DM% of silage changes or the amount of component is changed. Thus, farmers are able to react to changes in dry matter as quickly as possible.

ID: 2575

Damages produced to citrus fruits during detachment using a high amplitude and low frequency shaker

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The crucial problem of the high costs of the manual harvesting of fresh citrus in Spain could be solved using mechanical systems. Previous results have shown that long amplitudes, 100 mm or

more, combined with low frequencies, 3 to 6 Hz, are highly efficient in citrus fruit detachment and produce low defoliation. Low frequency commercially available canopy shakers are too large to be used in the citrus orchards cultivated in Valencia (Spain) and produce excessive damage to the fresh market fruit. A light shaker, that can be hitched to the three point hitch of an orchard tractor or to the arms of a compact track loader was developed, it is a linear shaker, based in a slider and crank mechanism that allows the amplitude regulation, and a rigid arm that grips the tree branch. Previous results have demonstrated good removal efficiency (between 62 % and 97 %) when shaking with frequencies from 3 to 6 Hz and amplitudes from 100 to 180 mm. However, fruit damages during detachment and falling through the canopy have not been tested. Video image analysis and accelerometers were used to measure rubbing of the fruit against branches and fruit striking against other fruits or branches. A methodology to assess fruit damage during detachment has been proposed. Further research should be carried out to study other factors involved in fruit injuries previous to the collecting systems during mechanical harvesting.

ID: 2655

Effects of planter attachments on corn emergence and corn yield

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Conservation tillage and no till practices to sustain soil coverage and soil structure, to avoid erosion and to optimize soil functions put high requirements on seeding and planting technologies. Today single-seed drills are designed and optimized to cope with the specific conditions of these practices. But there are still situations where the seeds are not well placed and covered with soil causing bad emergence and yield losses. To avoid these problems different planter attachments like row cleaners, leading coulters, combinations of both and different types of closing wheels are offered. Although planter attachments are very popular in the USA and more than 10 manufacturers are producing them, publications or reports on scientific investigations about their effects on plant emergence and crop yield could not be found. Therefore own investigations have been conducted. To investigate the effects of selected planter attachments on corn emergence and corn yield, randomized field experiments with large plots (40 x 3 m) have been carried out over 4 years and on 3 locations in Bavaria.The 3 factors of the trials have been tillage strategy (conservation Tillage / no-till), type of leading planter attachment (no additional attachment, lwaved coulter, fixed row cleaner, combination of waved coulter and floating row cleaner) and closing wheel combinations (two standard closing wheels, one standard closing wheel plus a structured closing wheel). All 16 variants have been repeated 4 times at each location. The tillage strategies showed a significant influence on germination and yield of corn (conservation tillage higher than no-till). Only a few attachments had significantly positiv effects on the germination (waved coulter + floating row cleaner) or the yield (waved coulter). The different closing wheel combinations showed no influence. The tested planter attachments showed only little improvements.

ID: 3538

A new paradigm in biosystems engineering: technology-4-ecology based farming

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Agricultural production worldwide faces huge challenges to achieve the UN Sustainability Development Goals and international agreements with respect to environment (depletion of scarce resources, global warming, acidification, nutrient losses, and biodiversity loss), labour (availability of skilled workers), and society (consumer/societal acceptance of novel technology). We believe that further optimization of current farming practices with precision agriculture and precision livestock farming technologies is not sufficient for this. A paradigm shift is required for the next-generation agricultural production systems that are sustainable, circular and regenerative. The Synergia research program addresses this need through the new concept of 'Technology-4-Ecology-based farming' (T4E): biological/ecological principles in farming lead the development of new farming systems, and by that the required technological knowledge, principles and tools. With a multi-disciplinary team of people with biology, ecology, agronomy and technology backgrounds, we definedthe following 4 principles for Ecology-based solutions and strategies: 1. Rely on natural processes as driver for agricultural ecosystems and primary productivity; 2. Sensing of traits should focus on a) following biological production processes instead of momentary states, and b) on biological and ecological traits in the systems instead of production traits and problem indicators only; 3. Modelling should focus on understanding of the underlying biological ecological process; 4. Control and management should focus on prevention of problems, and make smart use of biological diversity and ecological complexity. Instead of opposing high tech to nature-based production, we will explore how current and future farming technologies can enable and support truly ecology-based farming systems. This is the basis of the Synergia research program and will be applied to three use-cases in horticulture, dairy and arable farming.

ID: 4695

Towards integrated mechanised management of olive farms

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Olive orchards need to increase their degree of technification to be competitive in a global market. For this, it is essential to mechanize the work, as well as the digitization of all the data associated with the crop. All this allows for integrated management and great profits in the entire supply chain. These include traceability and food safety, optimisation of resources and inputs, as

well as providing added value to the final product. This paper presents a methodological proposal to control the integrated management of plantations using mechanisation of operations and cloud-computing technology thanks to the Innolivar project. In this project, different prototypes of machinery and technology are being developed to mechanise and integrate all of field operations. The first step is to register all the operations carried out in the plantation, together with information on the machinery and products applied. Harvesting, the last field operation, is carried out with lateral canopy shakers which detach, intercept and store the fruit. These machines incorporate continuous weighing systems for olive batches and real-time geo-referencing to obtain harvesting yield maps. The olive batches are harvested and stored in big-box provided by a RFID tags to identify them. Once the batch is full, it is unloaded onto a cleaning and classification system in the field that separate branches, leaves or stones and sorts the received batch into different qualities according to bruising, size and ripeness index. Each quality batch that is generated is also tagged and transported to the industry, in cooled liquid (table olives) or trailers (olives for oil). In this way, the industry can consult the traceability of the batches and continue to associate information in its facilities until the final products are created. All the information generated is stored in the cloud and shared among all the actors in the food supply chain.

ID: 4716

Suitability of citrus mechanical harvesting methods from the fresh market to industrial transformation

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Most citrus production in Europe is destined for the fresh market. However, the lack of labor availability, the low price that the farmer receives for the product and the large variations in fruit production make the industrial market of special interest. The proposed alternative is the use of harvesting technology to facilitate the current plantations to achieve a double aptitude. First, an early manual harvesting of the highest quality and easily harvested fruit. Subsequently, when the fruit has ripened on the tree and reached industrial quality, a second harvest by mechanical equipment, removing all the fruit from the tree. The olive groves harvesting technologies have been selected for the mechanized harvesting of citrus fruits for industry. The adaptation of the same equipment able to work with different crops would facilitate their entry and spread into the market. Two harvesting technologies have been developed: canopy shakers and trunk shakers. The machines have been adapted according to the dynamic properties of the citrus trees. The most suitable vibration parameters have been selected to remove fruit without damaging the tree or dropping leaves and shoots. A prototype of lateral canopy shaker has been adjusted with a vibration of 4.5 Hz and high amplitude, greater than 150 mm. It achieved a fruit harvesting efficiency of 78.9% with a forward speed of 1 km/h. A trunk shaker, with a vibration frequency of 12 Hz and amplitude close to 28 mm, achieved a fruit harvesting efficiency of 72%. In both cases, the quality of the

harvested fruit was high and tree damage was reduced. Adaptation of the current orchards by pruning, removing lower branches and allowing machine access to the trunks was necessary for the use of the equipment. Modernization of citrus orchards through mechanical harvesting is a technologically viable alternative.

ID: 4728

A functional design framework for successional agroforestry systems in different bio-physical contexts

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Farming systems face the challenge of feeding the growing world population within the planetary boundaries. A radical shift towards regenerative agriculture, that imitates the functioning of natural ecosystems, is needed. Successional AgroForestry Systems (SAFS) are one of the potential solutions. However, so far they have mostly been adopted on small-scale farms in tropical regions. Design tools that facilitate the replication of SAFS in contrasting bio-physical contexts are lacking. This study combines the engineering design approach Reflexive Interactive Design with a trait-based approach from functional ecology. A function analysis of a case study large-scale SAFS from Brazil was performed, through interviews and observations. The set of 13 identified functions with relative subfunctions was then used to develop a Functional Design Framework. The framework encompasses a filtering mechanism from the total pool of plant species to the actual plant community, by three types of requirements a) those set by the biophysical conditions b) those set by the required function performance and c) performance of the whole system on the farm objectives. A Morphological Functions Diagram and a Strata, Successional Stage Functions Matrix were developed as practical and visual tools to facilitate the design of regenerative agroforestry systems in different biophysical contexts. The framework was tested in a theoretical SAFS design for the Mediterranean context, based on the needed functions and the plant compatibility over space and time, proving the usefulness of the proposed framework as a design tool. More extensive functional-traits-related data for species of agricultural interest is needed in order to apply the Functional Design Framework and trait-based approaches in general. This data would allow modelling and evaluating changes in ecosystem structure in relation to changes in agroecosystem functioning.

ID: 4732

Particulate matter emissions from soil preparation activities as influenced by minimum and strip tillage practices

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Land preparation activities are one of the main contributors of particulate matter (PM) emissions from agriculture. Nonetheless, particulate matter emissions from tillage operations are poorly studied, especially in southern Europe, where few assessments have been made. Moreover, it is important to describe the influence of tilling implements and soil preparation practices on the emissions of fine PM (PM_{10}) from fields. A research project, titled "Evaluation of particulate matter emissions from cropping and farm transformation activities in Maize production systems", has been funded by CRT foundation (grant numbers: 2018.2273) to tackle the issue of PM emissions from Maize cropping systems, including land preparation activities. This study, in particular, presents the results of field trials with assessment of three land preparation scenarios for maize: traditional tillage with ploughing at 30 cm followed by rotary harrow (TT), minimum tillage with disk harrowing (MT) and strip tillage, with soil tilled in strips of 25 cm wide at a working depth of 15 cm (ST). Emissions of PM_{10} resulted being of 143, 30 and 114 mg m^{-2} respectively for TT, MT and ST. These results give a first insight into reduced soil disturbance practices as mitigation measures for tillage induced direct PM_{10} emissions and highlight MT as the less emitting tillage practice.]

ID: 4736

Comparison of a light-weight experimental shaker and an orchard tractor mounted trunk shaker for fresh market citrus harvesting

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In a previous experiment, a designed light weight experimental shaker had been successfully used to collect oranges from ornamental trees. In this study the experimental device has been tested to harvest fresh market citrus. The objective of this work was to evaluate the removal efficiency and operational times of the experimental device compared to an orchard tractor mounted trunk shaker. Fruits were collected using cushioned canvas and elevated canvas to reduce citrus damage. The light weight, linear and low cost, experimental shaker was coupled to a pedestrian tractor. In a preliminary test, vertical branches from `Navelina´ and `Fukumato´ varieties were tested. In a second step, after a modification in the shaking arm, nine similar trees, according to size and structure, from the Navel group, `Caracara´ variety, were selected and tested. Removal efficiency, vibratory frequency and amplitude, fruit and tree damages and fruit quality were measured. Additionally, a high-speed camera was used to record operational times and to determine

cumulative removal percentage over vibration time. No significant differences in removal efficiency were found between the two harvesting systems (average values of 68 % with the prototype compared to 77 % with the trunk shaker). However, removal efficiency using the experimental device was reduced and working time increased when the access to the main branches to be shaken was difficult. In agreement with previous results, the curve representing the branch cumulative removal percentage in time followed a sigmoidal pattern. A model was developed showing that during the first 5 s more than 50% of the fruits were detached, after 12 s 60% and only 4% more when vibrating 40 s. Regarding fruit damage, slightly damaged fruit percentage was higher when using the experimental shaker, especially little cuts and abrasions. This fact could be due to the fruit friction against leaves and thin twigs during the high amplitude vibration.

ID: 4750

Estimating costs of a chestnut mechanical harvester

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In some European chestnut producing regions, harvest is mostly manually. However, due to the difficulty to find available labour, a significant number of producers are changing harvesting procedures, adopting mechanical systems. There is not reliable information about costs associated to this harvesting system. This information can assume great importance for producer's decision. To contribute for the performance assessment of harvesting equipment based on a vacuum harvester, field trials to evaluate work rates has been carried out in Northeast of Portugal. With the data collected it is possible to estimate associated costs and contribute for a better understanding of the feasibility of this procedure. To evaluate the equipment work rate, time for each elementary operation was measured. Working rate is presented by the ratio worked area / time. Harvesting performance is assessed by field efficiency: ratio between the sum of elementary operation time during harvesting and total working time. Costs are computed under international standards for agricultural machinery management. Under environmental conditions and agriculture systems in the geographical area were field trials took place, vacuum harvesters can reduce harvesting time and associated costs. It can be an answer to the lack of labour required for manual harvesting. Despite the need for further studies, this seems to be a good solution for lack of manpower problem. It is also necessary to change some agricultural practices in the field to improve the harvesting machines performance, such as soil management.

ID: 4768

Traditional apple picking vs. Harvest-platforms: combinations of methods compared for quality, productivity, and workload

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Apple picking can be accomplished using various methods—combinations of traditional ladder-n-bucket and mechanized harvest platforms. This study aimed to provide the growers with information with which they can choose an appropriate method. Four picking methods were compared, (a) two ground workers picking the lower fruit to the buckets were followed by two on-platform workers picking the higher fruit to the conveyor belts. (b) Two ground workers and two on-platform workers picked all of the fruit, placing them on the conveyor belts. (c) Two ground workers picking the lower fruit were followed by two on-platform workers picking the high fruit to buckets (no conveyor belts). (d) Four traditional ladder-n-bucket apple pickers. The methods were compared for yield quality, productivity, and workload. We hypothesized that (1) one of the methods incorporating a harvest-platform will outperform the other methods in quality and productivity. (2) The difference in workload can explain the change in productivity over time. Method: The study was conducted in Nov. 2020 during the Cripps Pink harvesting season. An experiment day began with all pickers filling a NASA TLX questionnaire, which was filled again at a fixed time interval throughout the workday. The filled apple containers were labeled and timed for productivity assessment. The containers were transported to the storage house, where experts estimated their quality. Results: The apple-picking method (b) outperformed the other methods in terms of fruit quality and productivity. In terms of person-hours per container, methods (b) and (c) outperformed the others. In terms of container filling time, method (b) outperformed the other methods. The lowest workload was measured for the ground workers picking only the buckets (b) and (c). This study provides the growers with a basis for informed management decisions during harvest, given financial, social, and agricultural constraints.

ID: 4775

Analysis of mixing efficiency in the vertical livestock manure compositing system using DEM

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The number of livestocks and manure production increased, based on the continuous growth of the livestock consumption in Korea. Livestock manure had been used as fertilizer, but if not properly treated, it can cause environmental problems such as eutrophication and water pollution. Manure is composted mainly through sedimentation, but this method has problems such as odor and lack of sedimentary area in korea. The vertical composting machine of livestock manure can

handle the odor by capturing by treatment systems, and can be efficiently utilized through vertical deposition. However, there is no clear design standard for vertical composting machine as the interior can't be identified. Mixing efficiency of manure in composting machine is affected by the internal configuration such as number, length and angle of blades. Complete compost requires a uniform temperature distribution inside. Uniform mixing of manure have an important effect on uniform temperature distribution inside. It is difficult to evaluate the mixing efficiency of the composting machine by field, there are many problems such as huge scale, high concentration of gas. So, discrete element method simulation was conducted to simulate internal mixing. This study analyzes the mixing efficiency according to the blade designs of vertical composting machine through DEM to propose an improved design. A technique for evaluating the mixing efficiency inside the machine was developed, and speed independent test was evaluated according to the blade rotation speed. As a result, resulting in no relationship between the rotation speed and final mixing ratio. However, the total number of rotation affected the final mixing rate. The DEM simulation model was verified through field experiment based on the mixing ratio of each sampling part. Through the verified model, the mixing efficiency according to the blade shape is analyzed, and optimal configuration is proposed.

New application technologies and mechanisation

ID: 2545

Lateral stability performance of narrow-track tractors

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A tractor losing lateral stability starts to rollover. It is a matter of fact that tractor lateral rollover accident is one of the most frequent causes of death and injuries for the farmers. Consequently tractor is fitted with a specific protective structure to minimise the consequences for the driver during the rollover (ROPS). The narrow-track tractor, designed to operate in vineyards and orchards, is a tractor category with a very narrow track width and the risk of rollover is higher. The aim of the study was to evaluate the narrow-track tractor types commercially available, including, the compact narrow-track tractors, designed to mount a cantilever engine in the forward position with effects on the Center of Gravity (CoG) because more than 50% of the tractor weight is loaded on the front axle, and specifically the articulated narrow-track tractors where the stability is affected by the pivot point connecting the two tractor bodies. As a consequence of the typical tractor design during the steering action the line passing through the front and rear wheel-ground contact points changes influencing the tractor rotation. Moreover the cab ROPS fitted on the articulated narrow-track tractor with its additional devices (air-conditioning system, filters, heating system etc..) influences the tractor CoG position and finally the tractor stability. The approach of the research was based on reproducing the lateral stability tractor condition by developing a kinematic model, with the goal to virtual simulate the tractor behaviour, calculating the limit angle of inclination for each tractor type. The kinematic model calculates the lateral stability limit angle for articulated and non-articulated tractors and if used during the tractor design phase allows adjusting the tractor parameters improving the lateral stability performance.

ID: 2715

Development of a test methodology that evaluates the efficiency of an idle-stop device for agricultural tractor

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Idling is a vehicle condition in which the engine is running at the minimum rotational speed without accomplishing any useful work besides the generation of energy required to keep it rotating. Agricultural tractors may idle from 10 to 43% of their entire operating time and this inoperative time has to be minimized because it is deleterious for the environment, public health, fuel economy and engine life span. The idling time could be reduced adopting anti-idling devices such as the idling-stop that is very popular on modern cars, however these devices are not currently present on tractor.

Since the engine restart requires an energy surplus from the battery to run the starter motor, idling-stop devices are not efficient for very short idling periods. The aim of this study is to develop a test methodology able to predict the minimum idling time over that an idling-stop device turns to be energy efficient. Tests were conducted performing repeated engine switching on and off with different time lapses on a tractor with a maximum engine power of 194 kW. The fuel consumption was evaluated fuelling the tractor engine through a tank positioned on a precision scale. The power contribution delivered by the battery was evaluated with electrical current and voltage sensors. In order to analyse how the auxiliaries and the engine temperature influences idling fuel consumption, tests were carried out with and without the auxiliaries switched on, both conditions with the engine at standard operating temperature and at low temperature. Results confirm that with very short idling periods an idling-stop device is not energy efficient since the power provided by the battery to run the starter motor is higher that the energy saved during the engine shutdown. The minimum idling time that permits an energy savings is dependent on the tractor conditions in terms of engine temperature and the switch on of the auxiliaries.

ID: 2812

A discrete element approach for modelling the breakability of crop stems

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The Discrete Element Method (DEM) is becoming increasingly important for the optimization of agricultural processes. DEM modelling was already successfully applied to simulate particulate processes in agriculture such as discharge flows in silos and fertilizer streams. The use of DEM simulations to optimize processes involving crop stems has been limited due to the lack of realistic virtual crop stems. This changed recently due to the development of bendable and compressible crop stems. However, the material flow behaviour in those simulations is still inadequate because the crop stems cannot break up. This paper introduces an approach to model the breakability of bendable and compressible crop stems in DEM. It was first found that repeated stretching of wheat straw stems is approximately linear elastic. Stem failure occurs after a certain maximum load has been exceeded. Prior to this breaking event, straw stems do not undergo plastic deformation. The maximum tensile load that a stem can withstand without breaking, depends on a number of physical properties. A statistical model to predict the maximum tensile load was developed based on a series of experiments conducted during the harvesting season of 2019 on winter wheat in France. Prior to the tensile measurement, each stem was bent using a three-point bending experiment. The angle over which the stem was bent was randomly chosen and is called the maximum historical angle (MHA). The amount of bending can be considered as damage which influences the stem's tensile strength. Using regression analysis, the experimental data was used to create a tensional damage model. Physical properties included in the model are stem diameter, wall thickness, Young's modulus and maximum historical angle. The best model which could be obtained had an R-squared of 0.84 and is therefore adequate to model the breakage behaviour of crop stems in DEM.

ID: 4619

Development and evaluation of a subsoil management system to increase yield capacity of arable land

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An increasing challenge for agriculture in times of climate change is to sustainably ensure or increase the yield capacity of crop production. Low-yielding sites are particularly at risk in this respect. One strategy to counteract is to promote the use of the subsoil through intensification of rooting. This article describes the procedure, technology and agronomical effects of strip wise subsoil melioration with admixing of compost in a layer of 30-60cm (www.soil3.de). A practical technology has been developed for this patented process, which allows the described procedure to be used over a large area. The melioration is carried out in one pass by an implement in an arrangement of 3 rows resulting in a working width of 3m. The first tool is used to clear the topsoil from these strips (width 30cm). Following injection coulters bring the compost up to 60cm into the subsoil and mix it in place. Depending on the soil condition, successive remixing coulters are deployed. Leveling blades leads the topsoil back to the thoroughly mixed subsoil. The tractor driven implement is suspended in the rear three-point hitch. During melioration process forward and backward-mounted depth guide wheels are supporting. A hopper with an embedded hydraulic system, agitator shafts and adjustable metering augers was designed to feed the compost into the injection coulter. The compost hopper is hooked up on the implements frame and can be filled by using an over-loading device. Results from multi-year field trials in different regions of Germany with standard crop rotations verifies yield increases of up to 20% still 5 years after melioration. An overview of these trials and results will presented. Regional conditions such as soil type and climate will also be considered. Finally, the process parameters and an economic evaluation of the melioration process are presented with consideration of regional conditions.

ID: 4668

Development of an optimization tool for three-point hitch geometry

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The tractive performance of an agricultural tractor is affected by the loads transmitted by the implement through the three-point hitch. The aim of this work was to develop a design tool to optimize the geometry of a three-point hitch in order to minimize the front-to-rear axle load transfer during typical operations. To this end, a nonlinear constrained optimization method was used to minimize an objective function while satisfying specific constraints. Constrains are based on the ISO-730 Standard functional requirements for a three-point hitch and other design considerations. The objective function is the front axle load change during a typical agricultural maneuver. For the

determination of the front axle load, a 3 degrees of freedom nonlinear dynamic model of an agricultural wheeled tractor equipped with a front axle suspension was developed. The external loads acting on the system were determined by simulating a lifting maneuver performed on a reference soil and with a reference implement. Different three-point hitch geometries were used as starting configurations for the optimization algorithm. As a result, similar optimized geometries were found that reduce the front axle load change by about 10% compared to the initial three-point hitch design. The developed tool can help designers by simplifying the testing of new three-point hitch designs and allows to increase tractor-implement performance by reducing weight transfer effects during agricultural field operations.

ID: 4717

Suitability of citrus mechanical harvesting methods from the fresh market to industrial transformation

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Most citrus production in Europe is destined for the fresh market. However, the lack of labor availability, the low price that the farmer receives for the product and the large variations in fruit production make the industrial market of special interest. The proposed alternative is the use of harvesting technology to facilitate the current plantations to achieve a double aptitude. First, an early manual harvesting of the highest quality and easily harvested fruit. Subsequently, when the fruit has ripened on the tree and reached industrial quality, a second harvest by mechanical equipment, removing all the fruit from the tree. The olive groves harvesting technologies have been selected for the mechanized harvesting of citrus fruits for industry. The adaptation of the same equipment able to work with different crops would facilitate their entry and spread into the market. Two harvesting technologies have been developed: canopy shakers and trunk shakers. The machines have been adapted according to the dynamic properties of the citrus trees. The most suitable vibration parameters have been selected to remove fruit without damaging the tree or dropping leaves and shoots. A prototype of lateral canopy shaker has been adjusted with a vibration of 4.5 Hz and high amplitude, greater than 150 mm. It achieved a fruit harvesting efficiency of 78.9% with a forward speed of 1 km/h. A trunk shaker, with a vibration frequency of 12 Hz and amplitude close to 28 mm, achieved a fruit harvesting efficiency of 72%. In both cases, the quality of the harvested fruit was high and tree damage was reduced. Adaptation of the current orchards by pruning, removing lower branches and allowing machine access to the trunks was necessary for the use of the equipment. Modernization of citrus orchards through mechanical harvesting is a technologically viable alternative.

ID: 4788

Dynamics assessment of carbon and energy fluxes from eddy covariance time series in three different european ecosystems

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Climate plays a key role on ecosystems carbon, water and energy fluxes, while the ecosystem itself is responsible for strong feedback processes to climate by modifying the energy and hydrologic balances of the land surface. The mechanisms and consequences of this feedback are uncertain and must be studied to assess the carbon cycle and its influence on global climate change. The Eddy Covariance (EC) technique has been established as a valid method to measure meteorological variables as well as carbon, water and energy fluxes between ecosystems and the atmosphere. The high temporal resolution of EC measurements makes the statistical time series analysis (TSA) an excellent method to assess these data. Some recent studies have demonstrated the usefulness of this technique to study trends and cycles, i.e. dynamics, and forecast these environmental variables. Our overall objective in this research is to assess and model the Gross Primary Production (GPP) dynamics and its relationship with meteorological variables and energy fluxes of three different forest European ecosystems by time series analysis (Evergreen Needleleaf Forest (ENF) of Finland, Deciduous Broadleaf Forest (DBF) of Denmark and Mediterranean dehesa ecosystem of Spain). Results show that temperature and solar radiation were the main limiting factors in ENF while water availability was determinant for growth in the Mediterranean ecosystem. The DBF showed a different GPP cycle related with an interaction of various factors during all the growing season. The three ecosystems are directly responsible for the energy fluxes partitioning and water fluxes dynamics. In Finland, latent heat was coupled to GPP during all growing season due to the factor of temperature while in Denmark began to be strongly coupled when leaf emergence occurred. In Spain, latent heat was coupled to GPP during all growing season but due to water availability.

Post-harvest technologies

ID: 2542

Prediction of flavour of tomatoes using non-destructive sensors

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When buying fruits and vegetables product characteristics flavour and freshness are most important for consumers. To encourage consumers to eat enough fruits and vegetables it is important to convince them of the product flavour and quality. Wageningen University Research has developed a flavour model for tomatoes that predicts the flavour liking of a tomato based on destructive measurements. Based on values for Brix, acidity, juiciness and firmness of a tomato, a score is calculated that reflects consumer liking . As destructive measurements are complex and time consuming, a non-destructive measurement is desired. The goal of our study is to develop a non-destructive measurement technique to predict the flavour liking of a tomato. Based on literature research several spectrometers (400-2500nm) and hyperspectral cameras (400-1700nm) were selected to perform the non-destructive measurements. For our trial we selected 20 different tomato varieties covering a wide range in flavour. Of each variety 50 tomatoes were randomly selected for the non-destructive measurements. First all tomatoes were measured using the non-destructive sensors. Then for each variety 15 of the tomatoes were used for destructive measurements and the remaining tomatoes were used for both a consumer panel (n=50) and a sensory panel (n=20) of trained experts. In the destructive measurements the parameters Brix, acidity, juiciness and firmness were measured. The consumer panel gave a liking score for each tomato sample while the sensory panel scored specific attributes. For each sensor a partial least squares (PLS) model was trained for predicting the destructive measures (brix, acidity, firmness) and the flavour liking. Input for the PLS model was the average spectrum of each fruit. Flavour liking prediction from the spectra was more accurate than using the flavour model on brix, acidity, juiciness and firmness. Regardless whether these compounds were measured destructively or non-destructively.

ID: 3180

Prototype plant operating at very low temperatures for quick freezing

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Food freezing is a valuable technique for preserving food by lowering the food temperature. Freezing retards indeed the growth of microorganisms and enzymes that cause food spoilage. An innovative plant for quick freezing at very low temperatures has been designed and here presented. The reached food processing temperature is lower than -80°C, which is much lower than temperatures of traditional vapour compression based plants. The innovative plant is constituted by two loops, the first one is based on a reversed Brayton cycle that transforms electricity into cooling energy while the second loop refers to a forced-air freezing room. The innovative features of the implemented prototype rely on the plant layout and the environmentally safe working fluid adopted in the reversed Brayton cycle. Moreover, the running cost resulted to be lower in comparison with liquid nitrogen based plants, which are the only alternative for quick freezing at very low temperatures (< -80°C). This work presents the preliminary results of the innovative plant. In particular, temperature and pressure values have been monitored at the inlet and outlet of the main components of the reversed Brayton cycle to evaluate its thermodynamic performance. The reversed Brayton cycle also allows recovering heat at low temperature (50-80°C) that can be used for space heating and/or food processing.

ID: 4722

A comparative study on existing interventions for tackling post-harvest losses in developing countries

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Food consumption has grown over the years in tandem with the insistent world population growth forecasted to reach a record high come 2050. As severe hunger remains a present-day challenge, the problem of Post-Harvest Loss and Waste calls for more sustainable solutions especially in developing countries. Although policies and interventions (including smart farming technologies) have been adopted, it is vital to understand the efficacy and limitations of some of these interventions to ensure sustainable outcomes. In this paper, we compare the efficacy and limitations of four different interventions for the reduction of Post-harvest food loss (PHL) in developing countries. The main research question tackled in this study is: *How effective are the existing interventions for the reduction of PHL in developing countries*? Also, *what are the primary limitations or drivers of these interventions in developing countries*? In this context, interventions refer to an action or set of actions aimed at positive change. The methodology of this study is both explorative and comparative. Information was gathered through the review of relevant literature

and different interventions in various cases were explored and compared. The initial findings of this study reflect the efficacy of interventions created from evidence-based approaches (a pre-informed process) and it also elaborates on the limitations encountered as a result of the adoption of these interventions in areas specifically, Africa. Based on the understanding of the limitations of different interventions, more tailored propositions to solving these malignant issues may suffice, given the potential of such solutions to aid policymaking, reduce hunger, promote sustainable growth and economic development. The mechanism for coping with PHL and how it can be adopted, merged, or form the basis of a new solution is an area recommended for further research.

ID: 4729

Potential of nirs technology for the determination of cannabinoid content in industrial hemp (cannabis sativa l.)

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Industrial hemp (*Cannabis sativa* L.) is a plant native to Asia, which has been one of the oldest sources of food, textile fiber, and medicines. It is characterized by containing minimal concentrations of delta-9 tetrahydrocannabidol (THC) which is the main psychoactive chemical component and cannabidiol (CBD), a non-psychoactive substance. In most European countries, the maximum concentration legally allowed for cultivation is 0.2% of THC and currently it is under debate whether to increase this level to 0.3%. Also, in many countries its production is being regularized and legalized, increasing the need for a rapid analysis method. The present work evaluates the cannabinoid content in hemp (*Cannabis sativa* L.) using NIRS technology in combination with chemometric techniques. For this, several samples of the Kompolti variety were analyzed. Samples were dried and ground and the content of total THC (%) and total CBD (%) was determined by HPLC-DAD as reference measurements. The spectra were collected in a NIRS instrument AOTF-NIR Luminar 5030, the same group of samples was used for both calibration and validation and partial least square regression models were developed. Good coefficients of determination of cross validation (Rcv^2) of 0.77 for THC and CBD were achieved and high predictive capacity (RPD) of 7.4 for total THC and 7.8 for CBD. The results obtained show that NIRS technology is an effective tool in the quantitative determination of cannabinoids. Therefore, this analytical method would allow a simpler, more robust, precise and sustainable estimation than the current HPLC.

Smart farming/precision agriculture

ID: 2496

Differentiated management center-pivot travel speed based on soil apparent electrical conductivity and remote sensing

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Climate change, in particular the trend towards global warming, will significantly affect the hydrological cycle leading to a general reduction of the available water for agriculture. In this scenario it is therefore essential that research could focus on the development of 'water saving' technologies and techniques. Conventional irrigation systems are based on the application of a homogeneous input over the field, considered as a uniform spatial unit. However, within the field, can be often recognized a spatial heterogeneity of soil characteristics, topography, microclimate, as well as of crop development. These factors result in spatial variability of irrigation efficiency and a non-uniform irrigation requirement. This work summarizes the methodology followed in a "Precision Irrigation" project for implementation of variable rate irrigation (VRI) systems in large scale application using center pivots. This is based on technologies for monitoring (i) soil electrical conductivity (EC_a), (ii) soil moisture, (iii) vegetation indices (Normalized Difference Vegetation Index, NDVI) obtained from satellite images, and automatic pivot travel speed control technologies. The VRI was achieved by varying the pivot travel speed. EC_a maps were the basis for the definition of irrigation management zones (IMZ) in an experimental corn field of 28ha located in Samora Correia (Portugal). NDVI time-series were used to establish the subsequent prescription irrigation maps. The main result of this study was the significant reduction in water consumption achieved in the 2018 corn crop campaign with the VRI management compared to the conventional irrigation management. This study demonstrates how a relatively simple solution could be designed and implemented in large scale, showing that precision irrigation techniques are ready to provide tangible results that represent an important contribution to the sustainability.

ID: 2534

Virtual MWIR spectra for improved PLS calibration of fuel mixtures

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Previous research of the authors has demonstrated that uncooled low-cost MWIR Spectroscopy is a fast and non-invasive method for the qualitative and quantitative evaluation of fuels and their blending with alcohols: methanol, ethanol and propanol among others. However impressive, the

preliminary tests have failed to reach the minimum required accuracy ± 1%. A main difficulty, in order to reach the expected estimation performance, lays on the generation of very narrow volume of mixture, of ever decreasing additive concentration. This paper proposes a new chemometric procedure, as an in-silico experimental procedure that would help the generation of stable virtual spectra of ultra-low additive concentration. To do so, a previous MANOVA model is used to generate noiseless points in the canonical plane of binary mixtures of fuel and alcohols. Afterwards the Cartesian coordinates of each mixture are de-projected into the estimated original spectra, which shall be onwards called virtual. The so called virtual spectra are then fed into a PLS model for the identification of the additive and corresponding estimation of the concentration, which is validated with regard to the experimental samples.

ID: 2578

Predicting the evolution of pasture quality by nirs: perspectives for real-time pasture and grazing management

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Pasture quality monitoring is a key element in the decision making process of the farm manager. The inter-annual variability of rainfall patterns has an important impact on the dryland pasture growth cycle, to the point that supplementation needs, normal in the critical summer period, can be anticipated by one to two months in years of reduced spring precipitation. Laboratory methods for assessing pasture quality parameters such as crude protein (CP) or neutral detergent fibre (NDF) require cutting, collection and analytical procedures involving technicians, time and reagents, making them laborious and expensive. The objective of this study was to evaluate the potential of near infrared reflectance spectroscopy (NIRS) as a rapid method to predict and monitor the evolution of pasture quality index (PQI=CP/NDF). During the 2018 and 2019 growing seasons a total of 496 samples from 9 biodiverse pastures (32 field tests), representing a wide range of botanical composition and phenological states, were scanned with a FT-NIR spectrometer. In the calibration phase 50% of the samples (8 field tests) were used, and the remaining 50% were used in the validation phase (24 field tests). Calibration and validation models were developed and regression equations between predicted and laboratory reference values of PQI were established. The coefficient of determination (R^2) in calibration and validation models of 0.903 and 0.810, respectively (RMSE of 0.032 and 0.040, respectively, and a residual predictive deviation, RPD of 3.0), demonstrate the potential of NIRS to predict the PQI. The results show the practical interest of portable spectrometry, associated with GNSS, as expeditious tools for monitoring pasture quality. Good prospects and opportunities open up for technology-based service providers to develop remote sensing-based computer applications from satellite imagery that enable dynamic management of animal grazing.

ID: 2630

Map based site-specific seeding of seed potatoes by fusion of proximal and remote sensing data

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Uniform rate seeding (URS) is not the optimal approach to utilize yield potential of different zones of a field. This study examines the potential of map-based site-specific seeding (SSS) of seed potato for improving crop yield and economic return. A field (6 ha) was scanned using an on-line visible and near infrared (vis-NIR) spectroscopy and an electromagnetic induction (EMI) sensors. The k-means clustering was used to divide this field into management zones (MZ) using two data sets i.e., apparent electrical conductivity (EMI-MZ), and data fusion of two normalized differential vegetation indexes (NDVIs) retrieved from Sentinel2 images with on-line vis-NIR measured soil pH, organic carbon, available P, K, Mg, Na and moisture content (visNIRSen-MZ). Seed potatoes (*Solanum tuberosum L. cv.* Hermes) were planted at 11, 13, 15, 17 and 19 cm spacing intervals by sowing more seeds to the fertile zones and vice versa. Yield analysis demonstrated that SSS increased overall yield (EMI-MZ: 32.42 t/ha, visNIRsen-MZ: 31.89 t/ha) compared to URS (31.06 t/ha). Although visNIRSen-MZ had lower gross yield than EMI-MZ, the increased yield of small size (28-45 mm) tubers, having higher market price than other size categories has resulted in actual market price for the former larger than that of the latter approach. Economic analysis revealed that SSS resulted in higher net economic return than the URS, whilst both the MZs approaches performed almost equally. The visNIRsen and EMI produced a net return of 4995 €/ha and 4947 €/ha, respectively while URS net return was 4528 €/ha. In contrast to URS, visNIRsen-MZ and EMI-MZ increased net profit by 467 €/ha and 419 €/ha, respectively. VisNIRsen-MZ approach saved seeding cost by 14 €/ha though EMI-MZ consumed 5 €/ha more compared to URS. Therefore, it is recommended to adopt SSS in seed potato, as a means of increasing crop yield, reducing input cost and thus maximizing profitability compared to URS.

ID: 2640

Automated assessment of rumen fill in dairy cows using 3D vision

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A dairy cow's rumen fill is determined by its feed intake, composition, digestibility, and rate of passage. Regularly monitoring the rumen fill of individual cows could help farmers to detect abnormal changes that are associated with digesting problems. So far, the rumen fill is assessed by manually determining the concavity of the left paralumbar fossa. The objective of this research was to automatically and non-invasively assess the rumen fill of individual cows by using three-

dimensional (3D) vision. A 3D camera was mounted in an automatic milking system to record the left paralumbar fossa of 20 lactating dairy cows in 3D videos during their milking visits. Additionally, a trained assessor also visually scored the rumen fill of each cow by using a 5-point scale. During the image processing of each video frame, the left paralumbar fossa was located and its surface concavity was calculated. The concavity values varied over time and its time series contained cyclic oscillations that corresponded with the rumen contractions. To classify the rumen fill scores from periodically varying concavity values, we firstly applied a fast Fourier transformation to identify each oscillation, secondly extracted four oscillation variables: the maximum, minimum, mean, and amplitude of the concavity values, and thirdly calculated the median of each of these oscillation variables. Thereafter, the nearest neighbor classification model was chosen with all four median oscillation variables served as inputs and manual rumen fill scores served as reference. By using leave-one-out cross-validation on the dataset (n = 20), we obtained a classification accuracy of 65%. This accuracy was adversely influenced by the low reliability of the referential manual rumen fill scoring and, hence, need to be improved in the future. In conclusion, the result of this study showed the potential of applying 3D vision to non-invasively estimate the rumen fill of dairy cows in an automatic setting.

ID: 2664

Automated imaging system for remote monitoring of insect pests in mango orchards

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This paper demonstrates the application of an integrated imaging and environmental sensing system for continuous monitoring of insect pests in mango orchards. The integrated system remotely collects sticky paper trap images and records environmental data such as temperature, humidity, and light intensity. The insects trapped on the sticky paper are counted and classified using a cascaded deep learning detection and recognition algorithm. The developed algorithm can classify up to seven insect species with an average F_1-score of 0.91. The species of insects are among the major insect pests in mango orchards such as: oriental fruit fly (*Bactrocera dorsalis*), brown mango leafhopper (*Idioscopus niveosparsus*), and thrips (*Thrips tabaci*), etc. From a two-year continuous monitoring period, the variation of insect pest counts was found to be highly associated with the recorded mango fruit growth stages and management practices, especially during fruit ripening. Experimental results reveal that there are certain peak times in which pesticides can be applied to prevent insect pest outbreaks and thus to reduce fruit damage. The rainfall data also show that observable reduction of insect pest appearance in rainy days. The results of this research corroborate that the automated monitoring system can be used to efficiently quantify the insect appearances in outdoor mango orchards and therefore efficient insect pest management strategies can be devised.

ID: 2675

A practical iot based tool to help farmers identify silage spoilage: a case study

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Making silage for cattle winter feed is a well-known and thoroughly researched process, with known quality parameters. Once silage has been created and sealed according to best practice guidelines, it is still possible and not very rare, that unwanted aerobic fermentation in parts of the bunker continues, which lowers the feeding value of the silage. The only way for a farmer to know, is to inspect the sileage by opening it, exposing the content to oxygen and promoting further spoiling. Biologically the spoiling process is exothermic, with local temperatures rising above the normal non-spoiling state within the silage. In this project, we focussed on creating a practical, Internet-of-Things based tool to continuously monitor temperatures within the silage. In the first phase of the project, we established a suitable temperature monitoring technology and determined operating envelopes: two silage bunkers have been monitored continuously since October 2019 with temperature sensors at the tip of stainless-steel rods (Quanturi Oy). Rods are of different lengths and were inserted into the bunkers, with the entry points sealed airtight. New, longer and multisensor rods were used in the second phase of the project (started July 2020). With the new multisensor rods, we have been able to monitor and model the 3D heat distribution within the silage. During this second phase of the project, a spoiling event occurred. In addition to the temperature data, physical samples from selected points were taken at depths representative of sensor positions for each location (at depths of approximately 50cm, 150cm, and 250cm) in November 2020. The samples were chemically analysed for nutrient content. The comprehensive data set has been evaluated and links to remaining nutrient levels and temperature excursions have been established.

ID: 2738

Unsupervised semantic interpretation of 3D point clouds of vineyards for precision agriculture

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In Precision Agriculture, autonomous machines and robots play a role of growing importance in effective and site specific management of crops. They can be profitably exploited to timely collect extensive crop data and/or to autonomously perform in field operations. In this context, enhanced path planning and complex interaction with crops can be achieved if, in addition to standard 2D georeferenced field maps, information provided by crops 3D models can be exploited. Nowadays, very dense 3D point clouds can be obtained by lidar and/or by processing imagery from unmanned aerial vehicle with structure from motion approach. Anyway, these huge raw datasets, even if accurate and reliable, should be properly interpreted by data mining techniques. In this work, a new

unsupervised algorithm to semantically interpret raw 3D point-cloud of vineyards is presented, which automatically classifies portion of the model as terrain, vines canopy or other. In addition, it provides a 3D mesh surface describing the external envelope of vine rows canopy, with a limited number of instances. Vineyards result to be spatially modelled by a dataset even 400 times lighter, assuring in the meanwhile a neglectable loss of information. Optimal values of algorithm parameters were determined by a linear programming approach, minimising an error function defined as combination of four model quality indices. The obtained georeferenced low-complexity 3D map of vineyards and, in detail, of vine row plants are compatible with real-time computation and allow to improve the reliability of autonomous vehicle navigation in complex scenarios. The developed methodology does not require vine rows to be rectilinear, it can properly process dense 3D models of hilly field and it is also robust to inter-row grassing occurrences.

ID: 2751

Heat recovery system for milk cooling units

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Milk cooling is preventing the multiplication of germs and bacteria in the milk. On farms, the milk has to be cooled within 2 hours to a temperature of max. 6 °C after milking. Usually, the milk is chilled by means of a heat exchanger and a cooling aggregate. In Switzerland most milk cooling systems are installed without any pre-cooler. The energy consumption of chillers is high and the waste heat is normally lost to the environment. With a heat recovery system the waste heat from the chiller can be used to preheat the water in a butter tank. To determine the efficiency of these cooling system in practise, on 10 dairy farms the electricity consumption of the boiler and the cooling unit as well as the hot water consumption were measured over a period of two weeks before and after retrofitting a heat recovery system. By installing the heat recovery system, the electricity consumption for the boiler was reduced in the average about 35% and the one of the refrigeration unit about 22%. The variability between the different farms was quite big. The highest electricity saving in the boiler was 49% and the lowest one only reached 17%. The relevant factors to characterise the efficiency of the heat recovery systems are the amount of produced milk, the used hot water. The consumption of hot water showed no significant difference before and after the retrofitting. The cooling time of the milk was up to 30 minutes shorter after retrofitting. A calculation showed that with the saved electricity costs the heat recovery system could be amortized within approx. 8 years. The investigation showed that many cooling units were not well maintained or not optimally installed, what lead in some cases to a quite high extra energy use. It shows, that combining milk cooling with hot water preparation is an efficient and profitable investment to save energy but it needs to be well installed and maintained to deploy its full efficiency.

ID: 2764

What makes the difference? State-of-the-art and new perspectives on precision- and task-oriented drones for agricultural use

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Nowadays, using drones, referred as Unmanned Areal Vehicle (UAV), and robots is becoming increasingly common in precision agriculture for increasing crop productivity and quality because of its effectiveness and speed in operation. Furthermore, labor costs can be avoided by using UAVs. Also quality-related aspects are relevant: Robots or drones that can precisely remove weeds or shoot them with a target spritz of pesticides, using 90 % fewer chemicals than a conventional blanket sprayer. Tiny sensors and cameras will monitor crop growth and alert farmers on their smartphones if there is a problem or when it is the best time to harvest. The main goal is to grow and harvest without humans entering the field. As the use of agriculture drones increases, their challenges and limitations become larger and more precise. One of the most challenging issues in precision agriculture and specially using drones is storing, processing, and analyzing big data. Furthermore, privacy and security, as well as safe behavior assurance, are challenging issues using drones in the agriculture context which are addressed in this paper. This paper highlights and elaborates the importance of semi-autonomous/autonomous drones in precision agriculture field. Newest agriculture drones available in the market are introduced considering their special sensors and properties. Additionally, the main hardware and software required to build an agriculture drone are introduced in detail considering specific and upcoming needs from the agriculture field. The main challenges and limitations of using agriculture drones are summarized. Briefly speaking, the main goal of this literature review research is first to deliberate new solutions and research trends on semi-autonomous/autonomous agriculture drones and second to present an actual overview of the different components required for precision agriculture considering actual limitations and research questions.

ID: 2770

State machine-based model for estimation and prediction of above ground biomass in corn during vegetative stage

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Ensuring optimal yield from a corn crop requires information about the growth and development of the plants at various stages. In combination with models (such as FAO Aquacrop), plant biomass measurements offer a predictive indication of expected yield, allowing timely decision making with regard to resource allocation. Existing biomass estimation models are

primarily targeted at forecasting of biomass at harvest, generating a cumulative value which does not allow for intermediate estimates at different phases of crop growth. This makes them unsuitable for applications requiring continuous monitoring and/or real time intervention. An existing state machine model employed to predict total leaf length in growing corn plants is expanded through the inclusion of leaf width measurements to allow progressive estimation of biomass. This is necessitated by the wider applicability of biomass as a means of assessment of plant growth as compared to leaf length. The model is trained using experimental data obtained from corn plants grown in an indoor greenhouse under varying irrigation conditions. Above ground biomass is estimated using leaf length and width measurements. The accuracy of the model is evaluated through comparison with estimates made using the FAO Aquacrop model for corn growth as well as comparison with actual values obtained from sampled plants harvested at different times during the growth experiments. The model generates a continuous progressive estimation of above ground biomass of corn plants during the entire vegetative stage, allowing for monitoring of crop growth, timely intervention as required as well as early projection of final yield.

ID: 2779

Modeling and prediction of corn growth during vegetative phase

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The stages of corn growth and development are characterized by different demands that are affected by natural and artificial resources, including those requiring partial or full management. Accurate prediction of specific growth variables during each stage is helpful in allowing proper resource planning and facilitating better prediction and control of growth targets. In this work, the appearance of new corn leaves as a measure for developmental stages is estimated/approximated using a linear modeling approach. This approach allows prediction of the time at which a system variable will achieve a predetermined value, and is adapted from prognostic monitoring approaches. The approach is applied to estimate new leaf appearance based on the measured growth trajectory of previously developed leaves. The established model parameters are defined and thereafter trained using experimental data obtained from corn plants grown in an indoor greenhouse under varying irrigation treatments. Based on the obtained experimental results, it can be stated that prediction of leaf appearance from the 4^{th} leaf to the 7^{th} leaf can be accurately realized using the linear model. It is hypothesized that the established model can be used to predict leaf appearance during the complete vegetative phase. This knowledge can be combined with growth control approaches to realize targeted timing of the transition from the vegetative to the reproductive phase.

ID: 2795

Discrete event simulation shows potential for small autonomous potato harvester

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Arable farming in North-West Europe faces challenges on the availability of labor, water and pesticides and as well yield reduction due to subsoil compaction by oversized machines, mostly at harvest. A new farming concept using strip intercropping, controlled traffic farming and small lightweight smart autonomous machines may have potential to overcome these challenges. In adopting controlled traffic farming there is a need for an alternative for the current harvesting machines. Such an alternative could be an autonomous mobile field robot harvester with several mobile field robot transporters. This study focusses on finding optimal solutions and technical requirements for potato harvest machines. To compare those solutions with conventional potato harvesters, a discrete event model was developed to simulate the movements of the harvesters and transport logistics on the field. The model imports real world field boundaries and can handle preconditions of traffic lanes and strip intercropping. For each solution several scenarios were simulated for a standard rectangular field of 6 ha. An autonomous mobile field robot harvester with a one-crate bunker together with two mobile field robot transport units with two-crates each, has a field efficiency of 82.5%, a field capacity of 0.41 ha/h, and a total operation time of 14.8h. A conventional self-propelled 4-row bunker harvester with two tractors with trailers had a field efficiency of 76%, a field capacity of 1.01 ha/h, and a total operation time of 6.0 h. The presentation will convince you of the value proposition of harvesting with mobile field robotics solutions as a viable option to overcome the challenges of current oversized machinery. In addition the model approach, the proposed solutions and assumptions made for the simulation will be presented.

ID: 3213

Optima - optimised integrated pest management for precise detection and control of plant diseases in perennial crops and open-field vegetables

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Crop protection can be briefly outlined by (i) several applications of synthetic Plant Protection Products (PPPs), (ii) limited use of biological PPPs, (iii) decision making on PPP application based on experience, and (iv) low efficiency in spraying application due poor sprayer adjustment and low technology adoption. OPTIMA aims to develop an environmentally friendly IPM framework for vineyards, apple orchards and open-field carrots by providing a holistic approach that: i) optimises disease prediction models for Downy mildew in vineyards, Apple scab in apple orchards and Alternaria leaf blight in carrots, to envisage faster the possibility of disease outspread, ii) creates a DSS for the operator to consult for selecting appropriate time, PPP type and sprayer settings for each application, iii) develops advanced early detection methods based on spectral imaging and deep learning techniques to precisely localise and quantify the infection, iv) screens and evaluates (in-lab and in-field), biological and synthetic PPPs for their combined ability to control the selected diseases. Moreover, weigh the optimum dosage and application timing and also identify and characterise induced host resistance mechanisms, in order to achieve higher and durable resistance, v) enhances and develop three innovative prototype sprayers (for carrots, apple orchards and vineyards) actuating different nozzle types and adopting variable rate control based on canopy characteristics, the pathogen dispersal and disease development, vi) tests and assesses the holistic developed IPM system in field conditions with the three selected crops. The advanced sprayer prototypes and the monitoring system will be tested in real-time to record field efficacy, vii) assesses health, environmental and socioeconomic impacts of the proposed IPM system in comparison to conventional systems using an extended Life-Cycle approach integrated with Human and Environmental Risk Assessment.

ID: 3759

Encouraging the adoption of precision fertilization technologies: steps from theory to practice

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Many studies report low levels of Precision Agriculture (PA) adoption due to, e.g. cultural and technological barriers, the average size of farms, and the difficulty of appreciating the resulting benefits. Following these findings, the present study focuses on the decision-making process farmers need to adopt a complete fleet of machines to perform precision fertilisation. To study the introduction of precision agriculture technologies, the CREA research centre experimental arable farm of Treviglio (Italy), 15 ha wide, was geo-referred and analysed under geophysical parameters using electrical-resistivity sensors. A 117 kW nominal power 4WD tractor was equipped with auto-guidance technology and the highest levels of PA capability that included a double-disc fertiliser spreader with variable rate technology (VRT), a terrestrial multiparameter sensor for crop mapping, a geomatic platform using Sentinel 2 satellite free information and a commercial field management system. The research highlighted that the choice of the tractor is fundamental to achieve the desired level of PA. However, additional services and fees are often necessary to reach the desired level of precision or to access tractor and field data management systems. The multiplicity of passages and the required information or strategies could make the preparation of the prescription maps difficult for their subsequent transfer to the tractor or the implement. It required the availability of data regarding crop yield, crop health, specific skills, or their combination, or the adoption of other specific technical devices.

ID: 4598

Simulation for variable-rate nitrogen fertilization with different application schemes

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Optimizing variable-rate nitrogen (N) fertilization (VRNF) is required to minimize input, maximize output, and reduce environmental footprint. This study aims at comparing the amount of N used by traditional uniform N fertilization (UR) against three VRNF treatments of map-based (MB), sensor-based (SB) and map-sensor-based (MSB) in four commercial fields using a new simulation software. Under the three VRNF treatments, two different application schemes were evaluated: applying more N fertilizer to the more fertile zone (Kings scheme, KS) and more N fertilizer to the least fertile zone (Robin Hood scheme, RHS). Simulations were made after imposing N legislation limits and without imposing them. Finally, VRNF application were evaluated for a full boom, a section control sprayer and a nozzle control sprayer. Results presented that the VRNF did not exceed the traditional UR approach only if the N limit by legislation is imposed. The RHS consumed 16.4-

118.1% less N fertilizer than the KS and 33.3-56.2% than UR approach. The best performing RHS-VRNF was the SB followed by the MSB treatments without imposing N limits. However, the KS without N limit always exceeded the applied N fertilizer, compared to the UR approach, imposing large risks of N leaching. When imposing the N limit, both KS and RHS consumed less N than the traditional UR approach, except for the MSB under the KS, which used the same N as the UR. Spatial variability can be observed in the MB approach, temporal variability in the SB approach and both variabilities in the MSB approach. Regarding the spatial variability, no significant differences between section and nozzle control options could be observed, whereas it was minimized when using the full boom control. We concluded that the optimal VRNF is a combination of the RHS and section control, which is expected to result in saving on N fertilizer cost, minimal risk of N leaching, and ensuring N applied is under the set legislation limits.

ID: 4603

Detection of leek rust and white tip disease under field conditions using hyperspectral proximal sensing and supervised machine learning

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Crop diseases are one of the key yield-limiting factors in leek production, necissitating continuous fungicide applications, with socio-economic and environmental costs. Precision agriculture aims at reducing these costs, while maintaining or improving farmer revenues. The first requirement for variable rate fungicide application is in-field disease measurement and mapping. In this work, a disease detection methodology was created that could detect early disease stages in field conditions for leek rust and white tip disease. A hyperspectral camera (400-1000 nm) was used to build a training library for both diseases separately, with spectra corresponding to healthy leek, weed plants, diseased leek and soil. A custom preprocessing and soil pixel removal strategy was constructed for each disease. Eleven common classifiers evaluated, of which a logistic regression classifier provided the highest classification accuracy. This logistic regression classifier was then trained on the hyperspectral library. For leek rust disease, the focus was on detection early infection (i.e. single rust pustules). For white tip disease, the model was used to classify the data into four classes: healthy plant material, early (pre-visual) disease, moderate disease, severe disease and fully developed disease. The overall prediction accuracy of the model was 98.14% for rust and 96.74% for white tip disease. Leek rust pustules could be detected at sizes below 1 mm, at early infection stages. White tip disease could be detected at several infection stages, and the spread of disease could be mapped throughout individual leaves. It can be concluded that the results in this work are an important step towards the mapping of leek rust and white tip disease, and that future research is needed to overcome certain challenges before variable rate fungicide applications can be adopted.

ID: 4608

Outline of a regenerative agriculture system at scale: definition of required outcomes

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Regenerative agriculture is seen and mentioned as a solution to a more sustainable way of farming, but not well defined. Building on scientific literature we have defined regenerative agriculture as 'an approach to farming that uses soil conservation as the entry point to regenerate and contribute to multiple provisioning, regulating and supporting ecosystem services, with the aspiration that this will enhance not only the environmental, but also the social and economic dimensions of sustainable food production'. In addition to this definition at farm level we propose the following vision for a regenerative agriculture system at landscape or higher system levels: A regenerative agriculture system enables production of food and biomass and enables ecosystems to maintain a healthy state and evolve, while contributing to biological diversity, integrity of the biosphere, human well-being and economic prosperity of society. Based on this long term vision we have defined a comprehensive outline of a regenerative agriculture system that encompasses includes all ecosystem services, soil functions and planetary boundaries. This outline covers 14 topics and describes the 'outcomes' that are needed to meet the overall objectives, without being prescriptive on 'how' these outcomes should be achieved. Therefore we use the term 'required outcomes' which precisely and quantitatively describe the target performance of the regenerative agriculture system. These 'required outcomes' are related to the inputs and use of resources, the output (food, biomass) and losses/emissions, and the preferred state of soils, water bodies, animals, biodiversity and people. The outcomes encompass environmental, social and economic aspects, and are defined at five different system levels: 1) field (above and below ground), 2) farm, 3) local landscape (including air and water bodies), 4) the Netherlands and 5) international. All required outcomes are based on and supported by scientific literature.

ID: 4610

Study on deployment of a truecolor sensor array for dual use - weed detection and n-fertilizer application

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In agriculture, efforts are being made to reduce pesticides and fertilizers because of the possible negative environmental impacts, high costs, political requirements, and declining social acceptance. With precision farming, significant savings can be achieved via the application of herbicides and fertilizers to individual plants.In contrast to currently available single systems, the capacity of a dual sensor is much higher and promises significant potential for faster profitability. Moreover, the high spatial resolution of 1 cm^2 is remarkable. In this study, experiments were

performed to evaluate the applicability of a TrueColor sensor array for site-specific nitrogen application of winter barley and weed detection in low growth stages.The sensor is based on recording the spectral reflectance of plants in the CIELab color space and by one IR-channel (850 nm). The unique selling point of this sensor is the reflection measurement without influence of ambient light. A database of reflection properties (L, a, b, IR) was build up in greenhouse. A spectrometer was used to reference the reflection values of the sensor array. According to our study, the sensor array can detect weed plants from a minimum size of 125 mm^2 in real-time.To underline the sensitivity of the array, the increase of leaf area and IR value of the array correlates with $R^2 = 0.97$ for small growth stages of daisy plants. The differentiation of sugar beet and cleaver, as well as daisy, is clearly possible for different growth stages using the CIELab color space sensor. In field experiments, strong correlations were found between the four reflection channels and the nitrogen level ($R^2 = 0.959$), plant coverage ($R^2 = 0.907$), and fresh mass yield ($R^2 = 0.866$) for winter barley plants. The fast signal processing allows this sensor to meet stringent demands for the operating speed, spatial resolution, and price structure.

ID: 4612

Estimating soybean yield spatial variability within-field scale through google earth engine in northeast Italy

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The study of spatial variability within agricultural fields is essential for all farmers who want to approach modern precision agriculture. This study investigated the possibility of estimating soybean yield spatial variability at field scale through different vegetation indices (VIs) derived from Sentinel-2 satellite images at different crop growth stages. The study considered yield records from seven fields located in Northeast Italy, have areas ranged between 9 to 18 ha and cultivated by soybean from 2016 to 2018. Sentinel-2 satellite images were used to calculate eight VIs through Google Earth Engine (GEE) between June to October. One-way ANOVA tested the linear correlation between yield and VIs measured at different soybean phenological stages corresponding to the available cloud-free Sentinel-2 images. Results showed that Green Chlorophyll Vegetation Index (GCVI), Green Normalized Difference Vegetation Index (GNDVI) and Wide Dynamic Range Vegetation Index (WDRVI) were the best correlated VIs with soybean yield variability. The highest correlation was observed between 85 and 105 days after sowing corresponding to grains forming and filling (phenological stage R5-R6). R^2 values ranged between 0.21 and 0.68 across whole fields and growth stages. The study proved the effectiveness of a linear model exploiting the equation of the regression line between the VIs and soybean yield from the field with the highest correlation. The model showed high yield estimation accuracy results in 2018 and 2017 seasons with root mean square error (RMSE) of 0.47 and 0.49 Mg/ha respectively compared to less accuracy in 2016 where RMSE was 1.02 Mg/ha. This study approach proved the ability to estimate the within-field variability of soybean yield which could be applied to other Sentinel-2 archived images starting from 2015, while a new model should be calculated each year for each geographic region to ensure the estimation accuracy.

ID: 4615

Estimation of ammonia concentration through indoor environmental variables in weaned piglet farms

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Measuring NH_3 in livestock housing presents numerous problems that hinder its incorporation to environmental control. This paper aims to study different environmental variables inside a weaned piglet building and determine the interaction between them, with setpoint temperatures of 26 °C and 25 °C, in order to control the concentration of NH_3 through other easily measured variables. The experimental test was conducted on a conventional farm in northwestern Spain. The best correlations with NH_3 concentration in the animal-occupied zone were found for CO_2 concentration in the animal-occupied zone (0.91 and 0.55) and for the speed of the air exhausted by the fan (VEX) (0.72 and 0.65), with setpoint temperatures of 26 °C and 25 °C respectively. Satisfactory results were also obtained in relation to relative humidity (RH) in the animal-occupied zone and temperature of inlet air (TIA). Because it is related to the operation of the ventilation system, ammonia concentration in the animal-occupied zone causes correlation values to be high, positive for TIA and negative for ventilation rates. The use of linear regression models based on the variables of CO_2 concentration in the animal-occupied zone and TIA is recommended, since they provide good adjustments and are based on easily measured variables.

ID: 4617

The effect of laser radiation for selective blossom thinning in Apple

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This research aims to improve the technique for selective blossom thinning in apple by applying laser radiation for controlling the number of flowers. A 4 Watt, 450 nm blue diode laser was deployed in a prototype of laser blossom thinner. The laser system was installed with microcontroller to adjust the exposure time by programming. A distance between flower cluster and laser device of 15 cm was used as focal length with the constant laser spot area of 3.92 mm^2. 350 flower clusters on apple cv. 'Hilieri' branches including untreated control were applied in the laser laboratory at the University of Bonn. Two different vegetative phases of flowering at a) balloon stage (BBCH 59) and b) full bloom (BBCH 65) were examined with regard to the thinning efficiency at four positions of the laser spot with a) from side of the bottom of flower cluster, b) from front of the flower cluster, c) from side of the flower bud at ovary and d) from front of the flower bud. The effect of laser energy density on the number of damaged flowers was additionally studied at the position of laser spot from the front of

flower cluster. The damage assessment on flowers was examined every other day after application by comparing with untreated flowers. The result demonstrates that the low power of laser radiation is a potential alternative technique for selective blossom thinning. There is no significant difference in thinning efficacy between balloon stage and full bloom. Emitting of laser with the position of laser spot from the front of flower clusters had the greatest effective thinning and succeeded most in reducing the number of flowers in the flower clusters. The efficacy of thinning was enhanced by increasing density of laser energy. The higher laser energy density (3.05 J/mm^2) caused lethal damage up to 50% more flowers as compared to the damage with the lower energy density (1.02 J/mm^2).

ID: 4622

The effect of image patch size on cnn-based just-in-time biomass yield estimators

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Just-in-time biomass yield estimation can aid silage optimisation. Automatic visual grassland assessment can leverage the fact that individual images are texturally rich, but can be uniform, enabling subdivision. However, there may be a trade-off between patch-size and number of patches generated. To investigate this, we analysed a rich grassland dataset that includes a four-channel VISNIR image, forage height estimates, and biomass yield ground truth Our null hypothesis was that there is no significant difference in outcome between a large number of small patches or a smaller number of large patches. The samples were partitioned into 5 subsets, wherein each sample was split into patches of different sizes, with each patch inheriting height and biomass from the parent. These subsets provided a basis for 5-fold cross validation. Two datasets were generated, the first small patch dataset (SP) split each sample into 48 156x156 pixel patches, resulting in ~10,000 patches. The large patch dataset (LP) split each sample into 24 240x240 pixel patches, resulting in ~5,000 patches. Each dataset was used to train ten different estimator networks, of varying design, and with and without Imagenet weights. The models were a shallow CNN, Inception ResNet, MobileNet and a hybrid using Inception ResNet and ResNet 50. Our performance metric was Minimum Average Precision Error on validation data. Performance varied from 62.84% for the shallow CNN run on LP, using RGB only, to 28.23% MAPE on the hybrid model, pre-trained with ImageNet, using RGB, NIR and height. A paired T-test compared performance between SP and LP. The mean of all 50 runs is 39.58 for SP and 38.95 for LP, with T-test giving a value of 0.78, with a p-value of 0.439, supporting the null hypothesis. However, omitting the shallow CNN, the 40 deeper runs result in mean 35.66 for SP and 33.71 for LP, with a T-test of 2.55 and p-value=0.016, so patch size may matter for deeper models.

ID: 4630

A vision-based road detection system for the navigation of an autonomous tractor

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RTK-GNSS (Real-time Kinematic-Global Navigation Satellite System) signal is necessary for the navigation of an autonomous tractor. However, the main problem associated with the GNSS is that the RTK correction signal might not be available at all geographical locations. While most RTK services require an internet connection, many rural areas have limited broadband and even cellular connections. In addition, several other factors such as separation between base and rover sites, and signal obstructions cause time delays, as well as signal loss at certain times, especially in the rural areas. These situations can lead the autonomous tractor to travel outside of its predetermined path, which is unsafe. To avoid such situations, this study aims to develop a vision-based road detection system, which does not rely on RTK-GNSS. The system aims to detect both paved and unpaved roads in rural farm areas. The system takes the RGB images obtained from an HD on-board camera and segments the road surface and road edges. The segmentation is performed by using several image filters, the sliding window method, and a set of rules that are determined manually. Finally, the lateral error obtained from the machine vision system is transmitted to the tractor's automatic navigation system. Experimental runs performed at the experimental farm of Hokkaido University showed that the lateral error calculated by this system is less than 0.1 m for unpaved roads. In the case of paved roads, manually driven sample videos recorded inside the university campus were tested in the system and it showed that the system is able to detect paved roads as well. Weather conditions and road conditions such as illumination and reflectance of the road surface, affect the detection to some extent. Future work addresses considerations to make the system more robust.

ID: 4631

Development of electrical vehicle robot for orchard application

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Hybrids and electric vehicles are rapidly widespread in the automotive industry, but the agricultural sector has still been underdeveloped. The purpose of this research is to develop an electric vehicle robot for agricultural use by utilizing the powertrain system of a hybrid automobile. We aim to develop speed controllers and steering controllers that can run on sloping terrain and bumpy fields for vehicle robots. In this study on speed control, the feedback controller by adding rolling resistance and climbing resistance as the feedforward term was developed. P-control has been implemented in steering control based on lateral and directional errors. In order to solve the

problem that the turning radius is larger than that of a normal tractor, we adopted a pass skip turning method that does not include backward movement. The vehicle robot could run at the set speed from 2 km/h to 6 km/h with a coefficient of variation under 25 % in the real vineyard. Even though there was an area with an inclination of nearly 10 degrees, robot speed was stable and slightly fluctuated. Although the lateral error increased with the set speed increase, the root mean squared error (RMSE) was within 0.10 m at all set speeds, and the maximum lateral error was under 0.22 m. Since the vehicle's width was approximately 1.7 m, the developed automatic controller was accurate enough to travel autonomously in tree rows with 2.5 m space. The robot was also able to conduct spraying in the vineyard without any damages to trees. Future work includes a prospect of automation in an orchard, such as not only variable-rate spraying, but also mowing or harvesting based on the electric vehicle robot.

ID: 4647

Low power gps-based systems to support herd management in extensive livestock systems

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The use of wearable sensors that record animal activity in intensive livestock systems has become more and more frequent for both early detection of diseases and improve quality of production. Their application may be also significant in extensive livestock systems, where there is an infrequent farmer-to-animal contact. The aim of the present study was to prove the feasibility of a novel automatic system for studying cow behaviour in extensive livestock systems based on space-time data provided by a low power global positioning system (LP-GPS). A customised device, placed within a rectangular PVC case compatible with the collar usually worn by animals, was equipped with a LP-GPS omnidirectional system, an integrated SigFox communication system and a power supply. The experimental trial was carried out in an existing semi-natural pasture characterized by good availability of meadow and cultivated grazing areas. Ten cows were embedded with LP-GPS collars and the data, i.e., geographical coordinates and the time intervals related to each cow detection, were recorded every 30 minutes. Data were collected through a developed AppWeb to be further imported and elaborated by using a GIS software tool. In GIS environment, the daily distances travelled by each cow were correlated with Heatmaps obtained by applying Kernel Density Estimation models. The results of the study made it possible to obtain information on some relevant aspects for livestock's management. In detail, it was possible to acquire information on herd behaviour related to the use of the pasture, e.g., the area of the pasture most frequently used during day, individual use of the pasture, possible animal interaction. These findings represent a first step towards further insights and research activities. The LP-GPS system could be further integrated with other sensors for monitoring a wider range of animal behaviour such as that related to feeding and oestrus.

ID: 4648

Idea: digitally connected model farm (digimo) with agriculture and fodder farming, dairy farming

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There are vast possibilities for digitization in agriculture. To realize those, a smart product and an intelligent product system are required. However, to date, the product systems focus on the separate system groups agriculture and animal husbandry. A connection has not yet been established. Networking of the digital products may also not be possible due to a lack of interfaces and compatibility problems. These problems can make it difficult to use digital tools on the farm and cause reluctance in many farmers to invest in digital technologies. With the goal of the project "DigiMo" (Digitally connected model farm**)** to establish intelligent production systems and to present and demonstrate those using practical application scenarios, the teaching and testing facility LAZBW Aulendorf is being expanded into a digital model facility with a focus on dairy farming. As a forage and dairy farm in combination with a Dairy Institute, the LAZBW Aulendorf offers all the prerequisites for expanding into a digital model farm. The focus of the project "DigiMo" is on the digitization of the milk process chain, starting with forage and arable farming and extending to dairy cow husbandry. A platform is to be created on which digital modules and technologies can first be tested and then evaluated. Particularly digital products and systems from the agricultural and livestock sector that are already commercially available are being added along the milk process chain. The linked tools and the transfer of their data sets should enable, for example, the calculation of material flows or nutrient cycles. With the model farm being created, the target groups (farmers, consultants, agricultural technology and sensor manufacturers) have the opportunity to gain insights into the networking and practical use of digital systems. In addition, the aspect of data protection and data security should be addressed and the communication of the digital systems presented.

ID: 4673

Evaluation of a sensor-based system for monitoring rumination in dairy cows with access to pasture

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Monitoring the health and welfare of dairy cows is time consuming, especially on pasture. Monitoring systems can assist the farmer in detecting the estrous and emerging health disorders by continuously predicting the animal behavior and its changes. Ruminating has proven to be a useful indicator. As most of the monitoring systems available on the market were either developed for the

stable or for pasture and fail to detect the behavior reliably in the other location, our goal was the development of a monitoring system for dairy cows kept on pasture as well as in the stable. As a first step, a model for the prediction of ruminating behavior was developed and evaluated.

Up to eleven cows each on two different farms were equipped with the collar-based prototype of the monitoring system. The system contained a 3D accelerometer and a gyroscope, both collecting data at 10 Hz. Ground Truth data were collected by recording the animals with cameras and labeling the videos based on an ethogram. On farm 1, animals were continuously kept on pasture while on farm 2 the observations were conducted in winter, i.e. in the stable. The data from three animals (30.4 h) on farm 1 were used for the training of the model. Random Forest and a window size of 5 s proved to achieve the highest accuracy compared to other classifiers and window sizes. The model was evaluated on data from the remaining animals (167.4 h). The output of the model and Ground Truth were compared second by second. Overall accuracy of the model in detecting ruminating behavior was 97.3 %. In the evaluated time, 3.52 h of ruminating were falsely classified as non-ruminating by the model and 0.95 h of non-ruminating were falsely classified as ruminating. Lying without ruminating was the behavior confused the most with ruminating by the model. Compared to other models for the prediction of ruminating, our model achieved high accuracies both on pasture and in the stable.

ID: 4676

M2M communication in a dairy barn - identifying farmers' needs and requirements

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Digital technologies in the dairy barn produce a lot of data during its operation and provide the information basis for appropriate decisions to be made at the right time. Although many decisions could be based on logical relations of this information, farmers cannot hand over the decision to the technologies due to the lack of machine-to-machine (M2M) communication. This frequently excludes the possibility to adapt the barn technology to the current conditions in the barn without the farmer's direct intervention. The issues of data security, reasons for investment motivation and social acceptance of digital dairy barn technologies have been researched intensively. The actual requirements for networking and interacting barn technologies from a view of farmers as end user are still scarce. The aim is to identify these requirements through a survey on farmer's expectations, experiences, and barriers of M2M networking and interacting of barn technology. The online survey was answered by dairy farmers (n=242) in Germany. Nearly 90% of all respondents identified opportunities in the use of a cross-system herd management program (HMP), e.g. for technology setting. Inter alia, the subset of farmers who are highly familiar with an automatic milking prioritised feeding operation and cow tracking as a new feature in an HMP among the possible technology settings. Approx. 70% of them (or slightly more than 30% if additional costs are involved) expressed willingness to use the networked operation of milking, feeding, manure removal and barn climate control technologies. Networking of bedding or cow locating technologies was less attractive (around 50% or under 20% in case of additional investment). The priorities can possibly be

attributed to the intensity of the use or the availability of certain technology on the farm. This and further results surround the farmer's requirements on M2M networking in the dairy barn.

ID: 4681

Design and evaluation of two new seed chutes for a stanhay webb precision seed drill using discrete element modelling

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Stanhay Webb Ltd, UK design and manufacture precision seed drills for over 200 different types of produce. In order to improve the performance of a Stanhay Pro Air whilst seeds are transferred to the soil, two new seed chute designs made from 3D printed ABS plastic and stainless steel were designed. EDEM Discrete Element Modelling (DEM) simulation software was used to evaluate the new designs at forward speeds of 1.0, 1.5 and 2.0ms^{-1} with carrot and cabbage seeds. One-way and two-way ANOVA tests were used to evaluate the QFI, Miss Index, Multiples Index and CP3 values for each seed chute. The ABS 3D printed chute performed best with the highest QFI value of 99.1%, the lowest Multiples index of 0.47%, the lowest Miss Index of 0.47% and the highest CP3 value of 87.6%.

ID: 4682

Understanding the barriers to uptake of precision livestock farming (PLF) in the uk sheep industry

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The UK has the largest number of sheep in Europe. Despite the sheep industry being worth £2.2 billion per annum, profitability on sheep farms in the UK remains low. The combination of Electronic Identification (EID) of sheep, being obligatory since 2010, and increased awareness of precision livestock farming (PLF) in other agricultural industries, offers the opportunity for UK sheep farmers to raise productivity by increasing their use of PLF techniques. Uptake of PLF on UK sheep farms remains low. The aim of this study was to understand the barriers restricting the uptake of PLF, explore existing technologies available to the industry and make further recommendations for increasing the uptake in the future, through the use of a questionnaire. A total of 193 responses were received from the online questionnaire of which 50.3% of the respondents said they were currently using PLF technologies with their sheep enterprise which included EID technologies, automatic weighing and drafting technologies, management software and livestock cameras. Flock size and position in the stratified system were the two main influencing factors as to whether PLF technologies are being used. The results suggest that the initial investment cost of the equipment is the largest barrier to entry, while the age and attitude of sheep farmers was also perceived as a

barrier. To increase future uptake, the biggest incentive to participants was for the technology and equipment to be subsidised through Government funded schemes.

ID: 4693

Comparison of the different growing substrates for the vegetative and reproductive growth of strawberry plants

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The optimal production of strawberries requires the essential nutrients and favourable substrate for growth. The present study was investigated to determine the effectiveness of growth parameters in two stages of strawberries in different substrates growing in a controlled greenhouse. To analyze the significant effect for the growth among the substrates, four treatments such as control soil (CS), bio plus compost (T1), the combination of bio plus compost and synthetic nutrient applied soil substrate (T2), and synthetic nutrient supplied soil substrate (T3) were assayed. Morphology parameters like plant height, canopy area, fresh weight, and dry weight of roots were measured after eight weeks and sixteen weeks for each treatment and analyzed using completely randomized block designs through analyzing the variance with a significance level of $P < 0.05$ and canopy area was evaluated using image processing technique applied in HSV colour space. Correspondingly, the maximum plant height, canopy area, fresh weight, and dry weight in the vegetative stage and reproductive stage 16.93±0.31 cm, 23.02±1.94 cm2, 18.00±3.06 g, and 5.15±1.26 g and 19.34±0.21 cm, 28.78±0.93 cm2, 20.15±3.49 g, and 6.66±2.34 g was observed in T2 followed by T1, T3, and CS respectively. A comparison of the relative growth parameters T2 exhibited better growth performance of the strawberry plants.

ID: 4704

Challenges for agriculture through industry 4.0

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Technology is subject to constant development. In addition to continuous development, there are always changes that fundamentally influence the system. These were, for example, the steam engine, the assembly line and digitalisation. With cyber-physical systems, a new stage is now emerging which is referred to as Industry 4.0. Here, intelligent and digitally networked systems enable self-organised production based on customer requirements. The question arises as to how far this development will also change agriculture and agricultural technology? In order to understand this problem, the current discussion on Industry 4.0 will be used to analyse where there

are similarities and differences to agriculture. The focus of Industry 4.0 is on digital individualisation, flexibility, information transparency, demand orientation, sustainability, process orientation, knowledge generation, collaboration and productivity optimisation. However, it quickly becomes clear that agriculture is also characterised by other aspects, such as environmental orientation and special work organisation. In addition to the customer, society and the state, agriculture must also take nature, the environment, farm animals and the weather into account. This shows that the socio-economic, technical and ecological systems in agriculture are much more closely interwoven, which makes it difficult to define Agriculture 4.0 in comparison to Industry 4.0. In order to explain the current status of Agriculture 4.0, examples from arable and livestock farming are therefore analysed in terms of their technology levels. It becomes apparent that there is still a need for development, especially in the areas of process organisation, standardisation of technology interfaces, communication infrastructure and educational opportunities for users.

ID: 4707

ICT-agri-food fosters the digital transformation towards sustainable and resilient agri-food systems

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The agri-food sector in Europe faces significant challenges in balancing the increasing demand for food and other outputs of the bioeconomy with society's increasing demand for an agri-food system with less damaging impacts on the environment, and positive societal effects. Structural changes in the European agri-food sector are accelerating. Adaptation to climate change will force significant changes to the food system. In order to keep pace with the increasingly complex relationships, the sector is more than ever forced to find innovative solutions for adaptation. The adoption of digital technologies by the actors offers much potential to address these challenges, but despite this, the uptake of new digital technologies has been slow. Additionally, much of the potential value of the data that is already collected remains untapped because it exists in silos unavailable to those who might use it. Unlocking the value of this data remains a significant challenge due to technological barriers, lack of trust between the different actors, and economic barriers, such as reluctance of stakeholders to invest because of unclear returns and variable ability of the private sector to serve transparency needs. ICT-AGRI-FOOD has launched a targeted joint transnational research and innovation call co-funded by the EC. Furthermore, the ERA-NET will implement three additional joint calls. These calls will target the development of data-driven ICT platforms and digital solutions that make use of data from across the food chain in order to transform our agri-food systems into sustainable, resilient, fair, and transparent systems. In addition, complementary additional joint activities aim at linking new research to existing platforms and to the outputs of ongoing and previously funded projects in order to make ICT-AGRI-FOOD a pivotal point connecting all actors along the food chain to ensure maximum impact.

ID: 4714

New approaches for improving nitrogen efficiency based on clustering algorithms

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Site-specific fertilization attempts to address heterogeneities within a field, whereby plants are to be supplied according to their actual needs of nutrients, taking account of the heterogeneous yield capacity of the soils. This is intended to increase efficiency, which, in addition to economic advantages, also brings ecological aspects. To determine the actual nutrient requirements of plants, data from the local site and vegetation condition must be interpreted and processed. Among other things, the use of satellite-based multispectral images (Sentinel-2) is being investigated and applied for the site description. The nitrogen uptake of the plants is compared with vegetation indices from satellite data of multi-year crop production trials in winter wheat and winter barley. Using these generated data from several trial locations, an empiric model is developed that infers the required amount of nutrients from the current vegetation index. The current development stage of the plants is also included. An additional focus is on the detection of low-yield areas or sub-areas at risk of leaching. These areas are to be excluded from the existing model and treated separately. For this purpose, historical vegetation patterns and anomalies are examined, and corresponding areas are identified with the help of clustering algorithms like k-means clustering. Interfaces and applications for the fertilizer models enable farmers to supply plants with nutrients efficiently and in line with their needs. One goal was that farmers can use these systems without additional financial expenditure or basic technical equipment.

ID: 4719

Data fusion modeling of visible, near infrared and mid infrared spectra

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Spectroscopy has emerged as a solution to estimate key soil attributes in precision agriculture (PA) during recent decades. Chemometrics and machine-learning methods are used in order to extract useful information out of the spectra. In this paper, the performance of a visible-near-infrared (Vis-NIR) and mid-infrared (MIR) spectrophotometers for the prediction of pH, organic carbon (OC), P, K, Mg, Ca, and Na were evaluated. We compared locally weighted regression (LWR) and partially least squares (PLS) regression using 267 soil samples measured with a CompactSens spectrometer (tec5 technology, Germany) with 350-1700nm spectral range and a 4300-FTIR (Agilent, US) with 650-4000nm spectral range. After dividing the dataset into calibration set (n=160) and validation set (n=107), first-derivative (FD), second-derivative (SD), and continuum removal (CR) were implemented before modeling. To take advantage of both sensors, the predictions given by

both spectra types were fused by the least-squares (LS) fusion method considering the existing correlation among the predictions. Moreover, the proposed LS fusion scheme was compared against the conventional Granger-Ramanathan (GR) fusion method which is simply a linear regression. Results showed that PLS outperforms LWR in the prediction of all studied attributes. Also, the results suggested that Vis-NIR outperforms MIR in the prediction of OC, P, K, and Na while MIR is better in the prediction of pH and Ca and both performed almost equally for Mg. Furthermore, the prediction performance was improved by the proposed data fusion for all the attributes with satisfactory performance (RPD≥2) and exceptional for Mg and Ca with RPD≥3. It is suggested to adopt the proposed LS data fusion algorithm to improve the prediction accuracy of the studied soil properties, which outperformed not only the individual spectrophotometer dataset but also GR in most cases.

ID: 4720

Effect of plant-growth stage on the performance of a weed-detection system

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Weeding robots have the potential to reduce herbicide and labour usage in the agricultural sector. A key component of such a robot is an accurate plant-detection system. The largest challenges in plant detection are occluding plants and variation in growth stage, which change during the growing season. In this research, we evaluated the detection performance of the YOLOv3 object-detection method throughout the growing season. As a use case, we focussed on the detection of volunteer potato in a sugar-beet field. Training and test images were collected once every three days, from the two-leaf stage on the 22nd of May, until canopy closure on the 6th of June. Images were acquired with a 5-megapixel camera mounted at a height of 1.5m resulting in a spatial resolution of 0.5mm/pixel. For each acquisition day, plants were annotated using bounding boxes. From the bounding boxes, plant size and occlusion were calculated. From the 22nd of May till the 6th of June, the sugar-beet plant size increased from 145cm^2 to 727cm^2 and occlusion increased from 5% to 40%. The potatoes were smaller in size, ranging from 36 to 300cm^2. Whereas the occlusion of the potato class was higher, from 19% on the 22nd of May to 53% on the 6th of June. On the detection performance, a decreasing trend was found. On the sugar beets, a detection performance of 0.90 Average Precision(AP) was achieved on the 22nd of May, which dropped slightly to an AP of 0.85 on the 6th of June. On the potato plants, which were smaller and had more occlusion, the performance was lower, with an AP of 0.75 on May the 22th, which dropped even further to 0.38 AP on the 6th of June. Based on these results, it can be concluded that the detection performance decreases for the later growth stages, mainly for the class potato. The major decrease in performance on the potato class can be attributed to the smaller size of the potato plants, and the high occlusion ratio compared to the sugar beet class.

ID: 4726

Early prediction of protein content and grain yield of rice (oryza sativa l.) Using multispectral imagery

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The objective of this study is to predict the protein content and grain yield of rice as early as possible with a multispectral sensor mounted on the unmanned aerial vehicles. Both cultivar (called Chucheong and Younghojinmi)'s fields were treated with different amounts of nitrogen fertilizer (0, 5, 7, 9, 11, 17kg/10a) in each plot. Images were acquired at 20m of height with a multispectral sensor (RedEdge-M, Micasense Inc, USA) mounted on the UAV (3DR Solo, 3D Robotics Inc, USA) and taken fifth times with a week intervals from the ripening stage to the harvest, Also, each images were merged with the one image using mapping software (Pix4d mapper pro, Pix4d S.A., USA) and the canopy reflectance was extracted by image processing software (ENVI 5.3, Exeils Visual Information Solution Inc., USA). Based on vegetation indices (NDVI, GNDVI, NDRE), protein content and grain yield, the simple linear regression models were developed and evaluated by the coefficient of determination (R^2) and the root mean square (RMSE). Early predictability of protein content and grain yield was compared with R^2 and RMSE of each model. As a result, in the protein content, the performance of the SLR model for Chucheong was lower as $R^2 \geq 0.396$, RMSE≤0.108%. But, based on GNDVI, it was good as $R^2 \geq 0.727$, RMSE≤0.139% for Younghojinmi. Also, grain yield was shown that the high performance of the SLR model using GNDVI such as $R^2 \geq 0.846$, RMSE≤22.19kg/10a for Chucheong and $R^2 \geq 0.795$, RMSE≤18.93kg/10a for Younghojinmi, respectively. It was possible to predict the protein content for two weeks before harvest and the performance of SLR models decreased since three weeks before harvest. There was no significant difference in the performance of SLR models for grain yield from the ripening stage to the harvest.

ID: 4727

Linking soil nitrate-nitrogen and crop nitrogen uptake by means of sensor support

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Sensor data can contribute to a real-time and spatial quantification of the N inputs, N outputs, and of the current N pool in the soil to better synchronize crop N demand and N fertilizer application, thus reducing the N surplus. In this study, the multispectral imagery acquired by an unmanned aerial vehicle was linked to *in situ* nitrate data measured from the soil solution in six site-years to monitor the in-season development of crop N uptake as a function of soil N dynamics. Wheat N uptake was determined as remotely estimated N uptake (REN) from the spectral data with a power regression model (mean absolute error = 17 kg N ha^{-1}). The nitrate-N in the soil solution (NSS), extracted by means of suction cups, was measured with an ion-selective electrode. We monitored and estimated

the time-normalized changes of NSS, which varied between −0.9 and 0.7 kg N ha^{-1} day^{-1}, and of REN, which showed values between 0.5 and 9.0 (mean = 2.9) kg N ha^{-1} day^{-1}. The relationship between the two variables REN and NSS showed potential for identifying areas with a low uptake rate, which leads to a higher risk of N surplus at the end of the season if the fertilizer rate is not adjusted during the season. The N balance calculated as '(soil N supply + N fertilizer) − crop N uptake' mainly resulted in N surplus in the range of 43–100 kg N ha^{-1} over the six site-years. The main constraints remain the availability of robust sensors allowing fast data acquisition and remote accessibility to monitor the available nitrate pools in real-time.

ID: 4749

Simulation of variable rate manure application under different schemes

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In order to implement variable rate manure (VRM) in fields correctly, at rates that do not exceed the maximum allowable limits set by legislations, simulations are needed for different VRM scenarios [e.g., map-based (MB), sensor-based (SB) and map-sensor-based (MSB)]. This study aims at the evaluation of these VRM scenarios based on simulation taking into account soil variability and manure limits set by legislations. A simulation software was designed and developed to allow variable rate manure prescription and calculate application rate. Then, it was used to compare traditional uniform rate manure (URM) application against two VRM treatments in three commercial fields in Flanders, Belgium. Under each of the three treatments, two VRM schemes were evaluated, e.g., applying more manure to the more fertile zone (Kings scheme - KS) and more manure to the least fertile zone (Robin Hood scheme - RHS). Results revealed that RHS consumed 0.8% -1.9% less manure than the KS and 0.5% -5.8% than the URM approach. Due to the fact that rich parts were of slightly larger area than the poor part in all three fields, the KS method may consumed more manure, hence, was more expensive than RHS. When imposing the "MAP6" legislation limits, both KS and RHS consumed less than the case of without restrictions, reducing environmental risks due to reducing both nitrogen (N) and phosphorus (P) applied. Simulation results also presented that non-sensor-based methods (MB and URM) exceeded sensor-based (SB and MSB) rates by 2.8%-6.6%, when the mean value of real-time sensed P in manure was higher than the nominal P (measured by laboratory methods) value used for calculating the manure recommendation. We concluded that the manure consumed in VRM depends on treatment approaches (MB, SB or MSB), application schemes (RHS or KS), measured manure quality, and the proportion of rich, medium, and poor fertility areas in a field.

ID: 4756

Spatio-temporal study of tree volume in response to soil eca using mobile lidar laser scanner in sweet cherry orchard

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Studying the spatio-temporal responses of fruit tree growth in respect to soil apparent electrical conductivity (EC_a) can support growers to maximize production through various precision orchard management practices e.g., variable rate fertilization, plant protection, and thinning. In this study, a 20-year-old sweet cherry orchard (*Prunus avium* L. 'Kordia') was scanned at different growth stages: 7, 32, 50 and 60 days after full bloom (DAFB) using a mobile LiDAR system in 2019. Soil EC_a of whole orchard and tree geometry (height and width) from 20 trees were recorded. The mobile LiDAR system consisted of three sensors: (i) 2D laser scanner, (ii) RTK-GNSS and (iii) inertial measurement unit in a metal frame mounted on a tractor. The tractor was driven at 0.5 km h^{-1} speed to scan cherry tree rows from both sides. The produced georeferenced 3D point clouds were aligned using iterative closest point method and finally merged. Each individual tree was localized from 3D point cloud data based on stem position along the rows. Tree data were processed by dividing its point cloud into horizontal slices, calculating each slice volume, and building the vertical profile of tree canopy volume. Regression analysis of LiDAR estimated and manually measured tree canopy volumes revealed high coefficient of determination ($R^2 = 0.92$). The spatial EC_a map was utilized to categorize trees based on positions in corresponding EC_a zone (high, medium and low). Results showed that variability in soil EC_a can affect tree volume growth differently in different growth stages. During the growing period of 7 to 60 DAFB, in high EC_a zone revealed 49.45 % increase in tree canopy volume whereas the trees located in low EC_a zone showed about 26.48 % increase. Concluding, 2D mobile LiDAR laser scanner can monitor the spatio-temporal growth of fruit tree volume allowing to evaluate, e.g., its responses to soil EC_a.

ID: 4761

Benefit of the variable rate technology in a top-dressed fertilization of a fodder crop in a nitrate vulnerable area

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The need to control the concentration of nitrates in vulnerable areas of the Alentejo region and the poor efficiency of nitrogen top-dressed fertilizations in winter crops, as a result of the rainfed characteristics of the Mediterranean regions, suggest new forms of mechanization based on precision farming technologies namely variable rate application (VRA). Overall, VRA technology is primarily used to detect information about a given landscape and to have a system make decisions based on that information. The objectives of this study were to: i) identify homogeneous

management zones to define crop optimal N fertilizer rates, ii) demonstrate the environmental benefits of precision nitrogen management in fodder crops in a nitrate vulnerable zone. The study was carried out in a 7,5ha plot located at Herdade Experimental da Comenda in Elvas, Southeast Portugal between October 2020 and April 2021. Surveys of apparent soil electrical conductivity (ECa) were conducted with an EM 38 soil sensor. A total of 8 sampling areas (95mx95m) were georeferenced to allow normalized difference vegetation index (NDVI) and normalized difference water index (NDWI) readings. Historical time series of these indices were obtained from satellite imagery (Sentinel-2) since crop early stem elongation, and crop biomass content in N was determined in a laboratory. Based on the obtained results, three homogeneous management zones were defined, and three N rates were applied in opposition to a conventional fixed N rate. The obtained results highlight the contribution of VRA to the environmental control of nitrates in vulnerable areas through the use of precision management technology.

ID: 4765

Characterizing lactating sow posture in farrowing crates utilizing automated image capture and wearable sensors

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Precision livestock management applies technology and real-time automated processes to provide a continuous data stream to aid in management decisions such as animal reproduction, welfare, health, and production. The need for these technologies is growing with decreases in labor sustainability. Pre-weaning mortality is a major economic and welfare issue in swine production, one of the major causes is crushing of the piglets by the sow. This experiment's objective is to track lactating sow posture changes and activity in farrowing crates using wearable sensors. The wearable sensor integrates an electronic sensing circuit with rigid, waterproof enclosure to monitor the posture of the sow. The electronic sensing circuit contains 1) microcontroller for signal processing, 2) non-volatile flash data storage, 3) real-time clock, 4) rechargeable battery, 5) and three-axis accelerometer with integrated temperature sensor. The wearable sensors were placed in denim pockets with a Velcro enclosure affixed to the sow using livestock tag cement. Four Brinno BCC100 time-lapse cameras were utilized for validation of the wearable sensors. The Brinno camera collected data at 2 frames/sec. The image data was used to assess major movements associated with changes in postures (standing, rolling, sitting, kneeling, and lying) and minor movement of head shakes and walking. The temperature data will be used to assess the microenvironment surrounding the sow. Data collection and processing are ongoing. The system provides a path towards the collection of phenotypic data related to maternal ability.

ID: 4787

Tracking grow-finish pigs across large pens using multiple cameras

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Increasing demand for meat products combined with farm labour shortages has resulted in a need to develop new real-time solutions to monitor animals effectively. Significant progress has been made in continuously locating individual pigs using tracking-by-detection methods. However, these methods fail for oblong pens because a single fixed camera does not cover the entire floor at adequate resolution. We address this problem by using multiple cameras, placed such that the visual fields of adjacent cameras overlap, and together they span the entire floor. Avoiding breaks in tracking requires inter-camera handover when a pig crosses from one camera's view into that of an adjacent camera. We identify the adjacent camera and the shared pig location on the floor at the handover time using inter-view homography. For videos acquired under low light conditions (e.g., at night), we enhance image contrast using gamma correction and adaptive histogram equalization. Our experiments involve two grow-finish pens, housing 16-17 pigs each, and three RGB cameras. We annotated 429 frames with a bounding box around every pig, feeder, and drinker and created an 80:20 training and validation split. Our algorithm first detects pigs using a deep learning-based object detection model (YOLO) and creates their local tracking IDs using a multi-object tracking algorithm (DeepSORT). We then use inter-camera shared locations to match multiple views and generate a global ID for each pig that holds throughout tracking. Additionally, we estimate the time spent at the feeder and drinker for each pig based on proximity to the feeder or drinker. For performance evaluation, we use the usual average height (precision) of the precision-recall curve, we obtain 99% for Intersection over Union threshold of 50%. We open-source our code and annotated dataset at https://github.com/AIFARMS/multi-camera-pig-tracking

ID: 4789

Yield estimation in tablegrape using the pronofrut it-supported methodology

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Pronofrut is a crop monitoring service developed for the fruit, winery and horticultural industries which incorporates a stereological sampling methodology supported by Information technologies to optimise sampling, data collection and processing. Modern tablegrape orchard management for high value production and export, involves the manipulation of individual tree canopies and individual fruit. We present results of yield estimations conducted in a 15.8 ha commercial tablegrape orchard (var. Crimson Seedless) in central Chile. A high resolution,

georeferenced tree-NDVI image of the orchard was derived from images obtained using an unmanned aerial vehicle (UAV) equipped with an adapted consumer camera and the OrchardMapper image analysis This information was used to select sample trees, with selection designs depending on the objective of the sampling and provided a prediction of the contribution to estimation error from the tree sample. Manual bunch counts and quality measurements were made on small selection of canes selected systematically uniformly at random across the plantation. Low counts are important to reduce human errors in counting. The smartphone app (Pronofrut Sampler) was used to guide sampling indicating to the user the exact position of the sample, and also to input data and, at the end of a survey, upload the data to a server for processing. Sample counts and measurements were used to estimate yield and distributions of quality parameters and a semi-empirical variance model was used to predict the error of the yield estimate. We present estimation results, workloads (person-hours) and predicted estimation errors and compare these with exhaustive manual counts carried out by the orchard personnel. We illustrate two different tree sampling designs based on UAV vegetation maps and the influence on sampling errors and efficiency (the balance between obtaining low errors and labour costs).

ID: 4790

Pronofrut sampler: smartphone application for sampling and yield estimation of specialty crops

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Gardi et al. [Journal of Microscopy, 2007] described handheld software for supporting sampling of branching structures. The software has been migrated to android for use with tablets and cellphones and enhanced with a special focus on counting and sampling for precision horticulture, and is included as an essential tool in a commercial yield estimation service, 'Pronofrut', providing the statistically sophisticated yet flexible manual sampling designs for different agricultural crops. The app directs the user to the next sample position (e.g. go to row W, tree X, branch Y to count fruit and then select fruit Z) and involves counting small quantities on small segments of the plant, eliminating human biases and counting errors. The user inputs data related to the sample (counts, weights, quality parameters, defects etc.) and at the end of a session uploads the survey to the cloud and the data are automatically processed on the Pronofrut server to generate client reports. In addition to the latitude and longitude from the GPS, the app also records the sample position in the orchard space (i.e. the row, tree, branch, ... number) permitting the posterior creation of maps of 2D or 3D distribution of fruit counts and quality. It is being used by fruit industry personnel including high school students on summer jobs, agricultural technicians, and older agricultural workers with only a basic education, as well as highly qualified researchers. In this paper we will present main features of the mobile application and examples of yield estimations (results, accuracies, labour costs) in grapes, cherries and apples using the application.

ID: 4799

Bluetooth low energy (BLE) and passive rfid integration for obstacle avoidance and autonomous vehicles management in agriculture

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Inadequate or poor interaction between operators and machines in agriculture can lead to severe accidents and thus represents one of the most relevant dangers. The simultaneous presence of autonomous vehicles and workers on foot calls indeed for inherently safer designs and major developments of safety devices meant to reduce the risk of crush and risk of being run over. The emerging technological advances make many common agricultural practices harder to understand for the operator and thus increase accident probability. In such an evolving context, remote-controlled and autonomous machines require deep safety analysis at design stage. SMARTGRID project, financed by the Italian National Institute for Insurance against Accidents at Work (INAIL), hence focuses on developing an integrated system based on Bluetooth Low Energy (BLE) and passive RFID tags designed to enhance safety management of smart machines in complex and harsh working conditions like agriculture and forestry operations. Statistical information, enriched with pros and cons from state-of-art safety technologies, has been considered to let SMARTGRID project address the specific challenges of everyday practice in agriculture: as a result, the deployment of a multilayer communication system has been designed in order to keep track of vehicles, position of workers and fixed obstacles on the working site. With on-board beaconing and UHF RFID antennas any tractor could share information with a server for risk management and deliver the information to any other machine or worker equipped with a wearable or mobile device.

ID: 4812

Innovation in behavioral indicators of pig welfare: total number of visits to the feeder and proximity index

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This study, made within the framework of AWARTECH project, aimed to evaluate growing pigs feeding and resting behaviors according to different environmental conditions. 3 trials were made differentiated by the environmental conditions (mean air temperature and relative humidity RH): Winter (W) - t=13°C, RH=74%, Thermoneutrality (TN) - t=21°C, RH=74%, Summer (S) - t=29°C, RH=63%. 8 improved genotype females were used in each trial, with an average initial weight of 48±3kg. The average final weight was different in the 3 situations: W=96±2Kg, TN=103±2Kg and S=99±2Kg. Pigs were housed in a room equipped with an environmental control system. Total Number of Feeder Visits (T.N.F.V) and Proximity Index (P.I) were the variables studied. The T.N.F.V

was controlled using an automatic feeding machine (*Schauer Compident MLP II*) and the P.I was obtained through an artificial vision algorithm developed in the frame of the project, in order to calculate the level of dispersion of the animals in the pen. This was possible thanks to the analysis of the images recorded by the 5 video cameras strategically placed, in order to record the entire pen area. The P.I obtained was represented on a scale of 0 to 1, where "0" corresponds to the maximum dispersion between the animals and "1" corresponds to the maximum proximity. Data was analyzed by ANOVA using trial as fixed factor and the average ± standard errors of the variables were considered. T.N.F.V was significantly lower in S trial ($p<0.001$) than W and TN that weren't different between them (W: 2455±324, TN: 2606±618, S: 1952±301). The P.I was significantly different ($p<0.001$) between all trials, being higher in W and lower in S (W: 0,88±0,04, TN: 0,79±0,05, S: 0,65±0,03). These results highlight the influence of environmental conditions, indicating adaptive changes of pigs on their feeding and resting behaviors.

ID: 4813

Awartech project: a new tool of precision livestock farming for growing-finishing pigs

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The world is, day by day, more demanding for high quality food, produced according to animal welfare regulations and ethical principles, and both social and environmental responsibility. This requires a special care with cost rationalization and increased efficiency in the use of production factors and value chains. Intensifying production pursing self-supply or higher competitiveness objectives may decrease animal welfare. Therefore, it's important to monitor the environment inside the swine facilities and the animal welfare conditions. The main objective of the AWARTECH (Animal Welfare Adjusted Real Time Environmental Conditions of Housing) project was to create and develop an innovative precision livestock tool that will support and reinforce the pig value chain, by management solutions based on monitoring, analysis and control of environmental, physiological, behavioral and productive parameters. Environmental data were collected by sensors of temperature, relative humidity, air velocity and gas concentration, which are integrated in a environmental control system (Webisense) and a platform (Nidus). Webisense controlled the ventilation system, the cooling system and the heating system. The physiological data (rectal temperature, surface temperature and α-amylase) were collected manually. In order to monitor the behavior of the animals, video cameras and microphones were installed. An individual feeding machine equipped with a scale has been installed. That allows, through an RFID system, individual monitoring and control of the quantity of food supplied and ingested, number and duration of visits, and the weight of the animals. The development of AWARTECH platform results from the integration of physiological data manually supplied and real-time data provided by Webisense, Nidus, feeding machine, video and sound analytics, that allow the control of the environmental conditions in order to promote the animal welfare.

Soil, land and water engineering

ID: 2597

Assessment of emitter clogging with different sand media filter underdrain designs using reclaimed effluent

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Sand media filters are usually recommended when reclaimed effluent are used in drip irrigation systems. Sand media filters usually differ on the design of their underdrain, but the possible effect of these designs on emitter clogging has not been widely studied. Three sand media filters with different underdrain designs (wands, inserted domes and drainage with porous media, respectively) were used in a surface drip irrigation system for filtering a reclaimed effluent. Pressure-compensating emitters with 2.3 l/h nominal discharge were placed every 0.4 m in 4 irrigation laterals each 90 m long. The filters worked for 1000 h with sand media heights of 0.2 and 0.3 cm and filtration velocities of 30 and 60 m/h. At the beginning, after 500 h of operation, and at the end of the experiment the emitter discharge of each one of the emitters was measured under field conditions. Overall, there was a statistically significant reduction ($p < 0.05$) on emitter discharge regarding the initial value of 8.03% at 500 h and 10.84% at 1000 h. Emitter clogging was primarily affected by the interactions between underdrain design, emitter location and irrigation time. Differences on emitter discharge due to underdrain design were only observed at 1000 h, showing those emitters protected with the filter with a wand underdrain a significantly higher flow rate ($p < 0.05$), despite that this filter did not achieve the highest turbidity removals. Emitter location had also a significant effect after 500 h of operation, being discharge significantly lower ($p < 0.05$) only in the last 2 m of the driplines, with the minimum values found for the final two emitters. The three different filters used in the experiment did not show a significant effect on the percentage of completely clogged emitters, which mainly depended on the interaction between irrigation time and emitter location.

ID: 2598

Hydraulic performance of a wand-type underdrain in a sand media filter for a drip irrigation system

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Sand media filters are commonly used in drip irrigation systems for preventing emitter clogging. Since commercial sand media filters have different underdrain designs that mainly affect pressure loss and flow rates, it is important to assess their performance. The wand-type underdrain design provides a large ratio of horizontal area covered by underdrains that should favour a uniform

flow of water through the medium. In the present study, the hydraulic performance of a commercial sand media filter with a wand underdrain was studied using a computational fluid dynamics (CFD) model that was developed assuming clean water and filtration conditions. The effects of changing the wand position and the slot open area were also assessed. The results obtained from the numerical model were validated using experimental data from an experiment carried out with a commercial sand media filter with 10 wands that operated with different sand media heights and filtration velocities. The original design presented unbalanced flows between underdrains, with differences between 44 and 51% regarding the lowest value. Aiming to solve this problem, two new designs were analysed: (1) a design with the same type of wands as the original filter but distributed to have an equal horizontal area served by each wand, (2) a design with the same spatial distribution as the original filter but with longer wands in those regions of the original filter with lower volumetric flow. The CFD simulations of the two designs showed that design (1) reduced the pressure drop through the filter at nominal volumetric flow rates by up to 5.8% with a more uniform flow inside the medium while design (2) could improve the performance of the filter by achieving an up to a 4.9% reduction of pressure drop. Design (1) also achieved the highest reduction (17-28%) of flow unbalancing among wands. Thus, the spatial distribution of underdrains is a key parameter in the hydraulic performance of sand media filters.

ID: 2935

Monitoring the water distribution in the lis valley irrigation district, Portugal

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Water savings on collective distribution systems is a complex issue because it should simultaneously guarantee higher distribution efficiency, improvement of the delivery performance through higher adequacy, reliability, equity and flexibility, and allowing the increase of the farmer's income. On gravity-fed conveyance systems, supplied by surface water runoff, it is usual to occur some periods of water scarcity. This limitation implies greater difficulties in the management practices aiming the best collective system performance. The monitoring of these systems is determinant to improve the management. This paper refers to the action of the Lis Valley Water Management Operational Group, of Agricultural European Innovation Partnership (EIP-AGRI), with the objective of monitoring the collective allocation and the on-farm irrigation demand, aiming water and energy savings and the improvement of the delivery performance. The methodology considered the recording of the main canals affluence, pumping energy consuming, and the on-farm irrigation demand, based on agrometeorological, crop and soil data. The results foccused on an irrigation sector of 410 ha, supplied by the Canal 2, gravity-fed by Lis river on the Arrabalde weir, and pumping recharged in its middle section, during the irrigation peak period. The allocation and irrigation demand, referring to a 10-day period, during the irrigation season, reveals the specificity of the drainage water reuse, which leads to a more flexible management of water distribution with

significant impact of delivery equity. Results point out to the need for: 1) Better maintenance and conservation of hydraulic infrastructures to reduce water losses and better flow control, 2) Better operational plans, adjusting demand with allocation and distribution, and 3) More efficient on-farm systems.

ID: 2936

Water saving in on-farm rice irrigation in the lis valley, Portugal

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The rice crop has an important socio-economic value in Portugal, being traditionally cultivated under continuous flooding irrigation. The common water management issues to deal with, are water scarcity, environmental impacts on water quality and agroecosystems and the methane emissions to the atmosphere. Global changes concerns call for water saving practices in rice production, to safeguard its economic and environmental sustainability. This paper presents the results of field experiments carried out in the Lis Valley, Portugal, sponsored by the MEDWATERICE project, with the objective of assessing the effectiveness of the alternative wetting and drying flooding (AWD), and the drip irrigation. The use of conventional methodologies enabled measuring the irrigation inflow, surface drainage, water level above soil surface, soil water data, crop phenological development, and yield. The water quality analysis was performed in the irrigation, drainage and groundwater. The results include the irrigation water use, crop evapotranspiration, deep percolation and runoff. Results showed that AWD has a potential of 10% of water saving, away with a yield reduction of 5.6%, a water productivity increase of 3.7%, and additional 28 days with non-flooded soil, compared with the traditional flooding. Some risks regarding soil salinization and water microbiological issues were identified in the traditional rice areas. The drip irrigation essay, innovative in this areas, uncovered problems with soil lateral wetting and fertilizers leaching in a light soil, explaining the yield losses. However, the maximum plot yield, makes glimpse a potential good performance. In the next season experimental adjustments of the distance between row crops, position of drip lines and the fertigation plan, will allow to confirm this putative potential.

ID: 3289

VSIM model adaption to qualified denomination of origin rioja soil and weather conditions

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Irrigation is a key practice for wine grapes production. Both, irrigation in excess and lack of irrigation could produce different wine faults. Traditionally, vineyard irrigation was considered as a way to increase yield although it reduced product quality. The aim of this research was to adapt VSIM model to weather and soil conditions of Qualified Designation of Origin Rioja in northeast Spain. Plots were planted mainly with Tempranillo cultivar, although Graciano, Tempranillo Blanco and Viura were also grown in three plots. Humidity sensors were placed at two depths to assess plant response to water stress. In addition, one weather station was set in each plot and data was transmitted in real time through a host control platform enabling data browsing by wineries technicians and researchers. Grape samples were analyzed during harvest to supplement in real time data. Two treatments were applied: irrigation based on adapted VSIM model and rainfed. Each monitoring system test weekly water balance relating those data with water status of each plant by dendrometry measurements. Adaptations of VSIM model to Rioja soil and weather conditions replaced Leaf Area Index (LAI) by Normalized Difference Vegetation Index (NVDI) along with trunk diameter measurements using dendrometry. Furthermore, crop coefficient was calculated based on NVDI instead of LAI and water stress thresholds were modified from originals. The main problem was to define a desired water stress to obtain an adequate yield without reducing fruit quality, although dendrometry measurements helped to check if the plant suffer or not water stress. In conclusion, adapted VSIM model contributed to optimize water resources through measuring soil humidity, grapevine growing and trunk diameter through dendrometry.

ID: 3290

Assessment of three different deficit irrigation strategies in super-high density olive orchard in La Rioja

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In the last years, olive cultivation has undergone to an intense process of intensification as much in planting density as in spread of irrigation techniques to increase yields and stabilize alternate bearing. This study evaluated three deficit irrigation strategies applied in super high density orchard planted with Arbequina cultivar olive trees, in order to reduce water consumption compared to a fully watered control. Water stress of trees was assessed by means of the continuous measurement of trunk diameter fluctuations through dendrometry techniques. Water stress threshold should be defined as stress value in which the productive and vegetative variables are not altered. On the one hand, results showed that regulated deficit irrigation, which subjected trees to

moderate stress during pit hardening phase, has been very interesting. It was due to trees were able to recover from this stress without significant reductions on vegetative growth or yield respect to the control treatment. On the other hand, continuous deficit irrigation showed significant reductions on vegetative and yield, causing an excessive reduction of oil yield. Water saving varied from 18,9 to 50 % respect to full irrigation while oil yield were only reduced from 2.3 to 16.4 % been even higher than fully irrigated plots when irrigation decisions were based on dendrometry measurements.

ID: 3308

Experimental investigation of sustainable water production by pv-ro desalination systems for crop irrigation

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Global population growth leads to increasing demand of food, feed and nutrients. Water is an essential element of life and based on World Health Organization, 844 million people today lack even basic fresh water services, this number is expected to increase due to population growth and growing food demand. Hence, it is imperative to find new solutions for sustainable production of fresh water, aiming at improving and increasing crop production and minimise environmental impact. Desalination powered by renewable energy seems to be a sustainable solution to this problem. Experimental studies have shown that powering a Reverse Osmosis (RO) desalination unit with photovoltaics (PV) that include short term energy storage offers excellent results regarding the specific energy consumption when operating the RO unit in part-load. However, the variable operation of the RO unit (transient feed flow rate and pressure) leads to a production of desalinated water of variable salinity depending on the instantaneous renewable power available. This paper regards the development of an integrated water management system for lettuce irrigation, using a RO unit powered by PV. An experimental study of lettuce irrigation is executed to study the growth rate, the quality characteristics and the yield under different salinity levels (0.3, 0.8, 1.2, 1.7, 2.2 and 3 dS m^{-1}) of irrigation water produced by such a RO unit. The objective of this work is to identify the optimum relationship between irrigation water salinity and lettuce yield/quality, so to set the RO unit to produce water of proper quality, while allowing it to operate in part-load conditions using the least energy consumption, contributing in reduced water desalination cost for irrigation purposes in semi-arid and arid areas. This way, economic development of such areas will be enforced with adapted water production technologies and assist on sustainable crop production.

ID: 4737

Influence of irrigation and nitrogen fertilization on kiwifruit production

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The ineffective water use and nitrogen (N) fertilization increases the cost of crop production and negatively affects the environment. Therefore, the present study aims to access the irrigation scheduling and N fertilization on kiwi production. A field experiment with 7500 m^2 was set up in 2020 as a randomized block design at the NW of Portugal with three blocks and factorial treatment structure. Nitrogen fertilization including full fertilization (50 kg ha^{-1}, N50) and deficit fertilization (30 kg ha^{-1}, N30) was combined with two irrigation rates comprising full irrigation (100% crop evapotranspiration, FI) and deficit irrigation (DI = 50% FI). Soil water content and stem water potential were assessed with the multi-depth capacitance probe and the Scholander pressure chamber. Until June, soil water content was similar for DI and FI conditions. However, the total soil water content decreased 14% at 80 cm depth for DI compared to FI conditions during July and August. Consequently, the stem water potential increased -0.1 MPa for DI in comparison to FI during the same period but the values of stem water potential (between -0.7 and -0.5 MPa) indicated that kiwivines were not exposed to water stress. Kiwifruit yield was similar for all treatments except for DI-N50. In contrast, the weight of the kiwis with large caliber 25-18 (> 120 g) increased for FI compared to DI. Moreover, the DI-N30 treatment showed a higher total solid soluble (°Brix) content and caused a higher flesh firmness compared to FI-N50 at harvest. Here, the findings suggest that irrigation based on 50% crop evapotranspiration and approximately 30 kg ha^{-1} N fertilization may maintain yields and increase fruit quality in the edaphoclimatic conditions of NW Portugal. Nevertheless, further research is needed to make solid conclusions on the effect of irrigation and N fertilization management on kiwi production.

ID: 4738

Calibration of crop coefficients of vitis vinifera l. Cv. Loureiro using simdualkc

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Vineyard irrigation management in temperate zone needs knowledge of the crop water requirements. The main objective of this work was to apply the dual crop coefficient approach (K_{cb}) to estimate the crop evapotranspiration (ET_c) of *Vitis vinifera* cv. Loureiro in presence of an active ground cover. In this work the soil evaporation and the vines and active soil cover transpiration were calculated. The study was carried out in a commercial vineyard located in Ponte de Lima, NW of

Portugal, during two growing seasons (2019-2020). Two irrigation treatments, Full Irrigation (FI) with100% of ET_c and Deficit Irrigation (DI) with 50% of ET_c were compared to a control rain-fed (R). The ET_c was estimated using the SIMDualKc model, which performs the soil water balance with the dual-K_c approach. This balance was obtained calculating the basal coefficient (K_{cb}), obtained through the coefficients for the grapevine ($K_{cb\ adj}$) and the active soil cover ($K_{cb\ gcover}$), and the soil evaporation coefficient (K_e). The model was calibrated and validated by comparing the simulated available soil water content (ASWC) with the soil water content measured with a capacitance probe (Diviner 2000®). A good adjustment between the simulated and observed soil water content was obtained in 2019 for the rain-fed treatment (calibration), with a determination coefficient (R^2) of 1. The root mean square error (RMSE) the percent bias of estimation (PBIAS, %) and the modelling efficiency (EF, dimensionless) were 2.57, -1.28 and 0.97, respectively. For the grapevine the best fit was obtained for $K_{cb\ full\ ini}$ = 0.33, $K_{cb\ full\ mid}$=0.79 and $K_{cb\ full\ end}$ = 0.60. The results of the simulation with SIMDualKc model led to the conclusion that computational procedures are accurate when using field data about active soil ground cover, thus allowing the evaluation of the active soil cover transpiration and the crop water requirements.

ID: 4772

Orchard level assessment of irrigation performance and water productivity of an irrigation community in eastern Spain

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Over the last three decades, a great investment effort has been made in the modernization of irrigation in the Valencian Community (Spain). The initial change of distribution networks to pressurized ones and the shift towards drip irrigation systems was followed by improvements in irrigation scheduling, based on agrometeorological data, soil water content sensors and remote sensing. These improvements are considered adequate for increasing irrigation water use efficiency but it is difficult to find systematic measurements to assess its impacts on irrigation adequacy along with irrigation productivity in fruit orchards. This work presents the results of a four-year assessment of irrigation water and energy use efficiency along with water productivity of a recently established irrigation community in the province of Valencia (Spain). The study was carried out at the orchard level and focused on two fruit crops: persimmon and peach trees. Five irrigation performance indicators, Relative Water Supply (RWS), Relative Irrigation Supply (RIS), global Water Productivity (WPglobal), Output per Unit Irrigation water (OUI), and Profit per Unit of Irrigation water (PUI), were defined and calculated for years 2017 to 2020 in 104 persimmon and peach orchards. The results showed that most of the farmers irrigated below the crop water requirements showing RWS and RIS values below 1, and there was a great variability among farmers, especially in WPglobal and OUI indicators.

Sustainable production in farm buildings

ID: 2656

Comparing direct and indirect measurements of ammonia emission (case study: poultry litter)

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Ammonia and other nitrogenous losses from agriculture contribute to acidification, eutrophication, and biodiversity loss through deposition of N in the environment. To achieve insight into total N loss, measurements can directly be made on various N-compounds or indirectly by a mass balance. Recent researches have shown that direct and indirect methods may substantially disagree on total N loss. The main objectives of this experiment were to 1) verify a presumable N-gap between methods and 2) figure out to what extent ammonia emission and additional estimates for N_2O, NO, NO_2 and N_2 could fill in the N loss difference between methods (N-gap). Ammonia emission (NH_3-N) from manure of laying hens was measured over a 7 day period by using a two-step impinger method. Eight vessels (each filled with 200 g litter) and 8 primary and secondary impingers (each contained 0.5 M HNO_3) were used. Litter samples were analysed both for the initial and final N content in order to calculate the N mass balance. For each total N content analysis, a thoroughly mixed sample was taken out all vessels and analysed in duplicate. Ammonia emission was 0.171 g/kg dry manure (SD 0.0175 g/ kg dry manure). In contrast, the N mass balance registered a total N loss of 2.05 g/kg dry manure. The difference between methods left approximately 92% of the N loss unexplained. Based on this study and literature estimates of N_2O, NO, NO_2 and N_2 it was estimated that about 23% of the N loss could be explained, leaving 77% unexplained. Results of this study not only opt for further investigation on how to explain a presumed N-gap between directly and indirectly measured N loss from (poultry) manure, but stress the need to verify current N-emission measurements and non-measured N compounds such as N_2.

ID: 2657

Thermal analysis for an unrefined sugar cane processing factory in colombia by using CFD

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In Colombia in most of the facilities dedicated to manufacturing, processing and treating agricultural goods it is common to find elevated humidity and temperature levels, due to the bad conditions in which these manufacturers operate. These are factors that can affect the life and

productivity of employees, also generating problems in healthiness, therefore spoiling the production and the expected profit. The main goal of this investigation was to evaluate the existing conditions for the workers in the unrefined sugar cane's juice processing factory, located in Cundinamarca, Colombia, based on temperature to measure and calculate values that show the actual situation, through the use of CFD tools. The simulation results showed high temperature levels, especially in places where the operators work, consequently demonstrating that the workers are under thermal stress, according to indexes developed in previous investigations, as the operative temperature. In conclusion, the structure lacks of proper ventilation systems, able to lower the elevated temperatures present in the inner environment. Thus, a change in the ventilation system is required to decrease these levels through natural methods, due to the geometry of the factory.

ID: 2683

Wind tunnel investigations for a direct measurement of volume flow and emissions of a naturally ventilated dairy barn

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In dairy husbandry, an accurate estimation of emissions leaving the barn is an unsolved problem due to the large openings of the mostly naturally ventilated dairy barns (NVDB). Despite the usually used indirect airflow rate measurement methods, e.g. mass-balance approaches, in this study the volume flow and the resulting emissions were measured with a direct approach. The goal was to identify the minimum number of sampling points (SP) and their respective positions when applying direct measurements on a simple test case. A 1:00 scaled model of an NVDB was investigated in a large atmospheric boundary layer wind tunnel. Inside the barn, a tracer gas with a known mass flow was continuously injected. Under a perpendicular inflow with resulting cross ventilation, parameters in the plane of the barn's outlet was measured with a matrix of 260 sampling points (SP). At each SP, the velocity vector and the concentration of the tracer gas were measured with a Laser-Doppler-Anemometer and a Flame-Ionization-Detector, respectively. The results show a large variability between the different SP, both for velocity and concentration. Comparing the SP with the highest velocity to the SP with the lowest velocity, a relative difference of -66 % is found. Comparing the SP with the highest gas concentration to the SP with the lowest gas concentration, a relative difference of – 86% is found. The results indicate that even for a simple case with a constant perpendicular inflow, the accuracy of directly measuring the volume flow and emissions is highly dependent on the number and position of the SP and the use of one individual SP is insufficient. The minimum number of SP and their respective positions for a needed accuracy will be presented at the conference.

ID: 2688

NMVOc emissions of a silage-based and a silage-free diet for dairy cows on a practical scale

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In addition to NH_3 and CH_4 emissions, dairy farming is a considerable source of NMVOC emissions. According to a literature review, the knowledge on NMVOC emissions is scarce, mostly from qualitative pilot studies, but the majority of emissions seems to originate from feeding (Bühler et al. 2018). Empa and Agroscope initiated a study to quantify NMVOC emissions of silage-based versus silage free feeding in the experimental dairy housing for emission measurements in Tänikon. The housing consists of two spatially separated compartments (20 cows each) which allows comparative quantification of emissions simultaneously. To cover climatic variations over the year, the measurements were carried out in summer, autumn and winter. In order to determine the effect of the two diets on emissions, a cross design was chosen. Thus, the cows were first fed the silage-free diet in compartment 1 and in parallel the silage-based diet in compartment 2 and then the diets were switched. A dual tracer-ratio method with SF_6 and SF_5CF_3 was used to determine emissions under natural ventilation (Mohn et al. 2018). SF_6 and SF_5CF_3 were analysed by gas chromatography with electron capture detector (GC-ECD) and NMVOC concentrations by gas chromatography with flame ionisation detector (GC-FID) and a total hydrocarbon monitor (THC). NMVOC emissions in the compartment with the silage-based diet were dominated by ethanol followed by ethyl acetate and methanol. Summer measurements show around 70% lower ethanol emissions in the compartment with the silage-free diet compared to the silage-based diet. In autumn and winter, ethanol emissions in the silage-free compartment were even lower - in the range or below detection limit. Ethanol emissions in the silage-based compartment showed clear maxima during the feed supply and the main feeding times. In a next step, annual emission values will be calculated based on the measured values and long-term temperature data.

ID: 2699

Influence of different ventilation systems on the activity and lying behavior of lactating dairy cows under heat load

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In the course of the predicted climate change, the problem of welfare and heat load of dairy cows has become increasingly important even under moderate climate conditions. Measures to increase the air circulation in the barn and intensify the convective and evaporative heat loss of the cows are increasingly implemented. The objective of the present study was to analyze the activity and lying behavior of lactating dairy cows under heat load in the summer months. Additionally, two different ventilation systems were installed in the barn and the cooling effect regarding the activity

and lying behavior was compared. The study was conducted in a naturally ventilated dairy barn in Germany. The measurements with cross ventilation of fans were carried out from June to September 2015/16. A tube ventilation system above the lying cubicles were installed in 2019 and data were collected from June to September. The barn climate was measured at eight points within the barn and the average temperature-humidity index (THI) was calculated per day to define the heat load the cows were exposed to. The activity and lying behavior of the dairy cows (n = 22) was measured using IceTag3D™ pedometers and described with several behavioral traits per cow and day. The results showed a decrease in the lying time and the average lying bout duration per day with increasing heat load. Furthermore, there was an increase in the number of steps. These changes in the behavior were most pronounced in the afternoon. The comparison of both ventilation systems showed that the behavior changes under tube ventilation were less strongly than under fans depending on increasing heat load. Visual observations also indicated that the cows were more homogeneously distributed in the barn during the measurement time with the tube ventilation system. This indicates that the tube ventilation system has a better cooling effect and could be an alternative compared with fan ventilation.

ID: 2702

Reduction of ammonia emission from dairy floors by urease inhibition

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Ammonia emissions from livestock farming has a negative impact on the environment. One of the options for reducing ammonia emission is to inhibit urease activity. Urease is the enzyme that ensures the conversion of urea to ammonia. Without the urease reaction this process and the subsequent ammonia emission will not take place. The purpose of this study was to determine the effect on urease activity and ammonia emission by treating different types of dairy floors with an acid or a disinfectant in combination with a manure removal system. In the first part of the study the effect on urease activity of 4 treatments were tested (hydrochloric acid, formaldehyde, peracetic acid -PA- and electrolysed oxidizing water -EOW) and compared with a control treatment (water). In the second part, the duration of action on urease activity for the most promising treatments (PA and EOW) was investigated. In the third part the effect of PA and EOW on the ammonia emission was determined. Based on the results of this study (a patent has been granted) the following conclusions were drawn: i) There is a strong effect of floor type, in combination with an efficient manure removal technique, on urease activity in dairy houses. The less porous/rough the surface of the floor the lower the urease activity; ii) The use of PA or EOW can greatly reduce urease activity on concrete floors. No effect of the acid / disinfectant was found for the slatted floor with rubber coating; iii) Treatment of a concrete floor with PA or EOW has an effect on urease activity for at least two days. Iv) Treatment of a concrete floor with PA or EOW, prior to a simulated urination, results in a significantly lower ammonia emission from the urine puddle than after only intensive cleaning with water. Measured ammonia reductions from the floor were 98.2% for PA and 68.2% for EOW.

ID: 2733

Effect of acacia mearnsii supplementation in forage-based diets on dairy cows ruminal methane emissions measured by the greenfeed

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Forage-based diets potentially increases ruminal methane (CH_4) emissions. Dietary supplementation of a condensed tannin-rich extract of *Acacia mearnsii* can reduce CH_4 production. Goal of this study was to investigate efficiency of *A. mearnsii* to mitigate ruminal CH_4 emissions in six different silage-based diets. Thirty multiparous Holstein cows were assigned randomly to six diets in 3×6 incomplete Latin square fed for 15 days of adaptation and 13 days of data and sample collection. Diets contained (dry matter basis) 79% silage and 21% concentrate. The silages were either ryegrass-rich (R), clover-rich (C) or sainfoin-rich (S). Either 2.1% of *A. mearnsii* extract or straw meal were added to the rations. Daily CH_4 emissions of each individual cow were determined using the GreenFeed system. Dry matter intake (DMI) and milk yield were recorded daily, milk composition weekly. Cows not receiving *A. mearnsii* had a higher (P<0.01) DMI and NDF intake (NDFI), but this effect was not consistent between the different silages (A. mearnsii × silage interaction, P<0.01). Cows fed C had the highest (P<0.05) DMI and NDFI, followed by cows fed S and R (for DMI) and R and S (for NDFI). Non-supplemented cows (P<0.001) and cows fed C had the highest (P<0.05) production of energy corrected milk (ECM). Daily CH<sub>4 production and DMI-related intensity were lower (P<0.001) in tannin-supplemented cows (359 g/d, 18.4 g/kg) compared to non-supplemented cows (398 g/d, 19.8 g/kg). Cows fed S and R emitted less (P<0.05) CH4 per day compared to cows fed C whereas, related to DMI S and C cows emitted less (P<0.05) CH<sub>4 than R cows (20.7 g/kg). No effects of tannin supplementation and silage type (P>0.05) were observed on NDFI- and ECM-related CH_4 intensity. Concluding, independent from silage type, supplementation of Acacia is efficient in reducing CH_4 production per day and related to DMI but not related to ECM and NDFI.

ID: 3028

Ammonia emission, pen hygiene and pig behavior in a fattening pig house with partly slatted floor during warm conditions

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Pens with partly slatted floor for fattening pigs make it possible to use straw for bedding and allow the pigs to lie down on solid floor surfaces, which is positive for the welfare of the pigs.

Compared to pens with fully slatted floor, pens with partly slatted floor show lower levels of ammonia emission. This is explained by a smaller area covered with urine and faeces. However, during warm conditions for the pigs, problems with fouled pens and high ammonia emissions arise. Heat stressed pigs try to cool themselves by lying on the slatted floor instead of the solid floor. They also start to urinate and defecate on the solid floor. The objective of this study was to test measures for improving pen hygiene in partly slatted pens by cooling the pigs during warm conditions reducing the pen fouling. Two methods were investigated, showers above the slatted floor, and increased air velocity (from max 0.5 to 1.0 m/s) on the lying area. The studies were carried out in a commercial fattening pig house with 10 identical rooms with 16 pens, and 9-14 pigs per pen. Two rooms were filled simultaneously (control vs. treatment). During 10 batches for two summer periods ammonia emission, pen hygiene and pig behaviour have been measured and analysed. NH_3 and CO_2 concentration were measured using a photo-acoustic multi-gas analyser. Ventilation rate was determined with indirect CO_2 tracer gas method. Pig behaviour was evaluated by means of machine vision and deep learning approaches, and pen hygiene was determined using a scoring scheme. The results show that both showers above the slatted floor and increased air velocity on lying area have a significant effect on pig occupation zone in the pen, pen hygiene and ammonia emission. The shower system reduce ammonia emissions by 45% and increased air velocity reduce the ammonia emission by 13%, during summer period. The study is part of the ERA-NET SusAn project PigSys.

ID: 3216

Novelties in the revised eurocode 1994, part 4: actions on silos and tanks

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Recently the European Committee for Standardization (CEN) has undertaken the systematic review of the Eurocodes. These standards of European scope are a world reference due to the incorporation of the most advanced knowledge and the participation of experts from all over the world in their preparation and discussion before the final approval. Many of the standards that are currently being revised have an impact on agriculture. One of the most used in this area and from which the final draft has already been prepared is Eurocode 1 part 4 which refers to the actions to be considered in the design of silos and tanks. This paper presents the main changes that have been introduced in the standard, which refer to the load coefficients, combination coefficients, definition of structural typologies for risk consideration, structure of the calculation process in two blocks and the introduction of new cases not considered in the previous version. The structure of the document includes definitions and symbols used in the standard, actions classification, consequences of the failure and structural complexity. The main body is structured in a Fundamental Silo Load Cases (FSLC) block and a Special Silo Load Cases block (SSLC), which greatly facilitates the calculation in most silos designs. The FSLC includes the actions in situation of filling and discharging for the different slenderness of silos. SSLCs include eccentric filling loads, large eccentricity filling loads in squat and intermediate circular silos, minor outlet eccentricity loads, unsymmetrical pressures

treated by proxy loads (previously patch loads), pipe flow, silos with entrained air, thermal actions, suction and special rectangular silos. In addition, a hopper calculation section is included, this time also considering special cases, such as the inverted cone, oblique hoppers or pipe flow. A section on material properties and its determination, with some improvements, are included.

ID: 3292

Evaluation of floating cooling fins for emission reduction in fattening pig barns

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Pig barns with fully slatted floor and underfloor manure storage have a high potential for gaseous emissions. In order to reduce the emissions of liquid manure decreasing the manure temperature is an effective measure. The objective of the study was to evaluate a practicable and retrofittable manure cooling system with regard to its potential of decreasing gaseous emissions from fattening pig barns. For the technical implementation, floating manure cooling fins in combination with a water circulation pump and a heat pump were installed beneath the slatted floor at two farm locations in one fattening pig compartment each. Emission measurements in accordance with the international VERA-protocol were performed as a case-control study in four compartments in total. For the compartments with cooling fins, a manure temperature constantly below 15 °C was set. At least six weeklong measurements at each location spread over one year during different fattening phases and periods allow a comprehensive evaluation of the emission reducing effect. The following pollutants were measured: NH_3, CO_2, CH_4 and odour. To monitor the manure temperature various temperature loggers were installed at different manure layers. In addition to that, parameters such as manure pH-value, slatted floor temperature and ammonia concentration at animal height were measured. Scorings of the fouling degree (slatted floor, walls, animals) complete the analyses of the boundary conditions during the measurements. A comprehensive technical evaluation should give further insight into the functionality and practicability of the system and includes aspects such as energy consumption, effects on animal welfare and manure management. The investigations are completed and initial evaluations indicate a significant reduction of the emissions from the compartments with cooling fins. By the time of the conference, the data of all measurement periods can be presented.

ID: 3334

Effect of photoconversion greenhouse films used as 'double covers' on tomato crop in almeria (Spain)

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Improving the sunlight spectrum can lead to increased crop yields and quality. The French company CASCADE developed a technology named 'LIGHT CASCADES®' (LC®) that modifies and adapts the sunlight spectrum closer to plant needs. The purpose of this study was to analyse the effect of a new LC® photoconversion film installed as 'double covers' above a tomato crop inside a greenhouse. In the trial, the effects of a photoconversion films were tested on the '*Elcabo*' tomato [*Lycopersicon esculentum* (L.) Mill.] variety in Almeria (Spain) in comparison to tomatoes grown under an equivalent colourless control film. The trial was carried out in a winter / spring crop cycle (from January to June 2019) under a multi-span greenhouse divided transversely by a polyethylene sheet. The experimental photoconversion LC® film was installed in the eastern section of the greenhouse and the colourless control film was located at the west side. Morphological plant traits, photosynthetic activity, marketable yield and quality of the fruits production were measured under each films. Results showed that under the photoconversion LC® film, yield gains reached up to +11% compared to tomatoes grown under colourless reference film. Average photosynthetically active radiation inside the greenhouse with the LC® film was statistically higher (211 µmol m^{-2} s^{-1}) compared to the control double cover film (195 µmol m^{-2} s^{-1}). Net photosynthetic rate measured at tomato leaves was also greater under the LC® film (8.1 µmol m^{-2} s^{-1}) than under the control film (7.8 µmol m^{-2} s^{-1}). Fruit's weight and sugar content measured on tomato grown under the LC® film tended to be improved. These results on tomato crop confirmed the positive effects of LC® technology photoconversion films observed on other crops such as pepper and berries in Spain.

ID: 3342

Differences in yield and water consumption in a tomato crop irrigated with desalinated seawater blended with well water

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Desalination is an inexhaustible source that provides water with a guarantee of supply in sufficient quantity and quality, regardless of the weather. Today, the costs of treatment and distribution of conventional water have been increasing in many regions around the world and desalination has become more competitive and economically attractive due mainly to advances in technology to reduce desalination costs. The purpose of this study was to quantify the differences in production, water consumption and fertilizer input, derived from the use of desalinated seawater and water from mixing it with well water, in a tomato crop (*Lycopersicum esculentum* Mill.) transplanted on 09/10/2018, grown in soil and in hydroponics with reuse of drainage. The trial was

conducted in an E-W oriented *Almería*-type greenhouse located at the UAL-Anecoop Experimental Station of the University of Almeria. In total there were 6 different treatments with a total area of 242.4 m^2 each, with three replications. The desalinated water was supplied by the Carboneras Desalination Plant (Almería), while the well water was simulated by adding in situ different salts to the desalinated water. The drains were treated in a small desalination plant installed next to the greenhouse, functioning with solar energy. In general, hydroponic crop obtained higher yield than the plants growing in soil, although soilless cultivation was less efficient in the use of water and more fertilizers were added. For the hydroponic crop, treatment with desalinated water obtained the highest productions. In the soil, the highest production and better efficiency of water corresponded to the treatment with the irrigation water of higher salinity, with a lower addition of fertilizers.

ID: 3363

The effect of envelope features on the energy efficiency of agricultural buildings under different environmental control settings

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Energy efficiency has become more and more important both for new and existing buildings. One of the most energy-consuming activity in a building is represented by indoor heating and cooling. The energy need reduction is pursued mainly in two ways: exploitation of renewable energy sources and optimization of the envelope design. Due to the developments of the last years the latter could drive to remarkable energy reductions by means of a proper use of materials and building features such as wall and roof constructions, glazing and orientation. These improvements are developed and optimized for the residential sector representing one of the highest energy consuming sector. Even if in most countries laws do not impose specific restrictions in the agricultural sector, an increasing attention is payed to energy efficient solutions in food-processing and storage buildings, where conservation and ageing play a fundamental role for product quality and safety. In this context, the efficiency of the solutions available on the market is not guaranteed since the indoor conditions are significantly different from the residential sectors in terms of required temperatures and operating schedules. This work aims at assessing the influence of building envelope features on the building energy performance. The methodology is based on energy simulations of a case-study building. Combining 5 typologies of building characteristics (walls, roof, glazing, orientation and shading), almost 600 models have been created, and their energy behavior have been calculated in 6 different temperature range requirements (from 0°C-4°C to 20°C-24°C), both in conditioned and unconditioned scenarios. The results highlight that energy performances are strictly connected to the chosen temperature range and building envelope features can show dual effects.

ID: 3367

Numerical approaches for the integrated analysis of large datasets collected in the dairy cattle sector

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Precision Livestock Farming is more and more adopted in the animal husbandry sector, so that large amounts of data concerning individual animals are becoming available. In particular, in dairy livestock, the increasing diffusion of automatic milking systems and electronic milking parlors is providing detailed data that the farmers could use to evaluate the health conditions of the herd, to ensure animal welfare and to improve the milk production. Moreover, other important data such as environmental parameters and animals' activity data are often measured in dairy barns but seldom recorded and systematically integrated in an overall database. In this context, due to the big size and extreme heterogeneity of datasets, the application of novel numerical approaches -including big data analytics - also in the PLF sector proves to be a very promising research topic in order to identify correlations between the parameters of the milk produced, health and behavioral data of the animals and the indoor environmental conditions of the barn. This study aims to describe a numerical approach suitable to integrate databases collected in dairy cattle farms from different devices and to propose a numerical model for the quantification of the influence of the thermo-hygrometric conditions on milk production. The study has been developed with reference to a study case of a dairy farm located in the in Po valley (Italy), equipped with automatic milking system and activity sensors, where thermo-hygrometric parameters were monitored. The numerical model proved suitable to characterize the response of individual cows to heat stress conditions and thus classify the animals in terms of susceptibility to heat stress. The model developed can be considered a building block for the development of ICT herd management tools capable of supporting farmers in defining and addressing targeted treatments to mitigate heat stress.

ID: 3492

CFD numerical study of the effect of airflow velocity on the dust releasing process from a poultry litter bed

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Poultry farming is one of the major agricultural sources of PM_{10} emission into the environment. Fine dust release from poultry litter bed has an adverse impact on human and animal health, environment and barn equipment lifetime. In 2015, about 17% of total fine dust emission in the Netherlands originated from poultry barns. For this purpose, some regulations have been executed nationally and internationally. It is known that the properties of the litter bed, chicken activity, and aerial micro/macro-climate conditions of a poultry barn play a pivotal role in dust release from poultry litter. However, the precise quantitative contribution of them on the rate of dust release is

hardly known. The main objective of this study is to conduct a numerical sensitivity analysis to determine the effect of poultry litter bed properties (density and particle size distribution) and the indoor aerial conditions (airflow velocity and direction) on the dust release rate from a litter bed. In this study, a CFD model was set-up to simulate the dust release process from a poultry litter bed. The results indicated that fine dust is not released from the litter bed at low airflow velocities. This finding broadly supports the work of other studies in the literature. It was investigated that fine dust particles are rarely released from the litter bed by the airflow in the absence of interaction between litter bed and an external moving object such as a chicken claw. We found that the fine particles being trapped between the coarse particles and consequently they are not able to exchange sufficient energy with the airflow to be released as dust particles. In addition, the results further showed that particles with low density are not released from the litter bed and are not dispersed in the indoor air as fine dust and only the erosion was seen for particles with low density at high airflow speeds.

ID: 4629

The 'manure shuffle': a system for frequent removal of fine manure particles from the foraging area of poultry barns

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Non-cage laying hen houses allow expression of natural behaviors by chicken like foraging and dust-bathing, and regarded as better for animal welfare than cage systems. An important drawback is their higher levels of indoor concentrations and emissions of particulate matter (PM) and ammonia. The use of dried manure as a substrate for these natural behaviors is the main cause. Animal behavior causes fine manure particles to be released into the air. In addition, manure is a source of ammonia. Presence of a substrate is required, however. We present a novel solution: the 'manure shuffle'. The manure shuffle is a device that moves frequently under a substrate suitable for foraging behavior. Manure will dry and decompose into smaller particles, which percolate through the substrate because of the movement of the manure shuffle and the larger particle size of the substrate. The small manure particles are collected inside the shuffle through a perforated upper surface and discarded at the end of the barn. The most important benefit of the manure shuffle is that it removes dry manure from the barn on a daily basis, while still providing a suitable environment for natural behaviors. We expect that the system will have a profound impact on the PM release into and out of the house, since PM is (1) isolated from the behavior of chickens in and under the substrate, and (2) frequently removed from the living area. Additionally, ammonia emissions might be lower as well. Further benefits include the prevention of out-of-nest eggs, a more hygienic living area, and the potential to make a much more engaging foraging area. This may positively impact animal health and welfare. We describe the way this solution originated from an interactive design process based on the Reflexive Interactive Design-approach (RIO) and was further developed in several iterations to a functioning demo-unit that is put to its first tests in a chicken farm.

ID: 4670

Ammonia and greenhouse gas emissions from norwegian cattle buildings

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Ammonia and greenhouse gas (GHG) emissions from cattle buildings are harmful to the environment, public health and wellbeing. Previous studies on NH_3 and GHG emissions of cattle buildings are mostly from the USA and other European countries than Norway. The main objective of this paper is to quantify NH_3 and GHG (CO_2, CH_4 and N_2O) emissions from different Norwegian cattle buildings under field conditions. Another objective is to compare the NH_3 and GHG emissions with the national inventories and emissions from neighbouring countries and to examine the influence of air temperature, relative humidity and ventilation rate on the emissions. The gaseous concentrations were measured using Fourier Transformed Infrared analyser at 8 different sampling locations in five cattle buildings. Continuous 24-hourly gaseous concentrations were measured between 3 and 12 days in a suckler cow barn and four dairy cow buildings during Autumn, Winter and Spring, including air temperature and relative humidity. Preliminary results indicate a large variation in NH_3 emissions between the cattle buildings due to difference in housing and manure management systems. The emission of CH_4 varied also between the barns, however the dairy barns emitted more CH_4 per cow than the suckler cow barn.

ID: 4671

CFD model development of winter thermal environment and gas concentrations in a suckler cow building

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CFD simulations has proved to be a useful tool for exploring the effects of ventilation designs on the thermal environment and air quality in livestock housing, because it helps to overcome the limitations of field measurements. However, recent CFD simulations of cattle buildings focus more on heat stress mitigation strategies during warmer seasons. Whereas cows in Norwegian buildings are exposed to unsuitable thermal and gaseous conditions during the longer winter season, when outdoor temperatures are below -10 °C and the ventilation in the buildings is at minimum. These conditions can affect animal health, performance, farmer's work condition and deteriorate farm structures. This is of particular concern to suckler cow buildings, which house both beef cows and calves. The objective is therefore to develop a validated CFD model capable of simulating the thermal environment and gaseous concentrations in a mechanically ventilated suckler cow building. The CFD model includes 3D geometry of half a section of the side wall air inlet cattle building with only pregnant cows represented as cylinders. A 22 mm thick layer around the shell of the cows was used to simulate moisture production. Whereas CO_2 and CH_4 were only generated from

the layer at the front of the head of the simulated cows. A user-defined function was developed to define NH_3 release from the slurry surface, while the slatted floor was modelled as porous media. The model was validated with experimental data from a suckler cow building, measured during the winter, consisting of air temperature, relative humidity, air velocity, NH_3, CO_2 and CH_4 concentrations. Preliminary validation indicates that the experimental results were adequately predicted by the CFD model. Subsequently, the validated model will be used to evaluate the effects of inlet and exhaust locations on thermal comfort and air quality in the building.

ID: 4697

AmmoniaN2K: ammonia emissions and ecological impacts in ireland

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Since 2016, Ireland has exceeded its national ammonia emissions ceiling limit under the National Emissions Ceilings (NEC) Directive (2016/2284/EU). While commitment to this Directive requires reducing the ceiling in 2020 and again in 2030, its expected that emissions will continue to rise. The AmmoniaN2K team (University College Dublin and the University of the West of England) set out to improve Ireland's understanding of ammonia emissions and subsequent impacts. This project carried out intensive emission monitoring on 17 animal production houses and modelled the subsequent contributions to local concentrations and deposition, inferring contribution to potential ecological impacts. A number of novel approaches were developed within this project to address current knowledge gaps, including locations of below Industrial Emission Directive (2010/75/EU) threshold intensive farms, and a national risk model. The project also carried out concentration monitoring on a network of Natura 2000 sites, allowing for assessments of site-specific critical level and load exceedances. The combination of concentration monitoring on sensitive sites, national modelling alongside detailed emissions monitoring was vital to the development of both updated national guidance alongside required national monitoring networks required under the NEC Directive.

ID: 4718

Structural design methodology for insect proof nets of nethouses under snow load

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The use of Nethouses becomes widespread in Mediterranean regions because of the prevailing mild climatic conditions during a long period of the year, offering a natural and environmentally

friendly cultivation method. Despite the dominant mild weather conditions at the countries where the nethouses are used the most, hailfalls or snowstorms are likely to occur. These actions are not always considered in the nethouse-structural design procedure as design requirement. Nethouses are usually designed for wind, thermal, permanent, crop and operational loads. However, snow loads expected in Mediterranean regions could be more critical than the conventional nethouse design loads. The insect proof nets that cover nethouses behave like tension membranes that exhibit extended deformations to bear the vertical loads. This entails the danger of plastic deformation, failure of the nets, damage of the equipment or damage of the structure in case that the extensively deformed net encounters other components of the nethouse, like the crop, or secondary structural elements. The objective of this paper is to produce innovative tools for a safer and accurate design procedure. For this purpose, elastic numerical analyses with large deformations have been performed to illustrate the structural behavior of the net as an integral structural component of the nethouse. The numerical models include the net as a membrane, but also the cable-based supporting system. Two nets with different mechanical properties were investigated and characteristic curves for each net in terms of stress and deflections vs. applied loads were generated. The analysis of the net as a load carrying component of the nethouse is done separately with the use of the design curves that could also simulate the design actions of the nets directly in the numerical model of the nethouse. Hence, the model of the main structure used for the analysis and design of nethouses remains simple and reliable.

ID: 4721

A full-scale experimental analysis of the microclimate in two neighbouring insect-proof nethouse tunnels

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The use of nethouses as a sustainable protected cultivation means is steadily growing due to their ability to regulate solar radiation (shadenets, photoselective nets, etc) or to exclude harmful insects (insect-proof nets). Their permeable character alleviates wind loads allowing for the design of light-weight and low-cost structures, easy to install. Insect-proof nethouses can be a beneficial alternative for the summer period open-field cultivations. They enable the implementation of environmentally friendly cultivation practices, producing higher quality produce and higher yields through decreasing the use of insecticides and the damages by insects and viruses and the irrigation needs. However, a dense mesh configuration is required for their insect-proof function, leading to lower ventilation rates. As a result, unfavorable microclimatic conditions may develop that could negatively affect the cultivation. Lately, manufacturing companies have focused on improving their net design and fabrication technology to enhance the ventilation performance of the insect-proof nets. This research work presents a full-scale experiment regarding two neighboring tunnel structures covered with insect-proof nets. Insect-proof nets offering enhanced ventilation (finer fibers) and optical exclusion (additives that disorient insects) were used as cladding materials for the nethouses. The air velocities around and inside the nethouses were measured to estimate their air-exchange ability. Microclimatic parameters such as temperature, relative humidity, and

irradiance were also recorded inside the nethouses and compared to the ambient conditions. The present study aimed to evaluate the performance of the new types of insect-proof nets. Comparisons between the data acquired for the different cladding materials demonstrate the pros and cons of the new technology insect-proof nets offering a guide for their optimization.

ID: 4723

Development and testing of an innovative system to acidify animal slurry with powdery sulphur before mechanical separation

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Slurry acidification is one of the most efficient mitigation strategies to reduce atmospheric emissions of ammonia (NH_3) and greenhouse gases (GHG) from animal slurry. Powdery sulphur (S) has been proposed as an alternative to strong acids to achieve slurry acidification, avoiding safety risks and foam formation. In the context of the Agriclose LIFE Project, a set of lab-scale trials has been carried out to test the effect of S addition to raw pig slurry before mechanical separation on NH_3 and GHG emission during storage of separated (liquid, solid) fractions. Powdery sulphur was added to fresh raw slurry in 2 doses: 0.1% (w/w) and 0.5% (w/w). Ammonia emission rates from raw slurry and separate fractions were reduced on average by up to 28% and 49% respectively. GHG emissions were reduced by 79% and 53%, respectively for raw slurry and the sum of separate fractions. On the basis of the results obtained from lab-scale tests, a full-scale prototype for acidification of pig slurry before mechanical separation has been designed, developed and tested. The prototype adopts a semi-continuous process and is composed of four main parts: a stainless-steel mixing tank provided with a rigid cover and filling sensors, an automatic system for mixing and dosing powdery S to slurry, a volumetric pump to transfer the acidified slurry to a screw press separator, and a control panel. The system automatically adds 0.2 to 1.5 kg S m^{-3} of slurry, allowing the separator to work at its full capacity (12-15 m^3 h^{-1}). The development of this prototype is a step forward to allow sulphur to be implemented at the farm level, achieving emission reduction and preserving slurry nutrients.

ID: 4743

Correlation between ammonia emission factors and pig farming system

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Ammonia emission from swine facility is influenced various factors as ventilation method, breeding environment, temperature and relative humidity. This study monitored ammonia emissions and calculated the emission factors. in mechanically-ventilated pig houses, which are the general type of pig farming in Korea, and analyzed the effects of various conditions, such as the number of heads, pigs' age, temperature and relative humidity inside pig farming on the ammonia emission. The results of correlation analysis showed high relevance between the independent variables and the ammonia emission. The regression model was statistically significant with F-value=29.22, p<0.001. Among the independent variables, relative humidity (p-value=3.81e-05) and breeding heads (p-value:9.96e-07) were significantly correlated with ammonia emission of pig houses. Ammonia emissions increased as the relative humidity (B=4.275e+03) and the breeding heads (B=2.22e+02) increased. Among the two independent variables, the number of breeding heads had more influence on ammonia emission.(Relative humidity: β=0.84, Heads: β=1.58)

ID: 4746

Structural design and analysed methodology for a flat-roof nethouse in Greece

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Nethouses are low-cost light-weight structures used for cultivation purposes, protecting plants from meteorological hazards and pests and enhancing internal microclimate naturally. They offer improved crop quality, increased yield, reduction of pesticides requirements and therefore higher profitability when compared to the open field cultivations. Nethouse applications can be effective in hot and mild climate regions and they are found in various geometrical configurations depending on the specific grower's needs and environmental conditions. The major reason growers in Europe hesitate to invest in nethouses is their empirical, inadequate design, which results in ineffective structures, since the existing Standards do not include provisions for their design and construction. In the present work, conventional nethouse typologies are presented, design requirements are discussed and design parameters are identified. Finally, the structural design of a steel flat-roof nethouse in south Greece, based on the previous established methodology, is presented. More specifically, the loads acting on the structure are determined according to the European Standards EN 1991 and EN 13031-1 regarding the actions on structures and the design of greenhouses,

respectively. Especially, wind loads are calculated through Computational Fluid Dynamic analysis due to the lack of normative provisions concerning the calculation of wind pressures on permeable surfaces. The structural design is realized according to the European Standard for the design of steel structures EN 1993. Results show that following the proposed rational structural analysis and design methodology, a safe and economic nethouse structure can be achieved.

ID: 4769

Monitoring of particulate matter to working environment in the broiler house

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As domestic meat consumption increases, the broiler production industry is becoming larger and denser. The dense breeding environment is able to make more particulate matter and harmful gases generated. Considering the aging of livestock farmers, exposure to high concentrations of organic dust in the broiler house can cause serious health problems for workers such as respiratory disease, asthma and allergies. Therefore, the purpose of this study is to monitor the concentration of internal particulate matter in forced ventilated broiler houses and to deriving the exposure factors of particulate matter to workers. The area of each experimental broiler houses were different and used same windowless forced ventilation system. The concentrations of TSP, PM10, and PM2.5 were measured at three points along the length direction from the inlet to the outlet ventilation openings. It was monitored for 6 hours at a height of 1.5 m from the floor by using air pumps and weighing the filters before and after monitorings. Real-time measurements using optical particle counter was conducted to determine the concentration of particulate matter exposure according to the movement of workers. The concentrations of particulate matter were high near outlet vent comparing to inlet. And the average dust concentrations showed TSP 1,426 $\mu g/m^3$, PM10 1,056 $\mu g/m^3$, and PM2.5 161 $\mu g/m^3$ respectively. The maximum concentration of TSP and PM10 were reached to 3,892 $\mu g/m^3$, and 3,007 $\mu g/m^3$. This results were exceed the dust exposure standard in European poultry farms, by up to 1.62 times on inhalable dust and 2.3 times on respirable dust. When the worker moved, the inhalable dust was exceeded up to 3.5 times on maximum while the respirable dust up to 1.89 times. Field monitoring results showed that the ventilation system and animal activity are closely related to particulate matter concentration.

ID: 4785

Influence of animal-related parameters on emissions of ammonia and methane from an open-sided free-stall barn in hot mediterranean climate

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Increased knowledge on the factors that affect emissions from open dairy buildings may lead to an improvement of the mitigation strategies. The aim of the study was to assess the daily emissions of ammonia (NH_3) and methane (CH_4) in an open dairy barn in hot Mediterranean climate. Measurements were carried out in a cubicle free-stall dairy barn located in Sicily in different weeks of 2016 during spring and summer. Concentrations of gases were continuously measured by a photo-acoustic analyser. Measurements of climate and microclimate variables were carried out and behavioural activity was monitored by a 24-h video-recording system. Emissions of NH_3 and CH_4 were estimated through the application of the CO_2 mass balance method. Data were organised in a dataset to carry out statistical analyses on values of gas concentrations. Application of a one-way analysis of variance tested the equality of the mean values of gas emissions for each group of the parameters analysed during each week. In the post-hoc analysis the mean values were separated by Tukey's honestly significant difference at P<0.05. At indoor prevalent air direction (135-225°), emissions of NH_3 and CH_4 changed in time and with sampling locations during the day inside the barn due to the variability of the ratio between the pollutants (i.e., NH_3, and CH_4) and the tracer gas (i.e., CO_2). In the barn under study, the variability of gas emissions was related to the effect of microclimate conditions (P<0.05) and animal activity (P<0.05) on the production of NH<sub>3 and CH_4. The highest emissions were recorded during cleaning procedures for both NH_3 (P<0.001) and CH<sub>4 (P<0.001). Whereas the lowest emissions were recorded during the afternoon when indoor air velocity was higher than 0.5 ms<sup>-1. The reduction of gas emissions inside the barn was found to be related to the barn management due to the climatic conditions and animal behaviour.

SFARM

ID: SFARM 1

Sustainable farming

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Our environment has become an area of concern over the last few decades. Current farming methodologies used are unsustainable and have a huge impact on the overall ecology and biodiversity, as well as they are impacting human and animal health. There are many examples of unsustainable techniques used in modern agriculture, such as: Use of chemicals and manufactured fertilizers; Growing genetically modified crops; Growing monoculture crops; Overproduction and food waste; Investment in global agriculture corporations rather than local farmers; Natural vegetation clearing; Raising animals and plants separately instead of in a carefully managed agricultural system; Wasting water and use of non-renewable sources of energy. It is clear that the farming industry needs to update and change its methods to become more sustainable. Sustainable farming or sustainable agriculture is using farming practices that consider the ecological cycles. It is sensitive towards the microorganisms and their impacts on the wider environment. Sustainable farming is farming ecologically by promoting methods and practices that are economically viable, environmentally sound and protect public health. It simply means the production of food, plants and animal products using farming techniques that prove to be beneficial for public health and promote economic profitability.

The benefits of sustainable farming are analysed such as: Environmental Preservation; Carbon Sequestration in the soil; Reduction of Greenhouse Gas Emissions from agriculture; Economic Profitability; Efficient use of non-renewable resources; Recycling of resources; Protection of public health and Social and economic equity. Next, important sustainable farming methodologies and technologies are presented such as: Use of renewable energy sources; Use of new farming technologies (precision agriculture); Integrated pest management; Crop rotation; Polyculture farming; Urban farming. Also, some aspects of the European Union GREEN DEAL are considered with regard to sustainable farming. Finally some thoughts are presented on how individuals can impact farming practices.

ID: SFARM 2

Sustainable farming – SFARM – an ERASMUS+ KA2 project: capacity building in the field of higher education

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Agriculture is both extremely vulnerable to climate change and a major contributor to it. It is also a major user and polluter of water, a driver of deforestation and of loss of biodiversity. The desired relationship between agriculture and the environment can be captured by the term "sustainable agriculture. In all Partner countries (Vietnam, Laos, and China) agriculture plays a key role in land management and has a huge responsibility in the preservation of natural resources. Higher education institutions in Vietnam, Laos and China must undertake better research, improve their teaching, and support enhanced extension services to provide a more effective response to the many environmental and agriculture- and development-related concerns in each country. The current state of higher education is not adequate to the task of addressing the many environmental, economic, and social problems associated with mainstream approaches to industrial agriculture. Therefore, is crucial to set-up an outcome-based model curriculum that requires transnational cooperation, primarily between higher education institutions (HEIs) from Vietnam, Laos and China and EU Countries. The SFARM project aims in advancing the skills of academic staff, students, and agricultural extension staff in partner counties HEIs through the development of new curricula and a MSc programme that integrate in a practical way the latest developments in agricultural applied research. The purpose is to provide agricultural stakeholders with knowledge, skills, and competencies in the field of agro-environmental technology for sustainable agriculture. The wider and long-term objective of the SFARM project is to make a viable contribution towards achieving sustainable agriculture in the project region. Moreover, in the SFARM project the communication gap between experts, researchers and agricultural workers will be bridged with the development of a virtual environment where all stakeholders meet and exchange opinions.

ID: SFARM 3

Training and learning needs for MSC programs in sustainable agriculture

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Sustainable agriculture is urgently needed to promote conservation and sustainable resources use in an equitable manner through integrated management of land, water, energy and biodiversity. In this way, education in agriculture emerges as a crucial tool for preparing agricultural technicians, researchers and farmers for productive contributions. Higher education institutions arise with an important mission of education in the context of social transformation and to integrate sustainable development into the educational system as a scientific subject. The aim of this study was to identify

the training and learning needs to be included in a MSc program in sustainable agriculture. It was based on a questionnaire prepared and distributed to academics' experts in Agrarian Sciences in Greece, Italy and Portugal. Technologies, legislation, management and business, local community leadership and marketing were the training needs considered very important expertise's in sustainable agriculture. Traditional face-to-face learning, experienced farmers as mentors and knowledge sharing mechanisms were rated as very applicable and important. Due to COVID-19 pandemic, online learning methods, which were not considered suitable for a MSc program in sustainable agriculture, became important by providing online education. Information and communication technology and technological tools showed to be important skills for sustainable agricultural practices to effectively implement online learning and to improve the efficient access, exposure and use of up-to-date information of the agricultural sector and awareness of sustainable agricultural practices. However, online training methods in agriculture programs should be seen as complementary tools and not as the main training methodology.

ID: SFARM 4

An exploration of case method in cultivating innovation ability of agricultural postgraduates

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Agricultural postgraduates generally have low admission scores, but they are required to have high practical ability. This fact makes it quite difficult for the cultivation of agricultural postgraduates, especially the cultivation of their innovation ability. Agricultural universities in China generally set a practice segment to address this issue. The postgraduates from Chongqing Three Gorges University, for instance, are required to fulfill a no less than 6 months practice task in the 2-3 years study duration. However, since the practice segment is usually arranged in the last study year, students would have no more class study opportunities when they realize the gap between theory and practice. On the requirement of Agricultural Sustainable Development, the curriculum of agricultural postgraduate programs need to be modified. According to our experiment results, the case method shows notable effect on cultivation of agricultural postgraduates. This method changes the traditional teacher-centered method to teacher-student two-way communication method, takes various authentic cases as teaching materials, and improves students' understanding of theories in the process of exploration of solving problems, as well as students' hands-on capability in collecting and analyzing cases. This study includes a comparison of traditional teaching method and case method, a design of teaching process and a reform of evaluation system. The purpose of this study is to enhance the innovation ability of agricultural postgraduates and provide intellectual support for Agricultural Sustainable Development.

ID: SFARM 5

The accreditation as quality assurance of higher education program

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The implementation of learning processes set by a study program from a university requires quality assurance carried out by an external institution. Understanding HE's accreditation processes from different countries are important to obtain beneficial insights and lessons learned. Eight universities from 4 countries, namely Hue University of Agriculture and Forestry (HUAF) and Tay Nguyen university (TTN) from Vietnam, Champasack University (CU) and Savannaket University (SKU) from Laos, Southwest University (SW) and Chongqing Three Gorges University (CTGU) from China, IPB University (a.k.a. Bogor Agricultural University/IPB) and Syiah Kuala University (USK) from Indonesia, that join the SFarm project have different policies for this quality assurance. Accreditation is mandatory in all universities, however in HUAF and TTN, the accreditation is granted by the University, while CU and SKU were granted by government institution. The accreditation of SW, CTGU, IPB, and USK were granted by a special body. In Indonesia, National Higher Education Accreditation Board (BAN-PT) is the institution body that is responsible to issue certificate of accreditation of the Higher Education Institution and the Study Program. The accreditation status is valid for 5 years, and it must be renewed. There is a generic model for accreditation process in Indonesia. The document for accreditation contains portfolio of study program and its academic home base and self-evaluation of study program.

ID: SFARM 6

Description and scope of the accreditation process masters program of agroecotechnology, Universitas Syiah Kuala - Indonesia

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The Master Program of Agroecotechnology (PSMAGR) was formed based on competent human resources needed in the development of sustainable agricultural technology. Recently, the Indonesian National Accreditation Board for Higher Education (BAN-PT) has developed the Study Program Accreditation Instrument (IAPS) 4.0 which is based on output and outcome-oriented. Quality measurement focused on aspects of the process, output and results, while the previous instruments measured more on the input aspects. Right now, the study program should prepared 9 different criteria thought the previous which used 7 criteria. The 9 criteria included vision, mission, goals and objectives; governance, governance and cooperation; student; human resources; finance, facilities, and infrastructure; education; research; community service; output and achievements of tree college service. The accreditation process was carried out by a group of panels, called

assessors. The documents submitted are first examined administratively, especially in terms of the completeness of the required documentation (Self Evaluation and Study Program Performance Report). This process then is carried out in the two phases, adequacy evaluation and location evaluation. The results of both assessments are then used as a basis for determining accreditation status. Accreditation status considered a key indicator of education quality. For example, "graduating from an institution with accreditation status B or A" is an administrative criterion in the recruitment process of civil servants. The Master's Program of Agroecotechnology (PSMAGR) have been accredited by using 7 standards with the "A" status and the validity of accreditation of this study program for 5 years from October 30th 2019 until October 30th 2024. Previously accredited ranking system was expected to be "A" as the best. Since 2020 with 9 criteria of accreditation, the status of accreditation has been divided into three criteria of accreditation; Excellence, Very Good and Good.

ID: SFARM 7

Master of science in sustainable agronomy programme in Champasack University

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The development of agriculture is a major priority for the national economic and social development policy in Laos. Due to the food security and food safety are both vulnerable to the climate change and the extensive production. Promoting postgraduate study programme in a sustainable approach is strongly concerned by the government. Master of Science in Sustainable Agronomy Programme (MSc.SAP) of Champasack University is one of the sustainable development plans of the Ministry of Education and Sports. Since CU is a young university, therefore, this sustainable master programme is the foundation of the university. The aims of the establishment of this programme was following the sustainable development policy of the government to promote and develop qualified human resources equipped with specific skills, particularly to the personnel who are involved with the development of agricultural production to be industrial agricultural products to serve the society for better and safer life. Under the cooperation and support by the ERASMUS Plus program allows CU to establish a very beneficial programme for the students especially in the southern region of Laos. The current students are the first batch of the programme and are mostly the government servants who are involved in the agricultural sector. Therefore, we strongly believe that after their graduation they would directly transfer and apply the knowledge gained from the programme to their respected job. In addition, this programme also allows CU's lecturers to gain their experiences through trainings, workshops and field study visits held in EU countries and could share their experiences with EU partners and other universities members. In conclusion, the establishment of this programme has very significant impact on the development of the university.

ID: SFARM 8

Master program development on sustainable farming in Savannakhet University (SKU), Laos

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Sustainable farming is one of the most concerned issues in Laos. Because some farming practices like shifting cultivation in upland areas and intensifying lowland rice farming together with socio-economic and environmental change would lead to unsustainable resources use. SKU tried to learn from European countries by adapting technology of sustainable faming to develop its master study programs being and to be offered by the university, in order to immediately transfer the techniques to students mainly from public services of the central provinces and finally to farmers. This papers is aimed to explain how SKU adapts sustainable farming techniques and examine impacts of SFARM program on learning outcomes of students and staff about the project. As results, SKU joined SFARM Project as a partner country under ERASMUS Plus program together with other Asian partners. This allowed SKU's teachers to participate in trainings, workshops and field visits held in EU programs countries and could learned and shared experiences with EU teachers and researchers and also with Asian participants themselves. Gaining experience, SKU developed a master program named "Sustainable Supply Chain Management of Agricultural commodities" consisting of, in total 17 courses with 52 credits of which 4 courses are elective ones. In addition, 14 related courses of two already existing master programs have been further elaborated to include more relevant concepts of sustainable farming. SFARM project is well known by staff of SKU; 100% of them answered as the **Well Known** project, more 80% as **Good to Very Good** understanding of sustainability concept and 80 to 90% of them expressed as **Very Useful** for their current and getting job. In conclusion, SFARM has high impacts on the master study programs development and improvement at SKU as well as adapting sustainable faming by staff and students.

ID SFARM: 9

Impact evaluation of SFARM project in hue agriculture and forestry (HUAF) university and Tay Nguyen University (TTN), in Vietnam

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Agriculture is one of the most important economic sectors in Vietnam. It employs 47% of the country population. However, over-intensive of input and natural resource use have been resulting in environmental problems and low profitability. HUAF and TTN are the two largest universities in the centre and the central highland areas of Vietnam. The universities are training main human resources for the development of agriculture in the regions. SFARM project has been implemented in the two universities since 2017. This project is funded by ERASMUS Plus. SFARM project is bringing

significant changes in the agricultural training toward sustainable farming in both HUAF and TTN. 46 academic staff were trained on development of agricultural MSc curricula by experts from European universities and institutes, 6 new MSc courses were updated and 6 new VET courses were developed. Until now, there were 32 and 35 students in Crop Science MSc programme were trained with new MSc curricula in HUFA and TTN, respectively. Additionally, 6 VET courses were organised in both university with more than 80 participants. There are 35 agricultural companies, 10 stakeholders and 15 farmers involved in the VET courses. SFARM project has successfully implemented in both HUAF and TTN creating a significant influencing in agricultural training toward sustainability. The project will end in July 2021. However, its impacts will be continued as the updated MSc programmes and VET courses will be implemented in the future.

EurAgeng 2021

Poster Presentations Abstracts

Automation, robotics and sensor technology

ID: 2909

Capacity and limitations of colour image processing to detect tetranychus urticae in citrus leaves

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Tetranychus urticae is an important citrus pest that produces chlorotic spots and fruit scarring. Its monitoring is done by inspecting visually symptomatic leaves in the trees, which is slow and expensive. This work studies the potential of colour image processing to detect the damages caused by *T. urticae* in citrus leaves as a faster and cheaper method to determine this pest presence. An analysis of 142 tangerine leaves with different ages (young and old) and with the presence of different type of damages (no damage and *T. urticae* damage, *Phyllocnistis citrella* damage and nutritional damages) were carried out through colour image processing. The images were taken with a digital camera and from both sides of the leaves. To build the processing algorithm, manual training was firstly done using representative regions in the images of leaves (healthy and damaged). The red, green and blue values of the selected pixels were manually assigned to predefined classes and used as input variables to create a Bayesian discriminant model. Because the colour of the symptoms was similar between *T. urticae* damage and some deficiencies but not the damage appearance and geometrical pattern, the number and size of damages per leaf and the total damaged area were included in the model as discriminative parameters. Results showed 100% success in healthy leaves while *T. urticae* was correctly identified in 90% of cases. Most errors were caused by confusion with some deficiencies. The results indicated the suitability of using optical sensors based on colour images to detect the *T. urticae* damage on citrus leaves. The technique was not able to differentiate between old and young damages.

ID: 4632

Potential of vis-nir hyperspectral imaging to detect automatically tetranychus urticae in citrus leaves

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Tetranychus urticae is one of the economically most significant pests in citrus. As a result of the feeding of their mites, they cause discolouration and desiccation, manifesting by chlorotic spots. The aim of this work studies the potential of hyperspectral image processing to detect the chlorotic spots in citrus leaves caused by *T. urticae* as an automatic and non-destructive alternative method and to differentiate between recent and older (previous seasons) infestations. For that, 120 tangerine leaves with different ages, with visible damages and without external symptoms of

damage were analysed. Images of both sides of the leaves were taken with a hyperspectral camera. The spectral response of the damages was analysed in the range 450 - 1000 nm by selecting regions of interest (ROI) of representative leaves. PLS-DA models were built for (i) the discrimination between sound areas and those damaged in the leaves and (ii) the detection between recent and older infestations. The vector of the regression coefficients was used to identify the optimal wavelengths. The models created could separate between sound and damaged areas in 100% of cases. On the order hand, recent infestations were distinguished from old ones in 92% of cases, bringing a 100% success for the underside of the leaves as the damage is more evident on this surface. Hyperspectral image systems show great potential as a faster and automatic tool for detecting the *T. Urticae* damages on citrus leaves.

ID: 6000

Towards a phenotype classification of agricultural robots

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The use of robot systems in agriculture has heavily increased in recent years. These technologies can represent, together with the Internet of Things and Big Data, an opportunity to make food production more sustainable. Being able to carry out hard physical tasks hitherto covered by operators and potentially ensuring night work cycles, these technologies accompany many advantages related to the reduction of work-related accidents and the autonomous conduction of operations. Despite these opportunities, their large-scale diffusion is limited today by lacks in clarity and exhaustiveness in the regulatory framework that is intrinsically tied with ethical and legal issues concerning the management of robots. The EU legislation places obligations related to machine registration and human supervision in operations, but several issues concerning the use of such technologies still have to be addressed, such as legal responsibility, privacy issues, and data management. To date, a clear and agreed classification of the various types of agricultural robots is missing. The main goal of this study is to classify the many types of robots available (i.e., phenotyping) to obtain an exhaustive and efficient information framework able to facilitate the production of ad-hoc legislative supports as well to promote primary market segmentation practices. To reach this goal, the survey method has involved a web search of robots and systems, which were described with qualitative variables based on specific criteria describing their usage in farms. Collected data was hence used to picture homogeneous groups of robots. The classification was performed with a double step cluster analysis based on the nominal descriptive variables and on a factor analysis used to reduce classification redundancy. Five clusters of robots have been identified, opening up the possibility to set specific regulatory policies and market strategies based on recurring characteristics within the identified clusters.

Artificial intelligence, data processing and management

ID: 2774

Prediction of ambient temperature for agricultural applications using anns: a case study in Castile and León, Spain

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This article evaluates predictive modelling of daily and hourly average ambient temperature using artificial neural networks (ANNs) for its application in agricultural sciences and technologies. For that purpose, the prediction of the daily ambient temperature the day after (maximum, T_{max}, average, T_{ave}, and minimum, T_{min}) and its hourly estimation (T_{0h},T_{23h}) is done using ANNs. The data series used were monitored at the agrometeorological station placed in Castile and León region, Spain. ANNs models formulated for the daily ambient temperature prediction the day after have three neurons in the outlet layer [$T_{max}(t+1)$,$T_{ave}(t+1)$,$T_{min}(t+1)$]. Two models were evaluated: 1) ANN1d had three inputs for the actual daily temperature data [$T_{max}(t)$,$T_{ave}(t)$,$T_{min}(t)$], and 2) ANN2d had the day of the year J(t) as the fourth input. Including J(t) improves the model predictions, achieving a RMSE for T_{max}=2.58, T_{ave}=1.67 and T_{min}=2.12 (°C), and it achieves better estimations compared with the classical statistical methods predictions (typical year T_{ave}=3.63 °C, weighted mobile mean T_{max}=2.75, T_{ave}=1.81 and T_{min}=2.52 (°C), lineal regression T_{ave}=1.85 °C, and Fourier analysis T_{max}=3.74, T_{ave}=2.66 and T_{min}=3.34 (°C)). ANN models formulated for average hourly ambient temperature estimation have 24 neurons in the outlet layer [$T_{0h}(t)$, $T_{23h}(t)$] corresponding to the daily hours. Two ANNs models have been trained: First model (ANN1h) has three inputs for the daily data of the actual daily temperature [$T_{max}(t)$,$T_{ave}(t)$,$T_{min}(t)$], and second one (ANN2h) had the day of the year J(t) as the fourth input. In this case, including the variable J(t) does not improve significantly the estimations of the first model, which achieves RMSE=1.24 °C, but it improves those of the ASHRAE method, with which a RMSE=2.35 °C is obtained.

ID: 3209

Observation, prediction, and control methods for machine intelligence in precision farming

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A key objective of Precision Farming is sustainability regarding animal health, human health, and environment. Precision Farming research is highly multidisciplinary, including engineering,

mathematics, statistics, sociology, informatics, and biology. There exists a vast methodology for developing machine intelligence for management support, and a lot of these methods are investigated in a Precision Farming context. However, the methods are scattered among various scientific disciplines (engineering, statistics, informatics, and control) and among separate application domains (arable farming, livestock farming, greenhouse, orchards, and fisheries). The purpose of this research was to create an overview that will help overcoming the barriers between scientific disciplines and application domains, and will help form a shared, common methodological framework. A literature study was performed on observation, prediction and control methods. These methods form the core of machine intelligence required for management support (i.e., automation and decision support) for Precision Farming. The main challenges for good performance turned out to be created by 1) system complexity, 2) errors and disturbances, 3) system limitations. An overview was made of some of the most common methods, including their advantages and drawbacks, depending on the which of the aforementioned challenges are faced. This overview may serve as a basic guide for method selection and development. The main conclusion of the study is that many different methods are readily available. Each of the studies methods has an unique combination of strengths and weaknesses, and moreover, farming systems are highly variable in system configuration, and challenges faced. Therefore, each different management support system ideally requires tailored machine intelligence.

ID: 4680

The impact of weather forecast uncertainty on greenhouse energy demand and cost prediction

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In greenhouse horticulture weather forecasts are used to predict energy usage to aid the buying energy on the open market. However, weather forecasts contain inaccuracies which inhibits the certainty of energy use predictions, which can lead to errors in energy buying, and a lower economic efficiency. To mitigate the risk of energy mis-buying this study proposes a methodology to quantify the impact of weather forecast error on greenhouse energy demand predictions. Within this methodology the 'forecast' energy use was calculated using the KASPRO greenhouse model (de Zwart, 1996) and a five day weather forecast of outside temperature, windspeed and radiation (MeteoConsult, 2019). The 'actual' energy demand was estimated using weather recordings of the same quantities, period and location as the forecasts. The 'actual' and 'forecast' energy use were compared to compute the prediction error. This was repeated using multiple overlapping sets of forecasts from October – December 2019, forming an error distribution. These error distributions showed that the inclusion of weather forecasts resulted in a consistent overestimation of greenhouse gas and electricity demand. In addition a data based sensitivity analysis was done. This showed that the misprediction in the electricity demand was contributed to most (with a mean relative error of 6.13%) by errors in the radiation forecast and that gas demand misprediction was caused mostly from errors in the windspeed (18.0%) and outside temperature forecast (17.2%). The

methodology presented here can help improve greenhouse management by allowing the grower to adapt their buying strategy to acceptable risk levels of over or under buying greenhouse energy considering the uncertainty in the weather forecast.

ID: 4709

Characterization of floating waste by means of artificial intelligence. Preliminary results

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Universidad Miguel Hernandez

Large amounts of floating debris accumulate in the Segura river and its irrigation infrastructure through the Vega Baja (Spain). More than 95% of floating waste is composed by reeds, but there are also significant amounts of anthropogenic waste. The characterization of waste using zenith images is time consuming and depends largely on the observer's skills. The objective of this work is to develop and artificial intelligence algorithm for automatic detection of objects in the monitoring of the floating waste accumulation in the irrigation infrastructure in Vega Baja.

Python programming language was use for image analysis, using Jupyter notebook, an open-source application. We used Tensorflow, an open source library for building and training neural networks. A pertained model "faster_rccn_renest101_coco" was used to do a fast object detection. Images of each object (plastic bottles, glass ...) were labelled and files generated were used to train the model algorithm, which was then used to analyse zenith images. Results obtained using the algorithm were compared to those obtained using image analysis on the same set of zenith photographs where visible objects were manually classified. Preliminary results of object count using both techniques are presented and discussed.

ID: 4730

Flower monitoring in a hedge almond orchard with image analysis

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The hedge almond orchards is a recent technology, for which available information is scarce. In an almond orchard, variety Soleta, planted in September 2014, in Herdade da Torre das Figueiras – Monforte - Portugal (39º 04' N, 07º 29' W), a trial to evaluate different pruning treatments was established. Four pruning treatments were considered: T0 – farmer pruning, with mechanical topping and hedging at the beginning of June in 2018, 2019 and 2020, winter manual pruning in 2018 and manual pruning complement in June 2019 and after harvest in 2020, T1 – winter manual pruning in 2018, 2019 and 2020, T2 – post-harvest mechanical pruning (topping and hedging) in September 2018, 2019 and 2020, winter manual pruning in 2018 and 2020, T3 – summer mechanical pruning

(topping and hedging) at the end of July in 2018, 2019 and 2020 and winter manual pruning in 2018 and 2020. Twelve lines of trees were randomly selected, in which three blocks of ten trees were randomly established. The impact of the pruning treatments was evaluated in 2019 and 2020, with image analysis, at a per tree level. For each tree, a vertical photograph of the crown was taken perpendicularly to the tree line, using a contrasting background. A total of 360 trees were surveyed. The flowering area was quantified per tree using an image analysis software. The results show significant differences for the flowering area between years, with the largest in 2019. This is indicative of trends towards the fluctuation of the flowering level. Significant differences were also observed between pruning treatments. In both years, the smallest flowering area was observed in treatment 1. Overall, manual pruning (T1) had lower flowers' density, which could be due to the removal of shoots of excessive development lengthwise. The results show that monitoring based on photograph image analysis might be an option to evaluate flowering and its variability between years for the hedge orchards.

Circular economy

ID: 2537

Modelling the remaining value of grape harvesters according to asabe and comparison with other statistical approaches

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Assessing the remaining value (RV) of agricultural machines is basic to compute the depreciation costs especially in the second-hand market, although previous scientific studies employ the value of the scrap (10% of the auction sale) as an estimate of RV (10 years of life). ASABE has developed a methodology to evaluate RV based on an experimental formula that takes into account the auction value, the age and the intensity of annual use. Our work adjusts the ASABE RV coefficients for grape harvesters, based on the online European market (Spain and France) considering 1290 visited ads in the period from September to October 2017 that report brands, models, ages, hours of use and sale value, refined to 89 unique records (44 complete). The ASABE approach is the compared to a stochastic model, adjusted by means logistic regression. A dedicated analysis and comparison of approaches, pros and cons, and the corresponding requirements in order to reach an adequate performance: estimation errors below 5%.

ID: 2816

The circular economy in the street food sector through the reuse of a naval shipping container

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Approximatively, 2.5 billion people around the world eat street foods every day. It represents a ready-to-eat, added-value food, it can be consumed everywhere without any cooking phase and represents an alternative to homemade preparations. The aim of this study is to evaluate the environmental impact of a food service provided in a street food format taking place thanks to the re-use of empty or end-of-life naval shipping containers, comparing it with the conventional street food format present in the market. The environmental impact analysis was performed using the Life Cycle Assessment method. The functional unit was defined as the food service, identified in the preparation of three food products: a portion of pasta, one sandwich and one portion of fries. The "from cradle to gate" approach includes the customization of a end of life container into a street food format, the construction and use of the cooking appliance, the logistics and the preparation phase. The results show that the higher impacts are attributable to the fries preparation (48%), then to the pasta (25%) and to the sandwich (18%). Considering the different factors of the analysed system, the two higher hotspots are electricity (35%) and oil used to fry (34%), while the

customization of the structure is the third hotspot (15%). The customization of the end of life container into a street food format produce 1280 kg CO_2eq, while the creation of a new container or of a new street food truck format release 12,800 kg CO_2eq and 20,900 kg CO_2eq, respectively. Allocating the impact of the structure to FU, the re-used container weights for 0.04 kg CO_2eq, it can increase 11.6 times for a new container street food format and 17 times for a new street food truck format. The results showed how the re-use of a naval shipping container can be a way to reduce the environmental impact of street food preparation, reducing the impact of the structure to 95%.

ID: 4688

A smart fertilization model: a study of multidisciplinary methods in monitoring fertilization in turfgrass

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The excessive use of chemicals products in green spaces provokes surface and groundwater contamination and severe environmental damage. Excess of nitrates, urea and phosphates, and other chemical fertilizers can lead to environmental harm and human health risk. Similarly, uncontrolled chemical fertilization incited a decrease in soil microbial activity and disturbance in plant nutrient balance. Consequently, the European Union has become stricter in regulating the compositions and quantities of fertilizers applied in large green surfaces, where fertilization is one of the most critical requirements. The objective of this study is the presentation of an intelligent model that can help in the regulation of fertilization in golf courses. The model is based on the calculus of the correct quantity of fertilizers needed by the plant, depending on their physiology cycle. Moreover, the model proposed controls soil properties, irrigation water quality, and climate condition before the fertilization application, allowing the best regulation of plant nutrient support. Foliar and root application of fertilizers were also taken into account to improve plant nutrient assimilation according to each growth phase. Furthermore, the fertilization model proposed combined the use of chemical fertilizers and natural biostimulants for the best turfgrass maintenance and soil preservation. Our results showed that the proposed model allowed a considerable decrease in the quantity of chemical fertilizers and reduced their economic costs. Moreover, natural fertilization (biostimulant) has improved soil organic matter, microbial activity, and soil catalase and dehydrogenase enzyme activities. The correct management of chemicals fertilizers combined with biostimulants application can improve the availability of nutrients to plants, permit a decrease in the chemical fertilizer application, and avoid soil damage and degradation.

ID: 4755

Environmental impact assessment of a aquaculture production systems using the life cycle approach

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Aquaculture has been identified as a promising alternative to fisheries to tackle the growing food security issue while avoiding depletion of wild fish stocks. The environmental and socio-economic sustainability of aquaculture have become major current concerns, especially among consumers, environmental advocates and policy makers. At the same time, concerns on environmental effect of aquaculture and the desire to facing sustainability problems, both socially and environmentally, require science based decisions. Like all agricultural production systems, aquaculture require a substantial number of inputs to achieve satisfactory fish production and quality. High inputs increase costs and reduce competitiveness. Moreover, environmental problems like nitrogen and phosphorus emissions to sea water enchase the impacts related to fish farming. The environmental impact of an aquaculture farm in Greece was assessed using the life cycle approach (LCA). The Impact assessment analysis in the characterization phase was performed with the CML-IA method and with FU 1ton of sea bass at the farm gate. The results shows that feed production has an important contribution percentage in the majority of the impact categories. Analysing the most important impact categories it is obvious that Acidification potential is dominated by feed production (almost 70%), probably due to nitrogen oxides emissions from the different processes of feed production followed by energy and fertilizer use and less from transportation and use of fuels. Eutrophication potential is dominated by sea bass production at the farm level (75%), due to direct N and P emissions into the aquatic environment, followed by feed production. Mean global warming potential influenced mainly by feed production with contribution of 70% followed by energy use and the rearing practices of sea bass in the fry production.

ID: 4782

The mediterranean diet potential – how do specific dietary choices can affect the portuguese nitrogen footprint?

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Agriculture is responsible for 80% of the total reactive nitrogen (Nr) emissions in the European Union. Population growth and its individual dietary choices are intrinsically connected to the increase of Nr emissions. The Nitrogen Footprint concept was created to communicate the importance and the negative effects of N to the public. The Nitrogen Footprint concept was created to communicate the importance and the negative effects of N to the public. This concept needs to be disseminated worldwide to show how personal choices of consumption affect nitrogen pollution and become a serious problem to human health. In this regard, the N-footprint for Portugal was

estimated and compared to other countries with different diets' patterns. Comparison between Portugal's diet and the recommended Mediterranean diet were also analysed. Comparison between Portugal's diet and the recommended Mediterranean diet were also analysed. The N-footprint model is based on the Nr loss to the environment from food consumption and production, transport and housing consumptions. Preliminary results show a high N-footprint for food production followed by food consumption, transport and housing. A total of 25.10 kg N/cap/yr were achieved for Portugal's diet which is extremely high in protein meals. In contrast, legumes also have a very high protein content, but their N-footprint is very low due to its biological N fixation. Animal-based products have a much higher N-footprint compared to plant-based products: 14,81 and 4,19 kg N/cap/yr respectively regarding food production. The Portuguese N-footprint shows similar patterns to other EU countries. No significant differences were found. On the other hand, a significant decrease in the consumption N-footprint were highlighted when the Portugal's Mediterranean diet was analysed based on N recommendations. The Nitrogen Footprint is a valuable tool to increase awareness about our daily choices and promote the reduction on global N pollution.

Education and rural development

ID: 2705

Study of the use of mobile devices in the classroom within agricultural engineering

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Technological changes occur daily, appearing new equipment and applications that require a rapid adaptation by society. This is reflected in the University where it is necessary to adapt the teaching methodology to the new digital tools, developing the digital skills of the students. So, the use of applications (Apps) for practical classes is interesting. However, to incorporate them into teaching practice, it is necessary to determine the devices available to students in the classroom (mobile phones, tablets or laptops). In January 2020, a survey was carried out on the students of the Higher Technical School of Agronomic, Food and Biosystems Engineering of the Universidad Politécnica de Madrid (UPM, Spain) to know their use of technology in the classroom and to incorporate into teaching the use of applications for mobile devices (Apps). 72 responses (40.3% men, 59.7% women) of five different degrees have been obtained. All respondents claim to have at least one laptop and one tablet in their home. 100% of respondents say they know how to work with the Microsoft Office package, 62.5% AUTOCAD or similar programs, 25% lighting computer programs, 19.4% budget programs, 18.1% modeling programs (Sketchup, among others), 6.9% construction programs and 1.4% Building Information Modeling (BIM). Although students claim to use Apps daily in their personal lives, through applications related to sports, restaurants and leisure, or messaging, only 15.5% use professional Apps in the subjects. This offers a huge opportunity to address the use of these digital tools in the use of teaching. In a public university, such as the UPM, students say they can take mobile phones (97.2%), laptops (90.3%) and tablets (43.1%) to class.

ID: 4634

Diagnosis and assessment of visual impacts for aesthetics improvement of jerte valley municipalities (Spain)

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The achievement of an inventory of the different visual impacts on each municipality of the Region “Valle del Jerte” has been proposed in this work. The analysis of each case, the diagnosis and the proposals of corrective actions and the enhancing actions of the resources of the area in an integral way, taking full advantage of the synergies that take place in the territory, have completed the work. The main aim of this work is to turn the “Valle del Jerte” into an innovative space that works for the sustainability of its natural, economic and cultural heritage. The

project was approached in two phases: 1st phase: where a methodology and work plan to generate an inventory of urban and landscape visual damage of each municipality was developed. Then, an analysis and diagnosis of urban and landscape impacts and the correct and empowering action proposals of each municipality was identified, given that the objective is to create a plan or guide to improve and strengthen each municipality. 2nd phase: where a proposal for budgeted action agreed with the municipal corporations of each municipality has been made, in order to reach villages aesthetically more attractive.

ID: 4751

Curriculums on smart greenhouses in the framework of the neghtra project

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Next Generation Training on Intelligent Greenhouses (NEGHTRA) is a specialized training project that addresses knowledge transfer in precision agriculture based on specific needs and challenges. On the one hand, competition with new production areas threatens the profitability of farms and forces a rethinking of production strategies. This situation may be aggravated by the growing uncertainty in the markets. In addition, the intensive agriculture sector isconsidered by society as one of the main causes and those most affected by climate change. Specifically, greenhouse growers must rethink their production strategy in order to promote sustainable production, with special emphasis on the use of new materials and technologies to improve the climate, irrigation and fertigation, and reduce inputs and waste, the use of renewable energies and the circular economy. The digitization of agriculture aims to improve and / or simplify all the processes included in the productive activity (data collection, communication and storage of information, analysis and interpretation of data, evaluation or diagnosis of the state of the crop, preparation of recommendations, decision-making and action). Finally, it is necessary to develop capacities that favor innovation and entrepreneurship to strengthen the sector and promote the resilience of this farms. NEGHTRA has the following target groups a) Higher Education Institutions and Research Institutions which will update the training curricula portfolio, b) agricultural intermediaries that provide counselling and training to the farming communities and c) the farming community. In this work we present the curriculums to provide the necessary capacities in order to improve the sustainability of production, promote the resilience of farms, increase the efficiency of crops and contribute to improving the social recognition of growers.

Energy and bioenergy

ID: 2701

Study of agronomic characteristics of 11 clones of ulmus pumila l. For use as an energy crop

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Increasing scarcity of fossil fuels is a pressing problem to be addressed by society. The use of alternative energy sources, such as woody biomass, is a good solution. In these terms, short-rotation crops (SRC) are an efficient alternative. The Siberian Elm (*Ulmus pumila* L.) is an ideal species for wood biomass due to its rapid growth, its low requirements and its great adaptability. Propagation from seed gives great variability, generating uncertainty to the farmer. For efficient use, reliable clones are necessary, that ensure high and constant productions. The vegetative propagation through cuttings allows to obtain lines specifically created for the production of biomass. The objective of this work is to develop clones of *Ulmus pumila* oriented to woody biomass. Individuals with the best characteristics for biomass were selected as progenitor plants, subsequently carrying out vegetative propagation by cuttings. In this study, productivity was compared with 11 clones, planted in two consecutive years. The cuttings were planted directly in the field, and using indole butyric acid for the rooting. After one year, plant height, trunk diameter and survival rate were evaluated. There was significant differences between clones of Siberian Elm for the parameters studied. Clones with highest growth in height were 30 and 29 (4.7 and 4.2 m), lowest growth in height were 24 and 21 (1.7 and 2.3 m). Similarly, clones with highest trunk diameter were also clones 29 and 30 (81 mm), and smaller diameter were 21 and 24 (39 and 40 mm). As expected, clones with higher heights correspond to larger diameters, and also for lower values. Clones with highest survival rate were 3 and 18 (80 and 70%), and the clones with lowest survival were 24 and 31 (17 and 27%). In conclusion, the study of different clones of Siberian Elm is essential to obtain viable breeding material to have high-yield energy crops.

ID: 3765

A simplified algorithm for the optimal setting of the factors affecting agricultural tractor fuel consumption during heavy drawbar tasks

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Heavy drawbar works on soils are the most critical issues of agricultural tractors regarding efficiency impairment. Some countermeasures, e.g. ballasting the tractor or adapting the tires pressure, aim at increasing drawbar force and reducing slippage, but, at the same time, increase the

power lost for rolling resistance. This research defines simplified algorithms to evaluate the weight of the key factors on fuel consumption during heavy drawbar works, considering that modern tractors have electronic engine management systems to improve efficiency. OECD Code 2 data from 100 tractors were used to obtain a regression equation as a starting point to analyze the driveline efficiency and the power lost as rolling resistance and for slippage. As OECD data are measured on asphalt or concrete test tracks, four tractors were tested in field conditions to correlate drawbar force to slippage. Standard equations for evaluating drawbar force during ploughing were adopted from the ASABE standard. Such information was implemented into a simplified algorithm that allows the estimation of tractor power, mass, slippage, working width, forward speed, working depth, and, above all, tractor engine management on the fuel consumption during ploughing per unit of worked area. The simplified algorithm estimates the impact that the different settings have on tractor fuel consumption, both as specific value (g/kW) and per hectare worked (kg/ha). The research highlights the importance of working operational settings and agricultural tires' traction capability at low slippage levels and presents some considerations to be taken into account to save fuel.

ID: 4711

Agrofossilfree - strategies and technologies to achieve a european fossil-energy-free agriculture

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AgroFossilFree project will create a framework under which, critical stakeholders will cooperate to evaluate and promote the available Fossil-Energy-Free Technologies and Strategies (FEFTS) in EU agriculture. It aims to decrease fossil energy in farming processes, while maintaining yield and quality of the end-product. The project will contribute in closing the gap between the available FEFTS and the agricultural practices by promoting effective exchange of novel ideas and information between research, industry, extension and farmers. Adoption of available FEFTS from EU farmers can be also enhanced significantly by offering training and by providing possible financing tools for de-fossilizing EU agriculture. Consequently, only when agricultural stakeholders gain knowledge of existing and future technological advancements in the energy sector and related training is achieved, EU agriculture will be able to fully align with the fossil energy use reduction policies and sustainable food production practices. To achieve its targets, AgroFossilFree will: i) assess and evaluate the current energy use status in EU agriculture; ii) consider needs and interests for the

future farm energy profile by identifying factors influencing adoption based on regional specificities; iii) identify and register available and directly applicable FEFTS from applied research results to market solutions and explore existing financing tools for de-fossilizing activities; iv) collaborate with relevant stakeholders with interactive physical and online methodologies to produce community-based ideas for FEFTS integration in regional and EU-basis agricultural systems; v) create an online tool (AgEnergy Platform) with available FEFTS and provide a Decision Support Toolkit to propose interventions and financing tools; vi) produce policy guidelines on EU, regional and national basis, communicate them and promote the proposed FEFTS in real agricultural activity in the near future.

Integrated and sustainable farming systems

ID: 3080

The team matters: mechanical apple harvest platform efficiency and yield quality depends on the individual picker's assignment and team size

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Apple growers face difficulties in completing harvest on time due to the low availability of pickers, increasing wages, and relatively low outputs. The present study explored integrating mechanical harvesting platform systems destined to replace the traditional use of buckets and ladders. Method: During the Gala species 2019 harvesting season, we compared assignments of 4, 5, and 6 pickers, including the driver, on two models, single- and multi-platform harvest systems. For each assignment, we: 1) conducted a continuous time-study observation in which we monitored the time and actions of the driver and apple pickers, according to their positioning on the platform, 2) gauged the output per minute of the driver and the team, 3) for expert apples' damage review, we sampled apples along the route the apples take from the pickers' hands, through the conveyors, to the container. Results: As the team size decreases from six to four, the time the driver invested in apple picking increased, at the same time, time invested in driving and managing the platform system decreased. When two pickers were positioned one behind the other on the same side of the platform, the picker behind was observed at idle mode 50-70% of the time. Concurrently, the picker in the front invested ~70% of her time in actions directly associated with picking, regardless of the team's size or platform model. As the team size decreased, the average picker's throughput per minute increased, at the cost of a higher damaged apple percentage, regardless of the platform model. Qualitative differences are found in the behavioral patterns of the workers on each platform model. Conclusions: The effectiveness of harvest platform team size is equivocal, more yield is achieved at the cost of a higher damage rate. Hence, the driver's role as a team manager is critical to ensure productivity while maintaining quality.

ID: 4735

Effect of mechanical pruning on olive yield in a high density olive orchard – an account of 14 years

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In Portugal the study of mechanical pruning in olive orchards started in 1997. Trials were made in traditional olive orchards and the results revealed that mechanical pruning can contribute for the reduction of pruning costs without reduction in yield. In 2005, the authors started the evaluation of mechanical pruning in a Picual irrigated olive orchard. The trial was organised in a randomised complete block design, with three replications. Four treatments are being compared, leading to 12 plots, with 30 trees by plot. The treatments are: T1 - manual pruning using chain saws, in 2005, 2010, 2014 and 2017, T2 - mechanical pruning: topping and hedging the two sides of the canopy in 2014 and 2017 followed by manual pruning complement inside the canopy, T3 - mechanical pruning: topping canopy in 2005, topping canopy and hedging canopy West side in 2008 and 2012, topping canopy and hedging canopy East side in 2010, 2014 and 2017, canopy summer topping in July 2015 followed by hedging the West side in winter 2016, T4 - mechanical pruning, topping canopy in 2005, topping and hedging the two sides of canopy in 2010, 2014 and 2017, canopy summer topping in July 2015. Common to all treatments was manual pruning to eliminate hanging branches, in 2006, mechanical pruning, topping the canopy parallel to the ground, to eliminate 0.50m, in 2007. The average yield per tree for each treatment was evaluated. In the first period of 5 years, no significant differences were found between treatments. In the second period of 4 years, although there were no significant differences between treatments, more frequency of mechanical pruning (T3) revealed lower yield. In the third period of 5 years more pruning severity reduced the olive yield (2014). Manual pruning complement after mechanical pruning (T2) didn't increase olive yield. However, the average yield over this period was similar. Olive yield has been maintained over a period of 14 years only applying mechanical pruning.

ID: 4783

Innovative agricultural technologies - decreasing the nitrogen footprint of tomato production

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Nitrogen (N) is a key indispensable nutrient for all living organisms including humans. For over one century, synthetic fertilizers and agriculture intensification allowed to feed the world population, but this came with high environmental costs. Nitrogen use efficiency is the solution to improve soil, water and air quality while avoiding increased costs to the farmers. Tomato is one of the most consumed crops worldwide and requires high amounts of N inputs to achieve high yields. The need for new agricultural practices to reduce N inputs and promote N losses mitigation urges.

One field experiment were set up to increase N use efficiency and decrease tomato production N footprint. Two different treatments were applied, with and without a bio-fertilizer named Blue-N. Conventional fertilization practice in the farm served as control and three other doses of N inputs were tested in both treatments. Blue-N was developed from a fixation bacteria to increase N absorption by plants and was tested in tomato plants for the first time. Two innovative probes were set up in the field, at two different depths, to measure the direct leaching of nitrates. Several samples of soil, plants and fruits were collected for chemical analysis and N monitoring along the growing cycle. At harvest, tomatoes from each treatment were collected, quantified and weighted to determine productivity. Fruit samples were analyzed for quality validation. Crop production yield and fruit quality found significant differences between treatments. Nitrate probes showed to be an efficient technology to monitor N losses. Blue-N promote the growth of tomato plants and the N absorption were significantly higher in the treatments with less N dose applied. This bio-fertilizer presents an alternative for the use of mineral N fertilizers, avoid aquifer contamination and, consequently, reduces the N-Footprint of tomatoes production.

ID: 4786

Sustainable agricultural practices on vineyard production – portuguese wine of low nitrogen footprint

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Nitrogen (N) is a key nutrient in crop production and crucial in vineyard management. When excessive reactive N is present in the environment, it may not only reduce crop production and increase pests and diseases incidence but can also be a serious environmental and human health problem. Agriculture is one of the more important activities where action can and must be taken to promote N losses mitigation and create awareness about the impact of excessive N inputs. The efficient use of N as fertilizer was tested in several field experiments to produce wine of low N-footprint. Conventional fertilization practices in each farm served as control and three other rates of N inputs were applied to vineyards located in two different regions in Portugal (Viseu and Évora). Two innovative soil probes were set up in the field, at two different depths, to monitor the nitrate leaching potential risks. Several samples of soil, plants and fruits were collected for chemical analysis along the growing cycle of each vineyard farm. At the harvest time, grapes of each treatment were collected, weighted, and vinified to produce a type of wine per treatment. Different N fertilizer management practices applied in the field of each farmer found no significant differences in fresh grapes production yield and quality. The new nitrate probes showed to be an efficient technology to monitor N losses. Wine of low nitrogen footprint were produced with a very good quality and taste.

ID: 4797

Effect of frequency irrigation on yield and biometrics characteristics of table olives (olea europaea l., cv. Negrinha de Freixo) under full and sustained deficit irrigation

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The olive tree (*Olea europaea* L.) is a crop that is very well adapted to water stress, although some studies have shown how irrigation can significantly increase productivity. The influence of irrigation on physiology, yield and different parameters of olive quality has been extensively studied. The objective of this study was to evaluate the effect of irrigation frequency, under deficit and full irrigation strategies, on yield and olive fruit parameters. The experiment was carried out during two consecutive years (2019 and 2020), in a 30 years old olive orchard cv. Negrinha de Freixo, located in Vilarelhos, north of Portugal (lat. 41°21'N, long. 7°02'W, alt. 250m). Olive tree spacing was 5 × 6 m. The irrigation system consisted of a single drip line with 1 meter spacing drippers (1.5 L/h). Two irrigation treatments were established: Full (FI) and Sustained Deficit Irrigation (SDI) – 100 and 60% of the ETc, respectively. For each irrigation treatment, three different frequency irrigation were applied: daily, one and three times a week. In each irrigation treatment and frequency irrigation, tree water status was assessed by measuring the predawn leaf water potential and fruit biometrics characteristics (diameters, fresh and pit weight and pulp/pit ratio) and yield were evaluated. The leaf water potential results showed no significant statistical difference between treatments. FI and SDI trees showed leaf water potentials values within the ranges of -0.8 to -1.27 MPa in 2019 and -0.7 to -0.95 MPa in 2020. The biometric parameters did not showed significant statistical differences between treatments. However, in 2019 there was a significant tendency to increase yield in trees irrigated once a week in both, FI and SDI treatments. Considering that 2020, was an alternate bearing “off” year, some more years will be needed to obtain more consistent results on the effect of irrigation frequency.

New application technologies and mechanisation

ID: 2624

Laboratory scale dewatering analysis of poultry manure via cylinder-piston batch separator

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Mechanical separators (i.e. screw-press) application is currently widespread in Iran for dewatering manure. However, it is used for all sorts of manures. Poultry manure contains completely different particle size, nutrient and moisture content compared to the other manures. As a result, available separators are not compatible for poultry manure resulting less dewatering efficiency. Determination of poultry manure particle size distribution and laboratory scale evaluation of its dewatering characteristics are vital steps before optimisation and implementation of poultry manure separator. Particle size distribution of laying hen manure was determined to select appropriate separation sieve size. Dewatering specifications of laying hen manure including dewatering capacity, filter size, feeding rate (manure thickness) was determined by the constructed laboratory scale cylinder-piston set-up to mimic in-field separators. The sealed cylinder-piston set-up was located under a universal pressure testing machine equipped with a load cell connecting to the data-logger and PC. The cylinder-piston set-up was filled with manure sample in a batch mode at three thickness levels of 0.5, 1 and 1.5 cm and loading magnitude of 1080 N to apply required pressure on piston. Furthermore, loading times of 10s, 15s and 20s were examined for each level of manure thicknesses and for two sizes of stainless steel sieves (1mm and 2 mm). Results indicated that the filter size of 2 mm showed the highest percentage of retained solids (51.40%) during dewatering, whereas, the filter size of 1mm caused dewatering clogging in the same condition. Additionally, the results obtained from cylinder-piston set-up revealed that loading time of 10s, manure thickness of 1cm and filter size of 2 mm were the most effective treatments to reduce the manure moisture content.

ID: 3316

Innovative tractor hitched prototype design from the demand side

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In agricultural machinery sector, innovative product development uses to start from an idea conceived by manufacturer or close customers attempting to adequate future product to customer requirements. However, other schedule for innovation could be stablished through Pre-Commercial Procurement in which public procurers act as technologically demanding customers. Innovative

prototypes were designed and manufactured by private companies that use their own innovative product development schedule. In that process a combined swathe rake and mulcher were developed to manage olive pruning residues for both mulching and biomass harvesting. The objective of this work was to define innovative product development schedule used by farm machinery builders when they face new challenges. This schedule had six steps: 1. Definition of minimal product features, 2. Prototype outline, 3. Prototype design, 4. Prototype manufacturing, 5. No-load test and 6. Test in-field conditions. These steps had different key issues that should be defined properly in order to avoid unsuccess of future prototype. For instance, on the one hand, tractor features were a key point that must be assessed before prototype design when the future product will be custom manufactured. On the other hand, when the prototype will be mass manufactured tractor features must be considered as minimal features of the targeted market segment. The final step used to imply different machine adjustments and several modifications and adaptations in order to achieve an adequate performance of the machine. In conclusion, innovative product development schedule was highly important but it is not enough to ensure prototype success.

ID: 3793

Mechanical compression strength analysis in jabre paths stabilized with cement. Comparison cem I 42.5R with cem II A-V 42.5N

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The aim of the work is to make known this jabre-cement stabilization trial, in this case comparing results of the studies carried out with CEM I 42.5R cements (Portland cement without additions whose basic component is clinker) with other cement called CEM II AV 42.5N having fly ash additions. Comparison between compression mechanical strengths obtained under the same compression test conditions has been studied. Previously, it was studied optimum humidity that provides the maximum dry density of the jabre material with Normal Proctor compaction energy. Subsequently, it was analyzed the influence of the cement dosage (from 0 to 10%) with different curing times of cylinder test, that is, repeating the tests with both cements at 2, 7 and 21 days. This way, not only the differences between cements have been analyzed, but also technical recommendations have been established regarding to the minimum resistance that this type of stabilized paths must have, in order to achieve the rules of the General Technical Specification for Road and Bridge Works (PG-3). As final conclusion, using CEM I 42.5R under 100% NP compaction, the minimum strength of 1.5 MPa is achieved with a concentration cement of 4.5% at 7 and 21 days. Under the same conditions, using the other cement with same strength but with fly ash, it would take a smaller cement proportion necessary, 3.5%, to obtain the same resistance. This allows to reduce square meter costs in a path.jabre.

ID: 4685

Aerodynamic properties of chopped rye grass

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Fibrous biomass crops such as grass and corn are used at large scale as feed for ruminants and feedstock for biogas production. These crops are typically chopped in small particles which are light and suitable for pneumatic transport. The handling of these crop materials highly depends on their behavior in air stream. While there is large literature available on the aerodynamic properties of other crops, few reports were found for rye grass (*Lolium L*.). Images of particles were taken with a flatbed scanner and further processed to estimate the size and surface area. Next, the fluidized bed method was used for measuring terminal velocity of grass leaf blades and stems. Rye grass blades are delicate biomaterials which are susceptible to loss of moisture content leading to shape changes, thus a portable vertical wind tunnel was designed and used to quantify the aerodynamic properties of freshly harvested grass particles. For both blades and stems, average terminal velocities of wet crop condition (73.9% *wb*) were 25% higher than for dry condition (56.4% *wb*), which is in line with theory as wet crops have higher density. Also, blades had 63% smaller average terminal velocities compared to stems for both crop conditions, which emphasizes the effect of mass on the terminal velocity over the projected surface area. The average drag coefficients calculated for blades were larger than stems, respectively 34% and 27% for wet and dry condition. This indicates that drag forces have a larger impact on blades rather than stems. Difference between the drag coefficient of stems in wet and dry condition was not statistically significant. However, there was slight variation in drag coefficients of blades between two conditions, which may be attributed to shape changes in the blades with changing moisture content. Furthermore, the negative correlation between drag coefficient and Reynold's number was observed.

ID: 4731

Development of a machine to remove by-products with brown spot disease inoculum from pear orchards

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In Portugal pear production is located in the Midwest region, occupying an area of about 12000 ha, under the registered designation of origin of "Pera Rocha do Oeste". In recent years, the incidence of brown spot disease (*Stemphylium vesicarium*) increased with considerable losses to the growers due to the depreciation of pears both in the orchards and in refrigeration chambers. The

control of the disease based on the use of chemical products was inefficient. In consequence, the development of integrated strategies will be necessary. The reduction of the sources of brown spot disease inoculum from the orchards is one of the strategies evaluated in the project GO – Protecestenfilio. The approach related in this work concerns the removal from the soil surface of the fruits with symptoms of the disease as well as leaves and pruning wood. No specific technology to remove these by-products from the orchards is available in the market. With the project "GO – Protecestenfilio", a machine was developed for this purpose. The machine is based on a farm tractor and consists in a front mounted windrow unit and rear semi-mounted lift and storage unit. The windrow unit is provided with two rotary swathers to remove the by-products from the base of the trees to the centre of the alley. In the lift and storage unit a transversal rotor lifts the by-products from the soil and to a conveyor elevator. This conveyer discharges the by-products into a temporary storage box placed at the rear of the unit. This paper shows the machine developed as well as the limitations identified throughout the field tests performed.

Post-harvest technologies

ID: 2535

First results of the spectral analysis of cantina oils

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In the context of an ATHENS course at UPM dedicated to the spectral analysis of edible oils, this research demonstrates the feasibility of using a variety of spectral technologies: VIS-NIR reflectance, UV-VIS low-cost fluorescence, Hyperspectral Imaging (HIS) with a silicon detector, as well as MWIR spectroscopy. In this paper, several proposals are made for combining several optical techniques as to improve the identification of AOVEE corresponding to several olive varieties and their mixtures. It is also considered the feasibility of identifying commercial frauds related to the adulteration of olive oils with other edible substance with vegetable origin. The samples have been gathered by ANECA-PEP (nov-dic 2019) from 12 regions in Spain, and ATHENS participant (several countries in Europe), a state commission and the ATHENS UPM 107 participants themselves. A variety of spectral pre-treatments and chemometric methods are tested on their performance towards the identification of the metabolic degradation of the high quality olive oil under improper storage conditions. Considerations are provided regarding the use of these techniques in the industry.

ID: 2815

Shelf life evaluation of fresh cut valerianella locusta l. Through packaging by visible/near infrared spectroscopy

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Operators and large retail chains can take advantage of the potential application of non-destructive techniques for a better management of the packaged product flows among producers, warehouses and final selling points. Moreover, large retail chains could provide real-time measurement tools in order to share with customers the quality information about fruit and vegetables on sale for maximum transparency and consumer loyalty. The aim of this work was to investigate the applicability of visible-near infrared spectroscopy (vis/NIR) to analyze the packaging influence on the measurements to evaluate the freshness decay of raw and fresh-cut Valerianella leaves. The samples were stored at 4 °C for 14 days, and 10 sampling were carried out, five sampling date before and five after the expiration date. Spectra were acquired in reflectance mode through packaging using a portable device operating in the wavelengths range from 350 nm to 2500 nm. To test the performance of optical analysis on closed salad bag, a comparison on 10 leaves without packaging were performed. Due to the sample thinness, a surface was placed on the opposite side of the leaf, in correspondence to the acquisition point. To also evaluate the optimal configuration

for optical data sampling, two background, dark and white surfaces were compared. An exploratory analysis (PCA, Principal Component Analysis) was applied on the spectral data in order to evaluate the vis/NIR capability to detect the shelf life days. Results demonstrated (i) the potential influence of the head space between the film and product surface tend to cancel out and (ii) the feasibility of the vis/NIR spectroscopy technique for quickly monitoring of the freshness of fresh-cut Valerianella leaves also through the packaging film.

ID: 3830

Discrimination of common defects on 'algerie' loquat fruit using hyperspectral imaging and machine learning techniques

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Loquat fruit (*Eriobotrya japonica* L.) is susceptible to mechanical damages and physiological disorders. VIS-NIR hyperspectral imaging was used to discriminate internal and external common defects of loquat cv. 'Algerie'. Three classifiers, PLS, RF and XGBOOST, and different spectral preprocessing techniques were evaluated to discriminate the sound and defective features according to three approaches. In the first approach, the fruit pixels were classified into two classes, sound or defect, in the second, the defective features were considered as internal or external defects, and in the third approach, each type of defect, purple spot, bruise, scars, flesh browning, were considered separately. The results indicated that the hyperspectral imaging combined with XGBOOST classifier could discriminate between sound pixels and defective pixels with an accuracy of 97.5% and between sound pixels or internal or external defective pixels with an accuracy of 96.7%. It was also possible to distinguish between the different defects with an accuracy of 95.9%.

ID: 4644

Prediction of internal quality properties of pomegranate fruits using hyperspectral imaging

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Pomegranate fruit is a source of organic acids and bioactive compounds, which report many positive health benefits. Consumers are demanding fruit ready to eat, and the processed arils are an alternative to commercialize this fruit. These properties depend mainly on the maturity stage. Hence, this work studies the potential of hyperspectral imaging to predict different physicochemical

properties in the arils of pomegranate cv. 'Mollar de Elche' fruit during maturity, since this cultivar is very appreciated due to its sweet taste. Seven sets of 30 fruits collected every two weeks (210 fruits in total) were imaged using a hyperspectral imaging system (450-1050 nm) and a colour camera. Images were captured from the intact frits and the arils. Some physicochemical properties, such as total soluble solids (TSS), titratable acidity (TA), antioxidant activity, and total phenolic compounds content (TPC), were measured in each fruit. Partial least squares regression was used to relate the spectral information obtained from the images of the arils with their physicochemical properties. Optimal results were obtained for the prediction of the maturity index BrimA, antioxidant activity and TPC with R^2 values of 0.87, 0.90 and 0.90, respectively. For TSS and the ratio TSS/TA, the R^2 obtained was 0.76 in both cases. The lowest value of R^2 was obtained for the prediction of TA, 0.43. better results were obtained from the intact images than from the arils. These results indicate the great potential of hypers

ID: 4646

Study on ultraviolet light-induced fluorescence of citrus fungal decay in different citrus varieties

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Citrus fungal infections develop rapidly during fruit storage and transportation periods, causing significant economic losses in post-harvest. The most serious is caused by the fungus *Penicillium digitatum*, which infects the fruit through wounds on the skin and causes a rot that can go unnoticed by the human eye when the fruit is inspected because, in the initial stages, the colour of the Infected skin is very similar to that of healthy skin. One of the methods used to detect this disease is to illuminate the fruit with ultraviolet (UV) light since it causes fluorescence detectable by trained inspectors. This personnel must carry out their inspection work in dark rooms where the fruit is illuminated with UV light, dangerous for the skin. An alternative is to use artificial vision systems and electronic callipers. Not all the fruit shows the same fluorescence level, and even some varieties do not have this phenomenon, making it challenging to create effective automatic detection systems. This work has studied and determined the fluorescence level of 117 varieties of oranges and tangerines obtained from the IVIA genebank. A total of 6 fruits of each variety were measured in the trials. Five of them were inoculated with the fungus, and the fluorescence of the rot was measured in images obtained with an artificial vision system under UV light. A healthy fruit with no apparent damage was used as a control, and images were captured under the same conditions. It has been determined which varieties do not produce fluorescence and the intensity of fluorescence in those varieties that do.

Smart farming/precision agriculture

ID: 2570

Design and implementation of dust organic treatment in vines to prevent fungal infections

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The main objective of the SOLES Project is to validate the dust cloud technique, as an effective phytosanitary treatment for the vine by assessing its practical viability in three types of soils: Inceptisol / Alfisols-Xerept (Haploxerept-Typic and Xeralfs-Dystroxerept- Typic), versus Entisol / Inceptisol-Orthent / Xerepts-Dystroxerept / Xerorthents-TypicDystroxerept / DystricXerorthents. To this end, the technique of generating and depositing a dust cloud of local origin has been analyzed, based on the construction of 3 identical units within the original design provided by Andrés Morate, a local grower which accumulates 50 years of experience since his grandfather viticulturist. With this study, an example of the traditional knowledge that exists in rural areas is valued, and it is intended to strengthen the links between viticulture and wine production with a better integration of environmental respect practices in the production process by trying in addition to improving the competitiveness of grape producers by reducing the cost of applying phytosanitary syntheses. After a data collection campaign gathered in five locations and two treatments for each one, it has been verified that the average dust deposit amounts on average to 6.7um cm-2 under the current conditions of regulation of the machine. The variability of the amount of dust deposited on the vine leaves in each plot, ranges between 6.6 and 39.8%, variability attributable to the type of soil and its humidity at the time of application of the treatment, as well as to the environmental conditions (T^a, HR and breeze) Despite this, it is verified that the variability between treatments in the same plot is 32% of that registered between plots. That is, there is a local factor in the generation and deposition of dust attributable to differences in geological origin and texture.

ID: 2573

Determining critical points in order to reduce fruit damages in fresh stone fruit packing lines

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Stone fruits are very sensitive and delicate and their evolution is very fast during the last stages of ripening. In certain areas of Valencia region (Spain) citrus packing lines are used during the non-citrus season to process stone fruits. Differences of fruit shape and size, texture, ripening procedure and damage susceptibility between stone fruit and citrus contribute to result in serious product

damage after fresh stone fruit postharvest handling. The objective of the present research study was to determine and evaluate the critical points in a citrus packing line used to process stone fruit and propose modifications in order to reduce fruit damages. A typical citrus packing line in Valencia region (Spain) used to process stone fruit was evaluated using an instrumented sphere. The main aggressive transfer points were: the manual dumping to the elevation conveyor belt, the transfer point between the manual sorting table and the third conveyor belt and the impact to the packing line when it is without fruit. In all these cases, with maximum impact values higher than 930 $m.s^{-2}$ and average impact values around 500 $m.s^{-2}$. Several solutions and modifications in the citrus packing line were proposed and analysed in order to reduce the aggressiveness of the process. In all the transfer points the dropping height should be reduced or the transfer points padded with shock absorbing materials. Besides the fruit speed should be reduced before the transfer point adding deceleration brushes.

ID: 2719

Analysis of camelina sativa cultivation through on-field sensors and remote sensing

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Camelina sativa (L.) Crantz can be a suitable crop in the rotation of cereals when sown in autumn.

Therefore, the annual land yield is higher. The cultivation of camelina requires few fertilization inputs, and has benefits in dry land cultivation areas like central Spain. Camelina is adapted to semi-arid and arid rainfed regions, thus minimizing fallow, where other oilseeds are less competitive. Consequently, it is an excellent alternative for disused or low productivity land, fallow land, as well as in a rotational crop with cereal. Within the CAMEVAR project (PDR18-CAMEVAR), our goal is to assess different varieties of camelina to guarantee they are adapted to the central Spain area. Hence, to evaluate the harvested oilseed yield it is mandatory to characterize the plot and take into account variables such as soil moisture, conductivity or crop vigour. We selected several plots (10 ha) in “El Encín” farm (Alcalá de Henares, Spain) and used a portable TDR soil moisture meter combined with a GPS to sample the field regularly. We interpolated and plotted this data in maps, and we combined them with NDVI (Normalised Difference Vegetation Index) maps, estimated trough SENTINEL-2 remote sensing and a handheld device (GreenSeeker®). There was a significant difference within the plot in terms of conductivity, soil moisture and crop vigour, that lead to a sectorization. Therefore, we expect a variation of the yield. Future work is to harvest camelina according to these sectors and correlate the yield with the sectors classification. We will assess not only the behaviour of this camelina varieties but the environmental parameters that may affect the yield.

ID: 2769

Development of the technical structure of the "cow energy" concept

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The research initiative of the TUM and the HSWT is concerned with the further development of animal-friendly and sustainable livestock farming systems with a high degree of automation. In the current research project "Cow Energy", an on-farm energy management system is being designed together with industrial partners and developed to market maturity. The aim is to optimally use the energy generated by the regenerative energy system in the farm in the barn itself and to make it available to the regional energy network in a way that is useful for the network. Special challenges are the different technical conditions between the energy consumers in the barn as well as the solutions for energy production and energy storage, the exchange of data between the systems, the grid-compatible integration into the power supply network and the necessary consideration of animal-technology-human interactions. Based on the previous test results and the current state of development of the central monitoring and control module, two practical pilot farms could be equipped with the EMS. Initial results of the investigation show that the farm can generate significantly more energy than it consumes itself, that multilayer energy storage systems are necessary for optimal control of the system and that the control units of the individual components have to be accessed to implement the control algorithms.

ID: 3691

Innoseta – innovative spraying equipment training advising

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Novel Spraying Equipment, Training and Advising procedures (SETA) have a potential to supply more productive and sustainable agricultural production, based on a more precise and efficient plant protection product (PPP) approach. However, the fast pace of development, their complexity, diversity in farm sizes in Europe, cultural perception, lack of expertise and economic constraints are drawbacks that have hindered adoption by farmers. INNOSETA is a H2020 Project that aims to set up an **Innovative** self-sustainable Thematic Network on **SETA**, in order to contribute in closing the gap between the available novel high-end crop protection solutions -either commercial or from applicable research results- with the everyday European agricultural practices, by (i) Accelerating

implementation of relevant Innovative practices for Spraying Equipment and (ii) Training and Advising in European agriculture through a multi-actor open dialogue and centralization of agricultural and research knowledge. This need of providing tools and solutions to guarantee a better profit of the latest developments and improvements in PPP use, for all EU farmers, will be achieved by: i) Creating an inventory of directly applicable spraying equipment and technologies, training materials and advisory tools available from the large amount of research results and commercial applications; ii) Assessing the SETA end-users needs and interests and identify factors influencing adaptation, and taking into account the regional specificities; iii) Engendering interactive multi-actor, innovation-based collaborations among different stakeholders; iv) Putting in place an ICT tool for the on-line assessment of the Spraying equipment, training and advising materials and allow crowd-sourcing of grassroots-level ideas and needs; v) Liaising with EIP-AGRI and its structures, in order to establish effective communication channels and the proper coordination and links of project activities.

ID: 3778

Smart agricultural monitoring and management of barley based on the use of ndvi satellite images and close detection sensors

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Spectral images from ESA's (European Space Station) Copernicus program Sentinel 2 satellites can be used to estimate vegetation indexes that relate spectral data to parameters that reflect crop vigor, such as biomass, leaf area or green intensity. The NDVI (Normalized Difference Vegetation Index), one of the most well-known Vegetation Indexes, allows the assessment of crops vigor and the estimation of their potential yield. This analysis can be complemented with data obtained by close detection with various sensors, such as chlorophyll meters, which provide information in an expeditious manner and in real time. The aim of this study was the monitoring of a barley crop, irrigated by center-pivot, at Herdade do Monte Novo e Figueirinha, Beja, Southern Portugal. For this purpose, the vigor of the culture was evaluated using NDVI images from the satellites, collected at five-day intervals, and measurements with portable sensors were made in the field, in particular with the NDVI Trimble GreenSeeker sensor and with the chlorophyll Minolta SPAD-502 Plus meter. The purpose of this work was to compare the data provided by the different sensors, establish their correlation with the barley grain yield and thus validate the data provided by the sensors reciprocally. The results showed a high and positive correlation between the NDVI values of the satellite images and the values measured by the portable NDVI sensor and of these two with the grain yield of barley. It thus appears that NDVI images can be a very useful tool for estimating the crop potential yield. With the NVDI satellite images it was possible to detect with great precision the

field variability in barley development and its yield potential, which will allow to adapt the application of agricultural inputs according to the variation of that potencial.

ID: 4678

Unmanned ground vehicles in agriculture: a bibliometric review

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Robotic technologies in agriculture have seen rapid evolution throughout the years. Among these technologies, the Unmanned Ground Vehicles (UGV) are becoming increasingly popular especially for on-field monitoring and operational agricultural activities. The introduction of this technology on the field, implemented with specific sensors and components, provides high-accuracy data in line with the precision agriculture principles. Moreover, UGVs may reduce human workload and improves work quality, enabling the automation of agricultural activities. These advantages, increasingly documented in the scientific literature, encounter a lack of reviews on UGVs applied for agricultural purposes. This paper aims to improve the body of knowledge about the application of UGVs in agricultural contexts. A detailed analysis on the interest of the academic community available on Web of Science, Scopus and IEEE Xplore databases was undertaken testing 12 different keywords. In this study, the features of the UGVs available in the market were also evaluated. The results showed that, among the several keywords utilized, the main outcomes were found for terms “Rover” and “Unmanned Ground Vehicles”. Across the three scientific search platforms, the studies conducted in this topic area were mostly found as conference papers. Considering the world distribution of the results for the keywords that included the term “Agriculture”, the countries mainly involved were found to be the United States, Italy, India and Spain. Finally, this paper presented the current challenges and forthcoming trends within the introduction of UGVs in agricultural farms.

ID: 4683

Evaluation of smart glasses for augmented reality: technical advantages on their integration in agricultural systems

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Recently the interest in augmented reality (AR) technologies and smart glasses (SG) has grown considerably in all production sectors. In agriculture, new technologies are being adopted to improve productivity and reduce farm input. In this perspective, the SG may be considered a valuable device to support modern farms. In the last decade, head-wearable devices with different characteristics e.g. display types (optical see-through, video see-through), interaction methods

(external Joypad, touchpad, voice control) and features (battery life, weight, camera definition, flash memory, etc.) have been developed. These aspects may affect SG experience, leading to different performance levels by the users and its integration on the farm. The aims of this study were to compare different types of SGs for AR and evaluate the technical advantages of their integration in agricultural systems. In this work, SGs with optical or video visualization systems, representing the main discriminating feature for augmented reality devices, were adopted. The tests were carried out on the available functionality of the SGs (e.g. QR code scanning time and distance, audio-video quality, battery life). The results showed that the devices, in relation to their operating system, have different performance detecting the markers and thus the augmented information in terms of time and distance. The audio-video quality performances result comparable for all devices, allowing to share detailed farm information in real-time. The present study demonstrated that the SG features and technical characteristics significantly differ between devices, highlighting how these should be carefully considered when selecting the most appropriate device for the farm.

ID: 4689

Granulometric parameters of solid blueberry fertilizers and their suitability for precision-fertilization

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For precise-fertilization of blueberry plants it is technologically the easiest and most suitable option to use a volumetric filling, which can be presumed that with the filler it is possible to precisely dose the fertilizer for each plant by grams. For setting up a volumetric filler it is necessary to know parameters such as: the size of the fertilizer particles and their bulk density. This research involves measuring up three different fertilizers (SQM Qrop K, Memon Siforga, Substral): width, height and length of randomly selected 100 fertilizer particles, also volumes and weights of 100 particles in 10 repetitions. According to the measurements, average diameters of fertilizer particles were found, also average mass, volumes and bulk density. Turned out that the average diameters and bulk densities of the 3 fertilizers differed far from each other, meaning that the given volume could be filled with different amount of fertilizer. Equations between mass and weight were formed according to the measurements. In result it was found that a volumetric filler can be used for fertilizing blueberry plants precisely, but it demands adjusting the filler each time in the situation, defined by the variety of blueberry plants: their age, size and health.

ID: 4741

Evaluation of livestock vehicle disinfection systems using aerodynamic simulations

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Infectious livestock diseases such as foot-and-mouth disease and avian influenza are causing economic and social damages every year, but the effective control measures have not yet been achieved through identifying the infection route. It is known that the most probable cause of the livestock disease outbreak is vehicles visiting the farms. Therefore, vehicles which visit to livestock farm should pass though a disinfection system before entering the livestock farm. Since there is no standard design or operation guideline for disinfection facilities, various types of vehicle disinfection systems actually used in livestock farms have not been verified for efficiency of disinfection. The purpose of this study is to evaluate livestock vehicle disinfection systems using fluid dynamics simulations. The problems of the existing disinfection systems were investigated through field experiments.The disinfection effect of two vehicle disinfection systems, tunnel type and simple type, on four different vehicles was measured using water sensitive papers. The average coverage rate was about 92% for tunnel type and 33% for simplified type. In particular, the simplified type showed low coverage rates around the upper and lower parts of the vehicle and around the wheels in all vehicle types. The computational fluid dynamics models were designed to complement the limited analysis of field experiments. The movement of spray disinfectant was modelled by the discrete phase model. The simulation model was verified by comparing to the field experimental results. The verified model will be used to improve the nozzle arrangement and operation method through future research.

ID: 4802

Remote sensing-based agri-environmental indicators for a cost-effective monitoring and assessment of agroecosystems

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A set of 28 agri-environmental indicators based on the Driver-Pressure-State-Impact-Response approach (DPSIR) has been proposed in the European Commission's Communication COM final 0508/2006 for monitoring the integration of environmental concerns into the Common Agricultural Policy (CAP). These indicators serve to: (i) provide information on the farmed environment, (ii) track the impact of agriculture on the environment, (iii) assess the impact of agricultural and environmental policies on environmental management of farms, (iv) inform agricultural and environmental policy decisions, and (v) illustrate agri-environmental relationships to the broader public. Remote sensing technology is generally accurate, objective and cost-effective. It allows

globally consistent coverage, therefore mitigating issues associated with field-based data collection. It is a powerful tool for monitoring ecosystems status and change, as it is able to characterize and quantify a broad range of ecosystem characteristics. This research aims at developing, organizing and presenting a remote sensing-based methodological and operational framework for a more cost-effective environmental assessment and monitoring in European agroecosystems.

Soil, land and water engineering

ID: 2842

Characterization of floating waste in the Vega Baja del Segura district

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The region of Vega Baja del Segura is located at southeast of Spain, in Alicante province, right at the mouth of the Segura river. The traditional irrigation system consists of a complex net of channels. Small dams located on the river bed divert water to irrigation channels which distribute water to the fields. The excess irrigation water is collected in drainage channels, which in turn are used as irrigation channels when they reach a sufficient height over the fields. The whole region is a great alluvial plain of about 23,000 hectares with a slope of less than 1 per 10000 which makes drainage difficult. Floating waste invades the entire water transport system, affecting the water quality and the water transport through the watercourses. Great amounts of waste accumulate on dams and retention elements along the river, and on sluices and syphons in channels. The aim of this paper is to characterize the floating residues stacked on the whole system. Zenith photographs were taken with a drone in points of waste accumulation. Image analysis was used for the characterization of waste. 11 categories were defined, based on the most likely material, use and origin. Waste was extracted from channels at two points and the manual counting of residues was contrasted with counting by image analysis. Reeds represent more than 95% of floating waste in the riverbank. Among the non-vegetal waste, plastic beverage bottles are by far the most abundant items, followed by glass bottles, plastic household containers, agricultural containers and other waste. Floating debris is of diverse origin, predominantly vegetable residues from the banks of the river itself, such as reeds, as well as various types of waste from domestic, agricultural and industrial activities, among which plastic waste predominates. These wastes cause economic, landscape, environmental, public health, social and legal problems.

ID: 4770

Analysis of the effects of reducing fine dust and fugitive dust by crop cultivation in reclaimed land

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Saemangeum is reclaimed land with developing 29,100 ha of land and 11,800 ha of fresh lake located in Korea. The soil in the Saemangum reclaimed land containssalinity and has a dry surface. Due to these soil properties, the exposed land area is large and Dust from the exposed land disperses to nearby areas. Fugitive dust can be reduced by spraying water, using windbreak or crop

cultivation. Crop cultivation has the advantage of increasing farmers' profits and securing food, and is expected to reduce fugitive dust and fine dust, so it is considered as a way of reducing fugitive dust in Saemangeum reclaimed land. Thus, this study analyzed the effect of the crop cultivation in the Saemangeum reclaimed land on the generation of fugitive dust. The experimental area was each 1 ha of barley and potato field in the Saemangeum reclaimed land, and the concentrations of PM-10 and PM-2.5 were monitored from March 2020 to June 2021 according to cultivation schedule. The effect of reducing the concentration of fine dust was analyzed through the changes in the concentration of PM-10 and PM-2.5 in windward and leeward. As a result of monitoring, In the early stage of crop growth, the concentrations of PM-10 is increased by 5% in barley (0.1m canopy) and potato (0.05m canopy),the concentrations of PM-2.5 is increased by 1% in barley, and decreased by 1% in potatoes. In the last stage of crop growth, the concentrations of PM-10 decreased by 21% in barley (1.1 m in canopy) and 2% in potato (0.3 m in canopy), and the concentrations of PM-2.5 decreased by 1% in barley and potatoes. Cultivation of crops in the Saemangeum reclaimed land reduced the generation of fugitive dust and was effective in reducing the concentration of fine dust.

Sustainable production in farm buildings

ID: 2686

Evaluation of the effects of antidrip and uv transmission properties of polyethylene films on a greenhouse strawberry crop

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Implementation of the 7-layer technology in the production of low density polyethylene films opened up the possibility to develop greenhouse cover films with totally new characteristics that make a real difference compared to 3-layer technology. These characteristics include long-lasting anti-drip anti-mist properties that combine 7-layer technology with a new system for avoiding the formation of droplets on the surface of a greenhouse film. This behaviour was also present in a 3-layer film but this attitude was vanished during time. The 7-layer technology enlarges the duration of this property and at the same time prevents the mist which is sometimes creating greenhouses covered with common anti-dripping films. The aim of this study was to investigate the application of novel 7-layer plastic greenhouse films on microclimate and growth and development of a hydroponic tomato crop and more detailed on marketable yield and fruit quality. Two different 7-layer plastic polyethylene films were tested. The first cover was characterized by normal anti-drip behaviour while the second by permanent anti-drip and anti-dust properties. The experiment took place in two identical, modified arched plastic greenhouses, located at University of Thessaly facilities, Velestino, Greece. The results showed that the cover that was characterized by permanent anti-drip and anti-dust behaviour did not affect the production of the greenhouses in any manner. Marketable yield as well as fruit quality aspects were preserved, meaning that no differences were found on fruit specific weight and dry matter. Also, no differences were observed on stem and leaf dry matter, chlorophyll content index and photosynthetic rate. This research has been co-financed by the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE – INNOVATE (project code:T1EDK--01499).

ID: 3340

Modelling heat and mass balances of a building with a recirculation aquaculture system (RAS)

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Modeling of energy flows was used to estimate the energy demand and to understand influencing factors in a fish farm. In this study, a mechanistic model was developed to describe the energy and mass balances of an indoor eel farm with a floor area of 1500 m2 and a stocking density of 145 kg eel/m^3. The RAS recirculated 900 m^3/h of water and exchanged 25% of the total water volume daily. The water setpoint temperature was 24˚C. The simulation was set based on data from the literature, observation, empirical data in the farm and the closest meteorological station for 3-5 Aug and 9-11 Jan. Model result showed in the summer heat was mainly lost through the exchange water (1979 MJ/d) and evaporation (835 MJ/d). Whiles in winter heat were mainly lost through longwave radiation from water to walls and roofs (1944 MJ/d) and evaporation (1445 MJ/d). In summer and winter, the biggest energy portion gained by convection through walls and roofs to indoor air. the air and water temperatures were more affected by the stocking density, ventilation and building insulation (U-values) at the investigated range of 107–179 kg/m^3, 6750-11250 m^3/h, and 1–5 W/m^2˚K, respectively. Stocking density in summer days and ventilation rate in winter days had a significant influence on the air temperature (T_a), water temperature (T_w) and humidity (RH). In summer 1% increase in stock density caused a rise of T_a 0.02 ˚C, T_w 0.04˚C and dropped RH by 0.02%. Whereas in winter the system was more affected by ventilation, 1% increase dropped T_a 0.05˚C, T_w 0.03˚C and increased RH 0.06%. U-values showed a weak influence on the indoor climate. The estimated winter heat demand to keep T_w at 24˚C was 0.14 kWh/m^2. The simulated heat fluxes show that evaporation from the fish tanks and trickling filter is a major mechanism of heat loss. In ongoing research, the significant effect of stock density and ventilation on heat fluxes indicates their main role in optimizing energy demand in the system.

ID: 3343

Influence of different cooling systems on the photosynthetic activity and yield of greenhouse tomato crops

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The purpose of this study was to analyse the effect of different evaporative cooling systems compared to natural ventilation on the photosynthetic activity and production of a tomato crop (*Lycopersicum esculentum* Mill.) in a spring-summer cycle. The study was carried out in three multi-span greenhouses: (i) a greenhouse with evaporative pads and fans (PAD-FAN system, PF), (ii) a greenhouse with a fog system and natural ventilation (FS), (iii) a greenhouse only with natural ventilation (NV). The photosynthetic activity was higher in the greenhouse with natural ventilation

(14.7 µmol CO_2 m^{-2} s^{-1}) than in the greenhouse with PAD-FAN system (14.6 µmol CO_2 m^{-2} s^{-1}, without statistically significant difference) and in the greenhouse with fog system (13.4 µmol CO_2 m^{-2} s^{-1}, with statistically significant difference). The production was higher in the greenhouse with PAD-FAN system (5.0 kg m^{-2}) than in the greenhouse with natural ventilation (4.8 kg m^{-2}, without statistically significant difference) and in the greenhouse with fog system (4.5 kg m^{-2}, with statistically significant difference). In general, photosynthetic activity and crop production increased as the maximum temperature (and the number of hours of exposure to high temperatures) decreased. It has been observed that the improvement in temperature conditions inside the greenhouses in spring-summer cycles produces increases in the photosynthetic activity of the tomato crop and consequently a growth in production.

ID: 4712

Modeling atmospheric dispersion of particulate matters emission from livestock using aermod

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As the rapid increase in the occurrence of particulate matter and the growing public awareness of particulate matter among air pollutants, it is necessary to determine the cause and background concentration of particulate matter. The importance of managing ammonia (NH3) emission is increasing due to that is known as a substance which generate secondary ultrafine particle matter. The major source of NH3 emission is agricultural production including cultivation and livestock, that is reported about 78% of total ammonia emission 297,000 tons (6.7% of agricultural land using fertilizer and 71.1% of manure management). Therefore, interest in the amount of particulate matter generated as well as NH3 derived from agriculture and the corresponding change in the concentration of particulate matter in the atmosphere is increasing. The purpose of this study is to analyze the atmospheric contribution of NH3 and concentrations of particulate matter from agricultural activities. This study used the AERMOD model provided by the US EPA to model the diffusion from the source to the atmosphere. The diffusion process of NH3 and particulate matter discharged from Gwangju metropolitan city into the surrounding area was predicted and the contribution to the particulate matter concentration in the nearby area was estimated. As a result, PM10, PM2.5, and NH3 diffused from livestock based on an 1-hour average concentration had been affected within each 2 µg/m3, 0.3 µg/m3, and 0.04 ppm repectively in the Southwest region of Gwangju City, its effects has been appeared insignificant on the annual average concentration. On average, PM10 and PM2.5 diffused from livestock facilities account for 0.7% and 0.2% of the total proportion of Gwangju.

ID: 4742

A preliminary study for measuring pesticide spray drift by aerial application

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The decline in the population of farm households and aging led to a reduce workforce in Korea. Most agricultural operations, including sowing, pesticides application, and harvesting, have been mechanized, but among them, pesticides application is highly dependent on man. For this reason, it tends to be rapidly increased an aerial application of pesticides using UAV. Aerial application has highly efficient way because it is able to spray a pesticide with low cost and short time. But aerial pesticide application has the problem that is occurred more spray drift than convention spraying. Positive List System (PLS) has implemented in Korea since 2019, pesticide spray drift can be an important social issue among agricultural workers because if the pesticide application was drift and detected around eco-friendly farmland, the agricultural products should be discarded. Therefore, it is very significant to quantitatively evaluate the amount of spray drift of pesticide during aerial spraying. The key factors influencing pesticide spray drift are method of application, drop size and meteorological condition. Spray drift measurements have conducted according to ISO22866:2005 protocol all over the previous study. But there is no guideline that can be applied for field experiment in Korea. The objectives of this study were conducting preliminary experiment in order to establish guidelines measuring pesticide spray drift by aerial application. This study made up the dedicated chamber which composed with two space, including spraying and drifting section in order to implement pesticide drift indoor. Spray the pesticide 1-3meter per second wind speed respectively using XR110 by Teejet™ in the spraying section, capture the pesticide drift by nylon screen in the drift section. The results on this experiment can be the basis for establishing an experimental protocol for measuring the amount of pesticide drift.

ID: 4745

Influence of chromatic plastic mulches on soil temperature and yield in a tomato crop inside greenhouse

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The aim of this work was to analyse the use of chromatic plastic mulches inside greenhouses during warm periods. The influence of this passive climate control technique on soil temperature and its impact on tomato production were analysed. Trials were carried out in an Almería type greenhouse (1922 m^2) with sand mulched soil ("*enarenado*"). A tomato crop (*Lycopersicum esculentum* Mill.) was cultivated in a long cycle. Yellow plastic mulch sheets 30-50 µm thick and grey plastic mulch sheets 25-40 µm thick were installed to compare its effect with the traditional sand

mulched soil. A randomized experimental block design was carried out with 4 repetitions (rows with 32 plants) for each of the three treatments. From the measurements of incident and reflected radiation, values of the reflection coefficient were obtained that ranged from 28.0-36.3 % for the yellow plastic mulch, from 18.7 to 22.7 % for the grey plastic mulch and from 14.0 to 17.5 % for the sand mulched soil. However, the use of the plastic mulches failed in reducing the average soil surface temperatures. The use of additional plastic mulch covering the sanded soil difficulted cooling of ground surface by conduction-convection, counteracting the effect of a greater reflectance. Thus, average air temperatures 10 cm over the soil were very similar for the three types of mulching (14.6-14.7 ºC). However, temperature of soil at 10 cm depth was statistically lower in the sand mulched soil (19.6 ºC) than in the soil with the yellow mulch (20.2 ºC) and the grey mulch (20.4 ºC). Tomato yields obtained with the different mulching treatments were very similar, ranging between 11.1 kg m^{-2} (grey plastic mulch) and 10.5 kg m^{-2} (yellow plastic mulch). Therefore, the use of the chromatic plastic mulches analysed did not show benefits with respect to the traditional "*enarenado*" sand mulched soil in tomato production.

ID: 4747

Effects on the microclimate of the use of low tunnels inside greenhouses

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The main objective of this work was to analyse the microclimate generated inside a low tunnel (floating row cover) installed in an Almería-type greenhouse. Low tunnels are commonly used in open field to protect the plants against insect attack and to improve production of muskmelon and strawberry. Floating row covers can also be used inside greenhouses during the first few weeks after the transplantation of muskmelon and watermelon crops in spring-summer cycles. This work was carried out during the first weeks of a watermelon culture (*Citrullus lanatus* Thunb.) growing with a polyethylene row cover inside an Almería-type greenhouse (2115 m^2). Air temperature and humidity, plant temperature and soil temperature and humidity were measured in the greenhouse inside and outside the row covers. During the three days of measurement, all greenhouse vent openings were closed. The use of the low tunnels increased average air temperature around plants from 24.0 ± 9.0 ºC to 26.9 ± 9.7 ºC. A maximum difference in air temperature about 5.9 ºC was observed at the noon. The average daily temperature of the crop was 28.2 ± 11.8 ºC inside the row cover and 24.6 ± 8.9 ºC without it. Similarly, the absolute humidity of air was clearly higher inside the low tunnel (0.0201 ± 0.0098 g g^{-1}) than around the plant rows without floating cover (0.0131 ± 0.0048 g g^{-1}). The soil temperature was also higher inside the low tunnel compared to the area without this second plastic cover. The effect of the tunnel decreases with depth, with average temperature differences of 1.2 ± 0.5ºC on the soil surface and 0.6 ± 0.5ºC at 20 cm depth.

ID: 4748

Effect of photoconversion films used as greenhouse double roof on the development of cucumber fungal diseases in Spain

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The French company CASCADE has developed the 'LIGHT CASCADES®' (LC®) technology that modifies the sunlight spectrum to plant needs. The purpose of this study was to analyse the effect of two double roof covers doped with the LC® technology on the development of fungal diseases on a cucumber crop (*Cucumis sativus*). The study was carried out in Almería (Spain) from September to December 2020 in three multispan greenhouses divided transversally with polyethylene sheets. Greenhouse 1 and 2 were divided into 4 sectors. In two of the sectors double covers with experimental photoconversion films (C1 in greenhouse 1 and C2 in greenhouse 2) were installed. In the other two sectors, colorless reference films were installed (not additive with LC® technology). A third greenhouse was divided in two parts, one with a double roof containing the experimental film C1 and other without double roof. The study evaluated the development of cucumber fungal diseases, inside each greenhouse using the European and Mediterranean Plant Protection Organization (EPPO) regulations (PP 1/57 and PP 1/65). The analysis evaluated 6 cucumber plants with 4 repetition in different lines per sector (50 random cucumber leaves were inspected per repetition to obtain the disease data). The development of 3 diseases was noticed, (i) downy mildew (*Pseudoperonospora cubensis*), (ii) powdery mildew (*Podosphaera fuliginia*), and (iii) *Mycosphaerella melonis*. Statistical differences were observed in the case of downy mildew. Less incidence of disease was detected in sectors with the different double roofs (up to 80% less), than in the sector without any double roof. A similar behaviour was observed for *Mycosphaerrella*. For powdery mildew, less incidence of disease was observed in the sectors with double roofs using the photoconversion films C1 and C2 with the LC® technology (up to 50% less), inside the three greenhouses.

ID: 4753

Ammonia and GHG emissions from livestock buidlings – LivAGE Cost Action

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Modern farm animal production is increasingly regarded as a source of solid, liquid and gaseous and dusts emissions which can be both a nuisance and environmentally harmful. The global livestock sector, particularly ruminants, contributes approximately 18% of total anthropogenic GHG emissions. In the EU, the livestock sector accounts for about 13% of total GHG emissions. LivAGE is a funded COST action (CA16106) with overall objective to enhance international discipline

cooperation so as to exchange ideas, share good practices and assess technologies that could result in reducing the emissions of ammonia and GHGs from livestock buildings and thus to lead to a more environmental friendly and sustainable livestock production. Specific objectives of the LivAGE action are: i) Assessment of techniques that could be applied to monitor GHGs and ammonia concentration will be assessed; ii) Compilation of a reference methodology to calibrate over methods and to have standard protocols that will make easy the comparison of the results and to certify the measured emissions levels; iii) Establishment of an agreement on measurement methodologies and techniques that will allow comparing results from different experiments carried out across Europe; iv) Identification of approaches for simulation-oriented analysis of emissions from livestock buildings that reduces the uncertainty of simulations; v) Environmental assessment using the Life Cycle Approach; vi) Development of a dissemination and exploitation strategy able to reach the main stakeholders and end- users (relative industry and SMEs, the scientific community, farmers, as well as a more general audience).

ID: 4633

The D5 Silo of Manganeses de la Lampreana (Zamora): history, construction characteristics and technology

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Spain's National Network of Silos and Granaries (NNSG) was built in 1951–1990 building a total de 668 silos and 282 granaries. 21 different typologies of silos were built, highlighting type D over all of them with a total of 389 units. This typology prolonged its construction for 34 years, appearing several subtypes (D_1, D_2, D_3 D_4 y D_5). The Manganeses de la Lampreana silo (Zamora) is a D_5 type silo with 3,350 t of storage capacity, distributed in 24 storage tanks called cells, built in 1968. This silo is a Reception silo whose objective was to be close to the farmers and transfer the cereal from it to the larger Transition and Reserve silos. Architecturally speaking it is a simple and powerful silo. It has a rectangular shape, made up of three rows of square cells, the outer rows of cells rested directly on the ground storey floor and the centre row is raised. Front tower between two cells, being embedded between them in a central position, achieving a compact and robust volume. Together with the D_4 subtype it represents the classic image of an NNSG silo. The structure is made up of reinforced concrete pillars at the corners of the cells and the cell walls of reinforce bricks. It is finished off with a flat roof. Technologically speaking it has many similarities with its predecessors, types A and B. Here the elevator receives the grain directly from the reception hopper raising wheat and emptying it onto an upper horizontal belt conveyor, where dampers motorised valves, it is distributed across other tubes to one of the three cells in each bay. The grain is unloaded onto lower horizontal belt conveyors lying at different heights depending on whether the cells stand off (central) or on (side) the floor. From there it is carried to a raised cell for bulk offloading onto a lorry. It also has a cereal cleaning system in case it is necessary. In addition, the silo has vacuum dust collection systems.

ID: 6001

Enabling smart livestock farming technologies for environmental sustainability using blockchain

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Farming livestock – cattle, sheep, goats, pigs and chickens – contributes around 6 billion tonnes of greenhouse gases (carbon dioxide, methane and nitrous oxide) to the atmosphere each year. While estimates vary, this could represent up to 18% of global emissions. Studies have shown that GHG emissions from livestock could be reduced by around 2.4 billion tonnes of greenhouse gases each year through technology and management. Achieving these savings will be dependent on improvements in feeding practices (better pastures, new types of food, more grains and others), improved ways of handling manure, and improved genetics and animal management. Precision Farming (PF) uses new technologies to handle and manage farm information. The premise of PF is that this better use of information improves economic returns and reduces environmental impact. Precision Livestock Farming (PLF) technologies enable continuous, automatic monitoring of animal welfare, health, production and environmental impact in real-time. However, due to the huge amount of data monitored and gathered it is not always easy to transform them into useful practices and services for the farmers and advisors. FarmSustainBI project will provide a reduction in GHG intensity of animal production systems in Europe by approaching three main pillars: one pillar relates to actual GHG reduction techniques, but it relies heavily on modelling and optimization in livestock management together with a blockchain component for preserving and maintaining the consumer and authority trust in the authenticity of produce from sustainable livestock agriculture. Distributed ledger technologies (DLTs) can introduce important efficiency gains along value chains, and improve trust, transparency and traceability. While large actors in livestock agriculture are already exploiting DLTs, small farmers and processors also stand to reap significant benefits, but are hampered by the technology which is not readily accessible to them. This raises the question of how an enabling environment can be created for smallholders to harness these new technologies, and, at a broader scale, for DLTs, so that these contribute to improving the functioning of global food and agricultural markets. Within a DLT scenario, supply chain actors can identify and examine the product's movement along every step in the supply chain from the agricultural and livestock inputs and practices (fertilisers, fodder, water practices, veterinary services, etc.) used on the farm to the transportation and storage conditions and details as the product moves to the retailer and consumers.

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