Effects of different Loader Base Materials on Slippage and Deviation in a Belt Conveyor System.

Sunmonu, Musliu Olushola. [1*], Odewole, Michael.Mayokun. [1], Sanusi, Saheed.Mayowa. [1], Adepoju, Abiola Lydia. [2] and Iyanda, M.O. [2].

[1] Department of Food Engineering, Faculty of Engineering and Technology, University of Ilorin, P.M.B. 1515, Ilorin, Kwara State, Nigeria.

[2]Department of Agricultural and Biosystems Engineering, University of Ilorin, PMB 1515, Ilorin, Nigeria.

*Corresponding author's email: sholams2000@yahoo.co.uk

Phone Number: +234(0)8050745127

Abstract

The article summarizes the results of development and performance evaluation of a semi-automated conveyor system for agricultural produce. It focused mainly on the incorporation of different replaceable loader base materials (wood, carton, sandpaper and rubber) in order to get the most efficient base with the least slippage and deviation for the available belt conveyor system. The device performance was evaluated using a 4^4 factorial experiment in a randomized complete block design. The four factors that were considered in the factorial design were; four levels each of speed (C); Loader weight (V); Degree of inclination (E) and Base material (H). The measured parameters from the performance evaluation of the device where slippage and deviation of the loader while moving on the conveyor belt. The results obtained were analyzed using SPSS 16.0 for the Analysis of Variance (ANOVA) and Duncan's New Multiple Range Test (DNMRT). For the base material, (sandpaper base) with the highest coefficient of static friction (0.82) recorded least deviation (1.3 mm). The base material (rubber base) with the least coefficient of static friction (0.58) recorded the highest deviation (10.7 mm).The result showed that deviation varied directly with speed and degree of inclination, but inversely with coefficient of static friction of the base materials and weight load. It was therefore inferred that higher degree of inclination caused more slippage and deviation but more weight gave less deviation and more slippage, while more speed caused less slippage but increased the deviation of the loader.

Keyword: Slippage, Deviation, Belt Conveyor system, Base materials, Speed, height of inclination, loader weight, Loading, Material handling equipment, unloading.

Effect of different Organic Binders and Other Machine Parameters on Nutritional Qualities of Cubed Sugar

Sunmonu, Musliu Olushola. [1] and Jimoh, M. [2].

[1] Department of Food Engineering, Faculty of Engineering and Technology,

University of Ilorin, P.M.B. 1515, Ilorin, Kwara State, Nigeria.

[2]Department of Agricultural and Biosystems Engineering, University of Ilorin, PMB 1515, Ilorin, Nigeria.

*Corresponding author's email: sholams2000@yahoo.co.uk

Phone Number: +234(0)8050745127

ABSTRACT

Binders are agents employed to impart cohesiveness to the granules. This ensures that the end solid product remains intact after compression as well as improving the flow qualities by the formulation of granules of derived hardness and size. The experiment was conducted to determine the effect of binding agents (cassava powder starch, extracted starch from sphaghetti and extracted starch from rice), sugar varieties (Dangote white granulated sugar, blend white granulated sugar and mixed white sugar) and other machine parameter like temperature (61^0C, 63^0C and 65^0C) on the production of cubed sugar. The machine consists of internal and external cylindrical stainless-steel container, stirrer, Dc motor one, two and three, cover, hopper, tap/control knob, condenser pipe, electric heater, shaft, support, plug, frame, thermocouple controller, Contactor, speed controller one, two and three, stand, mold, cooling fin, ejector, compressor, fan, a conveyor and mold casing for production of cubed sugar. Dangote sugar (blend, granulated and mixed) were collected in a cleaned Container, Addition of required grams of granulated sugar, binding agents in powder form or solution like cassava powder starch ¼ tea spoon, extracted starch from sperghetti and extracted starch from rice (boiling of sperghetti and rice in a separate cleaned pot) for nine samples as control experiment and get heated at temperature of 61^0C, 63^0C and 65^0C to form 27 samples which was A 3x3x3 factorial experiment in a Completely Randomized Design (CRD). The results were statistically analysed, and presented using SPSS 23.0 with ANOVA and New Duncan's Multiple Range Test (NDMRT) to determine the level of significance among the treatment factors. The out puts of binding agents and sugar varieties in combination with treatments (temperature) were significantly different at ($p \leq 0.05$) when compared to control experiment except carbohydrate (CHO) treated with temperature, ash and CHO treated with varieties of sugar and CHO treated with binding agents. Proximate composition of treated samples when compared with control samples increases Ash (1.27% to 1.29%), moisture (2.17% to 2.74), Protein (0.51% to 0.55%), Carbohydrate (81.03% to 82.70%) and Reducing Sugar increases (3.70% to 4.70%). Also microbial composition decreases TVC (5.35×10^3 cfu/g to 2.00×10^3 cfu/g). TCC (4.00×10^3 cfu/g to 1.95×10^3 cfu/g) and FC (7.70×10^3 cfu/g to 1.20×10^3 cfu/g). average percentage of water gained by cubed sugar 7.02%, water resistance by sugar cube 92.98%, average shattering index 0.0189 and percentage weight of sugar recovered 87.93%. the ash, moisture, protein, reducing sugar and carbohydrate contents of established Columbia and Ecuodorian Technical Standard for organic cubed sugar values were 1.39%, 4.33%, 0.87%, 5.23% and 86.03% respectively that was a little bit higher than the proximate experimental values as 1.29%, 2.74%, 0.55%, 4.70% and 82.70% respectively. The Total

Viable Count (TVC), Total Coliform Count (TCC) and Fungi Count (FC) values as microbial compositions for organic cubed sugar according to East Africa Standard were 3.20 $x10^3$ cfu/g, 2.44 $x10^3$ cfu/g and 1.48 $x10^3$ cfu/g respectively which was higher than the microbial experimental values (2.00 $x10^3$ cfu/g, 1.95 $x10^3$ cfu/g and 1.20 $x10^3$ cfu/g respectively).

Keywords: Binders, starch, sugar, blend, granulated

Teilflächenspezifische Anwendungen mit Sprühdrohnen

VDI LAND.TECHNIK
The Forum for Agricultural Engineering Innovations

- Animal Production Technologies
- Circular Biobased Economy / Sustainable Energy/ Waste Management
- Farm Buildings
- Land, Soil and Water Engineering
- ✓ **Plant Production Technologies**
- Post-Harvest Technologies
- ✓ **Precision Agriculture / Digitalization**
- Tractors / Power Trains / Electrical Drives

Zusammenfassung

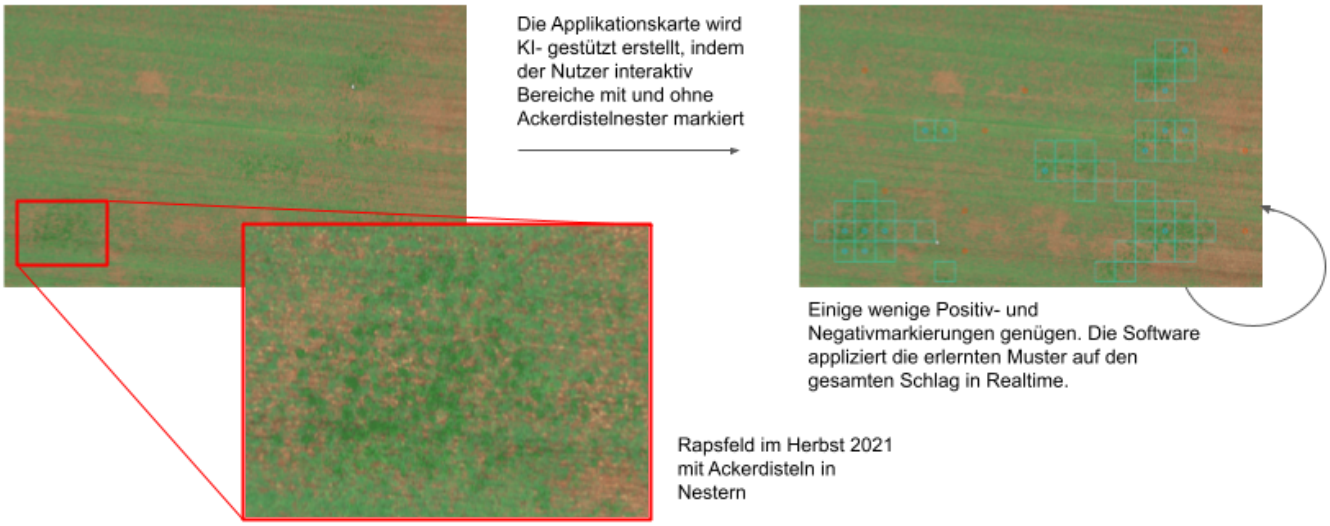
Teilflächenspezifische Anwendungen helfen dabei, die Ausbringung agrochemischer Substanzen in die Umwelt zu reduzieren und die ökonomische Effizienz landwirtschaftlicher Anwendungen zu verbessern. Das Ziel ist es, jeder Pflanze genau nur die Menge an Düngung und Pflanzenschutz zuzuführen, die tatsächlich notwendig ist.
Die Anwendungsplanung erfolgt üblicherweise über Drohnen-, Satellitenbildgebung, Boden- und Ertragskarten. Dem Landwirt stellen sich hier die Fragen, wie die Daten interpretiert, klassifiziert und in Applikationskarten überführt werden können.
Zusätzlicher Arbeitsaufwand mit ungewissem Nutzen, mangelnde Erfahrung in der Erstellung von Applikationskarten, sowie hohe Anschaffungskosten für die Technik bilden immer noch große Hürden für teilflächenspezifische Anwendungen. In Anbetracht der hohen Preise für landwirtschaftliche Betriebsmittel lohnt sich jedoch ein frischer Blick auf die Technologie, so kann sie doch zu deutlichen Kosteneinsparungen bei gleichbleibender Ertragslage führen - und obendrein wird die Umwelt geschützt.

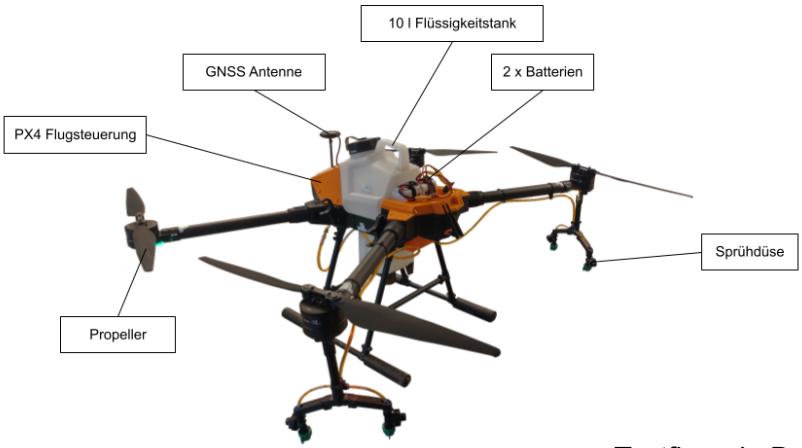
Pix4D hat das Softwarewerkzeugangebot (siehe https://www.pix4d.com/industry/agriculture) für den Landwirt dahingehend erweitert, über automatische KI-basierte Methoden die Klassifizierung von Teilflächen zu unterstützen. Wir haben zudem eine Sprühdrohne entwickelt, deren Anschaffungs- und Unterhaltskosten deutlich unter denen von teilflächenfähigen Feldspritzen liegen. In der Kombination von Remote Sensing, KI-gestützter Planung und Sprühdrohnentechnologie eröffnen sich dem Landwirt interessante neue Anwendungsfelder, die wir in dem Beitrag exemplarisch aufführen wollen.

Neben der Vorstellung der Technologie und Arbeitsabläufe gehen wir auch der Fragestellung der Anwendungsgebiete nach. Dazu gehört unter anderem die Bewirtschaftung des Weinanbaus, die aufgrund der Lage und Beschaffenheit optimal von Sprühdrohnen unterstützt werden kann, aber auch das Feldversuchswesen, das von der Agilität und Präzision einer Sprühdrohne profitiert, sowie spezielle Szenarien der Ausbringung von Untersaaten, Granulaten oder Nützlingen. Zur Unterstützung der Landwirte bei der Maschinenauswahl erfolgt ebenfalls eine detaillierte Aufstellung des Arbeitsaufwands, der nötigen Qualifikation und der Anschaffungs- und Betriebskosten einer Sprühdrohne im Vergleich mit herkömmlichen Bewirtschaftungsmethoden in den jeweiligen Anwendungsgebieten.

Vortrag und Paper können entweder in Englisch oder in Deutsch erstellt werden.

Abbildungen





Testflüge in Brandenburg

Zu den Autoren

Leonhard Krause, Engineer Pix4D GmbH

2017- 2020	BSc Maschinenbau an der TU Berlin
Seit 2020	MSc Maschinenbau an der TU Berlin
Seit 2021	bei Pix4D

Julius Petri, Head of Product at Pix4D

2014 - 2017	MSc in Agrarwissenschaften der Martin Luther University, Halle
2017 - 2020	Geospatial Analyst bei John Deere, Kaiserslautern
Seit 2020	bei Pix4D

Henrik Battke, Regionaler Geschäftsführer Pix4D GmbH

1990 - 1996	Studium der Informatik und Mathematik an der Humboldt-Universität zu Berlin
2002 - 2009	Geschäftsführender Gesellschafter und Mitgründer der bit-side GmbH, Verkauf an Nokia im Januar 2009
2009 - 2014	Director Nokia, Platform Services & Enterprise Business
2014 - 2017	Senior Director HERE Technologies
Seit 2017	bei Pix4D

Zu Pix4D

Pix4D ist der weltweite Marktführer im Bereich professioneller Softwarelösungen für Drohnenkartierung und Photogrammetrie. Das Unternehmen mit Sitz in der Schweiz und Büros in San Francisco, Denver, Shanghai, Berlin, Madrid und Tokio ermöglicht mit seinen Softwarelösungen die Erstellung von digitalen Karten und 3D Modellen als genaues Abbild der Realität. Von Hand, mit einer Drohne oder einem Flugzeug aufgenommene Bilder werden

automatisch in georeferenzierte 2D-Mosaike, Index- und Zonenkarten, 3D-Oberflächenmodelle und Punktwolken umgewandelt.

Der Standort von Pix4D in Berlin entwickelt Anwendungen für die Landwirtschaft und die öffentliche Sicherheit und trägt dazu bei, die führende Position von Pix4D in den Bereichen Bildverarbeitung, Computer Vision und Photogrammetrie weiter auszubauen.

Pix4D hat bereits folgende Beiträge im Rahmen von VDI-Konferenzen geliefert:

- „Seeing the Invisible, Multispectral Image Analysis in Arable Farming“, Henrik Battke (Pix4D), Klaus Schneider-Zapp (Pix4D), White Paper und Vortrag auf der 4th International VDI Conference – Smart Farming, March 2020, Düsseldorf
- „Remote Sensing im Feldversuchswesen“, Henrik Battke (Pix4D), Dr. Andreas Muskolus (IASP, Institut für Agrar- und Stadtökologische Projekte), LAND.TECHNIK, November 2020

Analysis of three different methods for reducing water ragwort (*Jacobaea aquatica*) on grassland

J. Maxa[1], J. Heel[2], M. Hofmann[2] and S. Thurner[1]
[1]Bavarian State Research Centre for Agriculture, Institute for Agricultural Engineering and Animal Husbandry, Voettinger Str. 36, 85354 Freising, Germany [2]University of Applied Sciences Weihenstephan-Triesdorf, Department of Sustainable Agriculture and Energy Systems, Am Staudengarten 1, 85354 Freising, Germany

Water ragwort (*Jacobaea aquatica*) causes a potential danger to animals on grassland due to its toxic effect of contained Pyrrolizidine alkaloids. Especially organic farms and farms that did not rely on chemical plant protection did not have an efficient and long-term possibility to reduce the spreading of this poisonous plant. With the hot water method, a new technology was created with which it is possible to achieve an efficient reduction of water ragwort without usage of herbicides. Therefore, a field trial was set up on several different sites to compare and evaluate of the different methods of water ragwort reduction. These were the (i) mechanical reduction using weeding trowel (ii) chemical reduction with the herbicide “Simplex” and (iii) the new method using a hot water high-pressure cleaner (80°C and 10^6 Pa with the treatment duration of 10 or 15 seconds. The repetitions of the trials differed in the growth condition of the plants, grassland inventory, soil conditions, management and climate. All three analysed methods were able to minimize the water ragwort plants but only with the chemical and hot water methods all plants were successfully eradicated over longer period. No difference was found in the treatment duration of the hot water method, so that a treatment duration of 10 seconds can be sufficient for practical purposes. The mechanical reduction using a weeding trowel still offers a cost-effective method, while the problem of disposal of collected plant material remains. The hot water method offers the chance to automate the whole process in the future and thus make tedious manual work, for example by a weeding trowel, unnecessary. Additionally, within the framework of good professional practice and according to the principles of integrated crop management, the new method of hot water can be preferred as a more environmentally friendly variant compared to chemical reduction of water ragwort.

Teleoperation of an Agricultural Mobile Robot inside Berry Orchard using Digital Twin

Dr. **Redmond R. Shamshiri**[1,2], **Tjark Schütte**[1,2], and Prof. **Cornelia Weltzien**[1,2]
[1]Leibniz Institute for Agricultural Engineering and Bioeconomy, Max-Eyth-Allee 100, 14469 Potsdam-Bornim, Germany;
[2]Technische Universität Berlin, Fachgebiet Agromechatronik, Straße des 17. Juni 135, 10623 Berlin, Germany;

Abstract

Autonomous control of agricultural mobile robots inside unstructured orchards proposes different challenges due to the extreme variations in high-density bushes and the inaccuracies in the GPS and IMU measurements. This paper reports on the use of digital twin for controlling a four-wheel steering mobile robot inside berry orchards. The robot was a combustion engine rover with a set of multi-arrays distance detection units that formed a distributed control architecture with the main navigation system. Robot operating system (ROS) was used for communication between different electronic control units (ECU). A virtual replica of the robot with the same sensing system was created inside simulation environment and was interfaced with the actual robot via bidirectional peer-to-peer 868 MHz LoRa protocol. The simulated robot was controlled using a fuzzy-knowledge-based algorithm inside 3D-LiDAR point cloud of the berry orchard for generating steering and speed commands. A wireless transceiver unit was used on the actual robot to receive signals from the simulated environment and to transmit a feedback summary message of all sensors to the digital model for real-time monitoring and evaluation. The proposed approach created a framework for exchanging data between the real-world and virtual environment and predicting the behavior of the actual robot in different what-if scenarios. The potential application of this study is to improve and optimize autonomous navigation and collision avoidance algorithms.

Keywords: Digital Twin, Autonomous Navigation, Collision avoidance, Sensor fusion, Simulation

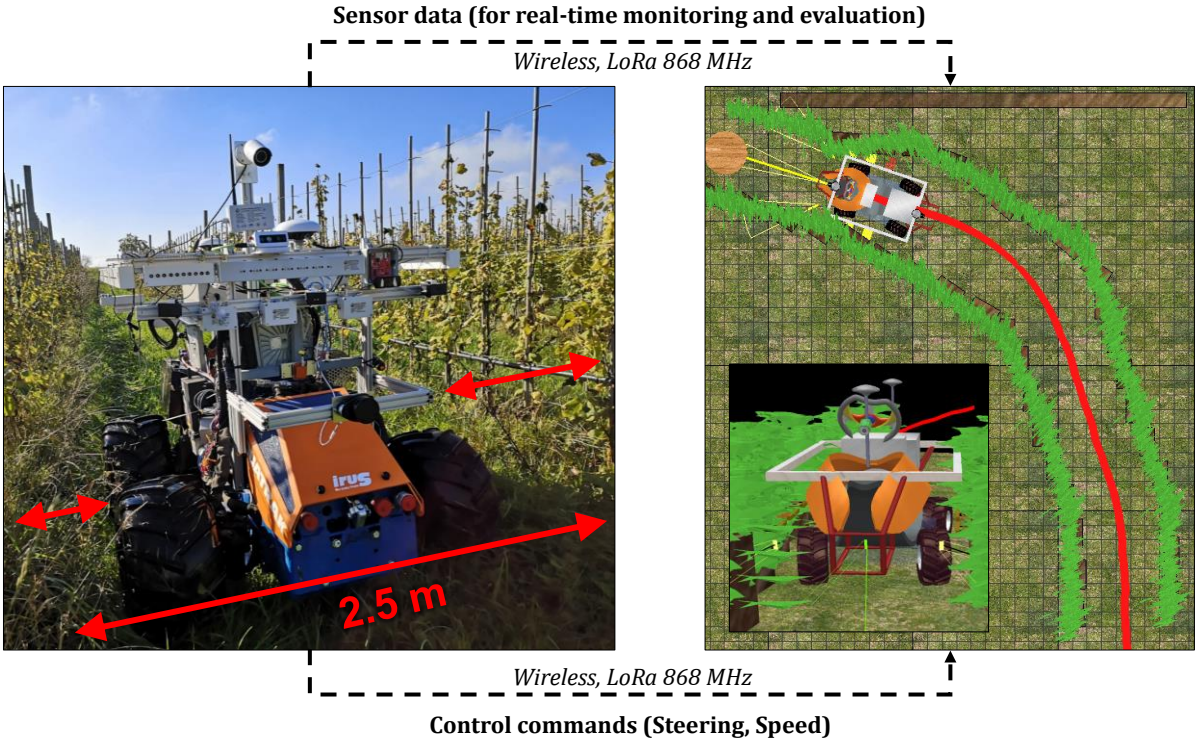


Fig 1. The use of digital twin for controlling of a mobile robot inside berry orchard

Smart Constituent Sensing using HarvestLab^{TM} 3000

Ambarish Panambilly, Dr Peter Schade
John Deere European Technology Innovation Centre
Straßurger Allee 3, 67657 Kaiserslautern, Germany
{PanambillyAmbarish, SchadePeter}@JohnDeere.com

Constituent Sensing refers to technologies used to determine quality parameters of agricultural goods. Near Infrared Reflectance (NIR) spectroscopy has proven to be an excellent non-destructive approach for real time constituent sensing in Agriculture. HarvestLab^{TM} 3000 is John Deere's NIR based commercial technology offering in the market. The device is currently used with Self-Propelled Forage Harvesting (SPFH) machines for sensing important constituents in particular Moisture and with manure tankers to sense Nitrogen and other constituents for manure applications. At present, the HarvestLab^{TM} 3000 sensor system is being further developed to cover grain sensing.

While NIR sensors can precisely estimate the quality parameters, opportunities exist for advanced diagnostic insights. We have studied the benefits of incorporating a camera inside an NIR sensor system to facilitate many additional capabilities on top of the existing constituent sensing application. This new feature provides better estimation and documentation of the overall quality of agricultural goods. Some of these include anomalous sample detection, sensor cleanliness detection etc.

For calibrations based on machine learning, another valuable addition is the ability of the sensor to estimate prediction confidence when generating constituent documentation. This is important because constituent predictions are coming from machine learning models and these models can be unstable when unknown or unseen materials are measured in field operations. An uncertainty indicator takes these unknown or unseen measurements into consideration and gives a degree of confidence around constituent predictions. This will enable the sensor to indicate strange or unseen samples as well as out of range constituent values.

Keywords

Constituent Sensing, Smart Sensor, Computer Vision,Uncertainty Estimation

Road To Autonomy: Soil Compactor Application

Speaker: Shelley Nation

Adding autonomy to your machine brings immediate and lasting value. Danfoss's PLUS+1 Autonomy is a software platform that enables machine manufacturers to bring operator assist and autonomous features to their vehicles. Our platform and advanced sensor management have been specifically integrated into a soil compactor at our Ames, Iowa, Application Development Center (ADC). This machine incorporates the platform's easy-to-use autonomous control library, enabling the quick and simple integration of steering, drivetrain, braking, remote control and advanced sensors. The control library operates on an XM100 autonomous controller, enabling faster processing speeds and the ability to handle increased data and advanced sensors. Overall, the platform leverages advanced software algorithms, high processing power controllers to deal with high-data-rate sensors, and a team that can work with the specific needs of an OEM to build and customize complex vehicle applications. PLUS+1 Autonomy will alter the way your vehicle is designed through innovation and expertise.

Effects of Roof Design on Near Ground Gaseous Emissions from a Naturally-ventilated Pig Barn

Qianying Yi [a], David Janke [a], Xiaoshuai Wang [b], Lars Thormann [a], Barbara Amon [c,d], Thomas Amon [a,e]

[a]*Department of Engineering for Livestock Management, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Max-Eyth-Allee 100, 14469 Potsdam, Germany*
[b]*College of Biosystems Engineering and Food Science, Zhejiang University, Yuhangtang Road 866, 310058 Hangzhou, China*
[c]*Department of Technology Assessment and Substance Cycles, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Max-Eyth-Allee 100, 14469 Potsdam, Germany*
[d]*Faculty of Civil Engineering, Architecture and Environmental Engineering, University of Zielona Góra, Licealna 9/9, 65-417 Zielona Góra, Poland*
[e]*Institute of Animal Hygiene and Environmental Health, Department of Veterinary Medicine, Free University Berlin, Robert-von-Ostertag-Str. 7-13, 14163 Berlin, Germany*

Abstract

Naturally ventilated pig barns with outdoor exercise areas are of increasing interest in livestock farming because they can improve animal welfare. However, the open house structure and the increase in soiled floor area are likely to lead to elevated ammonia (NH_3) emissions, which affect the nearby and wider environment. The objective of this study is to investigate the effects of the roof design on the near ground NH_3 emissions from a naturally ventilated pig barn with an outdoor exercise yard. The investigations were performed in a large boundary layer wind tunnel with a 1:50 scaled pig barn model with three roof configurations. Air velocities and tracer gas concentrations were measured and turbulent characteristic values were calculated. The measurements were performed at the positions densely distributed at different planes downwind of the barn model. The results showed that for a large inlet opening, both the near ground gas concentration and the estimated emission flux were the largest when the pig barn had a leeward roof with the roof slope of 25°. The results will help to further optimise roof design and also contribute to the emission measurement of naturally ventilated pig barns.

Keywords

Outdoor exercise area, ammonia emissions, wind tunnel, tracer gas

Data-driven models to improve animal barn control systems

Graef, Hannah A.; Payerl, Jonas F.; Hensel, O.; Nasirahmadi, A.

Department of Agricultural and Biosystems Engineering, University of Kassel, 37213 Witzenhausen, Germany

Abstract

On pig farms, husbandry data are limited integrated and fused. In addition, barn climate control systems are often very basic and depend on few sensors, not considering all important factors. To get aware of suboptimal barn conditions and facilitate animal control, improved control systems considering animal-based parameters are necessary that ideally consider the whole value chain. To develop these digital control systems, the major influencing factors on process performance need to be identified using appropriate models.

In a research study on a German pig value chain consisting of a breeding/ rearing, a fattening and a slaughtering company, a batch of individually tracked pigs was observed from birth to slaughter. Before allocating the animals to 3 different compartments for fattening, the animals had grown up in the same breeding and rearing compartment. Data collected in this study covered barn climate (temperature, relative humidity, carbon dioxide, ammonia, and air velocity) and extended husbandry data. The collected data were assigned to individual animals and location using transponders (ear tags) by software. The data were fused, correlations between influencing factors were calculated, and data patterns were examined. Then, the extent of the influence on the dependent variables was investigated considering differences in husbandry conditions, that the animals had encountered.

Results indicated that the data associated with the individual animals were fused successfully. Good relations within the data were discovered that propose designing a reliable control system based on these parameters.

The findings show that the automated individual animal tracking using transponders and merging their medical, health and environmental data allow improved animal control in large scale pig farming. Bringing these data together in real time allows immediate reaction on conditions potentially increasing animal welfare, productivity, and meat quality.

Keywords: pig barn, control system, climate control, individual animal tracking, transponder, pig value chain, meat quality, digitalization

SCIENTIFIC REVIEW REQUESTED

Solar-assisted heat recovery from milk refrigeration units

Alexander Loris[1], Sepehr Foroushani[2], Gunnar Lennermo[1], Manali Kulkarni[1], Joao Gomes[1], Thomas Amon[2,3]

[1] *MG Sustainable Engineering AB, Stationsgatan 23, 753 40 Uppsala, Sweden*
[2] *Engineering for Livestock Management, Leibniz Institute for Agricultural Engineering and Bioeconomy, 14469 Potsdam, Germany*
[3] *Institute of Animal Hygiene and Environmental Health, Department of Veterinary Medicine, Free University of Berlin, 14163 Berlin, Germany*

Abstract

Livestock farming is one of the most energy- and emission-intensive industrial sectors. The sector has therefore notable opportunities cost savings and decarbonisation through the reduction of fossil-fuel consumption. Given the large areas typically available in livestock farms for solar installations, solar energy in the form of electricity and/or heat is a promising alternative to fossil fuels. Some livestock applications such as swine farms tend to have large space heating demands, which enables effective use of low-grade solar heat. On dairy farm, on the other hand, thermal energy is mostly needed for heating the water used for cleaning and sanitization, requiring relatively high temperatures (~80°C), although there may be a smaller demand for space heating too (e.g. for offices buildings). In some cases, such as the pilot farm studied in the present work, the farm layout or other logistical considerations could pose challenges to the use of solar heat for space heating, especially if the technology is to be introduced in an existing farm. This paper presents an innovative design for the integration of solar-thermal energy with heat recovery systems that are conventionally used to recover low-grade heat from milk refrigeration systems. Combining solar energy with the waste heat available from milk refrigeration create the potential for meeting the high-temperature hot water demands of the farm and reducing reliance on fossil fuels.

The waste heat is used to preheat the grid water, which is then stored in a thermal storage tank. At times of high solar availability, solar heat can be used to further raise the temperature of the water in the storage tank, further reducing the need for non-renewable sources. In the case of hybrid photovoltaic thermal collectors (PVT), the solar electricity can be used to offset the electricity demand of electric boilers. Along with the design layout, a custom control strategy is presented to optimise the operation of the heat recovery and PVT systems and the respective storage tanks in order to maximise the water temperature and minimise electricity consumption. Given that the initial investment is the only major cost of the developed solution, it is expected that notable savings in the operating cost of the farm's water heating system can be achieved.

The proposed system will be installed and tested at the Leibniz Innovation Farm (*Leibniz-Innovationshof*) near Potsdam, Germany as part of the Horizon 2020 project RES4LIVE (Renewable Energy Sources for Livestock Management), where various renewable energy technologies are being adapted and tested to facilitate transitioning towards fossil fuel-free agriculture.

Conference topic: Circular Biobased Economy/Sustainable Energy/Waste Management

SCIENTIFIC REVIEW REQUESTED

Conversion of a diesel farm tractor to run on CNG

Mélanie Messieux[1], Daniela Touzé[1], Ronan Poupeau[1], Sepehr Foroushani[2], Thomas Amon[2,3]

[1] *CRMT Powertrain R&D, 3, Chemin de la Brocardière, 69570 Dardilly, France*
[2] *Engineering for Livestock Management, Leibniz Institute for Agricultural Engineering and Bioeconomy, 14469 Potsdam, Germany*
[3] *Institute of Animal Hygiene and Environmental Health, Department of Veterinary Medicine, Free University of Berlin, 14163 Berlin, Germany*

Abstract

Transition to lower-carbon energy sources is a priority in the agriculture sector's agenda for increased sustainability. Moreover, technologies that allow on-farm conversion of livestock manure and other agricultural waste to biogas and fuel-grade biomethane offer notable opportunities for enhanced circularity and energy independence. Nevertheless, farm tractors must be replaced or modified in order to utilize this opportunity. While compressed natural gas (CNG) tractors have been the subject of increasing interest from the industry with rapid developments in the recent years, little attention has been paid to retrofitting existing diesel tractors so they can run on CNG, including bio-methane produced on farm. The retrofitted tractor can offer a more cost-effective solution than a new CNG tractor, especially for a segment of the market where few alternatives to the conventional diesel tractor are available, namely small- and medium-sized tractors.

The present paper reports on the conversion of a conventional diesel tractor to run on CNG. The conversion entails the modification of the engine for gas combustion, adaptation of the cylinder head, modification of the pistons and reduction of the compression ratio, and addition of the spark plug. Furthermore, an engine control system is added to regulate combustion. A post-treatment system is also introduced to comply with the latest European standards for pollutant emission from non-road vehicles. Fuel tanks for storing CNG are added to the tractor. The retrofitted engine has been tested under Non-Road Mobile Machinery (NRMM) cycles. Starting in summer 2022, the retrofitted tractor will be tested and monitored at the Leibniz Innovation Farm (*Leibniz-Innovationshof*) near Potsdam, Germany. Biomethane produced on the farm will be used to fuel the tractor.

The work reported in this paper is part of the Horizon 2020 project RES4LIVE (Renewable Energy Sources for Livestock Management), where various renewable energy technologies are being adapted and tested to facilitate transitioning towards fossil fuel-free agriculture.

Conference topic: Tractors/Power Trains/Electrical Drives

SCIENTIFIC REVIEW REQUESTED

Design of an on-farm biomethane upgrading plant with hybrid compression and bio-CNG filling station

Lukas Wannasek[1], Sepehr Foroushani[1], Thomas Amon[1,2]

[1] *Engineering for Livestock Management, Leibniz Institute for Agricultural Engineering and Bioeconomy, 14469 Potsdam, Germany*
[2] *Institute of Animal Hygiene and Environmental Health, Department of Veterinary Medicine, Free University of Berlin, 14163 Berlin, Germany*

Abstract

The anaerobic digestion of manure, feed residues and agricultural by-products to produce biogas is a well-established technology. Small-scale biogas plants that use this technology are used especially on livestock farms, offering an effective waste management and renewable energy solution by processing the biogenic materials directly onsite. While the biogas thus produced on-farm is commonly used for power and heat generation (typically in combined heat and power plants), its further processing to fuel-grade biomethane is rare, mainly because the technology for small-scale plants is not readily available and the practice not economically attractive.

The present work seeks to address that gap by developing a modular biomethane upgrading plant for on-farm production of bio-CNG that can be used to replace fossil fuels, e.g. to power tractors. Part of the Horizon 2020 project RES4LIVE (Renewable Energy Sources for Livestock Management), where various renewable energy solutions are being developed for fossil fuel-free animal agriculture, this paper presents the design of a pilot bio-CNG plant for the Leibniz Innovation Farm (*Leibniz-Innovationshof*) near Potsdam, Germany.

The main challenge is to make the small pilot plant (production volume less than 10 m^3-biomethane per hour) economically competitive to larger commercial plant in terms of both of both capital and operating costs. As part of the efforts to reduce costs, a custom solution has been developed to replace the two conventional compression stages by a hybrid compression process. Thanks to the pressure and flow characteristics of a novel hollow-fiber membrane, the hybrid compression process allows the purification of biogas to biomethane and compression of biomethane to Bio-CNG (at up to 250 bar) in one single process.

Conference topic: Circular Biobased Economy/Sustainable Energy/Waste Management

Title:

A nested semi-mechanistic model to predict the temporal dynamics of ammonia emissions from a solid floor naturally ventilated dairy cattle building

Abstract:

National and international directives urge for a substantial reduction of airborne pollutants in order to limit climate change and protect the environment as well as the health of humans and animals. Ammonia, which is emitted predominately by the agricultural sector, is one of the most crucial substances in this context.

The estimation of emission rates from naturally ventilated housing systems can be realized based on two types of approaches: A top-down approach with intermittent volume flow and concentration measurements at the building scale to train regression models or a bottom-up approach to scale-up mechanistic modelling results. Both approaches have merits, drawbacks and uncertainties.

We investigated the potential of coupling different mechanistic modelling approaches towards an overarching barn scale ammonia emission model, which permits ammonia emission projections for naturally ventilated housing systems with minimal measurement efforts. As test case, a dataset with about ten months of on-farm measurements in a naturally ventilated dairy cattle building with scraped solid floor in Northern Germany is used. Data on climate and feed composition are included.

A sensitivity study indicated that particularly a refinement of the submodules for urine puddle alkalizing dynamics, urea concentration distribution, urination volume and timing, cleaning efficiency and local near-surface wind speeds have a great potential to further improve the overall model accuracy in order to capture seasonal and diurnal variability. Besides the discussion of the model sensitivity and uncertainties, we present a set of approaches for a cost-efficient estimation of crucial input parameters for the nested model and the refinement of the before mentioned submodules.

Authors:

- Dr. Sabrina Hempel, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Department Livestock Engineering, Max-Eyth-Allee 100, Potsdam, 14469, Germany; phone: ++49 331 5699 518; fax: ++49 331 5699 849; email: shempel@atb-potsdam.de

- Ms. Latifa Ouatahar, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Department Technology Assessment and Substance Cycle, Max-Eyth-Allee 100, Potsdam, 14469, Germany; phone: ++49 331 5699 519; fax: ++49 331 5699 849; email: louatahar@atb-potsdam.de

- Dr. David Janke, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Department Livestock Engineering, Max-Eyth-Allee 100, Potsdam, 14469, Germany; phone: ++49 331 5699 513; fax: ++49 331 5699 849; email: djanke@atb-potsdam.de

- Prof. Thomas Amon, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Department Livestock Engineering, Max-Eyth-Allee 100, Potsdam, 14469, Germany / Free University of Berlin, Institute of Animal Hygiene and Environmental Health, Department of Veterinary Medicine, Robert-von-Ostertag-Str. 7-13, Berlin, 14163, Germany; phone: ++49 331 5699 510; fax: ++49 331 5699 849; email: tamon@atb-potsdam.de

Presentation topic:

Precision Agriculture/Digitalisation

Abstract for an oral presentation in session Farm Buildings or Precision Agriculture/Digitalization

Development and validation of a low-cost online monitoring tool to manage barn climate and emissions from livestock housing systems

David Janke[1], Kobe Coorevits[2], Michael Bornwin[1], Philippe van Overbeke[2], Arnout Declerck[2], Peter Demeyer[2], Thomas Amon[1,4], Barbara Amon[1,3]

[1]*Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Max-Eyth-Allee 100, 14469 Potsdam, Germany, djanke@atb-potsdam.de*
[2]*Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Technology and Food Science Unit, Belgium*
[3]*University of Zielona Góra, Faculty of Civil Engineering, Architecture and Environmental Engineering, Licealna 9/9, 65-417 Zielona Góra, Poland Germany*
[4]*Freie Universität Berlin, Institute of Animal Hygiene and Environmental Health, Department of Veterinary Medicine, Robert-von-Ostertag-Str. 7-13, 14163 Berlin, Germany*

In dairy farming, the measurement of emissions of methane (CH4), carbon dioxide (CO2), and ammonia (NH3) requires the use of expensive gas analyzers and sampling devices. Thus, measurements are often limited to few scientific focus barns and not suitable for a broad application. In the FACCE ERA-GAS project MilKey, a low cow-cost online tool for monitoring Indoor barn climate and emission levels of air pollutants (OTICE) from naturally ventilated barns was developed to overcome this limitation.

OTICE consists of multiple nodes that are wirelessly connected with each other and spatially distributed inside the barn. Each node is equipped with low-cost sensors for CH4, NH3, CO2 and the climate variables temperature, relative humidity, pressure, and lux. The sensor nodes were tested in the lab under controlled and varied temperature and humidity conditions and with test gases for CO2, CH4 and NH3 under varied concentration levels. After these preliminary tests, OTICE was installed in two naturally ventilated dairy barns, one in Germany and one in Belgium. Gas concentrations for the estimation of emissions were measured in parallel with the low-cost sensor nodes and a reference method. The reference method was carried out following the quasi-standard of the VERA protocol. The validation measurements were conducted over a period of 6 months.

The reference measurements were used to assess and validate the OTICE system. Although deviances between the absolute values of OTICE and the reference measurements were clearly visible, the low-cost system is suitable as a proper trend monitoring system, which can be used for real-time monitoring purposes. In the talk, we will present results both for the lab validation and the on-farm validation in detail and give an overview on handling, acquisition costs, and further implementation of OTICE.

EurAgEng-Tagung

https://www.vdiconference.com/ageng/

Dr. Martin Geyer, Kotaiba Salama

Leibniz-Institut für Agrartechnik und Bioökonomie e.V., Abteilung Technik im Gartenbau
Max-Eyth-Allee 100
D-14469 Potsdam
Tel.: ++49 (0)331 5699-610
Fax.: ++49 (0)331 5699-849
Email: mgeyer@atb-potsdam.de

A procedure to recycle plastic film without polluting the environment in asparagus cultivation

The input of plastic into the environment is a huge ecological problem in horticultural production. Also in the cultivation of bleaching asparagus dams are covered with plastic films to facilitate the harvest. These asparagus covering films should be replaced after 7 to 8 years. In Germany alone, more than 2,500 tons of film with a length of 12.500 km must be disposed of annually, which is currently mainly thermally recycled. Large amounts of soil in the lateral film pockets (>80% of the total mass) impede the sustainable recycling of these films. Within the scope of the project presented here, together with a mechanical engineering company a machine is being developed that unwinds the film, opens lateral pockets filled with sand or soil, empties them, cleans and rewinds the film. From a labor management point of view, a two-phase workflow was chosen, as there is no free time for this work in summer. That is, the films are rolled up after harvest is completed, temporarily stored and cleaned in the fall or winter. This can be done directly on the farm or by contractors. In the trials carried out so far, cleaning efficiencies up to 85% have been achieved. This means that about 850 g of the approx. 1000 g of soil/dirt per running meter of film could be removed. At the same time, the input of micro and macroplastics into the environment should be prevented, i.e. no film residues should be released during the opening and shaking procedure. In order to verify this, the collected soil samples were sieved using different sizes of meshs, and then density separation is carried out in a higher density solution to separate the plastic pieces from soil particles. Depending on equipment settings and working speed, between 0.04 - 0.3 g of film particles per kg remain in the separated sand/soil mixture. Collected sand can be used to fill new film pockets. The operating principles and working results of the developed machine are presented and discussed.

Keywords: foil, plastic film, recycling, density separation, process development

Nicolas Schmid
John Deere GmbH & Co. KG
European Technology Innovation Center
Straßburger Allee 3, 67657 Kaiserslautern, Germany
Phone: +49 (0)1608484776
E-mail: schmidnicolas@johndeere.com

The Role of Business Model Innovation in the Context of Site-specific Weed Management

Broadcast application of herbicides is the common measure to control weeds in agricultural production systems. Increasing regulatory and public pressure, dramatic increase in herbicide resistant weeds combined with margin pressure is forcing the industry to rethink their current weed management strategies.

Heterogenous soil characteristics and applied management practices lead to patchy occurrence of weeds in agricultural productions systems. Targeted application, which address the field specific heterogeneity, offer the potential to reduce the amount of herbicides applied, increase sustainability while ensuring sufficient weed control success rates. In addition, need-based applications can contribute to better manage and prevent resistances. High resolution sensor technology, mounted on aerial or ground-based platforms, in combination with image-based machine learning techniques are required to separate weed from crop plants. While machine mounted approaches combine the detection of weeds and the actual application in one pass (online), offline approaches separate the tasks in two subsequent steps. Achievable saving potential is thereby correlated to in-field heterogeneity as well as sensing and application resolution. While economic, agronomic and ecological potential was proven, actual adoption rates of site-specific weed management technologies are still restrained. Besides technological readiness, the introduced tradeoff between high upfront investment costs and uncertainty regarding achievable saving potential, which makes calculation of return on investment difficult for customer, is perceived as significant adoption barrier. A similar phenomenon which also can be observed for other more advanced precision farming concepts such as variable rate application of nitrogen.

While in the past, Business Models of incumbent players evolved incrementally over time, radical innovations, such as real time weed sensing with spot spraying, require rethinking of existing mechanisms to create, deliver and capture value. If this complementary innovation dimension is not considered the value of the technology remain latent. Within traditional one-time-purchase models enterprises capture the value at the point of exchange and thereby transfer certain risk dimensions to the customer. The paradigm shift in innovative Business Models to value-in-use through recurring revenue streams or the focus on outcomes enable restructuring of the risk distribution between partners. This risk mitigation measure can accelerate market diffusion and thereby create a win-win situation for all involved stakeholders. In addition, unique value propositions enabled through innovations in different Business Model components can create competitive advantage even in a dynamic market environment. While Business Model Innovation is disrupting whole industry sectors, applications in the agricultural equipment sector are still limited.

This presentation will outline the potential contribution of Business Model Innovation within the adoption process of advanced precision farming technologies. Results from a Discrete Choice Experiment, conducted among a representative sample of arable customers in Western Europe, support the identification of utility drivers of different Business Model characteristics and their impact related to the adoption of online site-specific weed management technologies.

Influence of the temperature of storage on biogas production from dairy cows and fattening pigs' liquid manure

Authors: Julio E. Hilgert[1,2], Barbara Amon[2,3], Thomas Amon[1,2], Vitaly Belik[4], Federico Dragoni*[2], Christian Ammon[2], Aura Cardenas[2], Søren O. Petersen[5] and Christiane Herrmann[2]

[1]*Institute for Animal Hygiene and Environmental Health, Department of Veterinary Medicine, Freie Universität Berlin, Robert-von-Ostertag 7–13, 14163 Berlin, Germany* - Corresponding author: jhilgert@atb-potsdam.de

[2]*Leibniz Institute of Agricultural Engineering and Bioeconomy e.V. (ATB) Max-Eyth-Allee 100, 14469 Potsdam, Germany*

[3]*University of Zielona Góra, Faculty of Civil Engineering, Architecture and Environmental Engineering, Zielona Góra, Poland*

[4]*System Modeling Group, Institute for Veterinary Epidemiology and Biostatistics, Freie Universität Berlin, Königsweg 67, Berlin, DE*

[5]*Department of Agroecology, iClimate, Aarhus University, Blichers Allé 20, 8830 Tjele, Denmark*

*presenting author

It is common to have biogas facilities coupled with dairy cattle and fattening pig farms. In most cases, manure is stored for some time before being fed to the biogas digester. The manure stores are usually below the barn floor or outside and mostly uncovered, which makes them emitters of methane (CH_4) into the atmosphere. This work aims to experimentally quantify the losses of CH_4 during the storage of dairy and pig manure under different storage temperatures before it is fed to the biogas digester.

Dairy cows and fattening pig manure samples were collected from experimental farms. The samples were stored under strictly anaerobic conditions at 5 different and constant temperatures (5, 10, 15, 20, and 25°C) for 90 days. During this period, CH_4 emissions were measured by recording the produced gas volumes and methane concentrations within the gas. The chemical composition of the samples was determined before and after the storage in terms of dry matter, volatile solids, pH, and volatile fatty acids (VFAs) content. The fresh samples were analyzed in biochemical methane potential tests.

At temperatures above 10 °C, higher CH_4 emissions were observed, thus decreasing the biogas potential of the stored manure. The biogas potential of samples stored at 5 and 10°C is presumably not affected, since negligible CH_4 losses were observed during storage of dairy and pig manure, and the storage emissions can be neglected for both animal categories. Also, at storage temperatures above 10 °C, CH_4 emissions based on volatile solids were notably higher for pig manure than cow manure. This can be due to the accumulation of volatile fatty acids in cow manure that may decrease the methanogenic microorganisms' activity.

"MilKey" and "MELS": the role of information and communication technologies in mitigating emissions and increasing sustainability of livestock systems

Amon, B[1,2*]., Dragoni, F[1]., Cinar, G[1,5]., Díaz de Otálora, X[1,3]., Anestis, V[4]., Bartzanas, T[4].

[1]Leibniz Institute of Agricultural Engineering and Bioeconomy e.V. (ATB) Max-Eyth-Allee 100, 14469 Potsdam, Germany
[2]University of Zielona Góra, Faculty of Civil Engineering, Architecture and Environmental Engineering, Licealna 9, Zielona Góra, Poland.
[3]Basque Centre for Climate Change (BC3), Sarriena s/n, 48940 Leioa, Spain.
[4]Department of Natural Resources Management and Agricultural Engineering, Agricultural University of Athens, Iera Odos 75, 11855 Athens, Greece.
[5]Institute for Animal Hygiene and Environmental Health, Department of Veterinary Medicine, Freie Universität Berlin, Robert-von-Ostertag 7–13, 14163 Berlin, Germany

*Corresponding author: bamon@atb-potsdam.de

The global demand for animal products is expected to increase by 70% by 2050, undermining the efforts to minimize the environmental impacts of livestock production. In this regard, holistic and region-specific approaches are required to apply tailored mitigation strategies. Multicriteria sustainability assessments and whole system approaches can contribute to the reduction of negative environmental impacts while favoring economic profitability and social acceptance of livestock production. Nonetheless, a large amount of scientific evidence and data on the mitigation of environmental impacts of livestock systems under different management and climatic conditions is already available, although their impact at farm scale is often still limited. Thereby, MELS ("Mitigating Emissions from Livestock Systems", www.mels-project.eu) and MilKey ("Decision support system for sustainable and GHG optimized milk production in key European areas", www.milkey-project.eu) projects cooperate in designing more sustainable livestock systems and assisting farmers and stakeholders in the decision-making process, basing on scientific evidence from existing emission databases and whole farm-models.

To this end, information and communication technologies (ICT) such as decision support systems (DSS) and multi-actor online platforms will help farmers to choose tailored emission mitigation measures and check their effects on all three pillars of sustainability from a regional perspective. In detail, "MilKey" analyses the drivers and the sustainability aspects of dairy production systems (DPS) across Europe. A multicriteria sustainability assessment of case study farms is adopted to assess environmental, economic and social sustainability and identify interactions and emission mitigation potentials. As the main output of the project, the MilKey platform will assist dairy farmers in improving the sustainability of their production processes, by making knowledgeable decisions on sustainability concepts and assessing their consequences. In a follow-up project ("DairyMix"), the MilKey platform will be enhanced, including information on the sustainability of integrated crop-livestock systems (mixed farming for dairy production). On the other hand, "MELS" is drawing functional relationships between GHG and N emissions and activity/ancillary data (e.g. climate, housing system, manure management and characteristics) for dairy cattle, pigs and poultry, aiming to assess and recommend improvements to existing farm-scale DSSs in relation to GHG emissions. Stakeholders are engaged in developing a prototype farm-scale DSS for countries lacking such a tool, thus allowing the consequences of mitigation strategies on emissions and costs to be more accurately quantified and better documented.

In conclusion, providing relevant, accessible, and science-based information technology to stakeholders regarding emission mitigation and sustainability is key to design the livestock systems of the future, as improved knowledge and decision tools at farm scale will help the accuracy of emission inventories and the achievement of emission reduction targets at national level.

AI-based Tillage Job Quality Assessment for further Automation in Agriculture

Looking at the range of tasks a machine operator must carry out during field work, the overall work task can be divided into the subtasks "driving" and "controlling and monitoring the work process". In this paper, an approach for the automation of the subtask "controlling and monitoring the work process" is developed using the selected agronomic process cultivating as an example.

Agronomic job quality plays a major role in the automation of this subtask. A desired degree of coverage of crop residues or other biomass in the field is selected as agronomic job quality criterion for the work presented in this paper. The target value for the desired degree of residue coverage must be defined by humans.

Based on a systematic analysis of the overall work task of the person operating the agricultural machine during field work, a generic technical framework for the automation of the subtask "controlling and monitoring the work process" is developed.

The implementation of the developed generic technical framework requires a sensor system and a control concept to be developed. For the sensor system measuring the residue coverage, a monocular camera is selected. For image processing, a novel Deep Learning approach is developed. For automation, a cascaded control structure is developed. To provide robust behavior in critical situations, more functions are required than just the pure control loop. For example, a logic for handling significant concentrations of airborne dust is developed. Thus, a holistic concept for "behavior generation" for highly automated agricultural machinery is developed.

Finally, the developed Deep Learning models and the concept for behavior generation are successfully tested and verified in extensive field tests on different fields with different plant species.

Abstract submitted to conference topic: Precision Agriculture/Digitalization – no scientific review requested

Author:

M. Sc. Martin Schmidt
Software Engineer
John Deere GmbH & Co. KG, Mannheim
Phone: +49 173 6770705
E-Mail: schmidtmartinb@johndeere.com

Dipl.-Ing. Lukas Poppa – Research Assistant
Prof. Dr. Ludger Frerichs – Head of Institute
Institute of Mobile Machines and Commercial Vehicles, TU Braunschweig

M. Sc. Jintian Liu – Research Assistant
Prof. Dr.-Ing. Markus Böl – Head of Institute
Institute of Mechanics and Adaptronics, TU Braunschweig

Experimental method to analyse the black spot bruises of potato tuber flesh due to mechanical deformation

Proposition for a contribution to the International Conference AgEng-LAND.TECHNIK 2022

Particle simulation of agricultural harvesting processes enables broad opportunities to improve the performance of machines and reduce crop losses. With the commonly used Discrete Element Method (DEM), it is possible to get a deep insight in the potato handling process, aiming for process optimisation. The DEM technique relies on the calculation of contact forces and virtual deformations between the particles or between particles and machine parts. In order to integrate a model predicting mechanical damage of potato tuber into the DEM environment, the tissue discoloration responding to mechanical deformation needs to be analysed experimentally.

The planned contribution describes a method to analyse the formation of black spot bruises in potato tubers and to assess the absolute discoloration of the tuber tissue. With an illustration of the different causes for discoloration, we want to give a brief description of the chemical processes. In order to understand the influence of mechanical damage, a newly developed testing rig, with the ability to deform tuber tissue at controlled deformation and rates, was used. The deformation rates range from quasi-static 0,1 %/s to high dynamic 10.000 %/s of the specimen height. The strains range from low values of 20 % without rupture of the tissue to high values of 50 % with complete rupture and fluid loss. After loading, the specimen were stored inside of potato slices to achieve the natural ambient conditions for 48 hours and the discoloration was characterised with unloaded tuber tissue as the reference. The colour-metering device consists of a digital camera with controlled external lighting. The colour change was measured by comparing the colours of unloaded and loaded specimen. The correlation of mechanical strain and strain rate on the discoloration will be implemented as an extension in the DEM.

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Assignment to topic: 1.5 Plant Production Technologies
Scientific reviewing requested: Yes

Contact:
Dipl.-Ing. Lukas Poppa
Institute of Mobile Machines and Commercial Vehicles, Technische Universität Braunschweig
Langer Kamp 19a, 38106 Braunschweig
l.poppa@tu-braunschweig.de Tel.: 0531/391-2667 Fax: 0531/391-5951

Homogenization of belt drying of hops by controlling the supply air humidity using partial air recirculation

Dr.-Ing. J. Mellmann[1], Dr.-Ing. T. Ziegler[1], Dipl.-Ing. T. Teodorov[1],

Dipl.-Ing. R. Joachim[2], Dr. agr. T. Hoffmann[1], Prof. Dr. habil. B. Sturm[1,3]

[1)] Leibniz-Institut für Agrartechnik und Bioökonomie e.V. (ATB), Max-Eyth-Allee 100, D-14469 Potsdam,

[2)] HOOB GmbH, Kalkstrasse 2, D-04749 Ostrau OT Schrebitz

[3)] Humboldt Universität zu Berlin, Albrecht-Daniel-Thaer-Institut für Agrar-und Gartenbauwissenschaften, Hinter der Reinhardstrasse 8-18, D-10115 Berlin

E-Mail: jmellmann@atb-potsdam.de

Abstract

The growers of the Elbe-Saale Hop Growers' Association in Saxony, Saxony-Anhalt and Thuringia use Czech-design three-belt dryers of the PCHB-750 type for preserving their various hop varieties. These dryers are conventionally operated with fresh air, which is heated to the desired drying temperature in exhaust gas-air heat exchangers. The heat is provided by fuel oil-fired burners. The main disturbance variables of the drying process include the daytime fluctuations in temperature and humidity of the fresh air, in addition to other disturbance variables such as product changes (hop variety) and fluctuations in initial moisture content of the hop cones. Experience shows that the absolute humidity of the fresh air can vary by up to 40% around its daily mean value. In changeable weather (rain), the absolute air humidity can more than double or halve within hours.

As part of a research project, ATB developed an energy-optimized control concept for the belt dryer, which was tested at the drying plant of the hop cultivation company HOOB GmbH Ostrau. Part of this concept was the implementation of a partial air recirculation with the aim of controlling the absolute humidity of the supply air to a constant value over time. For the recirculation of part of the exhaust air, a recirculation duct with an integrated fan was set up prior to the harvesting campaign. The control of the recirculation fan via a frequency converter was implemented in the process control. This control concept was technically implemented and tested at the Schrebitz site in the 2021 harvest period.

As the results show in comparison with the actual state, the water content of the supply air could be set very stably with the new control concept to about 10 g/kg at a supply air temperatures of 65-70°C over the entire test period. The controlled supply air condition had a positive effect on the condition of the exhaust air after belt drying, which was much more constant compared to the measurements of the actual state. The controlled partial recirculation operation ultimately had a positive effect on the entire drying process. As a result of the more stable exhaust air condition over time, increasingly smaller fluctuations were observed in the moisture content of the hop cones after drying. The recirculation of energy-rich exhaust air (up to ¼) saved thermal energy in the order of up to 10%.

Abstract AgEng Berlin 22-23.11.2022

Title:

Individual on-barn assessment of the daily methane production rates of dairy cows by the Cubicle Hood Sampler: A validation study.

Authors:

ir. C.M. Levrault[1*], dr.ir. J. Dijkstra[3], MSc J.T. Eekelder[1], prof.dr.ir. P.W.G. Groot Koerkamp[1], dr. K. Nichols[3], ing. J.P.M. Ploegaert[2], dr.ir. N.W.M Ogink[1,2]

Affiliation:

[1] Farm Technology Group, P.O. Box 16, 6700 AA Wageningen University & Research, The Netherlands

[2] Livestock & Environment, P.O. Box 338, 6700 AH Wageningen University & Research, The Netherlands

[3] Animal Nutrition Group, P.O. Box 338, 6700 AH Wageningen University & Research, The Netherlands

[*] Corresponding author: cecile.levrault@wur.nl, +33622092065, Oude Kerkplein 38 6711 AZ Ede, The Netherlands

Abstract:

Over the past decades, the potent greenhouse gases emissions from cattle farming have kept rising, and alleviating the impact of the sector on the environment has become undeniably crucial. Whilst animal geneticists and nutritionist actively work on discovering lineages and rations that will allow to lower enteric methane emissions, the evaluation of the performance of these measures remains limited by the available assessment methods. Several devices have already been developed in an attempt to quantifying the individual methane production levels from dairy cows under barn conditions. Unfortunately, they often appear to be either inaccurate, laborious or expensive. The newly developed Cubicle Hood Sampler (CHS), however, could finally offer a way to compensate for this lack.

The principle of the CHS relies on the implementation of extraction hoods in the cubicles' structure, allowing to collect - in a non-intrusive manner - the gas mixtures produced by cows while lying down. Additional sensors allow each measurement to be assigned to a specific cow, permitting individual methane production rates (IMPR) to be calculated. Due to the physiological rhythm of cattle and the location of the system, individual monitoring of up to 12 hours per day can be achieved. To investigate the ability of the CHS to 1) assess IMPR, and 2) build a ranking index to select cows based on their methane production levels, the methane emissions of 28 lactating Holstein cows were monitored using, alternatively, individual respiration chambers (RC) (4 days) and CHS (1 week). Using a model developed by the authors, post-prandial IMPR were computed to convert discrete measurements into continuous methane production curves. Comparisons with the IMPR obtained with the RC show that variability between cows can be sensed by the CHS, and that parameters of the CHS-based model can be used to predict IMPR of the RC (adjusted R^2 = 0.492, p-value = 0.027). Overall, first results position the CHS as a promising system to monitor IMPR of cows.

Presentation topic: Animal Production Technologies (Scientific reviewing requested)

Title

Assessment of cutting quality on a combine harvester header using optical flow

Authors

Dekkers S.[1,3], Missotten B[2]., Saeys W.[1]

Address

[1]KU Leuven Department of Biosystems (BIOSYST), MeBioS division, Kasteelpark Arenberg 30, 3001 Leuven, Belgium

[2]CNH Industrial Belgium N.V., Léon Claeysstraat 3A, 8210 Zedelgem, Belgium

[3] sam.dekkers@kuleuven.be, +32 16 324 162

Abstract

The harvest of cereal crops is a complex process which consist of multiple steps ranging from the cutting and collection of stems to the separation of the grains from the chaff and straw. Thanks to improvements to the internal processes, the cutting system, separating the stems from the roots, has become a limiting factor for further capacity increases. Variation in stubble height has been proposed as a measure for the cutting quality, but its quantification is labour intensive and it does not provide insight in the causes of poor cutting quality. Therefore, there is a demand for a more detailed measurement that provides insight in the crop behaviour during cutting. In this study, it is hypothesized that a camera with an optical flow algorithm could be used to assess the cutting quality on a combine harvester header.

A cutting setup was elaborated and measurements were performed on dry winter wheat crop for driving velocities ranging from 4 to 12 km/h and crop densities between 222 and 888 stems/m². During these measurements, the crop movements were registered with a high speed camera at a framerate of 240 frames per second (fps). Next, an optical flow algorithm was applied to the acquired videos to extract the velocity fields in the imaged scene. With the use of a calibration pattern, the image velocity fields were translated to real world velocities of the crop flow. After each measurement, calibrated images of the stubble were acquired. The variation in stubble height was calculated from these images by an image processing algorithm. The algorithm extracted the stems based on the Hough transform line detection methodology, quantified the height of the individual stems and calculated the standard deviation per image.

The results from the stubble height measurements showed an increase in height variation at high driving velocities. A higher cut ratio defined as the reciprocal of the cutting velocity to the driving velocity, improved the cutting quality, in line with earlier studies. At a sufficiently high cut ratio (>1.0 at a density of 444 stems/m²), the stubble height variation remained rather constant.

The flow field of the crop showed incoming crop at the expected, constant velocity and decelerating crop around the knife. This deceleration was found to be a good indicator for the cutting quality, as it correlated well (R>75%) with the stubble height measurements. The flow field deceleration was found to be positively correlated with the feed rate and negatively correlated with the knife frequency.

While the variation in stubble height only gives a general measure for the cutting quality, the calculated flow field could provide more insight in the causes of the poor cutting quality. The straw movement prior and after cutting could have a large impact on the cutting process.

Presentation topic: Plant production technologies

Scientific reviewing requested: Yes

Electric tractors - Sustainable and Profitable?
Economic and environmental impact of autonomy and electric drivelines in agriculture

Authors: Oscar Lagnelöv* [1] (M.Sc.), Dr. Gunnar Larsson[1], Dr. Anders Larsolle[1], Prof. Per-Anders Hansson[1]
[1] Swedish University of Agricultural Science (SLU), Dept. of Energy and Technology, P.O Box 7032 SE-75007
*Corresponding author. Email adress: oscar.lagnelov@slu.se, Phone: +46(0)70-2217979
Presentation topic: Tractors/Power Trains/Electrical Drives

The European Union have set a goal to be carbon neutral by the year 2050 [1], an effort which include agricultural emissions. One proposed solution to these emission is electric vehicles which would enable renewable electric to be used instead of diesel [2-4] and might be a cost-effective way of reducing agricultural GHG emissions [5]. However, to enable broad market appeal and be considered interesting to farmers, these machine systems must be cost-competitive with current machine systems. Studies have been made on the economic impact of on-farm compact loaders [6], hybrid tractors [7, 8] and electric vehicles in specialized crops [9, 10], there are few studies on the economics of fully electric fieldwork machines in agricultural production. In order to gain a clearer understanding the economic and environmental effects needs to be studied in parallel.

This study used discrete-event simulation to study electric tractors and diesel tractors on a hypothetical grain farm of 200 ha in Uppland, Sweden. A conventional operation cycle for oats, barley, winter wheat and spring wheat was used. The economic and environmental impact was assessed, utilizing LCA [11] and annual cost of operations [12, 13] respectively. For the electric tractor, a machine system of two self-driving 50 kW tractors with 100 kWh NCA Li-ion batteries were assumed. The diesel tractor was modelled as a general contemporary 250 kW tractor, with both manned and self-driving modes considered.

Compared to the diesel tractor, the battery electric tractors was shown to have a higher impact during production in all studied environmental impact categories, with the battery being the main factor. When considering the entire life cycle, the electric tractors had a climate impact of 102 kg CO_{2eq} ha^{-1} yr^{-1} compared to 293 kg CO_{2eq} ha^{-1} yr^{-1} for the diesel tractor, a decrease of 65%. When considering the total impact by weighing and summarizing 18 different impact categories to a single score according to the ReCiPe methodology [14], the electric tractor system reduced the total impact with 72% compared to the diesel tractor. Both these reductions were mainly due to the more energy efficient driveline and the lower impact of the fuel for the electric tractors.

The annual cost for the tractors were calculated, including investment cost, capital costs, charging infrastructure construction, fuel, operator costs, maintenance and timeliness. The manned diesel tractor had a cost of 528 € ha^{-1} yr^{-1} and the self-driving diesel tractor 450 € ha^{-1} yr^{-1}, while the electric tractors had an annual cost of 429 € ha^{-1} yr^{-1}. The autonomous electric tractors reduced the costs for fuel (-66%), maintenance (-28%) and operator (59%, compared to manned diesel tractor). The other impactful cost categories (annuity and timeliness) were of similar magnitude, resulting in an overall cost reduction with the electric tractor system.

For both systems the fuel was the main deciding factor for climate impact, with diesel and Swedish marginal electricity mix (41% natural gas, 35% wind power & 24% woody biomass) used respectively. A change in fuel had a greater effect than any other factor in the study. The change of fuel and driveline was also the main driver behind the cost reduction, as electric tractors were shown to have a lower annual cost compared to even self-driving diesel tractors, showing that electrification of agricultural fieldwork can provide benefits both economically and environmentally.

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Investigation of the vertical distribution of ammonia, methane, and carbon dioxide in a naturally ventilated dairy barn

Harsh Sahu[1], David Janke[1], Thomas Amon[1,2], Sabrina Hempel[1]

[1]*Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Max-Eyth-Allee 100, 14469 Potsdam, Germany, hsahu@atb-potsdam.de*
[2]*Universität Berlin, Institute of Animal Hygiene and Environmental Health, Department of Veterinary Medicine, Robert-von-Ostertag-Str. 7-13, 14163 Berlin, Germany*

Abstract: The determination of emissions and ventilation rates from naturally ventilated barns (NVB) is widely acknowledged as challenging due to its structure, especially the large vents at the sides that allow environmental interference inside and around the barn. When measuring emission fluxes directly at these large vents, a high number of sensors for velocity and gas concentrations is needed. In order to achieve the highest possible accuracy with the least usage of sensors, it is requisite to study the spatial distribution of the gases and find an optimal gas sampling position. We studied the influence of the sampling height on the gas concentrations which were measured at the outlet of an NVB, taking the wind direction and wind speed into account. A high-frequency Fourier-transform-infrared spectrometer was employed to measure gas concentrations (CO_2, CH_4, and NH_3) at six different heights from the ground and an ultrasonic anemometer to estimate wind flow characteristics. Gas concentrations were measured every 3 minutes at each height over a period of two months. We found that the mean gas concentrations were significantly different at each height under most wind flow conditions. However, under straight cross-flow conditions, there were no significant differences in CO_2 and CH_4 concentrations at the middle (1.5 m, 1.8 m) and bottom (0.6 m) heights. The gas concentrations, especially NH_3, were highest at the top height (2.7 m), almost under all wind flow conditions. The outcomes of the presented study will be useful for the design of optimized gas sampling set ups for the direct measurement of emissions from large naturally ventilated barns.

Detection of ripening class of banana in postharvest condition analysing intensity retrieved from reconstructed 3D LiDAR point cloud

Kowshik Kumar Saha[1,2] and Manuela Zude-Sasse[2,*]

[1]Technische Universität Berlin, Chair of Agromechatronics, Straße des 17. Juni 135, 10623 Berlin, Germany
[2]Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Department of Horticultural Engineering, Max-Eyth-Allee 100, 14469 Potsdam, Germany; ksaha@atb-potsdam.de; mzude@atb-potsdam.de
[*]Correspondence: mzude@atb-potsdam.de; Tel.: +49 (0)331 5699 612

Presentation topic: Precision Agriculture/Digitalisation

Abstract

Destructive or manual visual detection of ripeness of fresh fruits such as banana are used extensively by farm managers, in the packing house, during transportation, by ripening managers and traders although those techniques are inefficient and subjective. Non-destructive technique such as spectroscopy in the visible wavelength range can detect the chlorophyll pigment content in the fruit's peel, which can objectively indicate the ripening class of the fruit. However, spectroscopy involves high cost and skilled labour, not feasible for commercial banana growing or marketing levels. Therefore, non-contact and fast detection technique of ripeness stage has increasing demand in the postharvest handling sector. Advancement of light detection and ranging (LiDAR) laser scanning technologies enables to reconstruct 3D digital model of object including its backscattered intensity information. In this study, banana fruit intensity of laser returns at 660 nm wavelength were extracted from reconstructed banana point cloud. Recorded intensity information was calibrated using the standard lowest and highest flat panels. Calibrated intensity information were subjected to correction process considering the surface curvature of banana. Subsequently, same area of interest were segmented from all the banana point clouds (n = 27). Segmented point clouds were subsampled by applying 1 mm × 1 mm voxel grid and mean intensity was calculated for each grid point, so that same number of points were obtained from each fruit. Intensity histogram curves of banana fruit were produced from the frequencies of intensity values. As reference data, chemical analysis was performed to determine the chlorophyll content of the banana samples. Intensity histogram data was utilized for building calibration model using partial least squares discriminant analysis (PLS-DA) to predict the chlorophyll content and related ripeness classes. According to the analysis result, the histogram patterns were found sensitive to the ripening class of the banana samples. The PLS-DA calibration model was cross-validated with leave-one-out approach. Finally, a confusion matrix was generated between true and predicted ripening classes of the banana samples. The overall classification accuracy was found as 75 %. In conclusion, the proposed approach of banana ripeness classification using LiDAR laser scanning was confirmed, and may be applicable on commercial scale.

smart traction – design and experimental set up of a track and traction-regulated caterpillar-track chassis for agricultural tractor-trailer combinations

Sascha Groß-Hardt, M.Sc.,

University of Applied Science Osnabrück, Faculty of Agricultural Sciences and Landscape Architecture, Am Krümpel 31, 49090 Osnabrück, Phone: 0541 969 5167, sascha.gross-hardt@hs-osnabrueck.de

Prof. Dr.-Ing. **Hubert Korte**,

University of Applied Science Osnabrück, Faculty of Agricultural Sciences and Landscape Architecture, Am Krümpel 31, 49090 Osnabrück, Phone: 0541 969 5174, h.a.korte@hs-osnabrueck.de

Topic: Plant Production Technologies

Note: scientific reviewing requested

Abstract

Large and heavy agricultural machines are not only a challenge for public roads (narrow paths/roads, damage to the road bank, social acceptance…), but to a greater degree, there is a necessity on the field for the chassis to interact as gently as possible with the soil, limiting unnecessary damage. A consistent focus on more soil protection, as prescribed, for example, by the Fertiliser Act in Germany and in other parts of Europe, requires further development of existing chassis concepts for the application of fertiliser to agricultural land. Modern caterpillar tracks are a space-saving means of realising large footprints whilst minimising ground pressure, provided the design of the chassis distributes the loads homogeneously across the area. However, when used in crops or on grassland, a large contact area is not always a positive feature. During cornering, shearing forces act and cause shearing of the topsoil and the crop. This destroys the structure of the soil and either inhibits or completely prevents plant growth. To minimise this disadvantage, a new caterpillar-track chassis concept has been developed, which in addition to the possibility of realising a variety of driving or steering strategies (true-to-track/track-shifted/unsteered), also generates a traction boost through its own drive. Changing application techniques cause a change in the centre of gravity on the slurry tanker and therefore inevitably affect the drawbar loads. To always ensure a positive drawbar load, the chassis can be fixed in five positions in the longitudinal direction of the vehicle. To validate the prototype, tests are being carried out under scientific conditions by the Osnabrück University of Applied Sciences (Department of Agricultural Engineering) against a benchmark of a wheeled chassis on grassland. The assumption here is that most stock and field damage is expected

on grassland. Deep ruts and/or sheared-off swards reduce the working quality of the subsequently used machines and lead to forage losses and lower forage quality. In the first series of tests, primarily agricultural parameters are examined in-situ on various soils in grassland. In a final analysis, laboratory-based research will be carried out to determine the actual risk of soil compaction.

The analysis of the combined impact of data based and parametric uncertainty on the prediction of greenhouse electricity demand

H.J. Payne[1], E.J. van Henten[1] and S. van Mourik[1]

[1]Farm Technology Group, Wageningen University, Wageningen, The Netherlands

Correspond author: Henry Payne, tel: +31 626694762, email: henry.payne@wur.nl

The Dutch greenhouse horticulture sector is large and uses a significant amount of electricity annually. Due to climate change it is increasingly important to minimize the greenhouse's electricity demand. In greenhouse horticulture, computer aided electricity management is done using mathematical models of the greenhouse and weather forecasts to predict the greenhouses future energy demand. These predictions are however vulnerable to uncertainty in the parameters of the models and errors in the weather forecasts. This study proposes a case study to investigate the absolute and relative impacts of model parameter and weather forecast based uncertainty on the predicted greenhouse electricity demand. This assessment allows for the targeted improvement of prediction uncertainty and subsequent energy management of the greenhouse sector.

This study assesses the impact on prediction uncertainty by sampling error distributions of the greenhouse model parameters and weather forecasts using a Monte Carlo method. This is done for the parametric and data based distributions both individually and in combination to asses their relative impacts on electricity demand prediction uncertainty. A global sensitivity analysis is then done by deriving the Sobol sensitivity indices from a meta-model that is fitted to the sampled input and output data.

This study has concluded that the key factors in creating prediction uncertainty is the parameter related to the lamp light intensity, creating 32% of the prediction uncertainty. In addition the radiation forecasts error mean and standard deviation create 42% and 26% of the prediction uncertainty respectively. As a result improvements in electricity prediction can be made by improving the accuracy of the parameterization of the greenhouse lighting module and the targeted improvement of the radiation forecasting.

This abstract is submitted to the following presentation topics:

- Circular Biobased Economy/Sustainable Energy/Waste Management
- Precision Agriculture/Digitalization

Topic: Post-Harvest Technologies

Extrusion of lignocellulosic residues from agriculture and agroforestry into fibre for peat replacement and pellets for animal bedding

Ralf Pecenka[1], Christian Dittrich[1], Carsten Lühr[1], Alev Kir[2], Federico Righi[3], Anne-Kristin Løes[4], Ulrich Schmutz[5]

[1] Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Potsdam, Germany
[2] Ministry of Agriculture and Forestry, Olive Research Institute, Izmir, Turkey
[3] University of Parma (UNPIR), Parma, Italy
[4] Norwegian Centre for Organic Agriculture (NORSØK), Tingvoll, Norway
[5] Centre for Agroecology, Water and Resilience, Coventry University, Coventry, UK

Corresponding author: Ralf Pecenka, Phone +49 331 5699 312, e-mail: rpecenka@atb-potsdam.de

Objective, Materials and Methods

Phasing out peat as substrate in horticulture is planned in the EU for the year 2030. Furthermore, re-wetting of drained peatland poses new challenges for farmers and innovative solutions for the use of grassy biomass from wetland are needed. The aim of this study was to develop resource and energy efficient technologies to produce fibres for peat replacement from various underutilised lignocellulosic plant materials from agriculture such as biomass from wetland, agroforestry and pruning. Different technologies for fibre production have been investigated at ATB in the recent years. These investigations have shown that a twin-screw extruder (Fig. 1 and 2), modified for processing of wood and woody residues from agriculture and forestry, can be efficiently used to produce fibres for different technical applications in agriculture and industry (e.g. as peat substitute, insulation material for building industry, reinforcement of composites). The technology is available in pilot scale at ATB and investigated in detail for the production of fibres for peat replacement and pellets for animal bedding in organic agriculture in the EU project Organic-Plus. The different agricultural raw materials have very different properties, which have an effect on the processed fibres and their quality. The energy demand for the extrusion process is a key factor for the economy of the whole fibre production process. Furthermore, particle size distribution and water holding capacity (WHC) of the fibres produced are an important measures for the fibre properties and their possible fields of application in agriculture.

Results and Conclusions

The investigation has shown that a large number of agricultural and forest residues can be processed to fibre in a twin-screw extruder with reasonable expenditure of energy. Depending on the raw material and process parameters these fibres reach WHCs which enable them to be used as a peat substitute in growing media or for production of pellets for animal bedding. The WHC of peat (82%) could not be achieved with any of the examined materials (Fig. 3). However, when compared with other natural fibre like coir, already commonly used as a peat substitute, materials like extruded sage and forest biomass are able to compete. The WHC of cattail (32%) grown on re-wetted peatland showed to be comparably low. However, different options for raw material specific process modifications still need to be investigated and ongoing investigations with other biomass from wetlands such as reed canary grass or sedges already showed promising results.

For the anticipated substitution of peat in growing media this research proved that the investigated process can be used to produce fibrous materials which, have a strong potential for replacing peat with focus on the physical properties. However, the extrusion process is very energy-intensive, so that raw material-specific process optimizations should be carried out as part of future investigations for cost-effective fibre production.

Figure 1: Open twin-screw extruder with material inside (left), whole extruder opened (right) at ATB

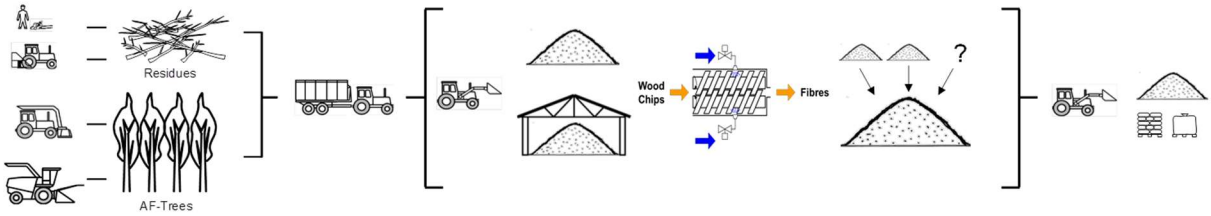

Figure 2: Process chain of lignocellulosic materials from agriculture/ forest residues to fibres

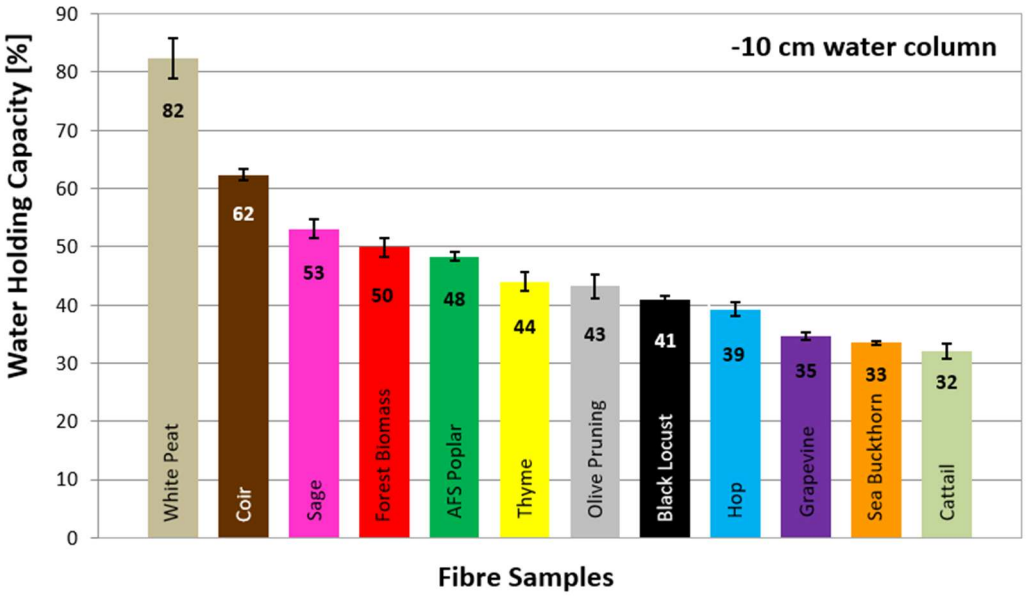

Figure 3: Water holding capacity WHC at -10 cm (-1 kPa suction tension, EN 13041) water column and standard deviation as a function of raw material, which was extruded at a 20 mm aperture.

Analysis of Combine Harvester Threshing Systems Across Different Climate Regions

Mohamed Altaleb * [a,b], Henning Deeken [a,b], Burkhard Wrenger [c], Joachim Hertzberg [a]

[a] Osnabrück University, Institute of Computer Science, Wachsbleiche 27, 49090 Osnabrück

[b] CLAAS E-Systems GmbH, Advanced Engineering, Sommerkämpen 11, 49201 Dissen am Teutoburger Wald

[c] Ostwestfalen-Lippe University of Applied Sciences and Arts, Environmental Engineering and Applied Computer Science, An der Wilhelmshöhe 44, 37671 Höxter

* mohamed.altaleb@claas.com

Problem Statement

In any combine harvester, improving the settings optimization (i.e. giving better initial settings and improving the optimization process during the harvest) requires a better understanding of the settings transitions through different environmental conditions, such as soil, weather, terrain, climatic conditions, and more. The combine harvester settings are monitored and configured by an optimization system or by an operator. In either case, the optimum settings correlate with the harvesting conditions. Therefore it is expected that different sets of settings will be nominated for different harvesting conditions independent of whether the optimization is done manually or automatically.

Data mining can help to further develop the optimization process based on big data by identifying set of environmental parameters that affect or correlate with the harvesting process. This allows providing a dynamic recommendation for the combine harvester settings not only based on crop type and moisture conditions but also based on additional process-related variables such as crop maturity level, soil conditions, etc. It also enables the optimization system to consider those variables to provide better settings as the machine will understand the relationship between machine settings and environmental conditions. As climate already implicitly includes many environmental aspects, this paper investigates whether the climate shows correlation with the threshing system parameters in the combine harvesters.

Method

The analysis was performed in two steps: a descriptive analysis and an inferential analysis. The objective of the descriptive analysis is to obtain insights into the data and summarize the dataset. The inferential analysis concludes whether the observations are statistically significant. The analysis checks whether the different sample groups that are collected in different climate regions are sampled from the same population. If that is the case, the operators of the combine harvesters have selected similar settings in different climate regions. Otherwise, it means that we have a different behavior for the settings selection of the threshing system.

The data used in the analysis belongs to CLAAS combine harvesters equipped with telemetry system. The system sends machine and quality parameters. The machines are middle size combine harvesters with the same manufacturing model. All the combines harvested wheat in different years, seasons, countries, and machines. In order to have comparable data and to minimize the effect of aspects other than climate, a set of criteria are introduced under three levels: machine-related (e.g. APS hybrid threshing system), operator-related (e.g. optimization system for cleaning and separation), region-related (e.g. different climate regions and countries). In the full paper, we will further discuss how data preparation relates to machine settings, crop type, and GPS validation. The climate is a complex system studied by different scientific fields. Therefore many climatic models exist. In our paper, the Köppen model is used to sort our data into distinct regions. The dataset contains three distinct climate regions.

The focus in the analysis is on the threshing drum speed and concave position. The settings in the combine harvester have dependencies not only on the environmental conditions, but also between each other, e.g. the threshing drum speed relates to the concave position and moisture conditions. Therefore, the analysis respects the multivariate aspect.

Results

The descriptive analysis shows that we have different distributions for the threshing system parameters. The distributions show different peaks in different locations in the histograms among the different climatic regions. The threshing drum speed was plotted against the concave position in the heat map. It shows that different combinations were often selected in different climatic regions. Regarding the inferential analysis, the Kolmogorov-Smirnov test was used to check that the difference is statistically significant. In order to verify whether the threshing system shows behavioral differences within the different climate regions, it is needed to show that the data were sampled from different populations. The test showed that the samples are coming from different populations, so this indicates that the threshing system parameters were selected differently among the climatic regions.

Conclusions

The analysis reveals correlations between climate and machine settings, which can be used as an additional decision variable to provide better configuration for the machine. The threshing system shows a different behavior in settings selection among different climate regions. The climate consists of many environmental aspect where weather is one of it. The results indicate that the weather might be a topic of our future work.

The climate correlation does not mean that the climate is a single causal factor. The reason behind the correlation might lie in weather conditions, terrain structure, differences in cultivation practice and harvesting strategies, or all these factors together. However, there might be further reasons not listed in this paper.

Process-based modelling approaches for integral assessment of the impact of feeding managment on greenhouse gas and nitrogen emissions in dairy production systems

Latifa Ouatahar[124], [4]Gary Lanigan, [3]André Bannink, [4]Dominika Kroll, [12]Thomas Amon, [25]Barbara Amon

[1]Institute for Animal Hygiene and Animal Health, Department of Veterinary Medicine, Freie Universität Berlin, Berlin, Robert-von-Ostertag 7–13, 14163 Berlin, Germany; louatahar@atb-potsdam.de

[2]Technology Assessment and Substance Cycles, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Max-Eyth-Allee 100, 14469 Potsdam, Germany

[3]Animal Nutrition, Wageningen University & Research, PO Box 338, 6700AH, Wageningen, Netherlands

[4]Environment, Soils and Land-Use, Teagasc, Johnstown Castle, Co. Wexford. Y35 Y521, Ireland

[5]Faculty of Civil Engineering, Architecture and Environmental Engineering, University of Zielona Góra, Zielona Góra, Poland.

Feed management decisions are crucial elements in managing greenhouse gas (GHG) and nitrogen (N) emissions from livestock farming systems. Statistical and empirical models are well suited for assessing practical applications of mitigation strategies, such as GHG calculator tools for farmers and for inventory purposes. Process-oriented simulation models can provide greater insight into the impact of biotic and abiotic drivers on GHG and N emissions. These models are based on equations that mathematically describe processes such as fermentation, aerobic and anaerobic digestion, nitrification and denitrification, etc. and require a great number of input parameters (such as climate data, animal data, detailed feeding data, soil and crop data). Using a cascade of process-oriented models (or their results) that simulate the variation in GHG and N emissions and the associated total farm budget represents a valuable method to describe the underlying processes within the system and their drivers, and to assess the overall impact of different mitigation options on GHG and N emissions. This latter method hasn't been used yet. Therefore, this study aims to describe how to implement this approach from animal to field level using a set of process-oriented models (i.e. Dutch tier 3 model, Manure DNDC model, and DNDC model) and describe the steps of the modelling process. Various well-monitored case study farms in Europe and New Zealand ranging between grazing, and confinement systems, were assessed using this method and compared to estimate the changes encountered in the carbon (C) footprints of the two systems. Animal simulation results showed significant differences between process-oriented model results and current generic emission factors used in national inventories.

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[1]Institute for Animal Hygiene and Animal Health, Department of Veterinary Medicine, Freie Universität Berlin, Berlin, Robert-von-Ostertag 7–13, 14163 Berlin, Germany; louatahar@atb-potsdam.de

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[3]Animal Nutrition, Wageningen University & Research, PO Box 338, 6700AH, Wageningen, Netherlands

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Evaluation of particulate matter concentrations by crop cultivation in reclaimed land

Seong-Won Lee , Il-Hwan Seo

ABSTRACT

Saemangeum is reclaimed land with developing 29,100 ha of land and 11,800 ha from fresh lake located in Korea. The soil in Saemangeum has a dry surface characteristic with a low moisture content ratio due to salinity and silt nature, hence the vegetation cover is low compared to other areas. Due to these soil properties, the exposed land area is large and fugitive dust from the exposed land disperses to nearby areas. Fugitive dust can be reduced by spraying water, using windbreak or vegetation cover. Vegetation cover methods in Saemangeum include growing halophytes or cultivating salt-tolerant crops. 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, the purpose of this study is to analyze the effect of suppressing the generation of fine dust and scattering dust by cultivating winter forage crops on the Saemangeum reclaimed land. While growing 0.5 ha of barley, 0.5 ha of potato and 0.5 ha of triticale in Saemangeum reclaimed land, the concentration of fine dust was monitored according to agricultural work and growth stage. Changes in the concentrations of PM-10, PM-2.5, and PM-1.0 were monitored from March 2020 to June 2021 on the leeward, the windward and centering on the crop field. As a result of monitoring, In the early stage of crop growth, the concentrations of PM-10 increased by 5% in barley (0.1m canopy) and potato (0.05m canopy),the concentrations of PM-2.5 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.

Key words: Cultivation, Particulate matter, Reclaimed land, Vegetation cover, Winter forage crops

Monitoring of workers' particulate matter exposure concentration in broiler houses

Hyo jae-Seo[a], Il hwan-Seo[b]

ABSTRACT

With the raise use of forced ventilation system application in broiler house, workers' PM(particulate matter) and harmful gases exposure have been increasing. Forced ventilated broiler houses have a closed environment in order to maintain a suitable internal environment for broiler growth. Broiler workers are exposed to organic dust originated from animal manure, feathers, feeds, ground beds during movement, shipment operation, dead animal sorting, feeding and drinking machine maintenance. Therefore, the health status and working environment exposed to workers should be considered inside broiler houses. It is necessary to secure basic data on PM concentrations in order to set up dust reduction and health safety plans.

To identify the PM concentration of working environment in forced ventilation broiler house, the PM concentrations were monitored in terms of PM distribution by broiler house location, PM concentration and particle size by animal activity. The concentrations distribution of TSP, PM-10 and PM-2.5 were measured at three points along the length direction from the inlet to the outlet ventilation openings. PM concentration and particle size monitoring by animal activity was measured using real-time optical particle counter.

The concentrations of particulate matter were high near outlet vent comparing to inlet. And the average dust concentrations showed TSP 1,426 $\mu g/m^3$, PM-10 1,056 $\mu g/m^3$, and PM-2.5 161 $\mu g/m^3$ respectively. According to workers' movement the animal activity increased and hence TSP about 2 times, PM-10 1.93 times, PM-2.5 1.59 times increased respectively. Field monitoring results showed that the ventilation system and animal activity are closely related to particulate matter concentration.

Keywords: Broiler house, Particulate matter, Field monitoring, Working environment

[a] Graduate Student, Jeonbuk National University, College of Agriculture & Life Sciences, Department of Rural Construction Engineering, Jeonju 54896, Korea

[b] Professor, Jeonbuk National University, College of Agriculture & Life Sciences, Department of Rural Construction Engineering, Jeonju 54896, Korea

Analysis of mixing efficiency by structural factors of livestocks manure compositing machine using DEM

Byung wook - Oh[1], Il hwan-Seo[2]

ABSTRACT

As Korean consumer's eating habits changed, meat consumption incresed and the number of livestock increased. As a result, the amount of livestock maure has also increased. Livestock manure has 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 many problems such as odor, lack of sedimentary area and difficulty to envioronment control. Vertical composting machine has advantages such as easy odor treatment, sufficient amount of sedimentation, and a suitable environment for composting. However, there is no clear design standard for vertical composting machine. Perfect compost requires a uniform and proper temperature distribution. Uniform mixing of manure in composting machine is affected by the structural factors such as number, length, angle of blades. Due to problems like huge scale, environmental difficulties, it is difficult to evaluate the mixing efficiency of composting machine by field monitoring. So, we conducted a study using discrete element method simulation. This study analyzes the mixing efficiency according to the structural factors of vertical composting machine and presentes pressure and impact load at blades. We determined the sutable rotational speed for the composting machine by performing the speed independence test of blades. The DEM simulation model was varified through field experiment. Using the developed model, we analyzed the mixing efficiency according to various combinations of structural factors. As a result, the length of blades, angle and number of blades respectively had the graeatest effcet on the mixing efficiency. Since the load on the blade can cause breakage and failure, collision and pressure load were also analyzed. Finally, we present the improved blade design of vertical composting machine.

Keyword : DEM, Vertical composting machine, Manure, Mixing efficiency

[1] Ph.D course, Jeonbuk National University, College of Agriculture & Life Sciences, Department of Rural Construction Engineering, Jeonju 54896, Korea

[2] Professor, Jeonbuk National University, College of Agriculture & Life Sciences, Department of Rural Construction Engineering, Jeonju 54896, Korea

A CFD study on ventilation and micro-environment distribution in Tomato greenhouse-complex located on Korea reclaimed land

Anthony Kintu. K, Hyo-Jae Seo, Il-Hwan Seo

ABSTRACT

Korean government has recently declared a development plan to establish large-scale greenhouse-complexes on reclaimed lands. However, the reclaimed lands are characterized by coastal colder weather and higher velocities of dry wind masses compared to inland conditions. To propose appropriate internal micro-environment control methods for greenhouses built under such unique conditions, field experimentations have been widely used. Field experiments however are not only limited in time consumption and labor requirement but also technically prone to natural changes in environmental conditions, limited measuring points and not economically feasible for large scale studies. As a remedy to these limitations, CFD (Computational Fluid Dynamics) simulations have been adopted in previous studies to study micro-environment inside greenhouses built on reclaimed lands. While these studies have been focused on single small-scale greenhouses, their findings don't seem relevant to developing micro- environment control strategies for large scale greenhouses within a complex setup. This is due to the large structural size, presence of obstacle to natural environmental flow into individual greenhouses and large volume of crop canopy in individual large-scale greenhouses within a complex.

The purpose of this study therefore is to develop a CFD model to visualize and predict natural ventilation and spatial distribution of micro-environment inside multiple large-scale greenhouses within a Tomato greenhouse complex, for winter and summer seasons. Reclaimed land weather data analysis results showed no specific wind direction and hence 3 major wind directions (0,45,90 degrees) were chosen for the study. The model parameters are based on a 0.1ha Venlo greenhouse located on Gyehwa reclaimed land, scaled-up to 2ha as the reference greenhouse for the model. Sixteen 2ha identical greenhouse models are oriented to form a 32ha greenhouse complex for this study. ANSYS fluent R20 is used for the model solution, as a multi-phase, 3D transient model with TGD (Tracer Gas Decay) method for ventilation simulation.

The study results will be used as basis for design of ventilation and micro-environment control systems for greenhouse complexes built on Korean reclaimed lands. Further studies to couple the effect of crop canopy sensible and latent heat (transpiration) into the current model, and optimize the gaps between individual greenhouses within the complex for optimal natural environmental flow is are required.

Key words: ***Greenhouse complex, Micro-environment, reclaimed land, Natural ventilation, computational Fluid Dynamics***

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TITLE: UNSPOKEN MISAPPLICATION: MICRO-AGRONOMICS AND VISUAL FALLACY OF AGRICULTURAL SPRAYING

AUTHOR: GARRETT MAURER, DIRECTOR OF PRODUCT, INTELLIGENT AGRICULTURAL SOLUTIONS

1810 NDSU RESEARCH CIRCLE N, FARGO, ND 58102

701.551.3562, GMAURER@INTELLIGENTAG.COM

ASSIGNMENT: PRECISION AGRICULTURE/DIGITALIZATION

ABSTRACT

Farmers do not know how their sprayer performs. This benign, and unintentional, ignorance leads to the misapplication of active ingredients in all aspects of agricultural spraying. Incorrect spraying leads to worsened pest management, increased weed resistance, and the need for further control and restriction of pesticides. Agricultural sprayers cost hundreds of thousands of dollars and all their value is generated in the two-inch space between the nozzle body and spray tip, yet there is no way to understand if each of those points is correctly applying their active ingredient.

Research and academia have historically focused their study on two important issues: (1) droplet efficacy on a single plant, and (2) overall active ingredient (AI) rates across the width of a sprayer boom. These studies miss a critical juncture for pesticide application; how nozzle variability and machine operation imperfections affect the micro-agronomic efficacy of the AI.

We performed our own multi-year field plot studies on the micro-agronomic impact of spray variability on a per nozzle basis. Our studies indicate that a single blocked nozzle within a test boom of six nozzles showed a 25.9% increase in identified weeds three weeks after a pre-emergence pesticide application. In a post-emergence test in soybeans, we found a 128% increase in weeds two weeks after application.

Contrary to often accepted industries narratives, every nozzle has an impact on the overall performance and efficacy in a spray operation, and small changes in the performance of an individual nozzle can have a significant impact on the AI's ability to control pests and/or enhance yields. The performance of every nozzle on a spray boom is significant, and we present an innovative sensor system for individual nozzle monitoring.

Plant Protection, Efficacy, Nozzle Monitoring

Impact of Microbial Load Reduction with Magnetic Field and Blanching on Selected Vitamins of Sweet Pepper

Michael Mayokun Odewole[1*] and Ayoola Patrick Olalusi[2]

1 Department of Food Engineering, Faculty of Engineering and Technology, University of Ilorin, Ilorin, Nigeria;

2. Department of Agricultural and Environmental Engineering, Federal University of Technology Akure, Nigeria.

Email: *odewole.mm@unilorin.edu.ng

Abstract: The conventional method of reducing or eradicating food microbes is through heat addition (thermal method), however, this approach has deleterious effect on food nutrients, most especially, the heat sensitive nutrients. A promising non-thermal method is the use of magnetic field, but the method is not so popular and information on its use in food processing is scanty and not readily available. Therefore, the objective of this study was to investigate the effect of three types of magnetic fields (static, pulse and alternating); magnetic field strength (5 - 30 mT) and pretreatment time (5 - 25 min) on the microbial load-Total Viable Count (TVC) of sweet pepper (SP). Design Expert software was used to design the experiment. Blanching pretreatment was used as the control. After the pretreatment, all samples were analyzed for microbial load. Results showed that MF pretreatment (a non-thermal method) at some combinations of pretreatment factors reduced the microbial load (TVC) of SP better than blanching. The lowest values of microbial load obtained for SP is 1.0×10^5 CFU/ml for MF pretreatment and 1.5×10^5 CFU/ml for blanched samples respectively. Also, magnetic field pretreatment significantly retained vitamins C and A than blanching at many combinations of MF pretreatment factors that gave higher values of microbial load above blanched and fresh samples of SP. The use of stronger magnetic field strength for more effective pretreatment and optimization of the process should be given consideration in future research. .

Keywords: Magnetic field; Microbial load (TVC); Blanching; Sweet pepper, Vitamins

Precimed: a simulation model for nutrient uptake prediction of a hydroponic cucumber crop grown in the Mediterranean region

Nikolaos Katsoulas*, Sofia Faliagka, Anastasia Bari

Laboratory of Agricultural Constructions and Environmental Control, Department of Agriculture Crop Production and Rural Environment, University of Thessaly, Fytokou Street, 38446 Volos Magnesia, Greece

*Correspondence: nkatsoul@uth.gr; Tel.: +30-24210-93249

Abstract

The Precimed simulation model was developed to improve water and nutrient use efficiency in a hydroponic greenhouse in the Mediterranean region, promoting precision agriculture for better resource management. The model takes into account several climatic inputs such as the daily maximum and minimum temperature and solar radiation and simulates the crop dry matter production and crop transpiration. Then, considering an optimal dry mater nutrient content, the optimal nutrients' content in the dry matter and the nutrients absorption concentration, the optimal ion (NO_3^-, K^+, PO_3^-, Ca^{2+}, and Mg^{2+}) concentration in the fertigation nutrient solution that has to be supplied to the plants is estimated. The model was evaluated in a hydroponic greenhouse cultivated with an autumn-winter cucumber crop grown on perlite slabs. Two fertigation treatments were applied: (a) a conventional one, where the plants were fertigated with a nutrient solution where nutrients concentration was almost constant during the cultivation period, as followed by the growers in the region and (b) a nutrient solution where the nutrients concentration varied in a weekly basis according to the weather prediction and crop dry matter production. To assess the effectiveness of the model, measurements of crop dry mater production, macronutrients concentration in the dry matter, water and nutrients consumption and of crop yield were performed. The results of the assessment showed that the application of such a model could result in more than 50% reduction of macronutrients use while reducing productivity by 8%. The ultimate purpose of this work is to provide the end-users a tool that will estimate in a weekly basis the optimal composition of the irrigation nutrient solution based on the growth stage of the crop and the weather conditions, as an alternative to the current practice where the composition of the nutrient solution changes about two to three times during the growth period. The work is carried out in the frame of the PRECIMED project that is funded by the General Secretariat for Research and Technology of the Ministry of Development and Investments of Greece under the PRIMA Programme. PRIMA is an Art.185 initiative supported and co-funded under Horizon 2020, the European Union's Programme for Research and Innovation. Project Acronym/Code: "PRECIMEDPrima2018-09". Project application number: 155331/I4/19.09.18.

Keywords: precision fertigation; dry matter production; nutrient uptake; productivity; nutrient consumption

Abstract for AgEng-LAND.TECHNIK 2022

Uncertainty estimation in deep-learning based plumage condition assessment for laying hens

Christian Lamping, Marjolein Derks, Peter Groot Koerkamp, Gert Kootstra
Farm Technology Group, Wageningen University & Research, 6700 AA Wageningen, The Netherlands

Modern livestock industry strongly focuses on efficiency, which resulted in increased automation in laying hen farms, like automated feeding and climate systems. However, health status of hens is usually observed and checked manually by the farmer. Regarding the large number of animals in modern farms, this is labor intensive and can lead to a lack of care for the individual. Therefore, reliable monitoring of health and welfare parameters such as plumage condition cannot be guaranteed.
To address this challenge, we developed ChickenNet, an end-to-end convolutional neural network that detects hens and simultaneously predicts a plumage condition score for each detected hen. Using this approach, we obtained a mean average precision (mAP) of 98.02% for hen detection while up to 91.83% of the plumage condition scores were predicted correctly.
However, the uncontrolled environmental conditions of commercial laying hen farms can influence the assessment performance of ChickenNet. Due to multiple factors, such as occlusions, motion blur, or the pose of the animal, not all assessments made by the network are reliable. Therefore, we additionally address the ability to deal with these variability factors by estimating the uncertainty of plumage condition assessments in an end-to-end fashion. Our method is able to successfully quantify uncertainty while distinguishing between model- and input-dependent uncertainties. We also identified a high correlation of the error in plumage conditions assessments and the estimated uncertainties. Further, we evaluated the performance of ChickenNet on images from a practical farm environment while rejecting samples that were classified as highly uncertain.

Simulation of Ca and K concentrations in the nutrient solution of an aquaponic system

Nikolaos Katsoulas[1*], Maria Aslanidou[1], Vangelis Vassiliadis[2], Angeliki Elvanidi[1], Anastasia Mourantian[1], Efi Levizou[1], Elena Mente[3]

[1]University of Thessaly, Dept. of Agriculture Crop Production and Rural Environment, Fytokou Str., 38446, Volos, Greece

2 Agrostis SA, A. Tritsi 21 B, Pylaia, 57001, Thessaloniki, Greece

[3]University of Thessaly, Dept. of Ichthyology and Aquatic Environment, Fytokou Str., 38446, Volos, Greece

*Correspondence: nkatsoul@uth.gr; Tel.: +30-24210-93249

Abstract

The application of aquaponic systems is closely related to the question if nutrient demand of crops can be covered by fish effluents. In this study, the flow of potassium and calcium macronutrients into a pilot-scale aquaponic system was studied. For this purpose, a simulation model was developed to assess the concentration of macronutrients in the main parts of the system. The main parts of the system are the fish tanks and the main aquaculture system buffer tank, the hydroponic head and the crop fertigation solution tank, the crop substrate, and the crop drainage tank. To validate the simulation model, measurements were performed in the pilot aquaponic system of the University of Thessaly in Volos, Greece. Basil plants were irrigated with fish effluent from tilapia after pH adjustment. The drainage solution from the crop was returned to the aquaculture system so that the system was completely closed. The measured nutrient concentrations were compared with the corresponding simulated data. The model predicted with fair accuracy the potassium and calcium concentrations for the total experimental period. The model is extended to the rest of the macronutrients sot that is could be finally used for the design and management of aquaponic systems. This research is co-financed 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, project acronym: FoodOASIS)

Keywords: aquaponic system; model; tilapia; nutrient solution; basil; aquaponics design

A digital shadow to study the convective drying of carrot slices

Jörg Schemminger [1, 2, 3]* Sharvari Raut [2], Barbara Sturm [2,3], Thijs Defraeye [1]

[1] Empa, Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Biomimetic Membranes and Textiles, Lerchenfeldstrasse 5, CH-9014 St. Gallen, Switzerland

[2] Leibniz-Institut für Agrartechnik und Bioökonomie e.V. (ATB), Max-Eyth Allee 100, 14469 Potsdam, Germany

[3] Humboldt-Universität zu Berlin, Faculty of Life Sciences, Albrecht Daniel Thaer-Institute of Agricultural and Horticultural Sciences, Hinter der Reinhardtsstrasse 6–8, 10115 Berlin, Germany

The optimization of food drying processes is strongly dependent on the behavior of different product quality characteristics during drying. Variability in raw product properties – such as composition, geometry, and initial moisture content – have an impact on these quality characteristics and are therefore important to consider. Digital shadows show a way to understand this variability and its influence on final product quality: a physics-based model of the product is linked to the real drying process by continuously updated measurement data.

In experimental investigations of carrot quality characteristics such as the carotenoid content, variability is always present: differences between batches, between cultivars, growing areas, cultivation practices, and other factors. If these products are to be dried, further variability affecting factors are introduced before the drying process by pre-processing methods such as mechanical treatment by peeling and cutting, but also by thermal and chemical pretreatments. As a consequence, each piece of material entering the drying process has different properties: their different behavior during the complex interactions in drying processes must be taken into account when optimizing quality preservation and energy consumption.

In this study, we show the influence of the raw material variability during convective drying by varying the thickness of carrot slices as well as the initial carotenoid content and investigating the resulting final total carotenoid content, the required drying time, and how these results are distributed. The results show that producing products with a predefined, narrow distribution of high quality during convective drying is made more difficult by the variability in raw material properties. The evolving dynamic process parameter control approach must therefore take into account not only changing raw product characteristics, but also their distribution. In order to determine the order of importance of the investigated influencing factors, the results of the study show how strong their influence is on the final product inhomogeneity. Digital shadows show the possibility to simulate relationships between the variability in raw material properties and those of final product metrics such as quality determining ingredient content and drying time. These real-world linked digital models are therefore a suitable tool for optimization of drying processes – provided distributions of input parameters are considered. The use of digital shadows will contribute to shift from current rigid trial-and-error approaches to a product-focused method that enables to design and control drying processes in an energy efficient and best product quality manner.

* Corresponding author: joerg.schemminger@empa.ch (J.Schemminger) Empa, Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Biomimetic Membranes and Textiles, Lerchenfeldstrasse 5, CH-9014 St. Gallen, Switzerland

IoT platform challenges, planning, and implementation for the Leibniz Innovation Farm (InnoHof)

Anderson, J. M.[1], Foroushani, S.[1], Hansen, A.[1], Hoffmann, G.[1], Ilte, T.[1], Janke, D.[1], Senft, M.[2,1], Shamshiri, R.[1], Sturm, B.[1], and Weltzien, C.[1,3]

[1]Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)

[2]Julius Kühn-Institut (JKI)

[3]Technische Universität Berlin, Chair of Agromechatronics

The Leibniz Innovation Farm (InnoHof) will develop and test leading-edge concepts and technologies for a sustainable, circular bioeconomy with various elements such as crop production, animal husbandry, research biorefinery, algae cultivation, insect rearing, natural fiber processing, production of biochemicals, and residue management through an on-site biogas plant. It will additionally focus on the transfer of technology and knowledge to farmers and the communication of modern, sustainable agriculture practices and biomass production to consumers. InnoHof will extend, diversify, and digitize an existing agricultural farm in Groß Kreutz, Germany, and be managed by the Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB) in cooperation with numerous industrial and research partners.

In order to enable modern research methods and measurement techniques for the numerous studies that will be carried out by the InnoHof scientists and farmers, a comprehensive Internet of Things (IoT) system will be developed, including

- widely-distributed sensor networks for automated and manually-controlled, mobile and stationary equipment for status detection (soil, plant, insect, animal, environmental conditions, biodiversity, and so on),
- still, spectral, and video systems using fixed and equipment-mounted (including drone) cameras,
- realtime monitoring of barn climate and animal welfare,
- specific farm equipment and implements for precision agriculture and on-farm field experiments,
- robotics and Global Navigation Satellite System technology for automation of new plant production techniques,
- communication and IT infrastructure for field monitoring stations as well as high-bandwidth and reliable site connectivity,
- highly extensible computing and storage resources on site to securely store and process petabyte-scale data,
- modern virtualisation solutions to react flexibly and effectively to changing and rapidly growing requirements in storage and computing,
- traditional and AI-based methods for data analysis,
- implementation of digital twins based on sensor inputs to monitor, simulate, and control sundry farming, processing, and renewable energy systems, and
- a comprehensive data management system to handle manual and automated ingestion of data, control access rights for proprietary data, ensure FAIR (findable, accessible, interoperable, reusable) data principles, and simplify steps needed to publish datasets in order to enhance use and reuse of data and maximize scientific output.

The InnoHof farm has a land area of approximately 950 ha, with scattered fields located at distances up to about 10 km from the main research station in Groß Kreutz, presenting challenges for designing and implementing an IT infrastructure plan for a continuous, realtime sensor network. A feasibility study to determine the necessary usage requirements is currently underway. As InnoHof is planned to be a flexible research infrastructure, providing facilities for new research projects and open to new collaboration partners in the future, the InnoHof IoT infrastructure will be designed to be scalable, accepting changing sensor configurations and ever-increasing requirements for data storage and processing.

We present here a status report on the IoT platform design and implementation.

Performance evaluation of newly developed ethylene scavengers for applications in packaging of fruit and vegetables

Namrata Pathak, Pramod V. Mahajan

Department of Horticultural Engineering, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Potsdam, Germany

E-mail: npathak@atb-potsdam.de (Namrata Pathak); pmahajan@atb-potsdam.de (Pramod V. Mahajan)

Ethylene scavengers are being increasingly used in fruit and vegetables industry to remove ethylene, a plant-ripening hormone biosynthesized by fruit and vegetables, which can accelerate the ripening of fresh produce leading to shorter shelf life. In this study, different ethylene scavengers, such as zeolites, potassium permanganate, titanium dioxide and palladium, were investigated for their efficacy in ethylene removal before and after incorporation into paper or polymer films. Paper coated with potassium permanganate decreased ethylene but could not eliminate it completely. Titanium dioxide- palladium coated paper was effective in ethylene removal only under ultraviolet radiation. Furthermore, a comparative analysis of the developed polymer films was done with three commercially available ethylene-scavenging films namely, Peak fresh (Peakfresh Products Pty Ltd, Australia), Keep it Fresh (Keep it Fresh, CA, USA), and PrimePro® (DeltaTRAK, Inc., USA) under different temperatures (5 and 20 °C) and humidity conditions (0, 50, 100 %). These materials were put inside air-tight jars (0.25 L), and an initial ethylene concentration was injected (5 ppm). Air samples were drawn at regular intervals to determine the ethylene concentration with respect to time. Most ethylene-scavenging polymer films showed minimal ethylene removal. Furthermore, the impact of ethylene scavenging, using these materials, on the fruit quality of different products was analyzed. These materials could reduce ethylene concentrations in low ethylene producing commodities but may not be suitable for high ethylene producing fruits. The study showed that humidity severely impacted the performance of many scavengers. Scavengers inside sachets showed the best performance, whereas incorporation into films limited their ethylene absorption potential. Potassium permanganate in sachets showed the best results. Overall, this study presents an outlook on using such commercial products in fruit and vegetable packaging.

Assignment to specific presentation topic : Post-Harvest Technologies

The Effect of Diffuse Film Covers on the Development of Cucumber Fungal Diseases in a Mediterranean Greenhouse

Ávalos-Sánchez E.[1], Moreno-Teruel M.A.*[1,2], López-Martínez A.[1], Molina-Aiz F.D.[1], Baptista F.[2] Valera D.L.[1]

[1] CIAMBITAL (Centro de Investigación en Agrosistemas Intensivos Mediterráneos y Biotecnología Agroalimentaria), University of Almería, Ctra. Sacramento s/n, 04120 Almería, Spain.

[2] MED—Instituto Mediterrâneo para a Agricultura, Ambiente e Desenvolvimento, Departamento de Engenharia Rural, Escola de Ciências e Tecnologia, University of Évora, 7000-849 Évora, Portugal

* Corresponding author. Email: mamorenoteruel@ual.es

Abstract

The aim of this work was to analyse the effect of an experimental film greenhouse cover, with high transmittance and great light diffusivity, on the development of fungal diseases on a cucumber crop (*Cucumis sativus* L). The study was carried out in a Mediterranean greenhouse (Almería, Spain), in two different season (September-December 2020 and September-December 2021). The experimental multi-span greenhouse was divided in two sectors (by a polyethylene sheet): (i) East sector was covered with a commercial film (transmittance of 85% and diffusivity of 60%); (ii) West sector was covered with an experimental film (transmittance of 90% and diffusivity of 55%). The study evaluated the development of cucumber fungal diseases using the European and Mediterranean Plant Protection Organization (EPPO) regulation methods (PP 1/57 and PP 1/65). The development of three diseases was analysed: downy mildew (*Pseudoperonospora cubensis*), powdery mildew (*Podosphaera fuliginia*), and *Mycosphaerella melonis*. For these three diseases, a greater development were observed in the greenhouse sector covered with the commercial film, which less light transmission. Powdery mildew was the disease that showed the greatest development in the two years of study, with the greatest differences of incidence between both sectors of the greenhouse. In comparison with the areas covered with the commercial film, plants under the experimental film showed (with statistically significant differences): (i) an important powdery mildew reduction up to 50 %, (ii) a reduction of 30% for downey mildew and (iii) a reduction of around 25% for *Mycosphaerrella*.

Keywords: Sunlight transmissivity film, protected crop, plastic greenhouses, visible spectrum diffusion, fungal infection.

Numerical and Experimental Analysis of the Stomatal Resistance of a Tomato Crop in Almería (Spain)

Moreno-Teruel M.A.*[1,2], Molina-Aiz F.D.[1], Baptista F.[2], Valera-Martínez D.L.[1], López-Martínez A.[1]

[1] CIAMBITAL (Centro de Investigación en Agrosistemas Intensivos Mediterráneos y Biotecnología Agroalimentaria), University of Almería, Ctra. Sacramento s/n, 04120 Almería, Spain.

[2] MED—Instituto Mediterrâneo para a Agricultura, Ambiente e Desenvolvimento, Departamento de Engenharia Rural, Escola de Ciências e Tecnologia, University of Évora, 7000-849 Évora, Portugal

* Corresponding author. Email: mamorenoteruel@ual.es

Abstract

The present work was developed with the aim of comparing the stomatal resistance measured with the stomatal resistances estimated through models based on climatic data in a tomato crop (*Solanum lycopersicum* L.). The experimental work was carried out during a spring-summer cycle (transplant date December 23, 2019) in a multispans greenhouse of 1800 m^2 of the Center for Innovation and Technology Transfer "Fundación Ual-Anecoop" (Almería). In two sectors (East and West) of the greenhouse, temperature and relative humidity sensors of the indoor air at 1 m and 2 m height were installed, as well as sensors for the measurement of solar and PAR radiation. To compare the calculated values of the stomatal resistance of the crop, stomatal conductance measurements were made with a portable photosynthesis analyzer in 12 tomato plants distributed in the west and east sector, making a total of 100 means. From the measurement of climatic parameters inside the greenhouse, the stomatal resistance was calculated using several models for tomato crops in the greenhouse. None of the existing models (multiplicative or polynomial) allows an adequate adjustment to the experimental data. This is due to the great variability of the data measured, with stomatal resistance values ranging from 126 to 674 s m^{-1}, corresponding to solar radiation values at leaf level from 42 to 513 W m^{-2}, vapour pressure deficit values between 9.6 and 22.2 hPa and CO_2 concentrations of 388-580 ppm.

Keyword: greenhouse, stomatal resistance model, tomato, radiation, temperature.

Impact of packaging film thickness and perforation size on ethylene accumulation inside the fruit package

Akshay Sonawane, Namrata Pathak, Pramod Mahajan*

Department of Horticultural Engineering, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Max-Eyth-Allee 100, 14469 Potsdam, Germany.

Correspondence: Dr. Pramod Mahajan (PMahajan@atb-potsdam.de)

Abstract:

Ethylene is a ripening hormone, biosynthesized by fruit and vegetables that can accumulate inside the package and accelerate ripening in fresh produce which, in turn, affects its shelf life. Ethylene accumulation inside the package and transmission through the packaging plays a vital role in determining the ethylene concentration inside the fresh produce package. Several investigations describing the movement of oxygen and carbon dioxide in modified atmosphere packaging have been studied previously; however, there is a lack of studies on the ethylene accumulation and transmission rate through perforated packaging, considering the interference of oxygen and carbon dioxide. Therefore, this study evaluates the impact of packaging film thickness and perforation size on ethylene accumulation inside a package containing ethylene-producing fruit. The experimental setup included a cylindrical container (2.4 L) fitted with polypropylene on the top, having a single perforation, and avocado (high ethylene-producing fruit) was kept inside it. Ethylene transmission through perforated packaging film was measured as a function of film thickness (20, 25, and 30 μm) and perforation size (50 to 800 μm). Ethylene production by fruit and accumulation inside the package and transmission through perforation were also measured and modeled into differential equations. The matlab coding was developed to integrate different mass balance equations and solved to simulate ethylene evolution inside the package.

Keywords: Packaging; ethylene; transmission rate; perforation; modeling.

The Effect of Diffuse Films Covers on Yield, Fruit Quality and Photosyntesis Activity of Cucumber (*Cucumis sativus* L.) Crop

Moreno-Teruel M.A.*[1,2], Molina-Aiz F.D.[1], López-Martínez A.[1,] Valera-Martínez D.L.[1], Baptista F.[2], E. Ávalos-Sánchez[1]

[1] CIAMBITAL (Centro de Investigación en Agrosistemas Intensivos Mediterráneos y Biotecnología Agroalimentaria), University of Almería, Ctra. Sacramento s/n, 04120 Almería, Spain.

[2] MED—Instituto Mediterrâneo para a Agricultura, Ambiente e Desenvolvimento, Departamento de Engenharia Rural, Escola de Ciências e Tecnologia, University of Évora, 7000-849 Évora, Portugal

* Corresponding author. Email: mamorenoteruel@ual.es

Abstract

The aim of this study was to evaluate the effect of two plastic greenhouse covering films (experimental and commercial) with high transmittance and light diffusivity on the yield, fruit quality and photosynthetic activity of a cucumber crop (*Cucumis sativus* L.). The study was carried out during an autumn-winter cycle in a multispan greenhouse of the Innovation and Technology Transfer Center "Fundación Ual-Anecoop" (Almería). The five-spans greenhouse was divided transversely into two similar compartments (sectors). In the East sector a commercial film was installed (transmittance of 85% and diffusivity of 60%) and in the West sector an experimental film (transmittance of 90% and diffusivity of 55%). The results show an increase in marketable yield of 0.47 kg/m^2 in the West sector of the greenhouse with the experimental film, representing an increase of 4.9% compared to the commercial film. The photosynthetic activity measured in the leaves was 8.4% higher in the plants under the cover with the experimental plastic, but without statistical significance. The average values were 13.7 µmol CO_2 m^{-2} s^{-1} inside the West sector with the experimental film and 12.5 µmol CO_2 m^{-2} s^{-1} in the East sector with the commercial plastic. Although, fruits weight and equatorial diameter were greater in the East sector under the influence of commercial plastic cover, no significant statistical differences were observed for any of the fruit's quality parameters analysed.

Keywords: greenhouse; cucumber crop; diffuse film; yield; photosynthetic activity

A dynamic heat pump model for precise environment control of a broiler house in Northern Greece

D. Tyris[1], A. Gkountas[2], P. Bakalis[2], P. Panagakis[1], D. Manolakos[1]
[1] Agricultural University of Athens, Iera Odos 75, 11855, Athens
[2]THERMODRAFT IKE, Vasiladiou & Mikalis 6, 18540, Piraeus

Abstract

Environment control in broiler houses aims at achieving maximum flock performance and optimal growth rate, while at the same time ensuring health and welfare conditions for the broilers housed. Broilers are homeothermic animals and need to maintain their body temperature at constant levels. Temperatures outside the Thermoneutral Zone have a negative effect on broiler performance by reducing body weight gain and feed efficiency, deteriorating health and increasing mortality. In this framework, among others, heating and cooling play an important role. The most widespread systems used to achieve thermal comfort (Liquefied Petroleum Gas (LPG) heaters, mixing fans and evaporative cooling panels) use electricity or fossil fuels as energy sources, in most cases, and they are neither efficient nor renewable, contributing to the increase of Greenhouse Gases (GHG) from livestock operations, while they cannot always provide optimal comfort conditions, in terms of indoor temperature and relative humidity.

The heat pump HVAC technology can regulate the indoor environment conditions continuously within the desired set-point limits, as these are determined by the optimal growth curves of broilers. This is achieved by appropriately combining the operation modes of heating, cooling, humidification, dehumidification, and reheating. Heat pump has been considered a high-cost technology for environmental control in animal housing compared to the conventional technologies, but recent advancements have led to radical improvement of coefficients of performance (COPs), making the technology worthy to investigate. Moreover, heat pumps are fully aligned with EU directive for energy efficiency and nearly Zero Energy Buildings (nZEBs) as a Renewable Energy Source (RES).

The current study presents an analytical numerical tool developed in Simulink/ Simscape environment, to simulate the thermal loads of 10,000 broilers' house at the area of Kavala (Northern Greece), and the dynamic operation of three heat pumps aiming to cover the heating, cooling, and dehumidifying needs of the building. The estimation of thermal loads took into consideration the geographical location of the facility (outdoor temperature, relative humidity, and solar irradiance), the birds' heat production, as well as all the heat exchange mechanisms with the external environment (conduction, convection, radiation). The developed model simulates different production periods, based on a typical meteorological year. The study showed the cooling needs exceed the heating needs, while the COP may reach up to 3.8. The model is also capable of calculation the total electrical energy consumption based on the operating time of each heat pump.

PRESENTATION TOPIC:

- Farm Buildings

Thermodynamic modeling of a Biomass Organic Rankine Cycle for sustainable heat and power cogeneration in greenhouses

A. Gkountas[1], P. Bakalis[1], D. Tyris[2], D. Manolakos[2]

[1]Psyctotherm, Chrisostomou Smirnis 70-72, 18540, Piraeus

[2]Agricultural University of Athens, Iera Odos 75, 11855, Athens

ABSTRACT

Greenhouses play a key role in modern agricultural production and have been widely researched in terms of thermal energy use, depending on the product cultivation requirements and the climatic conditions of the region. The heating needs of a greenhouse may rise up to 60% of its total operating cost, leading to increased product pricing. In parallel, the raw biomass, consisting a renewable energy source that may be used as beneficial fuel for power generation cycles, remains unexploited in most Mediterranean case studies. As far as technologies are concerned, combined heat and power (CHP) systems consist a sustainable solution and may be implemented, leading to improved agricultural products, reduced energy costs and less carbon dioxide emissions.

An experimental facility has been developed at Agricultural University of Athens (Greece), aiming to explore a combined heat and power (CHP) system based on the technology of Organic Rankine Cycle (ORC), using as fuel the raw biomass for greenhouses. The main objectives of this experimental project are the design and selection of the individual components and their integration in a complete CHP-ORC system for a capacity of 200 kWth and power generation of 20 kWe, covering the heating needs of a greenhouse area of 1,000 m^2.

A steam boiler is considered as the system's main heat source, heating the steam up to 130^{o}C, while an ORC uses the hot steam as evaporation medium, providing heat to the greenhouse at about 50^{o}C. The working refrigerants under consideration are R245fa and new-generation refrigerants used as alternatives for this fluid, R1233zd(E) and R1224yd(Z).

Furthermore, the projects goals to develop and the demonstrate the robustness of this system and test its function in real environment, operating in full and part load and investigating the control modules. This paper describes the numerical assessment preceded the development of the system's experimental facility and signifies the lessons learnt from the components specification. The final results of the project are going to enhance the use and efficient management of residual biomass as primary energy source.

PRESENTATION TOPIC:

Circular Biobased Economy/Sustainable Energy/Waste Management

Non-destructive detection of Fusarium head blight in wheat kernels and wheat flour using Vis-NIR and mid-infrared spectroscopy

Muhammad Baraa Almoujahed[1], Dr. Aravind Krishnaswamy Rangarajan[1], Prof. Abdul M. Mouazen[1]*

[1] Department of Environment, Faculty of Bioscience Engineering, Ghent University, 9000 Ghent, Belgium;

Mhdbaraa.almoujahed@UGent.be; Aravind.KrishnaswamyRangarajan@UGent.be.

* Correspondence: Abdul.Mouazen@UGent.be; Tel + 32 9 264 6106; Fax + 32 9 264 6247

Presentation topic: Precision Agriculture/Digitalisation

Abstract:

Fusarium head blight (FHB) is one of the most severe fungal diseases that affect cereal crops. Aside from reducing production, FHB degrades grain quality by infection with mycotoxins, which are harmful to human and animal health. Despite the use of fungicides, full disease eradication in the field is nearly impossible. The major approaches for detecting FHB presence are chemical and biological methods, although while being extremely accurate, these procedures are destructive and laborious. Hence, a non-destructive, accurate, and robust method is required for FHB detection at post-harvest. The purpose of this study is a comparative analysis between the visible near-infrared (at the range of 400 to 1700 nm), and the mid-infrared spectrophotometers (at the spectral range of 4000 – 400 cm^{-1}), to predict the infection of wheat kernels and flour at the post-harvest. Hundred and three samples (93 infected, and 10 healthy) were collected from winter wheat, the kernels were extracted and scanned then grinded to flour. The collected spectral library was subjected to two different machine learning algorithms, namely, a support vector machine (SVM) and an artificial neural network (ANN). The results suggest that it is possible to detect FHB in wheat kernel and flour samples in the Vis-NIR bands and the mid-infrared bands with high accuracy. Furthermore, for SVM test accuracy, the kernel showed higher accuracy compared to the flour with 87.7 % and 91.7 % for vis-NIR and MIR, respectively. While the lowest accuracy was observed for the flour with 69.3 % and 71.4 % for vis NIR, and MIR, respectively. Unlike the SVM, the accuracy for the ANN model was roughly the same for the kernel and flour in the vis-NIR range with 96.4 % and 96.3 %, respectively. The findings suggest the use of spectrophotometers as a quick approach for classifying infected wheat kernels and flour at post-harvest, although the performance of machine learning models for FHB prediction was better for spectral data from the wheat kernels than the flour.

Title: Underground Sensing Probes for Precision Agriculture

Authors: David Sousa, Ruben Moutinho, Carlos Resende, João Oliveira, Antonio Oliveira-Jr, Waldir Moreira - {david.sousa, ruben.moutinho, carlos.resende, joao.oliveira, antonio.junior, waldir.junior}@fraunhofer.pt
Fraunhofer Portugal AICOS, Rua Alfredo Allen 455/461, 4200-135, Porto, Portugal
Lopo Carvalho {lj.carvalho@aquagri.com}
Aquagri Lda, R. Carlos Vieira Ramos 47, r/c Esquerdo, 2780-216, Oeiras, Portugal

Presentation topic: Precision Agriculture/Digitalization
Scientific reviewing requested.

Underground sensor networks are used in a wide number of science and industry applications, such as agriculture, mining/gas/oil exploration, geographic telemetry, etc. Each of these applications impose very specific requirements where the depth at which the sensor must be placed at is the most crucial and thus creating the biggest impact in the technology to be used. Our proposal focuses on the wireless technologies which allow the usage of underground-to-aboveground (UG2AG) transmissions, given that it is expected that most of the transmissions will occur from the underground devices to the aboveground gateways. Aboveground-to-underground (AG2UG) transmissions may occur for parameters settings or, in the case where the device allows, for actuation. Underground-to-underground (UG2UG) transmissions have a shorter range than the other two types of transmissions and are out of the scope.

Our proposal aims at a modular solution for soil monitoring that incorporates sensing and communication technologies bundled together for operation under the soil's surface, targeting precision irrigation at both urban and rural settings. Precision irrigation allows for a balanced moisture level along the soil profile, thus optimisingmoisture in the root zone between field capacity and the wilting point – Comfort Zone. Such a procedure not only improves the health of the plant, but also allows to optimize the utilization of water and to avoid exceeding-watering crops and garden landscapes. As a result, it makes more efficient use of water, the most precious resource on our planet. Moreover, it makes good business sense, having not only fine-tuned irrigation management results concerning water usage and energy savings but also an overall quality improvement in plant production.

Hence, our work addresses this context from the sensing perspective. The solution is to be as agnostic as possible to the sensors that can be connected to it. Regarding communication, the chosen technology shall be one that can provide a reliable medium for data exchange between the underground and above surface of soil, and that can operate with low-power consumption. By operating underground, the solution introduces an extra layer of protection as it shall be less prone to vandalism and theft as well as damage caused by machinery (e.g., during pruning, harvesting, mowing) and even animals.
This presentation covers the main requirements as well as relevant wireless communication and sensing technologies, and different sources of energy that could be incorporated into the solution. Given the operation conditions (e.g., high humidity), we also present a protective casing developed to house the electronics of the solution without interfering with the communication. The presentation introduces the architectural design and specification of the hardware and firmware for our solution, the conceptual design of its protective enclosure and a preliminary set of tests carried out on the developed prototype.

Correlation between colour and carotenoid content for carrot drying: A closer look

Sharvari Raut[1,*], Jörg Schemminger[1,2,3], Barbara Sturm[1,3]

[1] Leibniz-Institut für Agrartechnik und Bioökonomie e.V. (ATB), Max-Eyth Allee 100, 14469 Potsdam, Germany

[2] Empa, Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Biomimetic Membranes and Textiles, Lerchenfeldstrasse 5, CH-9014 St. Gallen, Switzerland

[3]Humboldt-Universität zu Berlin, Faculty of Life Sciences, Albrecht Daniel Thaer-Institute of Agricultural and Horticultural Sciences, Hinter der Reinhardtsstrasse 6–8, 10115 Berlin, Germany

Across any processing value chain, the final quality of the product is the most essential criterion. With quality being a relative property, the parameters for quality assessment differ between value chains, product in focus and between processors and consumers. In the food processing chain, for fresh products criteria such as colour, overall general appearance, smell, taste and shape are of great importance. With increasing awareness for the need of a healthy lifestyle, nutritional content has also been successively included in quality assessment. However, due to high moisture content, fresh produce is susceptible to significant degradation. To reduce these post-harvest losses, convection drying is a commonly implemented preservation technique to improve the shelf life of the produce. The settings currently implemented for the drying process i.e. process orientated settings with fixed air temperature have detrimental effect on the above mentioned quality parameters as well as on the overall process efficiency. Thus, leading to poor product quality and high-energy consumption. In order to optimise these settings, it is important to shift from a process oriented drying process to a product orientated drying process. For this shift, it is important to assess different drying strategies and their effect on the quality parameters and their correlation subsequently.

Carrot is a root vegetable that is nutritious in terms of vitamins, minerals, and is rich in β–carotene. Due to its popularity and the increased consumption of carrot and carrot-derived products, several studies have investigated the different quality parameters at various stages of the carrot processing chain. Previous studies have postulated a direct correlation between total colour change and total carotenoid retention i.e. higher the degradation of colour higher the degradation of carotenoid. The current study presents an approach for correlation of colour parameters and carotenoid content based on information derived from L*a*b* measurement. Carrots (var. Laguna) were sliced at a thickness of 3 mm and dried at 50 °C, 60 °C, 70 °C using three different strategies namely air temperature controlled, product temperature controlled and step wise temperature controlled. Colour of the carrot slices during the drying process was measured using a chromameter while the total carotenoid content was analysed using the routine chemical analysis. The results obtained from this investigation correlates the total carotenoid retention to L*, a* & b* components of the CIELab colour space across the different strategies and help identify the best-correlated component of the colour space for carotenoid degradation.

* Corresponding author: sraut@atb-potsdam.de, Leibniz-Institut für Agrartechnik und Bioökonomie e.V. (ATB), Department of Post-Harvest Technology, Max-Eyth Allee 100, 14469 Potsdam, Germany

Investigation of the cumulative influence of postharvest factors on product quality of dried apple slices

Gardis J.E. von Gersdorff[1], Boris Kulig[2], Manuela Zude-Sasse[1], Barbara Strum[1,3]

1 - Leibniz Institute for Agricultural Engineering and Bioeconomy, Potsdam, Germany

2 – University of Kassel, Kassel, Germany

3 – Humbold University of Berlin, Berlin, Germany

Many agricultural products in temperate latitudes are subject to seasonality, which leads to work and supply peaks, especially at harvest time. Usually, only a part of the products is sold as fresh produce while the other part is intended for further processing. The gap between harvesting and further processing is usually bridged by storing the raw material, thus giving the farms greater flexibility in terms of time.

A popular low-fat and high-fiber snack is dried apple slices. In the present study, the cumulative influence of post-harvest storage condition and duration on the final product quality of dried apple slices was investigated. For this purpose, apples (*Malus* x *domestica* Borkh.) of the cultivar Gala were harvested in experimental orchard and stored in cold air and controlled atmosphere at 1 °C for one and three months. Apples were cut into 3 mm slices and dried in an electric convection dryer at 60 °C to 10 % moisture content. Color (CIELAB), osmotic potential, Brix, sugars (glucose, fructose, sucrose, sorbitol), and hydroxymethylfurfural were used as evaluation parameters for fresh and dried samples.

The results revealed no differences in colour for the dried apple slices, while the sugar composition varied between storage treatments of dried apple rings. The study shows that storage management is crucial for the quality of final products.

Keywords: apples, postharvest, storage, drying, product quality,

RES4LIVE – Energy Smart Livestock Farming towards Zero Fossil Fuel Consumption

D. Tyris[1], D. Manolakos[1], T. Bartzanas[1], S. Benni[2], T. Amon[3], J. Maselyne[4], S. Lecompte[5], P. Grammelis[6], A. Balafoutis[6], G. Zhang[7], P. Bakalis[8], S. Kalogridis[9], O. Marchand[10], H. Hoes[11], J. Gomes[12]

[1]Agricultural University of Athens, [2]University of Bologna, [3]Leibniz Institute of Agricultural Engineering and Bio-economy e.V. - ATB, [4]Institute for Agricultural, Fisheries and Food Research - ILVO, [5]Ghent University, [6]Centre for Research and Technology Hellas, [7]Aarhus University, [8]PSYCTOTHERM, [9]Plegma Labs S.A., [10] CRMT SAS, [11]Terra Energy NV, [12]MG Sustainable Engineering AB

Abstract

Fossil fuel use in the agricultural domain, has rendered agriculture as a major source of Greenhouse Gas (GHG) emissions, with significant contributions to global climate change and the risk of food security. One of the most energy consuming sub-sectors of agriculture, mainly based on fossil fuels use, is intensive livestock farming. It requires both electricity and thermal energy to cover its strongly diversified energy demand, such as cooling and heating of the indoor livestock buildings environment, running of equipment and tractors, lighting, and ventilation systems. However, sustainable livestock production and de-fossilized husbandry facilities emerge as crucial aspects within EU. More recently though, the declining costs and improved reliability and performance of key Renewable Energy Sources (RES) technologies, increase the opportunities for farmers to achieve energy self-sufficiency and disengage from fossil fuels.

The H2020 project RES4LIVE is a first attempt for 100% replacement of the fossil fuel consumption of the industrial livestock farming sector, with the aid of cost-effective RES technologies. The overall objective is to provide advanced and cost-effective technologies to the livestock sector that ensure the sustainability of the farms' operation, becoming attractive in terms of cost effectiveness and low maintenance, offering operational flexibility, superior thermal comfort of the animals for increased productivity with minimum climate change impact, complying with and contributing to further implementation of EU's main environmental legislation.

In the framework of RES4LIVE, innovative, both adapted and commercial, RES technologies will be demonstrated, tested, and evaluated technically, economically, environmentally, and socially in 4 pilot farms in Belgium (swine), Italy (swine), Germany (dairy) and Greece (poultry). These technologies include PVT systems, modular heat pumps, biogas upgrading to biomethane, appropriately retrofitted tractors for biomethane use, smart control and energy management systems, as well as PV panels, geothermal energy storage, and electrification of on-farm machinery. The planned interventions will totally replace the fossil fuel consumption of certain needs in the pilot farms, proving that fossil-free-energy farming is possible to be achieved with a sustainable way. At the same time, the replicability potential will be another key activity, so that to prepare the commercialization process of the solutions.

PRESENTATION TOPIC: Farm Buildings

LIFE Carbon Farming and Climate Farm Demo: Development and implementation of a result-based funding mechanism for carbon farming in European mixed crop livestock systems

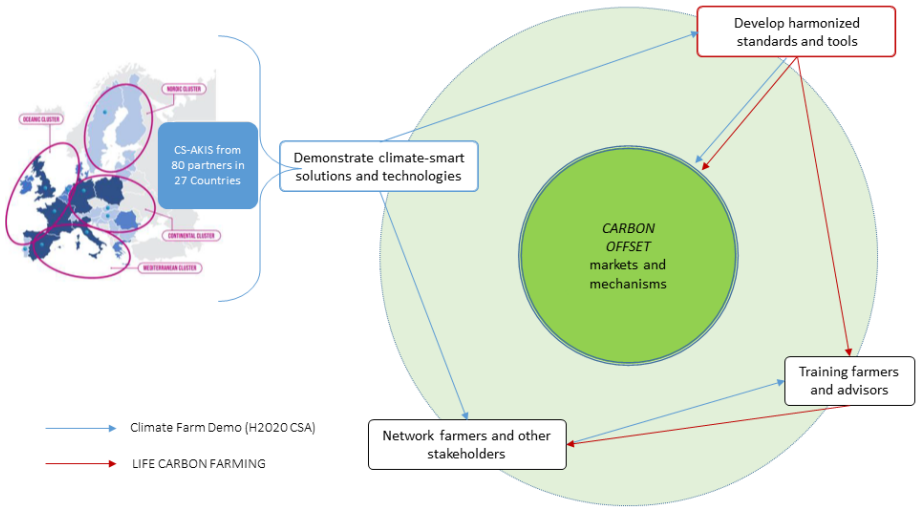
Aura Cardenas[1]*, Federico Dragoni[1], Jean Baptiste Dollé[3], Anaïs L'Hôte[3], Barbara Amon[1,2]

[1] *Leibniz Institute of Agricultural Engineering and Bioeconomy e.V. (ATB) Max-Eyth-Allee 100, 14469 Potsdam, Germany*
[2] *University of Zielona Góra, Faculty of Civil Engineering, Architecture and Environmental Engineering, Zielona Góra, Poland*
[3] *Idele, l'Institut de l'Élevage, France*
**presenting author*

Agriculture emits greenhouse gas emissions, but also contributes to CO_2 uptake through carbon sequestration. In particular, at global scale the livestock sector is accounted for 14.5% of human-sourced GHG emissions, while providing also promising potential for emission mitigation through different techniques, aimed for instance to increase energy efficiency, nutrient circularity, and crop-livestock integration (mixed farming). In fact, long-term conversion of grassland into cropland resulted not only in losses of soil carbon, but also of biodiversity, which depends as much on field-scale practices as on landscape components and diversity. Since mixed farming uses a large proportion of grasslands, it has a great capacity to preserve and increase carbon sequestration while enhancing biodiversity.

The agricultural sector is directly interested by the Effort Sharing Regulation-ESR-(EU) 2018/842, and by the Land Use, Land Use Change and Forestry (LULUCF) Regulation (EU) 2018/841. In particular, the ESR set Member States targets for emissions reduction in non-ETS sectors, including agriculture. Thus, a key challenge is to adopt measures to contribute to the emission reduction goals without threatening food production, while enhancing carbon storage, adapting to climate change and preserving biodiversity. For this purpose, innovative climate smart solutions and technologies need to be tested and implemented, giving particular attention to their assessment, replication and transfer across regions and countries, including the development of favorable market conditions for their adoption.

Therefore, the "Climate Farm Demo" and the "LIFE CARBON FARMING" projects are establishing a pathway to demonstrate regionally tested solutions, standardize assessment tools, then train and inform an extensive network of stakeholders, with specific regard to livestock and mixed farming systems. In detail, the "Climate Farm Demo" project builds on a network of pilot-demo farmers covering United Kingdom, Switzerland, Serbia and 24 EU Countries, providing demonstration and extensive knowledge on locally validated Climate Smart Agriculture Knowledge and Innovation Systems (CS-AKIS). The effects of the solutions and technologies, particularly in terms of emission reduction, need to be assessed by harmonized tools and methodologies, specifically developed in the "LIFE CARBON FARMING" project. Reporting and verification processes supporting farmers in reducing their carbon footprint will allow to implement and disseminate carbon offset and voluntary carbon market mechanisms.



Comparison of Augmented and Mixed Reality Technologies in Livestock Farming Operations

Sara G., G. Todde, D. Pinna, M. Caria

Dr Gabriele Sara, gsara@uniss.it, , Department of Agricultural Sciences, University of Sassari, Viale Italia 39, Sassari, 07100, 0039/079229284
Dr Giuseppe Todde, gtodde@uniss.it, Department of Agricultural Sciences, University of Sassari, Viale Italia 39, Sassari, 0039/079229283
Dr Daniele Pinna, dpinna1@uniss.it, Department of Agricultural Sciences, University of Sassari, Viale Italia 39, Sassari, 0039/079229280
Prof Maria Caria, mariac@uniss.it, Department of Agricultural Sciences, University of Sassari, Viale Italia 39, Sassari, 0039/079229375

Abstract: The use cases of Augmented Reality (AR) in agricultural contexts are increasing. In addition, Mixed Reality (MR) is advancing and progressively being tested for different professional contexts. Both technologies allow users to see and interact with virtual elements overlayed in the real world, even though differently (2D, 3D, hologram). Recent studies underlined the potentiality that AR technologies may have to assist farmers, breeders, and technicians (veterinary, agronomist) to solve tasks efficiently and in a more precise way. Moreover, the integration and connection of AR and MR devices with other farm sensors via IoT (Internet of Things), could improve the application range of augmented and mixed reality in agriculture. Nevertheless, limited application scenarios in specific work domains are available considering different AR glass and MR headset devices.

Thus, the study aims to compare AR and MR devices during a specific farming task to help operators during on-farm activities. Moreover, the AR and MR devices' influence on the users' task performance, workload, and satisfaction were investigated.

The tests were performed in the experimental facilities of the University of Sassari involving the farm operators. The task consists of the identification of the sheep through the mobile electronic identification system, and the visualization of specific animal information in AR or MR to manage the flock. The task was performed with the AR and MR headsets for each operator and different questionnaires for the evaluation of workload and satisfaction were submitted.

The results showed that the AR or MR devices could influence the perceived workload, satisfaction, and the animal identification process. However, AR glasses and MR headsets were a useful tools in the animal selection procedure offering promising opportunities for adoption in livestock operations in terms of assessing data consultation and information about animals.

Topic: Precision Agriculture/Digitalization

Prospective Thermal Processing of Soybeans Using a Bean Characteristic Model

Authors: Dipl.-Ing Dr.techn Matthias Trimmel[1]

Priv.-Doz. Dipl.-Ing. Dr. Karl Schedle[2]

Elias Eder, BSc[1]

Dipl.-Ing Dr.techn Peter Riegler-Nurscher[1]

[1] Josephinum Research, Rottenhauser Straße 1, 3250 Wieselburg,
Tel.: +43 7416 52175 628; Fax. +43 7416 52175 645;
E-Mail: matthias.trimmel@josephinum.at ; p.riegler-nurscher(at)josephinum.at ;

[2] Institut für Tierernährung, Tierische Lebensmittel und Ernährungsphysiologie, Boku, Muthgasse 11, 1190 Wien, karl.schedle@boku.ac.at

Thematic focus: Post-Harvest Technology

The quality of the thermal processing of soybeans is primary influenced by processing conditions and bean characteristics. Currently applied process adjustment leads to a variation in product quality. The adjustment is done subsequently after analysing different parameters of the already processed product. This means a retrospective way for adjustment where damage and faulty processing, up to 15 percent of the processed soybeans, may be the consequences. On the other hand, energy losses by the fact of too intensive treatment are also possible adverse effects.

In the present study a, prospective solution for process adjustment using a model based on bean characteristic is presented. Therefore, a pool consisting of 60 samples including a diversity of varieties and growing area was collected. Bean characteristics such as grain size, protein-, oil- and inhibitor content or thousand-corn-weight were analysed before thermal treatment using a laboratory roaster. The bean characteristics were collected using chemical, physical and imaging techniques. Changes in processing quality expressed by protein solubility in potassium hydroxide (KOH) and trypsin inhibitor activity (TIA) due to bean characteristics are described by the use of support vector regression and multivariate linear regression. The used methods for characterization, the relationships between bean characteristics and treatment as well as the accuracy and reliability of the model are presented.

Abstract for International Conference on Agricultural Engineering LAND.TECHNIK November 22th – 23th 2022

Title: **Valuation Method for Corn head integrated Stubble Cracker System**

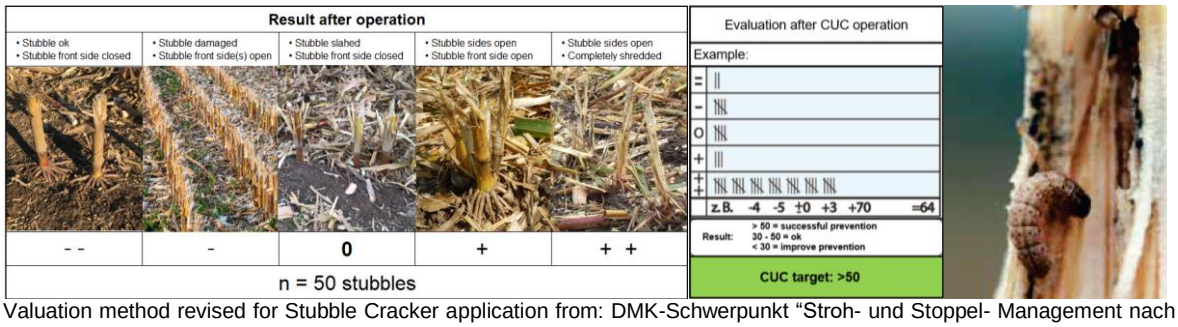
Authors: M.Sc. **László Bódi**, Dipl.-Ing. (FH) **Tim Lütke Harmann**
M.Sc. **Tibor Varga-Dudás**, M.Sc. **Péter Ivanics,**
M.Sc. **Christian Schwaer,** B. Eng. **Felix Herter**

CLAAS Selbstfahrende Erntemaschinen GmbH, Harsewinkel and CLAAS Hungaria Kft, Törökszentmiklós

Assignment to presentation topic: Post-Harvest Technologies

Abstract:

The European corn borer (*Ostrinia nubilalis*) is the biggest pest worldwide, which generates high yield- and economic losses in maize production. In addition, the infected areas has increased significantly in the recent years. In an attempt to minimize the European corn borer population CLAAS has integrated a mechanical stubble cracker system into CLAAS corn heads in order to destroy the habitat of the insect. Intensive destruction of corn stubble also supports a quicker decomposition process and therefore decreases the vulnerability to Fusarium (e.g. the ear rot of wheat) on the following crop as well.



Valuation method revised for Stubble Cracker application from: DMK-Schwerpunkt "Stroh- und Stoppel- Management nach Mais" © 2017 Deutsches Maiskomitee e.V. (DMK) | Brühler Straße 9 | 53119 Bonn | www.maiskomitee.de

The presentation describes:

- The customer demands
  - Working quality for effective insect control
  - Header integrated solution for an economical one pass operation
- The selection process of the technical solution
  - The operating principle of the integrated stubble cracker
  - The systematic design and dimensioning of power train components
- Judgment of operating results in field condition based on revised valuation method (adjustment of the method on corn maize condition)
- Correlation of operating results and additional CO_2 emissions

The engineered solution provides answers to the above-mentioned requirements. The rotating blunt tools with continuous ground following capability will cause the residual stubble to burst but not completely cut it off at ground level. Due to the proven high percentage of destruction, the European corn borer has less chance to overwinter in the processed stalk and stubble. The result is a sustainable reduction of the corn borer population without chemicals or GMO (genetically modified organism) corn with advantages in CO_2 emissions.

Abstract for International Conference on Agricultural Engineering LAND.TECHNIK November 22th – 23th 2022

Authors:

M.Sc. László Bódi
Product Unit Headers
Business Unit Grain
CLAAS Hungaria Kft.
Kombájn utca 1
5200 Törökszentmiklós
Hungary
Mobile: +36 30 5270465
laszlo.bodi@claas.com

Dipl.-Ing. (FH) Tim Lütke Harmann
AD Functional Technology
Business Unit Grain
CLAAS Selbstfahrende Erntemaschinen GmbH
Mühlenwinkel 1
33428 Harsewinkel
Germany
Mobile: +49 151 16754970
Tim.Luetke-Harmann@claas.com

M.Sc. Tibor Varga-Dudás
SF FT Corn Heads
Business Unit Grain
CLAAS Hungaria Kft.
Kombájn utca 1
5200 Törökszentmiklós
Hungary
Mobile +36 30 128 8168
Tibor.Varga-Dudas@claas.com

M.Sc. Péter Ivanics
Head of Functional Technology Corn Heads
Business Unit Grain
CLAAS Hungaria Kft.
Kombájn utca 1
5200 Törökszentmiklós Hungary
Mobile: +36 30 215 2773
peter.ivanics@claas.com

M.Sc. Christian Schwaer
SF FT Drives
Business Unit Grain
CLAAS Selbstfahrende Erntemaschinen GmbH
Mühlenwinkel 1
33428 Harsewinkel
Germany
Mobile: +49 178 6171104
christian.schwaer@claas.com

B. Eng. Felix Herter
Product Unit Headers
Business Unit Grain
CLAAS Hungaria Kft.
Kombájn utca 1
5200 Törökszentmiklós
Hungary
Mobile: +36 30 160 9560
felix.herter@claas.com

Simulationsumgebung für die Entwicklung intelligenter Algorithmen in der Landwirtschaft

Geprägt durch Smart Farming und Precision Farming bekommt auch die Autonomisierung von Maschine und Prozessen in der modernen Landwirtschaft eine ganz neue Bedeutung. Durch den gezielten Einsatz intelligenter, adaptiver Algorithmen zur Steuerung von Arbeitsmaschinen und Anbaugeräten lassen sich landwirtschaftliche Prozesse autonom abarbeiten, um eine Maximierung der Ertragssicherheit und -qualität sowie nachhaltige, integrative und umweltschonende Landwirtschaft zu erreichen.

Die stark unterschiedlichen Prozesse und die hohen Ansprüche an Qualität und Effizienz sind eine große Herausforderung für die Entwicklung solcher autonomer Systeme und Assistenzfunktionen im Agrarbereich. Insbesondere das Testen und die Validierung der Algorithmen kann sehr aufwendig und zeitintensiv ausfallen, gerade weil sich landwirtschaftlich bewirtschaftete Flächen kontinuierlich verändern und Pflanzen praktisch täglich anders aussehen. Hinzu kommen Störfaktoren, wie zum Beispiel die Verschmutzung der Sensorik, die im Zusammenhang mit der Feldarbeit berücksichtigt werden müssen.

AVL entwickelt eine Simulationsumgebung, die die Entwicklung von Assistenz- sowie auch autonomen Funktionen für landwirtschaftliche Anwendungen erheblich beschleunigen kann. Unter Verwendung der Unreal Engine, die eigentlich in der Computerspiele-Entwicklung eingesetzt wird, kann eine fotorealistische, physikalisch korrekte Umwelt mit parametrierbaren Agrarpflanzen in unterschiedlichen Wachstumsstadien sowie bei unterschiedlichen Wetter- und Lichtverhältnissen erzeugt werden. Virtuelle Kameras und Sensoren, die am digitalen Abbild der Arbeitsmaschine angebracht sind, erfassen Daten aus der simulierten Umwelt. Die Sensorinformationen werden in Form von Daten-Streams mittels geeigneter Schnittstellen in die reale Controller-Hardware übertragen. So können sowohl Algorithmen als auch Sensoren und deren Platzierung schon in der Konzeptphase, bevor ein Testfahrzeug verfügbar ist, unter variablen Randbedingungen getestet werden. Die initiale Validierungsphase unter realen Bedingungen kann somit erheblich verkürzt werden.

Simulation environment for the development of intelligent algorithms for agricultural applications

Characterized by smart farming and precision farming, the autonomy of machines and processes in modern agriculture is taking on a whole new meaning. By means of the targeted use of intelligent, adaptive algorithms to control farming machines and implements, agricultural processes can be handled autonomously in order to maximize yield security and its quality as well as sustainable, integrative and environmentally friendly agriculture.

The very different processes and the high demands on quality and efficiency are a major challenge for the development of such autonomous systems and assistance functions in the agricultural sector. In particular, the testing and validation of the algorithms can be very complex and time-consuming, especially because farmed areas are constantly changing and plants look different practically every day. There are also disruptive factors, such as soiling of the sensors, which must be taken into account in connection with field work.

AVL is developing a simulation environment that can significantly accelerate the development of assistance as well as autonomous functions for agricultural applications. Using the Unreal Engine, which is very common in computer game development, a photorealistic, physically correct environment can be created with parameterizable agricultural plants in different growth stages and under different weather and light conditions. Virtual cameras and sensors attached to the digital image of the working machine collect data from the simulated environment. The sensor information is transmitted to the real controller hardware in the form of data streams using suitable interfaces. In this way, algorithms as well as sensors and their placement can already be tested under variable boundary conditions in the concept phase, before a prototype vehicle is available. As a result, the initial validation phase under real conditions can be reduced considerably.

Challenges and potentials of NIR sensors to simplify the generation of nitrogen flow balances.

Introduction

Agriculture faces many challenges and ambivalent goals are often present in many areas. Nutrient cycles are one such example. On the one hand, high-quality food should be produced, and on the other hand, the environmental impact should be as low as possible. Nitrogen forms a central element for yield and quality formation. However, if the amount used in fertilization is too high, there is a risk of leaching into the groundwater or the escape of environmentally harmful nitrous oxide into the atmosphere.

For both fertilization and harvesting, reference values are used to establish the nutrient flow balance (Stoffstrombilanz) - which records the nutrient cycle. Existing sensor technologies have the potential to map the nutrient balances in site-specific areas in an automated and more accurate way. NIR sensors, in particular, can precisely map certain ingredients (e.g. N-content in liquid manure). Thus, it is possible to precisely record site-specific quality characteristics.

Material and methods

The aim is on the one hand to make it easier for the farmer to draw up the material flow balance and on the other hand to base it on sensor values instead of guide values. In this paper guideline values and sensor values per area are compared and in a second step possible optimization potentials are pointed out.

Specifically, acquired NIR sensor data from a dairy farm were recorded and then compared with stored guideline values in the material flow balances (templates). In total, crop and fertilizer application files are available for three years (2019-2021), from which the nitrogen content is calculated in each case from the measured ingredients.

Result

Comparison or benchmarking of the guideline values with the recorded sensor values. The relative deviation of the sensor data from the guideline value is calculated and presented. Furthermore, possible challenges of using NIR sensors (unexpectedly high deviations from the guideline value) are briefly discussed.

The collected data can be used as a basis for future optimization and prediction models. Thus, the analysis of the sensor data is not only interesting for documentation (legal point of view), but it can also be used for operational optimizations.

A comparative multidimensional evaluation of site-specific tillage strategies

Yongjing Wang[1], Ajit Borundia[2] and Abdul Mounem Mouazen[3]

[1]Department of Environment, Ghent University, Coupure Links 653, 9000 Gent, Belgium, Tel +3292646037, Fax + 3292646247, Yongjing.Wang@ugent.be, PhD Student
[2]Department of Environment, Ghent University, Coupure Links 653, 9000 Gent, Belgium, Tel +3292646037, Fax + 3292646247, Ajit.Borundia@UGent.be, Postdoctoral researcher
[3]Department of Environment, Ghent University, Coupure Links 653, 9000 Gent, Belgium, Tel +3292646037, Fax + 3292646247, Abdul.Mouazen@UGent.be, Full Professor

Abstract

Soil compaction is a key problem of soil degradation which results in reduction of agricultural productivity. Due to the lack of high-resolution compaction sensing technology, farmers usually apply the most aggressive tillage with maximum speed and depth, which does not necessary respond to tillage needs due to compaction level and depth that are spatially variable across the field area. Thus, site-specific tillage (SST) is expected to offer economic and environmental benefits. This study aims to evaluate the performance of different SST strategies of a moldboard plough based on simulations using soil bulk density maps measured with an online sensing platform. This platform consists of a load cell to measure subsoiler draught, a wheel gauge to measure depth and a visible and near infrared (vis-NIR) spectrometer for the measurement of moisture content (MC) and clay content (CC), and was used to collect data in two fields in Belgium and 2 fields in Spain. Packing density (PD) was calculated for all on-line measured points as a function of BD and CC. All fields were divided into three management zones with different tillage rates based on the PD maps. For the area with PD smaller than 1.4, minimum tillage depth (10 cm) and operation speed (5 km/h) were assigned; area with PD between 1.4 to 1.7 is considered requiring medium rate of tillage depth (20 cm) and operation speed (7 km/h), while the most aggressive tillage rate (30 cm depth, and 9 km/h speed) was applied in the area with PD > 1.7. A simulation software was developed in MATLAB to predict and compare power efficiency, fuel consumption and total operation time of the traditional homogenous tillage and different SST applications. The treatments considered in the simulation were homogenous tillage, SST depth only, SST speed only and combined SST depth and speed. Results revealed that the degree of soil compaction varies hugely from field to field, and the requirements of aggressive tillage also differ, ranging between 0% and 97% of the entire field area. Results showed that SST can reduce draught, fuel consumption and overall operation time by up to 28.9%, 33.4% and 67.3%, respectively. Optimal tillage depth and operation speed is recommended for the minimum draught, energy consumption and time of operation. A future study is needed to related SST application to crop growth and yield response.

Specific presentation topic: 1.7: Precision Agriculture / Digitalization

Keywords: Precision agriculture, Variable rate tillage, Simulation, On-line sensing

In-filed Spatial Variability and Potential for Profitability of Variable Rate Applications

Mingyi Zhao[1], Angela Guerrero[2], Muhammad Abdul Munnaf[3], Ludwig Lauwers[4,5] and Abdul Mounem Mouazen[6,*]

[1]Department of Environment, Ghent University, Coupure Links 653, 9000 Gent, Belgium. Tel:+3292646037, Fax: +32926466247, mingyi.zhao@ugent.be, PhD student

[2]Department of Environment, Ghent University, Coupure Links 653, 9000 Gent, Belgium. Tel:+3292646037, Fax: +32926466247, angela.guerrero@ugent.be, PhD student

[3]Department of Environment, Ghent University, Coupure Links 653, 9000 Gent, Belgium. Tel:+3292646037, Fax: +32926466247, munnaf.mabdul@ugent.be, PhD student

[4]Flanders Research Institute for Agriculture, Fisheries and Food, Burg. Van Gansberghelaan, 155 bus 2, 9820 Merelbeke, Belgium. Tel: +3292722356, ludwig.lauwers@ilvo.vlaanderen.be, Research staff

[5]Department of Agricultural Economics, Ghent University, Coupure Links 653, 9000 Gent, Belgium, Professor

[6]Department of Environment, Ghent University, Coupure Links 653, 9000 Gent, Belgium. Tel:+3292646037, Fax: +32926466247, abdul.mouazen@ugent.be, Professor

*Corresponding email: abdul.mouazen@ugent.be

Abstract

Profitability is a major driver for adoption of Precision Agriculture (PA) technologies, yet the actual uptake is lagging. As literature on PA profitability do not present uniform results, a more systematic approach of the economic incentive is needed to determine when, where and how an increased profitability can be realized. This paper examines how spatial variability of a field might influence the profitability of variable rate application (VRA) technologies, namely, nitrogen fertilisation and seeding. Field spatial variability is measured in two ways: the coefficient of variation and in an adjusted form of Cambardella Index (CI). In order to bridge the field information to profitability, a new key indicator is proposed to esteem a potential for profitability, being the margin between revenues and the variable costs directly associated with the VRA input (return after precision application costs (RAPCA). Data are recuperated from previous, published research and screened for suitability for current research objective. Results showed that both variability indices ranged from 0.5 to 9.5 and

RAPAC ranged from 847 to 6624 EUR per field. Both field variability indicators exhibited positive correlation with the potential profitability of VRA technologies, and CI was proved to be more relevant and is recommended for further studies regarding field variability. Results of this paper suggest a field with higher variability will benefit more from VRA applications. Findings are interpreted in a production-theoretical framework and discussed whether, when and under which circumstances, the potential will effectively lead to profitability increases.

Specific presentation topic: 1.7 Precision Agriculture/Digitalization

Keywords: Precision agriculture, field variability, variable rate applications, precision agriculture profitability, flat-earth economics

A comparative study of hydrothermal carbonization and humification of digested cow manure

Nader Marzban [a], Judy A Libra [a], Thomas Hoffmann [a], Svitlana Filonenko[b]

[a] Leibniz Institute of Agricultural Engineering and Bio-economy e.V. (ATB), Max-Eyth-Allee 100, 14469 Potsdam, Germany

[b] Max-Planck Institute of Colloids and Interfaces, Department of Colloid Chemistry, Am Mühlenberg 1, 14476 Potsdam, Germany

Abstract

Hydrothermal carbonization (HTC) is a promising technology for converting wet biomass into hydrochar and a process liquid, both containing a variety of organic and inorganic compounds. However, the presence of aromatic compounds as the end products in both solid and liquid phases play an inhibitory role in germination, plant growth and soil microbial activity. Here, we compare the production of organic compounds and nutrient distribution in HTC with hydrothermal humification (HTH) of digested cow manure.

The total yield of artificial humic acids (A-HAs) recovered from both the solid and liquid from HTH reached 37.4%, more than twice that found in the HTC products. This resulted in more than 70 and 90% reduction of aromatic compounds, respectively in solid and liquid phases of HTH. The concentration of organics, measured as TOC, in the HTH liquid was up to 60% higher than in HTC. Although approximately one third of the organic carbon can be recovered from the liquid as humic acid, a high concentration of TOC remains in the liquid. The majority of those are organic acids typically found in solids.

The results of analysis support that the products of HTH can be classified as synthetic analogs of natural humic acids. Particularly, the FTIR and UV-vis spectra of A-HAs and compositional (CHN) analysis plotted as a van Krevelen diagram correspond to those for natural humic acids. The A-HAs can be used to stimulate soil microorganisms and increase soil fertility by providing the nutrients to the plant root system, while increasing the water holding capacity.

Keywords: Digested cow manure, hydrothermal carbonization, hydrothermal humification, artificial humic acids, aromatic compounds

Effect of UV-B illumination on the production of edible crickets for their introduction in an urban co-cultivation system

Marios Psarianos: Horticultural engineering, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Max-Eyth-Allee 100, 14469 Potsdam, Germany, mpsarianos@atb-potsdam.de, +49 (0) 331 5699 927
Dr. Anna Fricke: Department of Plant Quality and Food Security, Leibniz Institute of Vegetable and Ornamental Crops (IGZ), Theodor-Echtermeyer-Weg 1, 14979 Grossbeeren, Germany, fricke@igzev.de, +49 (0) 33701/78-305
Dr. Shikha Ojha: Horticultural engineering, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Max-Eyth-Allee 100, 14469 Potsdam, Germany, sojha@atb-potsdam.de, +49 (0) 331 5699 634
Dr. Oliver Schlüter: 1. Horticultural engineering, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Max-Eyth-Allee 100, 14469 Potsdam, Germany
2. University of Bologna, Department of Agricultural and Food Sciences, Piazza Goidanich 60, 47521, oschlueter@atb-potsdam.de, +49 (0) 331 5699 613

Topic: Circular Biobased Economy/Sustainable Energy/Waste Management

House crickets (*Acheta Domestica)* offer good potential for utilization in the food and feed sector due to their high nutritional value and easy rearing process. As a potential part of a resilient food system the present study explores the possibilities to co-cultivate them with algae and plants. UV-B radiation has been suggested to affect positively the other organisms and therefore its applicability was tested on the insect rearing process. Crickets were exposed to UVB light (285 nm, 1.15 kJ, 0.08 W/m²) for 4h/day with an overall photoperiod of 8h/day until adulthood, combined with an illumination system at 50 µmol $m^{-2}s^{-1}$ of a 6500K LED light. Their weight, survival and growth were monitored, while their nutritional composition at a post-harvest stage was evaluated. The crickets exposed to the UV illumination showed no significant differences in compare to those deprived from UV illumination in terms of weight (360-400 mg/cricket), growth during the rearing or content of nutrients (proteins, phenolic compounds, chitin and crude fat). However, insects exposed to UV had a 70.51 % survival, compared to 61.53% survival for the ones grown without UV light, after 53 days of rearing. Further, different illumination conditions were evaluated. An illumination system of 50 µmol $m^{-2}s^{-1}$ of a 6500K LED light with an 8h/day photoperiod, a light treatment at 150 µmol $m^{-2}s^{-1}$ and a UV-B treatment at 1.5 kJ (285 nm, 0.08 W/m²) combined with a light intensity of 150 µmol $m^{-2}s^{-1}$ were compared. No significant differences were observed in terms of weight (400-450 mg/cricket). Nevertheless, the crickets exposed to UV-B showed again a higher survival (approx. 78%) in compare to the ones deprived of it (approx. 65%). Furthermore, among the crickets exposed to UV, the first adults were observed faster in compare to the other treatments. Finally, the crickets that were exposed to the UV showed a two times higher relative growth (weight increase in respect to the initial weight) in compare to the ones grown under the least intense illumination.

NEAR-INFRARED SPECTROSCOPIC SENSOR SYSTEM FOR MILK COMPOSITION ANALYSIS: AN ON-FARM REAL-TIME APPLICATION

Diaz-Olivares[1], J.A., van-Nuenen[1], A., Adriaens, I[1,3]., Saeys[2], W. and Aernouts[1], B.
[1]KU Leuven, Department of Biosystems, Division of Animal and Human Health Engineering, Campus Geel, Kleinhoefstraat 4, 2440 Geel, Belgium; [2]KU Leuven, Department of Biosystems, Division Mechatronics, Biostatistics and Sensors, Kasteelpark Arenberg 30, 3001 Leuven, Belgium;[3]Wageningen University and Research, Animal Breeding and Genomics, Droevendaalsesteeg 1, 6708 PB Wageningen, the Netherlands. Corresponding author: jose.diaz@kuleuven.be

INTRODUCTION

In previous studies, long-wave near-infrared (LW-NIR) spectroscopy has shown its utility in accurately characterizing the main components of raw milk (fat, protein and lactose). These components contain valuable information on the udder health and energy balance of individual dairy cows, as milk plays a critical role in their metabolism. In current practices, milk composition is monitored post-hoc with a low frequency, or on-farm with poor prediction performance. We present and evaluate an accurate analyzer for the on-farm, real-time monitoring of milk composition.

MATERIALS AND METHODS

For every milking performed by an automatic milking system (AMS), the milk analyzer extracts a milk sample, which is stabilized at 38 °C by a temperature control system. After stabilization, the sample is introduced into a flow-through borosilicate cuvette, and the system acquires reflectance and transmittance NIR spectra of the sample in the 960 to 1690nm wavelength range. Dark and white reference spectra were acquired using the same settings while the milk sample was loaded into the cuvette, just after performing the spectral recording. During a test period of 28 weeks, the system measured 1376 reflectance and transmittance spectra from raw milk samples. For these samples, laboratory reference values were obtained for fat, protein and lactose. Prediction models were trained exclusively with samples acquired during the first 8 weeks of the trial (n=890).

RESULTS AND DISCUSSION

The real-time prediction models were evaluated with the samples not included in the calibration population (n=486). Concretely, these models had a general prediction error (root-mean-square error of prediction, RMSEP) lower than 0.08% (all % are in weight/weight) for fat (range 2.01-7.95%), 0.14% for crude protein (2.55-4.91%) and 0.06% for lactose (3.81-5.21%), with a coefficient of determination R^2 higher than 0.99, 0.82 and 0.79 for fat, protein and lactose respectively.

CONCLUSION

The presented system, integrated into an AMS and targeted to on real-time prediction, can be used for accurate and autonomous monitoring of milk composition, with a prediction performance well within the ICAR requirements for at-line, on-farm milk analyzers (RMSEP < 0.2%) for fat, protein and lactose and even meeting the standards for laboratory milk analyzers (RMSEP < 0.1%) for fat and lactose. However, drift was observed in the predictions, especially for the prediction of crude protein over time. Therefore, further research on the development of online calibration maintenance techniques is required to correct this model drift.

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Insect-assisted bioconversion of aquaculture sludge in plant fertilizer

Giacomo Rossi*, Shikha Ojha, Oliver Schlüter

Quality and Safety of Food and Feed, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Potsdam, Germany

*grossi@atb-potsdam.de

Aquaculture sludge (AS) is a nutrients rich material, which may present a severe problem for the environment when not disposed properly. Black soldier fly (BSF, *Hermetia illucens*) has been described for playing a crucial role in the circular economy by upgrading several kinds of waste into valuable nutrients and can support the development of resilient food systems. In this study, two substrates consisting in 100% AS (dry matter = 8%) and 75% AS supplemented with 25% chicken feed (CF) (dry matter = 30%) were tested. One standard substrate (0% AS) for BSF larvae rearing (CF + distilled water: dry matter = 36.5%) was used as control. BSF final larval weight was significantly higher for larvae grown on 75% AS, while no significant differences were recorded on larval survival. Substrate reduction index on fresh matter basis was significantly higher in 100% AS, while waste conversion efficiency and bioconversion rate, both computed on dry matter basis showed no differences between substrates. Mineralization of the sludge organic matter, slight increase in organic carbon, reduction in total nitrogen and conversion of nitric and nitrous nitrogen in ammonium nitrogen were detected during 10 days of the recycling process. Significant increase in carbon to nitrogen ratio and pH were also observed. Particularly, higher carbon to nitrogen ratio was observed for 75% AS (14.06 ± 0.29; increase of ~30%) followed by 0% AS (13.82 ± 1.59; increase of ~3%) and 100% AS (7.96 ± 0.06%; increase of ~11%). pH showed higher final value on 100% AS (7.32 ± 0,03; increase of ~0.7 points) followed by 75% AS (7.23 ± 0.11; increase of ~ 2 points) and 0% AS (7.03 ± 0.33; increase of ~ 1 point). Increase in total phosphorous was also detected from substrate to frass, with highest rate in 100% AS (92%; final concentration = 23.68 ± 0.32 g/kg), compared to 75% AS (74%; final concentration = 8.53 ± 0.55 g/kg) and 0% AW (65%; final concentration = 3.53 ± 0.95 g/kg). In conclusion, BSF larvae show great potentiality for upgrading aquaculture waste in plant fertilizer and soil improvers. However, further studies focusing on physical and microbiological characteristics and their impact on plant status and growth performances are required.

Keywords: *Hermetia illucens*, aquaculture, waste treatment, circular economy, soil fertilizer

Conference topic: Circular Biobased Economy/Sustainable Energy/Waste Management

Effects of site-specific corn sowing on yield and quality in different climatic regions in Austria

Butzenlechner Fabian [a, *], Philipp Kastenhofer BSc.[a], DDI Dr. Markus Gansberger [b], DI Prankl Peter [b], Albert Müllner [c]
[a] Josephinum Research, Rottenhauser Straße 1, Wieselburg, Austria
[b] HBLFA Francisco Josephinum, Weinzierl 1, Wieselburg, Austria
[c] Saatbau Linz eGen, Schirmerstraße 19, Leonding, Austria
* Corresponding author. Email: f.butzenlechner@josephinum.at

Especially in dry years, different sub-areas within a field react differently to the lack of water supply in case of drought. This phenomenon is due to various physical soil properties and soil types. While crops such as wheat or rape can react more strongly to these different conditions through tillering or flower branching, this is much more difficult for crops such as maize. The ability to compensate is limited to the biomass growth and the cob formation of the individual plant, which leads to yield depression during prolonged drought if the water supply is insufficient.

The different subplots can be used to react to this in a subplot-specific way during sowing. In this way, the seed rate can be reduced in areas with a low water supply and the stand area of the individual plant can be increased to give the individual plant more space. As a result, more resources, including water, are available to the individual plant, which reduces the risk of any yield depression. In order to create a sub-area-specific sowing system for maize, the different sub-areas within a field must be determined and clustered. With the help of multi-spectral images from various satellites (Sentinel 2, Landsat), long-term information is available on the vegetation development of crops on Austrian arable land. This information can be used to define different sowing zones on the fields. When sowing maize, it is then possible to react to the different zones by varying the sowing intensity within a range. How clearly the differences are expressed on the sub-areas in the respective years depends largely on the precipitation amounts, the precipitation distribution and the heat sum in different climatic regions and the compensation capacity of the respective maize variety.

In the years 2020 to 2022, trials were set up for sub-area-specific maize sowing in four different climatic regions in Austria and the effect on yield and quality was investigated. The results show that site-specific maize sowing produces an additional yield of one to thirteen percent, depending on the climatic region and the weather. Especially in climatic regions with low, below-average annual precipitation, the yield advantage is given in all trial years. In wetlands it has been shown that the differences can be compensated well, and that the differentiation of the seed rate shows no or only a minor effect. It could thus be established that sub-area-specific maize sowing in particularly heterogeneous locations represents a yield and quality risk hedge for dry years.

GRASS-BASED CIRCULAR BUSINESS MODELS FOR RURAL AGRI-FOOD VALUE CHAINS

Lessons learnt from GO-GRASS project

Muluken E. Adamseged; Hyunjin Park, Philipp Grundmann; Richard Orozco, Sonja Germer; Thomas Hoffman, Thomas Heinrich, Zhengqiu Ding

Grassland and shrubland cover 28% of the EU areas. In some of these areas, large parts of the biomass produced currently rots and decays before and after mowing, incurring costs and depriving individuals and society of benefits. New technological and business solutions for improved grassland management can significantly contribute to the maintenance of agroecosystems and development of rural economies. The GO-GRASS project, using biomass from grassland, creates new business opportunities and replicates them in rural areas through deploying and validating four small-scale demonstration cases (DEMOs) of circular integrated agro-food systems in Denmark, Germany, Sweden and the Netherlands. In Denmark, the DEMO case develops a bio-refining technology to extract protein concentrates for monogastric animals. In Germany, the DEMO case proposes biochar production via pyrolysis of grassland-cuttings from wetlands for site-specific soil amendment of cropland. In the Netherlands, the DEMO case engages in fermentation technology to produce paper and carton products from roadside grass and nature and fauna protection area. In Sweden, the focus lies on establishing briquetting technology at local and small-scale to produce climate-friendly and heat-treated animal bedding using reed canary grass. The development of the technologies and transition into a business model are led by the principles of cumulativeness, innovation, replicability, inclusiveness, and circularity. The principles serve as guidelines and requirements for adapting and developing various tools to different contexts, integrating circular economy in rural areas, ensuring successful demo implementation, creating favorable business environments and maximising the replication potential in other rural areas in the EU. The GO-GRASS project is contributing to a range of circular and sustainable business models with high replication potential to be used by entrepreneurs, local authorities and other stakeholders. It demonstrates innovative business solutions as integral part of sociotechnical systems based on unused biomass and cost-effective processing technologies. The case study results of the DEMOs describe and reflect different approaches for learning and innovation in sociotechnical systems supported by a variety of tools for capacity development. The preliminary findings suggest that for the innovation and transformation of sociotechnical systems it is crucial to co-create social and technical solutions in action networks guided by entrepreneurship, which aligns its capacities and effectively exploits existing opportunities based on unused biomass from grassland and shrubland in circular and inclusive business models. The entrepreneurship-guided solution requires involvement of various actors' ranges from local producers, consumers, associations, research institutes, to regional and national level public agencies who make decision on the various rules and regulations and other strategic decisions.

Topic: Animal Production Technologies (Oral presentation)

Influence of barn climate on the rumen temperature of lactating dairy cows

Gundula Hoffmann[a], Julia Heinicke[a], Lena Dißmann[a], Kay Fromm[a], Sebastian Wille[b], Thomas Amon[a, c]

[a]*Leibniz Institute for Agricultural Engineering and Bioeconomy e.V. (ATB), Department of Engineering for Livestock Management, Max-Eyth-Allee 100, 14469 Potsdam, Germany; phone: +49331-5699520; E-mail: ghoffmann@atb-potsdam.de, jheinicke@atb-potsdam.de, ldissmann@atb-potsdam.de, kfromm@atb-potsdam.de, tamon@atb-potsdam.de*

[b]*Wille Engineering, Volkerstraße 14, 65795 Hattersheim am Main, Germany, E-mail: s.wille@wille-engineering.com*

[c]*Institute of Animal Hygiene and Environmental Health, Department of Veterinary Medicine, Freie Universität Berlin, Robert-von-Ostertag-Str. 7-13, 14163 Berlin, Germany, E-mail: thomas.amon@fu-berlin.de*

In the course of a predicted climate change, the problem of welfare and heat load of dairy cows has become increasingly important even under moderate climate conditions. In order to maintain the well-being of the cows and their performance, it is important to know when heat load leads to an impairment of physiological parameters such as body temperature. The objective of the present study was to analyze the body temperature of lactating dairy cows during the summer months in comparison to the ambient temperature and temperature-humidity index (THI) in the barn.

The study was conducted in a naturally ventilated dairy barn in Brandenburg, Germany as part of the DigiMuh project. Data from June to September 2021 were analyzed for this trial. The rumen temperatures of 40 dairy cows were measured every 10 min individually with a smaXtec bolus (smaXtec, Graz, Austria) placed in the reticulorumen. Recorded data during drink cycles were corrected and time periods of milking (cows outside the barn) were excluded from the statistical analysis (performed with JMP 15, SAS Institute Inc., Cary, NC, USA). The barn climate was measured at two points within the barn and the average THI was calculated every 10 min. The THI was used to define the heat load the cows were exposed to. The correlations (Pearson's correlation coefficient, r) between body temperature and barn climate were analyzed.

The results showed only a slight positive correlation ($P<0.001$) between rumen temperatures and ambient temperatures ($r=0.11$) as well as THI ($r=0.12$). This indicates that even at high ambient temperatures, cows are still able to keep their core body temperature relatively constant. However, it was also observed that there were isolated alarms on hot days (THI>70). These are generated by smaXtec when the individual body temperature of a cow deviates significantly from its mean value of the previous days. Therefore, an individual consideration of dairy cows is necessary to assess their heat load.

The project is supported by funds of the Federal Ministry of Food and Agriculture (BMEL) based on a decision of the Parliament of the Federal Republic of Germany via the Federal Office for Agriculture and Food (BLE) under the innovation support program.

Phosphorus-based variable rate manure application in wheat and barley

Jian Zhang [1], Steven Sleutel [1], and Abdul M. Mouazen [1,*]

[1] Department of Environment, Faculty of Bioscience Engineering, Ghent University, Ghent, Belgium

* E-mail of the corresponding author: Abdul.Mouazen@ugent.be

Manure is used as a source of nutrients and organic matter in soil, although issues associated with excess nitrogen (N) and phosphorous (P) are common in western Europe. One way to optimize the use of manure is variable rate (VR) application. This work aimed to evaluate the economic and environmental benefits of P-map-based VR manure application, compared to uniform rate (UR) application. An online visible and near infrared (vis-NIR) spectroscopy sensor was used to collect online spectral data of soils in two fields of 5 and 8 hectares (ha) with wheat and barley respectively in Belgium. A calibration model to predict P in soil was developed by partial least squares regression. The P content in soil was classified into four-class maps for these two fields, where different P_2O_5 fertilizer recommendations were given based on a polynomial fitted with data extracted from the manure action program 6 (MAP6). Then, the P_2O_5 fertilizer recommendations were divided by P_2O_5 content in manure to calculate the manure rates for the four P site-specific zones. A strip experiment was carried out to compare VR treatment with UR treatment with sufficient replicated. Results showed that P-based VR manure application resulted in almost the same yield as the UR treatment, but saved the environment in the sense of reducing both N by 46 kg/ha and 29 kg/ha, and P_2O_5 by 19 kg/ha and 12 kg/ha, applied in the two fields. Since the farmers in Belgium received 3 Euro/ton as compensation from the manure providers in return of allowing the manure to be applied in their fields, the P-based VR manure application scheme using less manure was not profitable compared the UR with more manure applied. However, if the farmers have to pay for purchasing application as in some countries in Europe, a P-based VR manure application scheme would be profitable.

Keywords: VR manure application; online measurement; vis-NIR sensor; environmental and economic evaluation.

An Automated System of Soil Sensor-based Site-specific Seeding for Silage Maize

Muhammad Abdul Munnaf[1], Abdul Mounem Mouazen[1,*]

[1]Department of Environment, Ghent University, Coupure Links 653, 9000 Gent, Belgium

[*]E-mail of the corresponding author: abdul.mouazen@ugent.be

Presentation topic: Precision Agriculture / Digitalization

Abstract

Despite recent studies of map-based site-specific seeding (SSS) revealed improved agronomic and economic outcomes over uniform rate seeding (URS), no sensor-based SSS exists to date. This study aimed to develop and evaluate an automated sensor-based SSS technology for silage maize production. An on-line visible and near-infrared reflectance spectroscopy (vis-NIRS) sensor was installed in front of a tractor to provide real-time input data to control the seed rate using a precision seeding machine mounted at the back end of the tractor. A LabVIEW-based software was developed and used to predict soil fertility index using on-line vis-NIR spectra, which was then used to calculate the seed rate and transfer it to the controller of the seeding machine. The agronomic and economic benefits of SSS were compared with URS for silage maize production under a site-year experiment. Results showed that the proposed sensor-based SSS technology was 87.5 % efficient in controlling the desired seed rates, according to the soil fertility status. In parallel with the observed spatial similarity between predicted SFI (Soil Fertility Index) and actual seed rates, a strong linear association (R^2=0.80) was also achieved. As a result, SSS improved silage yield by 1.4 t ha^{-1}, while sowing a lower seed rate (86,400 seeds ha^{-1}) than the URS (90,000 seeds ha^{-1}). This improved gross margin by 91 € ha^{-1}, of which only 7 € ha^{-1} was attributed to savings on seed cost. The proposed sensor-based SSS system is technically sound and accurate to assess soil fertility and thus transform within-field fertility variations into agro-economic benefits effectively.

Keywords: Automation; Precision agriculture; Soil sensing; Decision support system; Soil fertility assessment; Yield and Cost-benefit analysis

Potential of vis-NIRS spectroscopy for predicting soil nitrogen mineralization rate

Farida Yasmin Ruma[1], Muhammad Abdul Munnaf[2], Stefaan De Neve[3], Abdul Mounem Mouazen[4*]

[1]faridayasmin.ruma@ugent.be, [2]munnaf.mabdul@ugent.be, [3]stefaan.DeNeve@UGent.be

*corresponding author [4]abdul.Mouazen@UGent.be

Department of Environment, Ghent University, Coupure Links 653, 9000, Gent, Belgium

Presentation topic: Precision Agriculture / Digitalization

Abstract

Since nitrogen (N) mineralization governs soil and plant N dynamics, assessing the soil N mineralization rate (SNMR) is crucial for agriculture as well as environmental stewardship. Traditional methods to determine SMNR are labor- and time- intensive. This study aims at predicting SNMR using a visible and near-infrared reflectance spectroscopy (vis-NIRS) sensor, and to investigate the potential of spectra fusion with soil total N (TN) and total carbon (TC) to improve prediction accuracy. A total of 75 soil samples were collected from 4 arable fields in Flanders, Belgium. Aerobic laboratory incubation was conducted under controlled conditions (bulk density, temperature, moisture content) for a period of 60 days with 7 sub-sampling events (total 525 samples). Soils at each sampling time were extracted for mineral N (NH_4^+ + NO_3^-) estimation as well as scanned using a vis-NIRS (CompactSpec, Tec5 technology, Germany) with a spectral range of 305-1700 nm. Afterward, SNMR was calculated as the coefficients of linear fits between net increase in soil mineral N and incubation days. Per field partial least squares regression models were developed with a dataset comprising of SMNR and vis-NIRS scanned soil spectra with and without TN+TC from 6 of 7 sampling events except the 2nd sub-sampling, whose dataset was used for models' validation (prediction). Results revealed that vis-NIRS sensor estimated SMNR with moderate to high prediction accuracies both in cross-validation (coefficient of determination, R^2=0.64-0.95, root mean square error, RMSE=0.02-0.05 mg N day^{-1} kg^{-1}, ratio of prediction to interquartile, RPIQ=1.97-6.98) and prediction (R^2=0.62-0.84, RMSE=0.03-0.07 mg N day^{-1} kg^{-1}, RPIQ=1.79-3.32) phases justifying the models' reliability and robustness. Inclusion of soil TN and TC rather improved prediction accuracies explaining that vis-NIR spectra features may already reserve such information and hence additional information is not essential but beneficial. In conclusion, a short-ranged vis-NIRS sensor can effectively measure SMNR leading to significant efforts and time savings, and it encourages future studies for further validation of the proposed technology.

Title of Paper:
Agricultural Engineering development in times of planetary emergency.

Authors:
Dipl. Ing. Holger Friel — Friel & Schlegel UniverCity Engineering GbR
Dipl. Ing. Christoph Schlegel — Kirchenstrasse 3, 18057 Rostock friel@friel-schlegel.de

Wilhard Friel — Eichenallee 4, 19288 Glaisin

Abstract:

Feeding the world without destroying it, is actually the most important target for LOR's of all technical equipment, not only in agriculture. The WHO found out that we actual produce enough food for 12 Billion people. Stopping climate change, air pollution and species extinction will drive the way we live, the way we eat, the way we work, move and travel.
So this speech will show on different unpublished examples especially in harvesting technologies, how complexity and energy consumption can be reduced with scientific methods.
The need of mass reduction, noise reduction and in the same way environmental savings can be done with looking to bionic too. Sheep, horses, cows and all grazing animals don't use high speed cutting with super sharp knives to cut and eat grass. Sheep herds are also swarm intelligent. Looking back means looking forward, because all technologies that former worked by hand or by horse are under special interest for decarbonization the basic food production and in the same way for saving the insects and birds we need therefor. Driveline power will be renewable, sun driven, Battery EV is physically more efficient than FuelCell and synthetic fuels.
The beginn of our scientific work based in the beginn of the 80th at the university of Rostock. Reducing energy consumption from Forage Harvesters in silage production was demanded and a lot of scientist, engineers and manufacturer stuff worked on it in the „Technikum Halmfutterernte Klockenhagen“ until 1989. The Unicracker(later aka V-Cracker, Kernel Star, Scheibencracker) was born than and there. After the wall came down the marked economy took us over and our scientific results for feeding, cutting, processing and two phase throwing of gras and corn were still unpublished, all the special PhD's thesis got lost for public, because the AgEng Institute in Rostock was shutted down. But the knowledge and the persons behind are still there.
Friel&Schlegel started to work for and with Landtechnik Schönebeck and Same Deutz Fahr, since the mid 90th all forage harvester manufacturer in different areas. Since 2000 we also developed tillage, seeding, sprayer, fertilizing, ploughing and different mowing, harvest and drive line technologies, using 3D computer based simulation from the beginn and home office as the most effective way in a network with partners for developing, prototyping and testing agricultural machinery. What we always did, was to look for the most efficient technology and we always generated ideas around the LOR's we had to fulfill.
So over the Years we were deeply involved in different economic marked driven developments and were not always able to convince our customers(AgEng manufacturers) to start a new way of thinking. Because we worked for most of them, we tried to start an university leaded(Dresden) forage harvester development program together with all FH manufactures. Difficult until now.

The actual LOR's and the demand for more capacity and bigger working width with existing technologies ended often up in huge and complex „Transformer“ machines, that had bad effects to road regulations, material stress, costs explosion, and at least soil destruction, insect extinction, over nutrition and pollution. Solutions to reduce all of that including carbon footprint and nitration of groundwater are still there, we think.

Food production is actually in a disrupting change, driven by customers and the demands of the next generations. Meatless burger, milk, cheese, fish, eggs without harming animals are still there. Vertical farms with its low energy LED lights are entering even local supermarkets with plant cubes. On clean meat from stem cells are working different companies around the world. Agriculture has to be a part of cycle economy on lowest energy consumption level and mildest resource use. Automation will increase, AI based technologies will replace over fertilizing and the actual use of herbs. Those processes already started and will become better and better, next it will roll out exponential.
So how will AgEng give answers to all that? How will farming look like? Hopefully better for animals and humans than now. Stopping climate change at 1,5°C is one thing we have to do, species saving as the base for human life saving is most important. In Germany the Earth Overshoot Day will be actually in May, the (carbon)energy input in food production in Europe is ten times higher, then the nutrition energy output.
Time for discussions if whether or not to follow the all new way of new economic thinking is over.
Green Deal is a good base for new development in Agriculture - Time to act.

Topics:
Harvesting technologies
or
Product development, market performance

Integrated methodology for vibroacoustic and psychoacoustic evaluation of machinery and equipment

The requirements for the noise emission of machinery and equipment into the environment as well as noise and vibration at the operator's workstations are specified in the relevant standards and directives. Bearing this in mind, manufacturers of agricultural machinery and equipment are taking measures to not only meet the normative requirements, but also to further reduce noise and vibration and improve the "sound" of machinery in order to increase competitiveness in the market.
Taking technical measures to reduce noise and vibration requires specific technical knowledge of both the machine process and machine vibroacoustics, as well as an "understanding" of the vibroacoustic mechanisms that cause excessive emissions. So-called "blind" actions significantly prolong the noise reduction process, which turns into significant increase of design cost and extends time to market of the product
Additionally, the “right sound” identifies the product as high quality.
As part of ongoing research and development, a process for vibro/psychoacoustic optimization of machinery and equipment has been developed. This allows to evaluate the acoustic potential of structural and material changes. Virtual prototyping of solutions to reduce noise and optimize the sound of machines and devices and their drives is applied to reduce cost and development time.
The entire service is carried out in ARIC (Acoustic Research and Innovation Center), which provides dedicated laboratories – all in one place, in one research cycle, with direct involvement of the machine manufacturer and ARIC specialists. This allows for significant cost and time to market reduction. Additionally, the developed innovative process of integrating acoustic testing according relevant standards, vibration and psychoacoustic testing and prototyping of new solutions will enable a more detailed analysis and development of a “tailor-made” solution, ultimately increasing product competitiveness in the market.
The presentation will include a step-by-step process for vibro and psychoacoustic optimization using an example of an agricultural machine at ARIC.

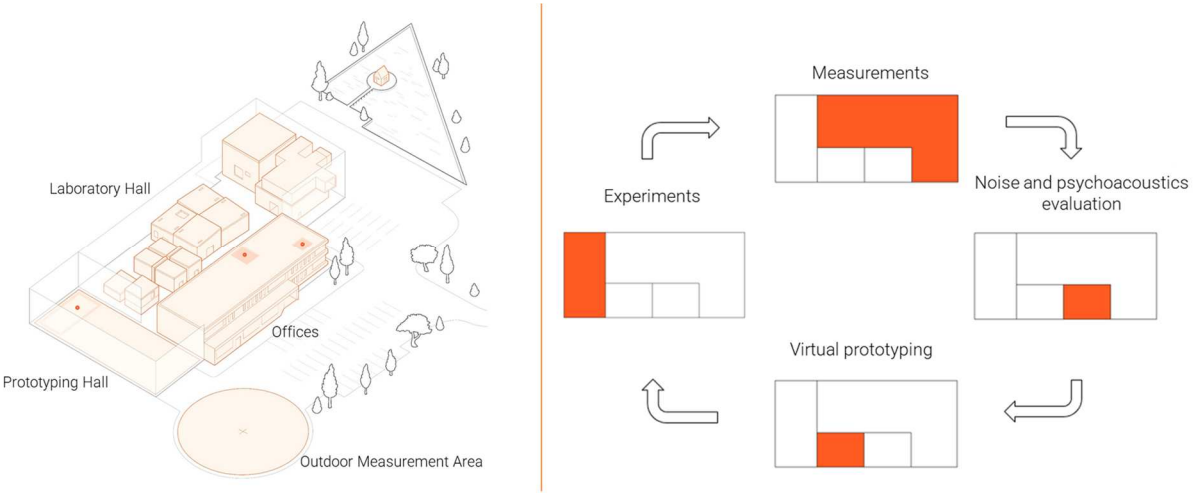


Figure 1 The process of implementation of the optimization process

KFB
KFB Acoustics GmbH
Lothringerstraße 38,
D-44805 Bochum
T +49 234/361818-18
E office@kfb-acoustics.com
www.kfb-acoustics.com

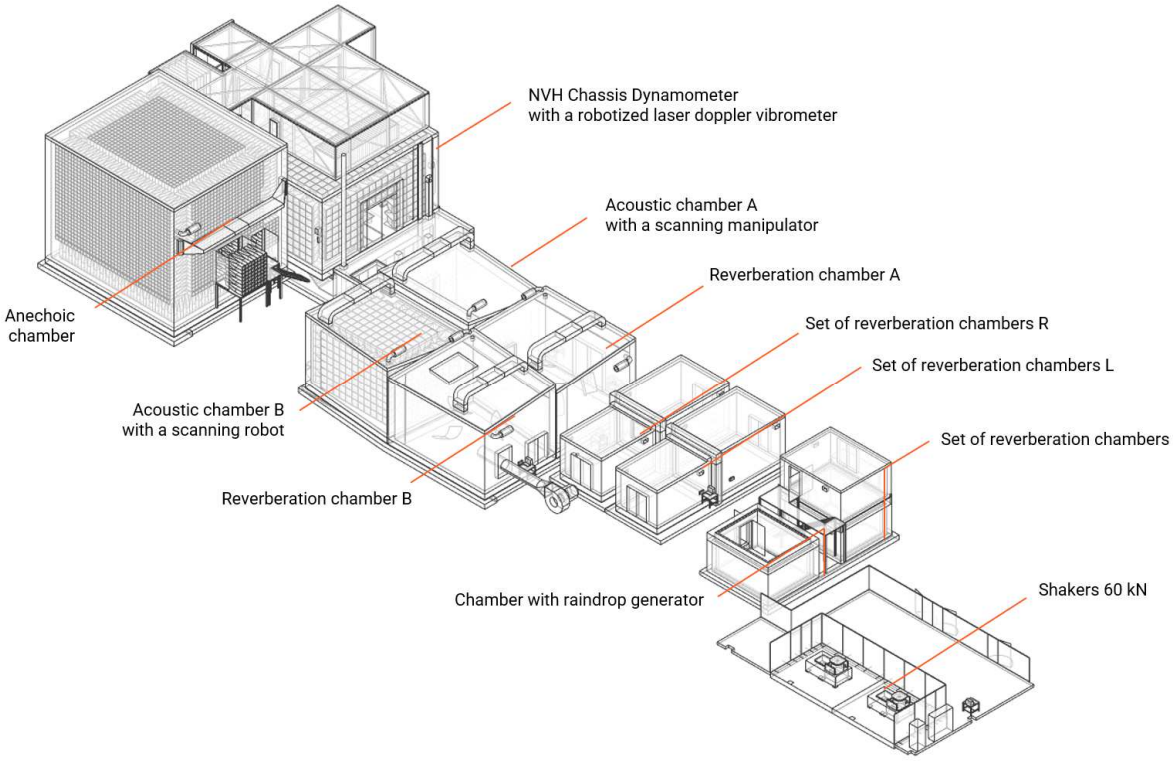


Figure 2 Research & Development areas

Name: Maik Gränitz
Telefon: +49 151 70625831

E-Mail: maik.graenitz@sick.de

SICK AG
Erwin-Sick-Str. 1
79183 Waldkirch
Germany

Submission of Papers for VDI AgEng-LAND.TECHNIK 2022

Sehr geehrte Frau Wunn, sehr geehrte Frau Schreiner,

anbei unsere Anmeldung für unseren Vortrag auf der VDI AgEng LAND.TECHNIK 2022 im November.

- *Assignment to a specific presentation topic:* Precision Agriculture/Digitalization
- *Title of the paper:* Sensors for agriculture robots
- *Subtitle:* How sensors enable the transformation towards highly automated and sustainable agriculture production systems
- *Authors:*
  - Manuel Fischer (Lead Industry & Program Management - Mobile Outdoor Automation)
    - SICK AG | Erwin-Sick-Str. 1 | 79183 Waldkirch | Germany
    - Mobile: +49 172 4033784 | Fax: +49 7681 202-5677 | manuel.fischer@sick.de
  - Dr.-Ing. Bernd Helge Leroch (General Manager)
    - Robot Makers GmbH | Merkurstraße 45 | 67663 Kaiserslautern | Germany
    - Mobile: +49 631 204013 13| Fax: +49 631 204013 99 | leroch@robotmakers.de
- *Abstract:* see below

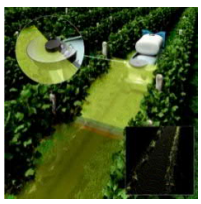
SICK is a global, leading manufacturer of intelligent sensors and sensor solutions for industrial applications. Within Mobile Automation SICK offers comprehensive solutions for environmental perception, motion control, smart data and connectivity, and functional safety.

In this field, a strong trend towards agricultural robotics has developed over the past years, partly due to labour shortages and an ever-growing awareness of sustainable and efficient agriculture. The use of agricultural robots is intended to automate agricultural work that is currently still often carried out conventionally. This means that humans can be relieved of performing monotonous and particularly strenuous tasks, thus reducing dependence on manual labour. To achieve this automation with agricultural robotics, the use of sensors is substantial.

SICK has developed a broad sensor solution portfolio for safeguarding vehicles, collision avoidance and warning, object detection, motion control and many more. The 3D-LiDAR sensor *MRS1000* from SICK, for example, is particularly well suited for object detection and navigation support for mobile machinery. Its four scanning planes make it possible to record the travel path of autonomous vehicles in three dimensions. A 3D point cloud can then be used to identify row distances and natural landmarks (e.g. vines). Obstacles on the travel path can thus be reliably avoided.

This sensor is also part of the autonomous mulcher, which can be seen in the picture below on the right. Besides our 3D-Lidar the robot is equipped with a SICK inclination sensor for leveling purposes.

Together with our partner Robotmakers as enabler for smart machines we offer customized solutions for mobile machinery, specialized on agriculture robotics.



Effects of different autoclaving parameters on the microbial qualities of raw milk samples

Timothy Denen Akpenpuun[1*], Musliu Olushola Sunmonu[2], Kehinde James Falua[3], Hamid Taye Muslim[4], and Funmilayo Ola[5]

[1] Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin PMB 1515, Nigeria
[2]Department of Food Engineering, University of Ilorin, Ilorin PMB 1515, Nigeria
*Correspondence: akpenpuun.td@unilorin.edu.ng ; Tel.: +234-706-657-6605

ABSTRACT

The study was conducted to determine the effect of different autoclaving parameters; time (10, 20, and 30 minutes), temperature (110, 121, and 130^{0}C), and holding materials (glass, aluminium, and stainless steel) on the microbial quality of raw milk. The raw milk samples from White Fulani and Sokoto Gudal breeds and a mixture of both breeds were autoclaved while varying the autoclaving parameters. These parameters were completely randomised and varied within and across their levels (81 runs) with three replications of raw samples. The autoclaving equipment and environment were sterilised to avoid contamination of the milk samples. Various microbial growth or count (bacterial and fungi) such as Total Viable Count, Coliform Count, Fecal Coliform Count, and Fungal Count of each treatment combination (holding material, time, and temperature) were observed at the end of the experiment, and the result was evaluated using ANOVA at $p \leq 0.05$. A total of five organisms, Fungi (*Saccharomyces* and *Aspergillus*) and Bacteria (*Lactobacillus*, *Bacillus, and Streptococcus*), were identified. From the result of the research, milk samples in glass jars showed a relatively low microbial count across all the parameters, with *Lactobacillus* and *Bacillus* showing the highest value of 5.49 x 10^{-3} CFU/ml and 11.02 x 10^{-3} CFU/ml. The best microbial load occurred at the highest temperature, glass material, and breed mixtures.

Keywords: Fungi, bacteria, autoclave, breeds

Title:

Development of a new structural undercarriage for combine harvesters

Authors:

Benedikt Pölling (CLAAS Selbsfahrende Erntemaschinen) +NN

Assignment to presentation topic

tbd

Abstract Compact abstract pre-info (as agreed via phone between S. Wunn and C.-P. Stickel)

The motivation was a high modularity with less complexity for two product ranges of combines, a larger swivel range of the rear axle for mountain application, less weight and cost.

With this new design, it is possible to reduce the number of welding assemblies for two combine ranges in the same production line. This has a significant advantage even in a mixed production line.

This paper covers the full development process of this new design of a structural combine undercarriage. It shows the way starting from the theoretical analyses including topology and FEA optimizations, validation in lab and field and the challenges in the industrializations phase.

An overview will explain the complete timeline with all activities, milestones and start of production.

A conclusion and summary will finish the paper.

Title of the paper:

Material and interaction properties of straw and wheat for Discrete Element Method

Scientific reviewing requested

Assignment to a specific presentation topic:

Post-Harvest Technologies

Meaningful abstract:

Simulation methods are an effective tool to reduce cost-intensive field experiments and can be used at the beginning of product development for design decisions. The application of simulation methods and the knowledge gained from simulation methods depend significantly on the parameterization of the models. In agricultural machinery, such as a combine harvester or Biokraft ball mill, material flows, as well as interactions between the machine and organic material are simulated. In the case of the combine harvester, this could be residual grain separation and in the case of the Biokraft ball mill, this could be mass flow. The parameterization of a simulation model includes material and interaction properties. At the University of Hohenheim, a grain and straw model is being developed for the discrete element method, for which extensive experiments have been carried out on the static friction coefficient between grain and straw and also on the elastic behavior of straw. The coefficient of static friction has been investigated using the inclined plane test setup. The three-point bending test corresponds to the test setup of a beam loosely supported on both sides. The straws have been recovered as whole plants and subdivided into three internode sections for sample preparation.

The coefficient of static friction of straw and grain has been investigated as a function of contact pressure. In the case of the straw, a distinction was also made between which internode section of the plant the sample originated from and whether the sample was oriented longitudinally or transversely to the direction of slip. Furthermore, the leaves were examined. The substrates of the static friction tests are steel, plastic, three internode sections of straw and the leaf material. The results indicate that the coefficient of static friction depends on all the varied parameters. For example, the static friction coefficient decreases with the increase of contact pressure for most of the material pairing, and most of the determined static friction coefficients for the longitudinal and transverse orientations of the specimens are significantly different.

The 3-point bending test has also been studied with specimens of the three internodes. Here, the focus has been on the elastic behavior of straw, in which, on the one hand, the Young's modulus has been calculated, and on the other hand, the deflection at maximum force and the maximum force have been recorded. For the calculation of the Young's modulus, it is necessary to record geometric properties of the straw samples. The modulus of elasticity is on average 1.96e+9 Pa, the maximum force is 3.75 N and the deflection at maximum force is 1.38 mm.

Potential and improvement of maintenance efficiency of agricultural machines by a new digital maintenance assistant

- scientific reviewing requested -

Presentation Topic: Precision Agriculture/Digitalization, Tractors/Power Trains/Electrical Drives

Heinz Bernhardt [1]*, Franz Hausmann [1], Fredrik Regler [1] and Max Krueger [2]

[1] Agricultural System Engineering, Technical University of Munich, 85354 Freising, Germany
[2] Smart and Digital Solutions, Walterscheid Powertrain Group, 53797 Lohmar, Germany
* Correspondence: heinz.bernhardt@wzw.tum.de; Tel.: +49-8161-713086

The current situation on agricultural farms is characterized by growing complexity due to a multitude of necessary machines and systems. In order to maintain competitiveness and make workplaces safer and more comfortable, automation in agriculture is advancing rapidly. Farm personnel are therefore challenged by the maintenance, servicing and repair of an increasingly complex machine fleet. In order not to jeopardize the efficiency advantage of highly automated machines by an increased risk of failure and maintenance effort, new, time- and cost-efficient maintenance and service concepts have to be developed.

In an online survey on current requirements and problems of agricultural various damage potentials and performance parameters of different machines in various fields of application in agriculture were collected. The most common and most critical component for agricultural machines are the PTO shafts. More than 80% of the participants of the survey have already experienced defects on PTO shafts. The mentality on farms regarding maintenance of PTO shafts can be classified on the basis of the following survey results. In order to analyse the mentality of the farm workers when it comes to maintenance, it was asked what criteria the users use to arrange maintenance on the farms. The results show that only 37% maintain the machines according to actual workload such as operating hours or hectares. 24% perform maintenance on a routine based (e.g. every morning) and 23% perform maintenance when ever they find time for it. 16% of the respondents maintain their machines according to instinct and thus without any well-founded data basis. In another question the farm workers were asked about the knowledge of specific maintenance intervalls. 54% of the respondents know that there are specific maintenance intervals for different types of cardan shafts, but only less then the half of those responden, that they are trying to follow the maintenance intervalls. When asked whether a digital system that reminds them of maintenance intervals and facilitates the process could be used, 62% of the respondents could imagine using such a system.

The lack of maintenance mentality can be concluded by a lack of knowledge of the consequences of an unappropriate maintenance. In order to demonstrate the benefit of an appropiate maintenance strategy, a total-cost of ownership simulation for the maintenance of agircultural implements have been developed. Maintenance costs consist of a portion for lubricants and a portion for labour costs. Additionaly, the expected component lifetime is significantly reduced, when maintenance intervals are not beeing followed. The simulation was carried out for the annual costs of several different maintenance scenarios "Daily maintenance", "No maintenance" and "Maintenance according the desired intervalls". It could be shown, that the lowest costs were achieved in each case for the "Maintenance according the desired intervalls" scenario. By following the desired mainteance rules, the maintenance costs were reduced by an average of 86% and working time by 75%.

In order to achieve an optimum of maintenance efficiency, the lack of information on maintenance intervalls and instructions need to be solved by a digital maintenance assistant. To successfully establish a digital maintenance assistant in practice in the future, it is necessary to develop a user-friendly application as well as to convincingly present the advantages of a maintenance assistant to the end-user. When asked in what form users would like to receive PTO shaft information in real time, 25% of respondents could imagine to receive maintenance informaiton via a smartphone app from the PTO shaft manufacturer. In order to provide accurate maintenance information in a digital format, an

operation hours counter was developed, in cooperation with a PTO shaft manufacturer, to track the hours of usage of an agricultural implement based on the roation of the PTO shaft. The operation hours are transmitted via a bluetooth protocol to a maintenance assistant app on a smartphone. The maintenance assistant app provides all relevant information for the installation, repair and maintenance as well as the current operation hours of the implement to the farmer. The digital maintenace assitant is currently tested together with selected farms in order to prove the usability in real life farm operation

Using specified sensor technic to develop a novel and gap-closed system for data acquisition in calf and heifer husbandry

- scientific reviewing requested -

Presentation Topic: Digitalization, animal husbandry, health management, animal production technologies

Heinz Bernhardt [1], Thomas Förster [3], Morteza Ghaffari [2], Kira Hemmert [3], Christian Koch [4], Felix Leixner [4], Jürgen Plesse [3], Fredrik Regler [1]*, Helga Sauerwein [2], Kathrin Ziegler [1]

[1] Agricultural System Engineering, Technical University of Munich, 85354 Freising, Germany
[2] Animal Physiology, Rheinische-Friedrich-Wilhelms University Bonn, 53115 Bonn, Germany
[3] Förster-Technik GmbH, 78234 Engen, Germany
[4] School and Research Institute for animal husbandry Neumühle, 67728 Münchweiler an der Alsenz, Germany
* Correspondence: fredri.regler@tum.de; Tel.: +49-8161-713440

Today the use of modern sensor technic to analyze the status, health and productivity of dairy cattle is getting more common for adult dairy cows, but is infrequent during the rearing time of calves and heifers. Occasionally, the calf is monitored during its first days of life and later as an adult cow again, which is leading to a major data gap for the time in between. Concomitant, during its adolescence, the calf and later heifer is laying out its foundations for future productivity and health.

Commonly, during the adolescence, regular health evaluation of the animals is an important task for the farmer, which is carried out mostly by quick looks over the animals while feeding. This circumstance leads to a major issue: Cows, also calves and heifers, are fleeing animals which hide pain and problems in front of predators, as which a human is seen. Therefore, a sick animal will try to cover up an injury and a farmer, who is just occasionally checking for the animals, will not be able to identify a sick animal during early stages of an illness. In modern farming, sensor technics are common tools to monitor the activity, behavior and condition of animals 24 hours per day and identify changes. Data is acquired in large scale for different reasons, but so far, it is fragmentary with major gaps during the period of heifers and nor used for illness detection in early stages, neither for breeding references.

The issue of data gaps can be solved by adapting novel sensor technics in all stages of growing cows, including the stages of calves and heifers, and reaching out over the birth of the adult cows first calf. In order to reach this goal and to close data gaps, a bundle of sensors was applied on three large research farms to generate quantitative data. Therefore, activity sensors, an automated milk feeder with an additional front hoof scale, a smart water station and a smart concentrate feeder were installed in all research stables. The activity sensors were applied around the neck of the calves, while the milk, water and concentrate intake is detected and measured by identifying the calf via radio-frequency identification (RFID) in the specific station. Beside the amount of intake, different activity, time, weight and temperature data is collected in the stations as well. In the development stage of heifers, activity data, water and concentrate intake will be detected and measured using the same sensors as used for calves. Additionally, heifers will be weight several times between the rehousing out of the calves stable and their first insemination. Data are collected from three different experimental farms in Southern, Central and Eastern Germany. In total 240 calves are born and housed between September 2021 and April 2022 with more calves in expectancy in the future months. The acquired data is gathered and stored online in a cloud for further analysis.

In further work, the data will be used to extract the information which indicates healthiness, preprocessed and analyzed automatically by an algorithm to give comprehensive information about the health status of an animal, to detect changes due to sickness in early stages and to give recommendation for possible treatments. Therefore, changes over short time periods like the past few days and of each animal individually as its own reference will be the key to an improved health and husbandry management in calves and heifers, and therefore to health and productive adult dairy cattle. Equally, the acquired date will be used for breeding references, as healthy and productive animals can be identified, selected

and information about their genomic potential can be given. Additionally, including data from the previous generation such as gestational data, the future performance and milk potential of heifers will be evaluated. Analyzing data, it will also be possible to detect the right moment of physical maturity and improve the chances of a successful first insemination, as the right moment is currently selected by age or weight of a heifer.

Modeling of animal occupied zones with precise porous medium techniques

Abstract

In the animal husbandry field, many questions regarding airflow and gas emission are still unanswered. This is due to the difficulties brought by the ever-changing climate conditions and various parameters related to the animals themselves.

By using computational fluids dynamics (CFD), three animal occupied zones (AOZ), with the same number of animals but different animal positions, are modeled and their airflow resistances in the main Cartesian directions are compared. The study are futher investigated the differences between their corresponding porous medium model (PPM). Here, viscous and inertial loss terms are modeled as velocity dependent in order to reduce the discrepancy between the AOZs and their corresponding PPMs.

The PPMs achieved to reproduce the airflow resistances of the AOZs with an error around 2% by time saving computation time till 70%.

Natural light interpretation for sustainable sports turf management and smart illumination development

Abstract:

Natural sports turfs in high quality are required for professional sports stadium. Their construction often limits the amount of necessary natural light for healthy growth and results in the frequent exchange of the complete sport turf. Average light data of weather stations or satellites can be used as basic light supply information. With the aid of the stadium construction a shadow analysis can be created for the complete year in that location. Changing sun angles over the months results in different illumination for single areas on the field leading to varying needs of additional light. Depending on season, location and stadium construction natural light reduction can be more than 50%.

According to that, additional lighting in the right amount and spectra is needed to maintain turf quality and reduce the exchange rates. The use of an appropriate light unit is also needed for the calculation of additional lighting. The amount of light is usually shown as the light energy in Watt per square meter (W/m^2). For plant light requirements the number of photons and the photon flux density (PFD) are used for the estimation of the light intensity. Especially the amount of light in the region of 400-700nm which is called the photosynthetic active radiation (PAR) is important for plants growth. It is displayed as micromoles per square meter and second ($\mu mol/m^2*s$). Depending on light measurement device and spectra these two units can be converted to each other.

The aim of this paper is to show the combination of average light data and the shadow analysis of the stadium structure for an estimate of additional lighting needs (intensities and lighting hours) for high quality sports turf in a plant based light unit.

In addition, it will give an overview of the standard light spectrum and the changes in shaded environments.

This paper will first deal with the natural amount of light available for the areas of the field and the light requirements for high quality sports turf. Secondly, the missing amount of light will be calculated to develop a smart illumination development system for the areas of the field. In the end an outlook will be given for the change in light spectra and the possibility to adjust additional light for increased turf quality.

M. Sc. Andreas Schweiger

Technical University Munich
Chair of Agricultural Systems Engineering

Dürnast 10
D-85354 Freising
Tel: +49 (0)8161 / 71-3444
Fax: +49 (0)8161 / 71-3895

Mail: andreas.schweiger@tum.de

High Nature Value grassland identification using deep learning

Deepak Hanike Basavegowda[1, 2], Cornelia Weltzien[1, 2]

[1] Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Max-Eyth-Allee 100, 14469 Potsdam, Germany

[2] Technische Universität Berlin, FG Agromechatronik, Straße des 17. Juni 135, 10623 Berlin, Deutschland

Background:

Grassland, especially extensively used grassland, is one of the most species-rich forms of agricultural land use in Europe and accounts for one third of the agricultural landscape in the European Union. The intensification of agricultural land use has caused a significant loss of grassland ecosystem over the last decades, both in terms of extent and species richness. Therefore, it is necessary to monitor the status and trends of grasslands, considering their high ecological and landscape value.

The potential of deep learning approaches for monitoring grassland vegetation has not been adequately explored due to the lack of suitable datasets for grassland plant species and the difficulty in identifying individual plants from high density and overlapping vegetation. The remote sensing images collected on a single location with a single spatial scale affects the deep learning model's ability to generalize to other datasets.

Methodology:

In this study, we aim to identify "high nature value" (HNV) grassland by identifying and localizing indicator plant species from Unmanned Aerial Vehicles (UAVs) data. For this task, we used a deep learning model trained with RGB image datasets of different spatial resolution collected through proximal sensing and UAVs. The model was trained with A) proximal data, B) high-resolution UAV data, and C) a combination of both data sets and evaluated with D) low-resolution UAV data for all cases.

Results:

The model trained with A) proximal data had a lowest mean Average Precision (mAP) as it struggled to generalize on UAV data due to scale variation between proximal and UAV data. The model trained with B) high-resolution UAV data had a lower mean mAP compared to case C), even though it was tested on a same dataset of lower resolution. The model trained on C) had a higher mAP as adding UAV data to proximal training data results in a good generalized model.

Conclusion:

We conclude that with the presented approach HNV grasslands can be accurately identified using high resolution UAV data. The first results show that training a deep learning model on images of different spatial scales improves the model's ability to generalize well and perform better on low-resolution UAV data. Further research is required to validate the findings in natural HNV grassland. Extending this approach to include more indicator species in the training database will contribute to easy and accurate monitoring of HNV grasslands.

(Key Words: digital agriculture; HNV farmlands; grassland biodiversity; remote sensing; deep learning)

"scientific reviewing requested"

Development of an innovative soil-cultivation-system for energy-saving straw conditioning and ultra-shallow tillage (“grinder”)

Author: Michael Pokriefke, seed2soil GmbH & Co. KG

Project partner:

seed2soil GmbH & Co. KG

Stahlstraße 43c, 26215 Wiefelstede

Saphir Maschinenbau GmbH

Wichernstr. 1, 27404 Gyhum

Cologne Institute of Construction Machinery and Agricultural Engineering, Technische Hochschule Köln – University of Applied Sciences

Betzdorfer Straße 2, 50679 Köln

The project is supported by funds of the German government’s Special Purpose Fund held at Landwirtschaftliche Rentenbank.

Increasing demands in field hygiene in arable farming – for example, due to restrictions in chemical plant protection – require new plant cultivation tools and methods. In order to reduce the negative effects of intensive soil cultivation – such as soil erosion – and to further reduce the intensity of cultivation, an equipment system for ultra-shallow stubble and soil cultivation is currently being developed.

After harvest, crop residues such as cereal, oilseed rape and corn stubble as well as weed and volunteer seeds remain on the field surface. The volunteer plants and/or the germination capacity of the remaining seed potential must be removed before sowing the following crop to reduce competition, especially in the critical juvenile stage. At the same time, it may be necessary to chop up crop residue and mix it in shallowly so that pathogens and pests – such as the European corn borer or fusarium fungus – can do as little damage as possible to the following crop. A common method of controlling weeds and volunteer seeds while promoting decomposing of straw and plant material, is called stubble cultivation. This means working chopped plant material and stubble into the soil. The aim is to encourage as many seeds as possible to germinate. Today, the emerged plants are then mechanically killed by tillage so that they no longer represent competition for the following crop.

One challenge in stubble cultivation with current equipment is the minimum technical working depth that is required to ensure that the tools cultivate the soil over the entire surface. Conventional machinery such as cultivators or compact discs usually achieve a depth of five to seven centimetres. As some species such as volunteer oilseed rape or black-grass fall into dormancy at this depth shallower working is required. In addition, straw needs to be processed to promote the decomposing process.

To improve field hygiene, seed2soil GmbH & Co. KG, the Cologne Institute of Construction Machinery and Agricultural Engineering and Saphir Maschinenbau GmbH are working on the "Grinder" project on a novel tool system for stubble and ultra-shallow soil cultivation. The team is working on the final design and the optimization of the prototype. In parallel, field tests – with the newly developed device and conventional comparison devices – are conducted.

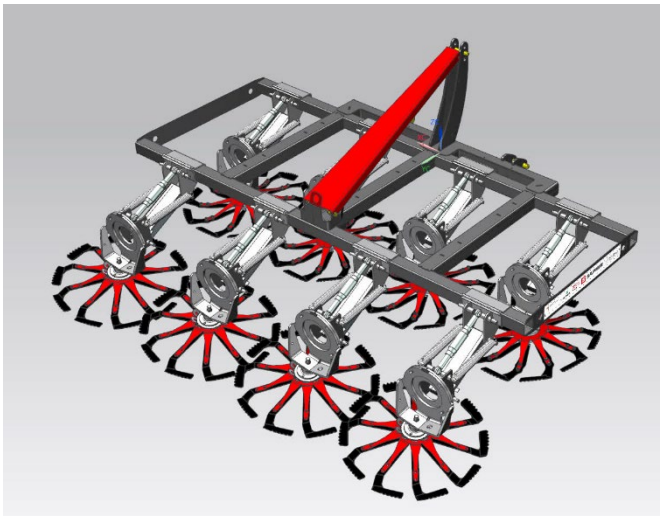


*Figure 1: 3 m wide frame of the **Grinder** with rotors and tools*

Many existing systems combine several different tools and thus become comparatively large and heavy, which also increases the power demand on the tractor. In contrast the Grinder consists of newly developed multifunctional tools that can cut and shred at the same time. The ground driven tools are mounted in a circle and are in contact with the ground half the time during one revolution. Two rotors arranged one behind the other are tilling the width of one rotor. As a result, the implement developed in the project not only works faster, but fuel consumption per hectare also drops significantly.

The project **Development of an innovative soil-cultivation-system for energy saving straw conditioning and ultra-shallow tillage ("grinder")** is supported by funds of the German government's Special Purpose Fund held at Landwirtschaftliche Rentenbank.

RapidMapper – a mobile multi-sensor platform for the assessment of soil fertility in precision agriculture

Hamed Tavakoli[a*], José Correa[a], Sebastian Vogel[a]

[a] Department of Engineering for Crop Production, Leibniz Institute for Agricultural Engineering and Bioeconomy e.V. (ATB), Max-Eyth-Allee 100, 14469 Potsdam, Germany

[*]Corresponding author: E-mail: htavakoli@atb-potsdam.de; Tel.: +49 (0)331 5699

ABSTRACT

A rapid, accurate and high-resolution assessment of soil properties is essential for managing soil fertility and productivity through adjusted fertilizer application, in precision agriculture. Digital soil mapping using proximal soil sensors is a time- and cost-efficient alternative to standard laboratory analyses. However, because of the complex nature of soils, a single sensor may not be able to provide sufficient data for an accurate estimation of soil attributes. By integrating multiple proximal sensing technologies in a single multi-sensor platform measuring simultaneously and by fusing the sensor data and applying machine learning algorithms, the performance of soil properties estimation can be improved.

In the BonaRes project 'I4S – Intelligence for Soil', we develop a multi-sensor platform called RapidMapper for on-the-go topsoil mapping. Currently, sensing technologies such as NIR spectroscopy, gamma-ray spectroscopy, Galvanic contact resistivity, and ion-selective pH electrodes have been integrated into the platform. However, other sensors such as a microwave soil moisture sensor, laser-induced breakdown spectroscopy (LIBS), X-ray fluorescence spectroscopy (XRF) are also planned to be added to the platform in the future. In this paper, we describe the platform, its functionalities and present some field mapping results.

Keywords: Digital soil mapping, soil properties, sensor data fusion, NIR spectroscopy, gamma-ray spectroscopy, Galvanic contact resistivity, ion-selective electrodes

Electric Unmanned Ground Vehicle Coupled with a Rotary Tiller: Evaluation of On-Field Performance

Sara G., G. Todde, D. Pinna, J. Waked, M. Caria

Dr Gabriele Sara, gsara@uniss.it, Department of Agricultural Sciences, University of Sassari, Viale Italia 39, Sassari, 07100, 0039/079229284
Dr Giuseppe Todde, gtodde@uniss.it, Department of Agricultural Sciences, University of Sassari, Viale Italia 39, Sassari, 0039/079229283
Dr Daniele Pinna, dpinna1@uniss.it, Department of Agricultural Sciences, University of Sassari, Viale Italia 39, Sassari, 0039/079229280
Dr Johnny Waked, jwaked@uniss.it, Department of Agricultural Sciences, University of Sassari, Viale Italia 39, Sassari
Prof Maria Caria, mariac@uniss.it, Department of Agricultural Sciences, University of Sassari, Viale Italia 39, Sassari, 0039/079229375

Abstract: The agricultural sector is moving towards increasing automation to minimize and streamline the effort of farmers in carrying out crop operations. Drones are part of this trend, both unmanned aerial (UAV) and ground vehicles (UGV). There are several scientific studies on the use of drones in agriculture that could assist the farmer work on field without the nearby presence of the operator. Unmanned Ground Vehicles, both remote controlled and autonomous, could improve the farmers' working safety on field in particular conditions, e.g., excessive slope, pesticides distribution, high vibration, and acoustic noise. Nevertheless, different steps are necessary for real integration and efficient use of UGV in agriculture. This study aimed to evaluate the work quality and performance of a specific UGV coupled with a rotary tiller. Moreover, the sustainability aspects were considered.

The electric UGV used in this study was 1.30 m wide and 1.05 m long, with tracks of 33 cm each, and powered by lead acid batteries. The rotary tiller was self-powered by an endothermic engine (4.8 kW) with a working width of 90 cm. The performance of the UGV coupled with the rotary tiller was evaluated considering three different forward speeds. Soil clumping and bulk density (g cm^{-3}) were evaluated in relation to the forward speed. Furthermore, the energy consumption (fuel and electricity) and the environmental impact (CO_2e) of the system (UGV-rotary tiller) were also assessed.

The driving performance tests allowed to measure the three forward speeds where the maximum speed corresponded to 0.77 m s^{-1}. The assessed working time of the system (UGV-rotary tiller) was 2.27 h ha^{-1} at maximum speed. The overall rotary tiller work quality improved soil characteristics, both clumping and bulk density. In addition, the soil tillage tests showed no significant difference comparing the three forward speeds. Finally, the estimated primary energy consumption of the UGV-rotary tiller system accounted to 57.49 MJ h^{-1}, which corresponded to 3.28 kg h^{-1} of CO_2e emissions. The outcomes of this study allowed to give a preliminary overview on the use of electric UGV coupled with specific implement for soil tillage, to support farmers in the management of the field in safer condition and with low environmental emissions.

Topic: Tractors/Power Trains/Electrical Drives

Title: Comparison of different classification methods for determining manure type and their influence on the accuracy of nutrient determination in organic manures using near-infrared spectroscopy

Topic: 1.7: Precision Agriculture / Digitalization

Author (s):

First name, last name: Leonard Friedrich [1,*], Patrick Simon [1], Andreas Hoffmann [2], Karl-Ludwig Krieger [1]

Address(es):

[1] ITEM Universität Bremen, Otto-Hahn-Allee 1, 28359 Bremen, Germany

[2] LUFA Nord-West, Institut für Düngemittel und Saatgut, Institut für Boden und Umwelt, Finkenborner Weg 1a, 31787 Hameln, Germany

* Correspondence: friedrich@item.uni-bremen.de; Tel.: +49-(0)-421 218 62567

Due to eutrophication, which is the accumulation of nutrients in an ecosystem, many regions in Germany are experiencing increased nitrate levels in groundwater, among other things. A major aspect contributing to eutrophication is the intensive fertilization of agricultural land. Farmers are required by the Fertilizer Ordinance [1] to routinely prepare a fertilizer balance so the nutrients applied to the soil can be controlled regularly. As a consequence, farmers have samples of their liquid manure analyzed. The samples are analyzed for their nutrient values using time- and resource-intensive laboratory testing procedures. This process contains a large number of potential sources of error. These include not only the representativeness of the sampling in relation to the total quantity due to insufficient homogenization, but also possible nutrient losses during transport. Therefore, a possible solution is the real-time analysis during application by means of near-infrared sensors (NIRS) [2]. As part of the necessary quality assurance, the German Agricultural Society [1] certifies sensors only with associated calibration models.

Knowing the type of manure is crucial for an automated and low error analyses of the manure. The increasing diversification in the handling and origin of liquid organic farm manure [2] due to changed feeding concepts or e.g. the fermentation of manure and the addition of solid manure in biogas plants as well as the separation and mixing of manure poses a significant, non-trivial challenge for NIR analysis in terms of calibration as well as validation.

In this study, on the one hand, different methods for the classification of types of manure are investigated and, on the other hand, the necessity of separate analysis is demonstrated. For this purpose, a representative data basis for the analysis of organic fertilizers was created during a measurement campaign in cooperation with LUFA Nord West. This measurement campaign examined pig and cattle slurry as well as fermentation residues. Following a wet chemical analysis, the measurement was performed by NIRS in a wavenumber range from 4000 to 12500 cm^{-1}. The data are classified with regard to their type of manure in dependence on different data pre-processing methods such as standard normal variate, multiplicative scatter correction, first derivation as well as their combinations. Classification methods of linear and quadratic discriminant analysis, k-nearest neighbor classification, support vector machines and neural networks are used for this purpose. In a final consideration the influence as well as the necessity of a precise and robust classification will be explored. For this purpose, the data are analyzed in a subsequent partial least squares regression with respect to the nutrient values dry matter, nitrogen and phosphorus.

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On Farm Validation of different NIR Sensor for manure sensing

Eiko Thiessen*, Mehdi Eslamifar*, Rainer Kock*, Peter Lausen† and Eberhard Hartung*

* Institute of Agricultural Engineering, Christian-Albrechts-Universität zu Kiel, Max-Eyth-Str. 6, 24118 Kiel, Germany

†Landwirtschaftskammer Schleswig-Holstein, Grüner Kamp 15-17, 24768 Rendsburg

Abstract

NIR sensors for measuring nutrients in manure are commonly in use for applications such as fertilising, managing and trading. They are predicting parameters like dry matter, total nitrogen, ammonium, phosphorus and potassium. The different device-models were tested by several institutions [1] and of course the manufactures. But how precise are the specific sensors in practical use and in a longer timespan? This and a lot of other question are part of the digital trial field "BeST-SH".

A mobile manure test station was design and mounted on a trailer, see fig. 1. It consists out of 6'' tubes with an inlet Perrot connection, further on an „U"-formed test line and ends with a „T"-junction for taking a big sample by mans of redirecting the total flow with a slider into a sample barrel. A vacuum manure tank with a PTO driven rotary pump set a constant flow of manure through the whole system. In the test line there were different NIR and other sensors for accompanying parameters like flowrate, pressure, and temperature. The huge sample in the barrel was partitioned into smaller subsample for reference analysis and was tested additionally in laboratory with benchtop devices (NMR and NIR spectrometers). The reference was conducted by three external laboratories.

At 13 farms in northern Germany the system was used to examine 51 different kinds of manure (hog, cow, biogas and mixtures). For that purpose, approx. 5 m³ of manure was sucked in the vacuum tank and then set in a way that the medium circulates in the whole system until homogenisation - indicated due to constant sensor values and manual inspection. The sample was taken by means of redirecting the total flow for about three seconds into the barrel.

The sensor values during the whole pumping were analysed. For the validation with the reference the readings were averaged over one minute before sample was taken.

It showed that the sensors were different in their results. Sometimes two of them had strong variation in the predicted nutrients only because of the automated process of calibrating the spectrometer to the internal dark and white reference. For total nitrogen one sensor differed in average about 80 % to the reference while the four others had a deviation of about 30 % expressed by the standard error of validation RMSE related to the mean reference, see tab. 1.

Detailed results and further analysis of the other ingredients and the performance of the benchtop sensors will be shown at the conference.

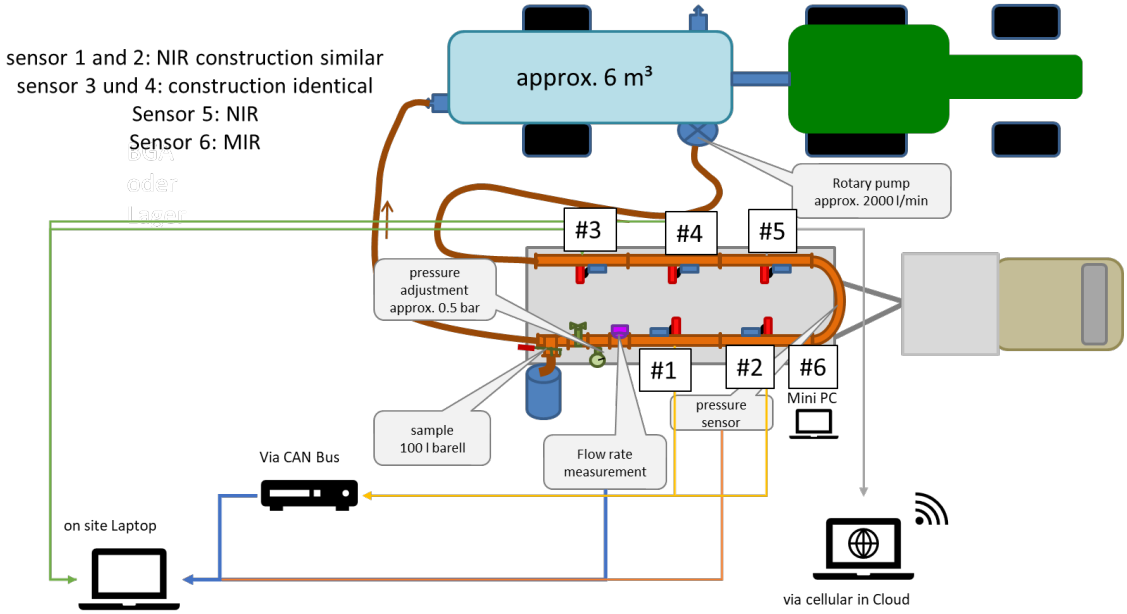

Figure 1: Scheme of the mobile test station used in the trial

Table 1: Selected results of the validation for the five NIR sensor for total nitrogen Ntot. r is the correlation according to a linear regression of the sensor values y to the reference values x, the mean deviation between y and x is given by means of the relative standard validation error rRMSEV (root mean square error related to the mean x), and the max. diff. is the maximum relative difference of y to x observed in all samples.

sensor	1	2	3	4	5
parameter	Ntot	Ntot	Ntot	Ntot	Ntot
r (y=sx+o)	0.67	0.65	0.52	0.35	0.38
slope s	0.45	0.43	0.46	0.31	0.44
offset o in kg/m³	2.30	2.37	1.56	1.75	4.51
rRMSEV	24%	25%	29%	37%	81%
max. diff.	266%	344%	237%	205%	552%

References:

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Methodology for the development of a plant detection system based on mechanical properties of crops using the example of corn

Simon Kubinski, M.Sc., Prof. Dr. Till Meinel, Prof. Dr. Wolfgang Kath-Petersen, Cologne Institute of Construction Machinery and Agricultural Engineering, Technische Hochschule Köln – University of Applied Sciences

Increasing restrictions in the use of chemical-synthetic herbicides require adaptations of established methods for weed control in arable farming. At the same time, farmers' requirements for mechanical weed control are changing due to climatically and politically induced modifications of tillage operations or crop rotations. In recent years, a renaissance of mechanical hoeing technology can be observed. New and advanced developments of hoes are supported by mergers and acquisitions of manufacturers and results in an increase in know-how as well as expanded production capacities.

The success of mechanical weed control still depends on external and internal conditions. External conditions that cannot be directly influenced include the weed population, the weather before, during and after the hoeing, soil type and stone proportions, as well as the terrain contour. Internal conditions can be identified as the adjustment of the hoe. Nowadays, most hoes are guided along the crop rows by camera systems. These detect the crop rows and control sideshift frames parallel to the rows.

For hoeing in row crops, which are planted with precision seed drills, the inter-row and intra-row areas can be distinguished from each other. The intra-row area is mostly worked by adaptable tools (finger hoes, torsion hoes, ridging elements) in advanced crop stages. A successful work result requires further developed crops compared to weeds as well as weeds that have not grown to large and thus are not susceptible to damage or spillage any more. This condition can be achieved by performing additional, full-area cultivation passes with harrows, thermal equipment or roller hoes before and during the youth development of the crops. Camera systems for the detection of individual plants are known from vegetable cultivation and are currently moving into arable farming in conjunction with appropriate actuator technology. Single plant detection is a further challenge in development and application, since in particular the development costs and the so far rather small sales market for hoeing technology with single plant detection questions the economic success.

As part of the project ***Abrasive Hacktechnik für den nachhaltigen Ackerbau (ABHA)***, the Cologne Institute of Construction Machinery and Agricultural Engineering at Technische Hochschule Köln is developing a sensor system for single plant detection, which in combination with actively controlled tools enables the hoeing in the intra-row area. The first cultivation pass with the hoe is carried out at the earliest possible time, so that weed suppression takes place over the entire crop development using only a single hoe with an adaptable assembly for intra-row hoeing. Detection of young crops is to be based on mechanical plant characteristics, so it is further assumed that the crops are more developed than the weeds. The extended period of use of the hoe provides the farmer the possibility of low-cost and effective mechanical weed control. In perspective, plant detection can also be installed on robots, since deviations from the theoretical plant position are still expected in coordinate-based seeding.

In the context of the VDI conference, the methodology for determining the mechanical properties on which the development of the plant detection system is based will be presented. A mechanical substitute system to simulate corn plants will be presented. Secondly the performance of comparative measurement series between real plants and substitute plants on a specially developed test rig, which can also be used to calibrate the sensor technology for single plant recognition, will also be explained.

The project is supported by funds of the German Government's Special Purpose Fund held at Landwirtschaftliche Rentenbank.

Topic: Plant Production Technologies

Author: Simon Kubinski, M.Sc.
Cologne Institute of Construction Machinery and Agricultural Engineering
Technische Hochschule Köln – University of Applied Sciences
Betzdorfer Straße 2
50679 Köln

+49 221 8275 4347
simon.kubinski@th-koeln.de

Co-authors: Prof. Dr. Till Meinel
Cologne Institute of Construction Machinery and Agricultural Engineering
Technische Hochschule Köln – University of Applied Sciences
Betzdorfer Straße 2
50679 Köln

+49 221 8275 2400
till.meinel@th-koeln.de

Prof. Dr. Wolfgang Kath-Petersen
Cologne Institute of Construction Machinery and Agricultural Engineering
Technische Hochschule Köln – University of Applied Sciences
Betzdorfer Straße 2
50679 Köln

+49 221 8275 2611
wolfgang.kath-petersen@th-koeln.de

Title:

An interactive solution to calibrate loss sensors of a combine harvester

Authors:

B.Sc. **Sascha Dieckmeyer**, MBA **Maximilian Schröder**, CLAAS Selbstfahrende Erntemaschinen GmbH, Harsewinkel

Assignment to presentation topic

Precision Agriculture/Digitalization

Abstract

In modern self-propelled harvesters different sensors are installed to control and optimize the harvesting process. The most important sensors for combine harvesters are the loss sensors, which identify the most effective working point based on agro economical goals. Due to technical constraints, the sensor itself cannot detect all of the grains leaving the combine. Therefore, a corrective calculation needs to be made. This corrective is based on the operators input. The operator needs to be aware about the real loss level on the field and their target loss level. Using this information, the operator needs to set the corrective value. To reach the target level repetitions are necessary. Wrong determined values could lead either to increased amount of losses or to a decreased performance of the machine.

This presentation will show different influences of the measurement of losses of the combine harvester. For example, the equipment of the machine or changing crop conditions has influence. Furthermore, there are several difficulties in measuring the losses depending on the material flow inside of the combine harvester and the measurement equipment.

The sensor can be easily calibrated by the operator using an intuitive dialog based step-by-step application. This application allows combining the targets and measurements of the operator using the knowledge of machine state and behavior. The main part of this presentation will focus on the process of calibrating the loss sensor and the internal calculation on the machine side.

As a result of this step-by-step process there will be a calculation depending on several machine and crop values, which in turn produces new calibration values for the sensor. These new values are recommendations to the driver, which should be used. Within the complete process, the driver has the control and is able to overrule proposed settings. The design of the dialog should lead to a stronger confidence in the calibration process itself as well as in the overall electronic system of the machine and its performance.

With this calibrated loss sensor, it will be possible to get a well-balanced machine, which operates reliably at the estimated agro economic targets (e.g. 1% losses are supposed to be obtained). It is no longer necessary for the driver to translate their goals to an abstract correction value and to differentiate between separation and cleaning losses.

To sum up, it shall be possible to get an intuitive and easy calibration process of a sensor that encourages the driver to process this calibration as often as needed. This will adapt the machine to new crop and field conditions, which normally change during a harvest day. As a result, the machine will reach the harvesting goal by performing as best as possible and take care about losses to optimize further cultivation and herbicide application.

Authors:

B.Sc. Sascha Dieckmeyer

CLAAS Selbstfahrende Erntemaschinen GmbH
Electronic development
Muehlenwinkel 1
33428 Harsewinkel
Germany

Phone +49 5247 12-3415
sascha.dieckmeyer@claas.com

MBA Maximilian Schröder

CLAAS Selbstfahrende Erntemaschinen GmbH
Product unit LEXION
Muehlenwinkel 1
33428 Harsewinkel
Germany

Phone +49 5247 12-3214
maximilian.schroeder@claas.com

Operation of Agricultural Campus Networks

The experimental test field LANDNETZ evaluates innovative connectivity solutions to be used in agricultural wireless communication use cases. It is currently in the phase of building and testing mobile private networks, which, for the first time, have been designed for agricultural applications and farm environments. The autonomously working LANDNETZ solution is an “agricultural campus network” that incorporates 5G SA, WLAN, LPWAN, and a Mobile Edge Cloud (MEC), all built into a mobile trailer. This trailer solution, referred to as a "nomadic network", enables numerous digital applications in agriculture with a wide range of requirements in terms of data rate, latency, and temporal/spatial availability [1]. In order to set up a use case, first, the network must function within the limits of the specified use case requirements, and second, the associated applications must be implemented with the available resources. For the first part, processes of network planning (i. e., determining a trailer position, antenna directions, etc.) and operational acceptance (i. e., measuring the targeted coverage area and the network performance in terms of data rate and latency) are required to ensure the operation of certain applications. Traditional procedures for mobile network planning and operational acceptance are time- and work-consuming and therefore unacceptable for the intended use of the trailers in agriculture. LANDNETZ considers this topic to find out how these processes can be made more efficient with acceptable cost. For the second part (i. e., having a private network in operation), further questions arise about the ratio of benefit and effort in the implementation of the selected use cases, for example the digital connection of agricultural machinery to transfer services (e.g., Agrirouter) or the implementation of data processing services such as ADS (Agricultural Data Space). In this paper, the authors present their first experiences and lessons learned regarding the operation of cellular campus networks for agricultural applications. The topics of site planning, performance measurement and use case implementation will be addressed.

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Title:	Operation of Agricultural Campus Networks
Authors:	Andreas Hecker, Dirk Stachorra, Gerhard Fettweis, Vodafone Chair Mobile Communication Systems, TU Dresden Norman Franchi, Advancing Individual Networks GmbH Benjamin Striller, Chair Agricultural Systems and Technology, TU Dresden Fredrik Boye, Fraunhofer Institute for Transportation and Infrastructure Systems
Main Topic:	Precision Agriculture/Digitalization

Optimal design of a hybrid power generation system for greenhouses

Nikolaos Katsoulas*, Catherine Baxevanou, Dimitrios Feidaros

Laboratory of Agricultural Constructions and Environmental Control, Department of Agriculture Crop Production and Rural Environment, University of Thessaly, Fytokou Street, 38446 Volos Magnesia, Greece

*Correspondence: nkatsoul@uth.gr; Tel.: +30-24210-93249

Abstract

Due to the climatic crisis and the increase of the energy price the issue of energy supply becomes crucial parameter in the design of greenhouses. One way to tackle both the problem of climate change and the cost of energy is, after ensuring the reduction of consumption by implementing energy saving measures, the local production of energy from renewable energy sources (RES). The renewable energy source that can be privileged to be used in greenhouses is solar for the production of electricity with photovoltaics. This is because on the one hand solar energy is available in a wide range of latitudes and on the other hand greenhouses have large areas where photovoltaics can be placed without depriving arable land. Photovoltaics (PVs)can be used either connected to a grid or stand-alone systems, usually in combination with power storage units and / or other available RES and / or conventional power production units, i.e., as part of hybrid power generation systems. The design of such systems has a dual purpose: the use of PVs must not compromise crop production, and to achieve the lowest final cost of energy produced with the smallest possible environmental footprint. The present work addresses the multifactorial problem of the optimal design (in terms of production quality, price of produced electricity and CO_2 emissions) of a hybrid power generation system (with PV, wind turbine, accumulators and gas or oil generating unit) to meet greenhouse needs. The design takes into account the needs of production (for tomato cultivation), different combinations of production and energy equipment (equipment for microclimate management). For the initial design of the system, the limitations set by the available area of the greenhouse and the time profile of energy demand are taken into account from existing information from the literature and based on simple methods of calculating graded accuracy of each component of the system separately (e.g., determining optimal surface area, optimal number of PV frames, the Ah method, the modified Wh method). Then the design of the whole system is optimised with a study to determine the minimum cost of energy production and minimum environmental footprint using HOMER software. This research is co-financed the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE – INNOVATE (project code: Τ2ΕΔΚ-00912).

Keywords: precision fertigation; dry matter production; nutrient uptake; productivity; nutrient consumption

Automatic onboard worktype identification of agricultural machinery with edge devices

Lukas Wenzel, Thoralf Stein, Prof. Dr.-Ing. Henning J. Meyer
Technische Universität Berlin, FG Konstruktion von Maschinensystemen
Straße des 17. Juni 144, 10623 Berlin

Lukas Wenzel, M.Sc.
Phone: +49 170 9595824
eMail: lukas.wenzel@tu-berlin.de

Thoralf Stein, M.Sc.
Phone: +49 30 314 22141
Fax: +49 30 314 26325
eMail: thoralf.stein@tu-berlin.de

Prof. Dr.-Ing. Henning J. Meyer
Phone: +49 30 314 78517
Fax: +49 30 314 26325
eMail: henning.meyer@tu-berlin.de

Abstract

Main Topic: Precision Agriculture/Digitalization
scientific reviewing requested

In today's agriculture, comprehensive documentation of the fieldwork plays an important role. It is needed for various reasons like managing and legal purposes. Data loggers or smart devices record the work processes. The recorded work logs are saved and processed in a farm management information system (FMIS). But the management of the FMIS involves additional work for the users and they are not always capable of fulfilling these tasks due a lack of time. Therefore, we present an approach, which suggest a work type via smart device, right after a field work is finished. The benefits of the approach are offline usability and highly pre-processed data logs for the FMIS with low effort for the user.

The presented work developed in the projects BiDa-LAP II and OsKoNa. The aim of BiDa-LAP II is the development of an electrical infrastructure to support farmers in documentation and decision making. OsKoNa has the aim to develop components and algorithms are used to build a stack of smart components for use in agriculture.

As part of the project BiDa-LAP II, a machine learning algorithm was developed that recognises the worktype based on the machine, crop and farm data. Currently, the algorithm is running as a cloud service and the recognised worktype has to be confirmed manually. Confirmation is often carried out long after the work has taken place, which leads to a high level of expenditure.

In this contribution, an algorithm is presented that detects the performed worktype directly on the communication module. The algorithm suggests a worktype that the machine operator can confirm or correct via a linked smart device. In addition to the worktype, the start and end time is automatically recognised. This significantly reduces the documentation effort and improves the quality of the data, while other applications can use the worktype and time as an additional input. Compared to a cloud-based solution, the functionality is independent of cellular coverage, which is still a major problem, especially in rural areas.

The developed algorithm is constructed in two stages. In the first stage, a machine learning algorithm is used to determine the start and end time of the action. After the action is completed, the second stage determines the worktype. After confirmation or correction by the machine operator, the detected action is saved with the remaining data and sent to the server, where they can be used for documentation or by other applications.

Finally, the results will be discussed. For this purpose, typical statistical parameters such as specificity and sensitivity are evaluated. The evaluation is done with a large amount of test data from farms which includes over 3000 work days and various machines and implements. In concluding of this contribution, the results will be examined critically, and a forecast will be given.

AgEng-LAND.TECHNIK 2022, Precision Agriculture/Digitalization

Concept and performance of an autonomous precision seeder for grain crops

Alexander Stana, David Reiser, Nils Lüling, Jonas Straub, Hans W. Griepentrog

Institute of Agricultural Engineering, University of Hohenheim, Garbenstr. 9, 70599 Stuttgart, Germany
Corresponding author: A. Stana, Email a.stana@uni-hohenheim.de, Tel. 49 711 459 24557

Today sustainable and efficient crop production becomes more and more important. The more efficient the production resources are used the higher the mitigation of fertilizer and pesticide use, climate effects, soil quality degradation and economic costs. A more precise and more even grain seed embedding into the soil has still the potential to enhance crop growth and therefore increase yield and decrease chemical inputs.

The aim of the project is to optimise grain seed embedding and distribution with a precision seeder with a combination of an autonomous machine. The objectives are, (i) to allow seed singulation for grain seeds, (ii) to allow row specific depth control, (iii) to allow row specific re-compactioning independent from depth control and (iv) to combine and control the 5-row seeder with an electric-belt-driven robot.

Precision seeding for grain crops is not common today. For conventional machinery with high workings width and high driving speeds, it is a big challenge to achieve accurate seed placements for e.g., 200 seeds/m² on a centimetre scale. Small autonomous robots are capable to achieve a much better performance due to much lower speeds and particular sensing, actuation and control functions.

A catch crop seeder was attached to the front of the robot with a small seed hopper and a pneumatic conveying system. Five row aggregates of a commercially available precision seeder for grain seeds were used to realise the robotic seeder. The row specific depth control was based on ultrasonic sensors and the row specific compaction wheel was based on vertical force sensing. Both controls are conducted independently and specifically for each row. This allows an optimised seed embedding into the soil. The actuation of depth and compactioning control were realised by electric linear motors. The depth control was based on the distance information between the toolbar and soil surface right before each row unit.

The singulation performance and quality of each dosing device were intensively tested. The singling units worked well for the necessary rpm range needed for the robot driving speeds. Criteria for the assessment were cell filling rate [%] and evenness of seed spacings [ms or cm]. Furthermore, the tests were also conducted with 4 different singling rotor discs containing 4, 3 and 2 cells and 1 cell per circumference. The results showed a very high filling rate of more than 90 % and very high spacing evenness for most rpm.

The toolbar with the aggregates was attached to a retrofitting frame which can be automatically shifted laterally and vertically as well as inclined in the longitudinal direction (pitch). The frame is the coupling interface to the robot Phoenix. The robot has a weight of 450 kg, is powered by two 5 kW electric motors, and it is belt-driven for optimizing traction and minimizing soil compaction. It was developed at our institute and is used in several research projects for different purposes. Various sensors are mounted, and a high-performance computer is capable of analysing the data and controlling many of the machine's functions. The robot has good navigating abilities based on relative positioning (camera) or absolute positioning (GNSS).

The complex autonomous machinery system is able to achieve a high spatial evenness of seed distribution for grains due to its special singling devices. Furthermore, the seed incorporation into the soil is optimized regarding depth control and re-compactioning. No other machine for grain sowing until yet is comparable in its overall complex performance.

Investigations on the rolling resistance of tractor tires using coast down tests

Authors (all Uni Hohenheim)

Ernst, Valentin (First author)

Schwehn, Julian (Co-author)

Ebertshäuser, Nathanael (Co-author)

Stefan, Prof. Dr.-Ing. Böttinger (Co-author)

Assignment to a specific presentation topic:

Tractors/Power Trains/Electrical Drives

Abstract

Reducing fuel consumption and therefore improving fuel efficiency of agricultural machines is an important topic when it comes to carbon emissions and the EU's climate goals for 2030. The rolling resistance of tires can have a large influence on fuel consumption of agricultural vehicles, especially with a view to high percentages of agricultural cargo. Tire technology adapted to these needs and specialized tire types come onto the market. Rolling resistance mainly depends on the wheel load, wheel pressure and vehicle speed. With increasing average vehicle masses of agricultural vehicles, it is worth to have detailed information about this value and its influences.

A practice-optimized method was developed in Hohenheim to determine the rolling resistance of tractor tires. During a coast down test over the complete speed range of the vehicle, several data is logged and processed afterwards. The required data can mainly be extracted from common information systems of modern tractors without the need of complex and specialized measurement equipment like force measuring rims. The method provides rolling resistance in dependence of vehicle speed and several adjustable outer parameter like wheel pressure and wheel load. For the end user, there is no free information about rolling resistance of agricultural tires available. A comparison of different possibly mounted tires and therefore an optimization is difficult. This method can be used to carry out comparisons of different tires to easily optimize the overall fuel consumption and operating costs.

The developed method was used for the comparison of three different tires of two manufacturers. One of the tires had a special road profile (Michelin ROADBIB), two had the typical traction profile for usage on fields. The results in dependence of driving speed, wheel pressure and different loads will be presented.

Scientific reviewing requested

Title: Walking activity of fattening pigs estimated with data originating from an RFID system

Authors: Anita Kapun[1] and Eva Gallmann[1]

[1]University of Hohenheim, Institute of Agricultural Engineering

Anita Kapun: Phone +49 711 459 225 07, Fax +49 711 459 243 07, Email anita.kapun@uni-hohenheim.de

apl. Prof. Dr. Eva Gallmann: Phone +49 711 459 225 08, Fax +49 711 459 243 07, Email eva.gallmann@uni-hohenheim.de

Presentation Topic: Animal Production Technologies

--Scientific reviewing requested--

Abstract:

The walking activity of animals could be related to their welfare, illness or lameness. Especially lameness could lead to shorter distances walked, shorter stride and step lengths, slower walking speed and less time spent walking generally. Due to various reasons, little is known about how much distance domestic pigs are covering daily.

In the present study, an automatically calculated estimation on walking distances for individual fattening pigs was developed based on data produced by a UHF-RFID system. The estimation functions as an activity measure for fattening pigs (daily and hourly). Data was collected during four different fattening periods.

The results show a generally higher walking activity in the first weeks of fattening than by the end of the fattening period and active phases on different times of a day. The influence of human interaction is visible in the data by higher average values during health observation days (twice a week) and lower average values on the weekend than on weekdays. Lameness often resulted in a lesser distance walked, but was individually different. The walking speed can be estimated by the time difference between two RFID readings and will be considered as an additional factor for a potential lameness detection. The impact of air temperature and tail-biting incidences on the walking activity at group level will also undergo a closer investigation.

An evaluation of Deep Learning Methods for Weed Classification of High Resolution UAV Images

Pendar Alirezazadeh, Michael Schirrmann, Frieder Stolzenburg

Because weeds compete directly with crops for moisture, nutrients, and sunlight, their monitoring and control is an essential necessity in agriculture. Diagnosing and classifying the weed species is the most important step in choosing an effective and time-saving weed control method. Deep learning approaches have been proven to be effective in smart agricultural tasks such as plant classification, disease detection, etc. In this study, we investigate the effect of varying the architecture depth and width on the performance of deep neural networks in the context of weeds recognition with Unmanned Aerial Vehicles (UAV) imagery. We compare the performance of Convolution Neural Networks (CNNs) and Vision Transformers (ViT) by scaling the deep layers with respect to the attention collapse problem. The specific objective of this study is to show the effects of scaling deep layers on the attentional performance and representation learning of deep networks and apply them to weed classification in UAV images. Data were collected using a high-resolution camera on a UAV flying at low altitude over a winter wheat field. Using the transfer learning strategy, we trained deep models and performed species-level classification tasks with the weed species: Stellaria media, Lamium purpureum, Lithospermum arvense, Capsella bursa-pastoris, Draba verna, Veronica persica, and Chenopodium album observed in that field. The results of this study show that networks with deeper layers fail to learn an effective representation and hinder the model from getting expected performance gain.

Disturbance Input Detection and Performance Monitoring for Smart Agricultural Implements

Dr.-Ing. **S. Röttgermann**, LEMKEN GmbH & Co. KG, Alpen (DE);
Dr. ir. **J. IJsselmuiden**, Track32 B.V., Ede (NL)

Topic: Precision Agriculture/Digitalization
Keywords: automation, implement, sensors

Abstract

Agricultural implements for soil preparation, mechanical weeding, sowing and other field work are becoming more and more intelligent. With a view to the major goal of autonomization, there is an inevitable need for an implement to be able to detect an (emerging) fault independently - without the intervention of an operator/supervisor - and to counteract it at an early stage. For current and future agricultural implements it is important to detect disturbance inputs/anomalies quickly, in order to react proactively. Furthermore, today the farmer himself is responsible for parameterizing the implement according to his specifications/needs and for keeping an eye on the quality of work. Similar to the detection of disturbance variables, future machine generations will have to focus on process intelligence and thus also on process monitoring and work quality assessment of the implement.
We are currently working on disturbance input detection (or anomaly detection) and performance monitoring for such implements. More specifically, we are working on vision-based blockage detection and tool damage detection e.g. for cultivators, and vision-based performance monitoring e.g. for cultivators and mechanical weeders.

With regard to the detection of disturbance variables, both continuous wear on soil cultivation tools and unscheduled wear in the form of tool breakage or faults resulting from collisions with obstacles in the soil should be detected automatically during machine operation. Another possible disturbance variable in agricultural soil tillage is the excessive accumulation of soil or plant material in the implement.

In addition to the monitoring of disturbance variables, there is an urgent need for a highly automated work process in the evaluation of the work result left on the field in the various work steps in agricultural field cultivation. Today, the work result is assessed by the machine operator and used as a criterion for a change in the machine setting. However, at the latest

when the field is tilled fully autonomously, the machine system must react to sensor-based variables.

In this paper we describe the various use cases such as blockage and tool damage detection as well as performance and condition monitoring. Further the approaches that we are working on e.g. the usage of machine learning algorithms to analyze camera and LiDAR data are described. In addition to that, some preliminary results from past field tests and ongoing field tests are presented. Furthermore we explain the next steps to take.

Title: Non-destructive internal disorder detection in pear fruit using X-ray radiographs and deep learning

Ir. Astrid Tempelaere [1,a], M.Sc. Hoang Minh Phan[1,b], Dr. Tim Van De Looverbosch[2,c], Dr. Pieter Verboven[1,d], Prof. Bart Nicolai[1,3,e]

1 Mechatronics, Biostatistics and Sensors (MeBioS), Biosystems Department, KU Leuven, Willem de Croylaan 42 – box 2428, 3001 Leuven, Belgium

2 Laboratory of Cell Biology and Histology, UAntwerpen, Universiteitsplein 1, 2610 Antwerpen, Belgium

3 Flanders Centre of Postharvest Biology, Willem de Croylaan 42 – box 2428, 3001 Leuven, Belgium

[a]astrid.tempelaere@kuleuven.be; [b]hoangminh.phan@student.kuleuven.be
[c]tim.vandelooverbosch@uantwerpen.be, [d]pieter.verboven@kuleuven.be; [e]bart.nicolai@kuleuven.be

Presenting author: Astrid Tempelaere (PhD researcher)

Presentation topic: Post-harvest technologies

Recently, X-ray technology has been introduced as a promising method to inspect the internal quality of fruits and vegetables in an industrial setting. This technology provides a large amount of data that has to be judged in a correct and fast way. To speed up this process, artificial intelligence (AI) has been recently proposed.

In our work, we developed an AI model that is able to detect and quantify the internal disorders in pear fruit (*Pyrus Communis*, cv. Conference) from X-ray radiographs. A new approach on simulating image semantics for the radiography data was therefore explored. In addition, different data augmentation strategies were applied in order to obtain a more robust AI model.

The development of the AI model consisted of different steps. First, radiographs were simulated from CT data of pear fruit. Also, semantics on the radiography data could be simulated from the manually segmented CT data that was available. Next, a deep learning model was trained for segmentation of the radiographs. Basic data augmentation, such as vertical and horizontal flipping, was conducted to enlarge our training dataset. On top of that, synthesized radiography data was included to obtain a model that is robust to a large inherent biological variation occurring in pear fruit.

The obtained deep learning model was effective at segmentation of healthy and disordered pear fruit. The additional synthesized data drastically improved the model accuracy and robustness towards defect pears. More in detail, the real training data only consisted of pears with both cavities and browning for the defect samples. This made it impossible for the model to detect pears with only browning and no cavities. The training data was therefore extended with synthesized data on brown pears, which seriously increased the model performance.

The approach on detection and quantification of internal defects in pear fruit is useful towards industrial applications on fast and cheap inline sorting by X-ray technology. In future research, adding more synthesized data with a high variation in pear shape and disorder appearance will be considered. Also, the model will be validated on healthy and defect pears from another season and origin.

Hydraulic Manifold Design & Simulation: A New Integrated Approach

In growing and competitive global market, the demand is increasing for customized machines and application types. OEMs are then pushed to deliver quicker and provide more flexibility and better performances to the end users. Consequently, in many cases, they are requiring a faster response from their component's suppliers and/or their system integrators. In this highly competitive hydraulic business, the needs of more efficient and compact hydraulic designs evolve quickly. Hydraulic manifold has been naturally more and more used to meet hydraulic business needs, thanks to the advantage of the hydraulic integrated cartridge (HIC) valves. But still, the current work process to bring an initial proof of concept to a manufactured manifold block if often not optimized between the stakeholders. On one side, component manufacturers and systems integrators need more productive tools and methods to design quickly to reduce their time to market and lower their cost without any compromises on OEMs expectations. On the other side, OEMs want often to initiate their own hydraulic design and participate actively in the block design phase of the hydraulic manifold solution. They want an optimized design based on hydraulic performances and other considerations related to machine specificities (Space, weight, accessibility, etc.). Then, they also require efficient tools, such as system simulation software, to design more easily and efficiently their manifold and make it fully integrated in the whole hydraulic circuit.

In this paper, we will present a new approach to greatly improve the global process of hydraulic manifold design and its integration to a machine. The integrated software solution presented allows the creation and simulation of a manifold, using the catalogues of the most common HIC valves' manufacturers. The available manufacturers' catalogues include many essential information such as the components' specifications, the ISO 1219 standard fluid power symbols, the simulation models, the 3D models and many more. To ensure more precise sizing and generate the manifold channels, the tool will come as well with a database of cavity characteristics compliant with various manufacturers of HIC valves. From an initial 2D standardized and simulated schematic, a 3D manifold editor which includes various features such as valves positioning, block size optimization and automatic routing help users to reduce the decision-making and manipulation time to get the best solution among different scenarios much faster.

Unlike current tools on the market, this tool also allows the HIC circuit solution to be virtually tested and simulated directly within the hydraulic circuit of the whole machine. The simulation advantage available in the tool will permit to analyze the effect of manifold modifications in the hydraulic system instantaneously without export or remodeling steps. Thus, this approach brings possibility to validate the behavior of the block, but also to quickly diagnose, troubleshoot and optimize the hydraulic performance (pressure drop, flow, power consumption, etc.) and also predict potential failures or design mistakes. Examples will be presented to demonstrate the different stages of the design approach and the different technical data generated and produced by the tool.

In short, all the trade-oriented features included in this all-in-one approach allows a greater number of hydraulic designers and engineers to increase their productivity and the quality of their solutions. It is worth mentioning that the communication between vendors and clients is improved with the presented integrated concept. And because of its flat learning curve, it could help many industries challenging today

with the turnover of employees which demand more and more training. It even brings more independence for OEMs or product integrators to make the selection of hydraulic solutions.

Keywords: Hydraulic Manifold, Simulation, Sizing, Pressure drop, Performances

Magnetized Water on Germination, Growth Rate and Yield of Popcorn under deficit irrigation

Yusuf*, K. O, Tokosi[1], R. O and Raji[2], M.

Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Nigeria

* = Corresponding author: yusuf.ok@unilorin.edu.ng or kamaru.yusuf@yahoo.com

1 = omotolani.tokosi@gmail.com, 2 = rajimubraq01@gmail.com,

ABSTRACT

Popcorn is an important cereal that is grown for consumption and snacks production in Nigeria but its low production with poor yield to meet the demand in the country. The study was conducted to determine the impact of Magnetized Water (MW) on the percentage germination (GP), growth rate and yield of popcorn under deficit irrigation. MW was produced by allowing the water to flow through hose carrying 1.5T neodymium magnet. Popcorn (FRESHTOP variety) was planted in 16 buckets for MW and 16 buckets for Non-Magnetized Water (NMW, control). A Completely Randomized Design was used, 4 levels of water application as the treatments with 100% water requirements (1.5litres), 80% (1.2litres), 60% (0.9litres) and 50%(0.75litres) were applied to the popcorn irrigated with MW or NMW and was monitored for 100 days. The popcorn was thinned to 1/bucket and grown in a garden shed of 5 by 5m and 3m high at the center and 2.5m at the edges. GP of the popcorn at 100, 80, 60 and 50% for MW were 75%, 88%, 75%, 63%, and for NMW were 50%, 63%, 50% and 50%, respectively. The mean grain yield after shelled for 100%, 80%%, 60 and 50% with MW were 43.43g/bucket, 50.86g/bucket, 39.65g/bucket and 35.80g/bucket and corresponding grain yield for NMW were 29.20g/bucket, 39.43g/bucket, 37.27g/bucket and 28.41g/bucket, respectively. Water applied at 80% gave the highest yield. MW increased the yield of popcorn by 48.73%, 28.88, 6.39 and 26.01% at 100%, 80%, 60% and 50%, respectively. MW is recommended for growing popcorn.

Keywords: popcorn, deficit irrigation, magnetized water, germination, paired t-test

An:
VDI: Sibylle Wunn
wunn@vdi.de

Von:
Carina Engelhart, CVO/PJ-VIA-BEG
Telefon +49 7062 911-8942, Telefax +49 7062 911-01
Carina.Engelhart@de.bosch.com

Robert Bosch GmbH
Postfach 13 55
74003 Heilbronn
Germany
Besucher:
Robert-Bosch-Allee 1
74232 Abstatt
Telefon 07062 911-01
www.bosch.com

- **Aussagekräftiger Titel:** 29. März 2021
  a. Innovative Umfeldsensorik von Bosch erobert die Landtechnik

- **Info Vortragende (Produktmanagement/Vertrieb Off-Highway):**
  a. Ansprechpartner: Carina Engelhart, M. Sc. MBA ist Produktmanagerin Multikamerasystem für Off-Highway bei der Bosch Engineering GmbH in Abstatt. Carina.Engelhart@de.bosch.com

  b. Vortragender 1: Michael Rattka, Dipl.-Wirtsch.-Ing. (FH), ist im technischen Vertrieb für Off-Highway bei der Bosch Engineering GmbH in Abstatt. Michael.Rattka@de.bosch.com

  c. Vortragender 2 (bei Ausfall Vortragender 1): Manuel Wesle-Zehetmair, Bachelor of Engineering, ist technischer Produktmanager für Off-Highway bei der Bosch Engineering GmbH in Holzkirchen. Manuel.Wesle-Zehetmair@de.bosch.com

- **Zuordnung zum thematischen Schwerpunkt:**
  a. Anwendung Multikamerasystem, Radar und Ultraschall in der Landwirtschaft. Kann thematisch bei Traktoren verortet werden.

- **Aussage zum Innovationsgrad:**
  a. Hoher Innovationsgrad durch:

  - Für die Anwendung auf mobilen Arbeitsmaschinen optimierte Umfeldsensorik aus dem bewährten Pkw Baukasten von Bosch.

  - Die Off-Highway Varianten des Radars, Multikamerasystems und Ultraschalls ermöglichen Systeme zur Kollisionsvermeidung und unterstützen bei der Automatisierung von mobilen Maschinen.

  - Innovative Funktionen des Multikamerasystems wie Fahrspureinblendung und Zoomfunktion der Draufsicht entlasten den Landmaschinenanwender optimal in seiner täglichen Arbeit.

- Einfache und schnelle Inbetriebnahme für Multikamerasystem für unterschiedliche Fahrzeugvarianten möglich.
- Optimale Kombination von Bosch Sensorik und Multikamerasystem bietet zusätzliche Unterstützung durch Visualisierung von Objekten.

- **Inhaltsangabe mit den Kernaussagen des Beitrages:**

Radarsysteme eignen sich hervorragend zur Nah- und Fernfeldüberwachung auf mobilen Arbeitsmaschinen. Sie sind robust und auch unter rauen Umgebungsbedingungen wie Nebel, starkem Regen und Schnee funktional zuverlässig. Die Radarsysteme von Bosch sind zusätzlich für die Objekterkennung in der Off-Highway-Umgebung optimiert und unterstützen die Bediener mit Informationen über Entfernung, Position und Geschwindigkeit der erkannten Reflexionen oder Objekte. Die beiden im Sensor integrierten Antennen, eine Nahbereichs- und eine Fernbereichsantenne, sorgen zudem für eine Variabilität des Sensorsichtfeldes. Damit sind die Off-Highway Radarsystem von Bosch ideal für den Einsatz in Assistenzsystemen zur Kollisionsvermeidung und Fahrspurüberwachung auf mobilen Arbeitsmaschinen in der Landtechnik geeignet.

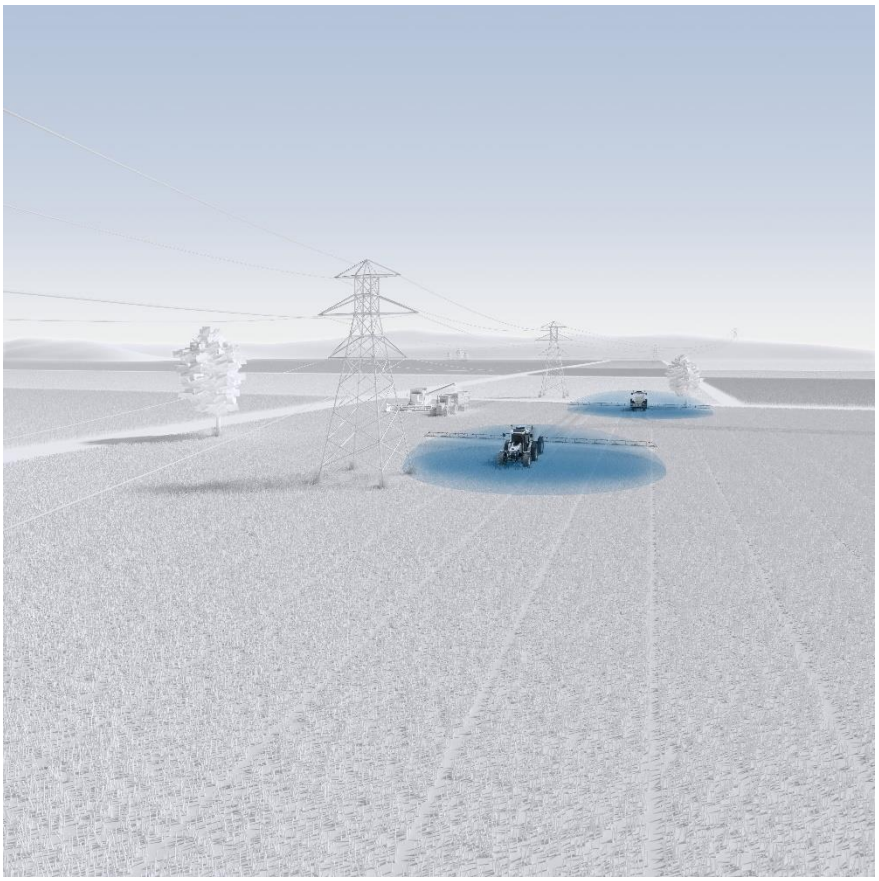
Ultraschallsensor-Systeme eignen sich perfekt für die Nahfeldüberwachung des Arbeitsbereichs von mobilen Maschinen. Die Sensorsysteme erlauben dabei größtmöglichste Flexibiltät bei der Installation und Anwendung. Dank ausgeklügelter Filtertechnik liefert das Sensorsystem auch unter schwierigsten Umweltbedingungen zuverlässige Distanz- oder Positionsinformationen und warnt vor Objekten im Sichtbereich der Sensoren. Das Ultraschallsensor-System eignet sich ideal zum Einsatz als Assistenzsystem zur Erhöhung der Sicherheit auf mobilen Maschinen in der Landtechnik. Dies eignet sich zum Beispiel zur Spurhaltung zwischen Weinreben oder der Höhenregulierung von Feldspritzen.

Das Multikamerasystem für Landmaschinen sorgt für erhöhte Sicherheit und Komfort. Unübersichtliche Situationen, der Schulterblick beim Rückwärtsfahren und das Rangieren in engen und schwer einsehbaren Umgebungen erschweren dem Fahrer seine tägliche Arbeit. Vier Nahbereichskameras sorgen, kombiniert zu einem Multikamerasystem, für eine 360°-Rundumsicht und ermöglichen dem Anwender so präzise Manöver auf engstem Raum – für ein sicheres und komfortables Bedienerlebnis. Die Fahrspureinblendung in Abhängigkeit des Lenkwinkels für bessere Distanzeinschätzungen während des Fahrens sowie für einfacheres Manövrieren und die Zoomfunktion der Draufsicht in Abhängigkeit der Geschwindigkeit überzeugen die Anwender. Für mobile Arbeitsmaschinen im Off-Highway-Bereich vereinfacht Bosch die Anpassung des Multikamerasystems an unterschiedliche Kundenanwendungen.

Das Off-Highway Vision System besteht zentral aus dem Multikamerasystem. Das Ganze wird durch die Möglichkeit der variablen und anwendungsorientierten Integration weiterer, von Bosch für den Off-Highway Einsatz optimierte Sensoren wie dem Off-Highway Ultraschallsystem und Radarsensoren ergänzt. Die vom Radar oder Ultraschallsystem erkannten Objekte werden dabei im Live-Bild des 360° Kamerasystems optisch hervorgehoben. Dadurch können Objekte, Hindernisse und Personen im Gefahrenbereich der Feldmaschinen rechtzeitig erkannt und Unfälle vermieden werden.

- **Angabe eigener Vorveröffentlichungen zum Thema**
- E/2020: Veröffentlichung: ATZ HeavyDuty 04/2020: Multikamerasystem
- vrs. 03/2021: Offensive Gutes Bauen: Personen-/Objekterkennung, Warnung in Gefahrenbereichen: Kamera-, Sensoriksysteme, intelligente Software im Arbeitsbereich von bemannten Flurförderzeugen. Fokus Multikamerasystem, Radar, Ultraschall.
- vrs. 11/2021: Offensive Gutes Bauen: Schwerpunkt Assistenzsysteme in der Landtechnik. (offizieller Titel noch nicht bekannt). Fokus Multikamerasystem, Radar, Ultraschall.

- **Anhang: Teaserbilder**
- Bild 1: Umfeldsensorik in der Landtechnik (© Bosch Engineering GmbH)



The best of two worlds: Spray boom control with hydropneumatic suspension technology

Dr.-Ing. Lars Brinkschulte*, Steffen Antoni
ARGO-HYTOS GmbH, Industriestraße 9, 76703 Kraichtal, Germany
*Corresponding author: Tel.: + 49 160 92186764; E-mail address: l.brinkschulte@argo-hytos.com

For years, crop protection machine manufacturers have had to deal with increasing demands posed on their machines. On the one hand, legal constraints keep getting more restrictive; on the other hand, prices for crop protection agents keep rising. In 2022, the prices for crop protection agents have reached an all-time high [1]. Politicians, society and farmers all call for the same thing: more precise and efficient spraying to protect the environment and the farmer's and consumer's wallets.

Due to this demand, technology in the field of crop protection application (e.g. systems for automatic boom control, spot spraying, ...) has developed rapidly in recent years. In this paper, a novel approach of an automatic boom guidance system [2] will be presented. An automatic boom control system generally has to maintain a desired distance between the spray nozzles and "target", e.g. the plant head. At the same time, these systems must be as independent as possible from external influences and forces. Therefore, the machine chassis and the boom must be decoupled from each other.

In state-of-the-art systems, this decoupling is mostly realized by means of mechanical spring-damper combinations. To ensure that the suspension properties (stiffness and damping) are independent of the inclination of the boom, an additional subframe, tilted by a hydraulic cylinder, is necessary. This additional subframe is related to an increased effort in terms of design, material and costs. In addition, the suspension characteristics of such systems are fixed and can only be adjusted with greater effort.

The innovative system introduced in this article addresses exactly this issue: A hydropneumatic suspension approach realizes the position-independent spring and damper characteristics by using hydraulic components, thereby making the subframe obsolete. The hydraulic cylinder for tilting the boom connects the machine chassis directly to the boom. The spring stiffness is predefined by accumulators and adjustable by a hydraulic pre-tensioning of the cylinder. A hydraulic valve, connected between cylinder and accumulator, is used for damping. With this system structure, a position-independent suspension can be achieved with a simpler mechanical design. The suspension characteristics can be adapted to individual sprayer booms and the damping can be adjusted to the individual field and working conditions (e.g. ground conditions).

ARGO-HYTOS supplies a complete and standalone system with all the necessary hydraulic and electronic components as well as the intelligence by in-house developed algorithms. First machines are in the field and show a very satisfying performance.

The content of the conference contribution will be the presentation of the innovative system approach, the comparison of the new system with conventional systems, including the respective advantages and disadvantages, as well as the presentation of the results gleaned from field experience.

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"Machine Learning Models for Predictions of Thermal Energy Need in Farm Buildings"

Alberto Barbaresi[a], Mattia Ceccarelli[a], Marco Bovo[a], Giulia Menichetti[b], Miki Agrusti[a], Enrica Santolini[a], Daniele Torreggiani[a], Patrizia Tassinari[a]

[a]Department of Agricultural and Food Sciences, University of Bologna, Italy
[b]Department of Physics, Northeastern University, Boston USA

Abstract. *Accurate prediction of building energy need plays a fundamental role in building design, but a huge number of* numerical *simulations is required to achieve energy saving solutions, in particular in farm buildings, where the required temperature range is different from residential units. Consequently, the reduction of computational time is becoming an essential requirement. An important advancement in the reduction of computational time could come from the application of machine learning (ML) models to avoid energy simulations.*
Considering these aspects, the research aims is to evaluate the effectiveness of different ML regressors in the prediction of the energy need of a case study food storage building. The models have been trained on a dataset of about 5000 simulations where each building configuration is associated with an annual energy need.
The ones tested were Linear Regression, Support Vector Machine, Random Forest, and Extreme Gradient Boosting. Between them, the tree-based Extreme Gradient Boosting showed the best performance, both in terms of regression accuracy and timing, being many times faster than classical energy simulations.
Moreover, the research tries to overcome the classical black-box nature of ML models by using SHAP values, which provide a model-independent framework to assess features' importance and explainability, helping academics and professionals to define novel design strategies.

Magnetized Water on Germination, Growth Rate and Yield of Popcorn under deficit irrigation

Yusuf*, K. O, Tokosi[1], R. O and Raji[2], M.

Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Nigeria

* = Corresponding author: yusuf.ok@unilorin.edu.ng or kamaru.yusuf@yahoo.com

1 = omotolani.tokosi@gmail.com, 2 = rajimubraq01@gmail.com,

ABSTRACT

Popcorn is an important cereal that is grown for consumption and snacks production in Nigeria but its low production with poor yield to meet the demand in the country. The study was conducted to determine the impact of Magnetized Water (MW) on the percentage germination (GP), growth rate and yield of popcorn under deficit irrigation. MW was produced by allowing the water to flow through hose carrying 1.5T neodymium magnet. Popcorn (FRESHTOP variety) was planted in 16 buckets for MW and 16 buckets for Non-Magnetized Water (NMW, control). A Completely Randomized Design was used, 4 levels of water application as the treatments with 100% water requirements (1.5litres), 80% (1.2litres), 60% (0.9litres) and 50%(0.75litres) were applied to the popcorn irrigated with MW or NMW and was monitored for 100 days. The popcorn was thinned to 1/bucket and grown in a garden shed of 5 by 5m and 3m high at the center and 2.5m at the edges. GP of the popcorn at 100, 80, 60 and 50% for MW were 75%, 88%, 75%, 63%, and for NMW were 50%, 63%, 50% and 50%, respectively. The mean grain yield after shelled for 100%, 80%%, 60 and 50% with MW were 43.43g/bucket, 50.86g/bucket, 39.65g/bucket and 35.80g/bucket and corresponding grain yield for NMW were 29.20g/bucket, 39.43g/bucket, 37.27g/bucket and 28.41g/bucket, respectively. Water applied at 80% gave the highest yield. MW increased the yield of popcorn by 48.73%, 28.88, 6.39 and 26.01% at 100%, 80%, 60% and 50%, respectively. MW is recommended for growing popcorn.

Keywords: popcorn, deficit irrigation, magnetized water, germination, paired t-test

A pilot system to replace fossil energy with renewable sources in pig barns

Stefano Benni[1], Mattia Ceccarelli[1], Alberto Barbaresi[1], Marco Bovo[1], Francesco Tinti[2], Miki Agrusti[1], Daniele Torreggiani[1]; Patrizia Tassinari[1]

1 DISTAL, University of Bologna. Vale G. Fanin, 48 – 40127 Bologna, Italy
2 DICAM, University of Bologna. Via Terracini, 28 - 40131 Bologna, Italy

Keywords. Renewable energy, Livestock barn, Defossilising agriculture, Energy efficiency.

Abstract. The study was developed within the innovation project RES4LIVE "Energy Smart Livestock Farming towards Zero Fossil Fuel Consumption", running in the period 2020-2024 under the call "Defossilising agriculture – solutions and pathways for fossil-energy-free farming" of the European program Horizon 2020

Fossil fuel use in farming has negative effects as a major source of greenhouse gas (GHG) emissions, with significant contributions to global climate change. One of the most energy-consuming sectors of agriculture is intensive livestock that is mainly based on fossil fuel use. Both electricity and thermal energy are required to cover strongly diversified energy demand, such as cooling-heating of the indoor livestock buildings environment, powering equipment, lighting and ventilation systems. With declining costs and improvement of reliability and performance of key renewable energy sources (RES) technologies, the opportunities for farmers to engage in RES production are increasing. The objective of RES4LIVE is to develop integrated, cost-effective and case-sensitive RES solutions towards achieving fossil-free livestock farming. To that end, the project adapts and tests promising RES technologies in energy-intensive livestock farming for greatly reducing the fossil energy that is the main source to cover the energy demand. Dedicated, optimal designs combined with energy efficiency and other solutions are proposed, demonstrated in pilot farms, and evaluated technically, economically, environmentally, and socially.

The pilot case presented in this research is a swine farm located in Modena province (northern Italy), rearing 500 sows and 2500 weaners. The de-fossilization project focuses on the nursery barn and consists in the development and installation of an integrated RES system combining a photovoltaic-thermal plant, a geothermal storage, and a modular heat pump. A smart control system was also designed to be installed for indoor environment monitoring and energy management.

The project is presented, and the results of the design phase are reported. The results highlight that the energy demand of a livestock farm can be met by a mix of RES properly designed, which takes advantage of the renewable resources available in the farm context.

A comparative life cycle analysis of living walls

Milad Reyhani*, Enrica Santolini*, Marco Bovo*, Alberto Barbaresi*, Daniele Torreggiani*, Patrizia Tassinari*

* Department of Agricultural and Food Sciences, University of Bologna, Viale G. Fanin 48, 40127, Bologna, Italy

Keywords. Life Cycle Assessment, Vertical Green system, Sustainability, Environmental Impact Assessment, Green wall.

Abstract. Urban population growth and changing people's lifestyles have led to the expansion of the construction sector, with environmental consequences such as increasing heat island effects, air pollution, storm runoff, and reduction of green spaces and biodiversity. A key strategy consists in the use sustainable solutions to improve the grey urban environment. Green infrastructures have a high potential of reduction of these environmental impacts: integrating green systems in the design of new buildings can turn the above-mentioned challenges into great opportunities, greening the building envelopes and providing more resilient urban spaces. The increasing interest on green wall systems and the advances made in recent years have led to the availability of various models with different designs and technical solutions. However, in their environmental assessment poor attention is usually paid to production and construction phases. By using the life cycle assessment (LCA) as a systematic and comprehensive approach, the sustainability of a product can be examined. LCA provides a quantification of product's potential burdens and environmental benefits. In this study, different components and materials used in the construction of vertical green systems are evaluated using LCA, with a cradle to gate approach. Both modular systems using soil as growing medium for plants and soilless living walls solutions are analysed, since the structural characteristics and related differences of the two systems can consistently affect their environmental performance. Both systems have been modeled in the OpenLCA software and analyzed using the CML-IA baseline impact assessment method. The results obtained from 11 different categories show that the processes involved in the production of plastic panels play a major role in terms of environmental burdens. The results emphasize the importance of the materials used in vertical green systems and confirm the need to design and create more sustainable products.

Corresponding Author
Tel.: +39 051 2096196
Email address: enrica.santolini2@unibo.it

Assessment of milk yield loss induced by heat stress in dairy cows

Miki Agrusti, Mattia Ceccarelli, Marco Bovo*, Stefano Benni, Alberto Barbaresi, Enrica Santolini, Daniele Torreggiani, Patrizia Tassinari

Department of Agricultural and Food Sciences, University of Bologna, Viale G. Fanin 48, 40127, Bologna, Italy

* phone: +39 051 2096167; email: marco.bovo@unibo.it

Keywords. Precision livestock farming, data analysis, agricultural engineering, animal welfare, numerical model,

Abstract. This study was developed within the EIT Food European project DAIRYSUST "Big data and advanced analytics for sustainable management of the dairy cattle sector", running in 2021-2022. The aim of the project is to improve sustainability, animal welfare and productivity in dairy farming through the use of advanced data analytics. Livestock farms routinely produce and monitor data relating to environmental conditions, animal behaviour, and production parameters. The development of data-driven platforms and solutions which bring together all the separate data could be used to enhance decision-making and improve the sustainability of the agri-food system. This project is developing a system which integrates and harmonises the different data types. The outcomes are planned to be used by stakeholders in the dairy farming sector to improve their decision-making processes relating to sustainability, animal welfare and productivity.

In this context, the study aims to define, train, and test a model developed through machine learning techniques, adopting a Random Forest algorithm, with the main goal to assess the trend in daily milk yield of individual cows in relation to environmental conditions. The model has been calibrated and tested on the data collected on dairy farms which expressed their availability in collaborating in the project. The results show that the model can detect the drop in the cow's milk yield due to extreme hot conditions inducing heat stress effects and milk yield loss. In fact, the average relative error provided by the model in the predictions, is 2% of the total milk production in the test days. The results confirm that the obtained Random Forest Model represents a reliable and viable tool for the evaluation of future production scenarios of dairy cows in presence of heat stress environmental conditions.

The model proposed may thus help to develop and improve decision support systems for farmers to increase both milk yield and animal welfare and, on the other hand, to reduce the resources needed, hence increasing sustainability of the dairy sector.

Definition of a Porous Media Model Simulating the Presence of a Small Canopy Crops in a Greenhouse

Shahad Hasan Flayyih Al- Rikabi*, Enrica Santolini*, Beatrice Pulvirenti, Marco Bovo*, Alberto Barbaresi*, Daniele Torreggiani*, Patrizia Tassinari***

* Department of Agricultural and Food Sciences, University of Bologna, Viale G. Fanin 48, 40127, Bologna, Italy

** Department of Industrial Engineering, University of Bologna, Via Terracini 34, 40131, Bologna, Italy

Keywords. Plant canopy, microclimate, Computational fluid dynamics, Energy balance models.

Abstract Controlling the indoor microclimate condition in a greenhouse is very important in order to ensure the best conditions for both crop growth and crop production. Therefore, to properly assess the indoor microclimate conditions in a protected environment with presence of crops, it is necessary to also consider the plant effects and the possible exchanges between plants and indoor air. To this regard, the present paper provides the results of a study aiming to define a porous media model simulating the crop presence and to evaluate the thermal energy exchange between crops and greenhouse environment.

As first, an experimental campaign has been carried out to evaluate temperature and air velocity distributions in a naturally ventilated greenhouse building with sweet pepper plants cultivated in pots. Then, the main aspects of energy balance, in terms of mass transfer and heat exchange, and both indoor and outdoor climate conditions have been combined to set up a computational fluid dynamics model. In the model, to simulate the crops presence and effect, an isotropic porous medium following Darcy's law has been defined based on the physical characteristics of the plants. The outcomes of the numerical simulations were then compared with the experimental one. The results show that the porous medium model could accurately simulate the heat and mass transfer between the crops, the indoor air, and the soil. Moreover, the adoption of this model helps to clarify the mechanism of thermal exchanges between crop and indoor microclimate and allows to assess in more realistic way the microclimate conditions close to the crops.

Intra row weeding in sugar beets with the use of Artificial Intelligence; from theory to the field.

A.W. van Dueren den Hollander MSc., Machinefabriek Steketee BV, Stad aan 't Haringvliet (NL)

Topic: Precision Agriculture/Digitalization
Keywords: automation, implement, cameras

Abstract

Camera guided hoeing systems are already common practise for several years. The continious pressure of reducing chemical inputs in agriculture, makes that the demand and interest in mechanical hoeing is increasing. Camera guidance makes the operation more efficient and effective. Meanwhile, it is also know that standard image processing, without the use of Artificial Intelligence (AI) has its limitations. Planted crops like lettuce have a head start on the weeds that are emerging from seeds. Therefore, this gives little to no issues in detection for the camera system. Seeded crops however have the same start time for emerging. This can sometimes cause the cultivated crop to be similar or even smaller in size than the weeds. Classical image processing then has a challenge in distinguising the crop from the weeds.

Since the rapid growth of the application of AI in all kinds of industries, the use of AI in Agriculture is an obvious next step. The capabilities of the detection algorithms are able to easily distinguish crops from weeds, and even one weed species from the other species. This led to the development of adding AI capabilities to the existing image processing software of the Steketee IC-Weeder. As a first crop, sugar beets were chosen, as there is a growing market for organic sugar in Europe.

Creating a general model, which is able to recognize sugar beets in various conditions, required a good training data set. To obtain the data, a data collection plan was set up. This was in order to include all possible variations and conditions, like variety and soil types. After gathering data and annotating, the model was trained optimally with the latest available object detection algorithms, to have the best performance.

Deploying the model to the actual implement is a step that cannot be thought of lightly. As there is a minimum required driving speed to make the implement commercially attractive, a minimum frame rate was set. In order to achieve the required frame rate of 30 frames per second, a high performance AI inference hardware platform was chosen. This platform was set up in such a way so it performs optimally for the number of cameras installed on the implement. After this, several optimization steps where necessary in order to have a sufficient inference speed, but also to speed up communication between the AI platform and the main controlling unit.

The last step was getting the graphical user interface (GUI) ready for customers. This means integrating the AI functionality seamlessly into the already existing GUI. Reducing the amounts of input parameters is key for a user friendly system. Visualizing the detected crop together with the confidence threshold ensured a clear but complete overview of the detection.

In this paper the complete process is described from how to go from a theoretical idea to the implementation of AI on a customer ready implement. Furthermore we explain the next steps to take and how the intellectual property was protected with obfuscation.

+31618528666 a.vanduerendenhollander@steketee.com

Abstract for AgEng-LAND.TECHNIK 2022

Title: Grassland yield prediction and mapping in small-scaled regions

Christoph Stumpe, M.Sc. (research assistant, University of Hohenheim, Institute of Agricultural Engineering, Department Fundamentals of Agricultural Engineering, Garbenstr. 9, 70599 Stuttgart, phone: +49 711 459 22870, fax: +49 711 459 22519, mail: christoph.stumpe@uni-hohenheim.de)

Stefan Böttinger, Prof. Dr.-Ing. (head of department, University of Hohenheim, Institute of Agricultural Engineering, Department Fundamentals of Agricultural Engineering, Garbenstr. 9, 70599 Stuttgart, phone: +49 711 459 23200, fax: +49 711 459 22519, mail: boettinger@uni-hohenheim.de)

Precision farming applications, like variable rate fertilisation or seeding based on site-specific information, are widespread in crop production and already in use in practical arable farming. In contrast, grassland management depends mainly on the knowledge and experience of farmers or their estimations instead of sensor-based measurements. For this reason, prediction of grassland yield already during the growing period and the creation of yield maps are current challenges particularly in small-scaled regions. Since this information serves as a basis for the application of precision farming technologies, it is of great interest to the farmer.

In this context, the advantages and disadvantages, the accuracy and practical aspects of three selected techniques for grassland yield prediction and determination are investigated by on-farm research. The selected techniques include yield prediction during the growing period based on measurements by a rising plate meter (RPM) and by an unmanned aerial system (UAS). Furthermore, yield determination based on the measurement of power requirements during the harvesting process is used and examined.

As part of a digital trial field-project the research shows the differences of the investigated techniques in accuracy and in application effort for the farmer. For example, the yield prediction based on multispectral data and the vegetation indices calculated from them is less accurate than the yield prediction using a RPM. Especially the application of sward- and region-adapted prediction equations leads to a higher prediction accuracy. Based on this, yield prediction by the combination of different measurement methods is studied with the help of machine learning methods. This approach will provide farmers with the most precise yield information, which will help them in grassland management and stock planning.

Presentation topic: Precision Agriculture/Digitalization

M.Sc. Christian Depenbrock – Research Assistant,
Prof. Dr. Ludger Frerichs – Director
Institute of Mobile Machines and Commercial Vehicles, TU Braunschweig

Investigation and testing of a novel concept for straw management with the “Kombi-Mulcher“

Proposal for a contribution to AgEng-LAND.TECHNIK 2022

Climatic changes are increasingly causing extreme weather conditions, which are making the demands on harvesting technology in the agricultural sector ever more challenging. These changes result in shorter periods for grain harvesting, higher demands on sustainable agriculture and leads to more incalculable economic developments. For a more sustainable agriculture, it is desirable to achieve a humus build-up in the field and to minimise the use of synthetic fertilisers.
The classic method of straw management is either the complete straw incorporation or straw removal from the field. For optimal control of the nutrient balance and more, it would be desirable to remove and remain the straw variably depending on location and crop rotation. In addition, a high cutting combine harvester in particular can be used more efficiently and productively due to a lower straw content in the crop flow. The straw remaining in the field will have advantages for incorporation into the soil and for uniform mixing with the soil rooting due to a balanced distribution of chaff in the transverse and longitudinal directions. With this concept, it is possible to recover the straw remaining on the field after the high cut in variable quantities and optional to shred the remaining stubble.
In scope of a research project, a machine that enables the variable straw removal after high cutting was developed. The concept of the so-called “Kombi-Mulcher” was already presented on the LAND.TECHNIK 2020. In the meantime, the machine was built up and tested in field. This contribution to the conference provides the design and construction of both the individual units and the overall machine. The sub-processes of cutting, conveying and mulching are considered. The built prototype is tested in field by means of statistical test planning. The advantages of this procedure are shown and the results of the trials in in the latest harvest seasons are presented. For evaluation of the machine and the concept itself, the focus is on energy efficiency and environmental protection. Therefore, the entire process chain is considered. Furthermore, interesting findings on saving tillage and the possibility of using the "Kombi-Mulcher" to bring the volunteer grain to germination will be presented.

Contact:
M.Sc. Christian Depenbrock
Institute of Mobile Machines and Commercial Vehicles
Technische Universität Braunschweig
Langer Kamp 19a
38106 Braunschweig

c.depenbrock@tu-braunschweig.de
Tel.: 0531/391-7185
Fax: 0531/391-5951

Assignment to topic: 1.6: Post-Harvest Technologies

Scientific reviewing requested: Yes

Title: Smart farming technology adoption for improved decision-making: Perspectives from Australian broadacre agriculture

L.J. Armstrong, D.A. Diepeveen, D. M. Cook.
School of Science, Edith Cowan University, Joondalup, WA. Australia.
Corresponding Author Email: l.armstrong@ecu.edu.au

Abstract
Broadacre cropping is a significant contributor to the Australian economy, with exports of grain generating an average of $10.7bn in revenue, over the past 5 years. The average farm size in Australia is 5000 hectares, producing crops such as wheat, barley, canola, oats and pulses/lupins. Approximately 70% of wheat in Australia is exported with the remainder for domestic market including for animal production. The majority of grain is produced under rainfed Mediterranean environments with limited rainfall and poor soils.

Increasing the productivity at farm level is a key government objective in Australia with substantial research being undertaken in measuring and evaluating broadacre productivity. With this push to improve broadacre crop production to meet expected increasing demands for food security, there is a need for growers to find strategies and technologies to improve all aspects of the crop and pasture programs. The adoption of smart farm technologies is one avenue towards achieving this improved production. However, as technology is continually evolving, on-farm technology is likely to not be adopted uniformly across Australia.

While Australian broadacre farmers have readily adopted some technologies such as variable rate and controlled-traffic seeding, there is still a reluctance by growers to use some of these newer technologies. These technologies include: IOT and integrated data sensors, remote sensing and drones, and integrated in-season decision making to address lower overall farm risk. While technology cost and lack of infrastructure are barriers to this adoption, another major bottleneck is the need to upskill farmers to be able to adapt these smart farm technologies to their on-farm conditions. Agricultural Consultants or technology specialists (including servicing of new machinery) are used for strategic advice on improving profitability. Larger broadacre farms often use farm-budget Agricultural Consultants to improve individual paddock performance. By estimating individual paddock productivity, they can develop strategies across the farm(s) for the grower to reduce variable costs (such as fertiliser and fuel) and optimise profits and gross margins.

This paper addresses the specific regional bottlenecks of broadacre farmers in the adoption of smart farm practices. Round-table discussions with growers have indicated that each regional area may have different rates of adoption of smarter farming. A strategic approach is needed to ensure these smart technologies are adopted across different regions.

Smart farming approaches often make better use of data for in-season decisions as well as for alternative farming strategies such regenerative-agriculture, organic-farming, and net-zero farming. Farmers are becoming increasingly aware of the need for full access to their data, ensuring data security and maintaining data quality can improve their decision-making in crop management strategies.

The paper also addresses the need for broadacre farmers to continually refine the decision-making. As these technologies are adopted and become readily accessible online, farmers can then address and resolve critical crop management issues in- season to maximise crop production and quality. Any small reductions in production costs or increase in crop production will continue to have substantial impact on large-scale agricultural production profits.